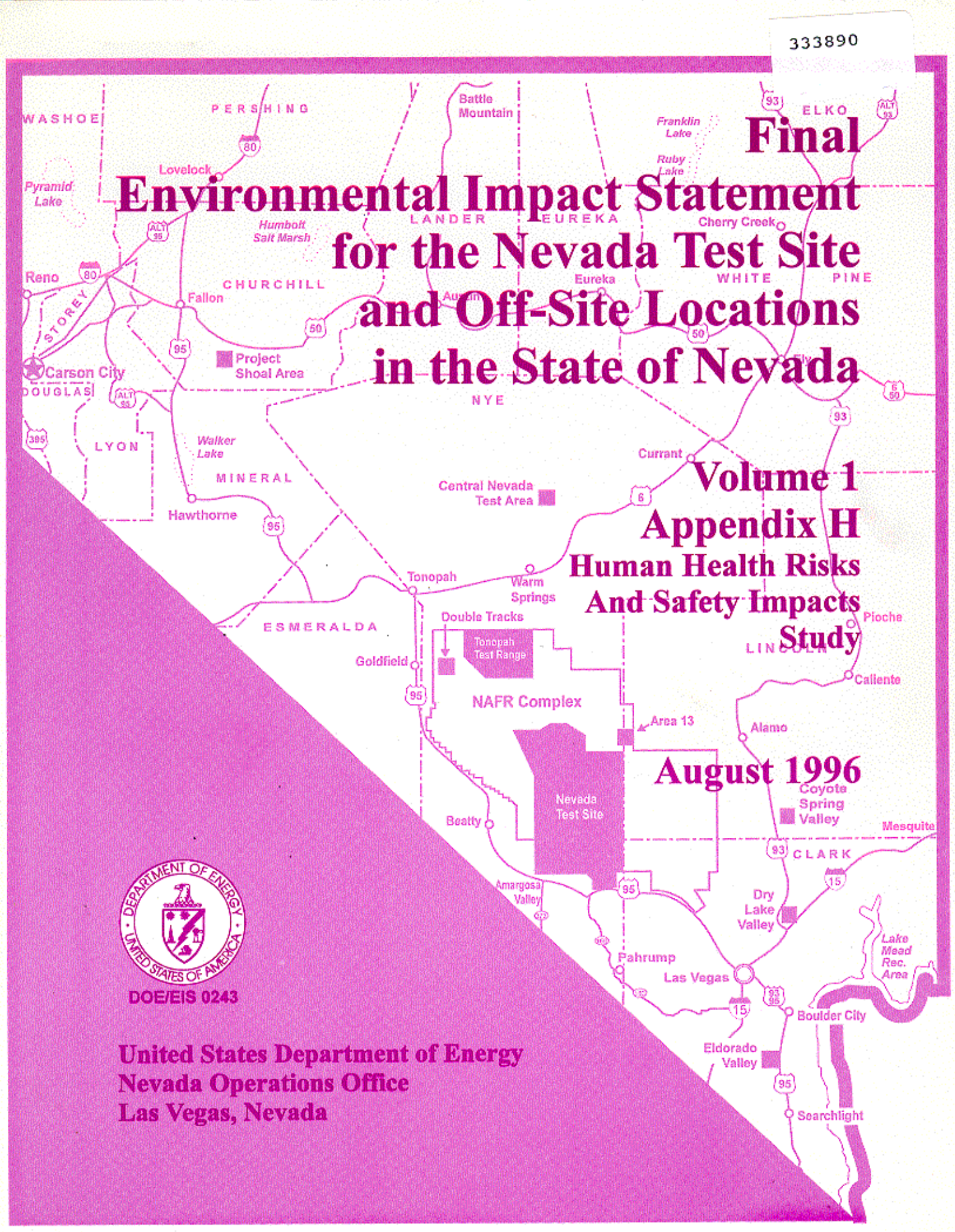
Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada

Volume 1
Appendix H
Human Health Risks And Safety Impacts Study

August 1996



DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·

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United States Department of Energy
Nevada Operations Office
Las Vegas, Nevada

Final
Environmental Impact Statement

for
the Nevada Test Site and Off-Site Locations
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Volume 1

Appendix H

U.S. Department of Energy
Nevada Operations Office
Las Vegas, Nevada

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ACRONYMS

BEEF	Big Explosives Experimental Facility
Ci	curie
CNTA	Central Nevada Test Area
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy, Nevada Operations Office
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
ER	environmental restoration
ERPG	Emergency Response Planning Guideline
HE	high explosive
HEPA	high efficiency particulate air
HLW	high-level waste
ICRP	International Commission for Radiological Protection
LCF	latent cancer fatality
LLW	low-level waste
MEI	maximally exposed individual
MW	mixed waste
NAFR Complex	Nellis Air Force Range
NEPA	National Environmental Policy Act
NTS	Nevada Test Site
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated byphenols
pCi	picocurie
pCi/L	picocuries per liter
rad	radiation absorbed dose
RCRA	Resource Conservation & Recovery Act
R&D	research and development
rem	roentgen equivalent man
SNF	spent nuclear fuel
TTR	Tonopah Test Range

GLOSSARY

Absorbed dose. The energy imparted to matter by ionizing radiation per unit mass of irradiated material. The unit of absorbed dose is the rad, which equals 100 ergs per gram.

Alpha particle. A positively charged particle ejected spontaneously from the nuclei of some radioactive elements. It is identical to a helium nucleus that has a mass number of 4 and an electronstatic charge of +2.

Aquifer. A body of rock that contains enough saturated permeable material to transmit groundwater and to yield significant quantities of groundwater to wells and springs.

Background radiation. Radiation arising from radioactive material other than that directly under consideration. Radiation from cosmic sources and from radioactive materials that are naturally occurring in the environment. Background radiation due to cosmic rays and natural radioactivity is always present.

Baseline. The initial environmental conditions against which the environmental consequences of various alternatives are evaluated.

Beta particle. A charged particle emitted from a nucleus during radioactive decay, with a mass equal to 1/1837 that of a proton. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a positron.

Carcinogens. Substances known to cause cancer in humans, or are known to cause cancer in animals and therefore may be capable of causing cancer in humans.

Collective effective dose equivalent (person-rem). A summation of the radiation doses received by individuals in an exposed population dose. See population dose.

Consequence. The situation or effect produced as a result of something occurring.

Cumulative impact. The impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions. Cumulative impacts can result from individual minor actions that may be collectively significant over a period of time.

Curie (Ci). A unit of radiation that describes the number of atoms undergoing nuclear transformations per unit time. The curie is equal to 37 billion (i.e., 3.7×10^{10}) disintegrations per second.

Direct impact. Effects resulting solely from the proposed program.

Direct effects. Beneficial or deleterious impacts that are caused by an action and occur at the same time and place.

Dispersion factor. A numerical term that accounts for the reduction in the concentration of a contaminant through natural mixing and dispersion in the atmosphere, surface water, or groundwater.

Dose (or radiation dose). A generic term that means absorbed dose, or effective dose equivalent, as defined elsewhere in this glossary.

Dose conversion factor. Any factor that is used to change an environmental measurement to dose in the units of concern. Frequently used as the factor that expresses the committed effective dose equivalent to a person from the intake (inhalation or ingestion) of a unit activity of a given radionuclide.

Dose-response relationship. A curve showing the percentage of organisms with observable toxic effects to the dose administered.

Dose to health effect correlation factor. A numerical term that estimates the probability that a health effect will occur as a result of exposure to a unit quantity of radiation or hazardous chemicals. Also referred to as health risk factor. Example: 0.0005 latent cancer fatality per rem of radiation dose received by the general population. If a population received a collective dose of 2,000 person-rem, the estimated number of latent cancer fatalities is estimated as (2,000 person-rem) x (0.0005 latent cancer fatality per rem) = 1 latent cancer fatality.

Effective dose equivalent. The sum over specified tissues of 1) the products of the dose equivalent in a tissue and 2) the weighting factor for that tissue. It is the amount of damage to the exposed individual's body as a result of radiation exposure.

Environmental Impact Statement. A detailed written statement that helps public officials to make decisions that are based on understanding of environmental consequences and to take actions that protect, restore, and enhance the environment.

Environmental transport medium. The object that transfers the source term to a human (i.e., the air, water, food chain, etc.)

Eolian. Applied to deposits arranged by the wind. Wind blown.

Ergs. A measure of energy. One erg is equivalent to 1 x 10-7 joules.

Exposure route. The method by which a contaminant may reach a person.

Fatal cancers. Cancers for which the cure rate is low and for which the period between diagnosis and death is usually short.

Fiscal year. A 12-month period of time to which the annual budget applies and at the end of which its financial position and the result of its operations are determined. Clark County, the city of Las Vegas, the city of North Las Vegas, Nye County, the towns of Tonopah and Pahrump, and the Clark County School District and Nye County School District fiscal years run from July 1 through the following June 30. Federal fiscal years are from October 1 through the following September 30.

Fissile. Capable of undergoing fission by interaction with thermal (slow) neutrons. The three primary fissile materials are uranium-233, uranium-235, and plutonium-239.

Fission. A nuclear transformation characterized by the splitting of a nucleus and the simultaneous release of energy.

Fugitive dust. Particulate matter composed of soil. Fugitive dust may include emissions from haul roads, wind erosion of exposed soil surfaces, and other activities in which soil is either removed or redistributed.

Fugitive emissions. Emissions released directly into the atmosphere that could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.

Gamma ray. Short wavelength electromagnetic radiation, with no mass, that is emitted from the nucleus.

Genetic disorders. Serious disabilities that may be transferred to offspring of parents that have been exposed to mutagens.

Groundwater. Subsurface water within the zone of saturation.

Half-life. The length of time required for an initial amount of radioactive substance to be reduced down to ½ of its original amount due to radioactive decay.

High-level waste (HLW). Highly radioactive waste that results from the reprocessing of spent nuclear fuel, that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation.

Human environment. The natural and physical environment and the relationship of people with the environment.

Human receptor. The person or group of people that can be or is exposed to the contaminant.

Hydrocarbons. Any of a vast family of compounds containing hydrogen and carbon. May include many organic compounds in various combinations. Most fossil fuels are composed predominately of hydrocarbons.

Latency. A term used to describe the period of time between the point of exposure and the resulting effect of the exposure on the human body.

Latent cancer fatality. A fatal cancer with a delayed onset of up to twenty years, or longer, from the time of exposure to the time of manifestation in the individual.

Low-level waste (LLW). Radioactive waste not classified as high-level waste, transuranic waste, or spent nuclear fuel, or the tailings or wastes produced by the extraction or concentration of uranium or thorium. Test specimens of irradiated fissionable material may be classified as LLW, provided the concentration of transuranic elements is less than 100 nanocuries per gram.

Maximum individual dose. A radiation dose received by a hypothetical individual whose location and habits are such that the dose received is the maximum expected to result from some given operation or accident.

Mitigation. Actions and decisions that (1) avoid impacts altogether by not taking a certain action or parts of an action, (2) minimize impacts by limiting the degree or magnitude of an action, (3) rectifying the impact by repairing, rehabilitating, or restoring the affected environment, (4) reducing or eliminating

the impact over time by preservation and maintenance operations during the life of the action, or (5) compensate for an impact by replacing or providing substitute resources or environments.

Mixed waste. Waste containing both radioactive and hazardous components as defined by the Atomic Energy Act and the Resource Conservation and Recovery Act, respectively.

Mutagenicity. The capability of a substance to cause permanent alteration of genetic material within living cells contained in the human body.

Noncarcinogens. Substances that may not be known to cause cancer, but may be capable of causing harm, such as invoking mutagenicity in a human.

Nonfatal cancers. Cancers for which the fatality rates may be low, but for which there can be either physical or psychological reasons for a reduced quality of life.

Notice of Intent. A notice that an environmental impact statement will be prepared and considered.

Nuclear testing. An underground nuclear weapons test of either a single underground nuclear explosion or two or more underground nuclear explosions conducted at the NTS within an area delineated by a circle having a diameter of two kilometers and conducted within a total period of time of 0.1 second. The yield of a test shall be the aggregate yield of all explosions in the test.

Person-rem. The collective total dose to a population. Person-rem is calculated by summing the individual doses of each member of the population.

Picocurie (pCi). One trillionth of a curie, (i.e., $1x10^{-12}$ Ci) (also see Curie).

Population dose (person-rem). A summation of the radiation dose received by individuals in an exposed population. Equivalent to collective dose.

Probability. A number expressing the likelihood of occurrence of a specific event.

Quality factor. A measure of the relative biological effectiveness of a given type of radiation. This is directly related to the linear energy transfer of that radiation, i.e., the energy deposited per unit of path length (keV per micron).

Radiation. The spontaneous emission of particles and energy from unstable atoms that occurs as these unstable atoms decay.

Radiation absorbed dose (Rad). The amount of energy absorbed by a material.

Radiation detriment. Adverse effects due to radiation exposure, not including latent cancer fatalities.

Radioactive decay. The process in which a nucleus emits radiation and undergoes spontaneous transformation into one or more different nuclei.

Radioactive waste. Solid, liquid, or gaseous material that contains radioactive nuclides regulated under the Atomic Energy Act of 1954, as amended, and is of negligible economic value given the cost of recovery.

Risk. A quantitative expression of possible loss that considers both the probability that a hazard causes harm and the consequences of that event.

Roentgen. A unit of radiation that measures the amount of ionizations in air produced by gamma energy per unit time.

Roentgen equivalent man (Rem). The number of ionizations in air that translates to a similar dose for a person.

Scenario. A proposed situation or sequence of events.

Scope. Consists of the range of actions, alternatives, and impacts to be considered in an environmental impact statement.

Source term. The contaminant(s) released to the environment.

Specific activity. A unit mass of radioactive material (i.e., 1 curie per gram).

Spent fuel. Nuclear reactor fuel that, through nuclear reactions, has been sufficiently depleted of fissile material to require its removal from the reactor.

Stockpile stewardship. The science and technology aspects of ensuring the safety, security, and reliability of the stockpile, including research and development to provide the technologies required for stockpile management. This includes a program of activities to maintain confidence in the safety, reliability, and performance of the Nation's nuclear weapons.

Storage. The collection and containment of waste or spent nuclear fuel in such a manner as not to constitute disposal of the waste or spent nuclear fuel for the purposes of awaiting treatment or disposal capacity.

Threshold concept. A concept that suggests most toxic substances will produce no effect on a biological organism, if the substances are given in small enough amounts.

Transuranic waste. Radioactive waste containing 100 nanocuries per gram or more of alpha-emitting radionuclides that have an atomic number greater than 92, and half-lives greater than 20 years.

Transuranic radionuclide. Any radionuclide having an atomic number greater than 92.

Uptake. The sorption of a substance into and onto an organism during an exposure to that substance.

Waste acceptance criteria. The requirements specifying the characteristics of waste and waste packaging acceptable to a waste receiving facility and the documents and processes the generator needs to certify that waste meets applicable requirements.

Waste management. The planning, coordination, and direction of those functions related to generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated surveillance and maintenance activities.

Waste management facility. All contiguous land, structures, other appurtenances, and improvements on the land, used for treating, storing, or disposing of waste or spent nuclear fuel.

Watershed. The land area that drains into a stream or river.

X-ray. A bundle of high energy with no mass. Similar to a gamma ray, except for its origin and, in general, its energy level.

SUMMARY

Proposed changes in the Nevada Test Site (NTS) operations, as well as the U.S. Department of Energy (DOE) policy of reviewing sitewide National Environmental Policy Act (NEPA) documents, have resulted in the need for the U.S. Department of Energy, Nevada Operations Office (DOE/NV) Operations Office to prepare a new Environmental Impact Statement (EIS) for the NTS. This report has been prepared to assess the human health and safety impacts from operations expected to be carried out under each of the four alternatives defined in the NTS EIS. These alternatives are:

- Alternative 1, Continue Current Operations (No Action)
- Alternative 2, Discontinue Operations
- Alternative 3, Expanded Use
- Alternative 4, Alternate Use of Withdrawn Lands

Five program areas are evaluated to the extent that they apply to each of the four NTS EIS alternatives. These are defense, environmental restoration, waste management, nondefense research and development, and work for others. In addition to these five program areas, site support services, such as fire protection and communications needed to support each of these program areas, are also evaluated.

This assessment was accomplished by evaluating effects upon human health of radiological, chemical, and toxicological substances, as well as physical hazards associated with construction, maintenance, and operations activities. To perform this assessment, scenarios (proposed situations and events envisioned to occur as a result of the implementation of one of the EIS alternatives) were created. The scenarios were then evaluated for human health and safety impacts on workers as well as the public.

The results of this study are presented in three parts: 1) the risks associated with the subsurface migration of tritium-contaminated groundwater; 2) the risks associated with activities performed under NTS EIS alternatives and program areas; and 3) the health and safety impacts of the maximum reasonably foreseeable accidents under each alternative.

Risks Associated with Migration of Tritium-Contaminated Groundwater. Tritium-contaminated groundwater exists in the subsurface as a result of past underground testing of nuclear weapons. Underground weapons tests were performed within the NTS and at two offsite locations, the Project Shoal Area and the Central Nevada Test Area. The migration of tritium-contaminated groundwater from test locations within the NTS is estimated to be maximized for the flow path from Pahute Mesa to Oasis Valley. Based on the combined results of studies performed by various authors, the estimated range of peak tritium concentrations at the closest uncontrolled use area varies from 5×10^{-4} pCi/L arriving 150 years after the beginning of migration to 3,800 pCi/L arriving in 25 to 94 years. These concentrations are well below the U.S. Environmental Protection Agency (EPA) maximum allowable tritium concentration in drinking water of 20,000 pCi/L. The hypothetical maximally exposed public individual at this location is estimated to have a lifetime probability of contracting a fatal cancer between 8×10^{-13} (about one in one trillion) and 1×10^{-5} (about 1 in 100,000).

The migration of tritium-contaminated groundwater from the test location at the Project Shoal Area could result in peak concentrations of 280 to 720,000 pCi/L arriving at the controlled area boundary 71 to 206 years after the test. Although no public wells currently exists at this location, a hypothetical individual consuming well water at this location for a standard lifetime of 70 years would have a lifetime probability of contracting a fatal cancer between 2×10^{-10}

(about one in five billion) and 2×10^{-3} (about 1 in 500). At the nearest existing public well, a hypothetical maximally exposed public individual is estimated to have a lifetime probability of contracting a fatal cancer between 4×10^{-24} (essentially zero) and 2×10^{-7} (about one in five million).

The migration of tritium-contaminated groundwater from the test location at the Central Nevada Test Area was predicted to have reached a peak concentration of about 1.2×10^{8} pCi/L at the southern boundary approximately 8 to 15 years after the test (between the years 1976 and 1983). This predicted concentration has not been confirmed by groundwater sampling and analysis. No public well currently exists at the boundary of the Central Nevada Test Area. But if a well did exist, a hypothetical individual consuming well water at this location for a standard lifetime of 70 years around the time of peak tritium concentrations would have a lifetime probability of contracting a fatal cancer between 1.4×10^{-5} (about one in 70,000) and 5.5×10^{-3} (about one in 200). At the nearest existing public well, a hypothetical maximally exposed public individual is estimated to have a lifetime probability of contracting a fatal cancer between 1.7×10^{-24} (essentially zero) and 3.2×10^{-10} (about one in three billion).

Risks Associated with Activities Performed Under NTS EIS Alternatives and Program Areas. In general, human health risks under each of the alternatives are expected to be dominated by occupational injuries to workers engaged in activities such as construction, maintenance, excavation, etc. By conducting activities for ten years under the various alternatives listed in the NTS EIS, it is estimated that the following number of injuries and fatalities would occur: Alternative 1 - 204 injuries and 3 fatalities; Alternative 2 - 3 injuries and no fatalities; Alternative 3 - 775 injuries and 9 fatalities; and Alternative 4 - 104 injuries and 1 fatality. The Waste Management Program had the greatest number of human health risks associated with it, when compared to all other program areas. It is unlikely that a single fatal cancer or other detrimental health effect would occur as a result of radiation exposure to workers or the public under any of the NTS EIS alternatives. Hazardous chemical spills could result in noncancer health effects to workers in operations conducted under Alternatives 1, 3 and 4.

Impacts Associated with the Maximum Reasonably Foreseeable Accident. The maximum reasonably foreseeable accidents associated with activities under the NTS EIS Alternatives would be as follows:

Alternative 1

The maximum reasonably foreseeable radiological accident involves a non-nuclear explosion in an Area 27 nuclear weapons storage magazine. The accident has a probability of 1×10^{-7} per year and could result in injuries or deaths to nearby workers due to the physical impacts of the explosion or delayed radiation health effects. Radiation exposure from the accident could result in 6 latent cancer fatalities in the worker population at the next nearest facility, and from 3 to 55 latent cancer fatalities in the offsite population within 50 miles.

The maximum reasonably foreseeable chemical accident involves an airplane crash into the Liquid Gaseous Fuel Spill Test Facility. The accident has a probability of 1×10^{-7} per year and could result in injuries or deaths to nearby workers due to the physical impacts of the crash or toxic effects of chemicals. Workers at the next nearest facility could experience non-life threatening health effects from exposure to airborne chemicals. The off-site population within 50 miles could experience up to 3 latent cancers as a result of this accident.

Alternative 2

The maximum reasonably foreseeable radiological accident involves a failure of an artillery fired test assembly at the Tonopah Test Range. The accident has a probability of 1×10^{-7} per year. Nearby workers would be under cover when the device fired, but up to 6 latent cancer fatalities could occur in workers at the next nearest facility. The off-site population within 50 miles would have an increased likelihood of 0.009 to 0.16 of a single latent cancer fatality.

The maximum reasonably foreseeable chemical accident involves a multi-container fire at the Area 5 hazardous waste storage unit prior to final shipment of these wastes off-site. The accident has a probability of 8×10^{-5} per year. Workers immediately downwind of the fire could be exposed to life-threatening air concentrations of hazardous chemicals. The off-site population within 50 miles would not be expected to experience any non-cancer health effects, and the likelihood of a single cancer in the population would increase by 0.002 to 0.004.

Alternative 3

The maximum reasonably foreseeable accidents for Alternative 3 are the same as those described for Alternative 1.

Alternative 4

The maximum reasonably foreseeable radiological accident involves an airplane crash into the Area 5 transuranic waste storage unit. The accident has a probability of 6×10^{-7} per year and could result in injuries or deaths to nearby workers due to the physical impacts of the crash or delayed radiation health effects. The worker population at the next nearest facility would have an increased likelihood of 0.04 of a single latent cancer fatality. The off-site population within 50 miles could experience 1 to 13 latent cancer fatalities.

The maximum reasonably foreseeable chemical accident is the same as that described for Alternative 1 (airplane crash into the Liquid Gaseous Fuel Spill Test Facility).

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1.0 INTRODUCTION

1.1 Purpose

The Nevada Test Site (NTS) is a multi-facility site that supports a diverse range of U.S. Department of Energy (DOE) mission objectives. Although the principal mission of the NTS has been to conduct nuclear weapons-related tests, and more recently to maintain a readiness to conduct nuclear tests, the NTS also supports other DOE activities. These activities include various types of research and development, as well as operations associated with radioactive waste management, and environmental restoration programs.

In recent years, changes in nuclear testing policy have occurred in the international community. These policy changes have resulted in the pursuit of additional DOE and non-DOE activities being proposed for siting at the NTS. These proposed changes in NTS operations, as well as the DOE's policy of reviewing sitewide National Environmental Policy Act (NEPA) documents, have resulted in the need for the U.S. Department of Energy Nevada Operations Office (DOE/NV) to prepare a new Environmental Impact Statement (EIS) for the NTS. It is the intent that this EIS serve as a support tool for policy makers and stakeholders; by providing an evaluation of the potential environmental impacts associated with various alternative uses of the NTS and its resources, being considered by the DOE.

This study follows DOE's EIS guidance *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE, 1993), for assessing human health and safety impacts. This assessment was accomplished by evaluating effects upon human health from radiological, chemical, and toxicological substances; as well as physical hazards associated with construction, maintenance, and operations activities. To perform this assessment scenarios, proposed situations and events envisioned to occur as a result of the implementation of one of the EIS alternatives), were created. The scenarios were then evaluated for human health and safety impacts on workers as well as the public.

Each scenario was evaluated for its impacts upon human health and safety, using a three-fold approach. First, for each scenario, a detrimental effect (deemed 'consequence') upon human health and safety, that could foreseeably result from an action or the lack of action was assessed. Second, the likelihood that a specific detrimental effect could materialize under each scenario (deemed 'probability') was estimated. Numerical values were then assigned to both the consequence and probability parameters, illustrating each parameter's relative degree of importance with regard to this human health and safety evaluation. Third, the values assigned to the parameters of consequence and probability were multiplied together, creating a parameter value that is known as 'risk'. This value denotes the amount of risk that is associated with each scenario. It is this value that will assist decision makers in making relative comparisons between the EIS alternatives that are directly associated with each of the scenarios.

However, it is important to note that the sole parameter of 'risk' may not always fully communicate the magnitude of potential adverse consequences, because the consequences are weighted by the probability. As such, in this study accident scenarios that were assumed to inflict the maximum impact to human health and safety, are presented in terms of their separate components of consequence and probability. These accident scenarios, referred to as maximum reasonably foreseeable accidents, illustrates the maximum consequences that are reasonably foreseeable in the event that an accident actually occurs.

1.2 Scope of Study

The public scoping period for the NTS EIS began with the publication of the Notice of Intent (to prepare an EIS) on August 10, 1994. During the scoping period and in subsequent meetings with

the DOE, some members of the public, elected officials, American Indian tribal governments, and private issue-advocacy groups expressed concern about the DOE's ongoing and expanding radioactive waste and nuclear materials management activities at the NTS. These groups asked the DOE to provide more information about the potential risks to human health that may be associated with the proposed alternatives. This report addresses those concerns as they relate to the specific alternatives identified in the NTS EIS. This report, however, does not address risks to human health that are associated with transportation activities or routine air emissions from NTS activities. Transportation issues are evaluated separately in Appendix I of the NTS EIS. Air quality impacts to human health are discussed in Chapter 5.0 of the NTS EIS document.

1.2.1 Alternatives Evaluated

Because the NTS EIS covers actions that are currently ongoing or proposed for the NTS between 1996 and 2005, this evaluation examines human health and safety impacts from activities conducted for a period of no more than 10 years.

The four alternatives, as they are identified in the NTS EIS, are:

Alternative 1	Continue Current Operations (No Action)
Alternative 2	Discontinue Operations
Alternative 3	Expanded Use
Alternative 4	Alternate Use of Withdrawn Lands

Alternative 1 is defined as the continuation of ongoing DOE and interagency programs, activities, and operations at the NTS and other associated areas within the State of Nevada. The No Action Alternative would also allow for continuation of past operations, as required.

Under Alternative 2 all current and planned program activities and operations would be discontinued. Only monitoring and other functions necessary for human health, safety, and security would be maintained.

Under Alternative 3 utilization of the NTS and its resources would be expanded to support national programs, both of a defense and non-defense nature.

Implementation of Alternative 4 would involve discontinuing all defense-related activities and most Work for Others programs. Certain programs and activities that are not included as responsibilities within the scope of the current NTS mission are also evaluated. This alternative could include other activities that would be dependent upon future land-use designations and withdrawal status, such as the relinquishment of portions of land from the NTS.

1.2.2 Program Areas Evaluated

Examined in the EIS are programs and activities, including those associated with the realignment of the national DOE mission as they relate to the DOE-utilized sites examined in this EIS. Five program areas and support infrastructure are evaluated, to the extent that they apply to each of the four alternatives. These program areas are briefly described below:

- Defense Program - The primary missions of defense programs are the stockpile stewardship and the maintenance of readiness to conduct underground nuclear tests.

- Waste Management - This program provides for the safe and permanent disposal of waste through disposal on the NTS, or at off-site commercial waste treatment/disposal facilities.

- Environmental Restoration - The goal of this program is to identify contaminated areas, and to remediate or contain those contaminated areas that might pose a risk to human health or the environment.

- Nondefense Research and Development - This program includes original research efforts by the DOE, universities, industry, and other federal agencies.

- Work for Others - This program provides for the use of NTS areas and facilities by other groups and agencies other than the DOE, for activities such as military training exercises.

- Site support activities - Included in this program area are the infrastructure activities and functions required to support all operations being conducted at the NTS. These functions include; environmental monitoring, security surveillance, communications, utilities services, and general building and road maintenance.

1.2.3 Sites Evaluated

The NTS EIS examines existing and potential impacts to the environment that have, or could result from current and proposed DOE operations in southern Nevada. The DOE-utilized sites examined in this EIS are the NTS and the Tonopah Test Range (TTR) (which are both surrounded by portions of the Nellis Air Force Range [NAFR Complex]), the Central Nevada Test Area (CNTA), the Project Shoal Area, Coyote Spring Valley, Dry Lake Valley, and Eldorado Valley (Figure H-1).

It should be noted that although all of these sites have been evaluated initially, not all geographical locations are expected to be impacted by each program or alternative. Table 1-1 provides a matrix of the geographical sites potentially affected by specific programs being performed under the various alternatives.

1.3 Organization of This Document

The purpose of this report is to provide an assessment of human health risks and safety performed under the various alternatives being considered in the NTS EIS. Chapter 1 focuses on the purpose and need for an assessment of human health risks and safety impacts resulting from NTS operations. The remaining chapters describe how this assessment has been performed, as well as providing the assessment's results. In particular:

- Chapter 2 provides a discussion on general risk assessment concepts and how they are used to provide a measure of human health risks. The methodology used to perform the analysis is also outlined in this section.

- Chapter 3 defines the various site operations, as they pertain to each program area/alternative combination.

- Chapter 4 outlines routine operation scenarios and accident scenarios used in the evaluation of the various program area/alternatiave combinations.

- Chapter 5 provides the numerical results of the analysis, as well as a brief discussion of the findings for each alternative.

- Chapter 6 presents conclusions from this study, including potential prevention and mitigation measures to reduce risk.

- Chapter 7 provides a list of documents containing information that was utilized for this study, or documents containing additional information that may be of interest to the public.

- Attachment A is a detailed summary of reasonably foreseeable accidents evaluated for each alternative and program area.

Figure H-1. NTS and Selected Areas of Interest

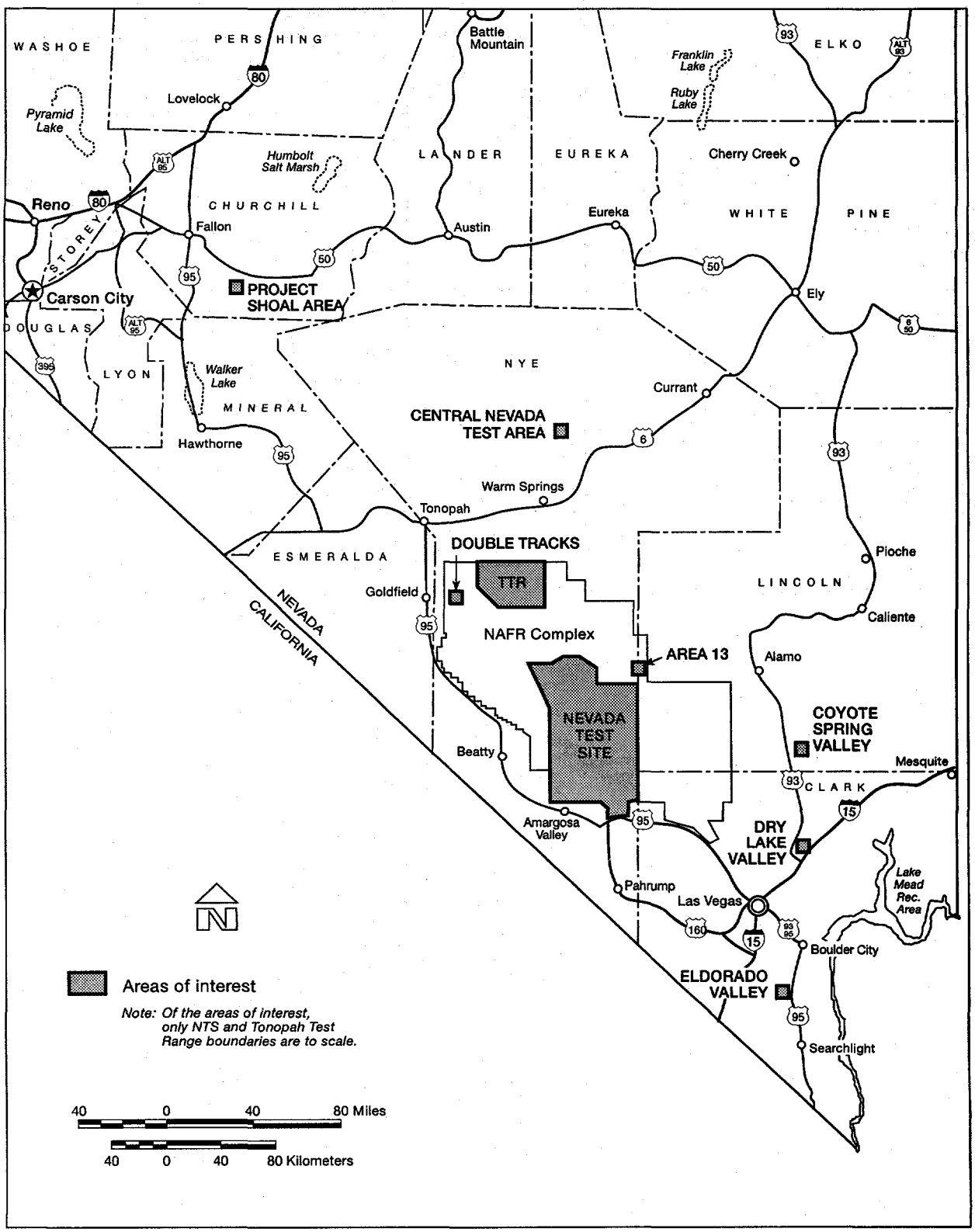

Table 1-1. Matrix of Alternatives Versus Programs Applicable to Each Site

	Defense	Waste Management	Environmental Restoration	Nondefense Research and Defense	Work for Others	Site Support Activities
Alternative #1 No Action - Continue Current Operations	NTS TTR	NTS	NTS CNTA Project Shoal Area TTR NAFR Complex	NTS	NTS TTR	NTS TTR
Alternative #2 Discontinue Operations	TTR	No DOE/NV Activities	No DOE/NV Activities	No DOE/NV Activities	TTR	NTS TTR
Alternative #3 Expanded Use	NTS TTR	NTS	NTS CNTA Project Shoal Area TTR NAFR Complex	NTS Coyote Spring Valley Eldorado Valley Dry Lake Valley TTR	NTS TTR	NTS TTR
Alternative #4 Alternate Use of Withdrawn Lands	TTR	NTS	NTS CNTA Project Shoal Area TTR NAFR Complex	NTS Coyote Spring Valley Eldorado Valley Dry Lake Valley TTR	TTR	NTS TTR

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2.0 RISK ASSESSMENT CONCEPTS AND METHODOLOGY

Risk assessment is the quantitative process of estimating the consequences to human health resulting from a release of contaminants to the environment. This risk assessment study focuses on the assessment of both radiological and chemical contaminants and their effects upon human health, as well as risks posed to human safety from occupational hazards. A brief discussion on the general concepts of risk assessment; as well as specifics concerning radiological, chemical, and safety assessments are presented below.

2.1 General Risk Assessment Concepts

Risk assessment is a multidisciplinary subject requiring the identification of events with the potential for a failure that could lead to an undesirable outcome (scenario), the prediction of contaminant types subject to release and their concentrations, the description of environmental transport (the identification of potential exposure pathways) the calculation of internal and external dose, and the extrapolation of this dose to human health effects. The purpose of a risk assessment is to illustrate the relationship between the types and quantities of contaminants released, and the effects they are expected to have on human health. The risk assessment process follows the contaminant of interest from its point of origin along various pathways in the environment. In addition, the risk assessment process is used to evaluate the various mechanisms that enable the transport of the contaminant to a human. These transport mechanisms can be either air, water, soil, or food. Once the contaminant's transport mechanism and the amount of contamination the human can be exposed to (the source term) are determined, the dose (the actual amount of contamination that the human's body will be subjected to) and the resulting risk to human health can be calculated.

2.1.1 Source Term and Its Link to Human Dose

The source term is a description of the chemical, radioactive, and toxic constituents that a human has the potential to be exposed to in a given scenario. The source term must not only identify the contaminants of concern, but their expected concentrations as well. The identification of the source term is a significant part of the risk assessment process. It is significant not only because the effect of each contaminant will be assessed for its impact upon human health, but multiple effects created from the presence of a combination of contaminants will also have to be evaluated.

The primary mechanisms used to transport the source term within the environment are air, surface water, and groundwater. To assess the degree to which a contaminant may become mobile in an environment, a few key parameters must be defined. These parameters include the contaminants chemical form, solubility in air and water, and physical state (e.g., liquid, solid, or gas). One main objective of a risk assessment is to predict the concentrations of contaminants that will reach humans, either through direct paths (e.g., inhalation, absorption), or indirect paths (e.g., consumption of contaminated water). Environmental transport modeling is used to estimate the amount of contamination present in a transport mechanism (e.g., air, water, soil, or food), and estimate the amount of contamination that is available to a person.

Human consumption rates of various food/water commodities as well as human metabolic rates are important links between the source term that is available to a human, and the actual intake dose to which the human body may be subjected. Once the human dose has been calculated, the detriment to human health can be estimated by multiplying this number by one or more risk factors. A risk factor is a numerical correlation between a dose, and the effect it will have on a human. Risk factors are based largely on epidemiological data, primarily from studies examining radiological and chemical health effects.

2.1.2 Radiological Effects

Radionuclides present in air, water, soil, or food can be inhaled/ingested into the human body, becoming incorporated into tissues and organs, causing resulting in internal irradiation of body organs. In addition, humans can be exposed to radionuclides as their skin absorbs radiation that is being emitted from external sources. Topics discussed here will include radioactive particles, radioactive decay, fission, fusion, and radioactive waste categories, as well as the terminology associated with the assessment of radiological exposure.

2.1.2.1 Nuclear Reactions: Radioactive Decay, Fission, and Fusion. All matter is composed of atoms. Through natural or man-made processes, atoms of elements can be placed into an unstable state. When an atom is in an unstable state, its nucleus (made up of protons and neutrons) will release energy in order to regain its stability. This alteration occurs as a result of either the radioactive decay, fission, or fusion process.

Radioactive decay is a process whereby the nuclei (plural of nucleus) of unstable atoms release or emit energy to regain their stability. This energy is emitted in the form of alpha particles, beta particles, or gamma rays, termed ionizing radiation. As this energy passes through a material, it can change the chemical structure as well as the behavior of the material's atoms. It is through this process of chemical structural change that radiation can lead to biological damage in humans. The level of damage is dependant upon several factors, including the amount of energy taken in by the human body.

Fission is the process whereby a large nucleus (e.g., uranium-235) splits into two fragments, resulting in the release of energy. In each fission neutrons are released. These neutrons may go on to produce fissions of nearby nuclei. If a neutron goes on to cause additional fissions and the process is repeated again and again, the effect is a self-sustained chain reaction. This condition is termed as the attainment of 'criticality.' When the energy released in the process of fission is controlled (as it is within a nuclear reactor), its use can be beneficial. Much of the low-level waste that has been shipped to the NTS from other DOE sites contains radioactivity that was generated from the operation of nuclear reactors. The fission process is also one of the fundamental nuclear reactions that may be involved when an underground nuclear weapons test is conducted.

Fusion is the process whereby two light nuclei (e.g., isotopes of hydrogen such as deuterium and tritium) collide and fuse together to form one heavier nucleus and one lighter nucleus. In the process, mass is converted to energy. This nuclear reaction is the process that energizes the sun. The amount of energy released per pound of heavy hydrogen is about four times as much as the amount of energy released per pound of uranium or plutonium in a fission reaction. The fusion process is another nuclear reaction that may be involved when an underground nuclear weapons test is conducted.

The processes of radioactive decay, fission, and fusion produce three main types of ionizing radiation: alpha particles, beta particles, and gamma rays. None of these can be detected by our senses. Each type of radiation can have a different level of energy, and thus have varying abilities to penetrate and harm the human body. Because each type of radiation poses a unique hazard to human tissue, individual characteristics must be noted when assessing radiological impacts upon human health.

2.1.2.2 Units of Measure. The biological effects of ionizing radiation vary according to the type of radiation, the dose received, and the type of cell affected. Any dose of radiation can damage body cells. However, at low radiation levels, such as those administered to patients receiving x-rays or those that may be received by workers handling radioactive wastes, damage to the cells is so slight that they can usually either repair themselves or be replaced by the regeneration of healthy cells. Special standards of measurement are used to gauge radiation and its effects. The most common units associated with radiological properties are the curie, picocurie, roentgen, radiation absorbed dose (rad), roentgen equivalent man (rem), person-rem, and effective dose equivalent. For purposes of

radiation protection and the calculation of population dose, one must also know the half-lives of all radionuclides that make up the source term. Definitions of these terms are provided below.

- *A curie (Ci)* - is a unit of radiation that describes the numbers of atoms undergoing radioactive decay in a period of time. One curie is equal to 37 billion disintegrations per second.

- *A picocurie (pCi)* - is one trillionth of a curie ($1x10^{-12}$ Ci).

- *Roentgen-* measures the amount of energy (or ionization) produced by gamma radiation.

- *Radiation absorbed dose (rad)* - is the amount of energy absorbed by a material.

- *Roentgen equivalent man (rem)* - is used to equate the biological damage done to organisms resulting from radiation. The unit rem is used, regardless of the type of ionizing radiation being evaluated. Neither the roentgen nor the rad gives an indication of biological damage.

- *Person-rem* - is defined as the collective total dose to a population. Person-rem is calculated by summing the individual doses of each member of the population. For example, if 100 workers each received 0.1 rem, then the collective dose would be 10 person-rem (100 persons x 0.1 rem).

- *Effective dose equivalent* - measures the amount of damage to the exposed individual's body as a result of the radiation exposure. The effective dose equivalent can be used to estimate the exposed individual's risk of health effects. Effective dose equivalent takes into account variables, such as the different susceptibilities of certain body tissues to different forms of radiation. The effective dose equivalent is often referred to simply as 'dose,' and is measured in units of rem.

- *A radiological half-life* - is the length of time required for an initial amount of a radioactive substance to be reduced down to ½ of its original amount, due to radioactive decay.

Human exposures are often classified into two categories, acute exposure and chronic exposure. An acute exposure is a large dose that is received by an individual over a few hours or less. With chronic exposure an individual is exposed to small doses repeatedly, over a long period of time (months to years). It is the general consensus that there is no threshold for radiation induced health effects based on the linear non-threshold hypothesis.

2.1.2.3 Radioactive Waste Types. Natural and man-made radiation area is produced on earth many ways. Natural forms of radiation include background radiation, such as the decay of naturally-occurring radioactive elements located in the earth's crust. In addition, radioactivity exists naturally within the human body. It comes mostly from potassium, which is an essential element for human health. Scientists have also deliberately created sources of ionizing radiation as a result of conducting various practices. These practices include nuclear-power generation of electricity, diagnostic and therapeutic medical techniques, non-destructive testing of pipes and welds, and the production and testing of nuclear weapons. These practices result in the generation of radioactive waste.

The DOE manages various types of radioactive wastes, generated in a large part due to weapons production and nuclear-power production research programs. Radioactive waste is defined as a solid, liquid, or gaseous material that contains radioactive nuclides regulated under the Atomic Energy Act of 1954, as amended, and is of negligible economic value given the cost of recovery. Such wastes may be classified as low-level, mixed wastes, transuranic or high level. Descriptions of these waste types that are managed by DOE/NV are provided below.

- Low-Level Waste (LLW) - Radioactive waste not classified as high-level waste,

transuranic waste, spent nuclear fuel, or the tailings or wastes produced by the extraction or concentration of uranium or thorium. Test specimens of irradiated fissionable material may be classified as LLW, provided the concentration of transuranic elements is less than 100 nanocuries per gram.

- Mixed Waste (MW) - Waste containing both radioactive and hazardous components as defined by the Atomic Energy Act and the Resource Conservation and Recovery Act of 1954 as amended, respectively.

- Transuranic Waste - Radioactive waste containing 100 nanocuries per gram or more of alpha-emitting radionuclides that have an atomic number greater than 92, and half-lives greater than 20 years.

- The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing of any solid waste derived from the liquid, that contains a combination of transuranic waste and fission products in concentrations requiring permanent isolation. This will make the document consistent with the waste definitions found in Section 2.4.2 of Volume 1, Chapter 2.

2.1.3 Chemical Effects

When certain natural or man-made materials or substances have harmful effects that are not random, the materials or substances are described as toxic (Ottoboni, 1991). Specific chemicals or biological substances may be labeled as toxic for many reasons, including such things as their ability to cause cancer; to harm or destroy tissue or organs; or to harm systems within the body, such as reproductive, immune, blood-forming, or nervous systems. A brief discussion on the types of toxic substances is provided below:

- Carcinogens are substances known to cause cancer in humans, or are known to cause cancer in animals and therefore may be capable of causing cancer in humans. Examples of human carcinogens include asbestos, benzene, and vinyl chloride (Kamrin, 1988). Cancers for which the cure rate is low and for which the period between diagnosis and death is usually short, are termed *fatal cancers*. Cancers for which the fatality rates may be low, but for which there can be either physical or psychological reasons for a reduced quality of life, are termed nonfatal cancers.

- Noncarcinogens are substances that may not be known to cause cancer, but may be capable of causing harm, such as invoking mutagenicity in a human. Mutagenicity is the capability of a substance to cause permanent alteration of genetic material within living cells contained in the human body. Serious disabilities that may be transferred to offspring of parents that have been exposed to mutagens are termed genetic disorders. Latency is a term used to describe the period of time between the point of exposure and the resulting effect of the exposure on the human body.

Even though chemical or biological substances may be determined to be toxic, many factors influence whether the inhalation or ingestion of a particular substance may have a toxic effect on a human. These factors include:

- How much of the substance the person comes into contact with, and

- Whether the person inhales or ingests the substance in a short period of time (an acute exposure), or inhales or ingests relatively small amounts of the substance repeatedly, over long periods of time (a chronic exposure).

Scientists determine a substance's toxic effect (known as toxicity) by performing controlled tests on biological organisms. During these tests specific parameters are examined to measure the toxicity of a substance on a biological organism. These parameters include the dose-response

relationship, and the threshold concept.

- Dose-response Relationship - The dose-response relationship is a curve showing the percentage of organisms with observable toxic effects versus the dose administered. This curve is established as a result of controlled tests on biological organisms. Once a dose is administered, it is increased until all of the biological organisms being tested are affected, and then is decreased until none of the biological organisms being tested are affected.

- Threshold Concept - The threshold concept suggests that most toxic substances will produce no effect on a biological organism if the substances are given in small enough amounts. Thus, the threshold can be defined as the largest amount of a particular substance that will not affect an organism.

2.1.4 Exposure Pathways

The magnitude of a human's exposure to a contaminant, whether it be radiological or chemical, is dependent on how the contaminant travels throughout the environment. The sequence of events which enables the contaminant to reach a person after it has been released into the environment is termed the 'exposure pathway.'

Exposure pathways can be both numerous and varied. In some cases exposure pathways are relatively simple, such as the direct exposure to radiation. In other cases exposure pathways may be complex processes. For example; radioactive particles may be released into the air due to an explosion, they then may fall out of the air and be deposited onto grass, the grass may then be eaten by a cow, radionuclides ingested by the cow may be transferred into its milk, which is then consumed by humans.

Normal and emergency operations at some DOE facilities have the potential to expose workers and members of the public to radioactive or toxic materials. To maintain high levels of safety, specialists analyze exposure scenarios possible for normal operations and accidents. The materials involved and any protective measures in place, that may lessen the consequences, are considered when evaluating these scenarios. The following list describes the four conditions that must exist to form a scenario, by which radioactive or toxic materials can be transported through the environment to workers or the public:

- Source Term - The contaminant(s) released to the environment.

- Environmental Transport Medium - Air, surface water, groundwater, or the food chain.

- Exposure Route - The method by which a contaminant may reach a person.

- Human Receptor - The person or group of people that can be or is exposed to the contaminant.

Using these elements in an example, one scenario might involve gases containing a contaminant (the source term) released from a stack. These gases are transported by the wind (the environmental transport medium). The air containing the contaminants is inhaled (the exposure route) by a worker (the human receptor). No matter which exposure pathway a scenario involves, local environmental factors such as the density of the region's population, its sources of water, agricultural practices, and weather patterns, may play a big role in determining whether or not the contaminant will reach a human receptor.

2.1.5 Occupational Risks

Human health can be at risk not only from radiological and chemical substances, but can also be at risk from physical hazards that are routinely present at a place of work, or from accidents that may happen during the course of performing routine activities at work.

Routine occupational hazards have the potential to inflict bodily injury upon personnel that are

performing normal day-to-day work activities. Examples of these hazards may include electrical shock, slipping or falling, falling objects and hazards normally associated with various types of equipment usage. Scenarios portraying routine occupational activities are examined to estimate the risks associated with performing these activities.

Occupational hazards that may occur as a result of an accident are also examined. Examples of occupational hazards that may occur as a result of an accident may include bodily injuries resulting from equipment malfunctions due to a design flaw or due to human error; material spills or leaks; or accidents resulting from natural phenomenon, such as tornados or earthquakes. Scenarios portraying occupational hazards associated with accidents are also examined to estimate the risks associated with performing routine operations within unstable environments.

2.2 Risk Assessment Methodology

This study takes a two-fold approach to the assessment of human health risks and safety impacts. First, human health risks are calculated for proposed activities within each EIS alternative. As noted earlier, risk is defined as the product of probability and consequence. The sum of the risks for all activities within an alternative is the total risk associated with that alternative. The systematic evaluation of risk across all alternatives allows decision makers to make relative comparisons among alternatives on the basis of risk. Although useful as a decision-making tool to discriminate among alternatives, risk by itself does not convey information on the magnitude of adverse consequences in the event that an accident actually occurs. Therefore, to supplement the assessment of risks, the second part of this assessment evaluates the probability and consequences of the maximum reasonably foreseeable accident within each alternative. This allows for the identification of maximum impacts that could be expected if an accident actually occurs.

To evaluate human health risk, three components; scenario, likelihood, and consequence must be identified. The first component, the scenario is made up of either one basic failure event or an initial failure event, followed by subsequent failures that lead to an outcome which may or may not be desirable. The second component, likelihood describes how often the scenario is expected to occur. Likelihood may be expressed as a probability, which is a subjective expression of the belief that something will, or will not, occur (e.g., there is a 70 percent chance of showers tomorrow). Probability is a unitless number and is always between zero and one. Likelihood may also be expressed as a frequency or rate, e.g., 0.07 injuries from construction accidents per year. The third component needed to evaluate human health risks is consequence which is the results of a scenario. To evaluate consequences, specific hazards within the scenario must be defined. For example, to evaluate the consequences of a release of hazardous material, the source term (what substance is released, how much is released, and what form it takes) must be defined and its dispersion predicted. From the exposure caused by the release, a dose is calculated. That dose leads to a predicted health effect, which is the consequence.

Based on DOE guidance (DOE, 1993), events having a probability of occurrence that is more than once in 10 million years (1×10^{-7} per year) are considered to be reasonably foreseeable, and need to be examined to satisfy the purposes of a NEPA review. The accident with the highest consequences to human health having a probability of occurrence greater than or equal to 1×10^{-7} per year is defined as the maximum reasonably foreseeable accident.

2.2.1 Scenario Development

Scenarios that contribute to the risk of proposed activities under the EIS alternatives include both routine operations and accidents. In either case, the identification of scenarios important to human health risk begins with the identification of the principal activities associated with each alternative and the hazards specific to those activities. For example, construction activities may not involve radiological hazards, but instead involve occupational hazards that could result in injuries or fatalities to workers. Section 3 of this report

identifies the operations proposed for each program area under each of the four EIS alternatives. These operations are the basis for the identification of hazards and the development of risk scenarios used in this study.

Scenarios for routine operations are not initiated by the failure of any safety system or procedure. In these scenarios, the activity itself involves risk which is managed within acceptable limits as defined by current standards for worker and public safety. Routine operations scenarios include events that could result in exposure of workers or the public to levels of radiation and/or toxic materials within regulatory limits.

Accident scenarios are developed based on the assessment of the hazards associated with specific activities and the engineered designs and safety systems in place to prevent hazards from impacting the health and safety of workers and the public. Accident scenarios require the failure of one or more safety systems or design features to result in an adverse health risk beyond the risk associated with routine operations. For example, a worker handling a drum of radioactive material is exposed to radiation within controlled limits during routine operations, but a handling accident that breaches the drum (a design feature) could result in release of radioactivity from the drum and expose the worker to radiation higher than normal (controlled limits) levels. In addition, if the high efficiency particulate air (HEPA) filters on the building ventilation system (a safety system) also fail, airborne radioactivity could be released to the environment above normal operating levels and result in potential radiation exposure to other workers or members of the public. Section 4.1 of this report summarizes the scenarios used for assessing risk from routine operations and accidents for each EIS alternative.

The general categories of accidents that are reasonably foreseeable for the types of activities proposed in the NTS EIS include construction accidents, mechanical upsets (e.g., forklift accidents), spills involving radioactive or chemically hazardous materials, fires, and explosions. A potential accidental venting of radionuclides from an underground nuclear-yield test is also evaluated. The occurrence of any accident requires an initiating event that causes the failure of design features or safety systems. The initiating event can be operations related, such as human error or equipment failure; or it can be an external event, such as an earthquake, high winds, or a flood.

2.2.2 Probability Analysis

An analysis of probability is not needed for routine operations scenarios because the events are assumed to occur. Therefore, the probability of routine operations scenarios is always 100 percent.

Accident scenarios require an initiating event that is accompanied by the failure of one or more safety systems or design features. Determination of the probability of an accident scenario requires the calculation of individual probabilities for the initiating event, and the failure probabilities of the safety features designed to prevent the accident. For example, the probability of an earthquake (the initiating event) in the vicinity of a radioactive waste storage facility may be once in 1000 years (1×10^{-3} per year). The probability that the earthquake is of sufficient magnitude to cause the building structure to fail and allow a release of radioactivity into the environment may be one out of 10 earthquakes (0.1). The probability that waste drums are breached (a design failure) from falling or crushing forces may be one out of ten (0.1). Because the total probability of this accident scenario is the product of the individual event probabilities that make up the scenario, the probability of this scenario occurring is calculated as $P = (1 \times 10^{-3}$ per year) x (0.1) x (0.1) = 1×10^{-5} per year, or once in 100,000 years.

Data for the calculation of accident scenario probabilities are derived from a variety of sources and include scientific studies of natural phenomena hazards, structural design guidelines for nuclear facilities, equipment failure rates, and accident statistics that have been compiled over many years by the DOE and other government agencies.

2.2.3 Consequence Analysis

The activities proposed under the NTS EIS alternatives could result in human health

consequences occurring as a result of normal operations or accidents. These consequences may result from either physical hazards (e.g., construction accidents, industrial accidents) or material hazards (e.g., exposure to radioactive or toxic materials). The principal consequences of routine operations include small increases in the likelihood of cancer or other detrimental health effects to workers and the public from exposure to regulated amounts of radiation or toxic materials. The consequences of accident scenarios may include injuries or fatalities to workers from physical hazards, as well as increased likelihood of cancer or other detrimental health effects to workers and the public from accidental releases of radioactive or toxic materials.

The analysis of consequences for releases of radioactive or toxic materials is a multiple-step process. For a given scenario, the analyst first determines the material at risk (which is the amount of radioactive or toxic material affected in the scenario). In the case of an airborne release scenario, the event will cause some fraction of the material at risk to become airborne. Release fractions have values between zero and 100 percent depending on the physical and chemical properties of the material and the type of accident (e.g., spill, fire, explosion, etc.). The product of the material at risk and the release fraction is the amount of material that actually becomes airborne this airborne material is referred to as the source term. The source term may be reduced by mechanisms such as filtration, gravitational settling, radioactive decay, or other factors depending on the path the material must travel to reach a human receptor.

Once the source term is developed, the analyst must assess the possible exposure pathways through which the material could impact workers or the public. The exposure pathways identified as being of most importance to risk in this study were inhalation of airborne contamination, ingestion of contaminated well water, and direct exposure to radiation. Other pathways that were evaluated include absorption of contamination through skin contact, consumption of contaminated crops, livestock, and milk.

For most scenarios, a transport mechanism is required to move the radioactive or toxic material from its source to a location where a person could be exposed. For example, building ventilation and wind can result in the atmospheric transport of contamination. Infiltration of precipitation into contaminated soil and eventually the groundwater can result in subsurface transport of contamination. The transport and dispersion of contaminants released were modeled using computer programs designed to simulate the atmospheric and hydrologic characteristics of the region. The result of this atmospheric or groundwater transport modeling is a dispersion factor. This dispersion factor is used to calculate the amount of contaminants that a human receptor could be exposed to downwind or downstream from the point of the release by accounting for natural processes of mixing and dispersal in the atmosphere or groundwater.

In the accident scenario, it is assumed that the human receptor is exposed by inhaling contaminated air or ingesting contaminated groundwater. The dose (the amount of radiation or chemical substance that a person receives) is calculated based on the concentration of the contaminated material taken into the body by breathing air or drinking water, as well as an average individual's breathing rate/ingestion rate, and the duration of the exposure. Potential health effects are estimated by multiplying the dose by health risk factors developed by the International Commission on Radiological Protection (ICRP, 1991) and the Environmental Protection Agency in *Health Effects Assessment Summary Tables (HEAST), FY-1995 Annual* (EPA 1995a), and in the *Integrated Risk Information System (IRIS) (For Microcomputers)* (EPA, 1995b).

Exposure to direct radiation is a pathway of importance principally for workers who work in close proximity to sources of radiation. Worker exposure by this pathway is estimated based on previous records of occupational radiation exposure for workers engaged in similar work activities, and estimates of the number of workers expected to be involved in each program activity. For example, if workers engaged in waste handling activities have previously received average individual doses of 0.1 rem per year, 10

workers would be estimated to receive a collective dose of 1 person-rem per year (0.1 x 10), or 10 person-rem in 10 years.

Consequences of accidents involving physical impacts to workers include injuries or fatalities, and are estimated using accident statistics developed by the U.S. Department of Labor and other sources.

2.2.4 Health Effect Risk Factors

Potential human health effects from exposure to radiation are estimated using risk factors developed by the ICRP, (1991) and are shown in Table 2-1. The predominant risk from radiation exposure is death from cancer. Radiation-induced cancers may have a latency period, that is a delayed onset of up to 20 years or longer. Therefore, this health effect is referred to as latent cancer fatality (LCF). Radiation exposure can also result in other detrimental health effects such as non-fatal cancers and genetic effects.

In this study, these other health effects are collectively referred to as radiation detriment. High doses of radiation in short periods of time can produce other health effects, including death. Potential human health effects from exposure to toxic chemical materials may include cancer as well as a wide range of other health effects depending on the toxicology of the material. Cancer risks are estimated using risk factors developed by the EPA. Risk factors are values used to estimate the potential of an individual developing cancer as a result of exposure to a carcinogenic substance (EPA, 1995a; EPA, 1995b). Noncancer health effects are evaluated in terms of a hazard index. Most noncancer health effects have a threshold dose which is the amount of a particular toxic substance below which no adverse effect has been observed. The hazard index is calculated by dividing the estimated dose by the threshold dose.

Because the methodology used to estimate the non-carcinogenic effects of hazardous substances is based on the assumption of linear time-independent dose response, Emergency Response Planning Guideline (ERPG) values associated with each chemical substance were defined. The ERPG values were used to identify any immediate health effects that could occur as a result of an acute exposure to a chemical substance.

2.2.5 Modeling of Risks from Subsurface Radioactivity

Residual radioactivity from underground nuclear weapons tests remains at various locations on the NTS and at two offsite test areas. Tritium, a radioactive isotope of hydrogen, is the material of principal concern because of its mobility in the form of water and its higher concentration compared to other radionuclides. The migration of tritium from underground test areas to locations outside the current control of the U.S. government has been evaluated in several studies: *Risk-Based Screening Analysis of Ground Water Contaminated By Radionuclides Introduced At The Nevada Test Site (NTS)* (Daniels et al., 1993); *A Fracture/Porous Media Model of Tritium Transport In The Underground Weapons Testing Area, Nevada Test Site* (GeoTrans, 1995); *Exposure Assessment of Groundwater Transport of Tritium From The Shoal Site* (Chapman et al., 1995); and *Exposure Assessment of Groundwater Transport of Tritium From The Central Nevada Test Area* (Pohlmann et al., 1995). The first two studies evaluated tritium migration from underground test sites located within the NTS boundaries. The other studies evaluated tritium migration from underground test sites in Nevada at the Shoal and Central Nevada Test Areas, which are located off of the NTS in Churchill and Nye counties, respectively. For efficiency and because of differences in scale, different model codes were used in these evaluations. The MC_TRANS model was used for the NTS; and for the off-site locations, the approach detailed in Daniels et al. (1993), was employed Both models account for standard transport phenomenon (advection, dispersion, decay, sorption, and mass transfer). The transport analysis in the GeoTrans study included an evaluation of the effects of matrix diffusion (the movement of radionuclides from fractures into the unfractured rock). Such an approach is considered appropriate for the regional scale NTS model, because it is known that

Table 2-1. Risk of Latent Cancer Fatalities and Other Detrimental Health Effects from Exposure to Radiation[a,b,c]

Population[d]	Latent Cancer Fatality	Radiation Detriment[e]
Workers	0.0004	0.00016
General Public	0.0005	0.00023

[a] When applied to an individual, units are lifetime probability of latent cancer fatalities per rem (or 1,000 millirem) of radiation dose. When applied to a population of individuals, units are excess number of cancers per person-rem of radiation dose.
[b] Source: ICRP (1991).
[c] For individual doses greater than 20 rem or 10 rem/hour dose rate, the ICRP risk factors for LCF and other detriment are doubled (ICRP, 1991).
[d] The difference between the worker risk and the general public risk is attributable to the fact that the general population includes more individuals in sensitive age groups (that is, less than 18 years of age and over 65 years of age).
[e] Radiation detriment includes health effects such as nonfatal cancers and genetic effects.

transport through many miles of fractured rock is necessary before any transport to site boundaries could occur. Given the differences between the types of sites, the nature of transport at each site, and the numerical solutions used, the results of the two different models provide comparable results. Additional evaluations of key transport characteristics are underway as part of the Environmental Restoration Program for the underground testing areas.

2.2.5.1 Underground Test Locations Within NTS Boundaries. Transport of tritium from test locations on the NTS has been evaluated in a number of recent studies. Daniels et al. (1993) and Andricevic et al. (1994) examined the groundwater flow path from Pahute Mesa to Oasis Valley and performed a screening assessment of potential risks to a hypothetical member of the public at the nearest uncontrolled area boundary in Oasis Valley. A more recent study conducted by GeoTrans (1995) also examined the flow path from Pahute Mesa to Oasis Valley, evaluated flow paths from Pahute Mesa to Amargosa Valley, and from Yucca Flat to the boundary of the NTS south of Mercury, Nevada. Each of the three studies based their radioactivity source terms on a compilation of observed concentrations in test cavity samples. The maximum observed concentration of tritium was 7.6 x 10^9 pCi/L obtained from the Cambric shot cavity in 1977. Other samples that have been collected had lower concentrations. Daniels et al. (1993) and Andricevic et al. (1994) assumed all groundwater at the source is contaminated to the highest observed tritium concentration of 7.6 x 10^9 pCi/L, while GeoTrans (1995) assumed an average groundwater concentration of tritium at the source of 1 x 10^9 pCi/L.

Daniels et al. (1993) and Andricevic et al. (1994) calculated potential human health risks associated with ingestion of tritium-contaminated groundwater over a 70-year lifetime. The committed effective dose to the maximally exposed individual was calculated by summing over the 70-year exposure period the products of the annual estimate of tritium concentration in groundwater, the age-related annual intake of tap water, and the age-specific dose conversion factor for each year of a 70-year lifespan. The risk of fatal cancer from the lifetime committed effective dose was calculated using the risk factor of 5 x 10^{-4} latent fatal cancer per rem (ICRP, 1991). Details of the human health risk calculations can be found in Daniels et al. (1993).

GeoTrans (1995) calculated tritium concentrations at potential receptor locations but did not calculate human health risk. This EIS estimated the committed effective dose to the maximally exposed individual by assuming ingestion of tritium-contaminated groundwater over a 70-year lifetime at the maximum concentrations calculated in GeoTrans (1995). The following equation was used for this calculation:

$$D_{70} = C \times I \times T \times \Phi$$

where,

D_{70} = Dose from 70-years ingestion of tritium in water (rem)
C = Tritium concentration in well water (pCi/L)
I = Annual residential water consumption (L/yr)
T = Exposure time (yr)
Φ = Internal dose conversion factor for tritium (rem/pCi)

Health effect risks from the estimated doses were calculated using the risk factors for the general public listed in Table 2-1.

2.2.5.2 Underground Test Locations Outside NTS Boundaries. Assessment of the groundwater transport of tritium from two off-site test locations, the Shoal site and the Central Nevada Test Area, were performed by the Desert Research Institute (Chapman et al., 1995; Pohlmann et al., 1995). Both assessments calculate the transport of tritium in groundwater from the test locations to the boundary of the current DOE land withdrawal, where no wells currently exist, and to the first existing wells along the flowpaths. Exposure scenarios assume an individual drinks contaminated water for 70 years around the time of peak tritium concentration.

The committed effective dose to the maximally exposed individual was calculated by summing over the 70-year exposure period the products of the annual estimate of tritium concentration in groundwater, the age-related annual intake of tap water, and the age-specific dose conversion factor for each year of a 70-year lifespan. The risk of fatal cancer from the lifetime committed effective dose was calculated using the risk factor of 5×10^{-4} latent fatal cancer per rem (ICRP, 1991). Details of the human health risk calculations can be found in (Daniels et al., 1993).

The health risks calculated by these two assessments are included in the results presented in Section 5 of this study.

2.2.6 Modeling of Risks from Routine Operations and Accident Scenarios

Section 4 of this study identifies the scenarios used for the estimation of risks for routine operations and accidents. This study evaluates 33 types of scenarios and calculates human health risks using the three components of risk (scenario, probability, and consequence) discussed earlier.

The detailed methodology for risk to workers associated with normal occupational radiation exposure; and the risk of physical injury or fatality to workers due to equipment accidents, falls, hoisting and rigging, and other activities is described in *Summary of the Human Health Risks for Safety Impacts Study for the Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV, 1996).

The methodology for risk to workers and the public associated with reasonably foreseeable accidental release of radioactivity or hazardous chemicals is summarized in Attachment A and described in detail in *Accident Assessments For Nevada Test Site Facilities And Off-Site Locations* (SAIC, 1996). The accident assessment followed a systematic approach to identify all facilities and operations involving radioactive material or hazardous chemicals associated with the four proposed alternatives, the five program areas, and the NTS and offsite locations. Attachment A summarizes the methods used to select and model the consequences of reasonably foreseeable accidents, and provides tables showing the probability and consequence of each postulated accident by alternative, program area, and location.

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3.0 NORMAL SITE OPERATIONS BY ALTERNATIVES

The NTS has been involved in supporting DOE as well as other national-security related research, development, testing programs, and waste management. General descriptions of programs and activities that accompany these policies are presented in Section 3.1 below. Individual programs and activities that are associated with each of the four alternatives being evaluated in the NTS EIS are identified in Section 3.2.

3.1 Programs and Activities Associated with the NTS

The NTS plays a major role in the implementation of DOE policies by participating in full partnership with the scientific and academic communities, business and industry, and community groups. The ways in which the NTS fulfills this role, through the programs and activities are discussed below.

For management purposes, the projects and activities at the NTS have been categorized into five program areas. These are defense, environmental restoration, waste management, nondefense research and development, and work for others. In addition to these five program areas; services, such as fire protection and communications needed to support each of these program areas, are placed into a sixth category of Infrastructure.

3.1.1 Defense Program

The primary missions of the Defense Program at the NTS involve helping to ensure the safety and reliability of the nation's nuclear weapons stockpile. The NTS has a long history in participating in the nation's stockpile stewardship program. This stewardship program includes maintaining the readiness and capability to conduct underground nuclear weapons tests, and to conduct such tests if so directed by the President. A potential accident associated with an underground nuclear-yield test is considered in the human health risk assessment for Alternatives 1 and 3.

Although there have been no underground nuclear tests conducted at the NTS since entering into the test-ban passed by Congress, research and weapons test verification activities have been conducted in the past at the Project Shoal Area, the Central Nevada Test Area, the Nellis Air Force Range, the Tonopah Test Range (TTR), and the NTS. This past testing resulted in a release of radioactive contaminants into the surrounding environment. Currently, the DOE is working in cooperation with other agencies to define remediation and clean-up levels for these geographical areas. These activities are included within the Environmental Restoration Program.

3.1.2 Environmental Restoration

The goal of the Environmental Restoration Program is to ensure that risks to the environment and to human health and safety, as posed by inactive and surplus facilities and sites, are eliminated or reduced to protective levels. Specific investigations and risk assessments are being conducted to determine the extent of contamination, the potential human health or environmental exposure to that contamination, and to compare that exposure to established standards for protection of human health and the environment.

Prior to the early 1980s, the major focus of environmental restoration was the decontamination of testing areas for future use, and the identification of contaminated areas that required restricted access. Starting in the 1980s, environmental restoration at the NTS grew significantly as compliance with the nation's environmental statutes was enforced. Environmental site characterizations, remediations, and closures were primarily driven by the Resource Conservation and Recovery Act (RCRA). During this time, underground storage tanks and PCBs were removed, and hazardous waste disposal trenches were closed. The DOE remains committed to the goal of cleaning up contaminated areas to safeguard human health. Ongoing

assessments to identify and remediate contamination will continue in pursuit of this goal. The shift in emphasis from weapons development, testing, and production to environmental restoration has resulted in a much greater volume of waste being generated. This generation of waste has created a continuing need for the evolvement of the Nevada Test Site's Waste Management Program.

3.1.3 Waste Management

The NTS presently serves as a disposal site for low-level waste and as a storage site for a limited amount of transuranic mixed wastes. A formalized Waste Management Program at NTS was started in 1961. The management of radioactive wastes generated at the NTS and other DOE-approved facilities across the United States has been an ongoing mission of the NTS. Wastes have been and are generated as a result of a variety of DOE activities including nuclear energy research, defense programs, and more recently, as a result of environmental restoration programs. The DOE has a need to continue a practical, cost-effective, and environmentally sound means of radioactive waste disposal.

3.1.4 Nondefense Research and Development

The DOE has historically supported a variety of research and development activities at the NTS and other sites in Nevada in cooperation with universities, industry, and other federal agencies. Examples of this include:

- The National Environmental Research Park Program, supports environmental research activities at the NTS, such as research on the safety aspects of handling, shipping, and storing hazardous fluids and liquefied gaseous fuels.

- The Corporation for Solar Technology and Renewable Resources, with funding provided by the DOE, is studying the feasibility of locating and constructing a solar energy facility within the state of Nevada.

- Although the Tonopah Test Range provides research and development test support for DOE-funded weapons projects, it represents a unique test environment both in location and capabilities, and is available for use by other government agencies and their contractors.

3.1.5 Work for Others

The Work for Others Program, hosted by the DOE, includes the shared use of certain facilities and resources with other federal agencies. Historically, this has been done when these agencies require a large, remote, and secured area, such as that offered by the NTS. Typical users of the past have utilized the NTS to conduct training exercises and research and development projects.

The NTS has also played a key role in the areas of nuclear nonproliferation and verification of associated international treaties. Sensitive isotope analysis techniques, derived from nuclear chemistry applications to tests, are being developed for treaty monitoring and intelligence analysis. Development is being advanced by the analysis of underground test residue conducted within environmental studies at the NTS. Additionally, nonnuclear high-explosive experiments at the NTS support design calculations for technologies aimed at disarming nuclear devices. The performance of research in the area of hydrodynamics, is also performed under Work for Others Programs.

3.1.6 Site Support Activities

The various programs being conducted at the NTS require a number of support services. These services include transportation, communication, utilities, monitoring, security systems, as well as equipment and personnel to render facility construction and maintenance services.

3.2 Programs by Alternative

The implementation of each alternative will have varying affects upon the programs taking place at the NTS. Table 3-1 identifies activities carried out under each of the major program areas. The following sections summarize which programs will be carried out under each of the proposed alternatives.

Table 3-1. Comparison of Program Activities for the Alternatives (Page 1 of 4)

Alternative 1	Alternative 2	Alternative 3	Alternative 4
Stockpile Stewardship - Maintain Readiness to Test - Conduct Underground Nuclear Weapons Testing (if directed) - Conduct Dynamic Experiments, including Subcritical Experiments, and Hydrodynamic Tests - Conduct Conventional High-Explosive Testing - Destroy Damaged Nuclear Weapons **Nuclear Emergency Response** - Nuclear Emergency Search Team - Federal Radiological Monitoring and Assessment Center - Aerial Measuring System - Accident Response Group - Radiological Assistance Program - Internal Emergency Management Program **Tonopah Test Range** - Impact Tests - Passive Tests - Chemical Tests	**Stockpile Stewardship** - Discontinue All Activities **Tonopah Test Range** - Impact Tests - Passive Tests - Chemical Tests	**Stockpile Stewardship** - Maintain Readiness to Test - Conduct Underground Nuclear Weapons Testing (if directed) - Conduct Dynamic Experiments, including Subcritical Experiments, and Hydrodynamic Tests - Conduct Conventional High-Explosive Testing - Construct Nuclear Weapons Simulators - National Ignition Facility (if selected in Stockpile Stewardship and Management Programmatic EIS) - Destroy Damaged Nuclear Weapons **Stockpile Management** - Store Nuclear Weapons - Disassemble Nuclear Weapons - Assemble Nuclear Weapons - Modify and Maintain Nuclear Weapons - Test Weapons Components for Quality Assurance - Provide Interim Storage of Pits **Nuclear Emergency Response** - Nuclear Emergency Search Team - Federal Radiological Monitoring and Assessment Center - Aerial Measuring System - Accident Response Group - Radiological Assistance Program - Internal Emergency Management Program **Storage and Disposition of Weapons-Usable Fissile Materials** - Store Weapons-Usable Fissile Material - Disposition Weapons-Usable Fissile Material - Construct New or Modify Tunnel Complexes - Increase Robotic Technology Experiment - Construct New or Modify Existing Structures - Heavy Industrial Facility **Tonopah Test Range** - Impact Tests - Passive Tests - Chemical Tests	**Stockpile Stewardship** - Discontinue All Activities **Tonopah Test Range** - Impact Tests - Passive Tests - Chemical Tests

Table 3-1. Comparison of Program Activities for the Alternatives (Page 2 of 4)

Alternative 1	Alternative 2	Alternative 3	Alternative 4
Area 3 Disposal: - Nevada Generated Low-Level Waste - Non-Nevada Generated Low-Level Waste Closure: - Disposal Crater Complex UE3ax/bl - Disposal Crater Complex UE3ah/at **Area 5** Disposal: - Nevada Generated Low-Level Waste - Non-Nevada Generated Low-Level Waste - Nevada Generated Mixed Waste - Greater Confinement Waste Storage: - Nevada Generated Mixed Waste - Transuranic Waste - Mixed Transuranic Waste - Hazardous Waste Closure Activities: - Close Designated Low-Level Waste Disposal Units - Close Designated Mixed Waste Disposal Units - Close Designated Greater Confinement Disposal Units **Area 6** Storage Activities: - PCB Waste Disposal Activities: - Hydrocarbon Landfill **Area 11** Treatment Activities: - Explosive Ordnance Disposal Unit	No Activity	**Area 3** Disposal: - Nevada Generated Low-Level Waste - Non-Nevada Generated Low-Level Waste Closure: - Disposal Crater Complex UE3ax/bl - Disposal Crater Complex UE3ah/at Construction: - Future Low-Level Waste Disposal Pit - Building 3-302 (expansion) - Area 3 Truck Decon Station **Area 5** Disposal: - Nevada Generated Low-Level Waste - Non-Nevada Generated Low-Level Waste - Nevada Generated Mixed Waste - Greater Confinement Waste Storage: - Nevada Generated Mixed Waste - Transuranic Waste - Mixed Transuranic Waste - Hazardous Waste Facility Construction Activities: - Breaching and Sampling Facility - Real-Time Radiography - Transuranic Waste Certification Facility - Transuranic Waste Handling and Loading Facility - Mixed Waste Storage Pad - Mixed Waste Disposal Units - Low-Level Waste Disposal Units - Greater Confinement Disposal Units - Hazardous Waste Storage Pad (expansion) - Water Supply Line - Access Control Building - Maintenance Building - 5-01 Road Reconstruction (may not be necessary) - 5-07 Road Reconfiguration (may not be necessary) - 500-Year Flood Protection - Low-Level Waste Storage Facility - Fire Protection Utilities - Telephone System Closure Activities: - Close Designated Low-Level Waste Disposal Units - Close Designated Mixed Waste Disposal Units - Close Designated Greater Confinement Disposal Units Treatment Facility: - Cotter Concentrate Mixed Waste **Area 6** Storage Activities: - PCB Waste Treatment Activities: - Low-Level Liquid Waste Treatment Facility - Mixed Liquid Waste Treatment Facility Disposal Activities: - Hydrocarbon Landfill **Area 11** Treatment Activities: - Explosive Ordnance Disposal Unit	**Area 3** Disposal: - Nevada Generated Low-Level Waste Closure: - Disposal Crater Complex UE3ax/bl - Disposal Crater Complex UE3ah/at **Area 5** Disposal: - Nevada Generated Low-Level Waste Storage: - Transuranic Waste - Mixed Transuranic Waste - Hazardous Waste Closure Activities: - Close Designated Low-Level Waste Disposal Units - Close Designated Mixed Waste Disposal Units - Close Designated Greater Confinement Disposal Units Facility Construction Activities: - Water Supply Line - Access Control Building - Maintenance Building - 5-07 Road Reconfiguration - 500-Year Flood Protection - Fire Protection Utilities - Telephone System Treatment Facility: - Cotter Concentrate Mixed Waste **Area 6** Storage Activities: - PCB Waste Treatment Activities: - Low-Level Liquid Waste Treatment Facility Disposal Activities: - Hydrocarbon Landfill **Area 11** Treatment Activities: - Explosive Ordnance Disposal Unit

Table 3-1. Comparison of Program Activities for the Alternatives (Page 3 of 4)

Alternative 1	Alternative 2	Alternative 3	Alternative 4
Underground Test Area Corrective Action Unit - Continue Groundwater Monitoring - Continue Drilling Characterization Wells - Evaluate and Implement Remediation Strategies **Soils Media Corrective Action Unit and Part of NAFR Complex** - Continue Studies to Identify, etc. Alternate Remedial Measures - Remove Contaminated Soils on NTS and Nellis Lands - Dispose of Contaminated Soils in Permitted Facilities - Select Alternate Remedial Action Method and Implement **Industrial Sites Corrective Action Unit** - Characterize and Dispose of Environmental Restoration Sites - Continue Field Program to Identify Sites - Dispose of Waste in Approved Facilities - Continue to Characterize and Remediate the Resource Conservation and Recovery Act Industrial Sites **Decontamination and Decommissioning Facilities** - Continue Remediation Action and Planning **Defense Nuclear Agency Sites** - Continue Operations to Stop Contaminant Migration - Characterize and Remediate Contaminated Muck Piles and Ponds - Select and Implement Alternate Remedial Action or Redesign **Tonopah Test Range** - Continue Characterization and Remediation **Central Nevada Test Area** - Continue Characterization and Remediation **Project Shoal Area** - Continue Characterization and Remediation	No Activity	**Underground Test Area Corrective Action Unit** - Continue Groundwater Monitoring - Continue Drilling Characterization Wells - Evaluate and Implement Remediation Strategies - Intensify Groundwater Monitoring - Accelerate, Evaluate, and Implement Remediation Strategies - Alternate Uses May Require Stricter Cleanup Levels **Soils Media Corrective Action Unit and Part of NAFR Complex** - Continue Studies to Identify, etc. Alternate Remedial Measures - Remove Contaminated Soils on NTS and Nellis Lands - Dispose of Contaminated Soils in Permitted Facilities - Activities Would Accelerate Above Present Levels - After Studies, Select Alternate Remedial Action Method and Implement - Alternate Uses May Require Stricter Cleanup Levels **Industrial Sites Corrective Action Unit** - Characterize and Disposition Environmental Restoration Sites - Continue Field Program to Identify Sites - Continue to Characterize and Remediate the Resource Conservation and Recovery Act Industrial Sites - Activities Would Accelerate Above Present Levels - Alternate Uses May Require Stricter Cleanup Levels **Decontamination and Decommissioning Facilities** - Accelerate Remedial Actions - Alternative May Require Clean Closure, Not Closure In Place **Defense Nuclear Agency Sites** - Accelerate Operations to Stop Radiation and Hazardous Contaminated Migration - Select and Implement Alternate Remedial Action or Redesign - Alternate Uses May Require Stricter Cleanup Levels - Characterize and Remediate Contaminated Muck Piles and Ponds. **Tonopah Test Range** - Accelerate Characterization and Remediation of Site **Central Nevada Test Area** - Accelerate characterization and remediation **Project Shoal Area** - Continue Characterization and Remediation - Accelerate Characterization and Remediation of Site	**Underground Test Area Corrective Action Unit** - Continue Groundwater Monitoring - Continue Drilling Characterization Wells - Evaluate and Implement Remediation Strategies - Intensify Groundwater Monitoring - Accelerate, Evaluate, and Implement Remediation Strategies - Alternate Uses May Require Stricter Cleanup Levels **Soils Media Corrective Action Unit and Part of NAFR Complex** - Continue Studies to Identify, etc. Alternate Remedial Measures - Remove Contaminated Soils on NTS and Nellis Lands - Dispose of Contaminated Soils in Permitted Facilities - Activities Would Accelerate Above Present Levels - After Studies, Select Alternate Remedial Action Method and Implement - Alternate Uses May Require Stricter Cleanup Levels **Industrial Sites Corrective Action Unit** - Characterize and Disposition Environmental Restoration Sites - Continue Field Program to Identify Sites - Continue to Characterize and Remediate the Resource Conservation and Recovery Act Industrial Sites - Activities Would Accelerate Above Present Levels - Alternate Uses May Require Stricter Cleanup Levels **Decontamination and Decommissioning Facilities** - Accelerate Remedial Actions - Alternative May Require Clean Closure, Not Closure In Place **Defense Nuclear Agency Sites** - Accelerate Operations to Stop Radiation and Hazardous Contaminated Migration - Select and Implement Alternate Remedial Action or Redesign - Alternate Uses May Require Stricter Cleanup Levels - Characterize and Remediate Contaminated Muck Piles and Ponds. **Tonopah Test Range** - Accelerate Characterization and Remediation of Site **Central Nevada Test Area** - Accelerate characterization and remediation **Project Shoal Area** - Continue Characterization and Remediation - Accelerate Characterization and Remediation of Site

Table 3-1. Comparison of Program Activities for the Alternatives (Page 4 of 4)

Nondefense Research and Development Program			
Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
- Establish Solar Enterprise Zone - Spill Test Facility - Alternate Fuel Demonstration Project (16 vehicles) - Technology Development (normal) - Environmental Research Park	- No Activity	- Establish Solar Enterprise Zone - Construct and Operate Solar Production Facilities - Spill Test Facility - Alternate Fuel Demonstration Project (16 vehicles plus fueling station) - Technology Development (expanded) - Environmental Research Park	- Establish Solar Enterprise Zone - Construct and Operate Solar Production Facilities - Spill Test Facility - Alternate Fuel Demonstration Project (16 vehicles) - Technology Development (expanded) - Environmental Research Park
Work for Others Program			
Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
Treaty Verification - Threshold Test Ban Treaty - Peaceful Nuclear Explosion Treaty - Chemical Weapons Convention Treaty - Treaty on Open Skies **Nonproliferation Projects** **Counterproliferation Research and Development** - Dipole Hail - Big Explosives Experimental Facility - Cut and Cover **Conventional Weapons Demilitarization** **Nondefense Research and Development** - Conduct Munitions Research and Development - Training Exercises	- No Activity	**Increased activity levels for:** **Treaty Verification** - Threshold Test Ban Treaty - Peaceful Nuclear Explosion Treaty - Chemical Weapons Convention Treaty - Treaty on Open Skies **Nonproliferation Projects** **Counterproliferation Research and Development** - Dipole Hail - Big Explosives Experimental Facility - Cut and Cover **Conventional Weapons Demilitarization** **Nondefense Research and Development** - Conduct Munitions Research and Development - Training Exercises	**Treaty Verification** - Treaty on Open Skies No Activity - Increased Use of Airspace by DoD
Site Support Activities			
Alternative 1	**Alternative 2**	**Alternative 3**	**Alternative 4**
No change in: - Facilities - Services - Utilities - Communications	- Facilities (cold standby) - Services (minimal) - Utilities (minimal) - Communications (minimal) **Tonopah Test Range** - Maintain Site Support for Stockpile Stewardship	**Expand as necessary:** - Facilities - Services - Utilities - Communications	**Modify as Necessary:** - Facilities - Services - Utilities - Communications

3.2.1 Programs Under Alternative 1 - Continue Current Operations

Under Alternative 1, the DOE would continue to support ongoing program operations, but no new initiatives would be pursued. Stockpile stewardship and maintaining a state of readiness to conduct underground nuclear tests would continue under the scope of defense programs. Work for Others program activities would continue at present levels. The National Environmental Research Park Program would continue to support environmental research activities at the NTS. Research on the safety aspects of handling, shipping, and storing hazardous fluids and liquefied gaseous fuels would continue at the Spill Test Facility. The Corporation for Solar Technology, with funding provided by the DOE, would continue to study the feasibility of locating and constructing a solar energy facility in the State of Nevada; and the Environmental Restoration and Waste Management Programs would continue to conduct research and development focused on overcoming major obstacles to progress in cleaning up the DOE sites, and handling the waste generated from these activities.

3.2.2 Programs Under Alternative 2 - Discontinue Operations

Under this Alternative, operations at the NTS would be severely limited. Only services required to continue the protection of human health and safety would be performed. These services would include environmental monitoring operations, as well as the continuance of communications, utilities, security, and transportation services on a modest scale.

3.2.3 Programs Under Alternative 3 - Expanded Use

The implementation of this alternative would not only result in the continuation of current programs, but would result in the expansion of scope for many of these programs. For environmental restoration programs this would mean the expansion of current remediation activities. The Waste Management Program would be expanded to include the construction of a number of facilities to enable a wider range of waste management activities to be performed at the NTS. Defense programs would be expanded to include activities such as the storage and disposition of fissile materials, tritium recycling, and the construction of a facility that would enable the stockpile of nuclear weapons to be managed at a higher level. Work for Others program activities would expand based on the requirements needs of other groups and agencies to use the NTS. For the Nondefense Research and Development Program implementation of this alternative would mean the construction and operation of Solar Production Facilities, and expansion of the Alternate Fuel Demonstration Project. Because of the increased operations and activity, the infrastructure and support services would have to be increased accordingly.

3.2.4 Programs Under Alternative 4 - Alternate Use of Withdrawn Lands

This alternative would result in the discontinuation of most of the activities being performed under defense programs, but would increase activities under Waste Management and Environmental Restoration Programs. Activities that would be pursued under these programs include acceleration of remediation activities, as well as construction of waste characterization and treatment facilities. Under the Nondefense Research and Development Program the construction and operation of the Solar Production Facilities would also be performed. Infrastructure and support services would have to be increased accordingly.

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4.0 RISK ASSESSMENT SCENARIOS BY ALTERNATIVES

The activities described in Section 3.0 of this study were examined to identify the routine operations and potential accidents important to the assessment of human health risk. For existing activities, the study reviewed operational records, safety analysis reports, and previous environmental impact statements or environmental assessments to identify activities most important to safety and risk. For new activities, the identification of activities most important to safety and risk was performed by conducting a review of planning documents, preliminary design data (where available), and by comparison with similar activities for existing operations and facilities. The result of this identification process is the development of specific scenarios that can be analyzed quantitatively to estimate the human health risks associated with both routine operations and accidents.

Section 4.1 identifies the scenarios developed for routine operations and accidents. Section 4.2 summarizes the program activities proposed under each NTS EIS alternative and the scenarios used to quantify the human health risks associated with those activities. The results of the risk assessment are presented in Section 5.0 of this study.

4.1 Scenarios for Routine Operations and Accidents

Activities expected to be performed during routine operations whose effects may be detrimental to human health or safety were included in several scenarios. These activities included radioactive materials operations, waste handling, waste packaging, waste treatment, construction, decontamination and decommissioning, maintenance, and excavation. They were proposed to result in the direct exposure of personnel to low levels of radiation or the inhalation by personnel of small amounts of radioactive materials and chemicals, up to limits identified by DOE and Occupational Safety and Health Administration (OSHA) safety guidelines.

Three broad categories of accident scenarios are evaluated in this study. First, scenarios are developed for occupational accidents that could result in worker injuries or fatalities during waste handling, construction, maintenance, excavation, or decontamination and decommissioning operations. Second, scenarios are developed to assess impacts to workers and the public from accidental releases of radioactive material. Third, scenarios are developed to assess impacts to workers and the public from accidental releases of carcinogenic and toxic chemicals. The accident scenarios selected in this study cover a range of reasonably foreseeable accidents, from high probability accidents with low consequences to low probability accidents with higher consequences. See Table 4-1 for Routine Operations and Accident Scenarios.

4.2 Scenarios by Program Areas and Alternatives

Tables 4-2 through 4-5 identify the scenarios that are used in this study to assess the human health risks associated with activities under each program are for each of the four NTS EIS alternatives. Scenario GW1 is a future scenario that is not expected to have impacts within the 10-year time frame of this EIS. This scenario is independent of any of the four NTS EIS alternatives and does not appear in Tables 4-2 through 4-5. The results of this scenario are reported in Section 5.1 of this study.

Table 4-1. Routine Operations and Accident Scenarios

Identification Number	Scenario Description
HR1	Radioactive materials operations - routine radiation exposure to workers
DPR1	P-Tunnel: mechanical release of Pu during handling
DPR2	DAF: explosion invoking 55 lb. HE and 5 kg PU
DPR3	TTR: mechanical release of Pu from test assembly
DPR4	TTR: failure of artillery fired atomic projectile during firing
DPR5	NTS Area 27: explosion in interim stored nuclear weapons
DPR6	Accidental venting from an underground test
DPH1	TTR: explosion of rocket test assembly containing DU and Be
DPH2	TTR: rocket propellant storage area fire
WMR1	NTS Area 5: explosion/fire in two TRU waste containers
WMR2	NTS Area 5: explosion/fire in multiple TRU waste containers
WMR3	NTS Area 5: airplane crash into TRU waste storage unit
WMH1	NTS Area 5: explosion/fire in two hazardous waste containers
WMH2	NTS Area 5: explosion/fire in multiple hazardous waste containers
WMH3	NTS Area 5: airplane crash into hazardous waste storage unit
ERR1	Environmental restoration waste spill in Pu-contaminated soil (evaluated for both TTR and NTS)
ERR2	Environmental restoration waste fire in Pu-contaminated soil (evaluated fsor both TTR and NTS)
ERR3	Airplane crash into environmental restoration site containing Pu-contaminated soil (evaluated for both TTR and NTS
ERH1	Fire involving one container-equivalent in composite hazardous environmental restoration site at NTS
ERH2	Fire involving multiple container-equivalents in composite hazardous environmental restoration site NTS
ERH3	Airplane crash into composite hazardous environmental restoration site at NTS
NDRDH1	LGFSTF: spill of one container of hazardous chemicals
NDRDH2	LGFSTF: tank failure
NDRDH3	LGFSTF: airplane crash into tank farm area
WFOR1	BEEF: 100 Ci tritium release
WFOR2	BEEF: 1,000 Ci tritium release
WFOH1	BEEF: heavy metal release
WFOH2	BEEF: Be and DU release
OR1	Operational accident - worker injury or fatality during waste handling accident involving forklift.
OR2	Operational accident - worker injury or fatality during waste handling accident not involving forklift.
OR3	Operational accident - worker injury or fatality during construction, decontamination and decommissioning, or maintenance activities.
EP1	Excavation and processing - worker injury or fatality during remediation of a contaminated site
GW1	Consumption of tritium-contaminated drinking water by member of the public

Table 4-2. Routine Operations and Accidents Scenarios, Alternative 1 (Page 1 of 2)

Program Area/Activities	Scenario Identification Number	
	Routine	Accidents
Defense Programs		
• Stockpile Stewardship	HR1	DPR2,DPR5, DPR6, OR3
• Nuclear Emergency Response	HR1	OR3
• Tonopah Test Range Stockpile Stewardship	HR1	DPR3,DPR4,DPH1,DPH2 OR3
Waste Management		
• Area 3		
- Disposal	HR1	OR1, OR2,
- Closure	HR1	OR3
• Area 5		
- Disposal	HR1	OR1, OR2
- Storage	HR1	WMR1,WMR2,WMR3 WMH1,WMH2,WMH3
- Facility construction activities	HR1	OR3
- Closure activities	HR1	OR3
• Area 6		
- Storage activities	HR1	a
- Disposal activities	HR1	a
• Area 11		
- Treatment activities	HR1	a
Environmental Restoration		
• Underground Test Area Sites	HR1	OR3, EP1
• Soils Media Sites	HR1	ERR1,ERR2,ERR3,ERH1, ERH2,ERH3, OR3, EP1
• Industrial Sites	HR1	ERR1,ERR2,ERR3,ERH1, ERH2,ERH3, OR3, EP1
• D&D Facilities	HR1	ERR1,ERR2,ERR3,ERH1, ERH2,ERH3, OR3, EP1
• Defense Nuclear Agency Sites	HR1	OR3, EP1
• Tonopah Test Range	HR1	ERR1,ERR2,ERR3, OR3, EP1
• Central Nevada Test Area	HR1	OR3, EP1
• Project Shoal Area	HR1	OR3, EP1
Nondefense R&D		
• Establish Solar Enterprise Zone	HR1	OR3
• Spill Test Facility	HR1	NDRDH1,NDRDH2, NDRDH3
• Environmental Research Park	HR1	a

Table 4-2. Routine Operations and Accidents Scenarios, Alternative 1 (Page 2 of 2)

Program Area/Activities	Scenario Identification Number	
	Routine	Accidents
Work for Others		
• Treaty Verification	HR1	[a]
• Non-Proliferation Projects	HR1	[a]
• Counter Proliferation Research & Development	HR1	WFOH1, OR3
• Conventional Weapons Demilitarization	HR1	OR3
• Defense Research and Development	HR1	OR3
Site Support Activities		
• Utilities	HR1	[a]
• Communications	HR1	[a]
• Transportation Systems	HR1	[a]
• On-Site Support	HR1	OR3
• Landlord-Related Construction & Maintenance	HR1	OR3

[a] No reasonably foreseeable accidents important to human health risk identified.

Table 4-3. Routine Operations and Accident Scenarios, Alternative 2

Program Area/Activities	Scenario Number	
	Routine	Accidents
Defense Programs		
• Tonopah Test Range Stockpile Stewardship	HR1	DPR3,DPR4,DPH1,DPH2
Waste Management		
• Area 5 Storage Phase out	[a]	WMR1,WMR2,WMH1, WMH2
Environmental Restoration		
• No Activities	[a]	[a]
Nondefense R&D		
• No Activities	[a]	[a]
Work for Others		
• No Activities	[a]	[a]
Infrastructure		
• Utilities	HR1	[b]
• Communications	HR1	[b]
• On-Site Support	HR1	OR3

[a] Not applicable - no activities.
[b] No reasonably foreseeable accidents important to human health risk identified.

Table 4-4. Routine Operations and Accident Scenarios, Alternative 3 (Page 1 of 2)

Program Area/Activities	Scenario Number	
	Routine	Accidents
Defense		
• Stockpile Stewardship	HR1	DPR2,DPR6, OR3
• Stockpile Management	HR1	DPR5, OR3
• Nuclear Emergency Response	HR1	
• Tritium Supply and Recycling	HR1	OR3
• Storage and Disposition to Weapons Usable Fissile Materials	HR1	DPR1, OR3
• Construct New or Modify Tunnel Complexes	HR1	OR3
• Increased Robotic Technology Experiment	HR1	OR3
• Construct New or Modify Existing Structures	HR1	OR3
• Tonopah Test Range Stockpile Stewardship	HR1	DPR3,DPR4,DPH1,DPH2 OR3
Waste Management		
• Area 3		
- Disposal	HR1	OR1, OR2
- Closure	HR1	OR3
- Construction	HR1	OR3
• Area 5		
- Disposal	HR1	OR1, OR2
- Storage	HR1	WMR1,WMR2,WMR3, WMH1,WMH2,WMH3
- Facility construction activities	HR1	OR3
- Closure activities	HR1	OR3
- Treatment facility	HR1	OR3
• Area 6		
- Storage activities	HR1	a
- Treatment activities	HR1	OR3
- Disposal activities	HR1	a
• Area 11		
- Treatment activities	HR1	a
Environmental Restoration		
• Underground Test Area Sites	HR1	OR3, EP1
• Soils Media Sites	HR1	ERR1, ERR2, ERR3, ERH1, ERH2, ERH3, OR3, EP1
• Industrial Sites	HR1	ERR1, ERR2, ERR3, ERH1, ERH2, ERH3 OR3, EP1

Table 4-4. Routine Operations and Accident Scenarios, Alternative 3 (Page 2 of 2)

Program Area/Activities	Scenario Number	
	Routine	Accidents
• D&D Facilities	HR1	ERR1,ERR2,ERR3,ERH 1,ERH2,ERH3, OR3, EP1
• Defense Nuclear Agency Sites	HR1	OR3, EP1
• Tonopah Test Range	HR1	OR3, EP1
• Central Nevada Test Area	HR1	ERR1, ERR2, ERR3, OR3, EP1
• Project Shoal Area	HR1	OR3, EP1
Nondefense Research and Development		
• Establish Solar Enterprise Zone	HR1	OR3
• Construct and Operate Solar Production Facilities	HR1	OR3
• Spill Test Facility	HR1	NDRDH1, NDRDH2, NDRDH3
• Alternate Fuel Demonstration Project	HR1	OR3
• Environmental Research Park	HR1	[a]
Work for Others		
• Treaty Verification	HR1	[a]
• Non-Proliferation Projects	HR1	[a]
• Counter Proliferation Research & Development	HR1	WFOR1, WROR2, WFOH1, WFOH2, OR3
• Conventional Weapons Demilitarization	HR1	OR3
• Defense Research and Development	HR1	OR3
Site Support Activities		
• Utilities	HR1	[a]
• Communications	HR1	[a]
• Transportation Systems	HR1	[a]
• On-Site Support	HR1	OR3
• Landlord-Related Construction & Maintenance	HR1	OR3

[a] No reasonably foreseeable accidents important to human health risk identified.

Table 4-5. Routine Operations and Accident Scenarios, Alternative 4 (Page 1 of 2)

Program Area/Activities	Scenario Number	
	Routine	Accidents
Defense Programs		
• Tonopah Test Range Stockpile Stewardship	HR1	DPR3, DPR4, DPH1, DPH2
Waste Management		
• Area 3		
- Disposal	HR1	OR1, OR2
- Closure	HR1	OR3
• Area 5		
- Disposal	HR1	OR1, OR2
- Storage	HR1	WMR1, WMR2, WMR3, WMH1, WMH2, WMH3
- Facility construction activities	HR1	OR3
- Closure activities	HR1	OR3
- Treatment facility	HR1	OR3
• Area 6		
- Storage activities	HR1	[b]
- Treatment activities	HR1	OR3
- Disposal activities	HR1	[b]
• Area 11		
- Treatment activities	HR1	[b]
Environmental Restoration		
• Underground Test Area Sites	HR1	OR3, EP1
• Soils Media Sites	HR1	ERR1, ERR2, ERR3, ERH1, ERH2, ERH3 OR3, EP1
• Industrial Sites	HR1	ERR1, ERR2, ERR3, ERH1, ERH2, ERH3 OR3, EP1
• Decontamination and Decommissioning Facilities	HR1	ERR1, ERR2, ERR3, ERH1, ERH2, ERH3 OR3, EP1
• Defense Nuclear Agency Sites	HR1	OR3, EP1

Table 4-5. Routine Operations and Accident Scenarios, Alternative 4 (Page 2 of 2)

Program Area/Activities	Scenario Number	
	Routine	Accidents
• Tonopah Test Range	HR1	ERR1, ERR2, ERR3, OR3, EP1
• Central Nevada Test Area	HR1	OR3, EP1
• Project Shoal Area	HR1	OR3, EP1
Nondefense Research and Development		
• Establish Solar Enterprise Zone	HR1	OR3
• Construct and Operate Solar Production Facilities	HR1	OR3
• Spill Test Facility	HR1	NDRDH1, NDRDH2, NDRDH3
• Alternate Fuel Demonstration Project	HR1	OR3
• Environmental Research Park	HR1	[b]
Work for Others		
• No Activities	[a]	[a]
Site Support Activities		
• Utilities	HR1	[b]
• Communications	HR1	[b]
• Transportation Systems	HR1	[b]
• On-Site Support	HR1	OR3
• Landlord-Related Construction & Maintenance	HR1	OR3

[a] Not applicable - No activities.
[b] No reasonably foreseeable accidents important to human health risk identified.

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5.0 RESULTS OF THE HUMAN HEALTH AND SAFETY ANALYSIS

The results of the human health risks and safety impacts study are presented in three parts. First, the risks to the public associated with the subsurface migration of tritium-contaminated groundwater from past underground test locations. Next, the risks associated with NTS program activities are presented for each proposed NTS EIS alternative. Finally, the safety impacts of the maximum reasonably foreseeable accidents for each program area and each alternative are discussed.

5.1 Risks to the Public from Subsurface Radioactivity

Tritium-contaminated groundwater exists in the subsurface as a result of past underground testing of nuclear weapons. The proposed NTS EIS alternatives are expected to result in little change to the amount of subsurface contamination that is present, even if underground testing resumes. As such, the results of the risk assessment for scenarios involving ingestion of contaminated well water by the public are identical for each alternative and are presented separately. These impacts to the public are not expected to occur within the 10-year timeframe addressed in the scope of the NTS EIS. For NTS workers tritium is not detectable in on-site drinking water wells. The existing monitoring programs and controls preclude inadvertent consumption of contaminated well water by workers.

Table 5-1 summarizes the results of the analysis of tritium migration to public lands and the potential risks to a hypothetical individual who consumes contaminated well water for a standard lifetime of 70 years.

For underground tests conducted within the NTS boundaries, groundwater modeling studies have been performed by Daniels et al. (1993), and GeoTrans (1995). Both of these studies evaluated the migration of tritium from test locations on Pahute Mesa to Oasis Valley. In addition, the GeoTrans study examined migration flow paths from Pahute Mesa to Amargosa Valley and from Yucca Flat to the boundary of the NTS south of Mercury, Nevada. The results of the GeoTrans analysis showed that for two of the modeled flow paths, Pahute Mesa to Amargosa Valley and Yucca Flat to Mercury, tritium concentrations in uncontrolled areas are never expected to exceed 1×10^{-4} pCi/L, which is well below the limit of detection (about 1 pCi/L) of present-day analytical equipment. (Note: the predicted tritium concentrations presented in this Appendix represent incremental increases above the natural background level of tritium which is in the range of 1 to 10 pCi/L).

The migration of tritium-contaminated groundwater from Pahute Mesa to Oasis Valley approximates the maximum health risks to a public individual. However, the results of studies by Daniels et al. (1993) and GeoTrans (1995) for this flow path provide mixed results. In the earlier study performed by Daniels et al. (1993), estimates of peak tritium concentrations in groundwater ranged from 890 pCi/L to 3,800 pCi/L at the nearest uncontrolled area boundary in Oasis Valley. These concentrations are above the natural background level of tritium but are below the EPA's maximum allowable tritium concentration in drinking water of 20,000 pCi/L. At approximately the same location, GeoTrans (1995) estimated peak tritium concentrations in the range of 5×10^{-4} pCi/L to 0.1 pCi/L. The results by Daniels et al. (1993). are higher due to the preliminary, or screening, basis of their calculations. For example, both studies base their source terms on shot cavity samples, but Daniels et al. (1993) assumed all groundwater at the source is contaminated to the highest observed tritium concentration of 7.6×10^{9} pCi/L, while GeoTrans (1995) assumed an average concentration of tritium at the source of 1×10^{9} pCi/L. Other assumptions used by Daniels et al. (1993) were conservative, or worst case, estimates that would lead to somewhat higher concentration and risk estimates than the average case estimates used by GeoTrans (1995).

Table 5-1. Health risks to a Maximally Exposed Public Individual[a] from Subsurface Radioactivity

Test Location	Receptor Location	Peak Conc. (pCi/L) at Receptor Location	Arrival Time[b] of Peak Conc. (yr)	Dose (rem)	Radiation LCF[c]	Radiation Detriment[d]
Pahute Mesa[e]	Oasis Valley closest uncontrolled use area[f]	5×10^{-4} to 3,800	25 to 150	7.7×10^{-3} to 1.6×10^{-9}	1×10^{-5} to 8×10^{-13}	5×10^{-6} to 4×10^{-13}
Pahute Mesa[f]	Amargosa Valley closest uncontrolled use area[g]	Less than 1×10^{-4}	Not estimated	Less than 3.3×10^{-10}	Less than 1.6×10^{-13}	Less than 7.5×10^{-14}
Yucca Flat[f]	NTS boundary south of Mercury[g]	Less than 1×10^{-4}	Not estimated	Less than 3.3×10^{-10}	Less than 1.6×10^{-13}	Less than 7.5×10^{-14}
Project Shoal Area[h]	Eastern boundary[g]	280 to 720,000	71 to 206	4×10^{-7} to 4	2×10^{-10} to 2×10^{-3}	9×10^{-11} to 9×10^{-4}
Project Shoal Area[h]	Nearest public well	0.1 to 20,000	88 to 278	8×10^{-21} to 4×10^{-4}	4×10^{-24} to 2×10^{-7}	2×10^{-24} to 9×10^{-8}
Central Nevada Test Area[i]	Boundary[g]	1.2×10^{8}	8 to 15	2.8×10^{-2} to 1.1×10^{1}	1.4×10^{-5} to 5.5×10^{-3}	6.4×10^{-6} to 2.5×10^{-3}
Central Nevada Test Area[i]	Nearest public well	5×10^{-15} to 0.9	117 to 410	3.4×10^{-21} to 6.4×10^{-7}	1.7×10^{-24} to 3.2×10^{-10}	7.8×10^{-25} to 1.5×10^{-10}

[a] The maximally exposed public individual is a hypothetical person assumed to obtain all their drinking water from a well at the receptor location for a lifetime of 70 years, centered around the time of peak tritium concentration in the well water.

[b] Time period from the underground test date to the arrival of the peak tritium concentration in well water at the receptor location.

[c] Lifetime probability that the hypothetical individual will experience latent cancer fatality from the radiation dose received.

[d] Lifetime probability that the hypothetical individual will experience other detrimental health effects from the radiation dose received.

[e] Results for upper end of range based on (Daniels et al., 1993); results for lower end of range based on analysis performed by (GeoTrans, 1995).

[f] Results based on analysis performed by (GeoTrans, 1995).

[g] No public well currently exists at these locations.

[h] Results based on analysis performed by (Chapman et al., 1995).

[i] Results based on analysis performed by (Pohlmann et al., 1995).

Based on the combined results from the studies performed by Daniels et al. (1993) and GeoTrans (1995), the estimated range of peak tritium concentrations at the closest uncontrolled use area varies from 5 x 10^{-4} pCi/L arriving 150 years after the beginning of migration to 3,800 pCi/L arriving in 25 to 94 years. The hypothetical maximally exposed public individual at this location is estimated to have a lifetime probability of contracting a fatal cancer between 8 x 10^{-13} (about one in one trillion) and 1 x 10^{-5} (about one in 100,000). Table 5-1 also shows the results of analysis for underground test locations outside NTS boundaries. For both the Project Shoal Area and the Central Nevada Test Area, health effects were estimated using scenarios that have hypothetical receptors at the boundary of the test areas, where no public wells currently exist, and receptors at the nearest existing well.

Health impacts to the public from Project Shoal subsurface radioactivity have been estimated by Exposure Assessment of Groundwater Transport from the Shoal Site (Chapman et al.,1995) based on future predictions of tritium concentrations in well water. Future tritium concentrations were predicted at the nearest existing public well, and at the boundary of the Project Shoal Area where no public wells currently exist. These impacts are not expected to occur within the 10-year time frame of the NTS EIS. The public exposure scenarios assume that a hypothetical individual consumes contaminated well water for 70 years centered around the time of peak tritium concentration in well water. Calculations were performed for both eastward and westward groundwater flow because of the uncertainty in flow direction at the Project Shoal Area. The calculations also considered variability in key groundwater modeling parameters such as flow velocity and hydraulic conductivity. Accounting for the uncertainties in modeling parameters resulted in a large range of predicted tritium concentrations and potential health effects. For example, considering eastward flow to a hypothetical well at the boundary of the Project Shoal Area (the transport pathway with the highest concentrations), calculated peak tritium concentrations vary from 280 pCi/L, arriving 206 years after the test, to 720,000 pCi/L arriving 71 years after the test. For comparison, the EPA's maximum allowable tritium concentration in drinking water is 20,000 pCi/L. The hypothetical maximally exposed public individual at this location is estimated to have a lifetime probability of contracting a fatal cancer between 2 x 10^{-10} (about one in five billion) and 2 x 10^{-3} (about one in 500). At the nearest existing public well, a hypothetical maximally exposed public individual is estimated to have a lifetime probability of contracting a fatal cancer between 4 x 10^{-24} (essentially zero) and 2 x 10^{-7} (about one in five million). Table 5-1 shows the predicted range of health effects for both the hypothetical well at the eastern Project Shoal Area boundary and the nearest existing public well.

Health impacts affecting the public from the Central Nevada Test Area subsurface radioactivity have been estimated by (Pohlmann et al., 1995), based on future predictions of tritium concentrations in well water, and assuming that a public well could be installed at the southern boundary of the Central Nevada Test Area. At the existing public well nearest to the Central Nevada Test Area, the tritium concentrations are never expected to exceed 1 picocurie per liter, and the highest concentration will not reach the well until at least 117 years after the test date (about the year 2085). The maximally exposed public individual is estimated to have a lifetime probability of contracting a fatal cancer between 1.7 x 10^{-24} (essentially zero) and 3.2 x 10^{-10} (about one in three billion). Near the southern boundary of the Central Nevada Test Area, where no public well currently exists, tritium concentrations are predicted to have reached a peak of about 1.2 x 10^{8} pCi/L approximately 8 to 15 years after the test (between 1976 and 1983). If a public well were to be drilled at a location near the southern boundary of the Central Nevada Test Area, and assuming a peak tritium concentration of about 1.2 x 10^{8} pCi/L, it is estimated that the maximally exposed public individual would have a lifetime probability of contracting a fatal cancer between 1.4 x 10^{-5} (about one in 70,000) and 5.5 x 10^{-3} (about one in 200). The predicted impacts to a hypothetical individual near the southern boundary of the Central Nevada

Test Area are based on a peak tritium concentration calculated to have passed the boundary in about 1983. By the year 1996, the peak tritium concentration would have traveled further downgradient and would be reduced by a combination of radioactive decay and diffusion. Radioactive decay would result in a 50 percent reduction by the year 1996, and additional reductions in peak concentration would result from diffusion within the aquifer. These predicted tritium concentrations near the southern boundary of the Central Nevada Test Area have not been confirmed by groundwater sampling and analysis.

5.2 Risks from NTS Program Activities

Detailed results of the human health risk and safety impacts analysis are provided in DOE/NV (1996) and SAIC (1996). A summary of the results of these studies is presented in this section. Results are provided for each NTS EIS alternative and for each NTS program area, with the exception of the results of the scenarios for ingestion of contaminated well water by the public.

5.2.1 Alternative 1

Table 5-2 summarizes the results of the risk analysis for NTS program activities proposed under Alternative 1. The results of this analysis indicate that under Alternative 1, human health risks are expected to be dominated by occupational injuries and fatalities to workers engaged in activities such as construction, maintenance, excavation, etc. Over the 10-year period evaluated by the NTS EIS, about 204 occupational injuries and 3 fatalities are expected as a result of performing all NTS activities. Most of the injuries and fatalities are expected to be associated with Waste Management Program activities. In contrast, the risks associated with occupational exposure to radiation are smaller. The probability that a single latent cancer fatality will occur in the entire worker population as a result of the radiation exposure received over 10 years is estimated to be about 0.12 (or about 1 in 8). The probability of any other de/trimental health effect occurring in the worker population is estimated to be about 0.047 (about 1 in 21).

The probability that accidental occupational exposure to hazardous chemicals over 10 years could result in a single cancer in the entire worker population is estimated to be about 4.1×10^{-6} (1 in 240,000). An accidental occupational exposure to life-threatening concentrations of noncarcinogenic chemicals has a probability of occurrence of 0.58 during the 10 years evaluated in the EIS. The public health risks presented in Table 5-2 represent risks from reasonably foreseeable accidents that could result in the release of radioactive and chemically hazardous material to the environment. The probability of a single latent cancer fatality in the offsite population being caused as a result of radiological accidents at the NTS over the 10 years evaluated by the EIS is about 5.5×10^{-5} (1 in 18,000). The probability of any other detrimental health effect occurring in the off-site population is estimated to be about 2.5×10^{-5} (about 1 in 40,000). Should DOE be directed by the President to conduct underground nuclear-yield testing under Alternative 1, the probability of a single latent cancer fatality in the offsite population being caused as a result of radiological accidents over the 10 years evaluated by the EIS would be about 0.0055 (about one in 180). The probability of any other detrimental health effect occurring in the offsite population would be about 0.0025 (about one in 400).

The probability that accidental releases of hazardous chemicals over the 10 years evaluated in the EIS could result in a single cancer in the off-site population is estimated to be about 2.3×10^{-4} (1 in 4,000). No noncancer health effects from accidental releases of hazardous chemicals would be expected in the off-site population.

5.2.2 Alternative 2

Table 5-3 summarizes the results of the risk analysis for NTS Program activities proposed under Alternative 2. Under Alternative 2, all operations at the NTS would cease except for security and environmental monitoring functions necessary for human health, safety and security. Minimal human health impacts are estimated for the five major program areas because all projects and activities are discontinued. Transuranic and

Table 5-2. Health Risks to Workers and the Public from Program Activities, Alternative 1

Program Area	Worker Health Risks						Public Health Risks			
	Occupational Safety Risks		Occupational Radiation Risks		Occupational Chemical Risks		Public Radiation Risks		Public Chemical Risks	
	Injuries	Fatalities	Radiation LCFs[a]	Radiation Detriment[b]	Chemical Cancers[c]	Chemical Hazard Index[d]	Radiation LCFs[a]	Radiation Detriment[b]	Chemical Cancers[d]	Chemical Hazard Index[d]
Defense										
NTS (without testing)	6.8	0.012	0.032	0.012	e	e	4.0×10^{-6}	1.8×10^{-6}	e	e
NTS (with testing)	--	--	(0.034)	(0.013)	e	e	(0.0054)	(0.0025)	e	e
TTR	2.5	0.0044	0.0025	0.0010	8.4×10^{-12}	1.8×10^{-5}	9×10^{-9}	4.1×10^{-9}	1×10^{-10}	9.6×10^{-7}
Waste Management	153	2.9	0.020	0.0081	5.2×10^{-7}	0.48	5.1×10^{-5}	2.3×10^{-5}	2.0×10^{-5}	3.8×10^{-6}
Env. Restoration										
NTS	10	0.031	0.0085	0.0034	3.0×10^{-7}	0.14	2.3×10^{-10}	1.1×10^{-10}	6.0×10^{-6}	2.4×10^{-6}
TTR	0.0049	9.7×10^{-4}	2.4×10^{-4}	1.3×10^{-4}	e	e	1.2×10^{-9}	5.7×10^{-10}	e	e
Project Shoal	1.6×10^{-4}	3.1×10^{-5}	1.7×10^{-5}	9.0×10^{-6}	e	e	f	f	e	e
CNTA	1.6×10^{-4}	3.1×10^{-5}	1.7×10^{-5}	9.0×10^{-6}	e	e	f	f	e	e
Nondefense Research and Development	1.9	0.0033	0.0031	0.0013	3.2×10^{-6}	0.58	f	f	1.9×10^{-4}	1.5×10^{-4}
Work for Others	11	0.019	0.0055	0.0022	6.1×10^{-8}	4.4×10^{-3}	f	f	2.9×10^{-7}	1.9×10^{-8}
Site Support Activities	19	0.033	0.046	0.018	e	e	f	f	e	e
Total (without testing)	**204**	**3**	**0.12**	**0.047**	**4.1×10^{-6}**	**0.58**	**5.5×10^{-5}**	**2.5×10^{-5}**	**2.3×10^{-4}**	**1.5×10^{-4}**
(with testing)			**(0.15)**	**(0.059)**			**(0.0055)**	**(0.0025)**		

[a] Number of radiation-induced latent cancer fatalities in the exposed population associated with activities conducted over the 10- year period of analysis.

[b] Number of radiation-induced detrimental health effects (e.g., nonfatal cancers, genetic effects) in the exposed population associated with activities conducted over 10-year period of analysis.

[c] Number of chemical-induced cancers (fatal and nonfatal) in the exposed population associated with activities conducted over the 10-year period of analysis.

[d] A hazard index of greater than one indicates that the non-cancer chemical effects could be life-threatening to individuals exposed for one hour or more.

[e] No reasonably foreseeable scenarios resulting in exposure to chemically hazardous materials have been identified.

[f] No reasonably foreseeable scenarios resulting in exposure to radiation have been identified.

Table 5-3. Health Risks to Workers and the Public from Program Activities, Alternative 2

Program Area	Worker Health Risks						Public Health Risks			
	Occupational Safety Risks		Occupational Radiation Risks		Occupational Chemical Risks		Public Radiation Risks		Public Chemical Risks	
	Injuries	Fatalities	Radiation LCFs[a]	Radiation Detriment[b]	Chemical Cancers[c]	Chemical Hazard Index[d]	Radiation LCFs[a]	Radiation Detriment[b]	Chemical Cancers[d]	Chemical Hazard Index[d]
Defense										
NTS	e	e	e	e	e	e	e	e	e	e
TTR	2.5	0.0044	0.0025	0.0010	8.4×10^{-12}	1.8×10^{-5}	9.0×10^{-9}	4.1×10^{-9}	1.0×10^{-10}	9.6×10^{-7}
Waste Management	h	h	0.016	0.0064	5.2×10^{-7}	0.48	4.7×10^{-5}	2.1×10^{-5}	2.0×10^{-5}	3.8×10^{-6}
Env. Restoration										
NTS	e	e	e	e	e	e	e	e	e	e
TTR	e	e	e	e	e	e	e	e	e	e
Project Shoal	e	e	e	e	e	e	e	e	e	e
CNTA	e	e	e	e	e	e	e	e	e	e
Nondefense Research and Development	e	e	e	e	e	e	e	e	e	e
Work for Others	e	e	e	e	e	e	e	e	e	e
Site Support Activities	e	e	0.0025	0.0010	f	f	g	g	f	f
Total	**2.5**	**0.0044**	**0.021**	**0.0084**	**5.20×10^{-7}**	**0.48**	**4.7×10^{-5}**	**2.1×10^{-5}**	**2.0×10^{-5}**	**4.8×10^{-6}**

[a] Number of radiation-induced latent cancer fatalities in the exposed population associated with activities conducted over the 10- year period of analysis.

[b] Number of radiation-induced detrimental health effects (e.g., nonfatal cancers, genetic effects) in the exposed population associated with activitiesconducted over the 10-year period of analysis.

[c] Number of chemical-induced cancers (fatal and nonfatal) in the exposed population associated with activities conducted over the 10-year period of analysis.

[d] A hazard index of greater than one indicates that the non-cancer chemical effects could be life-threatening to individuals exposed for one hour or more.

[e] No activities.

[f] No reasonably foreseeable scenarios resulting in exposure to chemically hazardous materials have been identified.

[g] No reasonably foreseeable scenarios resulting in exposure to radiation have been identified.

[h] No routine operations anticipated, only shipment and disposal of current waste inventory.

hazardous wastes would continue to be stored until arrangements could be made to ship these materials off-site. Consequently, accident scenarios associated with storage and handling of these wastes could be considered a reasonably foreseeable accident scenario for the Waste Management Program under Alternative 2. Site support activities related to security and environmental monitoring functions are expected to result in occupational exposure to radiation. About 3 occupational injuries and no fatalities are expected as a result of NTS activities for this alternative. The probability that a single latent cancer fatality will occur in the entire worker population as a result of the radiation exposure received over the 10 years evaluated in the EIS is estimated to be 0.021 (or about 1 in 47). The probability of any other detrimental health effect occurring in the worker population is estimated to be 0.0084 (about 1 in 120).

The probability that accidental occupational exposure to hazardous chemicals over the 10 years evaluated in the EIS could result in a single cancer in the entire worker population is estimated to be about 5.2×10^{-7} (about 1 in 2 million). An accidental occupational exposure to life-threatening concentrations of noncarcinogenic chemicals has a probability of occurrence of 0.48 during the 10 years evaluated in the EIS.

The probability of a single latent cancer fatality in the offsite population being caused as a result of radiological accidents at the NTS and off-site areas over the 10 years evaluated by the EIS is about 4.7×10^{-5} (about 1 in 20,000). The probability of any other detrimental effect occurring in the off-site population is estimated to be about 2.1×10^{-5}

The probability that accidental releases of hazardous chemicals over the 10 years evaluated in the EIS could result in a single cancer in the off-site population is estimated to be about 2×10^{-5} (1 in 50,000). No noncancer health effects from accidental releases of hazardous chemicals would be expected in the off-site population.

5.2.3 Alternative 3

Table 5-4 summarizes the results of the risk analysis for NTS program activities proposed under Alternative 3. As with Alternative 1, the results of the analysis indicate that human health risks under Alternative 3 are expected to be dominated by occupational injuries and fatalities to workers engaged in activities such as construction, maintenance, excavation, etc. Over the 10-year period evaluated in the NTS EIS, about 775 occupational injuries and 9 fatalities are expected for all NTS activities. Most of the injuries and fatalities are expected to be associated with Waste Management Program activities. In contrast, the risks associated with occupational exposure to radiation are smaller. The probability that a single latent cancer fatality will occur in the entire worker population as a result of the radiation exposure received over the 10 years evaluated in the EIS is estimated to be about 0.13 (or about 1 in 8). The probability of any other detrimental health effect occurring in the worker population is estimated to be about 0.051 (about 1 in 20).

The probability that accidental occupational exposure to hazardous chemicals over 10 years could result in a single cancer in the entire worker population is estimated to be about 4.1×10^{-6} (1 in 240,000). An accidental occupational exposure to life-threatening concentrations of noncarcinogenic chemicals has a probability of occurrence of 1 during the 10 years evaluated in the EIS.

The public health risks presented in Table 5-4 represent risks from reasonably foreseeable accidents that could result in the release of radioactive and chemically hazardous material to the environment. The probability of a single latent cancer fatality in the off-site population as a result of radiological accidents at the NTS over the 10 years evaluated by the EIS is about 5.6×10^{-5} (about one in 18,000). The probability of any other detrimental health effect occurring in the off-site population is estimated to be about 2.5×10^{-5} (about 1 in 43,000). If the DOE is directed by the President to conduct underground nuclear-yield testing under Alternative 3, the probability of a single latent cancer fatality in the off-site population being caused as a result of radiological accidents over the 10 years evaluated by the EIS would be about 0.0055 (about one in 180). The probability of any other detrimental health effect occurring in the off-site population would be about 0.0025 (about one in 400).

Table 5-4. Health Risks to Workers and the Public from Program Activities, Alternative 3

Program Area	Worker Health Risks						Public Health Risks			
	Occupational Safety Risks		Occupational Radiation Risks		Occupational Chemical Risks		Public Radiation Risks		Public Chemical Risks	
	Injuries	Fatalities	Radiation LCFs[a]	Radiation Detriment[b]	Chemical Cancers[c]	Chemical Hazard Index[d]	Radiation LCFs[a]	Radiation Detriment[b]	Chemical Cancers[d]	Chemical Hazard Index[d]
Defense										
NTS (without testing)	65	0.12	0.051	0.020	f	f	4.4×10^{-6}	2.0×10^{-6}	f	f
NTS (with testing)	--	-	0.053	0.021	f	f	(0.0054)	(0.0025)	f	f
TTR	2.6	0.0046	0.0028	0.0011	8.4×10^{-12}	1.8×10^{-5}	9.0×10^{-9}	4.1×10^{-9}	1.0×10^{-10}	9.6×10^{-7}
Waste Management	467	8.7	0.0025	0.0010	5.2×10^{-7}	0.48	5.1×10^{-5}	2.3×10^{-5}	2.0×10^{-5}	3.8×10^{-6}
Env. Restoration[e]										
NTS	11	0.035	0.0096	0.0036	3.0×10^{-7}	0.14	2.3×10^{-10}	1.1×10^{-10}	6.0×10^{-6}	2.4×10^{-6}
TTR	0.0054	0.0011	2.6×10^{-4}	1.4×10^{-4}	f	f	1.2×10^{-9}	5.7×10^{-10}	f	f
Project Shoal	1.7×10^{-4}	3.4×10^{-5}	1.9×10^{-5}	7.6×10^{-6}	f	f	g	g	f	f
CNTA	1.7×10^{-4}	3.4×10^{-5}	1.9×10^{-5}	7.6×10^{-6}	f	f	g	g	f	f
Nondefense Research and Development	8.6	0.015	0.0042	0.0017	3.2×10^{-6}	0.58	g	g	1.9×10^{-4}	1.5×10^{-4}
Work for Others	11	0.019	0.0055	0.0023	8.9×10^{-8}	2.4	2.0×10^{-7}	9.2×10^{-8}	4.2×10^{-7}	6.4×10^{-7}
Site Support Activities	210	0.37	0.054	0.021	f	f	g	g	f	f
Total (without testing)	**775**	**9**	**0.13**	**0.051**	**4.1×10^{-6}**	**2.4**	**5.6×10^{-5}**	**2.5×10^{-5}**	**2.3×10^{-4}**	**1.5×10^{-4}**
(with testing			**(0.18)**	**(0.072)**			**(0.0055)**	**(0.0025)**		

[a] Number of radiation-induced latent cancer fatalities in the exposed population associated with activities conducted over the 10-year period of analysis.

[b] Number of radiation-induced detrimental health effects (e.g., nonfatal cancers, genetic effects) in the exposed population associated with activities conducted over the 10-year period of analysis.

[c] Number of chemical-induced cancers (fatal and nonfatal) in the exposed population associated with activities conducted over the 10-year period of analysis.

[d] A hazard index of less than one indicates no chemical-induced noncancer health effects are expected to occur.

[e] Includes Environmental Restoration activities at NTS, Tonopah Test Range, Project Shoal Area, and Central Nevada Test Area.

[f] No reasonably foreseeable scenarios resulting in worker or public exposures to carcinogenic chemicals have been identified.

[g] No reasonably foreseeable scenarios resulting in public exposures to radiation have been identified.

The probability that accidental releases of hazardous chemicals over the 10 years evaluated in the EIS could result in a single cancer in the off-site population is estimated to be about 2.3×10^{-4} (1 in 4,000). No noncancer effects from accidental releases of hazardous chemicals would be expected in the off-site population.

5.2.4 Alternative 4

Table 5-5 summarizes the results of the risk analysis for NTS Program activities proposed under Alternative 4. Under Alternative 4, no activities are expected to occur associated with Defense Programs or Work for Others Programs. The results of the analysis indicate that human health risks are expected to be dominated by occupational injuries and fatalities to workers, but the overall risks are smaller compared to Alternatives 1 and 3. Over the 10-year period evaluated by the NTS EIS, about 104 occupational injuries and 1 fatality are expected for all NTS activities. Most of the injuries and fatalities are expected to be associated with Waste Management Program activities. In contrast, the risks associated with occupational exposure to radiation are smaller. The probability that a single latent cancer fatality will occur in the entire worker population as a result of the radiation exposure received over the 10 years evaluated in the EIS is estimated to be about 0.077 (or about 1 in 13). The probability of any other detrimental health effect occurring in the worker population is estimated to be about 0.033 (about 1 in 30).

The probability that accidental occupational exposure to hazardous chemicals over the 10 years evaluated in the EIS could result in a single cancer in the entire worker population is estimated to be about 4.0×10^{-6} (1 in 250,000). An accidental occupational exposure to life-threatening concentrations of noncarcinogenic chemicals has a probability of occurrence of 0.58 during the 10 years evaluated in the EIS. The public health risks presented in Table 5-5 represent risks from reasonably foreseeable accidents that could result in the release of radioactive and chemically hazardous material to the environment. The probability of a single latent cancer fatality in the off-site population being caused as a result of radiological accidents at the NTS over the 10 years evaluated in the EIS is about 5.1×10^{-5} (about 1 in 20,000).

The probability of any other detrimental health effect occurring in the off-site population is estimated to be about 2.3×10^{-5} (about 1 in 43,000).

The probability that accidental releases of hazardous chemicals over the 10 years evaluated in the EIS could result in a single cancer in the off-site population is estimated to be about 2.3×10^{-4} (1 in 4,000). No noncancer health effects from accidental releases of hazardous chemicals would be expected in this off-site population.

5.3 Impacts from the Maximum Reasonably Foreseeable Accident

The impacts described in Section 5.2 above are a compilation of the risk from NTS program activities to workers and the public from normal operations and reasonably foreseeable accidents with a range of probabilities (Attachment A). The maximum reasonably foreseeable accidents described in this section show the highest impacts that could occur as a result of worst-case accident conditions under each proposed alternative. The objective of analyzing maximum reasonably foreseeable accident is to determine events that would produce effects that would be as severe or more severe than any other accidents that might be reasonably foreseeable under each proposed alternative.

5.3.1 Alternative 1

Defense Program. The maximum reasonably foreseeable radiological Defense Program accident at the NTS would be an explosion of high explosives associated with interim stored nuclear weapons at the Area 27 storage bunkers. This accident has a probability of occurrence of 1×10^{-7} (1 in 10 million) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the explosion,

Table 5-5. Health Risks to Workers and the Public from Program Activities, Alternative 4

Program Area	Worker Health Risks						Public Health Risks			
	Occupational Safety Risks		Occupational Radiation Risks		Occupational Chemical Risks		Public Radiation Risks		Public Chemical Risks	
	Injuries	Fatalities	Radiation LCFs[a]	Radiation Detriment[b]	Chemical Cancers[c]	Chemical Hazard Index[d]	Radiation LCFs[a]	Radiation Detriment[b]	Chemical Cancers[d]	Chemical Hazard Index[d]
Defense NTS TTR	e 2.5	e 0.0044	e 0.0025	e 0.0010	e 8.4×10^{-12}	e 1.8×10^{-5}	e 9.0×10^{-9}	e 4.1×10^{-9}	e 1.0×10^{-10}	e 9.7×10^{-7}
Waste Management	64	0.97	0.020	0.0099	5.2×10^{-7}	0.48	5.1×10^{-5}	2.3×10^{-5}	2.0×10^{-5}	3.8×10^{-6}
Environmental Restoration NTS TTR Project Shoal CNTA	 10 0.0049 1.6×10^{-4} 1.6×10^{-4}	 0.031 9.7×10^{-4} 3.1×10^{-5} 3.1×10^{-5}	 0.0085 $2.4 \text{x-} 10^{-4}$ 1.7×10^{-5} 1.7×10^{-5}	 0.0034 9.5×10^{-5} 6.8×10^{-6} 6.8×10^{-6}	 3.0×10^{-7} f f f	 0.14 f f f	 2.3×10^{-10} 1.2×10^{-9} g g	 1.1×10^{-10} 5.7×10^{-10} g g	 6.0×10^{-6} f f f	 2.4×10^{-6} f f f
Nondefense Research and Development	8.6	0.0015	g	g	3.2×10^{-6}	0.58	g	g	1.9×10^{-4}	1.5×10^{-4}
Work for Others	e	e	e	e	e	e	e	e	e	e
Site Support Activities	19	0.033	0.046	0.018	f	f	f	f	f	f
Total	**104**	**1**	**0.077**	**0.033**	**4.0×10^{-6}**	**0.58**	**5.1×10^{-5}**	**2.3×10^{-5}**	**2.3×10^{-4}**	**1.5×10^{-4}**

[a] Number of radiation-induced latent cancer fatalities in the exposed population associated with activities conducted over the 10-year period of analysis.
[b] Number of radiation-induced detrimental health effects (e.g., nonfatal cancers, genetic effects) in the exposed population associated with activities conducted over the 10-year period of analysis.
[c] Number of chemical-induced cancers (fatal and nonfatal) in the exposed population associated with activities conducted over the 10-year period of analysis
[d] A hazard index of greater than one indicates that the non-cancer chemical effects could be life-threatening to individuals exposed for one hour or more.
[e] No activities
[f] No reasonably foreseeable scenarios resulting in exposure to chemically hazardous materials have been identified.
[g] No reasonably foreseeable scenarios resulting in exposure to radiation have been identified

- Maximally exposed non-involved worker: 62,000 rem (2,700 rem in first year after exposure), acute radiation effects could
- Non-involved worker population at the nearest major facility area: 16,000 person-rem, 6.4 latent cancer fatalities, 2.6 other detrimental effects,
- Maximally exposed off-site individual at the nearest point of public access: 34 rem, 3.4×10^{-2} chance of latent cancer fatality, 1.6×10^{-2} chance of other detrimental effects,
- Population within 50 miles: 5,800 to 110,000 person rem, 3 to 55 latent cancer fatalities, 1 to 25 other detrimental effects.

No Defense Program accident resulting in measurable chemically hazardous effects at the NTS has been identified.

The maximum reasonably foreseeable radiological Defense Program accident at the Tonopah Test Range would be a failure of an artillery fired test assembly. This accident has a probability of occurrence of 1×10^{-7} (1 in 10 million) per year. The following consequences are estimated if this accident occurs:

- Involved worker: Not applicable; involved workers are under cover when the device is fired
- Maximally exposed non-involved worker: 71 rem, 0.057 chance of latent cancer fatality, 0.023 chance of other detrimental effects,
- Non-involved worker population at the nearest major facility area: 7,100 person-rem, 5.7 latent cancer fatalities, 2.3 other detrimental effect,
- Maximally exposed off-site individual at the nearest point of public access: 2.3 rem, 0.0012 chance of latent cancer fatality, 5.3×10^{-4} chance of other detrimental effects,
- Population within 50 miles: 18 to 310 person-rem, 0.009 to 0.16 chance of a single latent cancer fatality, 0.004 to 0.071 chance of any other detrimental effects.

For Defense Program hazardous chemical effects at the Tonopah Test Range, the maximum reasonably foreseeable accident would be an explosion of a rocket test assembly containing depleted uranium and beryllium. This accident has a probability of occurrence of 6×10^{-6} (1 in 170,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the explosion,
- Maximally exposed non-involved worker: 1.4×10^{-8} chance of cancer, 0.30 noncancer hazard index for potentially life-threatening one-hour concentration,
- Non-involved worker population at the nearest major facility area: 1.4×10^{-7} chance of a single cancer, 0.30 noncancer hazard index for potentially life-threatening one-hour concentration,
- Maximally exposed off-site individual at the nearest point of public access: 4.1×10^{-7} chance of cancer, 1.0 noncancer hazard index for potentially life-threatening one-hour concentration,
- Population within 50 miles: 1.7×10^{-6} to 1.1×10^{-7} chance of a single cancer, 0.03 to 0.016 noncancer hazard index for potentially life-threatening one-hour concentration.

Waste Management Program. The maximum reasonably foreseeable radiological Waste Management Program accident at the NTS would be an airplane crash into the Area 5 transuranic waste storage unit, which has a probability of occurrence of 6×10^{-7} (1 in 1,700,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the crash,
- Maximally exposed non-involved worker: 3,500 rem (154 rem in the first year after exposure), 1.0 chance of cancer fatality, 1.0 chance of other detrimental effects,
- Non-involved worker population at the nearest major facility area: 99 person-rem, 0.04 chance of a single latent cancer fatality, 0.016 chance of any other detrimental effects,
- Maximally exposed off-site individual at the nearest point of public access: 3.5 rem, 1.8×10^{-3} chance of latent cancer fatality, 8.0×10^{-4} chance of other detrimental effects,
- Population within 50 miles: 1,400 to 25,000 person rem, 1 to 13 latent cancer fatalities,

0 to 6 other detrimental effects.

For Waste Management Program hazardous chemical effects, the maximum reasonably foreseeable accident would be an airplane crash into the Area 5 hazardous waste storage unit. This accident has a probability of occurrence of 1×10^{-7} (1 in 10 million) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the crash,
- Maximally exposed non-involved worker: 6.6×10^{-2} chance of cancer, 340 noncancer hazard index for potentially life-threatening one-hour concentration,
- Non-involved worker population at the nearest major facility area: 1.1×10^{-3} change of a single cancer, 0.09 noncancer hazard index for potentially life-threatening one-hour concentration,
- Maximally exposed off-site individual at the nearest point of public access: 2.4×10^{-5} chance of cancer, 0.013 noncancer hazard index for potentially life-threatening one-hour concentration,
- Population within 50 miles: 0.027 to 0.10 chance of a single cancer, 0.005 to 0.01 noncancer hazard index for potentially life-threatening one-hour concentration.

Environmental Restoration Program. The maximum reasonably foreseeable radiological Environmental Restoration Program accident at the NTS would be an airplane crash into the Area 13 site. This accident has a probability of occurrence of 7×10^{-7} (1 in 1,400,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the crash,
- Maximally exposed non-involved worker: 0.0011 rem, 4.4×10^{-7} chance of latent cancer fatality, 1.8×10^{-7} chance of other detrimental effects,
- Non-involved worker population at the nearest major facility area: 0.0055 person-rem, 2.2×10^{-6} chance of a single latent cancer fatality, 8.8×10^{-7} chance of any other detrimental effects,
- Maximally exposed off-site individual at the nearest point of public access: 0.0022 rem, 1.1×10^{-6} chance of latent cancer fatality, 5.1×10^{-7} chance of other detrimental effects,
- Population within 50 miles: 0.04 to 0.71 person rem, 2.1×10^{-5} to 3.6×10^{-4} chance of a single latent cancer fatality, 9.4×10^{-6} to 1.6×10^{-4} chance of any other detrimental effects.

The maximum reasonably foreseeable radiological Environmental Restoration Program accident at the Tonopah Test Range would be an airplane crash into the Project Roller Coaster site, which has a probability of occurrence of 1×10^{-6} (1 in 1,000,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the crash,
- Maximally exposed non-involved worker: 0.012 rem, 4.8×10^{-6} chance of latent cancer fatality, 1.9×10^{-6} chance of other detrimental effects,
- Non-involved worker population at the nearest major facility area: 1.2 person-rem, 4.8×10^{-4} chance of a single latent cancer fatality, 1.9×10^{-4} chance of any other detrimental effects,
- Maximally exposed off-site individual at the nearest point of public access: 0.0034 rem, 1.7×10^{-6} chance of latent cancer fatality, 7.8×10^{-7} chance of other detrimental effects,
- Population within 50 miles: 0.2 to 3.3 person rem, 9.5×10^{-5} to 1.7×10^{-3} chance of a single latent cancer fatality, 4.4×10^{-5} to 7.6×10^{-4} chance of any other detrimental effects.

For Environmental Restoration Program hazardous chemical effects, the maximum reasonably foreseeable accident would be an airplane crash into a hypothetical environmental restoration site consisting of a composite of hazardous sites across the NTS . This accident has a probability of occurrence of 7×10^{-7} (1 in 1,400,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the crash,
- Maximally exposed non-involved worker:

0.008 chance of cancer, 45 noncancer hazard index for potentially life-threatening one-hour concentration,

- Non-involved worker population at the nearest major facility area: 9.4×10^{-5} change of a single cancer, 0.0097 noncancer hazard index for potentially life-threatening one-hour concentration,
- Maximally exposed off-site individual at the nearest point of public access: 8.5×10^{-6} chance of cancer, 9.8×10^{-4} noncancer hazard index for potentially life-threatening one-hour concentration,
- Population within 50 miles: 1.5×10^{-3} to 3.3×10^{-3} chance of a single cancer, 6.1×10^{-4} to 6.5×10^{-4} noncancer hazard index for potentially life-threatening one-hour concentration.

No Environmental Restoration Program accidents resulting in measurable radiological or chemically hazardous effects at the Project Shoal Area or the Central Nevada Test Area have been identified.

Nondefense Research and Development Program. No Nondefense Research and Development Program accident resulting in measurable radiological effects at the NTS has been identified.

For Nondefense Research and Development Program hazardous chemical effects, the maximum reasonably foreseeable accident would be an airplane crash into the tank farm at the Liquid Gaseous Fuel Spill Test Facility. This accident has a probability of occurrence of 1×10^{-7} (1 in 10 million) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the crash,
- Maximally exposed non-involved worker: 1.0 chance of cancer, 1,000 noncancer hazard index for potentially life-threatening one-hour concentration,
- Non-involved worker population at the nearest major facility area: 0.054 chance of a single cancer, 0.80 noncancer hazard index for potentially life-threatening one-hour concentration,
- Maximally exposed off-site individual at the nearest point of public access: 8.8×10^{-4} chance of cancer, 0.34 noncancer hazard index for potentially life-threatening one-hour concentration,
- Population within 50 miles: 0 to 3 cancers, 0.01 to 0.19 noncancer hazard index for potentially life-threatening one-hour concentration.

Work for Others Program. No Work for Others Program accident resulting in measurable radiological effects at the NTS has been identified.

For Work for Others Program hazardous chemical effects, the maximum reasonably foreseeable accident would be a heavy metal release as a result of an unplanned detonation of a test assembly at the Big Explosives Experimental Facility. This accident has a probability of occurrence of 1×10^{-2} (1 in 100) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the explosion,
- Maximally exposed non-involved worker: 1.8×10^{-4} chance of cancer, 0.044 noncancer hazard index for potentially life-threatening one-hour concentration,
- Non-involved worker population at the nearest major facility area: 6.1×10^{-7} chance of a single cancer, 4.0×10^{-6} noncancer hazard index for potentially life-threatening one-hour concentration,
- Maximally exposed off-site individual at the nearest point of public access: 1.4×10^{-9} chance of cancer, 1.9×10^{-7} noncancer hazard index for potentially life-threatening one-hour concentration,
- Population within 50 miles: 2.9×10^{-6} to 1.3×10^{-7} chance of a single cancer, 1.9×10^{-7} noncancer hazard index for potentially life-threatening one-hour concentration.

5.3.2 Alternative 2

Defense Program. No Defense Program activities would be conducted at the NTS under Alternative 2. The maximum reasonably foreseeable

radiological Defense Program accident at the Tonopah Test Range would be the same as Alternative 1 (a failure of an artillery fired test assembly, which has a probability of occurrence of 1×10^{-7} (1 in 10,000,000) per year).

For Defense Program hazardous chemical effects at the Tonopah Test Range, the maximum reasonably foreseeable accident also would be the same as Alternative 1 (an explosion of a rocket test assembly containing depleted uranium and beryllium, which has a probability of occurrence of 6×10^{-6} (1 in 170,000) per year).

Waste Management Program. Removal of transuranic and hazardous waste from the NTS under Alternative 2 was assumed to require some period of time to fully implement, and accidents could occur during the implementation period. The maximum reasonably foreseeable radiological Waste Management Program accident at the NTS would be a multi-container fire at the Area 5 transuranic waste storage unit, which has a probability of occurrence of 1×10^{-6} (1 in 1,000,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: plume rise from the fire carries the plume over close-in workers,
- Maximally exposed non-involved worker: 3.7 rem, 0.0015 chance of latent cancer fatality, 5.9×10^{-4} chance of other detrimental effects,
- Non-involved worker population at the nearest major facility area: 0.10 person-rem, 4.0×10^{-5} chance of a single latent cancer fatality, 1.6×10^{-5} chance of any other detrimental effects,
- Maximally exposed offsite individual at the nearest point of public access: 0.0036 rem, 1.8×10^{-6} chance of latent cancer fatality, 8.3×10^{-7} chance of other detrimental effects,
- Population within 50 miles: 1.5 to 26 person rem, 7.5×10^{-4} to 0.013 chance of a single latent cancer fatality, 3.5×10^{-4} to 0.006 chance of any other detrimental effects.

For Waste Management Programs hazardous chemical effects, the maximum reasonably foreseeable accident would be a multi-container fire at the Area 5 hazardous waste storage unit, which has a probability of occurrence of 8×10^{-5} (1 in 13,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: plume rise from the fire carries the plume over close-in workers
- Maximally exposed non-involved worker: 8.8×10^{-3} chance of cancer, 51 noncancer hazard index for potentially life-threatening one-hour concentration,
- Non-involved worker population at the nearest major facility area: 1.0×10^{-4} chance of a single cancer, 0.013 noncancer hazard index for potentially life-threatening one-hour concentration,
- Maximally exposed off-site individual at the nearest point of public access: 1.2×10^{-6} chance of cancer, 0.0019 noncancer hazard index for potentially life-threatening one-hour concentration,
- Population within 50 miles: 0.002 to 0.004 chance of a single cancer, 0.0019 noncancer hazard index for potentially life-threatening one-hour concentration.

Environmental Restoration Program. No Environmental Restoration Program activities would be conducted at the NTS, Tonopah Test Range, Project Shoal Area, or Central Nevada Test Area under Alternative 2.

Nondefense Research and Development Program. No Nondefense Research and Development Program activities would be conducted at the NTS under Alternative 2.

Work for Others Program. No Work for Others Program activities would be conducted at the NTS under Alternative 2.

5.3.3 Alternative 3

Defense Program. The maximum reasonably foreseeable radiological Defense Program accident at the NTS would be the same as Alternative 1 (an explosion of high explosives associated with interim stored nuclear weapons at the Area 27 storage bunkers. This accident has a probability of

occurrence of 1 x 10^{-7} (1 in 10,000,000 per year).

No Defense Program accident resulting in measurable chemically hazardous effects at the NTS has been identified.

The maximum reasonably foreseeable radiological Defense Program accident at the Tonopah Test Range would be the same as Alternative 1 (a failure of an artillery fired test assembly). This accident has a probability of occurrence of 1 x 10^{-7} (1 in 10 million) per year.

For Defense Program hazardous chemical effects at the Tonopah Test Range, the maximum reasonably foreseeable accident would also be the same as Alternative 1 (an explosion of a rocket test assembly containing depleted uranium and beryllium). This accident has a probability of occurrence of 6 x 10^{-6} (1 in 170,000) per year.

Waste Management Program. The maximum reasonably foreseeable radiological Waste Management Program accident at the NTS would be the same as Alternative 1 (an airplane crash into the Area 5 transuranic waste storage unit). This accident has a probability of occurrence of 6 x 10^{-7} (1 in 1,700,000) per year.

For Waste Management Programs hazardous chemical effects, the maximum reasonably foreseeable accident would also be the same as Alternative 1 (an airplane crash into the Area 5 hazardous waste storage unit). This accident has a probability of occurrence of 1 x 10^{-7} (1 in 10,000,000) per year.

Environmental Restoration Program. The maximum reasonably foreseeable radiological Environmental Restoration Program accident at the NTS would be the same as Alternative 1 (an airplane crash into the Area 13 site, which has a probability of occurrence of 7 x 10^{-7} (1 in 1,400,000) per year.

The maximum reasonably foreseeable radiological Environmetnal Restoration Program accident at the Tonopah Test Range would also be the same as alterntive 1 (an airplane crash into the Project Roller Coaster site). This accident has a probability of occurrence of 1 x 10^{-6} (1 in 1,000,000) per year.

For Environmental Restoration Program hazardous chemical effects, the maximum reasonably foreseeable accident would be the same as Alternative 1 (an airplane crash into a hypothetical environmental restoration site consisting of a composite of hazardous sites across the NTS). This accident has a probability of occurrence of 7 x 10^{-7}(1 in 1,400,000 per year).

No Environmental Restoration Program accidents resulting in measurable radiological or chemically hazardous effects at the Project Shoal Area or the Central Nevada Test Area have been identified.

Nondefense Research and Development Program. No Nondefense Research and Development Program accident resulting in measurable radiological effects at the NTS has been identified.

For Nondefense Research and Development Program hazardous chemical effects, the maximum reasonably foreseeable accident would be the same as Alternative 1 (an airplance crash into the tank farm at the Liquid Gaseous Fuel Spill Test Facility). This accident has a probability of (1 in 10 million) per year.

Work for Others Program. The maximum reasonably foreseeable radiological Work for Others Program accident at the NTS would be an inadvertent detonation of a test assembly at the Big Explosives Experimental Facility and release of 1,000 curies of tritium. This accident has a probability of occurrence of 3 x 10^{-5} (1 in 33,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the explosion,
- Maximally exposed non-involved worker: 0.35 rem, 1.4 x 10^{-4} chance of latent cancer fatality, 5.6 x 10^{-5} chance of other detrimental effects,

- Non-involved worker population at the nearest major facility area: 0.006 person-rem, 2.4×10^{-6} chance of a single latent cancer fatality, 9.6×10^{-7} chance of any other detrimental effects,
- Maximally exposed off-site individual at the nearest point of public access: 4.7×10^{-5} rem, 2.4×10^{-8} chance of latent cancer fatality, 1.1×10^{-8} chance of other detrimental effects,
- Population within 50 miles: 0.02 to 0.35 person rem, 1.0×10^{-5} to $1.8^{-5} \times 10^{-4}$ chance of latent cancer fatality, 4.6×10^{-6} to 8.1×10^{-5} chance of other detrimental effects.

For Work for Others Program hazardous chemical effects, the maximum reasonably foreseeable accident would be a depleted uranium and beryllium release as a result of an unplanned detonation of a test assembly at the Big Explosives Experimental Facility, which has a probability of occurrence of 1×10^{-3} (1 in 1,000) per year. The following consequences are estimated if this accident occurs:

- Involved worker: fatally injured in the explosion,
- Maximally exposed non-involved worker: 8.0×10^{-4} chance of cancer, 240 noncancer hazard index for potentially life-threatening one-hour concentration,
- Non-involved worker population at the nearest major facility area: 2.8×10^{-6} chance of a single cancer, 0.023 noncancer hazard index for potentially life-threatening one-hour concentration,
- Maximally exposed offsite individual at the nearest point of public access: 6.3×10^{-9} chance of cancer, 6.4×10^{-5} noncancer hazard index for potentially life-threatening one-hour concentration,
- Population within 50 miles: 1.3×10^{-5} to 5.6×10^{-7} chance of a single cancer, 6.4×10^{-5} noncancer hazard index for potentially life-threatening one-hour concentration.

5.3.4 Alternative 4

Defense Program. No Defense Program activities would be conducted at the NTS under Alternative 4. The maximum reasonably foreseeable radiological Defense Program accident at the Tonopah Test Range would be the same as Alternative 1 (a failure of an artillery fired test assembly). This accident has a probability of occurrence of 1×10^{-7} (1 in 10 million) per year.

For Defense Programs hazardous chemical effects at the Tonopah Test Range, the maximum reasonably foreseeable accident also would be the same as Alternative 1 (an explosion of a rocket test assembly containing depleted uranium and beryllium). This accident has a probability of occurrence of 6×10^{-6} (1 in 170,000) per year).

Waste Management Program. The maximum reasonably foreseeable radiological Waste Management Program accident at the NTS would be the same as Alternative 1 (an airplane crash into the Area 5 transuranic waste storage unit). This accident has a probability of occurrence of 6×10^{-7} (1 in 1,700,000) per year.

For Waste Management Programs hazardous chemical effects, the maximum reasonably foreseeable accident would also be the same as Alternative 1 (an airplane crash into the Area 5 hazardous waste storage unit). This accident has a probability of occurrence of 1×10^{-7} (1 in 10,000,000) per year.

Environmental Restoration Program. The maximum reasonably foreseeable radiological Environmental Restoration Program accident at the NTS would be the same as Alternative 1 (an airplane crash into the Area 13 site). This accident has a probability of occurrence of 7×10^{-7} (1 in 1,400,000) per year.

The maximum reasonably foreseeable radiological Environmental Restoration Program accident at the Tonopah Test Range would also be the same as Alternative 1 (an airplane crash into the Project Roller Coaster site). This accident has a probability of occurrence of 1×10^{-6} (1 in 1,000,000) per year.

For Environmental Restoration Program hazardous chemical effects, the maximum reasonably foreseeable accident would be the same as Alternative 1 (an airplane crash into a hypothetical

environmental restoration site consisting of a composite of hazardous sites across the NTS). This accident has a probability of occurrence of 7×10^{-7} (1 in 1,400,000) per year.

No Environmental Restoration Program accidents resulting in measurable radiological or chemically hazardous effects at the Project Shoal Area or the Central Nevada Test Area have been identified.

Nondefense Research and Development Program. No Nondefense Research and Development Program accident resulting in measurable radiological effects at the NTS has been identified. For Nondefense Research and Development Program hazardous chemical effects, the maximum reasonably foreseeable accident would be the same as Alternative 1 (an airplane crash into the tank farm at the Liquid Gaseous Fuel Spill Test Facility which has a probability of occurrence of occurrence of 1×10^{-7} (1 in 10 million) per year.

Work for Others Program. No Work for Others Program activities would be conducted under Alternative 4.

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6.0 CONCLUSIONS

The goal of this study is to evaluate human health risks as a result of proposed activities associated with the four alternatives identified in the NTS EIS. The results indicate that the principal risks to human health are associated with occupational activities and the risk is borne by NTS workers. Because of the sparse population within 50 miles (80 kilometers) of the NTS and the operational safeguards associated with NTS facilities and activities, public health risks are unlikely to result in a single fatal cancer or other detrimental health effect for each of the NTS EIS alternatives.

This study concluded that worker health risks related to NTS activities are expected to be dominated by occupational safety risks, that is, events that could cause injury or death due to physical hazards in the workplace. These risks are reduced by strict adherence to DOE and OSHA safety standards, formal procedures for conduct of operations, worker training, and internal audits and assessments of work practices and procedures. Occupational safety risks are highest under Alternative 3 and lowest under Alternative 2. Alternative 1 poses the second highest occupational safety risks which are approximately 25-30 percent of the potential risks under Alternative 3. For all alternatives except Alternative 2, most of the occupational safety risk is attributed to Waste Management Program activities.

Although not trivial, worker health risks from exposure to radiation and hazardous chemicals are estimated to be low in comparison with occupational safety risks. It is unlikely that any workers will contract fatal cancers as a result of exposure to radiation or hazardous chemicals. However, involved workers, non-involved workers, and the worker population may experience non-carcinogenic health effects in the event of a hazardous chemical accident associated with the Defense, Waste Management, Environmental Restoration, and Nondefense Research and Development Program Areas. Risks from exposure to radiation and hazardous chemicals are reduced by containment of radioactive and hazardous materials, strict adherence to DOE and OSHA limits for occupational exposure to radiation and hazardous chemicals, monitoring of radiation and hazardous chemical exposure levels in the workplace, formal procedures for conduct of operations, worker training, and internal audits and assessments of work practices and procedures.

Estimated risks to the public as a result of NTS activities are lower than worker risks. Subsurface migration of tritium in groundwater is not expected to result in tritium concentrations above EPA drinking water standards at existing public wells at any time in the future. However, the results of theoretical modeling of tritiated groundwater from the Project Shoal Area and the Central Nevada Test Area suggest the need to conduct further investigations prior to installing any new public wells closer to these areas than the nearest existing public wells.

In the event that a maximum reasonably foreseeable accident actually occurred, cancer fatalities and other detrimental health effects could occur in the off-site population. However, when the probability of these accidents is considered, it is unlikely that a single fatal cancer or other detrimental health effect would occur in the off-site population as a result of accidents at the NTS.

The U.S. Department of Energy's National Safety Policy goal can be used as a guide to compare calculated risks and potential health effects (DOE 1991). This Policy goal states, in part, that the cancer fatality risk to the population with 10 miles of a DOE nuclear facility should not exceed one tenth of one percent of the sum of all cancer fatality risks from all other cases. The goal equals a risk of approximately 2×10^{-6} per year of latent cancer fatality. With the exception of an accidental venting of radionuclides from an underground nuclear test, all reasonably foreseeable accidents have risks of latent cancer fatality to the public below the Policy Goal. For an accidental venting from an underground test, the risk of latent cancer

fatality to a maximally exposed member of the public at the nearest point of public access is conservatively estimated to be 3×10^{-6} per test. If DOE is directed by the President to perform underground testing under Alternatives 1 and 3, and a member of the public were to be located at the nearest point of public access during the test (boundary with Bureau of Land Management land to the north west), the Policy Goal could potentially be exceeded under worst-case conditions.

The radiation and hazardous chemical exposure estimated in this EIS for the various accident scenarios is the exposure that would be received if only limited protective actions were taken. The NTS has detailed plans for responding to accidents of the type described here, and the response activities would be closely coordinated with state and local officials. Mitigative and preventive measures that reduce or eliminate the risk of accidents to workers and members of the public include emergency procedures, routine inspection and monitoring of facility areas and material handling equipment, design criteria for facilities and material packaging, safety reviews and safety analysis by qualified review teams/committees, worker training programs, access restrictions, and controls on commercial and private flights over the NTS and off-site areas.

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Attachment A to Appendix H

HUMAN HEALTH RISK ACCIDENT ANALYSIS

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A.1 Introduction

A potential exists for accidents at facilities associated with use, storage, and disposal of radioactive and chemically hazardous materials. Accidents can be categorized into events that are abnormal (for example, spills), events a facility was designed to withstand, and events a facility was not designed to withstand (but whose consequences it may nevertheless mitigate). These categories are termed design basis, and beyond design basis accidents, respectively. Summarized in this Attachment are consequences of possible facility accidents in these categories for workers and the public. Details of assessments of the accidents are in *Accident Assessments for Nevada Test Site Facilities and Off-Site Location* (SAIC, 1996). Volume 1, Appendix I (Transportation Study) provides the assessment of transportation accidents.

An accident is a series of unexpected or undesirable events starting with an initiating event, and leading to a release of radioactive or hazardous materials within a facility or to the environment. Initiating events for accidents are defined in three broad categories: external initiators, internal initiators, and natural phenomena initiators. All types of initiators were defined in terms of those events that cause or may lead to a release of materials and energy by failure or bypass of confinement. The analyses of accidents are intended to be conservative in the sense that where uncertainties exist, assumptions that bound the potential for credible environmental consequences are used.

A.2 Methodology

Radioactive and chemically hazardous materials are involved in a wide variety of operations at the Nevada Test Site (NTS) and off-site locations; including scientific research and engineering development, waste management, and environmental restoration. The hazard of a facility to workers and the public is directly related to the quantity of radioactive or hazardous material located at a facility that could be released to the environment by an accident. Other important factors include design of confinement systems and structures, presence of energy sources such as explosives or flammable materials, and the distance to people that may be exposed to accidental releases of radioactive or hazardous materials. To obtain a perspective on potential accidents, the approach was to:

- Identify facilities with quantities of radioactive or chemically hazardous materials that could result in impacts to workers or the public under accident conditions,
- Identify potential internal, external, and natural phenomena events that could initiate accidents
- Perform independent analyses of reasonably foreseeable accidents.

To characterize potential impacts at NTS and off-site locations, accidents with a range of frequencies are reported for each proposed alternative. Three broad frequency ranges are used: abnormal events with frequencies greater than 10^{-3} per year, design basis accidents with frequencies in the range from 10^{-3} to 10^{-6} per year, and beyond design basis accidents with frequencies in the range from 10^{-7} to 10^{-6} per year. Within each frequency range, a bounding accident is determined so that any other reasonably foreseeable accident within a frequency range would be expected to have smaller consequences. The results are point estimates of maximum reasonably foreseeable accidents by frequency category rather than a cumulative assessment of all possible accidents in each category. Possible causes, assumptions, likelihood of occurrence, and consequences are discussed for the bounding accident within each frequency category analyzed. Details on the analyses, including supporting references, are given in (SAIC, 1996).

A.3 Accident Screening and Selection Process

Many types of postulated events could lead to an accidental release of radioactive or hazardous material, or both. Some of these postulated events have the potential for only local (within controlled site boundaries) consequences with no potential for a release that would have consequences for a member of the public at the nearest site boundary.

Internal and external initiators associated with a wide range of activities not necessarily covered in existing safety analyses were considered. For example, potential radiological accident scenarios initiated by construction activities associated with constructing new facilities or modifying existing facilities (as proposed under the various alternatives) were postulated. Typically, events involved in the construction of new facilities would act as external initiators while events involved in modifying existing facilities would act as internal initiators. Examples of construction or industrial-type events considered included fires, confinement impacts or puncture events, equipment failure, terrorism, and human error.

Five major program areas are conducted at the NTS and off-site areas. Each facility in the five program areas were screened for quantities of radioactive and hazardous material (including materials in inventory) that have the potential for being involved in a substantive release and thus worthy of consideration. Initiating events were defined in three broad categories: external initiators, internal initiators, and natural phenomena initiators.

- External initiators originate outside the facility and may impact the ability of the facility to maintain confinement of radioactive or hazardous material. These may be related to fires and explosions nearby, or caused by events at co-located facilities.

- Internal initiators (for example, equipment failures or human error) originate within a facility and are a result of operating the facility.

- Natural phenomena initiators include weather-related and seismic events. All types of initiators were defined in terms of those events that cause or may lead to a release of materials by failure of confinement or a bypass of confinement.

Seismic events (see Environmental Impact Statement Volume 1, Section 4) were found to be the most likely common-cause initiators with the potential to cause releases at more than one facility and involve more than one material type. Thus, some individual impacts presented herein for seismically initiated accidents could be additive. However, because the screening methods focused on facilities with the largest inventories rather than all possible facilities, summing impacts from the assessed seismic accidents could be misleading and was not attempted. No cases were found where an accident in one facility could cause an accident in a co-located facility.

Each facility area was screened for initiating events with the potential to cause nonnegligible consequences. Only those locations identified with substantial quantities of materials were considered. Accidents with bounding consequences were assessed as discussed below.

A.4 Analysis of Accident Consequences

For health effects to occur, an accident must involve (a) a direct radiation exposure or (b) a loss of confinement of the hazardous and/or radioactive material and a release of some fraction of the material to the immediate environment. For the latter, the material must then be transported to people. Emergency preparedness plans discussed in Volume 1, Section 7.11, Occupational and Public Health and Safety, can be invoked to reduce human exposures for scenarios where time is available to take action. The quantities of materials that reach people, and the ways the materials interact with human beings are important factors in determining health effects.

In determining the consequences (radiological and toxicological) associated with the postulated maximum reasonably foreseeable accidents, the following definitions were used:

- Involved Worker. The involved worker is defined as an individual directly involved in facility operations at the time of the accident, and within 100 meters (328 feet) of the point of release.

- Noninvolved Worker. The noninvolved worker is defined as an on-site individual located greater than 100 meters (328 feet) from the point of release.

- Worker Population. The worker population is defined as the population of workers (both involved and noninvolved) within the path of the plume with the wind assumed blowing toward the nearest populated on-site facility area.

- Nearest Public Access. The nearest public access is the location of the nearest point of land to the release location where members of the public have unrestricted access and could be present.

- Maximally Exposed Individual (MEI). The MEI is defined as a hypothetical individual located at the nearest public access.

- Off-Site Population. The off-site population is defined as the collective sum of individuals located within an 80-kilometer (50-mile) radius of the facility and within the path of the plume with the wind blowing in the most populous direction.

The ways radioactive material reach human beings, how it is absorbed and retained in the body, and the resulting health effects have been studied in great detail. The International Commission on Radiological Protection has made specific recommendations for quantifying these health effects. This organization is the recognized body for establishing standards for protecting workers and the public from the effects of radiation exposure. Health effects include acute damage (up to and including death) and latent effects, including cancers and genetic damage. An INEL-developed computer code, *The Radiological Safety Analysis Computer Program (RSAC-5), WINCO-1123* (Wenzel, 1993), estimates potential radiation doses to maximally exposed individuals or population groups from accidental releases of radionuclides. This computer code uses well-established scientific and engineering principles as the basis for the various calculational steps. The code has been validated to accepted standards for this kind of computer software.

For hazardous materials, several government agencies recommend quantifying health effects as threshold values of concentrations in air or water that cause short-term effects. The long-term health consequences of exposure to hazardous materials are not as well understood as those for radiation. Thus, the potential health effects reported here for hazardous materials are more qualitative than for radioactive materials. EPIcode™ (*Emergency Prediction Information Manual*) (Homann, 1988) was used to estimate human health effects associated with the release of chemically hazardous materials.

A.5 Accident Impacts

A.5.1 Impacts from Alternative 1, Continue Current Operations (No Action)

The accident impacts from Alternative 1 are summarized in Table A.5.1-1 (radiological accidents) and Table A.5.1-2 (hazardous chemical accidents).

A.5.2 Impacts from Alternative 2, Discontinue Operations

The accident impacts from Alternative 2 are summarized in Table A.5.2-1 (radiological accidents) and Table A.5.2-2 (hazardous chemical accidents).

A.5.3 Impacts from Alternative 3, Expanded Use

The accident impacts from Alternative 3 are summarized in Table A.5.3-1 (radiological accidents) and Table A.5.3-2 (hazardous chemical accidents).

A.5.4 Impacts from Alternative 4, Alternate Use of Withdrawn Lands

The accident impacts from Alternative 4 are summarized in Table A.5.4-1 (radiological accidents) and Table A.5.4-2 (hazardous chemical accidents).

Table A.5.1-1 Nevada Test Site and Off-Site Areas Radiological Facility Accident Probabilities and Consequences

(Page 1 of 2)

Alternative 1							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Defense Program							
Accidental venting from an underground test	$3x10^{-3}$/test	N/A[a]	1.6 rem $6.7x10^{-4}$ LCF $2.6x10^{-4}$Det.	$1.6x10^{1}$ pers. rem $6.6x10^{-3}$ LCF $2.6x10^{-3}$ Det.	2.0 rem $1.0x10^{-3}$LCF $4.6x10^{-4}$Det.	$3.6x10^{2}$ pers. rem $1.8x10^{-1}$ LCF $8.3x10^{-2}$ Det.	N/A
Area 27 explosion in interim stored nuclear weapons	$1 x10^{-7}$	N/A[a]	$6.2x10^{4}$ rem 1.0 LCF 1.0 Det.	1.6 pers. rem 6.4 LCF 2.6 Det.	$3.4x10^{1}$rem $3.4x10^{-2}$ LCF $1.6x10^{-2}$ Det.	$5.8x10^{3}$ pers. rem 2.9 LCF 1.3 Det.	$1.1x10^{5}$ pers. rem $5.5x10^{1}$ LCF $2.5x10^{1}$ Det.
DAF explosion involving 55 lb. HE and 5 kg Pu	$2x10^{-6}$	N/A[b]	$1.2x10^{3}$ rem $9.6x10^{-1}$ LCF $3.8x10^{-1}$Det.	$1.1x10^{2}$ pers. rem $4.4x10^{-2}$ LCF $1.8x10^{-2}$ Det.	$1.9x10^{-1}$ rem $9.3x10^{-5}$ LCF $4.3x10^{-5}$ Det.	$1.1x10^{2}$ pers. rem $5.5x10^{-2}$ LCF $2.5x10^{-2}$ Det.	$1.9x10^{3}$ pers. rem $9.5x10^{-1}$ LCF $4.4x10^{-1}$ Det.
TTR test assembly mechanical release of Pu	$1x10^{-6}$	N/A[a]	$1.3x10^{-2}$ rem $5.2x10^{-6}$ LCF $2.1x10^{-6}$ Det.	$2.6x10^{-1}$ pers. rem $1.0x10^{-4}$ LCF $4.2x10^{-5}$ Det.	$6.7x10^{-3}$ rem $3.4x10^{-6}$ LCF $1.5x10^{-6}$ Det.	$5.4x10^{-4}$ pers. rem $2.7x10^{-7}$ LCF $1.2x10^{-7}$ Det.	$9.4x10^{-3}$ pers. rem $4.7x10^{-6}$ LCF $2.2x10^{-6}$ Det.
TTR artillery fired test assembly failure	$1x10^{-7}$	N/A	$7.1x10^{1}$ rem $5.7x10^{-2}$ LCF $2.3x10^{-2}$ Det.	$7.1x10^{3}$ pers. rem 5.7 LCF 2.3 Det.	2.3 rem $1.2x10^{-3}$ LCF $5.3x10^{-4}$ Det.	$1.8x10^{1}$ pers. rem $9.0x10^{-3}$ LCF $4.1x10^{-3}$ Det.	$3.1x10^{2}$ pers. rem $1.6x10^{-1}$ LCF $7.1x10^{-2}$ Det.
Waste Management Program							
Area 5 TRU waste release - two container fire/explosion	$1x10^{-2}$	$7.4x10^{1}$ rem $5.9x10^{-2}$ LCF $3.4x10^{-2}$ Det.	2.3 rem $9.2x10^{-4}$ LCF $3.7x10^{-4}$ Det.	$6.5x10^{-2}$ pers. rem $1.6x10^{-1}$ LCF $6.4x10^{-2}$ Det.	$2.3x10^{-3}$ rem $1.2x10^{-6}$ LCF $5.3x10^{-7}$ Det.	$9.3x10^{-1}$ pers. rem $4.7x10^{-4}$ LCF $2.1x10^{-4}$ Det.	$1.6x10^{1}$ pers. rem $8.0x10^{-3}$ LCF $3.7x10^{-3}$ Det.
Area 5 TRU waste release - five container fire/explosion	$1x10^{-6}$	N/A[c]	3.7 rem $1.5x10^{-3}$ LCF $5.9x10^{-4}$ Det.	$1.0x10^{-1}$ pers. rem $4.0x10^{-5}$ LCF $1.6x10^{-5}$ Det.	$3.6x10^{-3}$ rem $1.8x10^{-6}$ LCF $8.3x10^{-6}$ Det.	1.5 pers. rem $7.5x10^{-4}$ LCF $3.5x10^{-4}$ Det.	$2.6x10^{1}$ pers. rem $1.3x10^{-2}$ LCF $6.0x10^{-3}$ Det.
Area 5 TRU waste airplane crash	$6x10^{-7}$	N/A[b]	$3.5x10^{3}$ rem 1.0 LCF 1.0 Det.	$9.9x10^{1}$ pers. rem $4.0x10^{-2}$ LCF $1.6x10^{-2}$ Det.	3.5 rem $1.8x10^{-3}$ LCF $8.0x10^{-4}$ Det.	$1.4x10^{3}$ pers. rem $7.0x10^{-1}$ LCF $3.2x10^{-1}$ Det.	$2.5x10^{4}$ pers. rem $1.3x10^{1}$ LCF 5.8 Det.
Environmental Restoration Program							
NTS Area 13 single container spill	$3x10^{-2}$	$3.0x10^{-3}$ rem $1.2x10^{-6}$ LCF $4.8x10^{-7}$ Det.	$1.5x10^{-8}$ rem $6.0x10^{-12}$ LCF $2.4x10^{-12}$ Det.	$7.5x10^{-8}$ pers. rem $3.3x10^{-6}$ LCF $1.3x10^{-6}$ Det.	$6.0x10^{-9}$ rem $3.0x10^{-12}$ LCF $1.4x10^{-12}$ Det.	$5.6x10^{-7}$ pers. rem $2.8x10^{-10}$ LCF $1.3x10^{-10}$ Det.	$9.7x10^{-6}$ pers. rem $4.9x10^{-9}$ LCF $2.2x10^{-9}$ Det.
TTR Project Roller Coaster site single container spill	$3x10^{-2}$	$3.0x10^{-3}$ rem $1.2x10^{-3}$ LCF $4.8x10^{-4}$ Det.	$1.2x10^{-7}$ rem $4.8x10^{-11}$ LCF $1.9x10^{-11}$ Det.	$1.2x10^{-5}$ pers.rem $3.3x10^{-6}$ LCF $1.3x10^{-6}$ Det.	$3.4x10^{-8}$ rem $1.7x10^{-11}$ LCF $7.8x10^{-12}$ Det.	$1.9x10^{-6}$ pers. rem $9.5x10^{-10}$ LCF $4.4x10^{-10}$ Det.	$3.3x10^{-5}$ pers. rem $1.7x10^{-8}$ LCF $7.6x10^{-9}$ Det.
NTS Area 13 multiple container fire	$4x10^{-6}$	N/A[c]	$1.4x10^{-7}$ rem $5.6x10^{-11}$ LCF $2.2x10^{-11}$ Det.	$7.0x10^{-7}$ pers. rem $2.8x10^{-10}$ LCF $1.1x10^{-10}$ Det.	$2.4x10^{-7}$ rem $1.2x10^{-10}$ LCF $5.5x10^{-11}$ Det.	$5.1x10^{-6}$ pers. rem $2.6x10^{-9}$ LCF $1.2x10^{-9}$ Det.	$8.8x10^{-5}$ pers. rem $4.4x10^{-8}$ LCF $2.0x10^{-8}$ Det.
TTR Project Roller Coaster site multiple container fire	$4x10^{-6}$	N/A	$1.1x10^{-6}$ rem $4.4x10^{-10}$ LCF $1.8x10^{-10}$ Det.	$1.1x10^{-4}$ pers. rem $4.4x10^{-8}$ LCF $1.8x10^{-8}$ Det.	$3.1x10^{-7}$ rem $1.6x10^{-10}$ LCF $7.1x10^{-11}$ Det.	$1.7x10^{-5}$ pers. rem $8.5x10^{-9}$ LCF $3.9x10^{-9}$ Det.	$3.0x10^{-4}$ pers. rem $1.5x10^{-7}$ LCF $6.9x10^{-8}$ Det.
TTR Project Roller Coaster site airplane crash	$1x10^{-6}$	N/A	$1.2x10^{-2}$ rem $4.8x10^{-6}$ LCF $1.9x10^{-6}$ Det.	1.2 pers. rem $4.8x10^{-4}$ LCF $1.9x10^{-4}$ Det.	$3.4x10^{-3}$ rem $1.7x10^{-6}$ LCF $7.8x10^{-7}$ Det.	$1.9x10^{-1}$ pers. rem $9.5x10^{-5}$ LCF $4.4x10^{-5}$ Det.	3.3 pers. rem $1.7x10^{-3}$ LCF $7.6x10^{-4}$ Det.
NTS Area 13 airplane crash	$7x10^{-7}$	N/A	$1.1x10^{-3}$ rem $4.4x10^{-7}$ LCF $1.8x10^{-7}$ Det.	$5.5x10^{-3}$ pers. rem $2.2x10^{-6}$ LCF $8.8x10^{-7}$ Det.	$2.2x10^{-3}$ rem $1.1x10^{-6}$ LCF $5.1x10^{-7}$ Det.	$4.1x10^{-2}$ pers. rem $2.1x10^{-5}$ LCF $9.4x10^{-6}$ Det.	$7.1x10^{-1}$ pers. rem $3.6x10^{-4}$ LCF $1.6x10^{-4}$ Det.

Table A.5.1-1 Nevada Test Site and Off-Site Areas Radiological Facility Accident Probabilities and Consequences

Alternative 1							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Nondefense Research and Development Program							
No radiological activities	--	--	--	--	--	--	--
Work for Others Program							
No radiological activities	--	--	--	--	--	--	--

[a] Involved workers under cover or evacuated prior to event
[b] Involved workers fatally injured in crash or explosion
[c] Plume rise carries source term over and above nearby worker.

*at the nearest point of public access

Table A.5.1-2 Chemical Accident Probabilities and Consequences

Alternative 1							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Defense Program							
TTR Area 9 - Release of DU and Be from Rocket Test Assembly	$6x10^{-6}$	N/A[b]	$1.4x10^{-8}$ CR $8.8x10^{1}$ERPG1 3.0ERPG2 $3.0x10^{-1}$ERPG3	$1.4x10^{-7}$ CR $8.8x10^{1}$ERPG1 3.0ERPG2 $3.0x10^{-1}$ERPG3	$4.1x10^{-7}$ CR $2.7x10^{2}$ERPG1 $1.0x10^{1}$ERPG2 1.0ERPG3	$1.7x10^{-6}$ CR 1.3ERPG1 $1.6x10^{-1}$ERPG2 $1.6x10^{-2}$ERPG3	$1.1x10^{-7}$ CR $2.4x10^{1}$ERPG1 $3.0x10^{-1}$ERPG2 $3.0x10^{-2}$ERPG3
TTR Area 9 - Fire in Rocket Propellant Storage Building	$1.6x10^{-6}$	N/A[d]	N/A[c] CR 8.3ERPG1 $1.0x10^{-1}$ERPG2 $1.0x10^{-2}$ERPG3	N/A[c] CR 8.3ERPG1 $1.0x10^{-1}$ERPG2 $1.0x10^{-2}$ERPG3	N/A[c] CR $2.5x10^{1}$ERPG1 $3.2x10^{-1}$ERPG2 $3.2x10^{-2}$ERPG3	N/A[c] CR $7.6x10^{-2}$ERPG1 $9.4x10^{-4}$ERPG2 $9.4x10^{-5}$ERPG3	N/A[c] CR 1.2ERPG1 $1.4x10^{-2}$ERPG2 $1.4x10^{-3}$ERPG3
Waste Management Program							
NTS HWSU - Waste Handling	$3x10^{-2}$	$7.2x10^{-1}$ CR $3.8x10^{5}$ERPG1 $3.8x10^{4}$ERPG2 $3.8x10^{3}$ERPG3	$4.1x10^{-3}$ CR $2.2x10^{-1}$ERPG1 2.2ERPG2 $2.2x10^{1}$ERPG3	$4.4x10^{-5}$ CR $4.3x10^{-1}$ERPG1 $4.3x10^{-2}$ERPG2 $4.3x10^{-3}$ERPG3	$4.3x10^{-3}$ CR $3.8x10^{-2}$ERPG1 $3.8x10^{-3}$ERPG2 $3.84x10^{-4}$ERPG3	$1.7x10^{-3}$ CR N/A ERPG[e]	$1.7x10^{-4}$ CR N/A ERPG[e]
NTS HWSU - Fire in Waste	$8x10^{-5}$	N/A[d]	$8.8x10^{-3}$ CR $8.5x10^{3}$ERPG1 $5.1x10^{2}$ERPG2 $5.1x10^{1}$ERPG3	$1.0x10^{-4}$ CR 3.8ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	$1.2x10^{-5}$ CR $8.6x10^{-1}$ERPG1 $1.9x10^{-2}$ERPG2 $1.9x10^{-3}$ERPG3	$3.5x10^{-3}$ CR N/A ERPG[e]	$1.7x10^{-3}$ CR N/A ERPG[e]
NTS HWSU - Airplane Crash into Waste	$1x10^{-7}$	N/A[b]	$6.6x10^{-2}$ CR $6.2x10^{4}$ERPG1 $3.4x10^{3}$ERPG2 $3.4x10^{2}$ERPG3	$1.1x10^{-3}$ CR $1.6x10^{1}$ERPG1 $8.9x10^{-1}$ERPG2 $8.9x10^{-2}$ERPG3	$2.4x10^{-5}$ CR 2.3ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	$2.7x10^{-2}$ CR $8.3x10^{-1}$ERPG1 $4.5x10^{-2}$ERPG2 $4.5x10^{-3}$ERPG3	$1.0x10^{-1}$ CR 1.7ERPG1 $9.6x10^{-2}$ERPG2 $9.6x10^{-3}$ERPG3
Environmental Restoration Program							
NTS Area 5 - Waste Handling	$1.1x10^{-1}$	$1.8x10^{-1}$ CR $1.8x10^{5}$ERPG1 $1.0x10^{4}$ERPG2 $1.0x10^{3}$ERPG3	$1.1x10^{-3}$ CR $1.1x10^{3}$ERPG1 $6.1x10^{1}$ERPG2 6.1ERPG3	$2.6x10^{-5}$ CR $2.9x10^{-1}$ERPG1 $1.6x10^{-2}$ERPG2 $1.8x10^{-3}$ERPG3	$4.1x10^{-7}$ CR $3.8x10^{-2}$ERPG1 $2.2x10^{-3}$ERPG2 $2.2x10^{-4}$ERPG3	$4.5x10^{-4}$ CR N/A ERPG[e]	$1.3x10^{-3}$ CR N/A ERPG[e]
NTS Area 5 - Fire in Staged Waste	$8.0x10^{-5}$	N/A[d]	$4.5x10^{-3}$ CR $3.1x10^{3}$ERPG1 $2.5x10^{2}$ERPG2 $2.5x10^{1}$ERPG3	$4.9x10^{-5}$ CR $7.0X10^{-1}$ERPG1 $5.2x10^{-2}$ERPG2 $5.2x10^{-3}$ERPG3	$5.0x10^{-7}$ CR $8.4x10^{-2}$ERPG1 $5.0x10^{-3}$ERPG2 $5.0x10^{-4}$ERPG3	$1.8x10^{-3}$ CR N/A ERPG[e]	$4.3x10^{-4}$ CR N/A ERPG[e]
NTS Area 5 - Airplane Crash into Staged Waste	$7.0x10^{-7}$	N/A[b]	$8.1x10^{-3}$ CR $5.6x10^{3}$ERPG1 $4.5x10^{2}$ERPG2 $4.5x10^{1}$ERPG3	$9.4x10^{-5}$ CR 1.3ERPG1 $9.7x10^{-2}$ERPG2 $9.7x10^{-3}$ERPG3	$8.5x10^{-6}$ CR $1.5x10^{-1}$ERPG1 $9.8x10^{-3}$ERPG2 $9.8x10^{-4}$ERPG3	$3.3x10^{-3}$ CR $7.6x10^{-2}$ERPG1 $6.1x10^{-3}$ERPG2 $6.1x10^{-4}$ERPG3	$1.5x10^{-3}$ CR $1.0x10^{-1}$ERPG1 $6.5x10^{-3}$ERPG2 $6.5x10^{-4}$ERPG3

Table A.5.1-2 Chemical Accident Probabilities and Consequences (Page 2 of 2)

Alternative 1							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Nondefense Research and Development Program							
NTS LGFSTF - Spill at Chemical Storage Pad	$1.7x10^{-2}$	$1.4x10^{-2}$ CR $4.0x10^{5}$ERPG1 $2.7x10^{5}$ERPG2 $2.7x10^{2}$ERPG3	$1.4x10^{-4}$ CR $4.0x10^{3}$ERPG1 $2.7x10^{1}$ERPG2 2.7ERPG3	$1.7x10^{-5}$ CR 3.2ERPG1 $2.1x10^{-2}$ERPG2 $2.1x10^{-3}$ERPG3	$2.7x10^{-7}$ CR 1.3ERPG1 $8.8x10^{-3}$ERPG2 $8.8x10^{-4}$ERPG3	$8.5x10^{-5}$ CR $2.1x10^{-2}$ERPG1 $1.4x10^{-4}$ERPG2 $1.4x10^{-5}$ERPG3	$1.0x10^{-3}$ CR $7.6x10^{-1}$ERPG1 $5.1x10^{-3}$ERPG2 $5.1x10^{-4}$ERPG3
NTS LGFSTF - Tank Failure at Tank Farm	$1.0x10^{-4}$	$1.9x10^{-1}$ CR $2.2x10^{6}$ERPG1 $4.3x10^{3}$ERPG2 $4.3x10^{2}$ERPG3	$1.9x10^{-3}$ CR $2.2x10^{4}$ERPG1 $4.3x10^{1}$ERPG2 4.3ERPG3	$2.2x10^{-4}$ CR $1.6x10^{1}$ERPG1 $3.2x10^{-2}$ERPG2 $3.2x10^{-3}$ERPG3	$3.6x10^{-6}$ CR 6.9ERPG1 $1.4x10^{-2}$ERPG2 $1.4x10^{-3}$ERPG3	$8.7x10^{-4}$ CR $2.7x10^{-1}$ERPG1 $5.4x10^{-4}$ERPG2 $5.4x10^{-5}$ERPG3	$1.4x10^{-2}$ CR 3.9ERPG1 $7.9x10^{-3}$ERPG2 $7.9x10^{-4}$ERPG3
NTS LGFSTF - Airplane Crash at Tank Farm	$1.0x10^{-7}$	N/A[b]	3.3 CR $5.2x10^{6}$ERPG1 $1.0x10^{4}$ERPG2 $1.0x10^{3}$ERPG3	$5.4x10^{-2}$ CR $4.0x10^{3}$ERPG1 8.0ERPG2 $8.0x10^{-1}$ERPG3	$8.8x10^{-4}$ CR $1.7x10^{3}$ERPG1 3.4ERPG2 $3.4x10^{-1}$ERPG3	$2.1x10^{-1}$ CR $6.5x10^{1}$ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	3.4 CR $9.2x10^{2}$ERPG1 1.9ERPG2 $1.9x10^{-1}$ERPG3
Work for Others Program							
NTS BEEF - Heavy Metal Release	$1.0x10^{-2}$	N/A[b]	$1.8x10^{-4}$ CR $2.3x10^{1}$ERPG1 $4.4x10^{-1}$ERPG2 $4.4x10^{-2}$ERPG3	$6.1x10^{-7}$ CR $2.1x10^{-3}$ERPG1 $4.0x10^{-5}$ERPG2 $4.0x10^{-6}$ERPG3	$1.4x10^{-9}$ CR $9.7x10^{-5}$ERPG1 $1.9x10^{-6}$ERPG2 $1.9x10^{-7}$ERPG3	$2.9x10^{-6}$ CR N/A ERPG[e]	$1.3x10^{-7}$ CR N/A ERPG[e]

[a] Individual cancer risk is expressed as the increased probability of developing cancer. Population cancer risk is expressed as the increased number of cancers within the population

[b] N/A - Physical impacts of the event dominate consequences to involved workers

[c] No RfC is available in either IRIS or HEAST for chemicals of concern

[d] N/A - Plume rise from the fire carries the source term over and above nearby workers

[e] N/A - ERPG hazard indices are significantly below 1.0 at 20 km. All other public exposures occur at distances >20 km.

*at the nearest point of public access

Table A.5.2-1 Nevada Test Site and Off-Site Areas Radiological Facility Accident Probabilities and Consequences

Alternative 2							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Defense Program							
TTR test assembly mechanical release of Pu	$1x10^{-6}$	N/A[a]	$1.3x10^{-2}$ rem $5.2x10^{-6}$ LCF $2.1x10^{-6}$Det.	$2.6x10^{-1}$ pers. rem $1.0x10^{-4}$ LCF $4.2x10^{-5}$ Det.	$6.7x10^{-3}$ rem $3.4x10^{-6}$LCF $1.5x10^{-6}$Det.	$5.4x10^{-4}$ pers. rem $2.7x10^{-7}$ LCF $1.2x10^{-7}$ Det.	$9.4x10^{-3}$ pers. rem $4.7x10^{-6}$ LCF $2.2x10^{-6}$ Det.
TTR artillery fired test assembly failure	$1 x10^{-7}$	N/A[a]	$7.1x10^{1}$ rem $5.7x10^{-2}$ LCF $2.3x10^{-2}$ Det.	$7.1x10^{3}$ pers. rem 5.7 LCF 2.3 Det.	2.3 rem $1.2x10^{-3}$ LCF $5.3x10^{-4}$ Det.	$1.8x10^{1}$ pers. rem $9.0x10^{-3}$ LCF $4.1x10^{-3}$ Det.	$3.1x10^{2}$ pers. rem $1.6x10^{-1}$ LCF $7.1x10^{-2}$ Det.
Waste Management Program							
Area 5 TRU waste release - two container fire/explosion	$1x10^{-2}$	$7.4x10^{1}$ rem $5.9x10^{-2}$ LCF $3.4x10^{-2}$ Det.	2.3 rem $9.2x10^{-4}$ LCF $3.7x10^{-4}$ Det.	$6.5x10^{-2}$ pers. rem $1.6x10^{-1}$ LCF $6.4x10^{-2}$ Det.	$2.3x10^{-3}$ rem $1.2x10^{-6}$ LCF $5.3x10^{-7}$ Det.	$9.3x10^{-1}$ pers. rem $4.7x10^{-4}$ LCF $2.1x10^{-4}$ Det.	$1.6x10^{1}$ pers. rem $8.0x10^{-3}$ LCF $3.7x10^{-3}$ Det.
Area 5 TRU waste release - five container fire/explosion	$1x10^{-6}$	N/A[b]	3.7 rem $1.5x10^{-3}$ LCF $5.9x10^{-4}$ Det.	$1.0x10^{-1}$ pers. rem $4.0x10^{-5}$ LCF $1.6x10^{-5}$ Det.	$3.6x10^{-3}$ rem $1.8x10^{-6}$ LCF $8.3x10^{-7}$ Det.	1.5 pers. rem $7.5x10^{-4}$ LCF $3.5x10^{-4}$ Det.	$2.6x10^{1}$ pers. rem $1.3x10^{-2}$ LCF $6.0x10^{-3}$ Det.
Environmental Restoration Program							
No environmental restoration activities	--	--	--	--	--	--	--
Nondefense Research and Development Program							
No radiological activities	--	--	--	--	--	--	--
Work for Others Program							
No radiological activities	--	--	--	--	--	--	--

[a] Involved workers under cover or evacuated prior to event

[b] Plume rise carries source term over and above nearby workers.

*at the nearest point of public access

Table A.5.2-2 Chemical Accident Probabilities and Consequences

Alternative 2							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Defense Program							
TTR Area 9 - Release of DU and Be from Rocket Test Assembly	$6x10^{-6}$	N/A[b]	$1.4x10^{-8}$ CR $8.8x10^{1}$ERPG1 3.0ERPG2 $3.0x10^{-1}$ERPG3	$1.4x10^{-7}$ CR $8.8x10^{1}$ERPG1 3.0ERPG2 $3.0x10^{-1}$ERPG3	$4.1x10^{-7}$ CR $2.7x10^{2}$ERPG1 $1.0x10^{1}$ERPG2 1.0ERPG3	$1.7x10^{-6}$ CR 1.3ERPG1 $1.6x10^{-1}$ERPG2 $1.6x10^{-2}$ERPG3	$1.1x10^{-7}$ CR $2.4x10^{1}$ERPG1 $3.0x10^{-1}$ERPG2 $3.0x10^{-2}$ERPG3
TTR Area 9 - Fire in Rocket Propellant Storage Building	$1.6 x10^{-6}$	N/A[d]	N/A[c] CR 8.3ERPG1 $1.0x10^{-1}$ERPG2 $1.0x10^{-2}$ERPG3	N/A[c] CR 8.3ERPG1 $1.0x10^{-1}$ERPG2 $1.0x10^{-2}$ERPG3	N/A[c] CR $2.5x10^{1}$ERPG1 $3.2x10^{-1}$ERPG2 $3.2x10^{-2}$ERPG3	N/A[c] CR $7.6x10^{-2}$ERPG1 $9.4x10^{-4}$ERPG2 $9.4x10^{-5}$ERPG3	N/A[c] CR 1.2ERPG1 $1.4x10^{-2}$ERPG2 $1.4x10^{-3}$ERPG3
Waste Management Program							
NTS HWSU - Waste Handling	$3x10^{-2}$	$7.2x10^{-1}$ CR $3.8x10^{5}$ERPG1 $3.8x10^{4}$ERPG2 $3.8x10^{3}$ERPG3	$4.1x10^{-3}$ CR $2.2x10^{-1}$ERPG1 2.2ERPG2 $2.2x10^{1}$ERPG3	$4.4x10^{-5}$ CR $4.3x10^{-1}$ERPG1 $4.3x10^{-2}$ERPG2 $4.3x10^{-3}$ERPG3	$4.3x10^{-3}$ CR $3.8x10^{-2}$ERPG1 $3.8x10^{-3}$ERPG2 $3.8x10^{-4}$ERPG3	$1.7x10^{-3}$ CR N/A ERPG[e]	$1.7x10^{-4}$ CR N/A ERPG[e]
NTS HWSU - Fire in Waste	$8x10^{-5}$	N/A[d]	$8.7x10^{-3}$ CR $8.5x10^{3}$ERPG1 $5.1x10^{2}$ERPG2 $5.1x10^{1}$ERPG3	$1.0x10^{-4}$ CR 3.8ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	$1.2x10^{-6}$ CR $8.6x10^{-1}$ERPG1 $1.9x10^{-2}$ERPG2 $1.9x10^{-3}$ERPG3	$3.5x10^{-3}$ CR N/A ERPG[e]	$1.7x10^{-4}$ CR N/A ERPG[e]
Environmental Restoration Program							
N/A[e]							
Nondefense Research and Development Program							
N/A[e]							
Work for Others Program							
N/A[e]							

[a] Individual cancer risk is expressed as the increased probability of developing cancer. Population cancer risk is expressed as the increased number of cancers within the population

[b] N/A - Physical impacts of the event dominate consequences to involved workers

[c] No RfC is available in either IRIS or HEAST for chemicals of concern

[d] N/A - Plume rise from the fire carries the source term over and above nearby workers.

[e] N/A - No activities proposed for this program under this alternative.

*at the nearest point of public access

Table A.5.3-1 Nevada Test Site and Off-Site Areas Radiological Facility Accident Probabilities and Consequences

(Page 1 of 2)

Alternative 3							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Defense Program							
Accidental venting from an underground test	$3x10^{-3}$/test	N/A[a]	1.6 rem $6.7x10^{-4}$ LCF $2.6x10^{-4}$Det.	$1.6x10^{1}$ pers. rem $6.6x10^{-3}$ LCF $2.6x10^{-3}$ Det.	2.0 rem $1.0x10^{-3}$ LCF $4.6x10^{-4}$ Det.	$3.6x10^{2}$ pers. rem $1.8x10^{-1}$ LCF $8.3x10^{-2}$ Det.	N/A
P-Tunnel mechanical release of plutonium during handling	$1 x10^{-3}$	$1.5x10^{2}$ rem $1.2x10^{-1}$ LCF $4.8x10^{-2}$ Det.	4.5 rem $1.8x10^{-3}$ LCF $7.2x10^{-4}$ Det.	$5.4x10^{2}$ pers. rem $4.3x10^{-1}$ LCF $1.7x10^{-1}$ Det.	$3.5x10^{-4}$ rem $1.8x10^{-7}$ LCF $8.1x10^{-8}$ Det.	$7.0x10^{-2}$ per. rem $3.5x10^{-5}$ LCF $1.6x10^{-5}$ Det.	1.2 pers. rem $6.0x10^{-4}$ LCF $2.8x10^{-4}$ Det.
DAF explosion involving 55 lb. HE and 5 kg Pu	$2x10^{-6}$	N/A[b]	$1.2x10^{3}$ rem $9.6x10^{-1}$ LCF $3.8x10^{-1}$Det.	$1.1x10^{2}$ pers. rem $4.4x10^{-2}$ LCF $1.8x10^{-2}$ Det.	$1.9x10^{-1}$ rem $9.3x10^{-5}$ LCF $4.3x10^{-5}$ Det.	$1.1x10^{2}$ pers. rem $5.5x10^{-2}$ LCF $2.5x10^{-2}$ Det.	$1.9x10^{3}$ pers. rem $9.5x10^{-1}$ LCF $4.4x10^{-1}$ Det.
TTR Test Assembly mechanical release of Pu	$1x10^{-6}$	N/A[b]	$1.3x10^{-2}$ rem $5.2x10^{-6}$ LCF $2.1x10^{-6}$ Det.	$2.6x10^{-1}$ pers. rem $1.0x10^{-4}$ LCF $4.2x10^{-5}$ Det.	$6.7x10^{-3}$ rem $3.4x10^{-6}$ LCF $1.5x10^{-6}$ Det.	$5.4x10^{-4}$ pers. rem $2.7x10^{-7}$ LCF $1.2x10^{-7}$ Det.	$9.4x10^{-3}$ pers. rem $4.7x10^{-6}$ LCF $2.2x10^{-6}$ Det.
Area 27 explosion in interim stored nuclear weapons	$1x10^{-7}$	N/A[b]	$6.2x10^{4}$ rem 1.0 LCF 1.0 Det.	$1.6x10^{4}$ pers. rem 6.4 LCF 2.6 Det.	$3.4x10^{1}$ rem $3.4x10^{-2}$ LCF $1.6x10^{-2}$ Det.	$5.8x10^{3}$ pers. rem 2.9 LCF 1.3 Det.	$1.1x10^{5}$ pers. rem $5.5x10^{1}$ LCF $2.5x10^{1}$ Det.
TTR artillery fired test assembly failure	$1x10^{-7}$	N/A[a]	$7.1x10^{1}$ rem $5.7x10^{-2}$ LCF $2.3x10^{-2}$ Det.	$7.1x10^{3}$ pers. rem 5.7 LCF 2.3 Det.	2.3 rem $1.2x10^{-3}$ LCF $5.3x10^{-4}$ Det.	$1.8x10^{1}$ pers. rem $9.0x10^{-3}$ LCF $4.1x10^{-3}$ Det.	$3.1x10^{2}$ pers. rem $1.6x10^{-1}$ LCF $7.1x10^{-2}$ Det.
Waste Management							
Area 5 TRU waste release - two container fire/explosion	$1x10^{-2}$	$7.4x10^{1}$ rem $5.9x10^{-2}$ LCF $3.4x10^{-2}$ Det.	2.3 rem $9.2x10^{-4}$ LCF $3.7x10^{-4}$ Det.	$6.5x10^{-2}$ pers. rem $1.6x10^{-1}$ LCF $6.4x10^{-2}$ Det.	$2.3x10^{-3}$ rem $1.2x10^{-6}$ LCF $5.3x10^{-7}$ Det.	$9.3x10^{-1}$ pers. rem $4.7x10^{-4}$ LCF $2.1x10^{-4}$ Det.	$1.6x10^{1}$ pers. rem $8.0x10^{-3}$ LCF $3.7x10^{-3}$ Det.
Area 5 TRU waste release - five container fire/explosion	$1x10^{-6}$	N/A[c]	3.7 rem $1.5x10^{-3}$ LCF $5.9x10^{-4}$ Det.	$1.0x10^{-1}$ pers. rem $4.0x10^{-5}$ LCF $1.6x10^{-5}$ Det.	$3.6x10^{-3}$ rem $1.8x10^{-6}$ LCF $8.3x10^{-6}$ Det.	1.5 pers. rem $7.5x10^{-4}$ LCF $3.5x10^{-4}$ Det.	$2.6x10^{1}$ pers. rem $1.3x10^{-2}$ LCF $6.0x10^{-3}$ Det.
Area 5 TRU waste airplane crash	$6x10^{-7}$	N/A[b]	$3.5x10^{3}$ rem 1.0 LCF 1.0 Det.	$9.9x10^{1}$ pers. rem $4.0x10^{-2}$ LCF $1.6x10^{-2}$ Det.	3.5 rem $1.8x10^{-3}$ LCF $8.0x10^{-4}$ Det.	$1.4x10^{3}$ pers. rem $7.0x10^{-1}$ LCF $3.2x10^{-1}$ Det.	$2.5x10^{4}$ pers. rem $1.3x10^{1}$ LCF 5.8 Det.
Environmental Restoration Program							
NTS Area 13 single container spill	$3x10^{-2}$	$3.0x10^{-3}$ rem $1.2x10^{-6}$ LCF $4.8x10^{-7}$ Det.	$1.5x10^{-8}$ rem $6.0x10^{-12}$ LCF $2.4x10^{-12}$ Det.	$7.5x10^{-8}$ pers. rem $3.3x10^{-6}$ LCF $1.3x10^{-6}$ Det.	$6.0x10^{-9}$ rem $3.0x10^{-12}$ LCF $1.4x10^{-12}$ Det.	$5.6x10^{-7}$ pers. rem $2.8x10^{-10}$ LCF $1.3x10^{-10}$ Det.	$9.7x10^{-6}$ pers. rem $4.9x10^{-9}$ LCF $2.2x10^{-9}$ Det.
TTR Project Roller Coaster site single container spill	$3x10^{-2}$	$3.0x10^{-3}$ rem $1.2x10^{-3}$ LCF $4.8x10^{-4}$ Det.	$1.2x10^{-7}$ rem $4.8x10^{-11}$ LCF $1.9x10^{-11}$ Det.	$1.2x10^{-5}$ pers.rem $3.3x10^{-6}$ LCF $1.3x10^{-6}$ Det.	$3.4x10^{-8}$ rem $1.7x10^{-11}$ LCF $7.8x10^{-12}$ Det.	$1.9x10^{-6}$ pers. rem $9.5x10^{-10}$ LCF $4.4x10^{-10}$ Det.	$3.3x10^{-5}$ pers. rem $1.7x10^{-8}$ LCF $7.6x10^{-9}$ Det.
NTS Area 13 multiple container fire	$4x10^{-6}$	N/A[c]	$1.4x10^{-7}$ rem $5.6x10^{-11}$ LCF $2.2x10^{-11}$ Det.	$7.0x10^{-7}$ pers. rem $2.8x10^{-10}$ LCF $1.1x10^{-10}$ Det.	$2.4x10^{-7}$ rem $1.2x10^{-10}$ LCF $5.5x10^{-11}$ Det.	$5.1x10^{-6}$ pers. rem $2.6x10^{-9}$ LCF $1.2x10^{-9}$ Det.	$8.8x10^{-5}$ pers. rem $4.4x10^{-8}$ LCF $2.0x10^{-8}$ Det.
TTR Project Roller Coaster site multiple container fire	$4x10^{-6}$	N/A[c]	$1.1x10^{-6}$ rem $4.4x10^{-10}$ LCF $1.8x10^{-10}$ Det.	$1.1x10^{-4}$ pers. rem $4.4x10^{-8}$ LCF $1.8x10^{-8}$ Det.	$3.1x10^{-7}$ rem $1.6x10^{-10}$ LCF $7.1x10^{-11}$ Det.	$1.7x10^{-5}$ pers. rem $8.5x10^{-9}$ LCF $3.9x10^{-9}$ Det.	$3.0x10^{-4}$ pers. rem $1.5x10^{-7}$ LCF $6.9x10^{-8}$ Det.
TTR Project Roller Coaster site airplane crash	$1x10^{-6}$	N/A[b]	$1.2x10^{-2}$ rem $4.8x10^{-6}$ LCF $1.9x10^{-6}$ Det.	1.2 pers. rem $4.8x10^{-4}$ LCF $1.9x10^{-4}$ Det.	$3.4x10^{-3}$ rem $1.7x10^{-6}$ LCF $7.8x10^{-7}$ Det.	$1.9x10^{-1}$ pers. rem $9.5x10^{-5}$ LCF $4.4x10^{-5}$ Det.	3.3 pers. rem $1.7x10^{-3}$ LCF $7.6x10^{-4}$ Det.
NTS Area 13 airplane crash	$7x10^{-7}$	N/A[b]	$1.1x10^{-3}$ rem $4.4x10^{-7}$ LCF $1.8x10^{-7}$ Det.	$5.5x10^{-3}$ pers. rem $2.2x10^{-6}$ LCF $8.8x10^{-7}$ Det.	$2.2x10^{-3}$ rem $1.1x10^{-6}$ LCF $5.1x10^{-7}$ Det.	$4.1x10^{-2}$ pers. rem $2.1x10^{-5}$ LCF $9.4x10^{-6}$ Det.	$7.1x10^{-1}$ pers. rem $3.6x10^{-4}$ LCF $1.6x10^{-4}$ Det.

Table A.5.3-1 Nevada Test Site and Off-Site Areas Radiological Facility Accident Probabilities and Consequences

Alternative 3							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Nondefense Research and Development Program							
No radiological activities	--	--	--	--	--	--	--
Work for Others Program							
BEEF 100 Ci tritium release	$2x10^{-2}$	1.0 rem $4.0x10^{-4}$ LCF $1.6x10^{-4}$ Det.	$3.5x10^{-2}$ rem $1.4x10^{-5}$ LCF $5.6x10^{-6}$ Det.	2.9 pers. rem $1.2x10^{-3}$ LCF $4.6x10^{-4}$ Det.	$4.7x10^{-6}$ rem $2.4x10^{-9}$ LCF $1.1x10^{-9}$ Det.	$2.0x10^{-3}$ pers. rem $1.0x10^{-6}$ LCF $4.6x10^{-7}$ Det.	$3.5x10^{-2}$ pers. rem $1.8x10^{-5}$ LCF $8.1x10^{-6}$ Det.
BEEF 1,000 Ci tritium release	$3x10^{-5}$	N/A[b]	$3.5x10^{-1}$ rem $1.4x10^{-4}$ LCF $5.6x10^{-5}$ Det.	$6.0x10^{-3}$ pers. rem $2.4x10^{-6}$ LCF $9.6x10^{-7}$ Det.	$4.7x10^{-5}$ rem $2.4x10^{-8}$ LCF $1.1x10^{-8}$ Det	$2.0x10^{-2}$ pers. rem $1.0x10^{-5}$ LCF $4.6x10^{-6}$ Det.	$3.5x10^{-1}$ pers. rem $1.8x10^{-4}$ LCF $8.1x10^{-5}$ Det.

[a] Involved workers under cover or evacuated prior to event.
[b] Involved workers fatally injured in crash or explosion
[c] Plume rise carries source term over and above nearby workers.

*at the nearest point of public access

Table A.5.3-2 Chemical Accident Probabilities and Consequences (Page 1 of 2)

Alternative 3							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Defense Program							
TTR Area 9 - Release of DU and Be from Rocket Test Assembly	$6x10^{-6}$	N/A[b]	$1.4x10^{-8}$ CR $8.8x10^{1}$ERPG1 3.0ERPG2 $3.0x10^{-1}$ERPG3	$1.4x10^{-7}$ CR $8.8x10^{1}$ERPG1 3.0ERPG2 $3.0x10^{-1}$ERPG3	$4.1x10^{-7}$ CR $2.7x10^{2}$ERPG1 $1.0x10^{1}$ERPG2 1.0ERPG3	$1.7x10^{-6}$ CR 1.3ERPG1 $1.6x10^{-1}$ERPG2 $1.6x10^{-2}$ERPG3	$1.1x10^{-7}$ CR $2.4x10^{1}$ERPG1 $3.0x10^{-1}$ERPG2 $3.0x10^{-2}$ERPG3
TTR Area 9 - Fire in Rocket Propellant Storage Building	$1.6x10^{-6}$	N/A[d]	N/A[c] CR 8.3ERPG1 $1.0x10^{-1}$ERPG2 $1.0x10^{-2}$ERPG3	N/A[c] CR 8.3ERPG1 $1.0x10^{-1}$ERPG2 $1.0x10^{-2}$ERPG3	N/A[c] CR $2.5x10^{1}$ERPG1 $3.2x10^{-1}$ERPG2 $3.2x10^{-2}$ERPG3	N/A[c] CR $7.6x10^{-2}$ERPG1 $9.4x10^{-4}$ERPG2 $9.4x10^{-5}$ERPG3	N/A[c] CR 1.2ERPG1 $1.4x10^{-2}$ERPG2 $1.4x10^{-3}$ERPG3
Waste Management Program							
NTS HWSU - Waste Handling	$3x10^{-2}$	$7.2x10^{-1}$ CR $3.8x10^{5}$ERPG1 $3.8x10^{4}$ERPG2 $3.8x10^{3}$ERPG3	$4.1x10^{-3}$ CR $2.2x10^{-1}$ERPG1 2.2ERPG2 $2.2x10^{1}$ERPG3	$4.4x10^{-5}$ CR $4.3x10^{-1}$ERPG1 $4.3x10^{-2}$ERPG2 $4.3x10^{-3}$ERPG3	$4.3x10^{-3}$ CR $3.8x10^{-2}$ERPG1 $3.8x10^{-3}$ERPG2 $3.84x10^{-4}$ERPG3	$1.7x10^{-3}$ CR N/A ERPG[e]	$1.7x10^{-4}$ CR N/A ERPG[e]
NTS HWSU - Fire in Waste	$8x10^{-5}$	N/A[d]	$8.8x10^{-3}$ CR $8.5x10^{3}$ERPG1 $5.1x10^{2}$ERPG2 $5.1x10^{1}$ERPG3	$1.0x10^{-4}$ CR 3.8ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	$1.2x10^{-6}$ CR $8.6x10^{-1}$ERPG1 $1.9x10^{-2}$ERPG2 $1.9x10^{-3}$ERPG3	$3.5x10^{-3}$ CR N/A ERPG[e]	$1.7x10^{-3}$ CR N/A ERPG[e]
NTS HWSU - Airplane Crash into Waste	$1x10^{-7}$	N/A[b]	$6.6x10^{-2}$ CR $6.2x10^{4}$ERPG1 $3.4x10^{3}$ERPG2 $3.4x10^{2}$ERPG3	$1.1x10^{-3}$ CR $1.6x10^{1}$ERPG1 $8.9x10^{-1}$ERPG2 $8.9x10^{-2}$ERPG3	$2.4x10^{-5}$ CR 2.3ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	$2.7x10^{-2}$ CR $8.3x10^{-1}$ERPG1 $4.5x10^{-2}$ERPG2 $4.5x10^{-3}$ERPG3	$1.0x10^{-1}$ CR 1.7ERPG1 $9.6x10^{-2}$ERPG2 $9.6x10^{-3}$ERPG3
Environmental Restoration Program							
NTS Area 5 - Waste Handling	$1.1x10^{-1}$	$1.8x10^{-1}$ CR $1.8x10^{5}$ERPG1 $1.0x10^{4}$ERPG2 $1.0x10^{3}$ERPG3	$1.1x10^{-3}$ CR $1.1x10^{3}$ERPG1 $6.1x10^{1}$ERPG2 6.1ERPG3	$2.6x10^{-5}$ CR $2.9x10^{-1}$ERPG1 $1.6x10^{-2}$ERPG2 $1.8x10^{-3}$ERPG3	$4.1x10^{-7}$ CR $3.8x10^{-2}$ERPG1 $2.2x10^{-3}$ERPG2 $2.2x10^{-4}$ERPG3	$4.5x10^{-4}$ CR N/A ERPG[e]	$1.3x10^{-3}$ CR N/A ERPG[e]
NTS Area 5 - Fire in Staged Waste	$8.0x10^{-5}$	N/A[d]	$4.5x10^{-3}$ CR $3.1x10^{3}$ERPG1 $2.5x10^{2}$ERPG2 $2.5x10^{1}$ERPG3	$4.9x10^{-5}$ CR $7.0X10^{-1}$ERPG1 $5.2x10^{-2}$ERPG2 $5.2x10^{-3}$ERPG3	$5.0x10^{-7}$ CR $8.4x10^{-2}$ERPG1 $5.0x10^{-3}$ERPG2 $5.0x10^{-4}$ERPG3	$1.8x10^{-3}$ CR N/A ERPG[e]	$4.3x10^{-4}$ CR N/A ERPG[e]
NTS Area 5 - Airplane Crash into Staged Waste	$7.0x10^{-7}$	N/A[b]	$8.1x10^{-3}$ CR $5.6x10^{3}$ERPG1 $4.5x10^{2}$ERPG2 $4.5x10^{1}$ERPG3	$9.4x10^{-5}$ CR 1.3ERPG1 $9.7x10^{-2}$ERPG2 $9.7x10^{-3}$ERPG3	$8.5x10^{-6}$ CR $1.5x10^{-1}$ERPG1 $9.8x10^{-3}$ERPG2 $9.8x10^{-4}$ERPG3	$3.3x10^{-3}$ CR $7.6x10^{-2}$ERPG1 $6.1x10^{-3}$ERPG2 $6.1x10^{-4}$ERPG3	$1.5x10^{-3}$ CR $1.0x10^{-1}$ERPG1 $6.5x10^{-3}$ERPG2 $6.5x10^{-4}$ERPG3
Nondefense Research and Development Program							
NTS LGFSTF - Spill at Chemical Storage Pad	$1.7x10^{-2}$	$1.4x10^{-2}$ CR $4.0x10^{5}$ERPG1 $2.7x10^{3}$ERPG2 $2.7x10^{2}$ERPG3	$1.4x10^{-4}$ CR $4.0x10^{3}$ERPG1 $2.7x10^{1}$ERPG2 2.7ERPG3	$1.7x10^{-5}$ CR 3.2ERPG1 $2.1x10^{-2}$ERPG2 $2.1x10^{-3}$ERPG3	$2.7x10^{-7}$ CR 1.3ERPG1 $8.8x10^{-3}$ERPG2 $8.8x10^{-4}$ERPG3	$8.5x10^{-5}$ CR $2.1x10^{-2}$ERPG1 $1.4x10^{-4}$ERPG2 $1.4x10^{-5}$ERPG3	$1.0x10^{-3}$ CR $7.6x10^{-1}$ERPG1 $5.1x10^{-3}$ERPG2 $5.1x10^{-4}$ERPG3
NTS LGFSTF - Tank Failure at Tank Farm	$1.0x10^{-4}$	$1.9x10^{-1}$ CR $2.2x10^{6}$ERPG1 $4.3x10^{3}$ERPG2 $4.3x10^{2}$ERPG3	$1.9x10^{-3}$ CR $2.2x10^{4}$ERPG1 $4.3x10^{1}$ERPG2 4.3ERPG3	$2.2x10^{-4}$ CR $1.6x10^{1}$ERPG1 $3.2x10^{-2}$ERPG2 $3.2x10^{-3}$ERPG3	$3.6x10^{-6}$ CR 6.9ERPG1 $1.4x10^{-2}$ERPG2 $1.4x10^{-3}$ERPG3	$8.7x10^{-4}$ CR $2.7x10^{-1}$ERPG1 $5.4x10^{-4}$ERPG2 $5.4x10^{-5}$ERPG3	$1.4x10^{-2}$ CR 3.9ERPG1 $7.9x10^{-3}$ERPG2 $7.9x10^{-4}$ERPG3
NTS LGFSTF - Airplane Crash at Tank Farm	$1.0x10^{-7}$	N/A[b]	3.3 CR $5.2x10^{6}$ERPG1 $1.0x10^{4}$ERPG2 $1.0x10^{3}$ERPG3	$5.4x10^{-2}$ CR $4.0x10^{3}$ERPG1 8.0ERPG2 $8.0x10^{-1}$ERPG3	$8.8x10^{-4}$ CR $1.7x10^{3}$ERPG1 3.4ERPG2 $3.4x10^{-1}$ERPG3	$2.1x10^{-1}$ CR $6.5x10^{1}$ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	3.4 CR $9.2x10^{2}$ERPG1 1.9ERPG2 $1.9x10^{-1}$ERPG3

Table A.5.3-2 Chemical Accident Probabilities and Consequences

Alternative 3							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Work for Others Program							
NTS BEEF - Heavy Metal Release	1.0×10^{-2}	N/A[b]	1.8×10^{-4} CR 2.3×10^{1} ERPG1 4.4×10^{-1} ERPG2 4.4×10^{-2} ERPG3	6.1×10^{-7} CR 2.1×10^{-3} ERPG1 4.0×10^{-5} ERPG2 4.0×10^{-6} ERPG3	1.4×10^{-9} CR 9.7×10^{-5} ERPG1 1.9×10^{-6} ERPG2 1.9×10^{-7} ERPG3	2.9×10^{-6} CR N/A ERPG[e]	1.3×10^{-7} CR N/A ERPG[e]
NTS BEEF - Depleted Uranium Beryllium, & Heavy Metal Release	1.0×10^{-3}	N/A[b]	8.0×10^{-4} CR 1.0×10^{5} ERPG1 2.4×10^{3} ERPG2 2.4×10^{2} ERPG3	2.8×10^{-6} CR 9.9ERPG1 2.3×10^{-1} ERPG2 2.3×10^{-2} ERPG3	6.3×10^{-9} CR 2.8×10^{-2} ERPG1 6.4×10^{-4} ERPG2 6.4×10^{-5} ERPG3	1.3×10^{-5} CR N/A ERPG[e]	5.6×10^{-7} CR N/A ERPG[e]

[a] Individual cancer risk is expressed as the increased probability of developing cancer. Population cancer risk is expressed as the increased number of cancers within the population

[b] N/A - Physical impacts of the event dominate consequences to involved workers

[c] No RfC is available in either IRIS or HEAST for chemicals of concern

[d] N/A - Plume rise from the fire carries the source term over and above nearby workers

[e] N/A - ERPG hazard indices are significantly below 1.0 at 20 km. All other public exposures occur at distances >20 km.

*at the nearest point of public access

Table A.5.4-1 Nevada Test Site and Off-Site Areas Radiological Facility Accident Probabilities Consequences

Alternative 4							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Defense Program							
TTR test assembly mechanical release of Pu	$1x10^{-6}$	N/A[a]	$1.3x10^{-2}$ rem $5.2x10^{-6}$ LCF $2.1x10^{-6}$Det.	$2.6x10^{-1}$ pers. rem $1.0x10^{-4}$ LCF $4.2x10^{-5}$ Det.	$6.7x10^{-3}$ rem $3.4x10^{-6}$LCF $1.5x10^{-6}$Det.	$5.4x10^{-4}$ pers. rem $2.7x10^{-7}$ LCF $1.2x10^{-7}$ Det.	$9.4x10^{-3}$ pers. rem $4.7x10^{-6}$ LCF $2.2x10^{-6}$ Det.
TTR artillery fired test assembly failure	$1 x10^{-7}$	N/A[a]	$7.1x10^{1}$ rem $5.7x10^{-2}$ LCF $2.3x10^{-2}$ Det.	$7.1x10^{3}$ pers. rem 5.7 LCF 2.3 Det.	2.3 rem $1.2x10^{-3}$ LCF $5.3x10^{-4}$ Det.	$1.8x10^{1}$ pers. rem $9.0x10^{-3}$ LCF $4.1x10^{-3}$ Det.	$3.1x10^{2}$ pers. rem $1.6x10^{-1}$ LCF $7.1x10^{-2}$ Det.
Waste Management Program							
Area 5 TRU waste release - two container fire/explosion	$1x10^{-2}$	$7.4x10^{1}$ rem $5.9x10^{-2}$ LCF $3.4x10^{-2}$ Det.	2.3 rem $9.2x10^{-4}$ LCF $3.7x10^{-4}$ Det.	$6.5x10^{-2}$ pers. rem $1.6x10^{-1}$ LCF $6.4x10^{-2}$ Det.	$2.3x10^{-3}$ rem $1.2x10^{-6}$ LCF $5.3x10^{-7}$ Det.	$9.3x10^{-1}$ pers. rem $4.7x10^{-4}$ LCF $2.1x10^{-4}$ Det.	$1.6x10^{1}$ pers. rem $8.0x10^{-3}$ LCF $3.7x10^{-3}$ Det.
Area 5 TRU waste release - five container fire/explosion	$1x10^{-6}$	N/A[c]	3.7 rem $1.5x10^{-3}$ LCF $5.9x10^{-4}$ Det.	$1.0x10^{-1}$ pers. rem $4.0x10^{-5}$ LCF $1.6x10^{-5}$ Det.	$3.6x10^{-3}$ rem $1.8x10^{-6}$ LCF $8.3x10^{-6}$ Det.	1.5 pers. rem $7.5x10^{-4}$ LCF $3.5x10^{-4}$ Det.	$2.6x10^{1}$ pers. rem $1.3x10^{-2}$ LCF $6.0x10^{-3}$ Det.
Area 5 TRU waste airplane crash	$6x10^{-7}$	N/A[b]	$3.5x10^{3}$ rem 1.0 LCF 1.0 Det.	$9.9x10^{1}$ pers. rem $4.0x10^{-2}$ LCF $1.6x10^{-2}$ Det.	3.5 rem $1.8x10^{-3}$ LCF $8.0x10^{-4}$ Det.	$1.4x10^{3}$ pers. rem $7.0x10^{-1}$ LCF $3.2x10^{-1}$ Det.	$2.5x10^{4}$ pers. rem $1.3x10^{1}$ LCF 5.8 Det.
Environmental Restoration Program							
NTS Area 13 single container spill	$3x10^{-2}$	$3.0x10^{-3}$ rem $1.2x10^{-6}$ LCF $4.8x10^{-7}$ Det.	$1.5x10^{-8}$ rem $6.0x10^{-12}$ LCF $2.4x10^{-12}$ Det.	$7.5x10^{-8}$ pers. rem $3.3x10^{-6}$ LCF $1.3x10^{-6}$ Det.	$6.0x10^{-9}$ rem $3.0x10^{-12}$ LCF $1.4x10^{-12}$ Det.	$5.6x10^{-7}$ pers. rem $2.8x10^{-10}$ LCF $1.3x10^{-10}$ Det.	$9.7x10^{-6}$ pers. rem $4.9x10^{-9}$ LCF $2.2x10^{-9}$ Det.
TTR Project Roller Coaster site single container spill	$3x10^{-2}$	$3.0x10^{-3}$ rem $1.2x10^{-3}$ LCF $4.8x10^{-4}$ Det.	$1.2x10^{-7}$ rem $4.8x10^{-11}$ LCF $1.9x10^{-11}$ Det.	$1.2x10^{-5}$ pers.rem $3.3x10^{-6}$ LCF $1.3x10^{-6}$ Det.	$3.4x10^{-8}$ rem $1.7x10^{-11}$ LCF $7.8x10^{-12}$ Det.	$1.9x10^{-6}$ pers. rem $9.5x10^{-10}$ LCF $4.4x10^{-10}$ Det.	$3.3x10^{-5}$ pers. rem $1.7x10^{-8}$ LCF $7.6x10^{-9}$ Det.
NTS Area 13 multiple container fire	$4x10^{-6}$	N/A[c]	$1.4x10^{-7}$ rem $5.6x10^{-11}$ LCF $2.2x10^{-11}$ Det.	$7.0x10^{-7}$ pers. rem $2.8x10^{-10}$ LCF $1.1x10^{-10}$ Det.	$2.4x10^{-7}$ rem $1.2x10^{-10}$ LCF $5.5x10^{-11}$ Det.	$5.1x10^{-6}$ pers. rem $2.6x10^{-9}$ LCF $1.2x10^{-9}$ Det.	$8.8x10^{-5}$ pers. rem $4.4x10^{-8}$ LCF $2.0x10^{-8}$ Det.
TTR Project Roller Coaster site multiple container fire	$4x10^{-6}$	N/A[c]	$1.1x10^{-6}$ rem $4.4x10^{-10}$ LCF $1.8x10^{-10}$ Det.	$1.1x10^{-4}$ pers. rem $4.4x10^{-8}$ LCF $1.8x10^{-8}$ Det.	$3.1x10^{-7}$ rem $1.6x10^{-10}$ LCF $7.1x10^{-11}$ Det.	$1.7x10^{-5}$ pers. rem $8.5x10^{-9}$ LCF $3.9x10^{-9}$ Det.	$3.0x10^{-4}$ pers. rem $1.5x10^{-7}$ LCF $6.9x10^{-8}$ Det.
TTR Project Roller Coaster site airplane crash	$1x10^{-6}$	N/A[b]	$1.2x10^{-2}$ rem $4.8x10^{-6}$ LCF $1.9x10^{-6}$ Det.	1.2 pers. rem $4.8x10^{-4}$ LCF $1.9x10^{-4}$ Det.	$3.4x10^{-3}$ rem $1.7x10^{-6}$ LCF $7.8x10^{-7}$ Det.	$1.9x10^{-1}$ pers. rem $9.5x10^{-5}$ LCF $4.4x10^{-5}$ Det.	3.3 pers. rem $1.7x10^{-3}$ LCF $7.6x10^{-4}$ Det.
NTS Area 13 airplane crash	$7x10^{-7}$	N/A[b]	$1.1x10^{-3}$ rem $4.4x10^{-7}$ LCF $1.8x10^{-7}$ Det.	$5.5x10^{-3}$ pers. rem $2.2x10^{-6}$ LCF $8.8x10^{-7}$ Det.	$2.2x10^{-3}$ rem $1.1x10^{-6}$ LCF $5.1x10^{-7}$ Det.	$4.1x10^{-2}$ pers. rem $2.1x10^{-5}$ LCF $9.4x10^{-6}$ Det.	$7.1x10^{-1}$ pers. rem $3.6x10^{-4}$ LCF $1.6x10^{-4}$ Det.
Nondefense Research and Development Program							
No radiological activities	--	--	--	--	--	--	--
Work for Others Program							
No radiological activities	--	--	--	--	--	--	--

[a] Involved workers under cover or evacuated prior to event
[b] Involved workers fatally injured in crash or explosion
[c] Plume rise carries source term over and above nearby worker.

*at the nearest point of public access

Table A.5.4-2 Chemical Accident Probabilities and Consequences

Alternative 4							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Defense Program							
TTR Area 9 - Release of DU and Be from Rocket Test Assembly	$6x10^{-6}$	N/A[b]	$1.4x10^{-8}$ CR $8.8x10^{1}$ERPG1 3.0ERPG2 $3.0x10^{-1}$ERPG3	$1.4x10^{-7}$ CR $8.8x10^{1}$ERPG1 3.0ERPG2 $3.0x10^{-1}$ERPG3	$4.1x10^{-7}$ CR $2.7x10^{2}$ERPG1 $1.0x10^{1}$ERPG2 1.0ERPG3	$1.7x10^{-6}$ CR 1.3ERPG1 $1.6x10^{-1}$ERPG2 $1.6x10^{-2}$ERPG3	$1.1x10^{-7}$ CR $2.4x10^{1}$ERPG1 $3.0x10^{-1}$ERPG2 $3.0x10^{-2}$ERPG3
TTR Area 9 - Fire in Rocket Propellant Storage Building	$1.6 x10^{-6}$	N/A[d]	N/A[c] CR 8.3ERPG1 $1.0x10^{-1}$ERPG2 $1.0x10^{-2}$ERPG3	N/A[c] CR 8.3ERPG1 $1.0x10^{-1}$ERPG2 $1.0x10^{-2}$ERPG3	N/A[c] CR $2.5x10^{1}$ERPG1 $3.2x10^{-1}$ERPG2 $3.2x10^{-2}$ERPG3	N/A[c] CR $7.6x10^{-2}$ERPG1 $9.4x10^{-4}$ERPG2 $9.4x10^{-5}$ERPG3	N/A[c] CR 1.2ERPG1 $1.4x10^{-2}$ERPG2 $1.4x10^{-3}$ERPG3
Waste Management Program							
NTS HWSU - Waste Handling	$3x10^{-2}$	$7.2x10^{-1}$ CR $3.8x10^{5}$ERPG1 $3.8x10^{4}$ERPG2 $3.8x10^{3}$ERPG3	$4.1x10^{-3}$ CR $2.2x10^{-1}$ERPG1 2.2ERPG2 $2.2x10^{1}$ERPG3	$4.4x10^{-5}$ CR $4.3x10^{-1}$ERPG1 $4.3x10^{-2}$ERPG2 $4.3x10^{-3}$ERPG3	$4.3x10^{-3}$ CR $3.8x10^{-2}$ERPG1 $3.8x10^{-3}$ERPG2 $3.84x10^{-4}$ERPG3	$1.7x10^{-3}$ CR N/A ERPG[e]	$1.7x10^{-4}$ CR N/A ERPG[e]
NTS HWSU - Fire in Waste	$8x10^{-5}$	N/A[d]	$8.8x10^{-3}$ CR $8.5x10^{3}$ERPG1 $5.1x10^{2}$ERPG2 $5.1x10^{1}$ERPG3	$1.0x10^{-4}$ CR 3.8ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	$1.2x10^{-6}$ CR $8.6x10^{-1}$ERPG1 $1.9x10^{-2}$ERPG2 $1.9x10^{-3}$ERPG3	$3.5x10^{-3}$ CR N/A ERPG[e]	$1.7x10^{-3}$ CR N/A ERPG[e]
NTS HWSU - Airplane Crash into Waste	$1x10^{-7}$	N/A[b]	$6.6x10^{-2}$ CR $6.2x10^{4}$ERPG1 $3.4x10^{3}$ERPG2 $3.4x10^{2}$ERPG3	$1.1x10^{-3}$ CR $1.6x10^{1}$ERPG1 $8.9x10^{-1}$ERPG2 $8.9x10^{-2}$ERPG3	$2.4x10^{-5}$ CR 2.3ERPG1 $1.3x10^{-1}$ERPG2 $1.3x10^{-2}$ERPG3	$2.7x10^{-2}$ CR $8.3x10^{-1}$ERPG1 $4.5x10^{-2}$ERPG2 $4.5x10^{-3}$ERPG3	$1.0x10^{-1}$ CR 1.7ERPG1 $9.6x10^{-2}$ERPG2 $9.6x10^{-3}$ERPG3
Environmental Restoration Program							
NTS Area 5 - Waste Handling	$1.1x10^{-1}$	$1.8x10^{-1}$ CR $1.8x10^{5}$ERPG1 $1.0x10^{4}$ERPG2 $1.0x10^{3}$ERPG3	$1.1x10^{-3}$ CR $1.1x10^{3}$ERPG1 $6.1x10^{1}$ERPG2 6.1ERPG3	$2.6x10^{-5}$ CR $2.9x10^{-1}$ERPG1 $1.6x10^{-2}$ERPG2 $1.8x10^{-3}$ERPG3	$4.1x10^{-7}$ CR $3.8x10^{-2}$ERPG1 $2.2x10^{-3}$ERPG2 $2.2x10^{-4}$ERPG3	$4.5x10^{-4}$ CR N/A ERPG[e]	$4.3x10^{-3}$ CR N/A ERPG[e]
NTS Area 5 - Fire in Staged Waste	$8.0x10^{-5}$	N/A[d]	$4.5x10^{-3}$ CR $3.1x10^{3}$ERPG1 $2.5x10^{2}$ERPG2 $2.5x10^{1}$ERPG3	$4.9x10^{-5}$ CR $7.0x10^{-1}$ERPG1 $5.2x10^{-2}$ERPG2 $5.2x10^{-3}$ERPG3	$5.0x10^{-7}$ CR $8.4x10^{-2}$ERPG1 $5.0x10^{-3}$ERPG2 $5.0x10^{-4}$ERPG3	$1.8x10^{-3}$ CR N/A ERPG[e]	$4.3x10^{-4}$ CR N/A ERPG[e]
NTS Area 5 - Airplane Crash into Staged Waste	$7.0X10^{-7}$	N/A[b]	$8.1x10^{-3}$ CR $5.6x10^{3}$ERPG1 $4.5x10^{2}$ERPG2 $4.5x10^{1}$ERPG3	$9.4x10^{-5}$ CR 1.3ERPG1 $9.7x10^{-2}$ERPG2 $9.7x10^{-3}$ERPG3	$8.5x10^{-6}$ CR $1.5x10^{-1}$ERPG1 $9.8x10^{-3}$ERPG2 $9.8x10^{-4}$ERPG3	$3.3x10^{-3}$ CR $7.6x10^{-2}$ERPG1 $6.1x10^{-3}$ERPG2 $6.1x10^{-4}$ERPG3	$1.5x10^{-3}$ CR $1.0x10^{-1}$ERPG1 $6.5x10^{-3}$ERPG2 $6.5x10^{-4}$ERPG3

Table A.5.4-2 Chemical Accident Probabilities and Consequences (Page 2 of 2)

Alternative 4							
Accident	**Frequency (events/yr)**	**Involved Worker**	**Noninvolved Worker**	**Worker Population**	**Maximally Exposed Individual***	**Population, Neutral 50% Meteorology**	**Population, Stable 95% Meterology**
Nondefense Research and Development Program							
NTS LGFSTF - Spill at Chemical Storage Pad	1.7×10^{-2}	1.4×10^{-2} CR 4.0×10^{5}ERPG1 2.7×10^{5}ERPG2 2.7×10^{2}ERPG3	1.4×10^{-4} CR 4.0×10^{3}ERPG1 2.7×10^{1}ERPG2 2.7ERPG3	1.7×10^{-5} CR 3.2ERPG1 2.1×10^{-2}ERPG2 2.1×10^{-3}ERPG3	2.7×10^{-7} CR 1.3ERPG1 8.8×10^{-3}ERPG2 8.8×10^{-4}ERPG3	8.5×10^{-5} CR 2.1×10^{-2}ERPG1 1.4×10^{-4}ERPG2 1.4×10^{-5}ERPG3	1.0×10^{-3} CR 7.6×10^{-1}ERPG1 5.1×10^{-3}ERPG2 5.1×10^{-4}ERPG3
NTS LGFSTF - Tank Failure at Tank Farm	1.0×10^{-4}	1.9×10^{-1} CR 2.2×10^{6}ERPG1 4.3×10^{5}ERPG2 4.3×10^{2}ERPG3	1.9×10^{-3} CR 2.2×10^{4}ERPG1 4.3×10^{1}ERPG2 4.3ERPG3	2.2×10^{-4} CR 1.6×10^{1}ERPG1 3.2×10^{-2}ERPG2 3.2×10^{-3}ERPG3	3.6×10^{-6} CR 6.9ERPG1 1.4×10^{-2}ERPG2 1.4×10^{-3}ERPG3	8.7×10^{-4} CR 2.7×10^{-1}ERPG1 5.4×10^{-4}ERPG2 5.4×10^{-5}ERPG3	1.4×10^{-2} CR 3.9ERPG1 7.9×10^{-3}ERPG2 7.9×10^{-4}ERPG3
NTS LGFSTF - Airplane Crash at Tank Farm	1.0×10^{-7}	N/A[b]	3.3 CR 5.2×10^{6}ERPG1 1.0×10^{4}ERPG2 1.0×10^{3}ERPG3	5.4×10^{-2} CR 4.0×10^{3}ERPG1 8.0ERPG2 8.0×10^{-1}ERPG3	8.8×10^{-4} CR 1.7×10^{3}ERPG1 3.4ERPG2 3.4×10^{-1}ERPG3	2.1×10^{-1} CR 6.5×10^{1}ERPG1 1.3×10^{-1}ERPG2 1.3×10^{-2}ERPG3	3.4 CR 9.2×10^{2}ERPG1 1.9ERPG2 1.9×10^{-1}ERPG3
Work for Others Program							
N/A[f]							

[a] Individual cancer risk is expressed as the increased probability of developing cancer. Population cancer risk is expressed as the increased number of cancers within the population

[b] N/A - Physical impacts of the event dominate consequences to involved workers

[c] No RfC is available in either IRIS or HEAST for chemicals of concern

[d] N/A - Plume rise from the fire carries the source term over and above nearby workers.

[e] N/A - ERPG hazard indices are significantly below 1.0 at 20 km. All other public exposures occur at distances >20 km

[f] N/A - No activities performed under this program for this alternative.

*at the nearest point of public access

A.6 References

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