Used Fuel Disposition Storage, Transportation and Disposal Interface Cost Study

Fuel Cycle Research & Development

Prepared for
U.S. Department of Energy
Used Fuel Disposition

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Executive Summary

Introduction

In Fiscal Year (FY) 2012, the U.S. Department of Energy Office of Nuclear Energy (DOE-NE) requested the Used Fuel Disposition (UFD) Campaign to initiate system-level analyses of the interfaces between "at –reactor" used fuel management, consolidated storage, and ultimate disposition. The results of the analyses will provide DOE and other stakeholders information regarding the various alternatives for managing the back-end of the fuel cycle. Detailed system-level analyses of the back-end of the fuel cycle may take several years to complete. Therefore, the UFD Campaign developed multi-year milestones to complete the analyses and address the BRC and Nuclear Waste Technical Review Board (NWTRB) recommendation described in Section 1.0.

FY 2012 scope evaluated alternatives for an integrated approach to transportation, storage, and disposal of UNF with an emphasis on providing flexibility to respond to unknown situations and developments. Rough order of magnitude (ROM) cost factors associated with each alternative and the development of supporting logistics simulation tools were also included in FY 2012 scope.

This document describes the ROM cost study methodology and results for a work breakdown structure (WBS) approach for unit cost. These individual WBS elements will be used in conducting system level analysis. This activity fulfills the level 4 milestone (M4FT-12SR0814061) described in Work Package Number FT-12SR081406.

Scope

The Back-end Fuel Cycle once thru scope has been illustrated in Figure ES-1. UNF canisters stored at reactor sites will be transported to a Consolidated Storage Facility (CSF) in licensed transportation casks. Once at the CSF, UNF canisters will be unloaded from the transportation cask, loaded into a facility storage cask, and transferred to a storage pad or storage vault. Bare fuel will be unloaded from transportation casks and transferred to storage pool(s). Eventually, the canisters and bare fuel will be transferred to a Repackaging Facility (RF) for repackaging into waste packages that meet the Repository Facility disposal criteria, or transferred directly to a Repository Facility for final disposal.

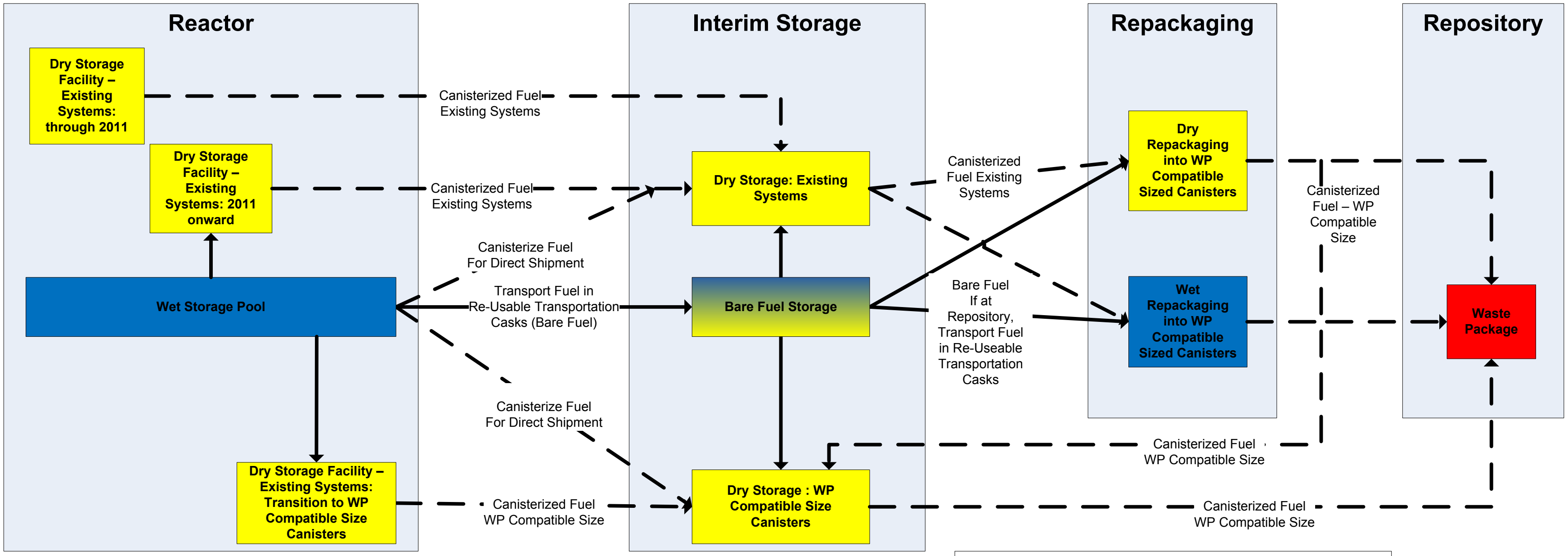
Figure ES-1 illustrates multiple path ways for UNF flow thru the four logistical steps. These multiple pathways will be examined in future reports. This report examined design concepts and unit cost for systems, structures and/or components that will likely be required for any single pathway.

ROM unit cost estimates were derived for the WBS elements at a CSF and RF sub-modules level. The unit cost estimates included the Total Project Costs (TPC) sometimes referred to as capital cost; the operations and maintenance cost (O&M) during the operational period; and the total Life Cycle Cost (LCC) which combined the TPC and O&M cost with additional capital project costs and facility decommissioning costs. Each of these costs were determined parametrically based on prior cost estimates for "like" or extremely similar facilities and operational concepts.

The bases for these parametric costs were generally information contained in the working files supporting the *Engineering Alternative Study (EAS) for Separations –Summary Report* (DOE 2007b) and *Follow-on Engineering Alternative Study (FOEAS) Summary Report, Global Nuclear Energy Partnership* (DOE 2008) conducted for DOE- NE. These studies included three dry fuel storage methods; pool storage; receipt facilities for large dry storage canisters with transportation over packs; receipt facilities for bare fuel transportation casks; and many other site infrastructure and balance of plant (BOP) facilities.

Repackage facilities were not directly included in these prior studies but parametric costs for the similar hardened radioactive material processing buildings included in these studies were used to estimate applicable parts of this facility. A cost study for a Test and Validation Facility (T&VF) was recently completed and the results were documented in the *Used Fuel Research and Development Test and Validation Facility Cost Study Report* (DOE 2012d). The ROM cost study estimates derived for the T&VF report were incorporated into this report as applicable.

The unit costs describe in this report will be used in conducting back end fuel cycle system level analysis.



At-Reactor Fuel Management: Options

1. Wet Storage Fuel Management
    1a. Transfer to dry-storage to maintain full core off-load capability
    1b. Accelerate transfer to dry storage (age ≥ 5 yr)

2. Continue off-loading of fuel in wet storage pools into existing sized dry storage systems

3. Initial off-loading of fuel in wet storage pools into existing sized dry storage systems – transition to WP compatible sized dry storage system at T = 20xx.

4. Transport all fuel in wet storage pool to CIS (when operational and has bare fuel storage capacity) in re-useable transportation casks

5. Canisterize fuel in wet pool for direct shipment to CIS (when operational and does not have bare fuel handling capability)
    5a. Existing dry storage systems
    5b. WP compatible sized dry storage systems

CIS Fuel Management: Options

1. Wet storage capability at CIS
    1a. Maintain fuel in wet storage
    1b. Transfer to existing dry storage systems
    1c. Transfer to WP sized canisters

2. Re-packaging locations
    2a. At CIS
    2b. At repository

3. Re-packaging technology alternatives
    3a. Wet
    3b. Dry

4. Received fuel at CIS in existing dry storage system sized canisters
    4a. Store as-is
    4b. Repackage into WP compatible size canisters and store

Figure ES-1 UNF Back-end Fuel Cycle Scope

CONTENTS

FIGURES

TABLES

Acronyms

BOP	Balance of Plant
BRC	Blue Ribbon Commission
BWR	Boiling Water Reactor
CRCT	Cask Receipt and Canister Transfer
CSF	Consolidated Storage Facility
DOE	Department of Energy
DOE-NE	Department of Energy – Nuclear Energy
DPC	Dual Purpose Canister
DSC	Dry Storage Canister
EAS	Engineering Alternative Study
FRS	Fuel Receipt and Storage
FTE	Full-time Employee
GNEP	Global Nuclear Energy Plan
HEPA	High-Efficiency Particulate Air
MAP	Mobile Access Platform
MRS	Monitored Retrievable Storage
MT	Metric Ton
MTU	Metric Ton of Uranium
NAC STC	NAC (Vendor) Storage and Transportation Cask System
NRC	Nuclear Regulatory Commission
NWPA	Nuclear Waste Policy Act
NWTRB	Nuclear Waste Technical Review Board
O&M	Operation and Maintenance
PWR	Pressurized Water Reactor
RF	Repackaging Facility
SPMT	Self-propelled Modular Transport
SRNL	Savannah River National Laboratory
SRS	Savannah River Site
SVCT	Storage Vault Canister Transfer
TBD	To Be Determined
TPC	Total Project Cost
TVF	Test and Validation Facility
U.S.	United States
UFD	Used Fuel Disposition
WBS	Work Breakdown Structure
UNF	Used Nuclear Fuel
WBS	Work Break-Down Structure
WHB	Waste Handling Building

1. Background

The United States (U.S.) currently utilizes a once-through fuel cycle where used nuclear fuel (UNF) is stored on-site, in either wet pools or in dry storage systems, with ultimate disposal in a deep mined geologic repository envisioned. A variety of dry fuel storage systems have been and continue to be developed and deployed. Of the 65,200 metric ton of uranium (MTU) of UNF generated to-date, approximately 30% is stored in 1,640 dry storage casks (DOE 2012a). The amount of fuel that will be transferred from wet to dry storage is expected to increase.

For economic reasons, the nuclear industry is currently using large dry storage systems with typical canister capacities of 32 pressurized water reactor (PWR) and 68 boiling water reactor (BWR) fuel assemblies (DOE 2012a). The quantities stored in the dry storage systems continue to trend upwards. These systems are either single purpose (storage only) or dual-purpose (storage and transportation). None of them are currently licensed for disposal. In addition, such large capacity canisters may not be able to be emplaced in a geologic repository without either long periods of extended storage to allow for the thermal output of the fuel to decay such that repository thermal limits are met or due to physical emplacement constraints. Potentially, repackaging of the fuel assemblies will be required.

The Blue Ribbon Commission (BRC) for America's Nuclear Future, in its report to the Secretary of Energy recommended that prompt efforts to develop one or more consolidated storage facilities be undertaken. The Nuclear Waste Technical Review Board (in June 30, 2011 correspondence to the BRC) stated that:

> *"The Board believes that the system-wide implications of developing consolidated interim storage should be considered as part of a detailed evaluation that includes the advantages and disadvantages of such approach," and "Information from the detailed analysis, suggested above, also will inform decisions about what technical capabilities may be required at UNF storage-site locations. The Board agrees that taking full account of the complex nature and integrated dependencies of the entire waste disposal system is vitally important in making any decisions about options for managing UNF and HLW. Thus, siting an interim storage facility without an integrated waste management plan is not recommended."*

2. Scope and Objective

In Fiscal Year (FY) 2012, the U.S. Department of Energy Office of Nuclear Energy (DOE-NE) requested the Used Fuel Disposition (UFD) Campaign to initiate system-level analyses of the interfaces between "at –reactor" used fuel management, consolidated storage, and ultimate disposition. The results of the analyses will provide DOE and other stakeholders information regarding the various alternatives for managing the back-end of the fuel cycle. Detailed system-level analyses of the back-end of the fuel cycle may take several years to complete. Therefore, the UFD Campaign developed multi-year milestones to complete the analyses and address the BRC and Nuclear Waste Technical Review Board (NWTRB) recommendation described in Section 1.0.

FY 2012 scope evaluated alternatives for an integrated approach to transportation, storage, and disposal of UNF with an emphasis on providing flexibility to respond to unknown situations and developments. Rough order of magnitude cost factors associated with each alternative and the development of supporting logistics simulation tools were also included in FY2012 scope.

3. Back-end Fuel Cycle

The Back-end Fuel Cycle once thru scope has been illustrated in Figure 4-1. UNF canisters stored at reactor sites will be transported to a Consolidated Storage Facility (CSF) in licensed transportation casks. Once at the CSF, UNF canisters will be unloaded from the transportation cask, loaded into a facility storage cask, and transferred to a storage pad or storage vault. Bare fuel will be unloaded from transportation casks and transferred to storage pool(s). Eventually, the canisters and bare fuel will be transferred to a Repackaging Facility (RF) for repackaging into waste packages that meet the Repository Facility disposal criteria, or transferred directly to a Repository Facility for final disposal.

Figure 4-1 illustrates multiple path ways for UNF flow thus the four logistical steps. These multiple pathways will be examined in future reports. As noted in Section 3, this report studied the unit cost for systems, structures and/or components that will likely be required for any single pathway.

4. Document Scope

To support the system level analysis (or system architecture study), Savannah River National Laboratory (SRNL) was requested to conduct a rough order of magnitude (ROM) cost study to estimate the unit cost of systems, structures and/or components needed to manage the back-end of the fuel cycle. This document describes the ROM cost study methodology and results. This activity fulfills the level 4 milestone (M4FT-12SR0814061) described in Work Package Number FT-12SR081406.

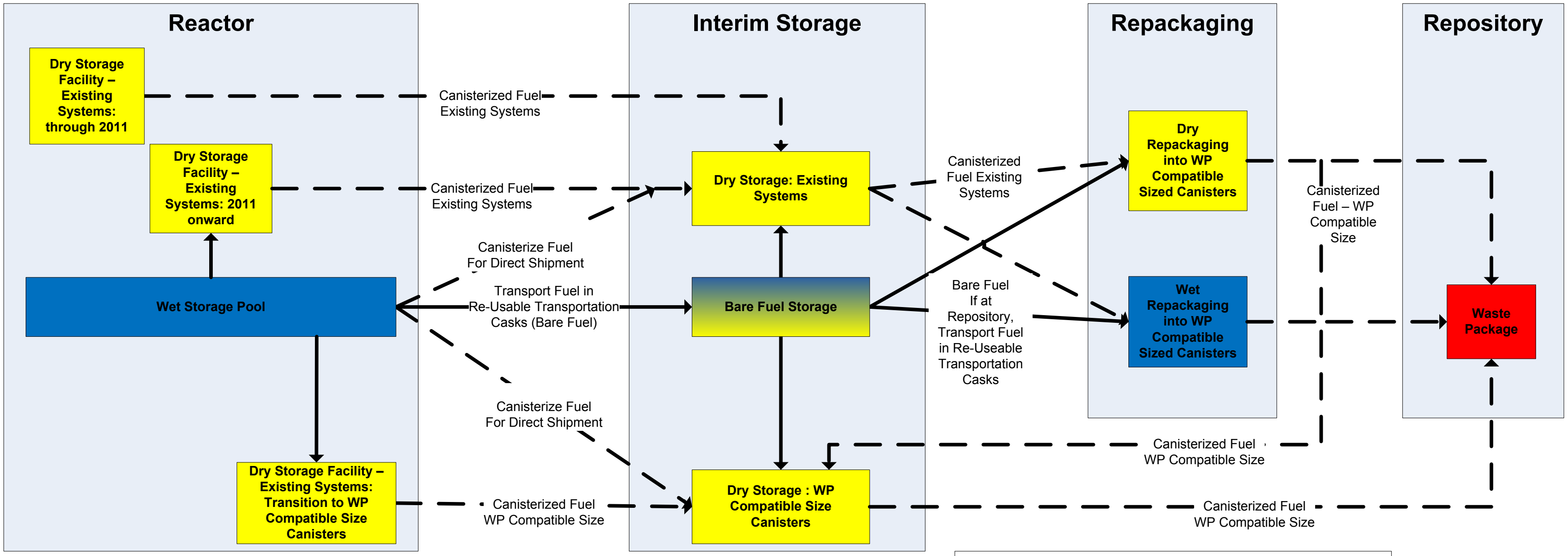


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Figure 4-1 UNF Back-end Fuel Cycle Scope

5. Facility Design Concepts

Since the passage of the Nuclear Waste Policy Act (NWPA) in 1982, DOE and others have completed many studies directly and indirectly relevant to the role consolidated storage should play in the back-end of the fuel cycle including the associated estimated cost. In August, 2011, the DOE's UFD Campaign – System Architecture team examined and documented prior relevant studies related to both the Monitored Retrievable Storage (MRS) facility and the surface facility proposed for the Yucca Mountain Repository. The purpose of the task was to identify prior studies which can be applied to future scoping, design, and cost studies. The results of the examination were documented in the report titled *"Consolidated Storage Lessons Learned and Background Information"* (DOE 2011a). Appendix A of the referenced report provides a list of prior studies judged as most important to informing future studies.

While the present UNF and consolidated storage missions have changed considerably from the prior studies, the core functions --- to receive, store, package, and continually monitor nuclear fuel and then ship it for subsequent disposition - remain unchanged. Many of the design attributes of the previous studies remain valid technical solutions for managing the back-end of the fuel cycle. The Reference Section (Section 11.0) provides a list of prior studies judged by this team to be most relevant to this study.

6. CSF Scope

The scope of the CSF includes the following major functions:

- Receiving fuel from reactors, currently in various wet and dry storage configurations, that will need to be considered by consolidated storage
- Storing dry fuel on pads
- Storing dry fuel in vaults
- Storing bare fuel in pools
- Transferring fuel to a Repackaging Facility where it would be processed into waste package sized containers, with the size dependent upon specific repository geologic conditions
- Transferring fuel to a Repository for final disposition

6.1 CSF Modules

In order to provide DOE-NE the flexibility to respond to unknown situations and developments associated with accomplishing the back-end of the fuel cycle, the team subdivided the CSF physical features into the following potential stand-a-lone facility modules. The cost study (Section 9.0) provides a work breakdown structure (WBS) at a sub-module level. The individual WBS elements can then be used in the future to derive cost for various system configurations of capabilities, through-put, and capacity.

- Cask Receipt and Canister Transfer (CRCT) Facility
- Dry Storage Pads (Vertical and Horizontal)
- Dry Storage Canister (DSC) Storage Vault Canister Transfer (SVCT) Facility
- Bare Fuel Receipt and Storage (FRS) Facility

6.2 CSF Facility Modules Design Concepts

The CSF will receive commercial UNF, currently in various wet and dry storage configurations, from reactor sites. If the fuel is packed in closed canisters, the canisters will be shipped in licensed transportation casks that measure approximately seven feet in diameter and 17 feet in length. Each cask may weigh as much as 175 tons, gross container weight, including fuel.

The CSF module design concepts are based on receiving and storing cask/canister systems whose designs are similar to the commercially available Holtec International HI-STAR and HI-STORM system for vertical storage or the Transnuclear NUHOMS system for horizontal storage, and are representative of other storage systems designs.

At no time, during the shipment or storage processes, beyond initial fuel canister loading at the reactor, would it be intended that the canisters be opened or the UNF fuel assemblies be direct handled, until the fuel is subsequently transferred into the repackaging facility, in preparation for disposal.

In general, the cask and canister handling, and storage design concepts are similar to concepts developed by DOE's Yucca Mountain facility and Private Fuel Storage L.L.C. (PFS) proposed for Toole County, Utah (DOE-PFS). The receipt and the vertical storage design concepts are based closely on the facility that the US NRC licensed as PFS (US NRC-PFS).

6.2.1 Cask Receipt and Canister Transfer Facility

The scope for the CRCT includes the following processes. The pre-conceptual layout of the CRCT is illustrated in Appendix A, Figures A-1, A-2, And A-3.

- Receiving containerized fuel from the reactors in legacy existing storage systems
- Removing canisters from the transport over packs (or casks)
- Transferring canisters to facility over packs (or casks)
- Transferring fuel to CSF dry storage

The CRCT building will be located at the CSF and is envisioned as a structural steel high-bay structure, consisting, of at least one receipt bay, each on the order of 168.5 ft. wide, 162 ft. long, and 90 ft. high. This structure will have rail carrier access into each cask bay for cask handling and canister unloading/transfer operations. Each CRCT building transfer bay would contain a 250 ton, single trolley, overhead bridge crane. This crane would also be equipped with a 25 ton auxiliary hoist

Each bay would be utilized to receive the transportation cask on its rail carrier, remove the transportation cask impact limiters and remove the transportation casks from the carriers, open the transportation casks, unload the UNF canisters from the cask, and place the canisters into the facility storage casks for transfer to the dry storage pads.

The loaded storage casks and empty transportation casks would be removed from the building by the same rail carrier "pusher engine" used to deliver the loaded rail cars from the Site security rail inspection siding, located at the site perimeter, as reflected in Appendix A, Figures A-4 and A-5. The CRCT building will have the ability to provide localized (at the work site) HEPA filtered ventilation for cask venting and sampling operations.

Following removal of the loaded storage casks from the building, the transportation cask would be radiologically surveyed, decontaminated if necessary, and reassembled for shipment offsite. Each loading bay would provide for rail carrier pass through for fuel transportation cask receipt, & returns and storage cask transfer to dry storage.

Adjacent to the rail line, the structure would contain two below grade shielded wells (for placement of the loaded transportation cask and empty storage cask) approximately 20 ft. in depth, with one at approximately 8 ft. diameter and one at approximately 12 ft. diameter. Two additional, shallow inline wells would exist for temporary placement of the transportation cask lid and storage cask lid, with their tops resting at the level of the floor surface. Although other concepts and alternatives might be considered, the concept of use of the four casks & lids inline wells is suggested, vs. transfer cask handling and heavy component placement operations on and above the level of the CRCT building floor. The suggested concept would reduce overhead building height and allow a 50 ton floor running bell crane to travel over the shielded wells, transferring the UNF canisters from the transportation casks to the storage casks, on a standard handling cycle.

6.2.2 Dry Storage Pads

The loaded storage cask would be mounted on a self-propelled modular transporter (SPMT) at the CRCT and transferred to a dry storage pad or vault. The storage casks are equipped with vents and channels that provide cooling by passive, natural convection processes. It is proposed that the storage casks and pads would be constructed, on an as needed basis, at the CSF to the respective licensed storage unit design. A concrete batch plant will be located within the boundary of the CSF to support on-site final fabrication of the storage units.

6.2.2.1 Dry Storage - Pads (Horizontal)

Horizontal storage casks would be transported from the CRCT building to a storage pad with a SPMT. At the storage pad, the SPMT would position itself and the shielded cask for precise insertion of the canister into a horizontal storage module. This process of loading the storage casks is illustrated by pictures in Figures 6-1 through 6-5. The representative photos are courtesy of Doerfer Wheelift Systems and Transnuclear NUHOMS Systems.

Figure 6-1 Downending a Horizontal Shielded Cask on an SPMT for transfer to the Storage Pad

Figure 6-2 SPMT Transporting Horizontal Shielded Cask And Canister From The CRCT Building

Figure 6-3 SPMT In Transit with Horizontal Shielded Cask and Canister

Figure 6-4 Positioning SPMT for Canister Insertion Into A Horizontal Storage Module

Figure 6-5 SPMT Canister Insertion Into A Horizontal Storage Module

Transnuclear NUHOMS systems, such as shown in Figure 6-6, can be aligned with multiple single canisters, horizontal storage units in a module. Horizontal storage module arrays containing 12 canisters are assumed for layout purposes. Each module is approximately 52 ft. wide by 89 ft. long, containing 12 horizontal storage units. Rows of modules would be separated by approximately 50 ft. to allow access for the SPMT shielded transporter. Areas between the modules would have transporter access and be surfaced sufficiently to allow travel of heavy lift equipment.

Figure 6-6 Nuhoms Horizontal Storage Unit

6.2.2.2 Dry Storage – Pads (Vertical)

Vertical storage casks would be transported from the CRCT building to a storage pad with a SPMT as shown in Figure 6-7. At the storage pad, the vertical cask would be lifted by a service crane or vertical cask crawler crane and placed on the storage pad.

Figure 6-7 SPMT Carrying A UNF Storage Cask

Figure 6-8 illustrates a typical vertical cask storage pad. The team assumed, multiple vertical cask storage pads are employed, each holding 8 storage casks. Each storage pad would be constructed flush with grade level and accept up to eight storage casks in a 2 x 4 array. The typical vertical storage pad dimensions would be on the order of approximately 67 feet long by 30 feet wide by 3 feet thick. Each cask would contain ~10 to 14 MTHM, assuming the Holtec Hi-Storm basis of 68 BWR or 32 PWR assemblies in each cask, although canister loading densities will be a function of licensed canister design and actual loading densities achieved at reactor source sites. Although other pad configurations can be designed, each pad would be surrounded by a compacted gravel skirt, on the order of 30 feet wide. Areas between the pads would have transporter access and be surfaced sufficiently to allow travel of heavy lift and transfer equipment such as a SPMT.

Figure 6-8 Typical Vertical Cask Dry Storage Pad

6.2.3 DSC Storage Vault and Canister Transfer Facility

The scope for the Storage Vault Canister Transfer (SVCT) facility includes the following functions. The pre-conceptual layout of the SVCT has been illustrated in Appendix A, Figure A-6.

- Receiving containerized fuel from the Reactors in either existing storage systems or newly designed waste packages that are compatible with future repository disposal criteria.
- Transferring fuel to CSF DSC vaults

A dry storage vault concept for the receipt, unloading, and storage of 3,000 MTHM of containerized fuel was previously developed in the *Engineering Alternative Study (EAS) for Separations –Summary Report* (DOE 2007b). The basic receipt and storage concept has been adopted for the SVCT with an expansion of the module storage capacity to 7,500 MT.

The SVCT facility is envisioned to receive commercial UNF packaged in closed canisters. The UNF canisters will be transported to the facility by rail. The UNF canister will be transferred from the shipping over-pack to an underground vault for storage.

When received, the licensed transportation cask will be opened and unloaded by removal of its sealed fuel canister into a transfer cask. The canister will be moved to an underground transfer shuttle cart which moves the canister into the vault operations area. Overhead crane mounted shielded transfer casks are then used to locate the canister in the desired vault storage location. The underground vault ventilation provides cooling by passive, natural convection.

Following transfer of the of the fuel canisters to the storage vault, the transportation cask would be radiologically surveyed, decontaminated if necessary, and reassembled for shipment offsite. Each loading bay would provide for railroad pass through of fuel transportation cask carriers.

6.2.4 Bare Fuel Receipt and Storage Facility

The scope of the bare Fuel Receipt and Storage (FRS) Facility for the pool storage includes the following functions. The pre-conceptual layout is illustrated in Appendix A, Figures A-7, A-8, and A-9.

- Receiving bare fuel from the reactors in either transport vehicle or newly designed waste packages that are compatible with future repository disposal criteria.
- Removing bare fuel from the transport vehicle
- Transferring bare fuel to CSF pool storage

A pool storage concept for the receipt, unloading, and storage of 3,000 MTHM was previously developed in the *Engineering Alternative Study (EAS) for Separations –Summary Report* (DOE 2007b). The basic receipt concept was adopted for this study with an expansion of the storage capacity to 7,500 MT.

The wet storage pool is separated from the cask receipt bays by an airlock. The transportation cask is moved from the cask receipt bays, through the airlock, lowered into the pool and flooded with water prior to removal of the inner container lid. Once the lid is removed, the individual fuel assemblies are transferred to the desired fuel assembly storage rack location.

The pool consists of 8 interconnected basins. Each basin is approximately 158 ft. long by 60 ft. wide and 55 ft. deep. Each basin contains 100 storage racks providing 35 assembly storage positions using a 15 by 15 inch array. Thus each fuel pool basin corresponds to 3500 bare fuel assembly storage positions.

If an 8 basin, 28K assemblies pool (3500 assemblies per basin) were fully loaded with high-burn-up UNF, on a ratio of 43% PWR fuel assemblies and 57% BWR assemblies, the total assemblies of each type would be about 12,040 PWR and 15,960 BWR. On that basis, at approximately 0.436 MTU per PWR assembly and 0.179 MTU per BWR assembly, the total decay heat (60GWd/MT PWR fuel is ~3,530 watts/MT and 50 GWd/MT BWR fuel is ~2,920 watts/MT) would be about 26.9 MW. The decay heat is discharged to the atmosphere by cooling towers. Water treatment, ventilation, and support areas are adjacent to the pools.

Used nuclear fuel assemblies will arrive onsite via commercially licensed transport vehicle. The transport vehicle will consist of a special railcar or special truck with casks specifically designed for the safe and secure transport of UNF. All shipping casks will be NRC licensed, and contents will be within license constraints. For baseline planning purposes, it can be assumed that rail casks contain approximately 26 PWR fuel assemblies (or 61 BWR assemblies) based on the NAC STC cask, and truck casks contain approximately 4 PWR fuel assemblies (or 9 BWR assemblies).

The fuel transportation casks will be received and initially staged in a receipt area where contamination surveys, other integrity checks and transportation & shipment documentation verification can be performed, to assure that receipt documentation and package condition is in order and that decontamination or repairs are not required before unloading.

The transport vehicle and transportation cask, upon completion of the radiological survey, will proceed to the Fuel Receipt and Storage (FRS) facility for removal, inspection, survey and storage of the bare spent fuel assemblies. Cameras, scanners, manipulators and similar equipment are likely to be required to perform this function. The used fuel assembly may require washing and de-scaling prior to release to storage.

Equipment will be provided within the FRS facility to remotely handle, monitor, inspect and temporarily store the used fuel assemblies in a suitable environment that precludes physical degradation, including active cooling if necessary

7. Repackaging Facility

Current storage and transportation systems’ design, operations, and licensing requirements do not consider disposal requirements because the disposal requirements are not defined and are not connected to storage and transportation functions. To accomplish their goals of continued safe and cost-effective electricity generation, nuclear utility decisions related to UNF storage are largely motivated by minimizing their cost and minimizing potential impacts to continued safe and cost-effective operation of their nuclear plants. This disconnect between storage and transportation and disposal, as well as insufficient pool storage capacity to enable continued operation, has led to widespread use of large capacity dry storage casks. Direct disposal of the large canisters currently used by the commercial nuclear power industry is beyond the current experience base domestically and internationally, and represents significant engineering and scientific challenges. Repackaging of fuel from these larger canisters into smaller ones for disposal, may be required to avoid extensive surface decay storage, or to meet physical constraints on disposal systems, or because additional criticality controls are determined to be necessary.

For the purpose of this analysis, the repackaging of the canisters will be accomplished at a stand- alone facility or is co-located with a CSF or Mined Geologic Repository. The scope for the Repackaging Facility (RF) includes the following processes. The pre-conceptual design of the RF is illustrated in Appendix B, Figures B-1, B-2, and B-3.

- Receiving fuel from CSF
- Transferring repackaged fuel to CSF
- Transferring repackaged fuel to a Repository

The RF module is sized for 1500 MTU/yr throughput. The main sub-structures within the module include a Carrier Receipt Bay, a Waste Handling Building (WHB), and a Carrier Release Bay. Two air locks are included—one between the Receipt Bay and the WHB and one between the WHB and the Release Bay (Figure 7-1). The configurations of the Receipt Bay and the Release Bay may vary considerably depending on whether the RF is co-located with a CSF or a Mined Geologic Repository, or is a stand-alone facility. For example, if the repackaging facility is co-located with a Mined Geologic Repository, then the Release Bay would not necessarily be needed and could potentially be replaced with a transfer corridor to a facility for placing waste package over packs on the canisters as described in *Disposal Concepts/Thermal Load Management (FY11/12 Summary Report)* (DOE 2012c).

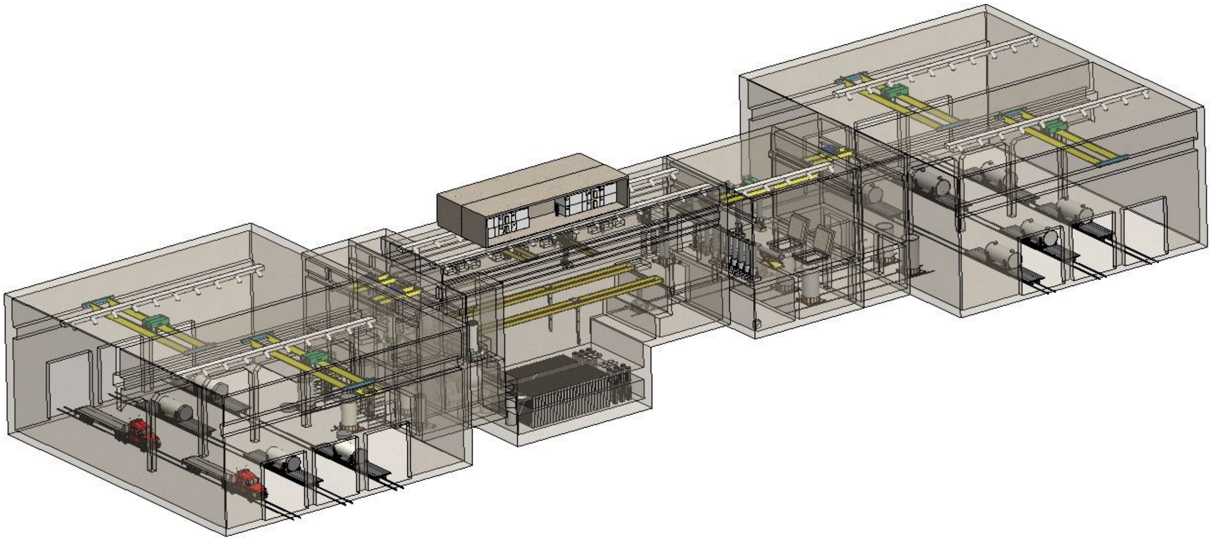

Figure 7-1Isometric view of the overall Repackaging Facility Module Concept, including Carrier Receipt Bay, Airlocks, Waste Handling Building and Carrier Release Bay

Commercial UNF will be transported to RF in NRC-certified transportation casks. The waste will be transported by rail or road to the Facility Operations Area security station, where personnel will verify the shipping manifests, then inspect and survey the cask and its carrier. After the cask and its carrier enter the Radiologically Controlled Area, they will be staged in parking areas designated for either truck carriers or rail carriers. When the cask is scheduled for processing, a site prime mover will move the cask and carrier to the Carrier Receipt Bay. The facility operations security station is assumed to be a shared facility with either the CSF or the Repository, depending on where the RF is co-located.

7.1 Carrier Receipt Bay Features and Operations

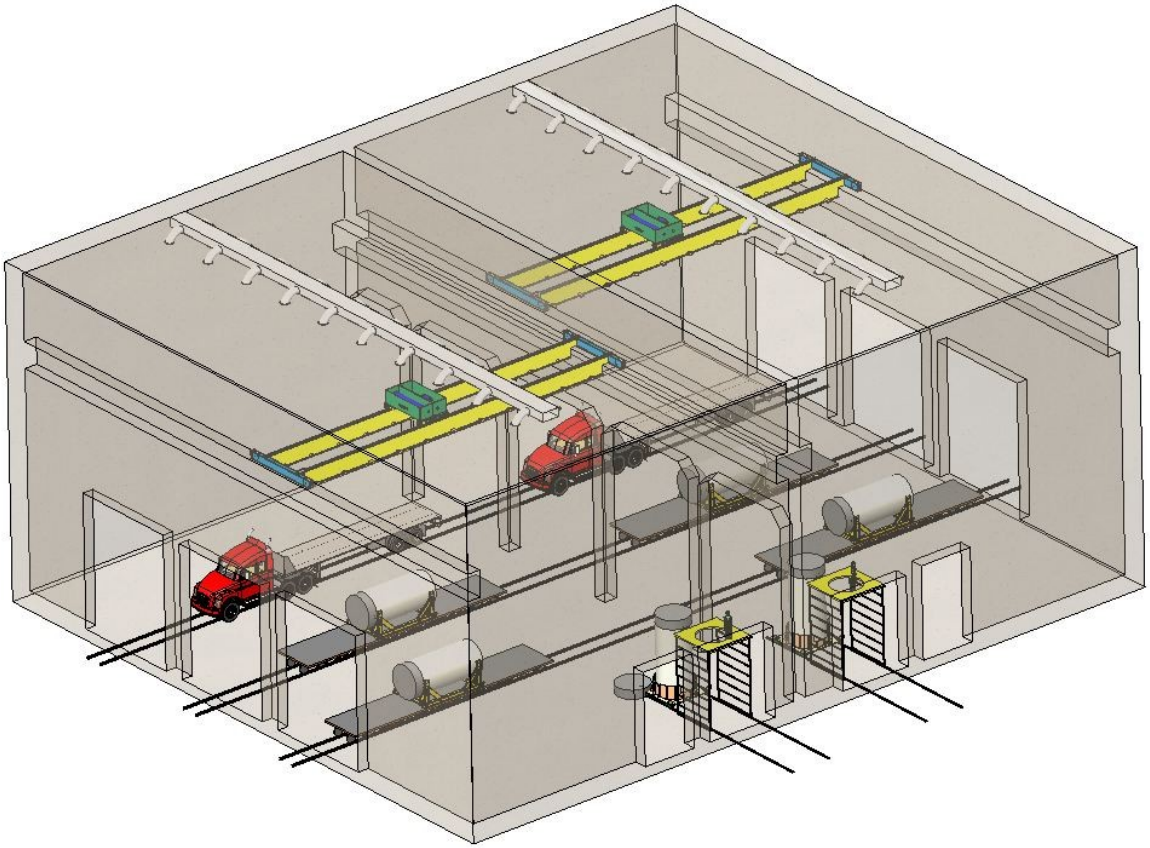

Figure 7-2 Carrier Receipt Bay Module

The Carrier Receipt Bay Module is envisioned as a structural steel high-bay structure. The structure would be nominally 75 ft high. For a 1500 MTU/year throughput, this structure would require at least two lines with two 250 ton gantry cranes. A third line is shown in Figure 7-2 for additional flexibility. The actual number of lines and bays will be a function of projected through-put. The material handling system in the Carrier Receipt Bay will receive and inspect shipping casks from the carrier/cask transport system, prepare the casks for unloading, and unload transportation casks from the railcar or truck. The Carrier Receipt Bay will include sufficient space between lines for a Mobile Access Platform (MAP), Cask Stand for Tilt Frame Bare Fuel Transportation Casks and Horizontal Dual Purpose Canister (DPC) Transportation Casks, Tilt Frame, Transportation Cask Transfer Trolley, and lay down areas for impact limiters and other equipment. The MAP will allow personnel access to transportation casks brought in by rail or truck. The MAP bridges over the cask lying on the carrier. The MAP includes platforms to provide access by personnel to different features on the cask (e.g., personnel barriers and impact limiters). Railcars and trucks will enter and exit the Carrier Receipt Bay by 30 ft high by 25 ft wide roll up metal doors.

Receiving operations will include the following and were based on the operations documented in *Civilian Radioactive Waste Management System (CRWMS) Management and Operations (M&O)* Attachment II, Section 1.3.2.1 (DOE 2000a)

- Performing a radiation survey of the carrier and the DPC transportation cask or bare fuel transportation cask

- Removing or retracting the personnel barrier(s)
- Sampling the cask exterior for contamination
- Measuring the cask's temperature
- Removing or retracting the cask impact limiters
- Installing the cask's lifting attachments (if any).

Shipping operations for empty carriers/casks leaving the facility will include:

- Removing the cask's trunnions (if required)
- Checking the cask's tie-downs
- Installing the cask's impact limiters
- Performing another radiation survey of the cask
- Installing the personnel barriers.

7.2 Transportation Casks Handling Operations

The concept of operations assumes that two types of transportation casks will be received at the Repackaging Facility:

- Transportation casks that can be upended directly on the railcar to a vertical orientation for unloading (Direct Vertical Cask)
- Transportation casks that must be transferred from the railcar in a horizontal orientation to a tilting frame that is used to upend the cask to a vertical orientation for unloading (Tilt Frame Cask)

The handling operations differ based on the type of cask.

7.2.1 Direct Vertical Casks Operations

Associated operations include:

- Receive and move a Direct Vertical Transportation Cask on a railcar into preparation area for unloading
- Remove personnel barriers if present
- Remove impact limiters from transportation cask
- Attach lift yoke to transportation cask
- Upend cask
- Transfer transportation cask to cask transfer trolley/cart
- Remove cask lid bolts, and attach cask lid lift fixture; remove and store lid
- Move cask transfer trolley/cart into position in front of WHB Airlock

7.2.2 Tilt Frame Cask Operations

Associated operations include:

- Receive and move a Tilt Frame Transportation Cask on a railcar into preparation area for unloading
- Remove personnel barriers if present
- Attach slings to transportation casks for horizontal lift
- Make horizontal transfer of cask to cask stand

- Remove impact limiters from transportation cask
- Transfer cask stand to tilt frame
- Attach lift yoke to transportation cask
- Upend cask
- Transfer transportation cask to cask transfer trolley/cart
- Remove cask lid bolts, and attach cask lid lift fixture; remove and store lid
- Move cask transfer trolley/cart into position in front of Waste Handling Building Airlock

7.3 Waste Handling Building Features and Operations

The WHB is a multi-level reinforced concrete structure made of noncombustible materials with interior and exterior shear walls, concrete floor, concrete roof slab diaphragms, concrete mat foundations, and a pool. The nominal footprint of the WHB, including air locks is about 282 ft by 92 ft. The maximum height of the building is about 100 ft above grade, with the majority of the building under a roof approximately 80 ft above grade. The WHB pool substructure includes the rooms surrounding the pool that provide internal buttresses for the actual pool and space for make-up tanks, pumps and filters, ion exchangers, etc. The concrete base mat for the basement structure (pool and surrounding rooms) mat is 55 ft below the top of the at-grade concrete mat. The spent fuel pool is sized hold approximately 750 MTU of used nuclear fuel (6 month worth of spent fuel assembly inventory for a 1500 MTU module.) This will allow some flexibility for fuel blending as a thermal management strategy as well as decouple waste receipt and unloading critical path operations from waste package canister loading and closure operations. The pool is split into separate basins and storage racks for BWR assemblies and PWR assemblies and includes separate spent fuel transfer machines (handling cranes) for BWR and PWR assemblies to avoid change out of lifting grapples.

The foundation for the WHB is a reinforced concrete mat at grade and another reinforced concrete mat below the pool having the necessary thickness to adequately support the structure. The foundation mat at grade for the Waste Handling structure is 3 ft thick and the pool foundation is a 5-ft-thick mat.

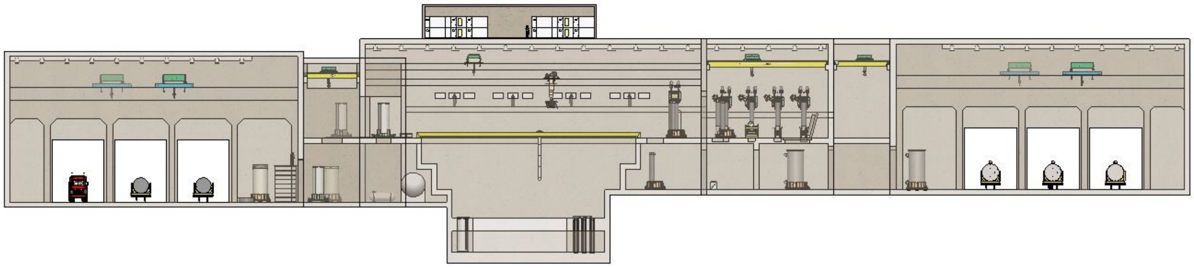

Figure 7-3 Plan Elevation of Waste Handling Building

An airlock structure connects the Receipt Bay with the WHB. The cask transfer cart will move the transportation cask into the air lock, which will have isolation doors to maintain a lower air pressure in the canister transfer work areas than in the carrier bay. The cart will take the cask through the air lock to the cask preparation area similar to the area in (*Civilian Radioactive Waste Management System (CRWMS) Management and Operations (M&O)* Attachment II, Section 1.1.2.1 (2000b).

If the cask contains a DPC, an overhead bridge crane will lift the DPC out of the cask to the second level and the empty transportation cask will be decontaminated (if necessary) and returned to the Receipt Bay where it will be reconfigured for re-deployment to the transportation system.

7.4 Cask Cavity Gas Sampling Subsystem

The cask cavity gas sampling system samples the gas inside a loaded transportation cask or DPC before it is opened to obtain an indication of the condition of the waste inside. The presence of gaseous fission products or gases other than helium is indicative of off-normal conditions inside the cask. The cask cavity gas sampling system also vents the cask or DPC to the HVAC system to equalize pressure with the room prior to opening the cask.

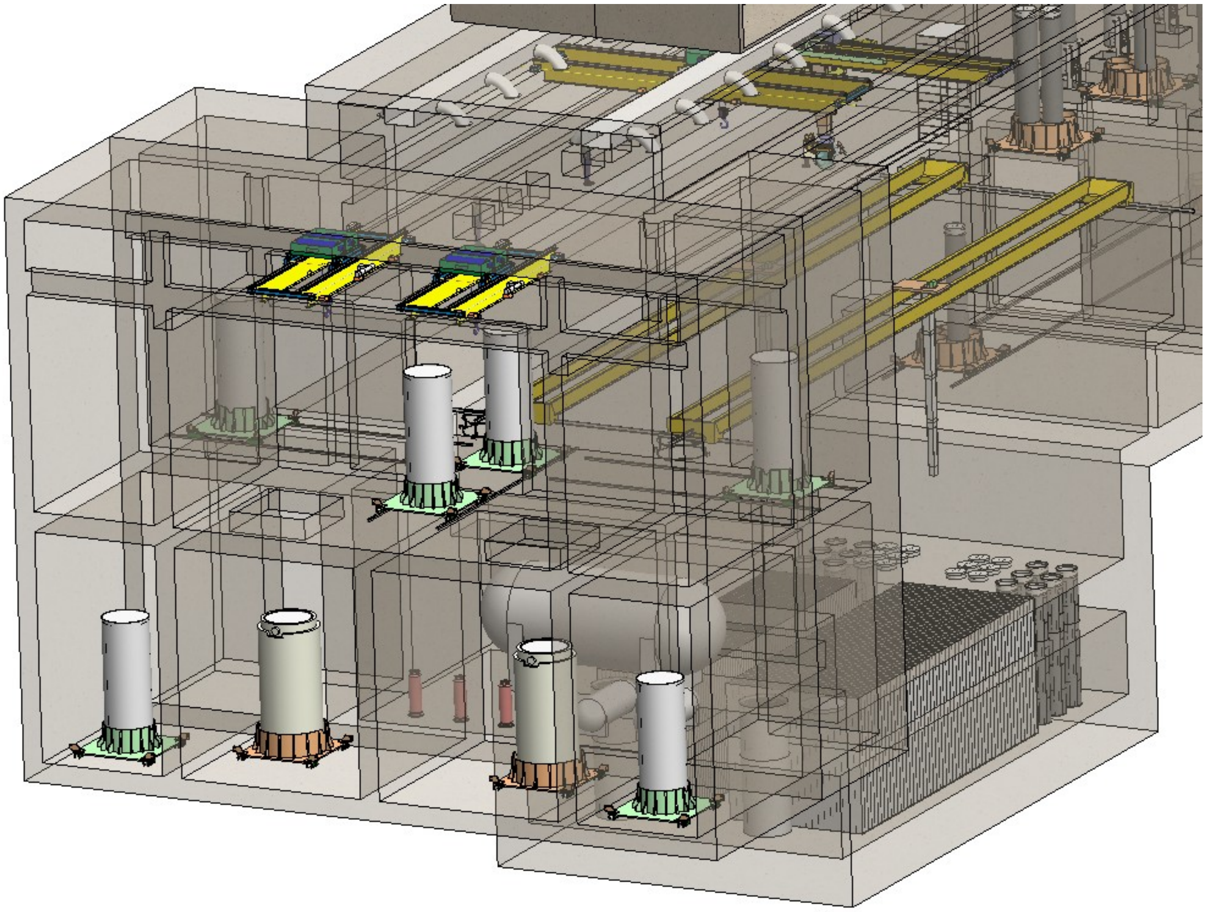

Figure 7-4 View of Receipt Side Airlock

7.5 Dual Purpose Canister Unloading Operations

DPC cutting is done at the DPC cutting station in the cask preparation area. Although DPC lid cutting is done dry, within a hot cell area of the WHB the reference concept assumes DPC UNF unloading is done wet.

- The DPC contained within a shielded site transfer cask is transferred to the DPC cutting station using the cask handling crane.
- A shield ring may be installed to limit personnel exposure.
- The DPC cutting jib crane is used to remove the shielded transfer cask lid.
- The DPC cutting machine is placed onto the DPC outer lid. The DPC outer lid weld is then cut, and the DPC cutting jib crane is used to remove the DPC cutting machine and the outer lid. (The DPC cutting machine is assumed to include an integral vacuum system to remove metal cuttings during the cutting process.)
- The DPC cutting machine is placed back onto the DPC to cut the siphon and vent port cover welds. The siphon and vent ports are used to sample and vent the DPC interior and fill the DPC with treated borated water in preparation for transfer to the pool.
- The DPC cutting machine is then used to cut the final weld on either the inner lid or the shield plug, depending on the DPC type.
- If the DPC is a type that has an inner lid, the inner lid is removed from the DPC after the weld is cut. A lifting adapter is then attached to the shield plug. The lid to the shielded transfer cask is replaced using the DPC cutting jib crane. The shield ring is removed.
- Transfer casks with BWR DPC canisters are positioned next to BWR UNF basin and transfer casks with PWR DPC canisters are positioned next to the PWR UNF Basin.
- The shielded transfer cask containing the DPC is then transferred to the pool, where the shielded transfer cask lid is removed.
- If the DPC is a type that has a siphon tube attached to the shield plug, the shield plug is raised above the shielded transfer cask and the siphon tube is detached from the shield plug using the siphon tube shear tool. The detached siphon tube remains in the DPC.
- The shield plug is placed in a staging area in the pool.
- The used fuel transfer machine then accesses the interior of the DPC to remove the UNF assemblies. The UNF assemblies consist of PWR or BWR fuel; therefore, the used fuel transfer machine uses the PWR grapple or the BWR grapple to remove the UNF assemblies.
- The UNF assemblies are then transferred to a disposal canister or to the UNF staging rack. If the cask or canister contains damaged-fuel cans, these are transferred in the same manner. A limited number of special oversized cells are provided as part of the UNF staging racks to accommodate damaged-fuel cans or baskets shipped to the facility or encountered during UNF transfer within the WHB pool

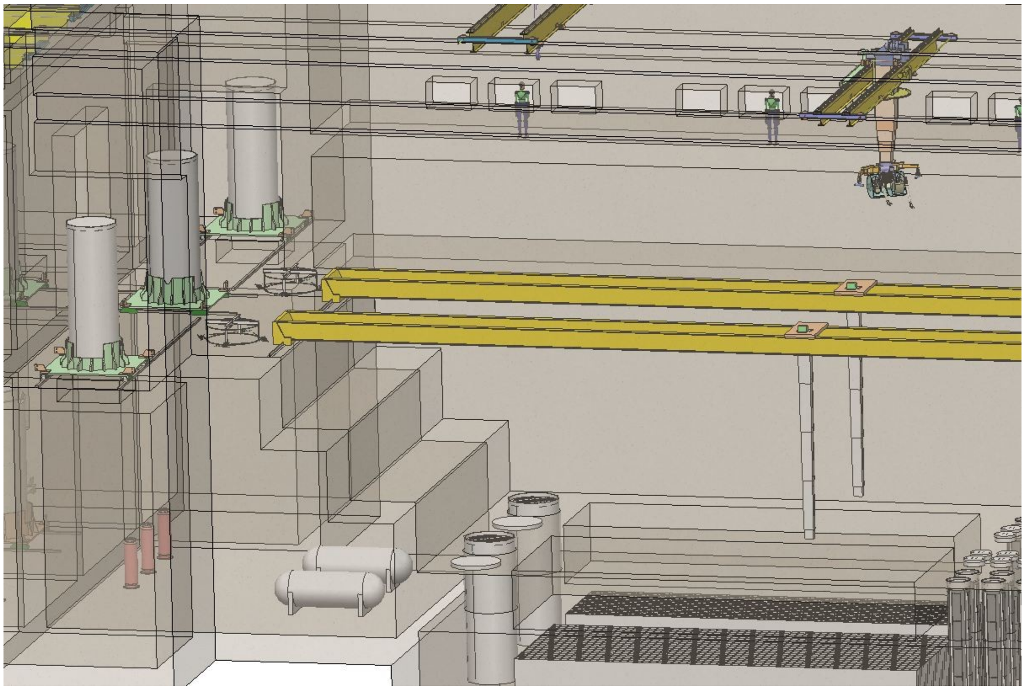

Figure 7-5 View of DPC Cutting Stations Adjacent to Pool and Canister Unloading Space. The observation corridor/control room is shown on the upper level

7.6 Disposal Canister Loading Operations

- An empty disposal canister (and transfer cask if utilized) is placed on a disposal canister transfer trolley in the Carrier Release Bay
- The empty disposal canister is moved through the Release Side Airlock and into the staging area below the canister welding and drying stations.
- A bridge crane lifts the empty disposal canister through the portal and places it in a disposal canister transfer trolley.
- The disposal canister transfer trolley positions the empty canister on the deck next to the canister loading area in the pool.
- The canister is filled with water and is lowered into the pool.
- The spent fuel transfer machine grapple is positioned over the UNF assembly to be moved. Once in position, the grapple is engaged and the assembly is lifted to the proper height under water for movement. The spent fuel transfer machine moves laterally to a position over the waste package canister and lowers the assembly into the canister, then disengages the grapple. This operation will repeat until the canister is full.
- The canister closure lid is seated on top of the canister using the overhead crane.
- The loaded canister (and transfer cask if utilized) is removed from the fuel pool and placed in the canister transfer trolley

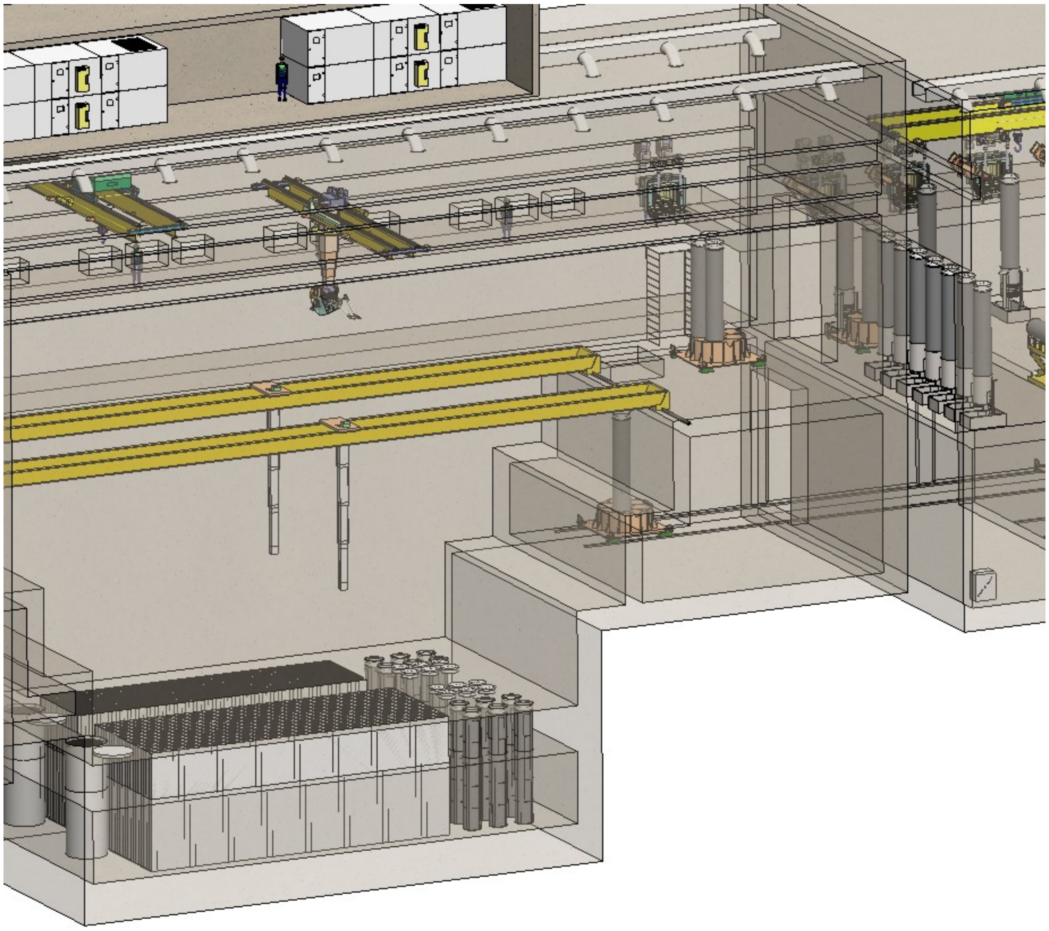

Figure 7-6 Detail View of the Disposal Canister Side of the Packaging Pool

7.7 Disposal Canister Closure:

- The Disposal Canister Transfer Trolley moves the loaded disposal canister to one of the welding stations
- The canister lid is welded onto the disposal canister
- The Disposal Canister Transfer Trolley moves the welded canister to one of the drying stations.
- Residual water is removed from the canister cavity by either a vacuum or forced helium drying system
- The disposal canister is backfilled with helium to provide an inert atmosphere.
- An empty transportation cask is positioned in the room below the disposal canister closure and drying area using a transportation cask transfer cart/trolley.
- The overhead crane lowers the disposal canister into a transportation cask in the vertical position.
- The cask transfer cart moves the loaded transportation cask into the airlock between the WHB and the Carrier Release Bay.

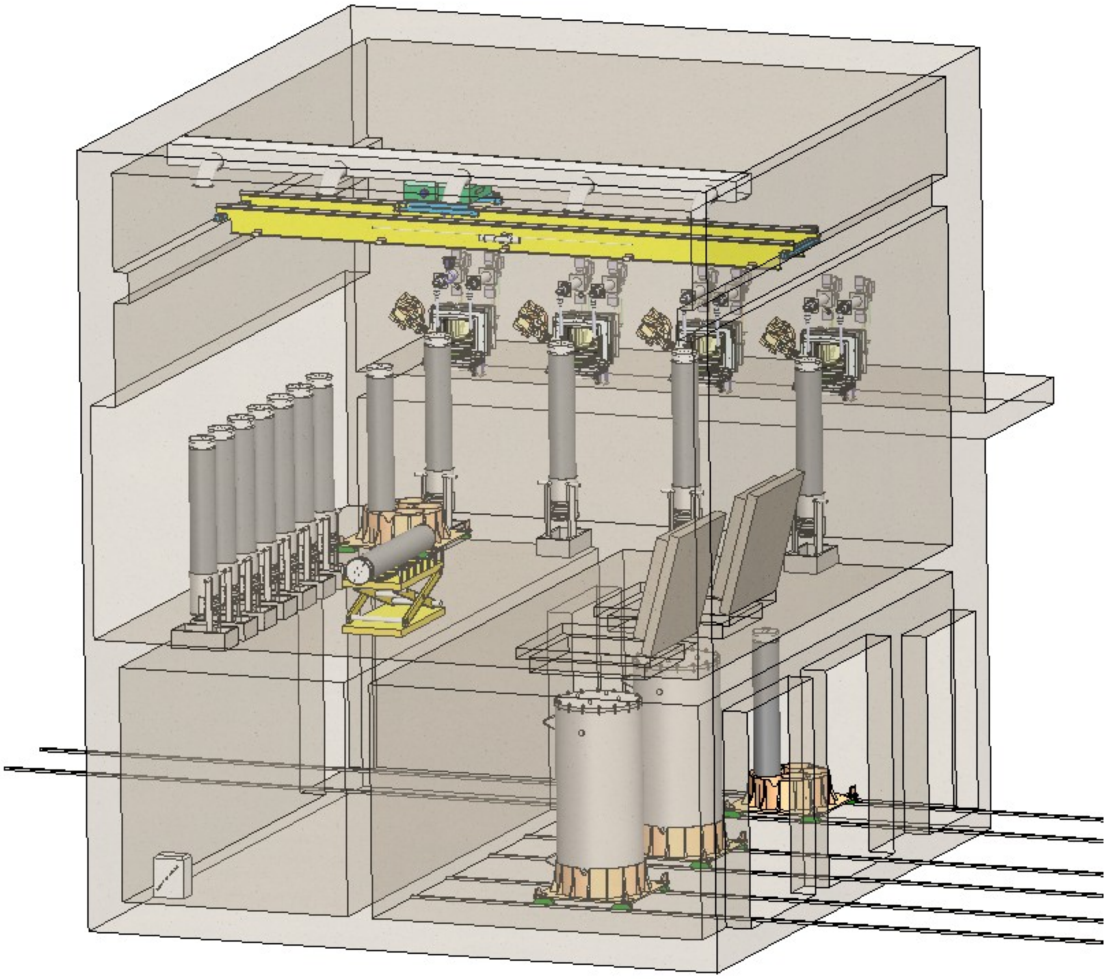

Figure 7-7 View of Disposal Canister Closure and Drying/Inerting Area

7.8 Carrier Release Bay Features and Operations:

The Carrier Release Bay Module is envisioned a as a structural steel high-bay structure similar in design and construction to the Carrier Receipt Bay Module described above. The main difference between the Receipt Bay and the Release Bay would likely be the number of lines required with the Release Bay requiring more lines due to the greater number of loaded canisters being shipped out for the same level of throughput. The material handling system in the Carrier Release Bay will receive and inspect empty transportation casks and empty disposal canisters from the carrier/cask transport system, prepare the casks for unloading, and unload transportation casks from the railcar or truck and reload the transportation cask and loaded disposal canister for release to the repository. Like the Receipt Bay, the Carrier Release Bay will include sufficient space between lines for a Mobile Access Platform (MAP), Cask Stand Tilt Frame, Transportation Cask Transfer Trolley, and lay down areas for impact limiters and other equipment. The MAP includes platforms to provide access by personnel to different features on the cask (e.g., personnel barriers and impact limiters). Railcars enter and exit the Carrier Release Bay by 30 ft high by 25 ft wide roll up metal doors.

Release operations will include:

- The cask transfer cart moves the loaded transportation cask from the airlock to the Carrier Release Bay.
- Placing the loaded transportation cask on a tilt frame and moving it to the horizontal position.
- Attaching impact limiters to the transportation cask
- Loading the transportation cask on the railcar
- Replacing the personnel barrier(s)

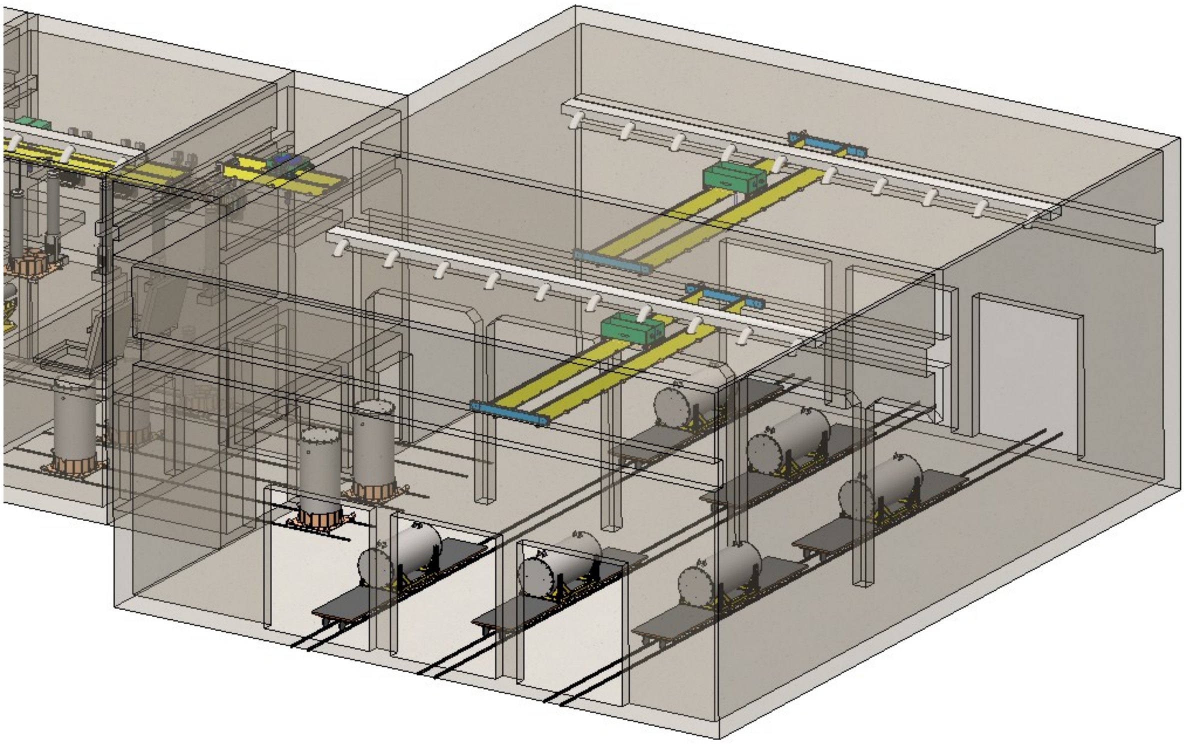

Figure 7-8 Release Side Airlock and Carrier Release Bay

8. Support Facilities

To support the CSF and RF major facility modules described in Sections 6.0 and 7.0, the team subdivided the physical features into the following support facilities. The description of each support facility has been provided below in Sections 8.1.1 through 8.1.4.

- Low Level Waste Building
- Operations/Maintenance/Radiological Protection Building
- Security Building
- Administrative Building

8.1.1 Low Level Waste Building

The Low Level WHB would be constructed adjacent to one of the facilities described in Section 6.0 and 7.0 would be of a single story steel frame construction. This building will provide space and utilities necessary to package low level solid waste, and solidify and package low level liquid waste for offsite disposal. This structure and accompanying facility area will also provide space for the interim staging of accumulated waste packages pending offsite disposal. This building would also have the ability to provide localized (at the work site) HEPA filtered ventilation.

Long term storage of low level waste would not be provided at the facility. On this basis it would be interim-staged, for periodic disposal at a licensed disposal facility, offsite.

8.1.2 Operations/Maintenance/Radiological Protection Building

The Operations / Maintenance / Radiological Protection building would be of a single story steel frame construction. This building would provide space for light industrial maintenance shops, radiological laboratory facilities, and personnel office space.

8.1.3 Security Building

The Security building would be located at the entrance to the receipt facility. This building will provide office space for security staff and house security, communication, and normal service and back up emergency power electrical equipment needed for these personnel and services.

8.1.4 Administrative Building and Other Services

The Administration building would be of a single story steel frame construction. It would include office and record management space, an emergency response center, and meeting rooms.

A fuel storage cask and horizontal storage module fabrication completion area would be provided, together with a batch plant, to allow fuel storage unit shells, provided by the licensed manufacturer, to be filled and cured, on site, according to the licensed design basis.

All buildings would be provided domestic water, sanitary waste, normal electric power, and controlled atmosphere ventilation services.

8.2 Test and Validation Facility R&D Module

During FY 2012, a design concept for implementing DOE’s Research Development & Demonstration plan recommendations at a new “greenfield” CSF coupled with a test and validation facility (T&VF) was developed and documented in the *Used Fuel Research and Development Test and Validation Facility Cost Study* document (DOE 2012 b). This cost was included in the unit cost provided in Section 9.3.

9. Cost Study Methodology

This section describes the methodology used to derive ROM unit cost estimates for the CSF, T&VF and RF modules described in the earlier sections. This section provides a WBS at a sub-module level. The individual WBS elements can then be used in the future to derive costs for various system configurations of capabilities, through-put, and capacity. For the purpose of this study, the team allocated the unit cost estimates to the cost nomenclature defined below.

Cost Nomenclature
The unit costs estimates included the Total Project Costs (TPC) sometimes referred to as capital cost; the operations and maintenance cost (O&M) during the operational period; and the total Life Cycle Cost (LCC) which combined the TPC and O&M cost with additional capital project costs and facility decommissioning costs.

Cost Basis
Each of the costs defined above were determined parametrically based on prior cost estimates for "like" or extremely similar facilities and operational concepts. These parametric costs are discussed below in Sections 9.1 and 9.2.

The basis for these parametric costs were generally information contained in the working files supporting the *Engineering Alternative Study (EAS) for Separations –Summary Report* (DOE 2007b) and *Follow-on Engineering Alternative Study (FOEAS) Summary Report, Global Nuclear Energy Partnership* (DOE 2008) conducted for DOE- NE. These studies included three dry fuel storage methods; pool storage; receipt facilities for large dry storage canisters with transportation over packs; receipt facilities for bare fuel transportation casks; and many other site infrastructure and balance of plant (BOP) facilities.

Repackage facilities were not directly included in these prior studies but parametric costs for the similar hardened radioactive material processing buildings included in these studies were used to estimate applicable parts of this facility. A cost study for the T&VF was recently completed and the results were documented in the *Used Fuel Research and Development Test and Validation Facility Cost Study Report* (DOE 2012d).

9.1 Operation and Maintenance Costs

Operations and Maintenance costs (O&M) were estimated based on the full time equivalent (FTE) annual staffing for the following three categories: 1) management, 2) salaried, and 3) hourly. The staffing was converted to annual labor cost by the labor rates in Table 9-1, and adding the labor overhead cost at 28.5% (21.5% overheads and 7% fee).

Table 9-1 Staffing Labor Rates

Labor Category	Annual Labor Cost ($/yr)
Management	150,000
Salaried	150,000
Hourly	83,000

9.1.1 Resource (FTE) Staffing Estimates

The resource (FTE) staffing estimates for dry fuel receipt and storage were determined by the study team based on the FOEAS (DOE 2008) Early Fuel Receipt Sensitivity Analysis in which 8,000 MT of used fuel was received at a rate of 1,500 MT/year. The staffing was split into two groups; "direct" fuel handling support and BOP staffing. This staffing estimate is in Table 9-2 which also describes the method used to vary staffing as a function of processing rate. This method will be applied to determine staffing for future dry storage receipt and storage scenarios.

The FTE staffing estimates for bare fuel receipts and wet storage were estimated by the team based on the EAS (DOE 2007b) in which 3,000MT/year of fuel was received and stored in a pool awaiting reprocessing. Table 9-2 provides this base staffing estimate along with the method used to vary staffing as a function of processing rate.

For a given system level analysis, the total direct CSF staffing is the sum of the dry and bare fuel handling staff. Total CSF staffing is the total direct plus BOP staffing.

The T&VF and RF staffing estimates determined by the team are also provided in Table 9-2 along with the method used to vary the RF staffing as a function of capacity. The staffing for the T&VF functions is assumed to be constant over the life of the facility.

Table 9-2 Staffing Estimates

Base Staffing Description	Full Time Equivalent (FTE)	Method of Scaling
Dry fuel receipt and inspection storage cask loading and crane operations (30), Cement Plant/Storage Cask Production (18), and LLW Treatment and Packaging (7)	55	Base staffing for 1,500 MT/yr staffing is increased linear with receipt rate
Bare Fuel Receipt and Inspection and Cask Unloading	116	Base staffing for 3,000 MT/yr staffing is increased or decreased linear with receipt rate.
CSF BOP includes site management, engineering, QA/QC, safety, radiation control, warehouse, entry control, equipment maintenance, domestic and sanitary water treatment, cranes and rigging support	76	Constant
T&VF fuel handling includes fuel receipt/inspection, cask and crane operations (10), R&D technicians and scientist (49), and LLW staging (6)	65	Constant
T&VF BOP includes site management, engineering, QA/QC, safety, radiation control, equipment maintenance, mock-up shop, and rigging support	59	Constant
RF fuel receipt/inspection, cask unloading and crane operations	145	Base facility operations as described in Section 7.3 which includes 4 final waste package welding stations. The FTE staffing is a ratio to the number of welding stations divided by 4.
RF BOP includes site management, engineering, QA/QC, safety, radiation control, warehouse, entry control, equipment maintenance, domestic and sanitary water treatment, cranes and rigging support	76	Constant

9.1.2 Annual Consumable Materials

Consumable materials were estimated by algorithm based upon Savannah River Site (SRS) historical data. Consumable materials at SRS range from 7 to 15% of direct labor cost. This study assumes 10% of direct labor cost. Overheads at 28.5% are also applied. The RF materials cost also includes the cost of a thin wall (5/8") stainless steel dry storage canister. The unit cost for these canisters is provided in Table 9-3.

Table 9-3 Repackaging Dry Storage Canister Unit Cost

Waste Package Description		Diameter (M)	Cost ($) per Package
4 PWR/9 BWR	5/8" Stainless	0.82	$60,000
12 PWR/24 BWR	5/8" Stainless	1.29	$90,000
21 PWR/44 BWR	5/8" Stainless	1.60	$117,000

9.1.3 Annual Utilities

Utilities (electricity) estimates were based upon the power demand previously determined by the FOEAS (DOE 2008) Early Fuel Receipt Sensitivity Analysis for 1,500 MT/year receipt of dry fuel storage. Power consumption is varied linearly with receipt rate and was doubled when pool storage is included to account for the additional mechanical equipment required.

Power consumption for the T&VF was assumed to be 1/10 the FOEAS (DOE 2008) Early Fuel Receipt Sensitivity Analysis due to the low annual thru-put of the T&VF. Power consumption for the RF was based upon the FOEAS (DOE 2008) for 1,500 MT/year. Power consumption was varied linearly with receipt rate. The cost of power was based on current SRS cost of $85/mw.

9.1.4 Contract Services and Spare Parts

Contract services included janitorial services, equipment rentals (e.g. computers, non-routine heavy lift equipment), etc. These CSF costs were estimated based on the FOEAS (DOE 2008) Early Fuel Receipt Sensitivity Analysis at $250,000/yr. Contract services and spare parts were varied to account for the type of storage. The cost was assumed to double when both wet and dry storage is required.

Contract services and spare parts for T&VF operations were assumed to be $250,000/year. Contract services for RF was also estimated to have a base cost of $250,000/year for the concepts described in Section 7.0. This cost was scaled to the number of package welding stations divided by the 4 (the number of welding stations in the based concept).

9.1.5 Annual O&M to Life Cycle Operations Cost

Table 9-4 summarizes the operational years which can be used in future studies. The annual O&M cost (labor, materials, utilities, contracts and spare parts) is converted to LCC operations cost by multiplying by the annual O&M cost by the total estimated number of operating years, plus an allowance for start-up (1 year prior to operations) staffing and initial decommissioning support (2 years).

For the CSF and T&VF, the number of operating years is determined based on planned start of CSF (e.g., 2020 or 2035) to the end of the repository emplacement period. The end of the repository emplacement period is determined by the planned start of emplacement operations (e.g. 2040 or 2055) and the period required to emplace 140,000 MT at a specified rate of emplacement (e.g., 1,500, 3,000, or 6,000 MT/year).

The RF is assumed to operate in support of repository emplacement. The operation time period is the waste emplacement time period plus an allowance of 1 year to build an initial inventory for emplacement and 3 years for start-up and decommissioning.

Table 9-4 Scenario Specific Operational Time Periods

Project Phase		**Project Duration (yrs)**	
		CSF and T&VF	**RF**
Operations Start-up		1	1+1
CSF Operations			
CSF Start	Repository Start		
2020	2040	20	
2020	2055	35	
2035	2055	20	
Repository Operations Emplacement Rate (MT/yr)			
1,500		93	93
3,000		47	47
6,000		23	23
Decommissioning Support		2	2

9.1.6 Decommissioning and Dismantlement

The life cycle operations cost also includes an allowance for D&D. This cost is determined by algorithm where the D&D costs is 10% of the TPC (Section 9.2) plus 10% of the additional capital used for building expansion (e.g. pool storage buildings) plus 2% of additional capital used for dry storage (e.g., storage over packs).

9.2 Total Project Cost

TPC is comprised of four major segments:

1) Conceptual Design
2) Site Improvements and Infrastructure
3) BOP facilities, and
4) Process Facilities

9.2.1 Conceptual Design

The study team estimated the conceptual design activities to range from $10,000K to $15,000K inclusive for all three of the major facilities (CSF, T&VF and RF). A single conceptual design allowance was judged adequate given that all three facilities would be developed as an integrated facility.

9.2.2 Site Improvements and Infrastructure

The site improvements and infrastructure estimate was based on the FOEAS (DOE 2008) Early Fuel Receipt Sensitivity Analysis in which a dry storage facility for 8,000 MT required approximately 50 acres. This area is representative of an initial capital investment needed to begin CSF operations site improvements and infrastructure. The cost is expected to range between $57,600K and $74,900K and is detailed below in Table 9-5.

The same estimate is used for the RF site improvements and infrastructure cost since this facility may not be co-located with the CSF. The stand a-lone RF will require these same WBS items. The T&VF is to be co-located with the CSF. Therefore, no additional cost is assumed.

9.2.3 Balance of Plant

Similarly, BOP WBS items are also based upon FOEAS (DOE 2008) Early Fuel Receipt Sensitivity Analysis. These items are expected to range between $33,040K and $42,170K and are detailed in below in Table 9-6. The same estimate is used for the RF which may not be co-located with the CSF. The T&VF is co-located with the CSF. Therefore, no additional cost is assumed.

9.2.4 Process Facilities

Process Facilities estimates are derived from the EAS (DOE 2007b), FOEAS (DOE 2008) Early Fuel Receipt Sensitivity Analysis and T&VF Cost Study (DOE 2012d) estimates. These WBS items are summarized in Table 9-7 which includes the data source study, the cost estimate range, a description of the items included the individual item and a resulting unit cost derived by this study.

For example, the 3,000 MT/yr (EAS (DOE 2007b)) reprocessing estimate included 6 horizontal storage vaults at a cost range of $125,796K to $155,747K for a unit cost range of $62,900K to77,900K which will be used in system level scenarios requiring horizontal storage.

Cask receiving/shipping areas, pool storage areas, pool HVAC, and pool support areas were derived from the EAS (DOE 2007b) – Fuel Handling Building estimate using the foot print and equipment allocated to these areas. These sub-module WBS elements are used in system level analysis to derive system level costs for both bare fuel CSF functions and some RF functions.

The RF area for canister opening is ~9,200 sq.ft. and for canister closure is ~15,200 sq.ft. (Appendix B, Figures B-1, B-2, and B-3). These areas were converted to cost using the cost per sq.ft. parametric from the T&VF (~$10, 160 sq. ft. to $ 14,730 sq.ft.). Use of this parametric is judged acceptable since both processes will require a performance category 3 structure and both handle bare fuel (potentially damaged) assemblies, using remote handling techniques.

Table 9-8 provides an example TPC roll-up for the RF facility described in Section 7.0 with a through-put of 1,500 MT/year. Each of the facility segments in Table 9-8 will be varied future for specific system level analyses scenarios.

The LLW staging facility was derived from the FOEAS (DOE 2008) Early Fuel Receipt Sensitivity Analysis. This WBS item was assumed to double for the RF which is expected to generate more LLW from repackaging compared to fuel storage. The T&VF was taken from the T&VF Cost Study (DOE 2012d) which was specific to this WBS item.

9.3 Additional Capital

The TPC is scoped to provide 2 years of initial dry storage capacity or the first pool building which contains 8 basins and the associated support facilities (water treatment, HVAC, etc.) Storage requirements beyond the initial TPC require additional capital which is system level analysis specific.

The same unit costs in Table 9-8 are used to estimate the additional capital required for the CSF Life Cycle. Additional capital is not required for the T&VF or RF.

Table 9-5 Site Improvements and Infrastructure Unit Costs

WBS	Description	Source Data	WBS Low Range Costs ($1000)	WBS High Range Costs ($1000)
01.02.03	**Site Improvements & Infrastructure**		**$57,591**	**$74,870**
01.02.03.01	Clearing & Grading	FOEAS SA2 Early Fuel Receipt[1]	$5,749	$7,187
01.02.03.02	Construction Roads & Laydown & Central Temporary Facilities (Including permanent Cement Batch Plant and Silos)	FOEAS SA2 Early Fuel Receipt[1]	$8,565	$10,706
01.02.03.03	Retention Pond (1) & Storm Drainage	FOEAS SA2 Early Fuel Receipt[1]	$4,328	$5,410
01.02.03.05	Paved Roads	FOEAS SA2 Early Fuel Receipt[1]	$4,753	$5,941
01.02.03.06	Parking Areas	FOEAS SA2 Early Fuel Receipt[1]	$901	$1,126
01.02.03.07	Landscaping	FOEAS SA2 Early Fuel Receipt[1]	$1,643	$2,054
01.02.03.08	Railroads	FOEAS SA2 Early Fuel Receipt[1]	$10,942	$13,677
01.02.03.15	Admin Building	FOEAS SA2 Early Fuel Receipt[1]	$1,751	$2,501
01.02.03.19	Electrical Switch Yard (Including Site Elec. Distribution)	FOEAS SA2 Early Fuel Receipt[1]	$6,392	$9,132
01.02.03.24	Cranes and Rigging Building	FOEAS SA2 Early Fuel Receipt[1]	$5,465	$7,807
01.02.03.25	Cranes and Rigging Laydown	FOEAS SA2 Early Fuel Receipt[1]	$99	$123
01.02.03.26	Rad Support Services	FOEAS SA2 Early Fuel Receipt[1]	$4,197	$5,197
01.02.03.30	General Warehouse	FOEAS SA2 Early Fuel Receipt[1]	$2,806	$4,009

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1. Information from the working files supporting the FOEAS sensitivity analysis #2, Early Fuel Receipt (DOE 2008)

Table 9-6 Balance of Plant Facilities

WBS	Description	Source Data	WBS Low Range Costs ($1000)	WBS High Range Costs ($1000)
01.02.04	**Balance of Plant (BOP) Facilities**		**$33,037**	**$42,171**
01.02.04.11	Site Boundary Entrance Control (1)	FOEAS SA2 Early Fuel Receipt[1]	$4,090	$4,980
01.02.04.21	Domestic Water Treatment Plant	FOEAS SA2 Early Fuel Receipt[1]	$9,117	$11,288
01.02.04.22	Domestic Water Storage Tank w Wells (1), Includes supply and return system	FOEAS SA2 Early Fuel Receipt[1]	$2,229	$2,694
01.02.04.23	Sanitary Waste Treatment	FOEAS SA2 Early Fuel Receipt[1]	$5,055	$6,258
01.02.04.25	Fire Water Tank with Pump House (1)	FOEAS SA2 Early Fuel Receipt[1]	$8,081	$11,544
01.02.04.37	Gray Water Pond	FOEAS SA2 Early Fuel Receipt[1]	$243	$303
01.02.04.38	Electric Substation(1)	FOEAS SA2 Early Fuel Receipt[1]	$4,222	$5,104

---

1. Information from the working files supporting the FOEAS sensitivity analysis #2, Early Fuel Receipt (DOE 2008)

Table 9-7 Process Facilities and Additional Capital Unit Costs

		Prior Study TPC			Unit Cost For This Study	
Description	**Source Data**	**WBS Low Range Costs ($1000)**	**WBS High Range Costs ($1000)**	**Unit Cost Basis**	**WBS Low Range Costs ($1000)**	**WBS High Range Costs ($1000)**
Dry Storage Concept WBS						
Canister Transfer Building	FOEAS SA2 Early Fuel Receipt[1]	$124,164	$170,876	2 Transfer Stations	$124,164	$170,876
Horizontal Dry Cask Storage	EAS 3000 MT/yr (Benchmark 1)[2]	$125,796	$155,747	6 Vaults for 12 DSC Unit Cost per Vault	$62,898	$77,874
Pads & Cask Storage (Including Storage Casks)	FOEAS SA2 Early Fuel Receipt[1]	$220,389	$272,863	30 – 8 Cask Pads Unit Cost per Pad	$7,346	$9,095
DSC Dry Vault Storage	EAS 3000 MT/yr (Benchmark 1)[2] – Split Fuel Building	$459,989	$667,794	132 positions increased to 269 positions	$1,031,490	$1,360,883
Bare Fuel Handling Concept WBS						
Cask Receiving/Shipping	EAS 3000 MT/yr (Benchmark 1)[2] – Split Fuel Building	$633,088	$908,305	5 Receipt Bays Unit Cost per Bay	$126,618	$181,661
Pool Area	EAS 3000 MT/yr (Benchmark 1)[2] – Split Fuel Building	$1,784,953	$2,508,755	4 Basins Unit Cost Per Basin	$446,238	$627,189
Pool HVAC	EAS 3000 MT/yr (Benchmark 1)[2] – Split Fuel Building	$83,062	$144,076	HVAC System for every 8 Basins	$83,062	$144,076
Pool Support Area	EAS 3000 MT/yr (Benchmark 1)[2] – Split Fuel Building	$134,289	$215,252	Pool Support for every 8 Basins	$134,289	$215,252
Support Facility Concept WBS						
LLW Staging Area	FOEAS SA2 Early Fuel Receipt[1]	$378	$468	Doubled for RF	$378	$468
T&VF Mock-Up Facility	T&V Facility Report Table S-2[3]	$ 150,000	$220,000	Not Scaled	$ 150,000	$220,000
Test and Validation Facility	T&V Facility Report Table S-2[3]	$1,330,000	$1,940,000	78,570 Sq. Ft. Unit Cost per Sq. Ft.	$10.16	$14.73

1. Information from the working files supporting the FOEAS sensitivity analysis #2, Early Fuel Receipt (DOE 2008)
2. Information from the working files supporting the EAS for Separations – Summary Report (DOE 2007b)
3. Information from the Used Fuel research and Development Test and Validation Facility Cost Study (DOE 1012d)

Table 9-8 1,500 MT/yr Repackaging Facility TPC

	Prior Study TPC	
Description	WBS Low Range Costs ($1000)	WBS High Range Costs ($1000)
Cask Receiving	$253,235	$363,322
Pool Area	$443,051	$622,709
HVAC	$145,358	$252,132
Pool Support Area	$16,666	$26,714
Outbound shipping Bays	$1,646,028	$2,361,592
Canister Loading cells	$268,800	$389,760
TPC Total	**$2,819,869**	**$4,083,988**

10. References

1. (DOE 2012a) - *Dry Storage of Used Fuel Transition to Transport Details*, FCRD-UFD-2012-000253, Rev.0, August 2012, D. R. Leduc
2. (DOE 2012b) - *Used Fuel Disposition System Architecture Report* (2012b), DRAFT, September 2012, W.M. Nutt et.al.
3. (DOE 2011) - *Consolidated Storage Lessons Learned and Background Information"* , FCRD-USED-2011-000345, Rev. 0, September 13, 2011, J. Carter, A. Delley, T. Cotton
4. ((DOE- PFS)- DOE's Yucca Mountain facility and Private Fuel Storage L.L.C. (PFS) proposed for Toole County, Utah (http://www.privatefuelstorage.com/project/facility.html)
5. (US NRC-PFS) – NRC News Release No. 06-028, February 22, 2006, *NRC Issues License To Private Fuel Storage For Spent Nuclear Fuel Storage Facility In Utah*
6. (DOE 2007a) - *Follow-on Engineering Alternative Studies for Separations(FOEAS), Early Fuel Receipt & Storage (EFR&S) Considerations*, FRS-G-ESR-G-00053, Rev. 0, September 2007, P. Rodwell, R. Geddes, S. McConnell
7. (DOE 2007b) –*Engineering Alternative Studies(EAS) for Separations-Summary Report,* EAS-G-ESR-G-00049, June 2007, S. McConnell, D. W. Ostby, et.al
8. (DOE 2008) - *Follow-on Engineering Alternative Studies (FOEAS) Summary Report, Global Nuclear Energy Partnership (GNEP),* GNEP-CFTC-PMO-MI-DV-2008-00087, March 2008, Consolidated Fuel Treatment Center
9. (DOE 2012c) - *Disposal Concepts/Thermal Load Management FY11/12 Summary Report,* 2012, Hardin et.al.

10. (DOE 2000a) - *Civilian Radioactive Waste Management System (CRWMS) Management and Operations (M&O)* Attachment II, Section 1.3.2.1
11. (DOE 2000b) - *Civilian Radioactive Waste Management System (CRWMS) Management and Operations (M&O)* Attachment II, Section 1.1.2.1
12. (DOE 2012d) - *Used Fuel Research and Development Test and Validation Facility Cost Study,* FCRD-UFD-2012-000206, Rev. 0, August 2012, J. Carter, A. Delley, et. al
13. (DOE 2010) - DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, November 29, 2010

11. Appendix A – Consolidated Storage Facility Lay-out Drawings

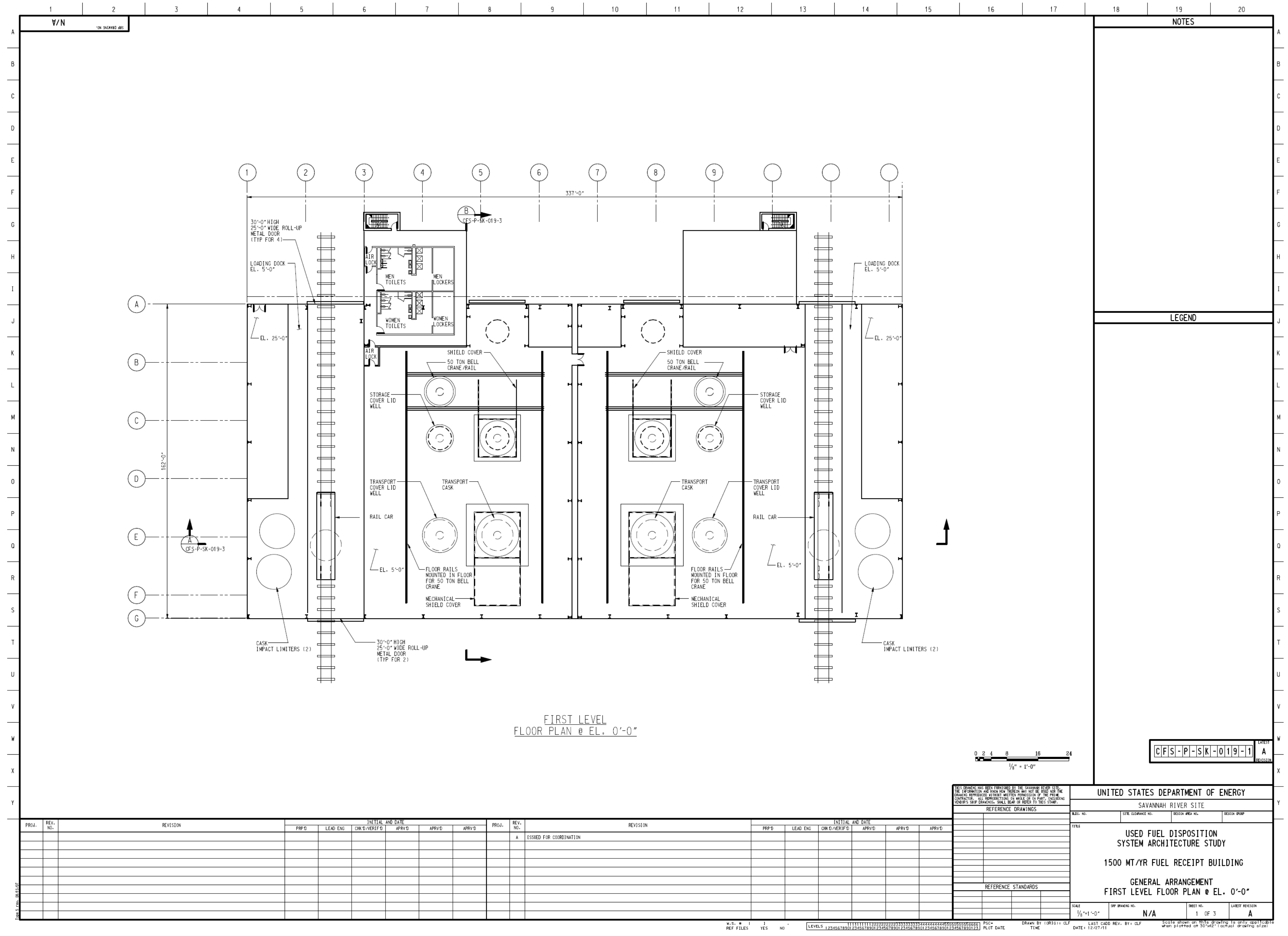


Figure A-1

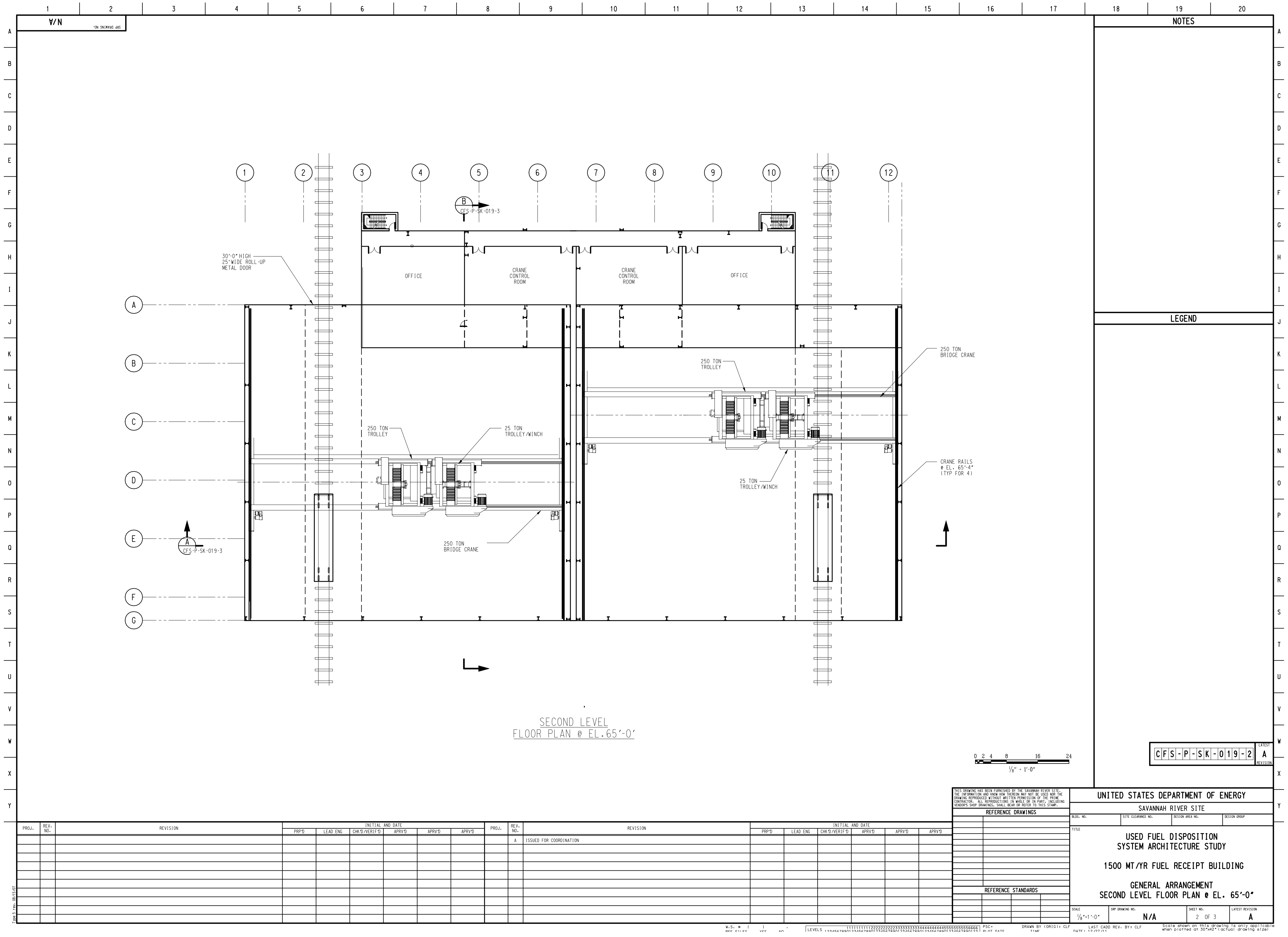
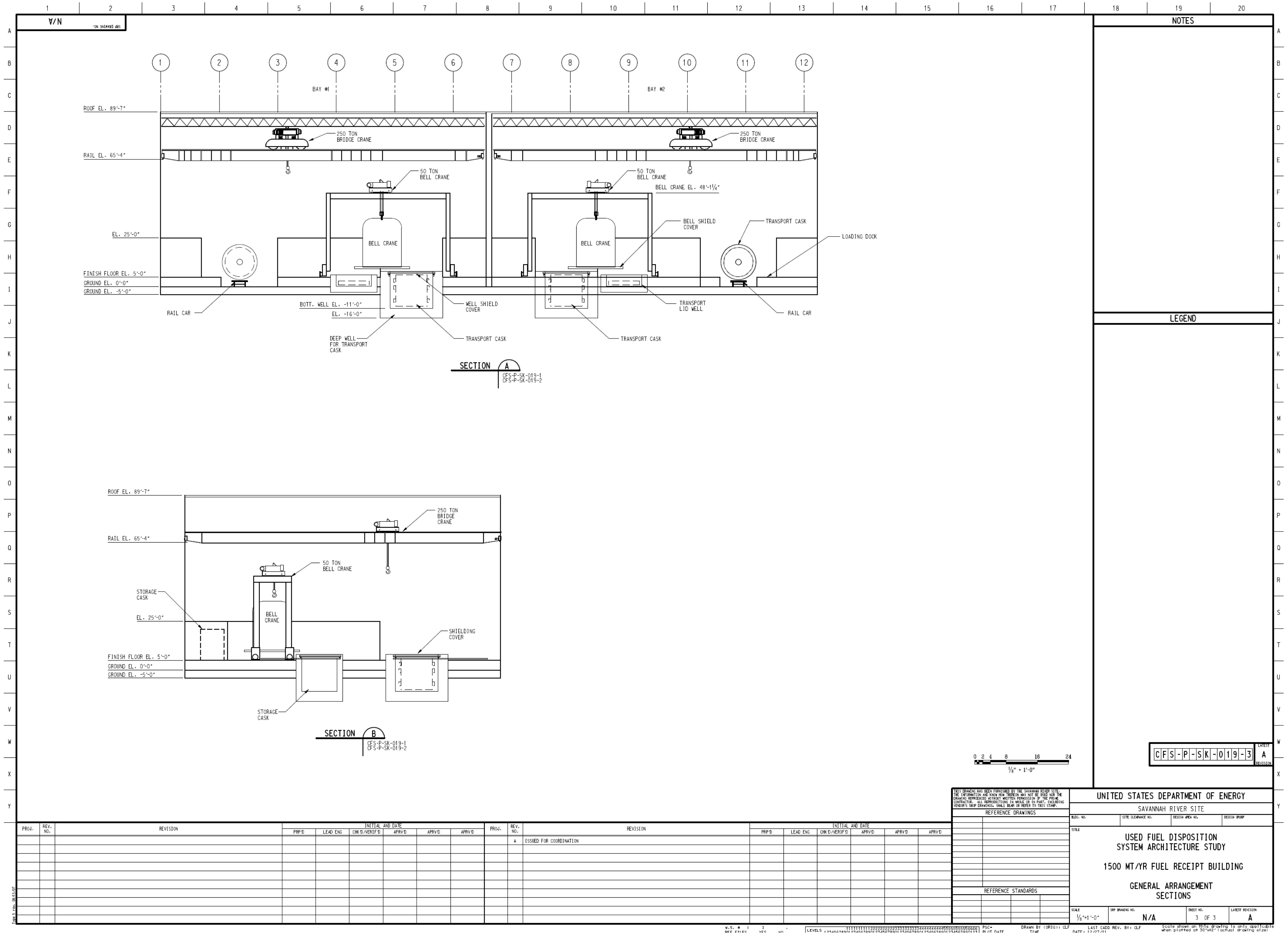

NOTES
LEGEND
1
2
3
4
5
6
7
8
9
10
11
12
A
B
C
D
E
F
G
B
CFS-P-SK-019-3
A
CFS-P-SK-019-3
30'-0" HIGH 25' WIDE ROLL-UP METAL DOOR
OFFICE
CRANE CONTROL ROOM
CRANE CONTROL ROOM
OFFICE
250 TON TROLLEY
25 TON TROLLEY/WINCH
250 TON BRIDGE CRANE
250 TON TROLLEY
250 TON BRIDGE CRANE
CRANE RAILS @ EL. 65'-4" (TYP FOR 4)
25 TON TROLLEY/WINCH
SECOND LEVEL FLOOR PLAN @ EL.65'-0"
0 2 4 8 16 24
1/8" = 1'-0"
CFS-P-SK-019-2
LATEST A REVISION
THIS DRAWING HAS BEEN FURNISHED BY THE SAVANNAH RIVER SITE. THE INFORMATION AND KNOW HOW THEREON MAY NOT BE USED NOR THE DRAWING REPRODUCED WITHOUT WRITTEN PERMISSION OF THE PRIME CONTRACTOR. ALL REPRODUCTIONS IN WHOLE OR IN PART, INCLUDING VENDOR'S SHOP DRAWINGS, SHALL BEAR OR REFER TO THIS STAMP.
REFERENCE DRAWINGS
REFERENCE STANDARDS
UNITED STATES DEPARTMENT OF ENERGY
SAVANNAH RIVER SITE
BLDG. NO.
SITE CLEARANCE NO.
DESIGN AREA NO.
DESIGN GROUP
TITLE
USED FUEL DISPOSITION
SYSTEM ARCHITECTURE STUDY
1500 MT/YR FUEL RECEIPT BUILDING
GENERAL ARRANGEMENT
SECOND LEVEL FLOOR PLAN @ EL. 65'-0"
SCALE 1/8"=1'-0"
SRP DRAWING NO. N/A
SHEET NO. 2 OF 3
LATEST REVISION A
PROJ.
REV. NO.
REVISION
INITIAL AND DATE
PRP'D
LEAD ENG
CHK'D/VERIF'D
APRV'D
APRV'D
APRV'D
A
ISSUED FOR COORDINATION
PSC=
DRAWN BY (ORIG): CLF
LAST CADD REV. BY: CLF
Scale shown on this drawing is only applicable when plotted at 30"x42" (actual drawing size)

Figure A-2


N/A
SRP DRAWING NO.
BAY #1
BAY #2
ROOF EL. 89'-7"
250 TON BRIDGE CRANE
RAIL EL. 65'-4"
50 TON BELL CRANE
BELL CRANE EL. 48'-1¼"
EL. 25'-0"
BELL CRANE
BELL SHIELD COVER
TRANSPORT CASK
LOADING DOCK
FINISH FLOOR EL. 5'-0"
GROUND EL. 0'-0"
GROUND EL. -5'-0"
RAIL CAR
BOTT. WELL EL. -11'-0"
EL. -16'-0"
WELL SHIELD COVER
TRANSPORT LID WELL
DEEP WELL FOR TRANSPORT CASK
TRANSPORT CASK
SECTION A
CFS-P-SK-019-1
CFS-P-SK-019-2
STORAGE CASK
SHIELDING COVER
SECTION B
CFS-P-SK-019-1
CFS-P-SK-019-2
NOTES
LEGEND
0 2 4 8 16 24
⅛" = 1'-0"
CFS-P-SK-019-3
LATEST REVISION A
A ISSUED FOR COORDINATION
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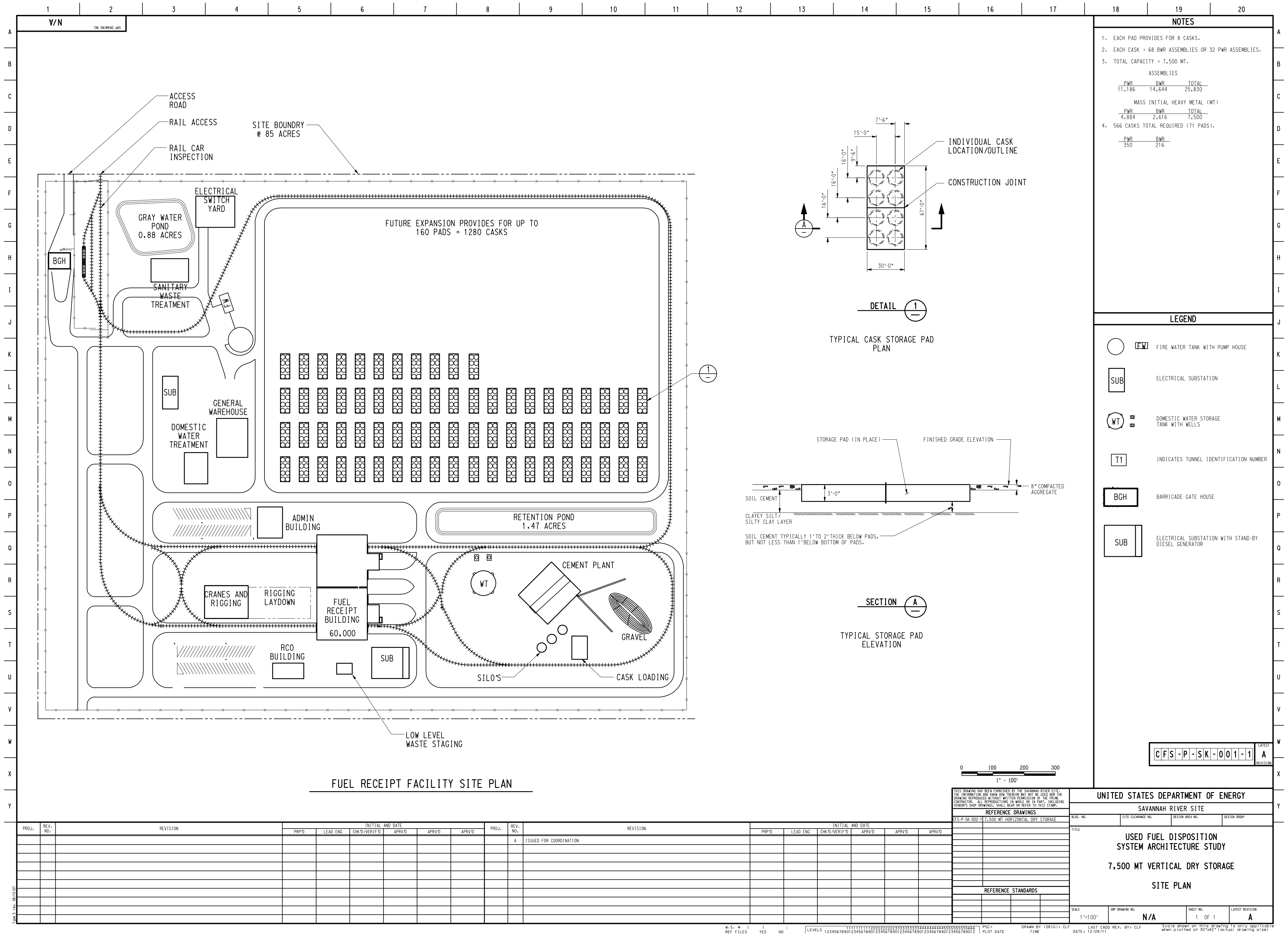
REFERENCE DRAWINGS
REFERENCE STANDARDS
UNITED STATES DEPARTMENT OF ENERGY
SAVANNAH RIVER SITE
TITLE
USED FUEL DISPOSITION SYSTEM ARCHITECTURE STUDY
1500 MT/YR FUEL RECEIPT BUILDING
GENERAL ARRANGEMENT SECTIONS
SCALE ⅛"=1'-0"
SRP DRAWING NO. N/A
SHEET NO. 3 OF 3
LATEST REVISION A
DRAWN BY (ORIG): CLF
LAST CADD REV. BY: CLF
DATE: 12/27/11
Scale shown on this drawing is only applicable when plotted at 30"x42" (actual drawing size)

Figure A-3


ACCESS ROAD
RAIL ACCESS
RAIL CAR INSPECTION
SITE BOUNDRY @ 85 ACRES
GRAY WATER POND 0.88 ACRES
ELECTRICAL SWITCH YARD
BGH
SANITARY WASTE TREATMENT
FUTURE EXPANSION PROVIDES FOR UP TO 160 PADS = 1280 CASKS
SUB
GENERAL WAREHOUSE
DOMESTIC WATER TREATMENT
ADMIN BUILDING
RETENTION POND 1.47 ACRES
CEMENT PLANT
WT
CRANES AND RIGGING
RIGGING LAYDOWN
FUEL RECEIPT BUILDING
60,000
GRAVEL
RCO BUILDING
SUB
SILO'S
CASK LOADING
LOW LEVEL WASTE STAGING
FUEL RECEIPT FACILITY SITE PLAN
7'-6"
15'-0"
16'-0"
9'-6"
67'-0"
30'-0"
INDIVIDUAL CASK LOCATION/OUTLINE
CONSTRUCTION JOINT
DETAIL 1
TYPICAL CASK STORAGE PAD PLAN
STORAGE PAD (IN PLACE)
FINISHED GRADE ELEVATION
8" COMPACTED AGGREGATE
SOIL CEMENT
3'-0"
CLAYEY SILT/ SILTY CLAY LAYER
SOIL CEMENT TYPICALLY 1'TO 2'THICK BELOW PADS, BUT NOT LESS THAN 1'BELOW BOTTOM OF PADS.
SECTION A
TYPICAL STORAGE PAD ELEVATION
0 100 200 300
1" = 100'
NOTES
1. EACH PAD PROVIDES FOR 8 CASKS.
2. EACH CASK = 68 BWR ASSEMBLIES OR 32 PWR ASSEMBLIES.
3. TOTAL CAPACITY = 7,500 MT.
ASSEMBLIES
PWR 11,186 BWR 14,644 TOTAL 25,830
MASS INITIAL HEAVY METAL (MT)
PWR 4,884 BWR 2,616 TOTAL 7,500
4. 566 CASKS TOTAL REQUIRED (71 PADS).
PWR 350 BWR 216
LEGEND
FW FIRE WATER TANK WITH PUMP HOUSE
SUB ELECTRICAL SUBSTATION
WT DOMESTIC WATER STORAGE TANK WITH WELLS
T1 INDICATES TUNNEL IDENTIFICATION NUMBER
BGH BARRICADE GATE HOUSE
SUB ELECTRICAL SUBSTATION WITH STAND-BY DIESEL GENERATOR
CFS-P-SK-001-1 LATEST A REVISION
PROJ. REV. NO. REVISION INITIAL AND DATE PRP'D LEAD ENG CHK'D/VERIF'D APRV'D APRV'D APRV'D
A ISSUED FOR COORDINATION
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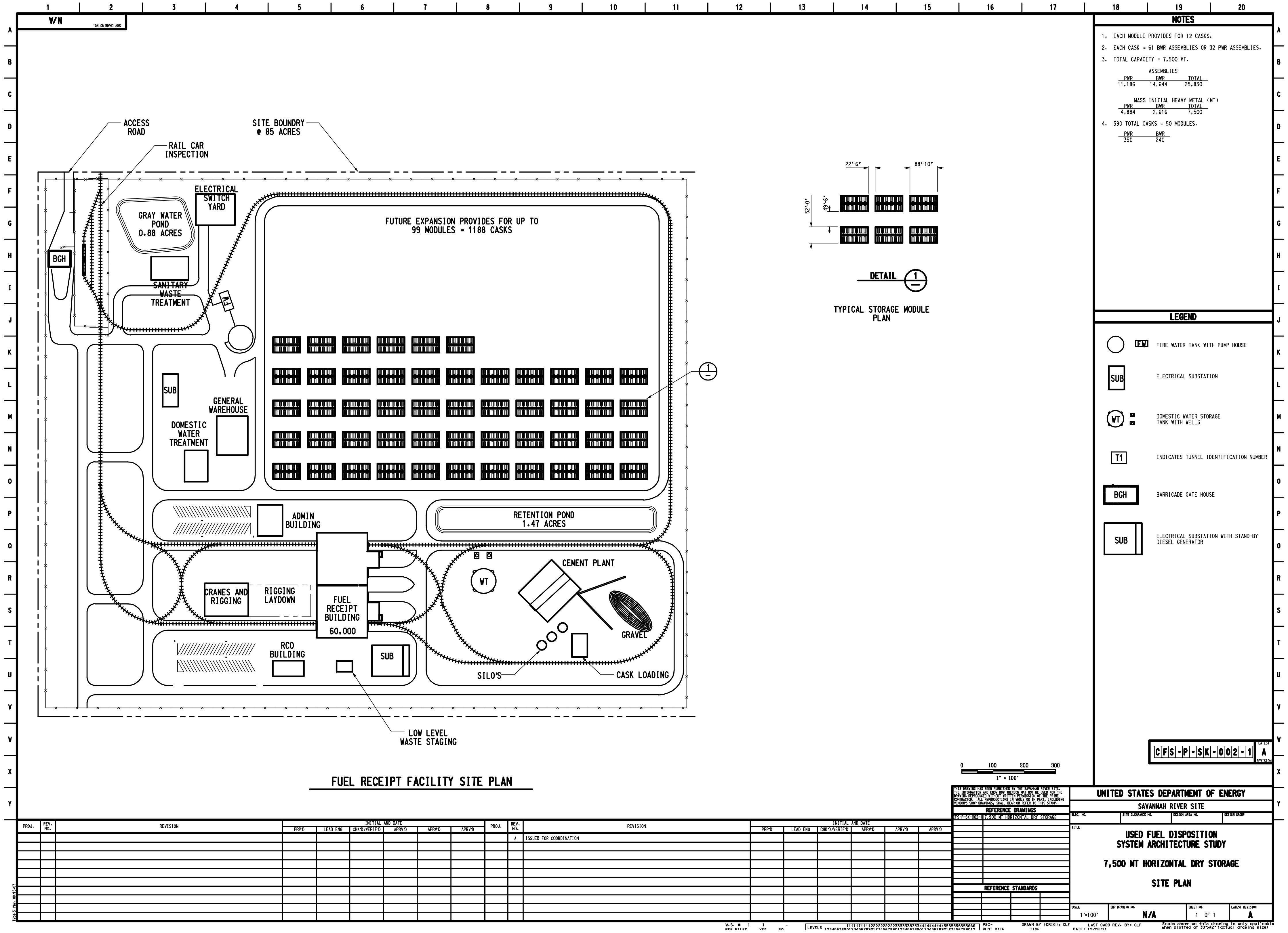
REFERENCE DRAWINGS
CFS-P-SK-002-1 7,500 MT HORIZONTAL DRY STORAGE
REFERENCE STANDARDS
UNITED STATES DEPARTMENT OF ENERGY
SAVANNAH RIVER SITE
BLDG. NO.
SITE CLEARANCE NO.
DESIGN AREA NO.
DESIGN GROUP
TITLE
USED FUEL DISPOSITION SYSTEM ARCHITECTURE STUDY
7,500 MT VERTICAL DRY STORAGE
SITE PLAN
SCALE 1'=100'
SRP DRAWING NO. N/A
SHEET NO. 1 OF 1
LATEST REVISION A
PSC= PLOT DATE
DRAWN BY (ORIG): CLF TIME
LAST CADD REV. BY: CLF DATE: 12/28/11
Scale shown on this drawing is only applicable when plotted at 30"x42" (actual drawing size)

Figure A-4



NOTES

1. EACH MODULE PROVIDES FOR 12 CASKS.
2. EACH CASK = 61 BWR ASSEMBLIES OR 32 PWR ASSEMBLIES.
3. TOTAL CAPACITY = 7,500 MT.

ASSEMBLIES

PWR	BWR	TOTAL
11,186	14,644	25,830

MASS INITIAL HEAVY METAL (MT)

PWR	BWR	TOTAL
4,884	2,616	7,500

4. 590 TOTAL CASKS = 50 MODULES.

PWR	BWR
350	240

LEGEND

○ FW	FIRE WATER TANK WITH PUMP HOUSE
SUB	ELECTRICAL SUBSTATION
WT	DOMESTIC WATER STORAGE TANK WITH WELLS
T1	INDICATES TUNNEL IDENTIFICATION NUMBER
BGH	BARRICADE GATE HOUSE
SUB	ELECTRICAL SUBSTATION WITH STAND-BY DIESEL GENERATOR

CFS-P-SK-002-1 LATEST A REVISION

PROJ.	REV. NO.	REVISION	PRP'D	LEAD ENG	CHK'D/VERIF'D	APRV'D	APRV'D	APRV'D

PROJ.	REV. NO.	REVISION	PRP'D	LEAD ENG	CHK'D/VERIF'D	APRV'D	APRV'D	APRV'D
	A	ISSUED FOR COORDINATION						

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REFERENCE DRAWINGS

CFS-P-SK-002-1	7,500 MT HORIZONTAL DRY STORAGE

REFERENCE STANDARDS

UNITED STATES DEPARTMENT OF ENERGY
SAVANNAH RIVER SITE

BLDG. NO. | SITE CLEARANCE NO. | DESIGN AREA NO. | DESIGN GROUP

TITLE
USED FUEL DISPOSITION
SYSTEM ARCHITECTURE STUDY

7,500 MT HORIZONTAL DRY STORAGE

SITE PLAN

SCALE	SRP DRAWING NO.	SHEET NO.	LATEST REVISION
1'=100'	N/A	1 OF 1	A

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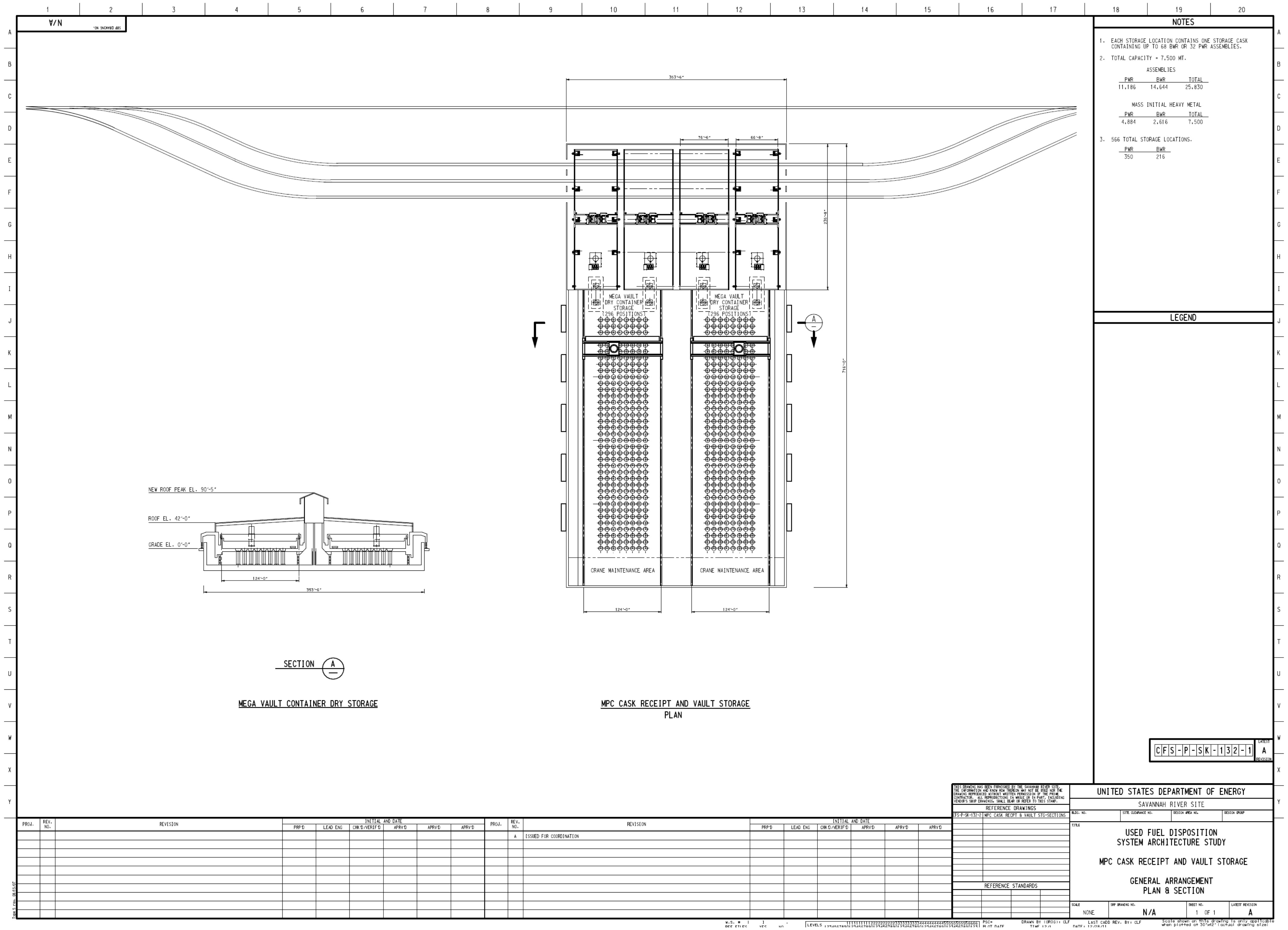
Scale shown on this drawing is only applicable when plotted at 30"x42" (actual drawing size)

Figure A-5



NOTES

1. EACH STORAGE LOCATION CONTAINS ONE STORAGE CASK CONTAINING UP TO 68 BWR OR 32 PWR ASSEMBLIES.
2. TOTAL CAPACITY = 7,500 MT.

ASSEMBLIES

PWR	BWR	TOTAL
11,186	14,644	25,830

MASS INITIAL HEAVY METAL

PWR	BWR	TOTAL
4,884	2,616	7,500

3. 566 TOTAL STORAGE LOCATIONS.

PWR	BWR
350	216

CFS-P-SK-132-1
LATEST REVISION A

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REFERENCE DRAWINGS
CFS-P-SK-132-2 MPC CASK RECPT & VAULT STG-SECTIONS

REFERENCE STANDARDS

UNITED STATES DEPARTMENT OF ENERGY
SAVANNAH RIVER SITE
BLDG. NO.
SITE CLEARANCE NO.
DESIGN AREA NO.
DESIGN GROUP

TITLE
USED FUEL DISPOSITION
SYSTEM ARCHITECTURE STUDY

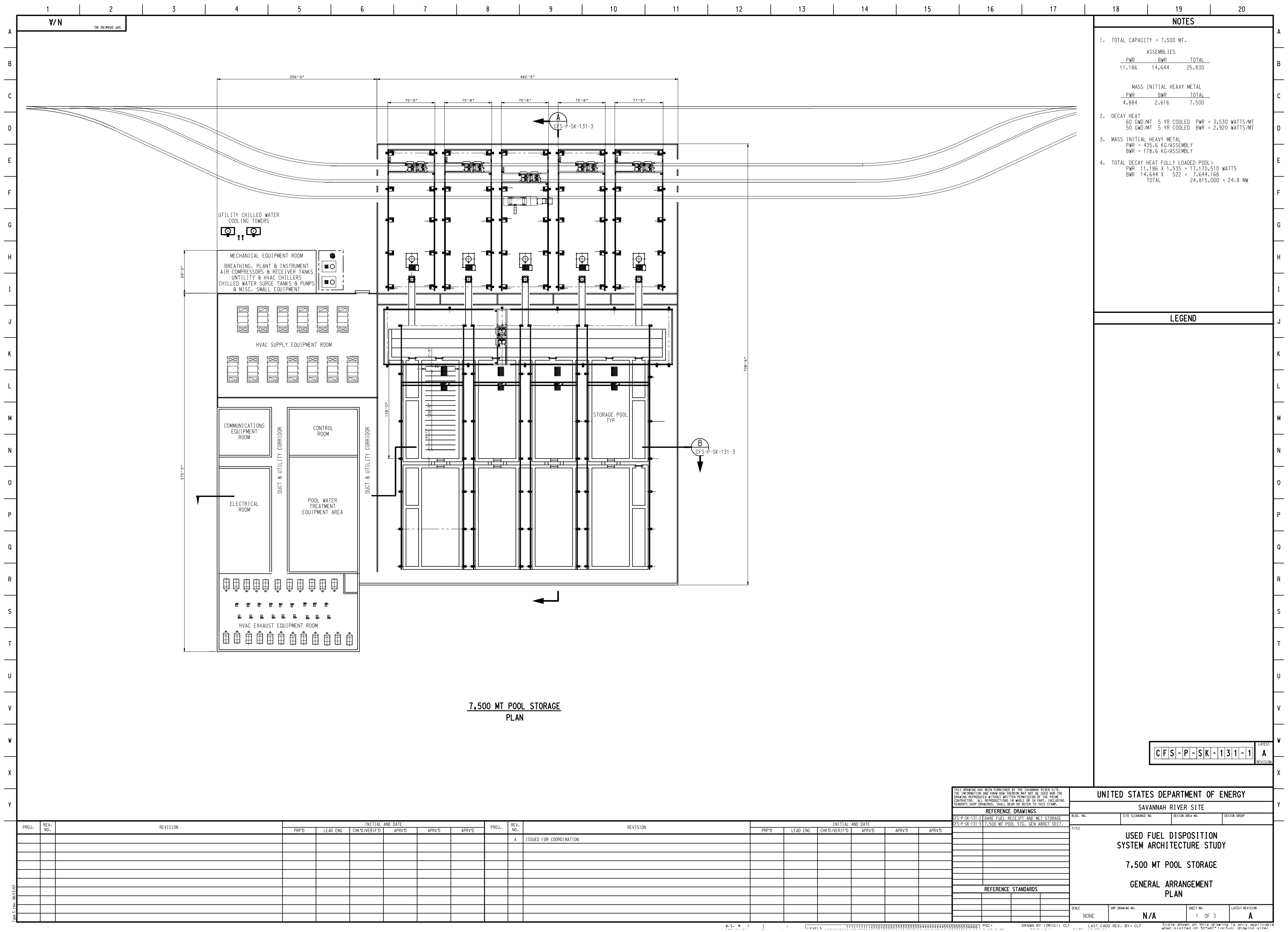
MPC CASK RECEIPT AND VAULT STORAGE

GENERAL ARRANGEMENT
PLAN & SECTION

SCALE NONE
SRP DRAWING NO. N/A
SHEET NO. 1 OF 1
LATEST REVISION A

DRAWN BY (ORIG): CLF
LAST CADD REV. BY: CLF
DATE: 12/28/11
Scale shown on this drawing is only applicable when plotted at 30"x42" (actual drawing size)

Figure A-6



NOTES

1. TOTAL CAPACITY = 7,500 MT.

ASSEMBLIES

PWR	BWR	TOTAL
11,186	14,644	25,830

MASS INITIAL HEAVY METAL

PWR	BWR	TOTAL
4,884	2,616	7,500

2. DECAY HEAT
   60 GWD/MT 5 YR COOLED PWR = 3,530 WATTS/MT
   50 GWD/MT 5 YR COOLED BWR = 2,920 WATTS/MT

3. MASS INITIAL HEAVY METAL
   PWR = 435.6 KG/ASSEMBLY
   BWR = 178.6 KG/ASSEMBLY

4. TOTAL DECAY HEAT FULLY LOADED POOL:
   PWR 11,186 X 1,535 = 17,170,510 WATTS
   BWR 14,644 X 522 = 7,644,168
   TOTAL 24,815,000 = 24.8 MW

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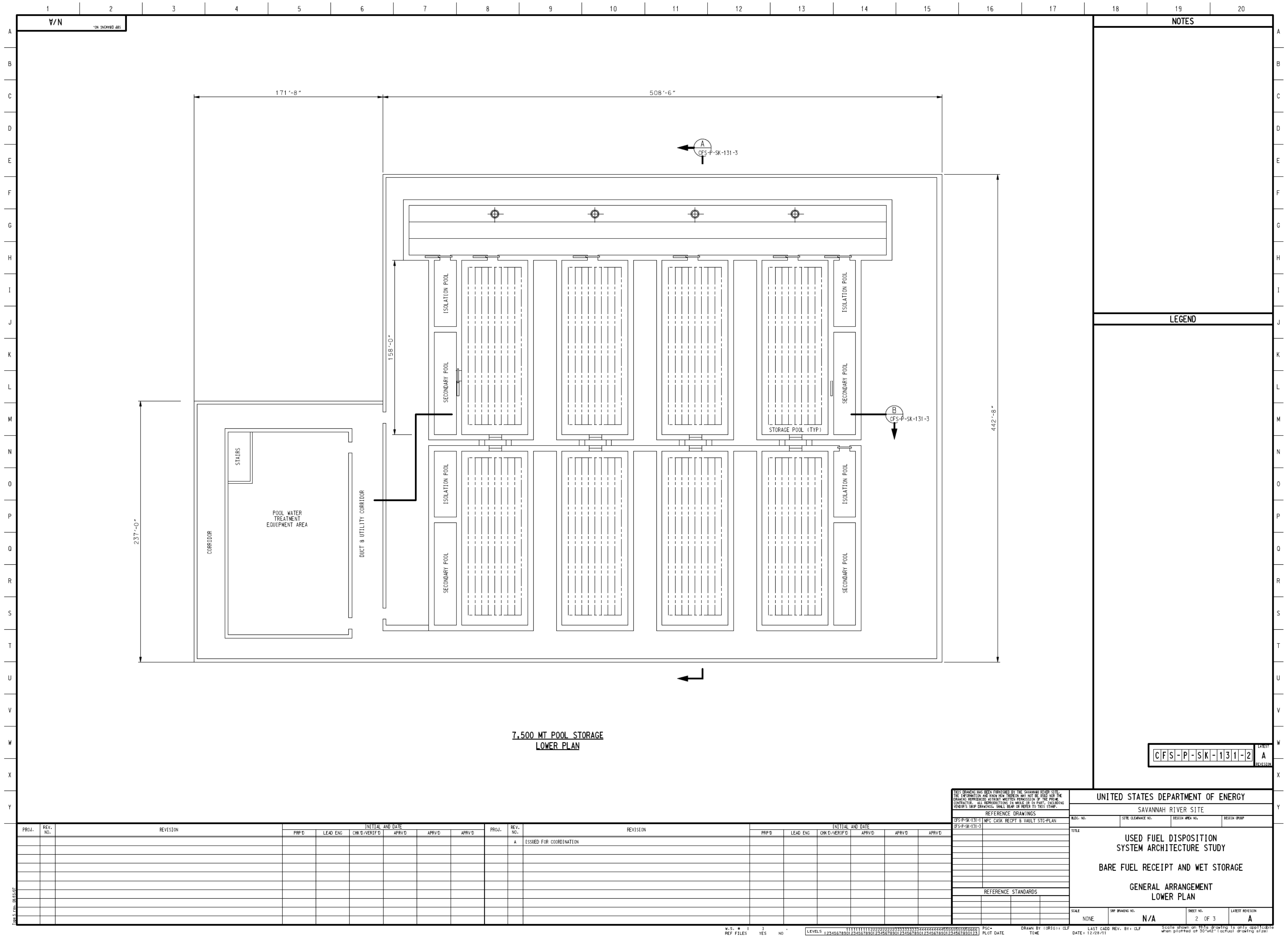
REFERENCE DRAWINGS

CFS-P-SK-131-2	BARE FUEL RECEIPT AND WET STORAGE
CFS-P-SK-131-3	7,500 MT POOL STG. GEN ARRGT SECT.

Figure A-7


N/A
SRP DRAWING NO.
171'-8"
508'-6"
A
CFS-P-SK-131-3
158'-0"
ISOLATION POOL
SECONDARY POOL
STORAGE POOL (TYP)
B
CFS-P-SK-131-3
442'-8"
237'-0"
STAIRS
POOL WATER TREATMENT EQUIPMENT AREA
CORRIDOR
DUCT & UTILITY CORRIDOR
7,500 MT POOL STORAGE
LOWER PLAN
NOTES
LEGEND
CFS-P-SK-131-2
LATEST REVISION A
ISSUED FOR COORDINATION
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REFERENCE DRAWINGS
CFS-P-SK-131-1 MPC CASK RECPT & VAULT STG-PLAN
CFS-P-SK-131-3
REFERENCE STANDARDS
UNITED STATES DEPARTMENT OF ENERGY
SAVANNAH RIVER SITE
BLDG. NO.
SITE CLEARANCE NO.
DESIGN AREA NO.
DESIGN GROUP
TITLE
USED FUEL DISPOSITION
SYSTEM ARCHITECTURE STUDY
BARE FUEL RECEIPT AND WET STORAGE
GENERAL ARRANGEMENT
LOWER PLAN
SCALE NONE
SRP DRAWING NO. N/A
SHEET NO. 2 OF 3
LATEST REVISION A
DRAWN BY (ORIG): CLF
LAST CADD REV. BY: CLF
DATE: 12/28/11
Scale shown on this drawing is only applicable when plotted at 30"x42" (actual drawing size)

Figure A-8

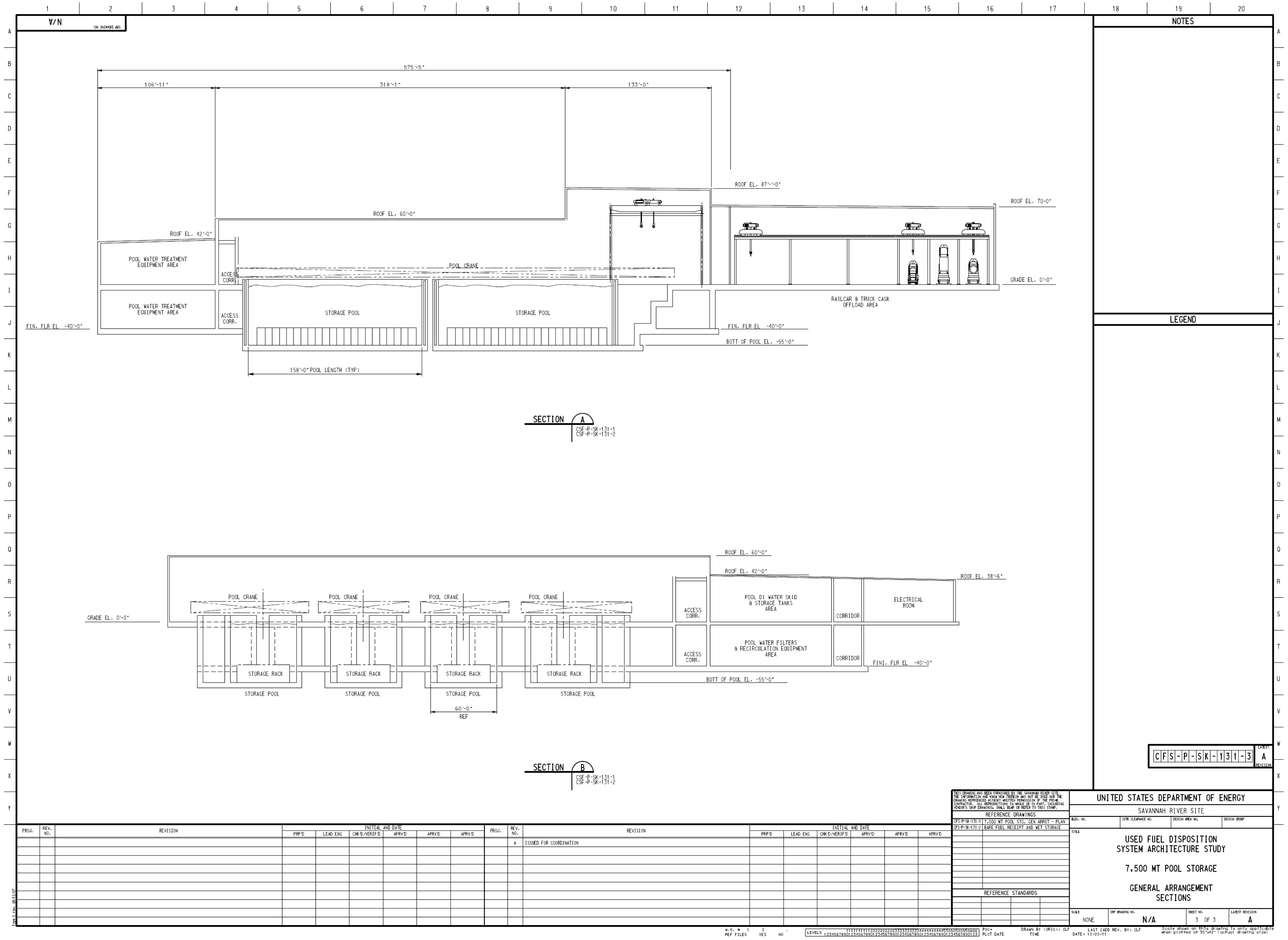
575'-5"
106'-11"
318'-1"
133'-0"
ROOF EL. 87'-'-0"
ROOF EL. 70-0"
ROOF EL. 60'-0"
ROOF EL. 42'-0"
POOL WATER TREATMENT EQUIPMENT AREA
POOL WATER TREATMENT EQUIPMENT AREA
ACCESS CORR.
ACCESS CORR.
POOL CRANE
STORAGE POOL
STORAGE POOL
GRADE EL. 0'-0"
RAILCAR & TRUCK CASK OFFLOAD AREA
FIN. FLR EL -40'-0"
FIN. FLR EL -40'-0"
BOTT OF POOL EL. -55'-0"
158'-0" POOL LENGTH (TYP)
SECTION A
CSF-P-SK-131-1
CSF-P-SK-131-2
ROOF EL. 60'-0"
ROOF EL. 42'-0"
ROOF EL. 38'-6"
GRADE EL. 0'-0"
POOL CRANE
POOL CRANE
POOL CRANE
POOL CRANE
ACCESS CORR.
POOL DI WATER SKID & STORAGE TANKS AREA
CORRIDOR
ELECTRICAL ROOM
ACCESS CORR.
POOL WATER FILTERS & RECIRCULATION EQUIPMENT AREA
CORRIDOR
FINI. FLR EL -40'-0"
STORAGE RACK
STORAGE RACK
STORAGE RACK
STORAGE RACK
BOTT OF POOL EL. -55'-0"
STORAGE POOL
STORAGE POOL
STORAGE POOL
STORAGE POOL
60'-0" REF
SECTION B
CSF-P-SK-131-1
CSF-P-SK-131-2
NOTES
LEGEND
CFS-P-SK-131-3
LATEST REVISION A
THIS DRAWING HAS BEEN FURNISHED BY THE SAVANNAH RIVER SITE. THE INFORMATION AND KNOW HOW THEREON MAY NOT BE USED NOR THE DRAWING REPRODUCED WITHOUT WRITTEN PERMISSION OF THE PRIME CONTRACTOR. ALL REPRODUCTIONS IN WHOLE OR IN PART, INCLUDING VENDOR'S SHOP DRAWINGS, SHALL BEAR OR REFER TO THIS STAMP.
REFERENCE DRAWINGS
CFS-P-SK-131-1 7,500 MT POOL STG. GEN ARRGT - PLAN
CFS-P-SK-131-2 BARE FUEL RECEIPT AND WET STORAGE
REFERENCE STANDARDS
UNITED STATES DEPARTMENT OF ENERGY
SAVANNAH RIVER SITE
BLDG. NO.
SITE CLEARANCE NO.
DESIGN AREA NO.
DESIGN GROUP
TITLE
USED FUEL DISPOSITION SYSTEM ARCHITECTURE STUDY
7,500 MT POOL STORAGE
GENERAL ARRANGEMENT SECTIONS
SCALE NONE
SRP DRAWING NO. N/A
SHEET NO. 3 OF 3
LATEST REVISION A
PROJ.
REV. NO.
REVISION
INITIAL AND DATE
PRP'D
LEAD ENG
CHK'D/VERIF'D
APRV'D
APRV'D
APRV'D
A
ISSUED FOR COORDINATION
PSC-
PLOT DATE
DRAWN BY (ORIG): CLF
TIME
LAST CADD REV. BY: CLF
DATE: 12/20/11
Scale shown on this drawing is only applicable when plotted at 30"x42" (actual drawing size)

Figure A-9

12. Appendix B – Repackaging Facility Lay-out Drawings

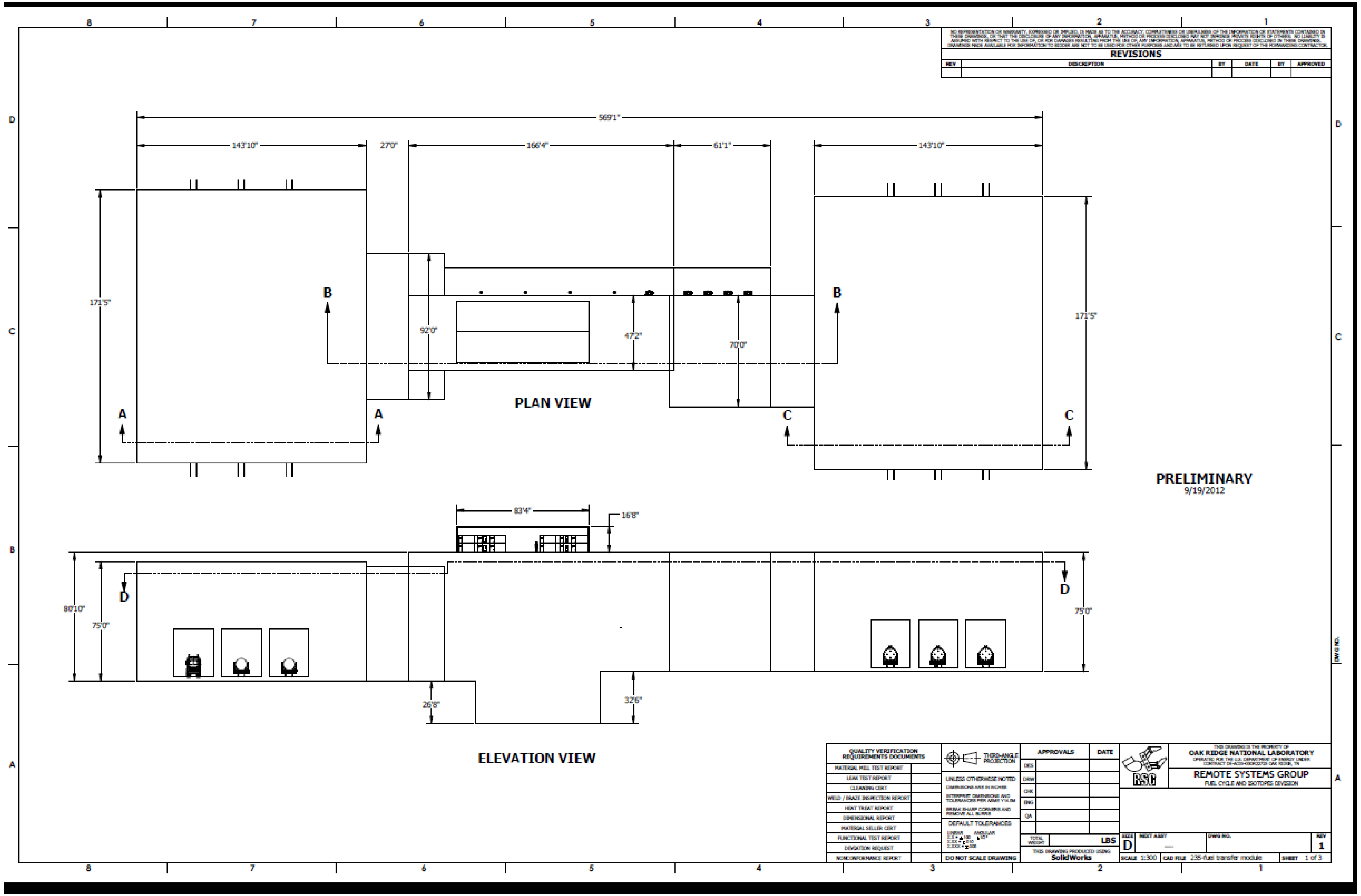

Figure B-1

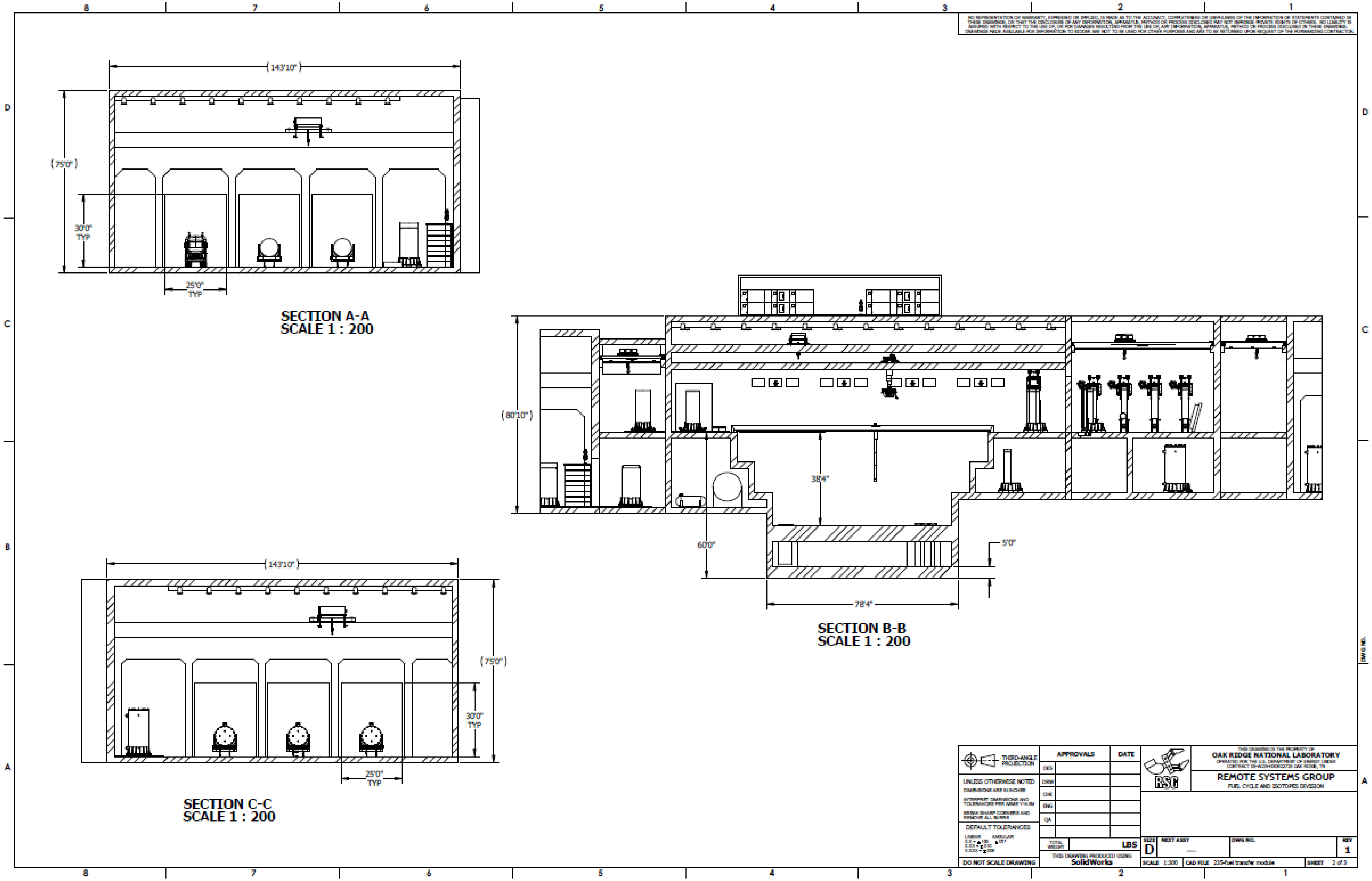
143'10"
(75'0")
30'0" TYP
25'0" TYP
SECTION A-A
SCALE 1 : 200
(80'10")
38'4"
60'0"
5'0"
78'4"
SECTION B-B
SCALE 1 : 200
143'10"
(75'0")
30'0" TYP
25'0" TYP
SECTION C-C
SCALE 1 : 200
THIRD-ANGLE PROJECTION
APPROVALS
DATE
DES
DRW
CHK
ENG
QA
UNLESS OTHERWISE NOTED
DEFAULT TOLERANCES
TOTAL WEIGHT
LBS
DO NOT SCALE DRAWING
THIS DRAWING PRODUCED USING SolidWorks
RSG
OAK RIDGE NATIONAL LABORATORY
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
SIZE D
NEXT ASSY
DWG NO.
REV 1
SCALE 1:300
CAD FILE 235-fuel transfer module
SHEET 2 of 3

Figure B-2

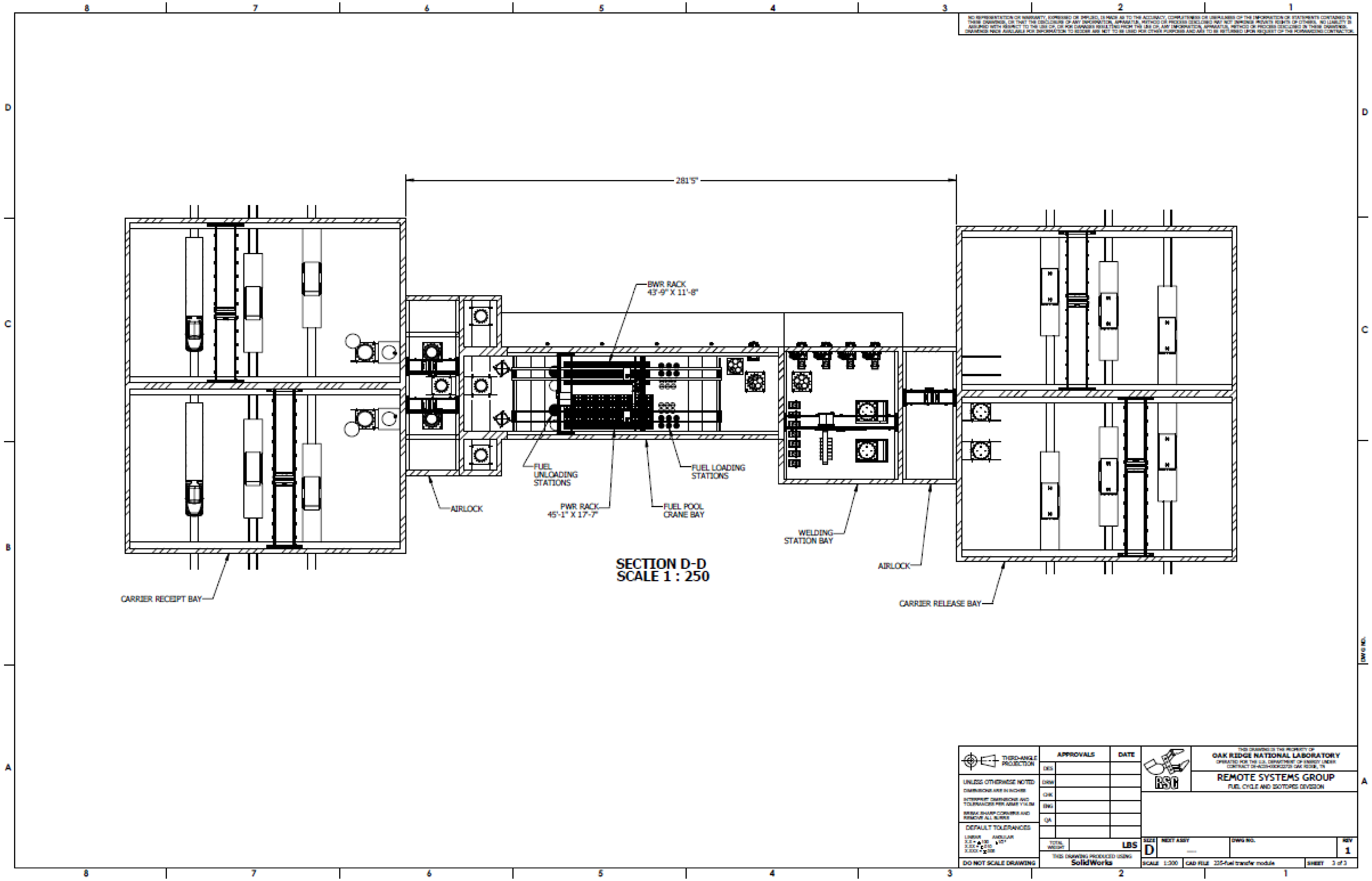
281'5"
BWR RACK
43'-9" X 11'-8"
FUEL UNLOADING STATIONS
FUEL LOADING STATIONS
AIRLOCK
PWR RACK
45'-1" X 17'-7"
FUEL POOL CRANE BAY
WELDING STATION BAY
AIRLOCK
CARRIER RECEIPT BAY
CARRIER RELEASE BAY
SECTION D-D
SCALE 1 : 250
THIRD-ANGLE PROJECTION
UNLESS OTHERWISE NOTED
DEFAULT TOLERANCES
DO NOT SCALE DRAWING
APPROVALS
DATE
DES
DRW
CHK
ENG
QA
TOTAL WEIGHT
LBS
THIS DRAWING PRODUCED USING SolidWorks
RSG
OAK RIDGE NATIONAL LABORATORY
REMOTE SYSTEMS GROUP
FUEL CYCLE AND ISOTOPES DIVISION
SIZE
D
NEXT ASSY
DWG NO.
REV
1
SCALE 1:300
CAD FILE
SHEET 3 of 3
8
7
6
5
4
3
2
1
D
C
B
A

Figure B-3