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ENVIRONMENTAL ASSESSMENT FOR LGF SPILL TEST
FACILITY AT FRENCHMAN FLAT, NEVADA TEST SITE

Scott E. Patton
Michael G. Novo
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April 1986

Lawrence
Livermore
National
Laboratory

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MASTER

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I. INTRODUCTION

The United States Department of Energy (DOE) is constructing a spill test facility for hazardous materials in the Frenchman Flat area of the Nevada Test Site (NTS). The need for such a facility has been expressed by both industry and governmental agencies to supply information to aid with risk assessment, emergency response, regulation, plant design, and plant siting. Researchers working in the related fields of dense gas dispersion, vapor cloud combustion, and other scientific disciplines central to understanding accidents associated with the transportation and storage of hazardous substances, also have suggested the need for such a facility.

Perhaps the most important need of such a facility is obtaining fundamental atmospheric dispersion data for model validation of both theoretical and wind-tunnel simulations. These models must eventually be relied upon for hazard prediction, since it is not possible to test all potential accident scenarios. The spill test facility will also be capable of source definition experiments on a variety of spill surfaces, combustion experiments, and experiments to evaluate hazard mitigation equipment and emergency response procedures. (Koopman, 1985).

This document, the Environmental Assessment for the LGF Spill Test Facility at Frenchman Flat, Nevada Test Site, will consider the environmental consequences of spilling hazardous test materials in the Frenchman Flat basin. The document is an evaluation of environmental impacts for spilling any proposed material, and an environmental impact assessment for 14 proposed test materials. From this evaluation, mitigations are made in order to establish spill-test criteria that will protect natural resources and reduce land use impacts of areas adjacent to the spill test facility.

Guidelines and restrictions for spill-test procedures will be determined by DOE/NV Manager or his designee for the Liquefied Gaseous Fuels (LGF) Spill Test Facility based on recommendations made by the Environmental Assessment and test-proposal documentation provided by the user (Appendix III). Documentation for a proposed spill test will include the spill material's toxicity and gaseous dispersion modeling to be used for an environmental impact evaluation. Restrictions will then be imposed upon the amount of material spilled, the time of day and time of year of the spill, and the number of spills allowed in order to reduce environmental impacts due to the proposed spill test.

II. PROPOSED ACTION AND SPILL FACILITY DESCRIPTION

A. Proposed Action

The United States Department of Energy (DOE) is constructing a spill-test facility for liquified gaseous fuels and other hazardous materials in the Frenchman Flat area of the Nevada Test Site (NTS) (Figure 2.1). The Lawrence Livermore National Laboratory (LLNL) is assisting DOE in the construction of the spill facility and will be involved with facility operations when completed.

The spill facility consists of two process systems. One is designed to handle cryogenic fluids such as liquified natural gas (LNG), and the second, the noncryogenic spill system, is designed to handle fluids that are normally stored and shipped as pressurized liquids such as ammonia.

The spill facility can accommodate most test materials of the nature stated above. The test materials can vary in their degree of toxicity. The main concern of this document is the environmental impact due to the toxicity of proposed spill materials. Test procedures recommended by the Environmental Assessment will confine lethal and life-threatening concentrations to a barren playa. Potential environmental impacts will be restricted to the Frenchman Flat basin, an area bounded by the 4400 ft elevation contour, and ranging 13 to 25 km downwind and northeast of the spill point (defined in detail in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action).

B. Spill Test Facility Purpose and Description

The Liquified Gaseous Fuels (LGF) Spill Test Facility is proposed as the basic research tool for studying the dynamics of accidental releases of various hazardous materials. The Spill Test Facility (STF) is designed to (1) discharge, at a controlled rate, a measured volume of hazardous test material on the surface of a normally dry lake bed (Frenchman Flat); (2) monitor and record operating data, close-in and downwind meteorological data, and downwind gaseous concentration levels; and (3) provide a means to control and monitor these functions from a remote location (Johnson and Thompson, 1984).

The baseline Spill Test Facility is described in detail by Johnson and Thompson (1984) and reviewed by Koopman (1985). It consists of two generally separate process systems. The larger and more complex of the two systems is designed to handle cryogenic materials such as LNG, while the smaller system is designed for non-cryogenic materials such as ammonia that are normally stored and shipped as pressurized liquids. The cryogenic spill system consists of two 100 m³ (28,000 gal) cryogenic storage tanks

Figure 2.1. General location of LGF Spill Test Facility at Frenchman Flat, NTS (Koopman, 1985).

connected to 500 ft long spill pipes that lead to the spill area. The cryogenic material is pressure driven by 150 psi nitrogen gas from a storage tank (2000 psi). The storage tank is continuously filled from a liquid nitrogen Dewar through a vaporizer and pumping system. The non-cryogenic spill system includes a 90 m³ (26,000 gal) storage tank connected to the 500 ft long spill pipes that are utilized in common with the cryogenic system. The system is driven by 280 psi nitrogen gas, similar to the drive system for the cryogenic materials (Johnson and Thompson, 1984).

To obtain cloud-dispersion data, an array of diagnostic sensors will be placed up to 18 km downwind from the spill point. This array will consist of up to 20 anemometer stations to gather wind-speed and wind-direction data, up to 41 sensor stations to gather data from a large variety of sensors at various levels above ground, and a photographic and meteorological tower. The sensors will measure gas concentration, humidity, heat flux, aerosol characteristics, turbulence and flame speed. The sensor array and the associated data-acquisition system will be linked to the control point by means of telemetry (Johnson and Thompson, 1984).

The operation and performance of the STF will be controlled and monitored from the Command, Control and Data Acquisition System (CCDAS) building located a safe distance upwind from the Spill Test Facility's process-systems location. The general location and intersystems relationship of the STF are shown in the Site Plan in Figure 2.2 (Johnson and Thompson, 1984).

The basic Spill Test Facility is configured to accommodate what is considered the most common type of testing:

- Vapor dispersion
- Pool fire on soil and water
- Vapor cloud fire
- Rapid phase transition (RPT)
- Vapor cloud fireball
- Vapor cloud explosion

The STF systems will be capable of discharging specified quantities of test materials from a fixed point. Most materials will be tested under the general conditions listed below:

Figure 2.2. Site plan of the STF at Frenchman Flat, Nevada Test Site (Koopman *et al*, 1985).

Spill surface	Soil (provisions for water or other substrates included as modifications)
Dispersion surface	Flat
Wind speeds	Calm to 15 m/sec
Test hours	Daylight
Test rate	Up to two per day
Wind direction	Within 10° of 225°

Some tests may have to be conducted under conditions other than those listed above. For pool and vapor-cloud ignition tests, testing after sunset may be necessary for visual monitoring and analysis. Tests involving consecutive spills may be necessary to analyze techniques of controlling hazardous material dispersion.

Currently proposed test materials include (Johnson and Thompson, 1984):

<u>Cryogenic</u>	<u>Non-cryogenic</u>	
Ammonia	Nitrogen tetroxide	Cyclohexane
Methane	Chlorine	Sulfur dioxide
Ethylene	Hydrazine	Carbon dioxide
Propane	Phosgene	Hydrogen fluoride
Butane	Propane	Ammonia
LNG	Butane	Hydrogen sulfide

C. Alternatives to the Proposed Action

1. No Project

Under this alternative, no environmental impact would occur. However, these tests are necessary in order to predict accurately the behavior of hazardous gases that may be accidentally released to the atmosphere. Without these tests, the health and safety of the public would be at greater risk.

2. Testing at a Different Location

Testing at a different location would not impose any environmental impacts on the Frenchman Flat basin. Based on the need for a spill site for testing dispersion properties of hazardous materials, a site survey was conducted in 1981 to select a site that would present the best opportunity for large-scale testing. Following the criteria established for a hazardous

material spill-test site (Table 2.1), no other site was found as suitable as Frenchman Flat, Nevada Test Site (O'Neal and Hogan, 1981).

Table 2.1: Characteristics required for a large-scale spill facility.

-
1. Minimal environmental effects
 2. Low safety hazards
 3. Minimal administrative constraints
 4. Acceptable surface winds
 5. Flat land
 6. Wide range of atmospheric conditions
 7. Large body of water (original site selection was for LNG tests and included pool fire testing)
 8. Available water supply
 9. Low costs
 10. Low rainfall
 11. Variable topography
-

An initial list of 99 federally owned installations was compiled. These installations had test areas greater than 64 square kilometers, low probability of environmental effects from testing, existing environmental impact reviews, and would be under controlled access to present low safety hazards to the public. Based primarily on minimal environmental effects, administrative constraints, and safety factors, five candidates were chosen for final selection:

Frenchman Flat, Nevada
White Sands Missile Range, New Mexico
Hill Air Force Range, Utah
Wendover Air Force Range, Utah
China Lake Naval Weapons Center, California

With further comparisons between the five sites, Frenchman Flat, Nevada Test Site, was chosen as the most appropriate test site. Frenchman Flat has had previous surveys on threatened and endangered species and an extensive meteorological data base, factors lacking for the other four final candidates.

III. EXISTING ENVIRONMENT

A. General Description and Land Use

Frenchman Flat is an alluvial desert basin located on the east side of Area 5 of the Nevada Test Site (NTS) and astride the NTS-Nellis Air Force Range (Nellis AFR) boundary (Figs. 3.1 and 3.2). NTS is surrounded on the north, west, and east by Nellis AFR, except for approximately 19 km of the western boundary, which is adjacent to public land administered by the Bureau of Land Management (BLM). The western boundary of the Desert National Wildlife Range (DNWR) is 3 km east of the NTS-Nellis boundary.

Frenchman Flat is 17 km north of Mercury, Nevada (a DOE support facility on the NTS), and about 80 km northwest of Las Vegas, Nevada. Mercury Highway, the main north-south access road in NTS, is 6 km west of the playa. The region is currently a sparsely populated rural area; the main economic activities are mining and grazing. The area south of NTS is crossed by U.S. Highway 95, which passes through Beatty (pop. 500, 75 km from Frenchman Flat), Lathrop Wells (pop. 40, distance 46 km), and Indian Springs (pop. 1800, distance 30 km). To the east of Nellis AFR is Highway 93. The nearest community in this area is Alamo (pop. 500), 90 km to the northeast of Frenchman Flat (U.S. Energy Research & Development Administration, 1977; U.S. Department of Interior, BLM, 1980).

Frenchman Flat has been used in the past for surface nuclear bomb tests, underground nuclear bomb tests, and non-nuclear explosives tests. Currently the area is occasionally used for non-nuclear explosives testing. A shallow-burial storage site for low-level radioactive waste is 4 km north of the playa. Two km further north is a support location for the Defense Nuclear Agency (DNA), which is occasionally used for their projects. The large areas of desert to the southeast and west of NTS have been used for mining, farming, and grazing (U.S. Energy Research & Development Administration, 1977; U.S. Department of Interior, BLM, 1980).

Nellis AFR is used for military aircraft bombing and gunnery practice. Area 64, which borders NTS to the east, and Area 65N are used as practice ranges with only Area 65N having manned ground operations. The portion of Frenchman Flat that is within Nellis AFR is not used as a practice range, though military aircraft do occasionally fly over. These two areas are used extensively year-round, but the peak use occurs between October and December (Figs. 9.1 and 9.2, Appendix I). A large portion of Nellis AFR, including the area directly east of the test site, is under Wilderness Area review by the U.S. Department of the Interior, Fish and Wildlife Service. The Papoose Lake Research Natural Area, an area where natural processes are allowed to predominate without human intervention,

Figure 3.1. Location map, Nevada Test Site environs (Leitner *et al*, 1983).

Figure 3.2. Nevada Test Site, Frenchman Flat location within Area 5 (Leitner *et al*, 1983).

is located 27 km to the northeast of Frenchman Flat in the proposed Wilderness Area (Fig. 3.3).

B. Topography, Geography, and Soils

Frenchman Flat is one of the three main desert basins in NTS. It is an oval-shaped basin with a large flat playa (dry lake bed) in the center, at an elevation of 3080 ft (939 m), without external drainage for water. The walls of the basin are formed by mountains and ridges. Between the mountains and the valley floor are bajadas, sloping alluvial fans that merge with the valley floor (U.S. Energy Research & Development Administration, 1977; U.S. Department of Interior, BLM, 1980). The mountains are composed of Paleozoic sea-bed sediments consisting of limestone, dolomite, quartzite, shale, and conglomerates (Fig. 3.4,3.4a). During the Mesozoic period they were upthrust and folded. Portions of the mountains were covered with Tertiary volcanic deposits, principally rhyolitic and quartz-latic tuffs. Quaternary deposits of eroded material from the surrounding mountains form the bajadas. The playa itself is formed of sedimentary deposits over 300 m deep that are derived from the surrounding mountains and bajadas. Its sands, gravels, silts, and clays form a level flood plain. Because the sediments are relatively impervious to water, large shallow ponds form on the playa during times of seasonal precipitation, their size varying from year to year (Leitner *et al.*, 1983; U.S. Energy Research & Development Administration, 1977).

In addition to the natural features, there are several man-made topographic features. The center of the playa contains a large blast circle from the Small Boy surface nuclear blast. There are two subsidence craters from underground nuclear tests just north of the playa. The smaller crater is approximately 120 m in diameter; the larger crater measures approximately 130 by 195 m. The depth of the craters is about 30 m. On the north side of the playa there is a pond formed by dikes that contains water from a tritium migration test well (RNM2S). There are four wells on the west edge of the playa that supply potable water to the town of Mercury (U.S. Energy Research & Development Administration, 1977).

The soils of the Frenchman Flat area are typical desert soils, formed slowly under conditions of low moisture and high temperature. The soils have formed over a mixture of limestone and alluvium, and tend to be quite alkaline (pH 8-9). Where there is a high proportion of limestone, such as in the southern portion of Frenchman Flat, the soils have high carbonate levels. This leads to the development of a restrictive hardpan, usually within 70 cm of the surface. The coarsest soils are found near the mountains and bajadas. Finer textured soils are found in the valleys and flats. They have little moisture-retention capacity and almost no organic material in them.

Figure 3.3. Land use operations of NTS, Nellis Air Force Range, and the Desert National Wildlife Range adjacent to the Lofgren Spill Test Facility.

Figure 3.4. Geologic map of the Frenchman Flat basin (USGS Geologic Map of Nevada, 1978). Map index located on page 14 (Fig. 3.4a).

$$E_{\text{eff}} = E_0 \left(1 - \frac{1}{2} \frac{v_{\text{eff}}^2}{c^2} \right) \quad (1)$$

Because Frenchman Flat is a closed basin, the lower elevation soils accumulate salts. The soils in and around Frenchman Flat have the highest salt concentrations of any of the soils on the NTS (O'Farrell *et al.*, 1976; Allred *et al.*, 1963a; Romney *et al.*, 1973).

In Frenchman Flat, there exist concentrations of radionuclides in the soil from atmospheric nuclear tests of the 1950's and 1960's, with the highest concentrations located on the playa. Areas of concern are fenced and marked for exclusion. Exclusion areas of the NTS are defined as areas where an exposure greater than 5 mrem/hr occurs. They are resurveyed annually for as long as they exceed this standard (U.S. Energy Research and Development Agency, 1977). These areas include sections of Small Boy (east of the spill point), GMX (north of the spill point), and an ecology study site (north of GMX) (Fig. 3.5). For plutonium (^{239}Pu), one "hot spot" exists of 95 nCi/g (nanocuries per gram); no other area has a value greater than 5.2 nCi/g (Cramer and Hogan, 1978). Background measurements of resuspended ^{239}Pu at Frenchman Flat in the area of the spill test facility showed seasonal variations with a maximum value less than 150 aCi/m³ (attocuries per cubic meter) and an average summer value near 30 aCi/m³ (Table 9.1, Appendix I) (Shinn J.H. and D.N. Homan, unpublished).

C. Climate and Meteorology

Two major air-movement patterns affect the weather at NTS. Pacific air flowing over the Sierra Nevada exerts its influence from fall through spring. Then, as the Pacific high-pressure area dissipates in summer, the warm, moist airmass in the Gulf of Mexico exerts its influence. Although the precipitation is highly variable, two peaks in annual rainfall can be detected, the larger in winter and the smaller in late summer. The July and August summer rainfall often comes in intense thunderstorms that can cause local flashfloods. Table 9.2, Appendix I, shows precipitation (with a coefficient of variation), mean monthly humidity, and evaporation measurements from a standardized pan for the Frenchman Flat area. The average annual precipitation is largely a function of altitude within this region, with higher elevations receiving more than lower elevations. The valley floors, such as Frenchman Flat, average about 10 cm of precipitation per year. The higher mesas and mountains average 30 cm, with some precipitation falling as snow (U.S. Energy Research & Development Administration, 1977). Standing water on the valley floor is common in winter, with the possibility of a frozen surface (Table 9.3, Appendix I).

Average daily temperatures are lowest in January (2°C) and highest in August (24°C). Large daily fluctuations in temperature are common, especially on the valley floors. January temperatures at Frenchman Flat vary from -3°C to 12°C during a 24-hr period, while July temperatures show

Figure 3.5. Radioactive contaminated areas of the Frenchman Flat basin (Berry, 1984).

a daily range from 17°C to 36°C. At higher elevations the daily variation in temperature is not as pronounced. The winter temperatures are lower and the daily range is only a few degrees; in the summer the daily range may be more than 10°C (U.S. Energy Research & Development Administration, 1977).

Three main influences on the directional wind patterns occur at the NTS: 1) large-scale movement of major air-pressure systems, 2) intermediate-scale air movements due to regional topographic features, and 3) localized effects due to terrain (Quiring, 1968). As with rainfall, the Pacific airmass influences the winds from fall through spring, while the Gulf of Mexico airmass controls the summer wind pattern. Northerly winds predominate in winter and southerly winds in summer. Since there is a general topographic trend toward higher elevations in the northern portion of the NTS, the differential heating of the surface results in southerly (upslope) winds during the day and northerly (downslope) winds at night. This intermediate-scale effect is most pronounced during the summer; it frequently overrides the large-scale pattern. In turn, this regional pattern is strongly influenced by local terrain effects, especially by the orientation of valleys and ridges (U.S. Energy Research & Development Administration, 1977).

The annual pattern of wind speeds on the NTS is marked by strong winds in the spring and mild winds in the fall. The daily cycle shows little wind at night, increasing wind speeds from morning to afternoon, and declining wind speed in the evening. Average hourly wind speeds may reach 9 m/sec on spring afternoons. Wind gusts are often much stronger than hourly averages. Gusts occur throughout the year, but are often recorded in conjunction with late summer thunderstorms. Gusts of 28 m/sec are noted every few years; very rarely, wind speeds have exceeded 45 m/sec (Quiring, 1968; Shinn and Cederwall, 1981).

The wind patterns in Frenchman Flat have been studied in some detail (Cramer and Hogan, 1978; Quiring, 1968; Shinn and Cederwall, 1981). Here local topographic features modify the broad pattern described above for the NTS. The basin itself is essentially flat, devoid of any relief that would give rise to eddies or local convection currents. However, wind-flow patterns related to two nearby drainages exert considerable influence. The larger drainage, Mid Valley, lies to the northwest of Frenchman Flat; the smaller, Nye Canyon, adjoins Frenchman Flat to the northeast. Since little afternoon sun strikes Mid Valley, it begins to cool soon after sunset. During the night, cool air flows southeasterly out of Mid Valley across Frenchman Flat. In conjunction with the prevailing summer southerlies, this results in northwest-to-west winds throughout the night. After sunrise, Mid Valley

warms faster than Nye Canyon and a northeasterly airflow out of Nye Canyon dominates for a few hours. By midmorning the prevailing winds are out of the south, and by midday they are from the southwest. There is a consistent southwesterly wind through the afternoon. As the sun sets, cool air flowing downslope out of Mid Valley causes the wind to shift to a westerly direction. This directional pattern is most pronounced and consistent during the summer months, as shown for June in Figure 3.6.

Wind speeds in the summer at Frenchman Flat are generally light, 1 to 3 m/sec, from midnight to almost noon. As noon approaches, average hourly wind speeds increase rapidly, to about 7 m/sec by mid-afternoon. Wind speeds drop off gradually through the late afternoon and then decline more quickly after nightfall. Average wind speeds are usually below 3 m/sec (Fig. 3.7) (Shinn and Cederwall, 1981; Cramer and Hogan, 1978; Quiring, 1968).

D. Air Quality

The Clean Air Act of 1977 required the U.S. Environmental Protection Agency (EPA) to review the primary and secondary standards for the five major criteria pollutants; sulfur dioxide (SO_2), nitrogen dioxide (NO_2), total suspended particulates (TSP), carbon monoxide (CO) and ozone (O_3). In addition, seven substances have been listed as hazardous under Section 112 of the Clean Air Act; asbestos, mercury, beryllium, vinyl chloride, benzene, radionuclides and arsenic. States were required (July 1979) to bring air quality up to national standards in areas with continued violations of the major and hazardous pollutants.

Frenchman Flat is contained in the Nevada Intrastate Air Quality Control Region (AQCR-147), which is responsible for monitoring air quality in the state of Nevada excluding the two populous regions, Las Vegas Intrastate (AQCR-013) and Northwest Nevada Intrastate (AQCR-148). AQCR-013, which includes the metropolitan Las Vegas area, is immediately to the east and southeast of Frenchman Flat. The Clark County boundary, about 5 km east of the spill test facility, is also the boundary of the Clark-Mohave AQCR. Any standards that could be affected by the spill facility would be those of AQCR-013.

The EPA standards of concern to the spill facility are the five major criteria pollutants. There have not been any violations of the Clean Air Act annual arithmetic means for SO_2 or NO_2 for a five year period (1979-1983) in AQCR-013. TSP was higher than the arithmetic means for several monitoring stations (1979-1983) in Las Vegas, but in the rural areas of AQCR-013 no violations were reported. CO concentrations, primarily the result of the combustion of hydrocarbons, are regulated in eight-hour and

WIND ROSE: WELL 5b

July

Wind speed (knots)

Percent calms: 10.5

Length proportional to frequency

Figure 3.6. A typical summertime-pattern wind rose for winds measured at a 10 m tower at Well 5b, just east of Frenchman Flat playa; north is at the top (D. Soule, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Weather Service Nuclear Support Office, pers. comm., 1985).

Figure 3.7. Average windspeed in Frenchman Flat for June (1979-1980) from micrometeorological data, 2-m level, 62-m tower (Leitner *et al*, 1983).

one-hour averages and are in violation in all metropolitan areas but should not be of concern in the rural areas. O_3 , the product of photochemical oxidants, regulated by one-hour averages, was in violation only 22 days of the five year period (1979-1983) and would not be of concern to the spill test facility (Nevada Department of Conservation and Natural Resource, 1983). In the absence of an air quality standard or federal regulation for the emission of a spill test material, the State of Nevada has adopted 2.4% of the TLV-TWA as a screening tool for locations in which the general public has access. The TLV-TWA is the government standard for an eight-hour occupational exposure in the work place (G. Gentry, Nevada Division of Environmental Protection, Reno, pers. comm., 1985).

E. Water Resources

1. Surface Water

There are three sources of water in Frenchman Flat: rainfall, runoff from the surrounding mountains, and wells, including a tritium migration test well (RNM2S) located northwest of the playa (U.S. Energy Research & Development Administration, 1977; O'Neal and Hogan, 1981). Direct rainfall on Frenchman Flat averages 10 cm per year. Runoff from the mountains occurs only during heavy storms and is quite variable from year to year (O'Farrell and Emery, 1976). Because the flat is a closed basin with a hardpan near the surface, water reaching the playa accumulates in shallow ponds, which normally evaporate in a few hours to a few weeks, depending on their size and the time of year (U.S. Energy Research & Development Administration, 1977; O'Farrell and Emery, 1976). Since 1977, water has been pumped from a tritium migration test well (Well RNM2S) at the rate of 3270 m³/day (2.65 acre-ft/day), and is directed to a diked area on the northwest side of the playa (Burrows, DOE-Las Vegas, pers. comm., 1985; Leitner *et al.*, 1983). The pumps at the well operate continuously, which led to the formation of a permanent pond in 1979 when the dike was repaired. Originally quite open with an area of 28 acres, the pond has been progressively filling in with marsh vegetation each year since 1979 and is now void of open water with an area of approximately 10 acres (Shinn, pers. comm., 1985).

2. Groundwater

Frenchman Flat is within the Ash Meadows groundwater system. Depth to groundwater here is about 200 m (660 ft); an unknown quantity of water recharges annually from the surface and shallow alluvium into the deeper Paleozoic carbonate rocks of the regional aquifer (Fig. 3.8). The Ash Meadows groundwater system underlies the eastern two-thirds of the NTS and a large area to the north and east. Groundwater in this system

Figure 3.8. Groundwater map of the paleozoic aquifer underlying the Frenchman Flat basin (Winograd and Young, 1985).

generally flows at depth to the southwest, where most of it eventually discharges at Ash Meadows, along the California-Nevada border. The groundwater also recharges wells in the Frenchman Flat area (U.S. Energy Research & Development Administration, 1977; U.S. Department of Interior, BLM, 1980; O'Farrell and Emery, 1976).

F. Biological Resources

1. Vegetation

The vegetation of the NTS has been studied extensively by Beatley (1976, 1979), O'Farrell and Emery, (1976), Romney *et al.*, (1973), Romney (1981) and Allred *et al.*, (1963b). The sample sites of Romney and Beatley are shown in Figure 3.9. From these studies, characteristic vegetation associations have been determined.

The NTS is in the transition zone between the Mojave Desert and the Great Basin Desert (Allred *et al.*, 1963a; O'Farrell and Emery, 1976). As a result, vegetation associations typical of both desert regions intermingle here in a complex pattern. Vegetation associations of the Great Basin are often found in cooler, high-elevation areas above 4900 ft (1520 m), while those characteristic of the Mojave Desert usually occur at lower elevations below 3900 ft (1200 m). Mid-elevations often support a mixture of vegetation types. Variations in local microclimate, such as cold air drainages associated with canyons, and edaphic conditions produce many exceptions to this general pattern. Thus, the distribution of vegetation types within the NTS is complex and closely associated with topography and exposure (Allred *et al.*, 1963a; O'Farrell and Emery, 1976).

a. Associations

There are six major vegetation associations in Frenchman Flat named for their dominant shrub species (O'Farrell *et al.*, 1982):

<i>Larrea tridentata</i>	(creosote bush)
<i>Atriplex</i> sp.	(salt bush)
<i>Lycium pallidum</i>	(wolfberry)
<i>Lycium shockleyi</i>	(wolfberry)
<i>Ephedra-Atriplex</i>	(Mormon tea, salt bush)
<i>Coleogyne ramosissima</i>	(blackbrush)

These associations form a mosaic around the playa, which is essentially devoid of plant life. Their distribution in the project area is shown in Figure 3.10. Typical shrub species found in each association are indicated in Table 3.3. In addition to the six naturally occurring associations, there is vegetation associated with a small freshwater marsh in a diked area on the northern edge of the playa. This marsh is maintained

Vegetation Study Sites

- Beatley
- Romney - Vegetation/ Soil
- Romney - Abiotic

Figure 3.9. Vegetation study sites of Beatley (1963) and Romney *et al* (1973) at the Frenchman Flat basin.

Vegetation Associations

Figure 3.10. Vegetation associations of the Frenchman Flat basin (Leitner *et al.*, 1983).

Table 3.3: Typical shrub components of the six vegetation associations found in Frenchman Flat.

Shrub species	Vegetation association					
	<i>Larrea tridentata</i>	<i>Atriplex</i>	<i>Lycium pallidum</i>	<i>Lycium shockleyi</i>	<i>Ephedra-Atriplex</i>	<i>Coleogyne ramosissima</i>
<i>Acanthopappus shockleyi</i>	x	x		x		x
<i>Ambrosia dumosa</i>	x				x	
<i>Artemisia spinescens</i>	x	x				
<i>Atriplex canescens</i>	x		x			
<i>Atriplex confertifolia</i>	x		x	x	x	x
<i>Ceratoides lanata</i>	x	x	x	x		
<i>Coleogyne ramosissima</i>						x
<i>Eucelia virginensis</i>						x
<i>Ephedra funereus</i>						x
<i>Ephedra nevadensis</i>	x				x	x
<i>Grayia spinosa</i>	x	x	x			
<i>Hymenoclea salsola</i>	x					
<i>Krameria parvifolia</i>	x				x	x
<i>Larrea tridentata</i>	x			x	x	
<i>Lycium andersonii</i>	x					
<i>Lycium pallidum</i>			x	x		
<i>Lycium shockleyi</i>	x	x		x		x
<i>Opuntia spp.</i>						x
<i>Psoralea argemonea</i>	x					
<i>Stanleya pinnata</i>			x			
<i>Yucca baccata</i>						x
<i>Yucca brevifolia</i>	x					x

by water pumped from Well RNM2S (Leitner et al., 1983).

The desert-shrub association dominated by *Larrea tridentata* has the most extensive distribution in Frenchman Flat (11,981 ha). It is found from just above the margin of the playa up onto the surrounding bajadas. In its pure form, it is a Mojave Desert vegetation type. In Frenchman Flat, three subtypes of the *Larrea* association that grade into each other without distinct boundaries are found. *Larrea-Lycium shockleyi* subtype is found on the bajadas south of the playa, while the *Larrea-Psoralea* subtype is distributed on the bajadas to the east. The *Larrea-Ambrosia-Atriplex* subtype occurs to the northwest, northeast, and south of the playa. It is a mixture of Mojave (*Larrea* and *Ambrosia*) and Great Basin (*Atriplex*) species (O'Farrell et al., 1982). In general, perennial shrub cover averages about 14% in the *Larrea* association.

The *Atriplex* association (1,920 ha) is found around the edge of the playa, immediately below the *Larrea* association. *Atriplex* is a Great Basin component and as such would be expected to occur at a higher elevation (O'Farrell and Emery, 1976; O'Farrell *et al.*, 1982). Its presence at a lower elevation than the *Larrea* may be due to cold air draining into the closed basin at night. The dominant species, *Atriplex confertifolia* and *A. canescens*, vary in their relative abundance. Perennial shrub cover averages about 6%, even less than in the *Larrea* association; an exception to this is a small, dense stand of *Atriplex* southeast of the playa.

The *Lycium pallidum* association (1,894 ha) is found southwest of the playa. It forms a band running out of the project area to the southwest. This vegetation association is transitional between Mojave and Great Basin types; both *Atriplex* species are found as codominants throughout the area (O'Farrell *et al.*, 1982). The occurrence of this association at elevations lower than usually expected is possibly due to cold air drainage into the basin but is probably due to the soil type (Allred *et al.*, 1963a; O'Farrell and Emery, 1976). This association forms a slightly denser shrub cover than the *Larrea*, averaging about 19%.

There is a very small patch (102 ha) of the *Lycium shockleyi* association on the southern side of Frenchman Flat. This is a transitional vegetation association; appropriately, it is found between a typical Mojave association (*Larrea*) and a typical Great Basin association (*Atriplex*). *L. shockleyi* is also found scattered throughout both of the latter associations. Typically, the *L. shockleyi* association forms a canopy cover of about 17% (O'Farrell *et al.*, 1982).

On the bajadas northeast of the playa and above the *Larrea* association is a wedge-shaped patch of the *Ephedra-Atriplex* association (358 ha), a typical Great Basin vegetation type. The patch gradually widens as it extends northeast and out of the project area. Dominant shrubs in this association are *Ephedra nevadensis* and *Atriplex confertifolia*. Many of the shrub species found in the adjacent *Larrea* association appear as codominants in this association, particularly *Krameria parvifolia* and *Ambrosia dumosa*. Average cover in the *Ephedra-Atriplex* association is about 18%, similar to that of the *Lycium* associations (O'Farrell *et al.*, 1982).

Finally, there are two narrow bands (128 ha) of fairly dense *Coleogyne ramosissima* running through the *Larrea* association to the southeast of the playa. This association is typical of the transition zone and is found at elevations of about 1000 m in Frenchman Flat. The stands of the *Coleogyne* association have an average cover of about 42%, the highest value for any association in the project area.

Over 700 plant species have been collected from the NTS and its environs (O'Farrell and Emery, 1976; Beatley, 1976; Allred *et al.*, 1963b; Romney *et al.*, 1973). Many of these are herbaceous annual plants that appear in the winter and spring seasons following significant rains. The abundance and productivity of these annuals are largely determined by the rainfall received between late September and early December. Many species require a minimum of 2.5 cm of rain for seed germination; more precipitation leads to greater germination and greater seedling survival. In some years there is an almost solid carpet of annuals covering the spaces between the shrubs. The species composition of these stands can vary from year to year.

Areas of the NTS that have been disturbed by human activity are often invaded by various introduced plants. Five species are particularly prominent in places such as roadsides and subsidence craters: two grasses (*Bromus rubens* and *B. tectorum*), two Russian thistles or tumbleweeds (*Salsola iberica* and *S. paulsenii*), and a forb (*Halogeton glomeratus*). They rapidly invade sites where the soil has been disturbed or the native shrubs have been removed and they can delay the natural revegetation by native plants (Allred *et al.*, 1963b; O'Farrell and Emery, 1976).

The pond on the north side of the playa was formed in 1979 when the dike was repaired. The dike has been irregularly maintained since then and emergent marsh vegetation has become established. There has been no detailed botanical survey of the marsh, but the vegetation includes cattails, reeds, willows and sedges (Shinn, pers. comm., 1985).

b. Desert Vegetation and Seasonal Photosynthetic Production

During the favorable spring conditions (high soil moisture and moderate temperatures), many desert plants carry out most of their photosynthesis and growth. These species are usually in a dormant state during the stressful summer months. However, a few species have adapted to the summer conditions (low soil moisture and high temperatures) and carry on photosynthesis and growth, but in a reduced capacity (Bamberg *et al.*, 1975).

Two studies have investigated transpirational and photosynthetic strategies of desert species at the Nevada Test Site. Kleinkopf *et al.* (1980) demonstrated that *Atriplex canescens* was highly competitive in growth and production during times of high soil moisture but the net photosynthetic production decreased to zero during the summer conditions of higher temperatures and lower soil moisture. But, he noticed that *Larrea tridentata* maintained a reduced positive net photosynthetic production during the summer conditions.

Bamberg *et al* (1975) studied the photosynthetic production of several desert shrubs in relation to the environmental stresses of the summer months:

Larrea tridentata - evergreen, low photosynthetic rates with an ability to depress transpirational loss during moisture and temperature stress, and will photosynthesize during any favorable period,

Krameria parvifolia - summer green with low photosynthetic rates during summer stress; winter deciduous, and

Lycium spp. - drought deciduous with a slight ability to withstand high temperature and moisture stress and with leaf abscission in summer.

Bamberg *et al* (1975) further noted that *L. tridentata* and *K. parvifolia* had, by mid-June, a positive CO₂ uptake only in the morning (photosynthesis), but this decreased to zero in early afternoon as air temperature rose.

These ecological studies of desert species common to Frenchman Flat indicate that growth and other physiological activities are reduced or dormant during the summer months. *Larrea tridentata* further adapts to the hot temperatures of summer by restricting CO₂ uptake (photosynthesis) to morning hours.

c. Range-Fire Potential

The range-fire potential at Frenchman Flat depends on prevailing climatic conditions, fuel quality and densities in adjacent vegetation associations, and the extent beyond the playa of the gaseous plume from the spill test. Wind speed, low relative humidity, lack of precipitation, and high air temperatures are climatic conditions that increase the possibility of range fires. The density and quality of fuel in areas of Frenchman Flat most associated with possible range fires (NE of the spill site) are low. In this area of *Atriplex* and *Larrea* vegetation associations, the perennial shrub cover averages a low 6% and 14%, respectively. The range-fire potential of the *Larrea* and *Atriplex* associations would increase with a higher production of winter annuals due to increased winter precipitation (O'Farrell *et al*, 1982).

d. Protected Species

There are no known plant species on the NTS that have been listed as threatened or endangered by the U.S. Fish and Wildlife Service. However, three species that do occur on the NTS, located 15 km north of Frenchman Lake (Fig. 3.11), are candidates for inclusion under Category 2 of the Federal Register for Endangered and Threatened Wildlife and Plants: *Astragalus beatleyae*, *Comissonia megalantha* and *Phacelia funereus* (U.S. Department of

Figure 3.11. Plants listed in Category II, Threatened and Endangered Plants (Federal Register, volume 48, number 229, November 28, 1983), and cleared areas of the Frenchman Flat basin (F. Bingham, DOE-Las Vegas, pers. comm., 1985).

the Interior, 1984). Category 2 comprises taxa for which information now in possession indicates that proposing to list the taxa as an endangered or threatened species is possibly appropriate, but for which substantial data on biological vulnerability and threat(s) are not currently known. These three species are not found in the proposed project area (Leitner *et al*, 1983).

2. Wildlife

The animal species found on the NTS, like the plants, include a mixture of forms from both the Mojave and Great Basin Deserts (Allred *et al*, 1963a). Thus, the fauna is a diverse assemblage for such a desert region. Some species are restricted to particular plant associations, but most range widely through a number of vegetation types (O'Farrell and Emery, 1976).

No hunting, fishing, or grazing are allowed on the NTS. In the past, weapons testing has had a significant impact on natural ecosystem interactions. Since 1962, when atmospheric tests were halted, the weapons-testing program has had only an indirect effect on animal populations through habitat modification. In general, there is now little human impact on natural population processes and species interactions on the NTS (U.S. Energy Research & Development Administration, 1977).

a. Fish

There are two introduced fish species on the NTS: goldfish (*Carassius auratus*) and golden shiners (*Notemigonus crysoleucas*) (O'Farrell and Emery, 1976). They have been found in the ditch supplying water to the marsh at Frenchman Flat and in the pond by Well 5b (Shinn, pers. comm., 1985).

b. Amphibians

There are no amphibians known to occur on the NTS (O'Farrell and Emery, 1976).

c. Reptiles

The NTS has a particularly diverse reptile fauna due to the overlap of species from both the Mojave and Great Basin Deserts (O'Farrell and Emery, 1976). Table 3.4 lists reptile species expected to be found in the Frenchman Flat area (O'Farrell, 1983).

The desert tortoise (*Gopherus agassizi*) is found on the NTS and has been reported in the Frenchman Flat area (Tanner and Jorgensen, 1963; Collins, 1984). There have been several studies of desert tortoise ecology and recent distribution, two on the NTS at Frenchman Flat, and a third study conducted southwest of Las Vegas. Burge and Bradley (1976) in the study southwest of Las Vegas found the desert tortoise in a desert-shrub

Table 3.4: Reptile species of Frenchman Flat.

<i>Gopherus agassizi</i> Desert Tortoise	<i>Crotalus cerastes</i> Sidewinder
<i>Coleonyx variegatus</i> Banded Gecko	<i>Leptotyphlops humilis</i> Western Blind Snake
<i>Dipsosaurus dorsalis</i> Desert Iguana	<i>Diadophis punctatus</i> Ringneck Snake
<i>Sauromalus obesus</i> Chuckwalla	<i>Phyllorhynchus decurtatus</i> Leaf-nosed Snake
<i>Callisaurus draconoides</i> Zebra-tailed Lizard	<i>Masticophis flagellum</i> Coachwhip
<i>Crotaphytus (Gambelia) wislizenii</i> Leopard Lizard	<i>Masticophis taeniatus</i> Striped Whipsnake
<i>Crotaphytus collaris</i> Collared Lizard	<i>Salvadora hexalepis</i> Patch-nosed Snake
<i>Sceloporus magister</i> Desert Spiny Lizard	<i>Arizona elegans</i> Glossy Snake
<i>Uta stansburiana</i> Side-blotched Lizard	<i>Pituophis melanoleucus</i> Gopher Snake
<i>Phrynosoma platyrhinos</i> Desert Horned Lizard	<i>Lampropeltis getulus</i> Common Kingsnake
<i>Xantusia vigilis</i> Desert Night Lizard	<i>Rhinocheilus lecontei</i> Long-nosed Snake
<i>Cnemidophorus tigris</i> Western Whiptail	<i>Sonora semiannulata</i> Western Ground Snake
<i>Tantilla utahensis</i> Utah Black-headed Snake	<i>Chionactis occipitalis</i> Western Shovel-nosed Snake
<i>Hypsiglena torquata</i> Night Snake	<i>Trimorphodon lambda</i> Sonora Lyre Snake
<i>Crotalus mitchelli</i> Speckled Rattlesnake	

vegetation dominated by *Larrea tridentata*, although shrub cover was much less than in the corresponding association at Frenchman Flat. Collins (1984) found desert tortoise habitat associated with the *Larrea tridentata* vegetation association at Frenchman Flat in elevations ranging from 3150 to 3700 ft and in a zone 6.5 km northeast to 9 km east of the spill site (3 km to 5.5 km from the playa edge). The habitat was contained in the Desert National Wildlife Range (Fig. 3.12). Leitner *et al* (1983) on a field survey of Frenchman Flat found potential desert tortoise habitat (deserted burrows) at 3100 ft on the banks of a major drainage from the northeastern slopes toward the playa, 4.5 km from the spill site (2 km from the edge of the playa), in vegetation associated with *Larrea tridentata* (Fig. 3.12). Desert tortoises are herbivorous, consuming low-growing vegetation. Burge and Bradley (1976) reported that the most important plants in the diet were the annual forb, *Plantago insularis*, and the desert mallow (*Sphaeralcea ambigua*). The desert tortoise excavates and uses two kinds of burrows; one type serves as a hibernation den, while the other provides shelter from high surface temperatures in summer (Woodbury and Hardy, 1948).

There are 14 lizard species on the NTS, 11 of which probably occur at Frenchman Flat, of Mojave Desert affinity and are listed in Table 3.4 (Tanner and Jorgensen, 1963; O'Farrell, 1983; O'Farrell and Emery, 1976). The other three species are of Great Basin affinity and are restricted to Great Basin Desert vegetation associations: sagebrush lizard (*Sceloporus graciosus*), western fence lizard (*S. occidentalis*), and western skink (*Eumeces skiltonianus*). Most of the lizards on the NTS are insectivores, although some are herbivores and others are omnivores (Stebbins, 1966). The desert iguana and chuckwalla are herbivorous, while the leopard lizard, zebra-tailed lizard, and desert spiny lizard are omnivorous. The collared lizard also eats smaller lizards in addition to insects.

Seventeen species of snakes are known from the NTS; all of them probably occur at Frenchman Flat (Table 3.4) (Tanner and Jorgensen, 1963; O'Farrell, 1983; O'Farrell and Emery, 1976). They are seldom observed or collected, and thus very little is known about population densities, habitat preferences, or activity patterns. The most common species seems to be the western shovel-nosed snake (*Chionactis occipitalis*). The sidewinder (*Crotalus cerastes*) and the speckled rattlesnake (*C. mitchelli*) are both venomous. All of the snakes are predators, eating rodents, small birds, insects, lizards, and other snakes (Stebbins, 1966).

(1). Protected Species

The Nevada State Board of Fish and Game Commissioners has listed the desert tortoise (*Gopherus agassizi*) as a protected species (Nevada Revised Statutes 503.080, Nevada Dept. of Wildlife, 1984). The species is currently being reviewed by the U.S. Fish and Wildlife Service for protection under the Endangered Species Act of 1973. The Beaver Dam Slope desert tortoise

Figure 3.12. Field surveys of the Frenchman Flat basin for desert tortoise and kit fox habitat (Collins, 1984; Leitner *et al*, 1983)

population in southwest Utah has already been placed on the federal threatened species list (U.S. Department of Interior, 1984; O'Farrell, 1983).

d. Birds

Due to the mobility of birds, their distribution on the NTS forms a much more complex picture than that of mammals or reptiles. Flight enables birds to migrate to favorable habitats on a seasonal schedule. Thus, the pattern of mixing of the major desert biota on the NTS is overlaid by the larger pattern of North American bird migration. The greatest species diversity occurs in contrasting vegetation associations, pinyon-juniper and *Larrea-Ambrosia* (O'Farrell and Emery, 1976). Some species found in the area of Frenchman Flat are listed in Table 3.5 (O'Farrell, 1983).

There are more than 190 avian species found on the NTS and they can be put in one of four general categories based on their migratory pattern: spring-summer resident, fall-winter resident, seasonal migrant, or year-long resident. Spring-summer residents breed on the NTS during those seasons and then migrate south to their wintering grounds. Fall-winter residents breed in regions to the north and migrate south to winter on the NTS. The majority of these are small passerine birds, usually seed-eaters; seeds of Russian thistle (*Salsola* sp.) are prominent in their diet. Each spring

Table 3.5: Birds common to Frenchman Flat.

<u>Residents</u>		<u>Migratory</u>
Red-tailed Hawk	Loggerhead Shrike	Pintail
Golden Eagle	House Finch	American Widgeon
Marsh Hawk	Killdeer	Green-winged Teal
Sparrow Hawk	Chucker	Cinnamon Teal
Prairie Falcon	Sage Thrasher	Canada Goose
Rough-legged Hawk	Le Conte's Thrasher	Shoveler
Roadrunner	Red-winged Blackbird	Common Snipe
Burrowing Owl		
Sparrow	<u>Spring/Summer</u>	<u>Winter/Fall</u>
Say's Phoege		
Horned Lark	Turkey Vulture	House Finch
Common Raven	Mourning Dove	Sage
Common Bushtit	Western Kingbird	Wh.-crowned Sparrow
Cactus Wren	Black-throated Sparrow	Starling
Mockingbird	Chipping Sparrow	
American Coot		

and fall, large numbers of migrants pass through the NTS. These birds are moving between their more northerly breeding grounds and their wintering areas to the south. Many are waterfowl that are attracted to the few areas of water along their migration routes through this desert region. Some stop at the artificial freshwater marsh on the north side of the Frenchman Flat playa or on the playa itself when flooded by winter runoff. All members of the year-round residents category breed on the NTS (O'Farrell and Emery, 1976; Hayward *et al.*, 1963).

(1). Protected Species

There are no known birds regularly found on the NTS that are currently listed as threatened or endangered under the federal Endangered Species Act of 1973 (U.S. Department of Interior, 1984). A few recent sightings of the endangered (Nevada state and federal regulations) American peregrine falcon (*Falco peregrinus anatum*) in the vicinity of Yucca Flat probably involved transient individuals (O'Farrell and Emery, 1976). All birds of prey (Order Falconiformes: vultures, hawks, and falcons, and Order Strigiformes: owls) and the roadrunner are fully protected under Nevada state law (Nevada Dept. of Wildlife, Nevada Revised Statutes 503.050, 1984) and may be present at NTS.

e. Mammals

There are 46 species of mammals known in the NTS (O'Farrell and Emery, 1976; Jorgensen and Hayward, 1965), almost half of these are rodents. Other mammals common to Frenchman Flat (Table 3.6) include three species of bats, two species of rabbits, four carnivores and mule deer (O'Farrell, 1983).

Though not obvious to observers, rodents are the most important group of mammals on the NTS in terms of biomass and species diversity. The densities of rodent populations are highly variable from year to year. High rainfall years, with large production of winter annual vegetation, leads to higher reproductive success and higher rodent densities the following spring and summer. Both rabbit species are herbivores and their populations probably fluctuate with the production of winter annuals, though not as markedly as do the rodent populations. All of the bat species are insectivores (O'Farrell and Emery, 1976; Jorgensen and Hayward, 1965).

Several species of large herbivores are found on or near the NTS (U.S. Energy Research & Development Administration, 1977; O'Farrell and Emery, 1976; Jorgensen and Hayward, 1965). The most common is the mule deer (*Odocoileus hemionus*); they usually inhabit the northern higher mesas, but come down to lower elevations during the winter (Giles and Cooper, 1985). There are no confirmed sightings of desert bighorn sheep (*Ovis canadensis*) on the NTS, although they do occur to the east on the Desert

Table 3.8: Mammal species common to Frenchman Flat.

<i>Canis latrans</i> Coyote	<i>Dipodomys merriami</i> Merriam's Kangaroo Rat
<i>Vulpes macrotis</i> Kit Fox	<i>Dipodomys microps</i> Great Basin Kangaroo Rat
<i>Lynx rufus</i> Bobcat	<i>Spermophilus tereticaudus</i> Round-tailed Ground Squirrel
<i>Odocoileus hemionus</i> Mule Deer	<i>Ammospermophilus leucurus</i> White-tailed Antelope Squirrel
<i>Mustela frenata</i> Long-tailed Weasel	<i>Neotoma lepida</i> Desert Wood Rat
<i>Spilogale gracilis</i> Western Spotted Skunk	<i>Onychomys torridus</i> Southern Grasshopper Mouse
<i>Taxidea taxus</i> Badger	<i>Peromyscus eremicus</i> Cactus Mouse
<i>Thomomys umbrinus</i> Southern Pocket Gopher	<i>Perognathus formosus</i> Long-tailed Pocket Mouse
<i>Lepus californicus</i> Black-tailed Jackrabbit	<i>Antrozous pallidus</i> Pallid Bat
<i>Sylvilagus audubonii</i> Desert Cottontail	<i>Pipistrillus hesperus</i> Western Pipistrelle (Bat)
<i>Dipodomys deserti</i> Desert Kangaroo Rat	<i>Myotis californicus</i> California Myotis (Bat)

National Wildlife Range. Bighorn sheep do not reside in the Spotted Range east of Frenchman Flat; however, they do migrate through this area in the fall and early spring when water is available. The U.S. Fish and Wildlife Service and the Nevada Department of Wildlife may introduce water into the Spotted Range in the future in order to bring sheep into the area on a year-round basis (B. Yoder, U.S. Fish and Wildlife Service, DNWR, pers. comm., 1985).

At the top of the food chain are the mammalian predators: coyote (*Canis latrans*), kit fox (*Vulpes macrotis*), badger (*Taxidea taxus*), bobcat (*Lynx rufus*) and long-tailed weasel (*Mustela frenata*). They may range through all vegetation associations on the NTS and Frenchman Flat. The coyote has a catholic diet and is found throughout the NTS, often reflecting the distribution of mule deer; it is the most commonly observed mammalian predator in the area. Badgers and long-tailed weasels are secretive and rarely seen, in contrast with the kit fox, which is rather tame and often seen (U.S. Energy Research & Development Administration, 1977; O'Farrell and Emery, 1976; Jorgensen and Hayward, 1965).

Kit foxes and coyotes have been observed at Frenchman Flat and bobcats near Well 5B (Shinn, pers. comm., 1985). The coyotes were observed on the playa and around the marsh on the north edge of the playa. Leitner *et al.* (1983) found evidence of kit fox dens in abandoned bunkers 1.5 to 2.5 km north of the spill site (Fig. 3.12).

(1). Protected Species

There are no known animals on the NTS that are currently listed as threatened or endangered under the federal Endangered Species Act of 1973 (O'Farrell, 1983; U.S. Department of Interior, 1984). The wild horse population on the NTS is protected under federal law by the Wild Free-Roaming Wild Horse and Burro Act of 1971 (Leitner *et al.*, 1983). Species protected by state regulations include game animals, such as the desert cottontail, and fur-bearing animals, such as the kit fox and bobcat (Nevada Dept. of Wildlife, Nevada Revised Statutes 503.025, 1984).

G. Cultural Resources

Human occupation of the NTS and its environs extends back to about 10,000 B.C. (U.S. Energy Research & Development Administration, 1977). A number of aboriginal hunting and gathering cultures were present during this long prehistoric period. When the first European settlers entered the area, it was occupied by the Paiute Indians. From about 1849 until the establishment of the NTS, the land was mainly used for livestock grazing and mining.

Investigations of archaeological and historical features of the NTS have resulted in the identification of numerous archaeological sites and several locations having historical interest. These sites have been recorded in the Site Record File of the Nevada State Museum. None from Frenchman Flat have been placed on the National Register of Historic Places and none are believed to meet the criteria for nomination for inclusion in the National Register (Leitner *et al.*, 1983; Worman, 1969).

Both historic and prehistoric sites on the NTS tend to be located near springs, in canyons, and at or near the bases of mountains. The larger valleys show little sign of early human occupation. No archaeological or historic sites have been reported at Frenchman Flat or in the surrounding area and it is extremely unlikely that they exist here (Fig. 3.13) (U.S. Energy Research & Development Administration, 1977; F. Bingham, DOE, Las Vegas, pers. comm., 1985).

Figure 3.13. Archaeologically cleared areas of the Frenchman Flat basin (F. Bingham, DOE-Las Vegas, pers. comm., 1985).

IV. CRITERIA FOR EVALUATING ENVIRONMENTAL CONSEQUENCES OF PROPOSED ACTION

Since an environmental assessment for the STF must focus on the impact of proposed spill materials on the environment, it is important to establish limits (geographic) to the downwind concentrations of hazardous spill materials in order to protect natural resources. The combination of a simulated trajectory analysis from extensive meteorological data, results of previous dispersion tests at Frenchman Flat, standard air-quality criteria, occupational exposure limits to hazardous materials, and Spill Test Facility operation procedures were used in determining geographic boundaries in order to confine toxic effects to manageable regions.

The first step was to use a simulation-trajectory analysis, for defined meteorological spill-test conditions, to establish the lateral boundaries of a spill-test impact zone. The next step was to define the downwind limits to hazardous spill material concentrations, in order to confine potential impacts to three specific geographic zones in the Frenchman Flat basin. Human occupational exposure limits, from toxicity data that are widely available for hazardous substances, were used to determine the maximum allowable effects in each zone. Finally, results from previous tests were analyzed to determine if dispersion models had accurately predicted the dispersion characteristics of the releases.

Limits to downwind hazardous material concentrations can be determined from the occupational exposure standards for any proposed test material. Spill rates and volumes will be determined from the limiting concentrations (zonal boundaries) with appropriate dispersion-prediction models selected by the LLNL STF Project Scientist and concurred by Operations Controllers Test Safety Review Panel.

A. Spill Trajectory and Dispersion Analysis

If the persistence of wind direction under certain meteorological conditions could be determined, spill tests could be conducted with the assurance that the cloud of test material would pass through the instrument array and that impacts would be confined to a defined area. Extensive meteorological data are available for the past 15 years at Frenchman Flat, and were recently summarized for a three year period (1979-81) (Shinn, pers. comm., 1985). A large amount of information is available on frequencies of wind speed, wind direction, and atmospheric stability conditions. The data-collecting system included a meteorological tower, 62 m (200 ft) in height with instruments at four levels (3, 10, 30, and 60 m), installed in 1978 (Fig. 4.1). Wind direction, wind speed, standard deviation of wind direction, vertical turbulence, temperature, humidity, and

Figure 4.1. Meteorological stations used in gathering data at Frenchman Flat.

barometric pressure were recorded. Each sensor was sampled once per second. A microprocessor-based data-acquisition system made possible detailed on-line calculations of the turbulent wind fluctuations and the mean values used in atmospheric stability indices. A data base was prepared that included 3 min as well as hourly summaries. In addition, five automatic weather stations measuring wind speed and direction were operated at sites (FF1, FF2, FF3, Kay Bunker and Well 5B) previously utilized by the National Weather Service, Nuclear Weather Support Office (Fig. 4.1). These stations provided summaries every 8 minutes, and operated with a high degree of reliability.

From these studies, data have shown that the wind direction is predictably and regularly from the southwest (225°) between March and September (Fig. 4.2). The wind direction prevails at about 225° with very little deviation and with a variety of speeds and associated atmospheric stabilities.

An analysis was performed using observed data of three years (1979-81) from the 62 m tower to investigate the possibility of wind-direction meander after a spill test is started. The proposed test criteria included: daytime tests when the wind direction is within 10° of the sensor array centerline (225°), wind speeds of 2 to 8 m/sec, and intensity of turbulence (standard deviation of wind direction) less than 30° for 9 min prior to the test. A spill duration approaching 10 min is desirable to achieve a meteorological steady state. Spills of greater than 15 min duration are unlikely to improve the data. During the succeeding hour of each possible test period the statistics showed a dependable wind persistence, both in direction and speed. It was found that in less than 3% of all hypothetical test periods did the cloud of released gas meander more than 30° from the array centerline, and in all cases the trajectories of hypothetical clouds were within 35° of the array centerline when they reached a distance of 7 km (Fig. 4.3). This figure shows all 144 trajectories satisfying the test criteria. Further analysis has shown that the judgement of the LLNL STF Project Scientist concerning wind steadiness, in addition to the test criteria, could eliminate the few erratic trajectories shown in Figure 4.3 and result in trajectories that are all quite regular and predictable.

When addressing dispersion properties of proposed test materials, it is necessary to take account of wind speed and turbulence. The mean wind speed (u) will transport a transient cloud of material downwind, while the turbulence, especially the standard deviation of mean wind direction for a three minute period (σ_θ), will spread and dilute the cloud. The atmospheric stability and the surface roughness determine the value of σ_θ at any particular time. Atmospheric stability categories are conventionally

Figure 4.2. Optimal period for testing at the LGF Spill Test Facility as determined through analysis of meteorological conditions at Frenchman Flat (Shinn and Cederwall, 1981).

Figure 4.3. Trajectories of 144 cases of simulated tests subsequent to meeting the test criteria: 8 a.m. to 7 p.m., wind direction within 10° of 225° , wind speed between 2 and 8 m/sec, and standard deviation of wind direction less than 30° (9 min prior to test).

classified according to ranges of σ_θ following the Nuclear Regulatory Commission (NRC) Safety Guide 1.23 as follows (Leitner *et al*, 1983):

Stability category (Pasquill-Gifford classes)		σ_θ (degrees of wind direction)
Very Unstable	A	> 22.5
Unstable	B	22.5-17.5
Slightly Stable	C	17.5-12.5
Neutral	D	12.5-7.5
Stable	E	7.5-3.75
Very Stable	F	< 3.75

The 144 test periods meeting the test criteria were found to occur mostly after 10 a.m. and the most frequent case was wind speed 6 to 8 m/sec and stability category D (neutral stability). It was found that of 144 test cases, the least dispersive test period was for a wind speed of 3.4 m/sec and stability category F (very stable). The results are summarized in Tables 4.1 and 4.2 (Table 9.4, Appendix I gives the joint frequencies of atmospheric stability for summer days).

Table 4.1: The joint frequencies of atmospheric stability categories and wind speed classes for periods meeting the test criteria.

Wind speed	Stability category						Total
	A	B	C	D	E	F	
2-3 m/sec	3	1	2	0	0	0	6
3-4	7	4	5	0	5	2	23
4-5	4	4	7	5	4	0	24
5-6	2	2	12	14	2	0	32
6-7	0	3	13	15	0	0	31
7-8	1	1	7	17	2	0	28
Total	17	15	46	51	13	2	144

Table 4.2: The frequency of periods meeting the test criteria by hour of the day and the average and worst (least dispersive) meteorological conditions observed for each hourly period.

Hourly period	No. of spills	<u>Dispersion conditions</u>	
		Wind speed (m/sec)-Stability	
		Average	Worst
8 - 9 a.m.	2	5.3 - D	5.2 - D
9 - 10 a.m.	4	5.3 - C	7.5 - D
10 - 11 a.m.	7	4.0 - C	2.1 - C
11 - 12 a.m.	16	5.7 - C	4.9 - D
12 - 1 p.m.	10	6.1 - C	6.7 - D
1 - 2 p.m.	20	5.4 - C	5.7 - D
2 - 3 p.m.	26	5.5 - C	5.2 - D
3 - 4 p.m.	30	5.9 - C	5.0 - D
4 - 5 p.m.	18	5.9 - D	7.3 - E
5 - 6 p.m.	4	4.0 - E	3.6 - F
6 - 7 p.m.	8	3.8 - E	3.4 - F
	144		

B. Summary of Ammonia (NH₃) and Nitrogen Tetroxide (N₂O₄) Test Spills at Frenchman Flat (1983)

Two test-spill series were conducted during the summer/fall of 1983 by LLNL at a temporary spill facility on Frenchman Flat at essentially the same location as the proposed permanent DOE Spill Test Facility. The spills be reviewed here as an example of the type of testing planned for the new test facility and the testing conditions available at NTS. The major purpose of both test series was to measure the atmospheric dispersion of the spilled material for simulated accidental releases under various meteorological conditions and compare the results with existing dispersion-model predictions. A series of large-scale (15 to 60 m³) ammonia (NH₃) spill tests were conducted for the U.S. Coast Guard, The Fertilizer Institute and Environment Canada (Goldwire *et al.*, 1985). A series of large-scale (3 to 5 m³) nitrogen tetroxide (N₂O₄) spill tests were conducted for the U.S. Air

Force (McRae *et al*, 1984). It was found that the models had underestimated downwind concentrations, showing that existing models are not entirely adequate for predicting the dispersion of these materials.

The data-acquisition system used in the NH_3 and N_2O_4 spills is similar to that available at the new facility and is reviewed by Koopman (1985). Measurements of temperature, flow rate and heat flux were made at the spill point. Atmospheric boundary layer, wind field, vapor-cloud temperature and concentration, and surface heat flux measurements were made downwind. There were three main types of arrays of diagnostic instruments used: a meteorological array, a mass flux array and a dispersion array. Test summaries including climatic and meteorological conditions are given in Tables 4.3 and 4.4. The detailed results of the spills are presented in McRae *et al* (1984), Koopman *et al* (1984), and Goldwire *et al* (1985).

1. Ammonia (NH_3) Test Spills

Table 4.3: Test summary for the ammonia (NH_3) spills, 24 August - 06 September 1983 (Koopman, 1985).

Test	Size (m^3)*	Rate (m^3/min)	Wind speed (m/s)	Wind direction	Stability class
1	14.9	7.0	7.4	224°	D
2	43.8	10.3	5.7	226°	D
3	32.4	11.7	7.4	219°	D
4	60.3	9.5	4.5	229°	E

*1 m^3 = 264 gallons

The primary purpose of the NH_3 experiments was to measure the effect of aerosols on the dispersion of the NH_3 vapor. The aerosols cause the cloud to be heavier than the surrounding air and cool the cloud as it evaporates, suppressing turbulence. This results in higher concentrations further downwind of the spill point than would release of the gas at ambient temperature.

The number 4 test was the largest of the NH_3 series. Most of the released NH_3 was immediately airborne either as cold vapor or aerosol, with as much as 83% of it in aerosol form, for the release conditions. The cloud demonstrated noticeable dense gas effects, such as gravity driven slumping and spreading, as soon as the strong jetting and turbulence effects associated with the release were exhausted. When the tests were compared to predictions by simple transient Gaussian models, the models underpredicted downwind ammonia concentrations by a large factor, and were clearly inadequate, even at long distances downwind (Goldwire *et al.*, 1985).

Downwind ammonia-vapor concentrations were measured, beyond the arrays of the data-acquisition system, with portable 0 to 5000 ppmv gas sensors. The sensors were placed in arcs at distances of 1.4, 2.8, 3.5 and 5.5 km downwind of the spill point, with the exact locations varying from test to test. The number 4 test, the largest of the ammonia spills, was monitored at the 2.8 km sensor array and recorded maximum concentrations of 1300 ppmv, 5000 ppmv, and 600 ppmv. Test number 1 was monitored at 3.5 km and 5.6 km, recording maximum downwind concentrations of 675 ppmv and 150 ppmv, respectively (Goldwire *et al.*, 1985).

2. Nitrogen Tetroxide (N_2O_4) Test Spills

Table 4.4: Test summary for the nitrogen tetroxide (N_2O_4) spills, 17 September - 30 October 1983 (Koopman, 1985).

Test	Size (m^3) [*]	Rate (m^3/min)	Wind speed (m/s)	Wind direction	Stability class
1	1.3	1.75	6.2	233°	C
2	1.5	1.4	5.8	223°	A
3	4.2	1.4	3.1	229°	D
4	2.8	0.5	4.9	233°	D
5	1.3	0.6	2.2	261°	A
6	3.4	0.7	5.0	223°	D

^{*}1 m^3 = 264 gallons

The primary purpose of the test series was to determine the importance of the heavy gas dispersion aspects of N_2O_4 vapors. The downwind reduction in concentration for the dispersion of a heavy gas is often not as great as for a trace or neutral gas. Heavy gas clouds are lower and wider than those from a trace or neutral gas; their flow behavior is often dominated by gravity and they can exclude or displace the normal wind flow as would a solid object. This can sometimes result in a larger hazardous corridor downwind and in a more persistent, longer lasting hazardous condition (Koopman, 1985).

A definite two-phase region in the vapor cloud due to aerosols was observed in all test spills. A HNO_3 mist formed from the reaction of the spilled, ground level N_2O_4 and the ambient humidity. This can be exemplified by the number 3 spill conducted under nearly ideal atmospheric conditions for the observation of dense gas effects on dispersion. The N_2O_4 did not evaporate as quickly as it spilled. Twenty percent of the 6090 kg of N_2O_4 spilled passed as NO_2 vapor through the 25 m row of gas sensors within the first 10 min and as much as 50% of the total material was transported downwind as an HNO_3 aerosol. Although the source strength fell off sharply, a low level of soil out-gassing could have continued for many hours, and would probably have accounted for the remaining material. Predictions by models of N_2O_4 dispersion, when compared to the results of the number 3 test, showed a substantial underprediction of downwind concentrations (Koopman, 1985).

Two portable NO_2 gas sensors were placed at various locations in an array 2.8 km downwind of the spill point. Both sensors were capable of detecting concentrations up to 10 ppmv NO_2 . The largest N_2O_4 spill, no. 3, recorded a maximum concentration of 9.0 ppmv (McRae *et al.*, 1984).

C. Geographic Limits to Test Material Concentrations

Three geographic zones have been defined within which downwind concentrations of proposed test materials must be limited in order to reduce impacts and protect natural resources (Fig. 4.4). These zones have been established in order to confine the impacts from the largest planned tests of any test material to a defined area. The size of the impact area, although defined for the largest planned tests, can be influenced by changing the rate of spilling: lower spill rates, smaller area affected; higher spill rates, larger area affected (up to the largest defined limit).

Governmental standards for human occupational exposures to hazardous materials were used in establishing maximum downwind test-material concentrations for each zone. Human occupational exposure standards were used because animals were found, in general, to be less

Figure 4.4. Maximum impact zones for testing at the LGF Spill Test Facility, Frenchman Flat.

sensitive to toxic substances than humans for short exposures. The zones have been determined for a maximum exposure of 15 min. This exposure time was selected because the government occupational exposure standards were established using either a 30 min exposure (IDLH)[†] or a 15 min exposure (STEL)[‡], and the meteorological test criteria necessary to produce useful data established a release period of about 10 min. With the test criteria, 15 min is likely to be the maximum amount of time any plant or animal will be exposed during the largest tests.

The criteria used in establishing limits to downwind concentrations of spill materials are similar to those of Leitner *et al* (1983). This is exemplified by their limits to downwind concentrations for the N_2O_4 and NH_3 spills at the temporary spill facility at Frenchman Flat (summer/fall, 1983). Although the geographic limits to downwind concentrations of the spill materials are similar, the temporary facility did not have the capability for larger spills as does the design for the permanent facility.

The three zones are listed below as to maximum allowable impacts at the boundaries of each zone:

Zone I: an area of lethal concentrations for exposures of less than 15 min to humans and wildlife. The lowest lethal concentration (found in scientific toxicological studies) is the maximum allowed downwind concentration at the boundary of this zone.

Zone II: an area in which the exposure for less than 15 min will have a low probability of mortality, though it will cause respiratory damage to humans or animals if in an exposed location. Vegetation will be affected; however, the extent of injury and recovery is species and test-material specific. The occupational exposure standard, IDLH (Immediately Dangerous to Life and Health), is the maximum allowed downwind concentration at the boundary of this zone. If an IDLH has not been

[†] IDLH : Immediately Dangerous to Life or Health; a maximum level from which one could escape within 30 min without any escape-impairing symptoms or any irreversible health effects; established by National Institute of Occupational Safety and Health (NIOSH) (Sax, 1984).

[‡] STEL : (TLV-STEL) Threshold limit value - short-term exposure level; maximal concentration to which one can be exposed for a period up to 15 min continuously without suffering from irritation, chronic or irreversible tissue change, or narcosis of sufficient degree; derived from the American Conference of Governmental Industrial Hygienists (ACGIH) (Sax, 1984).

determined, criteria are used which most closely fit the IDLH definition. IDLH standards have been defined for 30 min exposures and, therefore, is a conservative estimate for a 15 min exposure.

Zone III: The occupational exposure standard, STEL (Short-Term Exposure Limit), is the maximum allowed downwind concentration at the boundary of this zone. If no STEL has been determined, criteria are used which most closely fit the STEL definition. In this area, the only effects on wildlife are likely to be mild and reversible respiratory tract irritation. Any effect on vegetation would be minor and reversible.

The zones were established to confine impacts to an area that can be controlled and in such a way as to reduce impacts on wildlife and vegetation. Zone I is an area within which lethal concentrations for humans are allowed and absolute exclusion of personnel is required during tests. Exclusion of personnel other than those associated with the facility should be maintained at all times. Wildlife populations and vegetation are sparse. Zone I is confined to the Nevada Test Site so that potentially lethal concentrations do not occur on the Desert National Wildlife Range and the Nellis Air Force Range. Zone II also should be free of personnel during testing. Vegetation and wildlife will be affected during tests, so protected populations require protection through exclusion or mitigations. Zone II is set within the basin in order to control access during testing. In Zone III, minor impact may occur to vegetation, wildlife, and personnel of adjacent land operations, so the area has to be manageable. The 4400 ft elevation contour is the boundary for Zone III (as a downwind distance) to confine toxic concentrations to the Frenchman Flat basin (playa elevation 3080 ft). The public does not have access to any area within the three zones during tests.

In summary, the three zones (Fig. 4.4) are described by the following:

Zone I: 5 km - confined to the playa and the adjacent area, terminating before the Desert National Wildlife Range boundary.

Zone II: 10 km - confined within the Frenchman Flat basin and includes portions of the Desert National Wildlife Range and Nellis Air Force Range.

Zone III: 4400 ft elevation (12 to 25 km) - confined within the Frenchman Flat basin and portions of the Desert National Wildlife Range and Nellis Air Force Range.

V. ENVIRONMENTAL CONSEQUENCES OF TESTING HAZARDOUS MATERIALS

The potential environmental consequences of testing hazardous materials at the STF have been evaluated using geographic boundaries to establish limits to downwind concentrations for any test material and the proposed STF spill-test conditions. Two approaches have been taken in evaluating the environmental consequences: an overall evaluation for any test material, and the specific consequences of the 14 proposed test materials.

The overall evaluation of environmental consequences will be used in conjunction with Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action, to assess mitigations and recommendations for reducing the impact on the environment and for the protection of natural resources. The 14 proposed test materials are further evaluated in Section VII, Environmental Consequences of Proposed Test Materials.

The evaluation of environmental consequences is based on a maximum spill release of 15 min and a spill frequency of not more than 2 per day. For any variation from the test criteria addressed in this Environmental Assessment, extensive pretest research of environmental toxicology will be conducted. The concentrations of spill materials will not exceed those established for the boundary of each zone as stated in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

A. Land Use

The spill tests will potentially impact operations of the Nellis Air Force Range (AFR), Nevada Test Site (NTS) and Desert National Wildlife Range (DNWR). The safety of personnel is the primary concern. Mitigations are necessary to prevent exposure of personnel and to reduce impacts on operations of agencies within and adjacent to the impact zone. Coordination with the agencies is also necessary for access to and establishing monitoring stations on these lands. The environmental impact of the spill-facility structure has previously been evaluated (*Leitner et al.*, 1983).

Human occupational exposure will be closely monitored, especially at the spill point and in Zone I where lethal concentrations will be encountered. Concentrations in Zone II will be dangerous to life and health; access should be monitored and controlled. Zone III will contain concentrations that cause mild reversible effects.

Transporting and storage of the spill materials will meet Department of Transportation and NTS regulations.

Consideration will be given to potential noise and fire impacts. Tests involving flammable substances, pool-fire tests, vapor-cloud ignitions and rapid phase transition explosions will be mitigated if they threaten the safety of personnel or impact the operations of NTS, Nellis AFB or DNWR.

Resuspension of radioactively-contaminated soils, primarily from explosive tests, is not expected to have adverse environmental impacts on the biological resources of the NTS and adjacent lands for several reasons. The spill facility is not located near "hot spots" in the soil, tests can be conducted under meteorological conditions that will decrease the amount of dust leaving the control area, and calculations have shown that the amount of radioactivity in fugitive dust will not exceed EPA radiation-exposure standards (Cramer and Hogan, 1978; O'Neal and Hogan, 1979; McIntyre and Shinn, 1981; Shinn, 1981). These calculations were figured using worst-case scenarios and instantaneous detonations of spills of up to 1000 m³ LNG (maximum capacity is now only 200 m³).

Resuspension of plutonium from contaminated soils is of main concern for these tests as it poses an inhalation-hazard to humans and animals. Calculations by Anspaugh *et al* (1974) recommended a protective guideline for soil contamination of 7 nCi/g for a case where a landscape contaminated many years previously is reoccupied. The guideline is derived for an acceptable 50 yr lung dose of 75 rem, assuming 25% resuspended ²³⁹Pu is deposited in the pulmonary region of the lung. Further calculations by Anspaugh *et al* (1975) showed that for a soil protective guideline of 7 nCi/g (previous surface deposition) in the top 10 mm of soil, the average air concentration would be about 10⁵ aCi/m³ with a range of 10⁴-10⁶ aCi/m³. Background measurements made in the area of the proposed spill test facility (Shinn, pers. comm., 1985) showed seasonal variation with a maximum value less than 150 aCi/m³ and average summer values near 30 aCi/m³ (Table 9.1, Appendix I). We can conclude that exposure to resuspended ²³⁹Pu will be lower by a factor of 10³ compared to that implied by the soil protective guideline recommended by Anspaugh *et al* (1974). Precaution should be taken to avoid higher exposures due to disturbance such as by construction and traffic in the few areas of high soil contamination outside the perimeter of the spill test facility.

1. Nevada Test Site

Mitigations are necessary for preventing exposure of STF operators to adverse concentrations of spill materials in Zone I and Zone II of the impact zone.

Coordination with NTS operations is necessary to prevent accidental exposure of NTS personnel in Area 5, Area 11 and Area 6 (Fig. 5.1). The low-level radiation waste-management site is of concern in Area 5. It is located on the north side of the projected impact zone, 6 km north of the spill point. Area 11 to the north of the spill point and Yucca Flat of Area 6 are of concern for the larger spills. Yucca Flat could be impacted in the case of large spills with a deviation from the test-criteria wind direction (225° S). If this were to occur, the concentrations of material reaching the flat should be below the STEL (no-effect standard for 15 min exposure).

2. Nellis Air Force Range

The spill tests might impact operations of Nellis AFR, which is adjacent to the NTS, 3 km east of the spill point (Fig. 5.1). This area includes most of the impact zone from the spill tests. Only the western region of Nellis AFR Area 64 is within the impact zone defined by the 4400 ft elevation contour of Zone III. Area 64 is used in flight-training exercises by Nellis and flight patterns have been known to traverse the impact zone. Area 64 also has a number of unmanned operations in the valley between the Spotted Range and the Pintwater Range, 35 km east of the spill point. Nellis Area 65N, 22 km southeast of the spill point and beyond the Zone III contour, is used for targeted flight-training missions. Personnel will be on the ground in this area. These two areas are used extensively year-round, but the peak use occurs in the months between October and December (Tables 9.1 and 9.2, Appendix I). Testing will occur primarily in the months of March through September.

Exposure of Nellis AFR personnel should only be a concern for personnel in Area 64 adjacent to the spill site. The majority of Area 64 operations will not be impacted due to the confinement of toxic concentrations to the Frenchman Flat basin below the 4400 ft elevation contour. The combination of topography and the predominant wind direction will direct the majority of the plume toward Nye Canyon to the north. Pilots flying through Area 64 and 65N would be out of the defined impact zone. If pilots were to be exposed to the vapor, the exposure would be extremely brief and the concentration would be less than the STEL (a federal government no-effect standard for a 15 min exposure). Personnel in Area 65N located on the ground will not be impacted as the spill-test criteria require that spill tests will occur only with a wind direction that will not carry the plume over this area. If the plume were to carry over this area as a result of a change in wind direction, the concentration would be extremely low (below the STEL) due to the greater distance and turbulence associated with a change in wind direction and rough surface terrain.

Figure 5.1. Maximum impact zone for spill tests at Frenchman Flat, NTS. Adjacent land uses are also indicated.

Concentrations high enough to be within the flammability limits of each substance will be confined to the playa and the NTS and will not impact flight operations of Area 64. Also, concentrations of spill material high enough to be corrosive will be confined to the playa and will not impact flight operations of Area 64.

3. Desert National Wildlife Range

The spill impact zone includes the western boundary of the DNWR adjacent to NTS, 8 km northeast from the spill point (Fig. 5.1). No known operations are being conducted in the region up to the Spotted Range at the 4400 ft elevation contour boundary of Zone III, but coordination with DNWR is necessary to ensure exclusion of personnel from the impact zone during spill tests.

A large portion of the Desert National Wildlife Range is being considered by the U.S. Congress for inclusion as a wilderness area (Fig. 5.1). While under consideration, regulations pertaining to interim management similar to those for a wilderness area must be followed (U.S. Dept. of Interior, 1979). The Bureau of Land Management has determined that any activity may be permitted on lands under wilderness review as long as they meet the following criteria (U.S. Dept. of Interior, 1979): "1) it is temporary, 2) any temporary impacts caused by the activity must, at a minimum, be capable of being reclaimed to a condition of being substantially unnoticeable in the wilderness area, and 3) when the activity is terminated, and after any needed reclamation is complete, the area's wilderness values must not have been degraded so far, compared with the area's values for other purposes."

The Desert National Wildlife Range does allow limited access for the public, i.e. hunters, but they would be present in areas of bighorn sheep habitat located approximately 35 km to the east of the spill facility, and only during late fall (Oct.-Nov.); and they will not be impacted by the spill tests. The Papoose Lake Research Natural Area is not located within the defined impact zone.

B. Air Quality

As the proposed project area at Frenchman Flat is about 80 km northwest of the urban areas of Clark County (AQCR-013) and the proposed spill trajectory is to the northeast, it is unlikely that ambient concentrations of the major air pollutants resulting from the spills will have any significant impact on the air quality of the region.

All proposed testing at the spill site will meet the State of Nevada and federal air quality standards for the major pollutants and general ambient air-emission guidelines. These standards and guidelines will not be exceeded at any point accessible to the public, or at any other location outside the controlled area. In the case of spill materials not covered by state or federal guidelines, regulation by the State of Nevada may not be required because these tests constitute transient releases and the public does not have direct access to the spill-test impact area (State of Nevada guidelines NRS 445.461, 445.491, 445.496, and 445.571). A screening tool used by the State of Nevada is that a level 2.4% of the TLV-TWA will be met for unregulated pollutants at points to which the public has access. This standard is for an 8 hr averaging time.

There will be a smoke cloud after ignition and burn tests of hydrocarbon fuels. Burning vegetation will also generate smoke that may persist some time after a test. In the occurrence of such testing, air quality regulations will be followed and a burning permit will be obtained if determined necessary by State of Nevada guidelines.

C. Water Resources

None of the spill tests is expected to have any impact on the water resources of the Frenchman Flat area. Groundwater resources will not be affected in any way by the proposed project because an impervious layer underlies the playa and the groundwater is 200 m below the surface. The only surface water that could be contacted by the released gases is in the artificial marsh on the north side of the playa or on the playa itself during the rainy season. Although gas concentrations will be relatively high in these areas, none of the gas is expected to leave any significant residual from combination with water. If the trajectory of any of the clouds carries over the marsh, the period of exposure would be no more than 15 min.

D. Biological Resources

Past tests at Frenchman Flat have shown that when the test criteria are met, i.e., daytime tests with steady wind speeds between 2 and 8 m/sec, the gas clouds move downwind at very nearly the wind speed and do not persist for much longer than the spill duration. Steady winds, ground heating by the sun, and the ambient turbulence in the atmosphere mix the gas cloud with the air and keep it moving steadily downwind. Consequently, within the three zones the longest time period that any given point is likely to be exposed to the cloud would be approximately equal to the spill duration and would likely be less than 15 min. The previous spill tests of

ammonia and nitrogen tetroxide in the summer/fall of 1983 (Leitner et al., 1983) did not have any significant impact on the biological resources within the Frenchman Flat basin (F. Bingham, DOE-Nevada, pers. comm., 1985; B. Yoder, U.S. Fish and Wildlife Service, DNWR, pers. comm., 1985).

When evaluating the impact of spill testing on the biological resources, of primary concern is the playa, the associated marsh vegetation, and the vegetation associations located within Zone I. Vegetation is used by wildlife for food, nesting and fawning sites, and protection from climatic conditions. The Frenchman Flat playa and the associated marsh habitat are included in the range of many of the wildlife species found in the area.

1. Vegetation

There are no threatened or endangered plant species in the Frenchman Flat spill-test area. Toxic concentrations present in Zone I, especially those of phytotoxic materials, could severely injure or kill some vegetation. The extent of areal injury at this time is unknown due to the short exposure times and the low metabolic rate of desert species during the hot summer. Desert plant species lose their leaves or reduce their metabolic rate as much as 70% (E. Romney, UCLA, pers. comm., 1985; Bamberg et al., 1975; Kleinkopf et al., 1980). Few studies have been found on desert species' response to phytotoxic substances that take into account these variables. Parts of the *Atriplex* association and the marsh vegetation are contained in Zone I in a region adjacent to the playa. There would be no significant impact to the vegetation if exposed to the toxic levels associated with Zone I because of the abundance and distribution of the *Atriplex* and *Larrea* vegetation associations throughout the NTS. Also, vegetation recovery is documented for acute exposures to phytotoxic chemicals (Treshow, 1970; Jacobsen et al., 1970). Concentrations in Zones II and III will not impose any significant impact to vegetation. The effects on vegetation in these zones would be minor and reversible.

Different kinds of fires from certain proposed spill tests would produce different hazard zones. For pool-fire tests, the fuels would be ignited at the spill point. The wood-ignition distance for such a test would extend a maximum of 100 m from the spill point (Johnson and Thompson, 1984). There would be no impact on vegetation from a pool-fire test since the burn would be confined to the playa. When a dispersing vapor cloud is ignited some time after the fuel has evaporated and drifted a distance from the spill point, the expected wood-ignition distance would depend on the dispersion distance to the lower flammability limit. Thus the hazardous distance for a dispersion-burn test would be about 2 km downwind from the spill point, based on current results from dispersion models (Johnson and

Thompson, 1984). Although the impact zone will be restricted to the playa, mitigations are necessary to prevent possible range fires.

Mitigations are necessary to restrict off-road access by spill-test personnel to established jeep trails. This is necessary to minimize the impact to desert vegetation.

2. Wildlife

Zone I:

Most of Zone I is barren playa that does not support any wildlife populations during the summer when testing would occur. The *Atriplex* vegetation association at the edge of the playa and the marsh habitat are of concern. Transient wildlife, raptors, and migratory waterfowl have been known to use the marsh area as it provides cover, food and water. Concentrations of more toxic materials can be lethal or seriously injure wildlife of these vegetation associations during the larger tests. Marsh-associated vertebrates may be exposed to levels that could cause mortality. Red-winged blackbirds and American coots are both common and widely distributed throughout the western United States and any mortality, if it occurs, would have no significant impact on their populations in the region. The extent and diversity of marsh-dwelling mammals is not known, but the sightings of coyotes (Shinn, pers. comm., 1985) around the marsh and kit foxes in the *Atriplex* association north of the playa (Leitner et al, 1983), imply a diverse marsh fauna. With the presence of the kit fox, migratory game waterfowl, and raptors in the area, mitigations are necessary to reduce the impact on the marsh populations, especially those species protected by the State of Nevada.

Very few vertebrates are likely to be active on the surface in the *Atriplex* association from late morning to late afternoon. A few species of lizards, snakes, rodents and small birds, as well as black-tailed jack rabbits, could be exposed to potentially lethal concentrations. The number of individuals at risk is unknown. The habitat area that could be affected by a test spill is small in relation to the total area of similar habitat in Frenchman Flat, the species that are likely to be exposed are widespread and abundant, and any mortality would be rapidly compensated through reproduction and immigration from the surrounding habitat. Burrow-dwelling vertebrates are expected to be underground at the time of day when a spill test would be conducted. Many wildlife species normally plug the entrance of their burrows with loose dirt; this physical barrier should prevent exposure to any toxic gas. However, the gas is unlikely to penetrate an open burrow because of the temperature difference between

the burrow air and the gas cloud (Geiger, 1985; Leitner *et al.*, 1983; Shinn, pers. comm., 1985).

A protected species of concern is the kit fox. Suitable habitat and evidence of dens (Leitner *et al.*, 1983) were observed at the playa's north edge (Fig. 3.12). Mitigations are necessary for protection of the species in the cases of large spills where lethal concentrations will occur in areas beyond the playa.

Zone II:

The wildlife species at risk in Zone II are similar to, if not the same as, those found in the desert-shrub habitat of Zone I. Individual animals active at the surface could suffer injury to the respiratory system and possibly mortality, although this seems very unlikely because of the short exposure time (15 min or less).

During surveys of wildlife habitat, desert tortoise dens were observed that were associated with *Larrea* vegetation 4 to 5 km northeast of the spill point, and dens and an individual 6 to 9 km east of the spill point (Fig. 3.12) (Leitner *et al.* 1983; Collins, 1984). Since gas concentrations would be relatively low in this area, and since the animals are nocturnal and would in all likelihood be in their burrows at the time the tests are carried out, no adverse impact on this protected species is expected. The same conclusion would apply to any kit fox that may be present in Zone II. Mitigations are necessary to limit off-road traffic to established jeep trails in order to protect the desert tortoise habitat.

Zone III:

While the area included in Zone III is large, the relatively low concentrations here should ensure that the only impact on wildlife populations could be mild respiratory tract irritation and possibly minor lung damage, even during the largest planned tests. A species of concern, which could be located near Zone III for some of the larger tests of toxic substances, is the bighorn sheep. Their respiratory system is more sensitive than a human's to toxic gases, though the exact difference is not quantified (B. Padilla, Nevada Dept. of Wildlife, Las Vegas, pers. comm., 1985). The area of concern is to the southeast of the spill point in the Spotted Range. Sheep do not reside in this area; however, evidence has shown that they do pass through this area in the fall to early spring when water is present (B. Yoder, U.S. Fish and Wildlife Service, pers. comm., 1985). Water is a limiting factor for determining habitat for the sheep. No natural sources of water are known in the Spotted Range.

No impact on the bighorn sheep population is expected from the spill tests at Frenchman Flat. The impact zone is confined within the Frenchman Flat basin below the 4400 ft contour. This keeps the gases out of the mountain areas where bighorn sheep are known to occur. Also, the majority of tests will occur with the plume traveling up toward Nye Canyon, a lower pass, to the north, instead of toward the Spotted Range to the southeast. If the winds should push a plume toward the bighorn sheep habitat in the Pintwater Range, a buffer zone exists of approximately 20 km from the end of Zone III.

As discussed in the vegetation section, mitigations are necessary when pool fires or dispersion burns are proposed. Explosions, which may result from either rapid phase transition or ignition, would have a maximum shock pressure of 5 psi at 0.3 km from an explosion under the largest spill scenario (Johnson and Thompson, 1984). No significant impact will occur to animals in the projected impact zone.

E. Cultural Resources

The proposed spill tests will not impact cultural resources. There appear to be no archaeological or historical sites at Frenchman Flat. Studies have shown that the impact area within the Frenchman Flat basin is clear of archaeological sites (Fig. 3.13).

VI. MITIGATIONS AND RECOMMENDATIONS

A. Mitigation Measures

In evaluating the potential environmental impacts of hazardous material testing at the Spill Test Facility, mitigations and recommendations are presented in this section concerning Spill Test Facility operations that would considerably reduce or alleviate potential environmental impacts. The following five mitigation measures are necessary in order to protect natural resources and reduce land use impacts.

- In addition to testing under the criteria established by STF Operations, restricting testing to daylight hours, midmorning to late afternoon, between the months March to September, and a 15 min maximum spill duration, would have a reduced impact on vegetation and wildlife. Night and off-season testing will be restricted to the playa.

- It would be desirable to establish spill rates that would physically confine the concentration limits for the Zone III area to the playa. Small spill tests confined to the playa will not have a significant impact on the existing environment. In the event that larger spills are necessary to achieve the goals of the testing program, reconnaissance surveys must be conducted to analyze the impact of the spill material on vegetation and wildlife. If larger spills are conducted, the frequency of testing should be restricted in order to determine the effects on vegetation and wildlife and to reduce cumulative impacts.

- Smaller tests with a reduced spill rate should be conducted initially for each new spill material. The smaller tests will serve to validate dispersion-model predictions in order to confine environmental consequences to the defined impact zone. From these smaller tests, the maximum amount and rate of spill for each test material will be determined to confine the effects to the geographic zones established in Section IV.

- When testing spill materials of unknown or high phytotoxicity, experiments or smaller spills will be conducted prior to large-scale testing to determine the sensitivity of desert vegetation.

- An Operations Plan will be submitted for all proposed tests. This plan will cover all aspects of operating the facility and will assure compliance with this Environmental Assessment. This plan would address cleanup of the site as well as who will perform the various tasks such as choosing and running dispersion models, and conducting environmental and safety surveys. Cleanup, evacuation and safety procedures would be studied and a review of necessary permits will be completed.

1. Land Use

Coordination with the agencies responsible for access to lands adjoining NTS, as well as NTS activities in Area 11, Area 6 (Yucca Flat via Scarp canyon) and Area 5 (low-level radioactive waste-management site) is a necessary pretest mitigation. This is necessary to prevent accidental exposure to personnel during spill tests, gain permission for access to adjacent areas, and assure compliance with management policies of these adjacent areas. For toxic materials, where low concentrations are of concern, a detector of spill material should be placed at the 4400 ft elevation in Nye Canyon to monitor the concentrations of spill materials dispersing through the pass into Area 64 of Nellis AFR.

Desert tortoise habitats and marked radiation exclusion areas on NTS and Nellis AFR should be avoided by STF personnel working in those areas.

a. Nevada Test Site

All personnel working within the spill area, when the valves are unlocked, must wear approved protective clothing and be trained in the use of and carry approved respiratory equipment appropriate to the material being tested.

A safety plan and evacuation procedures must be available prior to testing by the STF operations. Coordination with the NTS Firestation and DOE operations is required when ignition or fireball tests are to be conducted.

b. Nellis Air Force Range

Coordination with Nellis AFR operations is necessary to exclude personnel from the eastern region of Area 64 during test spills. Access to Nellis AFR must be coordinated with operations for placing of monitors and sensors, and for reconnaissance surveys. Desert tortoise habitats must be avoided when possible and care should be taken not to disturb the habitat.

Weekend testing has been recommended by Nellis AFR, especially in the case of large spills or when testing more toxic materials, to reduce impacts on their operations.

c. Desert National Wildlife Range

Access will be coordinated with DNWR and is limited in compliance with proposed Wilderness Area management guidelines, as discussed in Section V, Environmental Consequences of Hazardous Materials Testing.

2. Air Quality

Spill-test proposals must predict emission rates and ambient air concentrations, especially during stable or nighttime conditions. Every effort will be made to assure that the tests comply with state or federal regulations when appropriate. Monitoring, both on- and off-site, will be conducted in accordance with the Operations Plan of the STF.

3. Water Resources

Since the proposed spill tests will have no significant impact on surface or groundwater resources, no mitigation measures will be required.

4. Biological Resources

Permanent study sites for evaluating the impact on vegetation and wildlife of hazardous material spill testing will be established downwind of the spill facility prior to testing. DOE will conduct field surveys and evaluate the effect of spill testing in order to minimize potential impacts.

a. Vegetation

To prevent significant impact as a result of the spill tests, certain measures will be taken. The downwind study sites will be surveyed periodically to ensure that no significant impact occurs on desert species. Prior testing of vegetation is recommended in the case of highly phytotoxic materials to determine the sensitivity of desert species. It may be necessary to construct fire lines, depending on the spill scenario and fuel quantity, when fireball or ignition testing is to be conducted. Coordination with NTS, Nellis AFR, Nevada Dept. of Wildlife, and DNWR is necessary prior to construction.

If deemed hazardous by the LLNL Project Scientist and concurred by Operations Controllers Test Safety Review Panel, any toxic residue will be removed from the playa or surrounding soils after a spill test. The spill facility user is responsible for cleanup operations.

b. Wildlife

Whenever possible, the concentration of spill materials associated with the impacts for Zone III should be restricted to the playa during testing to avoid impacting wildlife. In the case of the larger spill scenarios, there are several areas and/or species of concern.

The artificial marsh habitat on the north side of the spill-impact zone must be rendered void of protected species prior to any testing. Wildlife, particularly waterfowl and kit foxes, must be scared away or the habitat moved or removed prior to testing. The bunkers on the north side of

the playa, in the *Atriplex* vegetation association must be void of inhabitants prior to testing. It is recommended that the habitats (bunkers) be removed by professional wildlife-management personnel. Off-road traffic must not impact the desert tortoise habitat northeast and east of the spill point.

5. Cultural Resources

As there are no archaeological or historical resources at Frenchman Flat, no mitigations are required.

B. Spill Tests of Different Magnitude

If the size of the proposed spill tests were reduced, the environmental impact would also be reduced.

If tests of larger magnitude than are assessed in this Environmental Assessment (due to differences in test criteria) are proposed, pretest research must show that the spill tests will not exceed the impact limits defined by this Environmental Assessment. Reduced release rates or control measures must be implemented to limit downwind concentrations. Any test should not have a greater impact on resources than those established for releases of 15 min or less.

C. Unavoidable Adverse Impacts

If the spill tests are conducted with implementation of the proposed mitigation measures and recommendations, certain potential adverse impacts will still need to be considered. The release of hazardous materials to the atmosphere is necessary for the purpose of these tests. However, the amounts involved are such that there will be no significant impact on air quality. It is possible that small areas of natural vegetation close to the spill point in a downwind direction could suffer temporary injury and there is a chance of vegetation loss at the edge of the playa. No federal rare, threatened, or endangered plant species are present in the area that might be impacted. There is a small risk of death or injury to a few individuals of certain wildlife species that may be present in areas close to the release point. No federal rare, threatened, or endangered wildlife species are at risk within the impact area. Two species of concern that are protected by the State of Nevada, the kit fox and the desert tortoise, are very unlikely to be exposed to high concentrations of hazardous materials. They may be present in very low numbers in a habitat that could be exposed to dangerous levels of these hazardous materials. However, they should be underground in their burrows during the test periods. Assuming that testing is infrequent to allow recovery of wildlife and vegetation, an increase in the frequencies of spills will require conservative management to allow recovery time between

tests. Low concentrations of these test materials will drift onto lands being managed by the U.S. Fish and Wildlife Service that are being considered for wilderness designation. It could be stated for some materials that an odor threshold less than the TLV-STEL may be present during the tests (less than 15 min), but no harmful effects will occur because of the low concentrations.

D. Cumulative Environmental Effects

The environmental impact of the proposed project will be temporary and transient. Release of the gases to the atmosphere will involve limited amounts of these materials for brief periods of time. Dispersion and mixing with the regional air mass will occur quickly and even the total of all releases during this test program will not result in a significant impact on air quality. The larger planned tests of each series and tests of highly toxic materials have the potential to harm vegetation or wildlife. Although these releases could possibly affect the same area, it is very unlikely. Even if this cumulative exposure did occur, changes in plant and animal numbers or diversity would not be expected to result from this test program.

VII. ENVIRONMENTAL CONSEQUENCES OF PROPOSED TEST MATERIALS

This section evaluates the environmental consequences of testing currently proposed test materials in the Frenchman Flat basin. The scale of the impact will vary according to the toxicity of the substance being tested (Tables 9.5 and 9.6, Appendix I). Factors to be considered when assessing impacts include air and water resources, biological resources, cultural resources and land use. Mitigations to lessen the impact of spill tests on the resources of Frenchman Flat have been presented in the previous section.

The impact on land use within the projected impact zone for the spill testing is described in detail in Section V. Different areas within the impact zone will be affected by different test materials. For example, the impact of simple hydrocarbons on wildlife and humans will be confined to the playa and the NTS, and will not have any effect on operations at Nellis, the Desert National Wildlife Range, the Radioactive Waste Management Site, or any other land use in the NTS. However, for large test spills of toxic materials, mitigations such as coordination with personnel at Nellis, the Desert National Game Range, and NTS will be necessary to prevent exposure to dangerous concentrations. Concentrations that are high enough to be flammable will be confined to the playa (Table 9.7, Appendix I).

Regional air quality will not be significantly impacted by the spills of the proposed test materials. A large buffer zone between Zone III and any area accessible to the public, where air quality criteria must be met, will keep all tests from exceeding the air quality standards set by the State of Nevada. Three proposed test materials, which are specifically regulated by the State of Nevada and federal regulations, are SO_2 , H_2S and NO_2 . For any pollutant not specifically regulated by the state, a screening tool of 2.4% of the TLV-TWA is used by the State of Nevada and should not be exceeded where the public has access (G. Gentry, Nevada Division of Environmental Protection, Reno, pers. comm., 1985). TLV-TWA is the government standard for an 8 hr occupational exposure in the workplace. Table 9.6, Appendix I, includes the TLV-TWA values for the proposed test materials.

Water resources will not be impacted at the spill facility. All natural sources of water are located out of the impact zone. Standing water is found in the area only during the winter. In the summer, the marsh area is void of open water. Brief exposure to the gas as it passes over the marsh will not have an adverse effect on the water quality.

Several of the proposed test materials are of concern when addressing impacts on biological resources from the spill tests at Frenchman Flat and will warrant mitigations. Mitigations have been previously discussed (Section VI) for any spill-test material that will reduce impacts

from the testing. Phytotoxic materials of concern, which should be tested for acute toxic effects prior to spilling, include ethylene, chlorine, sulfur dioxide and hydrogen fluoride. Materials that are toxic to mammals and are, therefore, of concern, include cyclohexane, chlorine, hydrazine, sulfur dioxide, and especially phosgene, hydrogen sulfide and hydrogen fluoride.

With mitigations, vegetation will not be significantly impacted as a result of the spills of the proposed test materials. Mitigations have been previously stated (Section VI) that will reduce impacts from the spill tests. Although some mortality and injury are likely to occur, the impact will not be significant due to several factors. The area that might contain lethal concentrations during a test will be small in relation to the total area of *habitat for any of the species found within the zones*, and no rare, threatened, or endangered species (Federal) are known to occur there (Fig. 3.11). Spilling will occur when plants are in a dormant or reduced physiological stage. Also, germination will not be affected by spills after springtime. Mitigation measures are necessary to ensure that no significant effect on vegetation occurs as a result of testing at the STF. Spills that occurred at the temporary facility in the summer of 1983 left no significant impacts on either short-term or long-term vegetative processes (B. Yoder, U.S. Fish and Wildlife Service, DNWR, pers. comm., 1985).

With mitigations (Section VI), no significant impact will be expected on the wildlife populations at Frenchman Flat as a result of the spill tests. Impacts on wildlife are described in detail below for the proposed test materials and in general in Section V. Effects on wildlife will be reduced through the previously stated mitigating measures, if necessary. No rare, threatened or endangered species (Federal) are known at Frenchman Flat, however several species, such as the desert tortoise and kit fox, are protected by the State of Nevada.

The following definitions (Sax, 1984) are used to evaluate the toxicity of the proposed test materials:

- LCLo: Lethal Concentration Low, the lowest concentration of a substance in air, other than LC50, which has been reported to have caused death in humans or animals.

- LC50: Lethal Concentration Fifty, a concentration of a substance in air, exposure to which for a specified length of time is expected to cause death of 50% of an entire defined experimental population. It is determined from the exposure to the substance of a significant number from that population.

- **TCLo:** Toxic Concentration Low, the lowest concentration of a substance in air to which humans or animals have been exposed for any given period of time that has produced any toxic effect in humans or produced a carcinogenic, neoplastigenic, or teratogenic effect in animals or humans.

A. Simple Hydrocarbons: Methane, Propane, LNG, LPG, Butane, and Ethylene

Limits to downwind concentrations for the proposed test materials are listed below. These concentrations must not be exceeded at the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action. LPG is either propane or butane; LNG is either methane or a nominal mixture of 92% methane, 6% ethane and 2% propane. No occupational exposure standards have been established for methane.

	<u>Levels (ppmv)</u>		
	Zone I	Zone II	Zone III
Methane	620,000	---	---
Propane	620,000	20,000	1000
Butane	620,000	10,000	1250
Ethylene	550,000	375,000	1000

1. Air Quality

No significant impact. Hydrocarbons are not specifically regulated by the State of Nevada. Particulates are limited to 150 micrograms per m³ (24 hr averaging time). The following concentrations (2.4% of the TLV-TWA) will not be exceeded in an uncontrolled area for an 8 hr averaging time (TLV-TWA's are listed in Table 9.6, Appendix I):

Butane	14 ppmv
Propane	24 ppmv
Methane	24 ppmv
Ethylene	24 ppmv

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

Ethylene appears to be the only simple hydrocarbon among the ones proposed for testing that is a significant phytotoxicant. Methane, propane and butane will have no effect on the vegetation at Frenchman Flat.

With mitigations proposed in Section VI, such as laboratory pretesting of ethylene phytotoxicity, the proposed ethylene spill tests will have no significant impact on the natural vegetation of the Frenchman Flat basin. The only vegetated areas that might be exposed to high concentrations of ethylene are the artificial marsh on the north edge of the playa and the adjoining *Atriplex* shrub association. The area to the northeast of the playa where phytotoxic concentrations will occur during the larger tests, supports the *Atriplex*, *Larrea-Ambrosia-Atriplex*, *Larrea-Psoralea*, and *Ephedra-Atriplex* associations.

Most experimental studies on the effects of ethylene on plants have been designed to simulate exposure of flowers in greenhouses. As a result, the concentrations used have often been relatively low (0.01 to 10 ppmv) and the exposure times have ranged from hours to months. There are few data available on the response of desert species such as those found at Frenchman Flat.

Low levels of ethylene exposure can impose severe injury on sensitive plants; it interferes with the plant's hormones and growth regulators. Flowers are especially sensitive to exposure to ethylene (U.S. Dept. of Health, Education and Welfare, 1970a; National Research Council, 1976a):

orchid injury:	0.3 ppmv/ 1 hr
orchid injury:	0.05 ppmv/ 6 hr
orchid injury:	0.01 ppmv/24 hr
closing of flowers (carnation):	0.1 ppmv/ 6 hr

Grasses are relatively resistant to the effects of ethylene exposure; they can be exposed to 10 ppmv for ten days without injury (U.S. Dept. of Health, Education and Welfare, 1970a; Stern, 1977; Stahl, 1969).

No experimental data could be found on the response of vegetation to very short exposures of ethylene (less than 30 min) similar to those that might occur downwind of the proposed spill tests. Some references state that acute injury is not associated with this gas (Jacobsen and Hill, 1970) or that recovery is rapid after the fumigation (exposure) stops (Treshow, 1970). Other studies show that typical injury for acute exposure is tissue collapse and epinasty or necrosis of leaf parts, and the closing of flowers. Older tissue is the first to show injury (U.S. Dept. of Health, Education and Welfare, 1970a).

Though very low concentrations of ethylene are toxic to plants in chronic exposures, no significant loss of vegetation should occur from spills due to the duration of exposure and maximum concentrations permitted within each zone. As shown in studies (Treshow, 1970; Jacobsen, *et al*, 1970), any acute exposure will have either no effect or a temporary injury from which the plant will rapidly recover after the plume passes.

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer significant impact from the proposed hydrocarbon spill testing as the gases are not toxic to animals. They act as asphyxiants at high concentrations for acute exposures (Sax, 1984; Patty, 1981). The concentration at which oxygen present in the air is less than 8%, the calculated asphyxiant level, is approximately 620,000 ppmv. Experiments on the effects of butane on mammals such as rats and mice have been conducted; the LC50 for a rat exposed for 4 hr is 280,000 ppmv, whereas the LC50 for a mouse exposed for 2 hr is 300,000 ppmv. Acute exposures will be for durations of approximately 15 min, therefore, the asphyxiant level of 620,000 ppmv is used to define Zone I concentrations for the hydrocarbons.

For all the hydrocarbons, Zone I concentration limits will be confined to the playa, within 400 m of the spill point for the largest planned tests. The playa is barren of vegetation and does not support any wildlife. The marsh will not be exposed to Zone I concentration levels because lethal concentrations will only occur near the spill point. For the hydrocarbons for which control of Zone II is necessary (propane, butane and ethylene), concentrations will also be confined to the playa. Expected Zone III concentration limits for the maximum planned tests will not occur in the Desert National Wildlife Range under approved test conditions.

Fire associated with proposed RPT explosions, pool-fire and dispersion ignition testing (Table 9.7, Appendix I) involving LNG or LPG will impact wildlife present in the marsh and north of the playa as discussed in the environmental consequences section. Mitigation measures,

stated in Section VI, will be necessary to reduce impacts. There will be no significant impact due to the noise from explosions.

B. Cyclohexane

Limits to downwind concentrations of cyclohexane, Zone I - 10,000 ppmv*, Zone II - 10,000 ppmv, and Zone III - 375 ppmv, must not exceed the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Cyclohexane is not specifically regulated by the State of Nevada. The concentration of 7 ppmv (2.4% of the TLV-TWA) for an 8 hr averaging time will not be exceeded in uncontrolled areas.

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

No documentation of cyclohexane's phytotoxicity could be located. Mitigations, such as laboratory testing of cyclohexane phytotoxicity to desert vegetation, may be necessary to ensure that no significant impact occurs on vegetation.

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer significant impact from the cyclohexane spill tests. Cyclohexane is not highly toxic for acute exposures. The area that may be exposed to lethal concentrations, as well as the area exposed to Zone II concentration limits, will be confined to the playa for the largest planned spill test. The playa does not support any wildlife. The only wildlife habitat within the three zones for a maximum quantity spill would be the kit fox burrows noted by Leitner *et al* (1983).

Cyclohexane, a solvent that acts as a central nervous system depressant, is not highly toxic; however, the range between narcosis, loss of reflexes and death is relatively narrow. A rabbit exposed to 18,500 ppmv for 8 hr survives; yet a rabbit exposed to 26,600 ppmv for 1 hr will die (Patty,

*No lethal concentrations have been established for humans: 10,000 ppmv is the IDLH and is judged to be a conservative standard for lethal concentrations.

1981) Some experimental exposures to cyclohexane for exposures of an hour or less are listed below (Patty, 1981):

rabbit	26,600 ppmv	/1 hr	lethal
rabbit	18,000	/6 min	trembling
rabbit	18,000	/15 min	disturbed equilibrium
rabbit	18,000	/30 min	recumbent
rabbit	12,600	/1 hr	narcosis
guinea pig	18,000	/11 min	disturbed equilibrium
mouse	18,000	/5 min	trembling
mouse	18,000	/15 min	disturbed equilibrium
mouse	18,000	/25 min	recumbent

From these studies, lethal exposures appear to be somewhat above 18,000 ppmv for exposures of less than 30 min. The Zone I and II criteria easily meet this level. Both zones will be confined to the playa, even for maximum spill scenarios, and would not have significant impact on the wildlife of Frenchman Flat. Zone III concentrations will extend off the playa but should not reach the Desert National Wildlife Range and the observed desert tortoise habitats (Leitner *et al*, 1983; Collins, 1984).

C. Chlorine

Limits to downwind concentration of Chlorine, Zone I - 430 ppmv, Zone II - 25 ppmv, Zone III - 3 ppmv, must not be exceeded at the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Chlorine is not specifically regulated as an air pollutant by the State of Nevada. The concentration of 0.024 ppmv for an 8 hr averaging time (2.4% of the TLV-TWA) will not be exceeded in an uncontrolled area.

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

Chlorine is not a common air pollutant, and as such, has not received much attention as a phytotoxic agent, especially for short-term exposures (less than 30 min). Most experimental exposure periods last from 2 to 24 hr or longer (Bremner *et al*, 1965). No data are available on the response of desert species such as those found at Frenchman Flat.

Injury to plants that are sensitive to chlorine exposure can occur at very low concentrations (National Research Council, 1976b):

Buckwheat	0.46 ppmv / 1 hr
Corn	0.1-0.25 / 4 hr
Peach	0.56 / 3 hr

The threshold for tolerant species is not much higher than that for sensitive plants. They can be exposed to levels as high as 0.5 to 0.8 ppmv for 4 hr before injury occurs. This has a CT (concentration-time) value per hour of 2.0 to 3.2 ppmv which translates to approximately 8 to 13 ppmv for a 15 min exposure (Treshow, 1970).

Low soil moisture at Frenchman Flat will affect the impact of chlorine on the desert species. Studies have shown that injury is less severe under low soil-moisture conditions (Jacobsen and Hill, 1970), so it is possible that the threshold levels for the species at Frenchman Flat may be higher. This is an unknown, however, as the studies were done with species that are accustomed to a higher soil-moisture level.

Symptoms of acute injury vary according to the vegetation type. In grasses, chlorosis and streaking occur, but are not usually pronounced. Broadleaf plants show necrotic areas and chlorosis on the leaves. Defoliation can occur at very high concentrations and short exposures, but only with a very few species.

Though low levels of chlorine are phytotoxic, with the mitigations stated in Section VI, no significant loss of vegetation should occur from the amounts released at Frenchman Flat. The highest concentrations will occur on the playa, and the combination of short exposure time and decreased effects due to low soil moisture should only temporarily injure some plants.

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer significant impact from the chlorine-spill tests. Most of the area that may be exposed to concentrations that are lethal to mammals is confined to the playa, which does not support wildlife. The only wildlife habitat that may be exposed to these high concentrations is the marsh area and adjacent *Atriplex* association. During the time of the day the spill would occur, most animals would be in their burrows, out of the sun. The burrow provides them with extra protection from exposure to the chlorine gas.

Many studies have been done on acute exposures of chlorine on animals. Much species variation exists on the response of animals to chlorine (National Research Council, 1976b; U.S. Dept. of Health, Educ. and Welfare, 1976a; Sax, 1984):

mouse	1000 ppmv	/20-50 min	lethal
mouse	800	/10 min	lethal
mouse	250	/8 hr	lethal
rabbit	660	/4 hr	LCLo
rat	293	/1 hr	LC50
rat	63	/up to 16 hr	non-lethal
mammal	500	/5 min	LCLo

Exposure for a few minutes to concentrations above 500 ppmv is considered potentially life threatening for animals. Zone I concentration limits will be confined to the playa and, depending on the toxicity of the gas and the wind direction, possibly the artificial marsh and adjacent *Atriplex* habitat. Any wildlife present in an exposed location within this zone might be killed or seriously injured. Animals within Zone II could be exposed to levels of 25 to 430 ppmv for 15 min and may suffer some respiratory damage; there is a low probability of mortality. Animals exposed in Zone III might incur irritation of the respiratory tract but no mortality is expected due to the low concentrations and short exposure time.

D. Hydrazine

Limits to downwind concentrations of hydrazine, Zone I - 90 ppmv, Zone II - 80 ppmv, and Zone III - 30 ppmv, must not be exceeded at the boundaries of the geographic zones described in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Hydrazine is not specifically regulated as an air pollutant by the State of Nevada. The concentration of 0.0024 ppmv for an 8 hr averaging time (2.4% of the TLV-TWA) will not be exceeded in uncontrolled areas.

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

As hydrazine is not a common air pollutant, few data are available on the effects of hydrazine vapor on plants. Hydrazine appears to be a mild phytotoxicant, affecting plants at high concentrations when contacted as a gas. When dissolved in liquid, it has a slightly more toxic effect, especially to seedlings. Spraying of seedlings (cotton, squash, soybean, endive, and pinto bean) with 2000 ppmv hydrazine caused slight temporary injury. Concentrations of 6000 to 10,000 ppmv caused increased injury and some plants died. Concentrations below 200 ppmv reduced the germination of rice and peas but did not affect endive or alfalfa (National Research Council, 1974). Although there are no data available on the effect of hydrazine vapors on desert species, studies indicate a low phytotoxicity of hydrazine. No significant impact is expected on plant species at Frenchman Flat.

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer significant impact from the proposed hydrazine-spill tests. Most of the area that may be exposed to concentrations that are lethal to animals is confined to the playa. The only wildlife habitat that may be exposed to these high concentrations is the artificial marsh and adjoining *Atriplex* association. During the time of day the testing would occur, most animals are in their burrows, which gives added protection from the gas.

Studies have been conducted on acute exposures of hydrazine vapor on animals. The lethality of hydrazine is approximately the same whether it is given in a large single dose or in an equivalent quantity in discontinuous smaller doses. The concept of concentration-time (CT) can be used to calculate lethal concentrations for a very short exposure (National Research Council, 1974; Sax, 1984; U.S. Dept. of Health, Educ. and Welfare, 1978):

mouse	272 ppmv/30 min	LC50	CT: 540 ppmv/15 min
rat	640 ppmv/1 hr	LC50	CT: 2500 ppmv/15 min

From the above table, an exposure of over 500 ppmv would appear to be lethal to animals exposed for 15 min. The Zone I boundary concentration limit is 90 ppmv (lethal concentration for humans); any animal present in an exposed location within this zone may be killed or seriously injured. The kit fox burrows and the desert tortoise habitat to the northeast would be found in Zone I for the larger spill tests. However, these animals would be in their burrows, which protects them from exposure to the gas.

The artificial marsh and adjacent *Atriplex* shrub habitat are also located in this zone and any animal populations found here could be impacted. Mitigations, stated in Section VI, are necessary to ensure the protection of wildlife and species protected by the State of Nevada. Animals in Zone II could be exposed to levels of 80 to 90 ppmv and may suffer some respiratory damage. There is a low probability of mortality. Animals found in Zone III could suffer some irritation.

E. Phosgene

Limits to downwind concentrations of phosgene, Zone I - 50 ppmv, Zone II - 2 ppmv, and Zone III - 0.2 ppmv, must not be exceeded at the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Phosgene is not specifically regulated as an air pollutant by the State of Nevada. The concentration of 0.0024 ppmv for an 8 hr averaging time (24% of the TLV-TWA) will not be exceeded in uncontrolled areas.

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

Phosgene is a very uncommon air pollutant and has not been studied to a significant extent. References state that its phytotoxic effects are similar to those of chlorine and sulfur dioxide (U.S. Dept. Health, Educ. and Welfare, 1977a). No specific studies are cited and specific threshold limits are not published. Chlorosis, necrosis and defoliation may occur with high concentrations and short duration fumigations. Refer to part C., Chlorine, for more information on similar phytotoxic effects.

b. Wildlife

Studies show that low concentrations of phosgene for short exposures are highly toxic to animals (Sax, 1984; U.S. Dept. Health, Educ. and Welfare, 1977a; U.S. Dept. of Health, Educ. and Welfare, 1976b):

mammal	55 ppmv/10 min	lethal
mammal	50 ppmv/5 min	LCLo
rat	50 ppmv/30 min	LCLo
dog	80 ppmv/30 min	LCLo

With mitigations, as stated in Section VI, the proposed phosgene spill tests will have no significant impact on wildlife populations in Frenchman Flat. Spill rates will be reduced to meet the concentration limits established for the boundaries of the geographic zones (Section IV). Exposure to concentrations above 50 ppmv for a few minutes are considered life threatening or lethal to animals. The area of lethal concentrations will be confined mainly to the playa and the artificial marsh. Effects from lethal exposures in animals may take a few hours to appear; phosgene produces edema of lung tissue and lethality is delayed. Animals found in exposed locations in Zone II, unlikely at the time of day testing would occur, could be exposed to levels from 2 to 50 ppmv and could suffer some respiratory damage with a low probability of mortality. Allowable concentrations in Zone III may cause some mild irritation.

F. Sulfur Dioxide

Limits to downwind concentrations of sulfur dioxide, Zone I - 400 ppmv, Zone II - 100 ppmv, and Zone III - 5 ppmv, must not be exceeded at the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Sulfur dioxide is regulated by the state of Nevada. The standard is 0.5 ppmv for a 3 hr averaging time. This standard will not be exceeded where the public has access.

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

The proposed series of sulfur dioxide spill tests will have no significant impact on the natural vegetation of the Frenchman Flat basin. During the largest spill test, concentrations that are toxic to vegetation at exposures as short as 15 min will be confined to the playa, artificial marsh, and adjoining *Atriplex* association.

Most experimental studies of the effect of sulfur dioxide on plants have been designed to simulate smog exposure. As a result, the concentrations used have often been relatively low and the exposure times have ranged from hours to months. Few data are available on the response of desert species such as those found at Frenchman Flat downwind of the spill test facility. However, one study was undertaken using sulfur dioxide on desert species for 2 hr exposures (Hill *et al.*, 1974):

<i>Atriplex canescens</i>	6 ppmv	no injury
<i>Astragalus funereus</i>	6 ppmv	50% leaf damage
<i>A. funereus</i>	4 ppmv	30% leaf damage
<i>Ephedra viridis</i>	10 ppmv	95% leaf damage
<i>Penstemon</i> sp.	10 ppmv	70% leaf damage
<i>Penstemon</i> sp.	4 ppmv	15% leaf damage
<i>Sphaeralcea parvifolia</i>	6 ppmv	30% leaf damage
<i>S. parvifolia</i>	4 ppmv	38% leaf damage
<i>S. parvifolia</i>	2 ppmv	43% leaf damage
<i>S. parvifolia</i>	1 ppmv	22% leaf damage
<i>S. parvifolia</i>	0.5 ppmv	20% leaf damage
<i>Yucca</i> sp.	10 ppmv	no injury

Chlorosis can occur for acute exposures at 0.25 to 0.30 ppmv (Mukammal, 1976). Injury appears to be temporary for very short exposures; if fumigation is stopped before lesions appear, photosynthesis will return in 1 to 2 hr (Treshow, 1970).

There is no reason to expect loss of vegetation as a result of the sulfur dioxide spill tests. At most, some reversible damage may occur in areas within Zone I and II. In a small area on the north side of the playa, some leaf damage may occur.

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer any significant impact from the proposed sulfur dioxide spill tests. The zones of toxicity are established using levels that are adverse to humans; animals are less sensitive than man in their response to high concentrations of sulfur dioxide (U.S. Dept. Health, Educ. and Welfare, 1974).

Like the studies of sulfur dioxide effects on plants, most animal research has been concerned with sulfur dioxide exposures that resemble those experienced in smog conditions. Most studies were conducted with relatively low concentrations and long exposure times. However, some studies were done on acute exposures; mammalian subjects such as rats, mice, and hamsters were used (U.S. Dept. Health, Educ. and Welfare, 1974; Sax, 1984; Sittig, 1981):

mammal	3000 ppmv/ 5 min	LCLo
mouse	6000 ppmv/ 5 min	LCLo
mouse	1000 ppmv/ 2 hr	LC50
rat	1000 ppmv	LCLo
hamster	10,000 ppmv/ 8-10 min	lethal

Any animal that may be susceptible to adverse concentrations would have to be in an exposed location on the playa or in the artificial marsh area for mortality or serious injury to occur. Animals in Zone II could be exposed to sulfur dioxide concentrations of 100 to 400 ppmv for up to 15 min. Animals here could suffer some respiratory system damage; there is a low probability of mortality. Actual sulfur dioxide concentrations in Zone III will be from 5 to 100 ppmv. At these levels and with such a short exposure time, the only effects on wildlife are likely to be mild irritation of the respiratory tract.

G. Carbon Dioxide

Limits to downwind concentrations to carbon dioxide, Zone I - 70,000 ppmv, Zone II - 30,000 ppmv, Zone III - 15,000 ppmv, must not be exceeded at the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Carbon dioxide is not specifically regulated as an air pollutant by the State of Nevada. The concentration of 240 ppmv for an 8 hr averaging time (2.4% of the TLV-TWA) will not be exceeded in uncontrolled areas.

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

Carbon dioxide is a phytotoxicant; it causes a stimulating effect on the growth of plants. It is unknown whether a maximum exposure of 15 min will have a significant impact on plant growth. Some species of plants are less sensitive to ozone (and possibly other pollutants) when in an atmosphere containing higher than normal concentrations (500 ppmv) of carbon dioxide (Stern, 1977). No adverse significant impact on vegetation should occur from carbon dioxide testing at Frenchman Flat.

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer any significant impact from the carbon dioxide spill tests. Carbon dioxide is not highly toxic to animals and, as such, all three zones of toxicity will be confined to the playa during the largest planned test. A few studies show that the threshold value for animals exposed to carbon dioxide is high (Sax, 1984):

mammal	90,000 ppmv/ 5 min	LCLo
rabbit	130,000 ppmv/ 4 hr	TCLo
rat	657,190 ppmv/ 15 min	LCLo
rat	60,000 ppmv/ 24 hr	TCLo

Only animals located in exposed areas on the playa and within a few hundred meters of the spill point should be exposed to any adverse concentrations from the largest test. Off the playa, only minor, reversible effects should occur.

H. Hydrogen Sulfide

Limits to downwind concentrations of hydrogen sulfide, Zone I - 600 ppmv, Zone II - 300 ppmv, Zone III - 15 ppmv, must not be exceeded at the boundaries to the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Hydrogen sulfide is regulated as an air pollutant by the state of Nevada. The standard is a concentration of 0.08 ppmv for a 1 hr averaging time, which cannot be exceeded where the public has access.

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

Hydrogen sulfide is a relatively unimportant phytotoxicant. Plants "are not particularly sensitive to hydrogen sulfide at high concentrations for short exposures" (National Research Council, 1979). Any acute injury that might occur would consist of effects on younger tissue: scorching of young shoots, necrosis of immature tissue, and injury to the growing tip. These effects would not occur in the summer when the plants are somewhat dormant. Full symptoms would appear within a few days if a plant were to be injured from the tests (Jacobsen and Hill, 1970; Stern, 1977). No significant impact is expected on vegetation in the Frenchman Flat basin.

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer any significant impact from the hydrogen sulfide spill tests. Most of the area that may be exposed to concentrations lethal to mammals is confined to the playa, artificial marsh and adjoining *Atriplex* shrub association. During the time of day the spill would occur, most animals would be in their burrows, which would protect them from exposure to high concentrations of hydrogen sulfide.

Many studies have been done on acute exposures of animals to hydrogen sulfide at high concentrations. These tests were designed to simulate human exposure, as the effects on humans and animals are similar (U.S. Dept. Health, Educ. and Welfare, 1977b; Sax, 1984; National Research Council, 1979):

rat	1000 ppmv/ 10-20 min	lethal
dog	1000 ppmv/ 15-20 min	lethal
mammal	800 ppmv/ 5 min	LCLo
mouse	673 ppmv/ 1 hr	LC50
rhesus monkey	500 ppmv/ 35 min	death
rhesus monkey	500 ppmv/ 15 min	collapse
rabbit	100 ppmv/ 1.5 hr	unconsc., cardiac irreg.

From the studies on animals and humans, the limits to downwind concentrations have been established (Table 9.5, Appendix I). Exposure for a few minutes to concentrations above 600 ppmv is considered to be potentially life threatening. Any wildlife present in Zone I might be killed or seriously injured. Animals within Zone II could be exposed to levels of 300 to 600 ppmv and may suffer some respiratory damage; there is a low probability of mortality. Irritation may occur in the respiratory tract of animals exposed to concentrations of 15 to 300 ppmv in Zone III.

I. Hydrogen Fluoride

Limits to downwind concentrations of Hydrogen fluoride, Zone I - 50 ppmv, Zone II - 20 ppmv, and Zone III - 6 ppmv, must not be exceeded at the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Hydrogen fluoride is not specifically regulated as an air pollutant by the State of Nevada. The concentration of 0.7 ppmv for an 8 hr averaging time (2.4% of the TLV-TWA) will not be exceeded in uncontrolled areas.

2. Water Resources

No significant impact.

3. Biological Resources

a. Vegetation

Hydrogen fluoride in air is extremely phytotoxic. The response of different species to hydrogen fluoride varies greatly; as a result, it is difficult to assess the impact a short-term release will have on the desert species of Frenchman Flat. However, a few studies relating to the environment similar to Frenchman Flat have been found.

For hydrogen fluoride, high-concentration, short-duration exposures are more injurious than low-level, longer exposures. Repeated doses at lethal concentrations will extend the necrotic area with each successive exposure, if sufficient recovery time is not allowed (Doley, 1982; Taylor, 1973).

These factors show that vegetation at Frenchman Flat will be impacted by large spill tests of hydrogen fluoride. Mitigations are necessary to reduce the spill amounts in order to reduce impact on vegetation. The extent of injury cannot be determined from the data available at this time. Although hydrogen fluoride is significantly phytotoxic, two factors may reduce its impact on the vegetation. First, desert species are usually dormant

during the summer when testing would most likely occur. Some species reduce their metabolic processes as much as 70% (E. Romney, UCI-A, pers. comm., 1985; Bamberg *et al*, 1975; Kleinkopf *et al*, 1980). The plants at this stage will not absorb very much of the gas. Second, plants with small leaves are more resistant to fluoride injury. Salt-tolerant plants may also be fluoride tolerant (Horning and Mitchell, 1982).

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer significant impact from the proposed hydrogen fluoride spill tests. Most of the area that may be exposed to concentrations that are lethal to animals is confined to the playa. The only wildlife habitat that may be exposed to these high concentrations is the artificial marsh and adjacent *Atriplex* association. During the time of day the testing would occur, most animals are in their burrows, which gives added protection from exposure to adverse levels of the gas.

Studies have been conducted on acute exposures of hydrogen fluoride vapor to animals. Great species differences exist for acute exposures. Humans are more sensitive than the study animals for exposure to hydrogen fluoride. Guinea pigs, rats, and mice seem to be the most sensitive species of the animals tested (U.S. Dept. Health, Educ. and Welfare, 1976c):

guinea pig	3660 ppmv / 5-15 min	edema
guinea pig	660 ppmv / 30 min	lethal
guinea pig	250 ppmv / 1 hr	lethal
guinea pig	50 ppmv / 2 hr	lethal
guinea pig	30 ppmv / 1 day	lethal
guinea pig	10 ppmv / 5 days	not lethal
rat	4950 ppmv / 5 min	LC50
rat	2700 ppmv / 15 min	LC50
rat	2000 ppmv / 30 min	LC50
mouse	6250 ppmv / 5 min	LC50
rabbit	660 ppmv / 1.5 hr	lethal

Because the concentration limits for the zones are established using human-exposure safety levels, and humans are more sensitive than most animals, no significant impact is expected on wildlife populations at Frenchman Flat. Concentrations above 50 ppmv will be confined to the playa, marsh and adjacent *Atriplex* association. Only an animal in an

exposed location near the spill point would be severely or mortally injured. Concentrations between 20 and 50 ppmv in Zone II may cause some respiratory damage to any animal in an exposed location. Concentrations in Zone III, between 6 and 20 ppmv, may cause some mild, reversible lung damage or irritation.

J. Ammonia

Limits to downwind concentrations of ammonia, Zone I - 1500 ppmv, Zone II - 500 ppmv, and Zone III - 35 ppmv, must not be exceeded at the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. Ammonia is not specifically regulated by the State of Nevada. The concentration of 0.6 ppmv for an 8 hr averaging time (2.4% of the TLV-TWA) will not be exceeded in uncontrolled areas.

2. Water Resources

No significant impact.

3. Biological Resources

Previous tests of ammonia at Frenchman Flat have been conducted and the environmental assessment by Leitner *et al* (1983) discussed the toxicity of ammonia. No significant impact occurred on vegetation or animals of the basin even though dispersion models had underestimated downwind concentrations (Shinn, pers. comm., 1985).

a. Vegetation

The ammonia tests are not expected to impact significantly the natural vegetation of Frenchman Flat. The data available on ammonia's phytotoxic effects indicate leaf damage rather than plant mortality even with exposure to high concentrations. Leaf abscission is a typical injury, but no permanent injury occurred:

t...acco/buckwheat	1000 ppmv/8 min	50% leaf damage
tomato	250 ppmv/4 min	50% leaf damage

In all species tested, leaves appeared to be most sensitive to ammonia, while woody stems were quite resistant to damage and seeds were susceptible only when wet (Leitner *et al*, 1983).

b. Wildlife

The ammonia tests will have no significant impact on wildlife populations of Frenchman Flat. Lethal concentrations will be confined mainly to the playa, which does not support animal life. Several studies of laboratory species indicate significant mortality results from short-term exposures to concentrations of 5000 to 25,000 ppmv:

mice	25,000 ppmv/10 min	50% mortality
guinea pig	20,000 ppmv/10 min	50% mortality
rabbit	5,000 ppmv/1 hr	50% mortality

At exposures of 1000 ppmv, very few reports of mortality are found. At this level, few or no ill effects have been found on guinea pigs, rats, rabbits, dogs, and monkeys as a result of exposures of many hours to many days. However, there is some evidence that short-term exposure to these concentrations can increase susceptibility to secondary respiratory infection (Leitner *et al*, 1983).

K. Nitrogen Tetroxide

Limits to downwind concentrations of nitrogen tetroxide, Zone I - 50 ppmv, Zone II - 10 ppmv, and Zone III - 3 ppmv, must not be exceeded at the boundaries of the geographic zones established in Section IV, Criteria for Evaluating Environmental Consequences of Proposed Action.

1. Air Quality

No significant impact. The State of Nevada Guidelines for Significant Emission Rates of nitrogen oxides are set at 40 tons/year. The total quantity of nitrogen tetroxide to be vaporized in all releases will not exceed this amount. The State of Nevada has also set as a Guideline for Significant Air Quality Impact an annual arithmetic mean concentration of 0.014 mg/m³. This guideline will not be exceeded in uncontrolled areas.

2. Water Resources

No significant impact.

3. Biological Resources

Previous tests of nitrogen tetroxide at Frenchman Flat have been conducted and the environmental assessment by Leitner *et al* (1983) discussed the toxicity of nitrogen tetroxide. No significant impact occurred on vegetation or animals of the basin even though dispersion models had underestimated downwind concentrations (Shinn, pers. comm., 1985).

a. Vegetation

No significant impact will occur on natural vegetation at Frenchman Flat. During large spills, concentrations of nitrogen tetroxide higher than 50 ppmv will be confined mainly to the playa. No plant mortality has been reported in long-term exposure to concentrations up to 25 ppmv. Exposure to levels as high as 250 ppmv for 30 to 50 min resulted in abscission rates as high as 90%, although all plants recovered within 6 weeks (Leitner *et al.*, 1983). Some leaf damage may occur to plants along the edge of the playa, but loss of vegetation is not expected and has not been observed in previous tests.

b. Wildlife

Wildlife populations in Frenchman Flat will not suffer significant impact from the proposed tests. Most of the area that may be exposed to levels over 50 ppmv is dry lake bed and does not support animal life. Exposure to concentrations of 50 to 100 ppmv for a few minutes to an hour are considered potentially life-threatening to humans and may cause mortality among exposed wildlife. However, the tests will likely be conducted in the middle of the day when animals will be underground. For lower concentrations, animals must sustain long exposures before mortality occurs:

rabbit	10 ppmv/2 weeks	50% mortality
hamster	25 ppmv/6 months	no mortality
rat	12.5 ppmv/30 weeks	no mortality

Mortality usually occurred only when the animals were challenged with infectious agents (Leitner *et al.*, 1983).

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APPENDIX I: REFERENCED TABLES AND FIGURES

Table 9.1: Resuspended alpha radiation from a one-year observation (1981-82) at Frenchman Flat, NTS. ¹

Start of Sampling Period	²³⁹ Pu (aCi/m ³)(S.D.) ²	Ratio ²³⁹ Pu/ ²⁴¹ Am	Dust (μg/m ³)
02-19-81	40.0 (9.1)	19.6	12.6
03-11	63.8 (2.5)	32.2	8.9
03-31	107.9 (2.9)	28.0	15.1
04-14	61.0 (3.3)	31.8	13.3
04-30	108.5 (7.9)	41.8	23.0
05-13	67.5 (4.4)	40.2	12.2
05-27	70.3 (18.5)	46.0	17.8
6-10	50.2 (9.8)	19.2	23.0
6-22	25.5 (1.8)	8.4	25.2
7-07	39.6 (1.5)	11.6	28.1
7-22	30.4 (2.0)	6.3	27.6
8-04	35.5 (12.1)	6.2	31.7
8-19	12.1 (0.3)	4.8	22.3
9-01	37.4 (—) ³	9.4	47.0
9-15	10.2 (—) ³	14.2	22.3
9-29	8.2 (0.4)	9.2	12.8
10-14	7.5 (2.1)	4.8	8.5
10-27	8.4 (4.0)	7.5	10.1
11-10	10.3 (2.9)	9.7	12.4
12-02	33.3 (27.5)	6.0	30.1
1-07-82	5.7 (0.7)	14.2	6.1
1-20	14.1 (5.3)	3.6	7.4
2-03	10.3 (1.4)	22.4	6.8

¹ Samples were collected from Well 5b and 82 m tower. Data are average values of the two sample sites. Americium 241 (²⁴¹Am) is present but is a minor constituent of alpha radiation in the air (Shinn, pers. comm., 1985)

² Standard deviation.

³ Samples were collected from 62 m tower only.

Table 9.2: Humidity, evaporation and precipitation conditions of the Frenchman Flat Area, Nevada Test Site.

Month	Mean humidity ¹ Vapor pressure (mb)	Pan evaporation ² (mm/day)	Precipitation ³ (mm/day) (c. var.)
January	3.9	1.0	0.45 (1.2)
February	4.4	2.7	0.56 (1.4)
March	4.5	6.1	0.40 (1.5)
April	4.1	8.4	0.27 (1.3)
May	3.5	11.8	0.20 (1.2)
June	2.7	15.9	0.16 (1.6)
July	2.1	16.3	0.29 (1.2)
August	2.7	15.8	0.31 (1.2)
September	4.0	11.8	0.28 (1.2)
October	3.6	6.9	0.21 (1.4)
November	2.3	3.4	0.36 (1.2)
December	2.7	2.0	0.40 (1.3)

¹ Measured on Frenchman playa, 1978-1979, coefficient of variation between hourly averages was 0.41 across all months.

² Pan evaporation as measured by Reynolds Electrical and Engineering Co., Inc., on Frenchman Flat 1956-1958 and Jackass Flat 1967-1969.

³ Precipitation at Well 5B (E 705,200 N 747,600), elevation 3080 feet, from 1963-1979. Provided by Richard H. French, Desert Research Institute, Las Vegas, Nevada. Coefficients of variation in parenthesis.

Table 9.3: Conditions of shallow water surfaces at Frenchman Flat, Nevada Test Site.¹

Month	Mean max. water temperature (°C)	Mean min. water temperature (°C)	Probability of frozen surface
January	14.5	-6.7	0.94
February	16.7	-0.6	0.39
March	19.7	0	0.24
April	23.0	2.8	0.20
May	27.1	8.9	0
June	32.9	15.6	0
July	34.4	15.6	0
August	32.6	11.7	0
September	27.5	6.7	0
October	19.6	3.9	0.13
November	14.5	-5.0	0.67
December	12.8	-7.2	0.97

¹ From shallow pan observations by Reynolds Electrical and Engineering, Co., Inc.

Table 9.4: The joint frequencies of atmospheric stability category and wind speed classes for hourly averaged data of summer days (8 a.m. - 7 p.m.) at Frenchman Flat, NTS, 62 m Tower, 3 m level.

Wind speed	Stability category						Total
	A	B	C	D	E	F	
0-1 m/s	208	1	0	0	0	143	352
1-2	155	8	0	1	2	67	233
2-3	81	0	0	2	8	3	94
3-4	57	5	4	5	5	2	78
4-5	35	23	5	9	4	2	78
5-6	17	15	29	8	3	1	73
6-7	5	13	38	17	6	3	82
7-8	0	5	27	33	5	1	71
>8	<u>0</u>	<u>2</u>	<u>37</u>	<u>116</u>	<u>61</u>	<u>0</u>	<u>217</u>
Total	559	72	140	191	94	222	1278

Table 9.5: Criteria (human toxicity) used in establishing geographic limits to downwind concentrations of proposed test materials.

Substance	Levels (ppmv)		
	Zone I (Lethal)	Zone II (IDLH)*	Zone III (STEL)**
Chlorine	<430	<25	<3
Ethylene	550,000	375,000	1,000
Propane	620,000	20,000	1,000
Butane	620,000	10,000	1,250
Methane	620,000	-----†	-----†
Hydrazine	90	80	30
Cyclohexane	10,000‡	10,000	375
Sulfur dioxide	400	100	5
Carbon dioxide	70,000	30,000	15,000
Hydrogen sulfide	600	300	15
Phosgene	50	2	0.2
Nitrogen tetroxide	50	10	3
Ammonia	1,500	500	35
Hydrogen fluoride	50	20	6

* IDLH : "Immediately Dangerous to Life or Health"; a maximum level from which one could escape within 30 min without any escape-impairing symptoms or any irreversible health effects; established by National Institute of Occupational Safety and Health (NIOSH) (Sax, 1984).

** TLV-STEL : Threshold limit value - short-term exposure level; maximal concentration to which one can be exposed for a period up to 15 min continuously without suffering from irritation, chronic or irreversible tissue change, or narcosis of sufficient degree; derived from the American Conference of Governmental Industrial Hygienists (ACGIH) (Sax, 1984).

†No occupational exposure standards have been established for methane.

‡No lethal concentrations have been established for humans: 10,000 ppm is the IDLH and is judged to be a conservative standard for lethal concentrations.

Table 9.6: Human toxicity of proposed test materials (ppmv/time).

	Cl ₂	SO ₂	H ₂ S	CO ₂	Phosgene
Lethal	873/30min ⁽²⁾ 35-51/1h ⁽⁶⁾ 30/30min ⁽⁶⁾	400- 500 ⁽²⁾	1000 ⁽⁶⁾ 800/30min ⁽²⁾	100,000 ⁽²⁾ 70,000 ⁽²⁾	50 ⁽²⁾
IDLH	25/30min ⁽¹⁾	100/30min ⁽¹⁾	300/30min ⁽¹⁾	50,000/30min ⁽¹⁾	2/30min ⁽³⁾
TLV-STEL	3/15min ⁽¹⁾	5/15min ⁽²⁾	15/15min ⁽¹⁾	15,000/15min ⁽¹⁾	0.2/15min ⁽¹⁾
TLV-TWA	1/8h ⁽²⁾	2/8h ⁽²⁾	10/8h ⁽²⁾	10,000/8h ⁽⁶⁾	0.1/8h ⁽¹⁾
Odor det.	0.1-3 ⁽⁶⁾	-----	0.1-0.2 ⁽⁷⁾	-----	0.5 ⁽²⁾
EEL	7/5min(t) ⁽⁴⁾	150/5min(t) ⁽⁴⁾	-----	30,000/10min ⁽⁶⁾	-----

	Hydrazine	Butane	Propane	Cyclohexane
Lethal	-----	619,000 ⁽³⁾	619,000 ⁽³⁾	-----
IDLH	80/30min ⁽¹⁾	-----	20,000 ⁽¹⁾	10,000 ⁽¹⁾
TLV-STEL	-----	750/15min ⁽³⁾	-----	375/15min ⁽²⁾
TLV-TWA	0.1(skin) ⁽¹⁾	600/8h ⁽¹⁾	1,000/8h ⁽²⁾	300/8h ⁽¹⁾
Odor det.	3-4 ⁽⁶⁾	-----	-----	300 ⁽¹⁾
EEL	35/15min ⁽⁶⁾ 90/10min ⁽⁶⁾	-----	-----	-----

	Ethylene	Methane	N ₂ O ₄ ⁽⁹⁾	NH ₃ ⁽⁶⁾	HF
Lethal	619,000 ⁽³⁾	619,000 ⁽³⁾	50/15min	1500/15min	50/30min ⁽²⁾
IDLH	-----	-----	10/30min	500/30min	20/30min ⁽²⁾
TLV-STEL	-----	-----	5/15min	35/15min	8/15min ⁽²⁾
TLV-TWA	1,000 ⁽²⁾	-----	3/8h	25/8h	3/8h ⁽²⁾
Odor det.	-----	-----	-----	1	-----
EEL	-----	-----	30/10min	500/10min	-----

(continued on next page)

Table 9.6 (con't): Human Toxicity of Proposed Test Materials (ppmv/time).

Lethal : Lowest published concentration at which lethality occurred.

IDLH : "Immediately Dangerous to Life or Health"; a maximum level from which one could escape within 30 min without any escape-impairing symptoms or any irreversible health effects; established by National Institute of Occupational Safety and Health (NIOSH).

TLV-STEL : Threshold limit value- short-term exposure level; maximal concentration to which one can be exposed for a period up to 15 min continuously without suffering from irritation, chronic or irreversible tissue change, or narcosis of sufficient degree; derived from the American Conference of Governmental Industrial Hygienists (ACGIH).

TLV-TWA : Threshold limit value-time weighted average; maximal concentration to which one can be exposed for a period up to 8 h workday, 40 h work week; (ACGIH).

Odor det. : Lowest published concentration at which odor was detected.

EEL : Emergency exposure level; maximum exposure for temporary discomfort, effects reversible without residual damage; accidental exposure; (t=tentative).

- (1) Sittig, 1981.
- (2) Sax, 1984.
- (3) Patty, (Ed.), 1981.
- (4) Zeilhuis, 1970.
- (5) National Research Council, 1976b.
- (6) U.S. Dept. Health, Education and Welfare, 1977a.
- (7) National Research Council, 1979.
- (8) U.S. Dept. Health, Education and Welfare, 1978.
- (9) Leitner *et al*, 1983.

Table 9.7: Limits of proposed test material flammability.

Substance	Lower (%)	Upper (%)	Maximum distance (km)*
Butane	1.9	8.5	0.9
Propane	2.3	9.5	0.9
Methane	5.0	15.0	0.9
Ethylene	3.1	32.0	1.0
Cyclohexane	1.3	8.4	<0.5
Hydrazine	4.7	100.0	<0.5
Hydrogen sulfide	4.3	46.0	<0.5
Ammonia	16.0	25.0	0.7

Non-Flammable: Sulfur dioxide, Carbon dioxide, Phosgene, Chlorine, Hydrogen fluoride, and Nitrogen tetroxide

*Maximum distance from spill point, spilling maximum quantity under worst-case meteorological conditions, of the flammable area.

Figure 9.1. Land use of Nellis Air Force Range 64 by quarter for the years 1983-1985 (Col. H. Crook, Jr., Dept. of the Air Force, Headquarters 554th Range Group, Nellis Air Force Base, pers. comm., 1985).

* Data available only for first and second quarters.

Figure 9.2. Land use of Nellis Air Force Range 65 by quarter for the years 1983-1985 (Col. H. Crook, Jr., Dept. of the Air Force, Headquarters 554th Range Group, Nellis Air Force Base, pers. comm., 1985).

* Data available only for first and second quarters.

APPENDIX II: PERSONS AND ORGANIZATIONS CONSULTED AND RESPONSES TO REVIEWS OF THE ENVIRONMENTAL ASSESSMENT

A. Persons and Agencies Consulted

Lynn Anspaugh
Division Leader
Environmental Sciences Division
Lawrence Livermore Nat. Laboratory
Livermore, California

Frank E. Bingham
Environmental Specialist
Department of Energy
Nevada Operations Office
Las Vegas, Nevada

Ric Cederwall
Meteorologist
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Harley Dikensheets
Chief, Operation Plans
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Nellis Air Force Range
Las Vegas, Nevada

John Donaldson
Regional Supervisor, Region III
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Las Vegas, Nevada

Col. Robert J. Herculson, Jr.
Vice Commander
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Thomas O'Farrell
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Butch Padilla
Department of Wildlife
State of Nevada
Las Vegas, Nevada

Evan Romney
Biomedical and Environ. Sciences
University of California, Los Angeles
Los Angeles, California

Robert Strickler
Environmental Protection Specialist
Env. Audit and Compliance Division
Dept. of Energy Headquarters
Washington, D.C.

Robert Yoder
Refuge Manager
Desert National Wildlife Range
Las Vegas, Nevada

B. Responses to Review of the Environmental Assessment

Written comments reviewing the draft Environmental Assessment were received 19 February 1986 and are published in this section along with responses to the comments.

STATE OF NEVADA
DEPARTMENT OF WILDLIFE

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RICHARD H. BRYAN
Governor

WILLIAM A. MOLINI
Director

Region III
State Mailroom Complex
Las Vegas, NV 89158
January 24, 1986

Mr. Frank E. Bingham, Environmental Specialist
Environmental Branch
Health Physics Division
Department of Energy
Nevada Operations Office
P.O. Box 14100
Las Vegas, NV 89114-4100

REGION III-86-077
MPD
HPS
R.S.
AMC
AMS&S
AMC

Dear Frank:

We appreciate the opportunity to review and provide comment on the draft environmental assessment relative to the proposed LCF Spill Test Facility at Frenchman Flat, Nevada Test Site. This proposal has been reviewed by Habitat, Game and Nongame personnel in the Region III Las Vegas Office with regard to all wildlife resources in the immediate area:

1. The environmental assessment described Zone 1, which is five km from point zero, as the area where maximum impact would occur and this is the area of greatest concern to us. The Nevada Department of Wildlife is charged with the protection, management and enhancement of all wildlife in the State of Nevada regardless of land status. As such, we have concern for the reptiles and nongame birds which would be exposed to this type of testing.
2. The Spotted Range, located at the Desert National Wildlife Range, is thought to be occupied by desert bighorn sheep at various times during the year. Additional releases of sheep and corresponding water developments are planned for the future for this area. This type of testing activity could adversely impact this resource.
3. The desert tortoise, small mammals, various furbearers and possibly the Gila Monster all will be adversely impacted by this project. The tortoise and Gila Monster are both classified as protected and rare species in Nevada.

Mr. Frank Bingham

-2-

January 24, 1986

4. Although the test facility is located on DOE lands and will be administered by DOE, many of the impacts will be on Air Force lands or those administered by the Fish and Wildlife Service, Desert National Game Range. It is felt that this would set some precedent by allowing the testing of toxic substances on a National Wildlife Range.

5. If the project is implemented, Nevada Department of Wildlife recommends close monitoring of flora and fauna to ascertain impacts.

We realize that the Nevada Test Site was set aside for certain specific purposes and that other resources of the area are of secondary priority. However, the department is charged with the responsibility for all wildlife in the State of Nevada, and as such, must express concern for the welfare and perpetuation of same.

If you have any questions on the above or feel a need for further input, please feel free to contact the Las Vegas Office of the department.

Sincerely,

WILLIAM A. MOLINI, DIRECTOR

John DePaedison
Regional Supervisor

COP:sb

c.c. Habitat - Las Vegas (2), Reno
Game - Las Vegas

1. Department of Wildlife, State of Nevada

Response to comment 1: Mitigations have been stated (Section VI) to protect wildlife from lethal concentrations. It is not guaranteed that wildlife mortality will not occur, but the habitat of protected species (State of Nevada) has been excluded in establishing Zone I.

Response to comment 2: The Spotted Range, thought to be occupied by desert bighorn sheep at various times of the year, is not directly impacted by the proposed spills for the following reasons: 1) the Spotted Range is not located within the defined impact zone, 2) the boundary of Zone III is the 4400 ft elevation contour and bighorn sheep are known to occupy higher elevations, and 3) at the time of year that spill testing is proposed (summer/fall), the Spotted Range is not suitable habitat for desert bighorn sheep. If additional releases of sheep and corresponding water developments are to occur in the Spotted Range, a redefinition of the impact zone may be necessary and should be addressed at that time.

Response to comment 3: See response to comment 1.

Response to comment 4: It is not the position of the Environmental Assessment to address precedence. The Environmental Assessment, in evaluating the environmental consequences of spill testing in the Frenchman Flat basin, has taken into consideration the protection of natural resources when establishing maximum downwind concentrations of spill materials.

Response to comment 5: Prior to implementation of the project, ecological study sites will be established by the Department of Energy and they will periodically survey the sites and evaluate the extent of environmental impact as a result of spill testing.

APPENDIX III: STF USER DOCUMENTATION FOR EVALUATING ENVIRONMENTAL CONSEQUENCES OF HAZARDOUS MATERIALS TESTING

The following documentation must be provided by the STF user in order to establish maximum allowable concentrations within the geographic zones. The documentation will be reviewed by DOE/NV Manager or designee to evaluate the environmental consequences of spill testing any material in the Frenchman Flat basin.

The Spill Test Facility is located within the Frenchman Flat basin. All impacts will be confined to this basin in order to protect natural resources and minimize impact to adjacent lands (Nellis Air Force Range, Desert National Wildlife Range, and other NTS activities). No federal threatened or endangered species of vegetation or wildlife are located within the area that will be affected by spill tests. However, some wildlife species are protected by the State of Nevada and mitigations are necessary to reduce the impact on their populations (Section VI).

Limits to downwind concentrations (Fig. III.1), derived from federal human occupational exposure standards and spill material toxicity data, have been established to confine impacts to geographic zones within the Frenchman Flat basin (Section IV). The following downwind limits to spill material concentrations cannot be exceeded for exposures of 15 min. The Zone I boundary, 5 km from the spill point, is defined by the lowest known lethal concentration. The Zone II boundary, 10 km from the spill point, cannot exceed the concentration for the IDLH¹. The Zone III boundary, defined as the 4400 ft elevation contour, will limit concentrations at the boundary to the STEL². Table III.1 lists the maximum concentrations meeting the zone criteria for the proposed test materials addressed in the EA.

¹IDLH: "Immediately Dangerous to Life or Health"; a maximum level from which one could escape within 30 min without any escape-impairing symptoms or any irreversible health effects; established by National Institute of Occupational Safety and Health (NIOSH) (Sax, 1984).

²STEL: (TLV-STEL) Threshold limit value - short-term exposure level; maximal concentration to which one can be exposed for a period up to 15 min continuously without suffering from irritation, chronic or irreversible tissue change, or narcosis of sufficient degree; derived from the American Conference of Governmental Industrial Hygienists (ACGIH) (Sax, 1984).

Simulations of downwind concentrations will be derived from atmospheric dispersion models (approved by DOE/NV Manager or designee). From the spill material toxicity data and downwind concentration limits, evaluation of environmental consequences, and simulation results, spill test criteria will be established. Test series will initiate with smaller quantities of spill material to validate simulations, larger spills will be conducted when the maximum concentrations can be confined to the defined geographic zones.

The following documentation must be provided by the user for any test material not covered in the EA.

A. Toxicity of proposed spill material

Human toxicity data: STEL, IDLH, LCLo

Vegetation toxicity data: documented concentration/exposure time

Animal toxicity data: documented concentration/exposure time

B. Limits to downwind concentrations of the proposed spill material in Zone I, II, III.

C. Simulation analysis of proposed material with environmental zonation, utilizing an approved gas-dispersion model.

Figure III.1. Maximum impact zones for testing at the LGF Spill Test Facility, Frenchman Flat.

Table III.1: Criteria (human toxicity) used in establishing geographic limits to downwind concentrations of proposed test materials.

Substance	Levels (ppmv)		
	Zone I (Lethal)	Zone II (IDLH)*	Zone III (STEL)**
Chlorine	<430	<25	<3
Ethylene	550,000	375,000	1,000
Propane	620,000	20,000	1,000
Butane	620,000	10,000	1,250
Methane	620,000	-----†	-----‡
Hydrazine	90	80	30
Cyclohexane	10,000†	10,000	375
Sulfur dioxide	400	100	5
Carbon dioxide	70,000	30,000	15,000
Hydrogen sulfide	600	300	15
Phosgene	50	2	0.2
Nitrogen tetroxide	50	10	3
Ammonia	1,500	500	35
Hydrogen fluoride	50	20	6

* IDLH : "Immediately Dangerous to Life or Health"; a maximum level from which one could escape within 30 min without any escape-impairing symptoms or any irreversible health effects; established by National Institute of Occupational Safety and Health (NIOSH) (Sax, 1984).

** TLV-STEL : Threshold limit value - short-term exposure level; maximal concentration to which one can be exposed for a period up to 15 min continuously without suffering from irritation, chronic or irreversible tissue change, or narcosis of sufficient degree; derived from the American Conference of Governmental Industrial Hygienists (ACGIH) (Sax, 1984).

†No occupational exposure standards have been established for methane.

‡No lethal concentrations have been established for humans: 10,000 ppm is the IDLH and is judged to be a conservative standard for lethal concentrations.

EXECUTIVE SUMMARY*

The LGF Spill Test Facility at Frenchman Flat, Nevada Test Site, is being constructed by the United States Department of Energy (DOE). In this Environmental Assessment, environmental consequences of spilling hazardous materials in the Frenchman Flat basin are evaluated and mitigations and recommendations are stated in order to protect natural resources and reduce land-use impacts.

Guidelines and restrictions concerning spill-test procedures will be determined by the LGF Spill Test Facility Operations Manager and DOE based on toxicity documentation for the test material, provided by the user, and mitigations imposed by the Environmental Assessment.

In addition to Spill Test Facility operational procedures, certain assumptions have been made in preparation of this document:

- no materials will be considered for testing that have cumulative, long-term persistence in the environment,
- spill tests will consist of releases of 15 min or less, and
- sufficient time will be allowed between tests for recovery of natural resources.

Geographic limits to downwind concentrations of spill materials were primarily determined from meteorological data, human occupational exposure standards to hazardous materials and previous spill tests. These limits were established using maximum spill scenarios and environmental impacts are discussed as worst case scenarios; however, spill-test series will begin with smaller spills, gradually increasing in size after the impacts of the initial tests have been evaluated.

*Work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore National Laboratory under contract W-7405-ENG-48.