OCRWM	DESIGN CALCULATION OR ANALYSIS COVER SHEET				1. QA: QA 2. Page 1			
3. System Remediation				4. Document Identifier 130-00C-CR00-00100-000-00A				
5. Title Remediation Facility Worker Dose Assessment								
6. Group Radiological Engineering								
7. Document Status Designation ☒ Preliminary ☐ Final ☐ Cancelled								
8. Notes/Comments Entire report was prepared jointly by V. Arakali and E. Faillace A review (AP-2.14Q) is not required since the results of this calculation have no impact on the use of the technical output by other organizations and because this is an initial issue of the calculation.								
Attachments						Total Number of Pages		
See Section 9						Five (11"x17")		
RECORD OF REVISIONS								
9. No.	10. Reason For Revision	11. Total # of Pgs.	12. Last Pg. #	13. Originator (Print/Sign/Date)	14. Checker (Print/Sign/Date)	15. QER (Print/Sign/Date)	16. Approved/Accepted (Print/Sign)	17. Date
00A	Initial Issue	36	31	V. Arakali <i>V. Arakali</i> E. Faillace <i>E. Faillace</i> 2/26/04	Y. Yuan <i>Y. Yuan</i> 2/26/04	J.E. Clark <i>J.E. Clark</i> 2/26/04	D.B. Darling <i>D.B. Darling</i>	2/27/04

INTENTIONALLY LEFT BLANK

CONTENTS

	Page
ACRONYMS AND ABBREVIATIONS	6
UNITS OF MEASURE.....	7
1. PURPOSE	9
2. QUALITY ASSURANCE	9
3. METHOD	9
3.1 EXTERNAL DOSE CALCULATION METHODOLOGY	9
3.2 INHALATION AND SUBMERSION DOSE CALCULATION METHODOLOGY ..	11
3.3 TEDE DOSE CALCULATION	12
4. DESIGN INPUTS.....	13
4.1 FACILITY OVERVIEW	13
4.1.1 Facility Description.....	13
4.1.2 Facility Operations.....	14
4.2 ASSUMPTIONS.....	15
4.2.1 Throughput – Casks and Waste Packages Requiring Remediation	15
4.2.2 Throughput – Items Requiring Wet Remediation.....	16
4.2.3 Exposure Duration and Number of Workers – Remediation Operations	17
4.2.4 Exposure Duration and Number of Workers – Maintenance Operations	18
4.2.5 Exposure Rates – Remediation Facility Operations and Maintenance Workers.....	18
4.2.6 Spent Fuel Assembly Activities – Gaseous Radionuclides	19
4.2.7 Fuel Failure Rate – Fuel Stored in Spent Fuel Pool	20
4.2.8 Release Factors – Failed Spent Nuclear Fuel	20
4.2.9 Release Rate – Failed Spent Nuclear Fuel	20
4.2.10 Dimensions – Wet Remediation Room.....	20
4.2.11 Air Exchange Rate – Wet Remediation Room	21
4.2.12 Breathing Rate – Remediation Facility Worker.....	21
4.2.13 Dose Conversion Factors – Inhalation and Submersion	21
4.2.14 Airborne Release Dose – Contribution from Other Facilities	22
4.3 REGULATIONS.....	22
4.4 CRITERIA	23
5. USE OF SOFTWARE	23
5.1 BASELINED SOFTWARE.....	23
5.2 COMMERCIAL OFF-THE-SHELF SOFTWARE.....	23
5.2.1 MICROSOFT EXCEL 97 SR-2.....	23
6. CALCULATION	24
6.1 DOSE TO WORKERS FROM DIRECT EXTERNAL RADIATION	24
6.1.1 Remediation Operation Workers – Direct External Radiation Dose	24
6.1.2 Maintenance Workers – Direct External Radiation Dose.....	25

6.2	DOSE TO WORKERS FROM AIRBORNE RADIONUCLIDES	25
6.2.1	Remediation Operation Workers – Doses From Airborne Radionuclides.....	26
6.2.2	Maintenance Workers – Doses From Airborne Radionuclides	27
7.	RESULTS	28
7.1	COMPARISON WITH REGULATORY LIMITS	28
7.2	COMPARISON WITH ALARA GOAL	29
8.	REFERENCES	29
8.1	DOCUMENTS CITED	29
8.2	CODES, STANDARDS, REGULATIONS, AND PROCEDURES.....	30
9.	ATTACHMENTS.....	31

TABLES

	Page
Table 1. Description and Exposure Duration of Operations in the Remediation Facility	17
Table 2. Description and Exposure Duration of Maintenance Operations in the Remediation Facility	18
Table 3. Activity of Gaseous Radionuclides in Design Basis Spent Nuclear Fuel.....	19
Table 4. Radionuclide Dose Conversion Factors for Inhalation and Submersion	21
Table 5. Dose to Remediation Facility Workers Due to Airborne Releases from Other Facilities	22
Table 6. Individual and Collective Doses to Operations Workers in the Remediation Facility.	24
Table 7. Individual and Collective Doses to Maintenance Workers in the Remediation Facility	25
Table 8. Release Rate of Radionuclides to the Wet Remediation Room Air	26
Table 9. Concentration of Radionuclides to the Wet Remediation Room Air	26
Table 10. Individual Doses to Remediation Operations Workers from Inhalation of Radionuclides in Wet Remediation Room Air	27
Table 11. Individual Doses to Remediation Operations Workers from Submersion in Wet Remediation Room Air	27
Table 12. Summary of Individual and Collective Doses to Workers in the Remediation Facility	28

ACRONYMS AND ABBREVIATIONS

ALARA	as low as reasonably achievable	GROA	Geologic Repository Operations Area
ARR	airborne release rate	LDE	lens dose equivalent
Bq	becquerel	MTHM	metric tons heavy metal
BSC	Bechtel SAIC Company	NRC	U.S. Nuclear Regulatory Commission
CEDE	committed dose equivalent	PDC	Project Design Criteria
CFR	Code of Federal Regulations	PWR	Pressurized Water Reactor
CHF	Canister Handling Facility	RB	Remediation Building
DCF	dose conversion factor	SNF	spent nuclear fuel
DDE	deep dose equivalent	SDE	skin dose equivalent
DOE	U.S. Department of Energy	TEDE	total effective dose equivalent
DTF1	Dry Transfer Facility Number 1	WP	waste package
FGR	Federal Guidance Report		
HLW	high level waste		
HVAC	heating, ventilation, and air-conditioning		

UNITS OF MEASURE

Bq	becquerel
Ci	curie
ft	foot
hr	hour
m	meter
min	minute
mL	milliliter
mrem	millirem
μCi	micro curie
s	second
Sv	sievert
yr	year

INTENTIONALLY LEFT BLANK

1. PURPOSE

The purpose of this design calculation is to estimate radiation doses received by personnel in the Remediation Facility performing operations to receive, prepare, open, repair, recover, disposition, and correct off-normal and non-standard conditions with casks, canisters, spent nuclear fuel (SNF) assemblies, and waste packages (WP). The specific scope of work contained in this calculation covers both collective doses and individual worker group doses on an annual basis, and includes the contributions due to external and internal radiation. The results of this calculation will be used to support the design of the Remediation Facility and provide occupational dose estimates for the License Application.

2. QUALITY ASSURANCE

This document was prepared in accordance with [AP-3.12Q](#), *Design Calculations and Analyses*. Because the results of this calculation will be used to support the Preclosure Safety Analysis relative to radiological safety of the repository, this document is subject to the requirements of the *Quality Assurance Requirements and Description* document (DOE 2003, Sections [2.2.2](#)).

3. METHOD

The dose assessment involves the calculation of both annual collective worker doses and annual individual worker group doses. The calculated doses include the contributions from direct external radiation and airborne radionuclides. The methodology for calculating direct external radiation doses is described in [Section 3.1](#). The methodology for calculating inhalation and submersion doses from airborne radionuclides is described in [Section 3.2](#). The total effective dose equivalent (TEDE) is calculated by summing the component doses from inhalation, submersion and direct external radiation dose ([Section 3.3](#)).

The dose assessments are performed by job function, using time-motion inputs and dose rates calculated at worker locations. Dose calculations are made using an Excel spreadsheet on a per item basis (i.e., casks, SNF assemblies, or WPs), and then multiplied by the annual number of items processed by the facility. Since considerable uncertainty surrounds the throughput of items that may require remediation, conservative assumptions (see [Section 4.2](#)) are used to estimate the number of items processed annually in the facility.

The calculated individual dose is compared with applicable occupational dose regulations and criteria, including the as low as reasonably achievable (ALARA) design goal specified in the *Project Design Criteria* (PDC) document (Minwalla 2003, [Section 4.9.3.3](#)). The impact of uncertainties, conservative inputs and bounding assumptions on the results of this calculation is also discussed.

3.1 EXTERNAL DOSE CALCULATION METHODOLOGY

The external dose, ED_k , received by a worker in group g per operation, k , is calculated as follows. The dose rates are at the locations of each operation due to external radiation from the contained radiation sources.

$$ED_k = t_k \times EDR_l \quad \text{Equation 1}$$

where:

$$\begin{aligned} ED_k &= \text{External dose to a worker in group } g \text{ per operation } k \text{ (mrem/operation)} \\ t_k &= \text{Duration of exposure per operation } k \text{ (hr/operation)} \\ EDR_l &= \text{Dose rate at the worker's location } l \text{ (mrem/hr)} \end{aligned}$$

The total external dose, ED_o , to a worker in group g for N different operations (e.g., remediation of a cask, SNF assembly, or WP) is calculated as follows:

$$ED_o = \sum_{k=1}^N ED_k \times OP_k \quad \text{Equation 2}$$

where:

$$\begin{aligned} ED_o &= \text{External dose to a worker in group } g \text{ performing } N \text{ different operations} \\ &\quad \text{(mrem/operation)} \\ N &= \text{Number of different operations performed by the worker (unitless)} \\ OP_k &= \text{Number of operations of type } k \text{ performed per year (operations/year)} \end{aligned}$$

When not performing remediation operations on an item, the work-crew is assumed to remain inside the Remediation Facility doing support activities in continuous-access low radiation areas. This support-only time, T_n , is determined from the time available (i.e., 40 hrs/week x 50 week/year = 2000 hrs), minus the time performing remediation operations, T_o .

$$T_o = \sum_{k=1}^N t_k \times OP_k$$

Equation 3

and

$$T_n = 2000 \left(\frac{\text{hrs}}{\text{year}} \right) - T_o$$

where:

$$\begin{aligned} T_o &= \text{Time performing remediation operations for worker group } g \text{ (hrs/year)} \\ T_n &= \text{Support-only time for worker group } g \text{ (hrs/year)} \end{aligned}$$

The total annual external dose, ED_g , to a worker in group g for all operations plus support-only time is calculated as:

$$ED_g = ED_o + (T_n \times DR) \quad \text{Equation 4}$$

where:

$$\begin{aligned} ED_g &= \text{Annual external dose to a worker in group } g \text{ (mrem/year)} \\ DR &= \text{Dose rate in continuous-access low radiation areas (mrem/hr)} \end{aligned}$$

The total collective annual external dose, CED_g , to workers in group g is calculated as:

$$CED_g = \frac{ED_g \times W}{1000} \quad \text{Equation 5}$$

where:

$$\begin{aligned} CED_g &= \text{Collective annual external dose to workers in group } g \text{ (person-rem/year)} \\ W &= \text{Number of workers in group } g \text{ (persons)} \\ 1000 &= \text{Units conversion (mrem/rem)} \end{aligned}$$

3.2 INHALATION AND SUBMERSION DOSE CALCULATION METHODOLOGY

The following methodology is used to calculate the airborne concentrations and resultant doses from potential releases of radionuclides from failed spent fuel assemblies stored in the spent fuel pool of the Remediation Facility.

Under steady state conditions (i.e., the number of fuel assemblies placed into the pool equals the number of fuel assemblies removed from the pool) airborne activity concentrations in the room containing the spent fuel pool can be calculated by:

$$C_i = \frac{10^6 Q_i}{8760 \lambda_H V} \quad \text{Equation 6}$$

where:

$$\begin{aligned} C_i &= \text{Steady-state airborne concentration of isotope } i \text{ (}\mu\text{Ci/m}^3\text{)} \\ V &= \text{Room air volume (m}^3\text{)} \\ Q_i &= \text{Release rate of isotope } i \text{ from spent fuel pool (Ci/yr)} \\ \lambda_H &= \text{Room HVAC turn over rate (hr}^{-1}\text{)} \\ 10^6 &= \text{Units conversion (}\mu\text{Ci/Ci)} \\ 8760 &= \text{Units conversion (hr/yr)} \end{aligned}$$

The release rate of isotope i from the pool storage of pressurized water reactor (PWR) and boiling water reactor (BWR) spent fuel is given by:

$$Q_i = \sum_{SNF}^{PWR, BWR} (A_{SNF,i} \times N_{SNF}) \times F_{fail} \times F_{gap,i} \times F_{rel,i} \quad \text{Equation 7}$$

where:

$$\begin{aligned} A_{SNF,i} &= \text{Activity of isotope } i \text{ per PWR or BWR spent fuel assembly (Ci/assembly)} \\ N_{SNF} &= \text{Annual number of PWR or BWR spent fuel assemblies transferred to or from pool (assembly/yr)} \\ F_{fail} &= \text{Fraction of spent fuel assemblies that fail during their residence in the pool (unitless)} \\ F_{gap,i} &= \text{Gap release fraction of isotope } i \text{ (unitless)} \\ F_{rel,i} &= \text{Fraction of isotope } i \text{ released from pool to air (unitless)} \end{aligned}$$

The inhalation and submersion doses to a worker in worker group g for operation k due to pool releases is given by:

$$H_k^{inh} = \sum_i C_i \times DCF_i^{inh} \times 3.7 \times 10^9 \times BR \times t_k \times 3600$$

$$H_k^{sub} = \sum_i C_i \times DCF_i^{sub} \times 3.7 \times 10^9 \times t_k \times 3600$$

Equation 8

where:

$$\begin{aligned} H_k^{inh} &= \text{Inhalation dose per operation } k \text{ (mrem/operation)} \\ H_k^{sub} &= \text{Submersion dose per operation } k \text{ (mrem/operation)} \\ DCF_i^{inh} &= \text{Inhalation dose conversion factor for isotope } i \text{ (Sv/Bq)} \\ BR &= \text{Occupational breathing rate (m}^3\text{/s)} \\ DCF_i^{sub} &= \text{Submersion dose conversion factor for isotope } i \text{ (Sv /Bq s m}^{-3}\text{)} \\ t_k &= \text{Duration of exposure per operation } k \text{ (hr) (i.e., residence time in airborne activity)} \\ 3600 &= \text{Units conversion (s/hr)} \\ 3.7 \times 10^9 &= \text{Units conversion (mrem Bq /Sv } \mu\text{Ci)} \end{aligned}$$

The total annual inhalation and submersion dose, ID_g , to a worker in worker group g involved in spent fuel assembly handling operations in the Remediation Facility pool is calculated as follows:

$$ID_g = (H_k^{inh} + H_k^{sub}) \times OP_k + AR$$

Equation 9

where:

$$\begin{aligned} ID_g &= \text{Annual inhalation and submersion dose to a worker in group } g \text{ (mrem/yr)} \\ AR &= \text{Annual inhalation and submersion doses due to airborne releases from other on-site facilities (mrem/yr)} \end{aligned}$$

The total collective annual inhalation and submersion dose, CID_g , to workers in group g is calculated as:

$$CID_g = \frac{ID_g \times W}{1000}$$

Equation 10

where:

$$\begin{aligned} CID_g &= \text{Annual collective inhalation and submersion dose to workers from facility operations (person-rem/yr)} \\ 1000 &= \text{Units conversion (mrem/rem)} \end{aligned}$$

3.3 TEDE DOSE CALCULATION

The total annual effective dose equivalent (TEDE), to a worker in group g is calculated by summing the component doses from direct external radiation ([Equation 4](#)) and inhalation and submersion ([Equation 9](#)):

$$ITEDE_g = ID_g + ED_g$$

Equation 11

where:

$$ITEDE_g = \text{Annual TEDE to a worker in group } g \text{ (mrem/year)}$$

The collective TEDE to a worker in group g is calculated by summing the component doses from direct external radiation ([Equation 5](#)) and inhalation and submersion ([Equation 10](#)):

$$CTEDE_g = CID_g + CED_g \quad \text{Equation 12}$$

where:

$CTEDE_g$ = Annual collective TEDE to workers in group g (person-rem/year)

4. DESIGN INPUTS

4.1 FACILITY OVERVIEW

The following description of the facility and the operations conducted there form the basis for assumptions listed in [Section 4.2](#).

4.1.1 Facility Description

The Remediation Facility has four main areas as shown in the attached *Remediation Facility General Arrangement Ground Floor Plan D*:

- Cask Preparation Room
- Dual-purpose Canister Preparation/Cask Dry Remediation Room
- Dual-purpose Canister Cutting/WP Dry Remediation cell
- Cask Wet Remediation Room

A detailed description of the Remediation Facility is provided in the *Geologic Repository Operations Area (GROA) Waste Stream Handling Process and Facilities Study* (BSC 2003a, [Section 5.7](#)), where it is identified as the Remediation Building (RB). The RB is an integral part of the Dry Transfer Facility 1 (DTF1). Parts of the integrated facility are used to perform normal waste processing operations, while the other parts are devoted to remediation operations. The characteristics of the RB, as described in the GROA, are reproduced below.

Radioactive waste handling operations will occur under water in a SNF pool or in dry transfer cells with concrete shield walls similar to those in the DTF. Facility workers will be protected from radiation by over ten feet of water, thick below-grade stainless steel lined reinforced concrete fuel pool walls, and dry cells with thick reinforced concrete shield walls. The workers will use remotely controlled under-water or dry-cell equipment to remove the SNF from the transportation casks for staging, off-normal SNF remediation, and repackaging prior to transfer to other areas of the DTF1 or to the Aging Facility.

The DTF1 provides decontamination capability and uses remote equipment for normal cask preparation processes (e.g., cask lid unbolting). The decision to move a cask off the normal process line is made based upon the analysis of the problem encountered and estimation of the remediation time. Dry remediation of a full cask on which a problem is encountered depends upon the off-normal condition. However, cask remediation can be performed by moving the cask transfer trolley to the remediation

area. Dry cask remediation consists of remediation of the cask before and after unloading, where no cask opening is required. The dry cask remediation takes place in the cask preparation rooms (cask preparation includes both cask preparation before unloading and cask preparation after unloading), or in adjacent rooms next to the cask preparation area.

Dry remediation consists of handling SNF in the dry transfer cell such that assembly end-piece repair, bundle reinforcement, and assembly end-piece adaptation or repair is done. These repairs are performed in the dry transfer cell and use the remote handling equipment and the maintenance equipment of the transfer cell. For example, cranes, master-slave manipulators, shielded windows, and video cameras are used during dry SNF remediation. According to the non-conformance encountered, specific tools and materials are introduced into the dry transfer cell to repair the damaged SNF. These tools may include rigid bars to stiffen the SNF, special gripping tools suitable for damaged assembly end-pieces, single-assembly canisters to hold the damaged SNF, etc.

Wet remediation consists of underwater repairs in a pool used to remotely handle the cask and SNF. A bridge crane is used for transporting and placing the cask into the pool and removing full or empty casks to the cask drying area or decontamination area. Other lifting tasks within the pool such as lid removal and placement of fuel to and from racks are accomplished with a dedicated fuel transfer machine.

The pool in the Wet Remediation room is designed to temporarily stage and store a minimum of 48 PWR assemblies, 72 BWR assemblies, and 10 high-level waste canisters (BSC 2003b, [Asset WBS 1.5.04.01.05](#)).

4.1.2 Facility Operations

Since remediation operations are case-specific, no detailed lists of operational steps are currently available. General operations to be conducted in the RB are summarized in the GROA study (BSC 2003a, [Section 5.7.1](#)) and are reproduced below.

The waste transfer operations in the RB will be conducted with systems that receive, handle, store, dry, and package the fuel for return to DTF1. These operations are performed remotely in dedicated, shielded cells, or underwater in the cask unloading and SNF handling pool. The RB is provided with a suite of handling equipment and attachments to support the required cask, SNF, and WP transfer operations. The remote equipment will be designed to facilitate decontamination, maintenance, and the use of interchangeable components, where appropriate. Interfaces will be provided in the facility for utility, maintenance, safety, and auxiliary systems as required for support of operations and radiation protection activities.

The RB houses three subsystems: (1) cask and SNF dry remediation, (2) cask and SNF wet remediation, and (3) WP remediation.

The RB provides space and equipment to perform the following dry remediation operations:

- Remediation of a loaded cask when the cask does not require opening
- Remediation of empty casks after transfer of SNF
- Remediation of partially unloaded SNF in the dry transfer cell.

Dry cask remediation can be performed at different locations within DTF1 in rooms adjacent to the process cells, or directly in the process rooms or cells. Dry cask remediation consists of resolving a problem, undertaking appropriate actions, or developing short-term procedures to cope with off-normal conditions. For example, performing temporary repairs may be conducted until a detailed repair can be done in a cask maintenance facility. The objective is to allow unloading operations to be completed. Since these tasks are performed at a repository production facility, the tasks do not involve lengthy cask repairs that are normally done in a cask maintenance facility.

The RB provides space and equipment to perform the following wet operations:

- Unloading off-normal or non-standard casks that cannot be accommodated in DTF1 (e.g., damaged cask or incompatible cask design)
- Remediation of failed fuel, damaged fuel, non-standard fuel or canisters in a cask.

Wet remediation is performed underwater in a pool with an area for unloading casks and baskets for holding the fuel. The wet remediation area can also be used to decontaminate a cask that cannot be decontaminated or unloaded in DTF1. In this case, a decontamination pit near the pool could be used. The wet fuel handling system includes cranes for transfer of casks into the pool for lid removal and fuel transfer machines for underwater fuel transfer operations. The unloaded fuel can be staged in racks for repair, or directly loaded into an MSC if the off-normal situation involves the cask. When an MSC has been loaded, it is removed from the pool for draining, drying, inert gas backfilling, and decontamination. The MSC is then either transferred to the Transportation Cask Buffer Area, the Aging Facility, or the rail car staging area.

The RB provides space and equipment to perform the following dry WP remediation operations:

- WP closure remediation or remediation after retrieval from emplacement
- WP contamination remediation
- WP handling fixtures remediation.

Most of the operations for WP remediation are performed in a WP remediation or decontamination cell that is designed to recover from contamination issues. Some mechanical repairs of the WP handling devices may be performed in the WP handling and storage cell, when no cell contamination is introduced.

4.2 ASSUMPTIONS

The following assumptions are used to calculate worker doses.

4.2.1 Throughput – Casks and Waste Packages Requiring Remediation

One percent of the casks and WPs that would normally have been processed by CHF and DTF are assumed to require further processing in the Remediation Facility. This amounts to approximately 6 WPs and 11 transportation casks per year.

Rationale: Since the Remediation Facility is not a production facility, there is no facility throughput requirement. For the purpose of estimating worker dose, annual throughput is based on the waste processing rate and potential damage fraction for items being processed at the principal waste processing

facilities. About one percent of the throughput originally destined for the DTF and CHF is assumed to require some form of extensive remediation that cannot be accomplished in the DTF or CHF. A one percent fraction is consistent with Nuclear Regulatory Commission (NRC) guidance (NRC 2003, [p. 7](#)), for normal fuel handling operations. Once operational experience has been gained following the initial ramp up in production, it is considered unlikely that more than one percent of the containers would require remediation.

A peak WP production rate of 600 waste packages per year is consistent with the assumption contained in the *Recommended Surface Contamination Levels for Waste Packages Prior to Placement in the Repository* (Edwards and Yuan 2003, [Section 4.2.2](#)) and is conservative compared to Cloud (2003, [Table 4](#)). Therefore, at one percent of 600, six WPs represent a conservative estimate of the annual WP remediation rate.

According to the *2002 Waste Stream Projections Report*, the maximum number of commercial SNF cask shipments is estimated at 900 per year (BSC 2003c, [Table 13](#)) and the maximum number of DOE cask shipments is 214 per year (BSC 2003c, [Table 23](#)) for the full waste stream scenario. Using the base waste stream scenario would result in significantly lower annual cask shipments. Therefore, at one percent of a total of 1114, 11 casks represent a conservative estimate of the annual cask remediation rate.

Usage: This assumption is used in [Section 6](#).

4.2.2 Throughput – Items Requiring Wet Remediation

The annual throughput of SNF assemblies and canisters requiring wet remediation and/or pool storage is assumed to equal the capacity of the SNF pool (see [Section 4.1.1](#)), implying that the turnover rate of canisters and assemblies in the pool is one per year. In addition, the SNF pool is assumed to be filled to capacity at all times.

Rationale: The SNF pool capacity is 72 BWR assemblies and 48 PWR assemblies (BSC 2003b, [Asset WBS 1.5.04.01.05](#)). Cloud (2003, p. 4) calculated, from the 3000 metric tons heavy metal (MTHM) per year peak commercial SNF acceptance rate, that “approximately 34.3 percent...is contributed by BWR waste packages...and 65.7 percent is contributed by PWR waste packages...” Based on a conversion of 0.175 MTHM/BWR assembly and 0.436 MTHM/PWR assembly (Cloud 2003, pp. [4](#), [5](#)), and the assumption that 30 MTHM/yr (one percent of peak acceptance) would require remediation (NRC 2003, [p. 7](#)), results in an average of 59 BWR and 45 PWR assemblies requiring remediation during peak acceptance years. Therefore, the assumption that the turnover rate in the pool is approximately one per year will be slightly conservative for both types of SNF.

The pool capacity is 10 canisters. Cloud (2003, [p. 5](#)) estimated that 763 canisters would be accepted in the peak year. Rounding one percent of this throughput up to the nearest whole canister results in a projected rate of eight canisters per year, 20% lower than the value used in this assumption.

These assumptions maximize worker dose estimates of both external dose (by maximizing the number of assembly transfer operations to and from the SNF pool) and internal dose (by maximizing the potential for in-pool SNF failures resulting in airborne releases).

Usage: This assumption is used in [Section 6.2](#).

4.2.3 Exposure Duration and Number of Workers – Remediation Operations

[Table 1](#) shows the assumed duration for each type of operation that may be performed at the Remediation Facility. Based on the limited throughput of items requiring remediation, it is assumed that only one shift consisting of the same four workers will be required to conduct remediation operations at the Remediation Facility. For conservatism, all casks requiring remediation are assumed to undergo Operations 1 through 3 in [Table 1](#), while all WPs requiring remediation are assumed to undergo Operation 4 in [Table 1](#).

Table 1. Description and Exposure Duration of Operations in the Remediation Facility

Remediation Operation [A]	Duration (hr) [B]	Description of Major Subtasks [C]
Cask Unloading (Pool – Wet) [1]	8	Cask receipt from DTF, transfer to and immersion in pool, fuel assembly/canister removal and transfer to pool storage racks (transfer damaged assembly to canister, if needed), cask removal from pool, decontamination, transfer to Hot Cell or DTF.
Cask Loading (Pool – Wet) [2]	8	Cask receipt from DTF, transfer to and immersion in pool, fuel assembly/canister transfer from pool storage racks, cask removal from pool, decontamination, transfer to Hot Cell or DTF.
Empty Cask Remediation (Hot Cell – Dry) [3]	6	Cask receipt from DTF or pool, transfer to Hot Cell, external and internal cask decontamination, cask returned to DTF, Hot Cell decontamination.
Defective WP Remediation (Hot Cell – Dry) [4]	16	Defective WP staging and receipt from DTF, transfer to Hot Cell, storage cask receipt and transfer to Hot Cell, WP lid removal, transfer WP contents to dry storage cask, storage cask closure/decontamination/transfer to DTF, empty WP decontamination, transfer to DTF for eventual disposal, Hot Cell decontamination.

Rationale: No documented staffing or operations plan for the remediation operations and maintenance was available at the time of preparing this report. Thus, the number of workers and exposure times for normal operation and maintenance have been developed using engineering judgement derived from, and consistent with, spent fuel handling operations at other facilities (DOE 1996, Table F-102, [p. F-246](#)). As a result, no detailed worker/task breakdown of each of the major activities shown in [Table 1](#) is provided.

Some operations, either alone or in sequence, are expected to take longer than a total of 8 hours. For example, the contents of a transportation cask may be unloaded in the pool, but the unloaded cask may also require additional decontamination in a dry cell. Furthermore, the assemblies or canisters that were unloaded from the transportation cask to the pool may now be available for immediate loading into a storage cask. Since the remediation of a transportation cask in the dry cell could occur concurrently with the loading of a storage cask in the pool, the total operation time could be as short as 16 hours, during which 12 different workers could potentially be involved.

However, the limited throughput in the Remediation Facility may allow such consecutive or concurrent operations to be spread over more than one day to accommodate a single shift. In the above example, the same four workers may be available over three days to complete this set of operations. The assumption

that only one shift is required would conservatively maximize individual doses, but would have a minor effect on collective dose calculations.

Usage: This assumption is used in Sections [6.1.1](#), [6.1.2](#) and [6.2.1](#).

4.2.4 Exposure Duration and Number of Workers – Maintenance Operations

[Table 2](#) shows the assumed duration for each type of maintenance operation that may be performed at the Remediation Facility. The frequency of each maintenance operation is assumed to be bi-weekly (26 per year). Each maintenance crew is assumed to consist of two members. A different group of workers is assumed to conduct each type of maintenance operation (i.e., electricians would not perform maintenance on the HVAC system). These workers may conduct maintenance operations at other facilities. However, the dose incurred from maintenance operations conducted in other facilities is outside the scope of this calculation. For conservatism, it is assumed that all maintenance operations are conducted in the pool area. This assumption is appropriate because the calculated dose is so low that a rough estimate is sufficient to support the conclusion.

Table 2. Description and Exposure Duration of Maintenance Operations in the Remediation Facility

Maintenance Operation [A]	Duration (hr/event) [B]	Frequency (events/yr) [C]	Total (hr/yr) [D]
Electrical	2	26	52
Mechanical	2	26	52
HVAC	2	26	52
Utilities	2	26	52
General Facility	8	26	208
Radiation Monitoring	8	26	208

Column [D] = [B] x [C]

Rationale: No documented staffing or plans for the Remediation Facility maintenance operations was available at the time of preparing this report. Thus, the number of workers and exposure times for normal maintenance operations have been developed using engineering judgement derived from maintenance at other facilities. As a result, no detailed worker/task breakdown of each of the major activities shown in [Table 2](#) is provided.

Assuming that all maintenance operations are conducted in the pool area is bounding since it maximizes the dose to maintenance workers from airborne radionuclides released by the failed SNF stored in the pool.

Usage: This assumption is used in Sections [6.1.2](#) and [6.2.2](#).

4.2.5 Exposure Rates – Remediation Facility Operations and Maintenance Workers

The type of work performed by remediation workers is divided broadly into three categories: cask preparation, hot cell dry remediation, and wet remediation in the pool. It is assumed that all operators, maintenance personnel and other support staff will work in shielded locations where a continuous occupancy dose rate criterion of 0.25 mrem/hr applies. Maintenance and operations support work

functions are assumed to be performed when filled casks or waste packages are not present in the pool area or hot cells. It is further assumed that such functions are performed at radiation levels that are five times lower than the continuous occupancy criterion and five times higher than the natural external radiation background levels (i.e., 0.05 mrem/hr).

Rationale: The use of the continuous occupancy dose rate criterion in the PDC (Minwalla 2003, [Table 4.9.1-1](#)), which will drive the shielding requirements for the Remediation Facility, is conservative since the shielding would be derived by assuming design basis fuel is present at all times in the facility. The use of design basis fuel to derive shielding requirements for this facility is not unrealistic in determining annual doses because of the off-normal (non-average) condition of some of the items requiring remediation or temporary storage in the pool (e.g., failed SNF or SNF that exceeds thermal limits for repository emplacement). However, using this limiting criterion would still be conservative since some items requiring remediation could include failed casks or waste packages containing otherwise undamaged or average fuel assemblies.

A factor of five below the continuous occupancy dose rate criterion for time when no waste is being handled in the Remediation Facility is approximately a factor of five above the natural background radiation level. The natural background level from terrestrial, cosmic and cosmogenic radiation sources is assumed to be 96 mrem/yr (or 0.01 mrem/hr), equivalent to the dose rate reported for the Amargosa Valley (DOE 2002, Table 3-30). This is a conservative assumption that takes into account the potential contribution to external worker dose from operations in DTF and other nearby facilities handling radioactive sources.

Usage: This assumption is used in [Section 6.1](#).

4.2.6 Spent Fuel Assembly Activities – Gaseous Radionuclides

[Table 3](#) lists the principal gaseous radionuclides, and their activity, assumed to be contained in design basis SNF assemblies.

Table 3. Activity of Gaseous Radionuclides in Design Basis Spent Nuclear Fuel

Radionuclide [A]	Activity per Fuel Assembly (Ci)	
	PWR Fuel [B]	BWR Fuel [C]
H-3	1.14×10^2	4.0×10^1
Kr-85	1.13×10^3	3.8×10^2
I-129	2.20×10^{-2}	7.4×10^{-3}

Column [B]: From BSC 2003d, Section 4.1.1

Column [C]: From BSC 2003e, Attachment XIII

Basis: For PWR fuel, the activity of gaseous radionuclides per assembly is obtained from *PWR Source Term Generation and Evaluation* (BSC 2003d, Section 4.1.1). For BWR fuel, the activity of gaseous radionuclides per assembly is obtained from *BWR Source Term Generation and Evaluation* (BSC 2003e, Attachment XIII).

Usage: This assumption is used in [Section 6.2](#).

4.2.7 Fuel Failure Rate – Fuel Stored in Spent Fuel Pool

Release of gaseous fission products from SNF assemblies in a cask or WP is assumed to be negligible for damage occurring prior to its arrival in the Remediation Facility. However, it is assumed that an average of 10 percent of the total storage capacity in the pool per year may develop defects during storage in the Remediation Facility. Since vitrified high-level waste does not contain mobile gaseous radionuclides, any high-level waste canister failures would not result in any radionuclide releases into the air over the pool.

Rationale: This is a conservative assumption, since some of the fuel stored in the pool may already be failed and would have already released any gaseous radionuclides. Assuming that 10 percent of spent fuel assemblies stored in the pool would fail in one year is consistent with the value recommended by NRC for estimating the number of damaged off-normal assemblies in storage (NRC 2003, [p. 7](#)).

Usage: This assumption is used in [Section 6.2](#).

4.2.8 Release Factors – Failed Spent Nuclear Fuel

The release fraction of gaseous fission products (H-3, Kr-85, and I-129) from each failed SNF assemblies in the pool is assumed to be 30 percent of the radionuclide inventory in that assembly. The fraction of these released radionuclides that becomes airborne is assumed to be 100 percent for H-3 and Kr-85, and one percent for I-129.

Rationale: These release factors for gaseous radionuclides are consistent with the recommended assumptions included in NRC 2003 (Table 7.1) and NRC Regulatory Guide 1.25 regarding the release of gaseous radionuclides from failed spent fuel assemblies (Regulatory Guide 1.25, p. 25.2, Sections C.1.d, C.1.g, and C.1.h). These release factors apply to water depths greater than 23 ft (Regulatory Guide 1.25, p. 25.2, Section C.1.c).

Usage: This assumption is used in [Section 6.2](#).

4.2.9 Release Rate – Failed Spent Nuclear Fuel

The release of gaseous radionuclides from such failed fuel is assumed to occur at a constant rate.

Rationale: The annual dose to workers from airborne releases would be the same for continuous or intermittent releases, so long as the total annual releases are the same under either release mode.

Usage: This assumption is used in [Section 6.2](#).

4.2.10 Dimensions – Wet Remediation Room

The Wet Remediation room dimensions are assumed to be 80 ft x 147 ft x 92 ft, resulting in a volume of 1,100,000 cubic feet (31,000 cubic meters), not including the pool water volume. Ten percent of the room volume is assumed to be occupied by equipment and walls, resulting in an effective air volume of 28,000 cubic meters. The bottom of the pool is 55 feet below grade, with the water surface approximately 5 feet below grade.

Basis: The attachment to this document provides general arrangement floor plans and sections for the Remediation Facility, including the Wet Remediation Room. The room length and width are obtained from *Dry Transfer Facility #1/Remediation Facility General Arrangement Pool Floor Plan A* (Length = 49 ft + 33 ft + 65 ft = 147 ft; Width = 30 ft + 20 ft + 30 ft = 80 ft). The room height and pool depth are obtained from *Dry Transfer Facility #1/Remediation Facility General Arrangement Section P*. Reducing the effective volume of this room by 10 percent is conservative since a smaller volume increases the concentration of airborne radionuclides. The depth of the pool is such that there are at least 23 ft of water between the surface and the top of any fuel assemblies that may be stored in the pool, (see [Assumption 4.2.8](#))

Usage: This assumption is used in [Section 6.2](#).

4.2.11 Air Exchange Rate – Wet Remediation Room

The air exchange rate in the Remediation Facility pool area during normal operations is assumed to be 4 air changes per hour.

Rationale: The ventilation rate of 4 air changes per hour is the minimum prescribed for confinement areas served by the Nuclear HVAC system, per the PDC (Minwalla 2003, [Section 4.8.2.2.13](#)).

Usage: This assumption is used in [Section 6.2](#).

4.2.12 Breathing Rate – Remediation Facility Worker

The Remediation Facility worker is assumed to be breathing at a rate of 20,000 mL/min, which is equivalent to $3.33 \times 10^{-4} \text{ m}^3/\text{s}$.

Basis: This is the breathing rate for “light work” used in 10 CFR 20, *Standards for Protection Against Radiation* (Appendix B, Table 1), to calculate derived air concentrations for occupational exposures.

Usage: This assumption is used in [Section 6.2.1](#).

4.2.13 Dose Conversion Factors – Inhalation and Submersion

The inhalation DCFs listed in [Table 4](#) are from Federal Guidance Report 11 (Eckerman et al. 1988, Table 2.1) and submersion DCFs are from Federal Guidance Report 12 (Eckerman and Ryman 1993, Table III.1). The thyroid is assumed to be the limiting organ for inhalation doses. A lens DCF is not defined; the lens dose equivalent (LDE) is calculated by summing the skin dose equivalent (SDE) and the TEDE (LDE = SDE + TEDE) in accordance with NRC guidance (NRC 2003, [p. 10](#)).

Table 4. Radionuclide Dose Conversion Factors for Inhalation and Submersion

Radionuclide [A]	DCF^{inh} CEDE (Sv/Bq) [B]	DCF^{inh} Thyroid (Sv/Bq) [C]	DCF^{sub} DDE (Sv-m ³ /Bq-s) [D]	DCF^{sub} SDE (Sv-m ³ /Bq-s) [E]
H-3	1.73×10^{-11}	1.73×10^{-11}	3.31×10^{-19}	0
Kr-85	0	0	1.19×10^{-16}	1.32×10^{-14}
I-129	4.69×10^{-8}	1.56×10^{-6}	3.80×10^{-16}	1.10×10^{-15}

Columns [B] and [C]: From Eckerman et al. 1988, Table 2.1

Columns [D] and [E]: From Eckerman and Ryman 1993, Table III.1

Rationale: Only inhalation of I-129 results in a dose that affects one organ (the thyroid) more than all other organs. Inhalation of tritium (H-3) results in uniform organ irradiation, while Kr-85 does not contribute to any internal doses.

Usage: This assumption is used in [Section 6.2.1](#).

4.2.14 Airborne Release Dose – Contribution from Other Facilities

The annual doses to a Remediation Facility worker due to potential airborne releases from surface facilities during normal operations are assumed to be those presented in the *Preliminary Consequence Analysis for License Application* (BSC 2003f, [Section I.5.2.1](#) and [Table I-5](#)). These are reproduced in [Table 5](#).

Table 5. Dose to Remediation Facility Workers Due to Airborne Releases from Other Facilities

Airborne Release Dose [A]	Annual Dose (mrem/yr) [B]
Inhalation Dose (CEDE)	2.19
Submersion Dose (DDE)	0.132
Total (TEDE)	2.32

Column [B]: From BSC 2003f, [Table I-5](#)

Rationale: Per BSC (2003f, [Section I.5.2.1](#)), this dose represents the maximum annual dose to a surface facility worker in DTF1 due to re-entry of airborne radioactive contamination from normal airborne releases via the DTF1 exhaust vent stack. Since the Remediation Facility processes only a fraction of the waste handled in DTF1, airborne releases from the Remediation Facility should be much lower than those from the DTF; therefore, the DTF worker doses should bound those to a Remediation Facility worker.

Usage: This assumption is used in [Section 6.2](#).

4.3 REGULATIONS

The regulation applicable to worker doses is contained in 10 CFR 20.1201, *Occupational Dose Limits for Adults*:

- (a) The licensee shall control the occupational dose to individual adults to the following dose limits:
 - (1) An annual limit, which is the more limiting of:
 - (i) The total effective dose equivalent being equal to 5 rems;
 - or
 - (ii) The sum of the deep-dose equivalent and the committed dose equivalent to any individual organ or tissue other than the lens of the eye being equal to 50 rems.

- (2) The annual limits to the lens of the eye, to the skin, and to the extremities, which are:
 - (i) A lens dose equivalent of 15 rems, and
 - (ii) A shallow-dose equivalent of 50 rems to the skin or to any extremity.

4.4 CRITERIA

As low as is reasonably achievable (ALARA) design goals (Minwalla 2003, [Sections 4.9.3.2 and 4.9.3.3](#)) for occupational workers ensure that both individual and collective annual doses are maintained at ALARA levels during normal operations and as a result of Category 1 event sequences.

The following ALARA design goals are established for the design process.

- The ALARA design goal for individual radiation worker doses is to minimize the number of individuals that have the potential of receiving more than 500 mrem/yr TEDE. That goal is 10 percent of the annual TEDE limit in 10 CFR 20.1201, and includes both internal and external exposures.

5. USE OF SOFTWARE

5.1 BASELINED SOFTWARE

No software subject to verification under AP-SI.1Q, *Software Management*, was used in this design calculation.

5.2 COMMERCIAL OFF-THE-SHELF SOFTWARE

Only commercial off-the-shelf software was used in this calculation.

5.2.1 MICROSOFT EXCEL 97 SR-2

- Title: Excel
- Version/Revision Number: Microsoft® Excel 97 SR-2
- This version is installed on a Dell OptiPlex GX270 PC running the Microsoft Windows 2000 operating system (property tag YMP000730)

Microsoft Excel 97, a spreadsheet program, is used in this calculation. Excel was used to generate tables listing the Remediation Facility operations, the number of workers involved in each operation, the dose rates at the worker locations, and the time spent by the workers in the radiation field at each location. Methodologies and equations (derived in [Section 3](#)), design parameters and assumptions (listed in [Section 4](#)), and calculations (performed in [Section 6](#)) are documented in sufficient detail to allow for independent duplication of the various computations without recourse to the originator. Per [Section 2.1.6](#) of AP-SI.1Q, *Software Management*, this software is considered exempt.

6. CALCULATION

Individual and collective worker doses are calculated by applying equations and methodologies described in [Section 3](#) and by using design inputs defined in [Section 4](#). Doses from direct external radiation are calculated in [Section 6.1](#), while doses from airborne releases are calculated in [Section 6.2](#).

Calculated values are presented (rounded) only to the appropriate number of significant digits; however, calculations using Excel are carried out without regard to the number of significant digits in order to reduce round-off error between steps.

6.1 DOSE TO WORKERS FROM DIRECT EXTERNAL RADIATION

Individual and collective external doses to remedial operations workers are calculated in [Section 6.1.1](#). The same is done for maintenance workers in [Section 6.1.2](#). The external doses to remediation facility workers are calculated using the equations and methodology presented in [Section 3.1](#).

6.1.1 Remediation Operation Workers – Direct External Radiation Dose

[Table 6](#) presents individual and collective external doses to remediation operation workers as a result of four workers ([Assumption 4.2.3](#)) processing six WPs and 11 transportation casks per year ([Assumption 4.2.1](#)).

Table 6. Individual and Collective Doses to Operations Workers in the Remediation Facility

Remediation Operation [A]	Duration (hr/operation) [B]	Operations per year [C]	Dose Rate (mrem/hr) [D]	Individual Dose (mrem/yr) [E]	Collective Dose (person-rem/yr) [F]
Cask Unloading (Pool – Wet) [1]	8	11	0.25	22	0.088
Cask Loading (Pool – Wet) [2]	8	11	0.25	22	
Empty Cask Remediation (Hot Cell – Dry) [3]	6	11	0.25	17	0.066
Defective WP Remediation (Hot Cell – Dry) [4]	16	6	0.25	24	0.096
Total From Direct Operations [5]	338	39	0.25	85	0.34
Support Operations [6]	1662	N/A	0.05	83	0.33
Total From Direct and Support Operations [7]	2000	N/A	N/A	168	0.67

Column [A]: [Table 1](#), Column [A].

Column [B]: [Table 1](#), Column [B], except [B5] = Sum ([B1] x [C1]:[B4] x [C4]), [B6] = 2000 – [B5] per [Equation 3](#).

Column [C]: [Assumption 4.2.1](#), except [C5] = Sum ([C1]:[C4])

Column [D]: [Assumption 4.2.5](#).

Column [E] = [B] x [C] x [D] per [Equations 1](#) and [2](#), except [E5] = [B5] x [D5], [E6] = [B6] x [D6], and [E7] = [E5] + [E6], per [Equation 4](#).

Column [F] = 4 workers x [E]/1000 per [Equation 5](#), (4 operations workers per crew – [Assumption 4.2.3](#)).

N/A: Not Applicable

6.1.2 Maintenance Workers – Direct External Radiation Dose

[Table 7](#) presents individual and collective external doses to maintenance workers as a result of two workers in each crew performing 26 maintenance operations per year ([Assumption 4.2.4](#)).

Table 7. Individual and Collective Doses to Maintenance Workers in the Remediation Facility

Maintenance Operation [A]	Duration (hr/operation) [B]	Frequency per year [C]	Dose Rate (mrem/hr) [D]	Individual Dose (mrem/yr) [E]	Collective Dose (person-rem/yr) [F]
Electrical	2	26	0.05	3	0.0052
Mechanical	2	26	0.05	3	0.0052
HVAC	2	26	0.05	3	0.0052
Utilities	2	26	0.05	3	0.0052
General Facility	8	26	0.05	10	0.021
Radiation Monitoring	8	26	0.05	10	0.021
Total (All Maintenance Workers)	N/A	26	0.05	N/A	0.062

Column [A]: [Table 2](#), Column [A].

Column [B]: [Table 2](#), Column [B].

Column [C]: [Assumption 4.2.4](#).

Column [D]: [Assumption 4.2.5](#).

Column [E] = [B] x [C] x [D] per Equations 1 and 2.

Column [F] = 2 workers x [E]/1000, per [Equation 5](#), (2 maintenance workers per crew – [Assumption 4.2.4](#)), except
Total = sum of all maintenance worker collective doses in Column [F].

N/A: Not Applicable

6.2 DOSE TO WORKERS FROM AIRBORNE RADIONUCLIDES

The inhalation doses to remediation facility workers are calculated using the equations and methodology presented in [Section 3.2](#). The airborne concentrations in the Wet Remediation Room (pool area) are the same for both operations and maintenance workers; these are calculated below.

The release rate, Q_i , of radionuclides from failed SNF in the pool is assumed to be constant ([Assumption 4.2.9](#)) and can be calculated using [Equation 7](#). The results of this calculation are presented in [Table 8](#).

The concentration, C_i , of radionuclides from failed SNF in the pool can be calculated using [Equation 6](#) and the average release rates calculated in [Table 8](#). The results of these calculations are presented in [Table 9](#).

Individual and collective doses to remedial operations workers from airborne releases are calculated in [Section 6.2.1](#). The same is done for maintenance workers in [Section 6.2.2](#).

Table 8. Release Rate of Radionuclides to the Wet Remediation Room Air

Radionuclide [A]		Inventory (Ci/assembly) [B]	Number of Assemblies per year [C]	Failure Rate per year [D]	Gap Release Fraction [E]	Fraction Released to Air [F]	Average Release Rate (Ci/yr) [G]	
PWR SNF	H-3	1.1×10^2	48	0.10	0.30	1	1.6×10^2	
	Kr-85	1.1×10^3					1.6×10^3	
	I-129	2.2×10^{-2}				0.01	3.2×10^{-4}	
BWR SNF	H-3	4.0×10^1	72				1	8.5×10^1
	Kr-85	3.8×10^2					8.2×10^2	
	I-129	7.4×10^{-3}				0.01	1.6×10^{-4}	
Total	H-3	N/A	120				1	2.5×10^2
	Kr-85						2.5×10^3	
	I-129					0.01	4.8×10^{-4}	

Column [A]: [Assumption 4.2.6](#), [Table 3](#), Column [A].

Column [B]: [Assumption 4.2.6](#), [Table 3](#), Column [B] (PWR) or Column [C] (BWR).

Column [C]: [Assumption 4.2.2](#).

Column [D]: [Assumption 4.2.7](#).

Columns [E] and [F]: [Assumption 4.2.8](#).

Column [G] = [B] x [C] x [D] x [E] x [F], per [Equation 7](#).

Total Column [G]: Summed PWR and BWR releases for each radionuclide.

N/A: Not Applicable

Table 9. Concentration of Radionuclides to the Wet Remediation Room Air

Radionuclide [A]	Average Release Rate (Ci/yr) [B]	HVAC Turnover (hr ⁻¹) [C]	Room Volume (m ³) [D]	Concentration (μCi/m ³) [E]
H-3	2.5×10^2	4	2.8×10^4	2.6×10^{-1}
Kr-85	2.5×10^3			2.5×10^0
I-129	4.8×10^{-4}			4.9×10^{-7}

Column [A]: [Assumption 4.2.6](#), [Table 3](#), Column [A].

Column [B]: [Table 8](#), Totals Column [G].

Column [C]: [Assumption 4.2.11](#).

Column [D]: [Assumption 4.2.10](#).

Column [E] = $(10^6 \times [B]) / (8760 \times [C] \times [D])$, per [Equation 6](#).

6.2.1 Remediation Operation Workers – Doses From Airborne Radionuclides

The doses to operations workers exposed to airborne radionuclides from failed SNF in the pool can be calculated using [Equation 8](#) and the concentrations calculated in [Table 9](#). The results of this calculation are presented in [Tables 10](#) and [11](#) for inhalation and submersion, respectively.

The annual exposure duration consists of the total time spent in the pool area performing wet remediation operations (cask unloading and loading in the pool). This time is equal to 16 hours per cask operation ([Assumption 4.2.3](#), [Table 1](#), Rows 1 and 2 summed) multiplied by 11 cask operations per year ([Assumption 4.2.1](#)), or 176 hr/yr. At a breathing rate of 3.33×10^{-4} m³/s ([Assumption 4.2.12](#)), and a conversion factor of 3600 s/hr, the volume of contaminated air inhaled by each remediation operations worker is 211 m³/yr.

Table 10. Individual Doses to Remediation Operations Workers from Inhalation of Radionuclides in Wet Remediation Room Air

Radionuclide [A]	Concentration ($\mu\text{Ci}/\text{m}^3$) [B]	DCF^{inh} CEDE (Sv/Bq) [C]	Worker CEDE (mrem/yr) [D]	DCF^{inh} Thyroid (Sv/Bq) [E]	Worker Thyroid Dose (mrem/yr) [F]
H-3	2.6×10^{-1}	1.73×10^{-11}	3.5	1.73×10^{-11}	3.5
Kr-85	2.5×10^0	0	0	0	0
I-129	4.9×10^{-7}	4.69×10^{-8}	0.018	1.56×10^{-6}	0.6
Total	N/A	N/A	3.5	N/A	4.1

Column [A]: [Assumption 4.2.6](#), [Table 3](#), Column [A].

Column [B]: [Table 9](#), Column [E].

Column [C]: [Assumption 4.2.13](#), [Table 4](#), Column [B].

Column [D] = [B] $\times$ [C] $\times 3.7 \times 10^9 \times 211$, per [Equation 8a](#) and calculated inhaled air volume of 211 m^3 over 176 hr.

Column [E]: [Assumption 4.2.13](#), [Table 4](#), Column [C].

Column [F] = [B] $\times$ [D] $\times 3.7 \times 10^9 \times 211$, per [Equation 8a](#) and calculated inhaled air volume of 211 m^3 over 176 hr.

N/A: Not Applicable

Table 11. Individual Doses to Remediation Operations Workers from Submersion in Wet Remediation Room Air

Radionuclide [A]	Concentration ($\mu\text{Ci}/\text{m}^3$) [B]	DCF^{sub} DDE (Sv- $\text{m}^3/\text{Bq-s}$) [C]	Worker DDE (mrem/yr) [D]	DCF^{sub} Skin (Sv- $\text{m}^3/\text{Bq-s}$) [E]	Worker Skin Dose (mrem/yr) [F]
H-3	2.6×10^{-1}	3.31×10^{-19}	2.0×10^{-4}	0	0
Kr-85	2.5×10^0	1.19×10^{-16}	7.1×10^{-1}	1.32×10^{-14}	78
I-129	4.9×10^{-7}	3.80×10^{-16}	4.4×10^{-7}	1.10×10^{-15}	1.3×10^{-6}
Total	N/A	N/A	0.71	N/A	78

Column [A]: [Assumption 4.2.6](#), [Table 3](#), Column [A].

Column [B]: [Table 9](#), Column [E].

Column [C]: [Assumption 4.2.13](#), [Table 4](#), Column [D].

Column [D] = [B] $\times$ [C] $\times 3.7 \times 10^9 \times 176 \times 3600$, per [Equation 8b](#) for a 176 hr exposure duration.

Column [E]: [Assumption 4.2.13](#), [Table 4](#), Column [E].

Column [F] = [B] $\times$ [D] $\times 3.7 \times 10^9 \times 176 \times 3600$, per [Equation 8b](#) for a 176 hour exposure duration.

N/A: Not Applicable

The total dose to an individual remediation operation worker due to airborne releases from the pool is 4.2 mrem/yr; including the doses contributed from other facilities ([Assumption 4.2.14](#), [Table 5](#)) increases this dose to 6.5 mrem/yr.

Per [Assumption 4.2.13](#), the lens dose is calculated as the SDE + TEDE (78 mrem/yr + 168 mrem/yr + 6.5 mrem/yr), or 250 mrem/yr.

The collective dose to the operations worker group can be calculated using [Equation 10](#) as follows: $(4 \times 6.5)/1000$, or 0.026 person-rem/yr.

6.2.2 Maintenance Workers – Doses From Airborne Radionuclides

Since both the inhalation and submersion doses are directly proportional to the time spent in the contaminated air, the doses to maintenance workers can be obtained by scaling the doses calculated in [Section 6.2.1](#) by the ratio of maintenance-to-operations time spent in the pool area. Thus, for the Electrical, Mechanical, HVAC, and Utilities maintenance workers working in the pool area, the doses would be a factor of $52/176$ (0.30) times lower. Adding the contribution from other facilities results in a

total dose to these workers of 3.6 mrem/yr from airborne contamination. For the General Facilities and Radiation Monitoring maintenance workers the doses would be a factor of 208/176 (1.2) times higher. Adding the contribution from other facilities ([Assumption 4.2.14](#), [Table 5](#)) results in a total dose to these workers of 7.2 mrem/yr from airborne contamination.

Per [Assumption 4.2.13](#), the LDE is calculated as the SDE + TEDE and is 30 mrem/yr (0.3×78 mrem/yr + 3 mrem/yr + 3.6 mrem/yr) for Electrical, Mechanical, HVAC, and Utilities maintenance workers. The LDE is 110 mrem/yr (1.2×78 mrem/yr + 10 mrem/yr + 7.2 mrem/yr) for General Facilities and Radiation Monitoring maintenance workers.

The collective dose to the Electrical, Mechanical, HVAC, and Utilities maintenance workers can be calculated using [Equation 10](#) as follows: $(2 \times 3.6)/1000$, or 0.0071 person-rem/yr. The collective dose to the General Facilities and Radiation Monitoring maintenance workers can be calculated in a similar manner: $(2 \times 7.2)/1000$, or 0.015 person-rem/yr.

7. RESULTS

Individual and collective doses to Remediation Facility workers are estimated using the methodology and equations described in [Section 3](#), the facility overview presented in [Section 4.1](#), the assumptions defined in [Section 4.2](#), the exempt software described in [Section 5](#), and the calculations performed in [Section 6](#). The parameters used in the dose calculations are supported by appropriate and conservative input data and assumptions. The calculated worker doses, summarized in [Table 12](#), represent reasonable maximum results compared with the inputs used to derive them. The results are therefore suitable for the intended use. Uncertainties in the results are identified primarily by the duration of operations, number of workers, and remediation throughputs, which are currently not easily quantifiable. However, the selected inputs are judged to be representative of conservative conditions.

Table 12. Summary of Individual and Collective Doses to Workers in the Remediation Facility

Operation	Individual TEDE mrem/yr	Collective TEDE person-rem/yr
Remediation	170	0.70
Electrical	6	0.012
Mechanical	6	0.012
HVAC	6	0.012
Utilities	6	0.012
General Facility	18	0.035
Radiation Monitoring	18	0.035
Total		0.82

7.1 COMPARISON WITH REGULATORY LIMITS

All the annual individual TEDEs summarized in [Table 12](#) are at least 28 times lower than the NRC regulatory limit of 5 rem/yr TEDE ([Section 4.3](#)). The maximum organ dose of 170 mrem/yr (170

mrem/yr DDE + 4.1 mrem/yr thyroid CDE) is 280 times lower than the regulatory limit of 50 rem/yr. The highest skin dose of 94 mrem/yr (1.2×78 mrem/yr) to a General Facilities or Radiation Monitoring maintenance worker is 530 times lower than the 50 rem/yr limit. A lens dose of 0.25 rem/yr to the most exposed worker is 60 times below the limit of 15 rem/yr. Therefore, all operations identified in this calculation comply with applicable regulations limiting occupational exposures with an ample margin of safety.

7.2 COMPARISON WITH ALARA GOAL

The individual doses to all workers are below the 500-mrem/yr ALARA goal ([Section 4.4](#)) by at least a factor of 3. Therefore, no additional ALARA considerations are required for such workers unless they are likely to be exposed to radiation from other activities not considered in this calculation.

While a formal ALARA evaluation for the Remediation Facility operations considered in this calculation is outside the scope of this calculation, some of the considerations presented here may be applied as part of such an evaluation.

8. REFERENCES

8.1 DOCUMENTS CITED

BSC (Bechtel SAIC Company) 2003a. *Geologic Repository Operations Area Waste Stream Handling Process and Facilities Study*. 000-30R-MGR0-00300-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: [MOL.20031212.0021](#). [DIRS 166015]

BSC 2003b. *Evolving Design for Surface Facilities*. Baseline Change Proposal YMP-2003-035, Rev. 0. Las Vegas, Nevada: Bechtel SAIC Company. ACC: [MOL.20030812.0345](#). [DIRS 164690]

BSC 2003c. *2002 Waste Stream Projections Report*. TDR-CRW-SE-000022 REV 01. Las Vegas, Nevada: Bechtel SAIC Company. ACC: [DOC.20031020.0002](#). [DIRS 165990]

BSC 2003d. *PWR Source Term Generation and Evaluation*. 000-00C-MGR0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: [ENG.20030324.0004](#). [DIRS 162471]

BSC 2003e. *BWR Source Term Generation and Evaluation*. 000-00C-MGR0-00200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: [ENG.20030723.0001](#). [DIRS 164364]

BSC 2003f. *Preliminary Consequence Analysis for License Application*. CAL-WHS-RL-000002 REV 00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: [DOC.20030929.0015](#). [DIRS 165091]

Cloud, J.D. 2003. "Waste Package Per Year Estimate for Planning Purposes." Interoffice memorandum from J.D.Cloud (BSC) to M.P. Board, P. McDaniel, T.W. Mulkey, and S.L. Sethi, April 30, 2003, 0429037098, with attachment. ACC: [MOL.20030527.0392](#). [DIRS 163991]

DOE (U.S. Department of Energy) 1996. Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel. DOE/EIS-

0218F. Washington, D.C.: U.S. Department of Energy. ACC: [MOL.20010727.0195](#); [MOL.20010727.0196](#). [DIRS 101812]

DOE 2002. Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. DOE/EIS-0250. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: [MOL.20020524.0314](#); through; [MOL.20020524.0320](#). [DIRS 155970]

DOE 2003. *Quality Assurance Requirements and Description*. DOE/RW-0333P, Rev. 13. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: [DOC.20030422.0003](#). [DIRS 162903]

Eckerman, K.F. and Ryman, J.C. 1993. External Exposure to Radionuclides in Air, Water, and Soil, Exposure-to-Dose Coefficients for General Application, Based on the 1987 Federal Radiation Protection Guidance. EPA 402-R-93-081. Federal Guidance Report No. 12. Washington, D.C.: U.S. Environmental Protection Agency, Office of Radiation and Indoor Air. TIC: [225472](#). [DIRS 107684]

Eckerman, K.F.; Wolbarst, A.B.; and Richardson, A.C.B. 1988. Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion. EPA 520/1-88-020. Federal Guidance Report No. 11. Washington, D.C.: U.S. Environmental Protection Agency. ACC: [MOL.20010726.0072](#). [DIRS 101069]

Edwards, T.A. and Yuan, Y. 2003. *Recommended Surface Contamination Levels for Waste Packages Prior to Placement in the Repository*. 000-30R-OSS0-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: [ENG.20030903.0001](#). [DIRS 164177]

Minwalla, H.J. 2003. *Project Design Criteria Document*. 000-3DR-MGR0-00100-000-001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: [ENG.20030402.0001](#). [DIRS 161362]

NRC (U.S. Nuclear Regulatory Commission) 2003. "Interim Staff Guidance - 5, Revision 1. Confinement Evaluation." ISG-5, Rev 1. Washington, D.C.: U.S. Nuclear Regulatory Commission. Accessed January 24, 2003. ACC: [MOL.20030124.0247](#). <http://www.nrc.gov/reading-rm/doc-collections/isg/spent-fuel.html> [DIRS 160582]

Regulatory Guide 1.25, Rev. 0. 1972. Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors. Washington, D.C.: U.S. Nuclear Regulatory Commission. Readily available. [DIRS 107691]

8.2 CODES, STANDARDS, REGULATIONS, AND PROCEDURES

10 CFR 20. Energy: Standards for Protection Against Radiation. Readily available. [DIRS 104787]

AP-3.12Q, Rev. 2, ICN 1. *Design Calculations and Analyses*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: [DOC.20030827.0013](#). [DIRS 165022]

AP-SI.1Q, Rev. 5, ICN 2. *Software Management*. Washington, D.C.: U.S. Department of Energy, Office of Civilian Radioactive Waste Management. ACC: [DOC.20030902.0003](#). [DIRS 165023]

9. ATTACHMENTS

This calculation document includes one attachment (five pages) consisting of the following five items, all of which are 11” by 17” drawings:

- Dry Transfer Facility #1/Remediation Facility General Arrangement Legend and General Notes
- Dry Transfer Facility #1/Remediation Facility General Arrangement Ground Floor Key Plan
- Dry Transfer Facility #1/Remediation Facility General Arrangement Ground Floor Plan D
- Dry Transfer Facility #1/Remediation Facility General Arrangement Pool Floor Plan A
- Dry Transfer Facility #1/Remediation Facility General Arrangement Section P

ROOM LEGEND

DRY TRANSFER FACILITY #1 & REMEDIATION FACILITY

GROUND FLOOR

1001	ELECTRICAL EQUIPMENT ROOM (NORMAL POWER)
1002	COMMUNICATIONS ROOM
1003	AIRLOCK
1004	DOOR PARK AND MAINTENANCE ROOM
1005	CRANE PARK CELL
1006	CORRIDOR
1007	AIRLOCK (HOLD)
1008	STAIRWELL
1009	HEPA FILTER LOADOUT AIRLOCK
1010	HEPA FILTER LOADOUT AIRLOCK
1011	HEPA FILTER LOADOUT AND DECONTAMINATION CELL
1012	HEPA FILTER CHANGEOUT CELL
1013	HVAC ROOM
1014	AIRLOCK (HOLD)
1015	AIRLOCK (HOLD)
1016	CORRIDOR
1017	UNASSIGNED
1018	CORRIDOR
1019	CORRIDOR
1020	AIRLOCK (HOLD)
1021	STAIRWELL
1022	SUPPORT AREA
1023	CORRIDOR
1024	ELECTRICAL ROOM TRAIN A
1025	CLOSURE SUPPORT AREA
1026	AIRLOCK (HOLD)
1027	AIRLOCK (HOLD)
1028	AIRLOCK (HOLD)
1029	AIRLOCK (HOLD)
1030	AIRLOCK (HOLD)
1031	AIRLOCK (HOLD)
1032	AIRLOCK (HOLD)
1033	AIRLOCK (HOLD)
1034	AIRLOCK (HOLD)
1035	WP HANDLING WORK STATION A
1036	WP HANDLING WORK STATION B
1037	WP HANDLING WORK STATION C
1038	WP POSITIONING CELL A (FUTURE)
1039	WP POSITIONING CELL B
1040	WP POSITIONING CELL C
1041	WP POSITIONING CELL D
1042	DOOR PARK AND MAINTENANCE ROOM
1043	DOOR PARK AND MAINTENANCE ROOM
1044	WP HANDLING AND STAGING CELL
1045	AIRLOCK
1046	WP HANDLING WORK STATION D
1047	DOOR PARK AND MAINTENANCE ROOM
1048	AIRLOCK
1049	UNASSIGNED
1050	SNF AND CANISTER STAGING CELL
1051	WP LOADING / DOCKING RING REMOVAL CELL
1052	WP DOCKING CELL
1053	WP PREPARATION ROOM
1054	WP LOADING (NAVY CANISTER) / DOCKING RING REMOVAL CELL
1055	WP DOCKING CELL
1056	WP / NAVY CASK PREPARATION ROOM
1057	WP TO TROLLEY TRANSFER ROOM
1058	WP / NAVY CASK SRTC RECEIPT AREA
1059	WP SRTC RECEIPT AREA
1060	WP AND NAVY CASK ENTRANCE VESTIBULE
1061	DOOR PARK AND MAINTENANCE ROOM
1062	AIRLOCK
1063	STAIRWELL
1064	WP HANDLING WORK STATION E, F & G
1065	AIRLOCK
1066	DOOR PARK AND MAINTENANCE ROOM
1067	CORRIDOR
1068	CORRIDOR
1069	CASK AND MSC DOCKING ROOM
1070	AIRLOCK (HOLD)
1071	AIRLOCK (HOLD)
1072	CASK RESTORATION ROOM
1073	CASK / MSC TURNABLE ROOM
1074	CASK PREPARATION ROOM
1075	AIRLOCK (HOLD)
1076	CASK AND MSC TO TROLLEY TRANSFER ROOM
1077	CASK AND MSC SRTC RECEIPT AREA
1078	IMPACT LIMITER AND PERSONNEL BARRIER STAGING ROOM
1079	CASK AND MSC ENTRANCE VESTIBULE
1080	CORRIDOR

GROUND FLOOR (CONT.)

1081	AIRLOCK
1082	CORRIDOR
1083	HVAC ROOM
1084	HVAC ROOM
1085	STAIRWELL
1086	EXIT VESTIBULE
1087	WP TRANSPORTER VESTIBULE
1088	WP LOADOUT CELL
1089	DOOR PARK AND MAINTENANCE ROOM
1090	UNASSIGNED
1091	WP LOADOUT WORK STATION A, B, & C
1092	AIRLOCK
1093	DOOR PARK AND MAINTENANCE ROOM
1094	WP / TROLLEY DECONTAMINATION ROOM
1095	AIRLOCK
1096	DOOR PARK AND MAINTENANCE ROOM
1097	DPC CUTTING / WP DRY REMEDIATION CELL
1098	DPC CUTTING / WP DRY REMEDIATION WORK STATION A, B, C & D
1099	CORRIDOR
1100	DPC PREPARATION / CASK DRY REMEDIATION
1101	DPC DOCKING ROOM
1102	SUPPLIES & EQUIPMENT RECEIVING BAY
1103	AIRLOCK (HOLD)
1104	AIRLOCK (HOLD)
1105	SUPPORT AREA
1106	STAIRWELL
1107	WP TRANSFER CORRIDOR
1108	DPC CUTTING / WP REMEDIATION WORK STATION E, F & H
1109	UNASSIGNED
1110	AIRLOCK (HOLD)
1111	AIRLOCK (HOLD)
1112	AIRLOCK (HOLD)
1113	AIRLOCK (HOLD)
1114	AIRLOCK (HOLD)
1115	DOOR PARK AND MAINTENANCE ROOM
1116	STAIRWELL
1117	CASK WET REMEDIATION
1118	AIRLOCK (HOLD)
1119	AIRLOCK (HOLD)
1120	CASK WET REMEDIATION ENTRANCE VESTIBULE
1121	AIRLOCK (HOLD)
1122	STAIRWELL
1123	STACK MONITORING ROOM

OPERATING FLOOR

2001	CONTROL ROOM
2002	CORRIDOR
2003	MAINTENANCE ROOM
2004	AIRLOCK (HOLD)
2005	DOOR PARK AND MAINTENANCE ROOM
2006	UNASSIGNED
2007	UNASSIGNED
2008	UNASSIGNED
2009	UNASSIGNED
2010	UNASSIGNED
2011	REMOTE HEPA CONTROL ROOM
2012	UNASSIGNED
2013	HVAC PRIMARY EMERGENCY EXHAUST ROOM
2014	AIRLOCK (HOLD)
2015	AIRLOCK (HOLD)
2016	AIRLOCK (HOLD)
2017	CORRIDOR
2018	HVAC PRIMARY EXHAUST ROOM
2019	AIRLOCK (HOLD)
2020	AIRLOCK (HOLD)
2021	CORRIDOR
2022	AIRLOCK (HOLD)
2023	SAFEGUARDS / SECURITY ROOM
2024	WP CLOSURE SUPPORT ROOM
2025	AIRLOCK (HOLD)
2026	AIRLOCK (HOLD)
2027	AIRLOCK (HOLD)
2028	AIRLOCK (HOLD)
2029	AIRLOCK (HOLD)
2030	WP CLOSURE CELL A (FUTURE)
2031	WP CLOSURE MAINTENANCE ROOM A
2032	WP CLOSURE CELL B
2033	WP CLOSURE CELL C
2034	WP CLOSURE MAINTENANCE ROOM B
2035	WP CLOSURE CELL D
2036	WP CLOSURE OPERATING GALLERY
2037	AIRLOCK
2038	AIRLOCK
2039	ELECTRICAL ROOM TRAIN B
2040	CONTROL ROOM HVAC
2041	CORRIDOR
2042	CONTROL ROOM HVAC
2043	NAVY TRANSFER / DOCKING RING REMOVAL CELL

OPERATING FLOOR (CONT.)

2044	MANIPULATOR REPAIR ROOM
2045	TRANSFER CELL WORK STATION STATION A - G
2046	AIRLOCK (HOLD)
2047	AIRLOCK (HOLD)
2048	WASTE TRANSFER CELL
2049	DOCKING RING STAGING ROOM
2050	WP DOCKING RING INSTALLATION ROOM
2051	CASK DOCKING RING INSTALLATION ROOM
2052	AIRLOCK (HOLD)
2053	AIRLOCK (HOLD)
2054	AIRLOCK (HOLD)
2055	AIRLOCK (HOLD)
2056	AIRLOCK (HOLD)
2057	DPC PREPARATION STATION
2058	AIRLOCK (HOLD)
2059	CASK PREPARATION WORK STATION A
2060	CORRIDOR
2061	UNASSIGNED
2062	HVAC RF SECONDARY EXHAUST SYSTEM
2063	CORRIDOR
2064	AIRLOCK (HOLD)
2065	DECON EQUIPMENT ROOM
2066	DOOR PARK AND MAINTENANCE ROOM
2067	AIRLOCK
2068	WASTE TRANSFER CELL CRANE PARK
2069	DOOR PARK AND MAINTENANCE ROOM
2070	ELECTRICAL MCC ROOM
2071	AIRLOCK (HOLD)
2072	UNASSIGNED
2073	CORRIDOR
2074	UNASSIGNED
2075	AIRLOCK (HOLD)
2076	HVAC SECONDARY/TERTIARY TRANSFER SYSTEM
2077	AIRLOCK (HOLD)
2078	AIRLOCK
2079	AIRLOCK (HOLD)
2080	UNASSIGNED
2081	WP LOADOUT CRANE PARK CELL

UPPER FLOOR

3001	HVAC PRIMARY AIR SUPPLY ROOM
3002	HVAC ROOM
3003	AIRLOCK (HOLD)
3004	AIRLOCK
3005	AIRLOCK (HOLD)
3006	CORRIDOR
3007	HVAC SECONDARY EXHAUST
3008	AIRLOCK (HOLD)
3009	CLOSURE MAINTENANCE ROOM
3010	VACUUM PUMP ROOM (HOLD)
3011	AIRLOCK (HOLD)
3012	AIRLOCK (HOLD)
3013	AIRLOCK (HOLD)
3014	AIRLOCK (HOLD)
3015	HVAC NON-CONFINEMENT RECIRCULATING FANS
3016	DOOR PARK AND MAINTENANCE ROOM
3017	AIRLOCK
3018	AIRLOCK (HOLD)
3019	ELECTRICAL EQUIPMENT ROOM (NORMAL POWER)
3020	AIRLOCK
3021	DOOR PARK AND MAINTENANCE ROOM
3022	AIRLOCK
3023	AIRLOCK
3024	AIRLOCK
3025	DOOR PARK AND MAINTENANCE ROOM
3026	AIRLOCK (HOLD)
3027	AIRLOCK
3028	UNASSIGNED
3029	HVAC RF SECONDARY EXHAUST SYSTEM
3030	VESTIBULE
3031	EXIT CORRIDOR
3032	VESTIBULE
3033	AIRLOCK (HOLD)
3034	HVAC SECONDARY AND TERTIARY AIR SUPPLY ROOM
3035	CRANE PARK CELL

ROOF

4001	CRANE MAINTENANCE ROOM A
4002	FREIGHT ELEVATOR MECHANICAL ROOM A
4003	FREIGHT ELEVATOR MECHANICAL ROOM B
4004	CRANE MAINTENANCE ROOM B
4005	CRANE MAINTENANCE ROOM C
4006	CRANE MAINTENANCE ROOM D
4007	FREIGHT ELEVATOR MECHANICAL ROOM D

BASEMENT

0001	LEAK DETECTION SUMP ROOM
0002	POOL WATER TREATMENT ROOM A
0003	POOL WATER TREATMENT ROOM B
0004	CASK PREPARATION PIT
0005	CASK DECON PIT
0006	TOOL STORAGE PIT A
0007	TOOL STORAGE PIT B
0008	POOL

DRAWING LEGEND:

---	MATCH LINE
---	GRID LINE
---	FLOOR GRATING
---	PARTITION WALL
---	CONCRETE SECTION
---	OVERHEAD CRANE HOOK LIMITS
XXXX	ROOM/AREA NUMBER
---	FUTURE EQUIPMENT/FACILITIES
---	GRADE SECTION

DRAWING INDEX

DRY TRANSFER FACILITY #1 / REMEDIATION FACILITY
GENERAL ARRANGEMENTS

110-P1K-WHS0-00101-000-00A	LEGEND & GENERAL NOTES
110-P1K-WHS0-00102-000-00A	GROUND FLOOR KEY PLAN
110-P1K-WHS0-00103-000-00A	OPERATING FLOOR KEY PLAN
110-P1K-WHS0-00104-000-00A	UPPER FLOOR KEY PLAN
110-P1K-WHS0-00105-000-00A	ROOF KEY PLAN
110-P1K-WHS0-00106-000-00A	NOT USED
110-P1K-WHS0-00107-000-00A	NOT USED
110-P1K-WHS0-00108-000-00A	GROUND FLOOR PLAN A
110-P1K-WHS0-00109-000-00A	GROUND FLOOR PLAN B
110-P1K-WHS0-00110-000-00A	GROUND FLOOR PLAN C
110-P1K-WHS0-00111-000-00A	GROUND FLOOR PLAN D
110-P1K-WHS0-00112-000-00A	OPERATING FLOOR PLAN A
110-P1K-WHS0-00113-000-00A	OPERATING FLOOR PLAN B
110-P1K-WHS0-00114-000-00A	OPERATING FLOOR PLAN C
110-P1K-WHS0-00115-000-00A	OPERATING FLOOR PLAN D
110-P1K-WHS0-00116-000-00A	UPPER FLOOR PLAN A
110-P1K-WHS0-00117-000-00A	UPPER FLOOR PLAN B
110-P1K-WHS0-00118-000-00A	UPPER FLOOR PLAN C
110-P1K-WHS0-00119-000-00A	UPPER FLOOR PLAN D
110-P1K-WHS0-00120-000-00A	ROOF PLAN A
110-P1K-WHS0-00121-000-00A	ROOF PLAN B
110-P1K-WHS0-00122-000-00A	ROOF PLAN C
110-P1K-WHS0-00123-000-00A	ROOF PLAN D
110-P1K-WHS0-00124-000-00A	POOL FLOOR PLAN A
110-P1K-WHS0-00125-000-00A	NOT USED
110-P1K-WHS0-00126-000-00A	NOT USED
110-P1K-WHS0-00127-000-00A	NOT USED
110-P1K-WHS0-00128-000-00A	SECTION A
110-P1K-WHS0-00129-000-00A	SECTION B
110-P1K-WHS0-00130-000-00A	SECTION C
110-P1K-WHS0-00131-000-00A	SECTION D
110-P1K-WHS0-00132-000-00A	SECTION E
110-P1K-WHS0-00133-000-00A	SECTION F
110-P1K-WHS0-00134-000-00A	SECTION G
110-P1K-WHS0-00135-000-00A	SECTION H
110-P1K-WHS0-00136-000-00A	SECTION J
110-P1K-WHS0-00137-000-00A	SECTION K
110-P1K-WHS0-00138-000-00A	SECTION L
110-P1K-WHS0-00139-000-00A	SECTION M
110-P1K-WHS0-00140-000-00A	SECTION N
110-P1K-WHS0-00141-000-00A	SECTION P
110-P1K-WHS0-00142-000-00A	SECTION Q, R & S

GENERAL NOTES:

1. NOMINAL GROUND FLOOR ELEVATION SET AT TOC 0'-0". FINAL ELEVATIONS TO BE DETERMINED AS DESIGN DEVELOPS.
2. ABBREVIATIONS AND ACRONYMS:
 - EL = ELEVATION
 - DPC = DUAL PURPOSE CANISTER
 - HEPA = HIGH-EFFICIENCY PARTICULATE AIR
 - HVAC = HEATING, VENTILATION AND AIR-CONDITIONING
 - LWT = LEGAL WEIGHT TRUCK
 - MCC = MOTOR CONTROL CENTER
 - MGR = MONITORED GEOLOGICAL REPOSITORY
 - MSC = MGR SITE SPECIFIC CASK
 - ONT = OVERNIGHT TRUCK
 - RF = REMEDIATION FACILITY
 - SNF = SPENT NUCLEAR FUEL
 - SRTC = SITE RAIL TRANSFER CART
 - TOC = TOP OF CONCRETE
 - TOR = TOP OF RAIL
 - TOS = TOP OF STEEL
 - UND = UNLESS NOTED OTHERWISE
 - WP = WASTE PACKAGE
3. DRAWING 110-P1K-WHS0-00101-000 SUPERCEDES DRAWINGS 110-P1K-CD00-10001-000 THROUGH 110-P1K-CD00-10010-000

INFORMATION ONLY

THIS DRAWING IS PRELIMINARY AND NOT INTENDED FOR CONSTRUCTION, PROCUREMENT OR FABRICATION.		DESIGN INPUTS SEE DOCUMENT INPUT REFERENCE SYSTEM (DIRS)	
APPROVALS DRAWN BY: U.EKS CHECKED BY: T.SAUER DATE: 12/14/00		U.S. DEPARTMENT OF ENERGY Office of Repository Development (ORD) Management and Operation of the Office of SAIC SAIC DRY TRANSFER FACILITY #1 / REMEDIATION FACILITY GENERAL ARRANGEMENT LEGEND AND GENERAL NOTES	
VERIFICATION DESIGN LEAD ENGINEER: F.BASAMANOWICZ QUALITY ENGINEERING REP: [Signature] PROJECT ENGINEER: J.ANDERSEN		SIZE: D SCALE: NONE DOCUMENT IDENTIFIER: 110-P1K-WHS0-00101-000-00A SAFETY CATEGORY: N/A CASE FILENAME: 110p1a0101.dgn SHEET: 1 of 42	
ISSUED FOR DESIGN DEVELOPMENT DATE: 12/10/00 BY: TS CHK: [Signature] APP: [Signature]		ARCH D - 24"x36" RECORD DESIGNATOR: 0A: N/A

GROUND FLOOR PLAN B
110-P1K-WHS0-00109-000GROUND FLOOR PLAN D
110-P1K-WHS0-00111-000POOL FLOOR PLANS
110-P1K-WHS0-00111-000
110-P1K-WHS0-00124-000

INFORMATION ONLY

THIS DRAWING IS PRELIMINARY AND NOT
INTENDED FOR CONSTRUCTION, PROCUREMENT
OR FABRICATION.

APPROVALS		INITIAL/DATE
DESIGNED BY	W. GUE	12/14/03
DESIGNED BY	T. SAUER	12/14/03
CHECKED BY		
DESIGNED BY	F. BASAMONWICZ	12/14/03
CHECKED BY	J. ANDERSEN	12/14/03

U.S. DEPARTMENT OF ENERGY
Office of Repository Development (ORD)
BECHTEL Management and Operation of the Office of
SAIC Civilian Radioactive Waste Management Program

DRY TRANSFER FACILITY #1
/REMEDATION FACILITY
GENERAL ARRANGEMENT
GROUND FLOOR KEY PLAN

SCALE: 1"=30'-0"

PROJECT IDENTIFIER: 110-P1K-WHS0-00102-000-00A

SHEET: 2

FILE NAME: 110p1a0102.dgn

ARCH: 0 - 24"x36"

RECORD DESIGNATOR: OA: N/A

- NOTES:
1. FOR DRAWING INDEX, LEGEND & GENERAL NOTES SEE 110-P1K-WHSO-00101-000-00A.
 2. ALL PERIMETER CONCRETE WALLS ARE 4'-6" THICK. ALL INTERIOR CONCRETE WALLS ARE 4'-0" UNLESS NOTED OTHERWISE (UNO).

INFORMATION ONLY

THIS DRAWING IS PRELIMINARY AND NOT INTENDED FOR CONSTRUCTION, PROCUREMENT OR FABRICATION.

APPROVAL	INITIALS/DATE
DRAWN BY	S. GODEAUX
DESIGNED BY	T. SAUER
CHECKED BY	F. BASAMANOWICZ
VERIFIED BY	J. ANDERSEN

U.S. DEPARTMENT OF ENERGY
Office of Repository Development (ORD)
BROCKTON, MA
Management and Operation of the Office of
SAIC, Inc., Civilian Radioactive Waste Management Program

DRY TRANSFER FACILITY #1
/REMEDICATION FACILITY #1
GENERAL ARRANGEMENT
GROUND FLOOR PLAN D

NO.	DESCRIPTION	DATE	BY	CHK	VER	REV	APP
00A	ISSUED FOR DESIGN DEVELOPMENT	12-12-03	SA	TS	FB		

GRAPHIC SCALE
0 10 20 40 60 FEET
1" = 20'

ARCH D - 24"x36" RECORD DESIGNATOR QA: N/A

- NOTES:
1. FOR DRAWING INDEX, LEGEND & GENERAL NOTES SEE 110-P1K-WHSO-00101-000-00A.
 2. ALL PERIMETER CONCRETE WALLS ARE 4'-6" THICK. ALL INTERIOR CONCRETE WALLS ARE 4'-0" UNLESS NOTED OTHERWISE (UNO).

NO.	DESCRIPTION	DATE	BY	CHK	APP	REV	DATE	DESCRIPTION
00A	ISSUED FOR DESIGN DEVELOPMENT	12/14/03	RP	TS	28			
001								
002								
003								
004								
005								
006								
007								
008								
009								
010								

THIS DRAWING IS PRELIMINARY AND NOT INTENDED FOR CONSTRUCTION, PROCUREMENT OR FABRICATION.

DESIGNED BY R. PAVELKA	INITIALS/DATE RP/4/03	U.S. DEPARTMENT OF ENERGY Office of Repository Development (ORD) Management and Operations of the Office of SAIC Civilian Radioactive Waste Management Program
DRAWN BY T. SAUER	INITIALS/DATE TS/4/03	
CHECKED BY		
VERIFIED BY		
DESIGN LEAD ENGINEER F. BASAMONWICZ	INITIALS/DATE FB/4/03	DRY TRANSFER FACILITY #1 /REMEDICATION FACILITY GENERAL ARRANGEMENT POOL FLOOR PLAN A
QUALITY ENGINEERING REP		
PROJECT ENGINEER J. ANDERSEN	INITIALS/DATE JA/12/03	
SIZE D	SCALE 1"=20'-0"	DOCUMENT IDENTIFIER 110-P1K-WHSO-00124-000-00A
SAFETY CATEGORY N/A	CAD FILE NAME 110p1A0124.dgn	SHEET 24
CASE CODE		

ARCH D - 24"x36" RECORD DESIGNATOR OA: N/A

NOTES:

1. FOR DRAWING INDEX, LEGEND & GENERAL NOTES SEE 110-P1K-WHS0-00101-000-00A.
2. ALL PERIMETER CONCRETE WALLS ARE 4'-6" THICK. ALL INTERIOR CONCRETE WALLS ARE 4'-0" UNLESS NOTED OTHERWISE (UNO).

SECTION P
9.11.13.15.17.19.21.23

INFORMATION ONLY

THIS DRAWING IS PRELIMINARY AND NOT
INTENDED FOR CONSTRUCTION, PROCUREMENT
OR FABRICATION.

DESIGN BY R. PAVELKA		DATE 12/14/03	U.S. DEPARTMENT OF ENERGY Office of Repository Development (ORD)	
ORIGINATOR T. SAUER		DATE 12/14/03	BRIEFING SAIC	
CHECKER			Management and Operation of the Office of Civilian Radioactive Waste Management Program	
VERIFICATION			DRY TRANSFER FACILITY #1 /REMEDICATION FACILITY GENERAL ARRANGEMENT SECTION P	
DESIGN LEAD ENGINEER F. BASAMANDWICZ		DATE 12/14/03	REVISIONS	
QUALITY ENGINEERING REP			110-P1K-WHS0-00141-000-00A	
PROJECT ENGINEER J. ANDERSEN		DATE 12/14/03	110p1a0141.dgn	
SAFETY CATEGORY N/A			41	
DATE CODE			1	

ARCH D - 24"x36"

RECORD DESIGNATOR QA: N/A

13-JUL-2003 16:23