BSC

Study Cover Sheet

QA: N/A

YUCCA MOUNTAIN PROJECT

Worker Dose Estimate for a Nominal Throughput

INFORMAL STUDY

DOE Contract No.:
DE-AC28-01RW12101

Rev.	Date	Reason for Revision	By Print Name and Sign	EGS/Lead Print Name and Sign	PE/RM Print Name and Sign	DEM Print Name and Sign
001	2/4/08	Revised tables to incorporate updated Aging Facility and Site Worker Dose Assessment results. Deleted design basis source term case and made editorial changes.	E. Salisbury	N.A. Kahler	R.C. Slovic	D.B. Darling
000	11/20/07	Issue for license application.	E. Salisbury	N.A. Kahler	R.C. Slovic	D.B. Darling

Document No.:
000-30R-MGR0-03300-000

Rev.:
001

CONTENTS

Page

TABLES 3
ACRONYMS 4
1. INTRODUCTION 5
   1.1 PURPOSE 5
   1.2 SCOPE 5
2. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS 5
3. STUDY BASIS 6
   3.1 REQUIREMENTS 6
   3.2 ASSUMPTIONS 6
4. EVALUATION OF ALTERNATIVES 9
5. REFERENCES 12

TABLES

Page

Table 4.0-1 Maximum Throughput with Maximum Source Term (1,055 casks per year)... 10
Table 4.0-2 Nominal Throughput with Maximum Source Term (500 casks per year)..... 11

ACRONYMS

ALARA	as low as is reasonably achievable
CRCF	Canister Receipt and Closure Facility
HLW	high-level (radioactive) waste
HPT	health physics technician
IHF	Initial Handling Facility
LLW	low-level radioactive waste
MTHM	metric tons of heavy metal
MTU	metric tons uranium
PWR	pressurized water reactor
RF	Receipt Facility
SNF	spent nuclear fuel
TAD	transportation, aging, and disposal (canister)
WHF	Wet Handling Facility
YMP	Yucca Mountain Project

1. INTRODUCTION

1.1 PURPOSE

The purpose of this informal study is to provide additional information related to the maximized worker dose assessments and from these worker dose assessments prepare an expected nominal throughput and nominal worker dose assessment for use in the license application and in the environmental impact statement for the Yucca Mountain Project (YMP). This document is an informal study prepared in accordance with procedure EG-PRO-3DP-G04B-00016, *Engineering Studies* (Reference 5.1.3).

1.2 SCOPE

The scope of this informal study includes all surface nuclear facilities worker doses for maximum and nominal site throughputs with maximum source terms.

2. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

The stated as low as is reasonably achievable (ALARA) design goal for individual worker doses at the repository is to minimize the number of individuals that have the potential of receiving more than 0.5 rem per year (Reference 5.1.2, Section 4.10.3.3.1). Tables 4.0-1 and 4.0-2 represent calculated individual and collective dose per surface facility for different throughputs with the maximum source term. The maximum throughput will never be realized by the repository. Table 4.0-1 was based on the maximum throughput capacity for each facility and maximum source term. Since the preclosure safety analysis is based on considerably less than the maximum throughput for each facility, and the preclosure safety analysis will be the basis for repository technical specifications, the results shown in table 4.0-1 are presented only to demonstrate compliance with the 10 CFR 20 (Reference 5.1.4) annual regulatory limit of 5 rem per year. Individual and collective doses were taken from current worker dose assessments for each facility. Table 4.0-2 (page 11) was derived to show the effect of a nominal throughput of 500 casks per year for the entire site on individual and collective doses. A ratio technique is used whereby the nominal over the maximum throughput is calculated and this factor applied to the individual and collective doses to arrive at the nominal dose for the facility. When a maximum throughput for each facility is used in conjunction with a maximum source term, the collective dose is 527 person-rem. When the site throughput is reduced to what is considered a nominal level with maximum source term, the collective dose is reduced to 270 person-rem. This value is comparable with typical site collective doses seen at multi-unit nuclear sites as described in NUREG-0713 (Reference 5.1.11, Vol. 27, Appendix B).

3. STUDY BASIS

3.1 REQUIREMENTS

The ALARA design goal for individual radiation worker doses is to minimize the number of individuals that have the potential of receiving more than 0.5 rem per year (Reference 5.1.2, Section 4.10.3.3).

Paragraph 20.1101 (c) of 10 CFR 20, "Standards for Protection Against Radiation" states that licensees should make every reasonable effort to maintain exposures to radiation as far below the limits specified in Part 20 as is reasonably achievable. Reasonably achievable is judged by considering the state of technology and the economics of improvements in relation to all the benefits from these improvements (Reference 5.1.4).

Regulatory Guide 8.8 states in part that merely controlling the maximum dose to the individuals is not sufficient; the collective dose to the group also must be kept as low as is reasonably achievable (Reference 5.1.10, Section B).

3.2 ASSUMPTIONS

3.2.1 **Not Used**

3.2.2 **Not Used**

3.2.3 **Assumption**–The individual worker dose and collective worker dose is directly proportional to the number of casks processed.

Rationale–The worker doses were calculated on a per-cask basis and the collective worker dose was calculated based on the number of workers processing the casks. Consequently, the worker doses are proportional to the number of casks processed.

Use–This assumption is used in Tables 4.0-1 and 4.0-2.

3.2.4 **Assumption**–Nominal throughput is based on processing of 500 casks (transportation casks and/or aging overpacks) of commercial spent nuclear fuel (SNF) and high-level (radioactive) waste (HLW) annually, of which 3,000 metric tons of heavy metal (MTHM) is received from off site.

Rationale–At full-scale, steady state operation, the repository shall accept and receive 3,000 MTHM of commercial SNF and HLW annually (Reference 5.1.1, Section 2.2.1.2). The assumption that the casks received from off-site are equivalent to 3,000 MTHM is based on the fact that not all SNF will arrive by rail cask. Casks arriving by rail will be approximately 10 MTHM per rail cask when containing 21 PWR assemblies of 0.471 metric tons uranium (MTU) per assembly (Reference 5.1.12, Section 5.1.7), but casks arriving by truck cask will be less than 2 MTHM per truck cask containing four pressurized water reactor (PWR) assemblies. Since the exact distribution of material between the different methods of shipment will vary annually, this throughput has been

estimated to be representative of the annual nominal throughput taking into account time for routine maintenance.

Use–This assumption is used in Table 4.0-2.

3.2.5 **Assumption**–It is assumed that the average nominal throughput of 500 casks (transportation casks or aging overpacks, or both) annually will be divided between the surface facilities in the following manner. The Initial Handling Facility (IHF) will receive 24 casks per year, the Receipt Facility (RF) will receive 210 casks per year, the Wet Handling Facility (WHF) will receive 50 casks per year, and each Canister Receipt and Closure Facility (CRCF) will receive 72 casks per year for a total of 216 casks for all three CRCFs.

Rationale–It is reasonable to assume that the nominal throughput of the IHF will only be 24 naval casks because this quantity is consistent with *Basis of Design for the TAD Canister–Based Repository Design Concept* (Reference 5.1.1, Section 3.2.1.2), which states that the IHF must meet the receipt rate of 24 naval casks annually as a minimum.

Therefore, 90% of the 3,000 MTHM (or 2,700 MTHM) received at YMP will arrive in transportation, aging, and disposal (TAD) canisters. Thus, the RF will receive the majority of the casks directly (Reference 5.1.1, Section 2.2.1.3). It is not expected, however, that the RF would handle all of these casks containing TAD canisters in a nominal throughput as was assumed in *Receipt Facility Worker Dose Assessment* (Reference 5.1.5 Section 4.3.2). Thus, a reduced number of casks of 210 was used to represent the nominal throughput in the RF.

It is reasonable to assume that the nominal throughput of the WHF will be 50 rail transportation casks considering that the WHF is required to handle 300 MTHM per year (Reference 5.1.1, Section 5.2.1.2) and not all casks will arrive by rail. If all 300 MTHM arrived by rail, this would equate to approximately 30 casks; approximately 10 MTHM per rail cask containing 21 PWR assemblies of 0.471 MTU per assembly (Reference 5.1.12, Section 5.1.7). Thus, more than 30 casks are expected and an assumption of 50 transportation casks is considered appropriate for the WHF.

The remaining casks were assumed to be handled by the CRCF.

Use–This assumption is used in Table 4.0-2.

3.2.6 **Assumption**–The nominal and maximum cask throughput for the WHF is the same since the WHF throughput is controlled by the number of TAD canisters produced per year such that the output of approximately 50 TAD canisters per year in the WHF will not be affected by the nominal cask inputs.

Rationale–It is expected that there will be enough pre-staged fuel in the pool so as to not be affected by cask inputs to the facility. The fuel storage pool has the capability to pre-stage as many as 200 fuel assemblies (Reference 5.1.12, Section 3.2.5). Thus, the facility can handle an assortment of varying capacity casks per year without an operational impact on the WHF. Thus, assuming the same throughput for the maximum and nominal cases is considered appropriate in this study.

Use–This assumption is used in Table 4.0-2.

3.2.7 **Assumption**–The volume of low level radioactive waste (LLW) generated is proportional to the number of casks processed.

Rationale–This assumption is based on the rationale that the amount of work performed is directly related to the amount of LLW generated, and the amount of LLW generated is directly proportional to the number of casks processed.

Use–This assumption is used in Table 4.0-2 for the LLW facility worker doses.

3.2.8 **Not Used**

3.2.9 **Assumption**–Annually, it is expected that the contents of 135 casks will be processed to the Aging Facility.

Rationale–A percentage of the transportation casks received from off-site will be processed to the Aging Facility. Although it is recognized that the amount of material sent to and from the Aging Facility will vary each year, the contents of 135 casks or aging overpacks represent what is expected to be the average number of these transfers annually taking into account time for routine maintenance.

Use–This assumption is used in Table 4.0-2.

3.2.10 **Assumption**–The number of canisters retrieved from the aging pads is equal with the number of canisters placed on the aging pads.

Rationale– This is consistent with Assumption 3.1.1.3 of Reference 5.1.9 which states in part that the number of canisters retrieved from the aging pads is equal with the number of canisters placed on the aging pads.

Use–This assumption is used in Tables 4.0-1 and 4.0-2.

3.2.11 **Assumption**–There will only be one crew on dayshift in the IHF during nominal throughput periods.

Rationale– The number of casks processed during nominal throughputs of 24 casks per year does not warrant 24/7 operations.

Use–This assumption is used in Table 4.0-2.

4. EVALUATION OF ALTERNATIVES

Worker dose and throughput values tabulated in Table 4.0-1 are based on the maximum transportation cask source term which allows the transportation cask to meet the regulatory limits on the package, and on the maximum throughput capacity of each facility. This tabulation was performed to demonstrate that facility worker doses would meet, regulatory annual dose limits for a radiation worker. The maximum cask source term assumes that all incoming casks will be at the upper transportation cask limits of 10 CFR Part 71, Subpart 3, Section 47 (Reference 5.1.13) and that there will be no operational delays or equipment downtime to process incoming casks. As shown in Table 4.0-1, the maximum site throughput is 1,055 casks per year, when the maximum throughput for each facility is used. Combining the maximum throughput with the maximum source term, results in a collective dose of 527 person-rem for the site.

The worker doses shown in Table 4.0-1 were adjusted to the nominal throughputs per assumptions 3.2.4, 3.2.5, and 3.2.9 and are tabulated in Table 4.0-2. These throughput adjustments consider 365 casks from off site and 135 casks in the form of an aging overpack to be received from the Aging Facility. As shown in Table 4.0-2, the resultant 500 casks per year facility throughput reduces the collective dose for the site to 270 person-rem.

Table 4.0-2 is shown to demonstrate the effect of nominal throughput on maximum source term.

Table 4.0-1 Maximum Throughput with Maximum Source Term (1,055 casks per year)

Facility	Total Number of Work Crews per Facility	Maximum Number of Casks per Facility (A)	Individual Dose (rem/year) (B)	Collective Annual Dose (person-rem) (C)	Basis
Receipt Facility	5 Crews 5 Operators 1 HPT	273	Operator – 4.5 HPT – 2.9	127	Reference 5.1.5, Section 6.9.
Canister Receipt and Closure Facility 1	5 Crews 5 Operators 1 HPT	214	Operator – 2.5 HPT – 1.8	70	Reference 5.1.7, Section 6.6.
Canister Receipt and Closure Facility 2	5 Crews 5 Operators 1 HPT	214	Operator – 2.5 HPT – 1.8	70	Reference 5.1.7, Section 6.6.
Canister Receipt and Closure Facility 3	5 Crews 5 Operators 1 HPT	214	Operator – 2.5 HPT – 1.8	70	Reference 5.1.7, Section 6.6.
Wet Handling Facility	6 Crews 5 Operators 1 HPT	50	Operator – 1.1 HPT – 0.7	36	Reference 5.1.8, Section 6.6.1.
Initial Handling Facility	5 Crews 5 Operators 1 HPT	90	Operator – 1.7 HPT – 1.1	48	Reference 5.1.6, Section 6.6.
Aging Facility	6 Crews 4 Operators 1 HPT	275	Operator – 0.9 HPT – 1.3	30	Reference 5.1.9, Table 7.17. Assumption 3.2.10.
Low Level Waste Facility	2 Crews 5 Operators 1 HPT	NA	Operator – 1.5 HPT – 1.2	18	Reference 5.1.8, Section 6.6.2.
Cask Receipt Security Station	5 Crews 4 Operators 1 HPT 1 Security	780	Operator – 2.1 HPT – 2.1 Security – 1.0	58	Reference 5.1.9, Table 7.14 with factor 780/500 applied. Assumption 3.2.3.
			TOTAL	**527**	

NOTES:

- The maximum number of casks per facility (column A value) for the Cask Receipt Security Station is determined by summing the throughput values in column A for all facilities with the exception of the aging facility and then subtracting the throughput of the Aging Facility from the total so it is not counted as part of the cask receipt security station throughput. Thus, the total number of casks processed is the sum of the Aging Facility and Cask Receipt Security Station.
- The column B and C values for the cask receipt security station were adjusted for the 780 casks by a factor of 780/500, based on values for a 500 cask throughput (Reference 5.1.9).
- HPT = health physics technician.
- The repository is not expected to operate under these conditions (maximum throughput and source term).

Table 4.0-2 Nominal Throughput with Maximum Source Term (500 casks per year)

Facility	Total Number of Work Crews per Facility	Nominal Number of Casks per Facility (A)	Individual Dose (rem/year) (B)	Collective Annual Dose (person-rem) (C)	Basis
Receipt Facility	5 Crews 5 Operators 1 HPT	210	Operator – 3.5 HPT – 2.2	98	Reference 5.1.5, Section 6.9 with factor 210/273 applied. Assumption 3.2.3, 3.2.5.
Canister Receipt and Closure Facility 1	5 Crews 5 Operators 1 HPT	72	Operator – 0.8 HPT – 0.6	24	Reference 5.1.7, Section 6.6 with factor 72/214 applied, Assumption 3.2.3, 3.2.5.
Canister Receipt and Closure Facility 2	5 Crews 5 Operators 1 HPT	72	Operator – 0.8 HPT – 0.6	24	Reference 5.1.7, Section 6.6 with factor 72/214 applied, Assumption 3.2.3, 3.2.5.
Canister Receipt and Closure Facility 3	5 Crews 5 Operators 1 HPT	72	Operator – 0.8 HPT – 0.6	24	Reference 5.1.7, Section 6.6 with factor 72/214 applied, Assumption 3.2.3, 3.2.5.
Wet Handling Facility	6 Crews 5 Operators 1 HPT	50	Operator – 1.1 HPT – 0.7	36	Reference 5.1.8, Section 6.6.1, Assumption 3.2.3, 3.2.5, 3.2.6.
Initial Handling Facility	1 Crew 5 Operators 1 HPT	24	Operator – 2.3 HPT – 1.5	13	Reference 5.1.6, Section 6.6, with factor 24/90 applied, Assumption 3.2.3, 3.2.5, 3.2.11.
Aging Facility	6 Crews 4 Operators 1 HPT	135	Operator – 0.6 HPT – 0.7	15	Reference 5.1.9, Table 7.18 Assumption 3.2.5, 3.2.9, 3.2.10.
Low Level Waste Facility	2 Crews 5 Operators 1 HPT	NA	Operator – 0.7 HPT – 0.6	9	Reference 5.1.8, Section 6.6.2, with factor 500/1,055 applied, Assumption 3.2.4, 3.2.7.
Cask Receipt Security Station	5 Crews 4 Operators 1 HPT 1 Security	365	Operator – 1.0 HPT – 1.0 Security – 0.5	27	Reference 5.1.9, Table 7.14 with factor 365/500 applied. Assumption 3.2.3, 3.2.4, 3.2.5.
			TOTAL	**270**	

NOTES:

- The column A throughput values are based on Assumption 3.2.5
- The column B and C values are based on the ratio of throughputs from in column A over the throughputs in Table 4.0-1 column A over times the perspective individual and collective doses in Table 4.0-1 with the exception of the Aging Facility which is based on Reference 5.1.9.
- HPT = health physics technician.

5. REFERENCES

5.1.1 BSC (Bechtel SAIC Company) 2007. *Basis of Design for the TAD Canister–Based Repository Design Concept*. 000-3DR-MGR0-00300-000-001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071002.0042; ENG.20071108.0002; ENG.20071109.0001; ENG.20071120.0023; ENG.20071126.0049; ENG.20071214.0009; ENG.20071213.0005; ENG.20071227.0018.

5.1.2 BSC 2007. *Project Design Criteria Document*. 000-3DR-MGR0-00100-000-007. Las Vegas, Nevada: Bechtel SAIC Company. ACCs: ENG.20071016.0005; ENG.20071108.0001; ENG.20071220.0003; ENG.20080107.0001; ENG.20080107.0002; ENG.20080107.0016; ENG.20080107.0017.

5.1.3 BSC 2007. *Engineering Studies.* EG-PRO-3DP-G04B-00016 Rev. 4. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG. 20070406.0004.

5.1.4 10 CFR 20. 2007. Energy: *Standards for Protection Against Radiation*. Internet Accessible.

5.1.5 BSC 2007. *Receipt Facility Worker Dose Assessment*. 200-00C-RF00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070730.0004.

5.1.6 BSC 2007. *Initial Handling Facility Worker Dose Assessment*. 51A-00C-IH00-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070529.0035

5.1.7 BSC 2007. *Canister Receipt and Closure Facility #1 Worker Dose Assessment*. 060-00C-CR00-00100-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACCs: ENG.20070425.0013 and ENG.20070524.0004.

5.1.8 BSC 2007. *Wet Handling Facility and Low Level Waste Facility Worker Dose Assessment*. 050-00C-WH00-00200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071017.0002.

5.1.9 BSC 2008. *Aging Facility and Site Worker Dose Assessment*. 000-00C-MGR0-04200-000-00B. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080131.0001.

5.1.10 Regulatory Guide 8.8, Rev. 3. 1978. *Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations will be As Low As is Reasonably Achievable*. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC:238609.

5.1.11 Thomas, M.L. and Hagemeyer, D. 2005. *Occupational Radiation Exposure at Commercial Nuclear Power Reactors and Other Facilities 2005, Thirty-Eighth Annual Report*. NUREG-0713, Vol. 27. Washington, D.C.: U.S. Nuclear Regulatory Commission. Internet Accessible.

5.1.12 BSC 2004. *Shielding Calculation for Transportation Rail Cask Receipt*. 140-00C-HCR0-00200-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20041217.0002.

5.1.13 10 CFR 71. 2007. Energy: *Packaging and Transportation of Radioactive Material.* Internet Accessible.