APPENDIX B

DOSE ANALYSIS

Northern States Power Company
Prairie Island Nuclear Generating Plant

Dose Study to Support ISFSI Certificate of Need

Report SL-018015
Revision 0
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S&L Nuclear QA Program Applicable:

☐ Yes

☒ No

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ISSUE SUMMARY AND APPROVAL PAGE

This is to certify that this document has been prepared, reviewed and approved in accordance with Sargent & Lundy's Standard Operating Procedure SOP-0405, which is based on ASQ/ANSI/ISO 9001:2015: Quality Management Systems–Requirements.

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ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition/Clarification
CFR	Code of Federal Regulations
CON	Certificate of Need
CY	Calendar Year
DCS	Dry Cask Storage
DG	Diesel Generator
DPC	Dual Purpose Container
EOCL	End of Current License
hr	Hour
ISFSI	Independent Spent Fuel Storage Installation
LE	License Extension
m	Meter
mrem	Millirem
MCNP	Monte Carlo N-Particle
MRS	Monitored Retrievable Storage
mSv	Millisievert
OCA	Owner Controlled Area
PI	Prairie Island
PINGP	Prairie Island Nuclear Generating Plant
SAR	Safety Analysis Report
SE	Southeast
Yr	Year

EXECUTIVE SUMMARY

PINGP has a site-specific license under 10 CFR Part 72 for independent storage of spent nuclear fuel and high-level radioactive waste storage. This license is specific to the PINGP site, the Orano TN Americas TN-40 and TN-40HT metal cask storage technology and to the amount of spent fuel assemblies that may be possessed. The ISFSI is currently licensed for 64 TN-40/TN-40HT casks. PINGP currently plans to load 55 of the TN-40/TN-40HT casks and is evaluating a potential change in technology to a new dry fuel storage system to occur after the loading of the 55th cask. In addition to the 55 TN-40/TN-40HT casks, PINGP also plans to load a total of 44 additional new technology casks to support the end of the current license (2033/2034) and the subsequent license renewal of 20 years (from 2033/2034-2053/2054).

In order to determine the impact from the additional new technology casks, dose rates for the TN-40/TN-40HT cask and the new technology cask options were reviewed to identify the most bounding new technology system. A dose rate analysis was performed using the most bounding new technology system to determine the total normal operation radiation dose values at the nearest site boundary and at the nearest resident when including the dose contribution due to 55 TN-40/TN-40HT casks and 44 new technology casks. The additional dose rates and collective doses to station personnel and the offsite population were also calculated.

It was determined that the calculated dose values at the nearest site boundary and at the nearest resident meet the acceptance criteria of 10 CFR 72.104(a), 40 CFR 190.10(a), and 10 CFR 20.1301(a). Therefore, a total of 99 casks (55 TN-40/TN-40HT casks and 44 new technology casks) is considered to be acceptable with respect to the radiation levels at the nearest site boundary and at the nearest resident.

1. PURPOSE/OBJECTIVE

The purpose of this report is to determine the total normal operation radiation dose values at the nearest site boundary and at the nearest resident when including the dose contribution from 55 TN-40/TN-40HT casks and 44 new technology casks. This analysis utilizes the approach established in the current design basis analysis (Reference 1). Reference 1 uses data from the original 48 cask ISFSI to account for an expansion to 64 casks. Because of the changes in cask technology and loading campaigns, the analysis in this study again utilizes the original 48 cask dose results and applies the same methodology from Reference 1 to account for changes in ISFSI loading (i.e., loading campaign years and number of casks in each loading campaign) and change in cask technology for casks 56-99. Table 1-1 compares the existing design basis analysis (Reference 1) and the analysis for this study.

Table 1-1: Comparison of Reference 1 to Study Analysis

Phase	Reference 1		Study Analysis	
	Number of Casks	Type of Cask	Number of Casks	Type of Cask
Original	48	TN-40/TN-40HT	48	TN-40/TN-40HT
Expansion	16	TN-40/TN-40HT	7 44	TN-40/TN-40HT New Technology
Total	64		99	

Note that the original 48 casks are a mixture of TN-40 and TN-40HT casks. The current design basis analysis utilizes dose rate data for the TN-40HT casks and documents that a 48 TN-40HT cask ISFSI conservatively bounds the mixture.

The total normal operation radiation dose consists of the dose from the 55 TN-40/TN-40HT casks, 44 new technology casks, and the dose due to non-ISFSI related operation of the PINGP. In addition, the dose rates and collective doses to station personnel and the offsite population from 55 TN-40/TN-40HT casks and 44 new technology casks are calculated.

The objective of this report is to demonstrate that the total normal operation radiation doses at the nearest site boundary and at the nearest resident (i.e., sum of the direct dose from 55 TN-40/TN-40HT casks and 44 new technology casks, and the dose from normal plant operations) will be in accordance with the requirements of 10 CFR 72.104(a), 40 CFR 190.10(a), and 10 CFR 20.1301(a).

2. ASSUMPTIONS/INPUT

2.1. ASSUMPTIONS

This ISFSI dose rate study is performed for information only and is not considered design basis. This study uses all assumptions from the current design basis calculation (Reference 1) unless modified by this report. The study includes conservative assumptions for the dose rate scaling factor (to bound the changes in dose rates from available new cask technologies) and the distance scaling factor (to account for the bounding location of new casks relative to the dose locations). This dose analysis does not consider dose contributions due to radioactivity releases from the fuel-loaded and sealed casks during normal, off-normal, or accident situations (Assumption 3.1 of Reference 1). In addition, the study does not assess new cask storage technologies with respect to direct radiation shine during an accident condition (Assumption 3.1 of

Reference 1).

2.1.1. Uranium Fuel Cycle Contribution

The dose at the nearest site boundary due to other uranium fuel cycle operations is assumed to be negligible when compared to the radiation level associated with the ISFSI. This assumption is consistent with assumptions made in Reference 1.

2.1.2. Cask Placement on ISFSI

There are currently three ISFSI pads (configured as two adjacent pads in the east - west direction, with one pad (i.e., the southeast pad) located directly south of the east pad). For the purpose of this study, it is assumed that two new pads will be placed directly north of the two adjacent existing pads. After the two adjacent ISFSI pads are filled with TN-40/TN-40HT casks, the existing southeast ISFSI pad will be filled with 7 TN-40/TN-40HT casks and then 16 new technology casks. Each additional ISFSI pad for the new technology casks will hold 24 new technology casks and be similar in dimensions and orientation to the existing three storage pads. The new pads will be 40 feet wide and 38 feet away from the existing pads. To be conservative, a total of 28 new technology casks are assumed to be placed on the two new pads north of the existing ISFSI pads. The assumed cask placement is shown in Figure 2-1. (Reference 3)

2.1.3. Geometry Effects

The dose rates in Tables 2-5 through 2-10 are calculated by MCNP. Although MCNP takes into account geometry effects due to the location of each cask with respect to the dose point, Equations 1 through 9 do not incorporate any geometry effects. It is assumed that geometry effects have no significant impact, on the values calculated using Equations 1 through 9, for the following reasons: 1) the dose receptors are located beyond the ISFSI berm, therefore, the dose rates at these locations are mostly due to skyshine radiation and the impact of geometry becomes less significant for skyshine radiation (particularly at significant distances from the source), 2) the dose receptor dose rates are calculated using bounding dose rate values. This assumption is consistent with assumptions made in Reference 1.

2.2. INPUT

2.2.1. Cask Loading Scheme

The loading scheme listed in Table 2-1 will be used to calculate the dose rates and collective doses for the expansion ISFSI. The loading scheme for this study will add 7 TN-40/TN-40HT casks and 44 new technology casks to the original 48 TN-40/TN-40HT casks for a total of 99 casks. (Reference 3)

2.2.2. Radiation Source Decay Constant

The decay constant used to calculate the original 48 TN-40/TN-40HT cask loaded ISFSI gamma and neutron radiation source strength due to the spent fuel assembly in-core region is 0.025 $year^{-1}$ (corresponds to approximately 27.7 years half-life) and 0.0358 $year^{-1}$ (corresponds to approximately 19.4 years half-life), respectively (Reference 1).

2.2.3. Plant Direct and Gaseous Effluent Dose for 40 CFR 190 Compliance

The nearest resident total plant direct and gaseous effluent dose (i.e., not associated with the ISFSI) that is used for 40 CFR 190 compliance is 1.50E-02 mrem/yr (i.e., 3.44E-05 mrem/yr gamma dose + 1.53E-04

mrem/yr beta dose + 1.48E-02 mrem/yr iodine, particulate, H-3 and C-14 dose) (Reference 1).

2.2.4. Nearest Resident (Original ISFSI)

The nearest resident from the original ISFSI is located 0.45 miles (724 m) northwest from the ISFSI site. The dose at the nearest resident due to the original ISFSI is based on the design basis calculation for the ISFSI (i.e., with 48 fuel-loaded TN-40HT casks) and is 3.05E+00 mrem/yr. (Reference 1)

2.2.5. Nearest Site Boundary (Original ISFSI)

The nearest site boundary from the original ISFSI is located 110 m from the western edge of the ISFSI concrete pads. The dose rate at the nearest site boundary due to the original ISFSI is based on the design basis calculation for the ISFSI (i.e., with 48 fuel-loaded TN-40HT casks) and is 3.13E-01 mrem/hr. (Reference 1)

2.2.6. 48 TN-40HT Cask Loaded ISFSI Offsite Population Dose Rates and Collective Doses

The offsite population dose rates and collective doses within 2 miles of the ISFSI loaded with 48 TN-40HT casks are listed in Table 2-2 of this study (Reference 1).

2.2.7. 48 TN-40HT Cask Loaded ISFSI Station Personnel Dose Rates and Collective Doses

Station personnel dose rates and collective doses at specific locations due to the ISFSI loaded with 48 TN-40HT casks are listed in Tables 2-3 and 2-4 of this study. The locations designated in Tables 2-3 and 2-4 are shown in Appendix A of this study. (Reference 1)

2.2.8. Total and Skyshine Dose Rates From 48 Loaded TN-40HT Casks

The gamma and neutron total (direct + skyshine) dose rates at different distances from a 48 TN-40HT fuel-loaded cask ISFSI are listed in Tables 2-5 through 2-7 of this study. The gamma and neutron skyshine dose rates from a 48 TN-40HT fuel-loaded cask ISFSI are listed in Tables 2-8 through 2-10 of this study. (Reference 1)

2.2.9. TN-40HT Individual Cask Dose Contributions

As discussed in Section 3.1 of this study, Reference 1 used the gamma and neutron dose rates from the ISFSI with 48 fuel-loaded casks (Tables 2-5 through 2-7 of this study) to determine D_0, the contribution to the dose rate at specific distances and directions for a single fuel-loaded cask placed on the ISFSI. The D_0 dose rates as a function of distance and direction are listed in Tables 2-11 through 2-13 of this study.

2.2.10. TN-40HT Skyshine Dose Contributions

As discussed in Section 3.1 of this study, Reference 1 calculated the skyshine radiation contribution from the 48 fuel-loaded cask ISFSI using a simplified scaling approach. The gamma and neutron skyshine scaling factors at each specific distance are listed in Tables 2-14 through 2-16 of this study.

2.2.11. TN-40HT Individual Cask Dose Contributions at Onsite & Offsite Locations

As discussed in Section 3.1 of this study, Reference 1 calculated D_0 for station personnel dose rates and collective doses at specific on-site locations. D_0 was also calculated for the offsite population dose rates and collective doses at specific locations and distances. All D_0 values are shown in Tables 2-17 through 2-19 of this study. Reference 1 did not calculate the gamma D_0 and neutron D_0 separately because those contributions were not available for the onsite and offsite locations.

Table 2-1: Loading Scheme

Year	Number of Casks	Type of Cask	Purpose
2022	3(1)	TN-40/TN-40HT	EOCL
2024	3	TN-40/TN-40HT	EOCL
2025	2	TN-40/TN-40HT	EOCL
2027	10	New Technology	EOCL
2031	8	New Technology	License Extension
2036	8	New Technology	License Extension
2041	8	New Technology	License Extension
2046	10	New Technology	License Extension

Note:

(1) One cask out of the three TN-40/TN-40HT casks loaded in 2022 was placed on the existing ISFSI pad as part of the original 48 casks. The other two casks loaded in 2022 were placed on the SE ISFSI pad. Only two casks loaded in 2022 are considered in the expansion ISFSI calculation.

Table 2-2: 48 TN-40HT Fuel-Loaded Cask ISFSI - Offsite Population Dose Rates and Collective Doses

Offsite Population	Description	Distance	Occupancy Times	Population	Dose Rate (mrem/hr)	Collective Exposure (person-rem) (1)
Permanent Population Within 2 Mile Radius	2 mile radius	> 0 .45 mile	8760	398	2.91E-04	1.01E+00
Transient Employee Population	2 mile – PI Community center, government center, and clinic	0.8 mile	2000	80	3.33E-05	5.33E-03
	2 mile - Employees at Treasure Island Casino	0.8 mile	8760	435	3.33E-05	1.30E-01
Transient Recreational Population	2 mile – Treasure Island Casino	0.8 mile	8760	5400	3.33E-05	1.58E+00
Marina and RV Park	2 mile – PI Community center, government center, and clinic	0.8 mile	1160	450	3.33E-05	1.74E-02
	Total Collective Within 2 Miles					2.74E+00

Note:

(1) Collective exposures are determined by multiplying the dose rate (column 6) by the population (column 5) and by the occupancy time (column 4). The product is divided by 1000 mrem/rem to obtain collective exposures in person-rem.

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Table 2-3: 48 TN-40HT Fuel-Loaded Cask ISFSI - Station Personnel Dose Rates

Location #	Location	Distance (feet from ISFSI center)	Full Time (Personnel)	Outage (Personnel)	Dose Rate (mrem/hr)
1	34 OCA Gatehouse (D-2)	[redacted]	2	0	2.57E-02
2	22 Receiving Warehouse (D-5) 55 13 P1ex Project Office (D-5) A 4 P1ex Project Office (D-5)		30	0	2.77E-02
3	24 NPD Building (E-6) 33 NPD Annex Building (E-5) Quality Assurance Modular Office (E-5)		60	1	2.26E-02
4	42 Fabrication Shop (C-5) 25 Steam Generator Mockup Building (C-5) 48 Fabrication Shop (D-5)		2	45	5.76E-03
5	30 Warehouse (C-5) 31 Multiuse Warehouse (C-5) 21 Warehouse -8 (C-6)		0	2	2.34E-03
6	12 Substation, SBO Structures (B-6)		0	2	4.12E-04
7	23 New Administration Building (D-6) 6 Security Building (D-6)		287	25	3.34E-03
8	4 Turbine Building (D-7) 28 Warehouse -2 (E-7) 3 Auxiliary Building (E-7) 13 New Service Building (D-8) 11 D5/D6 DG Building (D-7) 79 Security DG Building (D-7)		180	192	2.34E-03
9	9 Outage Trailers (E-7)		5	40	7.04E-03
10	60 Fabrication Shop (E-7) 29 Main Plant Warehouse (E-7) 66 Maintenance Storage Building (E-7)		23	45	2.94E-03
11	20 Environmental Lab (B-9)		2	0	1.85E-04
12	Training Center		49	0	3.16E-02
13	38 Old Administration Building (D-7) 71 Administration Building Addition (D-7)		68	0	1.73E-03
14	13 New Service Building (D-8)		9	0	1.05E-03

NOT-PUBLIC DATA ENDS]

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Table 2-4: 48 TN-40HT Fuel-Loaded Cask ISFSI - Station Personnel Collective Doses

Location #	Location	Distance (feet from ISFSI center)	Full Time (person-rem)	Outage (person-rem)	Total Exposure (person-rem)
1	34 OCA Gatehouse (D-2)	[redacted]	1.30E-01	0.00E+00	1.30E-01
2	22 Receiving Warehouse (D-5) 55 13 P1ex Project Office (D-5) A 4 P1ex Project Office (D-5)		2.08E+00	0.00E+00	2.08E+00
3	24 NPD Building (E-6) 33 NPD Annex Building (E-5) Quality Assurance Modular Office (E-5)		3.39E+00	1.22E-02	3.40E+00
4	42 Fabrication Shop (C-5) 25 Steam Generator Mockup Building (C-5) 48 Fabrication Shop (D-5)		3.00E-02	1.40E-01	1.70E-01
5	30 Warehouse (C-5) 31 Multiuse Warehouse (C-5) 21 Warehouse -8 (C-6)		0.00E+00	2.53E-03	2.53E-03
6	12 Substation, SBO Structures (B-6)		0.00E+00	4.45E-04	4.45E-04
7	23 New Administration Building (D-6) 6 Security Building (D-6)		2.39E+00	5.00E-02	2.44E+00
8	4 Turbine Building (D-7) 28 Warehouse -2 (E-7) 3 Auxiliary Building (E-7) 13 New Service Building (D-8) 11 D5/D6 DG Building (D-7) 79 Security DG Building (D-7)		1.05E+00	2.40E-01	1.30E+00
9	9 Outage Trailers (E-7)		9.00E-02	1.50E-01	2.40E-01
10	60 Fabrication Shop (E-7) 29 Main Plant Warehouse (E-7) 66 Maintenance Storage Building (E-7)		1.70E-01	7.00E-02	2.40E-01
11	20 Environmental Lab (B-9)		9.24E-04	0.00E+00	9.24E-04
12	Training Center		3.87E+00	0.00E+00	3.87E+00
13	38 Old Administration Building (D-7) 71 Administration Building Addition (D-7)		2.90E-01	0.00E+00	2.90E-01
14	13 New Service Building (D-8)		2.00E-02	0.00E+00	2.00E-02
Total			1.35E+01	6.70E-01	1.42E+01

NOT-PUBLIC DATA ENDS]

Table 2-5: 48 TN-40HT Fuel-Loaded Cask ISFSI - Dose Rates from ISFSI North/South Faces (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma Radiation Dose Rate (mrem/hr)	Neutron Radiation Dose Rate (mrem/hr)	Total (mrem/hr)
0	4.03	5.59E+00	6.65E+00	1.22E+01
10	14.03	3.76E+00	4.77E+00	8.52E+00
45	49.03	1.14E+00	1.54E+00	2.68E+00
100	104.03	8.04E-02	2.32E-01	3.13E-01
200	204.03	1.99E-02	4.46E-02	6.44E-02
300	304.03	6.02E-03	1.14E-02	1.74E-02
400	404.03	2.02E-03	3.30E-03	5.33E-03
500	504.03	7.62E-04	1.06E-03	1.82E-03
600	604.03	3.17E-04	4.06E-04	7.24E-04
700	704.03	1.43E-04	1.52E-04	2.95E-04
800	804.03	7.01E-05	5.79E-05	1.28E-04
900	904.03	3.49E-05	2.89E-05	6.38E-05
1000	1004.03	1.76E-05	9.95E-06	2.75E-05

Table 2-6: 48 TN-40HT Fuel-Loaded Cask ISFSI - Dose Rates from ISFSI East/West Faces (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma Radiation Dose Rate (mrem/hr)	Neutron Radiation Dose Rate (mrem/hr)	Total (mrem/hr)
0	70.47	3.46E+01	2.91E+01	6.36E+01
10	80.47	2.85E+00	4.49E+00	7.35E+00
45	115.47	6.56E-02	2.79E-01	3.45E-01
100	170.47	3.24E-02	1.06E-01	1.39E-01
200	270.47	8.01E-03	2.06E-02	2.86E-02
300	370.47	2.48E-03	5.33E-03	7.81E-03
400	470.47	8.53E-04	1.85E-03	2.70E-03
500	570.47	3.31E-04	5.66E-04	8.97E-04
600	670.47	1.58E-04	2.23E-04	3.81E-04
700	770.47	6.38E-05	8.03E-05	1.44E-04
800	870.47	2.96E-05	4.06E-05	7.02E-05
900	970.47	1.55E-05	1.55E-05	3.10E-05
1000	1070.47	8.53E-06	7.70E-06	1.62E-05

Table 2-7: 48 TN-40HT Fuel-Loaded Cask ISFSI - Dose Rates from ISFSI Corners(1) (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma Radiation Dose Rate (mrem/hr)	Neutron Radiation Dose Rate (mrem/hr)	Total (mrem/hr)
10	77.91	3.74E+00	4.97E+00	8.71E+00
45	107.91	5.10E-01	7.88E-01	1.30E+00
100	159.24	4.19E-02	1.23E-01	1.65E-01
200	256.49	1.15E-02	2.52E-02	3.67E-02
300	355.27	3.67E-03	6.75E-03	1.04E-02
400	454.58	1.40E-03	1.97E-03	3.37E-03
500	554.14	5.34E-04	7.20E-04	1.25E-03
600	653.84	2.27E-04	2.64E-04	4.91E-04
700	753.61	1.03E-04	1.04E-04	2.07E-04
800	853.44	5.21E-05	3.64E-05	8.84E-05
900	953.31	2.68E-05	1.78E-05	4.46E-05
1000	1053.20	1.49E-05	7.47E-06	2.24E-05

Note:
(1) Distances are measured along an imaginary line drawn from the corners of the ISFSI at 45 degrees.

Table 2-8: 48 TN-40HT Fuel-Loaded Cask ISFSI - Skyshine Radiation Dose Rates from ISFSI North/South Faces

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Skyshine Gamma Radiation Dose Rate (mrem/hr)	Skyshine Neutron Radiation Dose Rate (mrem/hr)	Total (mrem/hr)
0	4.03	4.85E+00	6.65E+00	1.15E+01
10	14.03	3.27E+00	4.76E+00	8.03E+00
45	49.03	9.88E-01	1.54E+00	2.53E+00
100	104.03	7.42E-02	2.32E-01	3.06E-01
200	204.03	1.85E-02	4.46E-02	6.31E-02
300	304.03	5.63E-03	1.14E-02	1.70E-02
400	404.03	1.89E-03	3.30E-03	5.19E-03
500	504.03	7.08E-04	1.06E-03	1.77E-03
600	604.03	2.93E-04	4.06E-04	7.00E-04
700	704.03	1.30E-04	1.52E-04	2.82E-04
800	804.03	6.36E-05	5.79E-05	1.21E-04
900	904.03	3.15E-05	2.89E-05	6.04E-05
1000	1004.03	1.56E-05	9.95E-06	2.56E-05

Table 2-9: 48 TN-40HT Fuel-Loaded Cask ISFSI - Skyshine Radiation Dose Rates from ISFSI East/West Faces

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Skyshine Gamma Radiation Dose Rate (mrem/hr)	Skyshine Neutron Radiation Dose Rate (mrem/hr)	Total (mrem/hr)
0	70.47	2.95E+01	2.90E+01	5.85E+01
10	80.47	2.46E+00	4.49E+00	6.95E+00
45	115.47	5.75E-02	2.79E-01	3.37E-01
100	170.47	2.93E-02	1.06E-01	1.35E-01
200	270.47	7.31E-03	2.06E-02	2.79E-02
300	370.47	2.26E-03	5.33E-03	7.59E-03
400	470.47	7.70E-04	1.85E-03	2.62E-03
500	570.47	2.98E-04	5.66E-04	8.65E-04
600	670.47	1.42E-04	2.23E-04	3.65E-04
700	770.47	5.60E-05	8.03E-05	1.36E-04
800	870.47	2.54E-05	4.06E-05	6.60E-05
900	970.47	1.31E-05	1.55E-05	2.87E-05
1000	1070.47	7.04E-06	7.70E-06	1.47E-05

Table 2-10: 48 TN-40HT Fuel-Loaded Cask ISFSI - Skyshine Radiation Dose Rates from ISFSI Corners(1)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Skyshine Gamma Radiation Dose Rate (mrem/hr)	Skyshine Neutron Radiation Dose Rate (mrem/hr)	Total (mrem/hr)
10	77.91	3.22E+00	4.96E+00	8.18E+00
45	107.91	4.40E-01	7.88E-01	1.23E+00
100	159.24	3.84E-02	1.23E-01	1.61E-01
200	256.49	1.07E-02	2.52E-02	3.59E-02
300	355.27	3.43E-03	6.75E-03	1.02E-02
400	454.58	1.31E-03	1.97E-03	3.27E-03
500	554.14	4.96E-04	7.20E-04	1.22E-03
600	653.84	2.09E-04	2.64E-04	4.73E-04
700	753.61	9.38E-05	1.04E-04	1.98E-04
800	853.44	4.70E-05	3.64E-05	8.34E-05
900	953.31	2.39E-05	1.78E-05	4.17E-05
1000	1053.20	1.33E-05	7.47E-06	2.08E-05

Note:
(1) Distances are measured along an imaginary line drawn from the corners of the ISFSI at 45 degrees.

Table 2-11: D_0 Dose Rate from ISFSI North/South Faces (Direct + Skyshine) (due to a Single Fuel-Loaded Cask on the ISFSI)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma D_0 (mrem/hr)	Neutron D_0 (mrem/hr)
0	4.03	1.51E-01	1.99E-01
10	14.03	1.02E-01	1.43E-01
45	49.03	3.08E-02	4.61E-02
100	104.03	2.17E-03	6.95E-03
200	204.03	5.38E-04	1.34E-03
300	304.03	1.63E-04	3.42E-04
400	404.03	5.46E-05	9.89E-05
500	504.03	2.06E-05	3.18E-05
600	604.03	8.57E-06	1.22E-05
700	704.03	3.86E-06	4.55E-06
800	804.03	1.89E-06	1.73E-06
900	904.03	9.43E-07	8.66E-07
1000	1004.03	4.76E-07	2.98E-07

Table 2-12: D_0 Dose Rate from ISFSI East/West Faces (Direct + Skyshine) (due to a Single Fuel-Loaded Cask on the ISFSI)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma D_0 (mrem/hr)	Neutron D_0 (mrem/hr)
0	70.47	9.35E-01	8.72E-01
10	80.47	7.70E-02	1.35E-01
45	115.47	1.77E-03	8.36E-03
100	170.47	8.76E-04	3.18E-03
200	270.47	2.16E-04	6.17E-04
300	370.47	6.70E-05	1.60E-04
400	470.47	2.31E-05	5.54E-05
500	570.47	8.94E-06	1.70E-05
600	670.47	4.27E-06	6.68E-06
700	770.47	1.72E-06	2.41E-06
800	870.47	8.00E-07	1.22E-06
900	970.47	4.19E-07	4.64E-07
1000	1070.47	2.31E-07	2.31E-07

Table 2-13: D_0 Dose Rate from ISFSI Corners (Direct + Skyshine) (due to a Single Fuel-Loaded Cask on the ISFSI)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma D_0 (mrem/hr)	Neutron D_0 (mrem/hr)
10	77.91	1.01E-01	1.49E-01
45	107.91	1.38E-02	2.36E-02
100	159.24	1.13E-03	3.69E-03
200	256.49	3.11E-04	7.55E-04
300	355.27	9.92E-05	2.02E-04
400	454.58	3.78E-05	5.90E-05
500	554.14	1.44E-05	2.16E-05
600	653.84	6.13E-06	7.91E-06
700	753.61	2.78E-06	3.12E-06
800	853.44	1.41E-06	1.09E-06
900	953.31	7.24E-07	5.33E-07
1000	1053.20	4.03E-07	2.24E-07

Table 2-14: Skyshine Scaling Factors from ISFSI North/South Faces

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma Skyshine Factor	Neutron Skyshine Factor
0	4.03	0.87	1
10	14.03	0.87	1
45	49.03	0.87	1
100	104.03	0.92	1
200	204.03	0.93	1
300	304.03	0.94	1
400	404.03	0.94	1
500	504.03	0.93	1
600	604.03	0.92	1
700	704.03	0.91	1
800	804.03	0.91	1
900	904.03	0.90	1
1000	1004.03	0.89	1

Table 2-15: Skyshine Scaling Factors from ISFSI East/West Faces

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma Skyshine Factor	Neutron Skyshine Factor
0	70.47	0.85	1
10	80.47	0.86	1
45	115.47	0.88	1
100	170.47	0.90	1
200	270.47	0.91	1
300	370.47	0.91	1
400	470.47	0.90	1
500	570.47	0.90	1
600	670.47	0.90	1
700	770.47	0.88	1
800	870.47	0.86	1
900	970.47	0.85	1
1000	1070.47	0.83	1

Table 2-16: Skyshine Scaling Factors from ISFSI Corners

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma Skyshine Factor	Neutron Skyshine Factor
10	77.91	0.86	1
45	107.91	0.86	1
100	159.24	0.92	1
200	256.49	0.93	1
300	355.27	0.93	1
400	454.58	0.94	1
500	554.14	0.93	1
600	653.84	0.92	1
700	753.61	0.91	1
800	853.44	0.90	1
900	953.31	0.89	1
1000	1053.2	0.89	1

Table 2-17: Station Personnel D_0 Dose Rate (due to a Single Fuel-Loaded Cask on the ISFSI)

Location #	Location	D_0 (mrem/hr)
1	34 OCA Gatehouse (D-2)	7.70E-04
2	22 Receiving Warehouse (D-5) 55 13 P1ex Project Office (D-5) A 4 P1ex Project Office (D-5)	8.30E-04
3	24 NPD Building (E-6) 33 NPD Annex Building (E-5) Quality Assurance Modular Office (E-5)	6.77E-04
4	42 Fabrication Shop (C-5) 25 Steam Generator Mockup Building (C-5) 48 Fabrication Shop (D-5)	1.73E-04
5	30 Warehouse (C-5) 31 Multiuse Warehouse (C-5) 21 Warehouse -8 (C-6)	7.01E-05
6	12 Substation, SBO Structures (B-6)	1.23E-05
7	23 New Administration Building (D-6) 6 Security Building (D-6)	1.00E-04
8	4 Turbine Building (D-7) 28 Warehouse -2 (E-7) 3 Auxiliary Building (E-7) 13 New Service Building (D-8) 11 D5/D6 DG Building (D-7) 79 Security DG Building (D-7)	7.01E-05
9	9 Outage Trailers (E-7)	2.11E-04
10	60 Fabrication Shop (E-7) 29 Main Plant Warehouse (E-7) 66 Maintenance Storage Building (E-7)	8.81E-05
11	20 Environmental Lab (B-9)	5.54E-06
12	Training Center	9.47E-04
13	38 Old Administration Building (D-7) 71 Administration Building Addition (D-7)	5.18E-05
14	13 New Service Building (D-8)	3.15E-05

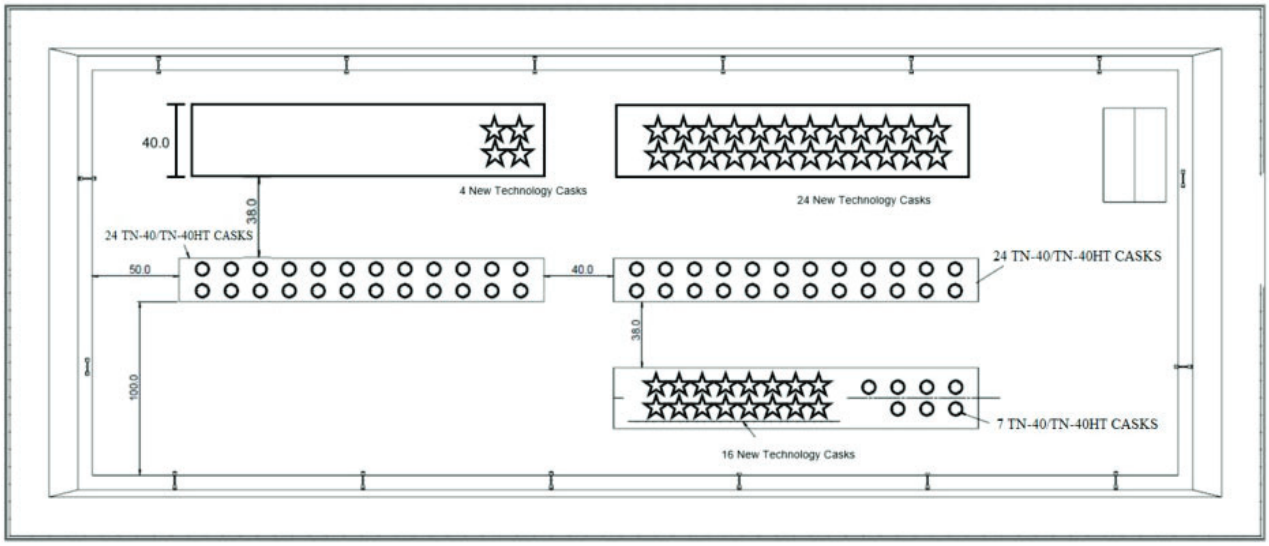
Table 2-18: Station Personnel Collective Exposure D_0 (due to a Single Fuel-Loaded Cask on the ISFSI)

Location #	Location	Full Time D_0 (person-rem)	Outage D_0 (person-rem)
1	34 OCA Gatehouse (D-2)	3.90E-03	0.00E+00
2	22 Receiving Warehouse (D-5) 55 13 P1ex Project Office (D-5) A 4 P1ex Project Office (D-5)	6.23E-02	0.00E+00
3	24 NPD Building (E-6) 33 NPD Annex Building (E-5) Quality Assurance Modular Office (E-5)	1.02E-01	3.66E-04
4	42 Fabrication Shop (C-5) 25 Steam Generator Mockup Building (C-5) 48 Fabrication Shop (D-5)	8.99E-04	4.19E-03
5	30 Warehouse (C-5) 31 Multiuse Warehouse (C-5) 21 Warehouse -8 (C-6)	0.00E+00	7.58E-05
6	12 Substation, SBO Structures (B-6)	0.00E+00	1.33E-05
7	23 New Administration Building (D-6) 6 Security Building (D-6)	7.16E-02	1.50E-03
8	4 Turbine Building (D-7) 28 Warehouse -2 (E-7) 3 Auxiliary Building (E-7) 13 New Service Building (D-8) 11 D5/D6 DG Building (D-7) 79 Security DG Building (D-7)	3.15E-02	7.19E-03
9	9 Outage Trailers (E-7)	2.70E-03	4.49E-03
10	60 Fabrication Shop (E-7) 29 Main Plant Warehouse (E-7) 66 Maintenance Storage Building (E-7)	5.09E-03	2.10E-03
11	20 Environmental Lab (B-9)	2.77E-05	0.00E+00
12	Training Center	1.16E-01	0.00E+00
13	38 Old Administration Building (D-7) 71 Administration Building Addition (D-7)	8.69E-03	0.00E+00
14	13 New Service Building (D-8)	5.99E-04	0.00E+00

Table 2-19: Offsite Population D_0 Dose Rate and Collective Exposure D_0 (due to a Single Fuel-Loaded Cask on the ISFSI)

Offsite Population	Description	Distance	Dose Rate D_0 (mrem/hr)	Collective Exposure D_0 (person-rem)
Permanent Population Within 2 Mile Radius	2 mile radius	> 0 .45 mile	8.72E-06	3.04E-02
Transient Employee Population	2 mile – PI Community center, government center, and clinic	0.8 mile	9.98E-07	1.60E-04
	2 mile - Employees at Treasure Island Casino	0.8 mile	9.98E-07	3.80E-03
Transient Recreational Population	2 mile – Treasure Island Casino	0.8 mile	9.98E-07	4.72E-02
Marina and RV Park	2 mile – PI Community center, government center, and clinic	0.8 mile	9.98E-07	5.21E-04

Figure 2-1: Expansion ISFSI Layout



3. EVALUATION

3.1. METHODOLOGY

This report determines the total normal operation radiation dose values at the nearest site boundary and at the nearest resident when including the dose contribution from 55 TN-40/TN-40HT casks and 44 new technology casks. In addition, this report determines the dose rates and collective doses to station personnel and offsite population due to the last 7 TN-40/TN-40HTcasks and the 44 new technology casks.

Figure 3-1 shows the ISFSI and the three existing ISFSI pads, two of which are aligned horizontally in the east-west direction. The assumed locations of the expansion ISFSI pads are directly north of the existing ISFSI pads (Figure 2-1). The locations of the expansion ISFSI pads were chosen as the most conservative/bounding location because the pad locations are the closest to the nearest resident. The nearest resident location is shown in Figure 3-2. Figure 3-3 shows portions of the site boundary, which is also the site exclusion area boundary and the ISFSI controlled area boundary defined in 10 CFR 20.1003 and 10 CFR 72.3 (Reference 1).

The calculated nearest site boundary and nearest resident total dose for the expanded ISFSI pad design includes 1) the dose contribution due to the original ISFSI (48 TN-40/TN-40HT casks on two pads at fully loaded conditions), 2) dose due to other uranium fuel cycle operations conducted on the site, and 3) dose due to the 7 additional fuel-loaded TN-40/TN-40HT casks and 44 fuel-loaded new technology casks as part of the expansion ISFSI. The station personnel and offsite population total dose for the expanded ISFSI pad design includes 1) the dose contribution due to the original ISFSI and 2) dose due to the 7 additional fuel-loaded TN-40/TN-40HT casks and 44 fuel-loaded new technology casks as part of the expansion ISFSI.

3.1.1. Individual Cask Dose Contribution from Original 48 Cask ISFSI

Direct scaling of the ISFSI dose versus distance information from the 48 cask ISFSI to obtain dose versus distance for the 51 cask expansion ISFSI (i.e., using a scaling factor of 51/48) is not accurate because the dose versus distance information takes credit for radiodecay due to scheduled ISFSI loading. As such, direct scaling of the 48 cask ISFSI doses for 51 additional casks would be nonconservative. The dose rates in Tables 2-5 through 2-7 were based on loading 48 TN-40HT casks over a 22-year period assuming 4 storage casks are loaded every 2 years. The dose rates were also based on a bounding source term with 18 years of cooling time. Reference 1 expressed the source term strength at any cooling time with the following equation:

$$A_t = A_0 e^{-\lambda(t-18)} \qquad \textbf{Equation 1}$$

Where

t = time in years

A_t = source strength at time t (18 < t < 40)

A_0 = initial source strength (at the time when the cask is placed on the ISFSI)

λ = decay constant

The decay constants are 0.025 year^{-1} (corresponds to approximately 27.7 years half-life for fission gammas) and 0.0358 year^{-1} (corresponds to approximately 19.4 years half-life for neutrons) (Input 2.2.2). Because Equation 1 reduces the source strength as if all the different gammas with their different half-lives and

energies decay in unison at the specified rate, the dose rate is directly proportional to the gamma source strength and A_0 and A_t can be replaced by dose rates, D_0 and D_t. Reference 1 then used a gamma dose rate at a particular distance from the ISFSI (e.g., 8.04E-02 mrem/hr at 104.03 meters (Table 2-5 of this study) which represents the dose rate at 104.03 meters from the north/south face of the fully loaded (i.e., 48 cask) ISFSI) to determine the contribution to the dose rate from a single TN-40HT cask. D_0 represents the dose rate for a cask when it is initially placed on the ISFSI with no radiodecay (other than that due to the required cooling time before the cask may be placed on the ISFSI). The time-dependent dose rate from any cask on the ISFSI is the product of D_0 and the exponent (which accounts for radiodecay for the specified number of years the cask has been on the ISFSI). The gamma D_0 dose rate was determined to be 2.17E-03 mrem/hr (Table 2-11 of this study) at 104.03 m from the north/south faces of the ISFSI for a cask with no additional radiodecay (other than 18 years of cooling time). The neutron dose rate D_0 from a cask was calculated using the same method. The neutron dose rate was determined to be 6.95E-03 mrem/hr (Table 2-11 of this study) at 104.03 m from the north/south faces of the ISFSI for a cask with no additional radiodecay (other than 18 years of cooling time). The individual D_0 cask dose rates calculated in Reference 1 (as a function of distance from the ISFSI) are shown in Tables 2-11 through 2-13 of this study and will be used to calculate dose rates for the expansion ISFSI.

3.1.2. Expansion ISFSI Dose Rates

The dose contribution due to the additional 7 TN-40/TN-40HT casks and 44 new technology casks is determined by using the same method discussed in Section 3.1.1. Equation 2 expresses the dose rate from any cask on the ISFSI as the product of D_0 and the exponent (which accounts for radiodecay for the specified number of years the cask has been on the ISFSI). Additional scaling factors F and M are included in Equation 2 to account for higher new technology cask dose rates and the location of the cask on the ISFSI pad.

$$D_t = D_0 F M e^{-\lambda t} \qquad \textbf{Equation 2}$$

Where

D_t = dose rate at time t

D_0 = dose rate of cask when initially loaded

t = time in years between when the cask was initially loaded and time when all additional 7 TN-40/TN-40HT casks and 44 new technology casks are loaded

F = scaling factor for new technology cask to adjust for different dose rates at the top surface of the cask

M = distance factor based on placement on the ISFSI pads

3.1.2.1. Dose Rate Scaling Factor

The dose rates of the bounding new technology system are different than the dose rates of the TN-40/TN-40HT cask system and therefore a scaling factor (F) will be used to reflect the difference in dose rates. The scaling factor will be based on the contact dose rates of the top surface of the cask. The dose rates from the top surface of the cask systems were used to determine the scaling factor because skyshine is the greatest dose contributor to areas outside the earthen berm and radiation from the top surface is a major contributor to the skyshine dose.

The new technology cask dose rates are proprietary and are not provided in this report. Instead, the dose

rates and methodology for calculating the scale factor are provided in Reference 4. The gamma and neutron scaling factors calculated in Reference 4 for the bounding new technology system are provided in Table 3-1, below.

Table 3-1: Dose Rate Scaling Factors for New Technology System

Gamma Scaling Factor	Neutron Scaling Factor
3.12	0.53

To be conservative, a neutron scaling factor of 1 was used instead of the 0.53 scaling factor in the table.

3.1.2.2. Distance Factor

Once the southern most ISFSI pad is filled with 7 TN-40/TN-40HT casks and 16 new technology casks, new ISFSI pads will be loaded north of the existing pads (Assumption 2.1.2). The new ISFSI pad locations are conservative (with respect to dose) and will bound any other pad locations within the ISFSI area. The new ISFSI pads will be located approximately 38 feet north of the current pads (Assumption 2.1.2) and therefore the face closest to the dose locations is approximately 25 m closer to the dose locations than the north face of the current pads. Because the new ISFSI pads are closer to the dose locations, the dose rate at each location will increase and a scaling factor must be used to account for the increase.

Although the site boundary is 110 m from the western edge of the ISFSI, it will not be used to calculate the scale factor because the new expansion ISFSI pads will not be moved any closer to the western site boundary. Location 12 is the second closest dose point to the ISFSI (after the site boundary) and is 905 feet or 276 m northeast from the ISFSI center (Training Center, Table 2-3 and Appendix A of this study). The new ISFSI pads are moved approximately 25 m north but to conservatively reflect the increase in dose rates due to the closer location, the scaling factor will be calculated based on the decrease in dose rates from 200 m to 300 m from the ISFSI face (204.03 m to 304.03 m from the ISFSI center for the north/south faces (Table 2-5) and 256.49 m to 355.27 m from the center for the ISFSI corners (Table 2-7)). The distance scaling factor M is calculated for the north/south faces and ISFSI corners using the following equation:

$$M = \frac{D_{200m}}{D_{300m}} \quad \textbf{Equation 3}$$

Where

D_{300m} = dose rate at 300 m from the ISFSI face or corner

D_{200m} = dose rate at 200 m from the ISFSI face or corner

Table 3-2: Distance Scaling Factors

Direction	Gamma Scale Factor	Neutron Scale Factor
North/South Faces	3.31	3.91
ISFSI Corners	3.13	3.73

To be conservative, the neutron scale factor from the north/south faces will be rounded to 4 and used to calculate both the gamma and neutron dose rates for the expansion ISFSI.

3.1.2.3. Equations for 44 Cask Expansion ISFSI

The maximum dose rates will occur when all 7 TN-40/TN-40HT casks and 44 new technology casks are loaded in 2046 (Table 2-1). Table 3-3 shows the loading scheme, cask location on the ISFSI pads, and the time period between when the cask was loaded and when all casks are loaded in 2046.

Table 3-3: Cask Loading Scheme

Year	Number of Casks	Type of Cask	Time in Cask (yr)	Position on ISFSI Pad
2022	3(1)	TN-40/TN-40HT	24	SE ISFSI Pad
2024	3	TN-40/TN-40HT	22	SE ISFSI Pad
2025	2	TN-40/TN-40HT	21	SE ISFSI Pad
2027	10	New Technology	19	SE ISFSI Pad
2031	8	New Technology	15	6 casks on SE ISFSI Pad, 2 on New ISFSI Pad North of Current Pads
2036	8	New Technology	10	New ISFSI Pad North of Current Pads
2041	8	New Technology	5	New ISFSI Pad North of Current Pads
2046	10	New Technology	0	New ISFSI Pad North of Current Pads

(1) One cask loaded in 2022 was part of the original 48 cask ISFSI. Only two casks loaded in 2022 will contribute to the expansion ISFSI dose rates.

Equation 4 expresses the maximum dose rate in 2046 for 7 TN-40/TN-40HT casks and 10 new technology casks loaded by the EOCL (Table 2-1). To be conservative, Equation 4 does not account for the increased distance between the casks on the southeast ISFSI pad and the dose locations. The dose rate factor F in the last term is added to account for the increased dose rates when using the new technology casks.

$$D_t = 2D_0e^{-\lambda 24} + 3D_0e^{-\lambda 22} + 2D_0e^{-\lambda 21} + 10D_0Fe^{-\lambda 19} \qquad \textbf{Equation 4}$$

Equation 5 expresses the maximum dose rate in 2046 for the additional 34 new technology casks loaded during license extension (Table 2-1). The dose rate factor F is added to all terms to account for the increased dose rates when using the new technology casks. Distance factor M is added to four terms to account for the new technology casks placed on the new ISFSI pads north of the existing pads.

$$D_t = 6D_0Fe^{-\lambda 15} + 2D_0FMe^{-\lambda 15} + 8D_0FMe^{-\lambda 10} + 8D_0FMe^{-\lambda 5} + 10D_0FMe^{-\lambda 0} \qquad \textbf{Equation 5}$$

Using the gamma decay constant of 0.025 yr^{-1}, equation 4 for EOCL reduces to:

$$D_t = 23.41440D_0 \qquad \textbf{Equation 6}$$

Using the gamma decay constant of 0.025 yr^{-1}, equation 5 for the additional 34 new technology casks for the license extension reduces to:

$$D_t = 320.68476 D_0 \quad \textbf{Equation 7}$$

Using the neutron decay constant of 0.0358 yr^{-1}, equation 4 for EOCL reduces to:

$$D_t = 8.22000 D_0 \quad \textbf{Equation 8}$$

Using the neutron decay constant of 0.0358 yr^{-1}, equation 5 for the additional 34 new technology casks for the license extension reduces to:

$$D_t = 97.30871 D_0 \quad \textbf{Equation 9}$$

Equations 6 through 9 and D_0 dose rates from Tables 2-11 through 2-13 are used to determine the gamma and neutron ISFSI dose rates as a function of distance for the 7 TN-40/TN-40HT casks and 44 new technology casks. The calculated dose rates for the north/south, east/west, and ISFSI corners are shown in Tables 3-4 through 3-6. Original ISFSI dose rates from Tables 2-5 through 2-7 and Expansion ISFSI dose rates from Tables 3-4 through 3-6 are added together to determine the total dose rates for the north/south, east/west, and ISFSI corners. The total dose rates (Original + Expansion ISFSI) are shown in Tables 3-7 through 3-9.

3.1.2.4. Expansion ISFSI Skyshine Dose Rates

Reference 1 used a simplified scaling approach to determine skyshine scaling factors. The scaling factors from Reference 1 are shown in Tables 2-14 through 2-16 of this study. Equation 10 is used with the scaling factors and the expansion ISFSI gamma and neutron total dose rates in Tables 3-4 through 3-6 to calculate the skyshine dose rates.

$$D_s = S D_T \quad \textbf{Equation 10}$$

Where

D_s = skyshine dose rate at a specific distance from the ISFSI

S = skyshine factor at a specific distance from the ISFSI

D_T = total dose (direct +skyshine) at a specific distance from the ISFSI

The skyshine radiation dose rates from the 7 TN-40/TN-40HT casks and 44 new technology casks are shown in Tables 3-10 through 3-12. Expansion ISFSI skyshine dose rates from Tables 3-10 through 3-12 and Original ISFSI skyshine dose rates from Tables 2-8 through 2-10 are added together to determine the total skyshine dose rates for the north/south, east/west, and ISFSI corners. The total dose rates (Original + Expansion ISFSI) are shown in Tables 3-13 through 3-15.

3.1.3. Station Personnel and Offsite Population Dose Rates and Collective Doses

The dose rates and collective doses for the expansion ISFSI for station personnel and the offsite population are calculated using the same approach described above in Section 3.1.2.3. The dose rate from any cask on the ISFSI at each specific location is the product of D_0 and the coefficients from Equations 6 and 7. The one difference to the approach is that the gamma contribution and neutron contribution are not separately

calculated since these contributions were not separately provided. Instead, the bounding gamma coefficient and decay constant are conservatively used for calculating the total contribution.

This translates to the use of Equation 6 for EOCL and Equation 7 for license extension since the gamma coefficients are larger than the corresponding neutron coefficients of Equations 8 and 9. The station personnel dose rates and collective doses for the 7 TN-40/TN-40HT casks and 44 new technology casks are listed in Tables 3-16 and 3-18. Total ISFSI station personnel dose rates and collective doses are listed in Tables 3-17 and 3-19, respectively.

Expansion ISFSI dose rates for the offsite population are determined as the product of the offsite population dose rate from Table 2-19 and the gamma coefficient from Equation 6 for the EOCL and from Equation 7 for new technology casks for LE. Expansion ISFSI collective doses are determined as the product of the offsite population collective dose from Table 2-19 and the gamma coefficient from Equation 6 for the EOCL and from Equation 7 for new technology casks for LE. The offsite population dose rates and collective doses for the 7 TN-40/TN-40HT casks and 44 new technology casks are listed in Tables 3-20 and 3-21, respectively. Total dose rates and collective doses (Original + Expansion ISFSI) are listed in Table 3-22.

3.1.4. Site Boundary

The nearest site boundary from the original ISFSI is located 110 meters from the western edge of the ISFSI concrete pads (Input 2.2.5). For conservatism, a distance of 100 meters from the ISFSI face is used for determining the dose rate at the nearest site boundary for the expansion ISFSI pad. The Expansion ISFSI gamma and neutron dose rates for EOCL and license extension at 100 m from the north/south face, east/west face, and ISFSI corners are shown in Tables 3-4 through 3-7. The most conservative total dose rate (gamma EOCL + gamma LE + neutron EOCL + neutron LE) for the expansion ISFSI at 100 m is 1.48E+00 mrem/hr at the site boundary (Table 3-4 for the north/south face).

3.1.5. Nearest Resident

The nearest resident from the original ISFSI is located 724 meters northwest from the ISFSI site (Input 2.2.4). For conservatism, a distance of 704.03 m from the center of the ISFSI for the North/South Faces, 670.47 m from the ISFSI center for the East/West faces, and 704.03 m from the ISFSI center for the ISFSI “Corners” are used for determining the annual dose to the nearest resident for the expansion ISFSI pad. The dose at the nearest resident due to spent fuel stored in association with the expansion ISFSI pad is determined from information in Tables 3-4 through 3-6.

The dose rate for the ISFSI corners is linearly interpolated from Table 3-6. The total dose rate at 653.84 m from the ISFSI center is 2.94E-03 mrem/hr (2.11E-03 mrem/hr gamma + 8.35E-04 mrem/hr neutron). The total dose rate at 753.61 m from the ISFSI center is 1.29E-03 mrem/hr (9.57E-04 mrem/hr gamma + 3.29E-04 mrem/hr neutron). The linear equation between the two dose points is y = -1.66E-05x+1.381E-02 where y is the dose rate (mrem/hr) and x is the distance (m). The dose rate at 704.03 m from the center of the ISFSI 2.11E-03 mrem/hr.

The east/west dose rate (1.47E-03 mrem/hr gamma +7.05E-04 mrem/hr neutron from Table 3-5 = 2.17E-03 mrem/hr after accounting for roundoff) at 670.47 m from the center is bounding compared to the dose rates at 704.03 m from the center for the north/south faces (1.81E-03 mrem/hr per Table 3-4) and the ISFSI corners (2.11E-03 mrem/hr from linear interpolation). The annual dose from the expansion ISFSI pad at 670.47 m from the center of the ISFSI is 1.90E+01 mrem/yr (i.e., 2.17E-03 mrem/hr x 8760 hr/yr).

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Figure 3-2: PINGP Nearest Residence Location

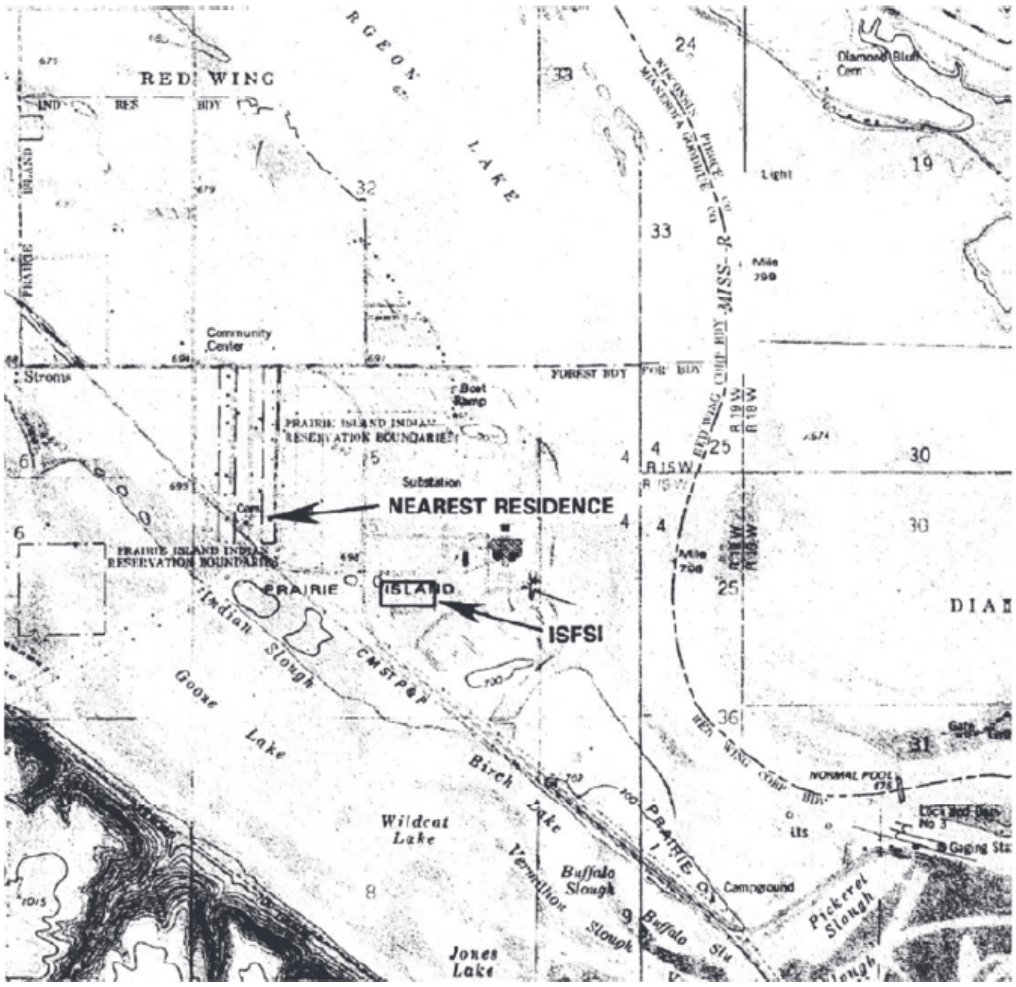
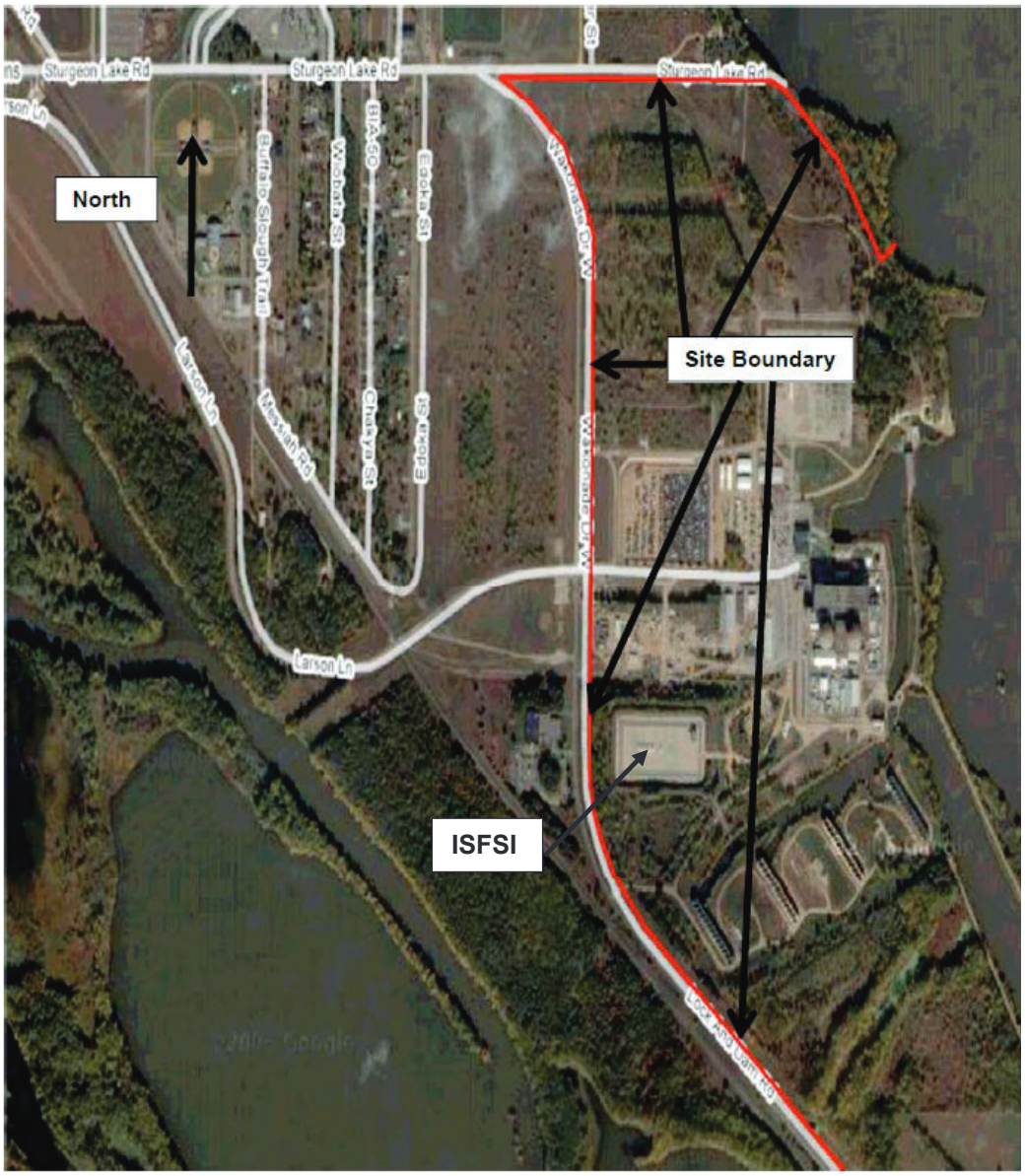


Figure 3-3: PINGP ISFSI Site Boundaries (boundary shown in red)



3.2. CALCULATION

Table 3-4: Expansion ISFSI Dose Rates from North/South Faces (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma			Neutron		
		EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)	EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)
0	4.03	3.54E+00	4.84E+01	5.20E+01	1.64E+00	1.94E+01	2.10E+01
10	14.03	2.39E+00	3.27E+01	3.51E+01	1.18E+00	1.39E+01	1.51E+01
45	49.03	7.21E-01	9.88E+00	1.06E+01	3.79E-01	4.49E+00	4.86E+00
100	104.03	5.08E-02	6.96E-01	7.47E-01	5.71E-02	6.76E-01	7.33E-01
200	204.03	1.26E-02	1.73E-01	1.85E-01	1.10E-02	1.30E-01	1.41E-01
300	304.03	3.82E-03	5.23E-02	5.61E-02	2.81E-03	3.33E-02	3.61E-02
400	404.03	1.28E-03	1.75E-02	1.88E-02	8.13E-04	9.62E-03	1.04E-02
500	504.03	4.82E-04	6.61E-03	7.09E-03	2.61E-04	3.09E-03	3.36E-03
600	604.03	2.01E-04	2.75E-03	2.95E-03	1.00E-04	1.19E-03	1.29E-03
700	704.03	9.04E-05	1.24E-03	1.33E-03	3.74E-05	4.43E-04	4.80E-04
800	804.03	4.43E-05	6.06E-04	6.50E-04	1.42E-05	1.68E-04	1.83E-04
900	904.03	2.21E-05	3.02E-04	3.24E-04	7.12E-06	8.43E-05	9.14E-05
1000	1004.03	1.11E-05	1.53E-04	1.64E-04	2.45E-06	2.90E-05	3.14E-05

Table 3-5: Expansion ISFSI Dose Rates from East/West Faces (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma			Neutron		
		EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)	EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)
0	70.47	2.19E+01	3.00E+02	3.22E+02	7.17E+00	8.49E+01	9.20E+01
10	80.47	1.80E+00	2.47E+01	2.65E+01	1.11E+00	1.31E+01	1.42E+01
45	115.47	4.14E-02	5.68E-01	6.09E-01	6.87E-02	8.14E-01	8.82E-01
100	170.47	2.05E-02	2.81E-01	3.01E-01	2.61E-02	3.09E-01	3.36E-01
200	270.47	5.06E-03	6.93E-02	7.43E-02	5.07E-03	6.00E-02	6.51E-02
300	370.47	1.57E-03	2.15E-02	2.31E-02	1.32E-03	1.56E-02	1.69E-02
400	470.47	5.41E-04	7.41E-03	7.95E-03	4.55E-04	5.39E-03	5.85E-03
500	570.47	2.09E-04	2.87E-03	3.08E-03	1.40E-04	1.65E-03	1.79E-03
600	670.47	1.00E-04	1.37E-03	1.47E-03	5.49E-05	6.50E-04	7.05E-04
700	770.47	4.03E-05	5.52E-04	5.92E-04	1.98E-05	2.35E-04	2.54E-04
800	870.47	1.87E-05	2.57E-04	2.75E-04	1.00E-05	1.19E-04	1.29E-04
900	970.47	9.81E-06	1.34E-04	1.44E-04	3.81E-06	4.52E-05	4.90E-05
1000	1070.47	5.41E-06	7.41E-05	7.95E-05	1.90E-06	2.25E-05	2.44E-05

Table 3-6: Expansion ISFSI Dose Rates from ISFSI Corners (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma			Neutron		
		EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)	EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)
10	77.91	2.36E+00	3.24E+01	3.48E+01	1.22E+00	1.45E+01	1.57E+01
45	107.91	3.23E-01	4.43E+00	4.75E+00	1.94E-01	2.30E+00	2.49E+00
100	159.24	2.65E-02	3.62E-01	3.89E-01	3.03E-02	3.59E-01	3.89E-01
200	256.49	7.28E-03	9.97E-02	1.07E-01	6.21E-03	7.35E-02	7.97E-02
300	355.27	2.32E-03	3.18E-02	3.41E-02	1.66E-03	1.97E-02	2.13E-02
400	454.58	8.85E-04	1.21E-02	1.30E-02	4.85E-04	5.74E-03	6.23E-03
500	554.14	3.37E-04	4.62E-03	4.96E-03	1.78E-04	2.10E-03	2.28E-03
600	653.84	1.44E-04	1.97E-03	2.11E-03	6.50E-05	7.70E-04	8.35E-04
700	753.61	6.51E-05	8.92E-04	9.57E-04	2.56E-05	3.04E-04	3.29E-04
800	853.44	3.30E-05	4.52E-04	4.85E-04	8.96E-06	1.06E-04	1.15E-04
900	953.31	1.70E-05	2.32E-04	2.49E-04	4.38E-06	5.19E-05	5.62E-05
1000	1053.20	9.44E-06	1.29E-04	1.39E-04	1.84E-06	2.18E-05	2.36E-05

Table 3-7: Total (Original & Expansion ISFSI) Dose Rates from North/South Faces (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Total Gamma(1) (mrem/hr)	Total Neutron(1) (mrem/hr)	Total (mrem/hr)
0	4.03	5.75E+01	2.77E+01	8.52E+01
10	14.03	3.89E+01	1.99E+01	5.87E+01
45	49.03	1.17E+01	6.40E+00	1.81E+01
100	104.03	8.27E-01	9.65E-01	1.79E+00
200	204.03	2.05E-01	1.86E-01	3.91E-01
300	304.03	6.21E-02	4.75E-02	1.10E-01
400	404.03	2.08E-02	1.37E-02	3.45E-02
500	504.03	7.85E-03	4.42E-03	1.23E-02
600	604.03	3.27E-03	1.69E-03	4.96E-03
700	704.03	1.47E-03	6.32E-04	2.10E-03
800	804.03	7.20E-04	2.40E-04	9.61E-04
900	904.03	3.59E-04	1.20E-04	4.80E-04
1000	1004.03	1.81E-04	4.14E-05	2.23E-04

Note:

(1) Gamma and neutron dose rates are the sum of the corresponding dose rates from Tables 3-4 and 2-5.

Table 3-8: Total (Original & Expansion ISFSI) Dose Rates from East/West Faces (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Total Gamma(1) (mrem/hr)	Total Neutron(1) (mrem/hr)	Total (mrem/hr)
0	70.47	3.56E+02	1.21E+02	4.77E+02
10	80.47	2.93E+01	1.87E+01	4.81E+01
45	115.47	6.75E-01	1.16E+00	1.84E+00
100	170.47	3.34E-01	4.42E-01	7.75E-01
200	270.47	8.23E-02	8.57E-02	1.68E-01
300	370.47	2.55E-02	2.22E-02	4.77E-02
400	470.47	8.80E-03	7.70E-03	1.65E-02
500	570.47	3.41E-03	2.36E-03	5.77E-03
600	670.47	1.63E-03	9.28E-04	2.56E-03
700	770.47	6.56E-04	3.35E-04	9.90E-04
800	870.47	3.05E-04	1.69E-04	4.74E-04
900	970.47	1.60E-04	6.45E-05	2.24E-04
1000	1070.47	8.80E-05	3.21E-05	1.20E-04

Note:

(1) Gamma and neutron dose rates are the sum of the corresponding dose rates from Tables 3-5 and 2-6.

Table 3-9: Total (Original & Expansion ISFSI) Dose Rates from ISFSI Corners (Direct + Skyshine)

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Total Gamma(1) (mrem/hr)	Total Neutron(1) (mrem/hr)	Total (mrem/hr)
10	77.91	3.85E+01	2.07E+01	5.92E+01
45	107.91	5.26E+00	3.28E+00	8.54E+00
100	159.24	4.31E-01	5.12E-01	9.43E-01
200	256.49	1.19E-01	1.05E-01	2.23E-01
300	355.27	3.78E-02	2.81E-02	6.59E-02
400	454.58	1.44E-02	8.20E-03	2.26E-02
500	554.14	5.49E-03	3.00E-03	8.49E-03
600	653.84	2.34E-03	1.10E-03	3.44E-03
700	753.61	1.06E-03	4.33E-04	1.49E-03
800	853.44	5.37E-04	1.51E-04	6.89E-04
900	953.31	2.76E-04	7.40E-05	3.50E-04
1000	1053.20	1.54E-04	3.11E-05	1.85E-04

Note:

(1) Gamma and neutron dose rates are the sum of the corresponding dose rates from Tables 3-6 and 2-7.

Table 3-10: Expansion ISFSI Skyshine Dose Rates from North/South Faces

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma			Neutron		
		EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)	EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)
0	4.03	3.08E+00	4.21E+01	4.52E+01	1.64E+00	1.94E+01	2.10E+01
10	14.03	2.08E+00	2.85E+01	3.05E+01	1.18E+00	1.39E+01	1.51E+01
45	49.03	6.27E-01	8.59E+00	9.22E+00	3.79E-01	4.49E+00	4.86E+00
100	104.03	4.67E-02	6.40E-01	6.87E-01	5.71E-02	6.76E-01	7.33E-01
200	204.03	1.17E-02	1.60E-01	1.72E-01	1.10E-02	1.30E-01	1.41E-01
300	304.03	3.59E-03	4.91E-02	5.27E-02	2.81E-03	3.33E-02	3.61E-02
400	404.03	1.20E-03	1.65E-02	1.77E-02	8.13E-04	9.62E-03	1.04E-02
500	504.03	4.49E-04	6.14E-03	6.59E-03	2.61E-04	3.09E-03	3.36E-03
600	604.03	1.85E-04	2.53E-03	2.71E-03	1.00E-04	1.19E-03	1.29E-03
700	704.03	8.22E-05	1.13E-03	1.21E-03	3.74E-05	4.43E-04	4.80E-04
800	804.03	4.03E-05	5.52E-04	5.92E-04	1.42E-05	1.68E-04	1.83E-04
900	904.03	1.99E-05	2.72E-04	2.92E-04	7.12E-06	8.43E-05	9.14E-05
1000	1004.03	9.92E-06	1.36E-04	1.46E-04	2.45E-06	2.90E-05	3.14E-05

Table 3-11: Expansion ISFSI Skyshine Dose Rates from East/West Faces

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma			Neutron		
		EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)	EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)
0	70.47	1.86E+01	2.55E+02	2.73E+02	7.17E+00	8.49E+01	9.20E+01
10	80.47	1.55E+00	2.12E+01	2.28E+01	1.11E+00	1.31E+01	1.42E+01
45	115.47	3.65E-02	4.99E-01	5.36E-01	6.87E-02	8.14E-01	8.82E-01
100	170.47	1.85E-02	2.53E-01	2.71E-01	2.61E-02	3.09E-01	3.36E-01
200	270.47	4.60E-03	6.30E-02	6.76E-02	5.07E-03	6.00E-02	6.51E-02
300	370.47	1.43E-03	1.96E-02	2.10E-02	1.32E-03	1.56E-02	1.69E-02
400	470.47	4.87E-04	6.67E-03	7.15E-03	4.55E-04	5.39E-03	5.85E-03
500	570.47	1.88E-04	2.58E-03	2.77E-03	1.40E-04	1.65E-03	1.79E-03
600	670.47	9.00E-05	1.23E-03	1.32E-03	5.49E-05	6.50E-04	7.05E-04
700	770.47	3.54E-05	4.85E-04	5.21E-04	1.98E-05	2.35E-04	2.54E-04
800	870.47	1.61E-05	2.21E-04	2.37E-04	1.00E-05	1.19E-04	1.29E-04
900	970.47	8.34E-06	1.14E-04	1.23E-04	3.81E-06	4.52E-05	4.90E-05
1000	1070.47	4.49E-06	6.15E-05	6.60E-05	1.90E-06	2.25E-05	2.44E-05

Table 3-12: Expansion ISFSI Skyshine Dose Rates from ISFSI Corners

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Gamma			Neutron		
		EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)	EOCL D_t (mrem/hr)	New Tech License Extension D_t (mrem/hr)	Total (mrem/hr)
10	77.91	2.03E+00	2.79E+01	2.99E+01	1.22E+00	1.45E+01	1.57E+01
45	107.91	2.78E-01	3.81E+00	4.08E+00	1.94E-01	2.30E+00	2.49E+00
100	159.24	2.43E-02	3.33E-01	3.58E-01	3.03E-02	3.59E-01	3.89E-01
200	256.49	6.77E-03	9.28E-02	9.95E-02	6.21E-03	7.35E-02	7.97E-02
300	355.27	2.16E-03	2.96E-02	3.17E-02	1.66E-03	1.97E-02	2.13E-02
400	454.58	8.32E-04	1.14E-02	1.22E-02	4.85E-04	5.74E-03	6.23E-03
500	554.14	3.14E-04	4.29E-03	4.61E-03	1.78E-04	2.10E-03	2.28E-03
600	653.84	1.32E-04	1.81E-03	1.94E-03	6.50E-05	7.70E-04	8.35E-04
700	753.61	5.92E-05	8.11E-04	8.71E-04	2.56E-05	3.04E-04	3.29E-04
800	853.44	2.97E-05	4.07E-04	4.37E-04	8.96E-06	1.06E-04	1.15E-04
900	953.31	1.51E-05	2.07E-04	2.22E-04	4.38E-06	5.19E-05	5.62E-05
1000	1053.2	8.40E-06	1.15E-04	1.23E-04	1.84E-06	2.18E-05	2.36E-05

Table 3-13: Total (Original & Expansion ISFSI) Skyshine Dose Rates from North/South Faces

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Total Gamma(1) (mrem/hr)	Total Neutron(1) (mrem/hr)	Total (mrem/hr)
0	4.03	5.01E+01	2.77E+01	7.77E+01
10	14.03	3.38E+01	1.99E+01	5.37E+01
45	49.03	1.02E+01	6.40E+00	1.66E+01
100	104.03	7.61E-01	9.65E-01	1.73E+00
200	204.03	1.91E-01	1.86E-01	3.77E-01
300	304.03	5.84E-02	4.75E-02	1.06E-01
400	404.03	1.96E-02	1.37E-02	3.33E-02
500	504.03	7.30E-03	4.42E-03	1.17E-02
600	604.03	3.01E-03	1.69E-03	4.70E-03
700	704.03	1.34E-03	6.32E-04	1.97E-03
800	804.03	6.55E-04	2.40E-04	8.96E-04
900	904.03	3.24E-04	1.20E-04	4.44E-04
1000	1004.03	1.61E-04	4.14E-05	2.03E-04

Note:

(1) Gamma and neutron dose rates are the sum of the corresponding dose rates from Tables 3-10 and 2-8.

Table 3-14: Total (Original & Expansion ISFSI) Skyshine Dose Rates from East/West Faces

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Total Gamma(1) (mrem/hr)	Total Neutron(1) (mrem/hr)	Total (mrem/hr)
0	70.47	3.03E+02	1.21E+02	4.24E+02
10	80.47	2.52E+01	1.87E+01	4.40E+01
45	115.47	5.93E-01	1.16E+00	1.75E+00
100	170.47	3.01E-01	4.42E-01	7.42E-01
200	270.47	7.49E-02	8.57E-02	1.61E-01
300	370.47	2.32E-02	2.22E-02	4.55E-02
400	470.47	7.92E-03	7.70E-03	1.56E-02
500	570.47	3.07E-03	2.36E-03	5.43E-03
600	670.47	1.46E-03	9.28E-04	2.39E-03
700	770.47	5.77E-04	3.35E-04	9.11E-04
800	870.47	2.62E-04	1.69E-04	4.31E-04
900	970.47	1.36E-04	6.45E-05	2.00E-04
1000	1070.47	7.30E-05	3.21E-05	1.05E-04

Note:

(1) Gamma and neutron dose rates are the sum of the corresponding dose rates from Tables 3-11 and 2-9.

Table 3-15: Total (Original & Expansion ISFSI) Skyshine Dose Rates from ISFSI Corners

Distance from the ISFSI Face (m)	Distance from the ISFSI Center (m)	Total Gamma(1) (mrem/hr)	Total Neutron(1) (mrem/hr)	Total (mrem/hr)
10	77.91	3.31E+01	2.07E+01	5.38E+01
45	107.91	4.52E+00	3.28E+00	7.80E+00
100	159.24	3.96E-01	5.12E-01	9.09E-01
200	256.49	1.10E-01	1.05E-01	2.15E-01
300	355.27	3.52E-02	2.81E-02	6.32E-02
400	454.58	1.35E-02	8.20E-03	2.17E-02
500	554.14	5.10E-03	3.00E-03	8.10E-03
600	653.84	2.15E-03	1.10E-03	3.25E-03
700	753.61	9.64E-04	4.33E-04	1.40E-03
800	853.44	4.84E-04	1.51E-04	6.35E-04
900	953.31	2.46E-04	7.40E-05	3.20E-04
1000	1053.20	1.37E-04	3.11E-05	1.68E-04

Note:

(1) Gamma and neutron dose rates are the sum of the corresponding dose rates from Tables 3-12 and 2-10.

[NOT-PUBLIC DATA BEGINS

Table 3-16: Expansion ISFSI Station Personnel Dose Rates

Location #	Location	Distance (feet from center ISFSI)	EOCL D_t (1) (mrem/hr)	New Tech License Extension D_t (1) (mrem/hr)
1	34 OCA Gatehouse (D-2)	[redacted]	1.80E-02	2.47E-01
2	22 Receiving Warehouse (D-5) 55 13 P1ex Project Office (D-5) A 4 P1ex Project Office (D-5)		1.94E-02	2.66E-01
3	24 NPD Building (E-6) 33 NPD Annex Building (E-5) Quality Assurance Modular Office (E-5)		1.59E-02	2.17E-01
4	42 Fabrication Shop (C-5) 25 Steam Generator Mockup Building (C-5) 48 Fabrication Shop (D-5)		4.05E-03	5.55E-02
5	30 Warehouse (C-5) 31 Multiuse Warehouse (C-5) 21 Warehouse -8 (C-6)		1.64E-03	2.25E-02
6	12 Substation, SBO Structures (B-6)		2.88E-04	3.94E-03
7	23 New Administration Building (D-6) 6 Security Building (D-6)		2.34E-03	3.21E-02
8	4 Turbine Building (D-7) 28 Warehouse -2 (E-7) 3 Auxiliary Building (E-7) 13 New Service Building (D-8) 11 D5/D6 DG Building (D-7) 79 Security DG Building (D-7)		1.64E-03	2.25E-02
9	9 Outage Trailers (E-7)		4.94E-03	6.77E-02
10	60 Fabrication Shop (E-7) 29 Main Plant Warehouse (E-7) 66 Maintenance Storage Building (E-7)		2.06E-03	2.83E-02
11	20 Environmental Lab (B-9)		1.30E-04	1.78E-03
12	Training Center		2.22E-02	3.04E-01
13	38 Old Administration Building (D-7) 71 Administration Building Addition (D-7)		1.21E-03	1.66E-02
14	13 New Service Building (D-8)		7.38E-04	1.01E-02

Note:

(1) EOCL and New Tech D_t dose rates are the product of the D_0 dose rate from Table 2-17 and the gamma coefficient from Equation 6 for the EOCL and from Equation 7 for New Tech.

NOT-PUBLIC DATA ENDS]

[NOT-PUBLIC DATA BEGINS

Table 3-17: Total ISFSI Station Personnel Dose Rates

Location #	Location	Distance (feet from center ISFSI)	Full Time (Personnel)	Outage (Personnel)	Dose Rate(1) (mrem/hr)
1	34 OCA Gatehouse (D-2)	[redacted]	2	0	2.91E-01
2	22 Receiving Warehouse (D-5) 55 13 P1ex Project Office (D-5) A 4 P1ex Project Office (D-5)		30	0	3.13E-01
3	24 NPD Building (E-6) 33 NPD Annex Building (E-5) Quality Assurance Modular Office (E-5)		60	1	2.56E-01
4	42 Fabrication Shop (C-5) 25 Steam Generator Mockup Building (C-5) 48 Fabrication Shop (D-5)		2	45	6.53E-02
5	30 Warehouse (C-5) 31 Multiuse Warehouse (C-5) 21 Warehouse -8 (C-6)		0	2	2.65E-02
6	12 Substation, SBO Structures (B-6)		0	2	4.64E-03
7	23 New Administration Building (D-6) 6 Security Building (D-6)		287	25	3.77E-02
8	4 Turbine Building (D-7) 28 Warehouse -2 (E-7) 3 Auxiliary Building (E-7) 13 New Service Building (D-8) 11 D5/D6 DG Building (D-7) 79 Security DG Building (D-7)		180	192	2.65E-02
9	9 Outage Trailers (E-7)		5	40	7.96E-02
10	60 Fabrication Shop (E-7) 29 Main Plant Warehouse (E-7) 66 Maintenance Storage Building (E-7)		23	45	3.33E-02
11	20 Environmental Lab (B-9)		2	0	2.09E-03
12	Training Center		49	0	3.57E-01
13	38 Old Administration Building (D-7) 71 Administration Building Addition (D-7)		68	0	1.96E-02
14	13 New Service Building (D-8)		9	0	1.19E-02

Note:
(1) Dose rate is the sum of the dose rates from Tables 3-16 and 2-3.

NOT-PUBLIC DATA ENDS]

[NOT-PUBLIC DATA BEGINS

Table 3-18: Expansion ISFSI Station Personnel Collective Doses

Location #	Location	Distance (feet from center ISFSI)	Full Time[1]		Outage[2]		Total (person-rem)
			EOCL (person-rem)	New Tech License Extension (person-rem)	EOCL (person-rem)	New Tech License Extension (person-rem)	
1	34 OCA Gatehouse (D-2)	[redacted]	9.13E-02	1.25E+00	0.00E+00	0.00E+00	1.34E+00
2	22 Receiving Warehouse (D-5) 55 13 P1ex Project Office (D-5) A 4 P1ex Project Office (D-5)		1.46E+00	2.00E+01	0.00E+00	0.00E+00	2.14E+01
3	24 NPD Building (E-6) 33 NPD Annex Building (E-5) Quality Assurance Modular Office (E-5)		2.39E+00	3.27E+01	8.57E-03	1.17E-01	3.52E+01
4	42 Fabrication Shop (C-5) 25 Steam Generator Mockup Building (C-5) 48 Fabrication Shop (D-5)		2.10E-02	2.88E-01	9.81E-02	1.34E+00	1.75E+00
5	30 Warehouse (C-5) 31 Multiuse Warehouse (C-5) 21 Warehouse -8 (C-6)		0.00E+00	0.00E+00	1.77E-03	2.43E-02	2.61E-02
6	12 Substation, SBO Structures (B-6)		0.00E+00	0.00E+00	3.11E-04	4.27E-03	4.58E-03
7	23 New Administration Building (D-6) 6 Security Building (D-6)		1.68E+00	2.30E+01	3.51E-02	4.81E-01	2.52E+01
8	4 Turbine Building (D-7) 28 Warehouse -2 (E-7) 3 Auxiliary Building (E-7) 13 New Service Building (D-8) 11 D5/D6 DG Building (D-7) 79 Security DG Building (D-7)		7.38E-01	1.01E+01	1.68E-01	2.31E+00	1.33E+01
9	9 Outage Trailers (E-7)		6.32E-02	8.66E-01	1.05E-01	1.44E+00	2.47E+00
10	60 Fabrication Shop (E-7) 29 Main Plant Warehouse (E-7) 66 Maintenance Storage Building (E-7)		1.19E-01	1.63E+00	4.92E-02	6.73E-01	2.47E+00
11	20 Environmental Lab (B-9)		6.49E-04	8.88E-03	0.00E+00	0.00E+00	9.53E-03
12	Training Center		2.72E+00	3.72E+01	0.00E+00	0.00E+00	3.99E+01
13	38 Old Administration Building (D-7) 71 Administration Building Addition (D-7)		2.03E-01	2.79E+00	0.00E+00	0.00E+00	2.99E+00
14	13 New Service Building (D-8)		1.40E-02	1.92E-01	0.00E+00	0.00E+00	2.06E-01

Note:
(1) Full time EOCL and New Tech Collective doses are the product of the Full Time Collective Dose, D_0, from Table 2-18 and the gamma coefficient from Equation 6 for the EOCL and from Equation 7 for New Tech.
(2) Outage EOCL and New Tech Collective doses are the product of the Outage Collective Dose, D_0, from Table 2-18 and the gamma coefficient from Equation 6 for the EOCL and from Equation 7 for New Tech.

NOT-PUBLIC DATA ENDS]

[NOT-PUBLIC DATA BEGINS

Table 3-19: Total ISFSI Station Personnel Collective Doses

Location #	Location	Distance (feet from center ISFSI)	Full Time[1] (person-rem)	Outage[1] (person-rem)	Total Exposure (person-rem)
1	34 OCA Gatehouse (D-2)	[redacted]	1.47E+00	0.00E+00	1.47E+00
2	22 Receiving Warehouse (D-5) 55 13 P1ex Project Office (D-5) A 4 P1ex Project Office (D-5)		2.35E+01	0.00E+00	2.35E+01
3	24 NPD Building (E-6) 33 NPD Annex Building (E-5) Quality Assurance Modular Office (E-5)		3.85E+01	1.38E-01	3.86E+01
4	42 Fabrication Shop (C-5) 25 Steam Generator Mockup Building (C-5) 48 Fabrication Shop (D-5)		3.39E-01	1.58E+00	1.92E+00
5	30 Warehouse (C-5) 31 Multiuse Warehouse (C-5) 21 Warehouse -8 (C-6)		0.00E+00	2.86E-02	2.86E-02
6	12 Substation, SBO Structures (B-6)		0.00E+00	5.02E-03	5.02E-03
7	23 New Administration Building (D-6) 6 Security Building (D-6)		2.70E+01	5.66E-01	2.76E+01
8	4 Turbine Building (D-7) 28 Warehouse -2 (E-7) 3 Auxiliary Building (E-7) 13 New Service Building (D-8) 11 D5/D6 DG Building (D-7) 79 Security DG Building (D-7)		1.19E+01	2.71E+00	1.46E+01
9	9 Outage Trailers (E-7)		1.02E+00	1.70E+00	2.71E+00
10	60 Fabrication Shop (E-7) 29 Main Plant Warehouse (E-7) 66 Maintenance Storage Building (E-7)		1.92E+00	7.93E-01	2.71E+00
11	20 Environmental Lab (B-9)		1.05E-02	0.00E+00	1.05E-02
12	Training Center		4.38E+01	0.00E+00	4.38E+01
13	38 Old Administration Building (D-7) 71 Administration Building Addition (D-7)		3.28E+00	0.00E+00	3.28E+00
14	13 New Service Building (D-8)		2.26E-01	0.00E+00	2.26E-01
		Total			160.50

Note:
(1) Full time and outage doses are the sum of the corresponding doses from Tables 3-18 and 2-4.

NOT-PUBLIC DATA ENDS]

Table 3-20: Expansion ISFSI Offsite Population Dose Rates

Offsite Population	Description	Distance	Occupancy Times	Population	EOCL D_t (1) (mrem/hr)	New Tech License Extension D_t (1) (mrem/hr)
Permanent Population Within 2 Mile Radius	2 mile radius	> 0 .45 mile	8760	398	2.04E-04	2.80E-03
Transient Employee Population	2 mile – PI Community center, government center, and clinic	0.8 mile	2000	80	2.34E-05	3.20E-04
	2 mile - Employees at Treasure Island Casino	0.8 mile	8760	435	2.34E-05	3.20E-04
Transient Recreational Population	2 mile – Treasure Island Casino	0.8 mile	8760	5400	2.34E-05	3.20E-04
Marina and RV Park	2 mile – PI Community center, government center, and clinic	0.8 mile	1160	450	2.34E-05	3.20E-04

Note:

(1) EOCL and New Tech dose rates are determined as the product of the offsite population dose rate from Table 2-19 and the gamma coefficient from Equation 6 for the EOCL and from Equation 7 for New Tech.

Table 3-21: Expansion ISFSI Offsite Population Collective Doses

Offsite Population	Description	Distance	Occupancy Times	Population	EOCL[1] (person-rem)	New Tech License Extension[1] (person-rem)
Permanent Population Within 2 Mile Radius	2 mile radius	> 0 .45 mile	8760	398	7.12E-01	9.75E+00
Transient Employee Population	2 mile – PI Community center, government center, and clinic	0.8 mile	2000	80	3.75E-03	5.13E-02
	2 mile - Employees at Treasure Island Casino	0.8 mile	8760	435	8.90E-02	1.22E+00
Transient Recreational Population	2 mile – Treasure Island Casino	0.8 mile	8760	5400	1.11E+00	1.51E+01
Marina and RV Park	2 mile – PI Community center, government center, and clinic	0.8 mile	1160	450	1.22E-02	1.67E-01

Note:

(1) EOCL and New Tech collective doses are determined as the product of the offsite population collective dose (D_0) from Table 2-19 and the gamma coefficient from Equation 6 for the EOCL and from Equation 7 for New Tech.

Table 3-22: Total ISFSI Offsite Population Dose Rates and Collective Doses

Offsite Population	Description	Distance	Occupancy Times	Population	Dose Rate(1) (mrem/hr)	Collective Exposure(1) (person-rem)
Permanent Population Within 2 Mile Radius	2 mile radius	> 0 .45 mile	8760	398	3.29E-03	1.15E+01
Transient Employee Population	2 mile – PI Community center, government center, and clinic	0.8 mile	2000	80	3.77E-04	6.04E-02
	2 mile - Employees at Treasure Island Casino	0.8 mile	8760	435	3.77E-04	1.44E+00
Transient Recreational Population	2 mile – Treasure Island Casino	0.8 mile	8760	5400	3.77E-04	1.78E+01
Marina and RV Park	2 mile – PI Community center, government center, and clinic	0.8 mile	1160	450	3.77E-04	1.97E-01
	Total Collective Within 2 Miles					3.10E+01

Note:
(1) Dose rates and collective are the sum of the corresponding values from Tables 3-20, 3-21, and 2-2.

4. CRITERIA

4.1. ACCEPTANCE CRITERIA

The objective of this calculation is to demonstrate that the total normal operation radiation doses (i.e., sum of the direct dose from the original ISFSI, from the expansion ISFSI, and the dose from normal plant operations) will be in accordance with the requirements of 10 CFR 72.104(a), 40 CFR 190.10(a), and 10 CFR 20.1301(a). Therefore, the acceptance criteria for this calculation is to verify that the total doses are below the dose limits provided in the aforementioned regulations. The dose limits for each regulation are provided below.

10 CFR 72.104(a):

(a) During normal operations and anticipated occurrences, the annual dose equivalent to any real individual who is located beyond the controlled area must not exceed 0.25 mSv (25 mrem) to the whole body, 0.75 mSv (75 mrem) to the thyroid and 0.25 mSv (25 mrem) to any other critical organ as a result of exposure to:

(1) Planned discharges of radioactive materials, radon and its decay products excepted, to the general environment,

(2) Direct radiation from ISFSI or MRS operations, and

(3) Any other radiation from uranium fuel cycle operations within the region.

40 CFR 190.10(a):

(a) The annual dose equivalent does not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other organ of any member of the public as the result of exposures to planned discharges of radioactive materials, radon and its daughters excepted, to the general environment from uranium fuel cycle operations and to radiation from these operations.

10 CFR 20.1301(a):

(a) Each licensee shall conduct operations so that –

(1) The total effective dose equivalent to individual members of the public from the licensed operation does not exceed 0.1 rem (1 mSv) in a year, exclusive of the dose contributions from background radiation, from any administration the individual has received, from exposure to individuals administered radioactive material and released under § 35.75, from voluntary participation in medical research programs, and from the licensee's disposal of radioactive material into sanitary sewerage in accordance with § 20.2003, and

(2) The dose in any unrestricted area from external sources, exclusive of the dose contributions from patients administered radioactive material and released in accordance with § 35.75, does not exceed 0.002 rem (0.02 millisievert) in any one hour.

5. LIMITATIONS

1) Dose rates calculated in this study are based on the assumption that the loading plan in Input 2.2.1 is followed. As discussed in Section 3.1.2.3 the maximum dose rates will occur when all 7 TN-40/TN-40HT casks and 44 new technology casks are loaded in 2046. Dose rates are dependent on the amount of time between initial cask loading and when all casks are loaded in 2046. Casks placed on the ISFSI pad earlier go through additional radiodecay while sitting on the ISFSI pad which will decrease dose rates. If a loading year is earlier than planned compared to the loading scheme in Input 2.2.1, the time in the cask (i.e., the decay time to 2046) will increase and the total dose rates in 2046 will decrease. If a loading year is later than planned compared to the loading scheme in Input 2.2.1, the time in the cask (i.e., the decay time to 2046) will decrease and the total dose rates in 2046 will increase.

2) Dose rates calculated in this study are based on the assumption that the on-contact dose rates at the top surface of the fuel loaded casks for the new technology system chosen by PINGP for future loading campaigns are bounded by the dose rates obtained by applying the scaling factors discussed in Section 3.1.2.1.

6. CONCLUSIONS

Table 6-1: Summation of 10 CFR 72.104 (a) and 40 CFR 190.10 (a) Annual Dose (Nearest Resident)

Source	Dose Contribution (mrem/yr)	Total (mrem/yr)	Criteria (mrem/yr)	Margin (mrem/yr)
Original ISFSI (48 TN-40/TN-40HT fuel loaded casks)	3.05E+00	22.11	25	2.89
Expansion ISFSI (7 TN-40/TN-40HT + 44 New Tech fuel loaded casks)	1.90E+01			
Planned Direct and Gaseous Effluent Discharges	1.50E-02			

Table 6-2: Summation of 10 CFR 20.1301 (a)(1) Annual Dose (Nearest Resident)

Source	Dose Contribution (mrem/yr)	Total (mrem/yr)	Criteria (mrem/yr)	Margin (mrem/yr)
Licensed Operation	22.11	22.11	100	77.89

Table 6-3: Summation of 10 CFR 20.1301 (a)(2) Dose Rate (Site Boundary)

Source	Dose Contribution (mrem/hr)	Total (mrem/hr)	Criteria (mrem/hr)	Margin (mrem/hr)
Original ISFSI (48 TN-40/TN-40HT fuel loaded casks)	3.13E-01	1.79E+00	2	0.21
Expansion ISFSI (7 TN-40/TN-40HT + 44 New Tech fuel loaded casks)	1.48E+00			
Other Sources	0.00E+00			

The calculated dose values at the nearest site boundary and at the nearest resident meet the acceptance criteria of 10 CFR 72.104(a), 40 CFR 190.10(a), and 10 CFR 20.1301(a). Therefore, the expansion ISFSI design is considered to be acceptable with respect to the radiation levels at the nearest site boundary and at the nearest resident. Dose rates in this analysis bound any loading configuration of 7 TN-40/TN-40HT casks and 16 new technology systems on the existing southeast ISFSI pad and 28 new technology casks on new pads north of the existing pads. Annual doses presented in Tables 6-1 and 6-2 and dose rates presented in Table 6-3 are determined using conservative assumptions and methodologies as discussed in this report and in Reference 1. Actual doses and dose rates are expected to be less than those presented in this report, which will result in larger dose margins than those presented in Tables 6-1 through 6-3.

7. REFERENCES

1. S&L Calculation 2018-04151, Dose Rate Analysis for Prairie Island ISFSI Expansion, Revision 1 [1]
2. Prairie Island Independent Spent Fuel Storage Installation Safety Analysis Report, Revision 20
3. DIT No. PICON-01, Study to Support ISFSI Certificate of Need (CON), 8/28/23 [2]
4. New Cask Storage Technology Vendor Specific Information, Supplement to SL-018015, Revision 0 [3]

1 Attached as Appendix C.
2 Attached as Appendix D.
3 Attached as Appendix E.

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CONTAINS SECURITY INFORMATION