5.5 BOUNDING ACCIDENT SCENARIOS

NEPA requires that an agency evaluate reasonably foreseeable adverse effects on the human environment in an EIS. This LLNL SW/SPEIS informs the decisionmaker and the public about the chances that reasonably foreseeable accidents associated with the No Action Alternative, Proposed Action, and Reduced Operation Alternative could occur, as well as the potential adverse consequences. An accident is considered bounding if no reasonably foreseeable accident can be found with greater consequences. An accident is reasonably foreseeable if the analysis of occurrence is supported by credible scientific evidence, is not based on pure conjecture, and is within the rule of reason (40 CFR §1502.22[b][4], DOE O 5400.5, DOE 1993b, DOE 2002t).

This section presents the potential impacts on workers, both involved and noninvolved, and the public due to potential accidents associated with operation of LLNL. Additional details supporting the information presented here, as well as approach to the analysis, are provided in Appendix D. Offsite transportation accidents are presented in Appendix J.

Many research activities at LLNL require the use of radioactive materials, hazardous chemicals, and explosives, all of which have the potential, under certain circumstances, to be involved in an accident. These materials are received at the sites, transferred onsite, and often shipped offsite. Activities using these materials onsite involve specialized facilities with appropriate safety equipment and procedures to reduce the possibility or the severity of accidents.

An accident is a sequence of one or more unplanned events with potential outcomes that endanger the health and safety of workers and the public. An accident can involve a combined release of energy and hazardous materials (radiological or chemical) that might cause prompt or latent health effects. The sequence usually begins with an initiating event, such as human error, equipment failure, or earthquake, followed by a succession of other events that could be dependent or independent of the initial event, which dictate the accident's progression and the extent of materials released. Initiating events are presented in Appendix D of this LLNL SW/SPEIS.

If an accident were to occur involving the release of radioactive, chemical, or biological materials, workers, members of the public, and the environment would be at risk. Workers in the facility where the accident occurs would be particularly vulnerable to the effects of the accident because of their location. The offsite public and noninvolved workers would also be at risk of exposure to the extent that meteorological conditions exist for the atmospheric dispersion of released hazardous materials. Using approved computer models, NNSA predicted the dispersion of released hazardous materials and their effects. However, prediction of latent potential health effects becomes increasingly difficult to quantify for facility workers as the distance between the accident location and the worker decreases. This is because the individual worker exposure cannot be precisely defined with respect to the presence of shielding and other protective features. The facility worker also may be injured or killed by physical effects of the accident itself.

5.5.1 Radiological Accident Scenarios

5.5.1.1 *Methodology*

Selection Process

The selection process for radiological accident scenarios used a multistep screening process to identify bounding events. For accidents associated with specific LLNL facilities, the screening process began with a review of all LLNL facilities with emphasis on building hazard classification, radionuclide inventories, including type, quantity, and physical form, and storage and use conditions. The selection process described in Appendix D reduced this list to 23 existing facilities and 5 proposed facilities and projects.

For each of these facilities, the next step was to identify the most current documentation describing and quantifying the risks associated with its operation. Current safety documentation was obtained for all of these facilities. From these documents, the next step was to identify potential accident scenarios and source terms (release rates and frequencies) associated with those facilities. Table D.2.4–1 in Appendix D lists the results of this process and serves as the basis for the subsequent consequence analysis described below.

Consequence Analysis

Consequences of accidental radiological releases were determined using the MACCS2 computer code (Chanin and Young 1997). MACCS2 is a DOE/Nuclear Regulatory Commission-sponsored computer code that has been widely used in support of probabilistic risk assessments for the nuclear power industry and in support of safety and NEPA documentation for facilities throughout the DOE complex.

Because of assumptions used in this LLNL SW/SPEIS analysis, not all of the code's capabilities were used. It was conservatively assumed that there would be no evacuation or protection of the surrounding population following an accidental release of radionuclides. This assumption is not expected to significantly affect the calculated doses.

NNSA estimated radiological impacts to four receptors: (1) the MEI at the LLNL boundary, (2) the offsite population within 50 miles of LLNL, (3) a noninvolved worker 100 meters from the accident location, and (4) the population of noninvolved workers.

Ten radial rings and 16 uniform direction sectors were used to calculate the collective dose to the offsite population. The radial rings were every 1 mile to 5 miles, a ring at 10 miles, and a ring every 10 miles for the initial 10 to 50 miles starting at the distribution center. The MEI was assumed to be located along the site boundary. The shortest distance to the boundary from each release location in all 16 directions was identified for the MEI analysis. Similarly, the noninvolved onsite worker location was taken as 100 meters from the release in any direction.

The calculated radiation doses were converted into LCFs using the factor of 6×10^{-4} LCFs per person-rem for both members of the general public and workers (Lawrence 2002).

5.5.1.2 *Results*

Table 5.5.1.2–1 presents the bounding radiological accident scenario for each of the evaluated facilities. Table D.2.4–1 in Appendix D presents all of the analyzed scenarios for each LLNL facility, which provides the basis for the bounding facility accident scenarios presented in Table 5.5.1.2–1. Detailed descriptions of the accident scenarios are presented in Appendix D.

Tables 5.5.1.2–1 and 5.5.1.2–2 show the building number and name, the scenario description, frequency, and results for the Proposed Action and the No Action Alternative. The values for the Reduced Operation Alternative are the same as for No Action Alternative. The results presented include estimates of radiation dose and corresponding incremental LCFs for both median (Table 5.5.1.2–1) and unfavorable (Table 5.5.1.2–2) meteorological conditions. The term "unfavorable" meteorological conditions means those conditions that result in radiation doses that would be exceeded only 5 percent of the time. Detailed discussion on meteorological conditions is presented in Appendix D, Section D.2.1 of this LLNL SW/SPEIS.

The bounding accident for each receptor is shaded in Table 5.5.1.2–1 and 5.5.1.2–2. The Reduced Operation Alternative scenarios are the same as for the No Action Alternative. Detailed descriptions of all accident scenarios are provided in Appendix D.

For median meteorology, the bounding accident scenarios for each receptor are as follows:

- For the offsite population, the bounding accident for the Proposed Action is an aircraft crash into Building 625. This accident is estimated to result in 2,020 person-rem to this population, which would result in an additional 1.21 LCFs in this population. For the No Action Alternative, the bounding accident is an aircraft crash into Building 696R, which is estimated to result in 1,290 person-rem (0.77 LCFs)

- For the MEI, the bounding accident for the Proposed Action and the No Action Alternative is an aircraft crash into Building 696R. This accident is estimated to result in 0.861 rem to the MEI, which would result in a probability of 5.17×10^{-4} of the development of a fatal cancer.

- For the population of noninvolved workers, the bounding accident for the Proposed Action is a room fire (unfiltered) in Building 332. The accident is estimated to result in 930 person-rem to this population, which would result in an additional 0.558 LCFs in this population. For the No Action Alternative, the bounding accident is an evaluation basis fire in Building 251, which is estimated to result in 826 person-rem (0.5 LCFs).

- For an individual noninvolved worker for the Proposed Action and the No Action Alternative, the bounding accident is an evaluation basis fire in Building 251. This accident is estimated to result in 5.7 rem to the noninvolved worker, which would result in a probability of 3.42×10^{-3} of the development of a fatal cancer.

For unfavorable meteorology, the bounding accident scenarios for each receptor are as follows:

- For the offsite population, the bounding accident for the Proposed Action is an aircraft crash into Building 625. This accident is estimated to result in 17,600 person-rem to this population, which would result in an additional 10.6 LCFs in this population. For the No Action Alternative, the bounding accident is an aircraft crash into Building 696R, which is estimated to result in 10,600 person-rem (6.4 LCFs).

- For the MEI, the bounding accident for the Proposed Action is an aircraft crash into Building 625. This accident is estimated to result in 23.1 rem to the MEI, which would result in a probability of 0.014 of the development of a fatal cancer. For the No Action Alternative, the bounding accident is an aircraft crash into Building 696R, which is estimated to result in a dose of 16.6 rem to the MEI (LCF probability of 0.0099).

- For the population of noninvolved workers, the bounding accident for the Proposed Action is a room fire (unfiltered) in Building 332. This accident is estimated to result in 7,800 person-rem to this population, which would result in an additional 4.68 LCFs in this population. For the No Action Alternative, the bounding accident is an evaluation basis fire in Building 251, which is estimated to result in 452 person-rem (2.7 LCFs).

- For an individual noninvolved worker, the bounding accident for the Proposed Action is an aircraft crash into Building 625. This accident is estimated to result in 82.3 rem to the noninvolved worker, which would result in a probability of 0.049 of the development of a fatal cancer. For the No Action Alternative, the bounding accident is an evaluation basis fire in Building 251 which is estimated to result in a dose of 64.6 rem to the noninvolved worker (LCF probability of 0.039)

Bounding Case Radiological Accident for Involved Workers

The bounding case radiological accident for involved workers is a plutonium criticality for a powder, slurry, or solution system in a workstation in Building 332. This accident has an estimated frequency of 3.2×10^{-5} per year. Severe worker exposures could occur inside the facility as a result of a criticality, due primarily to the effects of prompt neutrons and gammas. The methodology for determining these effects is presented in Appendix D, Section D.2.5, of this LLNL SW/SPEIS.

Personnel close to the criticality event (within the building) may incur prompt external exposures. Depending on distance and the amount of intervening shielding material, lethal doses composed of neutron and gamma radiation could be delivered. Some dose reduction could be achieved by immediate evacuation; however, most of the dose would be delivered within the response time of alarm instrumentation.

At a distance of 33 feet, the combined prompt gamma and neutron radiation dose to personnel from a plutonium powder criticality would be approximately 867 rem with no shielding and no evacuation. This dose is greater than the average lethal radiation dose to humans of approximately 450 rem. Thus, subsequent to a plutonium powder criticality, the potential for lethal exposure exists, and on average, there may be two workers in a room who could be exposed to this radiation.

In the event of a criticality, the shielding of the laboratory interior walls and rapid evacuation from the laboratories would reduce doses to personnel not in the immediate vicinity of the criticality excursion.

5.5.2 Chemical Accident Scenarios

5.5.2.1 *Methodology*

Selection Process

The selection process for chemical accident scenarios used the same multistep screening process as described for radiological accidents in Section 5.5.1.1. Appendix D, Table D.2.5–1 of this LLNL SW/SPEIS, lists the results of this process and serves as the basis for the subsequent consequence analysis described below. The chemical accident scenarios analyzed are the same under the No Action Alternative, Proposed Action, and Reduced Operation Alternative.

Protective and Emergency Response Planning Guidelines

The adverse effects of exposure vary greatly among chemicals. They range from physical discomfort and skin irritation to respiratory tract tissue damage and, at the extreme, death. For this reason, allowable exposure levels differ from substance to substance. None of the chemicals of concern in the bounding accidents are known carcinogens. The standards used to evaluate bounding case scenarios are the Emergency Response Planning Guideline (ERPG) values established for each chemical by the American Industrial Hygiene Association. The ERPGs provide emergency response planners with estimates of the potential hazards associated with accidental releases of various toxic chemicals from LLNL facilities. The comparison to ERPGs is made when possible to provide estimates of the area where health effects would be the greatest. These ERPGs are intended to provide estimates of concentration ranges at which adverse effects can be expected if exposure to a specified chemical lasts more than 1 hour. The ERPG levels are defined as follows:

- ERPG-1 – The maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor.
- ERPG-2 – The maximum airborne concentration below which it is believed that nearly all individuals could be exposed to up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.
- ERPG-3 – The maximum airborne concentration below which it is believed that nearly all individuals could be exposed to up to 1 hour without experiencing or developing life-threatening health effects.

If a chemical did not have published ERPG values, the temporary emergency exposure limits were used.

Consequence Analysis

Consequences of accidental chemical releases were determined using the ALOHA computer code (EPA 1999). ALOHA is an EPA/National Oceanic and Atmospheric Administration-sponsored computer code that has been widely used in support of chemical accident responses and in support of safety and NEPA documentation for DOE facilities.

The ALOHA code uses a constant set of meteorological conditions (e.g., wind speed, stability class) to determine the downwind atmospheric concentrations. The sequential meteorological data sets used for the radiological accident analyses were reordered from high to low dispersion by applying a Gaussian dispersion model, such as that used by ALOHA.

ALOHA contains physical and toxicological properties for approximately 1,000 chemicals. The physical properties were used to determine which of the dispersion models and accompanying parameters were applied. The toxicological properties were used to determine the levels of concern. Atmospheric concentrations at which health effects are of concern (e.g., ERPG-2) are used to define the footprint of concern. Because the meteorological conditions specified do not account for wind direction, since it is not known *a priori* in which direction the wind would be blowing in the event of an accident, the areas of concern are defined by a circle of radius equivalent to the downwind distance at which the concentration decreases to levels less than the level of concern.

5.5.2.2 *Results*

Tables 5.5.2.2–1 and 5.5.2.2–2 present the bounding chemical accident scenario for each of the evaluated facilities for median and unfavorable meteorological conditions, respectively. Table D.2.5–1 in Appendix D presents all of the analyzed scenarios for each LLNL facility, which provides the basis for the bounding facility accident scenarios presented in Tables 5.5.2.2–1 and 5.5.2.2–2.

Tables 5.5.2.2–1 and 5.5.2.2–2 show the building number and name, the scenario description, and results. The results presented include estimates of airborne concentrations of chemicals released during an accident and a comparison of these concentrations to the ERPGs. The results presented in Tables 5.5.2.2–1 and 5.5.2.2–2 apply to the No Action Alternative, the Proposed Action, and the Reduced Operation Alternative. Frequencies are presented in Appendix D, Table D.3.2–1 of this LLNL SW/SPEIS.

TABLE 5.5.2.2–1.—*Potential Chemical Accident Consequences (Median Meteorology)*

		Noninvolved Worker		Site Boundary		
ERPG-2 Concentration (ppm)	**ERPG-3 Concentration (ppm)**	**Average Predicted Concentration (ppm)**	**Fraction of ERPG-2**	**Average Predicted Concentration (ppm)**	**Fraction of ERPG-2**	**ERPG-2 Distance (meters)**
Building 191, High Explosives Application Facility – Chemical Dispersion (1,2-Dichloroethane)						
200	300	0.108	5.4×10^{-4}	0.0175	8.8×10^{-5}	11
Building 239, Radiography Facility – Toxic gas release (NO_2)						
5	20	27.5	5.5	0.81	016	246
Building 322, Plating Shop – Multiple Container Liquid Spill (Hydrofluoric Acid)						
20	50	371	18.6	4.86	0.24	475
Building 331, Tritium Facility actinide activities – Nitric acid spill						
6	78	24	4	0.24	0.04	205
Building 332, Plutonium Facility – Chlorine release						
3	20	593	198	11.6	3.9	1,700
Building 334, Hardened Engineering Test Building – Toxic gas release (NO_2)						
5	20	110	22	2.02	0.40	529
Building 514/612/625/693, Radioactive and Hazardous Waste Management Complex – Earthquake release of Freon-22						
7,500	7,500	415	0.06	169	0.023	19
Building 581, National Ignition Facility – Material Spill, Release of Nitric acid solution						
6	78	130	21.7	12.3	2.1	536
Site 300 Materials Management Facility – Hazardous materials release by fire (LiOH)						
1	102	1.42	1.42	0	0	119
Site 300 Explosive Waste Treatment Facility – Fire release of hydrogen fluoride						
20	50	28.1	1.41	0.097	0.049	119

[a] These consequences apply to the No Action Alternative, the Proposed Action, and the Reduced Operation Alternative.
ERPG = Emergency Response Planning Guideline.

TABLE 5.5.2.2–2.—*Potential Chemical Accident Consequences (Unfavorable Meteorology)*[a]

		Noninvolved Worker		MEI		
ERPG-2 Concentration (ppm)	ERPG-3 Concentration (ppm)	Average Predicted Concentration (ppm)	Fraction of ERPG-2	Average Predicted Concentration (ppm)	Fraction of ERPG-2	ERPG-2 Distance (meters)
Building 191, High Explosives Application Facility – Chemical Dispersion (1,2-Dichloroethane)						
200	300	1.41	7.1×10^{-3}	0.272	1.4×10^{-3}	11
Building 239, Radiography Facility – Toxic gas release (NO_2)						
5	20	1,430	286	35.2	7.04	1,600
Building 322, Plating Shop – Multiple Container Liquid Spill (Hydrofluoric Acid)						
20	50	4,680	234	46.4	2.32	1,400
Building 331, Tritium Facility actinide activities – Nitric acid spill						
6	78	68	11.3	1.1	0.18	358
Building 332, Plutonium Facility – Chlorine release						
3	20	5,220	1,740	16.9	5.64	1,900
Building 334, Hardened Engineering Test Building – Toxic gas release (NO_2)						
5	20	5,720	1,140	77.8	15.6	2,900
Building 514/612/625/693 Hazardous Waste Management Complex – Earthquake release of Freon-22						
7,500	7,500	4,080	0.54	1,312	0.17	75
Building 581, National Ignition Facility – Material Spill, Release of Nitric Acid Solution						
6	78	438	73	51.4	8.57	1,400
Site 300 Materials Management Facility – Hazardous materials release by fire (LiOH)						
1	102	59	59	0.151	0.15	865
Site 300 Explosive Waste Treatment Facility – Fire release of hydrogen fluoride						
20	50	1,168	58.4	2.98	0.15	860

[a] These consequences apply to the No Action Alternative, the Proposed Action, and the Reduced Operation Alternative.
ERPG = Emergency Response Planning Guideline; MEI = Maximally Exposed Individual.

Bounding Accident Involving Chemical Releases and Impacts

The bounding accident for the onsite and offsite population for median meteorological conditions is the chlorine release from Building 332. For this accident, concentrations above the ERPG-2 level would exist as far out at 1.7 kilometers from Building 332, which would extend about 600 meters beyond the site boundary (the largest distance of any of the facility accident scenarios). At the site boundary, the concentration would be below ERPG-3 values, but above ERPG-2 values, indicating that members of the public exposed to this concentration could experience irreversible or other serious health effects or symptoms that could impair their ability to take protective action. At the noninvolved worker location, the concentration would be above ERPG-3 values, indicating that individuals exposed to this concentration could experience or develop life-threatening health effects. The workers inside the facility would be protected by the intact building structure and safety systems and thus would be unaffected by this incident.

For unfavorable meteorological conditions, the bounding accident is the toxic gas release (NO_2) from Building 334. For this accident, concentrations above the ERPG-2 level would exist as far out as 2.9 kilometers from Building 334, which would extend about 2,000 meters beyond the site boundary. At the site boundary and at the noninvolved worker location, the concentration would be above ERPG-3 values, indicating that individuals exposed to this concentration could experience or develop life-threatening health effects.

5.5.3 High Explosive Accident Scenarios

5.5.3.1 *Selection Process*

The selection process for explosive accident scenarios used the same multistep screening process as described for radiological accidents in Section 5.5.1.1. Section D.4 in Appendix D, Section D.4, lists the results of this process and serves as the basis for the subsequent consequence analysis described below.

5.5.3.2 *Results*

Table 5.5.3.2–1 presents the bounding explosive accident scenario for each of the evaluated facilities. Appendix D, Section D.4, presents all of the analyzed scenarios for each LLNL facility, which provides the basis for the bounding facility accident scenarios presented in Table 5.5.3.2–1.

Table 5.5.3.2–1 shows the building number and name, the scenario description, frequency, and an indication of the potential adverse impacts of the scenario. The impacts presented include estimates of the number of persons who might reasonably be present in the area near the accidental detonation and an indication of the acute impacts to these personnel. Also, where applicable, Table 5.5.3.2–1 provides a description of any impacts to personnel outside of the facility.

Bounding Case Accident Involving High Explosives

The bounding explosive accident is an accidental detonation at the Contained Firing Facility or on an open air firing table. This accident would result in severe or fatal injury to personnel (normally 2 to 20) and could result in significant damage to the service building and equipment. This robust building is designed to confine the effects of this level of explosion, thus preventing any impact to noninvolved workers or the public.

TABLE 5.5.3.2–1.—*High Explosive Accident Scenario Summary*

Building and Name	Scenario Description	Frequency (per year)	Results
Site 300 Materials Management Facilities	Accidental detonation in an explosives assembly storage magazine.	10^{-6} to 10^{-4}	Severe injury or death to the immediate workers (normally two) and the destruction of the magazine, with possible injuries to nearby personnel within intraline and fragment distance, and damage to nearby facilities. Additionally, low-level environmental releases and low-level exposures of personnel to airborne hazardous materials would be lesser consequences. Onsite exposure to the resulting plumes would be below ERPG-3 levels. Offsite consequences would be limited to overpressures (impulse noise) and the potential for hazardous material exposures below ERPG-2 levels.
Site 300 Weaponization Program	Accidental bare explosives detonation in a test building with personnel present.	10^{-6} to 10^{-4}	Severe or fatal injuries to the immediate workers (normally two to five) and damage to the test equipment and building. Injuries to nearby personnel subjected to blast effects are also possible.
Site 300 B-Division Firing Areas	Accidental detonation at the CFF or on an open-air firing table.	10^{-6} to 10^{-4}	Severe or fatal injury to personnel (normally 2 to 20). An accidental detonation could result in significant damage to the service building and equipment.
EMPC	Accidental detonation in an EMPC Assembly Bay.	10^{-6} to 10^{-4}	Severe or fatal injury to personnel (normally two to six) involved in assembling explosives and other components. Other personnel within the EMPC would not be injured.
Building 191 High Explosives Application Facility	Accidental detonation of explosives during contact operations.	10^{-6} to 10^{-4}	Personnel inside the room of occurrence (up to six people) could receive fatal injuries. Personnel outside the room of occurrence could also receive injury from overpressure effects (walls, mazes, and doors would preclude fragment hazards). Overpressure predictions outside the room of occurrence (but inside the facility) would be expected to result in some eardrum rupture. Lung damage would also be possible. There would be no blast effects (overpressure or fragments) outside the facility.

Source: Original
EMPC = Energetic Materials Processing Center.

5.5.4 Biological Accident Scenario

Microbiology laboratories are unique work environments that may pose special risks to personnel working within that environment. For purposes of this section, NNSA has selected a representative facility accident that has been previously analyzed by the U.S. Army in their *Final Programmatic Environmental Impact Statement Biological Defense Research Defense Program* (Army 1989). NNSA believes that this accident scenario is comparable to and bounds any potential scenarios associated with the proposed BSL-3, Building 368 at LLNL. Appendix D provides further details on this accident scenario.

The organism selected for this scenario is *Coxiella burnetii*, the rickettsial agent causing Q fever, a disease of varying degrees of incapacitation. *Coxiella burnetii* grows to high concentrations in chick embryos. It is a hardy organism that withstands laboratory manipulation with little or no loss in viability. It is highly stable in aerosol and undergoes a biological decay rate of about 1 percent per minute over a wide range of humidities. *Coxiella burnetii* is extremely infectious in a small particle aerosol.

This accident scenario involves an immunized laboratory worker processing *Coxiella burnetii.* In this scenario, the laboratory worker fails to use rubber O-rings to seal the centrifuge tubes, and all six bottles leak, allowing some of the slurry into the rotor, with some of the slurry also escaping into the centrifuge compartment that houses the rotor. The leakage of six bottles is highly improbable.

As shown in Appendix D, approximately 5×10^4 HID_{50} (the term "HID_{50}" refers to the dose causing infection 50 percent of the time for man) could escape from the building exhaust stack. This is a conservative assumption as the facility would likely be required to have HEPA filters on the exhaust system. The quantity of human infectious doses, by simple Gaussian plume dispersion models, would dissipate to less than 1 HID_{50} per liter of air in less than 2 meters from the stack, less than 0.1 HID_{50} per liter of air at 16 meters, and less than 0.01 HID_{50} per liter of air at 38 meters. Thus, this level of escape of *Coxiella burnetii* from the containment laboratory, even under the worst-case meteorological conditions, does not represent a credible risk to the noninvolved worker or offsite population.

The centrifuge operator would be at the greatest risk of becoming ill with Q fever. In opening the centrifuge, the infectious aerosol would be released initially and momentarily into a very confined area. The concentration of airborne infectious doses, seconds after the lid was opened, was calculated as 1.3×10^3 HID_{50} per liter of air. Assuming that the centrifuge operator was in the area for no more than 5 minutes, the operator could have inhaled approximately 100,000 infectious doses. Previous studies cited reported that previously vaccinated men, when exposed to defined aerosols of 150 or 150,000 infectious doses of virulent *Coxiella burnetii*, did not consistently become ill (Army 1989). Since the centrifuge operator received about the same dose reported in these studies, it is uncertain whether the operator would become sick, since he was, by required procedures, immunized.

5.5.5 Offsite Transportation Accident Scenarios

Under the No Action Alternative, Proposed Action, and Reduced Operation Alternative, NNSA would transport radioactive materials, hazardous chemicals, explosives, and biological agents that could potentially be involved in accidents that release the cargo for exposure of the public. NNSA considers these accidents in this section to identify the bounding offsite transportation accident, its consequences, and its probability. The onsite transportation accidents are presented in Section 5.5.1.2 and Appendix D.

5.5.5.1 *Radiological Transportation Accidents*

Appendix J, Section J.4, of this LLNL SW/SPEIS examines the transport of special nuclear material, TRU waste, LLW, and tritium. For the Proposed Action, the bounding accident scenario involves special nuclear material (in this case, a fine oxide powder consisting primarily of plutonium isotopes). This accident was calculated to result in 2.7×10^4 person-rem, which corresponds to 16 LCFs. The probability of this accident is 5.3×10^{-11} per year and is not considered reasonably foreseeable. For the No Action Alternative and Reduced Operation Alternative, the bounding accident scenario involves 10 grams of gaseous tritium. This scenario is estimated to result in 338 person-rem, which is equivalent to 0.2 LCFs. The probability of this accident is 9.9×10^{-10} per year, which is also not reasonably foreseeable. Appendix J describes the methods by which these values were calculated.

5.5.5.2 *Hazardous Chemical Transportation Accidents*

Based on information in Appendix D, Section D.3, a transportation accident involving chlorine gas is likely to be the most severe, with the potential to cause death to individuals in the immediate vicinity. However, NNSA is examining only accidents involving transport by LLNL vehicles and personnel, i.e., those not involving materials delivered by common carrier or local vendors. For hazardous chemicals transported by LLNL, shipments of paint and lithium hydride are the most frequent. NNSA does not believe that these accidents would result in serious consequences other than those directly from the impact.

5.5.5.3 *Explosives Transportation Accidents*

Although LLNL does ship explosives offsite, the great majority of shipments with quantities sufficiently large to create a bounding accident are between Site 300 and the Livermore Site. Over 500 one-way shipments between the two LLNL locations per year are common. Approximately 30 shipments to the Nevada Test Site occur per year. LLNL uses packaging and operational controls to limit the probability of an accident occurring.

Should a sufficiently severe accident occur to detonate the explosives, potential impacts could be death or severe injury to the driver(s) and passengers in adjacent vehicles. Nearby buildings could be affected with projectiles providing the greatest hazard to any inhabitants. Secondary traffic accidents could affect individuals in vehicles not adjacent to the transport conveyance. Appendix D, Section D.4, examines explosives accidents in LLNL facilities for comparison.

5.5.5.4 *Biological Agent Transportation Accidents*

NNSA considered biological agent transportation accidents in its Environmental Assessment and Finding of No Significant Impact on the BSL-3 facility (NNSA 2002e). This EA/FONSI concludes that accidents due to transportation of micro-organisms are not expected to increase over those under current conditions. The addition of milliliter-quantity samples shipped to and from the BSL-3 facility through commercial or private courier would not be expected to change the overall incidence of risk of transportation accidents. Samples could consist of cells in media contained within U.S. Department of Transportation-certified packages. The consequences of such accidents would be anticipated to be minor.

5.5.6 Multiple Building Accident Scenario

5.5.6.1 *Methodology*

This section addresses the potential releases and consequences of a situation involving multiple source terms (both radiological and chemical) stemming from a single event affecting LLNL. The consequences of these releases will be assessed in the same manner as described previously.

An earthquake with a return period of 5,000 years (i.e., 2×10^{-4} per year) was postulated as the initiator for this accident scenario. This earthquake has an effective peak ground acceleration of approximately 0.8 *g*. As a rough comparison, the Livermore earthquakes on January 24 and January 27, 1980, recorded as 5.4 and 5.6 Richter Magnitude events, generated maximum measured peak ground accelerations of 0.26 *g* at a distance of 18 kilometers from the epicenter.

5.5.6.2 *Results*

This section provides a description of the radiological and chemical releases that may occur as a direct result of an earthquake. Scenarios and consequences are discussed in general terms only. For specific information concerning individual scenarios, refer to the referenced sections.

Radiological Releases

Under the multiple-building release scenario for the Proposed Action, the risk to the offsite MEI and to the population within 50 miles of LLNL is primarily attributable to releases from Buildings 251, 331, and 334. The offsite MEI for releases from these would not be at the same location. Therefore, summing the doses for each of the individual facilities is conservative. Taking this conservative approach results in a total radiation dose at the site boundary nearest to the release of 1.03 rem. Using the dose-to-risk conversion factor of 6×10^{-4} LCFs per person-rem, the MEI dose results in a 6.2×10^{-4} LCF probability.

The collective radiation dose to the approximately 6,900,000 people living within 50 miles of LLNL under the multiple-building release scenario was calculated to be 420 person-rem. Using the dose-to-risk conversion factor of 6×10^{-4} per person-rem, the collective population dose is estimated to result in an additional 0.25 fatal cancers to this population. The dose to the individual noninvolved worker was calculated to be 11.7 rem. This dose is estimated to have a 6.35×10^{-3} LCF probability (or 1 chance in 157) of the development of a fatal cancer.

The collective radiation dose to the population of noninvolved workers under the multiple-building release scenario was calculated to be 1,380 person-rem using the dose-to-risk conversion factor of 6×10^{-4} per person-rem. This collective dose is estimated to result in an additional 0.83 fatal cancers in this worker population.

Chemical Releases

Under the multiple-building release scenario, the risk at the site boundary would be dominated by the chlorine rupture and release from Building 332. For this accident, concentrations above the ERPG-2 level would exist as far out at 1.7 kilometers from Building 332, which would extend about 600 meters beyond the site boundary. At the site boundary, the concentration would be below ERPG-3 values, but above ERPG-2 values, indicating that persons exposed to this concentration could experience irreversible or other serious health effects or symptoms that could impair their ability to take protective action. At the noninvolved worker location, 100 meters from the release point, the concentration would be above ERPG-3 values, indicating that individuals exposed to this concentration could experience or develop life-threatening health effects. Health effects to involved workers are also anticipated to be life threatening.

The location of the highest site boundary concentration for releases from other facilities as a result of this earthquake would be at a different location than that for Building 332. The contribution from these other facilities at the location of highest site boundary concentration for Building 332 would be small and would provide a negligible contribution to the overall risk to an individual at this location.

5.5.7 Impacts of Postulated Accidents on Each Alternative

Under the No Action and Reduced Operation Alternatives, the potential exists for the accidental release of radioactive materials and hazardous chemicals, and the accidental detonation of explosives at several facilities during ordinary operations, during transportation, and as a result of an event affecting more than one facility. These accidents are summarized in Section 5.5 and detailed further in Appendix D. The Proposed Action described in Chapter 3 of this LLNL SW/SPEIS can affect the postulated accident scenarios for some of the facilities analyzed in this section.

For Building 331, under the Proposed Action, the material-at-risk value would increase from the current 3.5 grams of tritium to 30 grams. As described in Appendix D, during an aircraft crash with subsequent fire, the entire material–at-risk is assumed to be released to the environment. For the 30-gram material-at-risk under the Proposed Action, the collective dose to the population within 50 miles of LLNL was calculated to be 113 person-rem, which is estimated to result in an additional 0.068 LCFs in this population of approximately 6,900,000 people. Under the No Action Alternative, this collective dose would be approximately 13 person-rem, which is estimated to result in an additional 7.8×10^{-3} LCFs to the 50-mile population. Radiation dose and adverse health effects to the offsite MEI and the noninvolved worker would be similarly increased under the Proposed Action (i.e., from 0.019 rem [1.1×10^{-5} LCF probability] to 0.163 rem [9.8×10^{-5} LCF probability] and from 0.25 rem [1.5×10^{-4} LCF probability] to 2.11 rem [1.27×10^{-3} LCF probability], respectively).

Under the Proposed Action, the Building 332 material-at-risk limit would increase from the current 20 kilograms of 30-year fuel-grade equivalent plutonium to 60 kilograms for each of two rooms that support the ITP and plutonium casting. For the Proposed Action, the bounding accident scenario is a room fire (unfiltered). For the No Action Alternative, the bounding accident scenario is an aircraft crash. Under the Proposed Action, the collective dose to the population within 50 miles of LLNL for the room fire (unfiltered) accident scenario was calculated to be 280 person-rem under median meteorological conditions, which is estimated to result in an additional 0.168 LCF in this population. Under the No Action Alternative, for an aircraft crash accident, the collective dose would be approximately 97 person-rem, which is estimated to result in an additional 0.058 LCF to the 50-mile population. Radiation dose to the offsite MEI and the noninvolved worker would be similarly increased under the Proposed Action (i.e., from 0.148 rem [8.9×10^{-5} LCF probability] to 0.44 rem [2.6×10^{-4} LCF probability] and from 1.84 rem [1.1×10^{-3} LCF probability] to 4.94 rem [2.9×10^{-3} LCF probability], respectively).

For the NIF, under the Proposed Action, tests would be conducted using plutonium targets. As shown above, the bounding accident for the NIF under the Proposed Action is an earthquake during a plutonium shot without yield shot. As described above, under the Proposed Action, the collective dose to the population within 50 miles of LLNL for this accident was calculated to be 0.55 person-rem, which is estimated to result in an additional 3.3×10^{-4} LCFs in this population. Under the No Action Alternative, this collective dose would be approximately 0.20 person-rem, which is estimated to result in an additional 1.20×10^{-4} LCFs to the 50-mile population. Radiation dose to the offsite MEI and the noninvolved worker would be similarly increased under the Proposed Action (i.e., from 4.78×10^{-4} rem [2.87×10^{-7} LCF probability] to 1.65×10^{-3} rem [9.9×10^{-7} LCF probability] and from 1.43×10^{-3} rem [8.58×10^{-7} LCF probability] to 4.99×10^{-3} rem [3.00×10^{-6} LCF probability], respectively).

For Building 625, under the Proposed Action, the source term for the bounding accident aircraft crash would increase from 0.46 plutonium-equivalent curies to 1.40 plutonium-equivalent curies. As described above, under the Proposed Action, the collective dose to the population within 50 miles of LLNL for the aircraft crash accident was calculated to be 2,020 person-rem, which is estimated to result in an additional 1.2 LCFs in this population. Under the No Action Alternative, this collective dose would be approximately 662 person-rem, which is estimated to result in an additional 0.40 LCF to the 50-mile population. Radiation dose to the offsite MEI and the noninvolved worker would be similarly increased under the Proposed Action (i.e., from 0.24 rem [1.44×10^{-4} LCF probability] to 0.73 rem [4.38×10^{-4} LCF probability] and from 0.65 rem [3.9×10^{-4} LCF probability] to 1.97 rem [1.18×10^{-3} LCF probability], respectively).