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Acronyms List

ACD	Advanced Conceptual Design
ALARA	As low as reasonably achievable
BP	bottom plate
BWR	boiling water reactor
CSC	Canister Staging Cell
CDA	Controlled Data Assumptions
CDB	Characteristics Data Base
CFR	Code of Federal Regulations
Ci	curie
cm	centimeters
DC	disposal container
DBF	design basis fuels
DDCC	Decontaminate Disposal Container and Cart
DI	Document Identifier
DOE	U. S. Department of Energy
DBE	design basis event
DR	dose rate
DOT	U. S. Department of Transportation
EDE	effective dose equivalent
EMM	electromechanical manipulator
EPA	Environmental Protection Agency
GROA	Geologic Repository Operations Area
GWd	Giga-Watt-Day
g	grams
HLW	high-level waste
hr	hour
IBM	International Business Machine
IOC	interoffice correspondence
LWR	light water reactor
MeV	million-electron-volts
MGDS	Mined Geologic Disposal System
MPC	multi-purpose canister
mrem	milli-roentgen-equivalent-man
MTBF	mean time between failures
MTIHM	metric-tons-initial-heavy metal
MTTR	mean time to repair
MTU	metric-tons-uranium
MWd	mega-watt-day
NRC	Nuclear Regulatory Commission
OG	operating gallery
%BUSY	percent busy - percent of time equipment is busy
PC	personal computer

PM	prime mover
PWR	pressurized water reactor
QA	quality assurance
QAP	Quality Assurance Procedures
QARD	Quality Assurance Requirements and Description
QC	quality control
Qty	quantity
RDRD	Repository Design Requirements Document
Sec	second
SFA	spent fuel assembly
SNF	spent nuclear fuel
SFP	spent fuel pool
SQR	Software Qualification Report
TBD	to be determined
TBV	to be verified
TD	total dose
TTP	top tie plate
UGA	underground airlock
VF	volume fraction
WHB	Waste Handling Building
WHSCA	Waste Handling Systems Configuration Analysis
WP	waste package
WWS	Assembly Waste Staging
yr	year

1. PURPOSE

The objective of this analysis is to perform a dose assessment for normal and off-normal waste handling operations and to identify to the Repository Surface Design Group those operations that should be modified to further reduce occupational radiation exposure. The normal and off-normal waste handling operations are associated with the Mined Geologic Disposal System (MGDS) Waste Handling Building (WHB) and Carrier Prep Building operations from the arrival of a cask on-site to the exit of the disposal container (DC) from the WHB.

This analysis will include work presented in the Preliminary Dose Assessment for the MGDS Surface Facility Waste Handling Operations (Reference 5.1) and incorporate waste handling operations as identified in the Waste Handling Building - Concept of Operations (Reference 5.3). The Waste Handling Systems Configuration Analysis (WHSCA) (Reference 5.2) uses both wet and dry environments for spent fuel handling and a dry environment only for canistered waste and waste package (WP) handling. The WHSCA identified: 1) outage frequencies and outage time estimates associated with the equipment used in the waste handling operations, 2) task time and staffing estimates which were used to estimate dose, and 3) three wet and two dry lines..

“Failure” and/or off-normal waste handling operations for the purpose of this analysis are defined as an expected malfunction of equipment occurring during an operation, which halts the operation, but is recoverable within a limited duration, as identified in the WHSCA. Design basis events (DBE) and operational failures, which are expected to result in major delays and therefore additional radiological exposure, are not within the scope of this analysis.

2. QUALITY ASSURANCE

An activity evaluation has been performed in accordance with QAP-2-0 and has determined that the Quality Assurance (QA) Program applies to this analysis. The classification of permanent items described in QAP-2-3 Classification of Permanent Items has not been performed for the Waste Handling Systems and Facilities discussed in this analysis. However, the Waste Handling Systems and Facilities are identified as “Q” in the project Q-List (Reference 5.9) by direct inclusion. Therefore, the items addressed in this analysis will be treated as Q items and are subject to the requirements of the Quality Assurance Requirements and Description (QARD) (Reference 5.8) because they affect items on the Q-List. Therefore, as specified in NLP-3-18, this activity is subject to QA Controls.

Although the conclusions of this analysis will provide preliminary estimates of radiological exposure for operations in the MGDS Waste Handling Facilities, they are considered preliminary and can not be used as input into documents supporting procurement, fabrication or construction. Definitive calculations will be made in later phases of the design when configurations are known which will verify the radiological safety of the system. Therefore, the formal TBV and TBD tracking system described in NLP-3-15, To be Verified (TBV) and To Be Determined (TBD) Monitoring System, is not applicable. Any data from this analysis that is used as design input must be treated as

unconfirmed (TBV) and tracked per NLP-3-15 prior to inclusion in documents supporting fabrication, procurement, or construction.

3. METHOD

3.1 GENERAL METHODOLOGY

The methodology of this analysis used the factors of time, distance, and dose rate to determine the anticipated doses that would be received by personnel in various stages of normal waste handling operations and off-normal operations (maintenance) associated with the equipment used in the WHB waste handling operations.

The method used predefined operational sequences for the various stages of the WHB waste handling operations. The operational sequences used were provided by mechanical personnel and are documented in previous studies (Reference 5.1 and Reference 5.3). The Waste Handling Operational Steps normal operations will be divided into the following five categories:

- 1) Staging Waste Handling System
- 2) Carrier Bay Waste Handling System
- 3) Canister Waste Handling System
- 4) Assembly Waste Handling System
- 5) DC Waste Handling System

The Total Dose (TD) or yearly cumulative dose for each of the five categories listed above were determined and then summarized.

The TD associated with off-normal (maintenance) operations as defined in the WHSCA (Reference 5.2) were determined and added to the total dose.

3.2 CATEGORY-SPECIFIC METHODOLOGY

The dose rate used for the Staging and Carrier Bay Waste Handling Operations was based on the shielding results for the NAC-STC cask (Reference 5.14). The NAC-STC shielding analysis (Reference 5.14, Section 5.4) provided a contact dose rate, a 1 meter (3.28 feet) dose rate from the side of the cask, and a 2 meter (6.6 feet) dose rate from the vehicle or 7.26 feet (see Assumption 4.3.13). These dose rates were then extrapolated out in the radial direction to 25 feet to provide data for the Staging and Carrier Bay Waste handling operations dose assessment that requires the dose rate out to 20 feet and the Carrier Bay crane maintenance platform that required the dose rate at 25 feet.

The Canister (Dry), Assembly (Wet) and the DC Waste Handling Operations required the determination of hours per shift per year. The method used to calculate the hours per shift per year is as follows:

- 1) The % busy is obtained for the appropriate piece of equipment from either Table V or Table VII of Reference 5.2.
If multiple pieces (lines) of equipment are present, then the average of the % busy is used.
- 2) The % busy is divided by 100 and then multiplied by 2080 hours per shift per year to obtain the hours per shift per year.
2080 hours per shift per year = 52 weeks per year times 40 hours per week per shift.

Different methodologies were used to calculate the total dose based upon the data available. The category specific methodology are described below for the five categories specified in Section 3.1:

3.2.1 The Staging Waste Handling System

The Staging Waste Handling System consists of operational steps and task times associated with each waste handling operation (see Reference 5.1), from the arrival of a cask at the site boundary to the placement of the cask inside the WHB airlock.

The following parameters are obtained for the Staging Waste Handling Operations from Reference 5.1: 1) dose time (minutes), 2) persons per task, 3) occupation of personnel required, and 4) work distance (feet) from the radiation source. The dose rate (DR) in mrem/h, from the cask, at the work location is then applied.

A Lotus 1-2-3 spreadsheet is used to determine the Total Dose (TD) for each Staging Waste Handling Operation by using the following equation in Attachment I of this analysis:

$$TD = (\text{dose time}/60) \times (\text{number of personnel}) \times DR \text{ (at specified distance)}.$$

3.2.2 The Carrier Bay Waste Handling System

The Carrier Bay Waste Handling System consists of operational steps and the task time associated with each waste handling operation (see Reference 5.1), from the opening of the WHB Inside Airlock to the placement of the cask on the transfer cart.

The following parameters are obtained for the Carrier Bay Waste Handling Operation: 1) dose time (minutes), 2) persons per task, 3) occupation of personnel required, and 4) work distance (feet) from the radiation source (cask). The dose rate (DR) in mrem/h, from the cask, at the work location is then applied.

A Lotus 1-2-3 spreadsheet is used to determine the Total Dose (TD) for each Staging Waste Handling Operation by using the following equation in Attachment I of this analysis:

$$TD = (\text{dose time}/60) \times (\text{number of personnel}) \times DR \text{ (at specified distance)}.$$

3.2.3 The Canister (Dry) Waste Handling System

The Canister (Dry) Waste Handling operational steps and the task time associated with each waste handling operation are obtained from the WHSCA (Reference 5.2). The areas associated with the Canister (Dry) Waste Handling operations are: 1) Cask Prep (Dry), 2) MPC/HLW Transfer and 3) HLW/MPC Staging areas. The task time (hours per shift per year) for each of the Canister (Dry) Waste Handling Operations is obtained from the WITNESS Simulation Model (Reference 5.10 as described in the WHSCA, Reference 5.2). The task time is calculated based upon the %BUSY (percentage of time equipment is operating (busy) of the associated equipment. The following additional parameters are then established based on the following assumptions for each Canister Handling operational steps: 1) number of personnel required, 2) labor class of the personnel, 3) percentage of time working in area, and 4) the DR in mrem per hour at the work location.

The TD for the Canister Waste Handling Operation is then determined by using the following equation in Attachment II of this analysis:

$$TD = DR \times (\% \text{ Working in Area}/100) \times (\text{Number of Personnel}) \times (\text{hrs/shift/yr}) \times (\text{shifts/line}) \times (\text{lines})$$

where % Working in Area is defined as the percentage of time the personnel are working or exposed to the radiation source.

3.2.4 The Assembly (Wet) Waste Handling System

The Assembly (Wet) Waste Handling operational steps and the task time associated with each waste handling operations are obtained from the WHSCA (Reference 5.2). The areas associated with the Assembly (Wet) Waste Handling Operations are: 1) Cask Prep and Wet Handling, 2) DC Staging and DC Load, and 3) DC Decontamination. The task time (hours per shift per year) for each is obtained for the Assembly (Wet) Waste Handling Operations from the WITNESS Simulation Model (Reference 5.10) as described in the WHSCA (Reference 5.2). The task time is calculated based upon the percent busy of the associated equipment from Table V of Reference 5.2. The following parameters are then established based on the following assumptions for each Assembly (Wet) Waste Handling operational steps: 1) number of personnel required, 2) labor class of the personnel, 3) percentage of time working in area, and 4) the DR in mrem per hour at the work location.

The TD for each Assembly (Wet) Waste Handling Operation is then determined by using the following equation:

$$TD = DR \times (\% \text{ Working in Area}/100) \times (\text{Number of Personnel}) \times (\text{hrs/shift/yr}) \times (\text{shifts/line}) \times (\text{lines})$$

3.2.5 The DC Waste Handling System

The DC Waste Handling operational steps and the task time associated with each waste handling operations are obtained from the WHSCA (Reference 5.2). The areas associated with the DC Waste Handling Operations are: 1) DC Horizontalization, 2) DC Inspection, 3) WP Load, and 4) Airlock. The task time (hours per shift per year) for each is obtained for the DC Waste Handling Operations from the WITNESS Simulation Model (Reference 5.10 as described in the WHSCA ,Reference 5.2). The task time is calculated based upon the percent busy of the associated equipment from Table VII of Reference 5.2. The following parameters are then established based on the following assumptions for each DC Waste Handling operational steps: 1) number of personnel required, 2) labor class of the personnel, 3) percentage of time working in area, and 4) the DR in mrem per hour at the work location.

The TD for each DC Waste Handling Operation is then determined by using the following equation:

$$TD = DR \times (\% \text{ Working in Area}/100) \times (\text{Number of Personnel}) \times (\text{hrs/shift/yr}) \times (\text{shifts/line}) \times (\text{lines})$$

The TD for Staging, Carrier Bay, Canister (Dry) Waste, Assembly (Wet) and DC Waste Handling are added together to determine the total operational dose (mrem).

3.3 OFF-NORMAL OPERATION (MAINTENANCE)

The WHSCA identifies outage frequencies or off-normal operations and outage time estimates associated with the equipment used in the WHB waste handling operations. A remote or local tag is then associated with each equipment failure. On the basis of the remote or local tag, an associated dose rate in mrem per hour is then applied. The type and number of maintenance personnel associated with the recovery are estimated along with the number of hours those personnel are "exposed." The total dose for the recovery operation is determined by multiplying the exposure time by the dose rate associated with the repair times by the number of personnel exposed at the noted dose rates. The exposure time can be estimated from the mean time to repair (MTTR).

$$\text{Total Dose} = (\text{Exposure Time}) \times (\text{Dose Rate}) \times (6000/\text{MTBF}) \times \text{Qty.}$$

$$\text{Where } 6000 (\text{hours/yr}) = 8 \text{ hours/shift} \times 5 \text{ days/wk} \times 3 \text{ shifts/day} \times 50 \text{ wks/yr}$$

$$\text{MTTR} = \text{Mean Time To Repair (hr)}$$

$$\text{DR} = \text{Dose Rate (mrem/hr)}$$

$$\text{MTBF} = \text{Mean Time Between Failures}$$

$$\text{Qty} = \text{Quantity of Equipment in WHB}$$

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

The information shown as (TBV) identifies unqualified data. Consequently, the use of any data from this analysis for input into documents supporting procurement, fabrication, or construction is required to be controlled and tracked as TBV or TBD in accordance with NLP-3-15 or other appropriate procedures.

- 4.1.1 The waste arrival and emplacement schedules are discussed in Attachment IX of the WHSCA (Reference 5.2). [TBV]
- 4.1.2 The times to perform activities for waste handling operations in the WHB are found in Attachments II and III of this analysis. The source for these times is described in Attachments I and II of the WHSCA (Reference 5.2). [TBV]
- 4.1.3 The equipment outage frequency and outage times are shown in Table III-3-1 of Attachment III. The source for this data is described in Attachment X of the WHSCA (Reference 5.2). [TBV]
- 4.1.4 Table 4.1-1 contains the selected and calculated input parameters for this analysis.

Table 4.1-1. Input Parameters

	Parameter	Value	Data Source	TBV
1	Peak Year Waste Arrival Rate for Staging Operation	816 Casks	Attachment IX, Table 2 Reference 5.2	X
2	Average Year Waste Arrival Rate for Staging Operation	511 Casks	Attachment IX, Table 2 Reference 5.2	X
3	DCs emplaced/year	380 DCs emplaced/year	Ref 5.2, Att IX, Table 1	X
4	MPCs emplaced/year	300 MPCs emplaced /year	Ref 5.2, Att IX, Table 2	X
5	MPC Transfer Time (Total)	#60: 30 minutes #61: 30 minutes #62: 90 minutes #63: 80 minutes or 230 minutes (3.83 hours)	Ref. 5.2 Attachment I, - Ops #60, 61, 62 & 63.	X
6	MPC Transfer Time (Clean)	2.83 hours	Ref 5.2 Attachment I Ops #62 & 63	X
7	HLW Canisters emplaced/year	800 HLW Canisters emplaced/year	Ref 5.2, Att IX, Table 1(pg 2) & 2(pg 3)	X
8	DC Horizontalization time	120 minutes	Ref 5.2 Att I, Ops #24	X
9	Spent Fuel Machine(1)	37.87 % Busy	Ref 5.2 Att.V pg 7 SFA_MACH(1)	X
10	Spent Fuel Machine(2)	39.56 % Busy	Ref 5.2 Att.V pg 7 SFA_MACH(2)	X
11	Spent Fuel Machine(3)	36.36 % Busy	Ref 5.2 Att.V pg 7 SFA_MACH(3)	X
12	DC Load(1) - Wet Case	51.99 % Busy	Ref 5.2 Att.V pg 7 WST_CRAN(1)	X

	Parameter	Value	Data Source	TBV
13	DC Load(2) - Wet Case	54.13 % Busy	Ref 5.2 Att.V pg 7 WST_CRAN(2)	X
14	DC Load(3) - Wet Case	49.02 % Busy	Ref 5.2 Att.V pg 7 WST_CRAN(3)	X
15	DC Decon - Wet Case	3.98 % Busy	Ref 5.2 Att.V pg 4 DC_DECON(1)	X
16	DC Decon - Wet Case	4.1 % Busy	Ref 5.2 Att.V pg 4 DC_DECON(2)	X
17	DC Decon - Wet Case	3.7 % Busy	Ref 5.2 Att.V pg 4 DC_DECON(3)	X
18	WP Load - Wet Case	8.6 % Busy	Ref 5.2 Att.V pg 6 LOAD_WP	X
19	DC Inspection - Wet Case	12.9 % Busy	Ref 5.2 Att.V pg 4 DC_INSP	X
20	Cask Prep (Dry)	14.52 % Busy	Ref 5.2 Att.VII pg 3 CSK_PR_I(4)	X
21	Cask Prep (Wet) Total Time	#73: 150 minutes #74: 60 minutes #75: 60 minutes or 270 minutes (4.5 hours)	Ref 5.2 Att. II pg 2,3 & 4 Ops. 73, 74, & 75	X
22	Cask Prep (Wet) Manual	#73 Step 1: 20 minutes #73 Step 2: 20 minutes #73 Step 3: 10 minutes or 50 minutes (0.83 hours)	Ref. 5.2 Att. II pg 2 Steps 1,2 & 3 of Op.73.	X
23	Crane for the HLW and MPC operations	12.98 % Busy	Ref 5.2 Att.VII pg 6 WST_CRAN(4)	X
24	Facility annual operating time	40 hours per week x 50 weeks per year x 3 shift 6000 hours per year	Ref 5.2, pg 50	X
25	NAC-STC Dose Rates: Radial Surface Radial 1 m from cask Radial 2 m from vehicle	42.77 mrem/hr 19.48mrem/hr 7.96 mrem/hr	Ref 5.14, Table 5.1-10	X
26	NAC-STC Cask Diameter	87.6 inches (220.218 cm)	Ref 5.14 Drawing 800	X
27	SNF Peak Year Total	356 casks/yr	Ref 5.2, Att IX, Table 2	X

4.2 CRITERIA

This section documents the design criteria that are directly applicable to the assessment. Applicable requirements such as 10 CFR 20, Controlled Data Assumptions (CDA) (Reference 5.7), and the Repository Design Requirements Documents (RDRD) (Reference 5.6) are cited after each criteria. The RDRD requirements are restated in terms of what portion of each is addressed within the analysis.

- 4.2.1** The Surface Facilities that house radioactive materials or in which work is performed on radioactive materials will be designed to control occupational exposures to ALARA and less than 500 millirem per year.

Basis: Controlled Data Assumptions (CDA), DCS 003 (Reference 5.7)

- 4.2.2** The following criteria are based on information found in the RDRD (Reference 5.6).

- 4.2.2.1** The Surface Facilities that house radioactive materials or in which work is performed on radioactive materials shall, to the extent practicable, be designed and constructed to use procedures and engineering controls based upon sound radiation protection principles to achieve occupational doses and doses to members of the public that are as low as is reasonably achievable (ALARA). ALARA principles shall be based on the applicable sections of NRC Regulatory Guides 8.8 (Reference 5.11) and 8.10 (Reference 5.12).

[RDRD- 3.2.2.1.A]

- 4.2.2.2** The Surface Facilities design and operations shall include provisions for controlling doses such that, when approved operational procedures are followed, the exposure dose limits specified in 10 CFR 20.1201 for occupational doses, and 10 CFR 20.1301 for individual members of the public, are not exceeded.

[RDRD- 3.2.2.1.B]

- 4.2.2.3** The Surface Facilities shall be designed so that, until permanent closure has been completed, radiation exposures and radiation levels and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in 10 CFR 20 and environmental standards for radioactivity as established by the EPA and specified in this document.

[RDRD- 3.2.2.1.C]

- 4.2.2.4** If members of the public have access to controlled areas of the Surface Facilities, the limits for members of the public shall continue to be applicable to those individuals.

[RDRD- 3.2.2.2.B]

- 4.2.2.5** The (Geologic Repository Operations Area) GROA shall provide means to limit the levels of radioactive materials in effluents, during normal operations, anticipated occurrences, and under accident conditions.

[RDRD- 3.2.2.1.D]

Releases shall be limited as follows:

1. Under normal operations and anticipated occurrences, the annual dose equivalent to any real individual who is located beyond the controlled area must not exceed 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ as a result of exposure to: planned discharges of radioactive materials, radon and its decay products excepted, to the general environment; direct radiation from Repository operations; and any other radiation from uranium fuel cycle operations within the region. [TBV]

[RDRD- 3.2.2.1.D.1][TBV]]

4.3 ASSUMPTIONS

- 4.3.1** It is assumed that the Staging Waste Handling, as defined in this report, covers operation from cask arrival at MGDS boundary gate to cask arrival outside the WHB Carrier Bay Doors. [TBV]

Basis: Breakdown of WHB operations into specific areas (Reference 5.1).
Usage: Used throughout Attachment I of this report.

- 4.3.2** It is assumed that the Carrier Bay Waste Handling, as defined in this report, covers operation from opening the Carrier Bay Doors to securing the cask to the cart. [TBV]

Basis: Breakdown of WHB operations into specific areas (Reference 5.1).
Usage: Used throughout Attachment I of this report.

- 4.3.3** It is assumed that the Assembly Waste Handling which consist of 3 lines, as defined in this report, is equivalent to the Wet Waste Handling as stated in WHSCA (Reference 5.2) minus the Carrier Bay Operations and the DC Handling Operations. [TBV]

Basis: Breakdown of WHB operations for the Wet Waste Handling into specific areas as stated in WHSCA (Reference 5.2).
Usage: Used throughout Attachment II of this report.

- 4.3.4** It is assumed that the Canister Waste Handling which consist of 2 lines, as defined in this report, is equivalent to the Dry Waste Handling as stated in WHSCA (Reference 5.2) minus the Carrier Bay Operations and the DC Handling Operations. [TBV]

Basis: Breakdown of WHB operations for the Dry Waste Handling into specific areas as stated in WHSCA (Reference 5.2).
Usage: Used throughout Attachment II of this report.

- 4.3.5** It is assumed that the DC Waste Handling, as defined in this report, covers operations from opening the DC Storage Cell shield doors from either the Assembly Decon Cell or the Canister Load Cell to exiting of the Waste Package Transfer Cask from the WHB. [TBV]

Basis: Breakdown of WHB operations into specific areas (Reference 5.2).
Usage: Used throughout Attachment II of this report.

- 4.3.6** It is assumed that neutron exposure occurs during manual operation from cask arrival at MGDS gate until cask insertion into the wet handling pool or dry canister unload cell. [TBV]

Basis: Neutron exposure has to be accounted for during manual cask operations (10CFR20).
Usage: Used throughout the Staging and Carrier Bay Waste Handling Operations (Attachment 1, section 3.1 and 3.2) and the front-end of

the Canister and Assembly Waste Handling Operations (see Table II-1.6-1) where personnel are working in close proximity to a shipping cask.

- 4.3.7** For dose assessment purposes, the upper limit of 500 mrem per year has been assumed. The 500 mrem per year upper limit assumes continuous occupancy (40 hours per week for 50 weeks) at an exposure rate of 0.25 mrem per hour.

Basis: It is recognized that much lower average dose rates are expected in the operating corridors than the dose rate of 0.25 mrem per hour; however, the use of the upper limit will clearly identify trends /areas in the system where exposures will be able to be reduced by future design activities.

Usage: Used throughout the report and attachments.

- 4.3.8** For dose assessment it is assumed that the dose rate in operating corridors of the Waste Handling Building (WHB) is 0.25 mrem per hour at the operator station. [TBV]

Basis: This is a bounding assumption considering that 0.25 mrem per hour is at 1 cm outside the shield wall of the WHB operating corridors and would meet the dose criteria as stated in 4.3.9 (Reference 5.7).

Usage: Used throughout Attachment I dose rate calculations.

- 4.3.9** It is assumed that the Staging Waste Handling Operations are defined in Table 4.3-1. The table contains 1) the operational steps, 2) the dose time (minutes), 3) persons per task, and 4) occupation of person performing task. [TBV]

Basis: Rail Task Times - Operation List, pages 1-7 of Reference 5.3

Usage: Used in Attachment I - Dose Estimates for Staging Operations

Note: The terms "Radiologically Controlled Area" and "Dose Time" were used in Reference 5.1 and 5.3, portions of which are shown in Tables 4.3-1 and Table 4.3-2.. The Radiologically Controlled Area will be changed to "Controlled Area" in Attachment I as defined in 10 CFR 20. The Dose Time will be changed to "Exposure Time" in Attachment I.

Table 4.3-1. Staging Waste Handling Operations

Staging Operations	Dose Time (Minutes)	Persons/ Task	Persons/Occupation
Open security outer gate	1	1	Security officer
Shipment enters security	5	1	PM operator
Close security outer gate	1	1	Security officer
Perform security inspection	20	2	Security officer
Open security inner gate	1	1	Security officer
Shipment exits security	5	1	PM operator
Close security inner gate	1	1	Security officer
Take shipment to Radiologically Control Area gate	10	1	PM operator
Open Radiologically Control Area gate	1	1	Security officer

Table 4.3-1. Staging Waste Handling Operations, continued

Staging Operations	Dose Time (Minutes)	Persons/ Task	Persons/Occupation
Shipment enters Radiologically Control Area	5	1	PM operator
Close Radiologically Control Area gate	1	1	Security officer
Park shipment in Radiologically Control Area parking	15	1	PM operator
Unhitch Off-Site Prime Mover	5	1	PM operator
Detach each rail car	20	1	Crew member
Hitch Site Prime Mover	5	1	PM operator
Take cask to Carrier Staging Shed	20	1	PM operator
Open Carrier Staging Shed door	1	1	Operator
Park cask in Carrier Staging Shed	10	1	PM operator
Unhitch Site Prime Mover	5	1	PM operator
Rad survey of shipment for 10 CFR 71.47	20	2	Health Physics Tech
Contam survey of car/Personnel Barrier for 10 CFR 71.87	30	2	Health Physics Tech
Retract Personnel Barrier	15	1	Operator
Contam survey of cask surfaces	30	2	Health Physics Tech
Inspect cask and car for damage	10	2	Operators
Impact Limiter Bolter comes to cask	5	1	Operator
Crane brings Impact Limiter band assembly to upper Impact Limiter	10	1	Crane Operator
Install band assembly on upper Impact Limiter	10	1	Crane Operator
	10	2	Operators
Tighten/torque band assembly	5	2	Operators
Raise crane until load cell indicates correct wt	5	1	Crane Operator
		1	Operator
De-torque & un-thread Impact Limiter bolts	25	1	Operator
Verify Impact Limiter to cask keys are free	5	1	Operator
Crane removes upper Impact Limiter to store on car	10	1	Crane Operator
	10	1	Operator
Secure upper Impact Limiter to car	5	1	Operator
Disconnect band assembly from Impact Limiter	5	2	Operators
Install band assembly on lower Impact Limiter	10	1	Crane Operator
	10	2	Operators
Tighten/torque band assembly	5	2	Operators
Raise crane until load cell indicates correct weight	5	1	Crane Operator
	5	1	Operator
De-torque & un-thread Impact Limiter bolts	25	1	Operator
Verify Impact Limiter to cask keys are free	5	1	Operator
Crane removes lower Impact Limiter to store on car	10	1	Crane Operator
	10	1	Operator
Secure lower Impact Limiter to car	5	1	Operator
Disconnect band assembly from Impact Limiter	5	2	Operators
Hitch Site Prime Mover to cask	5	1	PM operator
Cask exits Carrier Staging Shed	5	1	PM operator
Take cask to Waste Handling Building air lock	15	1	PM operator
Open air lock outer door	1	1	Operator
Cask enters air lock	5	1	PM operator
Close air lock outer door	1	1	Operator

4.3.10 It is assumed that the distance from the cask for each operational step of the Staging Operation is specified in Table 4.3-2. [TBV]

Basis: Most operations can be performed at a distance of 10 to 20 feet (see Reference 5.1). Certain operations required personnel to be in close proximity to the cask. These operations include but are not limited to 1) security inspection, 2) health physics surveys (radiation and contamination), and 3) certain cask prep operations see Reference 5.1.

Usage: Used in Attachment I - Dose Estimate for Staging Operations

Table 4.3-2. Staging Cask Work Distances

	Occupation	Work Distance
		(feet)
Open security outer gate	Security officer	20
Shipment enters security	PM operator	15
Close security outer gate	Security officer	20
Perform security inspection	Security officer	3
Open security inner gate	Security officer	20
Shipment exits security	PM operator	15
Close security inner gate	Security officer	20
Take shipment to Radiologically Control Area gate	PM operator	15
Open Radiologically Control Area gate	Security officer	20
Shipment enters Radiologically Control Area	PM operator	15
Close Radiologically Control Area gate	Security officer	20
Park shipment in Radiologically Control Area parking	PM operator	15
Unhitch Off-Site Prime Mover	PM operator	15
Detach each rail car	Crew member	15
Hitch Site Prime Mover	PM operator	15
Take cask to Carrier Staging Shed	PM operator	15
Open Carrier Staging Shed door	Operator	10
Park cask in Carrier Staging Shed	PM operator	15
Unhitch Site Prime Mover	PM operator	15
Rad survey of shipment for 10 CFR 71.47	Health Physics Tech	2
Contam survey of car/Personnel Barrier for 10 CFR 71.87	Health Physics Tech	2
Retract Personnel Barrier	Operator	5
Contam survey of cask surfaces	Health Physics Tech	2
Inspect cask and car for damage	Operators	5
Impact Limiter Bolter comes to cask	Operator	10
Crane brings Impact Limiter band assembly to upper Impact Limiter	Crane Operator	20
Install band assembly on upper Impact Limiter	Crane Operator	20
	Operators	2
Tighten/torque band assembly	Operators	2
Raise crane until load cell indicates correct wt	Crane Operator	20

	Occupation	Work Distance
		(feet)
	Operator	3
De-torque & un-thread Impact Limiter bolts	Operator	10
Verify Impact Limiter to cask keys are free	Operator	2
Crane removes upper Impact Limiter to store on car	Crane Operator	20
	Operator	5
Secure upper Impact Limiter to car	Operator	10
Disconnect band assembly from Impact Limiter	Operators	10
Install band assembly on lower Impact Limiter	Crane Operator	20
	Operators	2
Tighten/torque band assembly	Operators	2
Raise crane until load cell indicates correct weight	Crane Operator	20
	Operator	3
De-torque & un-thread Impact Limiter bolts	Operator	10
Verify Impact Limiter to cask keys are free	Operator	2
Crane removes lower Impact Limiter to store on car	Crane Operator	20
	Operator	5
Secure lower Impact Limiter to car	Operator	10
Disconnect band assembly from Impact Limiter	Operators	10
Hitch Site Prime Mover to cask	PM operator	15
Cask exits Carrier Staging Shed	PM operator	15
Take cask to Waste Handling Building air lock	PM operator	15
Open air lock outer door	Operator	10
Cask enters air lock	PM operator	15
Close air lock outer door	Operator	10

4.3.11 It is assumed that the Carrier Bay Waste Handling Operations are defined in Table 4.3-3. The table contains 1) the operational steps, 2) the dose time (minutes), 3) persons per task, and 4) occupation of person performing task. [TBV]

Basis: Rail Task Times - Operation List, pages 1-7 of Reference 5.3

Usage: Used in Attachment I - Dose Estimates for Carrier Bay Waste Handling Operations.

Table 4.3-3. Carrier Bay Waste Handling Operations

Carrier Bay Operations	Dose (time)	Persons / Task	Occupation
Open air lock inner door	1	1	Operator
Cask enters Carrier Bay	5	1	PM operator
Park cask in Carrier Bay nearest open prep	5	1	PM operator
Unhitch Site Prime Mover	5	1	PM operator
Loosen the two U-bolts	20	2	Operators
Crane removes one U-bolt to store on car	10	1	Crane Operator
	10	1	Operator
Crane takes second U-bolt to store on car	10	1	Crane Operator
	10	1	Operator

Carrier Bay Operations	Dose (time)	Persons / Task	Occupation
Loosen both rear saddle braces	10	2	Operators
Crane takes cask to prep	40	1	Crane Operator
	40	1	Spotter
Secure cask to cart	10	2	Operators
Clean top of cask	15	1	Operator
Remove drain and purge cover plate	5	1	Operator
Inspect O-ring seal on cover plate	1	1	Operator
Inspect O-rings on vent & drain quick disconnects	1	1	Operator
Connect vent port to Waste Handling Building off-gas system	1	1	Operator
Check cavity pressure and contamination	20	1	Operator
De-tension 32 lid bolts and remove bolts	120	1	Operator
Install three lifting lugs on lid	10	1	Operator
Open port room shield door	10	1	Operator
Take cask to port room	30	1	Operator
	30	1	Spotter
Close Port room Shield Door	10	1	Operator

4.3.12 It is assumed that the distance from the cask for each operational step of the Carrier Bay Operation is specified in Table 4.3-4. [TBV]

Basis: Most operations can be performed at a distance of 10 to 20 feet (see Reference 5.1). Certain operations required personnel to be in close proximity to the cask. These operations include but are not limited to 1) security inspection, 2) health physics surveys (radiation and contamination), and 3) certain cask prep operations see Reference 5.1.

Usage: Used in Attachment 1.

Table 4.3-4. Carrier Bay Cask Work Distances

Operational Steps	Occupation	Work Dist (feet)
Open air lock inner door	Operator	10
Cask enters Carrier Bay	PM operator	15
Park cask in Carrier Bay nearest open prep	PM operator	15
Unhitch Site Prime Mover	PM operator	15
Loosen the two U-bolts	Operators	2
Crane removes one U-bolt to store on car	Crane Operator	20
	Operator	5
Crane takes second U-bolt to store on car	Crane Operator	20
	Operator	5
Loosen both rear saddle braces	Operators	2
Crane takes cask to prep	Crane Operator	20
	Spotter	10
Secure cask to cart	Operators	2

Clean top of cask	Operator	2
Remove drain and purge cover plate	Operator	2
Inspect O-ring seal on cover plate	Operator	2
Inspect O-rings on vent & drain quick disconnects	Operator	2
Connect vent port to Waste Handling Building off-gas system	Operator	2
Check cavity pressure and contamination	Operator	10
De-tension 32 lid bolts and remove bolts	Operator	10
Install three lifting lugs on lid	Operator	10
Open port room shield door	Operator	10
Take cask to port room	Operator	10
	Spotter	10
Close Port room shield door	Operator	15

4.3.13 It is assumed that the gamma and neutron dose rate profile from a NAC-STC (Reference 5.14) transportation cask represents typical dose rate profiles of similar casks, not necessarily a bounding cask.

[TBV]

Basis: Table of dose rates at contact, 1 meter (3.28 feet) and sides 2 meter (6.6 feet) dose rate from the vehicle or 7.26 feet (Reference 5.14, Table 5.1-10).

Usage: Used throughout the Staging and Carrier Bay Waste Handling Operations and the front-end of the Canister and Assembly Waste Handling Operations where personnel are working in close proximity to a shipping cask.

Table 4.3-5. NAC-STC Cask Dose Rate vs. Distance

Feet	Dose Rate (mrem/hour)	Feet	Dose Rate (mrem/hour)
0	42.77	10	4.4
1	35	11	3.4
2	28	12	2.7
3	21	13	2.1
3.28	19.48	14	1.7
4	18	15	1.4
5	16	16	1.1
6	12	17	0.81
7	8.5	18	0.66
7.26	7.96	19	0.52
8	6.8	20	0.41
9	5.2	25	0.14

4.3.14 The following assumptions are made relative to the Assembly Handling operations:

4.3.14.1 Cask preparation and staging activities will be done using robotic and remote handling equipment (unless otherwise specified) in a shielded area consistent with as low as reasonably achievable (ALARA) practices.[TBV]

Basis: This is based on readily available remote/robotic technology in the nuclear industry. (Reference 5.5).

Usage: Used in Attachment I.

4.3.14.2 Approximately eleven feet of water will provide adequate gamma and neutron shielding for spent fuel elements. The water will also shield and contain alpha and beta radiation contamination sources and prevent radioactive particulate matter from becoming airborne. [TBV]

Basis: This is based on the proven nuclear power plant practice of using a pool for both a shield and a confinement for radionuclides (Reference 5.5, Section 7.5.3).

Usage: Wet Handling Operations dose assessment.

4.3.15 The following assumptions are made based on normal conduct of operations and operating philosophy in DOE nuclear facilities in order to estimate mean time between failure (MTBF) and mean time to repair (MTTR) for major equipment items and operations (as used in Attachment III):

4.3.15.1 Weekends are available for preventive maintenance. [TBV]

Basis: WHB operations are based on a 5-day work week, 3 shifts per day (Reference 5.2).

Usage: Used in Attachment III of this analysis.

4.3.15.2 The WHB is available 6,000 hours per year. [TBV]

Basis: WHB operations are based on a 5-day work week, 50 weeks per year and 24 hours per day schedule (Reference 5.2, pg 12).

Usage: Used in Attachment III of this analysis.

4.3.15.3 Adequate tools, spares, maintenance personnel, and equipment are readily available to immediately repair failed equipment. [TBV]

Basis: Since the WHB is used continuously 50 weeks per year, the facility must also be continuously maintained over its

operating life. Adequate resources are needed to ensure that repair times are bounded (Reference 5.2).

Usage: Used in Attachment III of this analysis.

4.3.16 The following assumptions are made based on maintenance operations in the Carrier Bay relative to work on the Carrier Bay Crane:

4.3.16.1 It is assumed that the work platform for the Carrier Bay Crane is at EL.125'0".

[TBV]

Basis: Elevation drawing of WHB first floor from Space Allocation Study (Reference 5.15)

Usage: Used throughout Attachment III, Section 3.2 evaluations.

4.3.16.2 It is assumed that a horizontal cask is located at EL. 100'0", or 25 feet from the Carrier Bay Crane work platform.

[TBV]

Basis: Elevation drawing of WHB first floor (Reference 5.15)

Usage: Used in Attachment III, Section 3.2 .

4.3.16.3 It is assumed that the ladder to the Carrier Bay Crane work platform area is located mid-plane of a rail cask on the south side of the WHB.

[TBV]

Basis: This assumption would provide the maximum dose rate to maintenance personnel required to climb the ladder to perform maintenance on the Carrier Bay Crane.

Usage: Used in Attachment III, Section 3.2 .

4.3.16.4 It is assumed that the time required for maintenance personnel to reach the Carrier Bay Crane access ladder or staircase is 10 minutes (0.167 hours).

[TBV]

Basis: Time maintenance personnel are exposed.

Usage: Used in Attachment III, Section 3.2 .

4.3.16.5 It is assumed that the time required for maintenance personnel to climb the ladder or staircase to reach the Carrier Bay Crane work platform is 1 minute (0.0167 hours).

[TBV]

Basis: Time maintenance personnel are exposed in climbing ladder to Carrier Bay Crane work platform.

Usage: Used in Attachment III, Section 3.2 .

4.3.16.6 It is assumed that the time required for health physics personnel to survey the Carrier Bay Crane work platform is 15 minutes (0.25 hours). [TBV]

Basis: Time health physics personnel are exposed doing survey of crane work platform.

Usage: Used in Attachment III, Section 3.2 .

4.3.16.7 It is assumed that the supervisor spends 30 minutes (0.5 hours) supervising maintenance personnel at the Carrier Bay Crane work platform. [TBV]

Basis: Time supervisory personnel is exposed.

Usage: Used in Attachment III, Section 3.2 .

4.3.16.8 It is assumed that the south wall of the WHB is located 609.6 cm (20') from the rail cask. [TBV]

Basis: WHB functional layout. (Reference 5.15)

Usage: Used in Attachment III, Section 3.2 .

4.3.16.9 It is assumed that the Carrier Bay will require ladders and walkways for recovery access to the overhead bridge crane and elevated platforms. [TBV]

Basis: Access requirement for maintenance on Carrier Bay bridge crane and platforms as specified in Reference 5.5, Section 7.5.3.

Usage: Used in Attachment III, Section 3.2 .

4.3.17 The following assumptions are made relative to the transportation casks:

4.3.17.1 It is assumed that the dose rates on the side of the cask not exceeding 200 mrem/h at contact with the cask surface and/or 10 mrem/h at 2 meters (6.6 feet) from the vertical planes projected from the outer edge of the vehicle are based on 49 CFR 173.441 and 10 CFR 71.47(c).

Basis: DOT radiological shipping requirements.

Usage: Used throughout Staging and Carrier Bay Waste Handling Operations Dose Assessment.

4.3.18 The following sections contains the labor classes, the percent working, and the assumed work area dose rate for operating stations inside the WHB.

Basis: The number of personnel (#), the labor class of the personnel and the percent working are based on Engineering judgement and experience at operating facilities. Dose rate (mrem/hr) for the operating corridor is based on Criterion 4.2.1 and Assumption 4.3.8 . Other dose rates are based on Assumption 4.3.13 and 4.3.17.1.

Usage: Used in Attachment II of this analysis.

4.3.18.1 The following assumptions are made relative to the Spent Fuel Pool (SFP) Handling Machine Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-6. SFP Assumptions

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	2	operators/SFP machine	100	0.25
2	1	QA/QC	100	0.25
3	1	Supervisor	10	0.25
4	1	Health Physics	1	0.25

4.3.18.2 The following assumptions are made relative to the Assembly (Wet) Waste Staging (WWS) and DC Load Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-7. Assembly WWS and DC Load Assumptions

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	2	Operators (WWS/DC)	100	0.25
2	1	QA/QC	100	0.25
3	1	Supervisor	10	0.25
4	1	Health Physics	1	0.25
Note: 2 Operators are present, 1 at each station.				

4.3.18.3 The following assumptions are made relative to the Decontaminate Disposal Container and Cart (DDCC) Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-8. DDCC Assumptions

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	2	Operators (WWS/DC)	25	0.25
2	1	QA/QC	5	0.25
3	1	Supervisor	1	0.25
4	1	Health Physics	0.5	0.25
Note: 2 Operators are present, 1 at each station.				

4.3.18.4 The following assumptions are made relative to the MPC Handling Operations with and without Staging - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-9 (a). MPC Handling Operations - w/o MPC Staging

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	1	Operators (MPC)	73.9*	0.25
2	1	QA/QC	50	0.25
3	1	Supervisor	5	0.25
4	1	Health Physics	1	0.25

* Based on WHSCA, see Attachment II, pg II-5.

Table 4.3-9(b). MPC Handling Operations - with MPC Staging

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	1	Operators (MPC)	50	0.25
2	1	QA/QC	25	0.25
3	1	Supervisor	5	0.25
4	1	Health Physics	1	0.25

4.3.18.5 The following assumptions are made relative to the HLW Canister Handling Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-10. HLW Assumptions

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	1	Operators (HLW)	100	0.25
2	1	QA/QC	100	0.25
3	1	Supervisor	5	0.25
4	1	Health Physics	1	0.25

4.3.18.6 The following assumptions are made relative to the Cask Prep/Decon Canister (Dry) Handling Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-11. Cask Prep/Decon Canister (Dry) Assumptions

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	2	Operators	90 (Remote)	0.25
2	2	Operators	10 (2 meters)	10
3	1	QA/QC	5	0.25
4	1	Supervisor	1	0.25
5	1	Health Physics	0.5	0.25

Note: It is assumed that the operators may be required to enter the Cask Prep/Decon Canister (Dry) area for manual operations. [TBV]

Basis: Manual operations may be required to align equipment utilized in the cask prep area.

4.3.18.7 The following assumptions are made relative to the Cask Prep/Decon Canister (Wet) Handling Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-12. Cask Prep/Decon Canister (Wet) Assumptions

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	2	Operators	100	0.25
2	1	Operator	18.52*	19
3	1	QA/QC	5	0.25
4	1	Supervisor	1	0.25
5	1	Health Physics	0.5	0.25
* Based on the WHSCA, see Table II-1.6-1.				

4.3.18.8 The following assumptions are made relative to the DC Horizontalization Handling Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-13. DC Horizontalization Assumption

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	2	Operators	100	0.25
2	1	QA/QC	50	0.25
3	1	Supervisor	10	0.25
4	1	Health Physics	10	0.25

4.3.18.9 The following assumptions are made relative to the DC Inspection Handling Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-14. DC Inspection Assumptions

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	2	Operators	100	0.25
2	1	QA/QC	50	0.25
3	1	Supervisor	10	0.25
4	1	Health Physics	10	0.25

4.3.18.10 The following assumptions are made relative to the WP Load Handling Operations - Dose Assessment. [TBV]

Labor classes, percent working, and the dose rate are:

Table 4.3-15. WP Load Assumptions

	#	Labor Class	Percent Working	Dose Rate (mrem/hr)
1	2	Operators	100	0.25
2	1	QA/QC	50	0.25
3	1	Supervisor	10	0.25
4	1	Health Physics	10	0.25

4.4 CODES AND STANDARDS

4.4.1 Code of Federal Regulations (CFR):

- Title 10 Energy, Part 20-Standards for Protection Against Radiation,
January 1, 1996.
- Title 10 Energy, Part 71- Packaging and Transportation of Radioactive Materials,
April 1996
- Title 49 Transportation, Part 173-Shippers -General Requirements For Shipments
and Packaging, October 1, 1994.

5. REFERENCES

Supporting Studies

- 5.1** *Preliminary Dose Assessment for the MGDS Surface Facility Waste Handling Operations*, DI:B00000000-1717-5705-00022, REV 01.
- 5.2** *Waste Handling Systems Configuration Analysis*, BCBD00000-01717-0200-00001 REV 00.
- 5.3** *Waste Handling Building - Concept of Operations*, DI:BCB000000-01717-5705-00004, REV 00.
- 5.4** *MGDS Subsurface Radiation Shielding Analysis*, DI:BCAE00000-01717-0200-0001 REV 00.
- 5.5** *Waste Handling Facilities Recovery Analysis*, DI:BCBD00000-01717-0200-00003 REV 00.

Project Documents

- 5.6 *Repository Design Requirements Document (RDRD)*, Yucca Mountain Site Characterization Project, YMP/CM-0023, REV 0, ICN 1.
- 5.7 *Controlled Design Assumptions Document (CDA)*, M&O Document Identifier B00000000-01717-4600-00032, REV 04, ICN 2.
- 5.8 *Quality Assurance Requirements and Description (QARD)*, U. S. Department of Energy, DOE/RW-0333P, REV 7.
- 5.9 *Q-List*, U.S. Department of Energy, YMP/90-55Q, Rev. 4, 2/17/97.

Software

- 5.10 *Software Qualification Report (SQR) for WITNESS v7.4*, C.S.C.I: 30012 v7.4, M&O Document Identifier 30012-2003, MI:300012-MO4-001, January 1997.

Guides

- 5.11 NRC Regulatory Guides 8.8, *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will Be ALARA*, Revision 3, June 1978 (Second Proposed Revision 4, Draft OP 618-4, 5/82)
- 5.12 NRC Regulatory Guide 8.10, *Operating Philosophy for Maintaining Occupational Exposure ALARA*, Revision 1-R, May 1977.

Other References

- 5.13 (Not used).
- 5.14 NAC-STC *Safety Analysis Report*, Revision 9A, April 1997.
- 5.15 *Surface Nuclear Facilities Space Program Analysis*, DI:BCBD00000-01717-0200-00012, REV 00.

6. USE OF COMPUTER SOFTWARE

Computational support software was used for spreadsheets. The spreadsheet calculations used in this analysis were performed using Lotus 1-2-3 Release 4 software.

7. DESIGN ANALYSIS

This analysis was divided into distinct areas of operation for the operational dose assessment as described in Section 3 of this report.

The Staging Waste Handling Operation consists of operations from the arrival of the shipping cask at the MGDS gate to the placement of the shipping cask in the WHB Airlock. Attachment I was used for the analysis of the Staging Waste Handling Operations. The cask peak and average year dose totals are shown in Table 7-1.

The Wet and Dry Simulation Input (see Attachments I and II of WHSCA (Reference 5.2)) started with the opening of the carrier bay doors. The Wet and Dry Simulation Input describes the activity and time required to perform the activity.

Attachment I is used to calculate the total dose in mrem for the Staging and Carrier Bay Waste Handling Operations.

Attachment II of this analysis was used to analyze the waste handling operation of the Waste Handling Building from the Cask Preparation Area to the exit of the waste package (WP) from the WHB. The dose results from Attachment II are shown in Table 7-1. Table 7-1 contains the WHB Operations, Dose (mrem/yr), and a column that indicates the source of the data listed in Column 2 of the same line.

Attachment III of this analysis was used to document the total dose per year for equipment failure repairs (major and minor). Maintenance is assumed to be performed in an area with the dose rate less than 0.25 mrem per hour (unless otherwise noted). The TD in mrem per year was calculated using the following formula:

$$TD = MTTR \times DR \times 6000/MTBF \times Qty,$$

Where MTTR = Mean Time To Repair (hr)
 DR = Dose Rate (mrem/hr)
 MTBF = Mean Time Between Failures
 Qty = Quantity of Equipment in WHB

The TD (mrem/yr) for the anticipated equipment failures is listed under Maintenance in Table 7-1. The dose assessment associated with major and minor equipment failures of the Carrier Bay Bridge Crane was calculated in Section 3.2 of Attachment III. The Carrier Bay has the potential of containing multiple sources (casks) and therefore required separate consideration. The dose assessment results for the major and minor repair of the Carrier Bay Bridge Crane are included under the maintenance section of Table 7-1.

Table 7-1. Waste Handling Building - Operational Dose Summary

Staging Operations	Total Dose (TD) (mrem/yr)	Source of Data
Peak Year Total	119,789	Attachment I, Table I-3-1
Average Year Total	75,015	Attachment I, Table I-3-1
Carrier Bay Operations		
Peak Year Total	54,019	Attachment I, Table I-3-2
Average Year	33,828	Attachment I, Table I-3-2
WHB Operations		
Spent Fuel Pool	5,521	Attachment II, Table II-1.1-1
WWS and DC Load	7,527	Attachment II, Table II-1.2-1
DDCC	60	Attachment II, Table II-1.3-1
MPC w/o MPC Staging	373	Attachment II, Table II-1.4-1
MPC - with MPC Staging	328	Attachment II, Table II-1.4-2
HLW w/o MPC Staging	273	Attachment II, Table II-1.4-3
Cask Prep/Decon (Canister)	618	Attachment II, Table II-1.5-1
Cask Prep (Assembly)	6,462	Attachment II, Table II-1.6-1
DC Horizontalization	171	Attachment II, Table II-1.7-1
DC Inspection	181	Attachment II, Table II-1.7-2
WP Load	121	Attachment II, Table II-1.7-3
Total WHB Operations	21,635	
Maintenance		
Major and Minor Maintenance	4,894	Attachment III, Table III-3-1

8. CONCLUSIONS

Due to the unqualified/unconfirmed input data used in this analysis the output/conclusions from this analysis cannot be used as input into documents supporting procurement, fabrication, or construction unless they are controlled and tracked as TBV or TBD in accordance with NLP-3-15.

The objective of this analysis was to perform a dose assessment for normal and off-normal waste handling operations and to identify to the Repository Surface Design Group those operations that should be modified to further reduce occupational radiation exposure based on an ALARA analysis which evaluates the cost of the design modification against the estimated dose reduction. The normal and off-normal waste handling operations are associated with WHB and Carrier Prep Building operations from the arrival of a cask on-site to the exit of the DC from the WHB.

Table 8-1 presents the Waste Handling Building - Operational Dose Summary for both normal and off-normal operations.

As shown in Table 8-1:

- 1) The peak year Staging Operations Total Dose (TD) is 119,789 mrem based on NAC-STC cask dose rates. The peak year TD for all waste handling operations is 200,337 mrem. The Staging Operations TD is therefore $119,789/200,337$ or 59.79 % of the total peak year dose.
- 2) The peak year Carrier Bay Operation TD is 54,019 mrem based on actual cask dose rates. The Carrier Bay Operations TD is therefore $54,019.20/200,337$ or 26.96 % of the total peak year dose.
- 3) The WHB Operations TD per year is 21,954 mrem. The WHB Operations TD is therefore $26,529/200,337$ or 13.24% of the total peak year dose in spite of the use of the highly conservative 0.25 mrem per hour dose rate assumption as discussed below.

The Surface Facilities will be designed to control occupational exposures ALARA and less than 500 mrem per year (Criteria 4.2.1). The upper limit of 500 mrem per year was assumed for the operating corridors of the WHB. The 500 mrem per year upper limit assumed continuous occupancy (40 hours per week for 50 weeks) at an exposure rate of 0.25 mrem per hour. It is recognized that much lower average dose rates are expected in the operating corridors than the assumed dose rate of 0.25 mrem per hour; however, the use of the upper limit will identify trends /areas in the system where exposures will be able to be reduced by future design activities.

Based on the assumed dose rate of 0.25 mrem per hour at the operator station in the operating corridor of the WHB and the hours per shift per year (see Attachment II) of equipment operation the Total Dose in mrem per year was calculated for each WHB Waste Handling Operation.

The majority of the dose in mrem that will be received by operation personnel in any one year occurs in the Staging (59.79%), Carrier Bay (26.96%), and Cask Prep (Assembly) Operations where under the current operational sequence personnel are required to be in close proximity to the shipping cask. By modifying the task time, distance from the cask, or the total number of operating personnel doing the task, the exposure from the high dose operations can be reduced. If the TD for an individual task is high, then the operator's work location, distance from the cask, time at the work location and shielding (if any) must be reevaluated.

An example of a task that should be reevaluated is preparation of the cask for insertion into the SFP (see Table II-1.6-1). The operators are required to be within 2 feet of the top of the cask in order to 1) clean and remove the cask port cover plates, 2) inspect seal and o-rings, 3) connect the cask vent/purge lines and filter units, and 4) open the vent/purge valves (Reference 5.2, Attachment II, Operation 73). By increasing the distance from the shipping cask or decreasing the time required to perform the operations cited above, the total exposure per shipping cask will be reduced. Another option would be to automate some of these operations, thereby increasing the distance between the shipping cask and operators. Another option would be to move the inspection of the o-rings to cask preparation for shipment off-site when no fuel is in the cask.

Another example of a task that should be reevaluated is the performance of the security inspection, where two security guards are stationed only 2 feet from the shipping cask (see Table I.1-3-3, 4th operational step). By increasing the distance from the shipping cask or decreasing the time required to perform the security inspection, the total exposure per shipping cask can be reduced at little cost. Another option would be to remote this operation, thereby increasing the distance between the shipping cask and the security personnel.

Another high dose operation occurs when the Health Physics personnel are required to perform a contamination and radiation survey within 2 feet of the shipping cask (see Table I-1-3-3, steps 20 & 21). This task could be performed from a greater distance by using a teletector or other similar radiation detector. This operation could also be automated if a station is provided where radiation surveys are taken using stationary and movable detectors.

Table 8-1. Waste Handling Building - Operational Dose Summary

Staging Operations	Total Dose (TD) (mrem/yr)
Peak Year Total	119,789
Average Year	75,015
Carrier Bay Operations	
Peak Year	54,019
Average Year	33,828
WHB Operations	
Spent Fuel Pool	5,521
WWS and DC Load	7,527
DDCC	60
MPC w/o MPC Staging	373
MPC - with MPC Staging	328
HLW w/o MPC Staging	273
Cask Prep/Decon (Canister)	618
Cask Prep (Assembly)	6,462
DC Horizontalization	171
DC Inspection	181
WP Load	121
WHB Operations	21,635
Maintenance	
Major and Minor Maintenance	4,894
Peak Year TD (All WHB Operations)	26,529
Peak Year Grand Total (Staging Peak Year + Carrier Peak Year + WB All Ops)	200,337

It is recommended that for the Staging and Carrier Bay Waste Handling operations and other operations where the TD is high, then other methods should be implemented (e.g., reducing the time, increasing the distance away from the source, or remoting the operation) by the Surface Design Group to reduce the TD values given.

For comparative purposes, the information presented in Table 8-1 and Table 8-2, reinforces the need to concentrate design efforts to optimize the personnel dose in the Staging and Carrier Bay Waste Handling Operations using ALARA principles.

Note: The staffing requirements for the surface facilities has not been defined.

If no other measures are implemented (e.g., reducing the time, increasing the distance away from the source, or remoting the operation), the number of personnel required to maintain the personnel dose less than 500 mrem per year for the Staging and Carrier Bay Operations is shown in Table 8.2. The number of personnel is calculated based on the total Peak Year (Dose) divided by 500 mrem per year. The resultant number of personnel is then rounded up. Example: for operators, the peak mrem per year dose is 74,817.00 . Dividing 74,817.00 by 500, 150 operators would be required to maintain the dose per operator less than 500 mrem.

Table 8-2. Staging and Carrier Waste Handling Operations - Personnel Requirements

	Labor Class	Dose per Shipment	Peak Shipment	Total Dose (TD)	Personnel Required <500 mrem/yr
1	Operators	73.55	816	74,817	150
2	Crane Operators	0.68	816	555	21
3	PM Operators	1.95	816	1,591	3
4	Crew Member	0.3	816	245	0
5	Health Physics	50.67	816	41,347	104
6	Security Officer	10.03	816	8,184	21
7	Spotter	3.38	816	2,758	6
		146.8	816	119,789	289

Table 8-3 contains a column showing the number of personnel required to maintain the personnel dose less than 500 mrem per year for the WHB Waste Handling Operations. If no other measures are implemented (e.g., reducing the time, increasing the distance away from the source, or remoting the operation), the number of personnel required is calculated based on the mrem per year divided by 500 mrem per year. The resultant number of personnel is then rounded up. Example: for spent fuel pool operators in line 1 of Table 8-3, the mrem per year dose is 3,550.23. Dividing 3,550.23 by 500, 8 operators would be required to maintain the dose per spent fuel pool operator less than 500 mrem. The mrem per year values in Table 8-3 are from Attachment II tables. The QA/QC, HP and Supervisor mrem per year is a summation of the tabulated results contained in Attachment II.

The staffing requirements for the surface facilities have not been defined and the staffing requirements stated in Tables 8-2 and 8-3 represent the number of personnel required to maintain operating exposures less than 500 mrem per year based on the current operating sequence, distance from source, and time performing the operation. As the design of the MGDS Surface Facilities progresses, the operation sequence must be reevaluated for ALARA considerations (e.g., reducing the time, increasing the distance away from the source, or remoting the operation) in order to keep the exposure to operating personnel ALARA and less than 500 mrem per year.

Table 8-3. Waste Handling Building (WHB) Waste Handling Operations
- Personnel Requirements

	Labor Class: Operators	Total Dose (TD)	Personnel Required <500 mrem/yr
1	Spent Fuel Pool	3,550	8
2	WWS and DC Load*	4,841	10
3	DDCC*	48	1
4	MPC w/o MPC Staging*	212	1
5	MPC - with MPC Staging*	299	1
6	HLW w/o MPC Staging*	287	1
7	Cask Prep/Decon (Canister (gamma)	618	2
9	Cask Prep (Assembly) (gamma)	6,438	13
11	DC Horizontalization*	127	1
12	DC Inspection*	134	1
13	WP Load*	45	1
Total Operators		16,599	40
	Labor Class: Other Personnel		
14	QA/QC	4,946	10
15	Health Physics	72	1
16	Supervisor	492	1
* These are based upon maximum dose rates which are recognized to be higher than expected in this facility. They however represent only a small fraction of the total dose.			

9. ATTACHMENTS

- I Dose Estimates for Staging/Carrier Bay Operations
- II WHB Operations Dose Assessment
- III Dose Estimates for Equipment

Dose Estimates for Staging/Carrier Operations**1. PURPOSE**

The purpose and objective of this analysis is to calculate the total dose in mrem for the Staging and Carrier Bay Operations.

2. SUMMARY

This analysis provided preliminary dose estimates in mrem for total dose in mrem for the Staging Operations. The total Staging Waste Handling Operation and Carrier Bay Waste Handling Dose for peak and average years is shown in Table I-2-1.

Table I-2-1. Staging Operation Dose Summary

Cask Waste Arrival Rate		Dose (mrem/shipment)	Dose / Year (mrem/yr)
Peak	816	146.8	119,789
Average	511	146.8	75,015
Carrier Bay Dose Summary			
Peak	816	66.2	54,019
Average	511	66.2	33,828

If changes in the methods, operating times, work distance, dose rates, and number of personnel used are made, the results of this analysis should be revised.

3. METHOD

The method used to calculate the dose rate for the Staging and Carrier Bay Waste Handling categories is explained in Section 3.1 of this attachment for Staging Waste Handling and Section 3.2 of this attachment for Carrier Bay Waste Handling.

3.1 Staging Waste Handling Operations

Note: The information in Table I-3-3 is from Assumptions 4.3.9 and 4.3.10.

A description for each operational step of the Staging Waste Handling System is listed in Column 1 of Table I-3-3. The dose time in minutes for each operational step is listed in Column 2 of Table I-3-3. The dose time in minutes is the amount of time operating personnel are exposed. For the purposes of this calculation, the task time is equal to the dose time. The number of persons per task is listed in Column 3 of Table I-3-3. The occupation of the person performing the task is listed in Column 5 of Table I-3-3. The distance at which the person is working is listed in Column 6 of Table I-3-3.

Dose Estimates for Staging/Carrier Operations

The person hours (Column 4 of Table I-3-3) is defined as the number of persons (Column 3) multiplied by the dose time (Column 2) divided by 60 minutes per hour.

Assumption 4.3.13 contains a table of the dose rate versus distance in feet for the NAC-STC (Ref 5.14) transportation cask. The dose rate at the specified distance (Column 6) is listed in Column 7 of Table I-3-3.

The dose received (Column 8 of Table I-3-3) during this operational step is calculated by multiplying the person-hours in Column 4 by the dose rate in Column 7. The dose column is then summed to show a total dose of 146.8 mrem per cask.

From Table 7.4-5 of Ref 5.3, the peak and average year Waste Arrival Rates are 816 and 511 casks respectively. Based on the current operational times, personnel, sequence and waste arrival rates, the total dose (mr) per year is shown in Table I-3-1, Column 4.

Table I-3-1. Staging Operation Dose Summary

Cask Waste Arrival Rate		Dose (mrem/shipment)	Dose / Year (mrem/yr)
Peak	816	146.8	119789
Average	511	146.8	75015

3.2 Carrier Bay Waste Handling Operations

Note: The information in Table I-3-4 is from Assumptions 4.3.11 and 4.3.12.

A description for each operational step of the Carrier Bay Waste Handling System is listed in Column 1 of Table I-3-4. The dose time in minutes for each operational step is listed in Column 2 of Table I-3-4. The dose time in minutes is the amount of time operating personnel are exposed. The number of persons per task is listed in Column 3 of Table I-3-4. The occupation of the person performing the task is listed in Column 5 of Table I-3-4. The distance at which the person is working is listed in Column 6 of Table I-3-4.

The person hours (Column 4 of Table I-3-4) is defined as the number of persons (Column 3) multiplied by the dose time (Column 2) divided by 60 minutes per hour.

Assumption 4.3.13 contains a table of the dose rate versus distance in feet for the NAC-STC (Ref 5.14) transportation cask. The dose rate at the specified distance (Column 6) is listed in Column 7 of Table I-3-4.

The dose received (Column 8 of Table I-3-4) during this operational step is calculated by multiplying the person-hours in Column 4 by the dose rate in Column 7. The dose column is then summed to show a total dose of 66.20 mrem per cask.

Dose Estimates for Staging/Carrier Operations

From Table 7.4-5 of Ref 5.3, the peak and average year Waste Arrival Rates are 816 and 511 casks respectively. Based on the current operational times, personnel, sequence and waste arrival rates, the total dose (mr) per year is shown in Table I-3-2, Column 4.

Table I-3-2. Carrier Bay Dose Summary

Cask Waste Arrival Rate		Dose (mrem/shipment)	Dose / Year (mrem/yr)
Peak	816	66.2	54,019.20
Average	511	66.2	33,828.20

Table I-3-3. Staging Dose Assessment

Operational Steps	Exposure Time	Persons/	Person	Occupation	Grk Dist	Dose Rate	Total Dose	%	Cumulative
	(Minutes)	Task	Hours		(feet)	(MREM /H)	(MREM)	Total Dose	Percentage
Open security outer gate	1	1	0.017	Security officer	20	0.41	0.01	0.00	0.00
Shipment enters security	5	1	0.083	PM operator	15	1.40	0.12	0.08	0.08
Close security outer gate	1	1	0.017	Security officer	20	0.41	0.01	0.00	0.09
Perform security inspection	20	2	0.667	Security officer	3	21.00	14.00	9.54	9.63
Open security inner gate	1	1	0.017	Security officer	20	0.41	0.01	0.00	9.63
Shipment exits security	5	1	0.083	PM operator	15	1.40	0.12	0.08	9.71
Close security inner gate	1	1	0.017	Security officer	20	0.41	0.01	0.00	9.71
Take shipment to Controlled Area gate	10	1	0.167	PM operator	15	1.40	0.23	0.16	9.87
Open Controlled Area gate	1	1	0.017	Security officer	20	0.41	0.01	0.00	9.88
Shipment enters Control Area	5	1	0.083	PM operator	15	1.40	0.12	0.08	9.96
Close Controlled Area gate	1	1	0.017	Security officer	20	0.41	0.01	0.00	9.96
Park shipment in Control Area parking	15	1	0.250	PM operator	15	1.40	0.35	0.24	10.20
Unhitch Off-Site Prime Mover	5	1	0.083	PM operator	15	1.40	0.12	0.08	10.28
Detach each rail car	20	1	0.333	Crew member	15	1.40	0.47	0.32	10.60
Hitch Site Prime Mover	5	1	0.083	PM operator	15	1.40	0.12	0.08	10.68
Take cask to Carrier Staging Shed	20	1	0.333	PM operator	15	1.40	0.47	0.32	10.99
Open Carrier Staging Shed door	1	1	0.017	Operator	10	4.40	0.07	0.05	11.04
Park cask in Carrier Staging Shed	10	1	0.167	PM operator	15	1.40	0.23	0.16	11.20
Unhitch Site Prime Mover	5	1	0.083	PM operator	15	1.40	0.12	0.08	11.28
Rad survey of shipment for 10 CFR 71.47	20	2	0.667	Health Physics Tech	2	28.00	18.67	12.72	24.00
Contam survey of car/Personnel Barrier	30	2	1.000	Health Physics Techn	2	28.00	28.00	19.07	43.07
Retract Personnel Barrier	15	1	0.250	Operator	5	16.00	4.00	2.72	45.80
Contam survey of cask surfaces	30	2	1.000	Health Physics Techn	2	28.00	28.00	19.07	64.87
Inspect cask and car for damage	10	2	0.333	Operators	5	16.00	5.33	3.63	68.50
Impact Limiter Bolter comes to cask	5	1	0.083	Operator	10	4.40	0.37	0.25	68.75
Crane brings Impact Limiter band assembly to upper I	10	1	0.167	Crane Operator	20	0.41	0.07	0.05	68.80
Install band assembly on upper Impact Limiter	10	1	0.167	Crane Operator	20	0.41	0.07	0.05	68.85
	10	2	0.333	Operators	2	28.00	9.33	6.36	75.20
Tighten/torque band assembly	5	1	0.083	Operators	2	28.00	2.33	1.59	76.79
Raise crane until load cell indicates correct wt	5	1	0.083	Crane Operator	20	0.41	0.03	0.02	76.82
	5	1	0.083	Operator	3	21.00	1.75	1.19	78.01
De-torque & un-thread Impact Limiter bolts	25	1	0.417	Operator	10	4.40	1.83	1.25	78.06
Verify Impact Limiter to cask keys are free	5	1	0.083	Operator	2	28.00	2.33	1.59	79.65
Crane removes upper Impact Limiter to store on car	10	1	0.167	Crane Operator	20	0.41	0.07	0.05	79.70
	10	1	0.167	Operator	5	16.00	2.67	1.82	81.52
Secure upper Impact Limiter to car	5	1	0.083	Operator	10	4.40	0.37	0.25	81.77
Disconnect band assembly from Impact Limiter	5	2	0.167	Operators	10	4.40	0.73	0.50	82.27
Install band assembly on lower Impact Limiter	10	1	0.167	Crane Operator	20	0.41	0.07	0.05	82.31
	10	2	0.333	Operators	2	28.00	9.33	6.36	88.67
Tighten/torque band assembly	5	2	0.167	Operators	2	28.00	4.67	3.18	91.85
Raise crane until load cell indicates correct weight	5	1	0.083	Crane Operator	20	0.41	0.03	0.02	91.87
	5	1	0.083	Operator	5	16.00	1.33	0.91	92.78
De-torque & un-thread Impact Limiter bolts	25	1	0.417	Operator	10	4.40	1.83	1.25	93.12
Verify Impact Limiter to cask keys are free	5	1	0.083	Operator	2	28.00	2.33	1.59	94.71
Crane removes lower Impact Limiter to store on car	10	1	0.167	Crane Operator	20	0.41	0.07	0.05	94.76
	10	1	0.167	Operator	5	16.00	2.67	1.82	96.57
Secure lower Impact Limiter to car	5	1	0.083	Operator	10	4.40	0.37	0.25	95.01
Disconnect band assembly from Impact Limiter	5	2	0.167	Operators	10	4.40	0.73	0.50	95.51
Hitch Site Prime Mover to cask	5	1	0.083	PM operator	15	1.40	0.12	0.08	95.59
Cask exits Carrier Staging Shed	5	1	0.083	PM operator	15	1.40	0.12	0.08	95.67
Take cask to Waste Handling Building air lock	15	1	0.250	PM operator	15	1.40	0.35	0.24	95.90
Open air lock outer door	1	1	0.017	Operator	10	4.40	0.07	0.05	95.95
Cask enters air lock	5	1	0.083	PM operator	15	1.40	0.12	0.08	96.03
Close air lock outer door	1	1	0.017	Operator	10	4.40	0.07	0.05	96.08
Total							146.80		

Table I-3-4. Carrier Dose Assessment

Operational Steps	Dose Lim	Persons/	Person	Occupation	Work Dist	Dose Rate	Total Dose	%	Cumulative
	(Minutes)	Task	Hours		(feet)	(MREM/H)	(MREM)	Total Dose	Percentage
Open air lock inner door	1	1	0.017	Operator	10	4.40	0.07	0.11	
Cask enters Carrier Bay	5	1	0.083	PM operator	15	1.40	0.12	0.18	0.29
Park cask in Carrier Bay nearest open prep	5	1	0.083	PM operator	15	1.40	0.12	0.18	0.46
Unhitch Site Prime Mover	5	1	0.083	PM operator	15	1.40	0.12	0.18	0.64
Loosen the two U-bolts	20	2	0.667	Operators	2	28.00	18.67	28.20	28.84
Crane removes one U-bolt to store on car	10	1	0.167	Crane Operator	20	0.41	0.07	0.10	28.94
	10	1	0.167	Operator	5	16.00	2.67	4.03	37.10
Crane takes second U-bolt to store on car	10	1	0.167	Crane Operator	20	0.41	0.07	0.10	33.07
	10	1	0.167	Operator	5	16.00	2.67	4.03	32.97
Loosen both rear saddle braces	10	2	0.333	Operators	2	28.00	9.33	14.10	31.20
Crane takes cask to prep	40	1	0.667	Crane Operator	20	0.41	0.27	0.41	51.61
	40	1	0.667	Spotter	10	4.40	2.93	4.43	56.04
Secure cask to cart	10	2	0.333	Operators	2	28.00	9.33	14.10	70.14
Clean top of cask	15	1	0.250	Operator	2	28.00	7.00	10.57	80.72
Remove drain and purge cover plate	5	1	0.083	Operator	2	28.00	2.33	3.52	84.24
Inspect O-ring seal on cover plate	1	1	0.017	Operator	2	28.00	0.47	0.70	84.94
Inspect O-rings on vent & drain quick disconnects	1	1	0.017	Operator	2	28.00	0.47	0.70	85.65
Connect vent port to Waste Handling Building off-gas syste	1	1	0.017	Operator	2	28.00	0.47	0.70	86.35
Check cavity pressure and contamination	20	1	0.333	Operator	10	4.40	1.47	2.22	88.57
De-tension 32 lbd bolts and remove bolts	20	1	0.333	Operator	10	4.40	1.47	2.22	90.79
Install three lifting lugs on lbd	10	1	0.167	Operator	10	4.40	0.73	1.11	91.89
Open port room shield door	10	1	0.167	Operator	10	4.40	0.73	1.11	93.00
Take cask to port room	30	1	0.500	Operator	10	4.40	2.20	3.32	96.32
Close port room shield door	10	1	0.167	Operator	15	1.40	0.23	0.35	99.65
Total							66.20	100.00	100.00

Dose Estimates for Canister Handling Operations**1. DOSE ASSESSMENT**

The method used to calculate the hours per shift per year (see Table II-1) is as follows:

- 1) The % busy is obtained for the appropriate piece of equipment from either Table V or Table VII of Reference 5.2. If multiple pieces(lines) of equipment are present, then the average of the % busy is used.
- 2) The % busy is divided by 100 and then multiplied by 2080 hours per shift per year to obtain the hours per shift per year.

Unlike weekend shutdowns, in which all operations and equipment immediately stop for 48 hours (Saturday and Sunday), the "SHUTDOWN" schedule does not immediately direct that equipment in the WHB to halt operations. Instead, three actions occur which eventually result in all waste items either completing packaging operations and leaving the WHB or being stored in dedicated wet and dry storage locations. These three actions are:

- Arrivals of rail and truck casks are suspended.
- Rail and truck casks waiting in the parking lot do not enter the WHB.
- Empty DCs are not directed to the DC loading cells.

During the entire two-week period, equipment continues to be available for operation but remains idle for most of the period simply because of the stopping of casks and empty Disposal Containers into the building. Thus, the statistics indicating busy and idle utilization rates are based on the inclusion of this 80-hour period. The total available operating time per shift remains at:

$$8 \text{ hours/day} \times 5 \text{ days/week} \times 52 \text{ weeks/year} = 2080 \text{ hours/year}$$

References elsewhere in the WHSCA that refer to a 2000 hours/year operating time may incorrectly assume an immediate shutdown at the end of 50 weeks. However, the 24-36 hours of additional operations that occur at the beginning of this "Shutdown" period have little impact on the equipment operating statistics and very little impact of calculated personnel exposure levels.

1.1 Fuel Pool Operation**1.1.1 Objective**

The objective of this analysis was to perform a dose assessment for Spent Fuel Pool (SFP) Handling Machine Operations that are associated with the Mined Geologic Disposal System (MGDS) Waste Handling Building - Wet Handling Operations.

Dose Estimates for Canister Handling Operations

Table II-1. Hours per Shift per Year

Operation	Machine	% Busy ¹	2080	Hrs/shift/Yr	Used in Section
Spent Fuel Handling	SFA_MACH(1)	37.87			
	SFA_MACH(2)	39.56			
	SFA_MACH(3)	36.36			
		113.79			
		37.93	2080	788.94	1.1
DC Load	WST_CRAN(1)	51.99			
	WST_CRAN(2)	54.13			
	WST_CRAN(3)	49.02			
		155.14			
		51.71	2080	1075.68	1.2
DC Decon	DC_DECON(1)	3.98			
	DC_DECON(2)	4.1			
	DC_DECON(3)	3.7			
		11.78			
		3.93	2080	81.68	
Load WP	LOAD_WP	8.6	2080	178.9	1.8.5
DC Inspect.	DC_INSP	12.9	2080	268.32	1.8.4
Dry Cask Prep	CSK_PR_I(4)	14.52	2080	302.02	1.6.3
MPC Crane	WST_CRAN(4)	12.98	2080	269.98	1.4
¹ See Section 4.1 of the main analysis for reference information on % Busy values.					

1.1.2 Summary

The estimated annual exposure for a Spent Fuel Handling Machine Operations is 5521 mrem per year.

1.1.3 Spent Fuel Handling Machine - Operations Dose Assessment

The method used to calculate the dose rate for the Assembly (Wet) Waste Handling category is explained in Section 3.2.4 of the main analysis. The hours per shift per year for Column 6 are from Table II-1.

Table II-1.1-1. Spent Fuel Handling- Operations Dose Assessment

	#	Labor Class	Percent Working in Area	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/shift/yr	mrem/line/yr	Total Dose (mrem/yr)
1	2	Operators	100	0.25	788.94	394.47	1183.41	3550.23
2	1	QA/QC	100	0.25	788.94	197.235	591.71	1775.12
3	1	Supervisor	10	0.25	788.94	19.7235	59.17	177.51
4	1	Health Physics	1	0.25	788.94	1.97235	5.92	17.75
Total							1840.20	5520.61

Dose Estimates for Canister Handling Operations**1.2 Assembly Waste Staging****1.2.1 Objective**

The objective of this analysis was to perform a dose assessment for Wet Waste Staging Operations that are associated with the Mined Geologic Disposal System (MGDS) Waste Handling Building - Assembly Waste Handling Operations.

1.2.2 Summary

The estimated annual exposure for the Assembly Waste Staging Operations and the DC Load Operations is 7,527 mrem per year.

1.2.3 Wet Waste Staging and DC Load - Operations Dose Assessment

The method used to calculate the dose rate for the Assembly (Wet) Waste Handling category is explained in Section 3.2.4 of the main analysis. The hours per shift per year for Column 6 are from Table II-1.

Table II-1.2-1. WWS and DC Load Operations Dose Assessment

	#	Labor Class	Percent Working in Area.	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/shift /yr	mrem/ line/yr	Total Dose (mrem/yr)
1	1	Operators (WWS)	100	0.25	1075.68	268.92	806.76	2420.28
2	1	Operators (DC)	100	0.25	1075.68	268.92	806.76	2420.28
3	1	QA/QC	100	0.25	1075.68	268.92	806.76	2420.28
4	1	Supervisor	10	0.25	1075.68	26.892	80.68	242.03
4	1	Health Physics	1	0.25	1075.68	2.6892	8.07	24.20
Total							2509.02	7527.07

1.3 Assembly Line Decontaminate DC and Cart - Dose Assessment**1.3.1 Objective**

The objective of this Section of the analysis was to perform a dose assessment for the Assembly Line Decontamination of the DC and Cart Operations that are associated with the Mined Geologic Disposal System (MGDS) Waste Handling Building - Assembly Waste Handling Operations.

Dose Estimates for Canister Handling Operations**1.3.2 Summary**

The estimated annual exposure for the DDCC Operations is 60 mrem per year.

1.3.3 Decontamination of the DC and Cart Operations - Operator Dose Assessment

From Attachment IX of Reference 5.2, Table 1 - Assumed Waste Production Schedule for WHB Simulation the total number of disposal containers emplaced per year is 380. The number of Disposal Containers handled per Assembly line are therefore $380/3$ or approximately 127 disposal containers per line per year. If there are 3 shifts per day, 5 days per week, then there are $127/3 = 42.33$ disposal canisters per shift per year decontaminated. If one disposal container requires 2 hours for decontamination, then the total hours per shift per year required for decontamination is 42.33 times $2 = 84.66$ hours per shift per year. The 84.66 hours per shift per year is used in Column 6 of Table II-1.3-1.

The method used to calculate the dose rate for the DDCC Operation which is part of the Assembly (Wet) Waste Handling category is explained in Section 3.2.4 of the main analysis.

Table II-1.3-1. DDCC Operations Dose Assessment

	#	Labor Class	Percent Working in Area	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/shift /yr	mrem/ line/yr	Total Dose (mrem/yr)
1	1	Operators (WWS)	25	0.25	84.66	5.29	15.87	47.62
2	1	QA/QC	5	0.25	84.66	1.06	3.17	9.52
3	1	Supervisor	1	0.25	84.66	0.21	0.63	1.90
4	1	Health Physics	0.5	0.25	84.66	0.11	0.32	0.95
Total							20.00	60.00

1.4 Canister (Dry) Handling Operations**1.4.1 Decontaminate DC and Cart - Dose Assessment****1.4.1.1 Objective**

The objective of this section of the analysis was to perform a dose assessment for the Multi-Purpose Canister (MPC) and High Level Waste Canisters Handling (HLW) Operations, specifically with the dose associated with the operations for canister unload to the DC Load and/or Canister Stage Cell. These operations are associated with the Mined Geologic Disposal System (MGDS) Waste Handling Building - Canister Waste Handling Operations.

Dose Estimates for Canister Handling Operations**1.4.1.2 Summary**

The estimated annual exposure for the MPC Handling Operation without MPC Staging is 373 mrem per year. The estimated annual exposure for the MPC Handling Operation with MPC Staging is 328 mrem per year. The estimated annual exposure for the HLW Handling Operations is 273 mrem per year.

1.4.1.3 MPC Handling Operations- Operator Dose Assessment

From Attachment IX of Reference 5.2, Table 1 - Assumed Waste Production Schedule for WHB Simulation Model, the total number of MPCs emplaced per year is 300. The number of MPCs handled per Canister line is therefore $300/2$ or 150 disposal containers per line per year. If there are 3 shifts per day, then there are $150/3 = 50.00$ MPCs handled per shift per year (in a peak year). From Reference 5.2, Appendix I (Operations #60, 61, 62, & 63), the total time to unload a MPC from the cask and place the MPC inside a DC is 3.83 hours, then the total hours per shift per year required to unload the MPC from the cask is 50.00 times 3.83 = 191.50 hours per shift per year. The 191.50 hours per shift per year is used in Column 6 of Table II-1.4-1.

The percent working in an exposure area was determined by estimating the exposure time as follows:

- a) 30 minutes to stage empty DC.
- b) 30 minutes to transfer empty DC to DC Loading Station.
- c) 90 minutes to unload an MPC from the cask.
- d) 80 minutes to load MPC into DC.

Of the 3.83 hours required to perform the above operation (170 minutes, items c and d above) or 2.83 hours entail exposure from a MPC or MPC inside a DC. The ratio of $2.83/3.83 = 0.739$. The total dose per shift per year (mrem per shift per year) was determined by multiplying the number of personnel x (percent working in area/100) x (dose rate (mrem per hour) at the work location) x Labor (hours/shift/year). The total dose per shift per year (mrem per shift per year) was then multiplied by the number of shifts (3) to obtain the total dose (mrem per year) for a single DDCC Operations. The mrem/yr/line values are then multiplied by 3 lines to obtain the total dose (mrem per yr) for all the DDCC.

Table II-1.4-1: MPC Waste Handling - Operations Dose Assessment w/o MPC Staging

	#	Labor Class	Percent Working in Area.	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/shift/yr	mrem/line/yr	Total Dose (mrem/yr)
1	1	Operators (MPC)	73.9	0.25	191.5	35.38	106.14	212.28
2	1	QA/QC	50	0.25	191.5	23.94	71.81	143.63
3	1	Supervisor	5	0.25	191.5	2.39	7.18	14.36
4	1	Health Physics	1	0.25	191.5	0.48	1.44	2.87
Total							186.57	373.14

Dose Estimates for Canister Handling Operations

The method used to calculate the dose rate for the MPC Waste Handling - Operations Dose Assessment with MPC Staging which is part of the Canister (Dry) Waste Handling category is explained in Section 3.2.3 of the main analysis. The 269.98 hours per shift per year for Column 6 are from Table II-1.

Table II-1.4-2. MPC Waste Handling - Operations Dose Assessment with MPC Staging

	#	Labor Class	Percent Working in Area.	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/shift /yr	mrem/line/yr	Total Dose (mrem/yr)
1	1	Operators (MPC)	50	0.25	269.98	33.75	101.24	202.49
2	1	QA/QC	25	0.25	269.98	16.87	50.62	101.24
3	1	Supervisor	5	0.25	269.98	3.37	10.12	20.25
4	1	Health Physics	1	0.25	269.98	0.68	2.02	4.05
Total							164.01	328.03

1.4.1.4 HLW Canister Operations- Operator Dose Assessment

From Reference 5.2, Table 1 - Assumed Waste Production Schedule for WHB Simulation the total number of HLW canisters emplaced per year is 800. The number of HLW Canisters handled per Canister line are therefore $800/2$ or 400 disposal containers per line per year. If there are 3 shifts per day, then there are $400/3 = 134$ HLW Canisters handled per shift per year. From Attachment I of Reference 5.2 page 14, 30 minutes are required to transfer a HLW canister from the storage rack to the DC. The total time per shift per year for the transfer of HLW is therefore (30 minutes per transfer times/60 minutes per hour) x 134 HLW Canisters = 67 hours per shift per year.

The total dose per shift per year (mrem per shift per year) was determined by multiplying the number of personnel x (percent working in area/100) x (dose rate (mrem per hour) at the work location) x Labor (hours/shift/year). The total dose per shift per year (mrem per shift per year) was then multiplied by the number of shifts (3) to obtain the total dose (mrem per year) for a single DDCC Operations. The mrem/yr/line values are then multiplied by 3 lines to obtain the total dose (mrem per yr) for all the DDCC.

Table II-1.4-3. HLW - Operations Dose Assessment w/o MPC Staging

	#	Labor Class	Percent Working in Area.	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/shift /yr	mrem/line/yr	Total Dose (mrem/yr)
1	1	Operators	100	0.25	67	16.75	50.25	100.50
2	1	QA/QC	100	0.25	67	16.75	50.25	100.50
3	1	Supervisor	5	0.25	67	0.84	2.51	5.03
4	1	HP	1	0.25	67	0.17	0.50	1.01
Total							103.52	207.03

Dose Estimates for Canister Handling Operations**1.5 Cask Prep/Decon (Canister Line) - Operator Dose Assessment****1.5.1 Objective**

The objective of this section of the analysis was to perform a dose assessment for the Cask Prep/Decon (Canister Line) Handling Operations. These operations are associated with the Mined Geologic Disposal System (MGDS) Waste Handling Building - Cask Prep/Decon (Canister Line).

1.5.2 Summary

The estimated annual exposure for the Cask Prep/Decon (Canister Line) is 618 mrem per year.

1.5.3 Cask Prep/Decon (Canister Line) - Dose Assessment

The method used to calculate the dose rate for the Cask Prep/Decon (Canister Line) Operation which is part of the Canister (Dry) Waste Handling category is explained in Section 3.2.3. The cask prep area has 2 station per line (see Reference 5.2, Attachment II) and therefore 302.02/2 or 151.01 hours per shift per year per station. It has been assumed that the operator spends 90% of 151.01 or 135.91 hours per shift per year performing remote operations and 10% of 151.01 or 15.101 hours per shift per year within 2 meters of the cask. These hours per shift per year are used in Column 6 of Table II-1.6-1.

Table II-1.5-1. Cask Prep/Decon (Canister Line)
Operations Dose Assessment

	#	Labor Class	Percent Working in Area.	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/yr per station	mrem/yr per station per shift	Total Dose (mrem/yr)
1	2	Operators	90	0.25	151.01	6.80	13.59	13.59
2	2	Operators	10	10	151.01	302.02	604.04	604.04
3	1	QA/QC	5	0.25	151.01	0.19	0.38	0.38
4	1	Supervisor	1	0.25	151.01	0.04	0.08	0.08
5	1	Health Physics	0.5	0.25	151.01	0.02	0.04	0.04
						Total	618.12	618.12

1.6 Cask Prep/Decon (Assembly Line) - Operator Dose Assessment**1.6.1 Objective**

The objective of this section of the analysis was to perform a dose assessment for the Cask Prep/Decon (Assembly Line) Handling Operations. These operations are associated with the Mined Geologic Disposal System (MGDS) Waste Handling Building - Cask Prep/Decon (Assembly Line).

Dose Estimates for Canister Handling Operations**1.6.2 Summary**

The estimated annual exposure for the Cask Prep/Decon (Assembly Line) is 6462 mrem per year.

1.6.3 Cask Prep/Decon (Assembly Line) - Dose Assessment

From Reference 5.2, Attachment II pages 2, 3 and 4, the total time for Cask Prep/Decon (Assembly Line) is 270 minutes per cask (4.5 hours). Contact cask prep operations require 50 minutes (0.83 hours) at 2 feet from the cask. Table 2 of Reference 5.2 indicates 356 casks per year as the assumed waste production Schedule for the WHB Simulation. This would result in 4.5 hours per cask x 356 casks per year or 1602 hour per year. For 3 lines, this results in 1602/3 or 534 hours per line. For 3 shifts per day, this would result in 534/3 or 178 hour per shift per year. These hours per shift per year are used in Column 6 of Table II-1.7-1.

The method used to calculate the dose rate for the Cask Prep/Decon (Assembly Line) Operation which is part of the Assembly (Wet) Waste Handling category is explained in Section 3.2.4 of the main analysis.

Table II-1.6-1. Cask Prep (Assembly)
Operations Dose Assessment per Station

	#	Labor Class	Percent Working in Area.	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/yr per station	mrem/yr per station per shift	Total Dose (mrem/yr)
1	2	Operators	100	0.25	178	89.00	267.00	801.00
2	1	Operator	18.52	19	178	626.35	1879.04	5637.12
3	1	QA/QC	5	0.25	178	2.23	6.68	20.03
4	1	Supervisor	1	0.25	178	0.45	1.34	4.01
5	1	Health Physics	0.5	0.25	178	0.22	0.67	2.00
						Total	2154.72	6462.15

1.7 WP Operations**1.7.1 Objective**

The objective of this section of the analysis was to perform a dose assessment for the DC Horizontal Station, DC Inspection Station and the WP Load Station Operations that are associated with the Mined Geologic Disposal System (MGDS) Waste Handling Building - Assembly Waste Handling Operations.

1.7.2 Summary

The estimated annual exposure for the DC Horizontalization Station Operations is 171 mrem per year. The estimated annual exposure for the DC Inspection Station Operations is 181 mrem per year. The estimated annual exposure for the WP Load Station Operations is 121 mrem per year.

Dose Estimates for Canister Handling Operations**1.7.3 DC Horizontalization Operations - Operator Dose Assessment**

The method used to calculate the dose rate for the DC Horizontalization Operation which is part of the DC Waste Handling category is explained in Section 3.2.5 of the main analysis. The DC Horizontalization process is part of the transfer of the WP to the decon Cell. The total time to process one DC is 120 minutes (see Table 4.1-1). If 380 DC's are emplaced per year (see Table 4.1-1), then $380/3$, or 126.67 DCs, are emplaced per shift per year. The total time for the DC Horizontalization process is 120×126.67 , or 15,200.4 minutes per shift per DC per year, or 253.34 hours per shift per year. The 253.34 hours per shift per year is used in Column 6 of Table II-1.7-1.

Table II-1.7-1. DC Horizontalization Operation - Dose Assessment

	#	Labor Class	Percent Working in Area.	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/shift/yr	mrem/line/yr	Total Dose (mrem/yr)
1	2	Operators (WWS)	100	0.25	253.34	126.67	126.67	126.67
2	1	QA/QC	50	0.25	253.34	31.67	31.67	31.67
3	1	Supervisor	10	0.25	253.34	6.33	6.33	6.33
4	1	Health Physics	10	0.25	253.34	6.33	6.33	6.33
Total						171.00	171.00	171.00

1.7.4 DC Inspection - Operator Dose Assessment

The method used to calculate the dose rate for the DC Inspection Operation which is part of the DC Waste Handling category is explained in Section 3.2.5 of the main analysis. The 268.32 hours per shift per year for Column 6 are from Table II-1 and is used in Column 6 of Table II-1.7-2.

Table II-1.7-2. DC Inspection Operation - Dose Assessment

	#	Labor Class	Percent Working in Area.	Dose Rate (mrem/hr)	Labor: hrs/shift/yr	mrem/shift/yr	mrem/line/yr	Total Dose (mrem/yr)
1	2	Operators (WWS)	100	0.25	268.32	134.16	134.16	134.16
2	1	QA/QC	50	0.25	268.32	33.54	33.54	33.54
3	1	Supervisor	10	0.25	268.32	6.71	6.71	6.71
4	1	Health Physics	10	0.25	268.32	6.71	6.71	6.71
Total						181.12	181.12	181.12

Dose Estimates for Canister Handling Operations**1.7.5 WP Load - Operator Dose Assessment**

The method used to calculate the dose rate for the WP Load Waste Handling Operations which is part of the DC Waste Handling category is explained in Section 3.2.5 of the main analysis. The 178.9 hours per shift per year value from Column 5 of Table II-1 is used in Column 6 of Table II-1.7-3.

Table II-1.7-3. WP Load Operation - Dose Assessment

	#	Labor Class	Percent Working in Area	Dose Rate (mrem/hr)	Labor: hrs/shift/yr.	mrem/shift/yr	Total Dose (mrem/yr)
1	2	Operators (WWS)	100	0.25	178.9	89.45	89.45
2	1	QA/QC	50	0.25	178.9	22.36	22.36
3	1	Supervisor	10	0.25	178.9	4.47	4.47
4	1	Health Physics	10	0.25	178.9	4.47	4.47
						Total	120.76

Dose Estimates for Equipment Maintenance and Repair**1. PURPOSE**

The purpose and objective of this analysis is to calculate the total dose in mrem for equipment failure frequencies and equipment down time due to those failures (unplanned outages) associated with the Waste Handling Building (WHB) Handling lines.

2. SUMMARY

This analysis provided preliminary dose estimates in mrem, based on engineering judgement and fundamentals of WHB equipment MTBF and MTTR values for the Carrier Bay, Canister, Assembly, and DC handling lines. If changes in the operating times, availability data, or equipment used are made, the results of this analysis should be revised.

3. ANALYSIS**3.1 Equipment Failures Dose Analysis**

The definition of the equipment used, and equipment failure categories for both the dry and wet handling concepts, is presented in Tables 1 and 2 of Reference 5.2. Mean-time-to-repair (MTTR) is defined in Reference 5.2, page 50, and is the actual outage time to repair the equipment after each failure. Mean time between failure (MTBF) is defined in Reference 5.2, page 50, and represents a failure frequency. Equipment quantities are from Reference 5.2.

The WHSCA characterized expected equipment failures as major and minor. The major category consisted of those failures which have a relatively infrequent occurrence but results in a reasonably long outage time. The minor category consisted of those failures which happen relatively frequently but results in a relatively short outage time. Minor failures can occur locally, and are typically anticipated failures which were considered when designing the facility. Major equipment failures typically require equipment replacement and could require up to three days.

The next step required the assignment of a dose rate based upon an assessment of whether the repair would be performed locally or at a remote location. If the maintenance is performed in a remote location, then the dose rate assigned is 0.25 mrem per hour. With the MTTR as defined in the WHSCA, the estimated dose rate in mrem per hour was assigned as shown in Table III-4-1, and the total dose in mrem can be estimated for maintenance of each piece of major equipment as shown in Table III-3-1.

The equipment MTBFs and MTTRs are summarized in Tables 7.5-2 of Reference 5.2 for the dry and wet handling equipment, respectively. Table III-3-1 also contain a listing of the projected personnel required to perform the maintenance. The personnel categories are defined as follows:

Dose Estimates for Equipment Maintenance and Repair

SU	=	Supervisor
CO	=	Crane Operator
ME	=	Mechanical
HE	=	Helper
EE	=	Electrician
RG	=	Rigger
RM	=	Radiation Protection
DC	=	Decontamination
MS	=	Manipulator Specialist

Under each personnel position are listed the number of each type personnel required to perform the activity listed in the second column. Below the number of persons, is the number of hours each person is exposed. The next column contains the total number of personnel involved in the repair and the total exposure time in hours required for the repair. The total exposure time in hours required for the repair may be different than the MTTR number shown in Column 4.

The next to last column contains the calculated total dose per year associated with the maintenance activity for one piece of the specified equipment. This column is calculated as follows:

$$\text{Total Dose (mrem per year)} = (\text{Exposure time}) \times (\text{Dose Rate}) \times (6000/\text{MTBF})$$

where 6000 (hours/yr) = 8 hours/shift x 5 days/wk x 3 shifts/day x 50 wks/yr

The next to last column is then multiplied by the quantity (Qty) column to obtain the total dose for all the specified equipment.

3.2 Dose Assessment for Bridge Crane and Electromechanical Manipulator (EMM)

The method used to calculate the dose rate associated with the maintenance of major and minor equipment repairs is explained in Section 3.3 of the main analysis.

Table III-3-1. Major and Minor Maintenance

FAILURE CATEGORY	EQUIPMENT FAILURE	Qty.	MTBF (hr.)	MTTR (hr.)	Remote or Local	Dose Rate (mrem/hr)	Personnel										Total	Dose (mrem)	Dose / Yr (mrem)
							SU	CO	ME	HE	EE	RG	RM	DC	MS	Persons			
																hrs.			
1	Major Bridge Crane -Mechanical Repair	2	3000	24	Local hrs.	calc. (Table III-4-1)	1 2	1 2	1 7	1 7		2 2	1 4			7 24	45 (a)	90	
	Major Bridge Crane - Electrical Repair	2	3000	24	Local hrs.	calc. (Table III-4-1)	1 1	1 1		1 4	1 4	2 1	1 1			7 12			
2	Minor Bridge Crane -Mechanical Repair	2	1000	4	Local hrs.	calc. (Table III-4-1)	1 1	1 1	1 3	1 3		1 1	1 3			6 12	3.63 (b)	7	
	Minor Bridge Crane - Electrical Repair	2	1000	4	Local hrs.	calc. (Table III-4-1)	1 1			1 3	1 3		1 1			4 8			
3	Major Hot Cell Bridge Crane - Mechanical Repair	7	3000	72	Remote hrs.	0.25	1 4	1 2	1 10	1 10		2 3	2 4	2 2		10 35	36	252	
	Major Hot Cell Bridge Crane - Electrical Repair	7	3000	72	Remote hrs.	0.25	1 4	1 2		1 6	1 6	2 2	2 2	2 2		9 24			
4	Minor Hot Cell Bridge Crane - Mechanical Repair	7	1000	24	Remote hrs.	0.25	1 1	1 2	1 8	1 8		2 1	2 2	2 2		10 24	36	252	
	Minor Hot Cell Bridge Crane - Electrical Repair	7	1000	24	Remote hrs.	0.25	1 1	1 1		1 3	1 3	1 3	2 3	2 3		9 17			
5	Major In-Cell Hoist Crane - Mechanical (a)	14	6000	48	Remote hrs.	0.25	1 1	1 2	1 8	1 8			2 2	2 2		8 23	12	168	
	Major In-Cell Hoist Crane Electrical (a)	14	6000	48	Remote hrs.	0.25	1 1	1 2		1 6	1 6	1 1	2 2	2 1	1 4	10 23			
6	Minor In-Cell Hoist Crane - Mechanical	14	2000	12	Remote hrs.	0.25	1 1	1 2	1 6	1 6		1 1	2 1	2 4	1 1	10 23	9	126	
6	Minor In-Cell Hoist Crane Electrical	14	2000	12	Remote hrs.	0.25	1 1	1 2		1 2	1 2		2 1	2 2	1 1	9 10	9	126	
7	Major Transfer Cart -Mechanical	13	6000	8	Local hrs.	0.25	1 1	1 2	2 6	1 6		1 2	1 2			7 19	2	26	
	Major Transfer Cart - Electrical	13	6000	8	Local hrs.	0.25	1 1	1 1	1 1	1 3	1 3		1 1			6 10			
8	Major Dry SNF Transfer Machine	3	2000	72	Local hrs.	0.25	1 1	1 1	2 8	2 8	1 3	1 1	2 2	2 2	1 2	12 28	54	162	
9	Minor SNF Transfer Machine Mechanical	3	500	24	Local hrs.	0.25	1 1	1 1	1 4	1 4		1 1	1 1	2 2	1 2	9 16	72	216	
	Minor SNF Transfer Machine Electrical	3	500	24	Remote hrs.	0.25	1 1	1 1		1 4	1 4	1 1	1 1	2 2	1 2	9 16			
10	Major Port/Plug Shield Block	3	6000	48	Local hrs.	0.25	1 1	1 2	1 8	1 8	1 4	2 2	1 2	1 2	1 3	10 32	12	36	

Table III-3-1. Major and Minor Maintenance

FAILURE CATEGORY	EQUIPMENT FAILURE	Qty.	MTBF (hr.)	MTTR (hr.)	Remote or Local	Dose Rate (mrem/hr)	Personnel									Total Persons hrs.	Dose (mrem)	Dose / Yr (mrem)
							SU	CO	ME	HE	EE	RG	RM	DC	MS			
11	Major Contamination Barrier	3	6000	48	Local hrs.	0.25	1		1	1	1		1	1	1	7	12	36
							1		4	4	6		2	2	2	21		
12	Major Electro Mech. Manip.	15	4000	72	Remote hrs.	0.25	1	1	2		1	1	1	1	1	9	27	405
							1	2	8		4	2	2	2	3	24		
13	Minor Electro Mech. Manip.	15	1000	24	Remote hrs.	0.25	1			1	1		1			4	36	540
							1			4	4		1			10		
14	Major Lid Weld Machine	8	1000	48	Remote hrs.	0.25	1	1	1	2	1	2	2	2	2	14	3	23
							1	3	5	7	2	2	2	2	4	28		
15	Minor Lid Weld Machine	8	500	4	Remote hrs.	0.25	1	1	1	1	1	1	1	1	1	9	0	4
							1	1	1	2	2	1	1	2	1	12		
16	Major Decon System	7	1000	4	Local hrs.	0.25	1	1	1	1		1	1	1		7	6	42
							1	1	2	2		1	1	2		10		
17	Major Mobile Gantry	1	3000	48	Local hrs.	0.25	1	1	2	2	1	2	2	2	2	15	24	24
							1	1	8	12	4	1	6	2	4	39		
18	Minor Mobile Gantry	1	1000	8	Local hrs.	0.25	1	1		1	1	2	1			7	12	12
							1	1		2	2	1	1			8		
19	Major WP Transporter Not Part of Recovery Document	1	6000	48	Remote hrs.	0.25	1		1		1		1			4	12	12
																0		
20	Minor WP Transporter Not Part of Recovery Document	1	2000	4	Local hrs.	50.00 (c)	1		1				1			3	600	600
																0		
21	Major DC Horizontalizer	1	6000	72	Local hrs.	0.25	1	1	1	1		2	1			7	18	18
							2	2	8	8		2	1			23		
22	Minor Lid Severing System	6	1000	8	Remote hrs.	0.25	1	1	1	1			1	1		6	12	72
							1	1	2	2			1	1		8		
23	Major Isolation Door	45	6000	48	Local hrs.	0.25	1		1	2	1		1	1		7	12	540
							1		4	8	4		2	1		20		
24	Major Wet SNF Transfer	3	3000	24	Remote hrs.	0.25	1	1	1	2	1	1	2	2	2	13	12	36
							1	1	3	4		1	2	2	2	16		
25	Minor Wet SNF Transfer	3	1000	4	Remote hrs.	0.25	1	1	1	1	1	1	1	1		8	6	18
							1	1	4	4	2	1	2	1		16		
26	Major SNF Drying Vessel	6	3000	48	Remote hrs.	0.25	1	1	2		1	1	1	1		8	24	144
							1	2	6		2	1	2	2		16		
27	Minor SNF Drying Vessel	6	1000	4	Remote hrs.	0.25	1			1	1		1			4	6	36
							1			1	1		1			4		
27	Major Wet to Dry SNF Conveyor	5	6000	24	Remote hrs.	0.25	1		2	2			1	1		7	6	30
							1		6	6			3	3		19		
a) From Table III-4-1 Major Maintenance Total																	1233	4894
(b) From Table III-4-1 Minor Maintenance Total																		
© From WP Transporter Reference 5.4																		
Total																		

Table III-4-1. Major and Minor Bridge Crane Maintenance - Dose Assessment

Operation	Personnel	hr	cm from source	Dose Rate (mrem/hr) (see assumption 4.3.13)	Dose per trip	Number of trips	Total Dose (mrem)
Major Bridge Crane							
1) Mechanical personnel enters Carrier Bay from clean area and walks to ladder or staircase that leads to Carrier Bay work platform.	2	0.17	304.8	2.90	0.48	12	11.62
2) Mechanical personnel climb ladder or staircase to Carrier Bay work platform.	2	0.02	304.8	2.90	0.05	12	1.16
3) Mechanical personnel performing maintenance on Carrier Bay Crane.	2	7.00	792.5	0.10	0.69	12	16.46
4) Electrical personnel enters Carrier Bay from clean area and walks to ladder or staircase that leads to Carrier Bay work platform.	2	0.17	304.8	2.90	0.48	6	5.81
5) Electrical personnel climb ladder or staircase to Carrier Bay work platform.	2	0.02	304.8	2.90	0.05	6	0.58
6) Electrical personnel performing maintenance on Carrier Bay Crane.	2	4.00	792.5	0.10	0.39	6	4.70
7) Radiation Protection personnel enters Carrier Bay from clean area and walks to ladder or staircase that leads to Carrier Bay work platform performing radiation surveys.	1	0.17	304.8	2.90	0.48	4	1.94
5) Radiation Protection personnel climb ladder or staircase to Carrier Bay work platform.	1	0.02	304.8	2.90	0.05	6	0.29
6) Radiation Protection personnel perform survey on Carrier Bay Crane work platform.	1	0.25	792.5	0.10	0.02	1	0.02
7) Supervisor personnel enters Carrier Bay from clean area and walks to ladder or staircase that leads to Carrier Bay work.	1	0.17	304.8	2.90	0.48	4	1.94
8) Supervisor personnel climb ladder or staircase to Carrier Bay work platform.	1	0.02	304.8	2.90	0.05	4	0.19
9) Supervisor personnel observe work on Carrier Bay Crane work platform.	1	0.50	792.5	0.10	0.05	4	0.20
10) Rigger assist in area	1	0.02	304.8	2.90	0.05	2	0.10
Total					3.33	79	45.02
Minor Bridge Crane							

Table III-4-1. Major and Minor Bridge Crane Maintenance - Dose Assessment

Operation	Personnel	hr	cm from source	Dose Rate (mrem/hr) (see assumption 4.3.13)	Dose per trip	Number of trips	Total Dose (mrem)
1) Personnel enters Carrier Bay from clean area and walks to ladder or staircase that leads to Carrier Bay work platform.	3	0.17	304.8	2.90	0.48	2	2.91
2) Personnel climb ladder or staircase to Carrier Bay work platform.	3	0.02	304.8	2.90	0.05	2	0.29
3) Personnel performing maintenance on Carrier Bay Crane.	1.1	4.00	792.5	0.10	0.39	1	0.43
Total					0.92	5	3.63