APPENDIX B1

STUDY 2 - ALTERNATIVE CASK HANDLING METHODS

Alternative 1 - Current Cask Handling Operations (C-OPS)

Alternative 1 – Current Cask Handling Operations (C-OPS)

B1-1.0 Description of Handling Alternative

Alternative 1 examines the use of typical cask handling methods currently in use today at operating and decommissioned nuclear plants in the U.S. for application at the Interim Storage Facility (ISF). Commercial Operations, or C-OPS, is a simple extrapolation of current industry practices applied directly to the ISF. The methods described are thoroughly demonstrated and proven, and while small improvements are being developed all the time, these cask handling approaches are the best-understood of all of the alternatives discussed in this study.

For this study, all of the spent nuclear fuel (SNF) received at the ISF is packaged in canister-based systems. Canister-based systems use a dual purpose canister (DPC) which is licensed for both storage and transportation. The DPC is a welded sealed metal container where the SNF assemblies are placed. The DPC is placed in different overpacks or casks for transport, storage or transfer between the transport cask and storage overpack. A typical PWR canister will hold 24 to 37 PWR SNF assemblies and a typical BWR canister will hold 61 to 89 BWR SNF assemblies. These systems fall into one of two categories: vertical or horizontal type systems. These methods for cask handling use existing storage system and nuclear plant infrastructure to be deployed and therefore offer the opportunity for a "standard" option for the ISF. This alternative for cask handling uses well-known supporting infrastructure.

There are four companies that provide canister-based dry cask storage systems which are:

- AREVA TN
  - NUHOMS (horizontal) (Reference B1-1, B1-2 and B1-3)
- EnergySolutions
  - Fuel Solutions (vertical) (Reference B1-4 and B1-5)
- Holtec International
  - HI-STAR (vertical) (Reference B1-6)
  - HI-STORM (vertical) (Reference B1-7 and B1-8)
  - HI-STORM UMAX (vertical) (Reference B1-9)
- NAC International
  - MPC (vertical) (Reference B1-10 and B1-11)
  - UMS (vertical) (Reference B1-12)
  - MAGNASTOR (vertical) (Reference B1-13)

C-OPS only considers existing licensing configurations for these systems where the original overpack design is employed to house the DPCs at the ISF. This eliminates any infrastructure complexities.

For the vertical systems, the study considers the stack-up method used by all vertical systems for canister transfer. The general steps to unload and transfer a vertical DPC from a transport cask to a storage overpack are as follows (References B1-4 through B1-13):

1. Removing the transport cask from the railcar, up-righting it and placing it on the floor in a vertical orientation
2. Placing a transfer cask on top of the transport cask
3. Lifting the DPC out of the transport cask and up into the transfer cask
4. Securing the DPC in the transfer cask
5. Removing the transfer cask from the transport cask
6. Placing the transfer cask on the storage overpack
7. Lowering the DPC down into the storage overpack
8. Removing the transfer cask
9. Securing the storage overpack lid
10. Transporting the storage overpack to the storage location on the pad using a vertical cask transporter (VCT)
11. Reconfiguring the transport cask on the railcar for shipment off-site.

For horizontal systems, the study considers the NUHOMS methodology of canister transfer (Reference B1-1 through B1-3). The general steps to unload and transfer a horizontal DPC from a transport cask to a storage overpack are as follows:

1. Removing the transport cask from the railcar
2. Placing the transport cask onto a horizontal cask transporter (HCT)
3. Transferring the transport cask to a horizontal storage module (overpack) on the pad
4. Preparing the storage overpack to receive the DPC
5. Aligning the HCT so that the DPC is will slide smoothly into the storage overpack
6. Pushing the DPC into the storage overpack using a hydraulic ram
7. Securing the storage overpack
8. Returning the empty transport cask to the rail siding
9. Reconfiguring the transport cask on the railcar for shipment off-site.

Typical canister transfer operations are shown in **Figure B1-1** through **Figure B1-3**.

Figure B1-1
AREVA TN NUHOMS Horizontal Canister Transfer Using a TN Transport Trailer

Source: NMC Duane Arnold Energy Center

Figure B1-2
NAC International UMS "Stack-up" Vertical Canister Transfer

Source: Maine Yankee Atomic Power Company

Figure B1-3
Holtec International HI-STORM "Stack-up" Vertical Canister Transfer

Source: Holtec International

From **Figure B1-1**, horizontal canister transfer comprises the transfer cask (or transport cask), horizontal cask transporter (HCT) with a hydraulic ram to push the DPC out of the transfer cask into the horizontal storage overpack, concrete pad, horizontal storage overpack, concrete apron on which the HCT rests, mobile crane to lift door off storage overpack, and personnel. It should be noted that the transport cask for the NUHOMS system is designed with a port hole in the bottom so that canister transfer can be performed direct from the transport cask to the storage overpack.

From **Figure B1-2** and **Figure B1-3**, vertical canister transfer comprises the transfer cask, storage overpack (or transport cask), transfer adapter (NAC) or mating device (Holtec) that connects the two casks together and opens to allow transfer between casks, overhead crane to raise or lower the DPC, suitable concrete floor or pad, seismic struts, slings or structure to prevent the transfer cask from toppling over in the event of an earthquake, personnel lift to enable workers to access the top of the transfer cask. Most vertical transfers are performed with the use of a single-failure-proof overhead crane at the power plant to prevent an accidental drop of the DPC during the canister transfer. A few plants do not use a single-failure-proof crane and rely on impact limiters and a drop analysis to show that an accidental drop of the DPC onto the impact limiters will not harm the DPC.

Table B1-1 provides a comparison of major vertical canister transfer steps between C-OPS, A-OPS, R-OPS and S-OPS.

Table B1-1
Comparison of Major Vertical DPC Transfer Operational Steps

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack to rail siding.
Overhead crane places transport cask into transfer cell	Overhead crane places transport cask onto transfer cart.	Overhead crane places transport cask onto transfer cart.	Gantry crane places transport cask on hard stand
Overhead crane removes transport cask lid	Jib Crane removes transport cask lid	Jib Crane removes transport cask lid	Gantry crane removes transport cask lid
	Transfer Cart moves transport cask into cell	Transfer Cart moves transport cask into cell	Transport Cask is secured seismically to hard stand
Transfer cell doors are closed	Transfer cell doors are closed	Transfer cell doors are closed	
Mating adapters are mounted to top of transport cask and storage cask.			Mating adapters are mounted to top of transport cask and storage cask.
Overhead crane places transfer cask on transport cask.	Transfer sleeve is located over transport cask		Overhead crane places transfer cask on transport cask.

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
Seismic/stack-up struts are attached to transfer cask.			Seismic/stack-up struts are attached to transfer cask.
Transfer cask is bolted to mating adapter.			Transfer cask is bolted to mating adapter.
Overhead crane raises DPC from transport cask up into transfer cask.	Transfer sleeve hoist raises DPC from transport cask into transfer sleeve.	Dedicated cell crane raises DPC from transport cask	Gantry crane raises DPC from transport cask up into transfer cask.
Transfer cask is unbolted from mating adapter.			Transfer cask is unbolted from mating adapter.
Seismic/stack-up struts are removed from transfer cask.			Seismic/stack-up struts are removed from transfer cask.
Overhead crane moves transfer cask from transport cask to storage overpack.	Transfer sleeve is moved from transfer cask position to storage overpack position.		Gantry crane moves transfer cask from transport cask to storage overpack.
Seismic/stack-up struts are attached to transfer cask.			Seismic/stack-up struts are attached to transfer cask.
Transfer cask is bolted to the mating adapter.			Transfer cask is bolted to the mating adapter.
Overhead crane lowers DPC from transfer cask to storage overpack.	Transfer sleeve hoist lowers DPC from transfer sleeve to storage overpack.	Dedicated cell crane lowers DPC into storage overpack.	Gantry crane lowers DPC from transfer cask to storage overpack.
Seismic/stack-up struts are removed from transfer cask.			Seismic/stack-up struts are removed from transfer cask.
Transfer cask is unbolted from mating adapter.			Transfer cask is unbolted from mating adapter.
Transfer cask is removed and placed back into storage location.			Transfer cask is removed and placed back into storage location.
Mating adapters are removed from storage and transport casks.			Mating adapters are removed from storage and transport casks.
Outside doors are opened	Outside doors are opened	Outside doors are opened.	
VCT drives into transfer cell	Transfer cart moves storage overpack outdoors.	Transfer cart moves storage overpack outdoors.	VCT maneuvers onto hard stand
VCT attaches to storage overpack	VCT attaches to storage overpack	VCT attaches to storage overpack	VCT attaches to storage overpack
Storage overpack lid is bolted on.	Storage overpack lid is bolted on.	Storage overpack lid is bolted on.	Storage overpack lid is bolted on.
VCT takes storage overpack to pad.	VCT takes storage overpack to pad.	VCT takes storage overpack to pad.	VCT takes storage overpack to pad.

B1-1.1 Cask Handling Building

Currently cask handling operations begin in the reactor building (BWR) or fuel handling building (PWR) starting from the spent fuel pool. Once the loaded DPC is welded closed and inerted, a horizontal transfer cask is moved to the HCT for transfer to the ISFSI and a vertical transfer cask is prepared for DPC transfer to the storage overpack. Almost all vertical transfer operations are performed within the reactor building or fuel handling building. A few vertical transfers are performed outdoors at canister transfer facilities (CTFs) and are discussed in Appendix B4, S-OPS. For the purpose of this study, C-OPS considers the DPC handling and transfer operations performed within the reactor building or fuel handling building.

As noted in the previous section, the cask handling and transfer operations are performed with large overhead bridge cranes within the confines of a large concrete or steel support structure. The cranes are typically single-failure-proof and the building structures are robust - designed for radiation shielding and earthquakes, tornadoes and other manmade or natural hazards. This methodology has a substantial proven track record. Past conceptual models of various ISF type facilities have incorporated the use of an equivalent arrangement - using a robust concrete or steel structure housing a high capacity overhead bridge crane. For this study, a robust facility equivalent to a reactor building or fuel handling building that can safely handle dry fuel casks is called a cask handling building (CHB).

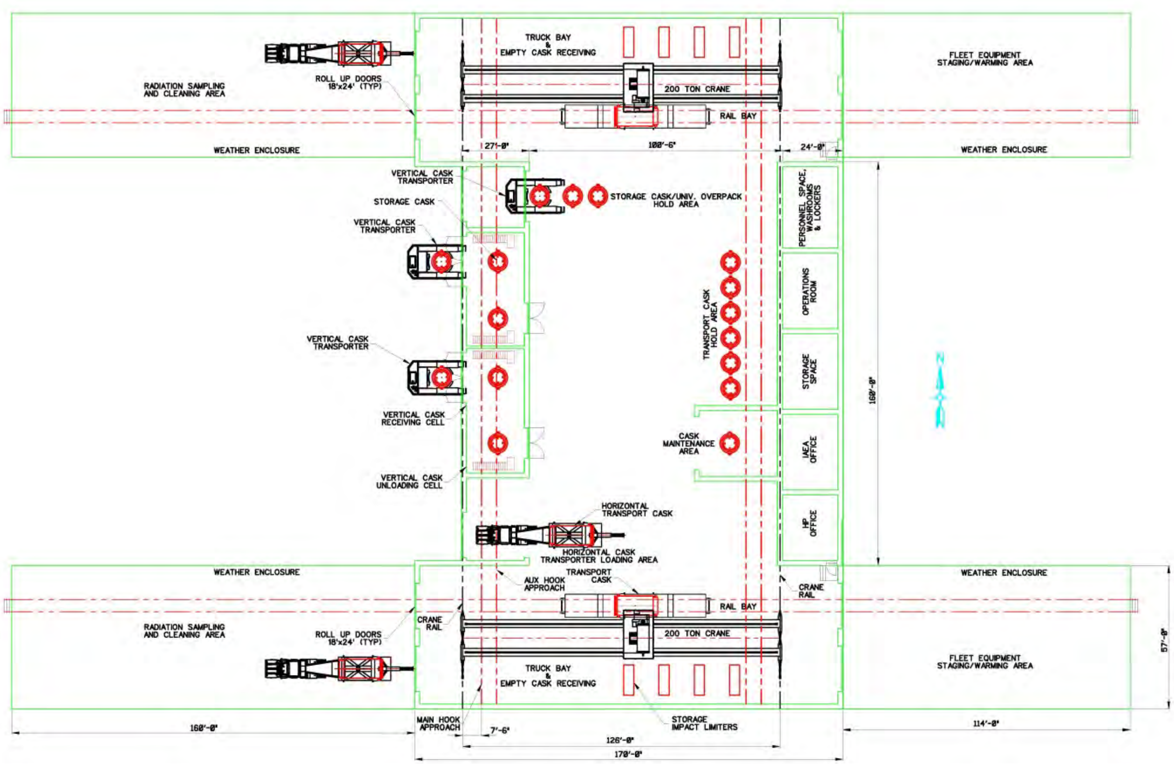
For the ISF, the purpose of the CHB is threefold; 1) receive SNF shipments (railcar and transport cask) in an environmentally controlled area; 2) provide the facilities to offload transport casks from railcars and place them on the horizontal cask transporter for horizontal systems or 3) offload transport casks to an radiological shielded area and transfer the DPCs from the transport casks to storage overpacks for vertical systems. Like a reactor building or fuel handling building, the CHB would be designed to provide physical protection for the canisters and radiation shielding to the workers.

Previous work on similar proposed CHB facilities was researched including the Transfer Facility for the Central Interim Storage Facility (CISF) (Reference B1-14), the Canister Transfer Building for the Private Fuel Storage Facility (PFSF)(Reference B1-15) and The Cask handling Building in the CB&I Task Order 11 Report (Reference B1-16). These buildings are constructed of reinforced concrete and provide a solid support structure for the overhead cranes used to offload and lift casks.

For this report, the Cask Handling Building is laid out based on experience from the evolution of the previous work as shown in **Figure B1-4 and Figure B1-5.**

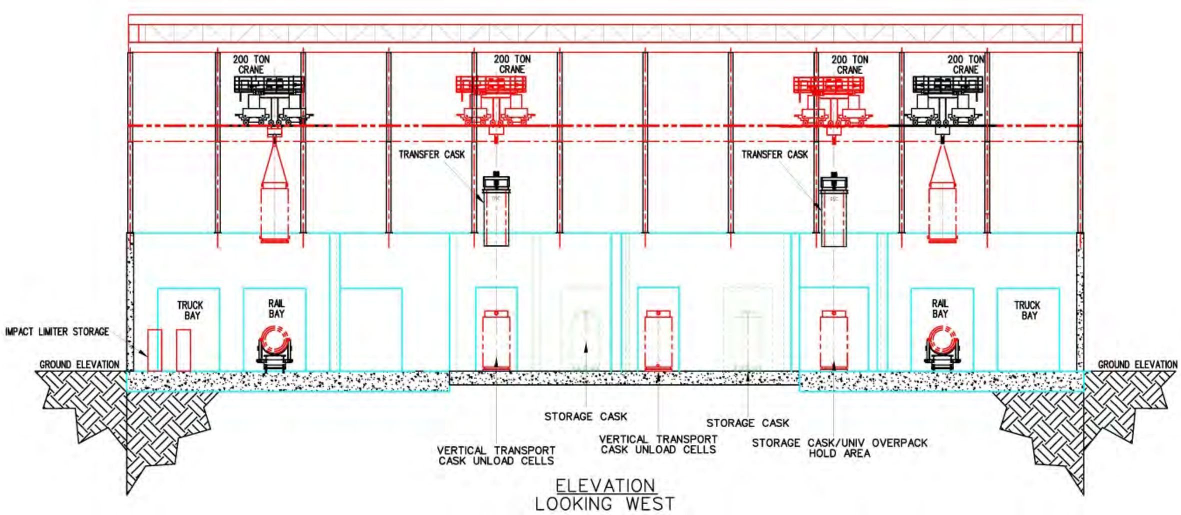
This CHB design concept for alternative C-OPS attempts to incorporate many of the characteristics of the previous structures with innovations that improve throughput and operation using typical storage system transfer equipment and methodology. The building consists of two sets of rail/truck bays and 2 vertical type canister transfer cells. The building is 274 feet long x 170 feet wide x 72 feet high. Weather enclosures on either side the rail/truck bays are added for shipment prep work. The CHB has 2 dedicated 200 ton single-failure-proof overhead bridge cranes that can be used across the entire building but can travel independently from rail/truck bay to the transfer cells so that two cask handling operations can be performed at one time. When performing the operations evaluation, it was determined that a single rail/truck bay and 2 transfer cells could accommodate the required throughput of 1,500 MTHM. The second rail/truck bay was added for redundancy so that any one equipment failure would not jeopardize the required throughput. However, this redundant rail/truck bay would also enable a higher throughput.

Figure B1-4
C-OPS Alternative – Cask Handling Building (Plan View)



For horizontal type systems, either of the rail/truck bays is used for transferring the transport casks onto a horizontal cask transporter. The design of the CHB with two sets of rail/truck bays can accommodate a throughput that will enable 5 DPCs to be placed into storage each week using 1 shift per day. This translates into an annual throughput of 260 DPCs placed into storage per year (approximately 3,000 MTHM per year) which is double the required throughput for the Pilot ISF.

Figure B1-5
C-OPS Alternative – Cask Handling Building (Elevation View)



The building also has a laydown area for impact limiters, staging area for transport casks and office area. The CHB would be a reinforced concrete structure with thick walls to protect all SNF casks, canisters, overpacks, and cask-handling equipment from the effects of earthquakes, tornado winds, tornado-generated missiles, fire, and explosions.

The CHB is designed to provide radiological shielding during canister transfer operations. The vertical type canister transfer cells with reinforced concrete walls shield workers from dose intensive operations.

B1-2.0 Concept of Operations

B1-2.1 Material Handling Flow Diagram

Figure B1-6 is a representation of the material handling flow for the C-OPS alternative for the ISF. It describes the three large material flows of the operation. The central flow is the movement of DPCs containing SNF to the site. But equally important to the operations of the ISF are the material flows necessary to support the production of suitable storage overpacks to place the DPCs into after being accepted by the site for storage. The vertical storage overpacks are prefabricated by the vendors and shipped to the site as steel structures packaged to protect them during transit. The site crew unpacks these overpacks and performs a receipt inspection to ensure that there has been no damage during shipping. Then the Fabrication Crew completes the fabrication and pours the concrete of the structure to complete the overpack in accordance with the vendor's specification. **Figure B1-7** shows concrete being poured into the Holtec HI-STORM 100 overpack steel shell. **Figure B1-8** shows the reinforced concrete being applied to the outside of the NAC UMS overpack.

Figure B1-6
Canister Handling Material Handling Flow Diagram

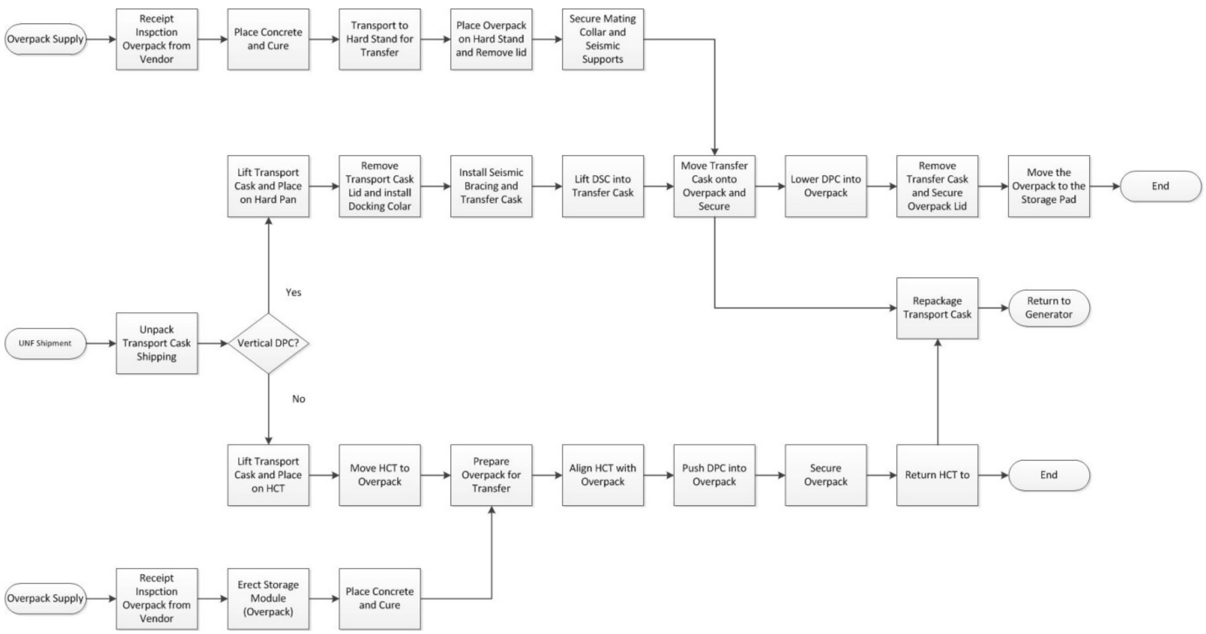


Figure B1-7
Holtec HI-STORM 100 Overpack Fabrication, Concrete Pour into Overpack

Source: Holtec International

Figure B1-8
NAC UMS Overpack Fabrication, Reinforcement Placement on Overpack

Source: Maine Yankee Atomic Power Company

For horizontal storage systems, the site fabrication crew needs to erect the DPC storage modules using the vendor's pre-fabricated modules that are shipped to the ISF. These modules are large construction packages and must be carried to the pad and erected and aligned so that the DPCs can be readily placed into storage. **Figure B1-9** shows the NUHOMS components that will make up the horizontal storage module.

All of the overpack fabrication and erection represents a fairly major construction effort.

Figure B1-9
AREVA TN Overpack Fabrication, Module Components Ready for Assembly

Source: CB&I

The largest operations challenge for the C-OPS alternative is controlling the supply chain to ensure that the proper storage system and its various components are available to match the DPC being received from the generator. The licensability of the final DPC is based on the conformance of the storage system with the original licensed dry storage system. Concrete takes at least 30-days to cure, so the minimum time required before the vertical overpacks can be placed into service would be month. However, practicalities of such a large material receipt and fabrication process would suggest that a 60-day period would be a better basis for planning. The lead time for delivery of these material components and fabrication of the initial overpacks is estimated to be 6 to 12 months. Therefore, up to a year ahead of the receipt of the SNF at the site, the supply chain manager needs to place an order for the necessary storage system components. Well in advance of delivery of specific DPCs from generator sites, the ISF staff needs to know what vendor-specific components are needed for the DPC being delivered. The coordination of the supply chain for the Overpack Fabrication and the SNF storage operations will be the largest management challenge for this design alternative.

B1-2.2 Operational Sequence

Cask handling operations are a series of heavy lifts and heavy equipment movements that move the SNF in sealed DPCs from the rail head to the storage pad. The operational sequence was benchmarked against ISFSI operations at operating nuclear plants. The C-OPS alternative is an exact reproduction of the approaches used at nuclear facilities so no extrapolations were required. The only variation to the existing commercial operational sequence is the limitation of a single 8-hour shift per day, five days a week. SNF movements at a nuclear plant are typically a significant operation conducted to make room in the fuel pool for a refueling outage. As such, they are usually performed in a continuous effort, utilizing multiple crews working 10 or 12-hour shifts to complete the operation as rapidly as possible.

Figure B1-10 shows the high-level schedule for the two storage concepts in C-OPS assuming 8-hour shifts. The operational sequence once the transport cask is accepted into the CHB can be divided into four major steps:

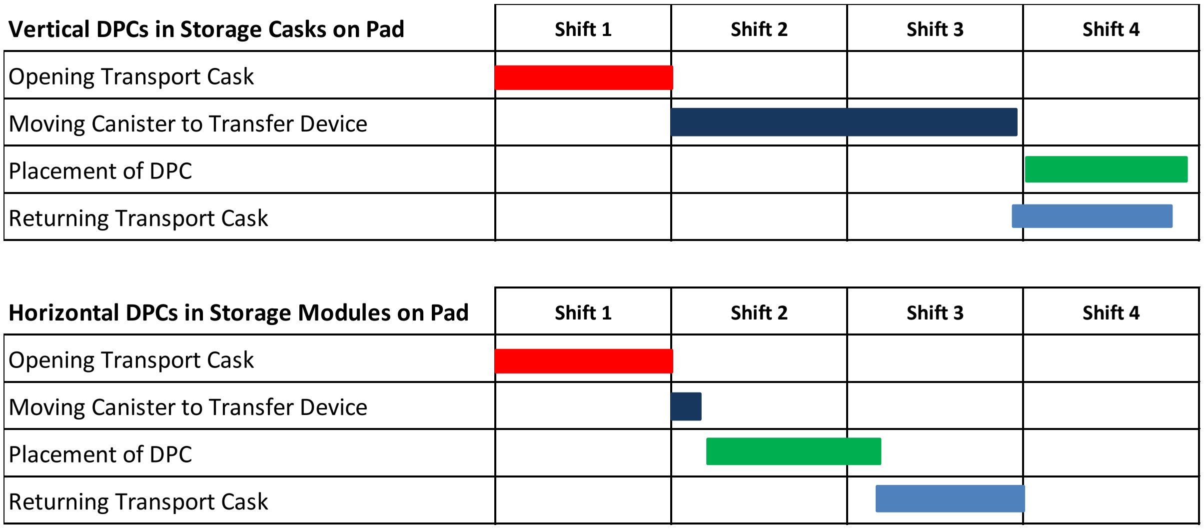
1. Opening the transport cask
2. Moving the DPC into the transfer device or system
3. Placement of the DPC in the storage overpack and
4. Preparing for the turnaround of the transport cask.

It should be noted that this is essentially a three shift exercise regardless of the original storage concept used. Even though the vertical DPCs take four shifts to complete all of the steps in the sequence, there is enough time so that the next railcar shipment could begin processing while the last steps of the sequence for the preceding shipment were completed.

Most of the effort is associated with unpacking the transport cask and reconfiguring the transport cask for shipment off-site. These activities take two shifts to accomplish whereas DPC placement takes about one shift. The key to starting the next DPC process is to move the railcar out of the way to make room for the next shipment. In the case of the vertical DPC system, the time to recycle the waste package is nearly identical to the horizontal DPC system even though it takes significantly longer for the vertical DPC to actually be placed into storage.

The packaging of the transport cask for railcar transporting is performed in the CHB using a single-failure proof 200 ton overhead crane. The crane is used to remove the transport cask cover, the impact limiters and tie-down straps. The crane has adequate capacity to lift the transport cask and to place the cask where needed. In the case of the vertical DPC, the crane can place the transport cask vertically on the CHB floor in a canister transfer cell. In the case of the horizontal DPC, the crane is used to upend and remove the transport cask from the railcar, place it on the HCT and down end it into the horizontal position.

Figure B1-10
High-Level Operational Sequences



The vertical transport cask is immediately secured by seismic/stack-up restraints or struts mounted to the CHB structure. The lid is removed and a transfer adapter or mating device is attached to the upper surface of the transport cask and a lifting fixture is bolted to the top of the DPC. During these activities, the workers are on platforms approximately 20 feet above the ground and they are exposed to the top of the DPC. Once the transport cask lid is removed, radiation streaming up the gap between the DPC and the transport cask makes the dose rates experienced while performing this work significant. The upper DPC cover is shielded making the doses on top of the DPC slightly less than the doses near the upper edge of the transport cask. Most of the work described above takes place in the higher dose rate area.

The next step in the vertical DPC cask is to mate the transfer cask onto the transfer adapter or mating device on top of the transport cask. Once the transfer cask is moved into place, the work crews need to bolt the cask in place on top of the transport cask. After the two casks are mated, the dose rates in the work area are minimized. Before the crane can release the cask, seismic restraints or struts need to be secured to the transfer cask. The overhead crane lowers a grapple that captures the DPC lifting lug and then the crane extracts the DPC out of the transport cask and raises it into position in the transfer cask. The bottom of the transfer cask contains a door that is slid under the DPC and the DPC lowered onto the door. Then, the workers unbolt the transfer cask and remove the seismic restraints. The crane lifts the transfer cask and moves it over to the storage overpack that has been prepositioned and fitted with seismic/stack-up restraints or struts and a transfer adapter or mating device. The workers reposition themselves to the overpack work platform and bolt the transfer cask to the transfer adapter or mating device on the overpack and attach the seismic restraints or struts. These activities take place in a very low or background dose rate.

The overhead crane lifts the DPC so that the transfer cask bottom doors can be opened, lowers the DPC into the overpack and releases the grapple. At this point, the workers unbolt the transfer cask, seismic restraints and the crane removes it and places it in its storage location for the next shipment. The workers remove the lifting lug assembly and the crane returns to lift it off of the DPC. Once again, the workers here are exposed to the elevated dose rates at the top of the DPC.

The workers disassemble the transfer adapter or mating device and remove it. Then they disconnect the seismic/stack-up restraints coordinated with the movement of the VCT to grapple the overpack. The overpack lid is captured on the VCT hoist and it is lowered into position and the workers bolt it to the top of the overpack. Once the lid is in place, the dose rates on the work platform, drop to lower levels.

The overpack is then transported to the pad for placement in the storage array with the VCT. This is a slow process but the dose rates are extremely low and workers can distance themselves from the overpack. If the overpack needs to be bolted to the pad due to the seismic zone of the ISF site, then the workers performing this activity may be exposed to relatively high dose rates resulting from streaming out of the air inlet at the bottom of the overpack.

For horizontal DPCs, the processes and radiological doses are quite different. The railcar packaging is removed in a manner identical to the vertical case. The crane lifts the transport cask, rotating the cask from a horizontal to vertical orientation. However, the crane sets the transport cask down directly onto a nearby horizontal cask transporter (HCT), lowering it into the horizontal orientation on the HCT. The HCT then moves off to the horizontal storage overpack on the pad.

While the HCT is making the trip, workers at the storage overpack are preparing to accept the DPC. They check the alignment makers to ensure that there has been no movement. They then remove the shield cover from the overpack using a mobile crane. When the HCT approaches the overpack, the mobile crane is used to remove the transport cask cover. Then, the HCT and overpack crews align the transport cask with the overpack opening and mate the transport cask to the opening. The alignment must be true and parallel with the internals of the overpack to avoid damage to the DPC. Some of these movements and alignment activities take place in a relatively high dose rate.

Once the transport cask is mated to the overpack and hydraulic ram is engaged and the DPC is pushed out of the transport cask into the overpack. Once the DPC is in place and the ram is withdrawn, the HCT moves back from the overpack. Then, a worker reaches inside the overpack and places a seismic shear pin into a boss (indention) to prevent the DPC from sliding into the overpack cover. This is accomplished in a high dose rate and needs to be done rapidly. After the seismic shear pin is installed, the shield cover over the overpack opening is reinstalled. This is activity is also conducted in a high dose rate.

B1-2.3 Time and Motion Analysis

B1-2.3.1 Methodology

This alternate is to use currently employed SNF DPC cask handling approaches at the ISF. Accordingly, the time and motion analysis is based on existing experience. These operational sequences were developed by subject matter experts in SNF handling. Interviews were conducted with several individuals with real, hands-on operational experience with moving SNF to achieve a consensus on the completeness, the durations and the staff size necessary to achieve each of these constituent activities. These were then pieced together to develop a bottom up estimate of durations and crew sizes for each step. While activities at nuclear plants routinely take place on a multi-shift 24-hour basis, this analysis will use the single 8-hour shift for a 40-hour week. Since the durations and crew sizes already include time for mobilization and for breaks, those issues are not explicitly described.

Additional steps were added to recognize the practice of having a “Plan of the Day” meeting and a safety meeting at the start of each shift. Also, steps not envisioned by the subject matter experts because they are part of the support systems at operating nuclear plants such as health physics (HP) coverage, record keeping, QA/QC oversight were included. Also, since operations stop at the end of each shift, steps were added to secure the DPCs during the off shifts periods.

B1-2.3.2 Conclusion

It is determined that the C-OPS can process an average of five horizontal DPCs placed into storage every week. This assumes that there are two railbays, with two OTB cranes and four operating HCTs. However, the vertical DPCs can only average half of that number per week. This is because the OTB crane is required for most of the steps associated with the stackup process. Therefore, it cannot be freed up to enable the unpacking of the next Transport Cask. The attractiveness of this concept is that it is linear. Two heavy lift cranes in the CHB coupled with two cask transporters of each type result in 5 DPCs every week.

The disadvantage of this approach is that it is labor intensive. In addition, it increases the radiation exposure necessary for each activity slightly over the more remote techniques. In addition, one crane is tied-up because the vertical DPCs are limited to a series operation so that the crane is required for the DPC transfer processes.

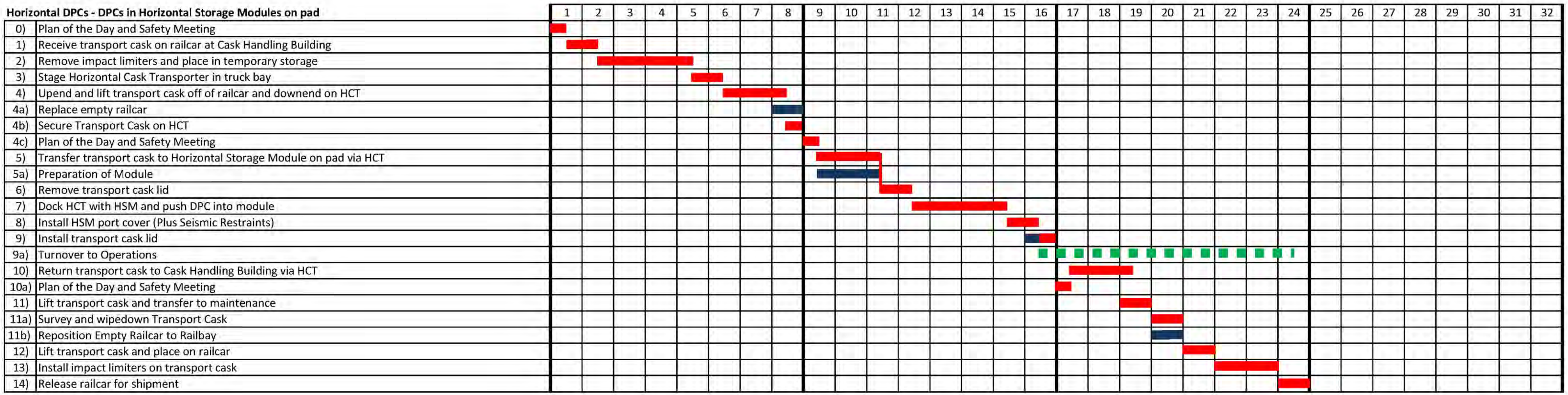
The horizontal DPCs would appear to have an advantage because the crane is available to unpackage the next transport cask while the HCT is delivering the DPC to the overpack on the pad. However, a problem arises when HCT returns with the empty transport cask. The transport cask on the railcar will be completely unpacked but will need to be positioned so that the crane can pick the emptied transport cask off of the HCT and place it on its railcar. So, a conservative sequence does not try to take advantage of the down time of the crane by staggering the processing of two railcars at the same time.

Figure B1-11 below shows the detail schedules for the vertical and for the horizontal commercial operations alternative.

The activities on the Y-axis are the steps necessary to process the DPCs from when they enter the CHB until the emptied transport cask is reloaded and the transport packaging has been reinstalled. The time across the top of the schedule is in hours. The red bars are critical path activities; the blue are near critical path activities. It has been assumed that it will take 24-hours of observations of the DPC once stored to accept the package. This activity is shown as a green dashed line on this chart but is not part of the Canister Handling Crew's responsibility. It is the hand-off to ISF Operations for long-term surveillance and safeguards. It will consist of a series of temperature, air flow and radiation measurements over the initial 24-hour period to validate that the expected performance has been achieved.

Figure B1-11
Time Motion Schedules for Commercial Operations (C-OPS)

Figure B1-11
Time Motion Schedules for Commercial Operations (C-OPS) (Cont'd)

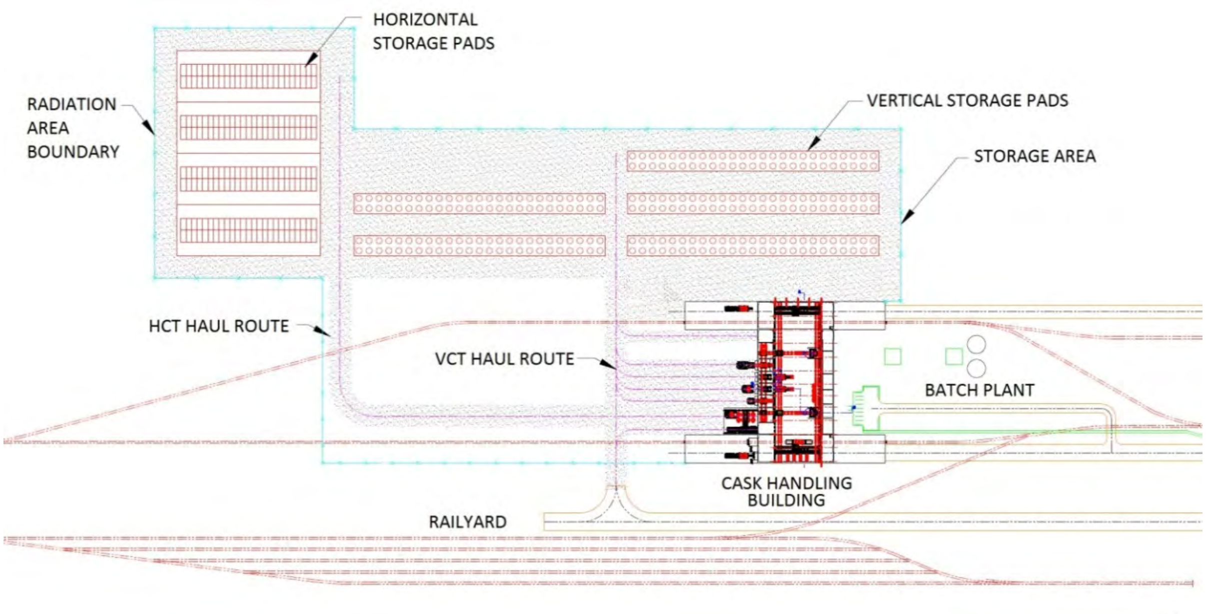


B1-3.0 Performance of Structures, Systems and Components

B1-3.1 Facility Layout and Equipment Evaluation

Figure B1-12 shows the layout of the site using the C-OPS cask handling approach. It shows the location of the CHB in relation to the storage pads and the HCT and VCT haul routes.

Figure B1-12
Pilot ISF Cask Handling Building in Relation to Storage Area



This approach requires the CHB which is a fairly large structure housing the cranes, rail bays, canister transfer cells, and VCT and HCT bays.

B1-3.2 Structural and Seismic Evaluation

The seismic stability of the pads and storage overpacks is addressed in Appendix A1. For Alternative B1, the primary structure affected by a seismic event is the CHB. The CHB is a fairly large structure. For the 0.25G earthquake, the capacity of the CHB, which is constructed of reinforced concrete, to resist seismic forces is significant.

For the 0.75G earthquake, the acceleration demands at the top of the CHB are significant especially when both overhead cranes are carrying large loads. Design consideration must be considered in relation to the height of the building, placement of the overhead crane rails, and smallest width of the building. The actual maximum seismic capacity of the CHB will be dependent on the structure design and material design limits to mitigate the 0.75G earthquake demands. Additional structures may need to be employed to stabilize the top of the structure. In addition, the foundation may need to be thickened to resist overturning moments applied across the minor axis. The seismic/stack-up restraints or struts will also need to be considered in the buildings ability to resist seismic loads.

B1-3.3 Radiological Evaluation

The exposures to radiation for the workers at the ISF were based on the time and motion study and the assumed average dose rates from the DPCs stored at the site. Once installed in their storage locations, the doses to workers and to the public are quite small. However, during canister handling operations, workers need to work on top of DPCs and near the transport cask and the transfer casks. In addition, plant security officers need to visually inspect the inside of the transport cask for contraband as soon as it is opened and will sustain some doses. Workers on vertical cask storage units need to bolt a lifting lug directly onto the DPC and after it has been transferred to the storage overpack.

Most of the activities are conducted well away from the DPC and behind shielding. But some of the activities require hands-on contact to the DPC or working near the open end of shield casks or overpacks.

The radiation doses associated with dry storage concepts are well understood and readily available from the literature regarding ISFSI operations at the generators' sites. Most of the radiation doses at operating plant sites are associated with the loading of the storage canisters in the fuel pool and the subsequent passivation steps of drying, inerting and welding closed the storage canisters. Once the canisters are loaded into their storage overpack, there are few remaining issues.

Vertical storage casks have radiation streaming at the bottom of the cask where the cool air inlets are. Also, when working around the top of the canister in either the transport cask or the storage cask, the dose rate streaming up the annular gap between the canister and the shield when the lid is removed is significant to the workers. So care needs to be exercised with securing the shield cask lid to the top of the cask and with securing the seismic hold downs for the cask on the pad.

Horizontal storage systems expose workers to higher radiological doses when preparing the module to receive the used nuclear fuel canister. The shielded cover needs to be removed from the storage module for the new storage location. However, the storage module is not well shielded from the neighboring module so that the area around the opening is a high radiation area. Once the HCT has docked with the storage module, the dose rates are quite low and remain so during the entire transfer operation. However, in order to secure the canister seismically, a worker needs to reach into the module and insert a shear pin in the module that precludes the canister shifting toward the cover plate during a seismic event. This is a high radiation evolution that needs to be addressed by the final ISF design. Design modifications could be developed to eliminate the need to have workers routinely reaching into a storage module to attach a seismic restraint.

Table B1-2 shows typical dose rates near waste packages of interest for this study. These values are for a predicted average SNF and were developed using a calculated percentage of the doses emitted from design base SNF from the vendor FSARs (Reference B1-1 through B1-13) based on typical nuclear plant experience.

Table B1-2
Typical Dose Rates Near Casks (mrem/hr)

Component	Top	Top Side	Side	Bottom
Transport Cask	15.0	31.8	34.0	15.0
Vertical Storage Cask Open	254.0	150.0	44.0	111.0
Vertical Storage Cask Sealed	18.4	20.0	44.0	111.0
Horizontal Storage Module	Near Opening 7.1		Inside 163.2	
General Area CHB	< 0.5 mrem/hr			

Section 6.4 of the Report, "Occupational Dose/ALARA Analysis of Storage Alternatives" shows cask handling operations for R-OPS and their respective doses which are shown in **Table B1-3**.

Table B1-3
Duration and Radiation Doses for C-OPS Cask Handling Operations

Alternative	Storage Configuration	Duration of Transfer Operation (hours)	Radiation Dose per Transfer (mrem) (Entire Operations Staff Dose)
C-OPS, Current Typical Canister Transfer	Vertical	29	391
	Horizontal	24	203

B1-3.4 Equipment Maintenance Evaluation

This approach relies on proven and demonstrated equipment. Single failure proof overhead cranes, transfer casks, HCTs, VCTs, mobile cranes and the miscellaneous tools and equipment necessary for this approach are all proven demonstrated and available commercially. The cranes and most of the equipment are highly reliable and require only minimal routine maintenance.

The HCTs and VCTs are extremely complex machines and are designed for episodic operation. Used continuously, it is reasonable to expect a great deal of maintenance to be necessary. For that reason, spare transporters should be added to the ISF's inventory to ensure availability.

B1-3.5 Licensing Evaluation

This handling alternative is based on existing approaches that have already been reviewed and approved by the NRC. Therefore, the licensing issues would focus on the repeated transport cask offload, canister transfer and transporter travel issues. The site specific Safety Analysis Report will need to detail the CHB structure design and margins, all operations, work areas within the CHB, radiation doses, and address a suite of manmade and natural accidents or off-normal events to show that there are no unsafe operations of the ISF. NUREG-1567 (Reference B1-17) contains detailed guidance that can be followed to ensure all aspects of this alternative are adequately addressed. The onsite worker doses and offsite dose to the public will need to be calculated at strategic locations around the ISF to ensure ALARA.

In addition, the Environmental Report will need to address all facility components and operational steps to ensure that environmental regulations are adhered to. The ramifications of the Environmental Report also affect off-site conditions that could be adversely altered due to traffic from worker numbers, noise, solid waste, liquid waste, sewage water, etc. All site activities will need to be addressed because this will be the basis for the NRC Environmental Impact Statement.

B1-3.6 Modular Concepts Evaluation

Modularization of this alternative is not necessary. Once the CHB is constructed it can provide the storage and throughput needs of the Pilot ISF, Expanded ISF and larger ISF. If higher throughput rates are desired additional shifts can be added to meet the demands rather than construct additional cask handling facilities. The approach appears to be essentially linear. Doubling the shifts and staffing will double the throughput.

B1-4.0 Summary

C-OPS is the typical means of cask handling at commercial nuclear plants and therefore an extremely predictable alternative that would serve the ISF well.

This alternative can process a vertical DPC in 4 shifts and a horizontal DPC in 3 shifts. C-OPS can process an average of five horizontal DPCs placed into storage every week resulting in an overall throughput of approximately 3,000 MTHM per year. This throughput can be attained providing the CHB has two rail/truck bays and two overhead cranes. A higher throughput can be established by utilizing more shifts per day.

The average overall dose to workers is 391 mrem processing a vertical DPC and 203 mrem processing a horizontal DPC.

In summary, the pros and cons to this alternative, listed from the highest most significant impact to the lowest least significant impact are as follows:

In summary, the pros and cons to this alternative, listed from the highest most significant impact to the lowest least significant impact are as follows:

<u>Pros</u>

- The C-OPS process is used at most of nuclear power plants and therefore very predictable. A wealth of operation procedures are available that have evolved over 25 years to address almost every conceivable issue using the equipment in this alternative.
- All of the operation steps in C-OPS and transfer casks and ancillary equipment have been reviewed by the NRC and licensed. Normal, off-normal and accident scenarios are well understood. The Pilot ISF Site Specific license under 10CFR72 (Reference B1-18) can utilize all the existing operational information which will streamline the licensing process.

<u>Cons</u>

- C-OPS uses a cask handling building to perform transport cask offloading and vertical canister transfer operations. This facility is a large structure that increases the cost of this alternative.
- C-OPS relies on a number of manual steps that increases transfer time and personnel radiation dose.
- There are 13 different systems that need to be accommodated. Currently, each system has been designed to use its own specific equipment. The C-OPS alternative would

likely use transfer casks and ancillary equipment designed and licensed for all 13 storage systems. Processing multiple systems will require space to store all the equipment, multiple procedures, and a variety of equipment that can introduce the potential for errors. Employing 13 sets of equipment to lift and offload a transport cask, transfer the DPC from the transport cask to a storage overpack could be burdensome. The creation of equipment that could be used for multiple systems would improve the process.

B1-5.0 References

1. AREVA TN Updated Final Safety Analysis Report for the Standardized NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No, 72-1004.
2. AREVA TN Updated Final Safety Analysis Report for the Advanced NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC, Docket Number 72-1029.
3. AREVA TN Final Safety Analysis Report for the NUHOMS HD Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1032.
4. FuelSolutions Storage System Final Safety Analysis Report, NRC Docket No. 72-1026.
5. FuelSolutions W74 Canister Storage Final Safety Analysis Report, NRC Docket No. 72-1026.
6. Holtec International Final Safety Analysis Report for the HI-STAR 100 Cask System, NRC Docket No. 72-1008.
7. Holtec International Final Safety Analysis Report for the HI-STORM 100 Cask System, NRC Docket No.: 72-1014.
8. Holtec International Final Safety Analysis Report on the HI-STORM FW MPC Storage System, NRC Docket No. 72-1032.
9. Holtec International Final Safety Analysis Report on the HI-STORM UMAX Canister Storage System, NRC Docket 72-1040.
10. NAC Final Safety Analysis Report for the Multi-Purpose Canister (NAC-MPC), NRC Docket No. 72-1025.
11. NAC Final Safety Analysis Report MPC-LACBWR Amendment, NRC Docket No. 72-1025.
12. NAC Final Safety Analysis Report for the Universal MPC System (UMS) Universal Storage System, NRC Docket No. 72-1015.

13. NAC Final Safety Analysis Report for the MAGNASTOR (Modular Advanced Generation Nuclear All-purpose STORage) System, NRC Docket No. 72-1031.

14. Centralized Interim Storage Facility Topical Safety Analysis Report, U.S. Department of Energy, Revision 1, September 30, 1998.

15. Private Fuel Storage Facility Final Safety Analysis Report, Private Fuel Storage, LLC, Revision 0, May 19, 2006.

16. Final Report, Task Order No. 11, Development of Consolidated Storage Facility Design Concepts, Shaw Environmental & Infrastructure, Inc., January 31, 2013.

17. NRC NUREG-1567, Standard Review Plan for Spent Fuel Dry Storage Facilities, Rev. 0, March 2000.

18. 10 CFR 72, Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste.

APPENDIX B2

STUDY 2 - ALTERNATIVE CASK HANDLING METHODS

Alternative 2 – Automated Cask Handling Operations (A-OPS)

Alternative 2 – Automated Cask Handling Operations (A-OPS)

B2-1.0 Description of Handling Alternative

Alternative 2 evaluates the impact of improving the cask handling operations by increasing the automation of the dual purpose canister (DPC) transfer operations. In the current cask handling operations study, C-OPS in Appendix B1, the cask handling operations are impacted by several labor intensive steps that slow the overall throughput process and add radiation doses to workers. .These impacts affect horizontal DSC transfer operation to some degree and vertical DSC transfer operations to a larger degree. Horizontal DSC transfers are already automated by the operation of the horizontal cask transporters (HCTs) but there is room for improvements, some of which are already being implemented in the industry.

Vertical DPC transfers traditionally have been nuclear plant dependent where equipment and space are limited. In addition, few power plants are designed similarly so the vertical transfer process is more of an adaptive arrangement tailored to suit plant conditions.

For this study, all of the spent nuclear fuel (SNF) received at the ISF is packaged in canister-based systems. Canister-based systems use a dual purpose canister (DPC) which is licensed for both storage and transportation. The DPC is a welded sealed metal container where the SNF assemblies are placed. The DPC is placed in different overpacks or casks for transport, storage or transfer between the transport cask and storage overpack. A typical PWR canister will hold 24 to 37 PWR SNF assemblies and a typical BWR canister will hold 61 to 89 BWR SNF assemblies. These systems fall into one of two categories: vertical or horizontal type systems. These methods for cask handling use existing storage system and nuclear plant infrastructure to be deployed and therefore offer the opportunity for a “standard” option for the ISF. This alternative for cask handling uses well-known supporting infrastructure.

There are four companies that provide canister-based dry cask storage systems which are:

- AREVA TN
  - NUHOMS (horizontal) (Reference B2-1, B2-2 and B2-3)
- EnergySolutions
  - Fuel Solutions (vertical) (Reference B2-4 and B2-5)
- Holtec International
  - HI-STAR (vertical) (Reference B2-6)
  - HI-STORM (vertical) (Reference B2-7 and B2-8)
  - HI-STORM UMAX (vertical) (Reference B2-9)

- NAC International
  - MPC (vertical) (Reference B2-10 and B2-11)
  - UMS (vertical) (Reference B2-12)
  - MAGNASTOR (vertical) (Reference B2-13)

This alternative considers the canister transfer operations at the horizontal storage module for horizontal systems and the cask stack-up process used by all vertical systems. These methods use manual operations and other unsophisticated means of achieving the transfers. A-OPS will examine the benefits of automating these processes as follows:

Horizontal systems

- Reduce overall canister transfer duration
- Reduce overall worker radiation dose
- Streamline alignment process of the HCT to the storage module
- Replace tractor trailer with self-propelled HCT that is easier to position
- Add shielding to the transport cask once on the HCT
- Install fixtures on the HCT or on mobile equipment that can enhance the transfer process
- Add manipulators at the railbay to assist in trunnion removal of the horizontal transport cask

Vertical systems

- Reduce overall canister transfer duration
- Reduce overall worker radiation dose
- Replace all DPC system's transfer casks with a track mounted shielded transfer sleeve to automate canister transfer, eliminate crane time to perform canister transfer and standardize the transfer cask for all vertical storage systems
- Add cask transfer carts that can move transport casks and storage overpacks in and out of the canister transfer cells to a set location
- Install jib cranes at canister transfer cell entrances to remove transport cask lids for improved cask preparation time and reduced overhead crane time
- Add horizontal canister transfer fixture and hydraulic cask upend fixture to place horizontal DPC in lifting cage for storage alternatives that use vertical only storage (C-STD – all vertical storage, C-UGS, C-BGV and C-AGV)

Figure B2-1 shows a fairly new innovative HCT by Wheelift that employs the first four improvements listed above for horizontal systems. The Wheelift HCT is self-propelled and can move in any direction including forward-backward, lateral, diagonal, and rotational. This enables the unit to move laterally down a narrow apron between rows of NUHOMS modules and directly in front of a storage module. Current tractor-trailer HCTs require 50' to 70' of apron width to facilitate the backup movements necessary to place the trailer in front of a module. In addition, the unit is remotely operated eliminating the need for a worker to sit for long hauls in close proximity to the transport cask receiving radiation doses.

The Wheelift HCT also incorporates lasers on either side of the machine to enable hydraulic positioning unit to align to the proper location and elevation required for smooth transfer of the DPC to the storage module. Typically, conventional methods employ survey equipment to perform the alignment. The Wheelift HCT also contains a fixture to store the transport cask lid. These improvements decrease setup time required to position the transport cask to the storage module and therefore decrease worker doses.

Figure B2-1
Wheelift Horizontal Cask Transporter for AREVA TN Systems

Source: Doerfor Companies

Figure B2-2 shows an existing innovation used at some nuclear power plants aimed at reducing large radiation doses caused by the use of low weight horizontal transfer casks. Low weight transfer casks are used at plants where the overhead crane capacity is lower than 125 tons. The weight is lessened by removing cask wall thickness which removes shielding. This same principle can be used on horizontal transport casks once they are loaded on the HCT to lower radiation doses to workers throughout the transport and canister transfer process.

Figure B2-2
Removal Radiation Shielding on an AREVA TN Transfer Cask

Source: Omaha Public Power District

Improvements can be made during the horizontal canister operation. Some of the highest dose operations occur when the transport cask lid is removed before the HCT has docked up to the storage module and before the storage module lid is installed once the DPC has been transferred into the storage module and the HCT has moved away from the module. Currently a mobile stick crane is used to lift these lids so that workers can position the lids to the transfer cask or storage module. This process can be made more automated with fixtures hug by the mobile stick crane so that allow the lids to be swung back into place with minimal worker involvement.

Lastly, installing one or more manipulators at the railbay to assist in removal/attachment of trunnions on the horizontal transport casks. The NUHOMS transport casks require removal of their trunnions for shipment in order to stay within rail clearance requirements. The trunnions are secured to the cask with large bolts. This operation consumes some time and can add a significant dose to workers. Since the ISF will experience several shipments every year, it is necessary to institute ALARA measures to reduce doses so that each cask handling operation does not contribute significantly to the overall facility doses. The manipulators could be fitted with stud tensioners and grapples that lifted the heavy trunnions out of the way rather than using the overhead crane.

Figure B2-3 shows a conceptual 3D cutaway view of the canister transfer cell inside the CHB and transfer sleeve. Vertical canister transfers must be performed every week, therefore adding a track mounted shielded transfer sleeve and cask transfer carts will automate the entire canister transfer process and enhance safety, reduce operation time, and reduce radiation doses. For vertical-type systems, processing several different DPC systems would be cumbersome at best. Rather than employ several individual transfer casks, lifting yokes, and associated handling equipment from each system, the shielded transfer sleeve would perform the canister transfer operation for all storage systems processed through the CHB.

Since the overhead crane would not be used for canister transfer operations, it frees the overhead crane for offloading impact limiters, placing the incoming transport casks onto the cask transfer carts, and transferring horizontal transport casks onto the HCT.

The shielded transfer sleeve, which is open on top and bottom, would be positioned on a floor above the transfer cell on tracks and designed to be positioned over an opening located directly above the transport cask and storage overpack. The transfer sleeve would be rail-guided and operate remotely. It would be constructed with a steel and lead gamma shield and neutron shield, like any other transfer cask, so as not to preclude personnel from being near it when it contains a DPC. But it could operate remotely to vastly reduce radiation doses to workers during canister transfer operations. Since the ISF would be performing canister transfers every week, it is essential that the canister transfer radiation doses are mitigated to the maximum extent possible.

To prevent radiation streaming as the DPC is passing up or down through the floor opening, shielding could be placed around the openings or a shielding collar could be used to fit each cask.

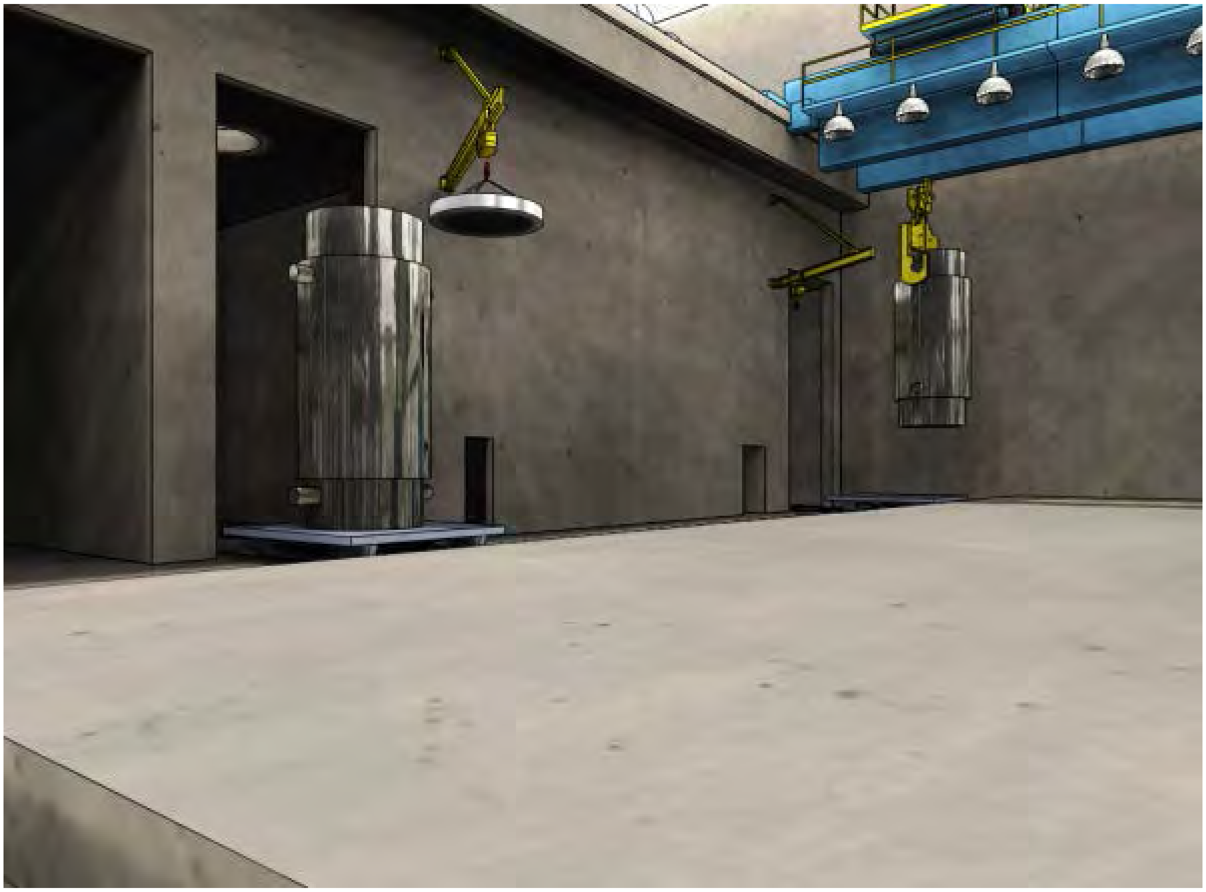
The use of the transfer sleeve would eliminate the cask “stack-up” configuration, in which the transfer cask is placed on top of a storage or transport cask to facilitate canister transfer between the casks. In addition, stacked cask stability during a seismic event is eliminated with use of a transfer sleeve. The installation of seismic struts to prevent a tip-over event, which take time to install or remove and subject workers to radiation doses, is eliminated. A single-failure-proof hoist would be mounted to the top of the shielded transfer sleeve to raise and lower the DPCs removing any need for overhead crane time.

Figure B2-3
3D Conceptual Cutaway View of the Canister Transfer Cell and Transfer Sleeve

Another innovation is the use of cask transfer carts that would be used to move both the transport cask and storage overpack in and out of the canister transfer cell. After the overhead crane unloads the transport cask, it would place the cask onto a transfer cart. The transfer cart would move the transport cask to a set position, directly under and fully aligned with the floor opening below the transfer sleeve. Likewise, a vertical cask transporter (VCT) would place a storage overpack onto a second transfer cart. This cart would move the storage overpack to a set position under a second floor opening. Once in place the transfer sleeve could retrieve the DPC from the transport cask, roll into position above the storage overpack and lower the DPC into the overpack. The transfer carts enable the canister transfer cell to be closed during the transfer to limit radiation dose exposure yet allow workers to enter the cell if there is a problem.

A third innovation is the use of a wall-mounted jib crane to enable removal of the transport cask lid prior to entry into the canister transfer cell. **Figure B2-4** shows the jib cranes in relation to the canister transfer cell door. The figure also shows the transport cask on a transfer cart. The jib crane would be sized for the lid weight. Once the lid was unbolted and secured by the jib crane, the lid could be swung out of way and then back again for reinstalling after the transport is returned from the canister transfer cell. The storage overpack lid would be removed and supported by the VCT that brought the overpack to the CHB. This is an innovation that came out of the dry cask industry and has proven to be a time saver. Removing both lids keeps the canister transfer cell free from lids, which consume valuable floor space.

Figure B2-4
3D Conceptual View of Jib Cranes for Securing the Transport Cask Lids



Lastly, the CHB could be designed with bays to facilitate a horizontal canister transfer fixture and hydraulic cask upend fixture. The fixtures would only be necessary for storage alternatives that use vertical only storage (C-STD-all vertical storage, C-UGS, C-BGV and C-AGV).

The horizontal transport canister would be offloaded from the railcar and placed on a HCT. The HCT would then move to this bay, align with the horizontal canister transfer fixture and the DPC pushed from the transport cask into the horizontal canister transfer fixture (See **Figure B2-5**). After the DPC is transferred, the horizontal canister transfer fixture would be upended using the hydraulic cask upend fixture. Once in the vertical position, the lifting cage with horizontal DPC cage would either be hoisted up into the transfer sleeve, moved over a standardized storage overpack (C-STD) or picked up by the VCT and transported to the underground storage system (C-UGS) or to a vault (C-BGV or C-AGV).

Figure B2-5
3D Conceptual View of Horizontal Canister Transfer Fixture

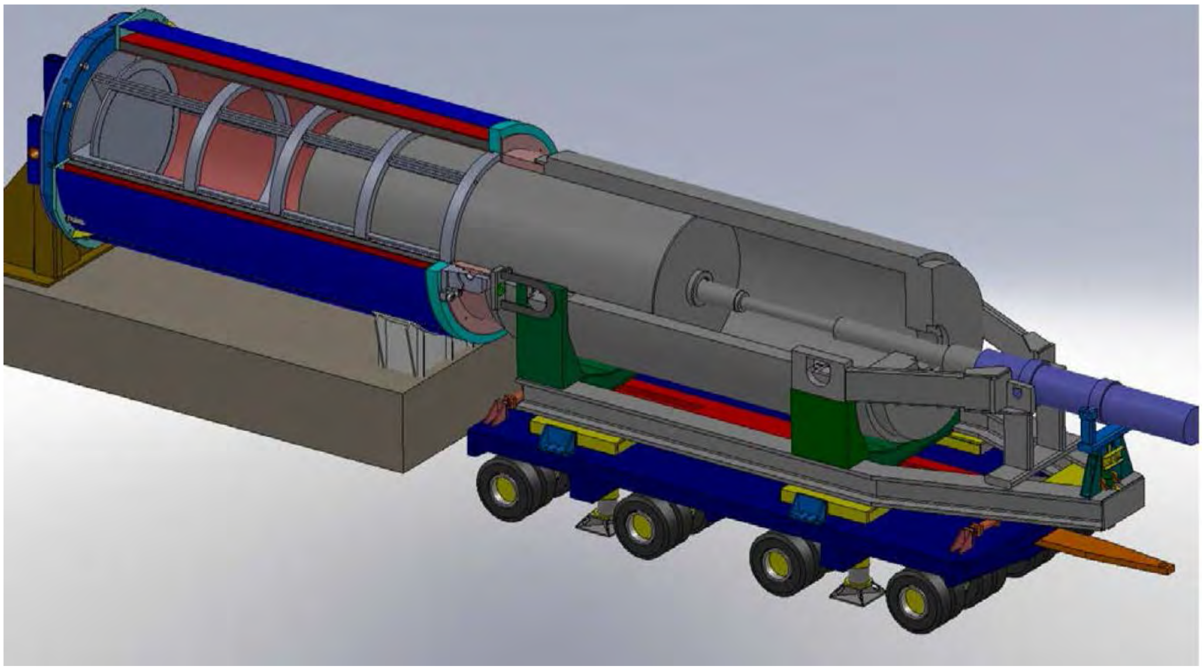


Table B2-1 provides a comparison of major vertical canister transfer steps between C-OPS, A-OPS, R-OPS and S-OPS.

Table B2-1
Comparison of Major Vertical DPC Transfer Operational Steps

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack to rail siding.
Overhead crane places transport cask into transfer cell	Overhead crane places transport cask onto transfer cart.	Overhead crane places transport cask onto transfer cart.	Gantry crane places transport cask on hard stand
Overhead crane removes transport cask lid	Jib Crane removes transport cask lid	Jib Crane removes transport cask lid	Gantry crane removes transport cask lid

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
	Transfer Cart moves transport cask into cell	Transfer Cart moves transport cask into cell	Transport Cask is secured seismically to hard stand
Transfer cell doors are closed	Transfer cell doors are closed	Transfer cell doors are closed	
Mating adapters are mounted to top of transport cask and storage cask.			Mating adapters are mounted to top of transport cask and storage cask.
Overhead crane places transfer cask on transport cask.	Transfer sleeve is located over transport cask		Overhead crane places transfer cask on transport cask.
Seismic/stack-up struts are attached to transfer cask.			Seismic/stack-up struts are attached to transfer cask.
Transfer cask is bolted to mating adapter.			Transfer cask is bolted to mating adapter.
Overhead crane raises DPC from transport cask up into transfer cask.	Transfer sleeve hoist raises DPC from transport cask into transfer sleeve.	Dedicated cell crane raises DPC from transport cask	Gantry crane raises DPC from transport cask up into transfer cask.
Transfer cask is unbolted from mating adapter.			Transfer cask is unbolted from mating adapter.
Seismic/stack-up struts are removed from transfer cask.			Seismic/stack-up struts are removed from transfer cask.
Overhead crane moves transfer cask from transport cask to storage overpack.	Transfer sleeve is moved from transfer cask position to storage overpack position.		Gantry crane moves transfer cask from transport cask to storage overpack.
Seismic/stack-up struts are attached to transfer cask.			Seismic/stack-up struts are attached to transfer cask.
Transfer cask is bolted to the mating adapter.			Transfer cask is bolted to the mating adapter.
Overhead crane lowers DPC from transfer cask to storage overpack.	Transfer sleeve hoist lowers DPC from transfer sleeve to storage overpack.	Dedicated cell crane lowers DPC into storage overpack.	Gantry crane lowers DPC from transfer cask to storage overpack.
Seismic/stack-up struts are removed from transfer cask.			Seismic/stack-up struts are removed from transfer cask.
Transfer cask is unbolted from mating adapter.			Transfer cask is unbolted from mating adapter.
Transfer cask is removed and placed back into storage location.			Transfer cask is removed and placed back into storage location.
Mating adapters are removed from storage and transport casks.			Mating adapters are removed from storage and transport casks.
Outside doors are opened	Outside doors are opened	Outside doors are opened.	

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
VCT drives into transfer cell	Transfer cart moves storage overpack outdoors.	Transfer cart moves storage overpack outdoors.	VCT maneuvers onto hard stand
VCT attaches to storage overpack	VCT attaches to storage overpack	VCT attaches to storage overpack	VCT attaches to storage overpack
Storage overpack lid is bolted on.	Storage overpack lid is bolted on.	Storage overpack lid is bolted on.	Storage overpack lid is bolted on.
VCT takes storage overpack to pad.	VCT takes storage overpack to pad.	VCT takes storage overpack to pad.	VCT takes storage overpack to pad.

B2-1.1 Cask Handling Building

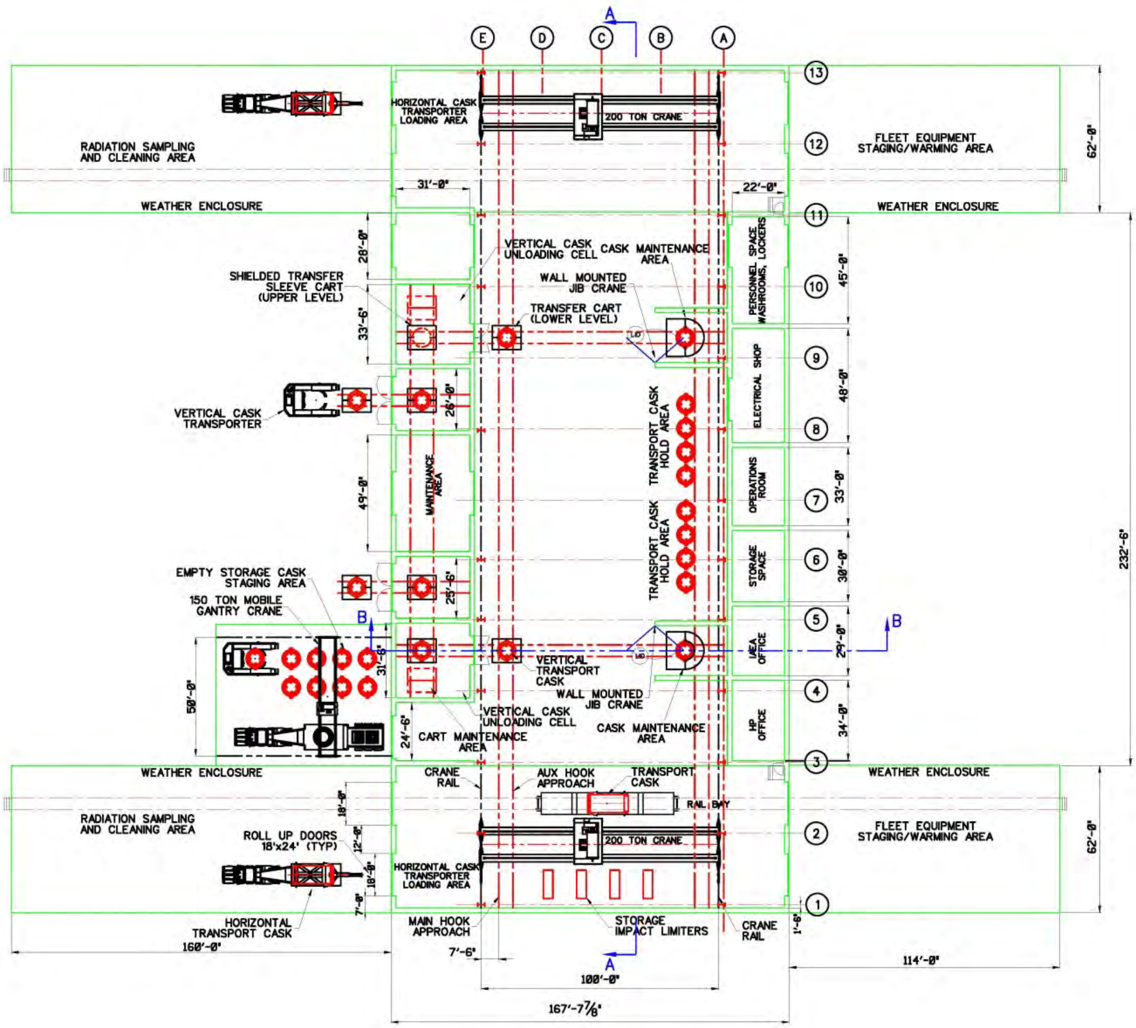
The A-OPS ISF would utilize a cask handling building (CHB). The purpose of the CHB is threefold; 1) receive SNF shipments (railcar and transport cask) in an environmentally controlled area; 2) provide the facilities to offload transport casks from railcars and place them on the horizontal cask transporter for horizontal systems or 3) offload transport casks to an radiological shielded area and transfer the DPCs from the transport casks to storage overpacks for vertical systems. A fourth purpose could be added in order to place a horizontal DPC into a lifting cage and upended if this alternative were used for placement into a storage overpack (C-STD-all vertical storage), underground storage system (C-UGS) or vault storage (C-BGV or C-AGV) alternatives.

The building would be designed to provide physical protection for the canisters and radiation shielding to the workers. For this alternative, the Cask Handling Building is laid out with all the features discussed above as shown in **Figure B2-6** and **Figure B2-7.**

The CHB for alternative A-OPS incorporates all of the automation features to improve throughput and operation as well as reduce worker doses. The building consists of two sets of a rail bay and truck bay servicing 2 vertical type canister transfer cells. This floor plan also includes two bays for moving a horizontal DPC into a lifting cage which is required for storage alternatives without horizontal storage since the horizontal DPCs have not means for vertical lifting.

The CHB has two dedicated 200 ton single-failure-proof overhead bridge cranes that can be used across the entire building but can travel independently from rail/truck bay to the transfer cells so that two cask handling operations can be performed at one time. When performing the operations evaluation, it was determined that a single rail/truck bay and 2 transfer cells would accommodate the required throughput of 1,500 MTU. The second half of the building is added for redundancy so that any one equipment failure will not jeopardize the required throughput. However, this redundant set of cells and bays would also enable a higher throughput. This design of the CHB can accommodate a throughput that will enable 5 DPCs to be placed into storage each week using 1 shift per day. This translates into an annual throughput of 260 DPCs placed into storage per year (approximately 3,000 MTHM per year) which is double the required throughput for the Pilot ISF.

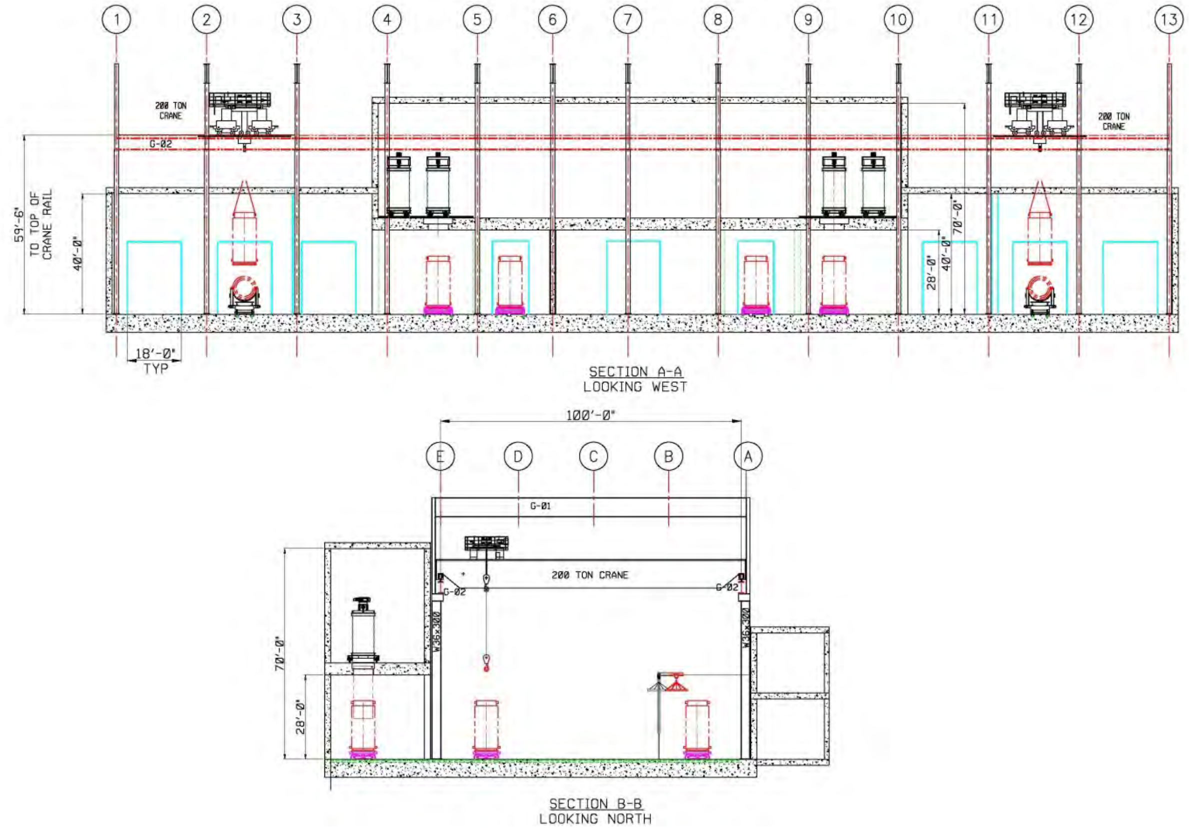
Figure B2-6
A-OPS Alternative – Cask Handling Building (Plan View)



The building also has a laydown area for impact limiters, staging area for transport casks and office area. The CHB would be a reinforced concrete structure with thick walls to protect all SNF casks, canisters, overpacks, and cask-handling equipment from the effects of earthquakes, tornado winds, tornado-generated missiles, fire, and explosions.

The CHB is designed to provide radiological shielding during canister transfer operations. Four vertical type canister transfer cells with reinforced concrete walls shield workers from dose intensive operations.

Figure B2-7
A-OPS Alternative – Cask Handling Building (Elevation View)



B2-2.0 Concept of Operations

B2-2.1 Material Handling Flow Diagram

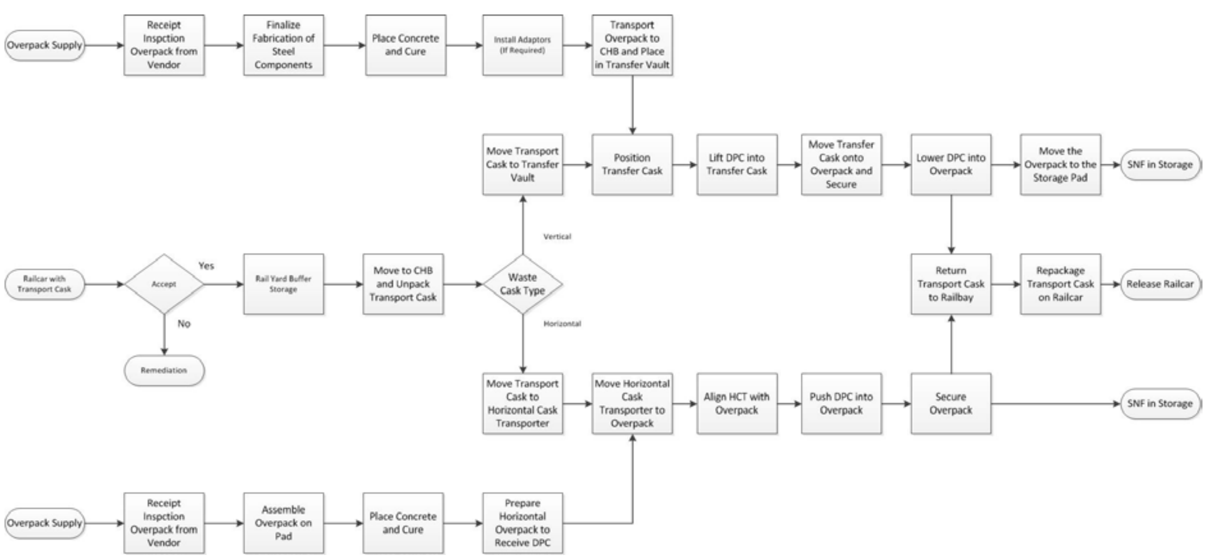
A-OPS evaluates labor-saving automated systems to improve the transfer of the DPC from the transport cask into the storage overpack. Instead of using riggers as spotters and a local crane operator to conduct the transfers, the A-OPS alternative uses remote sensors, and automated transfer carts and shielded transfer sleeves. The DPC transfer requires a canister transfer cell in the CHB to simplify DPC canister transfer operations. The transport cask is unpacked and placed vertically in a transfer cart. The transport cask lid is removed and a lifting lug assembly is bolted onto the top of the DPC. The cart then moves into the unloading side of the canister transfer cell and the shield door is closed. An automated shielded transfer sleeve mounted on rails above the transfer cell self-positions itself over the DPC lifting lug.

A hoist in the transfer sleeve lowers a grapple that engages the lifting lug and lifts the DPC up into the transfer sleeve. The transfer sleeve then rolls over to the receiving side of the transfer cell and aligns itself over the storage overpack that is prepositioned in the receiving side of the cell. The DPC is lowered into the storage overpack and the grapple is disengaged and withdrawn back into its uppermost position in the transfer sleeve. The storage overpack for this alternative is assumed to be the same as the original storage system used for this DPC at the SNF generator's site. The storage method will continue to be employed here at this version of the Interim Storage Facility (ISF).

Figure B2-8 is a representation of the material handling flow for the A-OPS alternative for the ISF. It describes the three large material flows of the operation. The central flow is the movement of DPCs containing SNF to the site. But equally important to the operations of the ISF are the material flows necessary to support the production of suitable storage overpacks to place the DPCs into after being accepted by the site for storage. The vertical storage overpacks are prefabricated by the vendors and shipped to the site as steel structures packaged to protect them during transit. The site crew needs to accept these packages as undamaged and then complete the fabrication and place the concrete necessary to complete the shield cask in accordance with the vendor's specification.

For horizontal storage systems, the site fabrication crew needs to fabricate and erect multi DPC storage modules using the vendor's design and components from the vendors. These modules are larger and more complex construction packages than the vertical overpacks and take longer to construct and to align to ensure that the DPCs can be readily placed into storage. Horizontal overpacks contain multiple DPCs so the lead time issues are exacerbated. The horizontal overpack represents a fairly major construction effort.

Figure B2-8
Canister Handling Material Handling Flow Diagram[1]



[1] Remediation is not part of this study's work scope and is not addressed other than to note that the packages are not accepted on site regardless of their condition.

The largest operations challenge for the A-OPS alternative is controlling the supply chain to ensure that the proper storage system and its various components are available to match the DPC being received from the generator. The licensability of the final DPC is based on the conformance of the storage system with the original licensed dry storage system. The preparation time for an overpack is at least a month after receipt of the hardware from the storage system vendor. The lead time for this shipment could be six to twelve months. Therefore, up to a year ahead of the receipt of the SNF at the site, the supply chain manager needs to place an order for the necessary storage system components. Well in advance of delivery of specific DPCs from the generator sites, the ISF staff needs to know what vendor-specific components are needed for the DPC being delivered. The coordination of the supply chain for the Overpack Fabrication and the SNF storage operations will be the largest management challenge for this design alternative. The correct DPC overpack needs to be staged in the receiving cell of the canister transfer cell or horizontal storage area prior to the beginning of the transfer process.

B2-2.2 Operations Sequence

Cask handling operations are a series of heavy lifts and heavy equipment movements that move the SNF in sealed DPCs from the rail head to the storage pad. The process sequence was benchmarked against ISFSI operations at operating nuclear plants. Although no one has actually performed all of the operations at an ISF, each operation has a precedent established in the nuclear industry. The crew sizes and the durations necessary to perform each activity therefore has basis. This benchmarking provides the underpinning supporting this operational sequence and the Time and Motion analysis in the following Section B2-2.3.

Table B2-2 lists all of the steps in the vertical DPC cask handling sequences. It shows the crew sizes and the durations for both the Base Case C-OPS process sequence and from the improved A-OPS sequence. As can be seen, the A-OPS approach reduces the duration of the cask transfer operations in C-OPS from the Base Case primarily by reducing the number of steps required. Whereas C-OPS takes four shifts to complete the cycle, the A-OPS takes only 2½ shifts. This reduction is achieved by simplifying and automating certain of the heavy lift activities associated with the positioning of the shielded casks and lifting and lowering the DPC with an automated process. These automated transfer systems not only reduce the time spent aligning the position of the heavy awkward casks relative to each other; it also reduces the crew sizes needed for the operations. This impact has the added benefit of reducing the radiation exposures to the workers for each DPC moved into storage.

Figure B2-9 shows the high-level schedule for the two storage concepts in C-OPS assuming 8-hour shifts. The vertical DPC shows the impact of the A-OPS improvements while the horizontal DPC schedule is presented for comparison. The operational sequence once the transport cask is accepted into the CHB can be divided into four large blocks:

1. Opening the Transport Cask
2. Moving the DPC into the Transfer device or system
3. Placement of the DPC in the Storage Overpack and
4. Preparing for the turnaround of the Transport Cask.

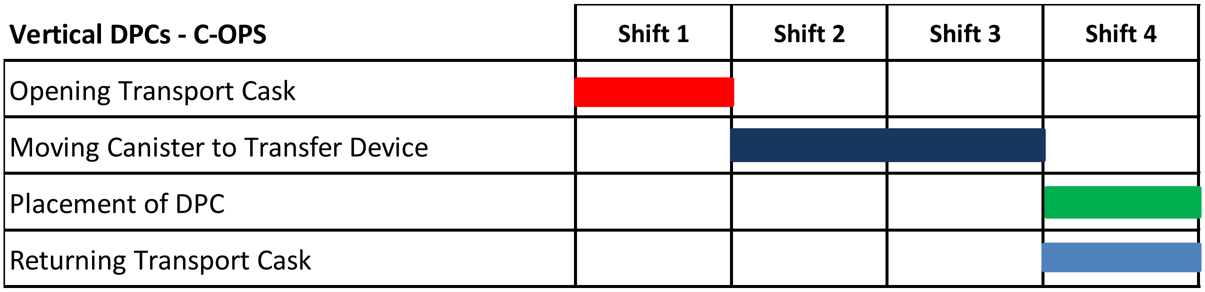
Table B2-2
Impact of Automated Canister Transfer Operation

Process Steps A-OPS for Vertical DPCs		C-OPS		A-OPS		Basis
		Total Staff	Duration (hrs)	Total Staff	Duration (hrs)	
0)	Plan of the Day and Safety Meeting	14	0.5	11	0.5	Standard Duration – Staffing Differs
1)	Receive transport cask on railcar at Cask Handling Building	11	1	11	1	No Change
2)	Remove impact limiters and place in temporary storage	8	3	8	3	No Change
3)	Upend and lift transport cask off of railcar and place on unloading cell	4	2	4	2	No Change
3a)	Remove railcar from Railbay	5	1	5	1	No Change
4)	Secure Seismic restraints to Transport Cask	10	2			Not Required
5)	Stage Empty Storage Cask into Receiving Cell using VCT	6	1	6	0.5	50% reduction due to automated positioning system
6)	Unbolt empty storage cask lid and hoist on VCT	7	1	6	0.75	25% reduction due to specialized detorque machines
7)	Retract VCT from receiving cell and close shield doors	4	0.5	4	0.5	No Change - Manual Process
8)	Secure Seismic Restraints to Storage Cask	6	1	3	0.25	75% reduction due to automated self-powered cart and preinstalled restraints
9)	Mount adapter plates to Storage Cask	9	0.5			Not Required
9a)	Plan of the Day and Safety Meeting	12	0.5	10	0.5	Standard Duration – Staffing Differs
10)	Unbolt and remove transport cask lid using jib crane	9	1	9	1	No Change - Manual Process
11)	Attach lifting lug to top of DPC	9	1	9	1	No Change - Manual Process
12)	Mount adapter plates to Transport Cask	14	1			Not Required
13)	Install the Transfer Cask on Transport Cask using the OTB Crane	7	1			Not Required
14)	Bolt Transfer Cask to Transport Cask adapter plate	12	1			Not Required
15)	Raise DPC from Transport Cask up into Transfer Cask	7	1	4	0.75	25% Reduction due to automated positioning sys.
15a)	Plan of the Day and Safety Meeting	11	0.5	10	0.5	Standard Duration – Staffing Differs
16)	Unbolt Transfer cask from the adapter plate	13	1			Not Required
17)	Move Transfer Cask to the Storage Cask using OTB crane	5	1	3	0.5	50% reduction due to automated self-powered transfer cart
18)	Bolt Transfer Cask to Storage Cask adapter plate	9	1			Not Required

Process Steps A-OPS for Vertical DPCs		C-OPS		A-OPS		Basis
		Total Staff	Duration (hrs)	Total Staff	Duration (hrs)	
19)	Lower canister from Transfer Cask into Storage Cask	5	1	5	0.5	50% reduction due to automated self-powered transfer cart
20)	Unbolt Transfer Cask from Adapter Plate	8	1			Not Required
21)	Remove Transfer Cask and place it back into storage	4	1			Not Required
22)	Remove adaptor plates from Storage Cask	12	1			Not Required
22a)	Plan of the Day and Safety Meeting	17	1			Not Required
23)	Remove Lifting Lug from Canister	9	0.5	9	0.5	No Change - Manual Process
24)	Remove seismic/stack-up struts from Storage Cask	12	1			Not Required
25)	Dock VCT with Storage Cask and bolt on the lid	7	1	6	1	No Change - Manual Process
26)	Transport Storage Cask to pad using VCT	4	2	4	2	No Change - Manual Process
26a)	Turnover to Operations	7	24	73	24	No Change
27)	Return VCT to CHB	4	2	4	1	No Change
28)	Remove adaptor plates from Transport Cask	11	1			Not Required
29)	Install transport cask lid	9	1	9	1	No Change - Manual Process
30)	Lift transport cask and transfer to maintenance	6	1	6	1	No Change - Manual Process
30a)	Survey and wipedown Transport Cask	3	1	3	1	No Change - Manual Process
30b)	Reposition Empty Railcar to Railbay	7	1	7	1	No Change - Manual Process
31)	Lift transport cask and place on railcar	8	1	8	1	No Change - Manual Process
32)	Install impact limiters on transport cask	7	2	7	2	No Change - Manual Process
33)	Release railcar for shipment	9	1	9	1	No Change

It should be noted that A-OPS enables the vertical DPC storage process to be completed in less than three shifts. This is the result of being able to the begin the moving the DPC into the storage overpack in the first shift that makes the Transport Cask available for repackaging early enough in the second shift to compete the repackaging during the second shift. Most of the amount of activity that extends into the third shift is non-critical path activities to return the VCT to the CHB.

Figure B2-9
High-Level Operational Sequences



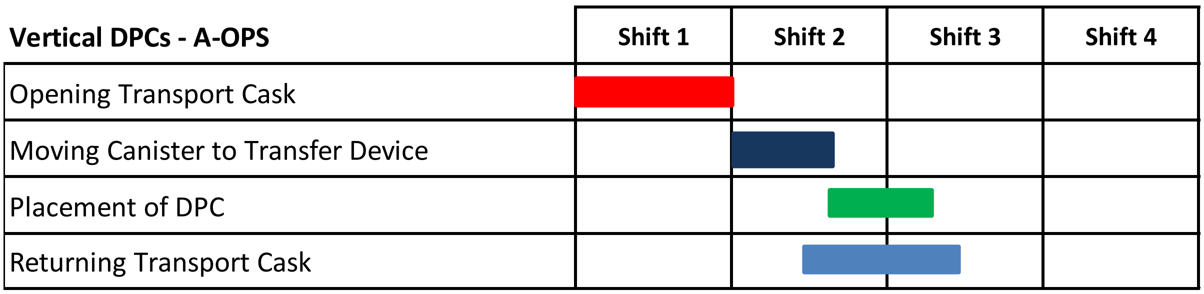
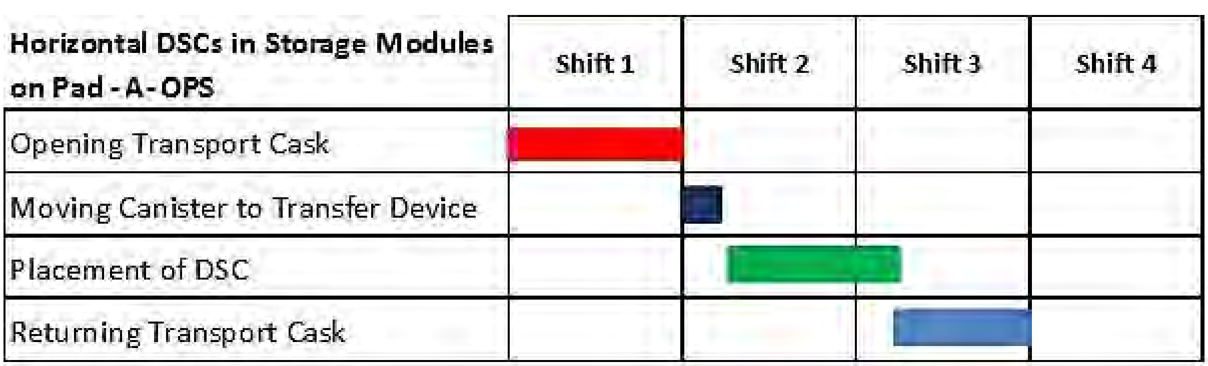


Figure B2-10 shows the impact of A-OPS on horizontal DSCs. As described above, the duration for the complete cycle remains essentially a three shift exercise even with the reduced duration by the Wheelift transporter. The Transport Cask is placed on the HCT in the first shift, it cannot be moved to the pad because the duration of the first steps at the pad exceed the time remaining in the first shift. So, they must be deferred until the second shift. Those activities take essentially an entire 8-hour shift, so the expedited recycling steps cannot be achieved earlier because the Transport Cask is on the HCT on the pad until the beginning of the third shift. So, some benefit is achieved, is it not significant in the case of horizontal DSCs.

Figure B2-10
High-Level Operational Sequences – Horizontal DSCs



B2-2.3 Time and Motion Analysis

B2-2.3.1 Methodology

No one has operated an automated canister transfer system for SNF bearing DPCs. For this study, a high-level operational sequence was developed by the concept designers for the A-OPS. These high-level activities were then decomposed down to their constituent activities. At this level, the activities were generally ones that have been performed by operators at existing nuclear facilities, or that could be estimated by small extrapolations of existing operational experience. Interviews were conducted with several individuals with real, hands-on operational experience with moving SNF to achieve a consensus on the completeness, the durations and the staff size necessary to achieve each of these constituent activities. These were then pieced together to develop a bottom up estimate of durations and crew sizes for each step. A-OPS would require a cask handling crew of 32 workers.

Automated transfer systems were postulated to reduce the times necessary to achieve alignment and safe lifts of the DPC. No means were considered that would have automated the installation and removal of the lifting lug assembly. Such a mechanism would have had a beneficial impact on dose rates but would not have appreciably improved the results. The alignment systems and automated transfer systems represent simple extrapolations of commonly available industrial positioning systems.

Since all of the transfer activities are automated, the exposures to radiation during this transfer are minimized. However, the activities that result in the greatest worker exposures are associated with activities that require direct contact with the DPC. These activities include opening the Transport Cask, attaching the lifting lug assembly, removing the lifting lug assembly and installing the overpack lid. No means were considered that would have automated the installation and removal of these components. Such a mechanism would have had a beneficial impact on dose rates but would not have appreciably improved the results. The alignment systems and automated transfer systems represent simple extrapolations of commonly available industrial positioning systems.

B2-2.3.2 Conclusion

It is determined that the A-OPS can process an average of five DPCs placed into storage every week. This assumes that there are two railbays, with two overhead bridge cranes and six cask transporters. Most of that time savings was achieved by the reduction in manual operations. Although there was considerable improvement over C-OPS, the vertical DPCs could only be processed a rate of four per week. This is an improvement over the C-OPS rate of 2.5 per week. There was a slight improvement on horizontal DPC process time but it was negligible over C-OPS and the throughput of horizontal DPCs at the ISF would remain at about five DPCs per week.

The addition of automated systems in a radiation environment raises the possibility of additional failure rates and extra maintenance activities. Due to the potential that the failure would occur when the system was transferring DPCs, any failure would result in an interruption in the ISF throughput. However, most of the transducers are employed when the shielding is in place, so this is judged to be a minor concern.

There needs to be four HCTs and two VCTs on site to develop and maintain full ISF throughput. This conclusion is slightly changed from the C-OPS Base Case. These are extremely slow moving machines. Their size and mass make them destructive of the road bed if they move too rapidly. Moreover, they are restrained from moving too rapidly when carrying DPCs in order to limit the potential impact should there be a failure of any kind. They become critical path constraints if any one of them is out of service. In addition, they are currently designed for a limited amount of duty. The ISF would use these machines far more than their design. This could force a great deal of maintenance to keep them available. One or two spares are considered necessary for the long-term functionality of the ISF.

Figure B2-11 below show the schedule for the A-OPS alternative. The activities on the Y-axis are the steps necessary to process the DPCs from when they enter the Cask Handling Building until the empty transport cask has been reinstalled on the railcar and removed from the CHB. The time across the top of the schedule is in hours. The red bars are critical path activities; the blue are near critical path activities. It has been assumed that it will take 24-hours of observations of the DPC once stored to accept the package. This activity is show as a green dashed line on this chart but is not really part of the cask handling crew's scope. It is the hand-off to ISF Operations for long-term surveillance and safeguards. It will consist of a series of temperature, air flow and radiation measurements over the initial 24-hour period to validate that the expected performance has been achieved.

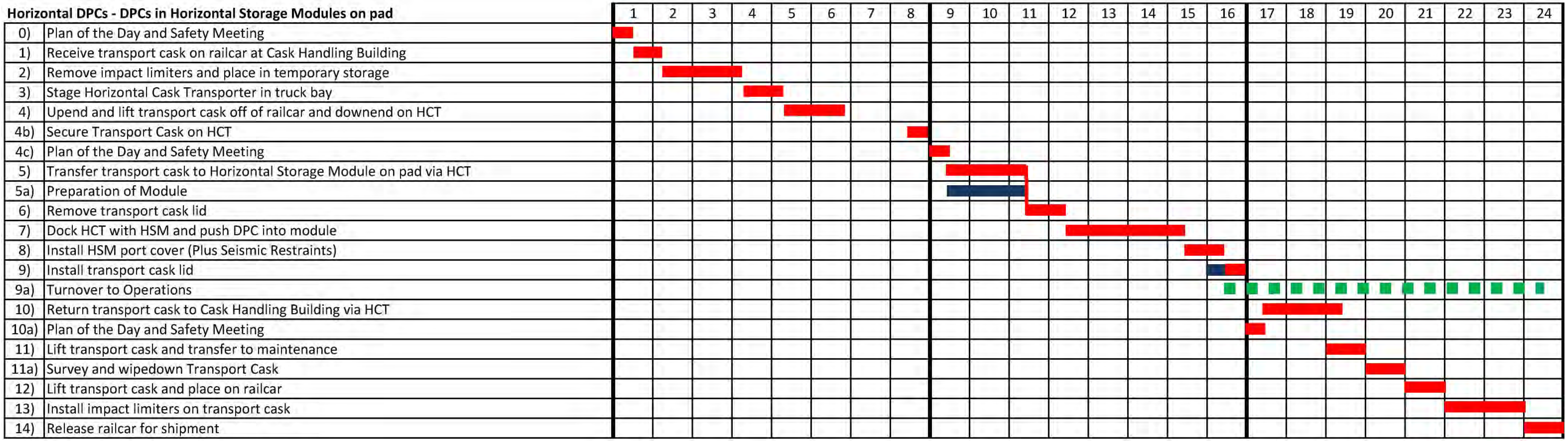
The schedules in **Figure B2-11** were then placed in series and in parallel to establish the maximum throughput of the ISF. The improvement in the overall schedule over C-OPS is enough to make it credible to start the second railcar midway through the third shift, thus enabling the processing of two vertical DPCs per railbay per week. Horizontal savings for A-OPS are negligible and the processing rate for horizontal DPCs employing A-OPS remains the same as the Base Case, i.e., five DPCs per week.

The crew size is reduced about ten FTEs over the Base Case. This reduction in cost would be the major improvement of this approach. The real tangible benefit of this approach is a reduction in the necessary Cask Handling Crew size from an average of 49 in the C-OPS Base Case to an average of 39 for the A-OPS alternative. The crew size for the processing of horizontal DPCs is unchanged from the base case.

Figure B2-11
Time Motion Schedules for Commercial Operations (A-OPS)

Vertical DPCs - DPCs in storage casks on pad		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0)	Plan of the Day and Safety Meeting																								
1)	Receive transport cask on railcar at Cask Handling Building																								
2)	Remove impact limiters and place in temporary storage																								
3)	Upend and lift transport cask off of railcar and place on unloading cell transfer cart																								
3a)	Replace empty railcar																								
4)	Unbolt and remove transport cask lid using jib crane																								
4a)	Secure Transport Cask on HCT																								
4b)	Plan of the Day and Safety Meeting																								
5)	Attach lifting lug to top of DPC																								
6)	Position transport cask transfer cart in unloading cell and close shield doors																								
7)	Stage empty storage cask in receiving cell using VCT																								
8)	Unbolt empty storage cask lid and hoist on VCT																								
9)	Retract VCT from receiving cell and close shield doors																								
10)	Position shielded transfer sleeve cart over unloading cell																								
11)	Lower shield sleeve hoist and grapple DPC lifting lug																								
12)	Raise DPC into shield sleeve																								
13)	Position shielded transfer sleeve cart over storage cask in receiving cell																								
14)	Lower DPC into empty storage cask, release grapple, and retract hoist																								
15)	Open receiving cell shield doors and position VCT at storage cask																								
16)	Remove lifting lug from DPC																								
17)	Install storage cask lid																								
18)	Pick up storage cask and transfer to pad using VCT																								
18a)	Turnover to Operations																								
19)	Return VCT to CHB																								
20)	Open unloading cell shield doors and position transfer cart under jib crane																								
21)	Install transport cask lid																								
22)	Lift transport cask and transfer to maintenance																								
22a)	Survey and Wipedown Transport Cask																								
22b)	Reposition Empty Railcar to Railbay																								
22c)	Plan of the Day and Safety Meeting																								
23)	Lift transport cask and place on railcar																								
24)	Install impact limiters on transport cask																								
25)	Release railcar for shipment																								

Figure B2-11
Time Motion Schedules for Commercial Operations (A-OPS) (Cont.)



B2-3.0 Performance of Structures, Systems and Components

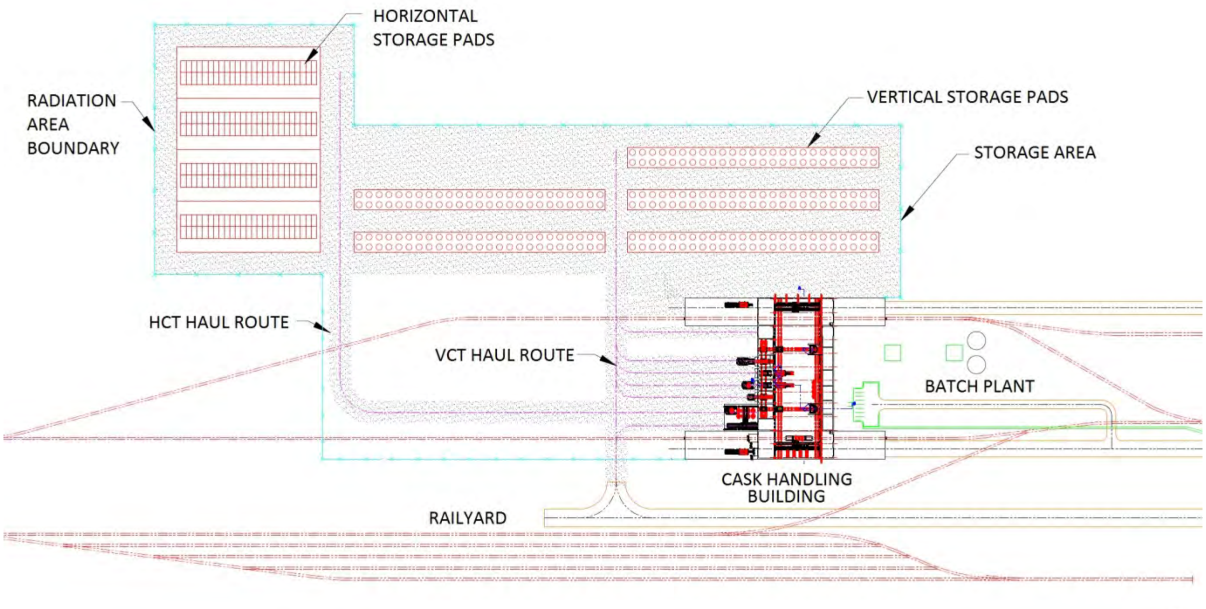
B2-3.1 Facility Layout and Equipment Evaluation

The facility layout is very similar to the C-OPS alternative except that the CHB contains all the equipment to automate the process. This alternative has automated systems and computer controlled operations that improve efficiency while reducing the need for people to be near the DPC packages. These improvements are built into the components and do not change the overall layout of the Base Case CHB.

The sensors and computer controls of the transfer carts, the transfer casks and the miscellaneous hoists and other features are all conventional devices commonly in use in industry today. They would need to be hardened against the effects of radiation, but otherwise do not extend technology beyond current practice.

Figure B2-12 shows the layout of the site using the A-OPS cask handling approach. It shows the location of the CHB in relation to the storage pads and the HCT and VCT haul routes.

Figure B2-12
Pilot ISF Cask Handling Building in Relation to Storage Area



This approach requires the CHB which is a fairly large structure housing the cranes, rail bays, canister transfer cells, and VCT and HCT bays.

B2-3.2 Structural and Seismic Evaluation

The seismic stability of the pads and storage overpacks is addressed in Appendix A1. For Alternative B2, the primary structure affected by a seismic event is the CHB. The CHB is a fairly large structure. For the 0.25G earthquake, the capacity of the CHB, which is constructed of reinforced concrete, to resist seismic forces is significant.

For the 0.75G earthquake, the acceleration demands at the top of the CHB are significant especially when both overhead cranes are carrying large loads. Design consideration must be considered in relation to the height of the building, placement of the overhead crane rails, and smallest width of the building. The actual maximum seismic capacity of the CHB will be dependent on the structure design and material design limits to mitigate the 0.75G earthquake demands. Additional structures may need to be employed to stabilize the top of the structure. In addition, the foundation may need to be thickened to resist overturning moments applied across the minor axis. The seismic/stack-up restraints or struts will also need to be considered in the buildings ability to resist seismic loads.

B2-3.3 Radiological Evaluation

The exposures to radiation for the workers at the ISF were based on the time and motion study and the assumed average dose rates from the DPCs stored at the site. Once installed in their storage locations, the doses to workers and to the public are quite small. However, during canister handling operations, workers still need to work on top of DPCs and near the transport cask and the transfer casks even though much of the process has been automated. In addition, plant security officers need to visually inspect the inside of the transport cask for contraband as soon as it is opened and will sustain some doses. Workers on vertical cask storage units need to bolt a lifting lug directly onto the DPC and after it has been transferred to the storage overpack.

Most of the activities are conducted well away from the DPC and behind shielding. But some of the activities require hands-on contact to the DPC or working near the open end of shield casks or overpacks.

The radiation doses associated with dry storage concepts are well understood and readily available from the literature regarding ISFSI operations at the generators' sites. Most of the radiation doses at operating plant sites are associated with the loading of the storage canisters in the fuel pool and the subsequent passivation steps of drying, inerting and welding closed the storage canisters. Once the canisters are loaded into their storage overpack, there are few remaining issues.

Vertical storage casks have radiation streaming at the bottom of the cask where the cool air inlets are. Also, when working around the top of the canister in either the transport cask or the storage cask, the dose rate streaming up the annular gap between the canister and the shield when the lid is removed is significant to the workers. So care needs to be exercised with securing the shield cask lid to the top of the cask and with securing the seismic hold downs for the cask on the pad.

Horizontal storage systems expose workers to higher radiological doses when preparing the module to receive the spent nuclear fuel canister. The shielded cover needs to be removed from the storage module for the new storage location. However, the storage module is not well shielded from the neighboring module so that the area around the opening is a high radiation area. Once the HCT has docked with the storage module, the dose rates are quite low and remain so during the entire transfer operation. However, in order to secure the canister seismically, a worker needs to reach into the module and insert a shear pin in the module that precludes the canister shifting toward the cover plate during a seismic event. This is a high radiation evolution that needs to be addressed by the final ISF design. Design modifications could be developed to eliminate the need to have workers routinely reaching into a storage module to attach a seismic restraint.

Table B2-3 shows typical dose rates near waste packages of interest for this study. These are not licensing basis values, but rather, typical values for old spent nuclear fuel.

Table B2-3
Typical Dose Rates Near Casks (mrem/hr)

Component	Top	Top Side	Side	Bottom
Transport Cask	15.0	31.8	34.0	15.0
Vertical Storage Cask Open	254.0	150.0	44.0	111.0
Vertical Storage Cask Sealed	18.4	20.0	44.0	111.0
Horizontal Storage Module	Near Opening 7.1		Inside 163.2	
General Area CHB	< 0.5 mrem/hr			

Section 6.4 of the Report, "Occupational Dose/ALARA Analysis of Storage Alternatives" shows cask handling operations for A-OPS and their respective doses which are shown in **Table B2-4**.

Table B2-4
Duration and Radiation Doses for C-OPS Cask Handling Operations

Alternative	Storage Configuration	Duration of Transfer Operation (hours)	Radiation Dose per Transfer (mrem) (Entire Operations Staff Dose)
A-OPS, Automated Canister Transfer	Vertical	21	251
	Horizontal	22	198

B2-3.4 Equipment Maintenance Evaluation

The A-OPS systems would increase the need for maintenance of the automated systems. In the C-OPS Base Case, these components are simplistic devices with a minimum of automated controls. Adding instrumentation necessary to automate the movements and the functions of these devices would represent a minor increase in the maintenance requirements. However, it should be noted that the major equipment maintenance requirement for the ISF is the need to keep the VCTs and the HCTs at the site operable. The changes in maintenance within the CHB are minor in comparison.

B2-3.5 Licensing Evaluation

The A-OPS alternative will be somewhat more difficult to license than C-OPS because it employs a number of features that have not been previously licensed. However, most of the innovations use equipment that has been licensed in some form. The shielded transfer sleeve introduces a new approach to canister transfer but still uses the basic transfer cask concepts already in use today. The design of the automated systems would have to be single failure proof and redundant in their design, but do not increase the risk of licensing this alternative over the C-OPS.

The site specific Safety Analysis Report will need to detail the CHB structure design and margins, all operations, work areas within the CHB, radiation doses, and address a suite of manmade and natural accidents or off-normal events to show that there are no unsafe operations of the ISF. NUREG-1567 (Reference B2-14) contains detailed guidance that can be followed to ensure all aspects of this alternative are adequately addressed. The onsite worker doses and offsite dose to the public will need to be calculated at strategic locations around the ISF to ensure ALARA.

In addition, the Environmental Report will need to address all facility components and operational steps to ensure that environmental regulations are adhered to. The ramifications of the Environmental Report also affect off-site conditions that could be adversely altered due to traffic from worker numbers, noise, solid waste, liquid waste, sewage water, etc. All site activities will need to be addressed because this will be the basis for the NRC Environmental Impact Statement.

B2-3.6 Modular Concepts Evaluation

Modularization of this alternative is not necessary. Once the CHB is constructed it can provide the storage and throughput needs of the Pilot ISF, Expanded ISF and larger ISF. If higher throughput rates are desired additional shifts can be added to meet the demands rather than construct additional cask handling facilities. The approach appears to be essentially linear. Doubling the shifts and staffing will double the throughput.

B2-4.0 Summary

A-OPS introduces a number of innovations that automate the canister transfer process which reduces the time workers need to be near the DPC and therefore worker doses

This alternative can process a vertical DPC in 2½ shifts and a horizontal DPC in 3 shifts or an overall average of five horizontal DPCs placed into storage every week resulting in an overall throughput of approximately 3,000 MTHM per year. This throughput can be attained providing the CHB has two rail/truck bays and two overhead cranes. A higher throughput can be established by utilizing more shifts per day.

The average overall dose to workers is 251 mrem processing a vertical DPC and 198 mrem processing a horizontal DPC.

In summary, the pros and cons to this alternative, listed from the highest most significant impact to the lowest least significant impact are as follows:

<u>Pros</u>

- The operation steps in A-OPS improve consistency, reliability, worker safety and reduce worker doses.
- A-OPS standardizes canister transfer equipment that would be designed to process all 13 different systems that need to be accommodated. This is a major advantage over C-OPS since it eliminates equipment required for multiple systems.

<u>Cons</u>

- A-OPS uses an enhanced cask handling building from C-OPS to perform transport cask offloading and canister transfer operations. This facility is a large structure that increases the cost of this alternative.
- A-OPS canister transfer using a canister transfer sleeve and through-the-floor canister movements will require shielding innovations yet to be designed.

B2-5.0 References

1. AREVA TN Updated Final Safety Analysis Report for the Standardized NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No, 72-1004.
2. AREVA TN Updated Final Safety Analysis Report for the Advanced NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC, Docket Number 72-1029.

3. AREVA TN Final Safety Analysis Report for the NUHOMS HD Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1032.
4. FuelSolutions Storage System Final Safety Analysis Report, NRC Docket No. 72-1026.
5. FuelSolutions W74 Canister Storage Final Safety Analysis Report, NRC Docket No. 72-1026.
6. Holtec International Final Safety Analysis Report for the HI-STAR 100 Cask System, NRC Docket No. 72-1008.
7. Holtec International Final Safety Analysis Report for the HI-STORM 100 Cask System, NRC Docket No.: 72-1014.
8. Holtec International Final Safety Analysis Report on the HI-STORM FW MPC Storage System, NRC Docket No. 72-1032.
9. Holtec International Final Safety Analysis Report on the HI-STORM UMAX Canister Storage System, NRC Docket 72-1040.
10. NAC Final Safety Analysis Report for the Multi-Purpose Canister (NAC-MPC), NRC Docket No. 72-1025.
11. NAC Final Safety Analysis Report MPC-LACBWR Amendment, NRC Docket No. 72-1025.
12. NAC Final Safety Analysis Report for the Universal MPC System (UMS) Universal Storage System, NRC Docket No. 72-1015.
13. NAC Final Safety Analysis Report for the MAGNASTOR (Modular Advanced Generation Nuclear All-purpose STORage) System, NRC Docket No. 72-1031.
14. NRC NUREG-1567, Standard Review Plan for Spent Fuel Dry Storage Facilities, Rev. 0, March 2000.

APPENDIX B3

STUDY 2 - ALTERNATIVE CASK HANDLING METHODS

Alternative 3 – Remote Cask Handling Operations (R-OPS)

Alternative 3 – Remote Cask Handling Operations (R-OPS)

B3-1.0 Description of Handling Alternative

Alternative 3 evaluates the impact of remotely handling the dual purpose canister (DPC) to accomplish the transfer operations. The evaluation will consider only the vertical DPC transfer operations because the horizontal DPC transfers are made on horizontal cask transporters (HCTs) and there are essentially no transfer activities that can be performed remotely.

For this study, all of the spent nuclear fuel (SNF) received at the ISF is packaged in canister-based systems. Canister-based systems use a DPC where SNF assemblies are placed into a welded sealed metal container. The DPC is a welded sealed metal container where the SNF assemblies are placed. The DPC is placed in different overpacks or casks for transport, storage or transfer between the transport cask and storage overpack. A typical PWR canister will hold 24 to 37 PWR SNF assemblies and a typical BWR canister will hold 61 to 89 BWR SNF assemblies. These systems fall into one of two categories: vertical or horizontal type systems. There are four companies that provide canister-based dry cask storage systems which are:

- AREVA TN
  - NUHOMS (horizontal) (Reference B3-1, B3-2 and B3-3)
- EnergySolutions
  - Fuel Solutions (vertical) (Reference B3-4 and B3-5)
- Holtec International
  - HI-STAR (vertical) (Reference B3-6)
  - HI-STORM (vertical) (Reference B3-7 and B3-8)
  - HI-STORM UMAX (vertical) (Reference B3-9)
- NAC International
  - MPC (vertical) (Reference B3-10 and B3-11)
  - UMS (vertical) (Reference B3-12)
  - MAGNASTOR (vertical) (Reference B3-13)

This alternative is compared to the base case presented in C-OPS described in Appendix B1 of this study. The C-OPS alternative uses the Cask Handling Building (CHB) for many cask and DPC handling activities. The base case employs a vertical canister transfer process using the cask stack-up approach used at the operating nuclear plants. The process relies on a transfer cask to extract the DPC from the transport cask and to transfer it to the storage overpack. The cask stack-up occurs when the transfer cask is bolted to the top of the transport cask or storage overpack. The cask stack-up must be seismically restrained due to a high center of gravity and the resulting potential for toppling over during an earthquake. R-OPS will examine the benefits of performing the vertical canister transfer remotely in a shielded "hot cell" which eliminates the need of a transfer cask and cask stack-up.

R-OPS will examine the benefits of a remote vertical canister transfer process as follows:

Horizontal systems

- No change from A-OPS. Use advanced HCT and additional shielding added in A-OPS

Vertical systems

- Streamline the canister transfer process by eliminating the transfer cask.
- No other changes from A-OPS

Figure B3-1 shows a 3D conceptual view of a remote canister transfer cell.

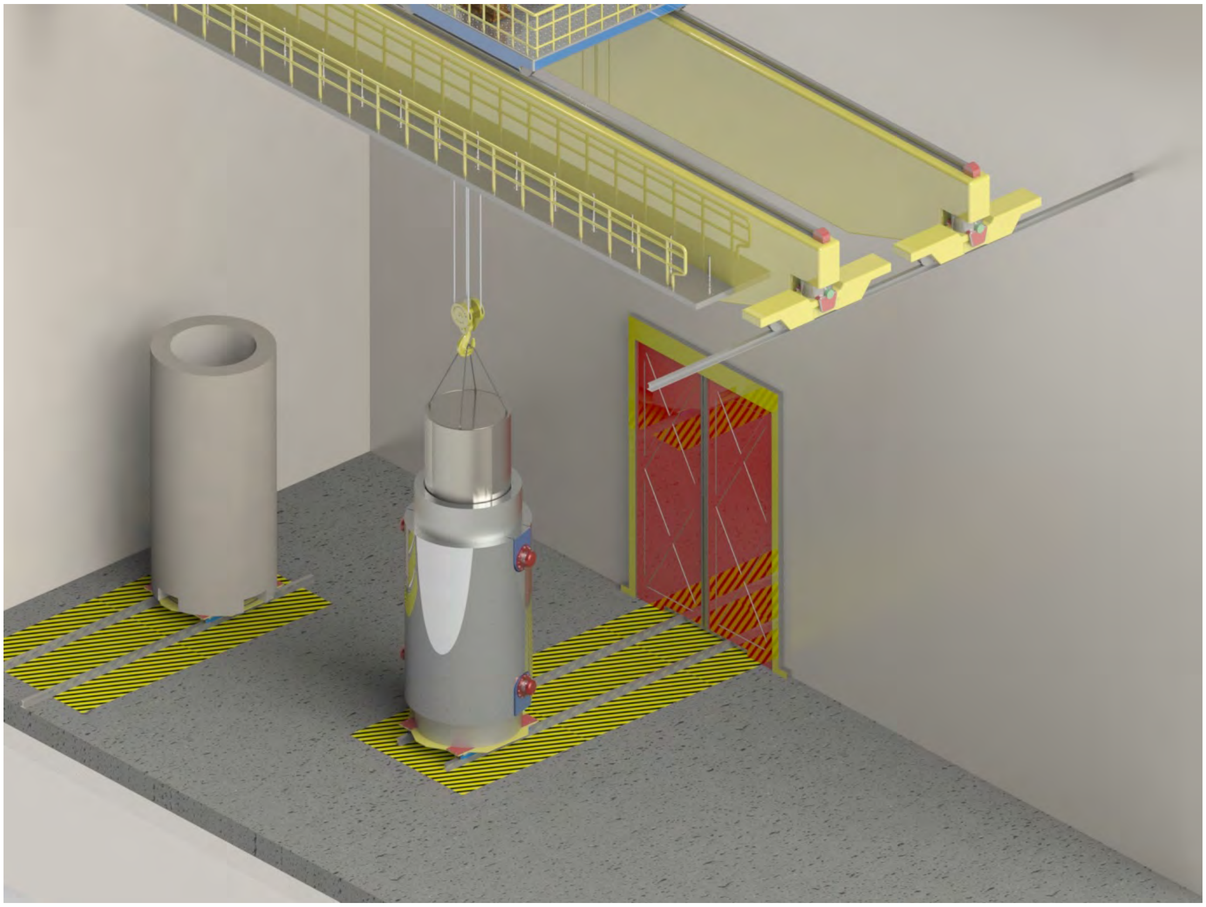
Typical vertical canister transfer activities utilize a transfer cask that serves as a temporary container and means of transfer for the DPC between the spent fuel pool, transport cask or storage overpack. The transfer cask also provides a means of lifting the DPC and radiation shielding during the transfer. The DPC is constructed of a thin metal shell which only provides containment of the spent nuclear fuel (SNF) assemblies. Without the transfer cask, the DPC radiation doses could reach between 2,000 to 10,000 Rem.

The use of the transfer cask involves a number of operations, many of which are eliminated by remote operation. **Table B3-1** provides a comparison of major vertical canister transfer steps between C-OPS, A-OPS, R-OPS, and S-OPS. Clearly it can be seen that fewer steps are required for R-OPS from the other alternatives. The R-OPS alternative shows time saved without a transfer cask.

Vertical canister transfers must be performed every week, therefore eliminating the transfer cask would reduce operation time and reduce radiation doses for workers that would otherwise be in close contact with the DPC. R-OPS also eliminates the prospect of having to employ 13 different individual transfer casks, lifting yokes, and associated handling equipment from each system. In addition, this alternative eliminates the seismic issues associated with cask "stack-up" configuration since no stack-up occurs.

A major impact to this alternative is that when the DPC is removed from either the transport cask or storage overpack it emits a very high radiation dose in the cell. This means that no workers can enter the cell during the transfer. Essentially, the cell becomes a "hot cell" environment. The walls of the cells would need to be thick enough to attenuate the radiation from the DPC. The ceiling over the cells would also need to be thick reinforced concrete. There could be no streaming paths around the cell and doors would need special seals. Each cell would need to be sealed off from all other cells. Oil filled or leaded windows could be used for operators to observe canister transfer activities. Closed circuit TV cameras could also be used to ensure that the alignment of the DPC is accurate so that the DPC never impacts the wall of the casks during movements. R-OPS frees the overhead crane from transfer activities, however, it requires a dedicated overhead crane of at approximately 100 tons inside each of the canister transfer cells.

Figure B3-1
3D Conceptual View of a Remote Canister Transfer Cell



Lastly, R-OPS would require remote equipment failure mitigation strategies. Workers could not enter the cell if a failure of the dedicated cell crane occurred with the DPC outside of a cask. Therefore, each cell would need to be designed so that the crane could manually lower the DPC back into a cask or to the floor and the crane winched into a shielded safe area where workers could resolve the crane problems.

Table B3-1
Comparison of Major Vertical DPC Transfer Operational Steps

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack to rail siding.
Overhead crane places transport cask into transfer cell	Overhead crane places transport cask onto transfer cart.	Overhead crane places transport cask onto transfer cart.	Gantry crane places transport cask on hard stand
Overhead crane removes transport cask lid	Jib Crane removes transport cask lid	Jib Crane removes transport cask lid	Gantry crane removes transport cask lid
	Transfer Cart moves transport cask into cell	Transfer Cart moves transport cask into cell	Transport Cask is secured seismically to hard stand
Transfer cell doors are closed	Transfer cell doors are closed	Transfer cell doors are closed	
Mating adapters are mounted to top of transport cask and storage cask.			Mating adapters are mounted to top of transport cask and storage cask.
Overhead crane places transfer cask on transport cask.	Transfer sleeve is located over transport cask		Overhead crane places transfer cask on transport cask.
Seismic/stack-up struts are attached to transfer cask.			Seismic/stack-up struts are attached to transfer cask.
Transfer cask is bolted to mating adapter.			Transfer cask is bolted to mating adapter.
Overhead crane raises DPC from transport cask up into transfer cask.	Transfer sleeve hoist raises DPC from transport cask into transfer sleeve.	Dedicated cell crane raises DPC from transport cask	Gantry crane raises DPC from transport cask up into transfer cask.
Transfer cask is unbolted from mating adapter.			Transfer cask is unbolted from mating adapter.
Seismic/stack-up struts are removed from transfer cask.			Seismic/stack-up struts are removed from transfer cask.
Overhead crane moves transfer cask from transport cask to storage overpack.	Transfer sleeve is moved from transfer cask position to storage overpack position.		Gantry crane moves transfer cask from transport cask to storage overpack.
Seismic/stack-up struts are attached to transfer cask.			Seismic/stack-up struts are attached to transfer cask.
Transfer cask is bolted to the mating adapter.			Transfer cask is bolted to the mating adapter.
Overhead crane lowers DPC from transfer cask to storage overpack.	Transfer sleeve hoist lowers DPC from transfer sleeve to storage overpack.	Dedicated cell crane lowers DPC into storage overpack.	Gantry crane lowers DPC from transfer cask to storage overpack.

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
Seismic/stack-up struts are removed from transfer cask.			Seismic/stack-up struts are removed from transfer cask.
Transfer cask is unbolted from mating adapter.			Transfer cask is unbolted from mating adapter.
Transfer cask is removed and placed back into storage location.			Transfer cask is removed and placed back into storage location.
Mating adapters are removed from storage and transport casks.			Mating adapters are removed from storage and transport casks.
Outside doors are opened	Outside doors are opened	Outside doors are opened.	
VCT drives into transfer cell	Transfer cart moves storage overpack outdoors.	Transfer cart moves storage overpack outdoors.	VCT maneuvers onto hard stand
VCT attaches to storage overpack	VCT attaches to storage overpack	VCT attaches to storage overpack	VCT attaches to storage overpack
Storage overpack lid is bolted on.	Storage overpack lid is bolted on.	Storage overpack lid is bolted on.	Storage overpack lid is bolted on.
VCT takes storage overpack to pad.	VCT takes storage overpack to pad.	VCT takes storage overpack to pad.	VCT takes storage overpack to pad.

B3-1.1 Cask Handling Building

R-OPS would utilize a cask handling building (CHB). The purpose of the CHB is threefold; 1) receive SNF shipments (railcar and transport cask) in an environmentally controlled area; 2) provide the facilities to offload transport casks from railcars and place them on the horizontal cask transporter for horizontal systems and 3) offload transport casks to an radiological shielded area and transfer the DPCs from the transport casks to storage overpacks for vertical systems.

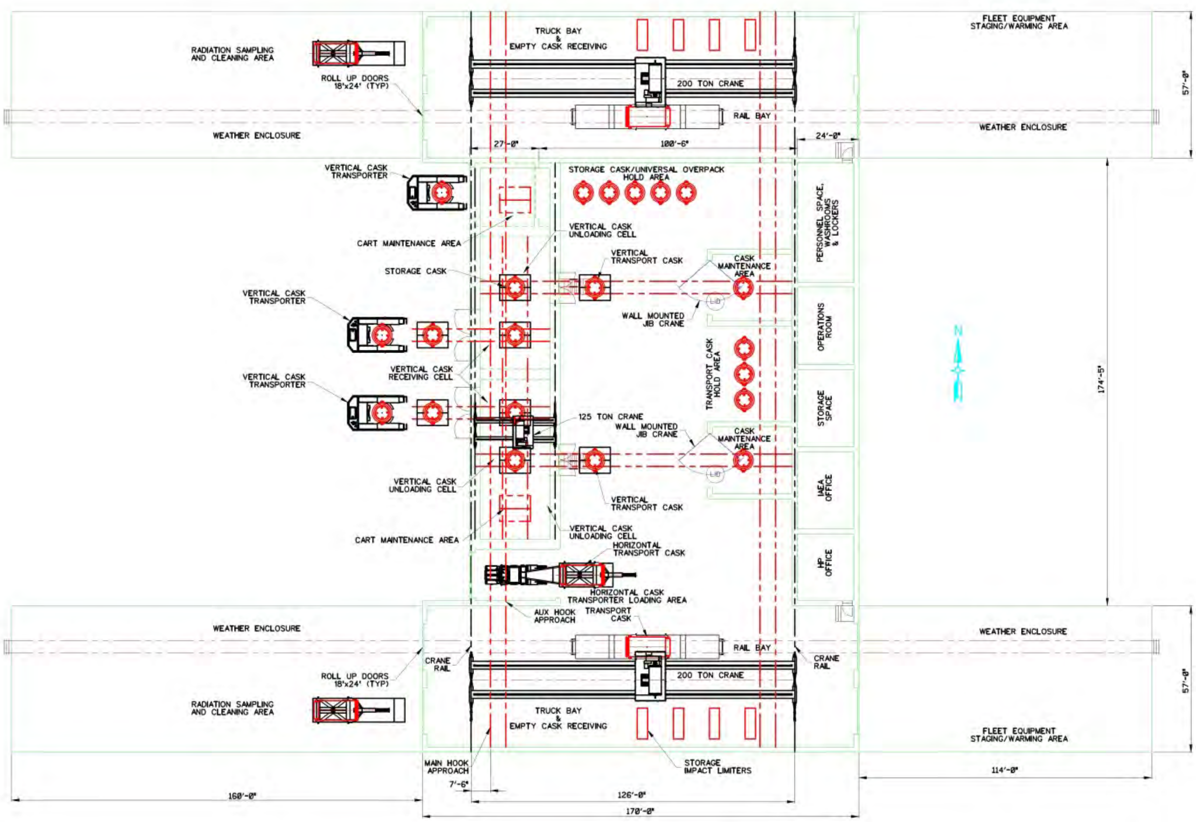
The building would be designed to provide physical protection for the canisters and radiation shielding to the workers. For this alternative, the Cask Handling Building is laid out with all the features discussed above as shown in **Figure B3-2** and **Figure B3-3.**

The CHB for alternative R-OPS incorporates all of the automation features incorporated in A-OPS to improve throughput and operation as well as reduce worker doses. The building consists of two sets of a rail bay and truck bay servicing 2 vertical type canister transfer hot cells.

The CHB has two dedicated 200 ton single-failure-proof overhead bridge cranes that can be used across the entire building but can travel independently from rail/truck bay to the transfer cells so that two cask handling operations can be performed at one time. The building also has two 125 ton dedicated canister hot cell overhead cranes.

When performing the operations evaluation, it was determined that a single rail/truck bay and 2 transfer cells would accommodate the required throughput of 1,500 MTU. The second half of the building is added for redundancy so that any one equipment failure will not jeopardize the required throughput. However, this redundant set of cells and bays would also enable a higher throughput. This design of the CHB can accommodate a throughput that will enable 5 DPCs to be placed into storage each week using 1 shift per day. This translates into an annual throughput of 260 DPCs placed into storage per year (approximately 3,000 MTHM per year) which is double the required throughput for the Pilot ISF.

Figure B3-2
R-OPS Alternative – Cask Handling Building (Plan View)



The building also has a laydown area for impact limiters, staging area for transport casks and office area. The CHB would be a reinforced concrete structure with thick walls to protect all SNF casks, canisters, overpacks, and cask-handling equipment from the effects of earthquakes, tornado winds, tornado-generated missiles, fire, and explosions.

The R-OPS CHB is designed to provide radiation shielding during canister transfer operations. Both vertical type canister transfer cells would be shielded with thick reinforced concrete walls to shield workers from very high dose operations and oil filled or leaded glass windows and cameras to enable workers to observe transfer operations.

Figure B3-3
R-OPS Alternative – Cask Handling Building (Elevation View)

B3-2.0 Concept of Operations

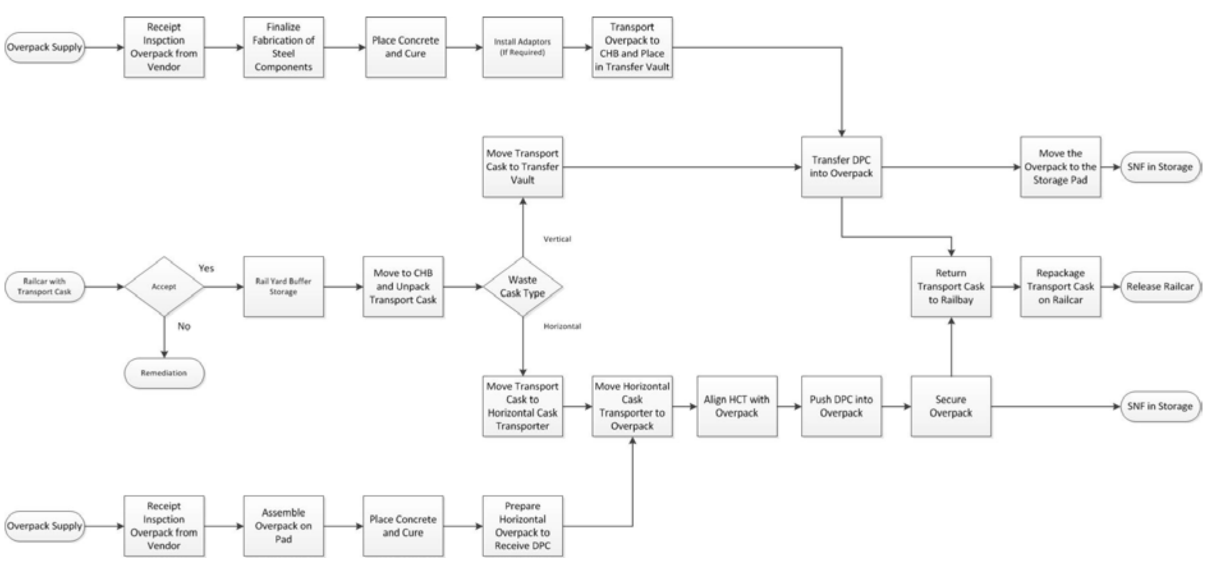
B3-2.1 Material Handling Flow Diagram

R-OPS considers the use of a remote hot-cell in which the transfer of the DPC from the transport cask to the overpack without the need for a shielded transfer cask. This alternative replaces the complexity of multiple steps to transfer the DPC first into a transport cask and then into a storage overpack with a simple pick and place using a crane in a shielded hot-cell. Instead of using riggers as spotters and a local crane operator to affect the transfers, the R-OPS alternative uses a remote viewing system and an overhead traveling bridge crane in a hot-cell to affect the DPC transfer. The DPC transfer requires a revision to the CHB in the Base Case to replace the transfer cells with a two story hot-cell with a dedicated overhead traveling bridge crane.

This would be an atmospheric hot-cell with shield doors. No inerting is required. The transport cask is unpacked and placed vertically in a transfer cart. The lid is removed and a lifting lug assembly is bolted onto the top of the DPC. The cart is then moved into the hot-cell. The storage overpack has already been placed in the hot-cell. The shield doors are closed and the crane grapples the lifting lug on the DPC, removes it from the transport cask and transfers to the overpack. Once the transfer has been accomplished, the shield doors are opened and the Overpack is moved out. The lifting lug assembly is removed and the overpack lid is installed. The vertical cask transporter (VCT) picks up the overpack and takes it to the storage location on the pad. Meanwhile, the transport cask is removed from the hot-cell and returned to the railbay for repackaging on the railcar.

Figure B3-4 is a representation of the material handling flow for the R-OPS alternative for the ISF. It describes the three large material flows of the operation. The central flow is the movement of DPCs containing SNF to the site. But equally important to the operations of the ISF are the material flows necessary to support the production of suitable storage overpacks to place the DPCs into after being accepted by the site for storage. The vertical storage overpacks are prefabricated by the vendors and shipped to the site as steel structures packaged to protect them during transit. The site crew needs to accept these packages as undamaged and then complete the fabrication and place the concrete necessary to complete the shield cask in accordance with the vendor's specification. As stated earlier, the R-OPS approach applies only to the canister transfer operations of the vertical DPCs.

Figure B3-4
Cask Handling Material Handling Flow Diagram[1]



[1] Remediation is not part of this study's work scope and is not addressed other than to note that the packages are not accepted on site regardless of their condition.

The largest operations challenge for the R-OPS alternative is controlling the supply chain to ensure that the proper storage system and its various components are available to match the DPC being received from the generator. The licensability of the final DPC is based on the conformance of the storage system with the original licensed dry storage system. The preparation time for an overpack is at least a month after receipt of the hardware from the storage system vendor. The lead time for this shipment could be six to twelve months. Therefore, up to a year ahead of the receipt of the SNF at the site, the supply chain manager needs to place an order for the necessary storage system components. Well in advance of delivery of specific DPCs from the generator sites, the ISF staff needs to know what vendor-specific components are needed for the DPC being delivered. The coordination of the supply chain for the Overpack Fabrication and the SNF storage operations will be the largest management challenge for this design alternative. The correct DPC overpack needs to be staged in the receiving cell of the hot cell prior to the beginning of the transfer process.

B3-2.2 Operations Sequence

Cask handling operations are a series of heavy lifts and heavy equipment movements that move the SNF in sealed DPCs from the rail head to the storage pad. The process sequence was benchmarked against ISFSI operations at operating nuclear plants. Although no one has actually performed all of the operations at an ISF, each operation has a precedent established in the nuclear industry. The crew sizes and the durations necessary to perform each activity therefore has basis. This benchmarking provides the underpinning supporting this operational sequence and the Time and Motion analysis the follows in **Section B3-2.3**.

Table B3-2 lists all of the steps in the vertical DPC cask handling sequences. It shows the crew sizes and the durations for both the Base Case C-OPS process sequence and from the improved R-OPS sequence. As can be seen, the R-OPS approach reduces the duration of the cask transfer operations in C-OPS primarily by reducing the number of steps required.

Whereas C-OPS takes four shifts to complete the cycle, the R-OPS takes only 2½ shifts. This reduction is achieved by simplifying and automating certain of the heavy lift activities associated with the positioning of the shielded casks and lifting and lowering the DPC with an automated process. These automated transfer systems not only reduce the time spent aligning the position of the heavy awkward casks relative to each other; it also reduces the crew sizes needed for the operations. This alternative eliminates the transport cask and all of its complexity and handling. This impact has the added benefit of reducing the radiation exposures to the workers.

Table B3-2
Impact of Remote Canister Transfer Operation

Process Steps R-OPS for Vertical DPCs		C-OPS		R-OPS		Basis
		Total Staff	Duration (hrs)	Total Staff	Duration (hrs)	
0)	Plan of the Day and Safety Meeting	14	0.5	11	0.5	Standard Duration – Staffing Differs
1)	Receive transport cask on railcar at Cask Handling Building	11	1	11	1	No Change
2)	Remove impact limiters and place in temporary storage	8	3	8	3	No Change
3)	Upend and lift transport cask off of railcar and place on unloading cell	4	2	4	2	No Change
3a)	Remove railcar from Railbay	5	1	5	1	No Change
4)	Secure Seismic restraints to Transport Cask	10	2			Not Required
5)	Stage Empty Storage Cask into Receiving Cell using VCT	6	1	5	0.5	50% reduction due to automated positioning system
6)	Unbolt empty storage cask lid and hoist on VCT	7	1	6	0.75	25% reduction due to specialized torque machines
7)	Retract VCT from receiving cell and close shield doors	4	0.5	4	0.5	No Change - Manual Process
8)	Secure Seismic Restraints to Storage Cask	6	1	3	0.25	75% reduction due to automated self-powered cart and preinstalled restraints
9)	Mount adapter plates to Storage Cask	9	0.5			Not Required
9a)	Plan of the Day and Safety Meeting	12	0.5	10	0.5	Standard Duration – Staffing Differs
10)	Unbolt and remove transport cask lid using jib crane	9	1	9	1	No Change - Manual Process
11)	Attach lifting lug to top of DPC	9	1	9	1	No Change - Manual Process
12)	Mount adapter plates to Transport Cask	14	1			Not Required
13)	Install the Transfer Cask on Transport Cask using the OTB Crane	7	1			Not Required
14)	Bolt Transfer Cask to Transport Cask adapter plate	12	1			Not Required
15)	Raise canister from Transport Cask up into Transfer Cask	7	1	4	0.5	Simplified Crane Movement w/o Transfer Cask
15a)	Plan of the Day and Safety Meeting	11	0.5	8	0.5	Standard Duration – Staffing Differs
16)	Unbolt Transfer cask from the adapter plate	13	1			Not Required
17)	Move Transfer Cask to the Storage Cask using OTB crane	5	1	3	0.5	Simplified Crane Movement w/o Transfer Cask
18)	Bolt Transfer Cask to Storage Cask adapter plate	9	1			Not Required
19)	Lower canister from Transfer Cask into Storage Cask	5	1	3	0.5	Simplified Crane Movement w/o Transfer Cask
20)	Unbolt Transfer Cask from Adapter Plate	8	1			Not Required

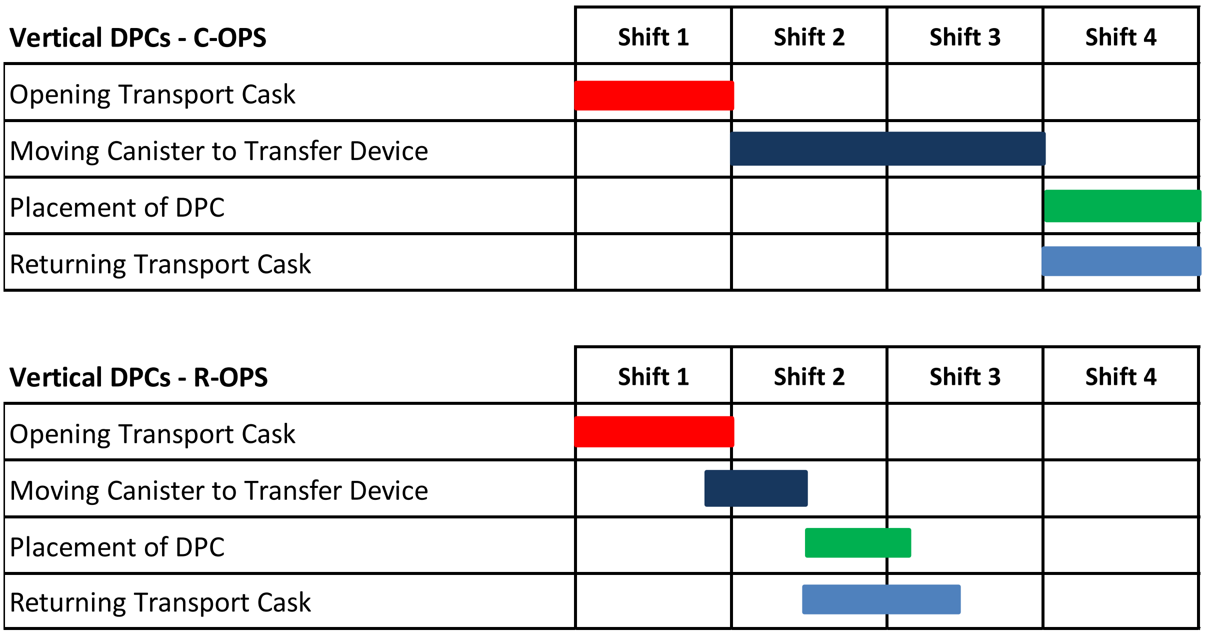
Process Steps R-OPS for Vertical DPCs		C-OPS		R-OPS		Basis
		Total Staff	Duration (hrs)	Total Staff	Duration (hrs)	
21)	Remove Transfer Cask and place it back into storage	4	1			Not Required
22)	Remove adaptor plates from Storage Cask	12	1			Not Required
22a)	Plan of the Day and Safety Meeting	17	1			Not Required
23)	Remove Lifting Lug from Canister	9	0.5	8	0.5	No Change - Manual Process
24)	Remove seismic/stack-up struts from Storage Cask	12	1			Not Required
25)	Dock VCT with Storage Cask and bolt on lid	7	1	6	1	No Change - Manual Process
26)	Transport Storage Cask to pad using VCT	4	2	7	24	No Change - Manual Process
26a)	Turnover to Operations	7	24	3	2	No Change
27)	Return VCT to CHB	4	2	4	1	No Change
28)	Remove adaptor plates from Transport Cask	11	1			Not Required
29)	Install transport cask lid	9	1	7	1	No Change - Manual Process
30)	Lift transport cask and transfer to maintenance	6	1	6	1	No Change - Manual Process
30a)	Survey and wipedown Transport Cask	3	1	3	1	No Change - Manual Process
30b)	Reposition Empty Railcar to Railbay	7	1	7	1	No Change - Manual Process
31)	Lift transport cask and place on railcar	8	1	8	1	No Change - Manual Process
32)	Install impact limiters on transport cask	7	2	7	2	No Change - Manual Process
33)	Release railcar for shipment	9	1	9	1	No Change

In general, the number of steps in R-OPS are significantly reduced compared to C-OPS.

Figure B3-5 shows a comparison of the high-level schedule for the C-OPS and R-OPS vertical DPC operation concepts assuming 8-hour shifts. The operational sequence once the transport cask is accepted into the CHB can be divided into four major operations:

1. Opening the Transport Cask
2. Moving the DPC into the Transfer device or system
3. Placement of the DPC in the Storage Overpack and
4. Preparing for the turnaround of the Transport Cask.

Figure B3-5
High-Level Operational Sequences



B3-2.3 Time and Motion Analysis

B3-2.3.1 Methodology

There is no operational experience for the transfer of DPCs in a hot-cell. For this study, a high-level operational sequence was developed by the concept designers for the R-OPS. These high-level activities were then decomposed down to their constituent activities. At this level, the activities were generally ones that had been performed by operators at existing nuclear facilities, or that could be estimated by small extrapolations of existing operational experience. Interviews were conducted with several individuals with real, hands-on operational experience with moving SNF to achieve a consensus on the completeness, the durations and the staff size necessary to achieve each of these constituent activities. These were then pieced together to develop a bottom up estimate of durations and crew sizes for each step. R-OPS would require a cask handling crew of 32 workers.

The remote transfer systems were identified and steps necessary only for the remote systems were retained. It appears that there is not inherent advantage of the Remote Transfer of SNF over the Automated Transfer systems postulated in the A-OPS alternative described in Appendix B2. R-OPS eliminates the transfer cask and their systems but adds a remote crane in a hot-cell. Hot-cell cranes are problematic because they need to be designed to recover from any failure remotely. If the crane fails with the load out of the shielding provided by the transport cask or the storage overpack, a means must be integrated into the design to recover without the need for workers to enter the hot-cell. This increases the costs and reduces the benefits of this alternative.

Since all of the transfer activities take place in a heavily shielded hot-cell, the exposures to radiation during this transfer are minimized. However, the activities that result in the greatest worker exposures are associated with activities that require direct contact with the DPC. These activities include opening the transport cask, attaching the lifting lug assembly, removing the lifting lug assembly and installing the overpack lid. No means were considered that would have automated the installation and removal of these components. Such a mechanism would have had a beneficial impact on dose rates but would not have appreciably improved the results. The alignment systems and automated transfer systems represent simple extrapolations of commonly available industrial positioning systems.

B3-2.3.2 Conclusion

It is determined that the R-OPS can process an average of five DPCs placed into storage every week. This assumes that there are two railbays, with two overhead bridge cranes, two hot cell overhead bridge cranes and six cask transporters. Most of that time savings was achieved by the reduction in manual operations. Although there was considerable improvement over C-OPS, the R-OPS alternative would represent a small improvement in ISF throughput A-OPS. Like A-OPS, it is possible to get the vertical canister cycle done in 2½ shifts which results in four vertical DPCs per week. Coupled with the same horizontal throughput as C-OPS or A-OPS, the overall throughput of the ISF using R-OPS would remain at about five DPCs per week.

The addition of remote systems in a radiation environment raises the possibility of additional failure rates and extra maintenance activities. Due to the potential that the failure would occur when the system was transferring DPCs, any failure would result in an interruption in the ISF throughput. However, most of the transducers are employed when the shielding is in place, so this is judged to be a minor concern.

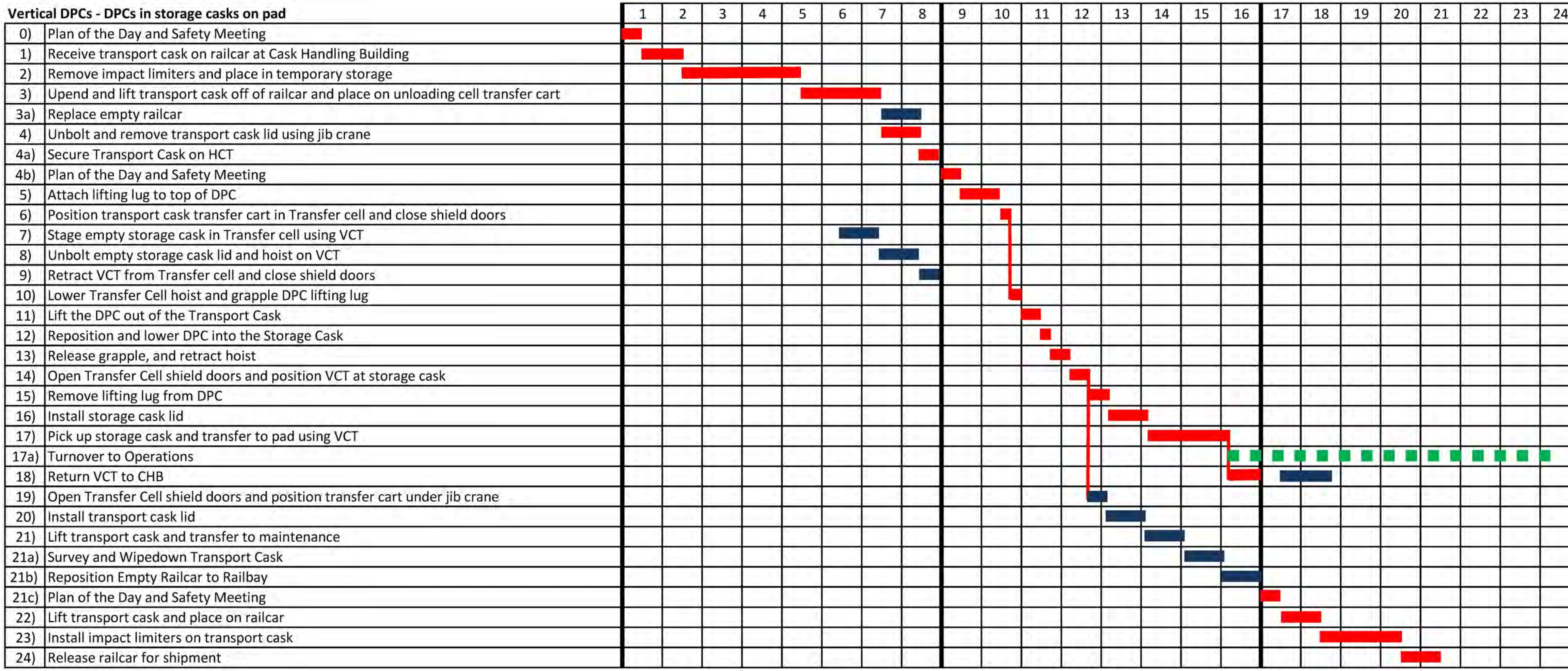
R-OPS requires four HTCs and four VCTs on site to develop and maintain full ISF throughput. This conclusion is unchanged from C-OPS but more than A-OPS which reduced the number of VCTs to two. These are extremely slow moving machines. Their size and mass make them destructive of the road bed if they move too rapidly. Moreover, they are restrained from moving too rapidly when carrying DPCs in order to limit the potential impact should there be a failure of any kind. They become critical path constraints if any one of them is out of service. In addition, they are currently designed for a limited amount of duty. The ISF would use these machines far more than their design. This could force a great deal of maintenance to keep them available. One or two spares are considered necessary for the long-term functionality of the ISF.

Figure B3-6 below shows the schedule for the R-OPS alternative. The activities on the Y-axis are the steps necessary to process the DPCs from when they enter the Cask Handling Building until the empty transport cask has been reinstalled on the railcar and removed from the CHB. The time across the top of the schedule is in hours. The red bars are critical path activities; the blue are near critical path activities. It has been assumed that it will take 24-hours of observations of the DPC once stored to accept the package. This activity is show as a green dashed line on this chart but is not really part of the cask handling crew's scope. It is the hand-off to ISF Operations for long-term surveillance and safeguards. It will consist of a series of temperature, air flow and radiation measurements over the initial 24-hour period to validate that the expected performance has been achieved.

The schedules in **Figure B3-6** were then placed in series and in parallel to establish the maximum throughput of the ISF. The improvement in the overall schedule over C-OPS is enough to make it credible to start the second railcar midway through the third shift, thus enabling the processing of two vertical DPCs per railbay per week. Since R-OPS doesn't change the horizontal DPC throughput, the processing rate for horizontal DPCs remains the same as the Base Case, i.e., five DPCs per week.

The crew size is reduced about ten FTEs over the Base Case. This reduction in cost would be the major improvement of this approach. The real tangible benefit of this approach is a reduction in the necessary Cask Handling Crew size from an average of 49 in the C-OPS Base Case to an average of 39 for the R-OPS alternative. The crew size for the processing of horizontal DPCs is unchanged from the base case.

Figure B3-6
Time Motion Schedules for Commercial Operations (R-OPS)



B3-3.0 Performance of Structures, Systems and Components

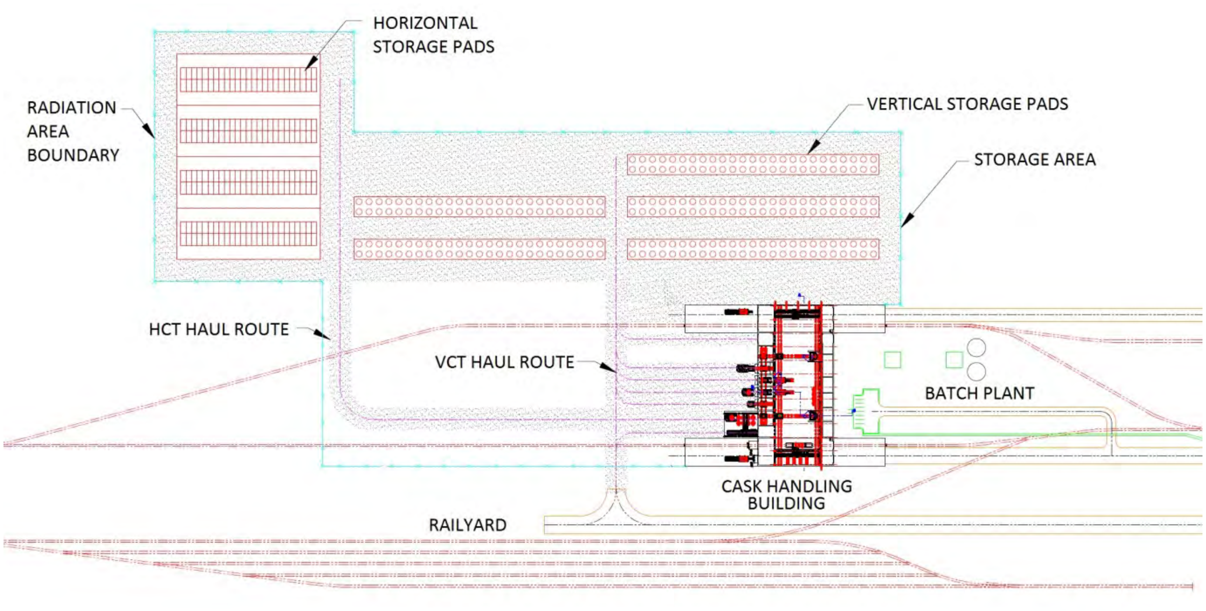
B3-3.1 Facility Layout and Equipment Evaluation

The facility layout is very similar to the C-OPS alternative except that the CHB contains all the equipment for the remote process. This alternative has hot cells, additional overhead cranes, automated systems and computer controlled operations that improve efficiency while reducing the need for people to be near the DPC packages.

The hot-cells are structural elements that add strength to the CHB structure, but that also add complexity to the design as well. The need to be able to address maintenance and equipment failures in the hot-cell adds cost and complexity to the design. In addition, the extra height of the structure needs to be carefully integrated into the design to avoid interferences with the Railbay Overhead Traveling Bridge (OTB) cranes. However, generally speaking, the layout of the hot-cells does not present a significant design change to the CHB layout or operation.

Figure B3-7 shows the layout of the site using the R-OPS cask handling approach. It shows the location of the CHB in relation to the storage pads and the HCT and VCT haul routes.

Figure B3-7
Pilot ISF Cask Handling Building in Relation to Storage Area



This approach requires the CHB which is a fairly large structure housing the cranes, rail bays, canister transfer hot cells, and VCT and HCT bays.

B3-3.2 Structural and Seismic Evaluation

The seismic stability of the pads and storage overpacks is addressed in Appendix A1. For Alternative B3, the primary structure affected by a seismic event is the CHB. The CHB is a fairly large structure. For the 0.25G earthquake, the capacity of the CHB, which is constructed of reinforced concrete, to resist seismic forces is significant.

For the 0.75G earthquake, the acceleration demands at the top of the CHB are significant especially when both overhead cranes and hot cell cranes may be carrying large loads. Design consideration must be considered in relation to the height of the building, placement of the overhead crane rails, and smallest width of the building. The actual maximum seismic capacity of the CHB will be dependent on the structure design and material design limits to mitigate the 0.75G earthquake demands. Additional structures may need to be employed to stabilize the top of the structure. In addition, the foundation may need to be thickened to resist overturning moments applied across the minor axis. The seismic/stack-up restraints or struts will also need to be considered in the buildings ability to resist seismic loads.

B3-3.3 Radiological Evaluation

The exposures to radiation for the workers at the ISF were based on the time and motion study and the assumed average dose rates from the DPCs stored at the site. Once installed in their storage locations, the doses to workers and to the public are quite small. However, during canister handling operations, workers still need to work on top of DPCs and near the transport cask and the transfer casks even though much of the process is remote. In addition, plant security officers need to visually inspect the inside of the transport cask for contraband as soon as it is opened and will sustain some doses. Workers on vertical cask storage units need to bolt a lifting lug directly onto the DPC and after it has been transferred to the storage overpack.

Most of the activities are conducted well away from the DPC and behind shielding. But some of the activities require hands-on contact to the DPC or working near the open end of shield casks or overpacks.

The radiation doses associated with dry storage concepts are well understood and readily available from the literature regarding ISFSI operations at the generators’ sites. Most of the radiation doses at operating plant sites are associated with the loading of the storage canisters in the fuel pool and the subsequent passivation steps of drying, inerting and welding closed the storage canisters. Once the canisters are loaded into their storage overpack, there are few remaining issues.

Vertical storage casks have radiation streaming at the bottom of the cask where the cool air inlets are. Also, when working around the top of the canister in either the transport cask or the storage cask, the dose rate streaming up the annular gap between the canister and the shield when the lid is removed is significant to the workers. So care needs to be exercised with securing the shield cask lid to the top of the cask and with securing the seismic hold downs for the cask on the pad.

Although R-OPS does not evaluate horizontal systems, they would be part of the ISF. Horizontal storage systems expose workers to higher radiological doses when preparing the module to receive the spent nuclear fuel canister. The shielded cover needs to be removed from the storage module for the new storage location. However, the storage module is not well shielded from the neighboring module so that the area around the opening is a high radiation area. Once the HCT has docked with the storage module, the dose rates are quite low and remain so during the entire transfer operation. However, in order to secure the canister seismically, a worker needs to reach into the module and insert a shear pin in the module that precludes the canister shifting toward the cover plate during a seismic event. This is a high radiation evolution that needs to be addressed by the final ISF design. Design modifications could be developed to eliminate the need to have workers routinely reaching into a storage module to attach a seismic restraint.

Table B3-3 shows typical dose rates near waste packages of interest for this study. These are not licensing basis values, but rather, typical values for old spent nuclear fuel.

Table B3-3
Typical Dose Rates Near Casks (mrem/hr)

Component	Top	Top Side	Side	Bottom
Transport Cask	15.0	31.8	34.0	15.0
Vertical Storage Cask Open	254.0	150.0	44.0	111.0
Vertical Storage Cask Sealed	18.4	20.0	44.0	111.0
Horizontal Storage Module	Near Opening 7.1		Inside 163.2	
General Area CHB	< 0.5 mrem/hr			

Section 6.4 of the Report, "Occupational Dose/ALARA Analysis of Storage Alternatives" shows cask handling operations for R-OPS and their respective doses which are shown in **Table B3-4**.

Table B3-4
Duration and Radiation Doses for R-OPS Cask Handling Operations

Alternative	Storage Configuration	Duration of Transfer Operation (hours)	Radiation Dose per Transfer (mrem) (Entire Operations Staff Dose)
R- OPS, Remote Canister Transfer	Vertical	21	248
	Horizontal	Horizontal system cannot be transferred remotely	

B3-3.4 Equipment Maintenance Evaluation

The R-OPS systems would increase the need for and the potential complexity of the maintenance of the automated systems within the hot-cell. In the Base Case, these components are simplistic devices with a minimum of automated controls. Adding a hot-cell with video viewing systems, remote controls, single failure proof cranes and grapples hardened against the effects of radiation increases the difficulty and frequency of maintenance. However, the most significant maintenance required by the ISF will still be the VCTs and the HCTs at the facility. So, overall, the impact should be minor.

B3-3.5 Licensing Evaluation

The R-OPS alternative will be significantly more difficult to license than C-OPS because it involves the use of hot cells. Although hot cells may have been previously licensed, they involve dangerous levels of radiation that would require significant NRC review to ensure that all normal, off-normal and accident conditions are thoroughly reviewed and shown to be safe for workers. The dedicated cell cranes will also require significant review. Not because of the crane design, which would be in accordance with well proven crane codes, but for the failure mitigation strategies that must show how any failure can be safely resolved.

The site specific Safety Analysis Report will need to detail the CHB structure design and margins, all operations, work areas within the CHB, radiation doses, and address a suite of manmade and natural accidents or off-normal events to show that there are no unsafe operations of the ISF. NUREG-1567 (Reference B3-14) contains detailed guidance that can be followed to ensure all aspects of this alternative are adequately addressed. The onsite worker doses and offsite dose to the public will need to be calculated at strategic locations around the ISF to ensure ALARA.

In addition, the Environmental Report will need to address all facility components and operational steps to ensure that environmental regulations are adhered to. The ramifications of the Environmental Report also affect off-site conditions that could be adversely altered due to traffic from worker numbers, noise, solid waste, liquid waste, sewage water, etc. All site activities will need to be addressed because this will be the basis for the NRC Environmental Impact Statement.

B3-3.6 Modular Concepts Evaluation

Modularization of this alternative is not necessary. Once the CHB is constructed it can provide the storage and throughput needs of the Pilot ISF, Expanded ISF and larger ISF. If higher throughput rates are desired additional shifts can be added to meet the demands rather than construct additional cask handling facilities. The approach appears to be essentially linear. Doubling the shifts and staffing will double the throughput.

B3-4.0 Summary

R-OPS introduces the use of a hot cell environment to reduce the number of steps in the canister transfer process which reduces the overall operational time and worker doses.

This alternative can process a vertical DPC in 2½ shifts and a horizontal DPC in 3 shifts or an overall average of five horizontal DPCs placed into storage every week resulting in an overall throughput of approximately 3,000 MTHM per year. This throughput assumes that the CHB has two rail/truck bays, two overhead cranes and two hot cell overhead cranes. A higher throughput can be established by utilizing more shifts per day.

The average overall dose to workers processing a vertical DPC is 248 mrem.

In summary, the pros and cons to this alternative, listed from the highest most significant impact to the lowest least significant impact are as follows:

Pros

- The operation steps in R-OPS reduce canister transfer steps and worker dose.
- R-OPS eliminates the transfer equipment that would be required to process all 13 different systems that need to be accommodated. Storage requirements from R-OPS are totally eliminated because the transfer equipment is not required.

Cons

- R-OPS performs canister transfer in essentially "hot cells" which are costly, involve very high radiation doses, and require failure mitigation strategies to safely handle the DPC when equipment fails.
- R-OPS requires two additional overhead cranes to accommodate isolated transfers in the hot cells.

B3-5.0 References

1. AREVA TN Updated Final Safety Analysis Report for the Standardized NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No, 72-1004.
2. AREVA TN Updated Final Safety Analysis Report for the Advanced NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC, Docket Number 72-1029.

3. AREVA TN Final Safety Analysis Report for the NUHOMS HD Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1032.
4. FuelSolutions Storage System Final Safety Analysis Report, NRC Docket No. 72-1026.
5. FuelSolutions W74 Canister Storage Final Safety Analysis Report, NRC Docket No. 72-1026.
6. Holtec International Final Safety Analysis Report for the HI-STAR 100 Cask System, NRC Docket No. 72-1008.
7. Holtec International Final Safety Analysis Report for the HI-STORM 100 Cask System, NRC Docket No.: 72-1014.
8. Holtec International Final Safety Analysis Report on the HI-STORM FW MPC Storage System, NRC Docket No. 72-1032.
9. Holtec International Final Safety Analysis Report on the HI-STORM UMAX Canister Storage System, NRC Docket 72-1040.
10. NAC Final Safety Analysis Report for the Multi-Purpose Canister (NAC-MPC), NRC Docket No. 72-1025.
11. NAC Final Safety Analysis Report MPC-LACBWR Amendment, NRC Docket No. 72-1025.
12. NAC Final Safety Analysis Report for the Universal MPC System (UMS) Universal Storage System, NRC Docket No. 72-1015.
13. NAC Final Safety Analysis Report for the MAGNASTOR (Modular Advanced Generation Nuclear All-purpose STORage) System, NRC Docket No. 72-1031.
14. NRC NUREG-1567, Standard Review Plan for Spent Fuel Dry Storage Facilities, Rev. 0, March 2000.

APPENDIX B4

STUDY 2 - ALTERNATIVE CASK HANDLING METHODS

Alternative 4 – Simplified Cask Handling Operations (S-OPS)

Alternative 4 – Simplified Cask Handling Method (S-OPS)

B4-1.0 Description of Handling Alternative

Alternative 4 examines the use of cask handling methods that are more simplified compared to those currently in use today at operating and decommissioned nuclear plants that could be employed at the Interim Storage Facility (ISF). Essentially, this method would do away with a cask handling building to greatly reduce the capital costs of the Pilot ISF. Simplified Operations, or S-OPS, is a simple extrapolation of current industry practices applied directly to the ISF. Some of the methods described are used at a few nuclear power plants and therefore are demonstrated and proven on limited quantities of operations. These methods require the least infrastructure to be deployed and therefore offer the opportunity for a “quick start” option for the ISF. Using these methods for cask handling operations will enable the ISF to start operations with a minimum of supporting infrastructure. All that is needed is some standard equipment and a hard surface near a rail line.

For this study, all of the spent nuclear fuel (SNF) received at the ISF is packaged in canister-based systems. Canister-based systems use a dual purpose canister (DPC) where SNF assemblies are placed into a welded sealed metal container. The DPC is a welded sealed metal container where the SNF assemblies are placed. The DPC is placed in different overpacks or casks for transport, storage or transfer between the transport cask and storage overpack. A typical PWR canister will hold 24 to 37 PWR SNF assemblies and a typical BWR canister will hold 61 to 89 BWR SNF assemblies. These systems fall into one of two categories: vertical or horizontal type systems.

There are four companies that provide canister-based dry cask storage systems which are:

- AREVA TN
  - NUHOMS (horizontal) (Reference B4-1, B4-2 and B4-3)
- EnergySolutions
  - Fuel Solutions (vertical) (Reference B4-4 and B4-5)
- Holtec International
  - HI-STAR (vertical) (Reference B4-6)
  - HI-STORM (vertical) (Reference B4-7 and B4-8)
  - HI-STORM UMAX (vertical) (Reference B4-9)
- NAC International
  - MPC (vertical) (Reference B4-10 and B4-11)
  - UMS (vertical) (Reference B4-12)
  - MAGNASTOR (vertical) (Reference B4-13)

Horizontal systems already employ a simplified canister transfer process so the S-OPS alternative only affects horizontal cask handling operations during transport cask unloading off the railcar. Vertical systems typically rely heavily on plant structures that house overhead cranes and truck or rail bays to perform canister transfer operations. S-OPS replaces those structures with much smaller structures that can perform all the cask handling operations. Typically these structures are outdoors though weather enclosures could be used if desired.

For the vertical systems, the study considers the stack-up method used by all vertical systems for canister transfer. The general steps to unload and transfer a vertical DPC from a transport cask to a storage overpack are as follows:

1. Removing the transport cask from the railcar, up-righting it and placing it on the floor in a vertical orientation
2. Placing a transfer cask on top of the transport cask
3. Lifting the DPC out of the transport cask and up into the transfer cask
4. Securing the DPC in the transfer cask
5. Removing the transfer cask from the transport cask
6. Placing the transfer cask on the Storage Overpack
7. Lowering the DPC down into the overpack
8. Removing the transfer cask
9. Securing the overpack lid
10. Transporting the overpack to the storage location on the pad using a vertical cask transporter (VCT)
11. Repackaging the transport cask on the railcar.

For horizontal concepts, the standard methodology of canister transfer is considered. The general steps to unload and transfer a horizontal DPC from a transport cask to a storage overpack are as follows:

1. Removing the transport cask from the railcar
2. Placing the transport cask onto a horizontal cask transporter (HCT)
3. Transferring the Transport cask to a horizontal storage overpack on the pad
4. Preparing the overpack to receive the DPC
5. Aligning the HCT so that the DPC is will slide smoothly into the overpack
6. Pushing the DPC into the overpack using a hydraulic ram
7. Securing the Overpack
8. Returning the empty transport cask to the rail siding
9. Repackaging the transport cask on the railcar.

Figure B4-1 and **Figure B4-2** show up-righting operations. These photos are of empty casks and therefore didn't need to be concerned with dropping a DPC loaded with SNF. However, they highlight some of the complexities with up-righting casks; use of two cranes simultaneously lifting and adjusting to successfully complete the operation. For the ISF, a more reliable and predictable means should be used to off-load transport casks and upright them.

Figure B4-3 through **Figure B4-6** show a number of canister transfer structures that could facilitate horizontal and vertical operations. The canister transfer facilities at Dresden and Trojan require the use of additional equipment such as air slides, fork lifts and heavy lift mobile cranes. The canister transfer facility at Diablo Canyon represents more recent innovations that eliminate steps required in the previous examples and uses a VCT that has single-failure-proof or redundant features that prevent drops and allows the VCT to hold the load several feet above the floor of the pit.

Figure B4-1
Holtec HI-STORM Empty Overpack Up-righting Operation

Source: Holtec International

Figure B4-2
NAC International MAGNASTOR Transfer Cask Up-righting Operation

Source: NAC International

Figure B4-3
AREVA TN NUHOMS Horizontal Canister Transfer at Calvert Cliffs ISFSI

Source: AREVA TN

Figure B4-4
Holtec Below Grade Vertical Canister Transfer Facility at the Diablo Canyon ISFSI

Source: Holtec International

Figure B4-5
Holtec Vertical Canister Transfer Facility at the Dresden ISFSI

Source: Holtec International

Figure B4-6
Holtec Vertical Canister Transfer Facility at the Trojan ISFSI

Source: Portland General Electric

Table B4-1 provides a comparison of major canister transfer steps between C-OPS, A-OPS, R-OPS and S-OPS.

Table B4-1
Comparison of Major DPC Transfer Operational Steps

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack into transfer cell.	Transporter removes lid and moves storage overpack to rail siding.
Overhead crane places transport cask into transfer cell	Overhead crane places transport cask onto transfer cart.	Overhead crane places transport cask onto transfer cart.	Gantry crane places transport cask on hard stand
Overhead crane removes transport cask lid	Jib Crane removes transport cask lid	Jib Crane removes transport cask lid	Gantry crane removes transport cask lid
	Transfer Cart moves transport cask into cell	Transfer Cart moves transport cask into cell	Transport cask is secured seismically to hard stand
Transfer cell doors are closed	Transfer cell doors are closed	Transfer cell doors are closed	
Mating adapters are mounted to top of transport cask and storage cask.			Mating adapters are mounted to top of transport cask and storage cask.
Overhead crane places transfer cask on transport cask.	Transfer sleeve is located over transport cask		Overhead crane places transfer cask on transport cask.
Seismic/stack-up struts are attached to transfer cask.			Seismic/stack-up struts are attached to transfer cask.
Transfer cask is bolted to mating adapter.			Transfer cask is bolted to mating adapter.
Overhead crane raises DPC from transport cask up into transfer cask.	Transfer sleeve hoist raises DPC from transport cask into transfer sleeve.	Dedicated cell crane raises DPC from transport cask	Gantry crane raises DPC from transport cask up into transfer cask.
Transfer cask is unbolted from mating adapter.			Transfer cask is unbolted from mating adapter.
Seismic/stack-up struts are removed from transfer cask.			Seismic/stack-up struts are removed from transfer cask.
Overhead crane moves transfer cask from transport cask to storage overpack.	Transfer sleeve is moved from transfer cask position to storage overpack position.		Gantry crane moves transfer cask from transport cask to storage overpack.
Seismic/stack-up struts are attached to transfer cask.			Seismic/stack-up struts are attached to transfer cask.
Transfer cask is bolted to the mating adapter.			Transfer cask is bolted to the mating adapter.
Overhead crane lowers DPC from transfer cask to storage overpack.	Transfer sleeve hoist lowers DPC from transfer sleeve to storage overpack.	Dedicated cell crane lowers DPC into storage overpack.	Gantry crane lowers DPC from transfer cask to storage overpack.
Seismic/stack-up struts are removed from transfer cask.			Seismic/stack-up struts are removed from transfer cask.

Major C-OPS steps	Major A-OPS steps	Major R-OPS Steps	Major S-OPS Steps
Transfer cask is unbolted from mating adapter.			Transfer cask is unbolted from mating adapter.
Transfer cask is removed and placed back into storage location.			Transfer cask is removed and placed back into storage location.
Mating adapters are removed from storage and transport casks.			Mating adapters are removed from storage and transport casks.
Outside doors are opened	Outside doors are opened	Outside doors are opened.	
VCT drives into transfer cell	Transfer cart moves storage overpack outdoors.	Transfer cart moves storage overpack outdoors.	VCT maneuvers onto hard stand
VCT attaches to storage overpack	VCT attaches to storage overpack	VCT attaches to storage overpack	VCT attaches to storage overpack
Storage overpack lid is bolted on.	Storage overpack lid is bolted on.	Storage overpack lid is bolted on.	Storage overpack lid is bolted on.
VCT takes storage overpack to pad.	VCT takes storage overpack to pad.	VCT takes storage overpack to pad.	VCT takes storage overpack to pad.

B4-1.1 Canister Transfer Facility

The alternative to canister transfer operations in the Cask Handling Building is to use a structure or facility designed specifically to accommodate the stack-up condition. The Canister Transfer Facility (CTF) would allow the canister transfer operation to be performed at any point between the rail tracks and storage area thereby minimizing the impacts to the Pilot ISF. **Figure B4-3** through **Figure B4-6** provide a number of actual CTFs in operation at nuclear power plants today.

There are various options that can be utilized for the CTF that are presented in the following sections. Note that each method involves a number of different pieces of equipment that add to the overall cost of the project. In addition, the number of transfers between each piece of equipment should be minimized to reduce the overall dry cask storage operation impacts.

B4-1.1.1 Holtec Below Grade Cask Transfer Facility©

Holtec has submitted a patent for a Below Grade Cask Transfer Facility (Reference B4-14) for vertical system transfers. The below grade cask transfer facility is a system for transferring a canister from a transfer cask to a storage cask without the need for a crane. The system is comprised of a below grade pit to house the storage overpack so that its top surface is approximately 3 ft above grade, a mating device to connect the storage overpack to the transfer cask and the HI-LIFT© VCT which is equipped with single-failure-proof hydraulic lifts and canister hoist (See **Figure B 4-7**).

Figure B4-7
Holtec HI-LIFT© VCT

HI-LIFT in its Fully Extended Position

HI-LIFT and HI-STORM Prior to Transport to an ISFSI Pad

Source: Holtec International

The Pilot ISF would need to install two pits, one to house the transport cask and one to house the receiving storage overpack as well as a transfer cask that can be used to transfer the DPC in a shielded environment.

The first step would be to offload a shipped transport cask off the rail car using the gantry crane discussed above. The transport cask would be picked up by the VCT and taken to CTF pit #1 and lowered into the pit and its lid removed. The transporter would then retrieve a storage overpack and place it into the CTF pit #2 with its lid removed. The VCT would place a mating device on top of the transport cask and another mating device on top of the storage overpack. Then the VCT would retrieve a transfer cask and place it on top of the transport cask mating device. If the ISF were located in a high seismic area like the Diablo Canyon ISFSI, seismic struts would need to be connected to the VCT to ensure it remained stable during the transfer process.

The hoist hook would be lowered down through the transfer cask and connected to the DPC. The hoist would raise the DPC up into the transfer cask. The mating device lid could be closed to support the DPC if it was not desired to support the DPC with the hoist during VCT movements. Once loaded with the DPC, the transfer cask would be disconnected from the transport cask and struts and transported to the storage overpack by the VCT. The VCT would move the transfer cask on top of the storage overpack where it would be secured to the mating device and struts (if required). Then the VCT would lower the DPC down into the storage overpack. Once down, the hoist hook would be removed from the DPC and the mating device and struts unbolted so that the VCT could remove the transfer cask from on top of the storage overpack. The mating devices would be removed from the transport cask and storage overpack and the lids bolted on. Then the VCT would raise the storage overpack out of the CTF pit and transport it to a storage pad. The VCT would then need to return or a second VCT used to raise the transport cask from the other CTF pit so that it could be taken back to the gantry crane to be placed back on a railcar, ready for the next shipment. Since this CTF is placed below grade, it would need to be designed and installed so that it would be free from any ground water conditions.

Figure B4-8 and **Figure B4-9** show a gantry crane that can straddle the rail tracks and transporters. The gantry would be designed to ASME NOG-1 (Reference B4-15) standards providing single-failure-proof hoist capabilities to ensure that a loaded transport cask can never be dropped. The gantry would be used to remove the impact limiters, offload and transfer the horizontal transport cask to the HCT in a horizontal position, and offload and upright the vertical transport cask placing it in a pit for canister transfer. The VCT would be used to place the storage overpack into the second pit and place the transfer cask on the transport cask and then the storage overpack for the canister transfer. Once complete, the VCT would move the storage overpack from the pit to the pad.

Figure B4-8
Pilot ISF Unloading Gantry Crane with BG-CTF (Plan View)

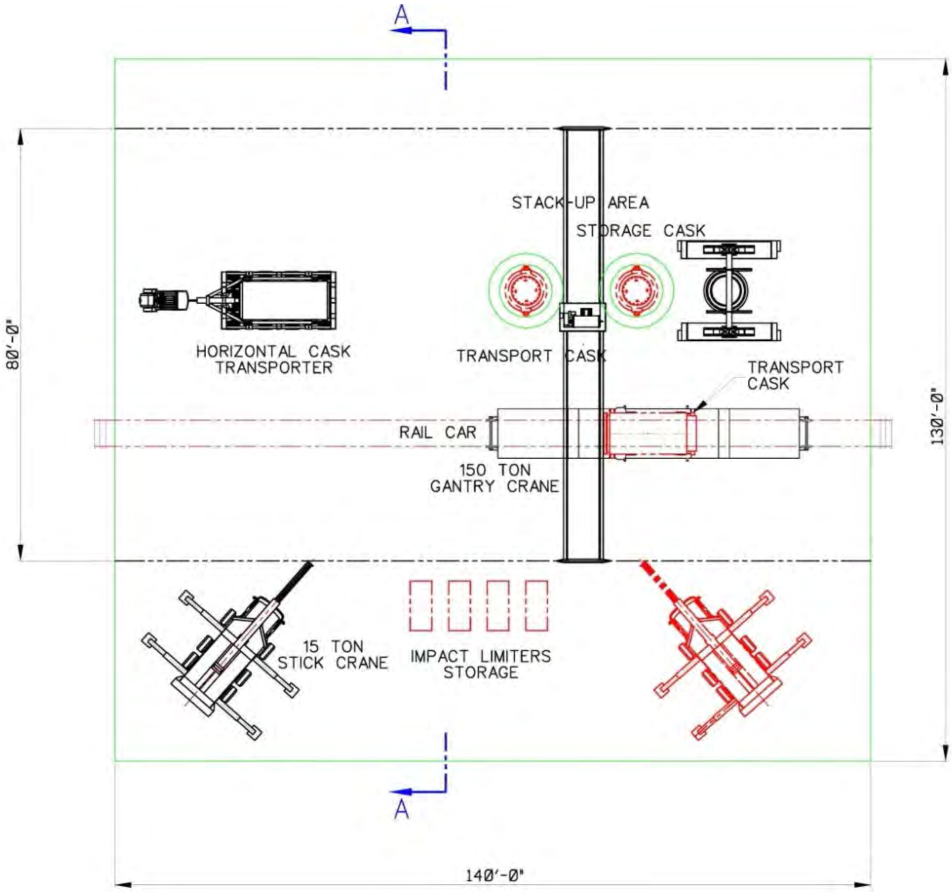
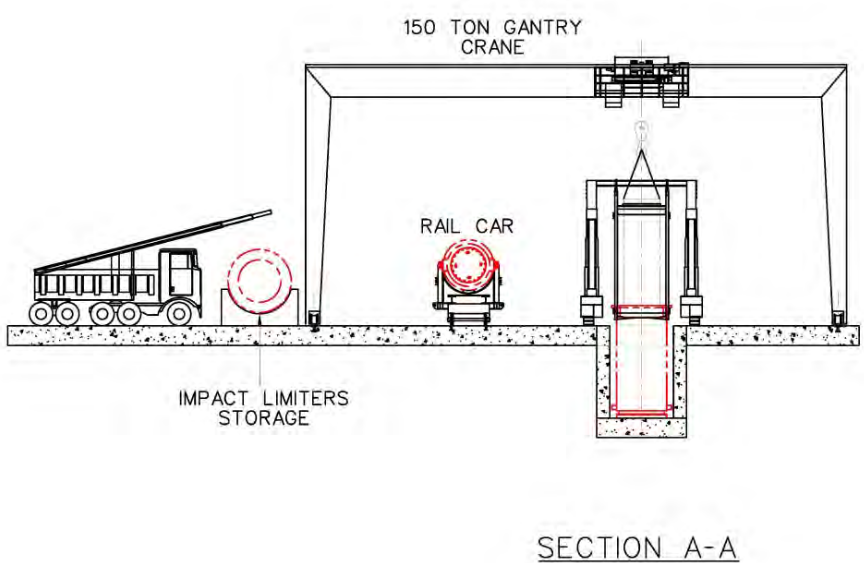


Figure B4-9
Pilot ISF Unloading Gantry Crane with BG-CTF (Elev View)



B4-1.1.2 Above Ground Fixed CTF

The Dresden and Trojan ISFSIs used a CTF that consisted of a fixed structure. These devices enabled the transfer cask to remain at a fixed location while the storage cask was inserted to receive the DPC and removed for transport to the storage pads. Therefore, the Pilot ISF would only need to install a single CTF.

The first step would be to offload a shipped transport cask off the rail car using the gantry crane discussed above. The transport cask would be picked up by the VCT and taken to CTF and fitted with a mating device if required. The Trojan CTF was designed so that no mating device was required. The transport cask would then be moved under the CTF transfer cask using an air slide or low profile transporter. This is because the VCT lift beam may not be able to clear the bottom of the transfer cask as in the case of the Trojan CTF. The Dresden CTF was able to raise and lower the transfer cask and therefore could be designed to clear the VCT lift beam.

The CTF hoist hook would be lowered down through the transfer cask and connected to the DPC. The hoist would raise the DPC up into the transfer cask. Once loaded with the DPC, the transfer cask remains in place. Then the transport cask would be slid out from under the CTF with air slides, low profile transporter or VCT, fitted with its lid, and returned to the offloading gantry crane for placement onto the railcar, ready for the next shipment.

The VCT would then retrieve a storage overpack, remove its lid and slide it under the CTF using air pads, low profile transporter or VCT. The CTF hoist hook would then lower the DPC down from the transfer cask into the storage overpack. Then the storage overpack would be slid out from under the CTF with air slides, low profile transporter or VCT, fitted with its lid, and transported to a storage pad.

Using air pads requires a level and smooth surface, jacks to raise the cask up so that the air bearings can be inserted, an air supply to the air pads, and a vehicle to move the cask and air bearings. The low profile transporter requires tracks (either for rail wheels or Hilman rollers) to maintain stability. These items facilitate the process but add a number of extra steps into the operation. The above ground CTF as currently used would probably not meet minimum throughput requirements for the ISF. A new design would be necessary incorporating features that do not rely on air pads in order for an above ground CTF to be a feasible option for the ISF.

B4-1.1.3 Gantry Crane CTF

This scenario consists of a single-failure-proof gantry crane CTF that is in a fixed location and is used to transfer the DPC from the transport cask to the transfer cask and from the transfer cask to the storage overpack. The gantry crane CTF could be used to perform both railcar offloads and canister transfer.

The first step would be to offload a shipped transport cask off the railcar using the gantry crane discussed above or this gantry crane and placed in position. The storage overpack would then be retrieved by the VCT and placed next to the transport cask. The lids to both casks would be removed and the casks would be fitted with a mating device. If the transport cask remained next to the gantry, the gantry crane would raise up the transfer cask and place it on top of the transport cask and secured to the mating device. Otherwise the VCT would need to retrieve the transfer cask before it could be placed on the transport cask. If the ISF were located in a high seismic area, seismic struts would need to be connected to the transfer cask to ensure it remained stable during the transfer process.

The hoist hook would be lowered down through the transfer cask and connected to the DPC. The hoist would raise the DPC up into the transfer cask. Once loaded with the DPC, the transfer cask would be disconnected from the transport cask and struts and moved to the adjacent storage overpack. The gantry crane would move the transfer cask on top of the storage overpack where it would be secured to the mating device and struts (if required). Then the hoist would lower the DPC down into the storage overpack. Once down, the hoist hook would be removed from the DPC and the mating device and struts unbolted so that the gantry crane could remove the transfer cask from on top of the storage overpack. The mating devices would be removed from the transport cask and storage overpack and the lids bolted on. Then the VCT would pick-up the storage overpack from under the gantry crane and transport it to a storage pad. The gantry could then move the transport cask back on the railcar, ready for the next shipment.

If the Pilot ISF is located in a high seismic area, then the high crane position could require a more robust gantry design that could withstand seismic accelerations.

Figure B4-10 and **Figure B4-11** show a gantry crane that can straddle the rail tracks and transporters. The gantry would be designed to ASME NOG-1 (Reference B4-15) standards providing single-failure-proof hoist capabilities to ensure that a loaded transport cask can never be dropped. The gantry would be used to remove the impact limiters, offload and transfer the horizontal transport cask to the HCT in a horizontal position, and offload and upright the vertical transport cask placing it on the concrete base pad of the gantry crane for canister transfer. The VCT would be used to place the storage overpack onto the concrete base pad next to the transport cask. The gantry crane would be used to place the transfer cask on the transport cask and then the storage overpack for the canister transfer. Once complete, the VCT would move the storage overpack from the gantry crane base pad to the pad.

Figure B4-10
Pilot ISF Unloading Gantry Crane/CTF (Plan View)

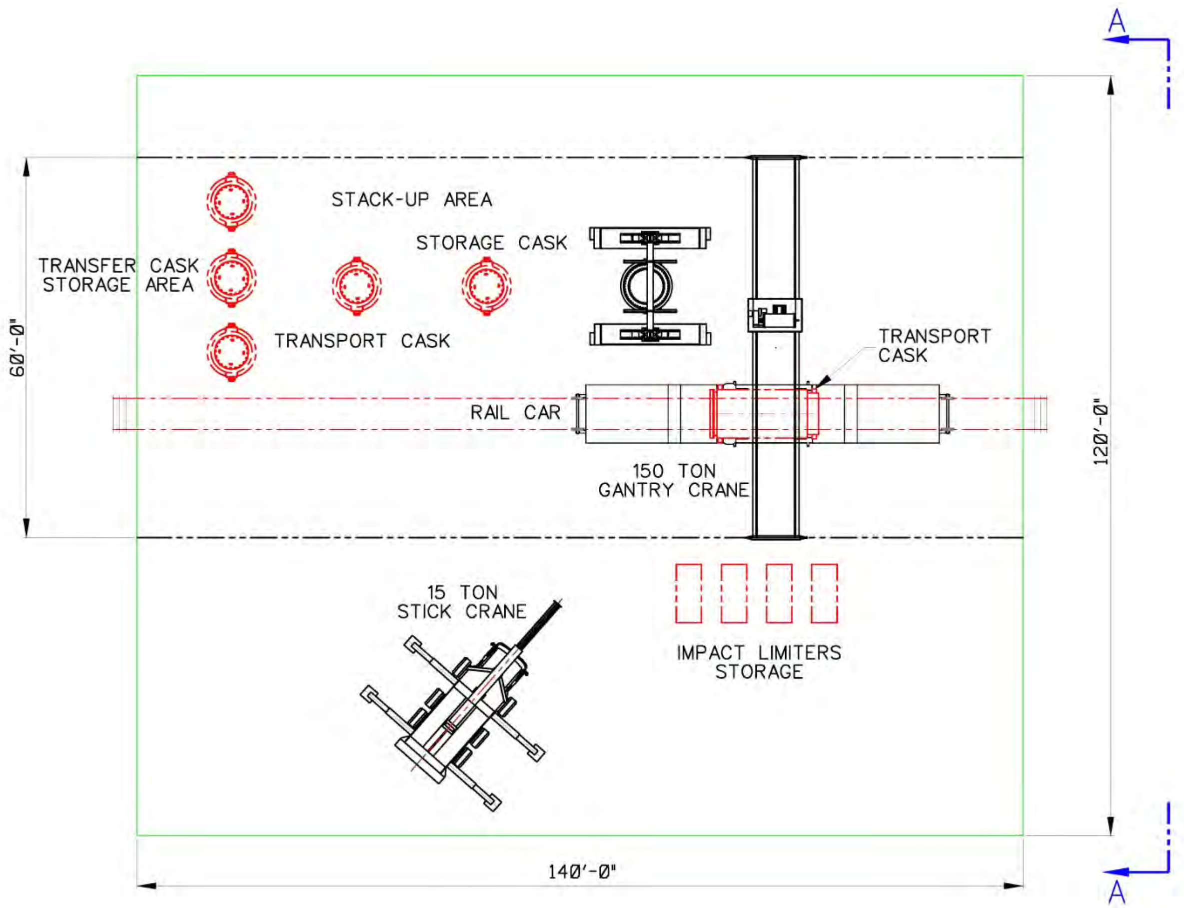
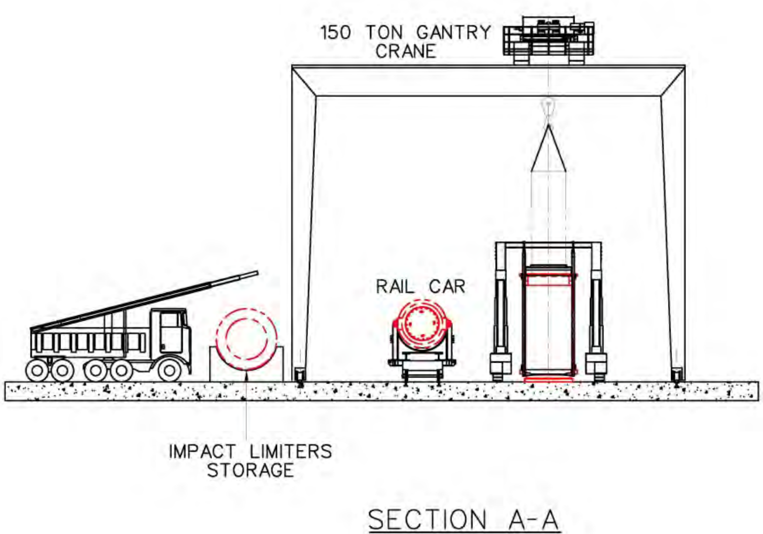


Figure B4-11
Pilot ISF Unloading Gantry Crane/CTF (Elev View)



Another consideration with this CTF, is that it could be designed to utilize a SAFLIFT Strongback Canister Hoist System. The SAFLIFT system is a patented design (Reference B4-16) by American Crane with a lifting yoke and a separate single-failure-proof hoist so that the crane can remain hooked to the transfer cask while the hoist is raising or lowering the DPC (See **Figure B4-12**). This eliminates the need to attach seismic struts to the transfer cask during stack-up conditions but would increase the height of the gantry crane.

Figure B4-12
American Crane and Equipment Co (ACECO) SAFLIFT Canister Hoist System

SAFLIFT™ Transferring Canister to Cask

Source: American Crane and Equipment Company

The SAFLIFT system is in full compliance with NUREG-0554 (Reference B4-17) and NUREG-0612 (Reference B4-18) which makes it very licensable under a Site Specific license. The SAFLIFT requires a crane with higher capacity than a typical 125 ton nuclear plant crane. However, a 200 ton gantry crane could easily accommodate the SAFLIFT system. This system requires an additional 12 feet of hook height and thus, raise the building approximately 20 ft.

B4-1.1.4 Other CTF Considerations

All of the CTF concepts shown are located outdoors and therefore subject to weather conditions. However, any of these CTF concepts could be housed in a pre-engineered steel building. This would protect the CTF from corrosive conditions as well as provide a suitable environment for year around canister transfer operations. However, this could not be applied to the horizontal canister transfer. Therefore, whether constraints should be taken into consideration if the ISF is located in an area subject to frequent rain or snow.

Another consideration is that the vertical canister transfer process is very time consuming having to move casks around to accommodate DPC transfer. However, these CTF are relatively inexpensive. More than one CTF could easily be installed to increase DPC throughput.

Lastly, the nature of all these CTFs including the horizontal canister transfer process exposes workers to potential high doses. If employed, some means of reducing doses should be considered. For example, loaded transfer casks are typically limited to 125 tons which meets most power plant crane capacities. The Pilot ISF could accommodate much heavier transfer casks fitted with additional shielding.

B4-2.0 Concept of Operations

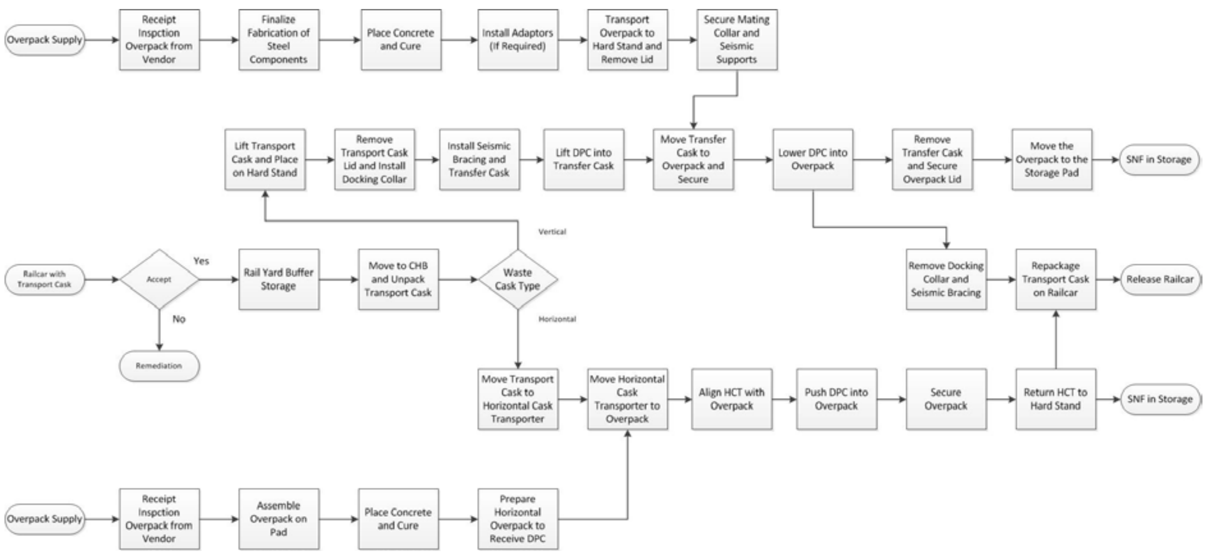
B4-2.1 Material Handling Flow Diagram

Figure B4-13 is a representation of the material handling flow for the S-OPS alternative for the ISF. It describes the three large material flows of the operation. The central flow is the movement of DPCs containing SNF to the site. But equally important to the operations of the ISF are the material flows necessary to support the production of suitable storage overpacks to place the DPCs into after being accepted by the site for storage. The vertical storage overpacks are prefabricated by the vendors and shipped to the site as steel structures packaged to protect them during transit. The site crew unpacks these overpacks and performs a receipt inspection to ensure that there has been no damage during shipping. Then the Fabrication Crew completes the fabrication and places concrete in the structure necessary to complete the overpack in accordance with the vendor's specification.

For horizontal storage systems, the site fabrication crew needs to fabricate and erect multi DPC storage modules using the vendor's design and components from the vendors. These modules are larger and more complex construction packages than the vertical overpacks and take longer to construct and to align to ensure that the DPCs can be readily placed into storage. Horizontal overpacks contain multiple DPCs so the lead time issues are exacerbated. The horizontal overpack represents a fairly major construction effort.

The largest operations challenge for the S-OPS alternative is controlling the supply chain to ensure that the proper storage system is available to match the DPC being received from the generator. The licensability of the final DPC is based on the conformance of the storage system with the original licensed dry storage system. Concrete takes at least 30-days to cure, so the minimum time required would be month. However, practicalities of such a large material receipt and fabrication process would suggest that a 60-day period would be a better basis for planning. The lead time for this shipment could be 6 to 12 months. Therefore, up to a year ahead of the receipt of the SNF at the site, the supply chain manager needs to place an order for the necessary storage system components. This means that the ISF staff needs to know well in advance of delivery what vendor and what model of DPC system is needed. The coordination of the supply chain for the Overpack Fabrication and the SNF storage operations will be the largest management challenge for this design alternative.

Figure B4-13
Canister Handling Material Handling Flow Diagram[1]



B4-2.2 Operations Sequence

Cask handling operations are a series of heavy lifts and heavy equipment movements that move the SNF in sealed DPCs from the rail head to the storage pad. The operational sequence was benchmarked against ISFSI operations at operating nuclear plants. The S-OPS alternative represents approaches used at a few nuclear facilities so no extrapolations were required. The only variation to the existing commercial operational sequence is the limitation of a single 8-hour shift per day, five days a week. SNF movements at a nuclear plant are typically a significant operation conducted to make room in the fuel pool for a refueling outage. As such, they are usually performed in a continuous effort, utilizing multiple crews working 10 or 12-hour shifts to complete the operation as rapidly as possible.

[1] Remediation is not part of this study's work scope and is not addressed other than to note that the packages are not accepted on site regardless of their condition.

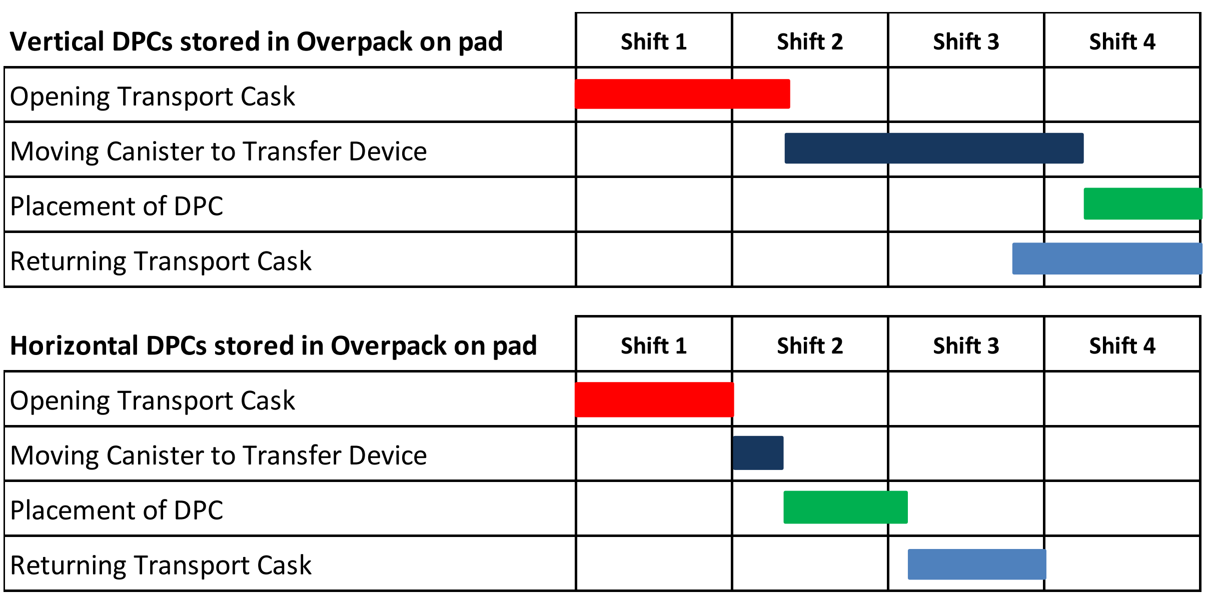
Figure B4-14 shows the high-level schedule for the two storage concepts in S-OPS assuming 8-hour shifts. The operational sequence once the transport cask is accepted into the ISF can be divided into four major steps:

1. Opening the transport cask
2. Moving the DPC into the transfer device or system
3. Placement of the DPC in the storage overpack and
4. Preparing for the turnaround of the transport cask.

It should be noted that the vertical DPCs take four complete shifts for a complete cycle. The horizontal DPCs take three complete shifts. The gantry crane serves as a backup support for the seismic stack and is available only periodically during this time. Since the S-OPS assumes only one gantry crane as the base assumption, it is highly unlikely that two DPCs can be processed simultaneously. If only vertical DPCs are being stored, then this process can move five DPCs into storage in four weeks. However, up to two and one half DPCs can be stored with an additional means for canister transfer such as a second single-failure-proof VCT and a second CTF.

Horizontal DPCs can be stored at a rate of five every three weeks. Alternatively, two and one half DPCs can be stored per week if two HCTs are used.

Figure B4-14
High-Level Operational Sequences



Most of the effort is associated with unpacking the transport cask and repackaging the transport cask. These activities take two shifts to accomplish whereas DPC placement takes about one shift. The key to starting the next DPC process is to move the railcar out of the way to make room for the next shipment. In the case of the vertical DPC system, the time to recycle the waste package is nearly identical to the horizontal DPC system even though it takes significantly longer for the vertical DPC to actually be placed into storage.

The railcar packaging of the transport cask is removed at the siding using a single-failure proof 200 ton gantry crane. The crane is used to remove the transport cask cover, impact limiters and the tie-down straps. The crane has adequate capacity to lift the transport cask and to place the cask where needed. In the case of the vertical DPC, the crane can place the transport cask vertically on a hard stand under the crane. In the case of the horizontal DPC, the crane is used to place the transport cask on the horizontal cask transporter and down end it into the horizontal position if necessary.

The vertical DPC is secured by seismic/stack-up struts mounted to the top of the vertical transport cask. The lid is removed and a mating ring is attached to the upper surface of the transport cask and a lifting lug fixture is raised and bolted to the top of the DPC. During these activities, the workers are on temporary platforms approximately 20 feet above the ground and they are exposed to the top of the DPC. Once the transport cask lid is removed, radiation streaming up the gap between the DPC and the transport cask makes the dose rates experienced while performing this work significant. The upper DPC cover is shielded making the doses on top of the DPC slightly less than the doses near the upper edge of the transport cask. Most of the work described above takes place in the higher dose rate area.

The next step in the vertical DPC transfer process is to mate the transfer cask onto the mating ring on top of the transport cask if one is required. In this case, once the transfer cask is moved into place, the work crews will need to bolt the cask to the mating ring on top of the transport cask. Once the two casks are mated or in place on the CTF, the dose rates in the work area are minimized. The CTF hoist lowers a grapple that captures the lifting lug and then the hoist extracts the DPC out of the transport cask and locks it into position in the transfer cask. Then, the workers unbolt the transfer cask and the crane lifts the transfer cask and moves it over to the storage overpack that has been prepositioned and fitted with seismic/stack-up supports and a mating collar while the railcar was being unpacked. The workers reposition themselves over to the overpack work platform and bolt the transfer cask to the mating ring on the overpack. These activities take place in a very low or background dose rate.

The transfer cask hoist lowers the DPC into the overpack, releases the grapple and retracts into its uppermost position. At this point, the workers unbolt the transfer cask and the crane removes it and places it in its storage location for the next shipment. The workers remove the lifting lug assembly and the crane returns to lift it off of the DPC. Once again, the workers here are exposed to the elevated dose rates at the top of the DPC.

The workers disassemble the mating collar and remove it. Then they disconnect the seismic/stack-up supports coordinated with the movement of the vertical cask transporter to grapple the overpack. The overpack lid is captured on the VCT hoist and it is lowered into position and the workers bolt it to the top of the overpack. Once the lid is in place, the dose rates on the work platform, drop to extremely low levels.

The overpack is then transported to the pad for placement in the storage array. This is a slow process but the dose rates are extremely low during this evolution. If the overpack needs to be bolted to the pad due to the seismic zone of the ISF site, then the workers performing this activity are exposed to relatively high dose rate resulting from streaming out of the air inlet at the bottom of the overpack.

For horizontal DPCs, the processes and radiological doses are quite different. The railcar packaging is removed in a manner identical to the vertical case. The single-failure-proof gantry crane picks the transport cask and can lift it in a vertical orientation or keep it in a horizontal position. The gantry crane sets the transport cask down directly onto the horizontal cask transporter (HCT) and lowers it down into the horizontal orientation on the HCT or places it on the HCT in a horizontal position. The HCT then moves off to the storage module (overpack) on the pad.

While the HCT is making the trip, workers at the overpack are preparing to accept the DPC. They check the alignment makers to ensure that there has been no movement. They then remove the shield cover from the overpack using a local stick crane. Once the cover is removed, the area in front of the opening is an extremely high radiation zone since there is no internal shielding within the overpack. Accordingly, any DPCs near the opening are shining directly out of the overpack. When the HCT approaches the overpack, a mobile stick crane is used to remove the transport cask cover. Then, the HCT and overpack crews align the transport cask with the overpack opening and mate the transport cask to the opening. The alignment must be true and parallel with the internals of the overpack to avoid damage to the DPC. All of these movements and alignment activities take place in a relatively high dose rate.

Once the transport cask is mated to the overpack and hydraulic ram is engaged and the DPC is pushed out of the transport cask into the overpack. Once the DPC is in place and the ram is withdrawn, the HCT moves back from the overpack. Then, a worker reaches inside the overpack and places a seismic shear pin into a boss to prevent the DPC from sliding into the overpack cover. This is accomplished in an extremely high dose rate and needs to be done rapidly. After the seismic shear pin is installed, the shield cover over the overpack opening is reinstalled. This is activity is also conducted in a high dose rate.

B4-2.3 Time and Motion Analysis

B4-2.3.1 Methodology

This alternate is to use SNF DPC cask handling approaches used at a few nuclear power plants. Accordingly, the time and motion analysis is based on existing experience. These operational sequences were developed by subject matter experts in SNF handling. Interviews were conducted with several individuals with real, hands-on operational experience with moving SNF to achieve a consensus on the completeness, the durations and the staff size necessary to achieve each of these constituent activities. These were then pieced together to develop a bottom up estimate of durations and crew sizes for each step. While activities at nuclear plants routinely take place on a multi-shift 24-hour basis, this analysis will use the single 8-hour shift for a 40-hour week. Since the durations and crew sizes already include time for mobilization and for breaks, those issues are not explicitly described.

Additional steps were added to recognize the practice of having a “Plan of the Day” meeting and a safety meeting at the start of each shift. Also, steps not envisioned by the subject matter experts because they are part of the support systems at operating nuclear plants such as health physics (HP) coverage, record keeping, QA/QC oversight were included. Also, since operations stop at the end of each shift, steps were added to secure the DPCs during the off shifts periods. S-OPS would require a cask handling crew of 60 workers.

B4-2.3.2 Conclusion

It is determined that the S-OPS can process between one and one and two thirds full-sized DPCs placed into storage every week. This assumes a single heavy lift gantry crane at the rail siding, one cask transporter of each type and a heavy lift crane at the CTF (The heavy lift crane at the CTF could be either the gantry crane or a single-failure-proof VCT). Vertical DPCs can be processed at a rate of five every four weeks because the gantry crane is used for many of the steps in the four shift operation. Horizontal DPCs can be processed at an average rate of one and two thirds DPCs per week with one HCT or two and one half DPCs per week with two HCTs. The horizontal DPCs have an advantage because most of the activity conducted on the HCT which frees up the gantry crane to begin preparing another package.

A significant advantage of the S-OPS alternative is that is extremely modular. Adding additional equipment will result in more throughput. Doubling the number of gantry cranes, transporters and CTFs results in up to five DPCs every week which achieves approximately 3,000 MTHM/yr. Doubling again to four gantry cranes, four cask transporters of each type and 4 CTFs should result in an average of between four and ten DPCs every week. As can be seen, S-OPS is extremely flexible and can achieve a wide range of performance objectives.

The disadvantage of this approach is that it is labor intensive. In addition, it increases the radiation exposure necessary for each activity slightly over the more typical or remote techniques. The horizontal DPCs would appear to have an advantage because the heavy lift crane is available to unpackage the next transport cask while the HCT is delivering the DPC to the overpack on the pad. However, a problem arises when HCT returns with the empty transport cask. The transport cask on the railcar will be completely unpacked but will need to be positioned so that the crane can pick the emptied transport cask off of the HCT and place it on its railcar. So, a conservative sequence does not try to take advantage of the down time of the gantry crane by staggering the processing of two railcars at the same time.

Another consideration for this concept is weather. This approach is significantly impacted by adverse weather and other environmental conditions during the loading process if a weather enclosure is not erected over the CTFs. This approach is extremely sensitive to high winds, precipitation, and low temperatures. People are working on lift platforms operating powerful hydraulic or pneumatic tools. Adverse weather conditions could preclude operations. Depending on the siting of the ISF, the placement of DPCs can be adversely impacted by external conditions at the ISF. This can limit the ability to site the ISF anywhere without the throughput being impacted.

Figure B4-15 below shows the detail schedules for the vertical and for the horizontal commercial operations alternative.

The activities on the Y-axis are the steps necessary to process the DPCs from when they enter the rail siding until the emptied transport cask is reloaded and the transport packaging has been reinstalled. The time across the top of the schedule is in hours. The red bars are critical path activities; the blue are near critical path activities. It has been assumed that it will take 24-hours of observations of the DPC once stored to accept the package. This activity is show as a green dashed line on this chart but is not really part of the Canister Handling Crew’s responsibility. It is the hand-off to ISF Operations staff for long-term surveillance and safeguards. It will consist of a series of temperature, air flow and radiation measurements over the initial 24-hour period to validate that the expected performance has been achieved.

Figure B4-15
Time Motion Schedules for Commercial Operations (S-OPS)

Vertical DPCs - DPCs in storage casks on pad	
0)	Plan of the Day and Safety Meeting
1)	Receive transport cask on railcar at siding
2)	Remove impact limiters and place in temporary storage using gantry crane
3)	Upend and lift transport cask off of railcar and place on pad
4)	Install seismic stack-up struts on Transport Cask using stick crane
5)	Transporter moves storage cask into position and removes lid
6)	Mount Adapter plates to top of Storage Cask Using Stick Crane
7)	Install seismic stack-up struts on Storage Cask and weather cover using stick crane
7a)	Plan of the Day and Safety Meeting
8)	Unbolt and remove transport cask lid
9)	Attach lifting lug to top of DPC
10)	Mount adapter plates to top of Transport Cask Using Stick Crane
11)	Install the Transfer Cask on Transport Cask using the gantry crane
12)	Bolt Transfer Cask to adapter plate
13)	Raise DPC from transport cask up into transfer cask
13a)	Plan of the Day and Safety Meeting
14)	Transfer cask is unbolted from adapter plate
15)	Crane moves transfer cask from transport cask to storage cask
16)	Install Weather Cover to Transport Cask
17)	Transfer cask is bolted to the Storage Cask adapter plate
18)	Lower DPC from transfer cask into storage cask
19)	Unbolt Transfer cask is from adapter plate
20)	Remove Transfer Cask and place back into storage location
21)	Remove adapter plates storage and transport casks
21a)	Plan of the Day and Safety Meeting
22)	Remove lifting lug from DPC
23)	Remove seismic/stack-up struts from Storage Cask
24)	Dock VCT with Storage Cask and bolt on the lid
25)	Transporter takes storage cask to pad
26)	Turnover to Operations
27)	Return VCT to Rail Siding
28)	Install transport cask lid
29)	Remove seismic/stack-up struts from Transport Cask
30)	Lift transport cask and transfer to maintenance
30a)	Survey and Wipedown Transport Cask
31)	Lift transport cask and place on railcar
32)	Install impact limiters on transport cask
33)	Release railcar for shipment

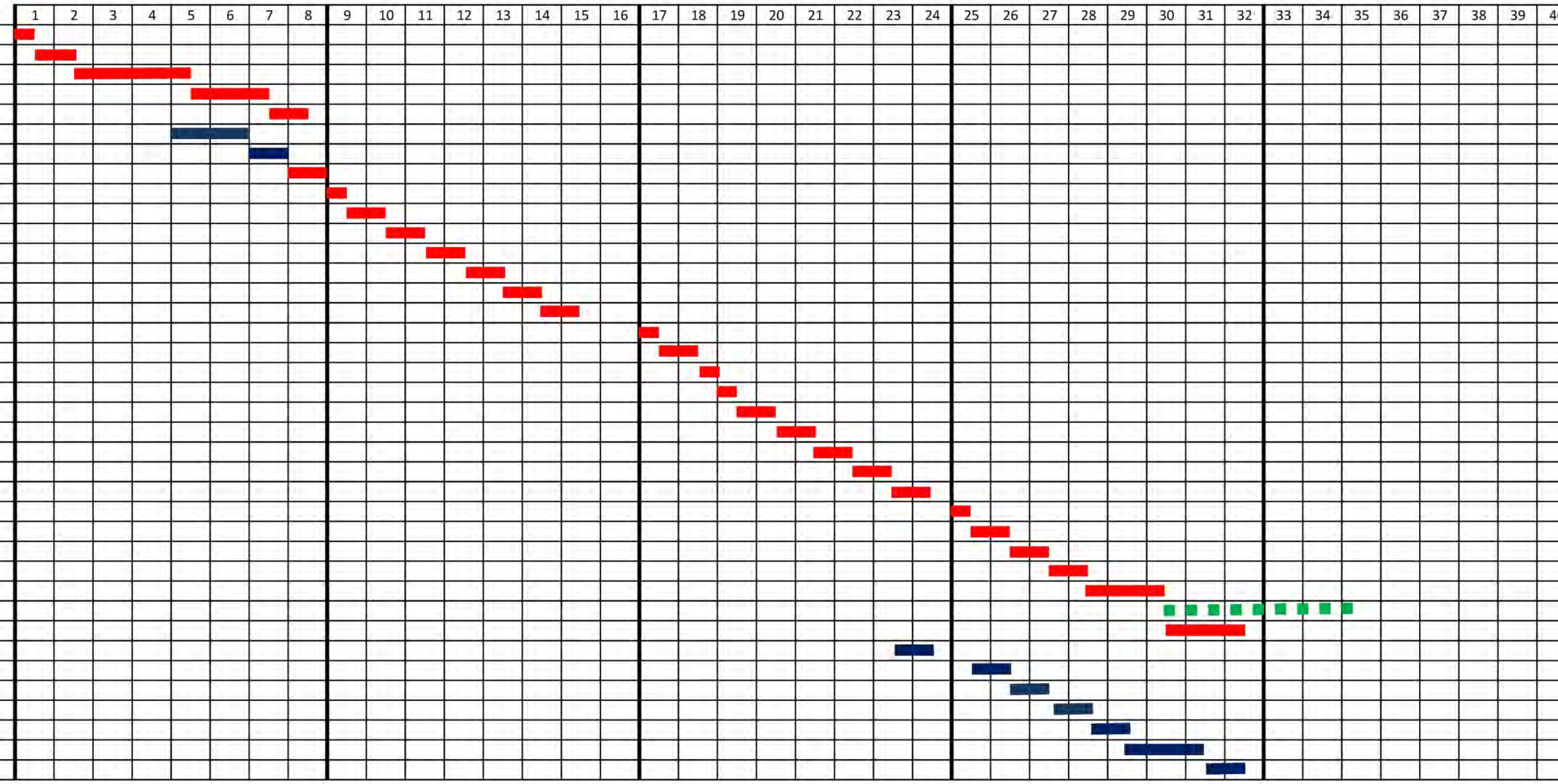
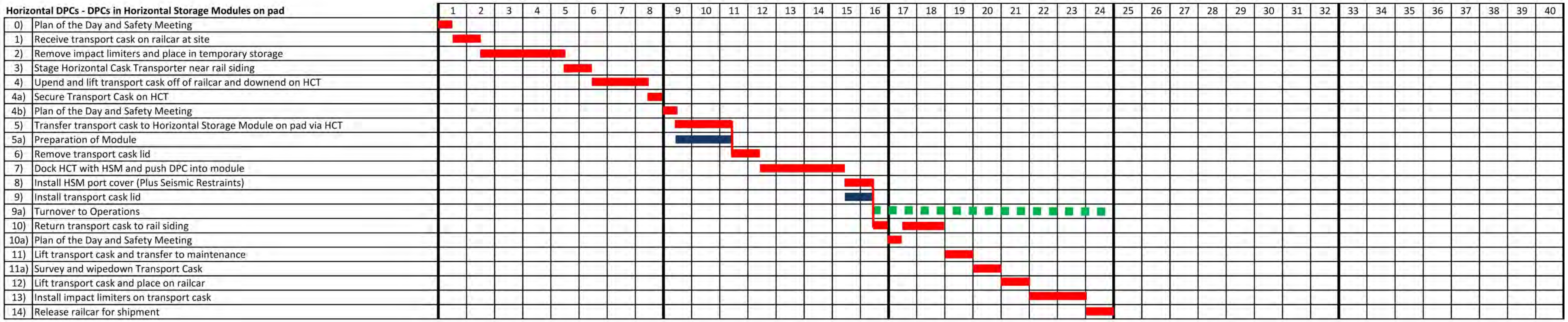


Figure B4-15
Time Motion Schedules for Commercial Operations (S-OPS) (Cont'd)

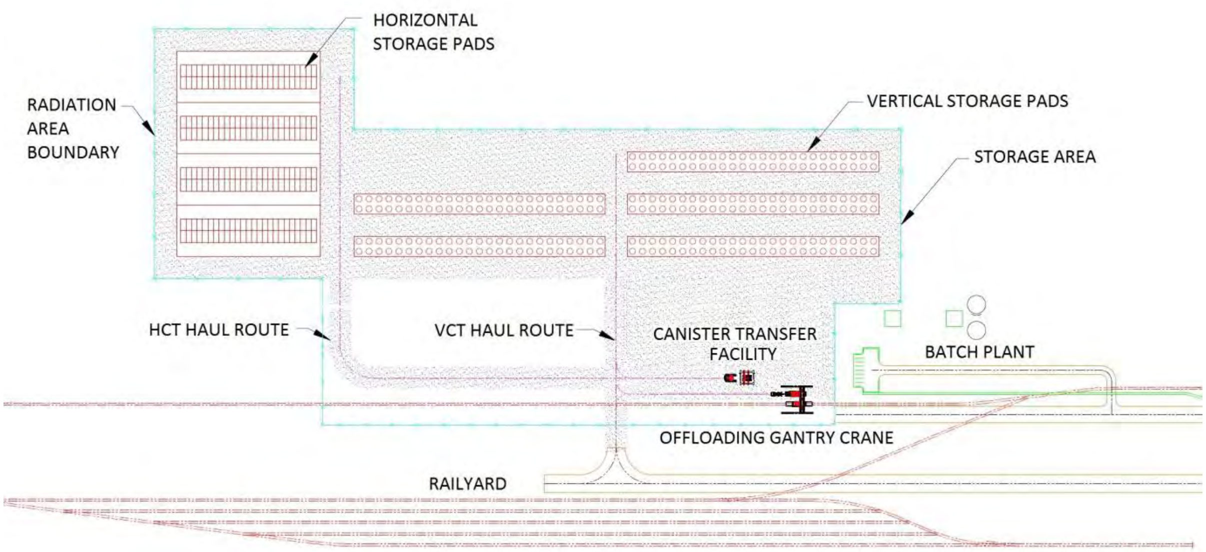


B4-3.0 Performance of Structures, Systems and Components

B4-3.1 Facility Layout and Equipment Evaluation

Figure B4-16 shows the layout of the site using the S-OPS cask handling approach. It shows the location of the offloading gantry crane and canister transfer facility in relation to the storage pads and the HCT and VCT haul routes.

Figure B4-16
Pilot ISF Gantry Crane and CTF in Relation to Storage Area



B4-3.2 Structural and Seismic Evaluation

The seismic stability of the pads and storage overpacks is addressed in Appendix A1. For S-OPS, the primary structure affected by a seismic event are the gantry crane and canister transfer facility. Neither of these structures are large. For the 0.25G earthquake, the capacity of the gantry crane and CTF to resist seismic forces is minimal.

For the 0.75G earthquake, the acceleration demands at the gantry crane and CTF could be more significant depending on the height to which they are established. Design loads must be considered in relation to the height of the structures in relation to their base footprint. Their foundations may need to be thickened to resist overturning moments applied across the minor axis. The seismic/stack-up restraints or struts will also need to be considered in the structures ability to resist seismic loads.

B4-3.3 Radiological Evaluation

The exposures to radiation for the workers at the ISF were based on the time and motion study and the assumed average dose rates from the DPCs stored at the site. Once installed in their storage locations, the doses to workers and to the public are quite small. However, during Canister Handling Operations, workers need to work on top of DPCs and near the transport cask and the transfer casks. In addition, plant security officers need to visually inspect the inside of the transport cask for contraband as soon as it is opened which increases their doses. Workers on vertical cask storage units need to bolt a lifting lug directly onto the DPC and after it has been transferred to the storage insert/adaptor/lifting frame, it needs to be unbolted and the storage insert/adaptor/lifting frame lid needs to be bolted in place.

Most of the activities are conducted well away from the DPC and behind shielding. But some of the activities require hands-on contact to the DPC or working near the open end of shield casks or overpacks.

The radiation doses associated with dry storage concepts are well understood and readily available from the literature regarding ISFSI operations at the generators' sites. Most of the radiation doses at operating plant sites are associated with the loading of the storage canisters in the fuel pool and the subsequent passivation steps of drying, inerting and welding closed the storage canisters. Once the canisters are loaded into their storage casks, there are few remaining issues.

Vertical storage casks have a streaming problem at the bottom of the cask where the cool air inlets are. Also, when working around the top of the canister in either the transport cask or the storage cask, the dose rate streaming up the annular gap between the canister and the shield when the lid is removed is significant to the workers. So care needs to be exercised with securing the shield cask lid to the top of the cask and with securing the seismic hold downs for the cask on the pad.

Horizontal storage systems have a radiological problem when preparing the module to receive the spent nuclear fuel canister. The shielded cover needs to be removed from the storage module for the new storage location. However, the storage module is not well shielded from the neighboring module so that the area around the opening is a high radiation area. Once the HCT has docked with the storage module, the dose rates are quite low and remain so during the entire transfer operation. However, in order to secure the canister seismically, a worker needs to reach into the module and insert a shear pin in the module that precludes the canister shifting toward the cover plate during a seismic event. This is a high radiation evolution that needs to be addressed by the final ISF design. A better way should be developed than having workers routinely reaching into a storage module to attach a seismic restraint.

Table B4-2 shows typical dose rates near waste packages of interest for this study. These values are for a predicted average SNF and were developed using a calculated percentage of the doses emitted from design base SNF from the vendor FSARs (Reference B4-1 through B4-13) based on typical nuclear plant experience..

Table B4-2
Typical Dose Rates Near Casks

Component	Top	Top Side	Side	Bottom
Transport Cask	15.0	31.8	34.0	15.0
Vertical Storage Cask Open	254.0	150.0	44.0	111.0
Vertical Storage Cask Sealed	18.4	20.0	44.0	111.0
Horizontal Storage Module	Near Opening 7.1		Inside 163.2	
General Area CTF	< 0.5 mrem/hr			

Section 6.4 of the Report, "Occupational Dose/ALARA Analysis of Storage Alternatives" shows cask handling operations for S-OPS and their respective doses which are shown in **Table B4-3**.

Table B4-3
Duration and Radiation Doses for S-OPS Cask Handling Operations

Alternative	Storage Configuration	Duration of Transfer Operation (hours)	Radiation Dose per Transfer (mrem) (Entire Operations Staff Dose)
S-OPS, Simplified Canister Transfer	Vertical	29	458
	Horizontal	24	203

B4-3.4 Equipment Maintenance Evaluation

This approach relies on proven and conceptual structures that uses conventional equipment. Heavy lift, single-failure-proof gantry cranes and VCTs, HCTs and the miscellaneous tools and equipment necessary for this approach are all proven demonstrated and available commercially. The cranes and most of the equipment are highly reliable and require relatively little maintenance.

The HCTs and VCTs are extremely complex machines and are designed for episodic operation. If they are used continuously, it is reasonable to expect a great deal of maintenance to be necessary. For that reason, spare transporters should be added to the ISF's inventory to ensure availability.

B4-3.5 Licensing Evaluation

This handling alternative is based on some existing approaches that have already been reviewed and approved by the NRC and conceptual approaches that would be expected to be approved by the NRC as well. Therefore, the licensing issues would focus on the repeated transport cask offload, canister transfer and transporter travel issues. The site specific Safety Analysis Report will need to detail the gantry crane and CTF structure design and margins, all operations, radiation doses, and address a suite of manmade and natural accidents or off-normal events to show that there are no unsafe operations of the ISF. NUREG-1567 (Reference B4-19) contains detailed guidance that can be followed to ensure all aspects of this alternative are adequately addressed. The onsite worker doses and offsite dose to the public will need to be calculated at strategic locations around the ISF to ensure ALARA.

In addition, the Environmental Report will need to address all facility components and operational steps to ensure that environmental regulations are adhered to. The ramifications of the Environmental Report also affect off-site conditions that could be adversely altered due to traffic from worker numbers, noise, solid waste, liquid waste, sewage water, etc. All site activities will need to be addressed because this will be the basis for the NRC Environmental Impact Statement.

B4-3.6 Modular Concepts Evaluation

The S-OPS alternative is extremely modular. In principle, it could be expanded to almost any throughput desired by the simple expedient of acquiring additional equipment. The approach appears to be essentially linear. Doubling the equipment and staffing will double the throughput.

B4-4.0 Summary

S-OPS is a relatively low-cost, extremely predictable cask handling alternative that should be seriously considered if construction of the Cask Handling Building is deferred for any reason. The S-OPS approach could permit the ISF to begin operations while construction of the infrastructure necessary for other approaches is completed. As such, it represents an alternative that does not preclude other options.

This alternative can process a vertical DPC in 4 shifts and a horizontal DPC in 3 shifts. S-OPS can only process an average of 1.25 vertical DPCs or 1.67 horizontal DPCs if only one gantry crane, one canister transfer facility, one horizontal cask transporter and one vertical cask transporter are used. However, doubling that number can achieve up to 2½ vertical DPCs and 2½ horizontal DPCs (5 DPCs total) per week resulting in an overall throughput of approximately 3,000 MTHM per year.

The average overall dose to workers is 458 mrem processing a vertical DPC and 203 mrem processing a horizontal DPC.

In summary, the pros and cons to this alternative, listed from the highest most significant impact to the lowest least significant impact are as follows:

<u>Pros</u>

- S-OPS offers the ability for the DOE to begin Pilot ISF operations without the cost or construction burden of a cask handling building. It could also be implemented with a plan that defers construction of a cask handling building to a later date while taking into account incremental startup of the transportation system (that is not included in this study). It is likely that S-OPS would be capable of keeping up with the arrival of initial SNF shipments until the CHB is constructed.
- S-OPS would use transfer casks and ancillary equipment that have already been proven and licensed. Equipment such as single-failure-proof gantry cranes are reliable having been designed to nuclear codes and standards with NRC guidance for testing, operation and maintenance which increases reliability.
- The operation steps in S-OPS are similar to those in C-OPS which have been reviewed by the NRC. Normal, off-normal and accident scenarios are well understood. The Pilot ISF Site Specific license under 10CFR72 (Reference B4-20) can utilize all the existing operational information at the few power plants that use a CTF which will streamline the licensing process.
- The throughput can be increase by adding additional components.

Cons

- S-OPS is very labor intensive and time consuming compared to other approaches. Several steps are required for every canister transfer operation which increases the duration of the activities as well as the radiological dose.
- There are 13 different systems that need to be accommodated. Currently, each system has been designed to use its own specific equipment. The S-OPS alternative would likely use transfer casks and ancillary equipment designed and licensed for all 13 storage systems. Processing multiple systems will require space to store all the equipment, multiple procedures, and a variety of equipment that can introduce the potential for errors. Employing 13 sets of equipment to lift and offload a transport cask, transfer the DPC from the transport cask to a storage overpack could be burdensome. The creation of equipment that could be used for multiple systems would improve the process.
- The entire process could be conducted outdoors and exposed to the elements if the gantry and CTF are not enclosed in a weather enclosure. Adverse weather and other conditions directly impact the efficiency of operations and may, if severe enough, could preclude operations at the ISF under certain conditions.

B4-5.0 References

1. AREVA TN Updated Final Safety Analysis Report for the Standardized NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No, 72-1004.
2. AREVA TN Updated Final Safety Analysis Report for the Advanced NUHOMS Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC, Docket Number 72-1029.
3. AREVA TN Final Safety Analysis Report for the NUHOMS HD Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1032.
4. FuelSolutions Storage System Final Safety Analysis Report, NRC Docket No. 72-1026.
5. FuelSolutions W74 Canister Storage Final Safety Analysis Report, NRC Docket No. 72-1026.
6. Holtec International Final Safety Analysis Report for the HI-STAR 100 Cask System, NRC Docket No. 72-1008.

7. Holtec International Final Safety Analysis Report for the HI-STORM 100 Cask System, NRC Docket No.: 72-1014.
8. Holtec International Final Safety Analysis Report on the HI-STORM FW MPC Storage System, NRC Docket No. 72-1032.
9. Holtec International Final Safety Analysis Report on the HI-STORM UMAX Canister Storage System, NRC Docket 72-1040.
10. NAC Final Safety Analysis Report for the Multi-Purpose Canister (NAC-MPC), NRC Docket No. 72-1025.
11. NAC Final Safety Analysis Report MPC-LACBWR Amendment, NRC Docket No. 72-1025.
12. NAC Final Safety Analysis Report for the Universal MPC System (UMS) Universal Storage System, NRC Docket No. 72-1015.
13. NAC Final Safety Analysis Report for the MAGNASTOR (Modular Advanced Generation Nuclear All-purpose STORage) System, NRC Docket No. 72-1031.
14. Holtec Patent No. US 7,139,358 B2, Below Grade Cask Transfer Facility (CTF), issued November 21, 2006.
15. ASME NOG-1, Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder), 2004.
16. American Crane and Equipment Company Patent No. US 6,674,828 B1, Safe Lift and Process for Transporting Canisters of Spent Nuclear Fuel, issued January 6, 2004.
17. NRC NUREG-0554, Single-Failure-Proof Cranes For Nuclear Power Plants, U.S. Nuclear Regulatory Commission, May 1979.
18. NRC NUREG-0612, Control of Heavy Loads at Nuclear Power Plants, U.S. Nuclear Regulatory Commission, July 1980.
19. NRC NUREG-1567, Standard Review Plan for Spent Fuel Dry Storage Facilities, Rev. 0, March 2000.
20. 10 CFR 72, Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste.

APPENDIX B5-1

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 1 - C-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST SUMMARIES

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: C-OPS Pilot (5,000 MTU)
PILOT Project - C-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB
Annual Escalation Factor 2.00%

Life Cycle Costs (40 Year Life)	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction	*$795,066,094*					*$795,066,094*
Operations & Maintenance (40 Year Life)		*$544,611,815*				*$544,611,815*
Cask Handling		$38,508,689				*$38,508,689*
Transportation Equipment	$0					*$0*
Transport Operations		$0	$0			*$0*
Repackaging	$0	$0				*$0*
Transport to Repository	$0		$0			*$0*
D&D				$91,292,445		*$91,292,445*
Escalation					$539,685,065	*$539,685,065*
Total Costs (40 year Life)						*$2,009,164,107*

Life Cycle Costs (80 Year Life)	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction	*$795,066,094*					*$795,066,094*
Operations & Maintenance (80 Year Life)		*$1,010,344,935*				*$1,010,344,935*
Cask Handling		$38,508,689				*$38,508,689*
Transportation Equipment	$0					*$0*
Transport Operations		$0	$0			*$0*
Repackaging	$0	$0				*$0*
Transport to Repository	$0		$0			*$0*
D&D				$91,292,445		*$91,292,445*
Escalation					$1,269,402,720	*$1,269,402,720*
Total Costs (80 Year Life)						*$3,204,614,882*

APPENDIX B5-1

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 1 - C-OPS, PILOT, LOW SEISMIC

CAPITAL COST SUMMARIES

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: C-OPS Pilot (5,000 MTU)
PILOT Project - C-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

Level 3 Cost Summary - First of A kind module

Level 1	Level 2	Level 3	Description		Level 3 Total
C-PAD EX 01			Interim Storage Facility and transportation Project		
	C-PAD EX 01.01		Pilot ISF Facility	$467,259,814	
		C-PAD EX 01.01.01	Storage Pads		$0
		C-PAD EX 01.01.02	Cask Handling (Transfer) Facility		$130,675,719
		C-PAD EX 01.01.03	Horizontal Dry Storage Modules		$95,969,797
		C-PAD EX 01.01.04	Vertical Dry Storage Module		$81,475,136
		C-PAD EX 01.01.05	Storage Cask Fabrication Facility		$0
		C-PAD EX 01.01.06	Cask Maintenance Facility		$0
		C-PAD EX 01.01.07	Concrete Batch Plant		$1,850,000
		C-PAD EX 01.01.08	Visitor Center/ Auditorium		$0
		C-PAD EX 01.01.09	Administration Building		$3,140,000
		C-PAD EX 01.01.10	Security		$24,148,975
		C-PAD EX 01.01.11	Rail Spur/ Receiving Yard		$58,752,800
		C-PAD EX 01.01.12	Utilities		$18,682,150
		C-PAD EX 01.01.13	Roads		$18,212,737
		C-PAD EX 01.01.14	Parking		$735,000
		C-PAD EX 01.01.15	Site Work		$23,417,500
		C-PAD EX 01.01.16	Warehouse		$10,200,000
		C-PAD EX 01.01.17	Maintenance Facility		$0
		C-PAD EX 01.01.18	Waste management Facility		$0
		C-PAD EX 01.01.01.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.02		Expanded Interim Storage Facility	$0	
		C-PAD EX 01.02.01	Expanded Storage Pads and Dry Cask Storage Systems		$0
		C-PAD EX 01.02.02	Expanded Cask Handling Facility (if required)		$0
		C-PAD EX 01.02.03	Horizontal Dry Storage Modules		$0
		C-PAD EX 01.02.04	Vertical Dry Storage Casks		$0
		C-PAD EX 01.02.05	Storage Cask Fabrication Facility (Expanded)		$0
		C-PAD EX 01.02.06	Cask Maintenance Facility (Expanded)		$0
		C-PAD EX 01.02.07	Concrete Batch Plant (Expanded if needed)		$0
		C-PAD EX 01.02.08	Visitor Center/ Auditorium (expanded if needed)		$0
		C-PAD EX 01.02.09	Administration Building (Expanded if needed)		$0
		C-PAD EX 01.02.10	Security (Expanded)		$0
		C-PAD EX 01.02.11	Rail Spur/ Receiving Yard (Expanded)		$0
		C-PAD EX 01.02.12	Utilities Expanded as needed)		$0
		C-PAD EX 01.02.13	Roads (Expanded)		$0
		C-PAD EX 01.02.14	Parking (Expanded as needed)		$0
		C-PAD EX 01.02.15	Site Work (Expanded)		$0
		C-PAD EX 01.02.16	Warehouse (Expanded if Needed)		$0
		C-PAD EX 01.02.17	Maintenance Facility (Expanded if needed)		$0
		C-PAD EX 01.02.18	Waste management Facility (Expanded if needed)		$0
		C-PAD EX 01.02.19	Hot Cell / Laboratories		$0
		C-PAD EX 01.02.20	Pool Packaging Facility		$0
		C-PAD EX 01.02.21	Standardized Storage System		$0
		C-PAD EX 01.02.22	Standardized Disposal Canister		$0
		C-PAD EX 01.02.23	Canister Repackaging Facility (For Repository		$0
	C-PAD EX 01.03		Transportation Equipment	$0	
		C-PAD EX 01.03.01	Transportation Casks		$0
		C-PAD EX 01.03.02	Rail Equipment		$0
		C-PAD EX 01.03.03	Rail Maintenance Facility		$0
		C-PAD EX 01.03.04	Transportation Systems Services		$0
	C-PAD EX 01.04		Pre-Construction Capitalized Costs	$57,815,000	
		C-PAD EX 01.04.01	Land or Land Leases		$1,920,000
		C-PAD EX 01.04.02	Site permits		$200,000
		C-PAD EX 01.04.03	Site Licensing		$6,240,000
		C-PAD EX 01.04.05	Plant Permits		$0
		C-PAD EX 01.04.06	Planning and Alternative Studies		$750,000

		C-PAD EX 01.04.07	Research and Development		$0
		C-PAD EX 01.04.08	Design		$23,955,000
		C-PAD EX 01.04.09	Other Pre-construction Costs		$14,750,000
		C-PAD EX 01.04.10	Pre-construction contingencies		$10,000,000
		C-PAD EX 01.04.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.05		Indirect Capitalized Costs	$63,180,000	
		C-PAD EX 01.05.01	Project Management		$2,700,000
		C-PAD EX 01.05.02	Construction Management		$3,600,000
		C-PAD EX 01.05.03	Field indirect services		$11,880,000
		C-PAD EX 01.05.o4	Design Services in support of Construction		$5,400,000
		C-PAD EX 01.05.05	QA/QC		$12,600,000
		C-PAD EX 01.05.06	Commissioning and Startup		$1,200,000
		C-PAD EX 01.05.07	Home office Engineering support to Construction		$7,200,000
		C-PAD EX 01.05.08	Document Control		$2,700,000
		C-PAD EX 01.05.09	Project Controls		$3,600,000
		C-PAD EX 01.05.10	Construction Testing		$2,700,000
		C-PAD EX 01.05.11	Inspections		$3,600,000
		C-PAD EX 01.05.12	Startup and Testing		$3,000,000
		C-PAD EX 01.05.13	Commissioning		$3,000,000
	C-PAD EX 01.06		Site Selection	$1,800,000	
		C-PAD EX 01.06.01	Site Selection		$1,200,000
		C-PAD EX 01.06.02	Public Information Process		$600,000
	C-PAD EX 01.07		Decontamination and Deconstruction	$0	
		C-PAD EX 01.07.01	Decommissioning		$0
		C-PAD EX 01.07.02	Decontamination		$0
		C-PAD EX 01.07.03	Deconstruction		$0
		C-PAD EX 01.07.04			$0
		C-PAD EX 01.07.05			$0
	C-PAD EX 01.08		Project Financial Costs	$79,067,345	
		C-PAD EX 01.08.01	Contractor Fees		$47,204,385
		C-PAD EX 01.08.02	Escalation Costs		$31,862,960
		C-PAD EX 01.08.03	Interest Payments		$0
		C-PAD EX 01.08.04	Indirect costs to support shipments to repository		$0
		C-PAD EX 01.08.05			$0
		C-PAD EX 01.08.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.09		Project Contingencies	$103,713,935	
		C-PAD EX 01.09.01	Management Reserve - Contractor Held		$33,456,108
		C-PAD EX 01.09.02	Contingency - DOE held		$70,257,827
	C-PAD EX 01.10				
		C-PAD EX 01.10.01	Other Direct Costs	$22,230,000	
		C-PAD EX 01.10.02	DOE Project Operations		$3,900,000
		C-PAD EX 01.10.03	DOE TM&E		$780,000
		C-PAD EX 01.10.04	Host site Operational Costs Miscellaneous		$15,600,000
		C-PAD EX 01.10.05	Miscellaneous ODC		$1,950,000
	C-PAD EX 01.11		Operational Costs	0	
		C-PAD EX 01.11.01	Operations Costs		$0
		C-PAD EX 01.11.02	Transportation Costs		$0
		C-PAD EX 01.11.03	Escalation (Operations/Transportation)		$0
Project Total					

TEC	(All Direct & indirect Costs, MR, Escalation)	$702,578,267
TPC	(TEC plus Contingency, ODCs)	$795,066,094
LCC	All Capitol, Operation, Transportation, Escalation	$795,066,094

APPENDIX B5-1

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 1 - C-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST – 40 YEAR OPERATING LIFE

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: C-OPS Pilot (5,000 MTU)
PILOT Project - C-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

Annual Escalation 2.00%

40 Year Operating life

YEAR	Design/Const	O&M	Cask Handling	D&D	Escalation	Annual Funding	Cumulative
1	$ 10,000,000	$ -	$ -	$ -	$ 200,000	$ 10,200,000	$ 10,200,000
2	$ 10,000,000	$ -	$ -	$ -	$ 400,000	$ 10,400,000	$ 20,600,000
3	$ 20,000,000	$ -	$ -	$ -	$ 1,200,000	$ 21,200,000	$ 41,800,000
4	$ 20,000,000	$ -	$ -	$ -	$ 1,600,000	$ 21,600,000	$ 63,400,000
5	$ 20,000,000	$ -	$ -	$ -	$ 2,000,000	$ 22,000,000	$ 85,400,000
6	$ 20,000,000	$ -	$ -	$ -	$ 2,400,000	$ 22,400,000	$ 107,800,000
7	$ 27,888,399	$ -	$ -	$ -	$ 3,904,376	$ 31,792,775	$ 139,592,775
8	$ 200,000,000	$ -	$ -	$ -	$ 32,000,000	$ 232,000,000	$ 371,592,775
9	$ 200,000,000	$ 22,503,661	$ -	$ -	$ 40,050,659	$ 262,554,320	$ 634,147,095
10	$ 267,177,695	$ 22,503,661	$ -	$ -	$ 57,936,271	$ 347,617,627	$ 981,764,722
11		$ 22,933,786	$ 12,836,230	$ -	$ 7,869,403	$ 43,639,419	$ 1,025,404,140
12	$ -	$ 22,933,786	$ 12,836,230	$ -	$ 8,584,804	$ 44,354,819	$ 1,069,758,959
13	$ -	$ 22,933,786	$ 12,836,230	$ -	$ 9,300,204	$ 45,070,219	$ 1,114,829,179
14	$ -	$ 11,643,328	$ -	$ -	$ 3,260,132	$ 14,903,460	$ 1,129,732,638
15	$ -	$ 11,643,328	$ -	$ -	$ 3,492,998	$ 15,136,326	$ 1,144,868,965
16	$ -	$ 11,643,328	$ -	$ -	$ 3,725,865	$ 15,369,193	$ 1,160,238,158
17	$ -	$ 11,643,328	$ -	$ -	$ 3,958,732	$ 15,602,060	$ 1,175,840,217
18	$ -	$ 11,643,328	$ -	$ -	$ 4,191,598	$ 15,834,926	$ 1,191,675,143
19	$ -	$ 11,643,328	$ -	$ -	$ 4,424,465	$ 16,067,793	$ 1,207,742,936
20	$ -	$ 11,643,328	$ -	$ -	$ 4,657,331	$ 16,300,659	$ 1,224,043,595
21	$ -	$ 11,643,328	$ -	$ -	$ 4,890,198	$ 16,533,526	$ 1,240,577,121
22	$ -	$ 11,643,328	$ -	$ -	$ 5,123,064	$ 16,766,392	$ 1,257,343,513
23	$ -	$ 11,643,328	$ -	$ -	$ 5,355,931	$ 16,999,259	$ 1,274,342,772
24	$ -	$ 11,643,328	$ -	$ -	$ 5,588,797	$ 17,232,125	$ 1,291,574,898
25	$ -	$ 11,643,328	$ -	$ -	$ 5,821,664	$ 17,464,992	$ 1,309,039,890
26	$ -	$ 11,643,328	$ -	$ -	$ 6,054,531	$ 17,697,859	$ 1,326,737,748
27	$ -	$ 11,643,328	$ -	$ -	$ 6,287,397	$ 17,930,725	$ 1,344,668,473
28	$ -	$ 11,643,328	$ -	$ -	$ 6,520,264	$ 18,163,592	$ 1,362,832,065
29	$ -	$ 11,643,328	$ -	$ -	$ 6,753,130	$ 18,396,458	$ 1,381,228,523
30	$ -	$ 11,643,328	$ -	$ -	$ 6,985,997	$ 18,629,325	$ 1,399,857,848
31	$ -	$ 11,643,328	$ -	$ -	$ 7,218,863	$ 18,862,191	$ 1,418,720,039
32	$ -	$ 11,643,328	$ -	$ -	$ 7,451,730	$ 19,095,058	$ 1,437,815,097
33	$ -	$ 11,643,328	$ -	$ -	$ 7,684,596	$ 19,327,924	$ 1,457,143,022
34	$ -	$ 11,643,328	$ -	$ -	$ 7,917,463	$ 19,560,791	$ 1,476,703,813
35	$ -	$ 11,643,328	$ -	$ -	$ 8,150,330	$ 19,793,658	$ 1,496,497,470
36	$ -	$ 11,643,328	$ -	$ -	$ 8,383,196	$ 20,026,524	$ 1,516,523,994
37	$ -	$ 11,643,328	$ -	$ -	$ 8,616,063	$ 20,259,391	$ 1,536,783,385
38	$ -	$ 11,643,328	$ -	$ -	$ 8,848,929	$ 20,492,257	$ 1,557,275,642
39	$ -	$ 11,643,328	$ -	$ -	$ 9,081,796	$ 20,725,124	$ 1,578,000,766
40	$ -	$ 11,643,328	$ -	$ -	$ 9,314,662	$ 20,957,990	$ 1,598,958,757
41	$ -	$ 11,643,328	$ -	$ -	$ 9,547,529	$ 21,190,857	$ 1,620,149,614
42	$ -	$ 11,643,328	$ -	$ -	$ 9,780,396	$ 21,423,724	$ 1,641,573,337
43	$ -	$ 11,643,328	$ -	$ -	$ 10,013,262	$ 21,656,590	$ 1,663,229,927
44	$ -	$ 11,643,328	$ -	$ -	$ 10,246,129	$ 21,889,457	$ 1,685,119,384
45	$ -	$ 11,643,328	$ -	$ -	$ 10,478,995	$ 22,122,323	$ 1,707,241,707
46	$ -	$ 11,643,328	$ -	$ -	$ 10,711,862	$ 22,355,190	$ 1,729,596,897
47	$ -	$ 11,643,328	$ -	$ -	$ 10,944,728	$ 22,588,056	$ 1,752,184,953
48	$ -	$ 11,643,328	$ -	$ -	$ 11,177,595	$ 22,820,923	$ 1,775,005,876
49	$ -	$ 11,643,328	$ -	$ -	$ 11,410,461	$ 23,053,789	$ 1,798,059,665
50	$ -	$ 11,643,328	$ -	$ -	$ 11,643,328	$ 23,286,656	$ 1,821,346,321
51	$ -	$ -	$ -	$ 21,175,000	$ 21,598,500	$ 42,773,500	$ 1,864,119,821
52	$ -	$ -	$ -	$ 20,000,000	$ 20,800,000	$ 40,800,000	$ 1,904,919,821
53	$ -	$ -	$ -	$ 16,705,815	$ 17,708,164	$ 34,413,979	$ 1,939,333,800
54	$ -	$ -	$ -	$ 16,705,815	$ 18,042,280	$ 34,748,095	$ 1,974,081,896
55	$ -	$ -	$ -	$ 16,705,815	$ 18,376,397	$ 35,082,212	$ 2,009,164,107
56	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,009,164,107
57	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,009,164,107
58	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,009,164,107
59	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,009,164,107
60	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,009,164,107
	Total Design/Const	Total O&M		Total D&D	Total Escalation		Total Life Cycle
	$ 795,066,094	$ 544,611,815	$ 38,508,689	$ 91,292,445	$ 539,685,065		$ 2,009,164,107

APPENDIX B5-1

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 1 - C-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST – 80 YEAR OPERATING LIFE

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: C-OPS Pilot (5,000 MTU)
PILOT Project - C-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

80 Year Operating Life

Annual Escalation
2.00%

YEAR	Design/Const	O&M	Cask Handling	D&D	Escalation	Annual Funding	Cumulative
1	$ 10,000,000	$ -	$ -	$ -	$200,000	$10,200,000	$10,200,000
2	$ 10,000,000	$ -	$ -	$ -	$400,000	$10,400,000	$20,600,000
3	$ 20,000,000	$ -	$ -	$ -	$1,200,000	$21,200,000	$41,800,000
4	$ 20,000,000	$ -	$ -	$ -	$1,600,000	$21,600,000	$63,400,000
5	$ 20,000,000	$ -	$ -	$ -	$2,000,000	$22,000,000	$85,400,000
6	$ 20,000,000	$ -	$ -	$ -	$2,400,000	$22,400,000	$107,800,000
7	$ 27,888,399	$ -	$ -	$ -	$3,904,376	$31,792,775	$139,592,775
8	$ 200,000,000	$ -	$ -	$ -	$32,000,000	$232,000,000	$371,592,775
9	$ 200,000,000	$ 22,503,661	$ -	$ -	$40,050,659	$262,554,320	$634,147,095
10	$ 267,177,695	$ 22,503,661	$ -	$ -	$57,936,271	$347,617,627	$981,764,722
11		$ 22,933,786	$ 12,836,230	$ -	$7,869,403	$43,639,419	$1,025,404,140
12	$ -	$ 22,933,786	$ 12,836,230	$ -	$8,584,804	$44,354,819	$1,069,758,959
13	$ -	$ 22,933,786	$ 12,836,230	$ -	$9,300,204	$45,070,219	$1,114,829,179
14	$ -	$ 11,643,328	$ -	$ -	$3,260,132	$14,903,460	$1,129,732,638
15	$ -	$ 11,643,328	$ -	$ -	$3,492,998	$15,136,326	$1,144,868,965
16	$ -	$ 11,643,328	$ -	$ -	$3,725,865	$15,369,193	$1,160,238,158
17	$ -	$ 11,643,328	$ -	$ -	$3,958,732	$15,602,060	$1,175,840,217
18	$ -	$ 11,643,328	$ -	$ -	$4,191,598	$15,834,926	$1,191,675,143
19	$ -	$ 11,643,328	$ -	$ -	$4,424,465	$16,067,793	$1,207,742,936
20	$ -	$ 11,643,328	$ -	$ -	$4,657,331	$16,300,659	$1,224,043,595
21	$ -	$ 11,643,328	$ -	$ -	$4,890,198	$16,533,526	$1,240,577,121
22	$ -	$ 11,643,328	$ -	$ -	$5,123,064	$16,766,392	$1,257,343,513
23	$ -	$ 11,643,328	$ -	$ -	$5,355,931	$16,999,259	$1,274,342,772
24	$ -	$ 11,643,328	$ -	$ -	$5,588,797	$17,232,125	$1,291,574,898
25	$ -	$ 11,643,328	$ -	$ -	$5,821,664	$17,464,992	$1,309,039,890
26	$ -	$ 11,643,328	$ -	$ -	$6,054,531	$17,697,859	$1,326,737,748
27	$ -	$ 11,643,328	$ -	$ -	$6,287,397	$17,930,725	$1,344,668,473
28	$ -	$ 11,643,328	$ -	$ -	$6,520,264	$18,163,592	$1,362,832,065
29	$ -	$ 11,643,328	$ -	$ -	$6,753,130	$18,396,458	$1,381,228,523
30	$ -	$ 11,643,328	$ -	$ -	$6,985,997	$18,629,325	$1,399,857,848
31	$ -	$ 11,643,328	$ -	$ -	$7,218,863	$18,862,191	$1,418,720,039
32	$ -	$ 11,643,328	$ -	$ -	$7,451,730	$19,095,058	$1,437,815,097
33	$ -	$ 11,643,328	$ -	$ -	$7,684,596	$19,327,924	$1,457,143,022
34	$ -	$ 11,643,328	$ -	$ -	$7,917,463	$19,560,791	$1,476,703,813
35	$ -	$ 11,643,328	$ -	$ -	$8,150,330	$19,793,658	$1,496,497,470
36	$ -	$ 11,643,328	$ -	$ -	$8,383,196	$20,026,524	$1,516,523,994
37	$ -	$ 11,643,328	$ -	$ -	$8,616,063	$20,259,391	$1,536,783,385
38	$ -	$ 11,643,328	$ -	$ -	$8,848,929	$20,492,257	$1,557,275,642
39	$ -	$ 11,643,328	$ -	$ -	$9,081,796	$20,725,124	$1,578,000,766
40	$ -	$ 11,643,328	$ -	$ -	$9,314,662	$20,957,990	$1,598,958,757
41	$ -	$ 11,643,328	$ -	$ -	$9,547,529	$21,190,857	$1,620,149,614
42	$ -	$ 11,643,328	$ -	$ -	$9,780,396	$21,423,724	$1,641,573,337
43	$ -	$ 11,643,328	$ -	$ -	$10,013,262	$21,656,590	$1,663,229,927
44	$ -	$ 11,643,328	$ -	$ -	$10,246,129	$21,889,457	$1,685,119,384
45	$ -	$ 11,643,328	$ -	$ -	$10,478,995	$22,122,323	$1,707,241,707
46	$ -	$ 11,643,328	$ -	$ -	$10,711,862	$22,355,190	$1,729,596,897
47	$ -	$ 11,643,328	$ -	$ -	$10,944,728	$22,588,056	$1,752,184,953
48	$ -	$ 11,643,328	$ -	$ -	$11,177,595	$22,820,923	$1,775,005,876
49	$ -	$ 11,643,328	$ -	$ -	$11,410,461	$23,053,789	$1,798,059,665
50	$ -	$ 11,643,328	$ -	$ -	$11,643,328	$23,286,656	$1,821,346,321
51	$ -	$ 11,643,328	$ -	$ -	$11,876,195	$23,519,523	$1,844,865,844
52	$ -	$ 11,643,328	$ -	$ -	$12,109,061	$23,752,389	$1,868,618,233
53	$ -	$ 11,643,328	$ -	$ -	$12,341,928	$23,985,256	$1,892,603,489
54	$ -	$ 11,643,328	$ -	$ -	$12,574,794	$24,218,122	$1,916,821,611
55	$ -	$ 11,643,328	$ -	$ -	$12,807,661	$24,450,989	$1,941,272,600
56	$ -	$ 11,643,328	$ -	$ -	$13,040,527	$24,683,855	$1,965,956,455
57	$ -	$ 11,643,328	$ -	$ -	$13,273,394	$24,916,722	$1,990,873,177
58	$ -	$ 11,643,328	$ -	$ -	$13,506,260	$25,149,588	$2,016,022,765
59	$ -	$ 11,643,328	$ -	$ -	$13,739,127	$25,382,455	$2,041,405,220

60	$ -	$ 11,643,328	$ -	$ -	$13,971,994	$25,615,322	$2,067,020,542
61	$ -	$ 11,643,328	$ -	$ -	$14,204,860	$25,848,188	$2,092,868,730
62	$ -	$ 11,643,328	$ -	$ -	$14,437,727	$26,081,055	$2,118,949,785
63	$ -	$ 11,643,328	$ -	$ -	$14,670,593	$26,313,921	$2,145,263,706
64	$ -	$ 11,643,328	$ -	$ -	$14,903,460	$26,546,788	$2,171,810,494
65	$0	$ 11,643,328	$ -	$ -	$15,136,326	$26,779,654	$2,198,590,148
66	$0	$ 11,643,328	$ -	$ -	$15,369,193	$27,012,521	$2,225,602,669
67	$0	$ 11,643,328	$ -	$ -	$15,602,060	$27,245,388	$2,252,848,057
68	$0	$ 11,643,328	$ -	$ -	$15,834,926	$27,478,254	$2,280,326,311
69	$0	$ 11,643,328	$ -	$ -	$16,067,793	$27,711,121	$2,308,037,431
70	$0	$ 11,643,328	$ -	$ -	$16,300,659	$27,943,987	$2,335,981,419
71	$0	$ 11,643,328	$ -	$ -	$16,533,526	$28,176,854	$2,364,158,272
72	$0	$ 11,643,328	$ -	$ -	$16,766,392	$28,409,720	$2,392,567,993
73	$0	$ 11,643,328	$ -	$ -	$16,999,259	$28,642,587	$2,421,210,579
74	$0	$ 11,643,328	$ -	$ -	$17,232,125	$28,875,453	$2,450,086,033
75	$0	$ 11,643,328	$ -	$ -	$17,464,992	$29,108,320	$2,479,194,353
76	$0	$ 11,643,328	$ -	$ -	$17,697,859	$29,341,187	$2,508,535,539
77	$0	$ 11,643,328	$ -	$ -	$17,930,725	$29,574,053	$2,538,109,593
78	$0	$ 11,643,328	$ -	$ -	$18,163,592	$29,806,920	$2,567,916,512
79	$0	$ 11,643,328	$ -	$ -	$18,396,458	$30,039,786	$2,597,956,298
80	$0	$ 11,643,328	$ -	$ -	$18,629,325	$30,272,653	$2,628,228,951
81	$0	$ 11,643,328	$ -	$ -	$18,862,191	$30,505,519	$2,658,734,471
82	$0	$ 11,643,328	$ -	$ -	$19,095,058	$30,738,386	$2,689,472,856
83	$0	$ 11,643,328	$ -	$ -	$19,327,924	$30,971,252	$2,720,444,109
84	$0	$ 11,643,328	$ -	$ -	$19,560,791	$31,204,119	$2,751,648,228
85	$0	$ 11,643,328	$ -	$ -	$19,793,658	$31,436,986	$2,783,085,214
86	$0	$ 11,643,328	$ -	$ -	$20,026,524	$31,669,852	$2,814,755,066
87	$0	$ 11,643,328	$ -	$ -	$20,259,391	$31,902,719	$2,846,657,784
88	$0	$ 11,643,328	$ -	$ -	$20,492,257	$32,135,585	$2,878,793,370
89	$0	$ 11,643,328	$ -	$ -	$20,725,124	$32,368,452	$2,911,161,821
90	$0	$ 11,643,328	$ -	$ -	$20,957,990	$32,601,318	$2,943,763,140
91			$ -	$ 21,175,000	$38,538,500	$59,713,500	$3,003,476,640
92			$ -	$ 20,000,000	$36,800,000	$56,800,000	$3,060,276,640
93			$ -	$ 16,705,815	$31,072,816	$47,778,631	$3,108,055,271
94			$ -	$ 16,705,815	$31,406,932	$48,112,747	$3,156,168,018
95			$ -	$ 16,705,815	$31,741,049	$48,446,864	$3,204,614,882
96				$ -	$0	$0	$3,204,614,882
97				$ -	$0	$0	$3,204,614,882
98					$0	$0	$3,204,614,882
99					$0	$0	$3,204,614,882
100					$0	$0	$3,204,614,882

Total Design/Const	Total O&M	Total Cask Handling	Total D&D	Total Escalation		Total Life Cycle
$795,066,094	$1,010,344,935	$38,508,689	$91,292,445	$1,269,402,720		$3,204,614,882

APPENDIX B5-2

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 2 – A-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST SUMMARIES

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: A-OPS Pilot (5,000 MTU)
PILOT Project - A-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB
Annual Escalation Factor 2.00%

Life Cycle Costs (40 Year Life)	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction	*$800,960,059*					*$800,960,059*
Operations & Maintenance (40 Year Life)		*$544,611,815*				*$544,611,815*
Cask Handling		$38,508,689				*$38,508,689*
Transportation Equipment	$0					*$0*
Transport Operations		$0	$0			*$0*
Repackaging	$0	$0				*$0*
Transport to Repository	$0		$0			*$0*
D&D				$91,292,445		*$91,292,445*
Escalation					$540,863,858	*$540,863,858*
Total Costs (40 year Life)						*$2,016,236,865*

Life Cycle Costs (80 Year Life)	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction	*$800,960,059*					*$800,960,059*
Operations & Maintenance (80 Year Life)		*$1,010,344,935*				*$1,010,344,935*
Cask Handling		$38,508,689				*$38,508,689*
Transportation Equipment	$0					*$0*
Transport Operations		$0	$0			*$0*
Repackaging	$0	$0				*$0*
Transport to Repository	$0		$0			*$0*
D&D				$91,292,445		*$91,292,445*
Escalation					$1,270,581,513	*$1,270,581,513*
Total Costs (80 Year Life)						*$3,211,687,640*

APPENDIX B5-2

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 2 – A-OPS, PILOT, LOW SEISMIC

CAPITAL COST SUMMARY

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: A-OPS Pilot (5,000 MTU)
PILOT Project - A-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

Level 3 Cost Summary - First of A kind module

Level 1	Level 2	Level 3	Description		Level 3 Total
C-PAD EX 01			Interim Storage Facility and transportation Project		
	C-PAD EX 01.01		Pilot ISF Facility	$471,759,814	
		C-PAD EX 01.01.01	Storage Pads		$0
		C-PAD EX 01.01.02	Cask Handling (Transfer) Facility		$135,175,719
		C-PAD EX 01.01.03	Horizontal Dry Storage Modules		$95,969,797
		C-PAD EX 01.01.04	Vertical Dry Storage Module		$81,475,136
		C-PAD EX 01.01.05	Storage Cask Fabrication Facility		$0
		C-PAD EX 01.01.06	Cask Maintenance Facility		$0
		C-PAD EX 01.01.07	Concrete Batch Plant		$1,850,000
		C-PAD EX 01.01.08	Visitor Center/ Auditorium		$0
		C-PAD EX 01.01.09	Administration Building		$3,140,000
		C-PAD EX 01.01.10	Security		$24,148,975
		C-PAD EX 01.01.11	Rail Spur/ Receiving Yard		$58,752,800
		C-PAD EX 01.01.12	Utilities		$18,682,150
		C-PAD EX 01.01.13	Roads		$18,212,737
		C-PAD EX 01.01.14	Parking		$735,000
		C-PAD EX 01.01.15	Site Work		$23,417,500
		C-PAD EX 01.01.16	Warehouse		$10,200,000
		C-PAD EX 01.01.17	Maintenance Facility		$0
		C-PAD EX 01.01.18	Waste management Facility		$0
		C-PAD EX 01.01.01.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.02		Expanded Interim Storage Facility	$0	
		C-PAD EX 01.02.01	Expanded Storage Pads and Dry Cask Storage Systems		$0
		C-PAD EX 01.02.02	Expanded Cask Handling Facility (if required)		$0
		C-PAD EX 01.02.03	Horizontal Dry Storage Modules		$0
		C-PAD EX 01.02.04	Vertical Dry Storage Casks		$0
		C-PAD EX 01.02.05	Storage Cask Fabrication Facility (Expanded)		$0
		C-PAD EX 01.02.06	Cask Maintenance Facility (Expanded)		$0
		C-PAD EX 01.02.07	Concrete Batch Plant (Expanded if needed)		$0
		C-PAD EX 01.02.08	Visitor Center/ Auditorium (expanded if needed)		$0
		C-PAD EX 01.02.09	Administration Building (Expanded if needed)		$0
		C-PAD EX 01.02.10	Security (Expanded)		$0
		C-PAD EX 01.02.11	Rail Spur/ Receiving Yard (Expanded)		$0
		C-PAD EX 01.02.12	Utilities Expanded as needed)		$0
		C-PAD EX 01.02.13	Roads (Expanded)		$0
		C-PAD EX 01.02.14	Parking (Expanded as needed)		$0
		C-PAD EX 01.02.15	Site Work (Expanded)		$0
		C-PAD EX 01.02.16	Warehouse (Expanded if Needed)		$0
		C-PAD EX 01.02.17	Maintenance Facility (Expanded if needed)		$0
		C-PAD EX 01.02.18	Waste management Facility (Expanded if needed)		$0
		C-PAD EX 01.02.19	Hot Cell / Laboratories		$0
		C-PAD EX 01.02.20	Pool Packaging Facility		$0
		C-PAD EX 01.02.21	Standardized Storage System		$0
		C-PAD EX 01.02.22	Standardized Disposal Canister		$0
		C-PAD EX 01.02.23	Canister Repackaging Facility (For Repository		$0
	C-PAD EX 01.03		Transportation Equipment	$0	
		C-PAD EX 01.03.01	Transportation Casks		$0
		C-PAD EX 01.03.02	Rail Equipment		$0
		C-PAD EX 01.03.03	Rail Maintenance Facility		$0
		C-PAD EX 01.03.04	Transportation Systems Services		$0
	C-PAD EX 01.04		Pre-Construction Capitalized Costs	$57,815,000	
		C-PAD EX 01.04.01	Land or Land Leases		$1,920,000
		C-PAD EX 01.04.02	Site permits		$200,000
		C-PAD EX 01.04.03	Site Licensing		$6,240,000
		C-PAD EX 01.04.05	Plant Permits		$0
		C-PAD EX 01.04.06	Planning and Alternative Studies		$750,000

		C-PAD EX 01.04.07	Research and Development		$0
		C-PAD EX 01.04.08	Design		$23,955,000
		C-PAD EX 01.04.09	Other Pre-construction Costs		$14,750,000
		C-PAD EX 01.04.10	Pre-construction contingencies		$10,000,000
		C-PAD EX 01.04.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.05		Indirect Capitalized Costs	$63,180,000	
		C-PAD EX 01.05.01	Project Management		$2,700,000
		C-PAD EX 01.05.02	Construction Management		$3,600,000
		C-PAD EX 01.05.03	Field indirect services		$11,880,000
		C-PAD EX 01.05.o4	Design Services in support of Construction		$5,400,000
		C-PAD EX 01.05.05	QA/QC		$12,600,000
		C-PAD EX 01.05.06	Commissioning and Startup		$1,200,000
		C-PAD EX 01.05.07	Home office Engineering support to Construction		$7,200,000
		C-PAD EX 01.05.08	Document Control		$2,700,000
		C-PAD EX 01.05.09	Project Controls		$3,600,000
		C-PAD EX 01.05.10	Construction Testing		$2,700,000
		C-PAD EX 01.05.11	Inspections		$3,600,000
		C-PAD EX 01.05.12	Startup and Testing		$3,000,000
		C-PAD EX 01.05.13	Commissioning		$3,000,000
	C-PAD EX 01.06		Site Selection	$1,800,000	
		C-PAD EX 01.06.01	Site Selection		$1,200,000
		C-PAD EX 01.06.02	Public Information Process		$600,000
	C-PAD EX 01.07		Decontamination and Deconstruction	$0	
		C-PAD EX 01.07.01	Decommissioning		$0
		C-PAD EX 01.07.02	Decontamination		$0
		C-PAD EX 01.07.03	Deconstruction		$0
		C-PAD EX 01.07.04			$0
		C-PAD EX 01.07.05			$0
	C-PAD EX 01.08		Project Financial Costs	$79,670,345	
		C-PAD EX 01.08.01	Contractor Fees		$47,564,385
		C-PAD EX 01.08.02	Escalation Costs		$32,105,960
		C-PAD EX 01.08.03	Interest Payments		$0
		C-PAD EX 01.08.04	Indirect costs to support shipments to repository		$0
		C-PAD EX 01.08.05			$0
		C-PAD EX 01.08.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.09		Project Contingencies	$104,504,900	
		C-PAD EX 01.09.01	Management Reserve - Contractor Held		$33,711,258
		C-PAD EX 01.09.02	Contingency - DOE held		$70,793,642
	C-PAD EX 01.10				
		C-PAD EX 01.10.01	Other Direct Costs	$22,230,000	
		C-PAD EX 01.10.02	DOE Project Operations		$3,900,000
		C-PAD EX 01.10.03	DOE TM&E		$780,000
		C-PAD EX 01.10.04	Host site Operational Costs Miscellaneous		$15,600,000
		C-PAD EX 01.10.05	Miscellaneous ODC		$1,950,000
	C-PAD EX 01.11		Operational Costs	0	
		C-PAD EX 01.11.01	Operations Costs		$0
		C-PAD EX 01.11.02	Transportation Costs		$0
		C-PAD EX 01.11.03	Escalation (Operations/Transportation)		$0
Project Total					

TEC	(All Direct & indirect Costs, MR, Escalation)	$707,936,417
TPC	(TEC plus Contingency, ODCs)	$800,960,059
LCC	All Capitol, Operation, Transportation, Escalation	$800,960,059

APPENDIX B5-2

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 2 – A-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST – 40 YEAR OPERATING LIFE

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: A-OPS Pilot (5,000 MTU)
PILOT Project - A-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

Annual Escalation 2.00%

40 Year Operating life

YEAR	Design/Const	O&M	Cask Handling	D&D	Escalation	Annual Funding	Cumulative
1	$ 10,000,000	$ -	$ -	$ -	$ 200,000	$ 10,200,000	$ 10,200,000
2	$ 10,000,000	$ -	$ -	$ -	$ 400,000	$ 10,400,000	$ 20,600,000
3	$ 20,000,000	$ -	$ -	$ -	$ 1,200,000	$ 21,200,000	$ 41,800,000
4	$ 20,000,000	$ -	$ -	$ -	$ 1,600,000	$ 21,600,000	$ 63,400,000
5	$ 20,000,000	$ -	$ -	$ -	$ 2,000,000	$ 22,000,000	$ 85,400,000
6	$ 20,000,000	$ -	$ -	$ -	$ 2,400,000	$ 22,400,000	$ 107,800,000
7	$ 27,888,399	$ -	$ -	$ -	$ 3,904,376	$ 31,792,775	$ 139,592,775
8	$ 200,000,000	$ -	$ -	$ -	$ 32,000,000	$ 232,000,000	$ 371,592,775
9	$ 200,000,000	$ 22,503,661	$ -	$ -	$ 40,050,659	$ 262,554,320	$ 634,147,095
10	$ 273,071,660	$ 22,503,661	$ -	$ -	$ 59,115,064	$ 354,690,385	$ 988,837,480
11		$ 22,933,786	$ 12,836,230	$ -	$ 7,869,403	$ 43,639,419	$ 1,032,476,898
12	$ -	$ 22,933,786	$ 12,836,230	$ -	$ 8,584,804	$ 44,354,819	$ 1,076,831,717
13	$ -	$ 22,933,786	$ 12,836,230	$ -	$ 9,300,204	$ 45,070,219	$ 1,121,901,937
14	$ -	$ 11,643,328	$ -	$ -	$ 3,260,132	$ 14,903,460	$ 1,136,805,396
15	$ -	$ 11,643,328	$ -	$ -	$ 3,492,998	$ 15,136,326	$ 1,151,941,723
16	$ -	$ 11,643,328	$ -	$ -	$ 3,725,865	$ 15,369,193	$ 1,167,310,916
17	$ -	$ 11,643,328	$ -	$ -	$ 3,958,732	$ 15,602,060	$ 1,182,912,975
18	$ -	$ 11,643,328	$ -	$ -	$ 4,191,598	$ 15,834,926	$ 1,198,747,901
19	$ -	$ 11,643,328	$ -	$ -	$ 4,424,465	$ 16,067,793	$ 1,214,815,694
20	$ -	$ 11,643,328	$ -	$ -	$ 4,657,331	$ 16,300,659	$ 1,231,116,353
21	$ -	$ 11,643,328	$ -	$ -	$ 4,890,198	$ 16,533,526	$ 1,247,649,879
22	$ -	$ 11,643,328	$ -	$ -	$ 5,123,064	$ 16,766,392	$ 1,264,416,271
23	$ -	$ 11,643,328	$ -	$ -	$ 5,355,931	$ 16,999,259	$ 1,281,415,530
24	$ -	$ 11,643,328	$ -	$ -	$ 5,588,797	$ 17,232,125	$ 1,298,647,656
25	$ -	$ 11,643,328	$ -	$ -	$ 5,821,664	$ 17,464,992	$ 1,316,112,648
26	$ -	$ 11,643,328	$ -	$ -	$ 6,054,531	$ 17,697,859	$ 1,333,810,506
27	$ -	$ 11,643,328	$ -	$ -	$ 6,287,397	$ 17,930,725	$ 1,351,741,231
28	$ -	$ 11,643,328	$ -	$ -	$ 6,520,264	$ 18,163,592	$ 1,369,904,823
29	$ -	$ 11,643,328	$ -	$ -	$ 6,753,130	$ 18,396,458	$ 1,388,301,281
30	$ -	$ 11,643,328	$ -	$ -	$ 6,985,997	$ 18,629,325	$ 1,406,930,606
31	$ -	$ 11,643,328	$ -	$ -	$ 7,218,863	$ 18,862,191	$ 1,425,792,797
32	$ -	$ 11,643,328	$ -	$ -	$ 7,451,730	$ 19,095,058	$ 1,444,887,855
33	$ -	$ 11,643,328	$ -	$ -	$ 7,684,596	$ 19,327,924	$ 1,464,215,780
34	$ -	$ 11,643,328	$ -	$ -	$ 7,917,463	$ 19,560,791	$ 1,483,776,571
35	$ -	$ 11,643,328	$ -	$ -	$ 8,150,330	$ 19,793,658	$ 1,503,570,228
36	$ -	$ 11,643,328	$ -	$ -	$ 8,383,196	$ 20,026,524	$ 1,523,596,752
37	$ -	$ 11,643,328	$ -	$ -	$ 8,616,063	$ 20,259,391	$ 1,543,856,143
38	$ -	$ 11,643,328	$ -	$ -	$ 8,848,929	$ 20,492,257	$ 1,564,348,400
39	$ -	$ 11,643,328	$ -	$ -	$ 9,081,796	$ 20,725,124	$ 1,585,073,524
40	$ -	$ 11,643,328	$ -	$ -	$ 9,314,662	$ 20,957,990	$ 1,606,031,515
41	$ -	$ 11,643,328	$ -	$ -	$ 9,547,529	$ 21,190,857	$ 1,627,222,372
42	$ -	$ 11,643,328	$ -	$ -	$ 9,780,396	$ 21,423,724	$ 1,648,646,095
43	$ -	$ 11,643,328	$ -	$ -	$ 10,013,262	$ 21,656,590	$ 1,670,302,685
44	$ -	$ 11,643,328	$ -	$ -	$ 10,246,129	$ 21,889,457	$ 1,692,192,142
45	$ -	$ 11,643,328	$ -	$ -	$ 10,478,995	$ 22,122,323	$ 1,714,314,465
46	$ -	$ 11,643,328	$ -	$ -	$ 10,711,862	$ 22,355,190	$ 1,736,669,655
47	$ -	$ 11,643,328	$ -	$ -	$ 10,944,728	$ 22,588,056	$ 1,759,257,711
48	$ -	$ 11,643,328	$ -	$ -	$ 11,177,595	$ 22,820,923	$ 1,782,078,634
49	$ -	$ 11,643,328	$ -	$ -	$ 11,410,461	$ 23,053,789	$ 1,805,132,423
50	$ -	$ 11,643,328	$ -	$ -	$ 11,643,328	$ 23,286,656	$ 1,828,419,079
51	$ -	$ -	$ -	$ 21,175,000	$ 21,598,500	$ 42,773,500	$ 1,871,192,579
52	$ -	$ -	$ -	$ 20,000,000	$ 20,800,000	$ 40,800,000	$ 1,911,992,579
53	$ -	$ -	$ -	$ 16,705,815	$ 17,708,164	$ 34,413,979	$ 1,946,406,558
54	$ -	$ -	$ -	$ 16,705,815	$ 18,042,280	$ 34,748,095	$ 1,981,154,654
55	$ -	$ -	$ -	$ 16,705,815	$ 18,376,397	$ 35,082,212	$ 2,016,236,865
56	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
57	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
58	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
59	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
60	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
	Total Design/Const	Total O&M		Total D&D	Total Escalation		Total Life Cycle
	$ 800,960,059	$ 544,611,815	$ 38,508,689	$ 91,292,445	$ 540,863,858		$ 2,016,236,865

APPENDIX B5-2

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 2 – A-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST – 80 YEAR OPERATING LIFE

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: A-OPS Pilot (5,000 MTU)
PILOT Project - A-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

80 Year Operating Life

					Annual Escalation		
					2.00%		
YEAR	Design/Const	O&M	Cask Handling	D&D	Escalation	Annual Funding	Cumulative
1	$ 10,000,000	$ -	$ -	$ -	$200,000	$10,200,000	$10,200,000
2	$ 10,000,000	$ -	$ -	$ -	$400,000	$10,400,000	$20,600,000
3	$ 20,000,000	$ -	$ -	$ -	$1,200,000	$21,200,000	$41,800,000
4	$ 20,000,000	$ -	$ -	$ -	$1,600,000	$21,600,000	$63,400,000
5	$ 20,000,000	$ -	$ -	$ -	$2,000,000	$22,000,000	$85,400,000
6	$ 20,000,000	$ -	$ -	$ -	$2,400,000	$22,400,000	$107,800,000
7	$ 27,888,399	$ -	$ -	$ -	$3,904,376	$31,792,775	$139,592,775
8	$ 200,000,000	$ -	$ -	$ -	$32,000,000	$232,000,000	$371,592,775
9	$ 200,000,000	$ 22,503,661	$ -	$ -	$40,050,659	$262,554,320	$634,147,095
10	$ 273,071,660	$ 22,503,661	$ -	$ -	$59,115,064	$354,690,385	$988,837,480
11		$ 22,933,786	$ 12,836,230	$ -	$7,869,403	$43,639,419	$1,032,476,898
12	$ -	$ 22,933,786	$ 12,836,230	$ -	$8,584,804	$44,354,819	$1,076,831,717
13	$ -	$ 22,933,786	$ 12,836,230	$ -	$9,300,204	$45,070,219	$1,121,901,937
14	$ -	$ 11,643,328	$ -	$ -	$3,260,132	$14,903,460	$1,136,805,396
15	$ -	$ 11,643,328	$ -	$ -	$3,492,998	$15,136,326	$1,151,941,723
16	$ -	$ 11,643,328	$ -	$ -	$3,725,865	$15,369,193	$1,167,310,916
17	$ -	$ 11,643,328	$ -	$ -	$3,958,732	$15,602,060	$1,182,912,975
18	$ -	$ 11,643,328	$ -	$ -	$4,191,598	$15,834,926	$1,198,747,901
19	$ -	$ 11,643,328	$ -	$ -	$4,424,465	$16,067,793	$1,214,815,694
20	$ -	$ 11,643,328	$ -	$ -	$4,657,331	$16,300,659	$1,231,116,353
21	$ -	$ 11,643,328	$ -	$ -	$4,890,198	$16,533,526	$1,247,649,879
22	$ -	$ 11,643,328	$ -	$ -	$5,123,064	$16,766,392	$1,264,416,271
23	$ -	$ 11,643,328	$ -	$ -	$5,355,931	$16,999,259	$1,281,415,530
24	$ -	$ 11,643,328	$ -	$ -	$5,588,797	$17,232,125	$1,298,647,656
25	$ -	$ 11,643,328	$ -	$ -	$5,821,664	$17,464,992	$1,316,112,648
26	$ -	$ 11,643,328	$ -	$ -	$6,054,531	$17,697,859	$1,333,810,506
27	$ -	$ 11,643,328	$ -	$ -	$6,287,397	$17,930,725	$1,351,741,231
28	$ -	$ 11,643,328	$ -	$ -	$6,520,264	$18,163,592	$1,369,904,823
29	$ -	$ 11,643,328	$ -	$ -	$6,753,130	$18,396,458	$1,388,301,281
30	$ -	$ 11,643,328	$ -	$ -	$6,985,997	$18,629,325	$1,406,930,606
31	$ -	$ 11,643,328	$ -	$ -	$7,218,863	$18,862,191	$1,425,792,797
32	$ -	$ 11,643,328	$ -	$ -	$7,451,730	$19,095,058	$1,444,887,855
33	$ -	$ 11,643,328	$ -	$ -	$7,684,596	$19,327,924	$1,464,215,780
34	$ -	$ 11,643,328	$ -	$ -	$7,917,463	$19,560,791	$1,483,776,571
35	$ -	$ 11,643,328	$ -	$ -	$8,150,330	$19,793,658	$1,503,570,228
36	$ -	$ 11,643,328	$ -	$ -	$8,383,196	$20,026,524	$1,523,596,752
37	$ -	$ 11,643,328	$ -	$ -	$8,616,063	$20,259,391	$1,543,856,143
38	$ -	$ 11,643,328	$ -	$ -	$8,848,929	$20,492,257	$1,564,348,400
39	$ -	$ 11,643,328	$ -	$ -	$9,081,796	$20,725,124	$1,585,073,524
40	$ -	$ 11,643,328	$ -	$ -	$9,314,662	$20,957,990	$1,606,031,515
41	$ -	$ 11,643,328	$ -	$ -	$9,547,529	$21,190,857	$1,627,222,372
42	$ -	$ 11,643,328	$ -	$ -	$9,780,396	$21,423,724	$1,648,646,095
43	$ -	$ 11,643,328	$ -	$ -	$10,013,262	$21,656,590	$1,670,302,685
44	$ -	$ 11,643,328	$ -	$ -	$10,246,129	$21,889,457	$1,692,192,142
45	$ -	$ 11,643,328	$ -	$ -	$10,478,995	$22,122,323	$1,714,314,465
46	$ -	$ 11,643,328	$ -	$ -	$10,711,862	$22,355,190	$1,736,669,655
47	$ -	$ 11,643,328	$ -	$ -	$10,944,728	$22,588,056	$1,759,257,711
48	$ -	$ 11,643,328	$ -	$ -	$11,177,595	$22,820,923	$1,782,078,634
49	$ -	$ 11,643,328	$ -	$ -	$11,410,461	$23,053,789	$1,805,132,423
50	$ -	$ 11,643,328	$ -	$ -	$11,643,328	$23,286,656	$1,828,419,079
51	$ -	$ 11,643,328	$ -	$ -	$11,876,195	$23,519,523	$1,851,938,602
52	$ -	$ 11,643,328	$ -	$ -	$12,109,061	$23,752,389	$1,875,690,991
53	$ -	$ 11,643,328	$ -	$ -	$12,341,928	$23,985,256	$1,899,676,247
54	$ -	$ 11,643,328	$ -	$ -	$12,574,794	$24,218,122	$1,923,894,369
55	$ -	$ 11,643,328	$ -	$ -	$12,807,661	$24,450,989	$1,948,345,358
56	$ -	$ 11,643,328	$ -	$ -	$13,040,527	$24,683,855	$1,973,029,213
57	$ -	$ 11,643,328	$ -	$ -	$13,273,394	$24,916,722	$1,997,945,935
58	$ -	$ 11,643,328	$ -	$ -	$13,506,260	$25,149,588	$2,023,095,523
59	$ -	$ 11,643,328	$ -	$ -	$13,739,127	$25,382,455	$2,048,477,978
60	$ -	$ 11,643,328	$ -	$ -	$13,971,994	$25,615,322	$2,074,093,300

61	$ -	$ 11,643,328	$ -	$ -	$14,204,860	$25,848,188	$2,099,941,488
62	$ -	$ 11,643,328	$ -	$ -	$14,437,727	$26,081,055	$2,126,022,543
63	$ -	$ 11,643,328	$ -	$ -	$14,670,593	$26,313,921	$2,152,336,464
64	$ -	$ 11,643,328	$ -	$ -	$14,903,460	$26,546,788	$2,178,883,252
65	$0	$ 11,643,328	$ -	$ -	$15,136,326	$26,779,654	$2,205,662,906
66	$0	$ 11,643,328	$ -	$ -	$15,369,193	$27,012,521	$2,232,675,427
67	$0	$ 11,643,328	$ -	$ -	$15,602,060	$27,245,388	$2,259,920,815
68	$0	$ 11,643,328	$ -	$ -	$15,834,926	$27,478,254	$2,287,399,069
69	$0	$ 11,643,328	$ -	$ -	$16,067,793	$27,711,121	$2,315,110,189
70	$0	$ 11,643,328	$ -	$ -	$16,300,659	$27,943,987	$2,343,054,177
71	$0	$ 11,643,328	$ -	$ -	$16,533,526	$28,176,854	$2,371,231,030
72	$0	$ 11,643,328	$ -	$ -	$16,766,392	$28,409,720	$2,399,640,751
73	$0	$ 11,643,328	$ -	$ -	$16,999,259	$28,642,587	$2,428,283,337
74	$0	$ 11,643,328	$ -	$ -	$17,232,125	$28,875,453	$2,457,158,791
75	$0	$ 11,643,328	$ -	$ -	$17,464,992	$29,108,320	$2,486,267,111
76	$0	$ 11,643,328	$ -	$ -	$17,697,859	$29,341,187	$2,515,608,297
77	$0	$ 11,643,328	$ -	$ -	$17,930,725	$29,574,053	$2,545,182,351
78	$0	$ 11,643,328	$ -	$ -	$18,163,592	$29,806,920	$2,574,989,270
79	$0	$ 11,643,328	$ -	$ -	$18,396,458	$30,039,786	$2,605,029,056
80	$0	$ 11,643,328	$ -	$ -	$18,629,325	$30,272,653	$2,635,301,709
81	$0	$ 11,643,328	$ -	$ -	$18,862,191	$30,505,519	$2,665,807,229
82	$0	$ 11,643,328	$ -	$ -	$19,095,058	$30,738,386	$2,696,545,614
83	$0	$ 11,643,328	$ -	$ -	$19,327,924	$30,971,252	$2,727,516,867
84	$0	$ 11,643,328	$ -	$ -	$19,560,791	$31,204,119	$2,758,720,986
85	$0	$ 11,643,328	$ -	$ -	$19,793,658	$31,436,986	$2,790,157,972
86	$0	$ 11,643,328	$ -	$ -	$20,026,524	$31,669,852	$2,821,827,824
87	$0	$ 11,643,328	$ -	$ -	$20,259,391	$31,902,719	$2,853,730,542
88	$0	$ 11,643,328	$ -	$ -	$20,492,257	$32,135,585	$2,885,866,128
89	$0	$ 11,643,328	$ -	$ -	$20,725,124	$32,368,452	$2,918,234,579
90	$0	$ 11,643,328	$ -	$ -	$20,957,990	$32,601,318	$2,950,835,898
91			$ -	$ 21,175,000	$38,538,500	$59,713,500	$3,010,549,398
92			$ -	$ 20,000,000	$36,800,000	$56,800,000	$3,067,349,398
93			$ -	$ 16,705,815	$31,072,816	$47,778,631	$3,115,128,029
94			$ -	$ 16,705,815	$31,406,932	$48,112,747	$3,163,240,776
95			$ -	$ 16,705,815	$31,741,049	$48,446,864	$3,211,687,640
96				$ -	$0	$0	$3,211,687,640
97				$ -	$0	$0	$3,211,687,640
98					$0	$0	$3,211,687,640
99					$0	$0	$3,211,687,640
100					$0	$0	$3,211,687,640

Total Design/Const	Total O&M	Total Cask Handling	Total D&D	Total Escalation	Total Life Cycle
$800,960,059	$1,010,344,935	$38,508,689	$91,292,445	$1,270,581,513	$3,211,687,640

APPENDIX B5-3

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 3 – R-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST SUMMARIES

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: R-OPS Pilot (5,000 MTU)
PILOT Project - R-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB
Annual Escalation Factor 2.00%

Life Cycle Costs (40 Year Life)	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction	*$812,093,104*					*$812,093,104*
Operations & Maintenance (40 Year Life)		*$541,181,213*				*$541,181,213*
Cask Handling		$38,508,689				*$38,508,689*
Transportation Equipment	$0					*$0*
Transport Operations		$0	$0			*$0*
Repackaging	$0	$0				*$0*
Transport to Repository	$0		$0			*$0*
D&D				$91,292,445		*$91,292,445*
Escalation					$542,267,122	*$542,267,122*
Total Costs (40 year Life)						*$2,025,342,573*

Life Cycle Costs (80 Year Life)	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction	*$812,093,104*					*$812,093,104*
Operations & Maintenance (80 Year Life)		*$1,006,914,333*				*$1,006,914,333*
Cask Handling		$38,508,689				*$38,508,689*
Transportation Equipment	$0					*$0*
Transport Operations		$0	$0			*$0*
Repackaging	$0	$0				*$0*
Transport to Repository	$0		$0			*$0*
D&D				$91,292,445		*$91,292,445*
Escalation					$1,271,984,777	*$1,271,984,777*
Total Costs (80 Year Life)						*$3,220,793,348*

APPENDIX B5-3

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 3 – R-OPS, PILOT, LOW SEISMIC

CAPITAL COST SUMMARY

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: R-OPS Pilot (5,000 MTU)
PILOT Project - R-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

Level 3 Cost Summary - First of A kind module

Level 1	Level 2	Level 3	Description		Level 3 Total
C-PAD EX 01			Interim Storage Facility and transportation Project		
	C-PAD EX 01.01		Pilot ISF Facility	$480,259,814	
		C-PAD EX 01.01.01	Storage Pads		$0
		C-PAD EX 01.01.02	Cask Handling (Transfer) Facility		$143,675,719
		C-PAD EX 01.01.03	Horizontal Dry Storage Modules		$95,969,797
		C-PAD EX 01.01.04	Vertical Dry Storage Module		$81,475,136
		C-PAD EX 01.01.05	Storage Cask Fabrication Facility		$0
		C-PAD EX 01.01.06	Cask Maintenance Facility		$0
		C-PAD EX 01.01.07	Concrete Batch Plant		$1,850,000
		C-PAD EX 01.01.08	Visitor Center/ Auditorium		$0
		C-PAD EX 01.01.09	Administration Building		$3,140,000
		C-PAD EX 01.01.10	Security		$24,148,975
		C-PAD EX 01.01.11	Rail Spur/ Receiving Yard		$58,752,800
		C-PAD EX 01.01.12	Utilities		$18,682,150
		C-PAD EX 01.01.13	Roads		$18,212,737
		C-PAD EX 01.01.14	Parking		$735,000
		C-PAD EX 01.01.15	Site Work		$23,417,500
		C-PAD EX 01.01.16	Warehouse		$10,200,000
		C-PAD EX 01.01.17	Maintenance Facility		$0
		C-PAD EX 01.01.18	Waste management Facility		$0
		C-PAD EX 01.01.01.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.02		Expanded Interim Storage Facility	$0	
		C-PAD EX 01.02.01	Expanded Storage Pads and Dry Cask Storage Systems		$0
		C-PAD EX 01.02.02	Expanded Cask Handling Facility (if required)		$0
		C-PAD EX 01.02.03	Horizontal Dry Storage Modules		$0
		C-PAD EX 01.02.04	Vertical Dry Storage Casks		$0
		C-PAD EX 01.02.05	Storage Cask Fabrication Facility (Expanded)		$0
		C-PAD EX 01.02.06	Cask Maintenance Facility (Expanded)		$0
		C-PAD EX 01.02.07	Concrete Batch Plant (Expanded if needed)		$0
		C-PAD EX 01.02.08	Visitor Center/ Auditorium (expanded if needed)		$0
		C-PAD EX 01.02.09	Administration Building (Expanded if needed)		$0
		C-PAD EX 01.02.10	Security (Expanded)		$0
		C-PAD EX 01.02.11	Rail Spur/ Receiving Yard (Expanded)		$0
		C-PAD EX 01.02.12	Utilities Expanded as needed)		$0
		C-PAD EX 01.02.13	Roads (Expanded)		$0
		C-PAD EX 01.02.14	Parking (Expanded as needed)		$0
		C-PAD EX 01.02.15	Site Work (Expanded)		$0
		C-PAD EX 01.02.16	Warehouse (Expanded if Needed)		$0
		C-PAD EX 01.02.17	Maintenance Facility (Expanded if needed)		$0
		C-PAD EX 01.02.18	Waste management Facility (Expanded if needed)		$0
		C-PAD EX 01.02.19	Hot Cell / Laboratories		$0
		C-PAD EX 01.02.20	Pool Packaging Facility		$0
		C-PAD EX 01.02.21	Standardized Storage System		$0
		C-PAD EX 01.02.22	Standardized Disposal Canister		$0
		C-PAD EX 01.02.23	Canister Repackaging Facility (For Repository		$0
	C-PAD EX 01.03		Transportation Equipment	$0	
		C-PAD EX 01.03.01	Transportation Casks		$0
		C-PAD EX 01.03.02	Rail Equipment		$0
		C-PAD EX 01.03.03	Rail Maintenance Facility		$0
		C-PAD EX 01.03.04	Transportation Systems Services		$0
	C-PAD EX 01.04		Pre-Construction Capitalized Costs	$57,815,000	
		C-PAD EX 01.04.01	Land or Land Leases		$1,920,000
		C-PAD EX 01.04.02	Site permits		$200,000
		C-PAD EX 01.04.03	Site Licensing		$6,240,000
		C-PAD EX 01.04.05	Plant Permits		$0
		C-PAD EX 01.04.06	Planning and Alternative Studies		$750,000

		C-PAD EX 01.04.07	Research and Development		$0
		C-PAD EX 01.04.08	Design		$23,955,000
		C-PAD EX 01.04.09	Other Pre-construction Costs		$14,750,000
		C-PAD EX 01.04.10	Pre-construction contingencies		$10,000,000
		C-PAD EX 01.04.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.05		Indirect Capitalized Costs	$63,180,000	
		C-PAD EX 01.05.01	Project Management		$2,700,000
		C-PAD EX 01.05.02	Construction Management		$3,600,000
		C-PAD EX 01.05.03	Field indirect services		$11,880,000
		C-PAD EX 01.05.o4	Design Services in support of Construction		$5,400,000
		C-PAD EX 01.05.05	QA/QC		$12,600,000
		C-PAD EX 01.05.06	Commissioning and Startup		$1,200,000
		C-PAD EX 01.05.07	Home office Engineering support to Construction		$7,200,000
		C-PAD EX 01.05.08	Document Control		$2,700,000
		C-PAD EX 01.05.09	Project Controls		$3,600,000
		C-PAD EX 01.05.10	Construction Testing		$2,700,000
		C-PAD EX 01.05.11	Inspections		$3,600,000
		C-PAD EX 01.05.12	Startup and Testing		$3,000,000
		C-PAD EX 01.05.13	Commissioning		$3,000,000
	C-PAD EX 01.06		Site Selection	$1,800,000	
		C-PAD EX 01.06.01	Site Selection		$1,200,000
		C-PAD EX 01.06.02	Public Information Process		$600,000
	C-PAD EX 01.07		Decontamination and Deconstruction	$0	
		C-PAD EX 01.07.01	Decommissioning		$0
		C-PAD EX 01.07.02	Decontamination		$0
		C-PAD EX 01.07.03	Deconstruction		$0
		C-PAD EX 01.07.04			$0
		C-PAD EX 01.07.05			$0
	C-PAD EX 01.08		Project Financial Costs	$80,809,345	
		C-PAD EX 01.08.01	Contractor Fees		$48,244,385
		C-PAD EX 01.08.02	Escalation Costs		$32,564,960
		C-PAD EX 01.08.03	Interest Payments		$0
		C-PAD EX 01.08.04	Indirect costs to support shipments to repository		$0
		C-PAD EX 01.08.05			$0
		C-PAD EX 01.08.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.09		Project Contingencies	$105,998,945	
		C-PAD EX 01.09.01	Management Reserve - Contractor Held		$34,193,208
		C-PAD EX 01.09.02	Contingency - DOE held		$71,805,737
	C-PAD EX 01.10				
		C-PAD EX 01.10.01	Other Direct Costs	$22,230,000	
		C-PAD EX 01.10.02	DOE Project Operations		$3,900,000
		C-PAD EX 01.10.03	DOE TM&E		$780,000
		C-PAD EX 01.10.04	Host site Operational Costs Miscellaneous		$15,600,000
		C-PAD EX 01.10.05	Miscellaneous ODC		$1,950,000
	C-PAD EX 01.11		Operational Costs	0	
		C-PAD EX 01.11.01	Operations Costs		$0
		C-PAD EX 01.11.02	Transportation Costs		$0
		C-PAD EX 01.11.03	Escalation (Operations/Transportation)		$0
Project Total					

TEC	(All Direct & indirect Costs, MR, Escalation)	$718,057,367
TPC	(TEC plus Contingency, ODCs)	$812,093,104
LCC	All Capitol, Operation, Transportation, Escalation	$812,093,104

APPENDIX B5-3

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 3 – R-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST – 40 YEAR OPERATING LIFE

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: R-OPS Pilot (5,000 MTU)
PILOT Project - R-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

Annual Escalation 2.00%

40 Year Operating life

YEAR	Design/Const	O&M	Cask Handling	D&D	Escalation	Annual Funding	Cumulative
1	$ 10,000,000	$ -	$ -	$ -	$ 200,000	$ 10,200,000	$ 10,200,000
2	$ 10,000,000	$ -	$ -	$ -	$ 400,000	$ 10,400,000	$ 20,600,000
3	$ 20,000,000	$ -	$ -	$ -	$ 1,200,000	$ 21,200,000	$ 41,800,000
4	$ 20,000,000	$ -	$ -	$ -	$ 1,600,000	$ 21,600,000	$ 63,400,000
5	$ 20,000,000	$ -	$ -	$ -	$ 2,000,000	$ 22,000,000	$ 85,400,000
6	$ 20,000,000	$ -	$ -	$ -	$ 2,400,000	$ 22,400,000	$ 107,800,000
7	$ 27,888,399	$ -	$ -	$ -	$ 3,904,376	$ 31,792,775	$ 139,592,775
8	$ 200,000,000	$ -	$ -	$ -	$ 32,000,000	$ 232,000,000	$ 371,592,775
9	$ 200,000,000	$ 22,503,661	$ -	$ -	$ 40,050,659	$ 262,554,320	$ 634,147,095
10	$ 273,071,660	$ 22,503,661	$ -	$ -	$ 59,115,064	$ 354,690,385	$ 988,837,480
11		$ 22,933,786	$ 12,836,230	$ -	$ 7,869,403	$ 43,639,419	$ 1,032,476,898
12	$ -	$ 22,933,786	$ 12,836,230	$ -	$ 8,584,804	$ 44,354,819	$ 1,076,831,717
13	$ -	$ 22,933,786	$ 12,836,230	$ -	$ 9,300,204	$ 45,070,219	$ 1,121,901,937
14	$ -	$ 11,643,328	$ -	$ -	$ 3,260,132	$ 14,903,460	$ 1,136,805,396
15	$ -	$ 11,643,328	$ -	$ -	$ 3,492,998	$ 15,136,326	$ 1,151,941,723
16	$ -	$ 11,643,328	$ -	$ -	$ 3,725,865	$ 15,369,193	$ 1,167,310,916
17	$ -	$ 11,643,328	$ -	$ -	$ 3,958,732	$ 15,602,060	$ 1,182,912,975
18	$ -	$ 11,643,328	$ -	$ -	$ 4,191,598	$ 15,834,926	$ 1,198,747,901
19	$ -	$ 11,643,328	$ -	$ -	$ 4,424,465	$ 16,067,793	$ 1,214,815,694
20	$ -	$ 11,643,328	$ -	$ -	$ 4,657,331	$ 16,300,659	$ 1,231,116,353
21	$ -	$ 11,643,328	$ -	$ -	$ 4,890,198	$ 16,533,526	$ 1,247,649,879
22	$ -	$ 11,643,328	$ -	$ -	$ 5,123,064	$ 16,766,392	$ 1,264,416,271
23	$ -	$ 11,643,328	$ -	$ -	$ 5,355,931	$ 16,999,259	$ 1,281,415,530
24	$ -	$ 11,643,328	$ -	$ -	$ 5,588,797	$ 17,232,125	$ 1,298,647,656
25	$ -	$ 11,643,328	$ -	$ -	$ 5,821,664	$ 17,464,992	$ 1,316,112,648
26	$ -	$ 11,643,328	$ -	$ -	$ 6,054,531	$ 17,697,859	$ 1,333,810,506
27	$ -	$ 11,643,328	$ -	$ -	$ 6,287,397	$ 17,930,725	$ 1,351,741,231
28	$ -	$ 11,643,328	$ -	$ -	$ 6,520,264	$ 18,163,592	$ 1,369,904,823
29	$ -	$ 11,643,328	$ -	$ -	$ 6,753,130	$ 18,396,458	$ 1,388,301,281
30	$ -	$ 11,643,328	$ -	$ -	$ 6,985,997	$ 18,629,325	$ 1,406,930,606
31	$ -	$ 11,643,328	$ -	$ -	$ 7,218,863	$ 18,862,191	$ 1,425,792,797
32	$ -	$ 11,643,328	$ -	$ -	$ 7,451,730	$ 19,095,058	$ 1,444,887,855
33	$ -	$ 11,643,328	$ -	$ -	$ 7,684,596	$ 19,327,924	$ 1,464,215,780
34	$ -	$ 11,643,328	$ -	$ -	$ 7,917,463	$ 19,560,791	$ 1,483,776,571
35	$ -	$ 11,643,328	$ -	$ -	$ 8,150,330	$ 19,793,658	$ 1,503,570,228
36	$ -	$ 11,643,328	$ -	$ -	$ 8,383,196	$ 20,026,524	$ 1,523,596,752
37	$ -	$ 11,643,328	$ -	$ -	$ 8,616,063	$ 20,259,391	$ 1,543,856,143
38	$ -	$ 11,643,328	$ -	$ -	$ 8,848,929	$ 20,492,257	$ 1,564,348,400
39	$ -	$ 11,643,328	$ -	$ -	$ 9,081,796	$ 20,725,124	$ 1,585,073,524
40	$ -	$ 11,643,328	$ -	$ -	$ 9,314,662	$ 20,957,990	$ 1,606,031,515
41	$ -	$ 11,643,328	$ -	$ -	$ 9,547,529	$ 21,190,857	$ 1,627,222,372
42	$ -	$ 11,643,328	$ -	$ -	$ 9,780,396	$ 21,423,724	$ 1,648,646,095
43	$ -	$ 11,643,328	$ -	$ -	$ 10,013,262	$ 21,656,590	$ 1,670,302,685
44	$ -	$ 11,643,328	$ -	$ -	$ 10,246,129	$ 21,889,457	$ 1,692,192,142
45	$ -	$ 11,643,328	$ -	$ -	$ 10,478,995	$ 22,122,323	$ 1,714,314,465
46	$ -	$ 11,643,328	$ -	$ -	$ 10,711,862	$ 22,355,190	$ 1,736,669,655
47	$ -	$ 11,643,328	$ -	$ -	$ 10,944,728	$ 22,588,056	$ 1,759,257,711
48	$ -	$ 11,643,328	$ -	$ -	$ 11,177,595	$ 22,820,923	$ 1,782,078,634
49	$ -	$ 11,643,328	$ -	$ -	$ 11,410,461	$ 23,053,789	$ 1,805,132,423
50	$ -	$ 11,643,328	$ -	$ -	$ 11,643,328	$ 23,286,656	$ 1,828,419,079
51	$ -	$ -	$ -	$ 21,175,000	$ 21,598,500	$ 42,773,500	$ 1,871,192,579
52	$ -	$ -	$ -	$ 20,000,000	$ 20,800,000	$ 40,800,000	$ 1,911,992,579
53	$ -	$ -	$ -	$ 16,705,815	$ 17,708,164	$ 34,413,979	$ 1,946,406,558
54	$ -	$ -	$ -	$ 16,705,815	$ 18,042,280	$ 34,748,095	$ 1,981,154,654
55	$ -	$ -	$ -	$ 16,705,815	$ 18,376,397	$ 35,082,212	$ 2,016,236,865
56	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
57	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
58	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
59	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
60	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
	Total Design/Const	Total O&M		Total D&D	Total Escalation		Total Life Cycle
	$ 800,960,059	$ 544,611,815	$ 38,508,689	$ 91,292,445	$ 540,863,858		$ 2,016,236,865

APPENDIX B5-3

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 3 – R-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST – 80 YEAR OPERATING LIFE

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: R-OPS Pilot (5,000 MTU)
PILOT Project - R-OPS 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

80 Year Operating Life

					Annual Escalation		
					2.00%		
YEAR	Design/Const	O&M	Cask Handling	D&D	Escalation	Annual Funding	Cumulative
1	$ 10,000,000	$ -	$ -	$ -	$200,000	$10,200,000	$10,200,000
2	$ 10,000,000	$ -	$ -	$ -	$400,000	$10,400,000	$20,600,000
3	$ 20,000,000	$ -	$ -	$ -	$1,200,000	$21,200,000	$41,800,000
4	$ 20,000,000	$ -	$ -	$ -	$1,600,000	$21,600,000	$63,400,000
5	$ 20,000,000	$ -	$ -	$ -	$2,000,000	$22,000,000	$85,400,000
6	$ 20,000,000	$ -	$ -	$ -	$2,400,000	$22,400,000	$107,800,000
7	$ 27,888,399	$ -	$ -	$ -	$3,904,376	$31,792,775	$139,592,775
8	$ 200,000,000	$ -	$ -	$ -	$32,000,000	$232,000,000	$371,592,775
9	$ 200,000,000	$ 22,503,661	$ -	$ -	$40,050,659	$262,554,320	$634,147,095
10	$ 273,071,660	$ 22,503,661	$ -	$ -	$59,115,064	$354,690,385	$988,837,480
11		$ 22,933,786	$ 12,836,230	$ -	$7,869,403	$43,639,419	$1,032,476,898
12	$ -	$ 22,933,786	$ 12,836,230	$ -	$8,584,804	$44,354,819	$1,076,831,717
13	$ -	$ 22,933,786	$ 12,836,230	$ -	$9,300,204	$45,070,219	$1,121,901,937
14	$ -	$ 11,643,328	$ -	$ -	$3,260,132	$14,903,460	$1,136,805,396
15	$ -	$ 11,643,328	$ -	$ -	$3,492,998	$15,136,326	$1,151,941,723
16	$ -	$ 11,643,328	$ -	$ -	$3,725,865	$15,369,193	$1,167,310,916
17	$ -	$ 11,643,328	$ -	$ -	$3,958,732	$15,602,060	$1,182,912,975
18	$ -	$ 11,643,328	$ -	$ -	$4,191,598	$15,834,926	$1,198,747,901
19	$ -	$ 11,643,328	$ -	$ -	$4,424,465	$16,067,793	$1,214,815,694
20	$ -	$ 11,643,328	$ -	$ -	$4,657,331	$16,300,659	$1,231,116,353
21	$ -	$ 11,643,328	$ -	$ -	$4,890,198	$16,533,526	$1,247,649,879
22	$ -	$ 11,643,328	$ -	$ -	$5,123,064	$16,766,392	$1,264,416,271
23	$ -	$ 11,643,328	$ -	$ -	$5,355,931	$16,999,259	$1,281,415,530
24	$ -	$ 11,643,328	$ -	$ -	$5,588,797	$17,232,125	$1,298,647,656
25	$ -	$ 11,643,328	$ -	$ -	$5,821,664	$17,464,992	$1,316,112,648
26	$ -	$ 11,643,328	$ -	$ -	$6,054,531	$17,697,859	$1,333,810,506
27	$ -	$ 11,643,328	$ -	$ -	$6,287,397	$17,930,725	$1,351,741,231
28	$ -	$ 11,643,328	$ -	$ -	$6,520,264	$18,163,592	$1,369,904,823
29	$ -	$ 11,643,328	$ -	$ -	$6,753,130	$18,396,458	$1,388,301,281
30	$ -	$ 11,643,328	$ -	$ -	$6,985,997	$18,629,325	$1,406,930,606
31	$ -	$ 11,643,328	$ -	$ -	$7,218,863	$18,862,191	$1,425,792,797
32	$ -	$ 11,643,328	$ -	$ -	$7,451,730	$19,095,058	$1,444,887,855
33	$ -	$ 11,643,328	$ -	$ -	$7,684,596	$19,327,924	$1,464,215,780
34	$ -	$ 11,643,328	$ -	$ -	$7,917,463	$19,560,791	$1,483,776,571
35	$ -	$ 11,643,328	$ -	$ -	$8,150,330	$19,793,658	$1,503,570,228
36	$ -	$ 11,643,328	$ -	$ -	$8,383,196	$20,026,524	$1,523,596,752
37	$ -	$ 11,643,328	$ -	$ -	$8,616,063	$20,259,391	$1,543,856,143
38	$ -	$ 11,643,328	$ -	$ -	$8,848,929	$20,492,257	$1,564,348,400
39	$ -	$ 11,643,328	$ -	$ -	$9,081,796	$20,725,124	$1,585,073,524
40	$ -	$ 11,643,328	$ -	$ -	$9,314,662	$20,957,990	$1,606,031,515
41	$ -	$ 11,643,328	$ -	$ -	$9,547,529	$21,190,857	$1,627,222,372
42	$ -	$ 11,643,328	$ -	$ -	$9,780,396	$21,423,724	$1,648,646,095
43	$ -	$ 11,643,328	$ -	$ -	$10,013,262	$21,656,590	$1,670,302,685
44	$ -	$ 11,643,328	$ -	$ -	$10,246,129	$21,889,457	$1,692,192,142
45	$ -	$ 11,643,328	$ -	$ -	$10,478,995	$22,122,323	$1,714,314,465
46	$ -	$ 11,643,328	$ -	$ -	$10,711,862	$22,355,190	$1,736,669,655
47	$ -	$ 11,643,328	$ -	$ -	$10,944,728	$22,588,056	$1,759,257,711
48	$ -	$ 11,643,328	$ -	$ -	$11,177,595	$22,820,923	$1,782,078,634
49	$ -	$ 11,643,328	$ -	$ -	$11,410,461	$23,053,789	$1,805,132,423
50	$ -	$ 11,643,328	$ -	$ -	$11,643,328	$23,286,656	$1,828,419,079
51	$ -	$ 11,643,328	$ -	$ -	$11,876,195	$23,519,523	$1,851,938,602
52	$ -	$ 11,643,328	$ -	$ -	$12,109,061	$23,752,389	$1,875,690,991
53	$ -	$ 11,643,328	$ -	$ -	$12,341,928	$23,985,256	$1,899,676,247
54	$ -	$ 11,643,328	$ -	$ -	$12,574,794	$24,218,122	$1,923,894,369
55	$ -	$ 11,643,328	$ -	$ -	$12,807,661	$24,450,989	$1,948,345,358
56	$ -	$ 11,643,328	$ -	$ -	$13,040,527	$24,683,855	$1,973,029,213
57	$ -	$ 11,643,328	$ -	$ -	$13,273,394	$24,916,722	$1,997,945,935
58	$ -	$ 11,643,328	$ -	$ -	$13,506,260	$25,149,588	$2,023,095,523
59	$ -	$ 11,643,328	$ -	$ -	$13,739,127	$25,382,455	$2,048,477,978
60	$ -	$ 11,643,328	$ -	$ -	$13,971,994	$25,615,322	$2,074,093,300
61	$ -	$ 11,643,328	$ -	$ -	$14,204,860	$25,848,188	$2,099,941,488
62	$ -	$ 11,643,328	$ -	$ -	$14,437,727	$26,081,055	$2,126,022,543
63	$ -	$ 11,643,328	$ -	$ -	$14,670,593	$26,313,921	$2,152,336,464

64	$ -	$ 11,643,328	$ -	$ -	$14,903,460	$26,546,788	$2,178,883,252
65	$0	$ 11,643,328	$ -	$ -	$15,136,326	$26,779,654	$2,205,662,906
66	$0	$ 11,643,328	$ -	$ -	$15,369,193	$27,012,521	$2,232,675,427
67	$0	$ 11,643,328	$ -	$ -	$15,602,060	$27,245,388	$2,259,920,815
68	$0	$ 11,643,328	$ -	$ -	$15,834,926	$27,478,254	$2,287,399,069
69	$0	$ 11,643,328	$ -	$ -	$16,067,793	$27,711,121	$2,315,110,189
70	$0	$ 11,643,328	$ -	$ -	$16,300,659	$27,943,987	$2,343,054,177
71	$0	$ 11,643,328	$ -	$ -	$16,533,526	$28,176,854	$2,371,231,030
72	$0	$ 11,643,328	$ -	$ -	$16,766,392	$28,409,720	$2,399,640,751
73	$0	$ 11,643,328	$ -	$ -	$16,999,259	$28,642,587	$2,428,283,337
74	$0	$ 11,643,328	$ -	$ -	$17,232,125	$28,875,453	$2,457,158,791
75	$0	$ 11,643,328	$ -	$ -	$17,464,992	$29,108,320	$2,486,267,111
76	$0	$ 11,643,328	$ -	$ -	$17,697,859	$29,341,187	$2,515,608,297
77	$0	$ 11,643,328	$ -	$ -	$17,930,725	$29,574,053	$2,545,182,351
78	$0	$ 11,643,328	$ -	$ -	$18,163,592	$29,806,920	$2,574,989,270
79	$0	$ 11,643,328	$ -	$ -	$18,396,458	$30,039,786	$2,605,029,056
80	$0	$ 11,643,328	$ -	$ -	$18,629,325	$30,272,653	$2,635,301,709
81	$0	$ 11,643,328	$ -	$ -	$18,862,191	$30,505,519	$2,665,807,229
82	$0	$ 11,643,328	$ -	$ -	$19,095,058	$30,738,386	$2,696,545,614
83	$0	$ 11,643,328	$ -	$ -	$19,327,924	$30,971,252	$2,727,516,867
84	$0	$ 11,643,328	$ -	$ -	$19,560,791	$31,204,119	$2,758,720,986
85	$0	$ 11,643,328	$ -	$ -	$19,793,658	$31,436,986	$2,790,157,972
86	$0	$ 11,643,328	$ -	$ -	$20,026,524	$31,669,852	$2,821,827,824
87	$0	$ 11,643,328	$ -	$ -	$20,259,391	$31,902,719	$2,853,730,542
88	$0	$ 11,643,328	$ -	$ -	$20,492,257	$32,135,585	$2,885,866,128
89	$0	$ 11,643,328	$ -	$ -	$20,725,124	$32,368,452	$2,918,234,579
90	$0	$ 11,643,328	$ -	$ -	$20,957,990	$32,601,318	$2,950,835,898
91			$ -	$ 21,175,000	$38,538,500	$59,713,500	$3,010,549,398
92			$ -	$ 20,000,000	$36,800,000	$56,800,000	$3,067,349,398
93			$ -	$ 16,705,815	$31,072,816	$47,778,631	$3,115,128,029
94			$ -	$ 16,705,815	$31,406,932	$48,112,747	$3,163,240,776
95			$ -	$ 16,705,815	$31,741,049	$48,446,864	$3,211,687,640
96				$ -	$0	$0	$3,211,687,640
97				$ -	$0	$0	$3,211,687,640
98					$0	$0	$3,211,687,640
99					$0	$0	$3,211,687,640
100					$0	$0	$3,211,687,640

Total Design/Const	Total O&M	Total Cask Handling	Total D&D	Total Escalation		Total Life Cycle
$800,960,059	$1,010,344,935	$38,508,689	$91,292,445	$1,270,581,513		$3,211,687,640

APPENDIX B5-4

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 4 – S-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST SUMMARIES

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: S-OPS Pilot (5,000 MTU)
PILOT Project - S-OPS Basic for PAD 60/40 Vertical/Horizontal - Low Seismic
Separate CHB
Annual Escalation Factor 2.00%

Life Cycle Costs (40 Year Life)	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction	*$654,304,171*					*$654,304,171*
Operations & Maintenance (40 Year Life)		*$544,611,815*				*$544,611,815*
Cask Handling		$45,620,269				*$45,620,269*
Transportation Equipment	$0					*$0*
Transport Operations		$0	$0			*$0*
Repackaging	$0	$0				*$0*
Transport to Repository	$0		$0			*$0*
D&D				$73,319,536		*$73,319,536*
Escalation					$493,828,718	*$493,828,718*
Total Costs (40 year Life)						*$1,811,684,509*

Life Cycle Costs (80 Year Life)	Capital	Operations	Transport	Decommissioning	Escalation	Total Costs
Design & Construction	*$654,304,171*					*$654,304,171*
Operations & Maintenance (80 Year Life)		*$1,010,344,935*				*$1,010,344,935*
Cask Handling		$45,620,269				*$45,620,269*
Transportation Equipment	$0					*$0*
Transport Operations		$0	$0			*$0*
Repackaging	$0	$0				*$0*
Transport to Repository	$0		$0			*$0*
D&D				$91,292,445		*$91,292,445*
Escalation					$1,242,957,114	*$1,242,957,114*
Total Costs (80 Year Life)						*$3,044,518,934*

APPENDIX B5-4

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 4 – S-OPS, PILOT, LOW SEISMIC

CAPITAL COST SUMMARY

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: S-OPS Pilot (5,000 MTU)
PILOT Project - S-OPS Basic for PAD 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

Level 3 Cost Summary - First of A kind module

Level 1	Level 2	Level 3	Description		Level 3 Total
C-PAD EX 01			Interim Storage Facility and transportation Project		
	C-PAD EX 01.01		Pilot ISF Facility	$359,789,095	
		C-PAD EX 01.01.01	Storage Pads		$0
		C-PAD EX 01.01.02	Cask Handling (Transfer) Facility		$23,205,000
		C-PAD EX 01.01.03	Horizontal Dry Storage Modules		$95,969,797
		C-PAD EX 01.01.04	Vertical Dry Storage Module		$81,475,136
		C-PAD EX 01.01.05	Storage Cask Fabrication Facility		$0
		C-PAD EX 01.01.06	Cask Maintenance Facility		$0
		C-PAD EX 01.01.07	Concrete Batch Plant		$1,850,000
		C-PAD EX 01.01.08	Visitor Center/ Auditorium		$0
		C-PAD EX 01.01.09	Administration Building		$3,140,000
		C-PAD EX 01.01.10	Security		$24,148,975
		C-PAD EX 01.01.11	Rail Spur/ Receiving Yard		$58,752,800
		C-PAD EX 01.01.12	Utilities		$18,682,150
		C-PAD EX 01.01.13	Roads		$18,212,737
		C-PAD EX 01.01.14	Parking		$735,000
		C-PAD EX 01.01.15	Site Work		$23,417,500
		C-PAD EX 01.01.16	Warehouse		$10,200,000
		C-PAD EX 01.01.17	Maintenance Facility		$0
		C-PAD EX 01.01.18	Waste management Facility		$0
		C-PAD EX 01.01.01.xx	(Add Further Breakdown as needed)		$0
	C-PAD EX 01.02		Expanded Interim Storage Facility	$0	
		C-PAD EX 01.02.01	Expanded Storage Pads and Dry Cask Storage Systems		$0
		C-PAD EX 01.02.02	Expanded Cask Handling Facility (if required)		$0
		C-PAD EX 01.02.03	Horizontal Dry Storage Modules		$0
		C-PAD EX 01.02.04	Vertical Dry Storage Casks		$0
		C-PAD EX 01.02.05	Storage Cask Fabrication Facility (Expanded)		$0
		C-PAD EX 01.02.06	Cask Maintenance Facility (Expanded)		$0
		C-PAD EX 01.02.07	Concrete Batch Plant (Expanded if needed)		$0
		C-PAD EX 01.02.08	Visitor Center/ Auditorium (expanded if needed)		$0
		C-PAD EX 01.02.09	Administration Building (Expanded if needed)		$0
		C-PAD EX 01.02.10	Security (Expanded)		$0
		C-PAD EX 01.02.11	Rail Spur/ Receiving Yard (Expanded)		$0
		C-PAD EX 01.02.12	Utilities Expanded as needed)		$0
		C-PAD EX 01.02.13	Roads (Expanded)		$0
		C-PAD EX 01.02.14	Parking (Expanded as needed)		$0
		C-PAD EX 01.02.15	Site Work (Expanded)		$0
		C-PAD EX 01.02.16	Warehouse (Expanded if Needed)		$0
		C-PAD EX 01.02.17	Maintenance Facility (Expanded if needed)		$0
		C-PAD EX 01.02.18	Waste management Facility (Expanded if needed)		$0
		C-PAD EX 01.02.19	Hot Cell / Laboratories		$0
		C-PAD EX 01.02.20	Pool Packaging Facility		$0
		C-PAD EX 01.02.21	Standardized Storage System		$0
		C-PAD EX 01.02.22	Standardized Disposal Canister		$0
		C-PAD EX 01.02.23	Canister Repackaging Facility (For Repository		$0
	C-PAD EX 01.03		Transportation Equipment	$0	
		C-PAD EX 01.03.01	Transportation Casks		$0
		C-PAD EX 01.03.02	Rail Equipment		$0
		C-PAD EX 01.03.03	Rail Maintenance Facility		$0
		C-PAD EX 01.03.04	Transportation Systems Services		$0
	C-PAD EX 01.04		Pre-Construction Capitalized Costs	$57,815,000	
		C-PAD EX 01.04.01	Land or Land Leases		$1,920,000
		C-PAD EX 01.04.02	Site permits		$200,000
		C-PAD EX 01.04.03	Site Licensing		$6,240,000
		C-PAD EX 01.04.05	Plant Permits		$0
		C-PAD EX 01.04.06	Planning and Alternative Studies		$750,000
		C-PAD EX 01.04.07	Research and Development		$0
		C-PAD EX 01.04.08	Design		$23,955,000
		C-PAD EX 01.04.09	Other Pre-construction Costs		$14,750,000

	C-PAD EX 01.04.10	Pre-construction contingencies		$10,000,000
	C-PAD EX 01.04.xx	(Add Further Breakdown as needed)		$0
C-PAD EX 01.05		Indirect Capitalized Costs	$63,180,000	
	C-PAD EX 01.05.01	Project Management		$2,700,000
	C-PAD EX 01.05.02	Construction Management		$3,600,000
	C-PAD EX 01.05.03	Field indirect services		$11,880,000
	C-PAD EX 01.05.o4	Design Services in support of Construction		$5,400,000
	C-PAD EX 01.05.05	QA/QC		$12,600,000
	C-PAD EX 01.05.06	Commissioning and Startup		$1,200,000
	C-PAD EX 01.05.07	Home office Engineering support to Construction		$7,200,000
	C-PAD EX 01.05.08	Document Control		$2,700,000
	C-PAD EX 01.05.09	Project Controls		$3,600,000
	C-PAD EX 01.05.10	Construction Testing		$2,700,000
	C-PAD EX 01.05.11	Inspections		$3,600,000
	C-PAD EX 01.05.12	Startup and Testing		$3,000,000
	C-PAD EX 01.05.13	Commissioning		$3,000,000
C-PAD EX 01.06		Site Selection	$1,800,000	
	C-PAD EX 01.06.01	Site Selection		$1,200,000
	C-PAD EX 01.06.02	Public Information Process		$600,000
C-PAD EX 01.07		Decontamination and Deconstruction	$0	
	C-PAD EX 01.07.01	Decommissioning		$0
	C-PAD EX 01.07.02	Decontamination		$0
	C-PAD EX 01.07.03	Deconstruction		$0
	C-PAD EX 01.07.04			$0
	C-PAD EX 01.07.05			$0
C-PAD EX 01.08		Project Financial Costs	$64,666,269	
	C-PAD EX 01.08.01	Contractor Fees		$38,606,728
	C-PAD EX 01.08.02	Escalation Costs		$26,059,541
	C-PAD EX 01.08.03	Interest Payments		$0
	C-PAD EX 01.08.04	Indirect costs to support shipments to repository		$0
	C-PAD EX 01.08.05			$0
	C-PAD EX 01.08.xx	(Add Further Breakdown as needed)		$0
C-PAD EX 01.09		Project Contingencies	$84,823,806	
	C-PAD EX 01.09.01	Management Reserve - Contractor Held		$27,362,518
	C-PAD EX 01.09.02	Contingency - DOE held		$57,461,288
C-PAD EX 01.10				
	C-PAD EX 01.10.01	Other Direct Costs	$22,230,000	
	C-PAD EX 01.10.02	DOE Project Operations		$3,900,000
	C-PAD EX 01.10.03	DOE TM&E		$780,000
	C-PAD EX 01.10.04	Host site Operational Costs Miscellaneous		$15,600,000
	C-PAD EX 01.10.05	Miscellaneous ODC		$1,950,000
C-PAD EX 01.11		Operational Costs	0	
	C-PAD EX 01.11.01	Operations Costs		$0
	C-PAD EX 01.11.02	Transportation Costs		$0
	C-PAD EX 01.11.03	Escalation (Operations/Transportation)		$0

Project Total

TEC	(All Direct & indirect Costs, MR, Escalation)	$574,612,882
TPC	(TEC plus Contingency, ODCs)	$654,304,171
LCC	All Capitol, Operation, Transportation, Escalation	$654,304,171

APPENDIX B5-4

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 4 – S-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST – 40 YEAR OPERATING LIFE

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: S-OPS Pilot (5,000 MTU)
PILOT Project - S-OPS Basic for PAD 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

Annual Escalation 2.00%

40 Year Operating life

YEAR	Design/Const	O&M	Cask Handling	D&D	Escalation	Annual Funding	Cumulative
1	$ 10,000,000	$ -	$ -	$ -	$ 200,000	$ 10,200,000	$ 10,200,000
2	$ 10,000,000	$ -	$ -	$ -	$ 400,000	$ 10,400,000	$ 20,600,000
3	$ 20,000,000	$ -	$ -	$ -	$ 1,200,000	$ 21,200,000	$ 41,800,000
4	$ 20,000,000	$ -	$ -	$ -	$ 1,600,000	$ 21,600,000	$ 63,400,000
5	$ 20,000,000	$ -	$ -	$ -	$ 2,000,000	$ 22,000,000	$ 85,400,000
6	$ 20,000,000	$ -	$ -	$ -	$ 2,400,000	$ 22,400,000	$ 107,800,000
7	$ 27,888,399	$ -	$ -	$ -	$ 3,904,376	$ 31,792,775	$ 139,592,775
8	$ 200,000,000	$ -	$ -	$ -	$ 32,000,000	$ 232,000,000	$ 371,592,775
9	$ 200,000,000	$ 22,503,661	$ -	$ -	$ 40,050,659	$ 262,554,320	$ 634,147,095
10	$ 273,071,660	$ 22,503,661	$ -	$ -	$ 59,115,064	$ 354,690,385	$ 988,837,480
11		$ 22,933,786	$ 12,836,230	$ -	$ 7,869,403	$ 43,639,419	$ 1,032,476,898
12	$ -	$ 22,933,786	$ 12,836,230	$ -	$ 8,584,804	$ 44,354,819	$ 1,076,831,717
13	$ -	$ 22,933,786	$ 12,836,230	$ -	$ 9,300,204	$ 45,070,219	$ 1,121,901,937
14	$ -	$ 11,643,328	$ -	$ -	$ 3,260,132	$ 14,903,460	$ 1,136,805,396
15	$ -	$ 11,643,328	$ -	$ -	$ 3,492,998	$ 15,136,326	$ 1,151,941,723
16	$ -	$ 11,643,328	$ -	$ -	$ 3,725,865	$ 15,369,193	$ 1,167,310,916
17	$ -	$ 11,643,328	$ -	$ -	$ 3,958,732	$ 15,602,060	$ 1,182,912,975
18	$ -	$ 11,643,328	$ -	$ -	$ 4,191,598	$ 15,834,926	$ 1,198,747,901
19	$ -	$ 11,643,328	$ -	$ -	$ 4,424,465	$ 16,067,793	$ 1,214,815,694
20	$ -	$ 11,643,328	$ -	$ -	$ 4,657,331	$ 16,300,659	$ 1,231,116,353
21	$ -	$ 11,643,328	$ -	$ -	$ 4,890,198	$ 16,533,526	$ 1,247,649,879
22	$ -	$ 11,643,328	$ -	$ -	$ 5,123,064	$ 16,766,392	$ 1,264,416,271
23	$ -	$ 11,643,328	$ -	$ -	$ 5,355,931	$ 16,999,259	$ 1,281,415,530
24	$ -	$ 11,643,328	$ -	$ -	$ 5,588,797	$ 17,232,125	$ 1,298,647,656
25	$ -	$ 11,643,328	$ -	$ -	$ 5,821,664	$ 17,464,992	$ 1,316,112,648
26	$ -	$ 11,643,328	$ -	$ -	$ 6,054,531	$ 17,697,859	$ 1,333,810,506
27	$ -	$ 11,643,328	$ -	$ -	$ 6,287,397	$ 17,930,725	$ 1,351,741,231
28	$ -	$ 11,643,328	$ -	$ -	$ 6,520,264	$ 18,163,592	$ 1,369,904,823
29	$ -	$ 11,643,328	$ -	$ -	$ 6,753,130	$ 18,396,458	$ 1,388,301,281
30	$ -	$ 11,643,328	$ -	$ -	$ 6,985,997	$ 18,629,325	$ 1,406,930,606
31	$ -	$ 11,643,328	$ -	$ -	$ 7,218,863	$ 18,862,191	$ 1,425,792,797
32	$ -	$ 11,643,328	$ -	$ -	$ 7,451,730	$ 19,095,058	$ 1,444,887,855
33	$ -	$ 11,643,328	$ -	$ -	$ 7,684,596	$ 19,327,924	$ 1,464,215,780
34	$ -	$ 11,643,328	$ -	$ -	$ 7,917,463	$ 19,560,791	$ 1,483,776,571
35	$ -	$ 11,643,328	$ -	$ -	$ 8,150,330	$ 19,793,658	$ 1,503,570,228
36	$ -	$ 11,643,328	$ -	$ -	$ 8,383,196	$ 20,026,524	$ 1,523,596,752
37	$ -	$ 11,643,328	$ -	$ -	$ 8,616,063	$ 20,259,391	$ 1,543,856,143
38	$ -	$ 11,643,328	$ -	$ -	$ 8,848,929	$ 20,492,257	$ 1,564,348,400
39	$ -	$ 11,643,328	$ -	$ -	$ 9,081,796	$ 20,725,124	$ 1,585,073,524
40	$ -	$ 11,643,328	$ -	$ -	$ 9,314,662	$ 20,957,990	$ 1,606,031,515
41	$ -	$ 11,643,328	$ -	$ -	$ 9,547,529	$ 21,190,857	$ 1,627,222,372
42	$ -	$ 11,643,328	$ -	$ -	$ 9,780,396	$ 21,423,724	$ 1,648,646,095
43	$ -	$ 11,643,328	$ -	$ -	$ 10,013,262	$ 21,656,590	$ 1,670,302,685
44	$ -	$ 11,643,328	$ -	$ -	$ 10,246,129	$ 21,889,457	$ 1,692,192,142
45	$ -	$ 11,643,328	$ -	$ -	$ 10,478,995	$ 22,122,323	$ 1,714,314,465
46	$ -	$ 11,643,328	$ -	$ -	$ 10,711,862	$ 22,355,190	$ 1,736,669,655
47	$ -	$ 11,643,328	$ -	$ -	$ 10,944,728	$ 22,588,056	$ 1,759,257,711
48	$ -	$ 11,643,328	$ -	$ -	$ 11,177,595	$ 22,820,923	$ 1,782,078,634
49	$ -	$ 11,643,328	$ -	$ -	$ 11,410,461	$ 23,053,789	$ 1,805,132,423
50	$ -	$ 11,643,328	$ -	$ -	$ 11,643,328	$ 23,286,656	$ 1,828,419,079
51	$ -	$ -	$ -	$ 21,175,000	$ 21,598,500	$ 42,773,500	$ 1,871,192,579
52	$ -	$ -	$ -	$ 20,000,000	$ 20,800,000	$ 40,800,000	$ 1,911,992,579
53	$ -	$ -	$ -	$ 16,705,815	$ 17,708,164	$ 34,413,979	$ 1,946,406,558
54	$ -	$ -	$ -	$ 16,705,815	$ 18,042,280	$ 34,748,095	$ 1,981,154,654
55	$ -	$ -	$ -	$ 16,705,815	$ 18,376,397	$ 35,082,212	$ 2,016,236,865
56	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
57	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
58	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
59	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
60	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,016,236,865
	Total Design/Const	Total O&M		Total D&D	Total Escalation		Total Life Cycle
	$ 800,960,059	$ 544,611,815	$ 38,508,689	$ 91,292,445	$ 540,863,858		$ 2,016,236,865

APPENDIX B5-4

STUDY 2 - ALTERNATIVE STORAGE SYSTEMS FOR DUAL PURPOSE CANISTERS

COST DETAILS

ALTERNATIVE 4 – S-OPS, PILOT, LOW SEISMIC

LIFE CYCLE COST – 80 YEAR OPERATING LIFE

Interim Storage Facility

Pilot Storage Facility (5,000 MTU)

Project: S-OPS Pilot (5,000 MTU)
PILOT Project - S-OPS Basic for PAD 60/40 Vertical/Horizontal - Low Seismic
Separate CHB

80 Year Operating Life

					Annual Escalation 2.00%		
YEAR	Design/Const	O&M	Cask Handling	D&D	Escalation	Annual Funding	Cumulative
1	$ 10,000,000	$ -	$ -	$ -	$200,000	$10,200,000	$10,200,000
2	$ 10,000,000	$ -	$ -	$ -	$400,000	$10,400,000	$20,600,000
3	$ 20,000,000	$ -	$ -	$ -	$1,200,000	$21,200,000	$41,800,000
4	$ 20,000,000	$ -	$ -	$ -	$1,600,000	$21,600,000	$63,400,000
5	$ 20,000,000	$ -	$ -	$ -	$2,000,000	$22,000,000	$85,400,000
6	$ 20,000,000	$ -	$ -	$ -	$2,400,000	$22,400,000	$107,800,000
7	$ 27,888,399	$ -	$ -	$ -	$3,904,376	$31,792,775	$139,592,775
8	$ 200,000,000	$ -	$ -	$ -	$32,000,000	$232,000,000	$371,592,775
9	$ 200,000,000	$ 22,503,661	$ -	$ -	$40,050,659	$262,554,320	$634,147,095
10	$ 273,071,660	$ 22,503,661	$ -	$ -	$59,115,064	$354,690,385	$988,837,480
11		$ 22,933,786	$ 12,836,230	$ -	$7,869,403	$43,639,419	$1,032,476,898
12	$ -	$ 22,933,786	$ 12,836,230	$ -	$8,584,804	$44,354,819	$1,076,831,717
13	$ -	$ 22,933,786	$ 12,836,230	$ -	$9,300,204	$45,070,219	$1,121,901,937
14	$ -	$ 11,643,328	$ -	$ -	$3,260,132	$14,903,460	$1,136,805,396
15	$ -	$ 11,643,328	$ -	$ -	$3,492,998	$15,136,326	$1,151,941,723
16	$ -	$ 11,643,328	$ -	$ -	$3,725,865	$15,369,193	$1,167,310,916
17	$ -	$ 11,643,328	$ -	$ -	$3,958,732	$15,602,060	$1,182,912,975
18	$ -	$ 11,643,328	$ -	$ -	$4,191,598	$15,834,926	$1,198,747,901
19	$ -	$ 11,643,328	$ -	$ -	$4,424,465	$16,067,793	$1,214,815,694
20	$ -	$ 11,643,328	$ -	$ -	$4,657,331	$16,300,659	$1,231,116,353
21	$ -	$ 11,643,328	$ -	$ -	$4,890,198	$16,533,526	$1,247,649,879
22	$ -	$ 11,643,328	$ -	$ -	$5,123,064	$16,766,392	$1,264,416,271
23	$ -	$ 11,643,328	$ -	$ -	$5,355,931	$16,999,259	$1,281,415,530
24	$ -	$ 11,643,328	$ -	$ -	$5,588,797	$17,232,125	$1,298,647,656
25	$ -	$ 11,643,328	$ -	$ -	$5,821,664	$17,464,992	$1,316,112,648
26	$ -	$ 11,643,328	$ -	$ -	$6,054,531	$17,697,859	$1,333,810,506
27	$ -	$ 11,643,328	$ -	$ -	$6,287,397	$17,930,725	$1,351,741,231
28	$ -	$ 11,643,328	$ -	$ -	$6,520,264	$18,163,592	$1,369,904,823
29	$ -	$ 11,643,328	$ -	$ -	$6,753,130	$18,396,458	$1,388,301,281
30	$ -	$ 11,643,328	$ -	$ -	$6,985,997	$18,629,325	$1,406,930,606
31	$ -	$ 11,643,328	$ -	$ -	$7,218,863	$18,862,191	$1,425,792,797
32	$ -	$ 11,643,328	$ -	$ -	$7,451,730	$19,095,058	$1,444,887,855
33	$ -	$ 11,643,328	$ -	$ -	$7,684,596	$19,327,924	$1,464,215,780
34	$ -	$ 11,643,328	$ -	$ -	$7,917,463	$19,560,791	$1,483,776,571
35	$ -	$ 11,643,328	$ -	$ -	$8,150,330	$19,793,658	$1,503,570,228
36	$ -	$ 11,643,328	$ -	$ -	$8,383,196	$20,026,524	$1,523,596,752
37	$ -	$ 11,643,328	$ -	$ -	$8,616,063	$20,259,391	$1,543,856,143
38	$ -	$ 11,643,328	$ -	$ -	$8,848,929	$20,492,257	$1,564,348,400
39	$ -	$ 11,643,328	$ -	$ -	$9,081,796	$20,725,124	$1,585,073,524
40	$ -	$ 11,643,328	$ -	$ -	$9,314,662	$20,957,990	$1,606,031,515
41	$ -	$ 11,643,328	$ -	$ -	$9,547,529	$21,190,857	$1,627,222,372
42	$ -	$ 11,643,328	$ -	$ -	$9,780,396	$21,423,724	$1,648,646,095
43	$ -	$ 11,643,328	$ -	$ -	$10,013,262	$21,656,590	$1,670,302,685
44	$ -	$ 11,643,328	$ -	$ -	$10,246,129	$21,889,457	$1,692,192,142
45	$ -	$ 11,643,328	$ -	$ -	$10,478,995	$22,122,323	$1,714,314,465
46	$ -	$ 11,643,328	$ -	$ -	$10,711,862	$22,355,190	$1,736,669,655
47	$ -	$ 11,643,328	$ -	$ -	$10,944,728	$22,588,056	$1,759,257,711
48	$ -	$ 11,643,328	$ -	$ -	$11,177,595	$22,820,923	$1,782,078,634
49	$ -	$ 11,643,328	$ -	$ -	$11,410,461	$23,053,789	$1,805,132,423
50	$ -	$ 11,643,328	$ -	$ -	$11,643,328	$23,286,656	$1,828,419,079
51	$ -	$ 11,643,328	$ -	$ -	$11,876,195	$23,519,523	$1,851,938,602
52	$ -	$ 11,643,328	$ -	$ -	$12,109,061	$23,752,389	$1,875,690,991
53	$ -	$ 11,643,328	$ -	$ -	$12,341,928	$23,985,256	$1,899,676,247
54	$ -	$ 11,643,328	$ -	$ -	$12,574,794	$24,218,122	$1,923,894,369
55	$ -	$ 11,643,328	$ -	$ -	$12,807,661	$24,450,989	$1,948,345,358
56	$ -	$ 11,643,328	$ -	$ -	$13,040,527	$24,683,855	$1,973,029,213
57	$ -	$ 11,643,328	$ -	$ -	$13,273,394	$24,916,722	$1,997,945,935
58	$ -	$ 11,643,328	$ -	$ -	$13,506,260	$25,149,588	$2,023,095,523
59	$ -	$ 11,643,328	$ -	$ -	$13,739,127	$25,382,455	$2,048,477,978
60	$ -	$ 11,643,328	$ -	$ -	$13,971,994	$25,615,322	$2,074,093,300
61	$ -	$ 11,643,328	$ -	$ -	$14,204,860	$25,848,188	$2,099,941,488
62	$ -	$ 11,643,328	$ -	$ -	$14,437,727	$26,081,055	$2,126,022,543
63	$ -	$ 11,643,328	$ -	$ -	$14,670,593	$26,313,921	$2,152,336,464

64	$ -	$ 11,643,328	$ -	$ -	$14,903,460	$26,546,788	$2,178,883,252
65	$0	$ 11,643,328	$ -	$ -	$15,136,326	$26,779,654	$2,205,662,906
66	$0	$ 11,643,328	$ -	$ -	$15,369,193	$27,012,521	$2,232,675,427
67	$0	$ 11,643,328	$ -	$ -	$15,602,060	$27,245,388	$2,259,920,815
68	$0	$ 11,643,328	$ -	$ -	$15,834,926	$27,478,254	$2,287,399,069
69	$0	$ 11,643,328	$ -	$ -	$16,067,793	$27,711,121	$2,315,110,189
70	$0	$ 11,643,328	$ -	$ -	$16,300,659	$27,943,987	$2,343,054,177
71	$0	$ 11,643,328	$ -	$ -	$16,533,526	$28,176,854	$2,371,231,030
72	$0	$ 11,643,328	$ -	$ -	$16,766,392	$28,409,720	$2,399,640,751
73	$0	$ 11,643,328	$ -	$ -	$16,999,259	$28,642,587	$2,428,283,337
74	$0	$ 11,643,328	$ -	$ -	$17,232,125	$28,875,453	$2,457,158,791
75	$0	$ 11,643,328	$ -	$ -	$17,464,992	$29,108,320	$2,486,267,111
76	$0	$ 11,643,328	$ -	$ -	$17,697,859	$29,341,187	$2,515,608,297
77	$0	$ 11,643,328	$ -	$ -	$17,930,725	$29,574,053	$2,545,182,351
78	$0	$ 11,643,328	$ -	$ -	$18,163,592	$29,806,920	$2,574,989,270
79	$0	$ 11,643,328	$ -	$ -	$18,396,458	$30,039,786	$2,605,029,056
80	$0	$ 11,643,328	$ -	$ -	$18,629,325	$30,272,653	$2,635,301,709
81	$0	$ 11,643,328	$ -	$ -	$18,862,191	$30,505,519	$2,665,807,229
82	$0	$ 11,643,328	$ -	$ -	$19,095,058	$30,738,386	$2,696,545,614
83	$0	$ 11,643,328	$ -	$ -	$19,327,924	$30,971,252	$2,727,516,867
84	$0	$ 11,643,328	$ -	$ -	$19,560,791	$31,204,119	$2,758,720,986
85	$0	$ 11,643,328	$ -	$ -	$19,793,658	$31,436,986	$2,790,157,972
86	$0	$ 11,643,328	$ -	$ -	$20,026,524	$31,669,852	$2,821,827,824
87	$0	$ 11,643,328	$ -	$ -	$20,259,391	$31,902,719	$2,853,730,542
88	$0	$ 11,643,328	$ -	$ -	$20,492,257	$32,135,585	$2,885,866,128
89	$0	$ 11,643,328	$ -	$ -	$20,725,124	$32,368,452	$2,918,234,579
90	$0	$ 11,643,328	$ -	$ -	$20,957,990	$32,601,318	$2,950,835,898
91			$ -	$ 21,175,000	$38,538,500	$59,713,500	$3,010,549,398
92			$ -	$ 20,000,000	$36,800,000	$56,800,000	$3,067,349,398
93			$ -	$ 16,705,815	$31,072,816	$47,778,631	$3,115,128,029
94			$ -	$ 16,705,815	$31,406,932	$48,112,747	$3,163,240,776
95			$ -	$ 16,705,815	$31,741,049	$48,446,864	$3,211,687,640
96				$ -	$0	$0	$3,211,687,640
97				$ -	$0	$0	$3,211,687,640
98					$0	$0	$3,211,687,640
99					$0	$0	$3,211,687,640
100					$0	$0	$3,211,687,640

Total Design/Const	Total O&M	Total Cask Handling	Total D&D	Total Escalation		Total Life Cycle
$800,960,059	$1,010,344,935	$38,508,689	$91,292,445	$1,270,581,513		$3,211,687,640