5.13.1.2 Source Terms

Dose estimates are calculated using time dependent radioisotope activities released to the environment determined using X-energy's suite of codes discussed above. Table 5.13.1-2 through Table 5.13.1-11 identify the time dependent inventories released for each DBA analyzed (or bounding DBA in a given category).

5.13.1.3 Dose Consequences

The dose consequences for the bounding DBA in each category are provided in Table 5.13.1-12. As discussed in NRC RG 4.2, Rev 3, Section 5.11.1, "Design Basis Accidents," for the environmental report, it is appropriate to evaluate the DBAs using the accident release assumptions in conjunction with realistic atmospheric transport assumptions. Doing so provides better estimates of the actual doses released to the environment during plant events when compared to the conservative modeling and assumptions used in plant safety analyses.

Thus, for the purpose of identifying doses to the environment, X-energy uses the dispersion factor presented in X-energy's licensing topical report discussed above (X-Energy, 2023), developed to evaluate non-DBA Licensing Basis Events in the safety analyses (1.89E-04 s/m^3). This value was developed using best-estimate analytical methods and credits additional phenomena.

As discussed above, a single, cumulative 30-day dose is provided for each DBA at the EPZ/LPZ using a best-estimate atmospheric dispersion factor. As the calculated doses are significantly below the non-seismic dose criteria specified in 10 CFR 100.21 and 10 CFR 50.34(a)(1), the impact of the postulated radiological releases on the environment during a DBA would be SMALL.

5.13.2 Severe Accidents

This subsection describes the methodology used to evaluate the potential environmental impacts of severe accidents at LMGS. The computer code MELCOR Accident Consequence Code System (MACCS2) is used to implement the methodology, which evaluates the various ingestions pathways and estimates the potential health risks.

5.13.2.1 Methodology

The LMGS Probabilistic Risk Assessment (PRA), with appropriate conservatisms, is used to evaluate a bounding severe accident. Specifically, a large depressurization (LD) beyond design basis event, with a release frequency of 1.85E-05 per plant year, is used to characterize the severe accident progression. Only safety-related systems are available for mitigation and conservative values for key safety analysis parameters, which include but are not limited to, atmospheric dispersion and initial fuel failure fraction, are used to provide a conservative source term for the MACCS2 calculation. ~~(see LD-DBA from Table 5.13.1-11.)~~

weighted transient population projected to 2070 in addition to the resident population projected to 2070 is used.

The MACCS2 calculation results and the release frequency are used to determine risk. Risk is the product of the release frequency of an accident multiplied by the consequences of the accident. The consequence can be radiation dose, fatalities, economic cost, or farmland that needs to be decontaminated. Dose-risk is the product of the collective dose times the accident frequency. The same process is applied to estimating the risk of fatalities (fatalities per reactor per year), the economic cost-risk (dollars per reactor per year), and the risk of farmland decontamination (hectares per reactor per year).

Chapter 5 of NUREG-1437, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, Rev. 0 (NRC, 1996), assesses the impacts of postulated accidents at nuclear power plants on the environment. NUREG-1437 was updated to Rev. 1 in 2013 and Rev 2. in 2024. Appendix E of NUREG-1437, Rev. 2, provides an update on postulated accident risk. Both Rev. 1 and Rev. 2 consider how more recent information on postulated accidents would affect the conclusions of Rev. 0 and provides comparative data where appropriate. However, Rev. 1 and Rev. 2 do not provide new information necessary for the evaluation of postulated accidents for all dose pathways and is not used in this evaluation.

5.13.2.3 Consequences to Population Groups

This subsection evaluates impacts of severe accidents from air, surface water, and groundwater pathways. The MACCS2 code is used to evaluate the doses from the air pathway and from water ingestion with site-specific data. MACCS2 does not model other surface water and groundwater dose pathways. These are analyzed qualitatively based on a comparison of doses from the atmospheric (air) pathway for LMGS to those of the existing fleet of United States nuclear reactors.

5.13.2.4 Air Pathways

The LD-LBE~~DBA~~ accident is analyzed in MACCS2 to estimate population dose, number of early and latent fatalities, cost, and farmland requiring decontamination. The analysis assumed that no emergency evacuation of the 50 mi (80 km) population occurred after the start of the accident. The total dose-risk to the 50 mi (80 km) population, risk of fatalities, economic cost, and farmland decontamination are provided in Table 5.13.2-1.

5.13.2.5 Surface Water Pathways

People are exposed to radiation when airborne radioactivity is deposited onto the ground and washed into surface water or directly deposited into the surface water. The exposure pathway can be from drinking the water, submersion in the water, activities taking place near the shoreline, or ingestion of fish. For the surface water pathway, MACCS2 only calculates the dose from ingestion of water. The water ingestion dose-risk to the 50 mi (80 km) population is provided in Table 5.13.2-1.

average individual residing in the vicinity of the plant is exposed to as a result of normal daily activities (driving, household, chores, occupational activities, etc.). For this evaluation, the sum of prompt fatality risks is taken as the U.S. accidental death risk value of 57.6 deaths per 100,000 people per year (CDC, 2023).

The risk to the population in the area near a nuclear power plant of latent cancer fatalities that might result from nuclear power plant operation should not exceed one-tenth of one percent (0.1%) of the sum of the cancer fatality risks resulting from all other causes. As noted in the Safety Goal Policy Statement (FR, 1985) "near" is defined as within 10 miles of the plant. The cancer fatality risk is taken as an average of 148.0 deaths per 100,000 people per year for 2017 to 2020 (CDC, 2023).

5.13.2.8 Conclusions

The total calculated dose risk to the 50 mi (80 km) population from the LD-LBEDBA is 3.76E-02 person-rem (3.76E-04 person-Sv) per plant year. This value is less than the dose risk from the five reactors analyzed in NUREG-1150 (Table 5.13.2-2) and less than the maximum, mean, median, and minimum dose risks for current generation reactors that have undergone or are undergoing license renewal (Table 5.13.2-3).

The early and latent cancer fatality risks from a severe accident are provided in Table 5.13.2-2. The prompt cancer fatality risk is zero and the latent cancer fatality risk is below the NRC Safety Goal.

As previously described, dose-risk is a product of dose and frequency. Normal operation has a frequency of one. For comparison, the total collective population dose from LMGS normal operation due to gaseous effluent is provided in Table 5.13.2-4. The dose risk of 3.76E-02 person-rem (3.76E-04 person-Sv) per plant year for the LD-LBEDBA is higher than the dose risk of 1.77E-03 person-rem (1.77E-05 person-Sv) per plant year for LMGS normal operation. However, the dose risk for the LD-LBEDBA is lower than the dose risk of 6.59E+01 person-rem (6.59E-01 person-Sv) per reactor year during normal operation of a U.S. Advanced Pressurized Water Reactor (US-APWR) at a PSEG Power, LLC site.

The MACCS2 analysis calculates the estimated number of people within 50 mi (80 km) of LMGS who receive acute or lifetime doses exceeding a threshold. The estimated number of people exceeding the dose limits of 25 rem (0.25 Sv) and 200 rem (2 Sv) is zero.

5.13.3 Severe Accident Mitigation Alternatives

In accordance with Regulatory Guide 4.2, an evaluation of severe accident mitigation alternatives (SAMAs) and severe accident mitigation design alternatives (SAMDAs) is required. SAMAs and SAMDAs can reduce risk by preventing substantial core damage or by limiting radiological releases from containment in the event of substantial core damage.

Tables

Table 5.13.1-1: Design Basis Accidents

DBA Sequence No.	Initiating Event	Remarks
CRW-DBA	Control Rod Group Withdrawal	DBA analysis results presented
SGTL-DBA[(a)]	10mm Leak in one Steam Generator Tube	DBA analysis results presented
SGTR-DBA	Double Ended Guillotine Break of one Steam Generator Tube Rupture (25 mm)	DBA analysis results presented
LOFW-DBA	Loss of Feedwater Flow	DBA analysis results presented
MFLB-DBA	Main Feed Line Break	DBA analysis results presented
LOPF-DBA	Loss of Primary Flow	DBA analysis results presented
MSLB-DBA	Main Steam Line Break	DBA analysis results presented
SD-DBA[(a)]	Small HPB Depressurization	DBA analysis results presented
MD-DBA[(a)]	Medium HPB Depressurization	DBA analysis results presented
~~LD-DBA~~	~~Large HPB Depressurization~~	~~DBA analysis results presented~~
TT-DBA	Turbine Trip	DBA analysis results not presented; bounded by LOPF-DBA
RT-DBA	Reactor Trip	DBA analysis results not presented; bounded by LOPF-DBA
LOOP-DBA	Loss of Off-Site Power	DBA analysis results not presented; Plant response identical to the LOPF-DBA
LOACB-DBA	Loss of Vital AC Bus	DBA analysis results not presented; covered by LOPF - DBA
LOCHS-DBA	Loss of Condenser Heat Sink	DBA analysis results not presented; covered by total loss of feedwater DBA (LFW - DBA)
LODCB-DBA	Loss of Vital DC Bus	DBA analysis results not presented; covered by LOPF - DBA
Seismic Event[(a)]	Seismic Event B causes large (95 mm) HPB leak in all four units resulting in depressurized loss of forced cooling. No leaks or breaks are assumed in the steam generator~~N/A~~	DBA analysis results presented~~As discussed in PSAR Section 2.5, a seismic event is not a credible initiating event for the LMGS site~~

Notes:

a) For these DBAs, several different sequences were analyzed using varying assumptions regarding the postulated HPB breach sizes, locations, and/or subsequent plant system availability

Abbreviations: DBA = design basis accident; mm = millimeter; HPB = Helium Pressure Boundary; AC = alternating current; DC = direct current; N/A = not applicable;

Table 5.13.1-11: Time Dependent Released Activity During Seismic Event DBA (Seismic B-DBA) (Bq) ~~Large HPB Breach DBA (LD-DBA) (Bq)~~

Isotope	Total 0 – 720 hr.
Kr-83m	8.32E+10~~3.14E+10~~
Kr-85	2.09E+10~~5.23E+09~~
Kr-85m	2.21E+11~~4.51E+10~~
Kr-87	2.92E+11~~1.11E+11~~
Kr-88	5.70E+11~~1.72E+11~~
Kr-89	1.17E+11~~1.05E+11~~
Xe-131m	4.92E+09~~1.21E+09~~
Xe-133	4.49E+11~~1.08E+11~~
Xe-133m	1.92E+10~~4.03E+09~~
Xe-135	3.92E+11~~9.10E+10~~
Xe-135m	5.29E+10~~3.64E+10~~
Xe-137	1.09E+11~~9.81E+10~~
Xe-138	2.57E+11~~1.81E+11~~
I-131	3.72E+11~~5.60E+10~~
I-132	7.01E+11~~3.84E+11~~
I-133	5.65E+11~~1.15E+11~~
I-134	4.47E+11~~3.19E+11~~
I-135	4.48E+11~~1.55E+11~~
Cs-137	1.73E+13~~4.31E+12~~
Cs-134	5.53E+12~~1.38E+12~~
Ag-110m	1.82E+12~~4.56E+11~~
Sr-90	1.05E+13~~2.62E+12~~
Eu-152	2.61E+10~~6.53E+09~~
Eu-154	2.11E+11~~5.28E+10~~
Eu-155	1.71E+11~~4.28E+10~~
Te-132	1.58E+14~~3.96E+13~~
La-140	1.52E+14~~3.80E+13~~
Abbreviations: ~~HPB = helium pressure boundary~~; DBA = design basis accident; hr = hour; Kr = krypton; Xe = xenon; m = metastable; I = iodine; Cs = cesium; Ag = silver; Sr = strontium; Eu = europium; Te = tellurium; La = lanthanum	

Table 5.13.1-12: Summary of Design Basis Accident Best Estimate Doses

DBA Sequence No.	Accident	EAB/LPZ[(a)] Doses (mrem)
CRW-DBA	Control Rod Group Withdrawal	3.23E+00
SGTL-DBA	10 mm Leak in one Steam Generator Tube	0.00E+00
SGTR-DBA	Double Ended Guillotine Break of one Steam Generator Tube Rupture (25 mm)	0.00E+00
LOFW-DBA	Loss of Feedwater Flow	0.00E+00
MFLB-DBA	Main Feed Line Break	0.00E+00
LOPF-DBA	Loss of Primary Flow	1.49E+01
MSLB-DBA	Main Steam Line Break	0.00E+00
SD-DBA	Small HPB Depressurization	3.29E+02
MD-DBA	Medium HPB Depressurization	3.77E+00
~~LD-DBA~~ Seismic B-DBA	~~Large HPB Depressurization~~ Seismic Event causing a large (95 mm) HPB leak	~~3.74E+00~~7.62E+03

Notes:

a) The Long Mott Generating Station EAB and LPZ are congruent with the site boundary, which is established at a distance of 400 m (1312 ft.) from the edge of the Reactor Building, the Fuel Handling Auxiliary Building, and the Helium Service Facility

Abbreviations: DBA = design basis accident; No. = number; EAB = Exclusion Area Boundary; LPZ = Low Population Zone; mrem = millirem; mm = millimeter; HPB = Helium Pressure Boundary; m = meter; ft. = feet

Table 5.13.2-1: Environmental Impacts within a 50 mi. Radius for Severe Accidents

Accident	Population Dose Risk (person-rem per plant year)		Fatalities (per plant year)		Economic Cost (dollars per plant year)	Farmland Decontamination (hectares per plant year)
	Water Ingestion	Total	Prompt	Latent Cancer		
LD-LBE~~DBA~~	6.48E-04	3.76E-02	0.00E+00	2.04E-05	1.05E+01	5.01E-04

Abbreviations: LBE~~DBA~~ = Licensing~~Design~~ basis event~~accident~~; rem = roentgen equivalent man

Table 5.13.2-4: Comparison of Population Dose Risk within a 50 Mi. Radius for Severe Accidents and Normal Operation

LMGS LD-LBEDBA Population Dose Risk (person-rem per plant year)	LMGS Normal Operation Dose Risk (person-rem per plant year)		US-APWR Normal Operation at a PSEG Site (person-rem per reactor year)
Total	**Four Modules**	**Per Module**	**Total**
3.76E-02	1.77E-03	4.41E-04	6.59E+01[(a)]

Note:

a) Based on NUREG-2168. The person-rem per plant year unit used for the LMGS values in this table is assumed to be equivalent to the person-rem per reactor year unit used for the US-APWR Normal Operation value in this table.

Abbreviations: LMGS = Long Mott Generating Station; LBEDBA = Licensingdesign basis eventaccident; rem = roentgen equivalent man; US-APWR = U.S. Advanced Pressurized Water Reactor; PSEG = PSEG Power, LLC/PSEG Nuclear, LLC

Table 5.13.4-1: Annual Shipments of Radioactive Materials to and from Long Mott Generating Station

Shipment	Number of Shipments per Year[(a)]	Normalized Shipments per Year[(b)]
Fresh Fuel	20	58
LLW	88	255
Total	**108**	**313[(c)]**

Notes:

a) Values taken from Section 5.7.2

b) 320 MWe Xe-100 at 95% capacity normalized to 1100 MWe Reference reactor at 80% capacity for 10 CFR 51.52 Table S-4 comparison

c) The reference reactor on which Table S-4 is based requires less than 1 truck shipment per day.

Abbreviations: LLW = Low-level Radioactive Waste; MWe = megawatt electric; CFR = Code of Federal Regulations

Figures

None