D.6 EPIDEMIOLOGIC STUDIES

Several epidemiologic studies have been completed on Y-12 workers to evaluate potential health effects from radiation and chemical exposures. Y-12 workers have also been included in many site-wide Oak Ridge Operations (ORO) health studies. In addition to these reviews, community-wide health patterns have been studied in Anderson and Roane Counties. A synopsis of many of these studies is presented in this section.

D.6.1 Background

Epidemiology is the study of the distribution and determinants of disease in a population. In epidemiologic studies, the distribution of disease is considered in relation to time, place, and person. Populations may be characterized by age, race, and gender distributions, as well as by social characteristics related to health (e.g., income and education), occupation, susceptibility to disease, and exposure to specific agents. Determinants of disease include the causes of disease, and factors that influence the risk of disease. Epidemiologic studies often lead to an understanding of the causes of disease.

The study of the health effects associated with ionizing radiation was first published in the 1930s to evaluate the incidence of cancer among painters who had used radium to paint watch dials from 1910 to 1920. The research and manufacture of nuclear weapons and subsequent radiation exposure occurred beginning in the late 1930s. Since that time, because of the concern with potential adverse health effects, numerous epidemiologic studies have been conducted among workers involved in the manufacture and testing of nuclear weapons. More recently, concerns about the effects of radiological contaminants on public health have resulted in health studies among communities that surround DOE facilities.

D.6.2 Types of Epidemiologic Studies

Ecological Studies. Ecological studies compare associations between people living in geographical areas with disease frequency. A group of people, rather than the individual, is the unit of comparison. Groups can be chosen by neighborhood, city, county, or region where demographic information and incidence and mortality data are available. The differences in the rates of disease between geographical areas can be correlated to certain distinct factors, such as the proximity to a paper factory. An example of an ecological study is the comparison of lung cancer mortality rates among communities with respect to distance from chemical industries.

The major disadvantage of ecological studies is that the measure of exposure is based on the average level of exposure in the community, when what is really of interest is each individual's exposure. Ecological studies do not take into account other factors such as age, race, and individual behaviors that may also be related to disease. As such, these types of studies may lead to incorrect conclusions. For example, the cause of lung cancer in the example above may be explained by a higher percentage of cigarette smoking among individuals in a community with the chemical industries rather than the industrial pollutants themselves. These incorrect conclusions are called an "ecologic fallacy." Due to these limitations, ecological studies are helpful only as initial steps in an investigation to determine the cause of disease.

Cohort Studies. Cohort studies include an identified population that can be classified as being exposed or not exposed to an agent of interest. Occupational studies fit well with a cohort study because workers have an individual work history which can provide the data on exposure for the pattern of disease (or mortality) of interest. Characterization of the exposure may be qualitative (e.g., high, low, or no exposure) or very quantitative (e.g., chemicals in milligrams per cubic meter [mg/m^3]). Job titles and area measurements are often used to estimate exposure in the absence of personal data.

In the cohort study, individuals are tracked for a period of time, and cause of death recorded. In general, overall rates of death and cause-specific rates of death have been assessed for workers at Y-12, and data sources are available from the DOE Comprehensive Epidemiologic Data Resource (CEDR) Program (CEDR 2000). Death rates for the exposed population are compared with death rates of workers who did not have the exposure (internal comparison), or they are compared with expected death rates based on the U.S. population or state death rates (external comparison). If the death rates vary from what is expected, an association is said to exist between the disease and exposure.

Most cohort studies at Y-12 have been historical cohort studies or studies of past exposures. This type of study can be a problem if the exposure records are incomplete. Y-12 studies often have used internal and external estimates of radiation exposure by job classification to approximate missing exposure data. Cohort studies require extremely large populations and are expensive to conduct. While they are not appropriate for studying rare diseases, they may, however, provide a direct estimate of the risk of death from a specific disease and allow an investigator to evaluate many disease end points.

Case-Control Studies. Case-control studies begin with the identification of individuals with a disease (cases) and match them with individuals without the disease (controls). The choice of controls is important, because they must be individuals who are at risk for the disease and are representative of the population that generated the cases. Cases and controls are then compared by the proportion of individuals exposed to the agent of interest. Case-control studies are also called "retrospective studies" because they start with people with the disease and look back in their history for exposure. These studies are well suited for rare disease and are generally used to examine the relationship between a specific disease and exposure.

D.6.3 Community Health Studies

D.6.3.1 *Oak Ridge Health Studies*

The State of Tennessee and DOE signed an agreement in July 1991, allowing the Tennessee Department of Health to sponsor the Oak Ridge Health Studies. An independent group was formed to identify the important historical materials and emission sources from the Oak Ridge sites and to identify any adverse health effects caused by these materials to the surrounding communities. To provide direction and to ensure the independence of the studies, the Oak Ridge Health Agreement Steering Panel was formed, including a panel of experts and local citizens. Project oversight was provided through the Tennessee Department of Health.

A dose reconstruction feasibility study (Phase I) was initiated in 1992 and the contract was awarded to ChemRisk by the State of Tennessee. They reviewed documents and concluded that there was enough information available to reconstruct past releases and offsite doses caused by radioactive and hazardous materials. They also indicated that potential harm to the surrounding population may have occurred from releases of the following contaminants: (1) mercury releases from Y-12, (2) PCBs from all sites, (3) radioactive iodine from ORNL, and (4) radionuclide releases from ORNL. A full-dose, in-depth reconstruction study was initiated in 1994 to investigate these priority contaminants, the quantity released to the environment, and the potential adverse effects to the health of the surrounding population. The Steering Panel added further study of uranium releases because of the historical role of Oak Ridge's uranium work. The mercury, PCB, and uranium investigations are included in this document, since they are relevant to Y-12.

Mercury Health Studies. The Health Studies' investigators reported that the past estimated mercury releases for Y-12 were too low. According to the researchers' estimates, Y-12 released about 70,000 lbs of mercury into the atmosphere from vents and 280,000 lbs into the EFPC between 1950 and 1982. The total of these, about 350,000 pounds, exceeded by about 60,000 lbs previously published estimate by DOE's 1980s Mercury Task Force. The investigators evaluated the toxic effects from elemental mercury, inorganic mercury and organic mercury. The concluded that the greatest potential health risk from the elemental mercury releases was to children in the Scarboro community, living one-half mile from Y-12, and to farm residents along EFPC who may have inhaled enough to cause damage to the central nervous system between

1953 and 1959. The hazard from organic mercury, specifically methylmercury, was estimated to be most toxic to people who ate large amounts of fish from Poplar Creek, the Clinch River, or Watts Bar Lake during this period. Pregnant women who ate fish from these sources between the late 1950s and early 1960s risked brain damage to their fetuses. They estimated that the number of fetuses exposed at a potentially toxic level was likely nearer to 100 than 1,000.

PCB Health Studies. The Health Studies reported that the estimates of PCB releases from the ORR were difficult to quantify since PCBs were not considered hazardous prior to the early 1970s, so releases were not monitored. In 1977, the manufacture of PCBs was banned in the United States. People eating fish from the Clinch River were reported as being at the greatest risk for illness from the PCB releases from the ORR. The report cited the Y-12 releases into EFPC on the east side of the plant as being of particular concern since the creek flows directly through the Oak Ridge community after leaving the plant. The researchers concluded that some fishermen at the Clinch River and Watts Bar Reservoir have eaten enough fish from these sources to affect their health, but estimates of how many have been affected are not possible at this time. The investigators estimated that fewer than three excess cancers have been caused by PCBs from the ORR. They recommend further studies of fish and turtle consumption, PCB blood levels in people consuming fish, PCB levels in core samples from the Clinch River and the Watts Bar Reservoir, PCB levels in the soils near EFPC, and PCB levels in cattle grazing near the creek.

Uranium Health Studies. The Health Studies investigators reported that the DOE reports of uranium releases have been understated. The study estimates Y-12 released about 50,000 kg of uranium to the air from 1944 to 1995, more than seven times the 6,535 kg previously acknowledged by DOE. Using the new data, the investigators calculated health risks to nearby residents, using a conservative screening method so as not to underestimate the risks. The new risk for cancer for residents included residents of the Scarboro community. The analyses reported career screening indexes that were slightly lower than the investigator's decision guide for carcinogens, but with a great deal of uncertainty. In response to this information, investigators have recommended a more extensive screening of uranium on the ORR.

ATSDR PCB Studies. The ATSDR is a governmental agency established to conduct public health assessments of Federal facilities and to carry out any needed follow-up health activities. These activities include health studies, registries, medical monitoring, and health education. To help characterize environmental contamination in the Oak Ridge area, ATSDR screened more than 500 persons for PCB and blood mercury levels in September 1997. Blood samples were obtained from 116 persons who met the criteria and volunteered, including 13 residents of the Scarboro community. Participants were interviewed, and blood samples were obtained for PCBs and mercury in the blood. The study found the participants had PCB levels and blood mercury levels comparable to levels found in the general population. Only 5 (4 percent) of the persons tested had elevated PCB levels (> 20 μg/L). Four of the five had PCB levels between 20 and 30 μg/L and one had a serum PCB level of 103.8 μg/L, which is higher than levels generally found. As for blood mercury, only one individual had a total blood mercury greater than 10 μg/L, which is considered elevated. The remaining participants had total blood mercury levels similar to the general population.

Cancer Mortalities in Children. In response to a British study reporting increased leukemia and lymphoma in children living near nuclear plants in the United Kingdom, the National Cancer Institute initiated a study of cancer mortality in the areas surrounding U.S. nuclear facilities (Jablon 1991) cancer deaths were compared in counties surrounding nuclear facilities with control counties from the same region. They also compared cancer deaths before start-up of the nuclear facility with cancer deaths after start-up. The study areas included nine DOE facilities, including Oak Ridge Operations, 52 commercial nuclear electric plants, and one former commercial fuel reprocessing plant. Anderson County and Roane County were included in the review and were compared locally to Blount, Bradley, Coffee, Jefferson, and Hamblen counties in Tennessee and Henderson County in North Carolina. Three comparison counties were matched with each county studies. For childhood leukemia, when compared to the control counties, there were fewer leukemia deaths after start-up than before. For the DOE facilities, operations began before the study time period, the year 1950, but there was no facility with a significantly elevated childhood leukemia mortality. The same results were obtained for mortality due to leukemia for all ages. The relative risk (in this study, the comparison of ratios of the SMRs for the study and control counties) for the DOE sites for mortality due to all types of cancer, except leukemia, were significantly high (1.04) after start-up but smaller than the rate-ratio before start-up (1.06). The study did report a significant increased incidence of childhood leukemia for one commercial site, but it predated the start-up of the nuclear facility. The authors concluded that the results do not prove the absence of an effect, but if an effect is present, it is too small to be observed by these methods.

Tennessee Medical Management, Inc., compared Tennessee, Oak Ridge, Anderson County, and Roane County cancer mortality and incidence data with the expected deaths and incidence rates for the U.S. for 1990 and for the interval 1988 through 1990. Actual deaths in Oak Ridge, as well as cancer deaths, were fewer than expected. Anderson County deaths from all causes and cancer deaths were equivalent to expected rates, as were Roane County deaths. The study also compared new cancer cases. Anderson County showed a higher incidence of lung and bronchial cancer than expected, and fewer than expected leukemias, stomach and small intestine cancers, and colon cancers.

D.6.4 Site-wide Studies of Oak Ridge Workers

D.6.4.1 *Mortality of Nuclear Workers in Oak Ridge*

A 1997 report, titled *A Mortality Study of Employees of the Nuclear Industry in Oak Ridge, Tennessee* (Frome 1997), expanded on an earlier study of the health of workers employed at the nuclear plants in Oak Ridge. The previous study had only included white males employed exclusively at ORNL and had excluded workers moving between plants. This study included 106,020 workers, employed for at least 30 days at any of the Oak Ridge nuclear facilities between 1943 and 1984 whose records were without critical errors (e.g., unknown sex, race, date of birth, or employment dates). The objectives of the expanded study were to include individuals omitted from the earlier study to compare the mortality patterns of workers among the Oak Ridge facilities, to address errors of redundancy when workers employed at more than one facility were included in the analysis, and to conduct dose-response analyses for workers exposed to external radiation. The most significant excess cancer mortality associated with external radiation was found in lung cancer for white males, with an SMR of 1.18 (1,849 deaths). An SMR of 1.12 (1,568 deaths) was reported for nonmalignant respiratory disease. The study reported a strong socioeconomic effect with the lung cancer results, and baseline rates were higher for Y-12 workers and workers employed at more than one facility. The authors acknowledged that information on cigarette smoking for this cohort of workers was not available for analysis and may have been a confounder.

D.6.4.2 *Lung Cancer Mortality Study*

A case-control study (Dupree 1995) of 787 lung cancer deaths from four uranium processing operations, including Y-12, Fernald Feed Materials and Production Center, and the Mallinckrodt Chemical Works, was conducted to investigate the relationship between lung cancer and uranium dust exposure. The cases consisted of workers who were employed in the facilities for at least 183 days, died before January 1, 1983, and had lung cancer listed anywhere on the death certificate. Each case was matched with a control by facility, race, gender, and birth and hire dates within 3 years. Included in the history of the cohort was information on smoking, first pay code (to estimate socioeconomic status), complete work histories, and occupational radiation monitoring records. Annual radiation dose to the lungs from deposited uranium was estimated for each individual and annual external dose was determined for workers who had dosimetry measurements available. Smoking (ever/never used tobacco) and pay code (monthly/nonmonthly) were potential confounders considered in the analysis. The odds ratios for lung cancer mortality for seven cumulative internal dose groups did not demonstrate increasing risk with increasing dose. An odds ratio of

2.0 was estimated for those exposed to 25 rads or more, but the 95 percent confidence interval of -.20 to 20 exhibited great uncertainty in the estimate. The study also suggested workers hired at age 45 years or older showed an exposure effect.

D.6.5 Y-12 Worker-Specific Studies

D.6.5.1 *Y-12 Worker Cohort Study*

Polednak and Frome reported a study of 18,869 white male workers employed at Y-12 between 1943 and 1947 and followed through 1974. The cohort included workers exposed to internal (alpha) and external (beta) radiation through the inhalation of uranium dusts, electrical workers who performed maintenance in the exposure areas, and other workers who were not exposed. The study did not include personnel monitoring for exposures to uranium dust, but inferred monitoring results were matched with the work area and job. The SMR for lung cancer was elevated among workers employed for 1 year or more compared with workers employed less than 1 year and was more pronounced in workers hired at 45 years of age or older (SMR - 1.51; 95 percent CI 1.01-2.31). Among the workers employed after the age of 44, the SMR for lung cancer was greatest for electrical workers (SMR - 1.55, 7 observed), alpha chemistry workers (SMR - 3.02, 7 observed), and beta process workers (SMR - 1.51, 11 observed). SMRs were also elevated for mental psychoneurotic, personality disorders (SMR - 1.36, 36 observed), emphysema (SMR - 1.16, 100 observed), diseases of the bones and organs of movement (SMR - 1.22, 11 observed), and external causes of death (SMR - 1.09, 623 observed).

D.6.5.2 *Cancer Mortality Among Y-12 Rad Workers*

In 1988, a study was conducted of Y-12 white male workers employed for at least 30 days from 1947 to 1979 (Checkoway 1988). The study included exposures to alpha and gamma radiation from insoluble uranium compounds. A statistically significant increase in deaths from lung cancer (SMR - 1.36, 89 observed; 95 percent CI - 1.09-1.67) was observed when compared with the U.S. lung cancer rates, but not when compared with Tennessee lung cancer rates (SMR- 1.18, 95 percent CI - 0.95-1.45). Positive dose-response trends were seen for lung cancer mortality with respect to cumulative alpha and gamma radiation, with the most notable trend occurring for gamma radiation among workers who received greater than or equal to 5 rem of alpha radiation. When a 10-year latency assumption was applied, these trends diminished. The authors noted the observed dose-response trends, while based only on small numbers, point to a potential carcinogenic effect to the lung from relatively low-dose radiation. In addition, nonstatistically significant increases were observed for all cancers (SMR - 1.01, 196 observed), diseases of the blood-forming organs (SMR - 1.48, 3 observed), kidney cancer (SMR - 1.22, 6 observed), and other lymphatic cancers (SMR -1.86, 9 observed). Brain and central nervous system cancer mortality was also higher than expected, but without a dose-response trend.

D.6.5.3 *Cancer Mortality Among Minority Rad Workers*

Loomis and Wolf updated the Checkoway study to include the years through 1990 and to include African-American and white female workers and men of other races (Loomis 1996). The exposures for the cohort included low dose, internal, alpha radiation and external, penetrating radiation plus beryllium, mercury, solvents, and other industrial compounds. The authors reported a low total mortality for all Y-12 workers and a total cancer mortality as expected. For the entire cohort, nonstatistically significant excesses were observed for pancreatic cancer (SMR - 1.36, 34 observed), skin cancer (SMR - 1.07, 11 observed), breast cancer (females only, SMR - 1.21, 11 observed), prostate cancer (SMR - 1.31, 36 observed), kidney cancer (SMR - 1.30, 16 observed), brain cancer (SMR -1.29, 20 observed), cancers of other lymphatic tissues (SMR - 1.32, 22 observed), and diseases of the blood-forming organs (SMR- 1.23, 6 observed). The lung cancer mortality was statistically significant (SMR - 1.17, 202 observed; 95 percent CI 1.01-1.34), especially for white males (SMR - 1.20, 194 observed; 95 percent CI - 1.04-1.38). The lung cancer excess was greatest among those workers hired prior to 1954 (SMR - 1.27, 161 observed), with 5 to 20 years of employment and with 10 to 30 . Another finding was evidence of excess breast cancer mortality among the 1,073 female workers (SMR 1.21; 95 percent CI - 0.60-2.17). The authors suggested more work needed to be done on lung cancer mortality due to radiation exposure and to the potential link between beryllium and lung cancer.

D.6.5.4 *Health Effects of Mercury Exposure*

A study of mortality patterns of all workers employed at least 5 months at Y-12 between January 1, 1953, and April 30, 1958 was published in 1984 (Cragle 1984). Mercury was used during this time frame to produce enriched lithium. The group was divided into mercury-exposed and nonmercury-exposed by results of urinalysis supplied by the plant. Vital status follow-up was complete through the end of 1978 and SMRs were calculated. There were no differences in mortality patterns for the mercury-exposed, when compared to the nonmercury exposed. Excesses of lung cancer mortality were observed in both groups of workers and were not related to the mercury exposure (exposed SMR=1.34; 42 observed, 31.36 expected; nonexposed SMR=1.34, 71 observed, 52.9 expected). The authors stated that mortality is not the optimal end point to assess mercury-related health effects.

Another study of mercury workers (Albers 1988) assessed neurological function and mercury exposure. The clinical study examined 502 Y-12 workers, 247 of whom worked in the mercury process 20 to 35 years prior to the examination. Several correlations between increasing mercury exposure and declining neurological function were discovered. An exposure assessment was determined for each mercury worker during the time of employment in the mercury process. Workers with at least one urinalysis equal to or greater than 0.6 mg/L of mercury showed decreased strength, coordination, and sensation along with increased tremor and prevalence of Babinski and snout reflexes when compared to the 255 nonexposed workers. Clinical polyneuropathy was associated with the level of the highest exposure but not with the duration of exposure.

D.6.6 Ongoing Studies of Y-12 Workers and the Community

DOE, along with U.S. Department of Health and Human Services, has published a *Draft Agenda for Public Health Activities for Fiscal Years 1999 and 2000 at U.S. Department of Energy Sites* (DOE 1999b). Included in this report are several ongoing occupational health studies dealing with Y-12.

Public Health Assessment. The ATSDR is involved in an ongoing study of the public health impact from releases of hazardous materials from the ORR. This assessment will help identify and characterize both the current and past exposures of offsite populations to radiologic and chemical contaminants. Morbidity and mortality data to identify increased rates of health outcomes associated with these materials are also included in this study.

DOE Beryllium Worker Medical Surveillance Program. Y-12 beryllium workers are included in the DOE Beryllium Worker Medical Surveillance Program currently under way to detect and diagnose chronic beryllium disease. Information from this program is being used to evaluate worker protection and control measures, to monitor trends in chronic beryllium disease frequency, and to strengthen work planning to minimize worker exposures. A communication effort to educate workers about chronic beryllium disease is included.

DOE's Former Worker Program. Under DOE's Former Worker Program, Dr. Eula Bingham of the University of Cincinnati, in cooperation with the United Brotherhood of Carpenters Health and Safety Fund and several other groups, is directing the Former Construction Workers Project. Phase I of the project has identified approximately 800 former construction workers. Phase II will focus on medical screening of workers exposed to asbestos, beryllium, noise, silica, solvents, and heavy metals.

Mortality Among Female Nuclear Weapons Workers. NIOSH is sponsoring the State University of New York in a study of mortality among female nuclear weapons workers. This includes female workers from 12 DOE sites and will be the largest study of mortality among the 80,000 females employed by DOE. Risk estimates will be developed for exposure to ionizing radiation and chemical hazards.

Lung Cancer and Leukemia Case-Control Studies. NIOSH has two ongoing case-control studies combining multiple DOE sites, including Oak Ridge, to answer specific cancer questions. One study is attempting to define the relationship between lung cancer and external radiation exposure. The second study, the largest of its kind, is exploring the relationship between external radiation and leukemia risk among 250 workers with leukemia compared to similar workers without leukemia.

Chemical Laboratory Workers Mortality Study. NIOSH has an ongoing cohort mortality study assessing potential worker exposures to groups of chemicals and ionizing radiation and their relationship to mortality patterns. This is in response to other studies, outside DOE, indicating an increased risk of cancers among chemical laboratory workers.

D.7 ACCIDENT ANALYSIS

Accidents are defined as unplanned sequences of events that lead to the release of hazardous material within a facility or into the environment (DOE STD-3009-94), exposing workers and/or the public to hazardous materials or radiation.

There are two objectives of this SWEIS accident analysis. First, the analysis conservatively characterizes the risk posed by the operations, creating a context for the decision maker and putting the site in perspective for the public. Second, the analysis provides a basis for evaluating the incremental risk among the several alternatives.

D.7.1 Characterization of the Risk from Accidents

Characterization includes a consideration of the type of the accident (e.g., fire, explosion, spill, leak, depressurization, criticality, etc.), the initiator (e.g., human error, chemical reaction, earthquake, strong wind, flood, vehicle accident, mechanical failure, etc.), and the material at risk (e.g., uranium, toxic chemical, explosives, flammable gas, etc.). Characterization also considers the type of consequence of the accident (e.g., immediate fatalities, prompt reversible and irreversible health effects, latent cancers—some of which may lead to eventual death), and the magnitude of the consequences to different exposed populations (e.g., to workers only, to hypothetical members of the public off-site, etc.). Finally, characterization considers the likelihood that an accident will occur.

Because Y-12 is a complex site conducting many processes, there is a wide range of accident scenarios that can be postulated with a corresponding range of likelihoods and potential consequences, both credible and incredible. Existing safety analyses, hazard analyses, and other documentation were reviewed to identify a range of postulated accidents that include high frequency-low consequence accidents as well as low frequency-high consequence accidents. The list of accidents presented in this appendix is representative of primarily high consequence accidents at the Y-12 Plant. The accidents presented are generally controlled by the implementation of hazard control strategies that reduce the likelihood or consequences of the postulated accidents. For this SWEIS, accidents were analyzed that could result in injuries to the public or workers (such as fires or explosions), or from the release of hazardous materials from particular facilities and operations.

To characterize the accident risk at Y-12, a representative range of accidents and consequences, including accidents for which the public has shown concern, has been chosen for analysis. That is, the analysts have not attempted to identify every possible accident scenario, but instead have selected a range of accidents that are representative of the risk to the public and workers from site operations. The analysis thereby provides an objective context for the stakeholders to evaluate the risk posed by site operations and a context for the comparison among alternatives.

D.7.2 Evaluation Methodologies and Assumptions

The potential for facility accidents and the magnitudes of their consequences are important factors in evaluating the alternatives addressed in this SWEIS. The health risk issues are twofold:

- The potential accidents that could occur at Y-12 facilities and the risks that these postulated accidents could pose to workers or the general public.

- The reduction in existing public or worker health risks when HEU Storage Mission and Special Materials Mission Alternatives in this SWEIS are compared to the existing facilities. (These reduced risks may arise either from modernized, improved facility systems that better protect the workers or public, or from design and construction of facilities built to higher seismic resistance standards.)

Guidance for preparing an EIS (40 CFR 1500) requires the evaluation of impacts which have low probability of occurrence but high consequences if they do occur; thus, facility accidents must be addressed to the extent feasible in this SWEIS. Further, public comments received during the scoping process clearly indicated the public's concern with facility safety and consequent health risks and the need to address these concerns in the comparison-making process.

For the Y-12 Site No Action - Status Quo Alternative and No Action - Planning Basis Operations Alternative, potential accidents are defined in existing facility documentation, such as safety analysis reports, bases for interim operation, hazards assessment documents, and NEPA documents. The accidents include radiological and chemical accidents that result in high consequences but have a low likelihood of occurrence, and a spectrum of other accidents that have a high likelihood of occurrence and low consequences. The data in these documents shown in Table D.7.2-1 include accident scenarios, frequency ranges, materials at risk, source terms (quantities of hazardous materials released to the environment), and accident consequences. For proposed new or expanded facilities, the identification of accident scenarios and associated data would normally be based on analysis reports performed on completed facility designs. However, facility designs have not been completed for the HEU Storage Mission and Special Materials Mission Alternatives analyzed in this SWEIS.

Accordingly, the accident information developed for this SWEIS has been developed based upon the best available existing information for similar facilities.

This analysis also includes semiquantitative or qualitative estimates of the differences in likelihood for accident initiation at new facilities. For example, the proposed new HEU Materials Facility, built at a higher elevation, would have a reduced potential for flooding. Also, qualitatively discussed are the opportunities for risk reduction afforded by the potential incorporation of new technologies, processes, or protective features in the newly constructed facilities. These would improve public health and safety compared to the existing facilities.

D.7.2.1 *Radiological Accident Selection*

The accident scenarios chosen to represent the impacts for each alternative were selected using a screening process based on a larger set of accidents presented in existing safety documentation for similar facilities. The existing safety analyses, hazard analyses, and other documentation shown in Table D.7.2-1 were reviewed for applicable accident scenarios and data to identify postulated accidents that represent a range of accidents that include high frequency-low consequence accidents as well as low frequency-high consequence accidents. The accidents presented are generally controlled by the implementation of hazard control strategies that reduce the likelihood or consequences of the postulated accidents. The analytical process identified bounding accidents in each of several types of events (e.g., fire, explosion, spill, criticality, etc.) applicable to the EIS proposed actions and alternatives.

For a SWEIS alternative, each selected radiological accident was analyzed to estimate the risk (i.e., combination of an accident's frequency and the accident's consequences, occasionally expressed as the mathematical product) and consequences (e.g., cancer fatalities) to a collocated (noninvolved) worker, a member of the public at the Y-12 Emergency Response Boundary, and the population out to a distance of 80 km (50 mi) from the accident.

Accident analyses for the Y-12 facilities (Table D.7.2-1) were reviewed to determine the representative accidents for use in this appendix. In these referenced documents, preliminary hazard analyses (PHAs) are described that identify hazards, accident scenarios, and consequences relevant to the SWEIS. The authorization basis documents listed in Table D.7.2-1 are safety analysis reports (prepared in accordance with DOE STD-3009-94), bases for interim operation (prepared in accordance with DOE STD-3011-94), or hazard assessments. For consistency, the frequency and consequences associated with each accident scenario evaluated in this SWEIS were evaluated using the risk matrix from DOE STD-3011-94 shown in Table D.7.2-2. The Significance of the Scenario was the classification based on its location within the matrix. The scenario classes were designated as follows.

- Scenario Class IV - Negligible
- Scenario Class III - Marginal
- Scenario Class II - Serious
- Scenario Class I - Major

Scenario classes are associated with sectors of the risk matrix in such a way as to prioritize accident scenarios for review or for further analysis, primarily in terms of the risk that they present.

Consequences were determined based on parameters such as the bounding quantity of hazardous material involved in an accident, the release mechanism associated with the accident, and the release pathway taken by the hazardous material. Conservative assumptions were used to determine the magnitude of the consequences. Radiological and chemical consequences were classified using both qualitative and quantitative measures as shown in Tables D.7.2-3 and D.7.2-4. Note that the values in Tables D.7.2-3 and D.7.2-4 are intended for sorting purposes only and do not reflect any consideration regarding risk acceptability. Doses from postulated radiological accidents are given as CEDE and are stated in rem for individual doses or person-rem for population doses.

Estimates of frequency were made by assessing the frequency of the initiating event along with the conditional probabilities of all other events necessary for the propagation of the accident leading to a release of radiological or toxicological material. Failure rate data, historical accident data, and other sources of information were also used to determine the accident frequency. Uncertainties in parameter values were accommodated by erring in the conservative direction from best-estimate values. Hand calculations were used in many cases to estimate numerical quantities for source terms, and onsite and offsite MEI consequences. This number provides an expected number of LCF for the population given that the dose has been received.

TABLE D.7.2–1.—*Source Documents Reviewed for Applicable Accident Scenarios*

Item Number	Title	Report Number	Date Published
1	*Basis for Interim Operation, Building 9720-5*	Y/ENG/BIO-010, Rev. 0, Chg. 1	9/30/98
2	*Safety Analysis Report for the Nuclear Material Safeguarded Shipping and Storage Facility,Building 9720-5*	Y/SAR/010/IA	Approval Date: 3/6/98
3	*Basis for Interim Operation of Building 9204-2E*	Y/ENG/BIO-003, Rev. 2	3/8/98
4	*Basis for Interim Operation, Disassembly and Storage Organization, 9204-4 Facility*	Y/ENG/BIO-004, Rev. 2	8/98
5	*Basis for Interim Operation for Building 9212 Enriched Uranium Operation Complex*	Y/MA-7254, Rev. 5	12/16/98
6	*Basis for Interim Operation for 9215 Complex Enriched Uranium Operation*	Y/MA-7290, Rev. 1	3/98
7	*Final Safety Analysis Report for Y-12 Chemical Processing Systems, Buildings 9212 and 9206*	Y/MA-6290	4/82
8	*The Basis for Interim Operation for the Building 9206 Complex*	Y/MA-7462, Rev. 0	Submitted for Approval
9	*Safety Analysis Report for the Nuclear Material Management Storage Facility, Building 9720-38*	Y/ENG/SAR-084/IFA, Rev. 1	1/27/99
10	*Basis for Interim Operation, 9215 Complex Non-Enriched Uranium Operations*	Y/NA-1816, Rev. 0	6/11/99
11	*Basis for Interim Operation, Disassembly and Storage Organization, 9204-4 Facility*	Y/ENG/BIO-004, Rev. 3	Draft 11/2/98
12	*Safety Analysis Report for the 9204-2E Facility*	Y/SAR-003/IFA, Rev. 0	8/98
13	*Final Safety Analysis Report for Transportation and Certification of Enriched Uranium Weapons Parts*	Y/MA-6398	8/83
14	*Nonnuclear Safety Analysis Report and Operational Safety Requirements for Lithium Operations*	Y/ENG/SAR-OSR-001, Rev. 0	9/30/98
15	*Basis for Interim Operation Document for Building 9201-5N/5W*	Y/ENG-BIO-002, Rev. 1	8/20/98
16	*Remedial Investigation/Feasibility Study for the Disposal of Oak Ridge Reservation CERCLA Waste,* Appendix F	DOE/OR/02-1637&D2	1/7/98
17	*U. S. Department of Energy Defense Programs Safety Survey Report, Volume III, Appendix B Uranium Facilities*	N/A	11/93
18	*Hazard Assessment for the Development Organization Facilities*	EMPO-514/HA-015, Rev. 0	4/25/00
19	*Hazard Evaluation, Development Organization Activities in Buildings 9202, 9203, 9205, and 9731*	Y/DA-9469, Rev. 0	9/99
20	*Facility Hazards Assessment for the Building 9720-26 Material Control Organization*	EMPO-514/HA-021, Rev. 0	3/1/00
21	*Building 9401-3 Hazards Assessment*	EMP-514/HA-003, Rev. 0	6/18/99

TABLE D.7.2–2.—*Risk Matrix - Consequence versus Frequency*[a]

	$<10^{-4}$ Extremely Unlikely	10^{-4} to 10^{-2} Unlikely	$>10^{-2}$ Anticipated
High Consequence	II	I	I
Moderate Consequence	III	II	I
Low Consequence	IV	III	III

[a] Frequency (yr^{-1})
Source: DOE STD-3011-94.

TABLE D.7.2–3.—*Radiological Accident Consequence Levels*[a]

	Public	Workers
High Consequence	> 5 rem at site boundary	> 25 rem at 200 m or prompt death in facility
Moderate Consequence	> 0.1 rem at site boundary	> 0.5 rem at 200 m or serious injury in facility
Low Consequence	< 0.1 rem at site boundary	< 0.5 rem at 200 m and no serious injuries in facility

[a] Values are intended for sorting purposes only and do not reflect the acceptability of accident consequences.
Note: DOE STD-3011-94 uses 600m for evaluating worker dose. The fence line is as close as 450m for evaluating public exposures. This evaluation uses 200m as an appropriate distance to evaluate the exposure of a worker.
Source: DOE STD-3011-94.

TABLE D.7.2–4.—*Chemical Accident Consequence Levels*[a]

	Public	Workers
High Consequence	> ERPG-2 at site boundary	> ERPG-3 to collocated workers or prompt death in facility
Moderate Consequence	Not applicable	Serious injury in facility
Low Consequence	< ERPG-2 at site boundary	No serious injuries in facility

[a] Values are intended for sorting purposes only and do not reflect the acceptability of accident consequences.
Note: ERPG -Emergency Response Planning Guideline.
Source: DOE STD-3011-94.

D.7.2.2 *Chemical Accident Selection*

The chemical accident selection consisted of a multiple step review of facilities for chemical accidents. The first step of the review was a screening of the nuclear facility accident analyses for chemical accidents related to the nuclear facilities (non-nuclear facilities were addressed in the second step). This screening consisted of reviewing the safety documentation listed in Table D.7.2-1. A range of accidents that included high frequency-low consequences as well as low frequency-high consequences was identified. A review of this range of accidents resulted in the generation of two consolidated scenarios for evaluation in this SWEIS (Section D.7.3.2).

The second step was a review of the annual SARA Section 311 and Section 312 reports (Evans 1999a, Evans 1999b). The SARA reports list all regulated chemicals in Y-12 facilities and the quantities in each facility. Table D.7.2-5 lists the SARA-reportable chemicals at Y-12. Some of these chemicals were also identified during the first step of the chemical accident selection and the duplicate listings were eliminated. This list of chemicals resulting from the second step was further screened to identify chemicals that were also listed as highly hazardous chemicals by OSHA (29 CFR 1910.119) or as substances regulated by EPA under 40 CFR 68.130. Finally, the list of chemicals was screened to determine if any of the chemicals in the SARA reports met all of the following criteria (DOE 1999a):

- Has a TWA less than 2 ppm (for chemicals without TWAs, the Temporary Emergency Exposure Limit-0 [TEEL-0] was used)
- Is found in a readily dispersible form (i.e., a gas or liquid)
- Has a boiling point of less than 212 °F (100 °C) and a vapor pressure greater than 0.5 mm mercury

This screening of chemicals in non-nuclear facilities resulted in acetonitrile and chromic acid being analyzed in the consolidated fire and loss of containment scenarios for chemicals. Also, one chemical of local interest (mercury) was added to the toxic chemical fire scenario (Section D.7.3.2).

D.7.2.3 *Human Health Effects of Accidental Exposure to Hazardous Chemicals*

Human health effects resulting from exposure to hazardous chemicals vary according to the specific chemicals of interest and the exposure route and concentration. The most immediate risks to human health from exposure to chemicals in the environment arise from airborne releases of toxic gases, and it is this route of exposure upon which the accident analysis for the SWEIS is focused. (The effects of radioactive and toxic chemicals have been discussed previously in Section D.1.) In this analysis, exposures to toxic chemicals were compared to Emergency Response Planning Guidelines (ERPGs). ERPGs are community exposure guidelines derived by groups of experts in industrial hygiene, toxicology, and medicine. ERPGs are published by the American Industrial Hygiene Association (AIHA) after review and approval by their ERPG Committee. ERPGs are defined as follows (AIHA 1991).

- ERPG-1 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing other than mild, transient adverse health effects or perceiving a clearly defined objectionable odor.
- ERPG-2 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair their abilities to take protective action. (Note that there are ERPG-2 limits for a few chemicals that use a 10-min exposure period. The 10-min ERPG-2 limits are published for hydrogen fluoride.)
- ERPG-3 is the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects. (Note that there are ERPG-3 limits for a few chemicals that use a 10-min exposure period. The 10-min ERPG-3 limits are published for hydrogen fluoride.)

Human responses to chemical exposure do not occur at precise exposure levels, but rather, vary over a wide range of concentrations. The values derived for ERPGs do not protect everyone, but are applicable to most individuals in the general population. Furthermore, the ERPG values are planning guidelines, not exposure guidelines. They do not contain the safety factors normally associated with exposure guidelines (AIHA 1991).

In developing an ERPG, emphasis is given to the use of acute or short-term exposure data. Human experience data are emphasized, but usually only animal exposure data are available. When it is believed that adverse reproductive, developmental, or carcinogenic effects might be caused by a single acute exposure, the data are considered in the ERPG derivation.

Unless one is provided information to the contrary by toxicologists, it is necessary to regard ERPGs as ceiling concentrations (i.e., the highest concentration acceptable for the time period). As such, the ERPG would be treated as an exposure that should not be exceeded within 1 hour. Any extrapolation from the

ERPG is not to be made without significant considerations; specifically, to make such an adjustment, the ERPG documentation for each chemical must be reviewed fully by toxicologists. The effects of exposure times longer than 1 hour may not be limited to those associated with the ERPG.

TABLE D.7.2–5.—*Superfund Amendments and Reauthorization Act Reportable Chemicals at Y-12*

Acetic Acid	Lithium Hydroxide
Acetylene	Magnesium Iron Silicate
Activated Carbon (carbon graphite, synthetic)	Magnesium Oxide
Aluminum Oxide	Mercury
Argon	Methanol (Methyl Alcohol)
Beryllium and Beryllium Compounds	Nickel and Nickel Compounds
Cadmium Oxide	Niobium Metal
Calcium Chloride	Nitric Acid
Calcium Hydroxide	Nitrogen
Calcium Carbonate	Oxygen
Carbon Dioxide (gas, solid)	Petroleum
Chlorine	Phosphoric Acid
Diatomaceous Earth	Portland Cement
Diesel (Fuel Oil No. 2)	Potassium Cyanide
Ferric Sulfate (solution)	Propane
Freon 11 (Trichlorofluoromethane)	Propylene Glycol
Freon 12 (Dichlorodifluoromethane)	Silica, Crystalline Quartz
Freon 22 (Chlorodifluoromethane)	Sodium Bisulfite
Freon 113 (Trichlorotrifluoromethane)	Sodium Carbonate, Monohydrate
Gasoline (unleaded)	Sodium Chloride
Helium	Sodium Hydroxide
Hydrochloric Acid	Sodium Hypochlorite
Hydrogen Fluoride	Sodium Metasilicate, Anhydrous
Hydrogen Peroxide	Sodium Zinc Polyphosphate
Isopropyl Alcohol	Sulfuric Acid
Lithium Chloride	Uranium and Uranium Compounds
Lithium Deuteride	Urea
Lithium Hydride	

Source: Evans 1999b.

In addition to ERPGs, this analysis incorporated the supplementary TEELs developed by the DOE Emergency Management Advisory Committee, Subcommittee of Consequence Analysis and Protective Actions. Published ERPG values were only available for about 70 chemicals. TEEL values (interim, temporary, or ERPG-equivalent exposure limits) are provided for an additional 297 chemicals. In the absence of ERPG or TEEL values, the hierarchy developed by the committee and published in the AIHA Journal was used (Craig 1995, Craig 1996).

D.7.2.4 *Safety Design Process*

One of the major design goals for the proposed newly constructed facilities is to achieve a reduced risk to workers and the public relative to that associated with existing facilities at Y-12. Significant changes between the design of proposed, new facilities and the current design criteria and safety standards should reduce total risk to the workers and to the public. These changes include design to more modern structural and safety criteria; smaller throughput, batch size and inventories of certain hazardous materials; and elimination of some forms of hazardous materials (such as anhydrous hydrogen fluoride). These changes will reduce potential health effects if an accidental release were to occur.

Areas within proposed new facilities will be designed to meet with current government regulations; DOE Orders; and consensus codes and standards. As a result, new facilities will be provided that are highly resistant to the effects of natural phenomena, including earthquake, flood, tornado, high wind, as well as credible events appropriate to the site, such as fire and explosions, and manmade threats to the structural integrity for containing hazardous materials.

The design process for new Y-12 nuclear facilities will comply with the requirements for safety analysis and evaluation in DOE Order 430.1A, *Life-Cycle Asset Management*; DOE Order 5480.23, *Nuclear Safety Analysis Reports*; and DOE Order 420.1, *Facility Safety*.

For new facilities, the safety analysis process begins early in conceptual design by identifying hazards with the potential to produce unacceptable safety consequences to workers or the public. As the design develops, hazard analyses are performed to identify initiators that have the potential to release hazardous material, hazardous energy, or cause injuries to workers or the public. The types of initiators considered include equipment failure, human error, chemical reaction, and natural phenomena hazards. These postulated events become focal points for design changes or improvements to prevent unacceptable accidents. These analyses continue as the design progresses to assess the need for safety equipment and to assess the performance of this equipment in accident prevention or mitigation. Eventually, the safety analyses are formally documented in an auditable safety analysis, hazard evaluation, or safety analysis report. The level of documentation depends upon the hazards presented by the new facility and is reflected in the use of a graded approach to safety analysis used by DOE.

D.7.2.5 *Analysis Methodology*

Introduction

The accident analyses in the source documents listed in Table D.7.2.1-1 were based on various assumptions (e.g., ground-level releases versus elevated releases, various stability classes, various release times, etc.) The consequences for the population doses for release accidents were recalculated using consistent assumptions (i.e., D stability, 2 m/s wind speed), and for the MEI (F stability and 1 m/s wind speed). A discussion of how the collocated workers and the public population doses were calculated using the MACCS code is provided below. A detailed description of the MACCS model is available in a three volume report: *MELCOR Accident Consequence Code System (MACCS)* (NUREG/CR-4691). The HGSYSTEM computer code was used to estimate the consequences of toxic gas release accidents. The HGSYSTEM code is discussed below. Hand calculations were performed using the Gaussion plume dispersion model to estimate concentrations for the other toxic chemical releases.

The closest potential public access to the Y-12 facilities is at the Y-12 Emergency Response Boundary. Distances from the Y-12 facilities to the Y-12 Emergency Response Boundary are listed below. This distance is used to estimate the dose to a maximally exposed member of the public since this is the closest to the facility that can be publicly accessed. It is unlikely that a member of the public would be present at this location at any time. Thus, the estimated dose provides a bounding limit to a maximally exposed individual.

Building	Distance (m)
9201-5	670
9202	700
9204-2	670
9204 - 2E	670
9204 - 4	670
9206	700
9212	450
9215	500
9401-3	1000
9720 - 5	1000
9720 - 26	1000
9720 - 38	1000

For radiological releases, the 200-m distance was selected for collocated (on-site) maximally exposed collocated worker receptors. The worker population doses presented include all workers onsite.

Radiological Population Dose

MACCS models the off-site consequences of an accident that releases a plume of radioactive materials to the atmosphere. Should such an accidental release occur, the radioactive gases and aerosols in the plume would be transported by the prevailing wind while dispersing in the atmosphere. The environment would be contaminated by radioactive materials deposited from the plume, and the population would be exposed to radiation. The objectives of a MACCS calculation are to estimate the range and probability of the health effects induced by the radiation exposures not avoided by protective actions.

In previous NEPA documentation (DOE 1994a) for Y-12, detailed MACCS modeling was performed for several hypothetical accidents. The results and assumptions for these MACCS models are documented in the report, *An Assessment of the Radiological Doses Resulting from Accidental Uranium Aerosol Releases and Fission Product Releases from a Postulated Criticality Accident at the Oak Ridge Y-12 Plant* (Fisher 1995). This assessment provides scalable results for releases of fission product gases resulting from a criticality accident and releases of HEU aerosols. This report contains detailed information for the site as well as a wind rose. This assessment provides scalable dose consequences for theoretical accidents and was used for estimating the radiological population doses presented in the accidents in this analysis. The assessment uses the local 1992 meteorological data and 1990 census population data in the calculations performed using the MACCS code (Fisher 1995).

The results presented by Fisher and Lenox (Fisher 1995) were verified by independent computations using 1998 meteorological data and the 1990 census data. The 1990 census data is the only data available in the detailed population grids necessary for the MACCS code. Some general conclusions may be drawn by looking at the population increases in the local area. Knox County, Tennessee, had a population of 335,749 in the 1990 census. Knox County's population was estimated to be 366,864 in 1998 by the U.S. Census Bureau, an increase of approximately 9 percent. Knox County's population in 2005 is projected to be 387,318. Anderson County, Tennessee, had a population of 68,250 in the 1990 census. Anderson County's population was estimated to be 71,587 in 1996 by the U.S. Census Bureau, an increase of approximately 5 percent. The city of Oak Ridge, Tennessee, had a population of 27,310 in the 1990 census. Oak Ridge's population was optimistically estimated to be approximately 28,000 in 1998 by the city of Oak Ridge, an increase of approximately 2 percent. The city of Oak Ridge's population in the near future is not expected to significantly increase. Based upon these population estimates, the doses presented for the accidents could be increased 5 percent to account for the population growth and provide a bounding upper estimate for the population doses. However, without the population grid data to properly account for the location of people for the exposures, these estimates would not necessarily increase the accuracy of the population doses. Another factor is that very few people live close to the Y-12 Plant where the highest doses would be received and the city of Oak Ridge population has not significantly changed, thus the errors may not be as large as 5 percent but may be closer to 2 percent. Additionally, the assumptions used for the MEI doses in Fisher and Lenox were modified and then new doses were estimated. Fisher and Lenox assumed a 7-day evacution for the MEI doses. This was considered to be unrealistic for Y-12 Plant workers and members of the public at the Y-12 Emergency Response Boundary. In this analysis, a 2-hour evacuation was used in accordance with DOE and Nuclear Regulatory Commission (NRC) guidance. Also, the MEI doses assume fixed, conservative weather conditions of F-stability and 1 m/s wind speeds.

The increased likelihood (probability) of an LCF to a member of the public is generally assumed to be 5.0×10^{-4} times the dose in person-rem. Doses to noninvolved workers were calculated similarly, except that these workers were assumed to have an increased likelihood of LCF of 4.0×10^{-4} times the dose in person-rem. These values are based on the *1990 Recommendations of the International Commission on Radiological Protection* (ICRP 1991).

HGSYSTEM Code

The HGSYSTEM code is a suite of codes, including a modification of the HEGADAS dense gas dispersion code. HEGADAS was modified to better model the dispersion of anhydrous hydrogen fluoride after test results in Nevada showed that existing models did not properly match the results of the outdoor testing. The modification incorporated several attributes: (1) the ability to account for HF/H_2O/air thermodynamics and plume aerosol effects on plume density (both positive and negative effects); (2) the ability to model both pressurized (jet) and unpressurized (pool) releases; (3) the ability to predict concentrations over a wide range of surface roughness conditions; (4) the ability to predict concentrations at specific locations for user-specified averaging periods (sampling times) that are consistent with release duration; (5) the ability to consider steady-state, time-varying, and finite-duration releases; and (6) the ability to compute crosswind and vertical concentration profiles. After the HGSYSTEM development was completed, the computer model was validated against the data from the Nevada testing series.

Especially near the source of a release, actual short-term gas concentrations will depart markedly from average model values in response to random turbulent eddies and are therefore unpredictable. As the actual released material moves downwind, concentrations within the plume become more similar to HGSYSTEM model calculations. HGSYSTEM shows concentrations that represent averages for time periods of 15 minutes and predicts that average concentrations will be highest near the release point and along the center line of the release (this is typical plume modeling). The concentration is modeled as dropping off smoothly and gradually in the downwind and crosswind directions. HGSYSTEM is the only dispersion code that can model releases of anhydrous hydrogen fluoride and account for the unique thermochemistry of depolymerization and hydrolysis.

Moreover, HGSYSTEM models the dispersion of heavy gases assuming the terrain is flat. Thus, if a ridge is located between the release point and a potential receptor, HGSYSTEM models the scenario as though the ridge were absent. This is a conservative approach because potential receptors are offered some protection from heavy gases by intervening ridges. Under the most stable atmospheric conditions (most commonly found late at night or very early in the morning), there is little wind, reduced turbulence, and less mixing of the released material with the surrounding air. High gas concentrations can build up in small valleys or depressions and remain for long periods of time. HGSYSTEM does not account for gas accumulations in low-lying areas.

HGSYSTEM allows the user to enter only a single wind speed and wind direction and assumes that these remain constant throughout the release and travel. In reality, air flow changes speed and direction when confronted with changes in terrain such as slopes, valleys, and hills. HGSYSTEM cannot account for these effects. Because wind is likely to shift direction and change speed over both distance and time, any predictions of atmospheric concentration beyond 1 hour or further out than 10 km are not as reliable as predictions made within a few minutes or at shorter distances. In general, wind direction is least predictable when the wind speed is low and at the lowest wind speed modeled in the code. HGSYSTEM does not account for particulate settling and deposition. For releases of hazardous materials forming liquid pools, the HGSYSTEM code presumes the surface beneath a liquid leak or spill to be level, so that the liquid is assumed to expand evenly in all directions.

During fire accidents, combustion products rise rapidly while moving downwind until they cool to the temperature of the surrounding air. HGSYSTEM cannot account for this plume rise. HGSYSTEM models the release and dispersion of pure chemicals only, and the properties of chemicals in its chemical library are valid only for pure chemicals. HGSYSTEM also does not account for chemical reactions of any kind.

The limitations of HGSYSTEM do not detract from its use in this SWEIS for screening chemical accidents and bounding their daytime consequences. HGSYSTEM was chosen for its ability to model heavy gases, especially anhydrous hydrogen fluoride as well as chlorine, chemicals of concern at Y-12.

Frequency Analysis

Frequency (F) levels were assigned primarily based on operating experience. Accidents that could result from operator error or violation of administrative controls were assumed to be "Anticipated," $F > 10^{-2}$/yr. If knowledge existed of a similar accident in the operating history of the facility, the frequency was also assumed to be "Anticipated." Equipment failures were assumed to be "Anticipated." Events that resulted from a series of operator errors and/or equipment failures were considered "Unlikely," $10^{-4}/yr \leq F \leq 10^{-2}$/yr, unless the accident sequence was very complex, in which case a frequency of "Extremely Unlikely," $F < 10^{-4}$/yr, was assigned. If physical conditions associated with an operation did not support a particular accident sequence, the event was considered to be "Extremely Unlikely." The unmitigated frequencies cited in the following scenarios do not credit administrative controls, engineering design features, building construction, etc., that could prevent the postulated accidents. The accident initiators in most cases are either human error or mechanical equipment failure.

D.7.3 Accident Scenarios

The accident scenarios are divided into radiological accidents and chemical accidents. The radiological accidents involve exposure to radioactive materials with a dose to a receptor (a collocated worker or the public). The accidents are presented with a discussion of the consequences and the expected frequency of the accidents. Many of the process facilities have controls (for prevention or mitigation) that serve to reduce the frequency or consequences associated with the accident. This information is presented in a table for each section. Some of the postulated accidents, such as the seismic accident, do not have facility controls listed to prevent the accident, and the frequency of the accident is the same as the initiating frequency (based upon an assumed return period) of the projected earthquake. Events with major consequences such as fire-induced releases due to an aircraft crash are not separately analyzed due to the very small frequency (less than 10^{-7}/yr) and the consequences of these events such as an aircraft crash are bound by the results of the facility fire or site-wide earthquake (DOE 1996). The consequences of radiological accidents are presented with worker and public doses. The worker doses are presented for the population of site workers and for an MEI who is standing 250m from the facility for 2 hours. The public doses are also presented for the population and for an MEI who is assumed to be located at the site boundary for 2 hours following the accident. The public population dose calculations assume no evacuation to mitigate the consequences. The MEI (worker or public) would be downwind and in the highest predicted concentration of the released material. The accident consequences are unmitigated. Many accidents would be mitigated, for example, by building HEPA filtration, fire suppression systems, etc.

The chemical accidents are presented with the frequencies and exposure concentrations for the postulated accident scenarios. For toxic gas releases of chlorine gas and anhydrous hydrogen fluoride, the accident scenarios have release times based upon a credible cylinder valve leak accident using typical atmospheric conditions for Y-12.

D.7.4 Radiological Accidents

D.7.4.1 *Criticality Accidents*

A criticality accident is defined as the release of energy and radiation resulting from an inadvertent self-sustaining or divergent chain reaction. Criticality accidents have been evaluated for Y-12 facilities that store or process enriched uranium. All recorded criticality accidents have been initiated by human error. The four main categories of criticality initiating events are those resulting from administrative error (procedural non-compliance), solutions being introduced into unfavorable geometries, holdup in fissile material equipment, and natural phenomena events. The DOE Headquarters Office of Oversight recently completed a field inspection and review of criticality safety at several DOE sites including Y-12. While the team noted no imminent hazards, several recommendations were made to improve criticality safety including two safety issues that warranted a formal response from Y-12. These two safety issues are related to fissile material movements and annual operation reviews (DOE 2000a, DOE 2000b).

Administrative Errors (Procedural Noncompliances). The nuclear criticality safety evaluation (CSE) identifies the limits and conditions necessary to ensure that fissile material operations comply with the double contingency principle. Compliance with the double contingency principle ensures that no single failure, either administrative or passive design, can result in the potential for a criticality accident. The criticality safety requirement (CSR)/criticality safety analysis (CSA) is used to document the requirements identified in the CSE. From the CSR/CSA, criticality safety requirements are incorporated directly into procedures, postings, or other implementing documents.

This scenario is initiated from a human/manual-operator action that could result in a criticality event. The improper handling or storage of material can create the potential for a criticality event. Operations are conducted in accordance with administrative controls (e.g., operating procedures or CSA postings) that incorporate the required nuclear criticality limits and conditions.

Solutions in Unfavorable Geometries. Uranyl nitrate solutions are present in tanks and equipment at Y-12. Administrative programs are in place to control the geometry of process equipment and containers used in solution processing areas to a geometrically favorable diameter and depth. In this event scenario category, solutions can leak from safe tanks or piping onto floor surfaces, backflow through interfacing safe piping to unsafe geometries, be released to unsafe containers by an operator error during transfer, or collect in equipment removed for maintenance. Design and/or procedural requirements on the interfaces of other systems with systems containing enriched uranium solutions and work control practices provide for the incorporation of features that will prevent solution from moving from a safe geometry to an unsafe geometry.

Holdup in Fissile Material Equipment. Dry enriched uranium holdup material can be collected in equipment such as filters, gloveboxes, open cans, and ventilation ductwork during normal operations. This scenario can involve the buildup of material inside these areas to the point of a critical amount or the material being moderated by the introduction of water from roof leaks, fire sprinkler discharge, or other piping failures. The majority of unsafe geometry equipment has passive design features (e.g., drain holes) to prevent these events.

Natural Phenomena. Beyond-design-basis natural phenomena initiators could result in spilling of solutions and/or the rearrangement of containers or metal parts into a critical configuration. Flooding could result in moderation of enriched uranium in the storage containers in the Y-12 facilities. Double contingency is applied to the storage of all fissile material so that rearrangement or flooding from a natural phenomena initiator is not likely to initiate a criticality accident.

Properties of Hazardous Material. The principal product of a criticality accident is radiation which arises from:

- Prompt gamma photons and neutrons resulting from the fission reaction itself
- Gamma and beta radiation from the radioactive decay of fission products produced by the reaction
- Radiation from the radioactive decay of materials surrounding the fission reaction that have been activated by neutrons

The prompt radiation is traditionally viewed as the most significant because, in the first pulse of an accident, an individual can take no actions to limit the dose from this source. The prompt dose is solely a function of pulse size, duration, distance, and intervening shielding. In an actual moderated criticality accident, the prompt radiation will be predominately gamma photons because of walls, equipment, etc., that absorb neutrons.

Analysis for HEU Storage Mission Proposed Alternatives

Either a new HEU Materials Facility or an addition to Building 9215 (Alternative 2B) is proposed for the HEU Storage Mission at the Y-12 Plant. These new facilities are meant to expand and consolidate the storage of HEU in one modern facility built to current codes and standards. Additionally, the new HEU storage facility will make greater use of engineered controls in lieu of administrative controls when possible. Thus, the controls that prevent or mitigate accidents will be more reliable. The likelihood of accidents involving HEU will decrease with the new facility over the present storage facilities. The likelihood of these accidents is expected to be significantly lower by a factor of 2 to 5. These facilities would be built to provide necessary improvements in safeguards and security, environmental safety and health (ES&H), and maintenance costs. A flood-induced criticality accident is the only criticality accident significantly affected by the location of the new facilities. Stream flooding is not credible except at elevations below 971 ft. Some HEU is presently stored below this level. The proposed new HEU Materials Facility or addition to Building 9215 would be constructed at an elevation above the predicted PC-3 (10,000-year return period) flood level and the beyond-design-basis flood would no longer be a concern. In addition, design and construction would ensure that flooding from rainfall runoff or roof ponding would not occur.

Source Term Calculations

The potential fission yield from a nuclear criticality accident varies according to the type of fissile material (i.e., solution, moderated and reflected, or dry powder or metal). DOE-HDBK-3010-94 (DOE 1994b) suggests values for fission yields of 1×10^{18} fissions for a fully moderated and reflected solid system and 1×10^{17} fissions for a dry powder or metal system. A solution criticality accident is the worst-case event and would yield an initial pulse of 1×10^{18} fissions followed by additional pulses over a period of 8 hr for a total of 1×10^{19} fissions.

Consequences

The consequences associated with a solution criticality accident have been evaluated using the prompt dose calculations and those associated with the CEDE. The predicted prompt dose for a solution criticality accident with an initial pulse of 10^{18} fissions (taking no credit for attenuation due to concrete, steel, or other intervening shielding material that might provide a significant dose reduction) drops below 100 rem within 19 m from the accident, below 25 rem at 35 m, and below 1 rem at 142 m. Acute lethal exposures can be received by unshielded persons who are within 5 to 10 m of an accident. Because of the potential for operator fatality, the consequence rating is "High." No credit is taken for shielding that may be available to any criticality accident that occurs inside the building. Assuming a ground-level release of fission products, the fission product release and radiation dose predicted for a moderated or dry metal criticality accident would be 10 to 100 times less than that of a solution criticality accident.

Although there is a potential for significant harm to operators or nearby workers, none of the nuclear criticality accidents are expected to result in a radiation dose that would cause fatalities among collocated workers or challenge the off-site evaluation guideline of 25 rem CEDE for an MEI member of the public. The evaluation guideline, while not considered an acceptable public exposure, is well below a level generally accepted as a value indicative of no significant health effects (i.e., low risk of latent health effects and virtually no risk of prompt health effects). DOE strives to reduce risks through preventive and mitigative measures to the extent practicable. Table D.7.4-1 summarizes the results for a criticality accident at Y-12 based upon the causes listed above. The on-site population doses are based upon an accident at Building 9212 as the bounding case (collocated employees are located closer to the building).

TABLE D.7.4–1.—*Summary Results for Criticality Accident Scenarios*

Unmitigated Accident Frequency (yr^{-1})[a]	Estimated Source Term and Consequences	Unmitigated Scenario Class	Preventors/ Mitigators	Mitigated Scenario Class
$1 > F > 10^{-2}$	**Release:** 1.0 x 10^{19} fissions; **collocated worker:** MEI less than 8 rem, 870 person-rem, 0.35 LCF; **off-site public:** MEI less than 3 rem, 8.6 person-rem, 4 x 10^{-3} LCF	I	Administrative controls, engineered controls, criticality accident alarm system, emergency management	II

[a] Without preventive measures
Source: Fisher 1995.

Criticality accident alarm systems mitigate the consequences of a criticality by alerting personnel to evacuate the affected area. Personnel are trained, thus reducing their exposure to radiation from continuing or subsequent criticality. The criticality accident alarm systems cannot prevent personnel from receiving a prompt dose from a criticality, but they can mitigate further exposure.

D.7.4.2 *Fire Events Involving Radioactive Materials*

The release of radioactive material in the event of a fire has been evaluated for Buildings 9720-5, 9204-4, 9204-2E, 9212, 9215, 9206, 9720-38, and 9201-5 (see Table D.7.2-1). The released materials include enriched uranium (solids and chips), depleted uranium, as well as uranium in solvents, thorium organics, and oil. PHAs were performed to screen the potential fire events and determine the worst-case scenarios. Accident frequencies and consequences were compared with a risk matrix from DOE STD-3011-94. These scenario classes included high frequency-low consequence events as well as low frequency-high consequence events. Dominant accidents, those that were categorized as Scenario Classes I and II, were then evaluated further. Structures, systems, and components were identified that either reduce the frequency or the consequences for the dominant scenarios. External fire scenarios that could involve multiple buildings were also considered. However, based on the design, construction and location of the facilities, no credible scenarios involving multiple buildings were identified.

Properties of Hazardous Material

The primary hazardous materials of concern are uranium and uranium compounds. They represent the most radioactive hazard for which a large, airborne, respirable release is possible. The typical enriched uranium (93.5 percent ^{235}U) that is present has a specific activity of 7 x 10^{-5} Ci/g and an inhalation dose conversion factor of 1.23 x 10^{8} rem/Ci CEDE. Higher enrichments do exist in limited activities; however, they will not significantly impact the consequences of the postulated accidents. Depleted uranium is present in large quantities at Y-12. Depleted uranium has a specific activity of 4 x 10^{-7} Ci/g and an inhalation dose conversion factor of 1.20 x 10^{8} rem/Ci CEDE. The toxicological effects outweigh the radiological effects for depleted uranium. Thorium and small quantities of other radionuclides such as plutonium, niobium, technetium, cesium, cerium, and neptunium may also be present in the Y-12 facilities. Fires involving materials typically present in other industrial facilities (solvents, organics, oils) were screened out as typical industrial hazards unless they initiated a fire involving uranium/uranium compounds.

Release Mechanism

Building fires involving enriched uranium were assumed as the worst-case scenarios. No credit was taken for separation of materials, storage containers, or building structure to assure the analysis did not assume any mitigation. Because of security concerns, specific events/inventories are not identified in the tabular results.

Analysis for HEU Storage Mission Proposed Alternatives

Either a new HEU Materials Facility (Alternative 2A) or Building 9215 (Alternative 2B) addition to store HEU is proposed under the HEU Storage Mission Alternatives. The conceptual design analysis of either facility to store HEU indicates that the frequency of fire would be controlled by limiting combustible materials from the facilities. The new facility would be constructed entirely of concrete and the contents would provide minimal combustible material loading. The potential radiological dose from material released by a fire based on the expected maximum inventory is less than 25 rem at 350 m (distance to Y-12 Emergency Response Boundary). Considering the segmentation of the inventory, the use of fire barriers, and the noncombustible building construction, the consequences of any release would be expected to be below the results presented for the existing facilities by a factor of 2 to 5. Current storage facilities do contain combustible materials or were built using combustible materials. The lower combustible material loading both prevents major fires and mitigates the fuel available for a fire.

Source Term Calculations

The source term is the amount of airborne respirable material dispersed from the accident scene and is calculated as the product of the material at risk (MAR), the damage ratio of the container, the airborne release fraction, the respirable fraction, and the leak path factor for the building. The MAR was based on the area and duration of the fire assumed for the scenarios. The damage ratio and leak path factor depend on the fire and container (building) characteristics as well as the nature of the released material. A conservative upper bound of 1.0 was assumed for both the damage ratio and leak path factor.

Source terms used to calculate the potential on-site and off-site consequences of a large fire were based on either (1) a limiting facility inventory (an inventory administratively controlled below the amount required to exceed the 5-rem threshold for a "High" consequence level event), or (2) by assuming that a fire involved the maximum inventory that could be consumed in the worst-case building fire.

Consequences

The consequences of a radiological fire in the facilities at Y-12 include potential exposure to airborne releases of various forms of uranium and uranium compounds. The potential consequences of the dominant accident scenarios are presented in Table D.7.4-2.

TABLE D.7.4–2.—*Summary Results for Radiological Fire Scenarios* [Page 1 of 3]

Building/ Accident	Unmitigated Accident Frequency (yr^{-1})	Estimated Source Term And Consequences	Unmitigated Scenario Class	Preventers/ Mitigators	Mitigated Scenario Class
Building 9212/ Safe Bottle Storage Area Organics Fire	$10^{-4} \leq F \leq 10^{-2}$	**Release:** 60 g airborne EU; **collocated worker:** MEI 1.13 rem, 1,067 person-rem, 0.43 LCF; **off-site public:** MEI 0.67 rem, 15.3 person-rem, 0.008 LCF	II	Sprinklers	III
Building 9212/ Chip Fire	$10^{-2} < F \leq 1$	**Release:** 100 g airborne EU; **collocated worker:** MEI 0.19 rem, 180 person-rem, 0.071 LCF; **off-site public:** MEI 0.11 rem, 2.6 person-rem, 0.0013 LCF	I	HEPA filters	III
Building 9212/ Dry Vacuum Fire	$10^{-2} < F \leq 1$	**Release:** 29 g airborne EU; **collocated worker:** MEI 0.05 rem, 51 person-rem, 0.02 LCF; **off-site public:** MEI 0.03 rem, 0.71 person-rem, 4 x 10^{-4} LCF	III	Flame-resistance bags	IV
Building 9212/ B-1 Wing Fire	$10^{-4} \leq F \leq 10^{-2}$	**Release:** 500 g airborne EU; **collocated worker:** MEI 0.93 rem, 890 person-rem, 0.35 LCF; **off-site public:** MEI 0.55 rem, 13 person-rem, 0.006 LCF	II	Sprinklers and administrative controls	III
Building 9206/ Safe Bottle Storage Area Organics Fire	$0^{-4} \leq F \leq 10^{-2}$	**Release:** 189 g airborne EU; **collocated worker:** MEI 0.05 rem, 472 person-rem, 0.19 LCF; **off-site public:** MEI 0.30 rem, 7.0 person-rem, 2.4 x 10^{-3} LCF	II	Sprinklers	III

TABLE D.7.4–2.—*Summary Results for Radiological Fire Scenarios* [Page 2 of 3]

Building/ Accident	Unmitigated Accident Frequency (yr^{-1})	Estimated Source Term And Consequences	Unmitigated Scenario Class	Preventers/ Mitigators	Mitigated Scenario Class
Building 9206/ Exhaust system baghouse fire	$10^{-2} < F \leq 1$	**Release:** 21 g airborne EU; **collocated worker:** MEI 0.04 rem, 37 person-rem, 0.015 LCF; **off-site public:** MEI 0.02 rem, 0.54 person-rem, 2.7 x 10^{-4} LCF	III	Equipment design, administrative controls	IV
Building 9206/ Argon glovebox pyrophoric U-compound fire	1 $10^{-2} < F \leq 1$	**Release:** 7 g airborne EU; **collocated worker:** MEI 0.01 rem, 12 person-rem, 0.0050 LCF; **off-site public:** MEI 0.01 rem, 0.18 person-rem, 9 x 10^{-5} LCF	III	Oxygen monitor, pressure release valves, HEPA filters/ equipment design	IV
Building 9206/ Building fire	$10^{-2} < F \leq 1$	**Release:** 800 g EU/16.2 g DU airborne; **collocated worker:** MEI 1.49 rem, 1400 person-rem, 0.57 LCF; **off-site public:** MEI 0.56 rem, 21 person-rem, 0.01 LCF	I	Sprinklers, building/ equipment design, administrative controls	III
Building 9215/ Hydraulic oil pool fire	$10^{-2} < F \leq 1$	**Release:** 75 g airborne EU; **collocated worker:** MEI 0.14 rem, 130 person-rem, 0.053 LCF; **off-site public:** MEI 0.07 rem, 1.9 person-rem, 0.001 LCF	III	Hydraulic oil that prevents ignition	IV
Building 9204-2E/ building fire	$10^{-4} \leq F \leq 10^{-2}$	**Release:** 22 kg airborne EU; **collocated worker:** MEI 40.92 rem, 3300 person-rem, 1.3 LCF; **off-site public:** MEI 15.53 rem, 570 person-rem, 0.28 LCF	I	Fire protection/ inventory limits/ Non-combustible building	II
Building 9204-4/ building fire	$10^{-4} \leq F \leq 10^{-2}$	**Release**: < 200 g airborne EU; **collocated worker:** MEI 0.37 rem, 29 person-rem, 0.012 LCF; **off-site public:** MEI 0.14 rem, 5.2 person-rem, 0.0026 LCF	II	Fire protection/ inventory limits/ non-combustible building	III

TABLE D.7.4–2.—*Summary Results for Radiological Fire Scenarios* [Page 3 of 3]

Building/ Accident	Unmitigated Accident Frequency (yr^{-1})	Estimated Source Term And Consequences	Unmitigated Scenario Class	Preventers/ Mitigators	Mitigated Scenario Class
Building 9720-5/fire	$10^{-4} \leq F \leq 10^{-2}$	**Release:** 18.3 kg airborne EU; **collocated worker:** MEI 56.91 rem, 2700 person-rem, 1.1 LCF; **off-site public:** MEI 7.01 rem, 470 person-rem, 0.24 LCF	I	Fire protection, administrative controls	III
Building 9720-38/fire	$10^{-2} < F \leq 1$	**Release:** 35 kg DU and 15 kg normal U airborne; **collocated worker:** MEI 1.21 rem, 50 person-rem, 0.020 LCF; **off-site public:** MEI 0.15 rem, 0.72 person-rem, 3.6 x 10^{-4} LCF	I	Administrative/ equipment/fire protection	IV
Building 9201-5/fire involving DU	$10^{-4} \leq F \leq 10^{-2}$	**Release:** 5.1 kg DU/DU alloy airborne; **collocated worker:** MEI 0.12 rem, 5.86 person-rem, 0.0023 LCF; **off-site public:** MEI 0.04 rem, 1.0 person-rem, 5 x 10^{-4} LCF	III	Administrative control of inventory	IV
Building 9201-5/DU chip dryout	$10^{-2} < F \leq 1$	Same as above	III	Same as above	IV
Building 9201-5/Duct/filter fire (DU)	$10^{-4} \leq F \leq 10^{-2}$	Same as above	III	Same as above	IV
Building 9201-5/ Building fire (DU)	$10^{-4} \leq F \leq 10^{-2}$	Same as above	III	Same as above	IV
On-site transport of HEU	$10^{-2} \leq F \leq 1$	**Release:** 0.41 kg EU airborne; **collocated worker:** MEI 1.28 rem, 60 person-rem, 0.024 LCF; **off-site public:** MEI 0.37 rem, 11 person-rem, 0.0053 LCF	I	Administrative controls	II

Note: DU-depleted uranium; EU-enriched uranium; HEPA-high-efficiency particulate air
Source: Fisher 1995 and Table D.7.2.1–1.

D.7.4.3 *Release Due to Explosion*

The bases for interim operation for Buildings 9212, 9206, 9204-2E, 9215, 9204-4, 9720-5, and the safety analysis report for 9720-38 (see Table D.7.2-1) identified the hazardous material inventories that could be involved in a release resulting from an explosion. The explosion accidents in the facility accident analyses were screened for the higher consequence levels using a conservative consequence assessment. An accident was not considered for further analysis if it was estimated to be less frequent than 10^{-6}/yr or if the consequences were bounded by the consequences associated with a facility fire for Buildings 9204-2E, 9215, 9204-4, 9720-5, and 9720-38. The dominant postulated explosion scenarios identified in the accident analyses are associated with organic chemical and nitrate reactions resulting in the formation of nitrated organic compound (red oil) explosions and fume-off reactions; flammable gas leaks from hydrogen, natural gas, and oxygen; as well as chemical reactions, steam and dust explosions. Table D.7.4-3 presents a summary of results for the explosion or thermal scenarios that were categorized in Scenario Classes I and II.

TABLE D.7.4–3.—*Summary Results for Explosion Scenarios*

Accident	Unmitigated Accident Frequency (yr^{-1})	Estimated Consequences	Unmitigated Scenario Class	Preventers/ Mitigators	Mitigated Scenario Class
Organic/nitrate solvent reaction, red oil explosion	$10^{-4} \le F \le 10^{-2}$	Worker fatality; low consequences to collocated workers and the public.	I	Design features, administrative controls	II
Fume-off explosion	$10^{-2} < F \le 1$	Worker injury; low consequences to collocated workers and the public.	I	Design features, administrative controls, personal protective equipment	III
Hydrogen gas explosion	$10^{-4} \le F \le 10^{-2}$	Worker fatality; low consequences to collocated workers and the public.	I	Design features, administrative controls	II
Natural gas explosion	$10^{-2} < F \le 1$	Worker fatality; low consequences to collocated workers and the public.	I	Design features, administrative controls	II
Chemical reaction	$10^{-2} < F \le 1$	Worker injury; low consequences to collocated workers and the public.	I	Administrative controls, personal protective equipment	III

Source: Table D.7.2–1.

The potential exists for a fire to develop as the result of an explosion. The effects of a fire developing after an explosion were assessed and were determined to be bounding for any explosion event. The explosion events are likely to occur in open areas with operators located in the immediate area. A nearby worker could be seriously injured or killed due to the physical effects of the explosion. These effects cannot be mitigated if the operator is in the immediate area; therefore, the consequences remain "High" to facility workers. However, significant quantities of radioactive material are not expected to become airborne.

Properties of Hazardous Material

The hazardous materials of concern are uranium and uranium compounds that present radiological hazards as the consequence of the postulated accidents. Thorium and small quantities of other radionuclides such as plutonium, niobium, technetium, cesium, cerium, and neptunium may also be present in the Y-12 facilities. The radiological doses from thorium and these small quantities of radionuclides are dominated by the dose resulting from an accidental release of enriched uranium.

Release Mechanism

The release mechanism was an explosion that involved the HEU materials in segmented locations in each analyzed facility. The HEU materials are present in small amounts in the potential accident locations often in nonrespirable forms and, in some cases, shielded from the force of the blast by equipment. No credit was taken for separation of materials, storage containers, or building structure.

Analysis for HEU Storage Mission Proposed Alternatives

Either a new HEU Materials Facility (Alternative 2A) or an addition to Building 9215 (Alternative 2B) is proposed for the HEU Storage Mission at the Y-12 Plant. These new facilities are meant to expand and consolidate the storage of HEU in one modern facility built to modern codes and standards. Additionally, the new HEU storage facility will make use of engineered controls in lieu of administrative controls when possible. Thus the controls that prevent or mitigate accidents will be more reliable. The likelihood of accidents involving HEU will decrease with the new facility over the present storage facilities. The likelihood of these accidents is expected to be significantly lower. The conceptual design analysis of the HEU Materials Facility or Building 9215 expansion to store HEU indicates that the frequency of an explosion would be controlled by excluding materials from the facilities that could cause an explosion. The new facilities would be constructed entirely of concrete and the contents would provide minimal combustible or flammable material loading. Considering the segmentation of the inventory, the use of fire barriers, and the lack of explosive materials, any release would be expected to be below the analytical results shown in Table D.7.3-3.

Source Term Calculations

The source term is the amount of airborne respirable material and is calculated as the product of the MAR, the damage ratio of the container, the airborne release fraction, the respirable fraction, and the leak path factor for the building. The MAR is based on the inventory in the area of the explosion assumed for the scenarios. The damage ratio and leak path factor depend on the explosion and container (building) characteristics as well as the nature of the released material. A conservative upper bound of 1.0 is assumed for both the damage ratio and the leak path factor.

Consequences

The consequences of an explosion in the facilities at Y-12 include potential exposure to small airborne releases of various forms of uranium and uranium compounds. All of the dominant explosion scenarios resulted in "Moderate" to "High" consequences to the worker but did not produce any significant radiological consequences to the collocated worker or off-site public. The potential consequences of the dominant accident explosion scenarios are presented in Table D.7.4-3. The explosion could be the initiator for a large building fire and this scenario was discussed in the preceding section.

D.7.4.4 *Beyond-Design-Basis Seismic Events*

To assure conservative consequence estimates, the beyond-design-basis seismic events with frequencies less than 5 x 10^{-4}/yr (2000-yr recurrence period) were considered. The accident forces associated with these events are determined from guidance in DOE Order 420.1, *Facility Safety* and DOE STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities.* In DOE Order 420.1 and DOE STD-1020–94, event frequencies provide a baseline for determining the natural phenomena resistance of structures, systems, and components important to safety. Seismic events of greater magnitudes

than those defined in the DOE requirements were selected for evaluation to assure that beyond-design-basis effects were being examined.

Further conservatism was included by a three-distinct-event criterion, where the natural phenomena initiator itself is considered the first distinct event. Two additional distinct events, defined as events which assume a pre-existing abnormal facility/equipment condition or an abnormal facility/equipment response, were postulated to maximize the consequences of the seismic event. The probability of fires following a beyond-design-basis seismic event is very high and assumed to be one for this analysis.

For the beyond-design-basis seismic events, structural collapse was postulated to be accompanied by the most significant internal events, including fire and explosions (the three-distinct-event criterion). This postulated sequence, coupled with the short distances to the Y-12 Emergency Response Boundary, results in overly conservative values for maximum doses to individuals at the boundary. Y-12 facilities that have the potential for such significant internal events are Buildings 9204-4, 9206, 9212, and 9215.

In general, a beyond-design-basis seismic event is a bounding accident scenario because it destroys building confinement and includes all significant individual fire and explosion scenarios.

Building 9204-4

For Building 9204-4, a beyond-design-basis seismic event was assumed to cause the facility to collapse. A ruptured flammable gas main was assumed to cause a plume of flammable gas to momentarily develop and immediately ignite. This served as an ignition source for oil fires. The event was assumed to affect the entire building. Energy sources included flammable gases and combustible oils.

Building 9206

For Building 9206, a beyond-design-basis seismic event was assumed to cause the facility to collapse, with a natural gas explosion, and accompanying fire. Energy sources included the flammable gases, combustible solids, and organic liquids.

Building 9212

For Building 9212, a beyond-design-basis seismic event was assumed to cause the building to progressively fail. A hydrogen explosion was postulated to occur, and a solvent fire was postulated to occur as well.

Building 9215

For Building 9215, a beyond-design-basis seismic event was assumed to cause the total building to collapse, followed by a propane explosion and a number of oil fires.

Analysis for HEU Storage Mission Proposed Alternatives

Either a new HEU Materials Facility (Alternative 2A) or an addition to Building 9215 (Alternative 2B) is proposed for the HEU Storage Mission at the Y-12 Plant. These new facilities are meant to expand and consolidate the storage of HEU in one modern facility built to current codes and standards. Additionally, the new HEU storage facility will make use of engineered controls in lieu of administrative controls when possible. Thus the controls that prevent or mitigate accidents will be more reliable. In comparison to the present storage facilities, the likelihood of a seismic event with forces greater than the planned design is expected to be significantly lower. The conceptual design analysis of the HEU Materials Facility or Building 9215 expansion to store HEU indicates that the new facilities would be designed and built to DOE PC-3 design standards and to current codes. That is, the performance goal for the annual probability of exceeding acceptable behavior (i.e., maintaining worker safety, confinement of hazards, safe operations) is 1×10^{-4}/yr. The proposed new facilities would be less subject to seismic force damage, and the resulting frequency for a design basis seismic event would be 5×10^{-4}/yr (a 2,000-year return period). The frequency of the beyond-design-basis seismic event would be less than 1×10^{-4}/yr. For comparison, the existing HEU storage buildings have a 5×10^{-4} /yr frequency estimate for a beyond-design-basis seismic event. Major consequences of a severe seismic event can include both a criticality accident and a fire. The frequency of a fire would be controlled by limiting combustible materials in the new facilities. The new facilities would be constructed primarily of reinforced concrete and the contents would provide an extremely low combustible material loading. Considering the segmentation of the inventory, the use of fire barriers as proposed in the HEU Materials Facility (and Building 9215 expansion), and the noncombustible building construction, any release as a result of the design basis seismic event would be expected to occur at a lower frequency. Off-site exposures to an MEI would be expected to be higher because the building will be closer to the Y-12 Emergency Response Boundary.

Consequence Calculations and Risk

The source terms for the release from each building and the consequences are presented in Table D.7.3-4. Because these are beyond-design-basis seismic events, no mitigation was considered.

TABLE D.7.4–4.—*Estimated Consequences of a Beyond-Design-Basis Seismic Event*

Building	Source Term	Collocated Worker	Public
9204-4	950 g of HEU	MEI: 2.0 rem Population: 140 person-rem, 0.056 LCF	MEI: 0.67 rem Population: 25 person-rem, 0.012 LCF
9206 Complex	6.2 kg of HEU	MEI: 11.5 rem Population: 10,944 person-rem, 4.4 LCF	MEI: 6.8 rem Population: 150 person-rem, 0.08 LCF
9212	6.8 kg of HEU	MEI: 13 rem Population: 12,000 person-rem, 4.8 LCF	MEI: 7.5 rem Population: 180 person-rem, 0.088 LCF
9215	1.9 kg of HEU	MEI: 3.6 rem Population: 3,400 person-rem, 1.3 LCF	MEI: 2.0 rem Population: 49 person-rem, 0.025 LCF

Source: Fisher 1995 and Table D.7.2.1-1.

D.7.4.5 *Evaluation Basis Tornado*

High winds and tornadoes have been evaluated for the Y-12 Site. The consequences that could result from these accident initiators were bounded by fire and criticality events. Evaluation basis tornado events were postulated separately for Buildings 9206 and 9212. The evaluation basis tornado event is defined as a tornado with a combined rotational and translational speed of 130 mph. This event has a 50,000-year return period (LMES 1995b).

This event could result in widespread roof and wall damage to the facilities. The effects of tornado missiles would result in scenarios similar to loss of confinement due to explosion. Loss of confinement would result in uranium-contaminated or uranium-containing solvent spills and fire. The source term for a spill of all contaminated solvent with subsequent burning of the spilled solvent is described in the fire scenario. The consequences of a tornado-initiated accident would be bound by the consequences estimated for fires. Additional release of uranium-bearing particulate material could be expected. The most significant radiological consequences would be from a criticality accident (Section D.7.3.1) or fires subsequent to the tornado. The frequency of a tornado event resulting in a significant radiological release was characterized using the DOE-STD-3011-94 criteria as "Extremely Unlikely" (DOE 1994a). The radiological consequences for the MEI off-site and the collocated worker result in a "Moderate" to "High" consequence classification for both Building 9206 and Building 9212.

A tornado-initiated release of material from the Environmental Management Waste Management Facility included under the No Action alternative in this SWEIS was postulated in the *Remedial Investigation/Feasibility Study* (RI/FS) report (DOE 1998a). The postulated release would be caused by the tornado scouring the top 6 in. of waste from the surface of any open cells and depositing this material over a 26 km^2 (10 mi^2) area of farmland. The assumptions of using a 26 km^2 (10 mi^2) area and farmland are considered conservative for the consequence dose calculations. A review of historical evidence indicates that most objects fall out from a tornado within 80 to 145 km^2 (50 to 90 miles) but some objects have reportedly been carried up to 210 miles. The latent cancer risk caused by the dispersal of material is estimated to be 2.2×10^{-4} with a population dose of less than approximately 0.4 person-rem. The report quotes an overall risk presented by the low frequency of occurrence (2×10^{-5}/yr), the 30-year life of the facility, and the latent cancer risk yields an overall risk estimate of 1.32×10^{-7} of an LCF. Additional information is available in the report.

D.7.4.6 *Flood*

In accordance with DOE STD-1020-94, the effects of a flood with a frequency of 5×10^{-4}, or a return period of 2,000 years, was evaluated. The flood hazard studies that were used to define the flooding conditions at the Y-12 Plant included the effects of stream flooding, upstream dam failures, snow loading, and intense local precipitation. Four buildings were identified as having a potential for flooding: Building 9720-5, Building 9204-4, Building 9204-2 and Building 9204-2E. Prevention of a criticality accident in the event of flooding is based on storing enriched uranium above the projected flood level or otherwise ensuring the storage arrangement meets the double contingency principle. Simply flooding the storage area will not result in a criticality accident unless several adjacent containers fail or leak. The proposed HEU Materials Facility or the Building 9215 expansion that would consolidate the HEU presently stored in Buildings 9720-5, 9204-4, and 9204-2E would be constructed above the 2,000-year return period flood level, above any potential flooding from intense local precipitation, and designed to prevent flooding from roof ponding.

Frequency

The estimated frequency of a flood that results in a criticality accident is less than 1×10^{-6}/yr.

Consequences

The consequences associated with a flood include moderation of fissile material and the potential for a criticality accident. The potential consequences to workers, collocated workers, and MEI off-site are the same as those discussed in Section D.7.3.1 for other criticality accidents.

D.7.4.7 *Wildfires*

A wildfire could be initiated by a lightning, an aircraft crash, a burning cigarette, the sun shining on a piece of glass, or even a "controlled burn" during windy conditions. Fires on the Oak Ridge Reservation are not common but they do occur. Records indicate that 9 wildfires have occurred on the Oak Ridge Reservation since 1966. The largest area burned by a wildfire was 400-500 acres. This wildfire occurred April 7, 1966 and originated in the Y-12 burning pits. Another significant wildfire occurred February 21, 1977. This wildfire burned uncontrolled on the Reservation on Pine Ridge, immediately west of a 500 kv transmission line. This wildfire resulted from brush piles being burned by a TVA contractor clearing the Watts Bar-Roane transmission line right-of-way on the northwest slopes of Pine Ridge. The total area burned by this fire was approximately 48.8 acres.

Although wildfires are not expected to reach Y-12 facilities, hot embers from such a fire could blow onto roof tops, potentially initiating a building fire. Depending on the proximity of the fire and wind conditions, ash and other byproducts from a wildfire could plug fresh air intakes and exhaust filters for the Y-12 facilities. Heavy smoke could cause the filters to become clogged or "loaded", which could lead to failure in the filtering system.

D.7.5 Chemical Accidents

D.7.5.1 *Toxic Chemical Release Due to Fire*

Releases of toxic materials from Y-12 facilities as a result of a large fire were evaluated. Accident frequencies and consequences were characterized using a risk matrix from DOE STD-3011-94. Dominant accidents, those that were categorized as Scenario Class I or II, were then evaluated further. Dominant scenarios were identified for Buildings 9202, 9204-2E, 9720-26, 9720-38 and 9206. Chemicals released as a result of these accidents are beryllium compounds, lithium hydride, acetonitrile, chromic acid, phosphoric acid, mercury, and depleted uranium.

Properties of Hazardous Material

The toxicological hazard from inhalation of depleted uranium is more severe than the radiological hazard. Other hazardous chemicals/ compounds are also present in varying amounts and chemical forms. Many chemicals that are used at the Y-12 Plant do not pose a risk to the public but do pose a significant risk to on-site facility workers. These chemicals (such as strong acids or caustic solutions, small quantities of flammable compounds, NaK heat transfer fluid, etc.) can cause serious thermal or chemical burns, lost-time accidents, maiming (loss of an eye or use of a limb), and are potentially lethal. In December 1999, a chemical explosion accident occurred within the skull caster furnace section of Building 9201-5 at the Y-12 Plant. The explosion occurred as workers were cleaning up a spill of sodium-potassium alloy (NaK). The NaK spill resulted from a combination of procedural errors during the replacement of the skull caster furnace crucible. NaK is pyrophoric and can be explosive under certain circumstances (e.g., when exposed to air it can form a potassium superoxide that is shock-sensitive and explosive when combined with hydrocarbons, such as mineral oil). As part of the preparation for removing the spilled NaK, the inside walls of the crucible containing the spilled NaK were repeatedly sprayed with mineral oil. Mineral oil has historically been used as a "bath" - that is, NaK or NaK oxides were placed in a bucket of mineral oil. Spraying mineral oil was apparently a practice that was used by workers at the Y-12 Plant in the past. This approach was made without any analysis of the potential hazards. The explosion occurred as a worker was attempting to break up the crust of the spilled NaK, using a steel rod. The explosion injured 11 workers, 3 of whom required hospitalization. As stated in the Type A Investigation Report of the explosion, Y-12 Plant management plans to discontinue the use of NaK systems across the Plant. They plan to collect and dispose of all NaK in the Y-12 Plant, including the material in Building 9201-5 and other areas at the Y-12 Plant. This accident, although serious in consequences to the involved workers, posed no risk to the public. Additional details regarding this accident can be found in the following document: *Type A Accident Investigation of the December 8, 1999, Multiple Injury Accident Resulting from the Sodium-Potassium Explosion in Building 9201-5 at the Y-12 Plant.*

Those fire accident scenarios which could result in an airborne release of hazardous material were compared to ERPG Values (or TEEL values if ERPG values are not established). An accident scenario was categorized as Scenario Class I or II if the accident could result in an off-site airborne hazardous material concentration exceeding the ERPG-2 guideline, or an on-site airborne hazardous material concentration exceeding the ERPG-3 guideline.

Release Mechanism

A fire that involves the maximum building inventory of hazardous materials was assumed to result in the worst-case scenario. Consequences of the dominant fire scenarios are presented in Table D.7.5-1.

Analysis for Special Materials Mission Proposed Alternative

A new Special Materials Complex is proposed for the Special Materials Mission (Alternative 3A) at the Y-12 Plant. This new complex of buildings and associated facilities is meant to consolidate production activities and the use of many special chemical compounds in one area of the Y-12 Plant while improving worker and public health and safety. This new materials complex would be built to modern codes and standards. Additionally, the new Special Materials Complex will make use of engineered controls in lieu of administrative controls when possible; thus, the controls that prevent or mitigate accidents will be more reliable. The likelihood of accidents involving the chemicals stored in the new complex will decrease with the new facility over the present process facilities. The likelihood of these accidents is expected to be significantly lower. The present locations that are being considered for the Special Materials Complex show that one of the candidate sites (Site 1) is located north of the Bear Creek Road and somewhat closer to the closest Y-12 Emergency Response Boundary and closer to the location of an MEI member of the public. This location would increase the likelihood of exceeding ERPG-2 (or TEEL-2) concentrations at the Y-12 Emergency Response Boundary if the same inventories of chemicals are stored at all of the candidate sites. However, the control of lower inventories could be used to reduce the potential for off-site exposure of the public below ERPG-2 (or TEEL-2) levels. It is possible that the lower inventories may not be conducive to efficient operations, but may be warranted to reduce the risk to the public of an off-site exposure greater than ERPG-2.

D.7.5.2 *Toxic Chemical Release Due to Loss of Containment*

Releases of toxic materials from Y-12 facilities as a result of loss of containment (spills) were evaluated. Accident frequencies and consequences were characterized with a risk matrix from DOE STD-3011-94. Dominant accidents, those that were categorized as Scenario Classes I and II, were then evaluated further. Dominant scenarios were identified for the 9206 Complex, Building 9401-3, and Building 9212. Chemicals released as a result of these accidents are nitric acid, sulfuric acid, and hydrogen fluoride.

Properties of Hazardous Material

The hazardous materials of concern are chemically toxic materials whose release as part of a loss of containment can result in potentially harmful airborne respirable concentrations of hazardous materials. Those release accident scenarios which could result in an airborne release of hazardous material were compared to the ERPG values (or TEEL values if ERPG values are not established). An accident scenario was categorized as Scenario Class I or II if the accident could result in an off-site airborne hazardous material concentration exceeding the ERPG-2 guideline, or an on-site airborne hazardous material concentration exceeding the ERPG-3 guideline.

TABLE D.7.5–1.—*Summary Results for Toxic Material Fire Scenarios*

Building/ Accident	Unmitigated Accident Frequency (yr^{-1})	Estimated Consequences	Unmitigated Scenario Class	Preventers/ Mitigators	Mitigated Scenarios Class
9202 Building Complex/ large building fire	$10^{-4} \le F \le 10^{-2}$	**MAR:** 181.4 kg beryllium compounds, 680.4 kg lithium hydride, and 453.6 kg acetonitrile thermal decomposition products; **collocated worker:** concentrates do not exceed ERPG-3 levels, 148 workers exposed to greater than ERPG-2 or TEEL-2 concentrations; **off-site public:** concentrations do not exceed ERPG-2 or TEEL-2	I	Limit on allowable hazardous material inventory	III
Building 9204-2E/ Fire on first , second, or third floor	$10^{-6} \le F \le 10^{-4}$	**MAR:** 113.4 kg chromic acid and 226.8 kg. phosphoric acid thermal decomposition products386 kg mercury; **collocated worker:** concentrations do not exceed TEEL-3 levels, 80 workers exposed to greater than TEEL-2 concentrations; **off-site public:** mercury concentrations may exceed TEEL-2	I	Fire prot. program; building structure; administrative controls	I
Building 9720-26/ Fire affects entire building	$10^{-4} \le F \le 10^{-2}$	**MAR:** 2,268,000 kg mercury; **collocated worker:** concentrations at 200m may exceed TEEL-3 levels, 80 workers exposed to greater than TEEL-2 concentrations; **off-site public:** concentrations may exceed TEEL-2	II	Fire protection program; building structure; very low loading of combustible materials; administrative controls	IV
Building 9720-38/ Fire affects entire building	$10^{-4} < F \le 10^{-2}$	**MAR:** 1,350,000 kg DU; **collocated worker:** concentrations at 200m do not exceed TEEL-3, 190 workers exposed to greater than TEEL-2 concentrations; **off-site public:** concentrations do not exceed the TEEL-2	I	Thermally insulated containers used for some materials; restrictions on storage location of some materials	II
Building 9206/ DU wet chip fire	$10^{-2} < F \le 1$	**MAR:** 115 kg DU; **collocated workers:** concentrations at 200m do not exceed TEEL-3 , 80 workers exposed to greater than TEEL-2 concentrations; **off-site public:** concentrations do not exceed TEEL-2	I	Administrative controls	I

Note: MAR-material at risk
Source: Table D.7.2-1

TABLE D.7.5–2.—*Summary Results* for *Toxic Material Loss of Containment Scenarios*

Building/ Accident	Unmitigated Accident Frequency (Yr^{-1})	Estimated Consequences	Unmitigated Scenario Class	Preventers/ Mitigators	Mitigated Scenario Class
9206 Complex/ Nitric acid tank failure due to external hazard accident	$10^{-4} \leq F \leq 10^{-2}$	**MAR:** 41,745 kg nitric acid; **collocated worker:** concentrations at 200 m do not exceed TEEL-3, potential worker injury, 80 workers exposed to greater than TEEL-2 concentrations; **off-site public:** concentrations do not exceed TEEL-2	II	Administrative controls	II
9206 Complex/ Nitric acid tank catastrophic failure	$10^{-2} < F < 1$	**MAR:** 41,745 kg nitric acid; **collocated worker:** concentrations at 200 m do not exceed TEEL-3, potential worker injury, 80 workers exposed to greater than TEEL-2 concentrations; **off-site public:** concentrations do not exceed TEEL-2	I	None	I
Multiple Buildings/ Spill of corrosive or reactive chemicals (equipment failure)	$10^{-2} < F \leq 1$	**MAR:** strong acid or reactive chemical; **collocated worker:** concentrations do not exceed TEEL-3potential worker injury or fatality; **off-site public:** concentrations do not exceed TEEL-2	I	Personal protective equipment, safety equipment	III
Building 9401-3/sulfuric acid tank failure due to external hazard accident	$10^{-4} \leq F \leq 10^{-2}$	**MAR:** 10,433 kg sulfuric acid; **collocated worker:** concentrations at 200 m do not exceed ERPG-3, potential worker injury, 80 workers exposed to greater than ERPG-2 concentrations; **off-site public:** concentrations do not exceed ERPG-2	II	Personal protective equipment, safety equipment	III
Building 9204-2/Sodium hydroxide tank failure due to external hazard accident	$10^{-4} \leq F \leq 10^{-2}$	**MAR**: 289,499 kg sodium hydroxide; **collocated worker**: concentrations at 200 m do not exceed ERPG-3, potential worker injury: 80 workers exposed to greater than ERPG-2 concentrations **off-site public:** concentrations do not exceed ERPG-2	II	Engineered design features, administrative controls	III

TABLE D.7.5–2.—*Summary Results for Toxic Material Loss of Containment Scenarios* (continued)

Building/ Accident	Unmitigated Accident Frequency (Yr^{-1})	Estimated Consequences	Unmitigated Scenario Class	Preventers/ Mitigators	Mitigated Scenario Class
Building 9212/ Release of hydrogen fluoride	$10^{-2} < F$	**MAR:** 600 kg hydrogen fluoride; **collocated worker:** concentrations at 400 m do not exceed ERPG-3, 310 workers exposed to greater than ERPG-2 concentrations, potential; **off-site public:** concentrations may exceed ERPG-2 levels 60m beyond the Y-12 Emergency Response Boundary, but will not reach the nearest residential area	I	Engineered design features, administrative controls	III
Building 1405/ Release of chlorine gas	$10^{-2} < F$	**MAR:**907 kg chlorine gas; **collocated worker:** concentrations at 400 m do not exceed ERPG-3, 1000 workers exposed to greater than ERPG-2 concentrations, potential worker fatality; **off-site public:** concentrations exceed ERPG-2 out to 1000 m, up to 6500 members of public exposed	I	Engineered design features, administrative controls	III

Note: MAR-material at risk
Source: Table D.7.2–1.

Release Mechanism

The release accidents were evaluated to determine the worst case scenario. In very high consequence scenarios (releases of hydrogen fluoride and chlorine) with widespread off-site public exposure, the accident scenarios have release times based upon a credible cylinder valve leak accident using typical atmospheric conditions for Y-12. Alternative, more realistic release scenarios were also evaluated. Table D.7.5-3 shows the consequences of the dominant loss of containment accident scenarios. Figures D.7.5-1 and D.7.5-2 show the extent of the potential plume radius for the loss of containment for anhydrous hydrogen fluoride and chlorine, respectively.

Analysis for HEU Storage Mission and Special Materials Mission Alternatives Under No Action - Planning Basis Operations Alternative

None of the proposed new facilities considered in this SWEIS would affect the dominant loss of containment accidents for the toxic chemicals at the Y-12 Plant. A note to the reader: Ownership and operation of the water treatment facilities presently at Y-12 have been transferred to the city of Oak Ridge. While this transfer does not eliminate the risk of a chlorine release to the Y-12 Plant workers or the public, it does terminate Y-12 control of these facilities.

FIGURE D.7.5–1.—*Estimated Radii of Emergency Response Planning Guidelines-2 and -3 Plumes for a Postulated Anhydrous Hydrogen Fluoride.*

FIGURE D.7.5–2.——*Estimated Radii of Emergency Response Planning Guidelines-2 and -3 Plumes for a Postulated Chlorine Release.*