Initial Site-Specific De-Inventory Report for Rancho Seco

RPT-3022581-001

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REVISION LOG

Rev.	Date	Affected Pages	Revision Description
000	8/23/19	N/A	Initial Issue
001	5/10/23	Disclaimer	Updated disclaimer per DOE GC recommendations
		Acronyms	Added Atomic Energy Act (AEA)
		Executive Summary	• Deleted first paragraph • Clarified some text • Updated here and throughout the report to "Security Plan"

			• Updated here and throughout the report to "Emergency Response Plan" • Updated year from 2019 to 2022 as the cost values between the two years will not have changed significantly
		Section 1	• Editorial changes made to clarify text • Added "Possible" to Figure 1-2 caption • Change from transportation cask to dry shielded canister
		Section 2	• Updated Figure 2-2 • Updated nearby solar projects and updated RSNGS FSAR and updated ISFSI license • Updated Figure 2-4 • Updated information on ancillary equipment • Updated Figure 2-8 • Updated on status of local rail spur • Added HSM adapter to equipment needs • Added information on TN Eagle transportation cask as alternative to MP197HB
		Section 3	• Editorial changes • Updated Figures 3-1, 3-8, and 3-9 with recent photos
		Section 4	• New introductory text has been added to identify the temporal nature of the information in this chapter • Two new paragraphs provided by the Department of Energy's General Counsel have been added • Clarified entities and persons in bulleted list
		Section 5	Minor grammatical updates
		Section 6	• Clarification of potential use of a TN-Eagle cask • Minor grammatical updates • Added new footnote to clarify NRC route approval is not typically required for DOE shipments • Deleted text related to the superceded DOE Manual 460.2 • Deleted paragraph related to NRC oversight

			• Deleted material in section 6.6 related to the QAP
		Section 7	• Updated year from 2019 to 2022 as the cost values between the two years will not have changed significantly • Added HSM adapter to equipment needs • Other minor grammatical changes • Revised section 7.6 title
		Section 8	• Revised section title (removed “”Safety”) • Clarifications made to the text • Added clarification of application of section material to RSNGS • Clarified protection of Safeguards Information • Renamed sections 8.4, 8.11, 8.12, 8.13 • Deleted text related to the superseded DOE Manual 460.2 and updated to 460.2B for the order and associated bullets in Sections 8.11, 8.12 & 8.13 • Added new bullets to Sections 8.11, 8.12 & 8.13 covering in-transit protection
		Section 9	• Modified section and sub-section titles • Minor grammatical updates made • Section 9.1 revised to reflect requirements associated with emergency response information that is commonly incorporated into an Emergency Response Plan • Updated information required for an emergency contact telephone number • Provided some clarifying remarks on the example index of an ERP and corrected some items in the index
		Section 10	• Clarified item #2 and #3 • Updated information on MP197HB • Added recommendation to consider TN-Eagle cask for transportation
		References	Updated references

DISCLAIMER

This is a technical report that does not take into account contractual limitations or obligations under the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract) (10 CFR Part 961).

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

This report reflects technical work which could support future decision making by the Department of Energy (DOE or Department). No inferences should be drawn from this report regarding future actions by DOE, which are limited both by the terms of the Standard Contract and Congressional appropriations for the Department to fulfill its obligations under the Nuclear Waste Policy Act including licensing and construction of a spent nuclear fuel repository. To the extent costs are discussed in this report, this report does not specify the party or parties responsible for the costs estimated herein.

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LIST OF ACRONYMS

AAR	Association of American Railroads
AEA	Atomic Energy Act
ALARA	As Low As Reasonably Achievable
ASNT	American Society for Nondestructive Testing
AZ	Arizona
B&W	Babcock & Wilcox
BNSF	Burlington Northern Santa Fe Railway
Bq	Bequerels
BOL	Bill of Lading
CA	California
CAD	Computer Aided Drawing
CalEPA	California Environmental Protection Agency
Caltrans	California Department of Transportation
CCT	Central California Traction Company
CFR	Code of Federal Regulations
CHP	California Highway Patrol
Ci	Curies
CoC	Certificate of Compliance
COTP	Captain of the Port
CRCPD	Conference of Radiation Control Program Directors, Inc.
DHS	Department of Homeland Security
DOE	Department of Energy
DOT	Department of Transportation
DSC	Dry Shielded Canister
DTSC	Department of Toxic Substances Control
ERP	Emergency Response Plan
FC-DSC	DSCs containing Fuel with Control Components
FF-DSC	DSCs containing Failed Fuel
FO-DSC	DSCs containing Fuel Only
FRA	Federal Railroad Administration
FSAR	Final Safety Analysis Report
FSO	Facility Security Officer
FSP	Facility Security Plan
GCUS	Geographical Center of the 48 Contiguous United States
GPS	Global Positioning System
GTCC	Greater Than Class C
GWd	GigaWatt-day
HAZMAT	Hazardous Material
HHT	Heavy Haul Truck/Trailer
HLW	High-Level Radioactive Waste
HRCQ	Highway Route Controlled Quantity
HSM	Horizontal Storage Module
HTUA	High Threat Urban Areas
ISFSI	Independent Spent Fuel Storage Installation
ISG	Specialty Granules, LLC.

KS	Kansas
kW	kiloWatt
lbs	pounds
LLEA	Local Law Enforcement Agency
LLW	Low-Level Radioactive Waste
M&TE	Measuring and Test Equipment
MCC	Movement Control Center
MO	Missouri
MOTCO	Military Ocean Terminal Concord
MTHM	Metric Tons Heavy Metal
MTSA	Maritime Transportation Security Act
MTU	Metric Ton Uranium
MUA	Multi-Attribute Utility Analysis
MW	MegaWatt
MW(e)	MegaWatt (electric)
n/a	not applicable
NM	New Mexico
NRC	U.S. Nuclear Regulatory Commission
NUHOMS	Nuclear Horizontal Modular Storage System
NWPA	Nuclear Waste Policy Act
OJT	On-the-Job Training
OR	Oregon
OSHA	Occupational Safety and Health Administration
OTLR	Open Top Loading Rules
PHMSA	Pipeline and Hazardous Materials Safety Administration
PIH	Poisonous Inhalation Hazard
PPE	Personal Protective Equipment
PTRA	Port Terminal Railroad Association
QA	Quality Assurance
QAP	Quality Assurance Program
QC	Quality Control
RCT	Radiation Control Technician
RP	Radiation Protection
RSAT	Risk and Security Assessment Team
RSNGS	Rancho Seco Nuclear Generating Station
RSSM	Rail Security Sensitive Materials
RWP	Radiation Work Permit
SAR	Safety Analysis Report
SFA	Spent Fuel Assembly
SME	Subject Matter Expert
SMUD	Sacramento Municipal Utility District
SNF	Spent Nuclear Fuel
SNM	Special Nuclear Material
START	Stakeholder Tool for Assessing Radioactive Transportation
STE	Stockton Terminal & Eastern Railroad
TC	Transport and Waste Management Coordinator

TIH	Toxic Inhalation Hazards
TN	TransNuclear
TPE	Training Program Evaluation
TS	Technical Specification
TSA	Transportation Safety Administration
TT	Transfer Trailer
TWIC	Transportation Worker Identification Credential
TX	Texas
UP	Union Pacific
UT	University of Tennessee
UT	Utah
U.S.	United States
USCG	U.S. Coast Guard
VA	Virginia
VDS	Vacuum Drying System
VSP	Vessel Security Plan
WY	Wyoming

EXECUTIVE SUMMARY

The purpose of this report is to assist the United States (U.S.) Department of Energy (DOE) in laying the groundwork for implementing an integrated nuclear waste management system. This includes preparing for future large-scale transport of Spent Nuclear Fuel (SNF), High-Level Radioactive Waste (HLW), and Greater Than Class C (GTCC) Low-Level Radioactive Waste (LLW). This report addresses the tasks, equipment, and interfaces necessary for the complete de-inventory of the independent spent fuel storage installation (ISFSI) site at the former Rancho Seco Nuclear Generating Station (RSNGS) located in the village of Herald, CA, 25 miles south-east of downtown Sacramento and 85 miles north-east of Oakland CA. As such, this report is intended to provide information useful for planning options within an integrated nuclear waste management system.

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

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

1. Rail directly from the RSNGS on-site rail spur on the Union Pacific (UP) through Sacramento, CA and Kansas City, MO.
2. Rail directly from the RSNGS on-site rail spur on UP through Fresno, CA and El Paso, TX.
3. HHT from RSNGS ISFSI to Ione, CA and then by rail on UP through Sacramento, CA and Kansas City, MO.
4. HHT from RSNGS ISFSI to Military Ocean Terminal Concord (MOTCO) and then by rail on UP through Sacramento, CA and Kansas City, MO.
5. HHT from RSNGS ISFSI to Stockton, CA and then by barge through the Panama Canal to Houston, TX and then by rail from the Port Terminal Railroad Association (PTRA) for about 8 miles and then the UP.

Sensitivity analyses were performed on the MUA results to examine the impact on the rankings of the routes created by changes in the weighting of metrics used to evaluate those routes (e.g., cost of rental equipment, ease of permitting, etc.) and by suppressing the evaluation range of some specific metrics (e.g., cumulative worker exposure). The sensitivity analyses showed extremely consistent rankings, with the routes maintaining the same ranking for every weighting variation analyzed.

Using the primary MUA result, a concept of operations and recommended budget and spending plan are detailed for the removal of existing SNF and GTCC LLW from the RSNGS site using the most attractive shipment route: by rail from the RSNGS on-site rail spur on UP through

Sacramento, CA and Kansas City, MO, to the GCUS. The total estimated budget for the RSNGS campaign organized over 26 calendar weeks is $8.7M (2022), noting this only covers on-site operational activities and not transportation costs, hardware costs, etc. Also documented in this assessment are aspects of a Security Plan and associated procedures and an Emergency Response Plan and associated preparedness for the prospective shipments. Finally, the recommended next steps are identified for the process of initiating the removal of the existing SNF and GTCC LLW from the RSNGS site.

1.0 INTRODUCTION

This report provides an assessment of the tasks, equipment, and interfaces that would be necessary to remove the SNF and GTCC LLW from the RSNGS ISFSI located in the village of Herald, CA, 25 miles south-east of downtown Sacramento and 85 miles north-east of Oakland CA. The objective of this removal activity would be to transport the existing SNF and GTCC LLW to a Class I railroad, where it could then be transported to a future consolidated interim storage facility or geological repository. A railroad hub in the central U.S. with connections to all other major rail carriers was used as the route endpoint for the purposes of this study, because it could serve as a connection point to storage or disposal facilities located in any region of the U.S. The use of GCUS as a hypothetical destination is not to imply that this location is being considered for a future consolidated interim storage facility, geological repository, or a transportation hub but was used, for purposes of this report, as a basis for scheduling and costing estimates assessed in this report.

In performing this assessment, the results are expected to support the laying of groundwork for implementing an integrated nuclear waste management system for the U.S. DOE. This includes preparing for future large-scale transport of SNF, HLW, and GTCC LLW. This assessment specifically examines the removal of the existing SNF and GTCC LLW contained within the RSNGS ISFSI using Orano's and our teaming partners' experiences in the shipping of like and similar materials. For the purposes of this assessment, it is assumed that DOE would be responsible for a federal consolidated interim storage facility or geological repository to which the material would be shipped and would be the shipper of record; it is also assumed that the shipments would be regulated by the U.S. Nuclear Regulatory Commission (NRC) and the Department of Transportation (DOT) like comparable commercial shipments.

To lay the foundation of the assessment, the report begins by examining the pertinent site information in **Section 2.0**, including a description of the site and its characteristics, the characteristics of the existing SNF and the GTCC LLW to be shipped from the site, a description of the TN Americas, LLC Standardized NUHOMS System used to store this material onsite and the associated transportation packaging system, the recommended TN MP197HB. The site information is vital to establishing whether sufficient space exists to perform transfer activities and to assessing and identifying the potential need for site infrastructure modifications (e.g., fence line modifications to optimize/streamline transfer operations and/or loading activities) and/or hardware requirements (e.g., need for an intermodal transport cradle) to facilitate the shipment of these MP197HBs from the RSNGS ISFSI. Although interacting directly with 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 the GTCC LLW at the RSNGS ISFSI provide information that will be necessary to verify compliance with the transportation license via the NRC Certificate of Compliance (CoC) for the MP197HB. Similarly, the description of the dry shielded canisters (DSCs) to be shipped from the RSNGS ISFSI will be provided to allow verification of compliance with their CoC, allowing, if necessary, provisions to be designated to bring them into compliance or identification of exemptions requiring approval from the regulator in the future.

After the pertinent site information was assessed, a transportation route analysis was performed, as described in **Section 3.0**, identifying transportation routes from the RSNGS ISFSI to a Class I railroad, which would then be used for subsequent shipment to a repository or interim storage facility. Multiple modes of transport of the existing SNF and GTCC LLW were considered (i.e., HHT, rail, and barge). From the RSNGS ISFSI site itself, HHT and rail were evaluated to be viable options for shipment of the existing SNF and GTCC LLW. **Figure 1-1** depicts the major steps of the potential transfer scenarios considered. As shown in this figure, the direct to rail scenarios (Routes A and B) appear to be the least complicated approach, with the minimum number of times the casks are handled, whereas the HHT-to-barge scenario (Route E) and the HHT-to-rail scenario (Routes C and D) appear 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 positive and negative, that require evaluation to identify the optimal and/or favored route to transport the existing SNF and GTCC LLW from the RSNGS 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 for all the potential routes would be burdensome, so initial screening criteria were established to allow for less attractive routes to be screened from further consideration based on attributes associated with a particular mode of transport (i.e., screening is performed only between routes associated with a particular mode of transport). These screening criteria were applied in **Section 3.0** to reduce the number of identified routes from a significant quantity to a manageable number of five. After the participating entities were identified in **Section 4.0**, these five routes were evaluated using the MUA to rank the routes for shipping the existing SNF and GTCC LLW from RSNGS to the hypothetical destination of GCUS by Class I rail in **Section 5.0**. **Figure 1-2** identifies the routes evaluated in the MUA.

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

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

Figure 1-1: Potential Flow of Operations Assessed for Loading a Consist per Mode of Transport from RSNGS ISFSI

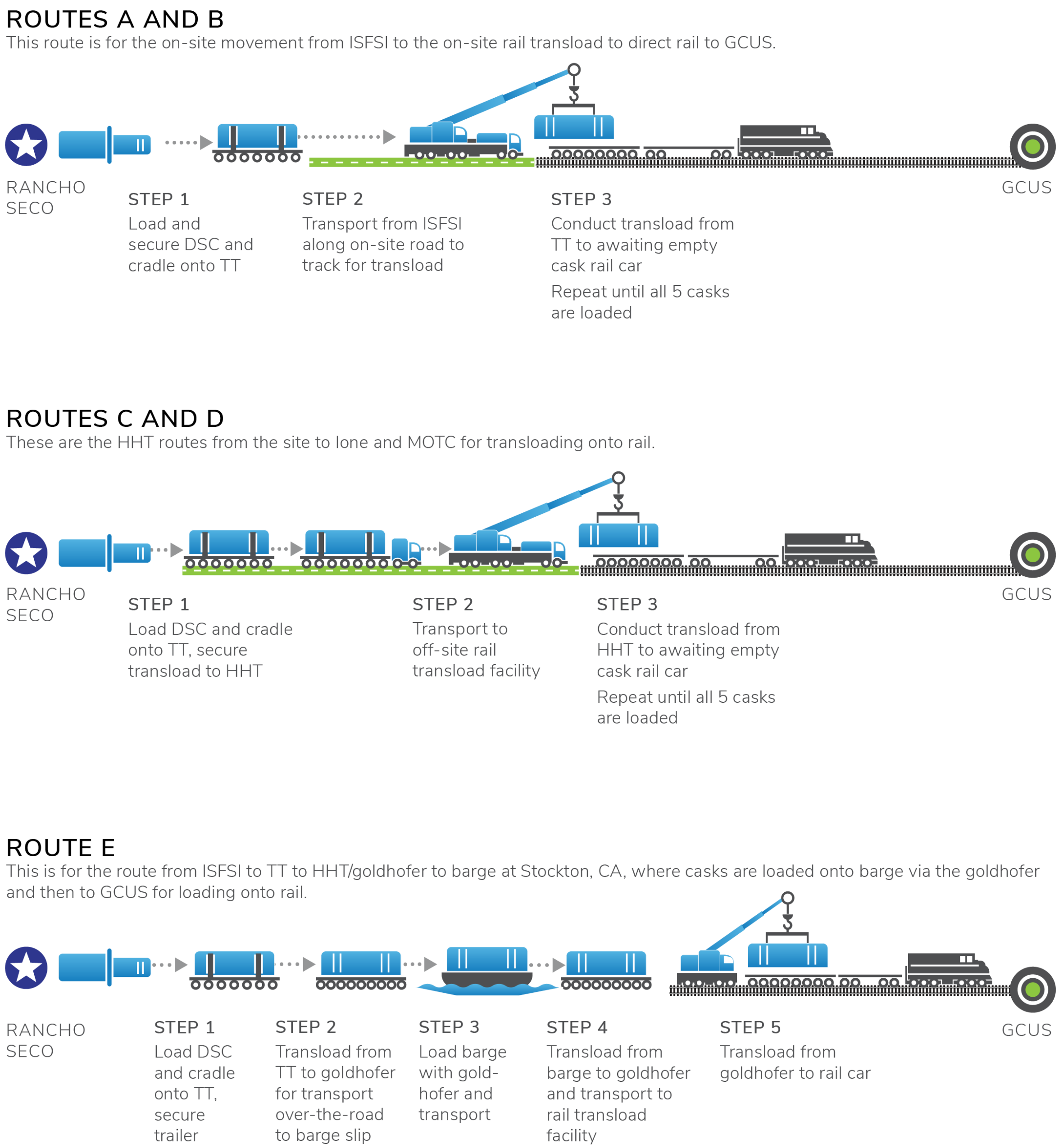
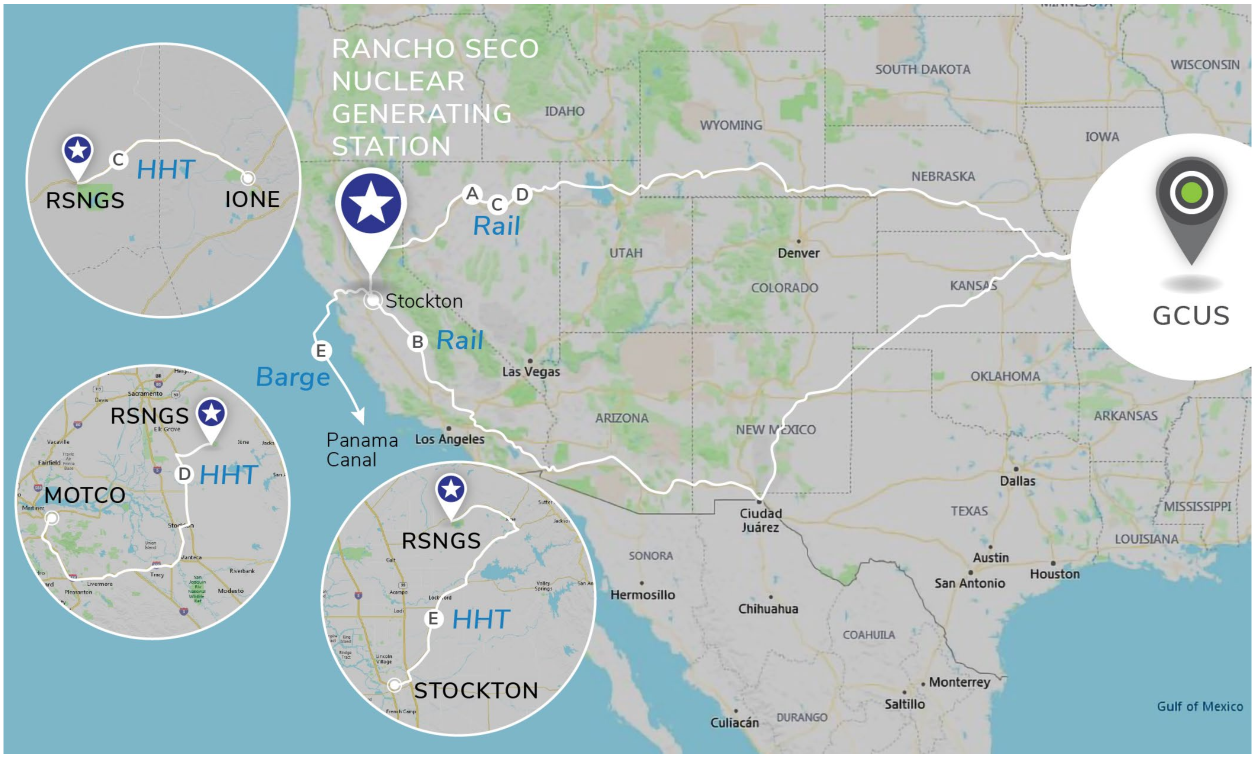


Figure 1-2: Possible Routes Evaluated by the MUA for Shipment of SNF and GTCC LLW from RSNGS ISFSI



2.0 PERTINENT SITE INFORMATION

2.1 Description of Site/Characteristics

The RSNGS site, owned by Sacramento Municipal Utility District (SMUD), is located in Herald, CA, approximately 25 miles southeast of Sacramento and 26 miles northeast of Stockton, between the foothills of the Sierra Nevada Mountains to the east and the Pacific Coast range bordering the Pacific Ocean to the west as shown in **Figure 2-1.**

Figure 2-1: RSNGS Site Location[2]

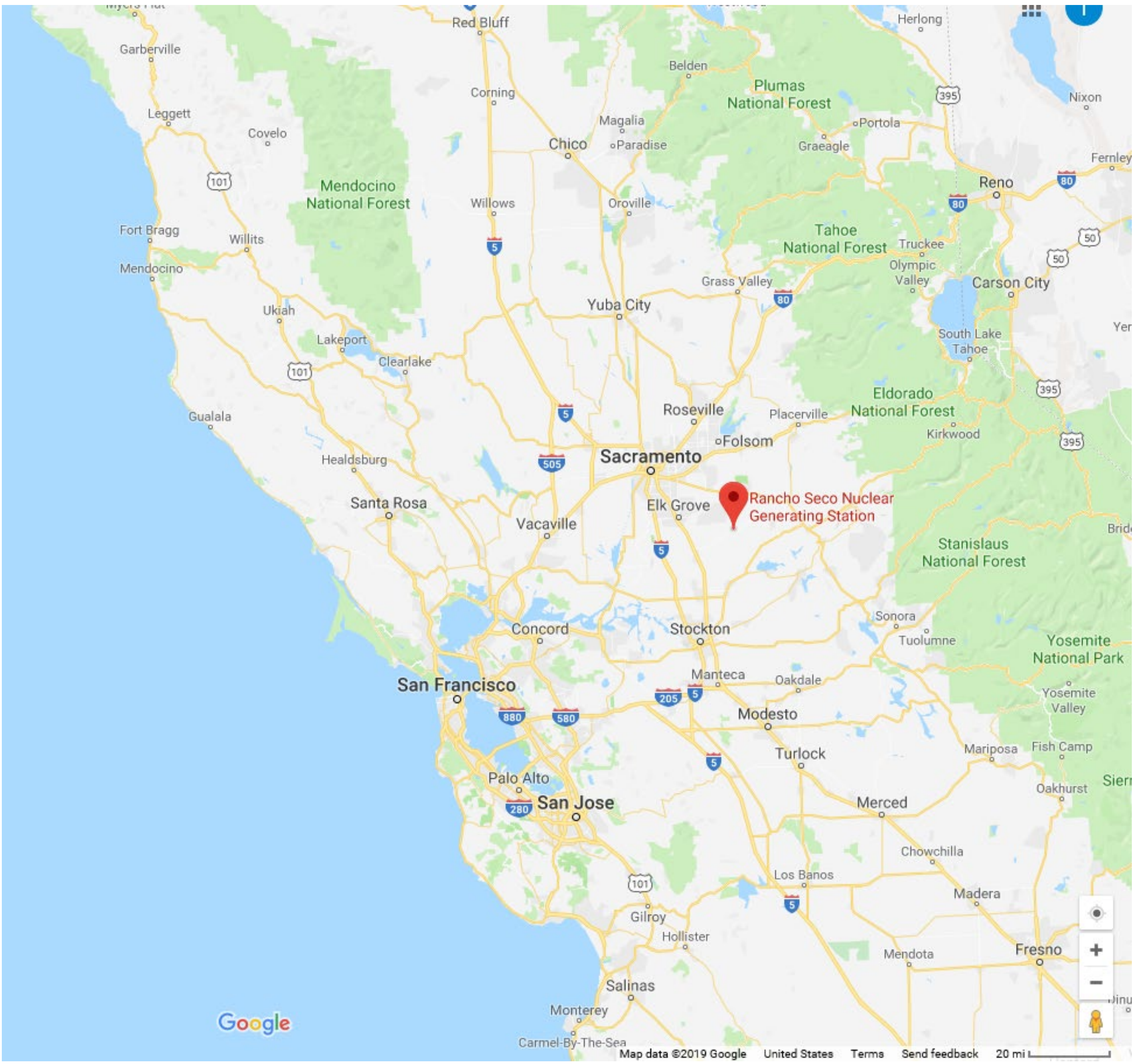
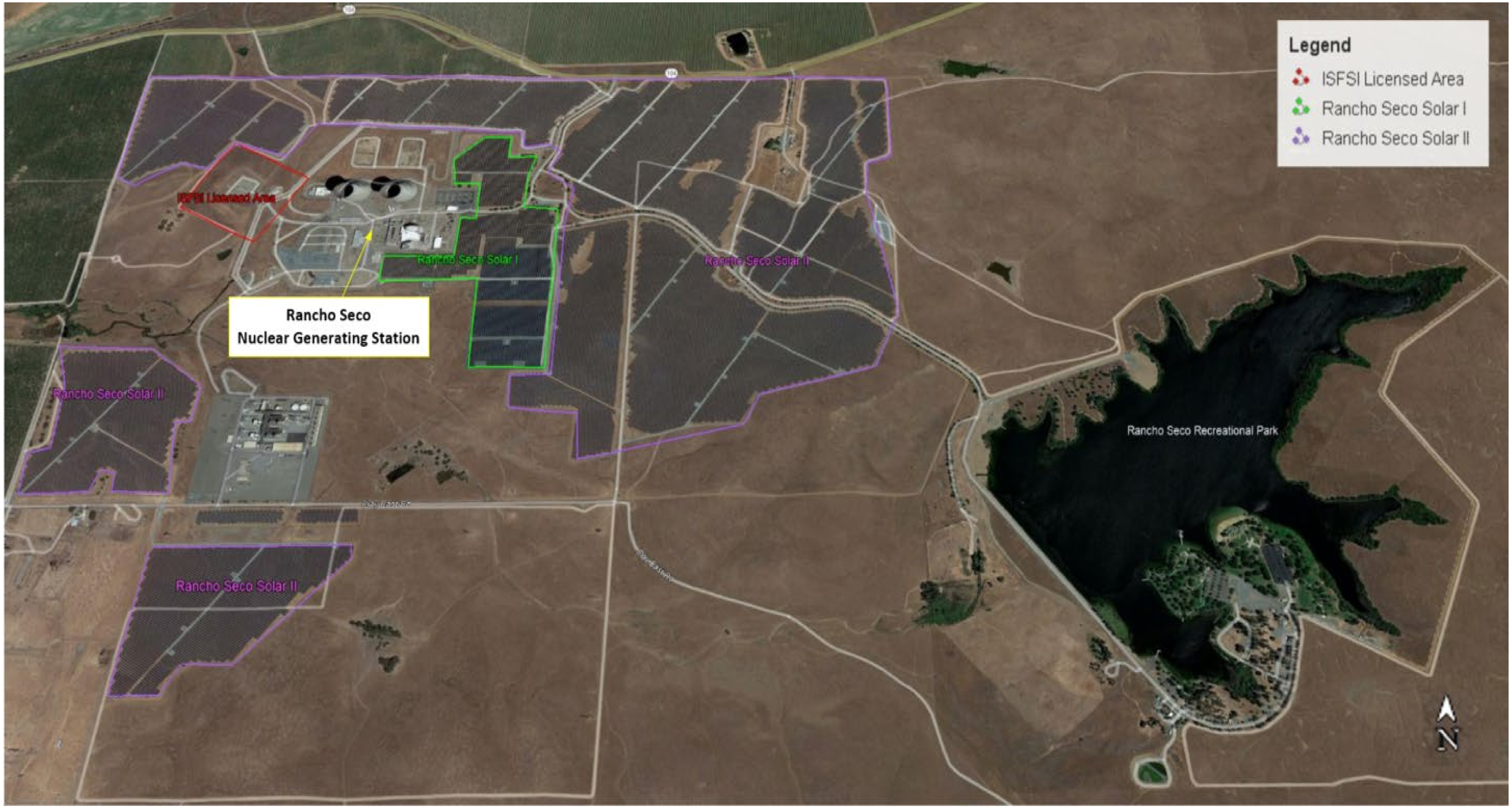


Figure 2-2: Rancho Seco Site



Photo/Boundary markings courtesy of SMUD, 11/2/2022

The 2,480 acre site, as shown in **Figure 2-1** and **Figure 2-2**, includes the decommissioned RSNGS, a 30-acre 500MW combined cycle gas-fired Cosumnes Power Plant, a 50 acre 10MW Photo-Voltaic Solar I Project, a 550 acre 160MW Photo-Voltaic Solar II Project, and a 560-acre Rancho Seco Reservoir and Recreation Area, as well as the 14-acre 10 Code of Federal Regulations (CFR) Part 72 licensed Independent Spent Fuel Storage Installation (ISFSI)[3]. Surrounding the ISFSI site to the north, east and south are rolling hills vegetated with naturalized annual grasses. **Figure 2-3** shows details of the owner-controlled area of the site.

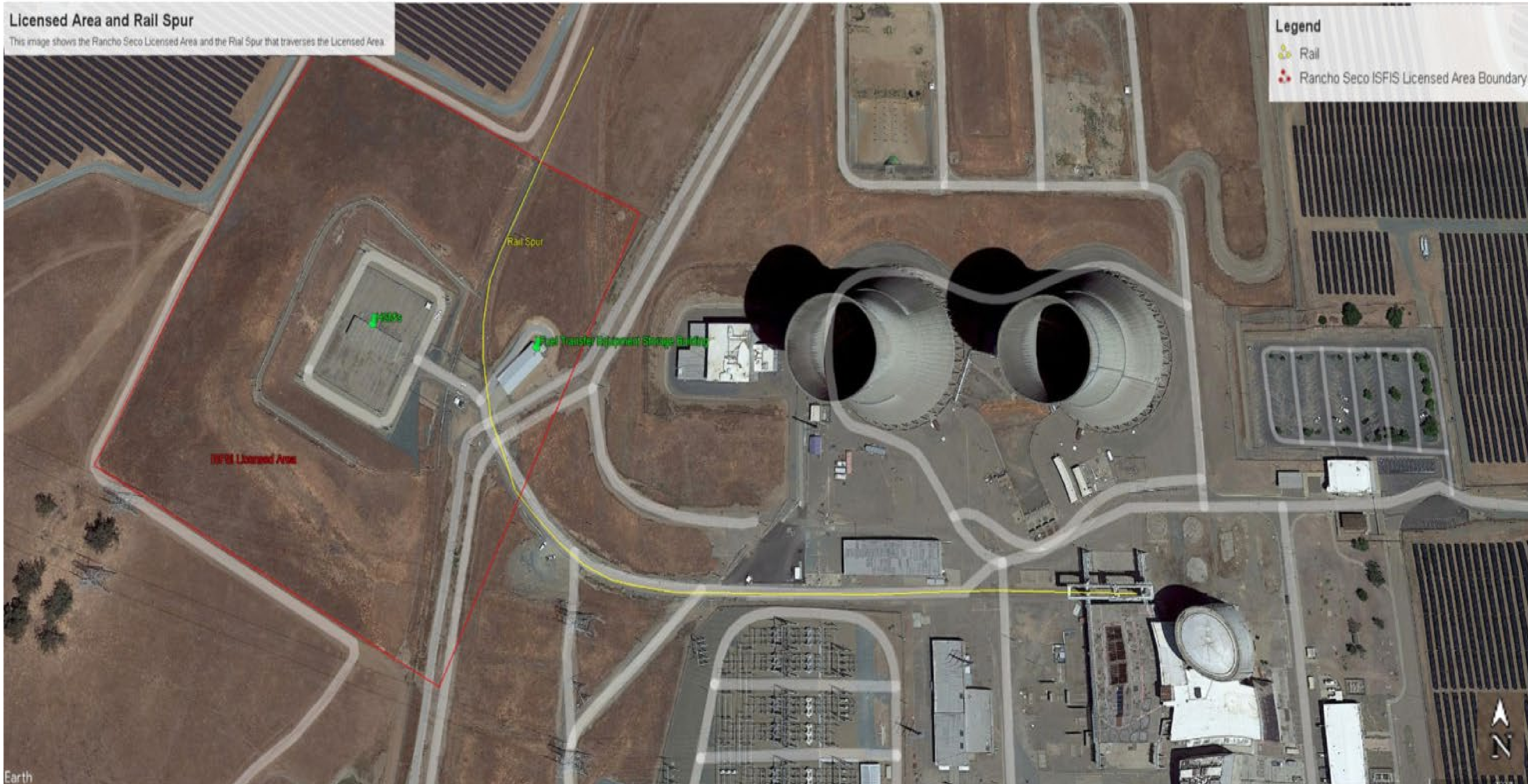
RSNGS was a 913 megawatt (electric) (MWe) Babcock & Wilcox (B&W) design nuclear power plant that began commercial operation April 18, 1975. It was shut down June 7, 1989 as the result of a voter referendum. The reactor was completely defueled on December 8, 1989[4]. The RSNGS facility 10 CFR Part 50 license (Docket 50-312, License # DPR-54) was terminated on August 31, 2018[5]. The cooling towers, reactor containment building, and other associated structures presently remain on-site. A 10 CFR Part 72 license (Docket 72-11, License # SNM-2510) for the ISFSI was issued for the RSNGS site in June 2000 under which the fuel assemblies and the reactor-related GTCC wastes are stored in the ISFSI. RSNGS is currently utilizing license SNM-2510 Amendment 4 and Final Safety Analysis Report (FSAR) Revision 10. The original 20-year ISFSI license was extended in 2020 and will now expire on June 30, 2060[6]. The location of the ISFSI and the licensed Part 72 boundary is shown in **Figure 2-4**.

The RSNGS site is directly served by UP via a 1-mile long private rail spur leading from the main line into the reactor building. A short length of track runs adjacent to the on-site ISFSI. The site also has direct truck access via U.S. Highway 104 that runs just north of the site in a general east-west direction and is the main access road to the plant and to nearby recreational facilities. There are no on-site public highways that traverse the RSNGS ISFSI. There is no on-site barge access at the site.

The storage system used at RSNGS is a site-specific model of the Standardized NUHOMS-24P system (Docket No. 72-11), which consists of transportable NUHOMS-24P DSCs, and reinforced concrete NUHOMS HSM-80 horizontal storage modules (HSM). The MP187 transfer cask (Docket No. 71-9255) was used to load and transfer the DSCs from the spent fuel pool to the HSMs and was originally planned to be used for the off-site transportation of the DSCs. However, this report will utilize the more universal MP197HB transport cask instead to retrieve the DSCs from the HSMs and for off-site transportation of the DSCs in the de-inventory process. A reconciliation of the MP197HB Safety Analysis Report (SAR) for use at RSNGS and a review of the operations and ancillary equipment are a prerequisite before starting planning for the operations. Refer to **Section 7.0** and **Section 10.0** for additional details and justification regarding the usage of the MP197HB as the transport cask. Refer to **Section 2.2** and **Section 2.3** below for information regarding the details of the SNF and GTCC to be shipped and for canister and overpack details.

Figure 2-3: Rancho Seco Owner Controlled Area[6]

Figure 2-4: Rancho Seco ISFSI Location



Photo/Boundary markings courtesy of SMUD, 11/2/2022

The ISFSI and HSMs are shown in **Figure 2-5** and **Figure 2-6**. The ISFSI storage pad consists of a concrete slab approximately 225ft long, 170ft wide, and 2ft thick at the location of the HSMs and 12 to 18 inches thick for the remainder of the ISFSI pad. The ISFSI and HSMs are contained within an approximately 14 acre licensed area and all 22 HSMs are all loaded. There is 6 inches between HSMs. The ISFSI pad is securely fenced and locked inside its own protected area. The ISFSI pad is surrounded on all sides by a concrete approach apron, several feet of gravel, and two 8 feet high security fences. A pre-engineered electrical building is housed in one corner of the ISFSI to house lighting and security equipment[7][8]. The ISFSI basemat is designed to support the two rows of 11 HSMs and end shield walls. The approach roadway slab is 20 ft wide and is designed according to the California Department of Transportation standard specifications[9]. The MP187 cask and the necessary ancillary equipment is available for use. The hydraulic ram system used to emplace and withdraw canisters from the horizontal storage modules is shown in **Figure 2-7** outside the Fuel Transfer Equipment Storage Building. The Fuel Transfer Equipment Storage Building is located in the Part 72 licensed area outside of the ISFSI access gated area.

Figure 2-5: RSNGS ISFSI[2]

Figure 2-6: RSNGS HSM[10]

Photo courtesy of Rancho Seco

Figure 2-7: Hydraulic Ram System Used to Emplace and Withdraw Canisters from HSMs at Rancho Seco (2013)[10]

Site Infrastructure

Figure 2-8 provides an aerial view of the RSNGS site, including the reactor site, ISFSI, and rail spur. The reactor building equipment and spent nuclear fuel pool have been decommissioned and removed, but the cooling towers, reactor containment building, and other associated structures remain on-site. In 2014, the remaining low-level radioactive waste that was stored on-site after decommissioning was shipped to Andrews, TX for disposal. Electrical power is available at the RSNGS ISFSI[10].

The on-site rail spur at the RSNGS site is approximately 1-mile long and is shown in the next three figures. **Figure 2-8** shows the short length of track running adjacent to the ISFSI and the longer length of track running into the RSNGS reactor site. **Figure 2-9** shows the junction of the short track adjacent to the ISFSI. **Figure 2-10** shows the longer track running into the RSNGS site.

A proposed haul path of approximately 100ft from the ISFSI pad to the track spur running adjacent to the ISFSI is shown in **Figure 2-11**. Fencing infrastructure improvements may be necessary for full enclosure of the ISFSI and the proposed transload site.

Figure 2-8: Aerial View of Rancho Seco Site[43]

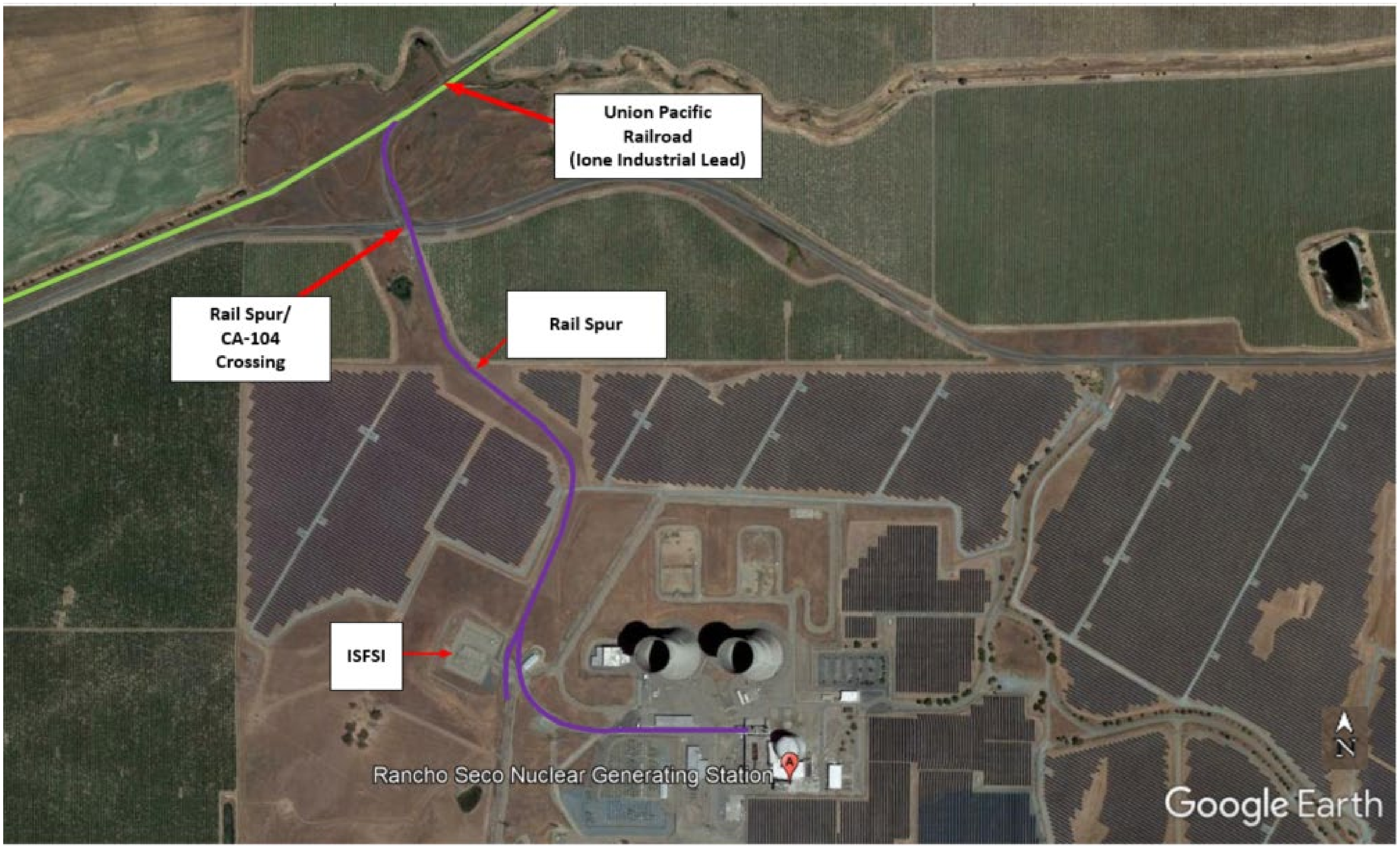
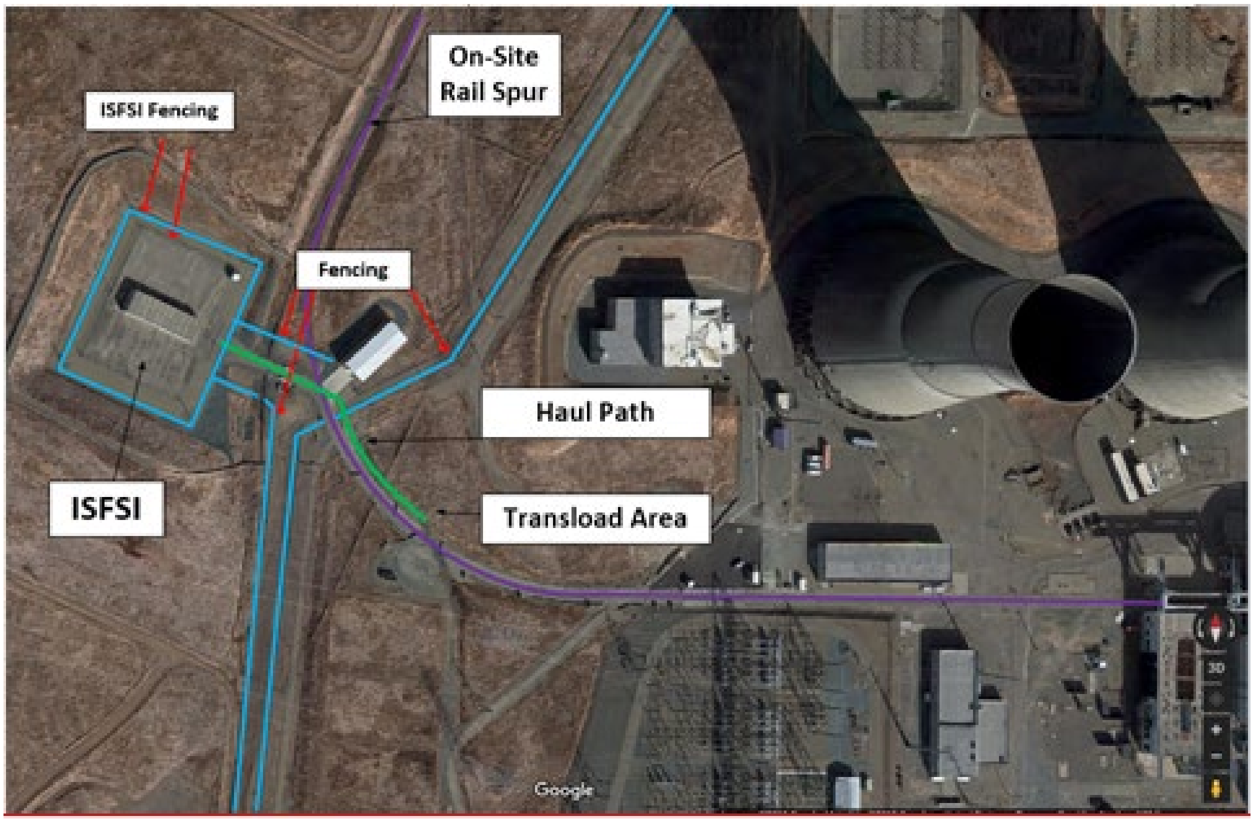


Figure 2-9: Junction of the On-Site Spur Running Adjacent to the ISFSI (right) and the Longer Track Running into RSNGS (left) (2013)[10]

Figure 2-10: On-Site Rail Spur Running into Rancho Seco Site (2013)[10]

Figure 2-11: ISFSI Haul Path to Track Spur[2]



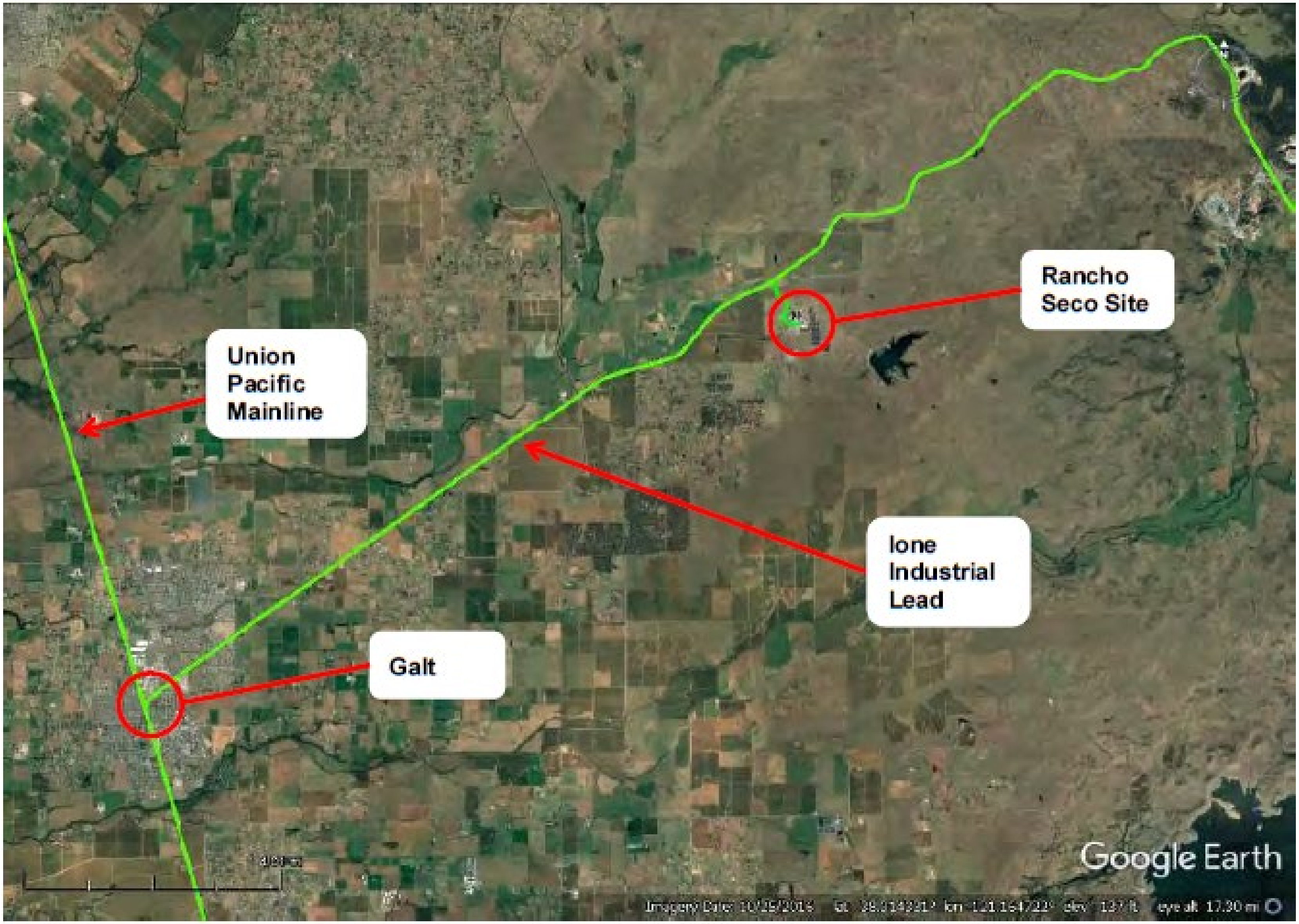
Near-site Transportation Infrastructure

SMUD owns the rail spur that provides access to the UP's Ione Industrial Lead, which runs west from the RSNGS site to the UP mainline in Galt, California (see **Figure 2-12)**, a distance of 12 rail miles. The distance from Galt to Sacramento, California is 26 rail miles and the distance from Galt to Stockton, California is 22 rail miles. The UP mainline is designated as track class 5 and the Ione Industrial Lead is designated as track class 2. The maximum gross weight of railcars on the Ione Industrial Lead between the RSNGS site and Galt is 158 tons (for a 4-axle car), and 6-axle locomotives are prohibited. Most of the restrictions in the current timetable for the Ione track apply east of the Rancho Seco point of switch (where the private siding intersects with the UP track), leading to Ione, CA. A loaded MP197HB transport cask would weigh between 151.5 tons and 167.5 tons and a cask-carrying railcar would weigh at least 43 tons, so the weight limit of 158 tons is likely to be exceeded; however, movement of these heavier cars on a 12-axle car over this track is not a problem and the loaded cask cars have been cleared at these dimensions and weights. California State Route 104 crosses the rail spur (see **Figure 2-8**). The rail spur was last maintained and certified in 2008 but is not currently being maintained. Past restoration of the rail spur to pass inspection was a relatively inexpensive, straightforward project[10]. UP performed minor maintenance involving railroad tie replacements on the rail spur portion near the UP mainline in 2020 for the purpose of storing rail cars.

Although RSNGS is not located on a waterway, commercial inland ports suitable for barge traffic are located at the Port of Sacramento, California, about 40 road miles from RSNGS, and the Port of Stockton, California, about 45 road miles from RSNGS. Heavy haul trucks have also been used to ship materials to and from the RSNGS site. During decommissioning, a 520-ton generator was transported by heavy haul truck from the RSNGS site to the Port of Stockton, California for transloading onto barge at a private facility. In 2000, Transnuclear, Inc. shipped a 100-ton (empty and without impact limiters) MP187 transportation cask from the eastern United States to the RSNGS site by HHT.

The transport casks will be moved on an onsite transfer trailer from the ISFSI area to the on-site transload site. Equipment staging in support of canister transfer operations from the HSM to the transport cask will occur in areas on the north and south sides of the ISFSI pad. Transfer will occur at the door of each HSM with a transfer trailer loaded with a MP197HB transport cask aligned to make the transfer. The prime mover will be attached to the transfer trailer for transfer of the transport cask from the ISFSI to the on-site transload site, which is approximately 438’ from the ISFSI. The licensed Part 72 boundary may need to be expanded in order to include the haul path from the ISFSI to the on-site transload area. Upon reaching the transload site, installation of impact limiters and personnel barriers will occur once the transport cask has been moved from the transfer trailer to the transport conveyance. Refer to **Section 6.2.3** for specific details of the canister transfer and cask preparation operations for the TN system.

Figure 2-12: Aerial View of Ione Industrial Lead and UP Main Line[2]



NUHOMS Storage System Details

The 22 NUHOMS 24P DSCs loaded at RSNGS, comprised of a total of 21 DSCs for 493 fuel assemblies and 1 DSC for GTCC low level radioactive waste, are currently stored in 22 NUHOMS HSM Model 80[6]. The 21 DSCs containing fuel were loaded using SNM-2510 License Amendment 0 and SAR Revision 1 or 2. The GTCC DSC was loaded using SNM-2510 License Amendment 2 and FSAR Revision 3. The SNM-2510 License Amendment 3 was issued on August 11, 2009, to allow for the continued storage of 6 suspected failed fuel assemblies in 5 DSCs for intact fuel already in storage on the pad. The discovery of the potentially failed fuel was made after the fuel had been loaded into the ISFSI. SMUD is currently on SNM-2510 License Amendment 4 and FSAR, Revision 10[11].

The HSM Model 80 design is similar to the Standardized NUHOMS HSM design. The HSM is a low profile, modular, reinforced concrete structure whose primary functions are to provide a means for passively removing spent fuel decay heat, provide structural support and environmental protection to the loaded DSC, and provide radiation shielding protection[6].

The HSMs, each measuring 15 feet high by 9 feet, 8 inches wide by 19 feet 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[8][9]. The HSMs are licensed to store DSCs with heat loads up to 13.5kW[6].

The HSM array at RSNGS includes two rows of eleven HSMs, positioned back-to-back, as shown in **Figure 2-5**. The HSMs are located on a 2-foot-thick concrete pad that measures 170 feet wide and 225 feet long[8]. 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 RSNGS include a separate shield wall.

To access the HSM, a shield door is provided on the front surface, which consists of a heavy steel plate with a core of concrete shielding material. The shield door is secured to the HSM using four bolted clamps 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[12]. Key features of the NUHOMS Model 80 HSM are included in **Figure 2-13**, **Figure 2-14**, **Figure 2-15**, and **Figure 2-16**.

Figure 2-13: Typical NUHOMS HSM Back-to-Back Layout[12]

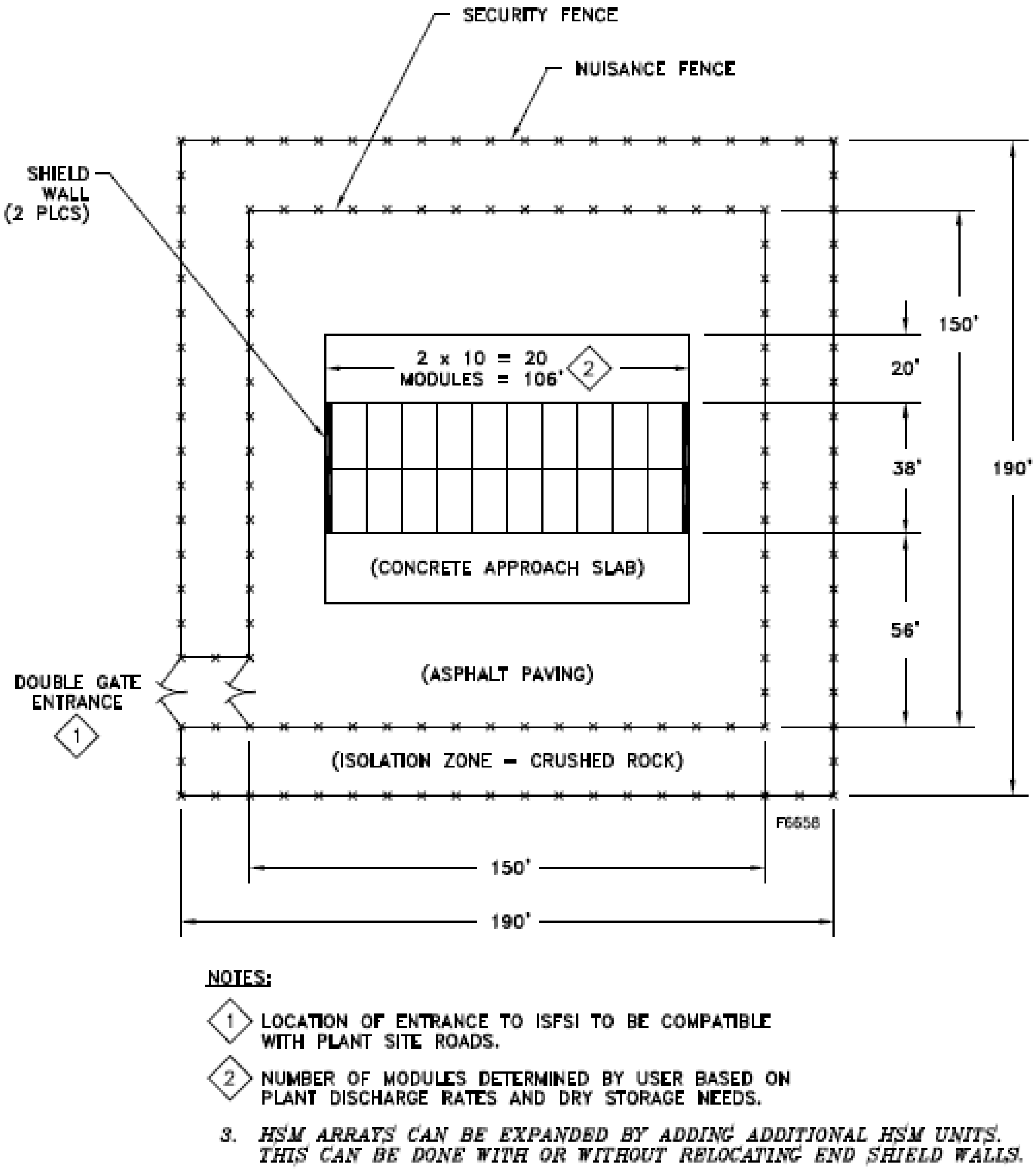


Figure 2-14: NUHOMS Model 80 HSM[12]

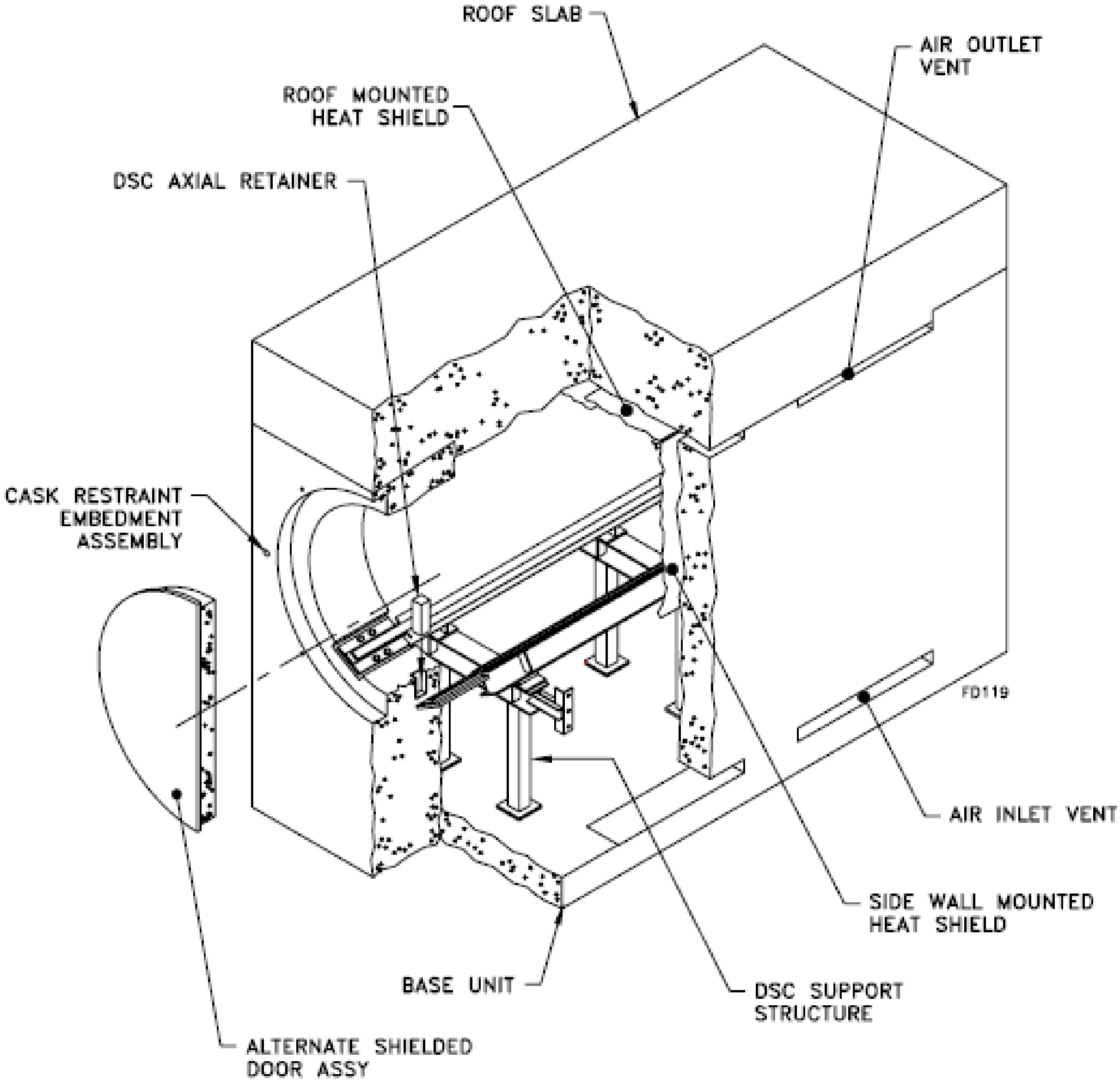


Figure 2-15: NUHOMS Model 80 HSM Arrangement[12]

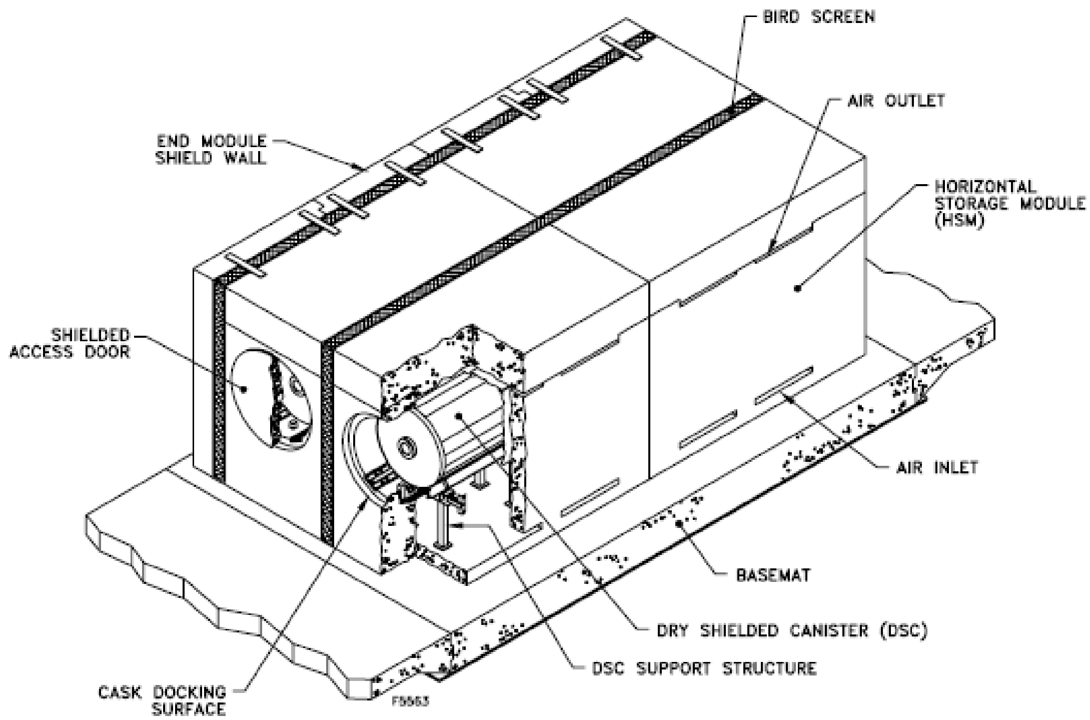
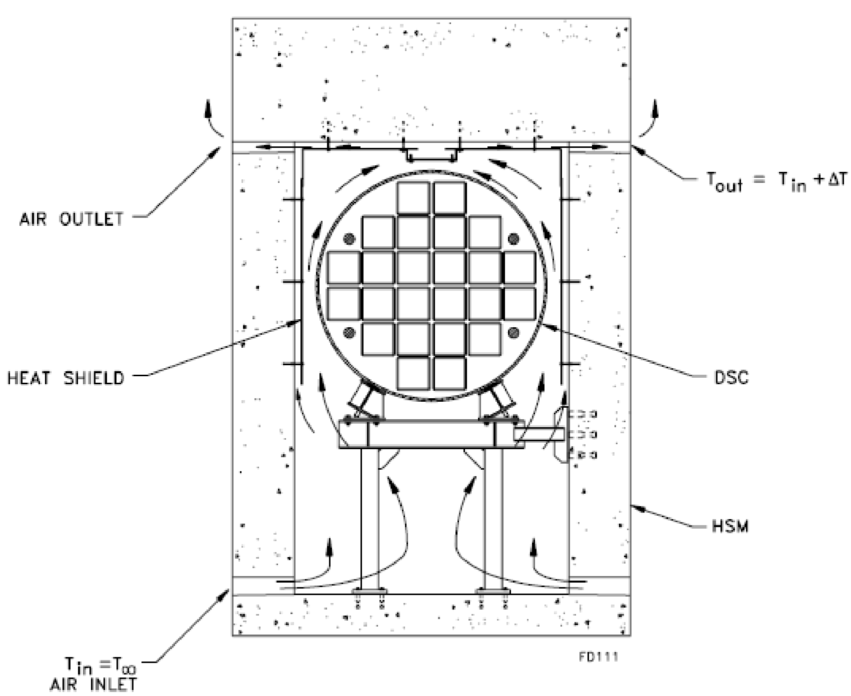


Figure 2-16: NUHOMS Model 80 HSM Ventilation Flow Diagram[12]



Transport Equipment

In preparation for loading the 24P canisters and subsequent placement in the HSMs at RSNGS, a complete set of transfer equipment, as listed below was used. The canisters were loaded into the HSMs using the MP187 transfer cask, although unloading of the canisters will be directly into the MP197HB transportation cask. As such, the MP187 transfer cask will not be used during the de-inventory operations. Due to the heavier weight of the MP197HB transportation cask, compared to the MP187 transfer cask, some of this equipment may require modifications for use during the de-inventory operations at RSNGS. Typical NUHOMS transfer equipment is depicted in **Figure 2-17** and **Figure 2-18**.

- MP187 Transfer Cask: not required during the de-inventory operations at RSNGS.
- MP187 Transfer Cask Lift Yoke: not required during the de-inventory operations at RSNGS.
- MP187 Transfer Cask Skid: not required during the de-inventory operations at RSNGS. A new transfer skid for the MP197HB will be needed for onsite transport cask handling with the transfer trailer. An MP197HB transport skid will be needed for the intermodal transportation of the transport cask.
- Transfer Trailer: will be needed to position the transport cask against the HSM.
- Prime Mover: will be needed to move the transfer trailer.
- Skid Positioning System: will be needed for final alignment of the transport cask to the HSM.
- Hydraulic Ram System: will be needed to pull the 24P canisters into the transport cask.
- Cask/HSM Restraints: will be needed to secure the transport cask against the HSM. Modification of the existing unit may be required.
- 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.
- Cask/HSM Adapter: will be needed to provide radial shielding when the larger diameter MP197HB cask is mated to the smaller diameter Model 80 HSM.

Figure 2-17: Staged NUHOMS Transfer Equipment

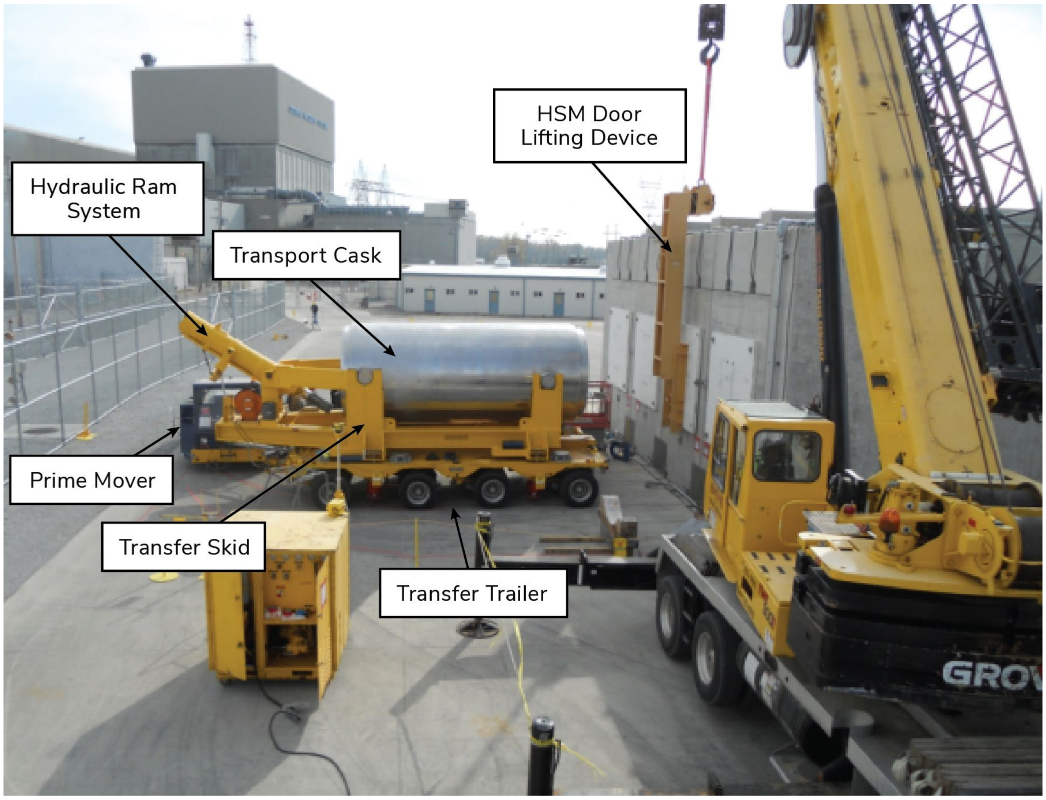
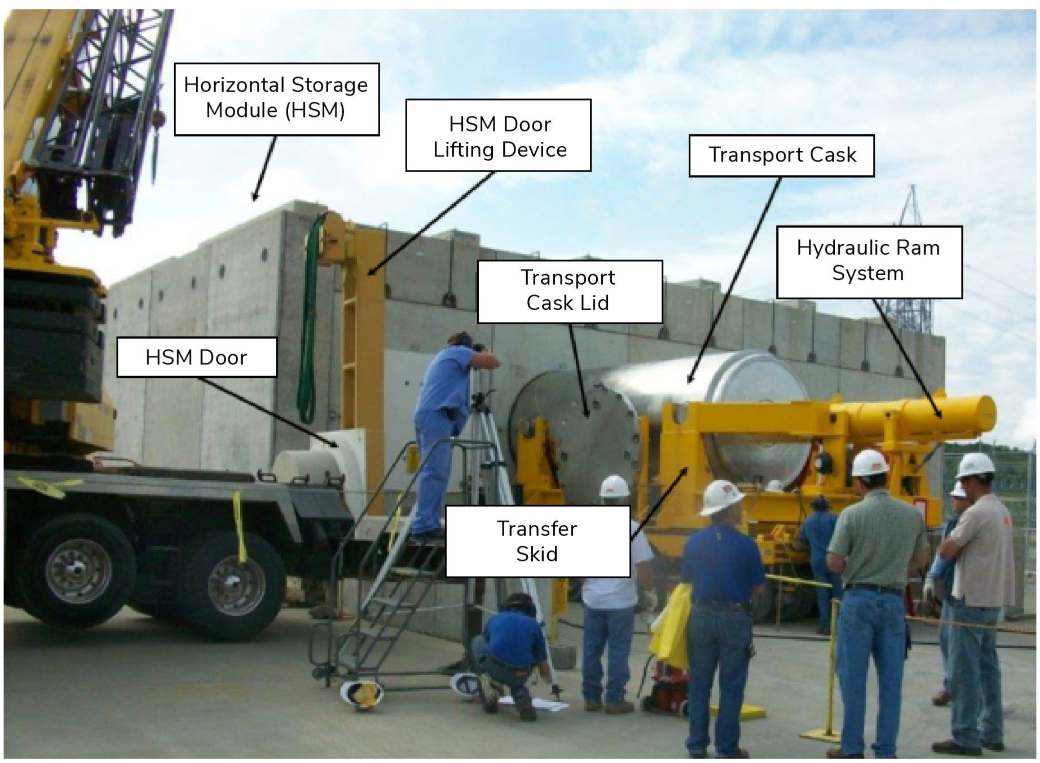


Figure 2-18: Docked NUHOMS Transfer Equipment



2.2 Characteristics of SNF and GTCC LLW to be Shipped

The transfer of 21 DSC containing 493 fuel assemblies to dry storage in the ISFSI was completed August 22, 2002. That number includes 13 failed fuel assemblies loaded into a dedicated failed fuel canister and 6 suspected failed fuel assemblies loaded into 5 undamaged spent fuel canisters[11]. In August 2006, a single DSC of GTCC material was moved into storage at the ISFSI. All spent fuel and GTCC waste are currently in dry storage and no more DSCs are to be loaded at RSNGS ISFSI. The complete inventory of SNF and GTCC material is intended to be shipped from the RSNGS. SMUD will maintain the RSNGS spent fuel and GTCC in dry storage until it is transferred to DOE for off-site shipment to a DOE facility[13]. There is a total of 493 SNF assemblies with a total of approximately 228.38 metric tons initial uranium (MTU)[1], which are stored at the RSNGS ISFSI[41]. There is one container of GTCC waste stored at the ISFSI containing 10.7 m^3 (36,000 Ci, 1.33E15 Bq)[3]. Refer to **Table 2-6** for details of the 493 SNF assemblies and GTCC LLW loaded in the 24P canisters.

The RSNGS SNF consist of B&W 15x15 Mark B Pressurized Water Reactor fuel. **Table 2-1** shows the Mark B spent fuel assembly (SFA) characteristics allowed for storage at the RSNGS ISFSI. In all cases, the fuel assemblies are 166.893 inches long with a cross section of 8.536 inches[14]. **Table 2-2** provides information on the RSNGS fuel design.

One canister of GTCC waste is non-fuel related material generated as a result of plant operations and decommissioning. This waste includes such items as in-core components and instrument tips, activated metal from core support structures, and small reactor-related miscellaneous parts resulting from the reactor vessel internals segmentation/decommissioning process[6]. The small parts (chips) were placed into baskets that were dewatered as part of the draining and drying procedure for the DSC.

[1] Total value of approximately 220.32 MTU to be stored at the ISFSI per [8] and the licensed capacity of the ISFSI is 228.8 MTU per [41].

Table 2-1: B&W 15x15 Mark B SFA Characteristics Allowed at RSNGS ISFSI[6]

DSC Type	DSC Design Basis Heat Load (kW)(1)	Max. Assembly Initial Enrichment (wt % U-235)(2)	Max. Burnup (GWd/MTU)(2)	Total Assembly Only Weight(2)	Cladding Type(2)	Damaged Fuel
Fuel Only & Fuel + Control	13.5	3.43	38.268	1530 lbs	Zircaloy-4	Yes(3)
Failed Fuel	9.93	3.43	38.268	1530 lbs	Zircaloy-4	Yes

Notes:
(1) The source of this information is Sect. 3.1.1.2 of the Rancho Seco ISFSI FSAR (Revision 6, August 2016).
(2) The source of this information is Table 3-1 of the Rancho Seco ISFSI FSAR (Revision 6, August 2016).
(3) Six fuel assemblies originally classified as "intact fuel" and later reclassified as "damaged fuel" are stored in five FC-DSCs as authorized by Amendment 3 to Materials License SNM-2510.

Table 2-2: RSNGS Fuel Design Information[8]

Parameter	Value
Fuel Design	B&W 15x15 Mark B
No. of Assemblies at RSNGS	493
Rods per Assembly	208
Control Rod Guide Tubes per Assembly	16
In-Core Instrument Position	1
Assembly Cross Section	8.536 in.
Fuel Rod Outside Diameter	0.430 in.
Cladding Thickness	0.0265 in.
Fuel Rod Pitch	0.568 in.
Active Fuel Length (nominal)	141.8 in.

Parameter	Value
Assembly Length (600°F, 40 GWd/MTU)	166.893 in.
Total Assembly Only Weight	1530 lb
Non-Fuel Component Weight	135 lb (max)
Maximum Enrichment	3.43%
Maximum Burnup	38,268 MWd/MTU
Cladding Material	Zircaloy-4

Table 2-3 and **Table 2-4** provide data associated with the 493 fuel assemblies loaded in the RSNGS ISFSI. The fuel was discharged from the reactor vessel between 1977 and 1989. The burnup of the fuel varies between 10.0 and 38.2 GWd/MTHM. The median burnup is 28.0 GWd/MTHM. There are no fuel assemblies having a burnup greater than 45 GWd/MTHM (i.e., high burnup) stored at RSNGS[10]. The initial enrichment (^{235}U weight %) of the fuel varied between 2.003% and 3.222%[14].

Table 2-3: RSNGS Fuel Discharge Data[14]

Year(1)	No. of Assemblies Discharged
1977	20
1978	56
1980	65
1981	41
1983	69
1985	65
1989	177
Total	493

Note:
(1) Year indicates when assemblies were last critical

Table 2-4: RSNGS Fuel Burnup Data[14]

Burnup (GWd/MTHM)	No. of Assemblies
5-10	56
10 – 15	0
15 – 20	60
20 – 25	54
25 – 30	132
30 – 35	147
35 – 40	44
Total	493

The 21 24P canisters of SNF contain a total of 493 intact fuel assemblies that were all originally supplied by Babcock & Wilcox. In 2006, SMUD notified the NRC that six potentially failed fuel assemblies had been loaded in storage canisters during the cask loading campaign in 2001 and 2002 that were not designed for storage of failed fuel. Amendment 3 to SNM-2510 license on August 11, 2009, approved the retrospective re-classification of six intact SFAs previously stored in five FC DSCs as damaged fuel. The reason for this classification change is due to the evolution to a more restrictive definition of damaged fuel (defects greater than hairline cracks or pinhole leaks) from an earlier less stringent definition after these six SFAs had already been loaded[3]. **Table 2-5** lists the details of the damaged fuel assemblies.

Table 2-5: Details of Damaged Fuel Assemblies[15]

Fuel Assembly	Estimated Flaw Size	Canister Number	Canister Location
2G6	0.25 in. x 0.04 in.	FC24P-P16	2
OEL	0.75 in. long with 0.2 in. hole	FC24P-P10	4
ODY	0.2 in. hole	FC24P-P10	15
17G	Unknown	FC24P-P17	4
1C34	1 in x 0.1 in.	FC24P-P18	16
1C04	0.3 in. holes (two)	FC24P-P03	16

Table 2-6 summarizes the contents of each 24P canister. The location of each fuel assembly within a particular canister is documented in the canister loading maps[15][16]. The fuel loading into the NUHOMS system was performed under SNM-2510 License Amendment 0 and SAR Revision 1 or 2. The GTCC DSC was loaded under SNM-2510 License Amendment 2 and FSAR Revision 3.

Table 2-6: RSNGS ISFSI Contents[15][16]

Loading Order	DSC Serial No.	HSM Serial No.	Date on Pad	Heat Load(1) (kW)	Burnup(2) (MWd/ MTU)
1	FO24P-P01	20	4/19/01	9.005	35,200
2	FC24P-P03	18	7/19/01	8.145	37,911
3	FC24P-P04	16	8/28/01	8.268	36,290

Loading Order	DSC Serial No.	HSM Serial No.	Date on Pad	Heat Load(1) (kW)	Burnup(2) (MWd/ MTU)
4	FC24P-P05	14	9/26/01	8.149	37,911
5	FO24P-P02	12	10/10/01	8.774	37,550
6	FC24P-P06	10	11/20/01	8.152	36,707
7	FC24P-P07	8	12/12/01	8.161	37,911
8	FC24P-P08	6	1/07/02	8.151	36,707
9	FC24P-P09	4	1/23/02	8.146	38,268
10	FC24P-P10	2	2/07/02	8.137	38,268
11	FC24P-P11	1	2/27/02	8.139	38,268
12	FC24P-P12	3	3/13/02	8.162	37,827
13	FC24P-P13	5	4/03/02	8.157	37,911
14	FC24P-P14	7	4/17/02	8.139	37,911
15	FC24P-P15	9	5/08/02	8.147	36,707
16	FC24P-P16	11	5/22/02	8.156	36,290
17	FC24P-P17	13	6/12/02	8.132	36,290
18	FC24P-P18	15	6/26/02	8.141	37,911
19	FC24P-P19	17	7/17/02	8.144	37,550
20	FC24P-P20	19	7/31/02	8.127	37,827
21	FF13P-R21	21	8/21/02	4.642	34,403
22	GTCC-01	22	8/24/06	n/a	n/a

Notes:

(1) Heat Load (kW) is the sum of the heat load values for all spent fuel assemblies in the cask based on 1999 decay.
(2) Burnup is the value for the spent fuel assembly with the highest individual discharge burnup.

2.3 Description of Canisters/Overpacks to be Shipped

The RSNGS ISFSI is a TN NUHOMS HSM Model 80 storage system utilizing the NUHOMS 24P canister and the recommended NUHOMS MP197HB transport cask. The design of the ISFSI originally included the NUHOMS MP187 cask for both on-site transfer and off-site transport of the fuel DSCs. While the MP187 cask is not certified for the transport of the GTCC low-level radioactive waste, the MP197HB cask is; see **Section 6.1** and **Section 10.0** for additional detail regarding the use of the MP197HB transport casks for the de-inventory off-site transport. In addition, the TN-Eagle transport cask (Docket 71-9382) is currently being evaluated by the NRC and once certified, may be the preferred transport cask to use for the de-inventory off-site transport. The application includes the 24P DSCs in storage at RSNGS[42], and the CoC is expected to be issued in 2023.

The RSNGS ISFSI provides for three types of DSC designs: Fuel Only DSC (FO-DSC), Fuel with Control Components DSC (FC-DSC) and Failed Fuel DSC (FF-DSC). **Table 2-7** lists details of the DSC fuel types. The RSNGS FO, FC and FF DSC designs are based on the Standardized NUHOMS 24P DSC design, except that the FO- and FC-DSCs include fixed neutron absorbers in the design of the DSC basket. Also provided is one canister for storage of GTCC waste consisting of solid, reactor-related waste such as activated reactor internals and in-core instrumentation. The external design characteristics of the GTCC waste containing DSC are identical to the fuel-containing DSCs (FO-/FC-/FF-DSCs). Hence, the term "DSC" has been used to address both the fuel and the GTCC DSCs[6]. The NUHOMS 24P DSC, shown in **Figure 2-19** is type 304 stainless steel, provides confinement of the contents, encapsulates the fuel in an inert atmosphere, and provides biological shielding (in the axial direction) during DSC closure, transfer, and storage.

Table 2-7: DSC Fuel Types[6][9]

DSC Type	Quantity	Capacity	Internal Cavity Length	Neutron Absorber
FC-DSC	18	24 SFAs+CCs	173"	Borated Panels
FO-DSC	2	24 SFAs	167"	Borated Panels
FF-DSC	1	13 SFAs	173"	Not Required

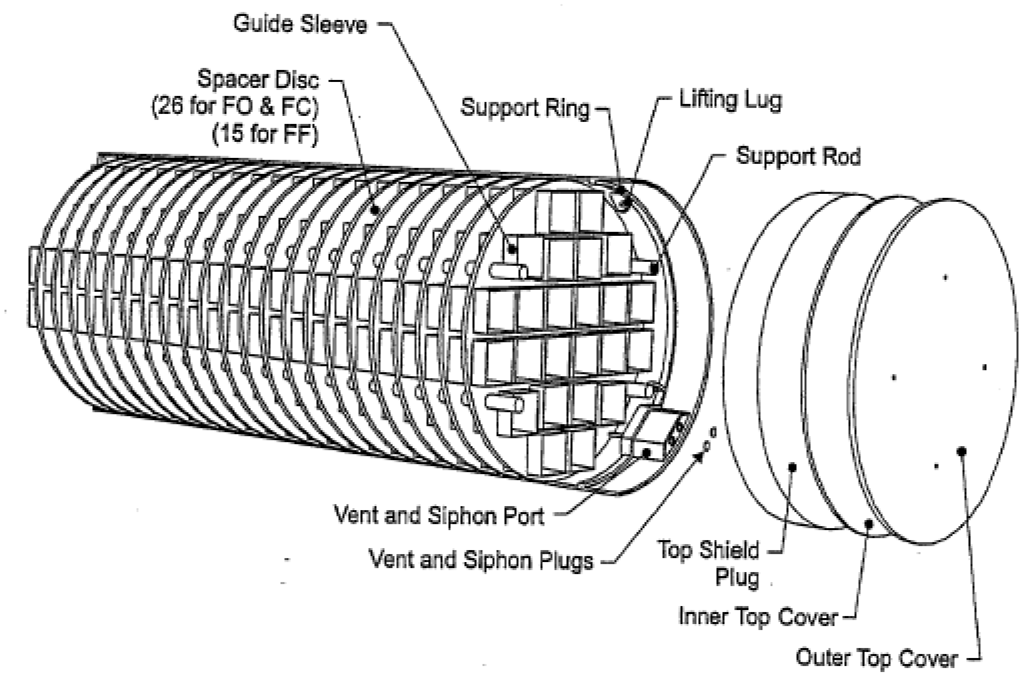
Details of this DSC design are as follows[6][9] (per **Figure 2-19**):

- The approximate loaded weights of the canisters are 81,000 pounds.
- The external size is 67.2" diameter by 186.2" long.
- The requirements of 10 CFR Part 71 have necessitated that the basket be designed to account for fuel assembly loading of the guide sleeves. The RSNGS basket design

incorporates 26 spacer discs for the FO-DSCs and FC-DSCs and 15 spacer rings for the FF-DSCs to address this concern. The spacer disc material is a high strength carbon steel.

- The FC-DSC uses lead shield plugs to provide a longer cavity to accommodate assemblies with control components without increase in overall canister length.
- The FO-DSC uses steel shield plugs since the assembly length without control components can be accommodated with a thicker shield plug.
- The GTCC basket, with an internal cavity length of 167 inches, has been modified to accommodate different waste forms and, therefore, does not contain spacer discs or guide sleeves. The basket, consisting of a perforated metal canister, is designed to accommodate 100% of RSNGS GTCC waste.
- 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. The DSC basket is keyed to the DSC shell and the grapple ring is keyed to the cask bottom closure to maintain the basket-to-cask alignment during all operations. This grapple ring key is required when the DSCs are shipped in the MP187 cask but would not be utilized in the MP197HB cask.
- There are no lifting features included in the design to enable lifting a loaded canister.

Figure 2-19: NUHOMS 24P Dry Storage Canister[8]



The combined heat load for the 24 fuel assemblies is 13.5 kW per FO- or FC-DSC and 9.93 kW for the 13 failed fuel assemblies in the FF-DSC. These heat loads are considerably less than the DSC heat load for the NUHOMS 24P system (24 kW).[8]

The inventory of 24P DSCs at the RSNGS ISFSI to be evaluated for shipment includes the 22 canisters listed in **Table 2-6**. The NUHOMS MP197HB Transportation Package Safety Analysis

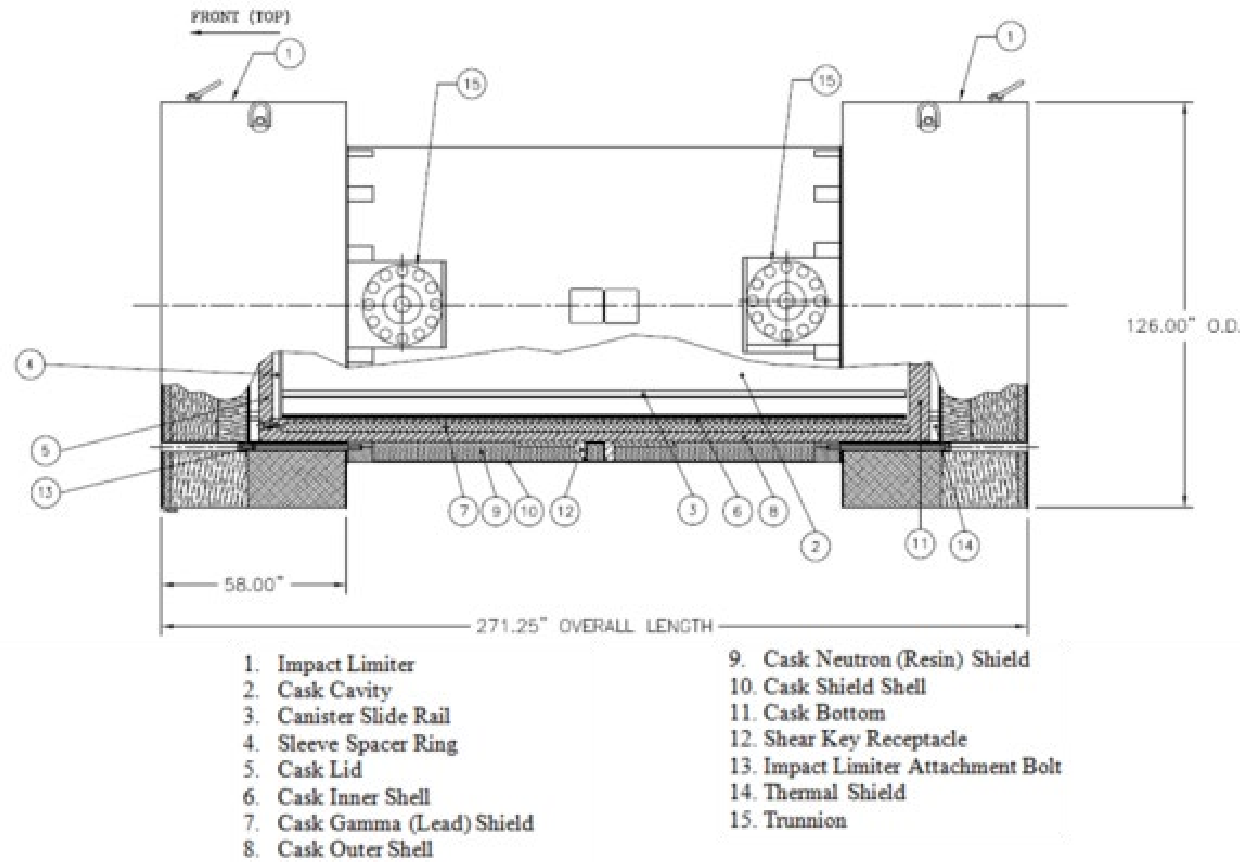
Report, Revision No. 20, dated September 2019 will need to be revised to include the RSNGS 24P DSC (see **Section 10.0**). As part of the effort to license the MP197HB cask for the RSNGS DSCs though, the characteristics of the waste and canister would need to be evaluated against the MP197HB requirements.

The MP197HB cask has been fabricated. 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 24P DSCs from RSNGS. 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[17].

The MP197HB cask is authorized to transport different NUHOMS DSCs, which vary in size. For the smaller diameter canisters, including the 24P DSCs at RSNGS, 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[17].

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[17]. **Figure 2-20** includes the main features of the MP197HB cask.

Figure 2-20: NUHOMS MP197HB Transport Cask[17]



The weights and dimensions of the NUHOMS MP197HB transport packaging are shown in Table 2-8.

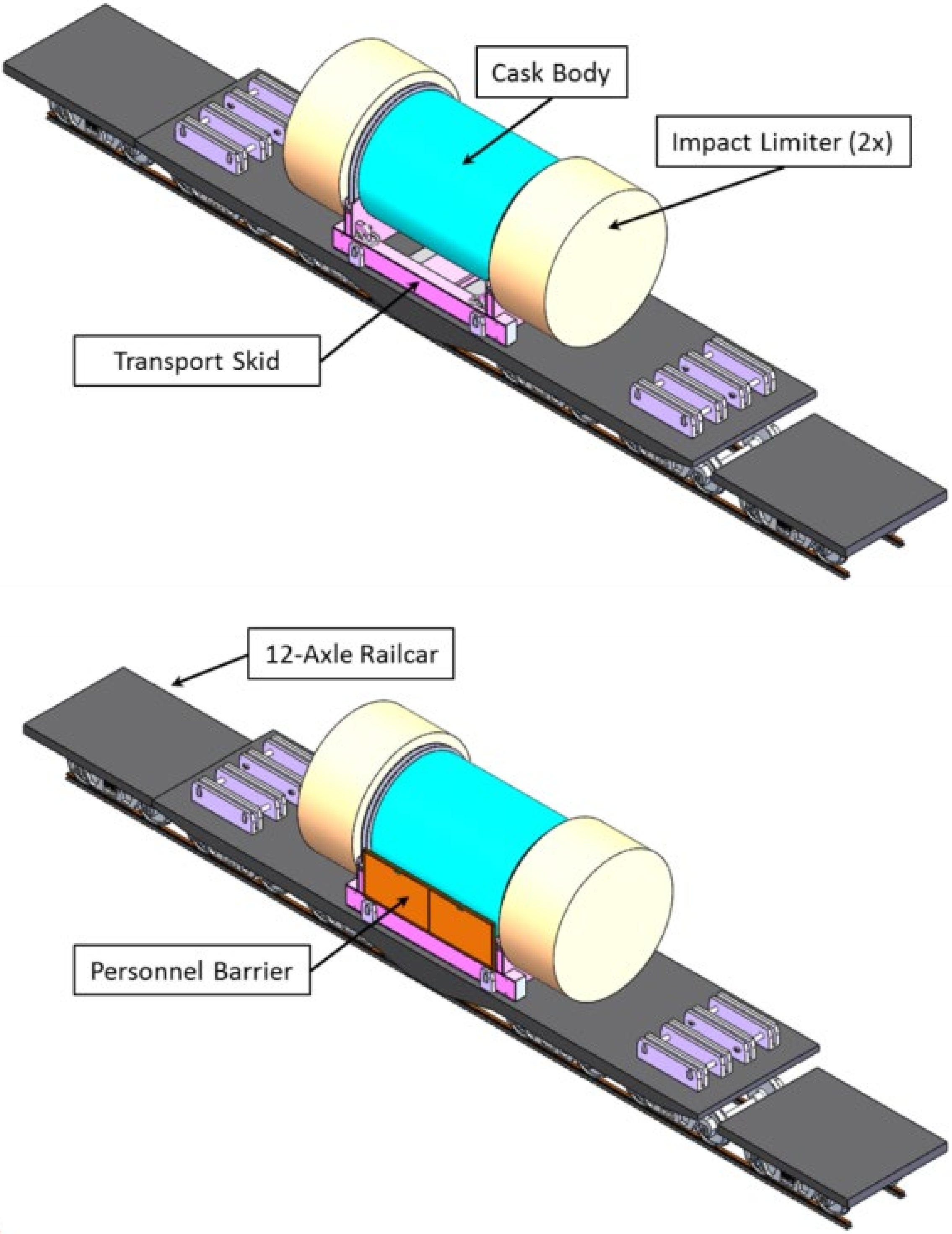
Table 2-8: NUHOMS MP197HB Weights and Dimensions[17]

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

Attribute	Value (lbs / in)	Comments
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 is primarily for rail, as opposed to barge or road (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). 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 2-20** 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 24P DSC from a Model 80 HSM to a NUHOMS MP197HB, and subsequent preparations for transport, will include the following high-level activities (detailed operations are described in **Section 6.2.3**):

- If not present, install a Cask/HSM Adapter onto the HSM.
- Receive empty MP197HB on rail car.
- Verify the integrity of the DSC and that the contents are authorized for the MP197HB[18] (see **Section 10.0**).
- Remove the personnel barrier and impact limiters.
- Transfer the empty transport cask from the transport skid on the rail car to the transfer skid on the transfer trailer.
- Remove the front trunnion covers from the cask and install the front trunnions.
- Remove the ram access closure plate.
- Remove the cask lid.
- 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.
- 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.
- Install the cask lid.
- Remove the cask front trunnions and install the associated trunnion covers.
- Perform the containment boundary leak tests.
- Transfer the loaded transport cask from the transfer skid on the transfer trailer to the transport skid on the rail car.
- Install the impact limiters and then install the personnel barrier.
- Perform pre-shipment inspections and surveys and depart

To perform the above activities, the below ancillary devices would be required[17]. 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. The leak test system is considered important to safety as it is confirming the performance of important to safety seals.
- 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 24P DSC, a spacer needs to be installed between the bottom of the cask and the DSC. This spacer will need to include a cutout large enough to accommodate the DSC grapple ring shear key. 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 24P DSC, an aluminum sleeve needs to be installed inside the cask. This sleeve, including the canister sleeve spacer ring, 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.
- Unloading Flange: Prior to transferring a smaller diameter DSC, such as the 24P, 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.
- Transport cradle/skid: A cradle (also referred to as a skid) for the MP197HB will need to be designed and fabricated. The transport skid will be used for the transportation (truck, rail, and/or barge) of the MP197HB transport cask to/from the site. A conceptual design of this transport skid[18], 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.
- Transfer Skid: A transfer skid will be needed for the MP197HB transport cask and will be used during the on-site DSC transfer operations. The transfer skid will be located on the

transfer trailer. The final design and fabrication of this transfer skid will likely need to be performed by the cask vendor.

- Intermodal Transport Cask Lift Beam: The horizontal intermodal transport cask lift beam would be used to lift and move an empty or loaded MP197HB transport cask at the transloading (intermodal transfer) site. The beam would engage the transport skid and lift the MP197HB/skid assembly while in its transport configuration (impact limiters and personnel barrier still attached). This device will need to be fabricated and should be provided by the vendor supplying the transport cask.
- On-Site Transport Cask Lift Beam: The horizontal cask lift beam would be used to lift and move an empty or loaded MP197HB transport cask between the transfer trailer and the transport conveyance. The beam would engage the cask with basket slings and lift the MP197HB without the impact limiters or personnel barrier attached. This device will need to be fabricated and should be provided by the vendor supplying the transport cask.
- Transfer Trailer: An onsite transfer trailer would be used to position the horizontally oriented MP197HB cask at the HSM. The transfer trailer used at RSNGS during loading of the HSMs is owned by SMUD and stored at their RSNGS plant. This trailer was designed to handle the MP187 Transfer Cask and can be re-used for transferring the DSCs from the HSMs to the MP197HB. The cask vendor maintains the design of this equipment and can provide the necessary design and fabrication services if required.
- Prime Mover: A 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.
- Skid Positioning System: A series of hydraulic cylinders and low-friction contact pads are used between the transfer trailer and transfer skid to allow final alignment of the transport cask to the HSM. 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 RSNGS during loading of the HSMs is owned by SMUD and stored at their RSNGS plant. It is expected that the same equipment can be used during the cask loading operations, although a new ram securement system may 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 RSNGS during loading of the HSMs is owned by SMUD and stored at their RSNGS 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 transport cask to mounting points embedded in the front face

of the HSM. These are used to prevent movement of the transport cask during DSC transfer operations between the HSM and the transport cask. The cask vendor maintains the design of this equipment and can provide the necessary design and fabrication services.

- Cask/HSM Adapter: A steel and concrete fixture that installs in place of the standard HSM door to provide radial shielding when a large diameter cask is mated to a smaller diameter HSM. The adapter includes a door that can be removed and installed as necessary to access the HSM.
- 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.
- Cranes: It is envisioned that two cranes would be required. A single mobile crane would be required to handle the ancillary equipment transfer operations at the ISFSI pad. Another single mobile crane would be required to load/unload the transport cask at the rail transload site.
- Impact limiters: The transportation cask will arrive with two impact limiters according to the requirements of the SAR. The impact limiters would be fabricated as part of the transport cask procurement and fabrication. 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.

3.0 TRANSPORTATION ROUTE ANALYSIS

This section describes the available routes identified to transport the transportation casks from RSNGS for delivery to a Class I railroad and subsequent rail movement to GCUS. A number of HHT, barge, and rail routes were reviewed and are presented. As discussed in **Section 3.5**, the team down-selected from the 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

RSNGS is located in Herald, CA on CA-104, Twin Cities Road. It is located 15 miles east of Galt, CA. The site is located in an isolated, rural area. The access road from the ISFSI to CA 104 is approximately 5,077 feet long. State Route CA-104 runs along the northern boundary of the site and connects with State Route 99 and Interstate Route 5 to the west and State Route 88 to the east. Rail access is available via a rail spur from the existing UP railroad line that runs roughly parallel to State Route 104 adjacent to the site[19].

HHT from RSNGS east or west from the plant is easily accessible via CA-104. No existing commercial transload facilities are in the immediate area with the closest being in Stockton, CA at the Port of Stockton. Two other rail served locations within close proximity to the plant may be available for establishing private transloading facilities and are discussed herein.

There are no state-designated Hazardous Materials (HAZMAT) routes from RSNGS.

HHT has been used in the past to remove components from the site when the overall dimensions were too large to obtain clearance for rail shipments, specifically for movement of the intact generator: "Heavy haul trucks have also been used to ship materials to and from the Rancho Seco site. For example, in 2000, Transnuclear, Inc. contracted with a heavy haul truck operator to ship the 100-ton (empty and without impact limiters) MP187 transportation cask from the eastern United States to the Rancho Seco site (see Figure 2-98). Also, during decommissioning, a 520-ton generator was transported by heavy haul truck from Rancho Seco to the Port of Stockton, California."[10]

The HHT movement of the generator was one of the largest components to move through this geographical area at the time. The HHT trailer was 335ft long, 20ft wide and 19ft high. The 52-axle truck traveled from RSNGS through Herald, Acampo, Lockeford, Highway 88, and Waterloo Road to Wilson Way to Weber Avenue over a four-day span. The HHT was moving at speeds of 2-5 miles per hour. This generator unit was much larger and heavier than the anticipated cask shipments. Based on the generator dimensions, it is presumed from a dimensional standpoint that truck permits of the identified HHT routes for the cask are obtainable for movement from the plant. The HHT route used country roads as much as possible although it did travel on Highway 88 for a portion of the route[20].

As seen in Figure 3-1, the location of the site has easy access to CA-104 for HHT shipments.

During decommissioning, other components were moved off-site by truck, including container shipments of the flange, nozzles, and hemi-head sections which were placed individually into top loading 20ft containers[21] and shipped over-the-road to Energy Solutions in Clive, UT for disposal[22].

Figure 3-1: Path from the ISFSI Across the Site to the Nearest Public Road[1]

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 use interstate highways wherever available to avoid using two-lane country roads and potentially alleviate congestion.

There are two close options for HHT to private rail sidings located 9 miles and 9.1 miles, respectively from Rancho Seco to Ione, CA. The first HHT route is via the site access road to CA-104 (Twin Cities Road), turn right onto CA-104 and travel east for 9 miles which becomes Michigan Bar Road. Turn right into the driveway for the Specialty Granules (ISG) plant located at 1900 CA-104 (see **Figure 3-2**). There are three locations within this site that are conducive for conducting a transload operation from HHT to railcar but would require permission from the private company and it would be necessary to avoid interference with the private company's unit train loading schedule.

An alternate HHT transload site is located at Indian Hill Processing plant. Take the site access road to CA-104 (Twin Cities Road), turn right onto CA-104 and travel east for 7.88 miles and make a left onto Michigan Bar Road. Travel for 122 feet to the end of the road, make a left and follow approximately 700ft and make a right turn into the access road to the plant.

Table 3-1 identifies sidings considered in this assessment, with length of track and any restrictions or benefits associated with the sidings. The closest tracks to the site can be reached by HHT transport, and include two separate private companies in Ione, CA. Only one of these sites is an active rail shipper with regular rail service. These sites are not ideal for the SNF loading campaign due to the fact that the first site is an active rail shipper and ships a significant number of railcars in unit trains from the site. There is ample track space available in several locations on the plant property; however due to the number of cars being loaded, stored, and shipped, it may be difficult to conduct both loading operations without interfering with the unit train loading. It may be possible to lease the farthest track from the conveyor to conduct the RSNGS shipping campaign, but careful coordination would be required to avoid the potential interference with the existing unit train loading (roofing granule loading operation). The UP mainline track ends just south of this plant (it bisects the plant). It may be possible to conduct the transload at this track location with careful coordination with the company. This customer has been shipping by rail from this location since 1999. The street address is Ione, but the railhead is Indian Hill, CA.

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

Track Location	Siding Length (ft)	HHT to Track (miles)	Site Description	Challenges/Considerations
1900 CA-104, Ione, CA 95640 (**Figure 3-4**)	8,599	9	Private Industry Track: Specialty Granules LLC (unit train loading)	Active rail shipper is a roofing granule manufacturer loading unit trains of covered hoppers. Has multiple storage tracks on the plant site including a mainline track running through the property and run-around tracks. Railhead: Indian Hill, CA UP track ends at this plant.
2201 Michigan Bar Road, Ione, CA 95640 (**Figure 3-4**)	2,215	9.11 miles	Private IndustryTrack: Indian Hill Processing Inc	Peat mining and processing business. Rail siding is not active although the switch is still in place and the lead is being used to store rail cars for Specialty Granules. Some of the track in the plant is paved reducing immediate usable track to 1,940ft. Restoring paved track is not difficult nor expensive. The majority of this track is the siding coming into the plant which is parallel to the entrance road. It is not a secure site.
MOTCO 5110 Port Chicago Hwy, Concord, CA 94520 (**Figure 3-3** and **Figure 3-5**)	46 miles of track and two classifcation yards	115 miles	Secure Government facility with access to both UP and Burlington Northern Santa Fe Railway (BNSF) for outbound	Longer HHT to reach MOTCO, large, secure, fenced and guarded site for conducting the transload, can load the entire consist and possibly can store casks on site if desired. Ability to ship on either BNSF or UP directly from this location.

Figure 3-6 and **Figure 3-7** present the HHT routes that include transloads at the closest railroad tracks to the plant and subsequent shipment to GCUS.

Figure 3-2: HHT Route from RSNGS to Transload Site at Ione, CA[1]

Figure 3-3: HHT Route from RSNGS to Transload Site at MOTCO[1]

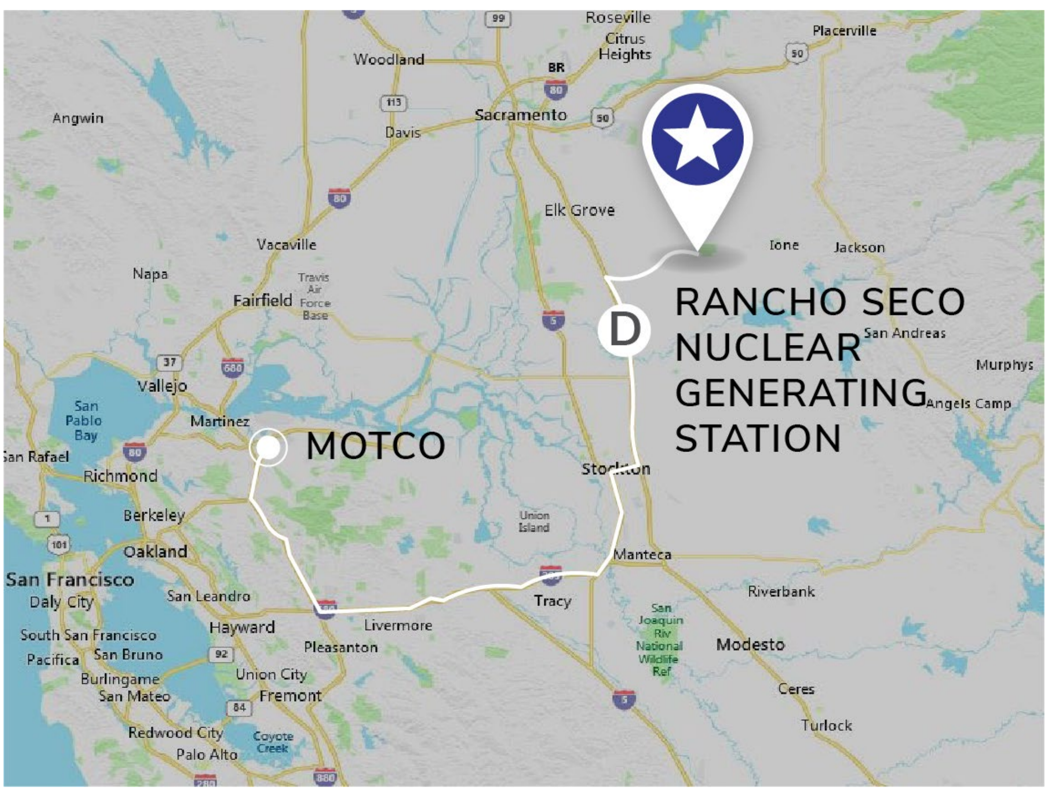


Figure 3-4: Proposed Transload Sites at Ione, CA[2]

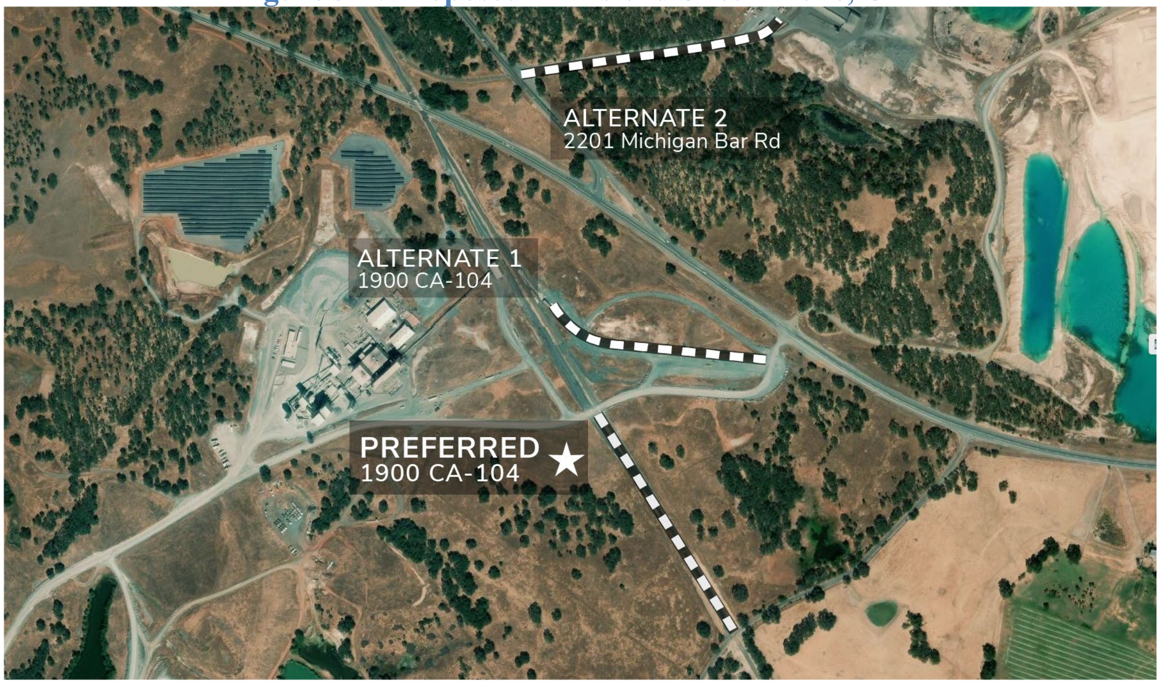


Figure 3-5: Proposed Transload Site at MOTCO[2]

Figure 3-6: HHT Route from RSNGS to GCUS via Transload Site at Ione, CA[1]

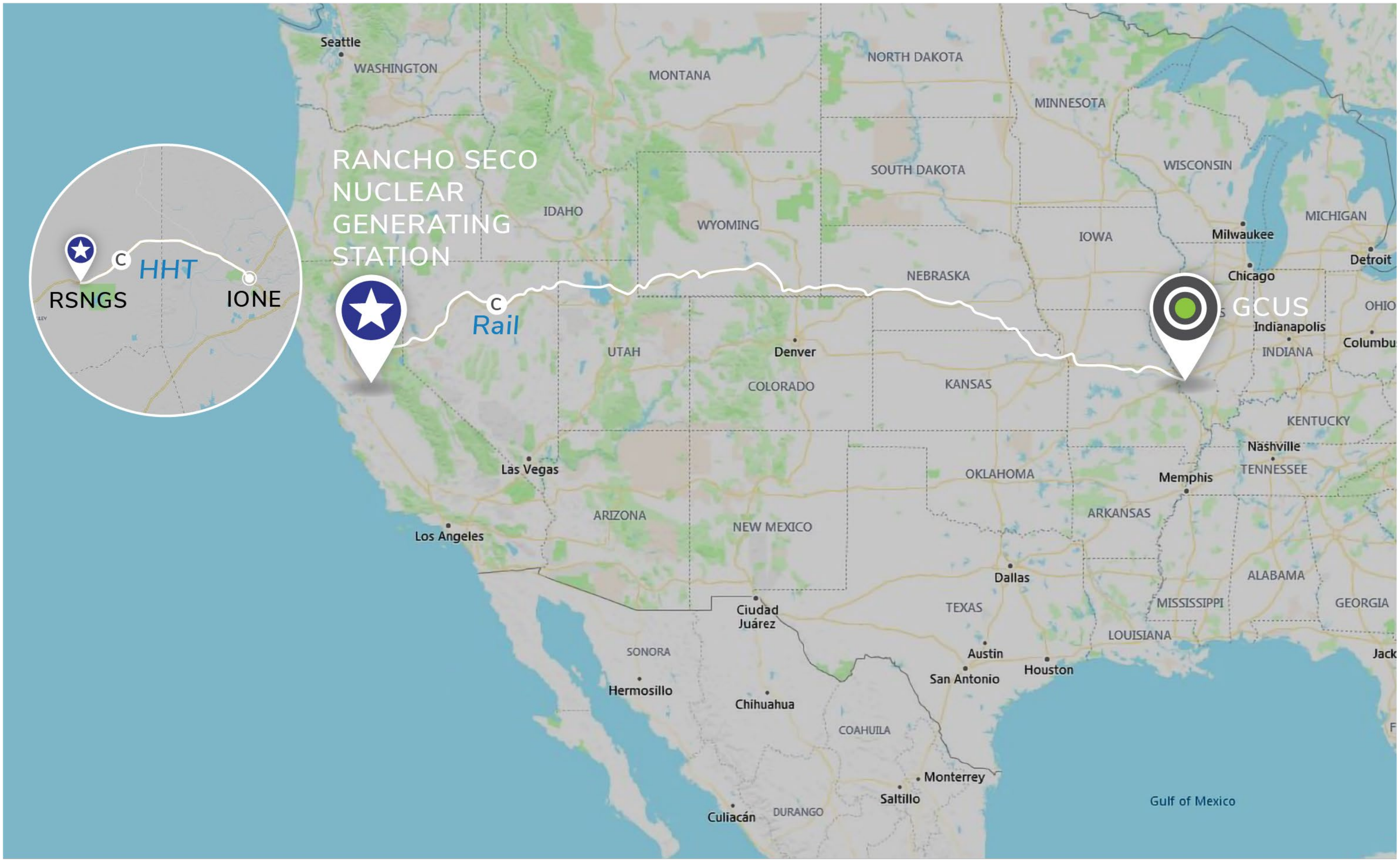
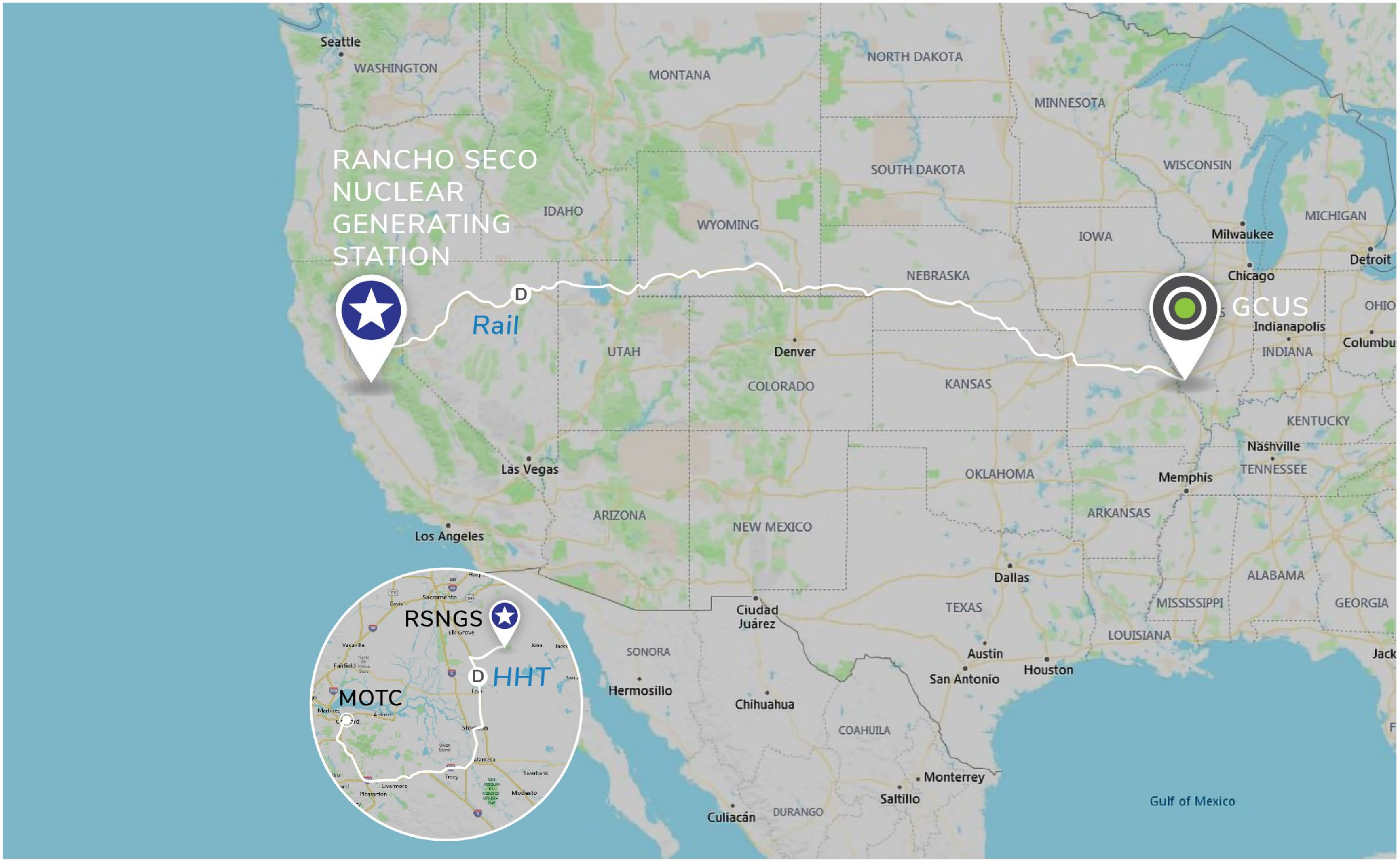


Figure 3-7: HHT Route from RSNGS to GCUS via Transload Site at MOTCO[1]



3.2. Rail Access Locations

The site is rail served by UP. It is the only rail carrier with access to the plant. UP Railroad is a Class I railroad that serves the majority of rail sidings within close proximity to RSNGS and in the general geographical area. Although RSNGS has not shipped or received rail cars since 2014, the switch to the Class I carrier is still in place, which is an advantage from a cost perspective. The private siding leading from the plant to the switch is also in place (see **Figure 3-8**). Before shipments resume, a track inspection would be required for both the private track (to be conducted by a private railroad contractor) and the existing switch connecting the plant with the UP main line track, referred to as the Ione Industrial Lead. The UP operates over the Ione Industrial Lead today between Galt and the only active rail customer east of the RSNGS plant located in Ione, CA (railhead: Indian Hills, CA). UP would conduct an inspection of the switch to ensure it is in good operating condition prior to the start of a shipping campaign from the site.

At this time, there is no local scheduled rail service for the plant. There are two local yards that conceivably could serve the plant. It will likely be the same yard and crew that serves the next closest active facility, ISG, which is located 10.66 rail miles east of RSNGS.

If direct rail shipments from RSNGS resume, the railroad will determine which of the two yards will serve the plant based on information including planned frequency of shipments, shipping cycle, capacity constraints of the railroad (crew and equipment) in the geographical area and overall impact on the network. These factors will be evaluated at the time service is requested by the shipper and will be used to develop a service plan for the site.

There is precedence for shipping some large and heavy components from the site during decommissioning:

1. Four reactor coolant pumps (50 tons each), the pressurizer (150 tons), and two steam generators (550 tons each) to the Energy Solutions low-level radioactive waste disposal facility in Clive, UT."[10]
2. The two steam generators were deemed too long and could not obtain clearance to move by rail intact, so they were cut into four sections each and shipped on 12-axle heavy duty flat cars for disposal.[10]
3. The segmented Rancho Seco reactor pressure vessel was also shipped by rail to the Energy Solutions low-level radioactive waste disposal facility in Clive, UT.[21]
4. The six beltline wall sections were packaged inside two metal boxes, filled with concrete, and allowed to cure before being moved by MHF Services LLC on one heavy duty, 8-axle rail car. They were shipped as "Radioactive Material, Low Specific Activity II, 7, UN3321, fissile-excepted."[10]

In the event that the switch is removed in the future, two options for rail service should be considered. The first would be to reinstall the switch, which would be at considerable cost. The minimum cost of replacing a switch is currently $250,000. The second option would be to utilize an existing private track located close to the plant. The two closest rail sidings were identified. These existing tracks are located east of RSNGS. The only active rail shipper at the time this report was written is ISG located in Ione, CA approximately 9 highway miles east of RSNGS. The railhead for this plant is called Indian Hills. This is an active rail shipper with a substantial amount of track which it uses for loading unit trains of roofing granules and other raw materials being shipped to customers or other ISG plants. There are three tracks comprising 4,153ft and a dead-end track leading off the UP main line track with another 4,451ft of track. The plant is loading covered hoppers from a fixed conveyor and overhead trestle system. The plant is shipping unit trains from this site. Some of the track on this site is being used to store both loaded and empty covered hoppers. Other track in the immediate area (both railroad and private track) is being used for storage for ISG cars.

A second plant, Indian Hill Processing Inc., is located approximately 2,435ft east of the ISG rail siding. It has 2,215ft of track; 1,940ft of the track is usable. Although the private rail siding and switch is in place, it appears the track is being used as a storage track for the inbound or outbound covered hoppers for its neighbor, the ISG plant. Indian Hill Processing is not an active shipper and there is no scheduled rail service for this location (similar to RSNGS). Some of the track located in the plant has been paved to allow easy access for trucks crossing the track. Some of the track leading from the main line to the plant is parallel to a road which would allow for placement of a crane and would provide sufficient room to conduct a loading operation.

The UP rail line running from Indian Hills, CA (which is the end of the rail line) west to Galt, CA is called the Ione Industrial Track.

The next closest railroad is another Class I carrier, the BNSF which has limited access in Stockton, CA, but no viable sites for establishing a transload location for the RSNGS campaign shipments. There are two other switching carriers approximately 49 miles from RSNGS but no practical, secure sites available with the desired track configuration for loading the train consist. There would be no advantage to using an off-site location for loading the rail cars as long as the switch and sufficient track is available on-site at RSNGS.

In order to utilize an off-site loading location, there would be added costs associated with the HHT to rail transload option which would include additional increased transit time for the HHT portion of the movement, the associated additional over-the-road permitting costs and the addition of another rail carrier to the route which would also result in increased overall transit time.

Table 3-2 lists the direct rail routes from RSNGS to GCUS.

Table 3-2: Direct Class I Routes from RSNGS to GCUS

Direct Routes from RSNGS	To GCUS
UP direct (**Figure 3-10**)	Via Galt, Sacramento, Kansas City to GCUS- one Class I carrier
START route: UP direct (**Figure 3-11**)	Via Galt, Fresno, CA and El Paso, TX to GCUS- one Class I carrier, much longer route

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

Table 3-3: Class I and Switching Railroads Near RSNGS

Railroad	Railroad Class	Notes
Union Pacific Railroad	Class I Carrier	Serves the majority of rail served sites near RSNGS
Burlington Northern Railroad	Class I Carrier	Stockton, CA
Central California Traction Company (CCT)	Switching Carrier	Directly serves Port of Stockton, is jointly owned by UP & BNSF, operates 16 miles of track between Stockton and Lodi, CA. No good options for transloads.
Stockton Terminal & Eastern Railroad (STE)	Switching Carrier	Operates 25 miles of track and interchanges with BNSF & UP. Too congested, no good options for transloads.

Figure 3-8 and **Figure 3-9** shows the railroad track on site and the portion of the track recommended for loading the train consist. The barge loading and unloading sites are captured in **Sections 3.3** and **3.4**, respectively. 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 3-8: Overall Track Configuration on RSNGS[1]

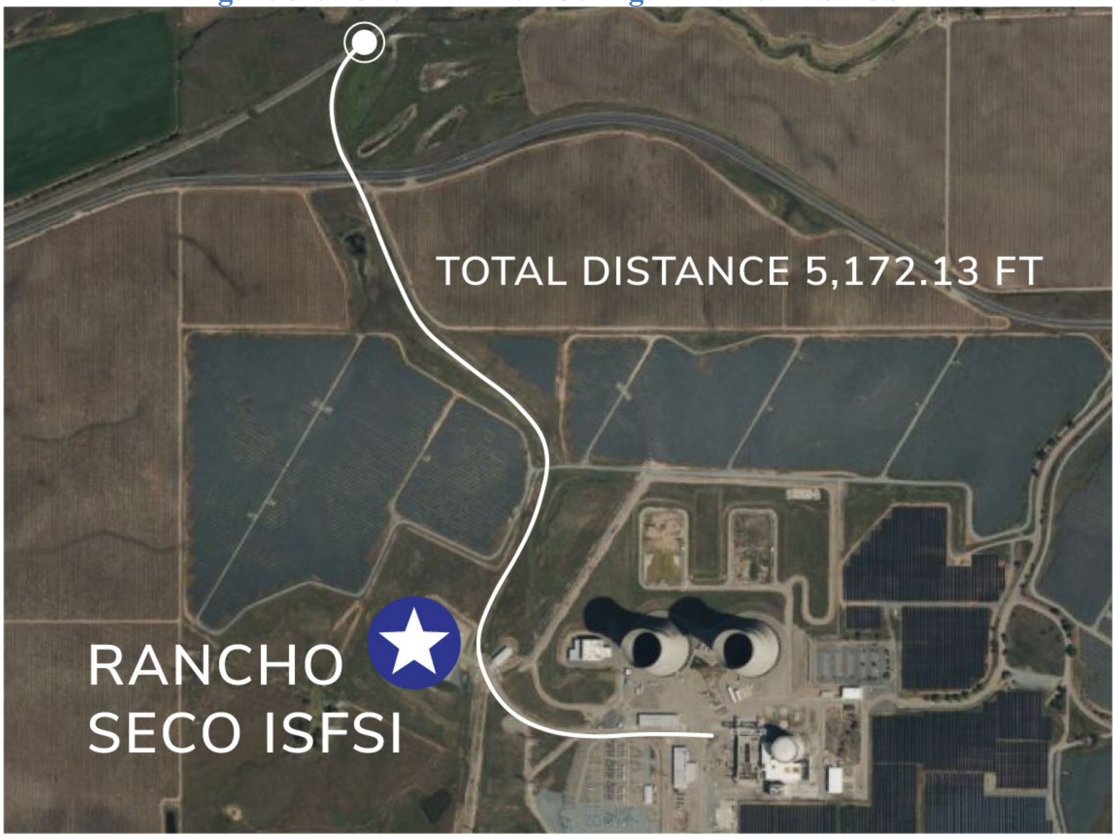


Figure 3-9: Portion of RSNGS Track Recommended for Transloading from Transfer Trailer to Train[1]

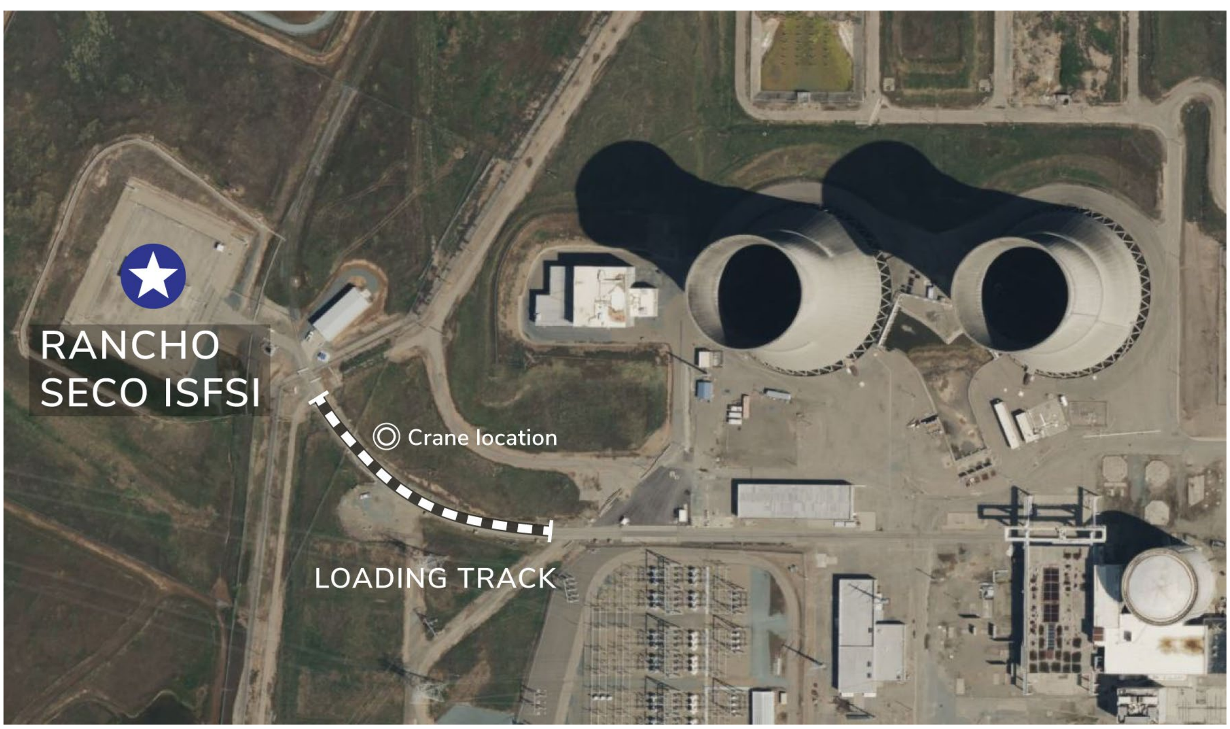
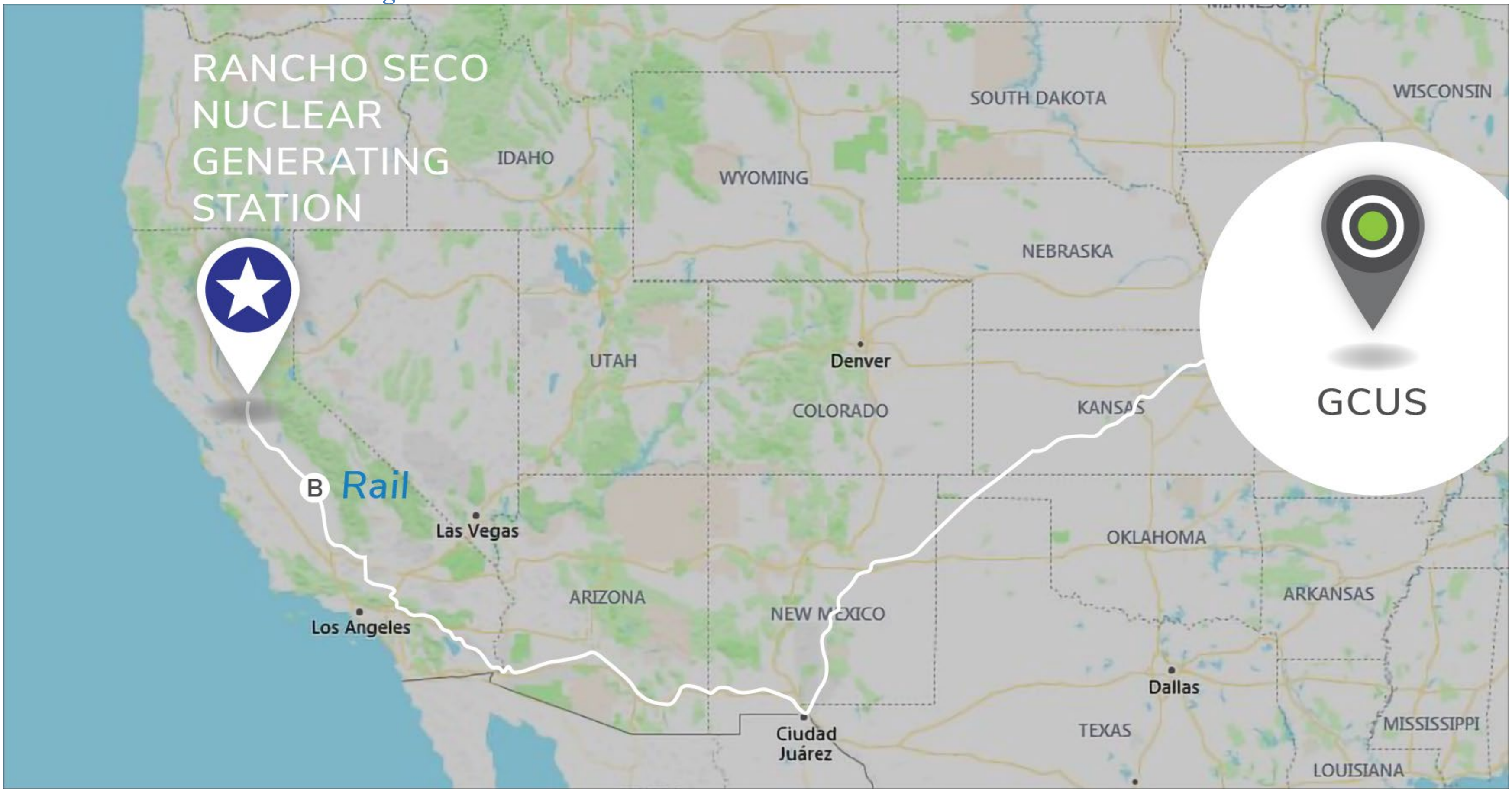


Figure 3-10: UP Direct Route from RSNGS to GCUS[1]

Figure 3-11: Alternative UP Direct Route from RSNGS to GCUS[1]



3.3. Barge Loading Locations

The RSNGS plant does not have direct water access. The site is located approximately 49 road miles from the closest water served facility where casks could be loaded onto barges or vessels for movement.

A HHT would be required for any barge or vessel movement from the site. The closest barge site is located in Stockton, CA. This is the same barge slip used for prior shipments from the plant when the steam generator was too large to clear for movement on rail. The generator was moved via a circuitous route that mostly used secondary, country roads by HHT from RSNGS to the Port of Stockton. Due to the weight and dimensions of this generator it took 4 days to make the over-the-road trip to the barge site at Port of Stockton located at 1541 W. Weber Street, Stockton, CA (**Figure 3-12** and **Figure 3-13**). This site is secured by a fence. There is no rail access. The entire route (via the Panama Canal) is shown in **Figure 3-14**.

This barge shipment was a successful option because the generator was too large to move by rail directly from the site. The MP197HB will not be as large or heavy as the generator sections and it is expected that it will easily clear from the site due to its dimensions which do not exceed the confines of the rail car. Due to the fact that there is sufficient rail track on site at RSNGS no other barge loading sites were considered (they were screened) because of the additional costs associated with a HHT to barge movement versus loading directly onto rail at RSNGS.

Figure 3-12: 1541 W. Weber Street, Stockton, CA – Not Rail Served. Prior Shipments HHT to Barge to VA[1]

Figure 3-13: HHT Route from RSNGS to Transload Site to Barge at Stockton, CA[1]

Figure 3-14: HHT Route from RSNGS to GCUS via Transload Site to Barge at Stockton, CA[1]

3.4. Barge Unloading Locations

Barge unloading locations near the GCUS have been identified in previous studies; however due to the fact that rail infrastructure is in place at the RSNGS site and the loaded MP197HB is within acceptable dimensions and weights to obtain railroad clearance to move from the site by direct rail, no barge unloading sites were specifically considered for this campaign. In addition, the MUA screening of the HHT to barge options negated the need to present a barge unloading location for this movement.

3.5. Down-Selected Transportation Routes

Considering the large number of potential 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 rail 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 routes that would require preapproval for Highway Route Controlled Quantity (HRCQ) shipments.[2]

Some of the potential transportation routes had unique characteristics that did not correlate with any of the 10 listed criteria above. These characteristics greatly reduced the viability of the

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

transportation route; therefore, an 11th category, "Other", was included to the screening criteria so that the unique criterion could be captured.

The above criteria were applied to a number of potential routes, to screen them before they are assessed in the MUA process. After applying the above screening criteria, a total of five possible routes were identified (see **Table 3-4**)and are included for further evaluation in the MUA (**Section 5.0**):

1. Rail directly from the RSNGS site on the on-site rail spur to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO (i.e., referred to as "A. Rail via Sacramento & Kansas City" route in the MUA) as shown in **Figure 3-15**.
2. Rail directly from the RSNGS site on the on-site rail spur to GCUS on UP rail lines via Fresno, CA and El Paso, TX to GCUS (i.e., referred to as "B. Rail via Fresno & El Paso" route in the MUA) as shown in **Figure 3-16**.
3. HHT from RSNGS ISFSI to Ione, CA and then by rail to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO (i.e., referred to as "C. HHT to Ione + Rail via Sacramento & Kansas City" route in the MUA) as shown in **Figure 3-17**.
4. HHT from RSNGS ISFSI to MOTCO and then by rail to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO (i.e., referred to as "D. HHT to Concord + Rail via Sacramento & Kansas City" route in the MUA) as shown in **Figure 3-18**.
5. HHT from RSNGS ISFSI to Stockton, CA and then by barge through the Panama Canal to Houston, TX and then by rail using the PTRA for about 8 miles and then the UP to GCUS (i.e., referred to as "E. HHT to Stockton + Barge via Panama Canal" route in the MUA) as shown in **Figure 3-19**.

Table 3-4: Routes versus Screening Criteria

Route	1	2	3	4	5	6	7	8	9	10	Other
Rail directly from the RSNGS site on the on-site rail spur to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO											
Rail directly from the RSNGS site on the on-site rail spur to GCUS on UP rail lines via Fresno, CA and El Paso, TX to GCUS											
Rail directly from the RSNGS site on the on-site rail spur north through Sacramento, CA, Cheyenne, WY, Topeka, KS, Hannibal, MO								X			
Rail directly from the RSNGS site on the on-site rail spur north through Sacramento, CA, Cheyenne, WY, Topeka, KS, Jefferson City, MO (closer to Pyramid Lake Paiute Reservation)								X			Route ran closer to Pyramid Lake Paiute Reservation
Rail directly from the RSNGS site on the on-site rail spur north through Sacramento, CA, Cheyenne, WY, Topeka, KS, Monroe City, MO								X			
Rail directly from the RSNGS site on the on-site rail spur south through Modesto, CA, Tuscon, AZ, El Paso, TX, Topeka, KS	X							X			
Rail directly from the RSNGS site on the on-site rail spur south through Modesto, CA, Tucson, AZ, El Paso, TX, Hutchinson, KS, Topeka KS, Jefferson City, MO	X										

Route	1	2	3	4	5	6	7	8	9	10	Other
Rail directly from the RSNGS site on the on-site rail spur south through Modesto, CA, Bakersfield, CA, Flagstaff, AZ, Gallup, NM, Dalhart, TX, Hutchinson, KS, Topeka, KS, Jefferson City, MO	X										
Rail directly from the RSNGS site on the on-site rail spur located in front of the ISFSI and rail to GCUS						X					Track length is to short
Rail directly from the RSNGS site on the on-site rail spur located to left as leaving ISFSI and rail to GCUS						X					No loading area located around track
HHT from RSNGS ISFSI to Ione, CA on Highway 104/Twin Cities Road and transload to rail at ISG and then by rail to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO											
HHT from RSNGS ISFSI to Ione, CA to Private Industry at 2201 Michigan Bar Road and transload to rail at Indian Hill Processing Inc and then by rail to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO						X					Rail siding is not active although the switch is still in place and the lead is being used to store rail cars. Some of the track at the plant is paved reducing immediate usable track to 1,940'.
HHT from RSNGS ISFSI to MOTCO and then by rail to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO											
Other HHT from RSNGS to other rail spur locations	X					X	X	X	X		

Route	1	2	3	4	5	6	7	8	9	10	Other
HHT from RSNGS ISFSI to Stockton, CA and then by barge through the Panama Canal to Houston, TX and then by rail using the PTRA and then the UP to GCUS											
HHT from RSNGS ISFSI to Port Richmond Point Potrero and then by barge	X						X				
HHT from RSNGS ISFSI to a Barge Site and then an Alternative Barge Route (e.g., Stockton to Portland, OR)	X				X	X	X				Some routes had extensive travel time, some required multiple transloads, some ports were not permitted to handle this cargo, some made no sense to barge to (e.g., Los Angeles), etc.

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 rail carriers
9. Avoidance of high-density transit areas
10. Characteristics of HHT routes requiring preapproval for HRCQ shipments

Figure 3-15: Rail Directly from the RSNGS On-Site Rail Spur on UP Rail Lines via Sacramento, CA and Kansas City, MO[1]

Figure 3-16: Rail Directly from the RSNGS On-Site Rail Spur on UP Rail Lines via Fresno, CA and El Paso, TX to GCUS[1]

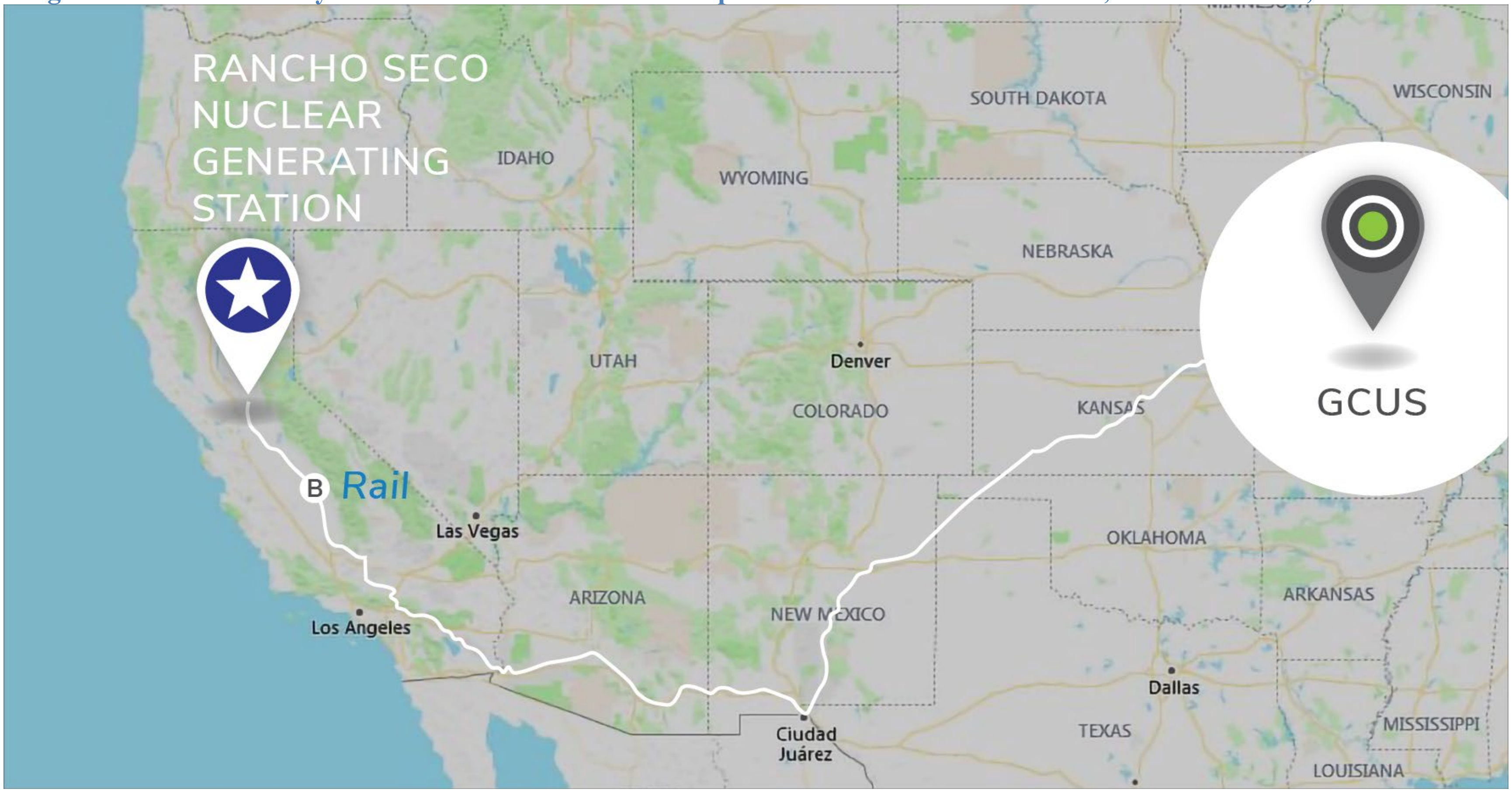


Figure 3-17: HHT from RSNGS ISFSI to Ione, CA and then by Rail on UP via Sacramento, CA and Kansas City, MO to GCUS[1]

Figure 3-18: HHT from RSNGS ISFSI to MOTCO and then by Rail on UP Rail via Sacramento, CA and Kansas City, MO to GCUS[1]

Figure 3-19: HHT from RSNGS ISFSI to Stockton, CA and then by Barge through the Panama Canal to Houston, TX and then by Rail using the PTRA and the UP to GCUS[1]

4.0 PARTICIPATING ENTITIES

This section identifies participating entities/persons this report assumed would be involved in the overall de-inventory implementation for the RSNGS ISFSI and summarizes some aspects of their potential roles. By providing this information, which is current as of the date of this report but can be out of date with new events (e.g., elections), an initial means for identifying these entities/persons in the future is considered to be provided.

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

Assuming DOE would use commercial carriers to conduct the shipments, regulatory authority over the shipments can be summarized as follows. In general, DOT would regulate the areas identified in the Memorandum of Understanding between the NRC and the DOT,[3] including package and conveyance radiological controls, routing, hazard communication, and carrier training. Assuming DOE takes custody of the material at the nuclear power plant site, DOE would have authority to regulate other aspects of the shipments (e.g., physical security), except as otherwise required by law.[4] Even where DOE does exercise its AEA authority over its shipments, DOE's general policy is that all DOE shipments must be conducted in a manner that achieves an equivalent level of safety and security to that required by DOT and NRC for comparable commercial shipments. For purposes of this report, it is assumed that the shipments to de-inventory the site would be conducted like typical commercial shipments in accordance with DOT and NRC regulatory requirements.[5]

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

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

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

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

- Utility employees;
- Subcontractors: crane suppliers, riggers, etc.;
- Transportation personnel: truck operator, rail carrier, barge transportation operator, private escorts for dimensional loads, State Police or Local Law Enforcement Agency (LLEA);
- Cask suppliers;
- U.S. Coast Guard (USCG) (if a marine mode of transport is used, or if the rail transload facility is located on or adjacent to water);
- Security personnel;
- Communication personnel associated with participating entities (e.g., local authorities, escorts, etc.) needed for advance notification of shipments as required by 10 CFR 73.37, 10 CFR 71.97, and as recommended in NUREG-0561 Revision 2[23]
- TRANSCOM or similar satellite and associated continuous in-transit communication service provider(s); and
- Transportation emergency responders.

The participating entities/persons can be categorized into the functional groups identified in **Table 4-1**. Please note that an evaluation of tribal entities that might be impacted during de-inventory operations was performed. The analyzed transportation route does briefly cross the Pyramid Lake Paiute Tribe's Reservation. However the tribe is not currently listed as one of the "participating tribes" referenced in 10 CFR 71.97 but their assistance in security planning may be required.

Table 4-1: Participating Entity Functional Identification

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

Function Group	Entity/Persons
	Equipment Operator (driver & crew)
	Security
	Shipment Response/Tracking
	Support Functions
Rail Transload Facility	Operations Supervisor
	Security
	Craft Support
	Shipment Response/Tracking
	Quality
Authorities	DOE
	State
	Local
	Federal Railroad Administration (FRA)
	U.S. Transportation Security Administration (TSA)*
	NRC
	DOT
	Pipeline and Hazardous Materials Safety Administration (PHMSA)

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

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

> (a)(1) As specified in paragraphs (b), (c), and (d) of this section, each licensee shall provide advance notification to the governor of a State, or the governor's designee, of the shipment of

licensed material, within or across the boundary of the State, before the transport, or delivery to a carrier, for transport, of licensed material outside the confines of the licensee's plant or other place of use or storage.

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

Similarly, NRC regulations in 10 CFR 73.37 and guidance in NUREG-0561 address the provision of advance notification of shipments to States and Tribes as well as other aspects of shipment coordination and communication with participating entities. Therefore, notification of governing authorities is required to coordinate transport in an actual de-inventory campaign. For transport of radioactive material[23], the government agencies listed in **Table 4-1** ("Authorities") issue regulations concerning the packaging and transport of radioactive materials.

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

California - Office of the Governor

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

Governor Gavin Newsom
c/o State Capitol, Suite 1173
Sacramento, CA 95814
Phone: (916) 445-2841
Fax: (916) 558-3160
https://govapps.gov.ca.gov/gov40mail/

California Environmental Protection Agency – (CalEPA)

Listed below is the contact information for the CalEPA.

http://www.calepa.ca.gov/
Department of Toxic Substances Control (DTSC)
Meredith Williams (Director)
1001 I Street P.O. Box 2815
Sacramento, CA
95812-2815
(919)323.2514
http://www.calepa.ca.gov/StaffDirectory/AgencyContacts.asp

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

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

Patty Monahan, Commissioner
California Energy Commission
1516 Ninth Street, MS-33
Sacramento, CA 95814
Phone: (916) 654-5036
24-hour phone: (916) 845-8911
Fax: (916) 653-9040

California Highway Patrol (CHP)

Listed below is the contact information for the CHP.

Commercial Vehicle Section
601 North 7th Street
Sacramento, CA 95811
(916) 843-3400
24 hours: (916) 843-4199,
Fax: (916) 322-3154
P.O. Box 942898
Sacramento, CA
94298-0001
CHP 340 Advanced Notification – Commercially Produced Sent Nuclear Fuel:
https://www.chp.ca.gov/CommercialVehicleSectionSite/Documents/chp340.pdf

California Department of Transportation (Caltrans)

Listed below is the contact information for the Caltrans.

http://www.dot.ca.gov/
District 3 (Services Rancho Seco)
703 B Street
Marysville, CA 95901
General Information - Phone: (530) 741-4572
Fax: (530) 741-4111

United States Coast Guard

Not applicable.

Site Management Provider

Dan Tallman
Site Facilities Manager
Sacramento Municipal Utility District
Phone: (916) 732-4893.

Heavy-Haul Transportation Service Providers

BIGGE

5050 Carpenter Road
Stockton, CA 95205
Phone: 209-251-1989
www.bigge.com

Railroad Transportation Contacts

Union Pacific Railroad Yard

844 East 5th Street
Stockton, CA 95206
Phone: 206-546-7200

Barge Operators

Vincent Schu

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

Cask Supplier

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

Orano TN
http://us.areva.com/EN/home-2271/areva-inc-transnuclear.html
Roger Maggi
Sales & Marketing
Phone: 410-910-6872

5.0 MULTI-ATTRIBUTE UTILITY ANALYSIS

As noted in **Section 3.0**, there are several potential routes for shipping the NUHOMS 24P canisters in TN MP197HB transportation casks from the RSNGS ISFSI to a railcar on a Class I railroad that can take the NUHOMS 24Ps 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 24Ps (i.e., by direct rail, HHT, or barge), and the access of RSNGS to these modes of transport. Furthermore, these routes potentially have both positive attributes (e.g., safe and secure transport) and negative attributes (e.g., expense) meriting an assessment approach that can evaluate these attributes in a combined manner that may distinguish one route from another and/or rank and prioritized routes.

The MUA is a structured methodology designed to handle the trade-offs among multiple objectives (i.e., attributes). The MUA provides a transparent, rational, and defensible analysis that is easy to explain and communicate. MUA methods have been used for decades to provide logically consistent analyses of options (i.e., modes and routes) that are intended to achieve more than one objective, where no single option dominates the others on all those objectives. Utility theory is a systematic approach for quantifying an individual's or team of individuals' ratings/preferences (*note: when "preference" is used together with "route" there is a specific connotation not intended to be covered in this analysis, thus "rating," "ranking," or "priority" will be used in its stead when associated with a route*). It is used to assign a numerical value on some measure of interest (e.g., metric of an attribute) and rescale it onto a normalized (0 to 1) scale with 0 representing the worst rating/option and 1 the best rating/option. This allows the direct comparison of many diverse objectives. The result is a rank-ordered evaluation of options that reflects the decision makers' preferences.

The MUA has been selected as the assessment approach for purposes of this report to evaluate the viable modes and routes (options) for moving the NUHOMS 24Ps containing SNF and GTCC LLW from the RSNGS 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 RSNGS ISFSI.

5.1. Description of MUA Applied to the RSNGS ISFSI

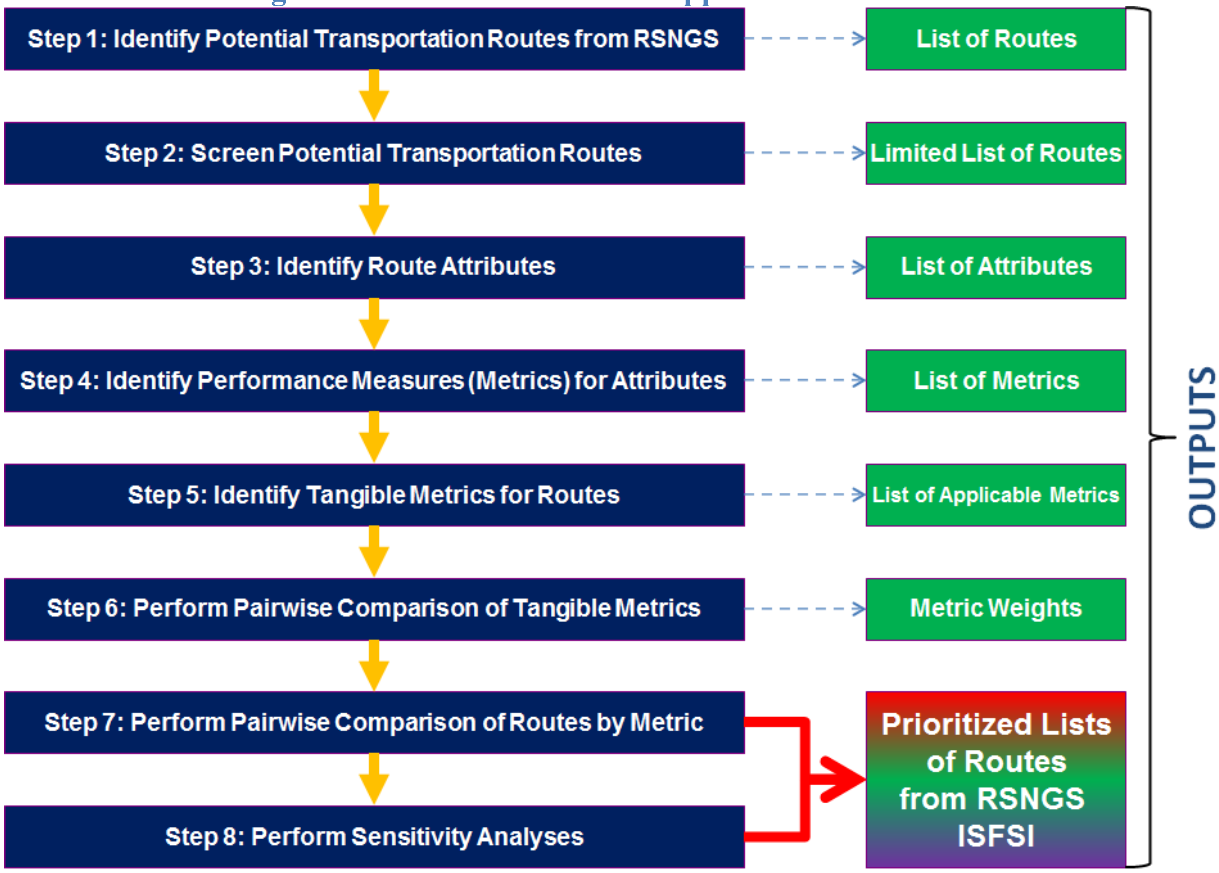
MUA is a straightforward concept. The three primary steps typically followed to frame the analysis are: (1) identify a set of objectives/attributes that an 'ideal' option will achieve; (2) define a set of performance measures (i.e., metrics) that provide a clear definition of each objective/attribute;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

1) Identified the potential modes and routes for transporting the NUHOMS 24Ps from the RSNGS ISFSI (see **Section 3.0**).
2) Due to the larger number of potential routes identified in Step 1 from the RSNGS ISFSI, a set of screening criteria was developed to reduce the number of routes per mode to a limited group for further evaluation; see **Section 3.5** (if this step were not performed, then the pairwise evaluations of the routes by metric would be too cumbersome to be practical due to the number of evaluations that would need to be performed).
3) Identified the general attributes associated with the routes and the activity of shipping the NUHOMS 24Ps from the RSNGS ISFSI; see **Section 5.3.1**.
4) For each identified attribute, identified the metrics that describe performance measures, which could contrast one mode and route from another; see **Section 5.3.1**.
5) Considering the limited list of routes to be evaluated, examined each attribute's metrics and identified the ones that could tangibly differ between two or more of these modes and routes; see **Section 5.3.1**.
6) Each team member performed a pairwise comparison between each of the tangible metrics, which was subsequently quantified and resulted in a relative ranking of the metrics based on individual ratings and were also combined to establish a weight for each of the tangible metrics based on an equivalent team rating; see **Section 5.3.2** (the individual rankings also provided the basis for the sensitivity analyses).
7) The collective team performed another pairwise comparison between the tangible metrics for each route (to ensure the SMEs' preferences were incorporated and not diluted by the ratings of other individuals), and the results were quantified and evaluated to establish a relative ranking of each of the routes based on SME ratings; see **Section 5.3.3**.
8) Finally, sensitivity analyses were performed to examine the sensitivity of the ranking to different weighting of the tangible metrics; this includes evaluating the metric weights at the minimum and maximum values identified by the individual members of the team; see **Section 5.5**.

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

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



5.2. Description of Evaluated Routes

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

- Transfer directly to onsite rail siding (onsite rail)
- Transport by HHT directly to an existing rail transload facility (HHT to rail), or establish a private transload facility
- Transport by on-site HHT to a barge or vessel, barge/vessel transport to a port, and transfer to a railcar (HHT to barge/vessel to rail)

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

The following screening criteria were used per mode of transport (i.e., routes having the same mode of transport were only contrasted against one another for screening purposes) to reduce the routes to the five routes identified in **Section 3.5**[6]**:**

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:

A. Rail directly from the RSNGS site on the on-site rail spur to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO (i.e., referred to as "A. Rail via Sacramento & Kansas City" route in the MUA).

B. Rail directly from the RSNGS site on the on-site rail spur to GCUS on UP rail lines via Fresno, CA and El Paso, TX to GCUS (i.e., referred to as "B. Rail via Fresno & El Paso" route in the MUA).

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

C. HHT from RSNGS ISFSI to Ione, CA and then by rail to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO (i.e., referred to as "C. HHT to Ione + Rail via Sacramento & Kansas City" route in the MUA).

D. HHT from RSNGS ISFSI to MOTCO and then by rail to GCUS on UP rail lines via Sacramento, CA and Kansas City, MO (i.e., referred to as "D. HHT to Concord + Rail via Sacramento & Kansas City" route in the MUA).

E. HHT from RSNGS ISFSI to Stockton, CA and then by barge through the Panama Canal to Houston, TX and then by rail using the PTRA for about 8 miles and then the UP to GCUS (i.e., referred to as "E. HHT to Stockton + Barge via Panama Canal" route in the MUA).

5.3. Evaluation of Routes

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

5.3.1. Identification of Attributes and Metrics

The attributes identified that can characterize the 'ideal' route are identified in **Table 5-1** (Step 3). These attributes were established based on solicitation of the members of the de-inventory team, past de-inventory studies[23][24][25][26][27][28], and also based on the large body of past MUA activities having been performed on nuclear waste management evaluations[29][30][31][32].

For each attribute, one or more performance measures (metrics) were 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 permitting needs, 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 16 metrics will be evaluated for each route and contrasted against the other routes. Another metric initially identified as having a tangible difference between the sites, namely "On-Site Rental Equipment Costs (e.g., mobile cranes)," apparently could have been screened as well, because during the pairwise comparison for this metric between the routes, no difference was assessed; hence, really only 15 metrics needed to be evaluated for the RSNGS site.

Table 5-1: Attributes and Associated Metrics

Attribute	Metric	Y/N	Comments
Cost[7]	On-Site Rental Equipment Costs (e.g., mobile cranes)	Y	Mobile cranes may be required for barge, but could instead use goldhofer and stands. Mobile cranes needed for loading on to railcar and HHT trailer for direct rail and HHT routes.
	Hardware Procurement Costs (e.g., transfer cask)	N	Hardware is expected to be relatively the same for all routes, with stands for barging being negligible exception.
	Infrastructure Improvement Costs (e.g., rail improvement, fortifying roads/bridges)	N	No improvements are expected to be necessary for any of the routes as ample space exists for on-site rail transloads and HHT transload sites (rail and barge) already exist and infrastructure to those sites is acceptable and barge off-load site is direct to rail and has acceptable infrastructure.
	Labor and Permitting Costs	Y	Labor and permitting costs are expected to vary by route, as on-site transfer to rail is expected to be minimal, off-site transfer by HHT to be more burdensome, and HHT to barge with barge to rail expected to be the most burdensome.
	Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	Y	The different modes of transport from the site of rail, HHT to rail, or HHT to barge to rail will result in different shipment costs and different transload costs.
	Cost of Rail Transport (e.g., costs associated with use of multiple railroads in route)	Y	Rail routes take different length routes and will have different numbers of interchanges.
	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.

[7] 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
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.
	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 utilize tunnels that may pose a challenge to the shipments of the material from the RSNGS site.
	Impact of Weather to Route (e.g., limited availability of route or instability of weather)	N	Local weather phenomena are not expected to impact shipments from RSNGS.
	Number of Water Areas Nearby Route (e.g., number of bridges crossed)	Y	According to START[1] the mileage over water shows some differences.
	Number of Sensitive Environmental Areas Nearby Route (e.g.,endangered species habitats)	N	START[1] does not identify distinguishable differences for number of environmentally sensitive areas traversed between the evaluated routes.
Institutional Considerations	Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churches)	Y	Based on results from START[1], the routes show significant differences between the number of these mass gathering places along the routes.
	Number of Tribal Lands Crossed	Y	Based on results from START[1], the routes show significant differences between the number of tribal lands crossed by the routes.
	Public Acceptability of Route	Y	This subjective metric will be evaluated as done in the previous evaluations based on our experts opinions and will consider nearby features of the routes.
Permitting	Ease of Permit Procurement	Y	All permit pulling is expected to be difficult to perform in California especially for HHT routes.
	Number of Permits	N	Number of permits for each route are considered to be relatively equal, since very short HHT routes are being utilized.

Attribute	Metric	Y/N	Comments
	Insurability of Route	N	All routes to be indemnified by DOE (Price Anderson Act).
Resource Requirements	Number of Personnel involved in Transfer	N	Impact considered to be covered by cost and safety metrics.
	Quantity of Hardware Needed	N	Hardware is expected to be relatively the same for all routes, with stands for barging being negligible exception.
	Availability of Specialty Equipment (e.g., rigging, transfer cask)	N	Speciality equipment such as a transfer cask, rigging, and a heavy haul truck (goldhofer) will be required for each route. 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 (proportional to handling time & number of workers)	Y	Some routes will involve greater cumulative worker exposure as a result of an additional transload activity (for barge and HHT routes) and/or the longer transient duration associated with some routes.
	Cumulative Population Dose along Route (proportional to 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 negligibly 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	Y	START[1] indicates differences between routes. Average population density per square mile ranges from 333 to 2834, total population ranges from 411,861 to 835,602, and emergency response capability ranges from 0.13 to 0.34 per square mile.
Schedule	Transit Duration per Conveyance and Consist	Y	START[1] identified distinguishable duration differences between the evaluated routes.

Attribute	Metric	Y/N	Comments
	Duration for Infrastructure Improvement (e.g., including dredging, fixing rail line)	N	No significant infrastructure improvements are expected on any of these routes.
	Ease of Access to Transload Site (e.g., consider usage of existing site)	N	Based on current usage, the transload sites for HHT and barge are not expected to pose a constraint to operations.
	Immediacy of Ability to Perform Transfer (e.g., ability to train crew)	N	The team decided there was no tangible difference between the routes as all routes were deemed equally immediately ready for performing a transfer.
	Size of conveyance (# of casks per shipment)	N	Although HHT routes will be limited to one cask per shipment versus the 5 per shipment for barge and rail, the combination of the shortness of the HHT routes and the potential for having more than one HHT utilized at one time is expected to result in no significant scheduling penalty.
Security/ Vulnerability	Security Vulnerability of Route	Y	Some routes may transit urban areas viewed as a higher risk, whereas 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 account for this metric.
Waste Generation	Quantity of Radiological Waste Produced from Normal Ops	N	A minimum amount of radiological waste is expected and will likely be nearly the same for all routes.
	Quantity of Non-Radiological Waste Produced from Normal Ops	N	A minimum amount of non-radiological waste is expected and will likely be nearly the same for all routes.

5.3.2. Evaluation of Individual Metrics

With the tangible metrics established in **Section 5.3.1**, a pairwise comparison between these metrics was performed by each of the 12 members of the Orano-led team to establish a relative weighting of the metrics and a range for the metric weight over which a sensitivity analyses was performed (Step 6). In a pairwise comparison, each metric is evaluated for its favorability against the other metrics. This exercise was performed by each of the 12 individuals of the Orano-led team to ensure a reasonable cross-section of preference samples was taken from the collective team, which allowed for an average metric weighting to be established and a prioritized list of metrics identified.

An example of the pairwise comparison performed by an individual is shown in **Table 5-2**. In this example, the "Public Acceptability of Route" metric (e.g., the perceived favorability of the route to the public relative to the other routes) is pairwise compared against the other metrics on a favorability scale. For example, the "Public Acceptability of Route" metric is rated more favorable against the "Ease of Permit Procurement" and is rated strongly unfavorable against "Cumulative Worker Exposure." These ratings are interpreted to mean that there is a benefit seen to increasing the burden of procuring permits (e.g., selecting a route that requires procuring more permits) at the expense of increasing the public's acceptance of a route (i.e., selecting a route that has more permitting requirements but is more acceptable to the public is a good outcome). However, if there were an improvement to the transport to rail Class I that resulted in decreased public acceptability but could improve (reduce) the cumulative worker exposure, then this will be a strongly favored/encouraged outcome (e.g., transloading at a site with more space allowing workers increased distance from the transportation cask but, for example, may be in a more populated area and is not as acceptable to the public relative to an alternative transload site with a smaller footprint, but in a less populated area, the larger foot print site would be favored by this evaluator).

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

Column A Metrics	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Metrics
Public Acceptability of Route		X						Ease of Permit Procurement
Public Acceptability of Route							X	Cumulative Worker Exposure
Public Acceptability of Route							X	Cumulative Population Dose along Route
Public Acceptability of Route					X			Risks Associated with Number of Lifting Activities
Public Acceptability of Route							X	Average Accident Frequency on Route
Public Acceptability of Route						X		Number of Fire Stations & Trained Personnel Nearby Route
Public Acceptability of Route			X					Transit Duration per Conveyance and Consist
Public Acceptability of Route							X	Security Vulnerability of Route

With 16 tangible metrics to be evaluated, 120 pairwise evaluations had to be performed by each individual. **Attachment A** shows the entire pairwise evaluation for these metrics. Note if the original 40 metrics were evaluated, then 780 pairwise evaluations will have had to have been performed to establish the weight for the metrics (burdensome).

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

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

Using this weight scheme, **Figure 5-2** shows the results for the relative weighting of the tangible metrics as established from the evaluation of twelve individual pairwise comparisons.

Table 5-3 shows the numerical values associated with these tangible metrics. Three sets of data are shown in this figure and four sets of data are shown in this table:

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

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

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

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

   where B = averaged biased relative weight.
4) The "Maximum" value as established from the 12 individual assessments.

Results from all 12 of the individual assessments are shown in **Attachment B**.

As shown in **Figure 5-2** and **Table 5-3,** the tangible metrics with the highest preferences (based on average weighting method) are Security Vulnerability of Route, Cumulative Worker Exposure, and Cumulative Population Dose, which rated at about 8.8%, 8.4%, and 8.0% of the total weight, respectively. The tangible metrics with the least preferences (based on average weighting method) are Labor and Permitting Costs, On-Site Rental Equipment Costs, and Number of Water Areas nearby Route which rated at about 4.5%, 4.5%, and 5.0% of the total weight, respectively. The preferences/ranking and weights of all the tangible metrics in descending order (based on average weighting method) are shown in **Table 5-3**.

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

- The Average Accident Frequency on Route metric, which ranked 5th overall, was ranked 3rd highest overall by an individual at 10.9% (as clearly seen in **Figure 5-2**) indicating a wide range of importance levels for this metric between the individual evaluators. This metric also was ranked fairly low by another individual at 4.9% giving it the largest range between maximum and minimum.
- The Cumulative Worker Exposure metric, which ranked 2nd overall, had the highest favorable ranking by an individual at 11.8%, but was also ranked fairly low by another individual at 6.5% (having the one of the highest ranges 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 Ease of Permit Procurement metric and the Transport to Rail Class I Costs metric, which ranked near the bottom of importance of all the metrics and hence, showing a fairly robust rating.

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

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

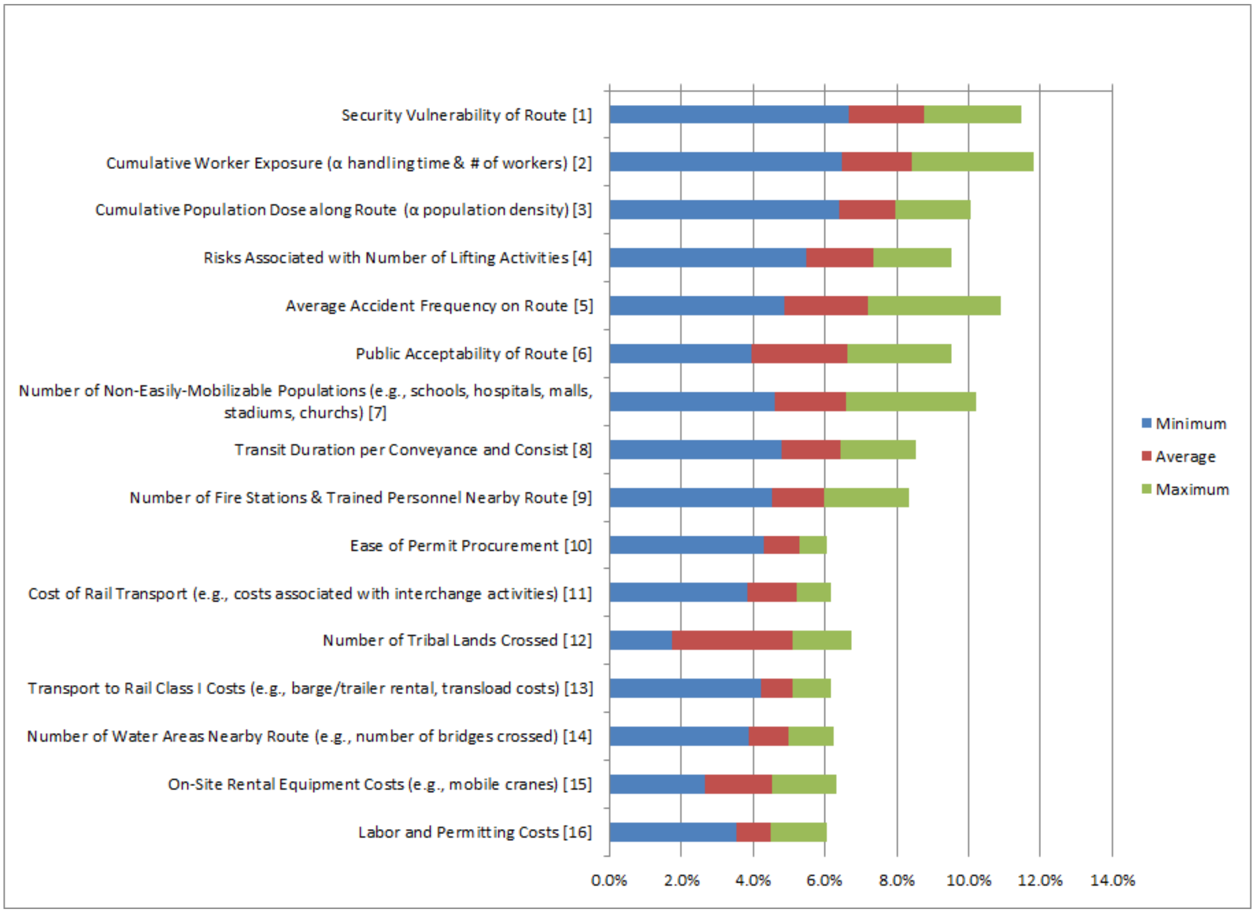


Table 5-3: Weighting of Tangible Metrics

Rank	Minimum	Average Weight	Biased Weight	Maximum	Metric
1	6.7%	8.76%	8.76%	11.5%	Security Vulnerability of Route
2	6.5%	8.43%	8.43%	11.8%	Cumulative Worker Exposure
3	6.4%	7.95%	7.95%	10.1%	Cumulative Population Dose along Route
4	5.5%	7.34%	7.34%	9.5%	Risks Associated with Number of Lifting Activities
5	4.9%	7.19%	7.19%	10.9%	Average Accident Frequency on Route
6	4.0%	6.63%	6.63%	9.5%	Public Acceptability of Route

Rank	Minimum	Average Weight	Biased Weight	Maximum	Metric
7	4.6%	6.57%	6.57%	10.2%	Number of Non-Easily-Mobilizable Populations
8	4.8%	6.45%	6.45%	8.5%	Transit Duration per Conveyance and Consist
9	4.5%	5.97%	5.97%	8.3%	Number of Fire Stations & Trained Personnel Nearby Route
10	4.3%	5.31%	5.31%	6.0%	Ease of Permit Procurement
11	3.8%	5.21%	5.21%	6.2%	Cost of Rail Transport
12	1.7%	5.10%	5.10%	6.7%	Number of Tribal Lands Crossed
13	4.2%	5.08%	5.08%	6.2%	Transport to Rail Class I Costs
14	3.9%	4.98%	4.98%	6.3%	Number of Water Areas Nearby Route
15	2.6%	4.54%	4.54%	6.3%	On-Site Rental Equipment Costs
16	3.5%	4.50%	4.50%	6.0%	Labor and Permitting Costs

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. On-Site Rental Equipment Costs

For the on-site rental equipment costs, during the pairwise comparison it was assessed that the rental costs for on-site equipment would be the same for each route (e.g., mobile crane, HHT, and trailer), as other rental equipment costs are not for on-site rental equipment but for off-site equipment. So for this metric, all routes evaluated equally (i.e., this metric could have been screened).

5.3.3.2. Labor and Permitting Costs

For the labor and permitting costs, the HHT routes are expected to have higher costs relative to the on-site rail costs. The HHT routes are expected to have higher permitting costs relative to the evaluated on-site rail routes, as local permits for the HHT are required whereas no local permits are necessarily needed for the on-site rail routes. Furthermore, labor costs for the HHT routes are expected to be higher due to the off-site transload activities the on-site rail routes would not have. Thus, the HHT routes would be unfavorable compared to the on-site rail routes. Finally, the HHT route that includes barge is expected to be the least favored route because, in addition to the HHT labor and permitting costs, an additional transload activity would be required to move the transport casks from the barge to rail.

5.3.3.3. Transport to Rail Class I Costs

For the transport to rail costs (not including on-site costs), each of the five routes were evaluated by the team to have a cost benefit or cost penalty relative to the other routes based primarily on composite costs associated with rental of barges, tugs, and HHTs and number of transload activities and associated security costs. For rail only routes, no transport to rail costs were identified beyond those already covered by the on-site rental costs and hence these were the most favored routes. For the route utilizing the barge, the costs are associated with: (1) 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 trailer (rolled on) and (2) 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, the number of shipments required to be performed for each route, and the security for each transload site would impact this assessment. The route involving the barge through the Panama Canal was deemed to be the most expensive route due to the equipment rental costs, distances traveled, and the need to perform a transload activity. The HHT route to Concord followed by the HHT route to Ione were the next two most expensive routes due to the equipment rental costs, distances traveled, and the need to perform a transload activity. The direct to rail routes were deemed to have equivalent (negligible) costs and were favored over the other routes for this metric.

5.3.3.4. Cost of Rail Transport

For the cost of rail transport, the route with the barge is mildly favored over both the HHT and direct to rail routes as the rail portion of this barge route is the shortest. Since the HHT to Ione and

Concord and the direct to rail route via Sacramento and Kansas City essentially follow the same rail routes, these routes evaluate neutrally against one another. These routes are also favored over the direct to rail route via Fresno and El Paso as they cover a shorter distance on the rail lines.

5.3.3.5. Number of Water Areas Nearby Route

Using data produced from the START program[1], each route could be evaluated for the number of water crossings the route traverses. Based on these results (see **Attachment D**), the number of water crossings ranged from 96 to 229. The route with the least number of water crossings is the direct rail route through Fresno and El Paso (96 crossings) followed by the HHT to Ione (213 crossings), the HHT to Concord (229 crossings), and the direct rail route through Sacramento and Kansas City (213 crossings). The HHT to Stockton that includes barging via the Panama Canal to Houston and then rail to the GCUS had fewer crossings (97) than most of the other routes, but one crossing was essentially continuous (via the Panama Canal) and hence, disadvantaged this route versus the others.

5.3.3.6. Number of Non-Easily-Mobilizable Populations

Using data produced from the START program[1], each route could be evaluated for the number of non-easily-mobilizable populations (mass gathering places), such as those found at schools, hospitals, malls, stadiums, churches, and retirement homes along the routes. Based on these results (see **Attachment D**), the number of non-easily-mobilizable populations along each route was lowest for the HHT to Ione and the direct rail route going through Sacramento and Kansas City (360 each). These routes were followed by the HHT to Stockton followed by barge route using the Panama Canal (383), the HHT route to Concord (423), and then the direct rail route via Fresno and El Paso (845) which had the highest number of non-easily-mobilized populations.

5.3.3.7. Number of Tribal Lands Crossed

Using data produced from the START program[1], each route could be evaluated for the quantity (square miles) of tribal land crossed. Based on these results (see **Attachment D**), the quantity of tribal lands crossed by each route was small (i.e., less than 16 square miles[8]) relative to the total land crossed by an entire route. Nevertheless, according to START, the routes did have some mild differences over one another: the HHT route to Stockton with barge did not cross any tribal lands, the HHT routes to Ione and Concord and direct rail route via Sacramento and Kansas City crossed 1.35 square miles of tribal land, and the direct rail route via Fresno and El Paso crossed 15.26 square miles of tribal land.

5.3.3.8. Public Acceptability of Route

The public acceptability of the five routes to be evaluated varied between each of the routes. The direct to rail route via Sacramento and Kansas City was judged to be mildly or more favorable over all the other routes due to the lack of off-site activities (e.g., HHT and transloading), utilizing

[8] START establishes the square miles of tribal land crossed by determining the number of miles a route crosses through tribal land, assuming 800 meters on either side of the route, as a buffer region, then multiplying these values together to establish the number of square miles of tribal land crossed.

rail lines with regular commercial service, and not utilizing public waterways and their associated environmentally sensitive areas. The direct to rail route via Fresno and El Paso was judged to be essentially the same as the HHT routes to Ione and Concord for many of the same reasons as identified above for the other direct to rail route, except this rail route was longer than the other rail route, which was partially off-set by the lack of off-site activities (e.g., HHT and transloading) and hence, these routes evaluated identically. The HHT route via Ione was deemed more favorable over the HHT routes to Concord and Stockton due to the lower population along the Ione route and the shorter distance from Ione. Finally, the HHT route to Concord and the HHT route to Stockton with barge were evaluated to be neutral against one another due to the heavier population along the Concord route that is countered by the longer Stockton route that travels through the Panama Canal.

5.3.3.9. Ease of Permit Procurement

The direct to rail routes from the RSNGS ISFSI do not require permits and hence have advantages over the HHT routes, which would require several local permits. The HHT routes going to rail have an advantage over the HHT route going to barge as permits required to performing the barging along the California coast and through the Panama Canal would further complicate this route over the other HHT routes.

5.3.3.10. Cumulative Worker Exposure

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

- Transfer to on-site rail (two lifts):
  - Lift of the MP197HB (loaded with the NUHOMS 24P) in its cradle onto the on-site trailer
  - Lift of the MP197HB from on-site trailer to cask railcar
- Transfer to HHT then to rail (two lifts):
  - Lift of the MP197HB (loaded with the NUHOMS 24P) in its cradle onto the HHT trailer.
  - Lift of transportation cask and cradle from HHT trailer to cask railcar at transload site (*Note: a single lift is assumed at the HHT-to-rail transload site*).
- Transfer to on-site barge to rail (two to three lifts):

- Lift of the MP197HB (loaded with the NUHOMS 24P) in its cradle onto the HHT trailer/goldhofer[9]
- 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)*
  - Use a crane to lift the transportation cask from the HHT trailer/goldhofer 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 direct to rail routes from the RSNGS ISFSI are mildly favored over the HHT routes and more favored over the HHT route that includes barge, the HHT route with rail through Sacramento and Kansas City is mildly favored over the HHT route to Concord due to the longer distance traveled, and the HHT route to Stockton is more unfavorable compared to the other HHT routes due to the longer distance traveled by this route.

5.3.3.11. Cumulative Population Dose Along Route

The cumulative population dose along each route is expected to be negligible (comparable to background) due to the significant amount of shielding afforded by the transportation casks and their canisters, the age of the SNF, and the minimal duration of exposure during each transport operation. Furthermore, doses to individual members of the public during normal transportation activities are expected to be below background levels. Nevertheless, the relative differences in preferences established for the assessment of this metric are based primarily on the total exposed population established from data provided by START[1] along each route as shown in **Table 5-4**. Those routes with the lowest total exposed populations are favored over the other routes.

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

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

ID	Route Description	Average Population Density (Persons/Square Mile)[1]	Total Exposed Population Estimate[2] (Thousands)
A	Rail via Sacramento & Kansas City	331	412
B	Rail via Fresno & El Paso	538	836
C	HHT to Ione + Rail via Sacramento & Kansas City	333	412
D	HHT to Concord + Rail via Sacramento & Kansas City	2834	591
E	HHT to Stockton + Barge via Panama Canal	1585	245

[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).

5.3.3.12. 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 5.3.3.10**. Based on this assessment, the on-site rail routes are deemed strongly favorable over the HHT to barge route, the HHT routes are more favorable over the HHT to barge route, and the on-site rail routes are more favorable over the HHT routes due to the transload operation taking place off-site with different equipment and personnel. These risks are minimized by the protection afforded the transportation 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 rail routes, the overall risk associated with a lifting device is deemed negligible.

5.3.3.13. Average Accident Frequency on Route

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

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

Accident Rate (per mi/yr)	Route				
	Rail via Sacramento & Kansas City	Rail via Fresno & El Paso	HHT to Ione + Rail via Sacramento & Kansas City	HHT to Concord + Rail via Sacramento & Kansas City	HHT to Stockton + Barge via Panama Canal
Average Accident Rate	0.000001	0.000001	0.42691	2.39893	1.727508
Factor Increase Over Lowest Rate	1 x	1 x	426,910 x	2,398,930 x	1,727,508 x

5.3.3.14. Number of Fire Stations & Trained Personnel Nearby Route

Using data produced from START[1], each route could be evaluated for Emergency Response Capability per square mile and although the values are not significantly different by route, there are sufficient differences to provide a basis for evaluation. **Table 5-6** provides the Emergency Response Capability per square mile by route.

Table 5-6: Emergency Response Capability Over Each Route[1]

Emergency Response Capability (total per mi^2)	Route				
	Rail via Sacramento & Kansas City	Rail via Fresno & El Paso	HHT to Ione + Rail via Sacramento & Kansas City	HHT to Concord + Rail via Sacramento & Kansas City	HHT to Stockton + Barge via Panama Canal
Emergency Response Capability	0.13	0.15	0.13	0.34	0.42
Factor Increase Over Lowest Rate	1 x	1.15 x	1 x	2.6 x	3.2 x

5.3.3.15. Transit Duration per Conveyance and Consist

The transit duration for each route was roughly estimated during the team meeting and arrived at the following estimates (detailed estimates for actual operations for the highest ranked route are included in **Section 6.5**):

1) Rail to GCUS via Sacramento & Kansas City
   a) Loading Cask: load NUHOMS 24P canister into MP197HB cask, load MP197HB cask on to on-site trailer/goldhofer, and attach truck/tug to on-site trailer/goldhofer (1 to 3 days per cask)

   b) Transload: prepare and load MP197HB onto cask railcar, secure, and prepare cask for shipment (1 day per cask)
   c) Complete Rail Consist (e.g., add buffer cars, locomotives, and escort car) (~1 day)
   d) Thus, approximately **11 to 21 days** for 5 MP197HB casks to load onto a full consist
   e) Total HHT and Rail Transit Duration from START[1]: 52 hours

2) Rail to GCUS via Fresno & El Paso
   a) Same as previous rail route: thus, approximately **11 to 21 days** for 5 MP197HB casks to load onto a full consist
   b) Total HHT and Rail Transit Duration from START[1]: 61 hours

3) HHT to Ione + Rail to GCUS via Sacramento & Kansas City
   a) Loading Cask: load NUHOMS 24P canister into MP197HB cask, load MP197HB cask on to HHT trailer/goldhofer, and attach HHT to HHT trailer/goldhofer (2 to 4 days per cask)
   b) Transportation: transport by HHT to Ione Rail Transload Site (< 1 day per cask)
   c) Transload: prepare and load MP197HB onto cask railcar, secure, and prepare cask for shipment (1 day per cask)
   d) Complete Rail Consist (e.g., add buffer cars, locomotives, and escort car) (~1 day)
   e) Thus, approximately **21 to 31 days** for 5 MP197HB casks to load onto a full consist
   f) Total HHT and Rail Transit Duration from START[1]: 53.5 hours

4) HHT to Concord + Rail to GCUS via Sacramento & Kansas City
   a) Same as previous HHT route: thus, approximately **21 to 31 days** for 5 MP197HB casks to load onto a full consist
   b) Total HHT and Rail Transit Duration from START[1]: 55 hours

5) HHT to Stockton + Barge via Panama Canal + Rail to GCUS from Houston
   a) Loading Cask: load NUHOMS 24P canister into MP197HB cask, load MP197HB cask on to HHT trailer/goldhofer, and attach HHT to HHT trailer/goldhofer (2 to 4 days per cask)
   b) Transportation: transport by HHT to Stockton Barge Transload Site (< 1 day per cask)
   c) Transload: transport to barge and either roll-on on-site trailer/goldhofer or lift MP197HB onto stands and then secure and prepare cask for shipment (1 day per cask)
   d) Barge Preparation: pre-barge briefings for procedures, quality, and safety reviews; assemble crew (1 to 2 days for 5 casks)
   e) Barging: transport 8,909 miles to Houston, TX (891 hrs per START[1] or 37 days for 5 casks)
   f) Unloading Barge: transload operations from barge to rail (2½ days for 5 casks)
   g) Thus, approximately **60½ to 71½ days** for 5 casks to load onto cask railcar
   h) Total Transit Duration from START[1]: 1,295 hours

As noted in these handling times, there are also the total route transit durations on the HHTs, barges, and rails. START[1] provides these distances and total transit times and **Table 5-7** provides a breakdown by route.

Table 5-7: Route Transit Durations[1]

Distance (miles)	Route					
	Rail via Sacramento & Kansas City	Rail via Fresno & El Paso	HHT to Ione + Rail via Sacramento & Kansas City	HHT to Concord + Rail via Sacramento & Kansas City	HHT to Stockton + Barge via Panama Canal	Rail via Sacramento & Kansas City
HHT	0	0	9	115	54	0
Barge	0	0	0	0	8909	0
Rail	2105	2425	2115	2140	877	2105
Total Duration (hrs)	52	61	53.5	55	1295	61

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 would 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 would be required by HHT to and from the site and do not account for time spent in locks for the barge route and intermodal transfer operations.

Using the data in **Table 5-7** from START[1] (note some of these times seem counter intuitive and hence were not solely used to establish the comparisons) and the above handling times, the pairwise comparisons were performed between the various routes.

5.3.3.16. Security Vulnerability of Route

For the metric on security vulnerability of the route, all routes were 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 high threat urban areas on the route, number of transload activities, and the lower vulnerability associated with barge routes over HHT routes, though this barge route goes outside of U.S. territorial waters. The shortest rail route direct from the site with no off-site transload activities was judged to be the most favored security route over the other routes. Similarly, the shorter distance and duration HHT routes evaluated in this comparison were mildly favored over the longer distance and duration barge routes.

5.4. Route Recommendations

Using the metric information identified for the routes listed in the previous section, the Orano-led team performed a pairwise comparison of each of the tangible metrics for each of the routes identified in **Section 5.2** (Step 7). This team evaluation, unlike the individual assessments performed for the tangible metrics, ensured SMEs' preferences and knowledge could appropriately influence the results for the SMEs' metrics used to compare the routes, while at the same time allowing those knowledgeable of the routes to provide beneficial inputs and all team members the opportunity to provide feedback to the discussion related to the evaluation of the route and metric.

Figure 5-3 provides an example of the pairwise comparison performed by the de-inventory team for the metric related to the Cumulative Population Dose along Route (as denoted on the far-left column). "Column A Routes" (2nd column on left) are subsequently compared against "Column B Routes" (last column on right) for the Cumulative Population Dose along Route metric. The favorability scale listed in this figure is the same as identified for the pairwise comparison of the tangible metrics (see **Table 5-2**). As an example, the fourth row of the evaluation (excluding the header row) shows that the E. HHT to Stockton + Barge via Panama Canal route is more favorable when compared to the A. Rail via Sacramento & Kansas City route for the metric related to the Cumulative Population Dose along Route, which is reflective of the information provided in **Section 5.3.3.11**.

With 16 tangible metrics and 5 routes to be evaluated, the team performed 160 pairwise evaluations. **Attachment C** shows the entire pairwise evaluation for these metrics.

Using the same weighting scheme as described in **Section 5.3.2** and the relative weighting of the tangible metrics identified in **Table 5-3** and **Figure 5-4** shows the resulting relative weighting of the routes in order of the highest rated (A. Rail via Sacramento & Kansas City) to the least rated (E. HHT to Stockton + Barge via Panama Canal). **Table 5-9** shows the numerical values associated with each of the routes for multiple different weighting schemes:

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

Figure 5-3: Examples of a Portion of a Pairwise Comparison for Routes Assessment

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Cumulative Population Dose along Route (α population density)	A. Rail via Sacramento & Kansas City		X						B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City						X		E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso						X		C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso					X			D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso						X		E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City						X		E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City						X		E. HHT to Stockton + Barge via Panama Canal

As shown in **Figure 5-4** and **Table 5-8**, the routes with the highest ratings (based on average weighting method) are: Rail from RSNGS to GCUS via Sacramento & Kansas City and Rail from RSNGS to GCUS via Fresno & El Paso. The route with the least favored rating (based on average weighting method) is the HHT to Stockton + Barge via Panama Canal + Rail to GCUS. The top route is almost 3% favored (based on the MUA team's assessments) over the other four routes, indicating some definitive preference of this route with direct loading of rail on the RSNGS site. Similarly, the route at the bottom of the list is separated by almost 3% from the one above it, indicating some definitive reservation by the MUA team with the use of this route.

Figure 5-4: Resulting List of Prioritized Routes from the RSNGS ISFSI Site

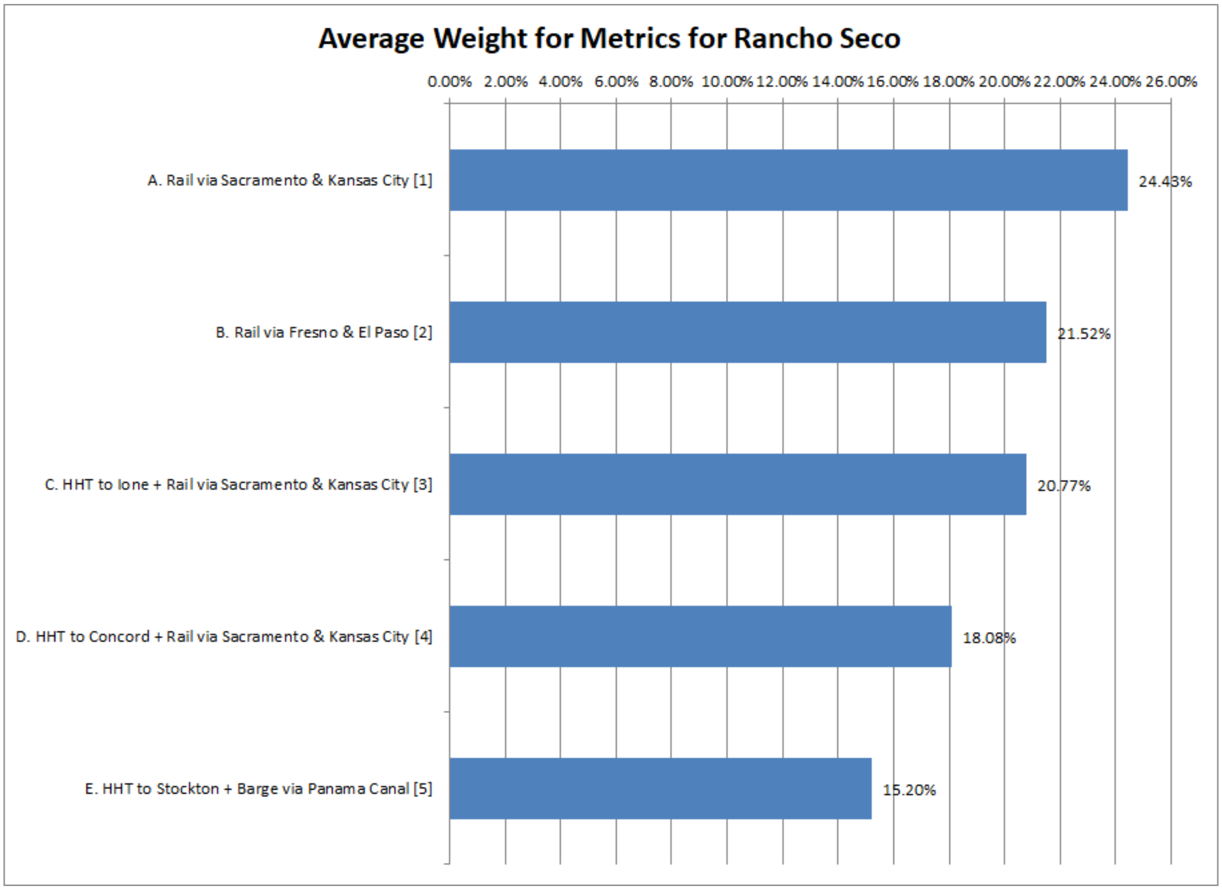


Figure 5-5 shows the impact each tangible metric had on the overall scoring of each route. There is no single dominant metric identified in this figure. However, this figure does show the two most favored routes (direct rail from the site) received significantly greater contributions from the following tangible metrics: labor and permitting costs, transport to rail Class I costs, public acceptability of routes, ease of permit procurement, cumulative worker exposure, risks associated with number of lifting activities, and security vulnerability of route. Whereas the barge route received significant contributions from the following tangible metrics: cumulative population dose along route, number of tribal lands crossed, and number of fire stations & trained personnel nearby route. The HHT routes received significant contributions from the following tangible metrics: cumulative worker exposure and security vulnerability of route.

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 5-9**, the route order does not change regardless of which of the metrics are removed from the assessment. Similarly, the removal of only the public acceptability metric results in no change to the order of the routes. The removal of the public acceptability, security, and safety metrics also results in no change to the order of the routes. Additional analyses and sensitivity results were performed on these metrics to examine their impact on the rankings in **Section 5.5**.

Table 5-9 shows the sensitivity of the rankings to the alternative weighting schemes. To further examine the impact to the ranking/scores of the routes to changes in the weighting of the metrics, a sensitivity analysis was performed using the range of the metrics identified in **Table 5-3** (Step 8). **Table 5-10**, **Table 5-11**, **Table 5-12**, and **Table 5-13** present the results of the sensitivity of the route rankings to the minimization of the weighting of a metric, using the minimum metric weights from **Table 5-3**. For example, under the metric column labeled "Transit Duration per Conveyance and Consist" in **Table 5-12**, results are presented using a weight of 4.8% for the "Transit Duration per Conveyance and Consist" (instead of the 6.45% in **Table 5-3**) with the other metrics proportionally re-normalized. The results again indicate no change to the ranking of the routes. **Figure 5-6** summarizes the minimum, average, and maximum results presented in **Table 5-10**, **Table 5-11**, **Table 5-12**, and **Table 5-13** for the minimization of individual metrics. As can be seen from these results, the rail from RSNGS to GCUS via Sacramento & Kansas City route remains robustly ranked as the most favored route for the removal of the SNF from the RSNGS ISFSI (at this time)

Table 5-14, **Table 5-15**, **Table 5-16**, and **Table 5-17** present the results of the sensitivity of the route rankings to the maximization of the weighting of a metric, using the maximum metric weights from **Table 5-3**. For example, under the metric column labeled "Public Acceptability of Route" in **Table 5-15**, results are presented using a weight of 9.5% for the "Public Acceptability of Route" (instead of the 6.63%), with the other metrics proportionally re-normalized. The results indicate that there is no change in the ranking of the routes. **Figure 5-7** summarizes the minimum, average, and maximum results presented in **Table 5-14, Table 5-15**, **Table 5-16**, and **Table 5-17** for the maximization of individual metrics. As can be seen from these results, the order of the routes remains robustly the same for the removal of the SNF and GTCC LLW from the RSNGS 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 all but one individual who switched the 2nd and 3rd ranked routes, the ranked order of the routes remains the same, with direct shipment from the RSNGS ISFSI as the favored routes for the removal of the SNF and GTCC LLW from the RSNGS ISFSI.

As a result of the MUA and its sensitivity analyses, the prioritized list of routes from the RSNGS ISFSI is found in **Table 5-8**.

Table 5-8: Prioritized List of Routes from RSNGS ISFSI

Rank	Prioritized Route
1	A. Rail via Sacramento & Kansas City
2	B. Rail via Fresno & El Paso
3	C. HHT to Ione + Rail via Sacramento & Kansas City
4	D. HHT to Concord + Rail via Sacramento & Kansas City
5	E. HHT to Stockton + Barge via Panama Canal

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

Table 5-9: 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
A. Rail via Sacramento & Kansas City	1	24.32%	1	24.43%	1	24.43%	1	24.08%	1	24.16%	1	23.55%
B. Rail via Fresno & El Paso	2	21.82%	2	21.52%	2	21.52%	2	21.67%	2	21.51%	2	21.67%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.57%	3	20.77%	3	20.77%	3	20.55%	3	20.64%	3	20.31%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.28%	4	18.08%	4	18.08%	4	19.03%	4	18.29%	4	19.53%
E. HHT to Stockton + Barge via Panama Canal	5	15.00%	5	15.20%	5	15.20%	5	14.67%	5	15.39%	5	14.94%

Table 5-10: Weighting of Routes at Minimum Metric Value (Part 1 of 4)

Metric Minimized:	On-Site Rental Equipment Costs		Labor and Permitting Costs		Transport to Rail Class I Costs		Cost of Rail Transport		Number of Water Areas Nearby Route	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail via Sacramento & Kansas City	1	24.52%	1	24.39%	1	24.39%	1	24.50%	1	24.48%
B. Rail via Fresno & El Paso	2	21.55%	2	21.45%	2	21.46%	2	21.59%	2	21.41%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.78%	3	20.79%	3	20.77%	3	20.78%	3	20.77%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.04%	4	18.09%	4	18.07%	4	18.05%	4	18.05%
E. HHT to Stockton + Barge via Panama Canal	5	15.11%	5	15.28%	5	15.30%	5	15.09%	5	15.28%

Table 5-11: Weighting of Routes at Minimum Metric Value (Part 2 of 4)

Metric Minimized:	Number of Non-Easily-Mobilizable Populations		Number of Tribal Lands Crossed		Public Acceptability of Route		Ease of Permit Procurement		Cumulative Worker Exposure	
Route	Rank	Result	Rank	Result	Rank	Rank	Result	Rank	Result	Rank
A. Rail via Sacramento & Kansas City	1	24.44%	1	24.53%	1	24.33%	1	24.39%	1	24.44%
B. Rail via Fresno & El Paso	2	21.72%	2	21.92%	2	21.52%	2	21.45%	2	21.47%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.71%	3	20.73%	3	20.72%	3	20.79%	3	20.75%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.07%	4	17.95%	4	18.16%	4	18.09%	4	18.04%
E. HHT to Stockton + Barge via Panama Canal	5	15.05%	5	14.86%	5	15.27%	5	15.29%	5	15.31%

Table 5-12: Weighting of Routes at Minimum Metric Value (Part 3 of 4)

Metric Minimized:	Cumulative Population Dose along Route		Risks Associated with Number of Lifting Activities		Average Accident Frequency on Route		Number of Fire Stations & Trained Personnel Nearby Route		Transit Duration per Conveyance and Consist	
Route	Rank	Result	Rank	Result	Rank	Rank	Result	Rank	Result	Rank
A. Rail via Sacramento & Kansas City	1	24.49%	1	24.34%	1	24.44%	1	24.57%	1	24.38%
B. Rail via Fresno & El Paso	2	21.68%	2	21.38%	2	21.46%	2	21.62%	2	21.42%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.76%	3	20.83%	3	20.74%	3	20.85%	3	20.69%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.10%	4	18.09%	4	18.23%	4	17.95%	4	18.10%
E. HHT to Stockton + Barge via Panama Canal	5	14.97%	5	15.36%	5	15.13%	5	15.01%	5	15.40%

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

Metric Minimized:	Security Vulnerability of Route	
Route	Rank	Result
A. Rail via Sacramento & Kansas City	1	24.39%
B. Rail via Fresno & El Paso	2	21.59%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.71%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.11%
E. HHT to Stockton + Barge via Panama Canal	5	15.21%

Table 5-14: Weighting of Routes at Maximized Metric Value (Part 1 of 4)

Metric Minimized:	On-Site Rental Equipment Costs		Labor and Permitting Costs		Transport to Rail Class I Costs		Cost of Rail Transport		Number of Water Areas Nearby Route	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail via Sacramento & Kansas City	1	24.36%	1	24.51%	1	24.49%	1	24.39%	1	24.38%
B. Rail via Fresno & El Paso	2	21.50%	2	21.64%	2	21.61%	2	21.48%	2	21.65%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.75%	3	20.73%	3	20.76%	3	20.76%	3	20.76%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.11%	4	18.05%	4	18.08%	4	18.09%	4	18.10%
E. HHT to Stockton + Barge via Panama Canal	5	15.28%	5	15.07%	5	15.07%	5	15.28%	5	15.11%

Table 5-15: Weighting of Routes at Maximized Metric Value (Part 2 of 4)

Metric Minimized:	Number of Non-Easily-Mobilizable Populations		Number of Tribal Lands Crossed		Public Acceptability of Route		Ease of Permit Procurement		Cumulative Worker Exposure	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail via Sacramento & Kansas City	1	24.42%	1	24.39%	1	24.54%	1	24.47%	1	24.43%
B. Rail via Fresno & El Paso	2	21.18%	2	21.34%	2	21.53%	2	21.58%	2	21.61%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.86%	3	20.78%	3	20.81%	3	20.75%	3	20.79%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.08%	4	18.13%	4	17.99%	4	18.07%	4	18.14%
E. HHT to Stockton + Barge via Panama Canal	5	15.46%	5	15.36%	5	15.13%	5	15.14%	5	15.03%

Table 5-16: Weighting of Routes at Maximized Metric Value (Part 3 of 4)

Metric Minimized:	Cumulative Population Dose along Route		Risks Associated with Number of Lifting Activities		Average Accident Frequency on Route		Number of Fire Stations & Trained Personnel Nearby Route		Transit Duration per Conveyance and Consist	
Route	Rank	Result	Rank	Result	Rank	Result	Rank	Result	Rank	Result
A. Rail via Sacramento & Kansas City	1	24.36%	1	24.53%	1	24.42%	1	24.22%	1	24.50%
B. Rail via Fresno & El Paso	2	21.32%	2	21.69%	2	21.62%	2	21.37%	2	21.65%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.77%	3	20.70%	3	20.80%	3	20.63%	3	20.85%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.05%	4	18.06%	4	17.85%	4	18.27%	4	18.05%
E. HHT to Stockton + Barge via Panama Canal	5	15.51%	5	15.02%	5	15.31%	5	15.50%	5	14.96%

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

Metric Minimized:	Security Vulnerability of Route	
Route	Rank	Result
A. Rail via Sacramento & Kansas City	1	24.49%
B. Rail via Fresno & El Paso	2	21.44%
C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.83%
D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.04%
E. HHT to Stockton + Barge via Panama Canal	5	15.20%

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

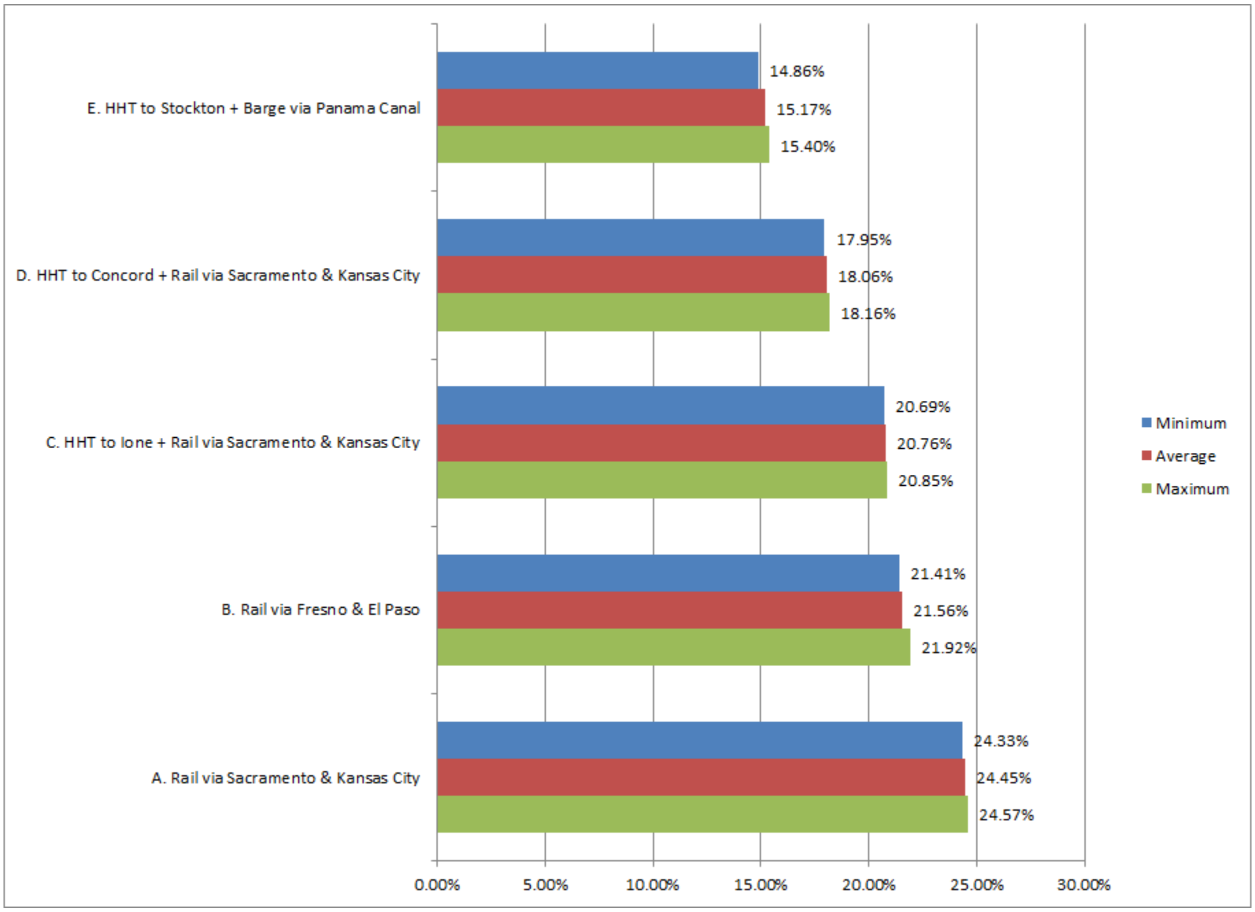
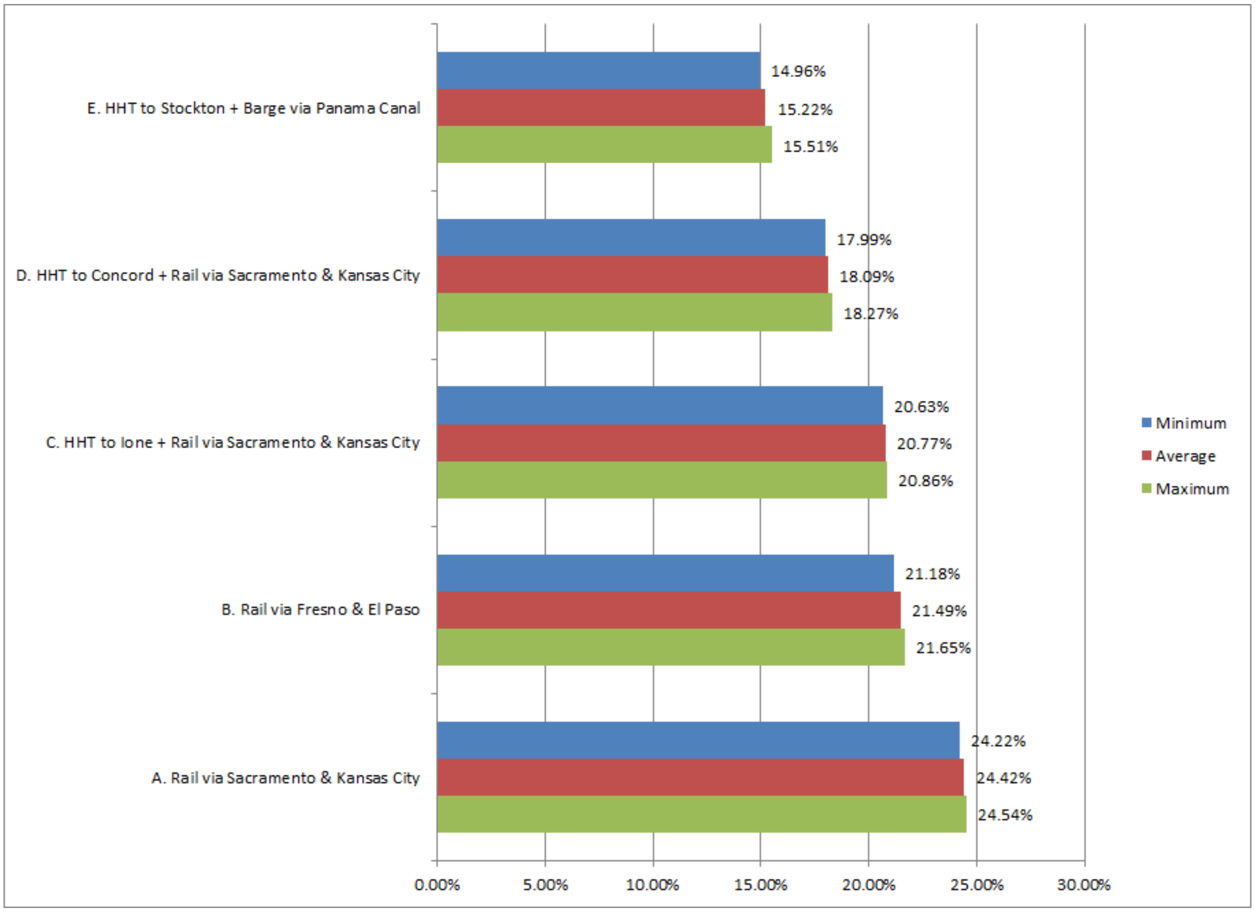


Figure 5-7: Minimum, Average, and Maximum Results from Sensitivity Analysis for Maximization of Each Metric



5.5. Additional Sensitivity Analyses

Additional sensitivity analyses have been performed to examine in more detail the impact of the results of some of the sensitivity analyses performed in **Table 5-8**. The purpose of the MUA is to use objective input, backed by numerical data generated from START[1] and evidence from other sources of information (e.g., pictures), to provide a quantitative ranking of the favorability of route scenarios. Sometimes, however, the subjective opinions of team members can span a larger range than may be necessary to distinguish between routes and may over emphasize the difference between routes. For example, as noted in **Section 5.3.3.11** 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 5-8**, was examined. Since these five metrics were ranked, by average, as the top five metrics from the pairwise comparison by individual team members, the suppression of the span of the pairwise comparison could impact the route rankings.

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

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Cumulative Population Dose along Route (α population density)	A. Rail via Sacramento & Kansas City			X					B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso					X			C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso					X			E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal

In **Figure 5-8**, assessments originally identified as "Strongly Favorable" or "More Favorable" were suppressed to "Mildly Favorable" and those originally identified as "Mildly Favorable" were moved to "Neither Favorable (neutral)" to examine the impact of suppressing the span of the pairwise comparison by route for metrics whose parameters are regulated to acceptable levels.

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

Table 5-18 compares the results from the original assessment and the modified results using the suppressed span. These results show little overall change in the results, with the exception that the results become more compressed (span from most favored to least favored is reduced). Hence the rail routes from the RSNGS site remain the highest ranked routes, which is consistent with the results identified by the other sensitivity analyses included in this report.

Figure 5-9: Ranking Results from Pairwise Comparison of Routes from the RSNGS Site with Spans of Safety and Security Metrics Suppressed

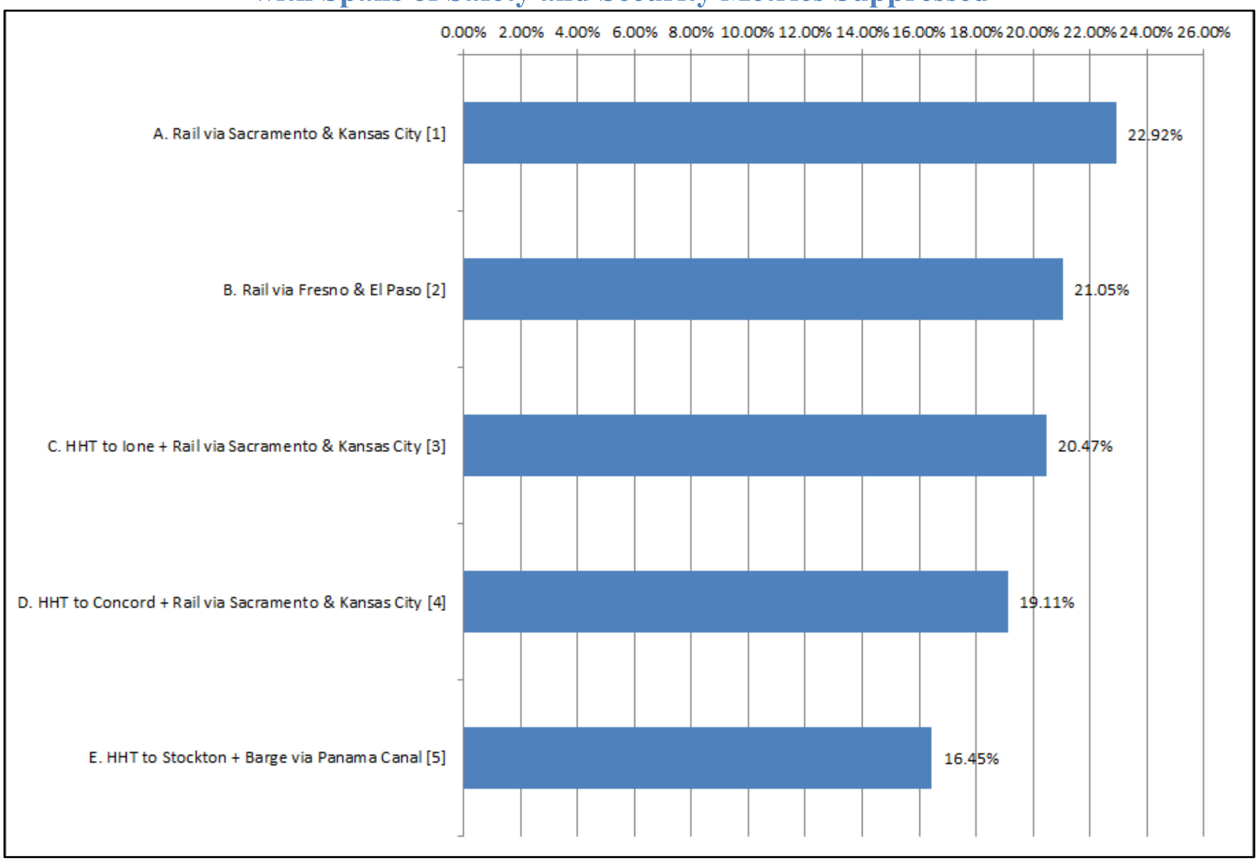


Figure 5-10: Impact of Each Tangible Metric on Each Route's Scoring for the Suppression of Span for Safety and Security Metrics

Table 5-18: Comparison of Original MUA Results to the Suppressed Span MUA Results

Suppression Results			Original Results	
Rank	**Avg**	**Results**	**Rank**	**Avg**
1	22.92%	A. Rail via Sacramento & Kansas City	1	24.49%
2	21.05%	B. Rail via Fresno & El Paso	2	21.44%
3	20.47%	C. HHT to Ione + Rail via Sacramento & Kansas City	3	20.83%
4	19.11%	D. HHT to Concord + Rail via Sacramento & Kansas City	4	18.04%
5	16.45%	E. HHT to Stockton + Barge via Panama Canal	5	15.20%

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 5-11** and **Table 5-19** for the removal of the safety metrics show the rankings remain intact, though the separation of the route from the others is greater than for other analyses. Results shown in **Figure 5-12** and **Table 5-20** for the removal of the security metric also shows no change from the original rankings. Results shown in **Figure 5-13** and **Table 5-21** for the removal of the public acceptability metric also shows no change from the original rankings. The final sensitivity analysis performed involved removing both the public acceptability and security metrics at the same time. **Figure 5-14** and **Table 5-22** show the results of this assessment with again no change to the ranking of the routes relative to the original ranking.

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

Figure 5-11: Impact of Removing the Safety Metrics

Table 5-19: Results from the Deletion of the Safety Metrics

Rank	Norm Points	Results
1	24.41%	A. Rail via Sacramento & Kansas City
2	21.25%	B. Rail via Fresno & El Paso
3	20.90%	C. HHT to Ione + Rail via Sacramento & Kansas City
4	18.73%	D. HHT to Concord + Rail via Sacramento & Kansas City
5	14.71%	E. HHT to Stockton + Barge via Panama Canal

Figure 5-12: Impact of Removing the Security Metric

Table 5-20: Results from the Deletion of the Security Metric

Rank	Norm Points	Results
1	24.22%	A. Rail via Sacramento & Kansas City
2	21.83%	B. Rail via Fresno & El Paso
3	20.52%	C. HHT to Ione + Rail via Sacramento & Kansas City
4	18.21%	D. HHT to Concord + Rail via Sacramento & Kansas City
5	15.22%	E. HHT to Stockton + Barge via Panama Canal

Figure 5-13: Impact of Removing the Public Acceptability Metric

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

Rank	Norm Points	Results
1	24.16%	A. Rail via Sacramento & Kansas City
2	21.51%	B. Rail via Fresno & El Paso
3	20.64%	C. HHT to Ione + Rail via Sacramento & Kansas City
4	18.29%	D. HHT to Concord + Rail via Sacramento & Kansas City
5	15.39%	E. HHT to Stockton + Barge via Panama Canal

Figure 5-14: Impact of Removing the Public Acceptability and Security Metrics

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

Rank	Norm Points	Results
1	23.90%	A. Rail via Sacramento & Kansas City
2	21.84%	B. Rail via Fresno & El Paso
3	20.36%	C. HHT to Ione + Rail via Sacramento & Kansas City
4	18.46%	D. HHT to Concord + Rail via Sacramento & Kansas City
5	15.43%	E. HHT to Stockton + Barge via Panama Canal

6.0 CONCEPT OF OPERATIONS FOR RECOMMENDED APPROACH

6.1. Considerations regarding the transportation package selection

The current transport package of reference for RSNGS is the MP187 transportation cask. The body of the MP187 package unit and its associated equipment is currently owned by SMUD and was used during pool offload operations as a transfer cask. Use of the MP187 for transportation will require significant licensing work and the construction of impact limiters. In addition, the canisters currently licensed in the MP187 are only in use at two storage sites. For the sake of this analysis, another cask should be considered especially considering the benefits of having an optimized fleet of packages or avoiding multiplying the different reconciliation and licensing efforts. In an effort to make the fleet of TN transportation casks more efficient, a high-level comparative analysis is done to justify the use of the MP197HB over the MP187 package as part of this report. As discussed in **Section 2.3**, the TN-Eagle cask may be yet an even better transport cask for use at RSNGS, although it is currently not licensed by the NRC so it should be evaluated in the future.

The main benefits of using a fleet of MP197HB casks instead of a fleet of MP187casks are:

- The same architecture for the operations (horizontal loading/unloading) can be used with very similar types of operations. The operational procedures are likely to be similar or at least very close to the procedure developed for the other sites. Also, the training and qualification of package operators would be simplified with one type of cask over two.
- No need to build a fleet of MP187 casks that could be used solely for two of the nuclear reactor fuels in dry storage in the U.S. This is an optimization regarding the capital money necessary to build this fleet of cask, the time to develop and build the fleet and the generation of contaminated material considering the entire fleet life cycle.
- A better capacity to mobilize a larger fleet of casks that will reduce the overall duration of the campaign. The access to a large fleet of casks similar to what can be considered for other sites using the MP197HB (see de-inventory reports for Kewaunee Power Station or Crystal River 3 for instance), allows RSNGS to have access to the most efficient and recent fleet without need for additional equipment, provided the timeframes for the different de-inventory operations do not overlap.
- No additional licensing effort to be made on the MP187 Part 71 certificate. Also, it can be reasonably expected at this stage that a reconciliation of the Part 71 certificate for the transport system to be used, with the actual as-built and loaded canisters will be necessary. Doing this reconciliation for the MP187 or for the MP197HB should be considered a similar type of effort.

The main disadvantages of using a fleet of MP197HBs over a fleet of MP187s are:

- The Part 71 licensing effort may be significant to include the RSNGS canisters to the MP197HB certificate of compliance. This effort may require a change of assumptions taken in the SAR regarding the different safety evaluations to account for these canisters.
- In addition, some design engineering work for the development of additional hardware may be required in order to make the RSNGS canisters to fit with the MP197HB cavity. The dimensions of the RSNGS canisters and the presence of a key on the canisters make the interface with the MP197HB different from what is the current SAR. Additional items such

as spacers or a sleeve could be necessary and would have to be described in the MP197HB SAR and built and tested before use.

This evaluation is not intended to be a commitment, but a proposed independent high level analysis of the long term needs to ensure the success of the de-inventory of RSNGS as a part of a larger de-inventory program based on lessons learned from other de-inventory reports and the current knowledge of the site and of the regulations as of 2022. Final decision on the path forward would require further analysis and concurrence from the licensee, the transport system designer, cask owner and the receiver of the canisters in addition with the review from NRC whenever it would be required. The MP197HB transportation cask is considered for the rest of the report.

6.2. Overview of Operations and Assumptions for TN Americas MP197HB System

The operations associated with the de-inventory of RSNGS fuel stored in NUHOMS systems at RSNGS would consist of lease or purchase of transportation casks, onsite transport equipment, auxiliary equipment and ancillary systems including mobile crane(s) and lifting equipment, development/confirmation of training program materials, training of operating personnel and supervisors, preparation and approval of site operating procedures, facility operational readiness review, dry run operations, de-inventory activities, transportation operations, and demobilization of equipment from the site. Due to the complexity of these operations, the sequence of activities is divided into five groups:

1) Mobilization operations: procurement/lease and delivery of required equipment to the site
2) Operational readiness: operating procedure preparation and approval, training program development, operator training, equipment checkouts, dry run(s), and operational readiness review(s)
3) ISFSI Site operations: performance of canister transfer operations from the NUHOMS HSM to the MP197HB transport casks respectively, for off-site transports
4) Rail transport operations
5) Demobilization of equipment and personnel from the RSNGS site

Based on the number of canisters to be loaded and shipped from the RSNGS ISFSI (i.e., 21 canisters with SNF and one GTCC waste canister), it is recommended to load and ship five transport casks for each off-site transport campaign by rail transport with a total of ten transport cask systems each committed to the de-inventory shipping campaign. Shipment of the empty casks from GCUS will be transported on a "dedicated train."

The following assumptions were used in planning this NUHOMS 24P canister transfer, loading, and off-site shipment campaign:

- The MP187 cask system will not be used for fuel transport from the RSNGS
- Ten MP197HB casks including impact limiters, cask cavity spacers, and intermodal transport cradle with integral tie-downs and personnel barrier.
- Two transfer trailers with transfer skids will be used for transfer operations at the RSNGS site.
- Impact limiters will be removed and installed onto the cask while the cask is positioned on the rail cars.

- 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.
  - Cask annual containment boundary leakage test.
- Canister and contents have been evaluated and are compliant with the cask SAR.
- Fuel/canister is assumed transportable for these activities (e.g., 10 CFR Part 71 dose and thermal limits are met).
- Revision to the RSNG FSAR allowing the loading and transport using the MP197HB System.
- All areas used for transfer operations, including the ISFSI, haul path, and transloading site, will be encompassed inside of the boundary and be covered by the safety basis associated with the relevant 10 CFR Part 50 or 10 CFR Part 72 license.
- The cask intermodal skid used to transport the cask on railcars will be attached and secured to the railcars in accordance with the AAR Open Top Loading Rules (OTLR).[33] Specifically, all restraint values meet the requirements of 7.5G x 2G x 2G[34], the requirement from the DOT and what is required for load securement in the transportation cask SAR.

6.2.1. Pre-Mobilization/Mobilization

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

Table 6-1 Activities to Prepare and Remove SNF and GTCC Waste from RSNGS ISFSI Using MP197HB System

Task		Task Activity Description
Programmatic Activities to Prepare for Transport Operations from the RSNGS 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 packaging including impact limiters, personnel barriers, intermodal transport cradles, if required; procurement of AAR Standard S-2043 railcars; and procurement of off-site transportation services including rail and HHT as applicable.

Task		Task Activity Description
3	Acquire/Lease Required Auxiliary Equipment Prime Mover, onsite Transfer Trailer, and Remaining Required Auxiliary Equipment	Equipment will need to be leased and shipped to site for setup and checkout prior to start of the training program and performance of the dry run(s). In addition, there is limited staffing at the RSNGS ISFSI site, so outside contractor crews will need to be assembled, trained, and evaluated to perform all transfer operations.
4	Prepare Transfer Area and Equipment in accordance with the Requirements of the NUHOMS CoC Technical Specifications (TS)	The transfer area will be adjacent to the ISFSI but some inferstructure modifications may be need to trasfer the cask to the loading area.Transfer will occur at the door of each HSM with a transfer trailer loaded with a MP197HB aligned to make the transfer and transport the transfer trailier to the rail car.
5	Conduct Preliminary Logistics Analysis and Planning	Determine fleet size, transport requirements, and modes of transport.
6	Coordinate with Stakeholders	Coordinates with carriers and makes notifications to federal, state, and applicable tribal nations.
7	Develop Campaign Plans/Procedures (e.g., prepare, review, and approve all required site operating procedures for the DSC unloading from the HSMs and transfer/loading into the 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 DSC unloading operations can be prepared from procedures initially prepared during the original loading campaign. Similar procedures will be required for the auxiliary equipment including transfer operations. New site procedures will be required for the handling of the transport casks, transfer operations, transfer trailer operations, proper tie-down and securing of the cask's 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 RSNGS Independent Safety Review.

Task		Task Activity Description
Operational Activities to Prepare, Accept, and Transport from RSNGS		
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 RSNGS's Systemic Approach to Training Programs. Training would require classroom, on-the-job training (OJT) (operating required equipment), and formal Training Program Evaluation (TPE) effectiveness. All de-inventory project personnel would require training commensurate with their responsibilities and work scope on the project.
9	Load for Off-Site (ISFSI) Transport	Unload storage systems and transfer DSCs to transport casks, install loaded casks onto intermodal transport cradles, installing impact limiters and personnel barrier.
10	Accept for Off-Site (ISFSI) Transport	Accept loaded casks onto railcars for off-site ISFSI transportation and shipment to the designated destination.

6.2.2. Operational Readiness

Prior to the performance of an Operational Readiness Review and Assessment, the assembled de-inventory project team would be required to be trained and competence confirmed in all required planned site operations and contingencies. All equipment would have been delivered, assembled, and proper operation verified. Required procedures and project instructions would have been approved and issued. When all preliminary activities have been completed, the Operational Readiness Review and Assessment would be performed. This is a process used to verify facility, equipment, processes, procedures, and other critical activities have been planned and can be executed safely. It also ensures that the project team and procedures 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 RSNGS ISFSI. The following subsection will discuss the operational readiness required to ensure operations at RSNGS are ready to commence and can be performed in a safe and regulatory compliant manner.

A review of the NUHOMS FSAR and transportation cask's SARs and the applicable CoCs would need to be performed. This would verify that the contents of the NUHOMS DSCs met the required content conditions and quantities listed in the storage CoC and Approved Contents, and the transportation cask CoC. The contents (form and quantity) of the NUHOMS DSCs 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 a commercial shipper of SNF, NRC would be involved in the initial routing approval, and those approved routes would be in place and valid for 5 and 7 years as indicated and described above.[10] Once route approval is granted, advanced notification would be provided prior to each shipment, since the campaign is longer in duration than one train movement.

As required by the 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 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 – RSNGS Site Safety and Security Training
- Module 2 – NUHOMS HSM, and MP197HB Systems Overview
- Module 3 – On-site ISFSI transport (Transfer trailer) Operations including Prime Mover
- Module 4 – Canister Unloading Operations from NUHOMS HSM
- Module 5 – MP197HB Transport Cask Handling and Loading Operations
- Module 6 – MP197HB Transport Cask Intermodal Transport Cradle Tie-Down and Transloading Operations
- Module 7 – Preparation of MP197HB Transport Cask for Transport
- Module 8 – Rail Shipment Preparation, Equipment Inspections, and Documentation Preparation
- Module 9 – MP197HB Transport Cask Containment O-Ring Helium Leakage Testing
- Module 10 – Use of Measuring and Test Equipment (M&TE)
- Module 11 – Radiological Concerns and As Low As Reasonably Achievable (ALARA) Planning
- Module 12 – Regulatory Requirements
- Module 13 – Supervisor Training

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

- Module 14 – Contingency RSNGS Procedures
- On the Job Training:
  - OJT-1 – Perform Pre-Use Inspections MP197HB casks, Lift Yoke, Chain Hoist, and other support equipment
  - OJT-2 – Prepare an HSM for Canister Transfer
  - OJT-3 – Off-Load Empty MP197HB Transport Cask from Intermodal Transport Cradle
  - OJT-4 – Perform MP197HB Setup for Canister Transfer from HSM
  - OJT-5 – DSC Loading into MP197HB Transport Cask
  - OJT-6 – Movement of MP197HB transfer trailer to/from ISFSI/HSM
  - OJT-7 – MP197HB Transport Cask Lid Installation and Torquing, and Cavity Evacuation, Backfill, and Helium Leakage Testing
  - OJT-8 – Onsite and Off-site ISFSI Operations
  - OJT-9 – Onsite and Off-site ISFSI Intermodal Transport Cradle Handling Operations
- At the completion of the classroom training and OJT elements, operations supervisors would perform TPE for each applicable project personnel to confirm the adequate knowledge and effectiveness of the training prior to final training certification.
- Operational dry runs with a DSC mockup to perform the transport cask loading operation would be conducted at RSNGS for the MP197HB cask and support equipment. This would include preparation of the HSM for DSC transfer, transfer of the DSC into the MP197HB cask, testing, and transfer of the cask onto the transport skid.

Communication and interfacing with the applicable stakeholders would be needed to ensure readiness. This would include, but would not be limited to, RSNGS, DOE, State, and local authorities. In addition, the NRC onsite and Region IV 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 would be performed as specified in the 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 RSNGS 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 RSNGS, 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 RSNGS transportation cycle.
- All vehicles have required registrations (as applicable).
- All vehicles have current inspections.
- Radiological packaging meets all current requirements.
- Packages are correctly identified (i.e., all required markings and placards are displayed properly, and are available at the site prior to beginning the operation).
- Copies of inspections are provided for equipment to be used to handle and transport the transport casks.
- Copies of all procedures associated with the transportation of the transport casks are provided.
- 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 RSNGS 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, and DOE, as applicable, and copies are provided on a need to know basis.
- 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.

6.2.3. Site Operations

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

6.2.3.1. Receiving the Cask and Preparation for Canister Loading

An inspection of the empty cask system and intermodal skid will be performed to verify no damage has occurred to the cask and intermodal skid during transport to the RSNGS site. 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, operations will remove the personnel barrier and impact limiters from the cask. The bolts that secure the personnel barrier to the cask intermodal skid will be removed. The personnel barrier will be removed from the intermodal skid/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 of radioactive material contamination 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. Once this is completed the cask tiedowns to the intermodal skid will be removed. The onsite transfer trailer will be positioned at a location for loading the empty cask onto the transfer trailer. 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.

The crane will use a horizontal lift beam with 2 slings basketing the cask body to lift the cask. The crane will slowly lift the cask from the rail car 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 onto the onsite transfer trailer and into the skid positioning system. The horizontal lift beam and rigging will be disconnected from the cask.

Operations will remove 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.

Loading of the second transfer trailer will start and be completed concurrently while loading a DSC into the first cask.

6.2.3.2. 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.

Using the target aligning system on the cask, trailer, and 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 with the ram access opening of the cask and positioned 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 and DSC loading of the second cask would start.

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.

6.2.3.3. Cask Final Assembly and Preparation for Shipment

Once the cask leak test has been completed, the loaded transfer trailer will be moved to the onsite transloading site and leak testing on the second cask would start. Transfer of the cask from the transfer skid to the rail car and final assembly for shipment will be further discussed in the "On-Site Movement to the Transload Facility" in **Section 6.2.4.**

6.2.4. Transport Operations

Special Permit Requirements

The following permits for transporting the loaded transportation casks from the RSNGS ISFSI would have to be obtained by the shipper:

- A formal clearance submission is required and 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 RSNGS site to the Class I rail carrier, UP, which would clear the entire route from the plant to the GCUS.
- In some cases, it is acknowledged that clearance may be required for movement of the empty cask on the rail car being positioned for the initial loading at the various ISFSI sites. In the case of the MP197HB, no clearance is required as it is within acceptable dimensions for movement without a clearance.
- For the purposes of this report, it is assumed that DOE would be the shipper and that the shipments would be conducted by commercial carriers like comparable commercial shipments. Although typically not required for DOE shipments, for purposes of this report, it is assumed that DOE would file an application with the NRC for an approved rail route from RSNGS to the identified destination. DOE Order 460.2B[41] provides information on the management of DOE materials transportation and packaging.

Figure 6-1: MP197HB Assembly Verification Leak Test Flow Chart

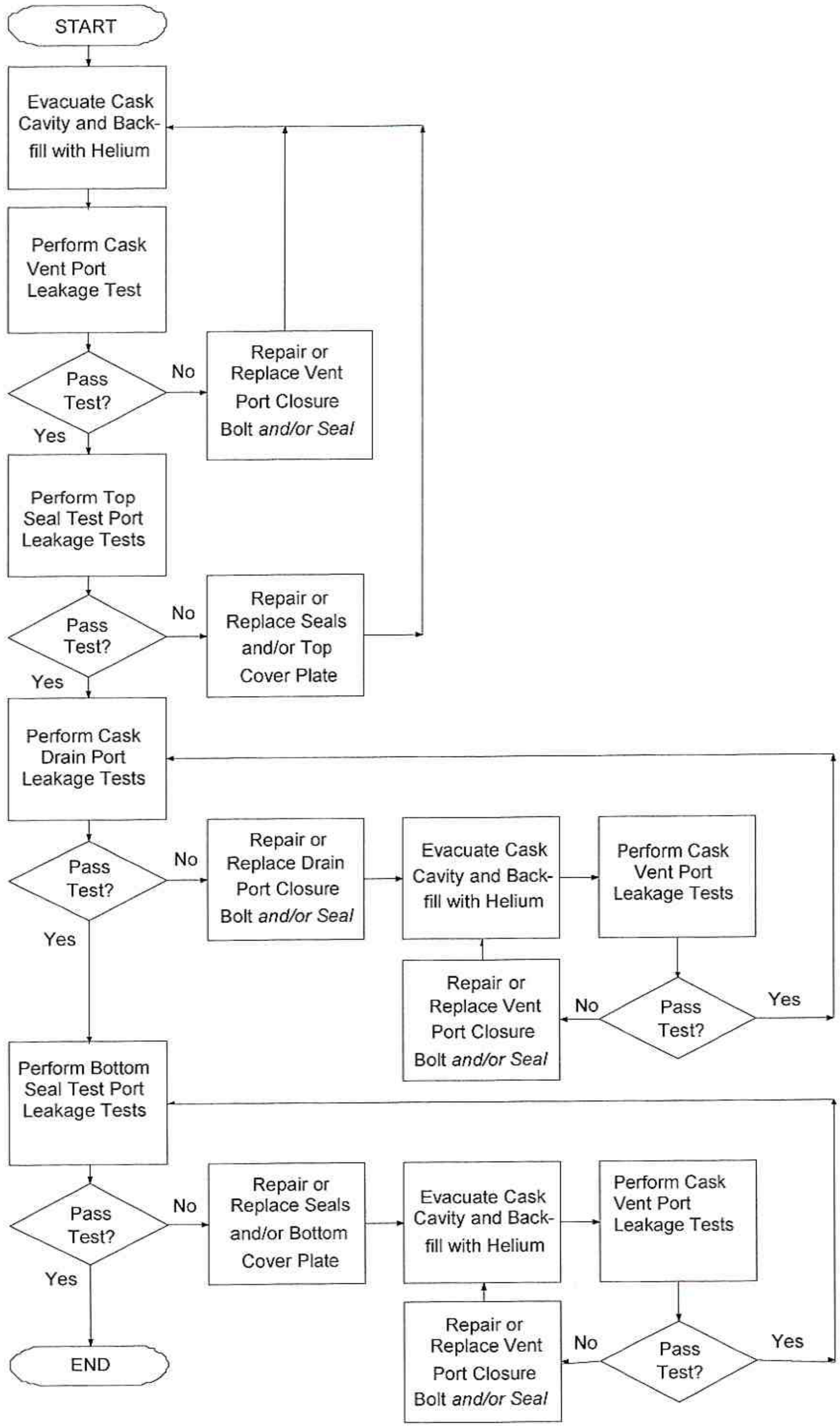


Table 6-2: Maintenance Program Schedule

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 Regulatory Performance leakage rate test of cask lid and lid port coverplate containment O-rings	Annually during use
Pre-shipment Operational/Assembly Verification leakage rate test of cask lid and lid port coverplate containment O-rings	Prior to each loaded transport
Maintenance (Regulatory Performance) 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 Limiter Shell Leak Test	Once every five years

Each Class I rail carrier has a formal procedure for clearance submissions, and all are electronically filed. Some require a fee to accompany clearance submissions and some do not. At this time, UP does require a fee to be paid electronically at the time the clearance submission is filed. 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 OTLR delineates what must be submitted for acceptance at interchange between carriers.

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

Furthermore, it is recommended that more than 6 months be 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) shipments. After the railroad clearance is completed and approved, the cleared route will be submitted to the NRC for approval. Once the railroad cleared route is approved by NRC, it would be valid and effective for 7 years for rail routes. The NRC would approve routes for a period of 5 years for combination routes (truck-to-rail siding, transloading, and rail to final destination). The minimum amount of time to submit cleared routes to the NRC for approval is 90 days; however, it would prefer 6 months.

Once the rail route is cleared by all involved railroads, the clearance is valid for 6 months for railroad purposes and should the campaign take longer than 6 months, the clearance must be resubmitted. However, with the initial submission an estimated shipment date is included and if the clearance expires before the shipment date and no dimensions have been changed, the clearance can be updated. 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 request.

This discussion purposely does not include the railroad requirements of 49 CFR 172.820. The carrier responsibilities dictated herein are independent of the shipper responsibly to submit the dimensional loads for clearance acceptance. These requirements listed in 172.820 are the rail carrier responsibilities which are mandated to be conducted on an annual basis -independent of specific shipments (apply to all HAZMAT moved on the network). The results of these assessments will not be made public or shared with shippers. The cleared routes will be assessed by the railroad in accordance with the regulations.

Therefore, clearance submissions are the responsibility of the shipper, and 49 CFR 172.820 is the responsibility of the railroad carrier. The railroad assessment may affect the result of the approved clearance routes.

Road permits would be required for movement of the cranes and other equipment to RSNGS to be used for lifting or transloading the transportation casks onto the rail cars. The permits will also dictate the requirement for private escorts (not the security team) and State Police escorts for both the mobilization and demobilization efforts of the equipment to be used in the on-site operations. These escorts are separate than those required by the regulations for LLEA for safety and security purposes.

No road permits are required for this campaign for the cask shipments because there is no HHT or transfer trailer (TT) movement off-site on public roads or highways for the recommended loading location, which is on the RSNGS private track adjacent to the ISFSI. The only TT movement will be from the ISFSI approximately 435ft to the rail transload site located at Rancho Seco.

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 RSNGS are listed as tasks in **Table 6-3**. These identified actions assume that DOE, or another management and disposal organization would be responsible for shipping to and operating the consolidated interim storage facility or repository. Based on these tasks, the characteristics of the site's inventories of SNF, the onsite conditions, the near-site transportation infrastructure and experience, time sequences of activities, and time durations were developed to prepare for and remove the loaded transportation casks.

Table 6-3: Activities to Prepare and Remove SNF and GTCC LLW from RSNGS ISFSI

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

Task		Task Activity Description
7	Load for Transport from ISFSI to on-site Transload Track for Loading Rail Cars	Load and prepare casks and place on RSNGS Transfer Trailer for the on-site transportation to the on-site rail siding.
8	Accept for Onsite Transport	Accept loaded casks on Transfer Trailer for on-site transportation to rail siding.
9	Transport	Ship shutdown site casks.

Additional Coordination Efforts

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

Description of Activities Necessary to Coordinate with Transload Site:

The private rail siding at the recommended loading location is on-site, inside the Rancho Seco plant. It is served by Class I carrier, UP. This is not an operating plant and although the switch is still in place, there is currently no active or regular rail service today. Prior to shipment, meeting with the railroad will need to be conducted to determine which of the two local rail yards will serve the plant. Meeting with the railroad 6 months prior to beginning the loading operation would allow for coordinating and planning with the railroad to set expectations for service level requirements and crew staffing for the additional rail service required to meet the desired shipping schedule. 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 from this location and is willing to do so. Knowing how many trains will be handled and with what frequency will be important to the railroad for staffing and equipment purposes. Other items to discuss would be security requirements for the crew entering the site, describing the intended loading operations and loading site on the existing track to specify placement of the empty trains, inspection of the loaded train to ensure compliance with the approved clearance, and all other operations including establishing the mechanics for pulling the released train from the site and obtaining the transit schedule for delivery to the GCUS.

- Develop a Security Plan for the rail transload site, notify the serving rail carrier, UP, of the fact the plan is in place and provide a contact name and number for the transload site. Provide proper notification that the transload site will be designated as a "rail secure area", which is based on the HAZMAT category of the commodity being loaded. The railroad does not need to approve the plan, but it must be notified of its existence and identify the proper contact information for the transload site.
    - The recommended on-site loading location is a portion of the existing private rail track leading to the reactor building. The track is not currently being used. The plant likely has not been designated as a rail secure area with the railroad due to the fact that there are currently no rail shipments and there is no service to the plant.
    - 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 interchanges and any other stops along the route on the way to the destination. This includes the entire route. They can provide extra observation in rail yards to deter rail fans, which typically "chase" dimensional shipments along the rail route and other trespassers in the yards. The UP has an active railroad police force. Railroad management personnel and the Class I railroad police will be present during times when the dedicated train is idle and at the one manned interchange upon delivery at the GCUS.
- Hold initial meetings with the Class I carrier, UP, to explain the movement, provide estimated number of trains to ship, discuss the dedicated train requirement, safety & security requirements and begin rate negotiations for the trains.
- Mention current safety and security measures for the site to UP to ensure the railroad is aware of special considerations and operating procedures in case it has no familiarity with these requirements as it does not currently serve other HAZMAT customers in this geographical area where these procedures are in place:
    - Note and discuss safety and security features that will be added to the site: fence, lights, defined perimeter, etc.
    - Discuss requirements of crew entry into the site (Transportation Worker Identification Credential (TWIC) cards, training, etc.).
    - Discuss manned interchanges with the railroad and record keeping requirements.
    - Discuss normal times of operation for the established plant and any extensions in hours the plant has granted to the shipper for the transload campaign. Coordinating operations hours and access to the plant is important for planning release of the

loaded train and consideration of the current rail operations on the division and normal operating parameters at the plant.

- Open communication with all rail carriers in the route to ensure a smooth transition at any interchange point. In this case, only one Class I railroad is involved in the route to the GCUS.
- Hold initial meetings with the local trainmaster and safety manager to discuss intended operations and parameters for operations, even though the transload is taking place inside a private and secure site.
- Communicate that all requirements have been exceeded for the intended site and operations.

Transportation-related Operational Readiness Items

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

Transportation Personnel Readiness:

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

Transportation Readiness Notifications:

- Provide copies and ensure proper notifications have been made to the Tribes, NRC, State and local governments, DOT and DOE as applicable.
- 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.
- Provide notice to serving rail carrier that the site meets the requirements for Rail Security Sensitive Materials (RSSM), per regulation.

Transport Operations

On-Site Movement to the Transload Facility

Once the transportation cask is loaded onto the transfer trailer at the RSNGS ISFSI and the cask leak testing completed, it would be secured by the site operations personnel. No California State DOT inspection is required for on-site movements. No permits or State Police escorts are required for on-site movements remaining exclusively on the private plant property. The transfer trailer would proceed to move the transport trailer the 435ft from the ISFSI into position at the designated portion of the track for loading.

Normally, hours of operation for the transport would be in accordance with the issued truck permits, which dictate the number of casks that may travel in one day. Since no truck permits are required for this transport, for purposes of this report, the assumption is that two casks every two days will move from the ISFSI to the rail transload site. Plant security or the private security team would provide the physical protection of the load during the 435ft transport and rail loading as applicable. No private escorts are required by state DOT since the TT movement is solely on private property.

Prior to any transportation operation, from the ISFSI to the Transloading Site a pre-job briefing with the operations staff, would be provided. This briefing would be conducted to review procedures, discuss any safety/quality-related concerns and practices, and verify adequate resources are available to support the activity including verification that prerequisite conditions are met. Once the briefings have been completed, the transportation team would be assembled and staged as directed by the transportation supervisor.

The transfer trailer will exit the RSNGS ISFSI gates and proceed along the existing road toward the rail transload location, moving into place parallel to the crane which will already be in place next to the rail track. No stops are anticipated during the short 435ft transit.

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

Performing the On-Site Transload from Transfer Trailer to the Railcars

The loaded transfer trailer would meet the crane at the rail transloading track, where the train is already staged. The intermodal skids would already have been secured 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 conform with the approved clearance window for the rail shipment.

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

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 intermodal skid.

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

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 Transport Index. 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 railcar(s) 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.

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

Once the transportation cask is secured to the railcar and 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 were 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 UP.

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

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

Once the serving railroad, UP, 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 UP 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 UP train crew. The chocks would be removed, and the locomotive would attach to the loaded train and pull it from the facility once the Rail Transload Supervisor unlocks the gate to allow the train to exit the transload facility property with the Rail Transload Security Team (armed security escorts) in the escort car.

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

The UP train will leave the facility and proceed to the Class I rail line which is located at the point of switch just outside the plant where the train will begin its dedicated journey to the GCUS. The Class I carrier will provide advance notification to the GCUS location to coordinate the arrival and manned delivery to the GCUS. It would proceed to the GCUS with no other interchanges taking place until arrival. Any stops along the route for refueling and changing the crew would result in the train being stopped only at interim rail yards and it would be guarded by railroad police during the minimal stops. An estimated transit schedule would be provided to the shipper for the entire train movement. The ability to monitor and trace the train would be limited to need-to-know personnel.

Upon arrival at the GCUS, the UP train crew would document the manned interchange, deliver the loaded train to the designated track, and then disengage its locomotive.

6.2.5. Demobilization

Once the de-inventory project (campaign) operations have been completed, demobilization would commence. This is the process of removing all the equipment and materials used during the operation at the RSNGS 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 DSC exterior surfaces are potentially contaminated as discussed earlier, large components, such as the transfer trailer, lift yokes, chain hoists, etc. would be decontaminated as needed, approved for free release, and returned to the owner(s) for storage. Specialized equipment (e.g., the vacuum drying system (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 intermodal skids, lift yokes, and the like would be decontaminated, placed in an assembled condition, and returned to DOE for storage and maintenance.

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

The empty HSMs would remain onsite for disposition by RSNGS as potentially contaminated and activated materials. In addition, the ISFSI site, after all removal of all 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 truck to its storage facility. This process takes approximately one week to complete. The train would be returned intact to its storage location and would likely move in regular train service, which may take a few weeks depending on the distance and route dictated for the movement.

6.3. Resource Requirements / Staffing

At the RSNGS site:

- Operations Manager
- Cask Operations Shift Supervisor
- Training Specialist
- Procedure Writers
- RP Specialist– in charge of the radiation monitoring and surveys.
- Transport and Waste Management Coordinator (TC) - provides supervision of the waste management aspects of the program and of the transport. The TC is in charge of the preparation of the shipping papers, verification of the proper labeling and placarding of the transport and tracking and response coordination. Position may be seconded by a Transport Analyst.

- Crane Operators.
- Riggers
- Rail Transload Supervisor
- Rail Transload Security Team (as applicable)
- Cask Operations Technicians/Mechanics
- Tractor, Driver, and Equipment Operators
- QA/QC Specialist
- Security Personnel

6.4. List of Ancillary Equipment

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

Table 6-4: Additional Equipment for RSNGS Transfer

Additional Equipment for RSNGS Transfer	
Secondary Mobile Crane (150-ton)	Required for lifting ancillary items, such as , HSM door, transfer adapters, transport cask lids, transport impact limiters, and personnel barriers.
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.
2 Transfer Trailers	Used to load atnd transfer the cask from the ISFSI to the rail car loading area
2 Prime Movers	Used to move the trasfer trailers on site

Table 6-5: Equipment for the Transload Facility

Equipment for the On-site Rail Transload Area	
Crane: 375-ton mobile crane	Crane would be used to conduct lift operations removing the MP197HB cask package onto and off of 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 intermodal skid combination.
Specialty rigging – spreader bar or other rigging specific to the overpack or intermodal skid	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 6-6: 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, per clearances and to distribute weight of the loaded casks over bridges.
Load (cask) cars	Heavy duty flat cars used to transport the loaded casks.
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

Rail Equipment (per consist)	
	by regulation or the railroad but are an additional means of ensuring safety and security in the handling of the units during transportation.

6.5. Sequence of Operations / Schedule

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

For the onsite loading sequence, it is estimated that 2 8-hour days per loading will be required to move the NUHOMS transfer trailer, load the DSC/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 intermodal skid and release for transport. Therefore, for a 5-cask train, approximately 1 week (6 days) will be required.

The sequence of operation timeline, presented in **Figure 6-2**, outlines the operations associated with the facility at the RSNGS site, the loaded transfer trailer transportation from the ISFSI to the rail loading site and the on-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. The transit times listed in **Figure 6-2** are provisional and may change as route details and operations are better defined. The total evolution from the initial transfer of a canister from a HSM to a transport cask to the return of the empty casks to the RSNGS ISFSI takes approximately 31 days.

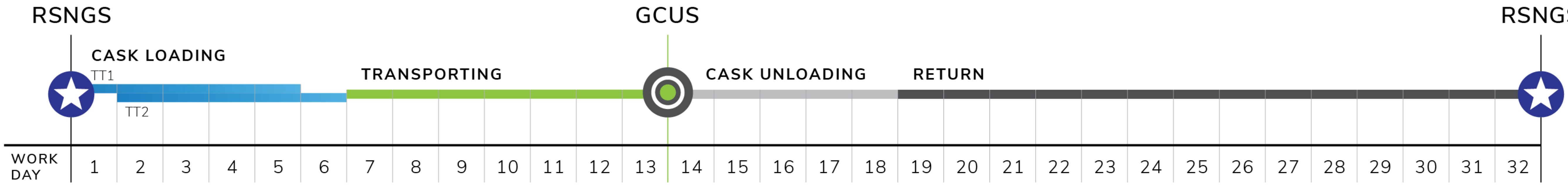
For the resources estimate, the timeline of the operations is taken to be comprised of 5 round trip shipments of 5 MP197HB packages per shipment over a period of 5 weeks for each shipment.

Table 6-7 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.

Figure 6-2: Sequence of Operations

RANCHO SECO DE-INVENTORY

SEQUENCE OF OPERATIONS FOR ONE BATCH OF CASKS



ASSUMPTIONS:

1. Will use 10 MP197HB transport casks: 5 casks per train
2. Will use 2 on-site transfer trailers
3. All transfer operations will be considered “on-site work”
4. Two crews will be used for on-site transfer operations: one at the ISFSI and one at the transloading site at RSNGS

COMPLETE SEQUENCE TIMELINE

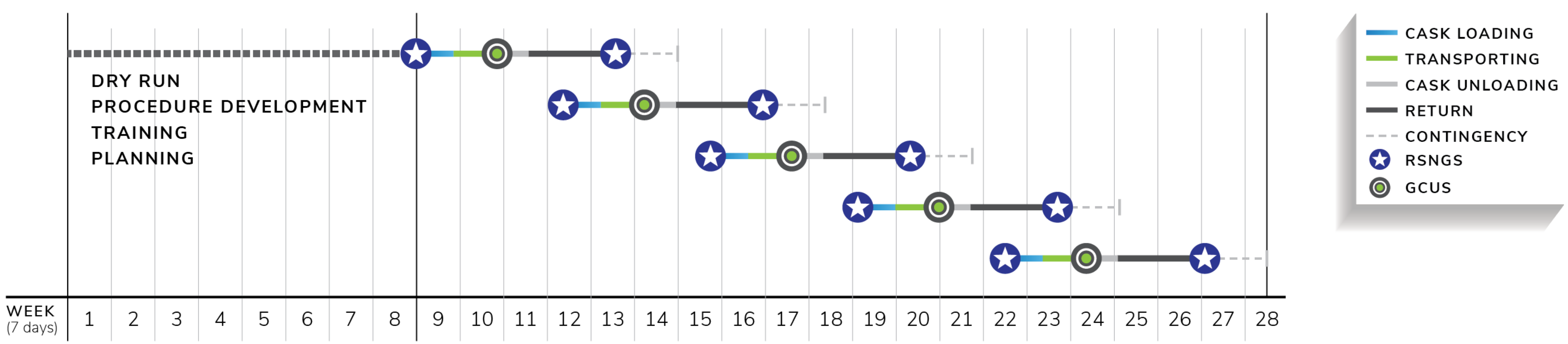


Table 6-7: Operations Timeline with Required Resources

	Major steps for a 38 DSC campaign	Resources required [in full-time equivalent]*											Estimated Duration (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	6 days per 5-cask campaign
3	Shipment to destination by rail	0.5			1		2						7 days per 5-cask campaign
4	Unloading	0.5	1		1	1	2						1 week per 5-cask campaign
5	Return transport of empty casks	0.5			1		2						14 days per 5-cask campaign

***Key:**

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

6.5 As Low As Reasonably Achievable (ALARA) Planning

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

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

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

- Approved radiological control procedures in place
- A sufficient number of trained and qualified RCTs are mobilized and ready to support operations at the pad (estimated at one supervisor and 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 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 Part 71, Subpart H (as related to transportation); 10 CFR Part 72, Subpart G (within the ISFSI site); and in consideration of 10 CFR Part 50, Appendix B (which normally would be applied within the owner-controlled area, but since the 10 CFR Part 50 license for this site has been terminated is no longer required), as applicable to the scope of work.

Fabrication of important safety components and support equipment for the 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[35] and NUREG/CR-6407[36] to establish a graded approach to QA. These QAPs are used to establish the quality category of components, subassemblies, and piece parts according to each item's relative importance to safety.

7.0 BUDGET AND SPENDING PLAN

The total estimated budget for the whole RSNGS campaign organized over 26 calendar weeks is $8.7M. This amount is based on the assumptions and estimates listed below. The estimates provided here are centerline estimates based on the current knowledge of the sites and of the operations needed. They are based on operations being performed at the time the data was gathered for this report (2022). This section provides a breakdown of the estimated campaign costs of deinventorying the RSNGS site, by activity, and to the extent cost information is currently available. This report does not specify the party or parties responsible for the costs estimated herein.

Assumptions:

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

1) A fleet of MP197HB is considered in the report as suggested in **Section 6.1**. The MP187 is not considered here.
2) Two sets consisting 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) The cask railcar, escort car, buffer cars, locomotives, etc. are provided by DOE. No estimate is provided here.
4) The site-specific physical road survey and the complete de-inventory study which includes communication with the site and official stakeholders are not included here.
5) It is assumed that no covered building would be used at the designed transload location. No cost for a new building construction is considered here.
6) No transport on a short line as the site is directly connected to a Class I railroad. Train delivery to the final destination and return shipment of the empties by train are not included. For scheduling purpose, the destination is considered to be GCUS. Only the cost of the loaded casks transports from the origin site to the Class I railroad is included.
7) Assumptions are made based on the current status of the origin site and current understanding of the operation. Some pieces of equipment are not designed yet, and no reasonable assumptions can be made at this point.
8) No additional onsite fencing and lighting is considered.
9) A total of 5 iterations of 6 working weeks each will be necessary to complete the de-inventory. 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 purpose. One week of contingency per iteration is included in the 6 weeks duration.
10) Pre-loading canisters inspection activities are not included in the cost estimates
11) Does not account for potential impact of additional specific local regulatory requirements, if applicable, and assumed labor performed by vendor-approved specialists.

7.1. Fees and Permits

No truck permit is expected to be necessary for these moves other than those that may be required for the mobilization of the transfer equipment (already included in the mobilization cost) for over-the-road movements into the plant. There are no permits needed for highway transport of the casks as the recommended transload site is located on site.

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

7.2. Campaign Operation Management

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

The estimated cost for the Management crew for the 26-week campaign is $0.9 million. In addition to the physical road survey, the management crew would also oversee the planning phase leading to a complete de-inventory study including communication with the site and official stakeholders. This is not included here.

7.3. Equipment for the Loading Operations

The estimated costs for the mobilization of the equipment on site, the lease of one 375-ton crane, a 150-tons crane and operators for 26 weeks at the shipper site one large forklift, two-man baskets, three welding machines, miscellaneous supplies, a telescopic handler, and the mobilization/demobilization of the equipment would be approximately $1.3 million for the duration of the RSNGS campaign.

Additional equipment is also necessary for the transfer of the TN NUHOMS system, including the NUHOMS HSM lid handling system, cask/HSM adapter, 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 $2.8M.

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**.

7.5. In-Transit Security

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

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

7.6. Cask Transportation Services at Transshipment Site

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

No transportation costs are included here as the site is directly connected to a Class I railroad.

The estimated costs for the cask transportation services are $1.0 million for the entire campaign.

7.7. Onsite Operations

The shipping site operations would be composed of the crew listed in **Section 6.3**. The estimate for the whole crew for the onsite operation is $2.4 million for the entire campaign.

7.8. Breakdown of the Costs by Activity

This section provides a breakdown of the estimated $8.7 million cost of de-inventorying the RSNGS site, by activity, and to the extent cost information is currently available.

- Equipment (e.g., transportation casks, railcars, cranes, movers, etc.): >$4.1 million (cost of casks and railcars is currently unknown)
- Transportation services and security: $1.3 million
- Management and labor: $3.3 million
- Infrastructure: $0

7.9. Additional Cost Estimates to Support De-Inventory Activities

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

- The shipment of the consist occurs in the current quarter of the calendar year (2nd quarter of 2022), as rates are temporal.
- The transportation casks meet the 10 CFR Part 71 regulatory limits (e.g., thermal, structural, and radiological) at the time of shipment.

- The maintenance and compliance activities assumed in the cost estimate for the transportation casks are representative of the yet to be built casks systems utilized in this report (i.e., the MP197HB) and are similar to one another.
- The maintenance activities projected for the railcars are representative of DOE's in-progress railcar design of the ATLAS cask car and will be built to ship the transportation casks identified in this report.
- The transportation cask systems and railcars are assumed to be leased to DOE and maintained at vendor operated facilities.
- The emergency response center is assumed to have been designed for the handling of multiple near-simultaneous rail shipments of SNF and estimated costs are for personal assigned full time to the monitoring of shipments only from the RSNGS ISFSI and the portion of the facility and communication equipment needed to support the shipments from the RSNGS ISFSI.

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

7.9.1. Estimate of Transportation Costs

For the Class I movement of a single rail consist from the RSNGS site to the GCUS site, which is a point-to-point distance of approximately 2,113 railroad miles, costs were developed to be comparable to current market rates for radioactive materials rail shipments and would include:

- Freight Costs per Consist
- Special Train Movement Costs: (empty casks return shipment done on merchandise train)
- Current Fuel Surcharge Costs: (this surcharge adjusts on a monthly basis)

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 the RSNGS site.
- The crew will be in charge of the coordination and necessary notifications. They will coordinate with the transport vendors (railroads, trucking companies, etc.), the DOE, and

the shipping and receiving sites. They will also act as the interface with the first responders and their contact information will be indicated on the shipping documentations.

- The entire crew will be trained to the DOT, NRC, DOE, and shipper's requirements. The crew will have the necessary DOE clearances, access to the safeguards information, and appropriate training. Additional emergency training such as Federal Emergency Management Agency (FEMA) training would also be useful.

7.9.3 Estimate of Railcar Maintenance Services Costs

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

- Routine railcar maintenance is assumed provided by the handling railroads and, depending on the costs, will be invoiced to the car owner (major and emergency maintenance) or covered by the shipping rate (minor/regular maintenance).
- Buffer car (4 axles) maintenance costs
- Cask car (12 axles) maintenance
- Escort car (4 axles) maintenance
- Costs associated with administering a fleet maintenance program.

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 RSNGS ISFSI, rather than the costs associated with establishing and maintaining a facility and fleet for the larger inventory of rail cars needed for a national campaign. A separate assessment would need to be performed to establish if it is more prudent to lease the needed support services from an existing qualified supplier rather than establishing a dedicated facility to service, maintain, and store this fleet of rail cars considering:

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

As noted above, routine maintenance activities for railcars are generally provided by the railroad and a portion is covered in freight rates.

7.9.4 Estimate of Transportation Cask Maintenance and Compliance Costs

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

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

  - Maintenance of the leak testing tools
  - Maintenance of cask leak testing equipment
  - Maintenance of lifting and support equipment (yokes, trunnions, skids, etc.)

- Leak testing will be performed according to American National Standards Institute (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/leak-test operator, and a part time ASNT level III procedure writer/reviewer.

8.0 SECURITY PLAN AND PROCEDURES

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

A Security Plan would encompass strategies and procedures in compliance with 49 CFR Part 172 and 10 CFR Part 73. It ensures the safety of the material, employees, and the public during loading, truck transportation from the ISFSI, transloading activities, and rail movement associated with the transportation of the SNF and GTCC LLW from the RSNGS site to the final destination and the security of this shipment.

The transportation activities covered by the plan would include the shipment, by HHT/transport trailer of the transportation casks from the RSNGS ISFSI site approximately 500ft to the designated rail transload site located on the RSNGS plant site where the train will be loaded and transported by rail to the hypothetical destination of the GCUS.

The basic statute regulating HAZMAT transportation in the U.S. is 49 U.S.Code 5101 et seq. 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 in 49 CFR Parts 171-180 and represents the DOT in international organizations. Another organization that would be involved in the transportation of overpacks from the RSNGS ISFSI site only in the event of a transload on a water served facility (port location like Stockton), would be the USCG. This is not the recommended route however, HAZMAT components have previously moved from the site via HHT to Stockton where the units were transloaded onto barge for water transport to Virginia. In the event of a water movement, the USCG would be involved. The relevant regulations addressing the security of SNF during transportation include: 49 CFR Parts 172-177; 10 CFR 73.21, 73.22, 73.37 and 73.72 (advanced notification); 49 CFR Part 172, Subpart I; and TSA 49 CFR 1580.107.

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

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

For the rail-served transload site located on RSNGS property, the railroad will be notified of the "rail secure area" establishment/status of the site, as required by regulation, TSA 49 CFR Part 1580.

While maintaining security protocols relevant to the control of sensitive information regarding the movement of the SNF and its associated procedures as specified in 10 CFR Part 73, 49 CFR Parts 172-177, and TSA 49 CFR 1580.107, all relevant parties to the transportation activity will receive a copy of the Security Plan, supplemented by training to its contents. All personnel will be required to return a signed copy of the Security Plan review signature sheet to the designated site administrator as part of documentation control.

8.1. Security Plan Requirements

Security plans for the transportation of hazardous materials in commerce are addressed in 49 CFR Part 172, Subpart I and in NRC regulations in 10 CFR Part 73, which mandate a Security Plan must be in writing and contain an assessment of security risks for transportation of hazardous materials identified in 49 CFR 172.800, which includes highway route controlled quantities of radioactive materials, and must address the identified risks including security while the material is en route. The Security Plan must also provide protection of the ISFSI facility and transload activities incidental to the transportation, including loading and unloading operations. This document assumes the provisions of the MTSA of 2002 are applicable to any water served or water adjacent facility, which does not include RSNGS. No formal determination has yet been made by the USCG or the NRC as to its applicability.

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

- Personnel security – measures to confirm information provided by job applicants hired for positions that involve access to, and handling of, the HAZMAT covered by the Security Plan.
- Unauthorized access – measures to address the assessed risk that unauthorized persons may gain access to the HAZMAT covered by the Security Plan or transport conveyances being prepared for transportation of the HAZMAT covered by the Security Plan.
- En-route security – measures to address the assessed security risks of shipments of HAZMAT covered by the Security Plan en route from origin to destination, including shipments stored incidental to movement.
- Security Plan Owner - identification, by job title, of the senior management official responsible for overall development and implementation of the Security Plan.
- Security duties - duties and responsibilities for each position or department tasked with implementing any portion of the plan and the process of notifying employees when specific elements of the Security Plan must be implemented.
- Training - description of the training required by HAZMAT employees in accordance with 49 CFR 172.704 (a)(4) and (a)(5).
- Risk Assessment with details addressing:

  - An assessment of transportation security risks for shipments of the specific HAZMAT listed in 49 CFR 172.800 (includes radioactive materials).
  - Site-specific or location-specific risks associated with facilities at which the HAZMAT is prepared for transportation, stored, or unloaded incidental to movement (e.g., rail transload facility).
  - Appropriate measures to address the assessed risks.
- The Security Plan, including the transportation security risk assessment, must be in writing and retained for as long as it remains in effect. It must be reviewed at 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.

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 (RSNGS) to the final destination. In addition, a physical route analysis will be conducted to determine any potential logistical issues that may exist or that could pose a risk to security during all phases of the operation. Security professionals involved will identify requirements for compliance as part of the action plan and define and establish procedures for the operation, including contingency plans.

8.3. Identifying and Selecting the Principal Parties (Administrative Team)

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

- The Security Contractor would chair the Administrative Team for the entire process or until an alternate is determined.
- Once the locations of each pick-up site are determined and the destination for the delivery of the SNF and GTCC LLW is determined, the contractor should then contact all the parties involved in the operation, including the rail and truck operators that will be involved with the transfer.
- Per 10 CFR 73.37 (b)(1)(viii), the initial contact with logistical partners should be made at a high level of the organizations in order to ensure the protection of Safeguards Information.

- Initial meetings should bring together the licensee, security, and risk assessment contractor or designee, high level logistical partners in truck, rail and other vendors (e.g., crane and rigging companies and monitoring partners), DHS, DOT, USCG, NRC, and other Federal and State officials, as needed.
- The meeting should address the concerns of each representative group, identify any groups that may not be present or need to be included, and come away with a framework for managing security for the project and how communications will be handled at all phases of the operation.
- The purpose of this meeting is to establish the Administrative Team as a partnership dedicated to working together to ensure the safety and security of the SNF and GTCC LLW in transportation and identify any areas of concern.

8.4. Select the Rail/Truck Transload Site to be Used

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

- If an existing site is identified, the preference is that it be a fully enclosed and secure commercial installation or lends itself to be secured; if it is established, these measures must be considered to enclose the site in an effort to create a secure perimeter around the loading location. This will include fencing and lighting the perimeter of the property, installing security cameras and modifying egress and ingress to secure gates with locks at both the rail and truck entrances.
- Establish direct contacts at the site(s) for logistics and security.
- Ensure that all persons on site with direct knowledge or access to the transfer location have background checks. Security clearances may also be considered, but are not required.
- MTSA is assumed to have jurisdiction over the site and/or transload locations and TWIC identification cards would be mandatory for workers. TWIC cards are issued by TSA and involve background and fingerprint checks.
- 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” [37] and the Enhancing Security of Hazardous Materials Shipments Against Acts of Terrorism or Sabotage[38] .
- Existing site security plans (transload locations) will be incorporated into the Security Plan for this campaign/project.
- The Security Plan hand-off of responsibility at each site will be reviewed by the RSAT and evaluated and approved by the Administrative Team, DHS, DOT, USCG, the licensee, and each individual state authority for each state that will be crossed.
- Strict chain-of-custody protocols will be established and all physical transfers will be “manned” and documented[39].

8.8. Develop Security and Communication Protocols

Security and communication protocols will be developed as follows:

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

8.9. 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 (water served or water adjacent transload location). This section will not apply to the SNF shipping campaign from the site and the recommended rail route from RSNGS to GCUS. Some of these provisions are recommended below to provide an added and layered security framework for the site.

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 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 pleasure vessels would not be permitted during a transportation activity at the site. If vessels are to be used to transport SNF, the vessels would need a Vessel Security Plan (VSP). The VSP outlines vessel security and identifies the Vessel Security Officer, who would be delegated the responsibility of implementing the VSP and coordinating with the USCG and the FSO during a transportation activity.

8.10. Railroad Security Requirements

The following are railroad security-related requirements:

- The TSA published rules regarding the rail transportation of certain HAZMAT, which became effective on December 26, 2008[39] and are still in effect. The materials subject to these rules include explosive, TIH, PIH, and HRCQ. TSA refers to these commodities collectively as 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[40] (the requirements remain the same for rail-served sites handling HAZMAT).
    - If the facility has not established a Rail Secure Area or put chain-of-custody procedures in place, declare when it expects to complete these requirements and what interim measures are in place to ensure compliance in the meantime.
    - Without compliance with these measures, the railroad may refuse to perform switching services at the facility until the requirements are met.
    - Proper and current contact information must be supplied, including company name, street address, phone number, and primary point of contact.

- There is no requirement to submit the Security Plan to the railroad for review or approval, but the shipper must inform the serving railroad that the plan exists.
- All of the above will apply to the SNF rail transload facility.
- Note: 49 CFR 172.820 requires railroads to perform specific assessments of all lanes on its network where HAZMAT are moved, along with alternate routes. The specific criteria are listed in Appendix D of 49 CFR Part 172. The railroads will conduct these assessments independently of any shipper interaction. The shipper will not be privy to the results of these assessments. These requirements mandate action and reporting of information on an annual basis and will occur independent of any shipper requested route for movement of HAZMAT whether or not the shipment is a dimensional shipment. The railroad assessments may affect the clearance approval granted to shippers requesting specific lanes or routes for movements of dimensional HAZMATs.

8.11. Provisions for Protection of In-Transit Road Shipments

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

- Transportation vehicles must be accompanied by at least two individuals
    - One serving as an armed escort
    - A second armed member of the LLEA in a mobile unit or
    - Led by a separate vehicle occupied by at least one armed escort and trailed by a third vehicle occupied by at least one armed escort
- All armed escort are equipped with a minimum of two weapons (as permitted by law); however, this requirement does not apply to LLEA personnel who are performing escort duties.Transport and escort vehicles are equipped with redundant communication abilities that provide 2-way communications between the transport vehicle, the escort vehicle(s), the MCC, LLEA, and one another. To ensure that 2-way communication is possible at all times, alternate communications should not be subject to the same failure modes as the primary communication.
    - Escorts must have the ability to call for assistance when necessary
    - Escorts must be provided with a way to quickly develop new LLEA contacts and obtain new route information when unexpected detours become necessary
    - Escorts must be provided a way to coordinate the movement of transport and escort vehicles when more than one transport vehicle is used in the shipment
    - Escorts must be able to reach the emergency phone number provided on the approved route
- The transport vehicle must be equipped with NRC-approved features that permit immobilization of the cab or cargo-carrying portion of the vehicle with the purpose being to render the vehicle inoperable or incapable of movement under its own power. It must take at least 30 minutes to reverse the immobility once engaged.
- The transport vehicle driver must be trained with, and capable of implementing, the transport vehicle immobilization, communications, and other security procedures.

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

The MCC shall:

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

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

8.12. Provisions for Protection of In-Transit Rail Shipments

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

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

8.13. Provisions for Protection of In-Transit Barge Shipments

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

- A shipment vessel while docked at a U.S. port is protected by:
    - Two armed escorts stationed on board the shipment vessel, or stationed on the dock at a location that will permit observation of the shipment vessel; or

  - A member of a LLEA, equipped with normal local law enforcement agency radio communications, who is stationed on board the shipment vessel, or on the dock at a location that will permit observation of the shipment vessel.

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

If the on-site facility or a transload facility were located on or adjacent to the water, the following will apply, even if no transportation on the waterways is expected to 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[45].
- 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 or TT to rail) near navigable waterways include:

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

- If vessels are docked at the water served site or transload facility, the escort requirements in 10 CFR 73.37(e) will apply to the site.

None of these provisions will apply to RSNGS if the direct rail route is available for use. However if the rail option in the future becomes unviable, then these provisions apply.

9.0 EMERGENCY RESPONSE PLAN AND PREPAREDNESS

The purpose of the emergency response plan (ERP) is to establish notification protocols and provide response guidance in the event of a reportable incident involving an HHT or rail shipment transporting HAZMAT. The ERP includes all pertinent contact and contingency information including specific contact names and phone numbers, as well as procedures in the event of an incident. These procedures encompass the requirements for providing and maintaining emergency information during transportation and at facilities where HAZMAT is loaded, stored, or otherwise handled during every phase of transportation[40][44].

Emergency response information is required to be immediately available for use at all times when HAZMAT is present. It is also required to be immediately available to any Federal, State, or local government agency representative who responds to an incident or is investigating an incident (per 49 CFR 172.600(c)(1)&(2))[44].

9.1. General Guidance for an Emergency Response Plan

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

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

This information must be written in English and available for use away from the package and provided in an approved format such as shipping papers or a document containing all the relevant information that will be found in shipping papers.[44]

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

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

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

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

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

The emergency response procedures apply to persons who offer, accept, transfer, or otherwise handle HAZMAT during transportation. In this case, the procedures will apply to site operations at RSNGS, onsite HHT/TT transport beginning with all transfer operations conducted at RSNGS to transfer the overpacks from the ISFSI to the TT for movement to the onsite 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 the site to the GCUS or final destination.

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

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

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

Section 1: Purpose & Scope

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

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

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

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

Section 6: Attachments - Incident Log – Checklist of notifications with internal and external notification contacts and contact numbers. The log provides notifications and conditions for contacting the National Response Center staffed by the USCG and State Agencies. Also included are blank incident logs for 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. RSNGS Site-Specific Considerations for the Emergency Response Plan

The MUA identified the highest ranked means for transporting the SNF and GTCC LLW from RSNGS by direct rail, with a 435ft TT movement from the ISFSI to the on-site rail track where loading the rail cars would be conducted at the private RSNGS plant facility on its private rail track located adjacent to the ISFSI. Even though the RSNGS plant site is not located on or adjacent to a U.S. waterway, it is assumed that MTSA security requirements apply in addition to the "Rail Secure Area" designation. These two sources of provisions would present a layered security approach for the operations involved in the campaign.

Because the MUA recommended route does not include a water-served site or transload facility, or mode of transportation, the USCG would not have a role in the security or ERP for these shipments and the USCG would not have to approve the Security Plan.

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

As previously stated, compliance with MTSA is recommended at this time as a conservative approach to a multi-tiered security plan.

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

Natural disaster planning should also be part of the Site Security Plan and ERP as the site is located in a portion of northern California that although the location has been considered low risk for hurricanes, tornados and earthquakes, it has encountered several other natural disasters in the past, including flooding and fires. Contingency plans for wild fires and flooding should be considered along with the findings from the 1987 California Senate Task Force on California Nuclear Emergency Response Plan which includes evacuation plans for Sacramento County in the event of a disaster. These proceedings and the weather impacts should be considered in the current plans if a natural disaster were to occur during the loading campaign.

10.0 RECOMMENDED NEXT STEPS

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

1. Examine the onsite path from the ISFSI to each loading area and evaluate the need for improvements to ensure acceptable conditions of transport exist. Consider the extent of the concrete roadway needed to be added/upgraded at the site to handle anticipated transportation activities, as well as grading improvements needed on steep paths. In addition, would also need to perform formal inspection of the onsite rail spur.
2. The TN 24P DSCs will need to be evaluated prior to transport to ensure 10 CFR Part 71 requirements are met and the MP197HB cask CoC requirements are satisfied. 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 a need to revise the CoC. In general, a complete transportability study consisting of a comparison of each transport cask and its contents in a transport configuration to the 10 CFR Part 71 CoC at the time the transport will be performed by the NRC licensee with the support of the transport cask CoC holder prior to transportation of each canister to be offered for transport.
3. This report should be updated once the GTCC LLW planned to be removed from the site has been loaded. Based on the waste characteristics and the loading configuration, the MP197HB cask CoC may need to be revised prior to transport of the GTCC LLW. Note if the MP187 cask were to be used to ship this GTCC LLW then its CoC would require an amendment.
4. Establish planned shipment date from the RSNGS ISFSI and verify:
    a. The CoC for the TN MP197HB package is still valid (currently under timely renewal by the NRC).
    b. The contents, as loaded in the TN canisters are compliant to the applicable CoC requirements (e.g., dose and thermal transport limits are satisfied).
    c. Ability for permitting the on-site transfer and off-site transportation activities along the selected route(s).
5. Establish equipment needs for transportation:
    a. Procurement of the ten MP197HB casks, associated impact limiters, cavity spacers, 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. Investigate the availability and capacity of the existing NUHOMS transfer equipment, previously used at RSNGS, 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 RSNGS ISFSI site operations related details:
    a. Establish electrical power requirements for performing operations and verify availability at RSNGS ISFSI.
    b. Determine the maximum height an MP197HB package 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 RSNGS ISFSI.
7. This report should be updated when CoC 9382 is issued by the NRC for the TN-Eagle cask. It is expected that the 24P DSCs at RSNGS will be included as allowable content and an evaluation should be performed at that time on whether the MP197HB or TN-Eagle cask should be used.
8. Due to the potential significant impacts of the conditions and assumptions identified in **Section 7.9** for the estimated costs associated with activities involving the rail shipment of transportation casks from the transload site to the GCUS site (i.e., cask consist transportation services costs, emergency response center operation costs, railcar maintenance services freight costs, and transportation cask maintenance and compliance costs), the development of more precise costs requires resolution to, or clarification of, the identified conditions and assumptions in **Section 7.9**, as well as consideration of economies of scale and synergies associated with the de-inventory of multiple sites at the same or nearly same time, understanding of equipment (e.g., railcars and casks) ownership impact, and the need for a comprehensive breakdown of activities involved in these costs.

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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
On-Site Rental Equipment Costs (e.g., mobile cranes)								Labor and Permitting Costs
On-Site Rental Equipment Costs (e.g., mobile cranes)								Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
On-Site Rental Equipment Costs (e.g., mobile cranes)								Cost of Rail Transport (e.g., costs associated with interchange activities)
On-Site Rental Equipment Costs (e.g., mobile cranes)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
On-Site Rental Equipment Costs (e.g., mobile cranes)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
On-Site Rental Equipment Costs (e.g., mobile cranes)								Number of Tribal Lands Crossed
On-Site Rental Equipment Costs (e.g., mobile cranes)								Public Acceptability of Route
On-Site Rental Equipment Costs (e.g., mobile cranes)								Ease of Permit Procurement
On-Site Rental Equipment Costs (e.g., mobile cranes)								Cumulative Worker Exposure (α handling time & # of workers)
On-Site Rental Equipment Costs (e.g., mobile cranes)								Cumulative Population Dose along Route (α population density)
On-Site Rental Equipment Costs (e.g., mobile cranes)								Risks Associated with Number of Lifting Activities
On-Site Rental Equipment Costs (e.g., mobile cranes)								Average Accident Frequency on Route
On-Site Rental Equipment Costs (e.g., mobile cranes)								Number of Fire Stations & Trained Personnel Nearby Route
On-Site Rental Equipment Costs (e.g., mobile cranes)								Transit Duration per Conveyance and Consist
On-Site Rental Equipment Costs (e.g., mobile cranes)								Security Vulnerability of Route
Labor and Permitting Costs								Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
Labor and Permitting Costs								Cost of Rail Transport (e.g., costs associated with interchange activities)
Labor and Permitting Costs								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Labor and Permitting Costs								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Labor and Permitting Costs								Number of Tribal Lands Crossed
Labor and Permitting Costs								Public Acceptability of Route
Labor and Permitting Costs								Ease of Permit Procurement
Labor and Permitting Costs								Cumulative Worker Exposure (α handling time & # of workers)
Labor and Permitting Costs								Cumulative Population Dose along Route (α population density)
Labor and Permitting Costs								Risks Associated with Number of Lifting Activities
Labor and Permitting Costs								Average Accident Frequency on Route
Labor and Permitting Costs								Number of Fire Stations & Trained Personnel Nearby Route
Labor and Permitting Costs								Transit Duration per Conveyance and Consist
Labor and Permitting Costs								Security Vulnerability of Route
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Cost of Rail Transport (e.g., costs associated with interchange activities)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Number of Tribal Lands Crossed
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Public Acceptability of Route
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								Ease of Permit Procurement
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)								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)								Number of Fire Stations & Trained Personnel Nearby 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)								Security Vulnerability of Route
Cost of Rail Transport (e.g., costs associated with interchange activities)								Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Number of Tribal Lands Crossed
Cost of Rail Transport (e.g., costs associated with interchange activities)								Public Acceptability of Route
Cost of Rail Transport (e.g., costs associated with interchange activities)								Ease of Permit Procurement
Cost of Rail Transport (e.g., costs associated with interchange activities)								Cumulative Worker Exposure (α handling time & # of workers)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Cumulative Population Dose along Route (α population density)
Cost of Rail Transport (e.g., costs associated with interchange activities)								Risks Associated with Number of Lifting Activities
Cost of Rail Transport (e.g., costs associated with interchange activities)								Average Accident Frequency on Route
Cost of Rail Transport (e.g., costs associated with interchange activities)								Number of Fire Stations & Trained Personnel Nearby Route
Cost of Rail Transport (e.g., costs associated with interchange activities)								Transit Duration per Conveyance and Consist
Cost of Rail Transport (e.g., costs associated with interchange activities)								Security Vulnerability of Route

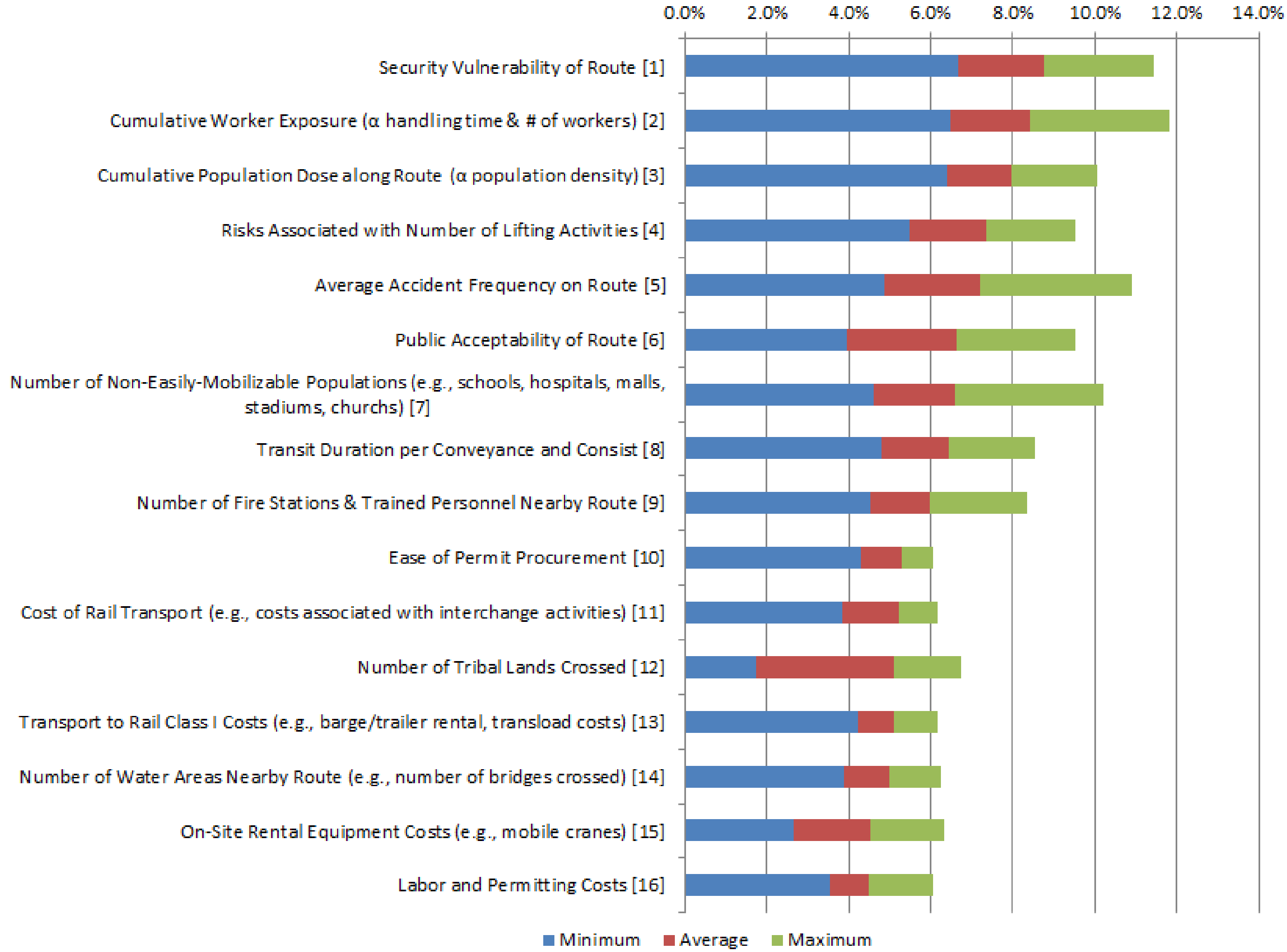
Column A Metrics	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Metrics
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Number of Tribal Lands Crossed
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Public Acceptability of Route
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Ease of Permit Procurement
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Cumulative Worker Exposure (α handling time & # of workers)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Cumulative Population Dose along Route (α population density)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Risks Associated with Number of Lifting Activities
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Average Accident Frequency on Route
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Number of Fire Stations & Trained Personnel Nearby Route
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Transit Duration per Conveyance and Consist
Number of Water Areas Nearby Route (e.g., number of bridges crossed)								Security Vulnerability of Route
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Number of Tribal Lands Crossed
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Public Acceptability of Route
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Ease of Permit Procurement
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Cumulative Worker Exposure (α handling time & # of workers)
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Cumulative Population Dose along Route (α population density)
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Risks Associated with Number of Lifting Activities
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Average Accident Frequency on Route
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Number of Fire Stations & Trained Personnel Nearby Route
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Transit Duration per Conveyance and Consist
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)								Security Vulnerability of Route
Number of Tribal Lands Crossed								Public Acceptability of Route
Number of Tribal Lands Crossed								Ease of Permit Procurement
Number of Tribal Lands Crossed								Cumulative Worker Exposure (α handling time & # of workers)
Number of Tribal Lands Crossed								Cumulative Population Dose along Route (α population density)
Number of Tribal Lands Crossed								Risks Associated with Number of Lifting Activities
Number of Tribal Lands Crossed								Average Accident Frequency on Route
Number of Tribal Lands Crossed								Number of Fire Stations & Trained Personnel Nearby Route
Number of Tribal Lands Crossed								Transit Duration per Conveyance and Consist
Number of Tribal Lands Crossed								Security Vulnerability of Route
Public Acceptability of Route								Ease of Permit Procurement
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								Number of Fire Stations & Trained Personnel Nearby Route
Public Acceptability of Route								Transit Duration per Conveyance and Consist
Public Acceptability of Route								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
Ease of Permit Procurement								Cumulative Worker Exposure (α handling time & # of workers)
Ease of Permit Procurement								Cumulative Population Dose along Route (α population density)
Ease of Permit Procurement								Risks Associated with Number of Lifting Activities
Ease of Permit Procurement								Average Accident Frequency on Route
Ease of Permit Procurement								Number of Fire Stations & Trained Personnel Nearby Route
Ease of Permit Procurement								Transit Duration per Conveyance and Consist
Ease of Permit Procurement								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)								Number of Fire Stations & Trained Personnel Nearby Route
Cumulative Worker Exposure (α handling time & # of workers)								Transit Duration per Conveyance and Consist
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)								Number of Fire Stations & Trained Personnel Nearby Route
Cumulative Population Dose along Route (α population density)								Transit Duration per Conveyance and Consist
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								Number of Fire Stations & Trained Personnel Nearby Route
Risks Associated with Number of Lifting Activities								Transit Duration per Conveyance and Consist
Risks Associated with Number of Lifting Activities								Security Vulnerability of Route
Average Accident Frequency on Route								Number of Fire Stations & Trained Personnel Nearby Route
Average Accident Frequency on Route								Transit Duration per Conveyance and Consist
Average Accident Frequency on Route								Security Vulnerability of Route
Number of Fire Stations & Trained Personnel Nearby Route								Transit Duration per Conveyance and Consist
Number of Fire Stations & Trained Personnel Nearby Route								Security Vulnerability of Route
Transit Duration per Conveyance and Consist								Security Vulnerability of Route

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

Metric	Rater																											Metric
	1		2		3		4		5		6		7		8		9		10		11		12		Average			
	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	%	Ranking	Average	
On-Site Rental Equipment Costs (e.g., mobile cranes)	4.44%	15	4.03%	15	4.79%	14	3.75%	15	2.64%	16	4.10%	15	4.86%	13	4.65%	13	6.32%	7	4.44%	15	5.28%	11	5.14%	14	4.6%	15	13.5	On-Site Rental Equipment Costs (e.g., mobile cranes)
Labor and Permitting Costs	4.38%	16	4.65%	14	4.65%	15	3.54%	16	3.82%	14	3.75%	16	4.24%	16	4.65%	13	6.04%	9	5.28%	12	3.82%	16	5.14%	14	4.6%	16	14.1	Labor and Permitting Costs
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	4.51%	14	6.18%	9	5.49%	10	4.65%	11	4.24%	12	5.76%	10	5.21%	11	4.31%	16	5.42%	12	5.49%	10	4.58%	15	5.14%	14	5.1%	12	12.1	Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)
Cost of Rail Transport (e.g., costs associated with interchange activities)	4.86%	13	6.18%	9	5.42%	11	5.21%	9	3.82%	14	5.49%	11	5.56%	9	4.65%	13	5.83%	11	5.63%	9	4.72%	14	5.21%	13	5.2%	11	11.5	Cost of Rail Transport (e.g., costs associated with interchange activities)
Number of Water Areas Nearby Route (e.g., number of bridges crossed)	5.21%	12	4.72%	12	4.31%	16	4.58%	12	3.89%	13	4.79%	13	5.28%	10	6.25%	10	5.21%	13	4.38%	16	5.14%	12	5.97%	5	5.0%	14	12.0	Number of Water Areas Nearby Route (e.g., number of bridges crossed)
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)	6.88%	6	6.39%	7	7.36%	3	5.69%	8	10.21%	1	6.74%	7	4.58%	15	7.08%	5	5.90%	10	6.32%	5	5.76%	9	5.97%	5	6.7%	6	6.6	Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)
Number of Tribal Lands Crossed	5.49%	11	4.72%	12	5.90%	7	5.90%	7	4.65%	10	4.44%	14	5.07%	12	6.74%	6	1.74%	16	5.07%	14	5.49%	10	5.97%	5	5.0%	13	10.6	Number of Tribal Lands Crossed
Public Acceptability of Route	9.03%	2	3.96%	16	7.29%	4	9.51%	2	5.90%	7	8.06%	3	4.79%	14	5.42%	11	6.32%	7	6.39%	4	6.94%	5	5.90%	12	6.4%	8	7.7	Public Acceptability of Route
Ease of Permit Procurement	5.76%	10	4.86%	11	4.93%	13	4.31%	14	4.65%	10	6.04%	9	5.90%	8	5.21%	12	5.21%	13	5.83%	8	5.00%	13	5.97%	5	5.4%	10	10.2	Ease of Permit Procurement
Cumulative Worker Exposure (α handling time & # of workers)	7.01%	4	7.78%	2	8.96%	2	8.54%	4	9.38%	3	8.40%	2	6.46%	5	7.92%	2	7.43%	4	11.81%	1	8.26%	3	9.17%	1	8.4%	2	2.6	Cumulative Worker Exposure (α handling time & # of workers)
Cumulative Population Dose along Route (α population density)	7.36%	3	6.94%	6	7.29%	4	8.54%	4	10.07%	2	8.75%	1	6.39%	6	7.92%	2	7.01%	5	9.03%	2	6.94%	5	9.17%	1	7.9%	3	3.4	Cumulative Population Dose along Route (α population density)
Risks Associated with Number of Lifting Activities	6.74%	7	7.78%	2	6.88%	6	9.51%	2	5.49%	8	7.01%	6	7.92%	3	7.99%	1	7.57%	3	6.11%	6	8.40%	2	6.67%	3	7.1%	5	4.3	Risks Associated with Number of Lifting Activities
Average Accident Frequency on Route	7.01%	4	7.78%	2	5.83%	8	4.86%	10	9.03%	5	7.29%	5	7.50%	4	7.50%	4	10.90%	1	5.14%	13	7.50%	4	5.97%	5	7.4%	4	5.0	Average Accident Frequency on Route
Number of Fire Stations & Trained Personnel Nearby Route	5.90%	9	7.01%	5	5.42%	11	4.51%	13	8.33%	6	5.21%	12	6.25%	7	6.53%	8	4.51%	15	5.35%	11	6.67%	7	5.97%	5	6.1%	9	8.7	Number of Fire Stations & Trained Personnel Nearby Route
Transit Duration per Conveyance and Consist	6.32%	8	6.25%	8	5.83%	8	6.53%	6	4.79%	9	6.46%	8	8.54%	2	6.46%	9	7.64%	2	6.04%	7	6.53%	8	5.97%	5	6.4%	7	6.7	Transit Duration per Conveyance and Consist
Security Vulnerability of Route	9.10%	1	10.76%	1	9.65%	1	10.35%	1	9.10%	4	7.71%	4	11.46%	1	6.74%	6	6.94%	6	7.71%	3	8.96%	1	6.67%	3	8.6%	1	2.8	Security Vulnerability of Route

Purple	lowest ranked
Red	highest ranked


0.0%
2.0%
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10.0%
12.0%
14.0%
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]
Average Accident Frequency on Route [5]
Public Acceptability of Route [6]
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs) [7]
Transit Duration per Conveyance and Consist [8]
Number of Fire Stations & Trained Personnel Nearby Route [9]
Ease of Permit Procurement [10]
Cost of Rail Transport (e.g., costs associated with interchange activities) [11]
Number of Tribal Lands Crossed [12]
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs) [13]
Number of Water Areas Nearby Route (e.g., number of bridges crossed) [14]
On-Site Rental Equipment Costs (e.g., mobile cranes) [15]
Labor and Permitting Costs [16]
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
On-Site Rental Equipment Costs (e.g., mobile cranes)	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City				X				E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso				X				E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City				X				E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City				X				E. HHT to Stockton + Barge via Panama Canal
Labor and Permitting Costs	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso	X							E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
Transport to Rail Class I Costs (e.g., barge/trailer rental, transload costs)	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso	X							E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal

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
Cost of Rail Transport (e.g., costs associated with interchange activities)	A. Rail via Sacramento & Kansas City			X					B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso					X			C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso					X			D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso					X			E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
Number of Water Areas Nearby Route (e.g., number of bridges crossed)	A. Rail via Sacramento & Kansas City						X		B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso	X							E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
Number of Non-Easily-Mobilizable Populations (e.g., schools, hospitals, malls, stadiums, churchs)	A. Rail via Sacramento & Kansas City		X						B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City			X					E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso						X		C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso					X			D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso						X		E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City				X				E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal

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 Tribal Lands Crossed	A. Rail via Sacramento & Kansas City		X						B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso						X		C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso						X		D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso						X		E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
Public Acceptability of Route	A. Rail via Sacramento & Kansas City			X					B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City				X				E. HHT to Stockton + Barge via Panama Canal
Ease of Permit Procurement	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso	X							E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal

Metric	Column A Routes	Column A Strongly Favorable	Column A More Favorable	Column A Mildly Favorable	Neither Favorable (neutral)	Column B Mildly Favorable	Column B More Favorable	Column B Strongly Favorable	Column B Routes
Cumulative Worker Exposure (α handling time & # of workers)	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City			X					C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso			X					C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
Cumulative Population Dose along Route (α population density)	A. Rail via Sacramento & Kansas City		X						B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City						X		E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso						X		C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso					X			D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso						X		E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City						X		E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City						X		E. HHT to Stockton + Barge via Panama Canal
Risks Associated with Number of Lifting Activities	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso		X						C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso	X							E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City				X				D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal

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
Average Accident Frequency on Route	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City			X					C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City			X					E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso			X					C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso			X					E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
Number of Fire Stations & Trained Personnel Nearby Route	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City						X		D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City						X		E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso				X				C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso						X		D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso						X		E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City						X		D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City						X		E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City					X			E. HHT to Stockton + Barge via Panama Canal
Transit Duration per Conveyance and Consist	A. Rail via Sacramento & Kansas City				X				B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City			X					C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso			X					C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso	X							E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City	X							E. HHT to Stockton + Barge via Panama Canal

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
Security Vulnerability of Route	A. Rail via Sacramento & Kansas City		X						B. Rail via Fresno & El Paso
	A. Rail via Sacramento & Kansas City			X					C. HHT to Ione + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	A. Rail via Sacramento & Kansas City		X						E. HHT to Stockton + Barge via Panama Canal
	B. Rail via Fresno & El Paso					X			C. HHT to Ione + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso			X					D. HHT to Concord + Rail via Sacramento & Kansas City
	B. Rail via Fresno & El Paso			X					E. HHT to Stockton + Barge via Panama Canal
	C. HHT to Ione + Rail via Sacramento & Kansas City		X						D. HHT to Concord + Rail via Sacramento & Kansas City
	C. HHT to Ione + Rail via Sacramento & Kansas City			X					E. HHT to Stockton + Barge via Panama Canal
	D. HHT to Concord + Rail via Sacramento & Kansas City			X					E. HHT to Stockton + Barge via Panama Canal

Attachment D: Route Information from START for RSNGS

Route	HHT Distance (mi.)	Barge Distance (mi.)	Rail Distance (mi.)
A. Rail on UP to GCUS through Sacramento, CA and Kansas City, MO	0	0	2105
B. Rail on UP to GCUS through Fresno, CA and El Paso, TX	0	0	2425
C. HHT to Ione, CA then Rail on UP to GCUS through Sacramento, CA and Kansas City, MO	9	0	2115
D. HHT to MOTC in Concord, CA then Rail on UP to GCUS through Sacramento, CA and Kansas City, MO	115	0	2140
E. HHT to Stockton, CA then Barge through Panama Canal, Rail on UP to GCUS from Houston	54	8909	877

Parameter	Route > Metric \/	A. UP rail (Sacramento, / Kansas City)	B. UP rail (Fresno / El Paso)	C. HHT to Ione, CA / UP rail (Sac / KC)	D. HHT to MOTC / UP rail (Sac / KC)	E. HHT to Stockton/ Barge/UP rail (Hou)
Total Dist. (mi)		2105	2425	2124	2255	9840
Travel Time (hr/min)	Duration of Route	52 hrs. 3142 min	61 hrs. 3641 min	53.5 hrs. 3210 min.	55 hrs. 3291 min.	1295 hrs. 77,683 min.
Accident Likelihood (per mi^2)	Accidents	0.000001	0.000001	0.42691	2.39893	1.727508
Water Crossings	Public Acceptability	213	96	213	229	97
Average Track Class		4.3	4.4	4.3	4.3	4
Average Rail Traffic Density		5.5	4.8	5.5	5.5	4.5
Average Population Density (per mi^2)		331.2	538.2	333	2833.8	1584.60
Total Population	Cumulative Population Dose	411,861	835,602	411,867	590,613	244,648
Mass Gathering Places	Cumulative Population Dose	360	845	360	423	383
Tribal Lands (per mi^2)	Public Acceptability	1.35	15.26	1.35	1.35	0
Sensitive Environmental Area (per mi^2)	Public Acceptability	299.96	434.63	299.96	304.83	184.92

Parameter	Route > Metric \/	A. UP rail (Sacramento, / Kansas City)	B. UP rail (Fresno / El Paso)	C. HHT to Ione, CA / UP rail (Sac / KC)	D. HHT to MOTC / UP rail (Sac / KC)	E. HHT to Stockton/ Barge/UP rail (Hou)
Locks		N/A	N/A	N/A	N/A	0
Tunnels		14	10	14	28	0
Emergency Response Capability (Total per mi^2)		0.13	0.15	0.13	0.34	0.42
Fire Departments (per mi^2)		0.07	0.08	0.07	0.18	0.24
Police (per mi^2)		0.05	0.06	0.05	0.14	0.17
Hospitals (per mi^2)		0.01	0.01	0.01	0.03	0.01
Educational Institutions (total)		258	485	258	329	185
Grammar Schools		251	462	251	314	180
Higher Education		7	23	7	15	5
Special Age Groups (total)		230	451	230	382	209
Day Care		147	329	147	231	173
Nursing Homes		83	122	83	151	36
Railroad Crossings (total at grade)		1323	1399	1330	1361	1208
Signs		342	289	345	358	294
Signals		114	69	14	116	80

Parameter	Route > Metric \/	A. UP rail (Sacramento, / Kansas City)	B. UP rail (Fresno / El Paso)	C. HHT to Ione, CA / UP rail (Sac / KC)	D. HHT to MOTC / UP rail (Sac / KC)	E. HHT to Stockton/ Barge/UP rail (Hou)
No signs or signals		0	0	0	0	0
Both signs and signals		0	0	0	0	0
Unknown signs/signals		867	1041	871	887	834