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(ESG-DOE-13365)

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RADIOACTIVE MATERIALS DISPOSAL FACILITY LEACH FIELD ENVIRONMENTAL EVALUATION REPORT

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SUMMARY

The action assessed is the Department of Energy's (DOE's) release for unrestricted use of the Radioactive Materials Disposal Facility (RMDF) leach field located at Rockwell International's Santa Susana Field Laboratory (SSFL), approximately 29 miles northwest of Los Angeles, California. In 1975, the leach field was discovered to be radioactively contaminated. When decontamination was completed in 1978, <0.6 mCi of Sr-90 and trace amounts of Cs-137 contaminated material remained isolated in cracks in the bedrock. The cracks are >10 ft below the surface and have been sealed with a bituminous asphalt mastic.

The environmental effects of the proposed action are negligible. Ground water contamination will not occur. The sandstone bedrock underlying the leach field is well cemented and has a very low porosity. In addition, the sealed cracks and small quantities of material preclude contamination of the ground water. The ground water at the site does not communicate with ground water in the surrounding valleys. Thus, there is no probability that radioactivity will be introduced into the food chain from this pathway.

Resuspension of materials into the atmosphere will not create a condition that would exceed the limit for airborne radioactivity. Material near the surface that could become airborne contains very low levels of radioactivity, and inhaling this material would result in no significant dose.

Analyses of vegetation on the leach field and surrounding area indicate that no radioactive material is being transported and concentrated in plants by root uptake. No concentration is expected since very little contamination remains at the site and that which does exist is located at depths beyond the normal root zone of the plants that inhabit the site. Therefore, were an individual to consume vegetation from the site, no significant dose would occur.

Direct external exposure from the leach field will not contribute to the naturally occurring background at the site. The 10 ft of overlying soil provides a more than adequate shield for the beta-gamma activity associated with the isotopes.

Details of the leach field decontamination will be available in the report "RMDF Leach Field Decommissioning Final Report," to be issued at a later date.

This action will have no effect on the cultural aspect of this site.

I. PURPOSE AND NEED FOR ACTION

This environmental evaluation report addresses the leach field at the Radioactive Materials Disposal Facility (RMDF). This facility is located at the Energy Systems Group Santa Susana Field Laboratory (SSFL) in the Santa Susana Mountains northwest of the San Fernando Valley. This report is the basis for recommending release for unrestricted use.

SSFL is a research and development facility owned by Rockwell International and operated by its Energy Systems Group and Rocketdyne Division. Several facilities, including the leach field, are owned by the federal government on land leased from Rockwell with option to buy. Rockwell operates and maintains the government facilities under contract to the government.

On release of the leach field from federal control, health and safety issues would be placed under the provisions of California law. The Public Health Sections of the California Administrative Code govern the use and handling of source and by-product materials. The leach field, an area of about one-quarter acre, falls into this category.

The RMDF (Figure 1) is a fenced area and consists of four main buildings: Building 021, radioactive wastes, decontamination, and packaging; Building 002, radioactive material storage vault; Building 034, offices; and Building 044, health physics services. In addition, there are several minor structures, such as Building 075, contaminated storage, and Building 621, radioactive accountable waste storage. An underground sanitary sewage leach field located outside the fence was constructed in early 1959 as part of the original improvement of the site consisting of Buildings 021 and 022. In late 1961, a central sanitary sewage system was constructed and connected to Building 021. The septic system was then abandoned in place, and the piping has since been disconnected and removed.

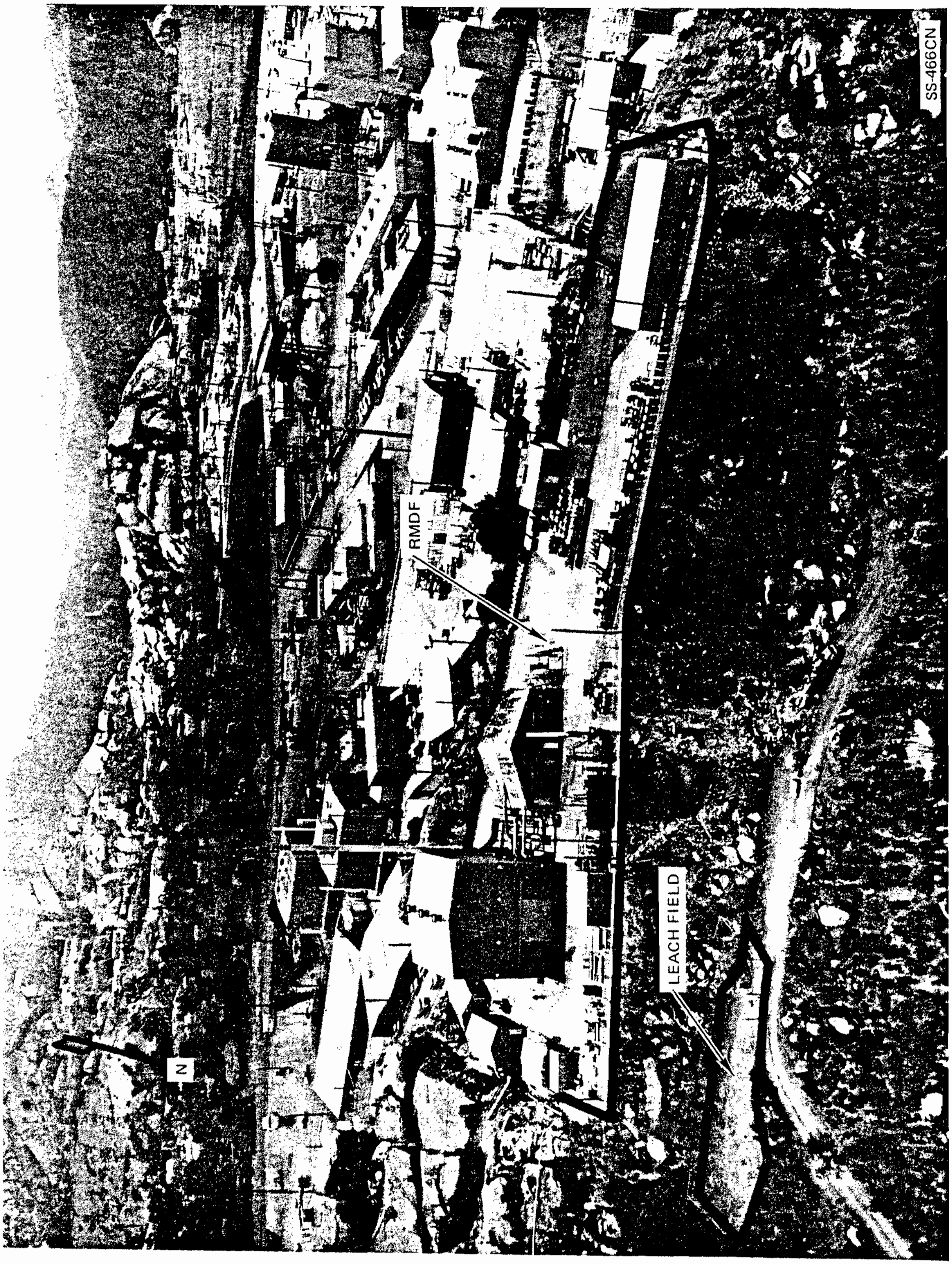

Figure 1. Radioactive Materials Disposal Facility (RMDF)

The RMDF leach field was the liquid effluent disposal point for a gravity septic tank sanitary waste system that accepted the sanitary wastes from the Building 021 lavatories, shower, and toilets. A second connection to the leach field, bypassing the septic tank, was made from the radioactive water processing system at the waste holding tank on the west side of Building 021. This connection allowed water from the holding tank to be discharged to the leach field after the water had been sampled, analyzed, and determined to contain radioactivity below the accepted levels. If the water was found to be above accepted levels, it was processed to separate the radionuclides from the water by a separation and evaporation technique. The sludge was then disposed of as radioactive waste.

During a site survey in July 1975, vegetation growing on the leach field site was discovered to be slightly contaminated by radioactivity. Further investigation of radioactive contamination in the leach field distribution box identified the source of contamination as root uptake from the underlying leach field.

Based on this evidence, it was concluded that, before the RMDF was connected to the central sanitary sewer in 1961, the valve that connected the holding tank of the radioactive water processing system to the leach field had either leaked or been inadvertently left open and this had allowed an unknown amount of contaminated water to enter the leach field system. The contaminants found in the leach field were Sr-90 and a relatively minor amount of Cs-137. Decontamination of the leach field was begun in 1975 and completed in 1978. During all of this period, the site was under federal control and was thus exempt from federal and state licensing regulations per 10 CFR Sections 5 and 170 and Section 202 of the Energy Reorganization Act of 1974.

II. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

A. PROPOSED ACTION

The proposed action is the DOE release of the RMDF leach field for unrestricted use.

Before decontamination, the leach field contained levels of radioactivity as high as 115,000 pCi/g in isolated spots. It was decontaminated to levels approaching the natural background radioactivity (15 to 30 pCi/g) for soils in this area. Decontamination was accomplished by excavating, packaging, and disposing of the contaminated soil in an NRC licensed or DOE disposal site. The excavation was then backfilled with clean soil from the SSFL site.

Excavation started in mid-1978 at the west end of the field and progressed easterly using a conventional back hoe. The material having the highest level of radiation was removed first to reduce the radioactive background at the site and to reduce the possibility of cross contamination.

The noncontaminated overburden was moved to the east end and stockpiled for backfill material. The contaminated gravel and underlying soil were removed with a back hoe and placed directly into plastic-lined boxes for disposal as radioactive waste. The filled boxes were transported from the leach field to the RMDF yard by a mobile crane. Water was sprayed on the leach field only as required to control dust. No runoff was permitted.

The remaining loose gravel and soil left by the back hoe were removed with hand shovels to the underlying sandstone rock surface. Radiological surveys indicated that radioactive material had penetrated fractures in the rock. A Hy-Ram, a hydraulically actuated jack hammer equipped with a 4-in.-diameter chisel point, was used to crush and split off the rock surface. This material was scraped up and packaged. The final scraping was done by hand to assure complete removal.

Several small areas continued to show that radioactive material had penetrated deeper into loosely cemented fractures and uncemented cracks. This contamination was followed using the same rock removal techniques, except more localized, which resulted in mining out holes up to 10 ft deep.

In the fall of 1978, three remaining contaminated cracks were mapped for location and radioactive material concentration. The areas were coated with a bituminous mastic to seal out percolation water that might transport the radioactive material. The whole field was then backfilled with compacted earth and finished to a grade several feet lower than the original surface. This protected the area from wind and water erosion. It was graded and contoured to pass surface water to the west, and erosion control was provided by seeding a rye grass on all of the disturbed soil areas.

It is estimated that 0.6 mCi of radioactive material is sequestered in the deeper recesses and three cracks of the bedrock beneath the leach field. The radioactivity remaining in the three cracks was estimated on the basis of determination of the extent of the cracks exposed at the final surface of the excavation, the crack widths, and measurements of the radioactivity in the exposed crack material. The cracks averaged 1.5 in. wide, were 7, 12, and 19 ft in length at the surface, and were roughly estimated to extend no more than 10 ft in the bedrock. This results in an estimated volume of 1.75 yd^3 of contaminated crack material. The average radioactivity in the exposed cracks is 300 pCi/g. Using a density of 1.4 g/cm^3 for the crack material, the residual radioactivity is 0.6 mCi. The total volume of contaminated material, 1.75 yd^3, is 0.16% of the total volume of the leach field.

Figures 2 and 3 show the RMDF leach field as it exists today.

B. POTENTIAL IMPACTS

1. Water Environment

Contamination of surface water from the leach field is not probable, primarily because very low amounts of radioactivity (above background) remain in the rock.

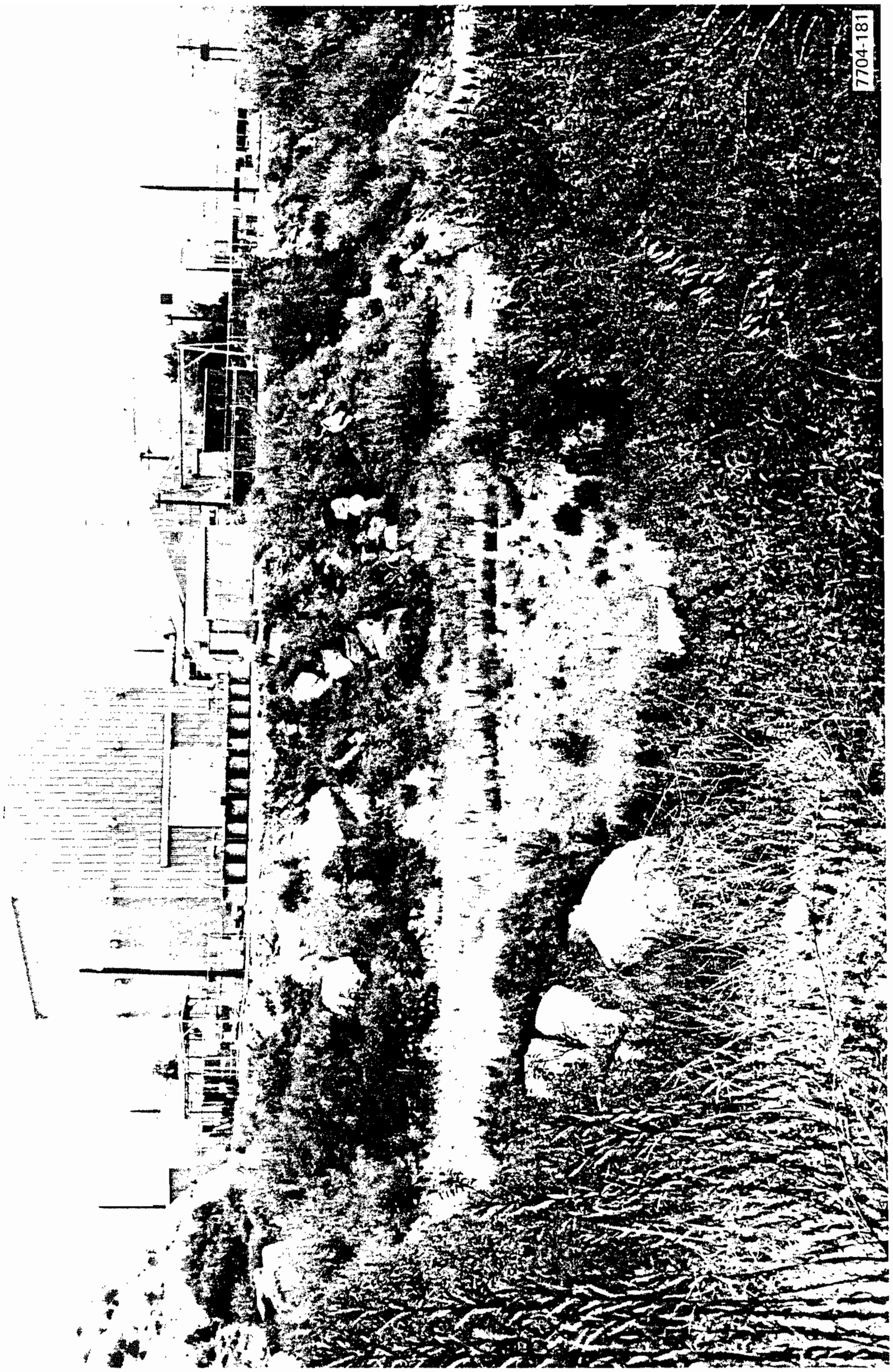

Figure 2. RMDF Leach Field Looking South

Figure 3. RMDF Leach Field Looking West

Surface water samples taken at the site boundary during the decontamination work showed less than 3.0×10^{-7} μCi/ml beta-gamma. This is below the release limit for Sr-90 in water, the most restrictive applicable limit (see Table B-1, Appendix B). Water moving through the leach field soil is unlikely to result in ground water contamination. The sandstone bedrock forms a virtually impermeable boundary to subterranean ground water. The ground water underlying the site is completely contained by geologic barriers, and there is no exchange with ground water in surrounding valleys.

2. Air Environment

Atmospheric resuspension of soil from the leach field will not result in activity above the maximum permissible concentration (MPC) allowed during continuous (168 h/week) use for the general public in an unrestricted area as listed in Appendix A of the California Radiation Control Regulations. No significant dose will result from inhalation of suspended soil particles.

3. Terrestrial Environment

Contamination of vegetation and wildlife from the RMDF leach field is extremely unlikely. The amount of remaining activity is small, is located approximately 10 ft below the surface, and has been immobilized. No significant dose would result from consuming food stuffs grown on the leach field.

C. ALTERNATIVES

1. Restricted Use

This classification will result in the property being exempt from licensing requirements provided certain restrictions are followed. Examples of restrictions that might be applied are:

1) No excavation on the leach field site
2) No drilling on the leach field site

3) No agricultural crop growth

4) Limitation on types of development.

However, this approach is unsatisfactory since it may require a routine surveillance program, a continued expenditure of funds to no real purpose, and a lessening of value for the surrounding property. In addition, the desire of DOE is to decontaminate for unrestricted use facilities located on private property that are surplus to current government needs. With activity levels on the site being approximately equal to those of naturally occurring soil, no real benefit would be obtained by following this approach. Rockwell plans call for the continued maintenance of the leach field as open space.

2. No Action

This action proposes that the control of the property remain with DOE.

III. AFFECTED ENVIRONMENT

A. LOCATION

The RMDF and leach field are located at Rockwell International's Santa Susana Field Laboratory, which is operated by the Energy Systems Group and the Rocketdyne Division. SSFL is located in the southeastern portion of Ventura County, adjacent to the Los Angeles County line. The site is about 29 miles northwest of downtown Los Angeles. The location is shown in Figures 4 and 5. Its position with respect to various surrounding populated communities is given below:

Santa Susana	—	3 miles north
Susana Knolls	—	3 miles northeast
Simi	—	5 miles northwest
Canoga Park	—	6 miles east-southeast
Chatsworth	—	6 miles east-northeast
Calabasas	—	7 miles south
Woodland Hills	—	7 miles southeast
Thousand Oaks	—	13.5 miles southwest

The main access road (Woolsey Canyon) originates in the San Fernando Valley near the communities of Chatsworth and Canoga Park. Additional access is provided by Black Canyon Road, leading up from Simi Valley.

ESG's operations are located at the west end of the field laboratory. All the decontamination activity is entirely within the boundaries of ESG operations. The leach field is located in an arroyo just north of Buildings 664 and 665 and is isolated from the surrounding facilities. Its isolation is further enhanced by its elevation, which places it 800 to 1000 ft above the populated valley floors.[1] This is depicted in the aerial photograph shown in Figure 6.

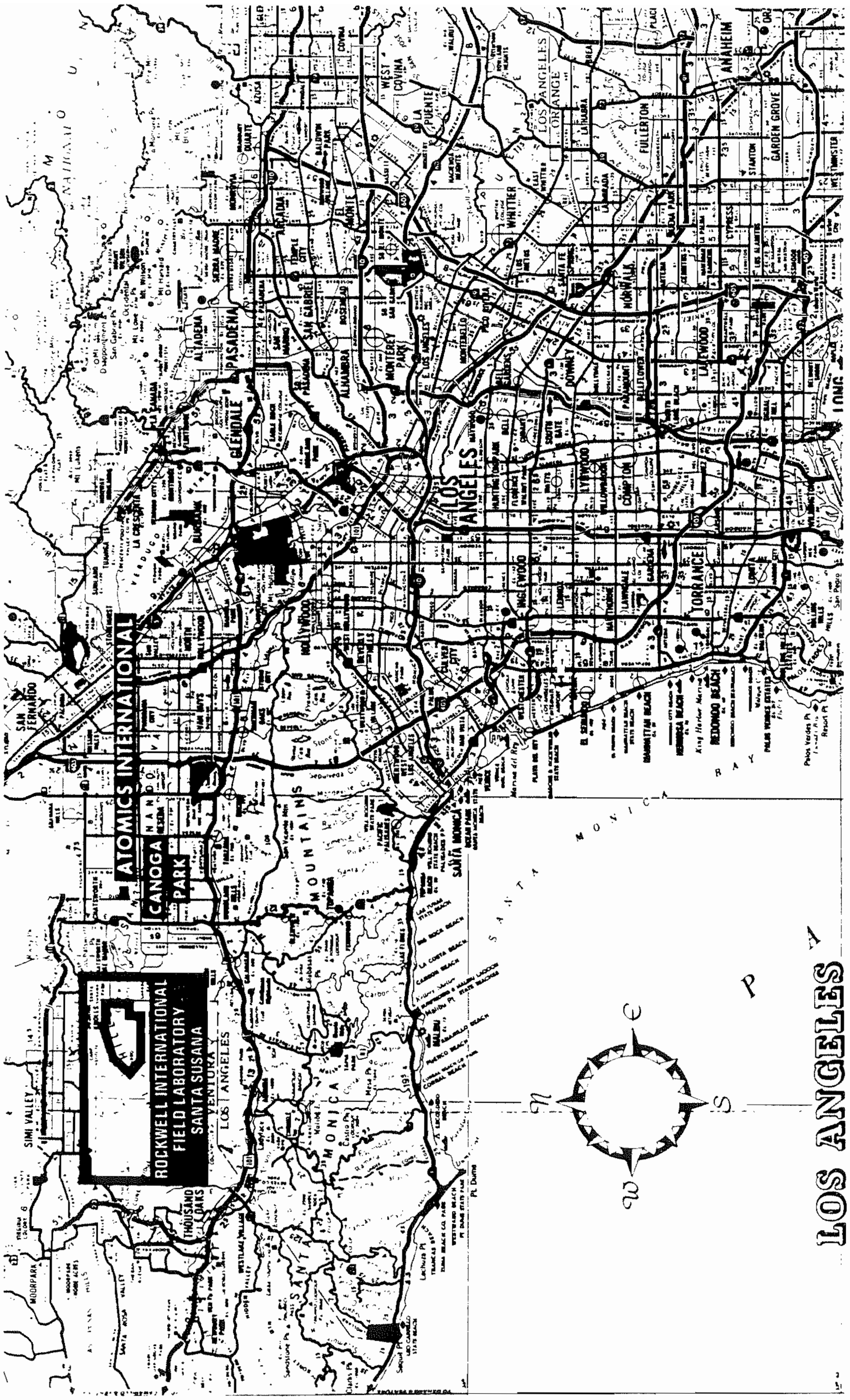

Figure 4. Map of General Los Angeles Area (Copyright Automobile Club of Southern California. Reproduced by permission.)

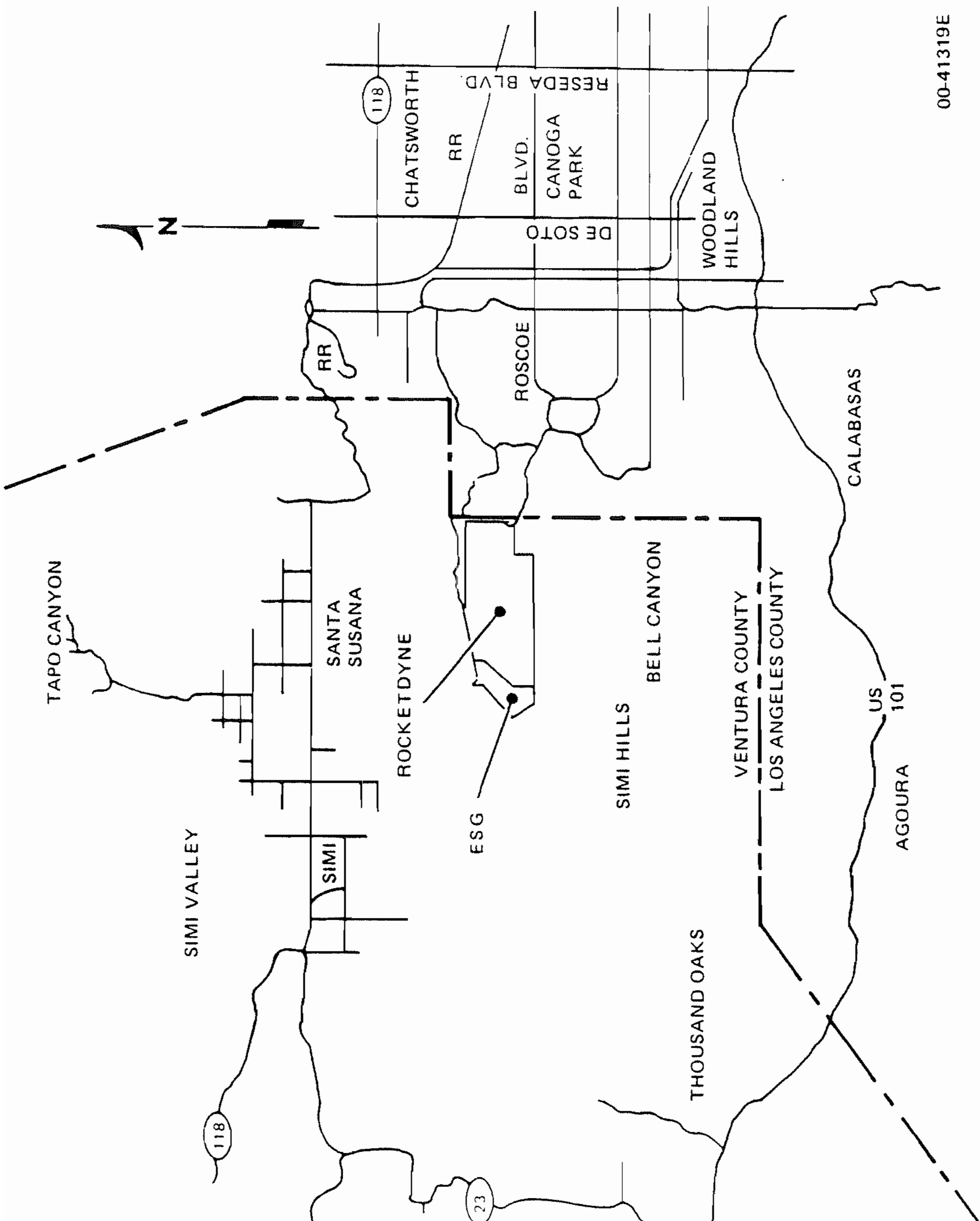

Figure 5. Location of the SSFL

Figure 6. Aerial View of the SSFL (1978)

B. DEMOGRAPHY

1. Distribution

The population density near the SSFL site is greatest in the western San Fernando Valley area. This includes the communities of Canoga Park, Chatsworth, and Woodland Hills. The nearest of these communities is more than 6 miles from the site.

The population of the Simi Valley, north of the SSFL, increased rapidly during the mid-1960s. The growth rate has slowed since then, but the population continues to grow. Communities located in the valley are Santa Susana and Susana Knolls, each about 3 miles away, and the City of Simi Valley, 5 miles from the site.

2. Population Growth and Trends

Population data and projections for areas relatively near the site are given in Table 1. The information was obtained from various local organizations.

Population growth in the lower valleys has spilled over into the canyon areas. Bell Canyon, within1-1/2 miles the southern boundary of the SSFL, is planned for 979 residential lots. Assuming an average household size of 3 to 4 persons, this would produce a population of about 2400 to 3200. Currently, 260 lots are occupied, and 80 more are under construction. Development is also occurring in Las Virgenes Canyon, about 4 miles south of the site. Mobile home development sites are located in Woolsey Canyon to the east. These development areas are adjacent to the main access road for the facilities (Woolsey Canyon Road). Of the estimated 357 mobile home sites located in the canyon, 231 are occupied. When fully occupied, these mobile home parks should house about 1000 to 1400 people.

TABLE 1

POPULATION ESTIMATES FOR COMMUNITIES SURROUNDING SSFL [2, 3]

Area	Most Recent Estimate	1985	1990	1995	2000
Simi Valley*	85,767	91,200	103,000	112,000	122,000
Woodland Hills - Canoga Park	132,000	143,900	160,900	164,600	167,900
Chatsworth - Porter Ranch	83,900	86,000	88,200	91,400	93,000
Calabasas Area†	38,280	39,400	44,500	50,000	55,000
Thousand Oaks§	88,213	107,500	121,700	136,200	150,700
Total	428,160	468,000	518,300	554,200	588,600

*Includes cities of Simi Valley, Santa Susana, and Susana Knolls
†Includes cities of Calabasas, Hidden Hills, Westlake Village, Topanga, and suburban homes
§Includes Newbury Park and unincorporated areas

Growth is also occurring in the canyon areas north of the site. Among these are Meier Canyon and Black Canyon, approximately 1 and 2 miles, respectively, from SSFL. The current plan by the Department of Planning for the City of Simi Valley, which incorporates the towns of Santa Susana and Susana Knolls, is to increase residential densities on the valley floor and to encourage lower densities on the periphery of the valley floor. Overall densities are to be at their lowest in the outlying canyon and slope areas, with density decreasing as slope increases.[4]

C. LAND USE

1. Land Use and Zoning

Located entirely within Ventura County, SSFL operates under the public jurisdiction of the various regulatory bodies of that county. Although not within city limits, it is designated to be within the "sphere of influence" of the City of Simi Valley. The Ventura County Planning Commission administers zoning laws and ordinances that regulate the use of buildings, structures, and land.[2]

In conformance with Ventura County's regional "open space" plan (Figure 7), neighboring lands to the north and west have been generally designated as open lands. These areas carry a zoning of Rural-Agricultural Five Acres (R-A-5Ac) or Agricultural Exclusive (A-E) for those under a 10-year contract between the county and Rockwell International. Lands immediately south of the Rockwell buffer zone, which is currently being leased for cattle grazing, have been designated as "urban" (Bell Canyon area) and are zoned Rural Exclusive One Acre (R-E-1Ac). To the east, in Los Angeles County, there are numerous zoning classifications; however, land contiguous to the property boundary has been zoned Light Agricultural Two Acres (A1-2Ac).[3] Trailer parks have been constructed along Woolsey Canyon Road, the closest of these being less than 3/4 mile from the entrance to the Rockwell facilities and about 3 miles from the decontaminated area. Permits for the construction of the trailer parks were granted under a variance by the Los Angeles County Regional Planning Commission.

Figure 8 shows the zoning in the area of the Rockwell property.

The percentage of land use within a 5-mile radius of the SSFL is depicted in Table 2. The vast majority of the land is still open space.

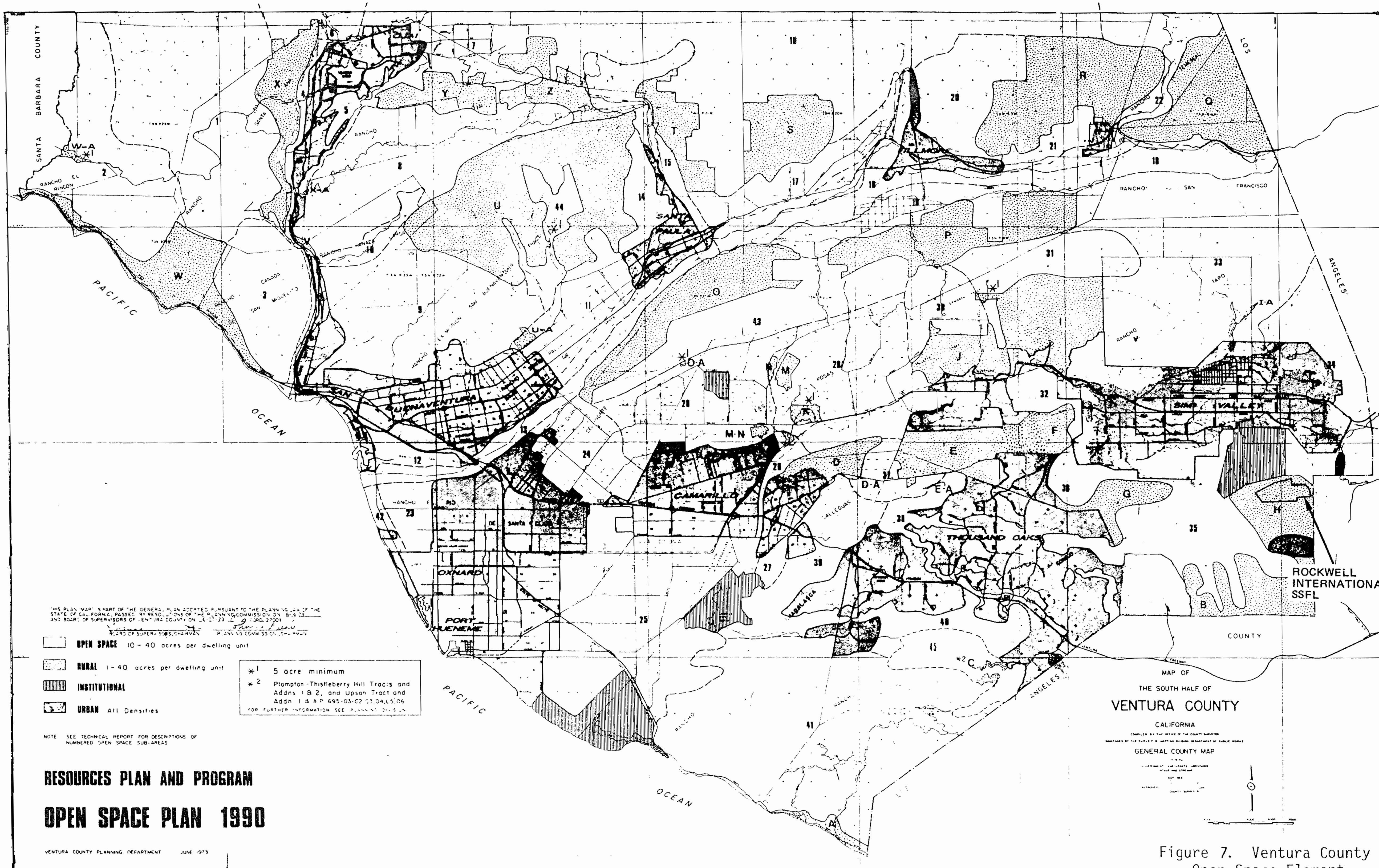

Figure 7. Ventura County Open Space Element

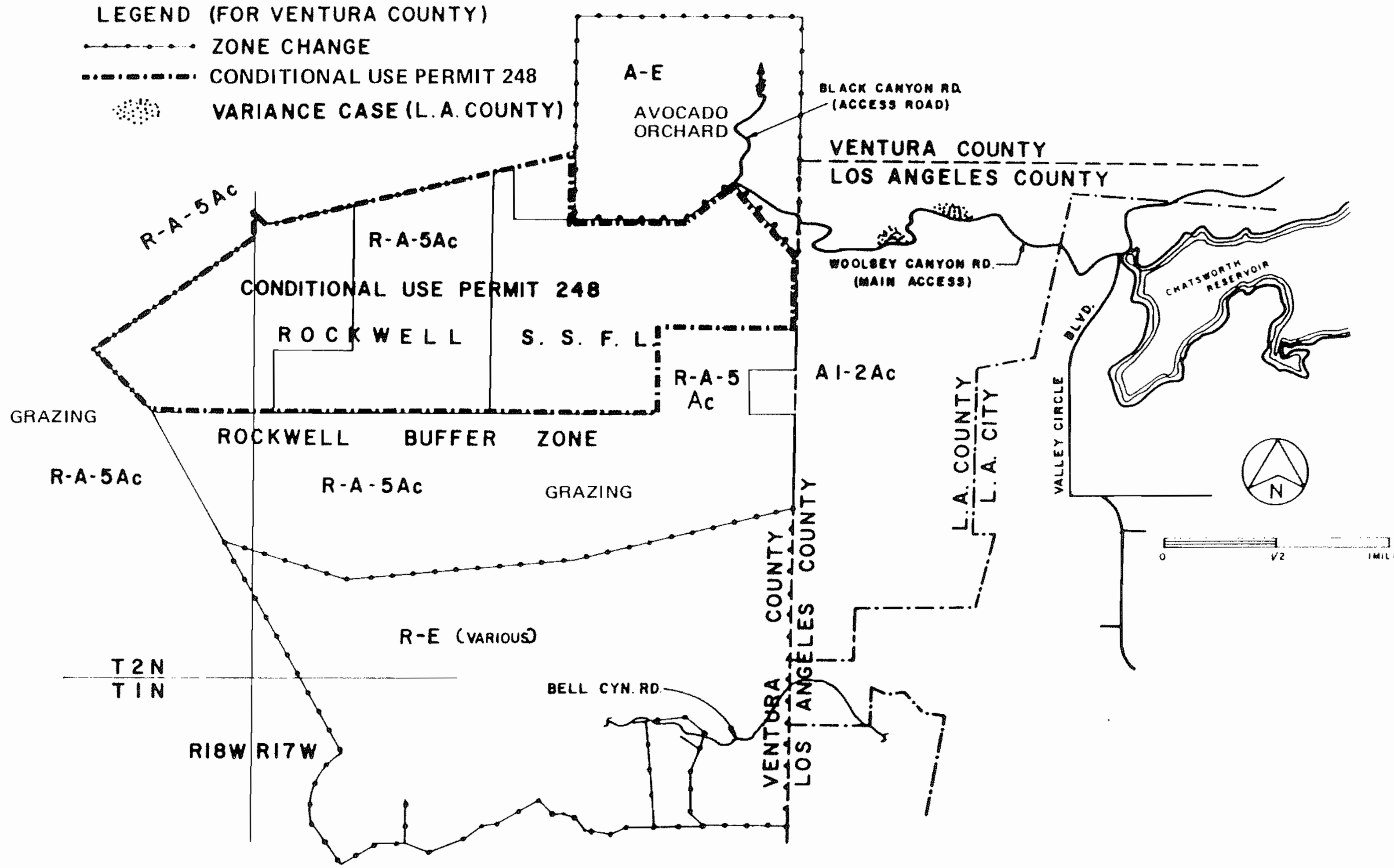

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Figure 8. SSFL and Vicinity Zoning

TABLE 2

LAND USE IN 5-MILE RADIUS OF SSFL*

Land Use	Percent of Total 78.5 Square Miles
Agriculture (including livestock and crops)	2.5
Commercial	0.8
Industrial	1.1
Residential	27.2
Unused raw land	68.4

*Updated from Reference 5 by use of NASA aerial photos of Ventura County, June 1979

2. Recreation

The Simi hills area does not receive extensive recreational use. Some residents in the area own horses and use the hills for riding. Occasionally, the lower canyons are used by youth groups for hiking and nature observation.

D. TOPOGRAPHY

SSFL is situated in rugged terrain typical of that usually found in mountain areas of recent geological age. Units composed predominantly of sandstone form characteristic, homoclinal strike-ridges with very steep, step-like antidip slopes and moderately inclined dip slopes; the rugged, distinctive, cuesta topography is a strikingly attractive feature of this area.[6]

The Burro Flats area on which most of the ESG area is located can be described as an irregular plateau with eroded ravines at the perimeters. Elevations over most of the site range between 1800 and 2100 ft above sea level, with extremes of 1650 and 2250 ft.[2] The topographic map in Figure 9 and photograph

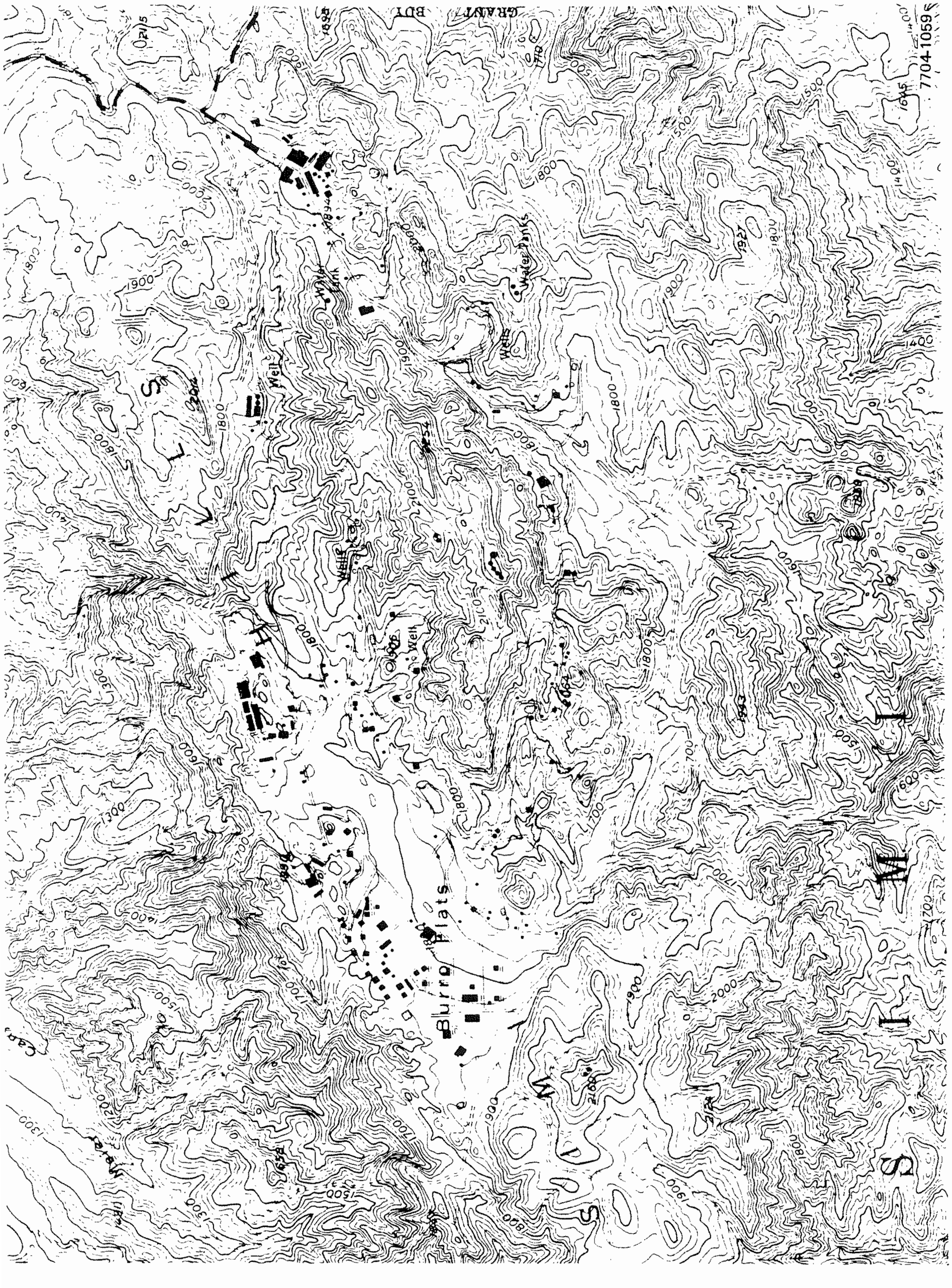

Figure 9. Topography of the SSFL, 25-ft Contour Intervals (from U.S. Geological Survey Topographic Map "Calabasas Quadrangle" 7.5-Minute Series, Revised 1967)

in Figure 10 indicate the rugged nature of the terrain surrounding SSFL and the leach field site.

The major drainage for Burro Flats is through Bell Canyon, which drains to the south from the site and then to the east farther down the canyon. Las Virgenes Canyon also drains south but is separated from the site by a high ridge. The major drainage for the leach field is to the north through Runkle Canyon and Meier Canyon.

E. GEOLOGY

1. General Geology

A major portion of the SSFL site (Figure 11) is underlain by a bedrock unit informally called the Chico formation (Ku). This formation is Upper Cretaceous in age and consists chiefly of brown to tan resistant, medium to massive bedded, fine-to-coarse grained, arkosic sandstone that may be locally cross-bedded and locally calcareous. It contains interbeds of gray to black marine siltstone, claystone, and shale. Maximum thickness of the formation is about 5,500 ft.

The southwest corner of the property is underlain by the Santa Susana-Martinez formation (Tss). This formation is predominantly green, gray, and brown, fine-to-coarse grained, thin-to-thick bedded fossiliferous sandstone, locally cross-bedded and calcareous. Also found in this formation are some green-gray, thin-bedded, concretionary sandstone and shale interbedded with hard limestone.[6]

The strike of the beds across the property ranges from N60E to N85E, with a dip to the north varying from 20 to 30 degrees.

Figure 10. Photograph of Terrain Surrounding the Leach Field

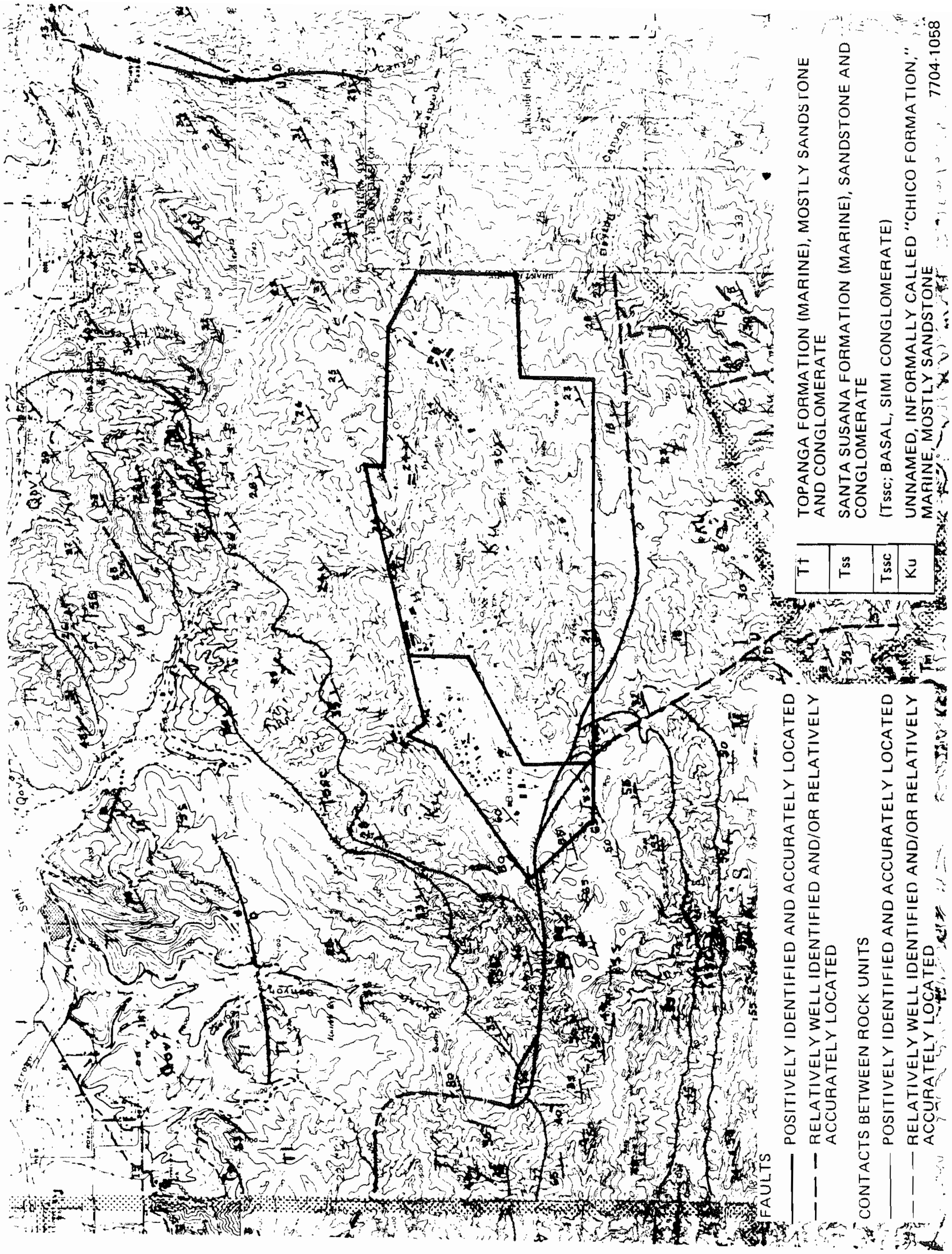

Figure 11. Geology of SSFL

2. Faults

Numerous minor faults have been identified on the SSFL site. One minor fault passes diagonally across the southwest portion of the ESG property. There is some confusion as to its name and the extent to which it is active. An arcuous east-northeast trending fault immediately north of SSFL acts as the northern barrier of the ground water table below the site.

Active faults and their proximity to the SSFL site are: San Andreas Fault, the dominant California fault, ~40 miles northeast; Santa Ynez Fault, 35 miles north; San Gabriel Fault, 30 miles north; Inglewood Fault, about 30 miles southeast; Red Mountain Fault, 35 miles northwest; San Cayetano Fault, 20 miles north.

F. SEISMOLOGY

The earthquake history of the area has been dominated by small to moderate shocks.[7] Many of those shocks have been severe locally, near their epicenters, but have caused only light damage regionally. More serious than effects from local shocks have been the effects from relatively numerous moderate to large earthquakes whose epicenters were located outside this area. The San Fernando earthquake of 9 February 1971 registered 6.6 with its epicenter (near the San Gabriel Fault) in the Newhall-Sylmar area about 20 miles east-northeast of SSFL. Minor to severe damage along with landsliding and rockfalls were associated with this quake. No structural damage and minimal rock disturbances were experienced at the SSFL site. Several other earthquakes of large magnitude have been recorded. In 1941, a 5.9 earthquake caused minor damage in portions of Ventura County. An earthquake that destroyed the business section of Santa Barbara in 1925 registered 6.3 and was epicentered nearly 60 miles from the city. The San Andreas Fault was the location of a 6.0 earthquake that occurred in 1916. An earthquake which occurred in the Tejon Pass area in 1857 and the more recent Tehachapi quake, on the White Wolf fault, are believed to have been the strongest earthquakes, with magnitudes of 7.7.[6,8]

G. HYDROLOGY

1. Surface Water

Surface water at the leach field derives solely from rainwater. Since the leach field is located in an arroyo, some of the water flowing along the surface infiltrates the soil; most of the water, however, continues down the arroyo, eventually joining an ephemeral stream in Meier Canyon.

2. Ground Water

The ground water supply beneath the SSFL site is completely contained by impervious barriers as a separate underground reservoir and hence is not directly connected to the ground water in either the Simi Valley or the San Fernando Valley.

The geologic structure that holds the ground water at an elevation 700 to 800 ft above that of the surrounding valley floors is unique. The Cretaceous massive sandstone is bounded on the northwest and west and partially on the south by Eocene shales. A large fault trending east-west apparently forms a seal toward the southern direction. On the east escarpment of the Santa Susana Mountains, the northwesterly dip of the formations with interbedded thin shale members apparently forms a barrier on each stratum to retain the water within the Chico sandstone. The barrier on the north is the arcuous fault north of SSFL.

The Chico formation is generally fairly well cemented throughout its entire thickness. The overall effective porosity is probably less than 1%. The ground water in the Chico formation of the Simi hills area appears to be concentrated in four geologic occurrences:

1) Along fault planes where movement has caused the sandstone to fracture
2) Along joints and fractures which are not directly associated with faults but are related to the overall faulting of the area

3) On bedding planes where there is a change of lithology of the formation

4) In limited permeable zones in the sediments where original cementation of the grains has not been entirely effective.

The Chico formation as a whole is a very poor aquifer. Most of the formation shows evidence of secondary cementation which has decreased the original porosity to a very low capacity. Water occurring in the formation is very closely associated with the fault planes, fractures, and joints throughout the entire thickness of sediments.[1]

Between 1948 and 1963, a total of 18 wells (some dry) were drilled on SSFL property, with the majority of these being in the Rocketdyne area. Data from these wells indicate that the ground water reserves are limited and, unlike conventional aquifers, receive little or no replenishment through rainfall and storm runoff. Eventually the wells will be completely dry. No relationship appears to exist between precipitation and well productivity.

All but four of the wells (see Figure 9) have been completely deactivated, and only three of these are currently producing. The water is for general plant use and is used in the ratio of 25% well water to 75% purchased Ventura County water.

H. CLIMATOLOGICAL DESCRIPTION

1. General Climatology

The Los Angeles basin is a semiarid region, controlled principally by the semipermanent Pacific high-pressure cell which extends from Hawaii to the Southern California coast. Associated with this high-pressure cell is a subsidence inversion tilting downward in the same direction. The seasonal changes in the position of this cell greatly influence the weather conditions over the area. During the summer, the high is displaced to the north. This results in mostly clear skies with little precipitation. During the winter, the cell moves sufficiently southward to allow some Pacific lows and their associated fronts to move into the area. This produces light-to-moderate precipitation with northerly and northwesterly winds.

The summer displacement of the Pacific high-pressure cell to the north results in Southern California being under the influence of a subsidence inversion practically every day during the summer. The injection of marine surface air under this inversion results in the fog along the coastal sections that is common for this season. Occasionally during this season, the minor perturbations in the placement of the Pacific high and the thermal low associated with the desert areas to the east cause an increase in both the flow and depth of marine surface air that extends the fog well into the inland valley. Since the SSFL site is several hundred feet above the average inversion base, it is usually within or above the inversion layer.[1]

2. Site Precipitation

Precipitation is extremely variable. The annual mean rainfall is 18.02 in. with over 93% of the total falling between the months of November and April. Although snow is rare, measurable amounts are occasionally received. Statistics for average and heaviest precipitation by month are given in Table 3.

TABLE 3

SITE TEMPERATURES AND PRECIPITATION*
(1959-1980)

Month	Temperature (^{o}F)				Precipitation (in.)	
	Mean		Extreme			
	Maximum	Minimum	Maximum	Minimum	Mean	Extreme
January	60.0	46.5	82	28	3.56	17.20
February	62.0	47.1	86	28	3.84	15.85
March	62.8	46.4	92	32	2.52	5.97
April	66.6	48.3	96	34	1.22	6.60
May	70.7	51.5	98	35	0.25	3.55
June	77.6	56.8	104	44	0.05	0.43
July	85.9	62.8	104	51	0.01	0.09
August	85.6	63.6	104	52	0.19	2.51
September	81.9	61.5	108	50	0.39	2.66
October	76.4	58.0	100	38	0.20	0.85
November	67.0	51.7	92	36	3.16	17.07
December	60.6	46.9	85	28	2.63	7.58

*Information supplied by Rocketdyne Meteorological Station at SSFL.

3. Site Temperatures

The elevation of the site, averaging about 1800 ft above sea level and 800 to 1000 ft above the surrounding valleys, moderates the temperature regime. In addition, the low latitude and ocean influence make for a relatively mild climate throughout the year. The temperature exceeds 90°F an average of 37 days per year; the maximum recorded temperature is 108°F. The temperature can usually be expected to drop below 32°F for at least 1 day of the year; the lowest annual minimum is about 28°F. Generally, SSFL experiences somewhat higher minimum and lower summer maximum temperatures than are recorded at the nearest National Weather Station in Van Nuys, on the floor of the San Fernando Valley. Temperature statistics for SSFL are also shown in Table 3.

I. METEOROLOGICAL DESCRIPTION

1. Site Meteorology

Average surface wind conditions for the SSFL site are depicted in Table 4. During the morning, the surface wind passes over Burro Flats into the Simi Valley. In the afternoon, the wind reverses and is generally directed toward the San Fernando Valley.

Estimated upper wind patterns are given in Table 5. This information is based on wind data from the U.S. Weather Bureau Station in Burbank. Since upper winds are controlled almost entirely by the large- or intermediate-scale pressure systems and do not vary much over a distance of a few miles, this information can be considered valid for the site also.

The prevailing summertime northwest winds occur from noon until sunset on 90% of the days in July to September and on 80% of the days in early spring and early autumn. Wind speed falls in the 5 to 10 mph range 64% of the time. Winds from

TABLE 4

SSFL SURFACE WIND CONDITIONS

	Summer	Winter
Prevailing morning direction	ESE	ESE
Prevailing afternoon direction	WNW	NW
Mean daytime speed (mph)	8	6
Mean nighttime speed (mph)	3	3

TABLE 5

SSFL UPPER WIND CONDITIONS

Elevation (ft)	Prevailing Wind Direction with Mean Speed in Prevailing Direction	
	Summer	Winter
3250	SSE 5 mph	N 5 mph
9750	SW 12 mph	NW 15 mph
16500	SW 15 mph	NNW 20 mph

the E to SE prevail at night, from 11:00 p.m. to sunrise, on the average, with speeds less than 7 mph. The remaining directions have a relatively low frequency, and speeds associated with them are usually very light.

The pattern of wind is similar in the winter but less consistent. NW flow occurs on 75% of the days during this period but speeds are lighter, with one exception, than observed in summer. The exception involves the NW winds that follow the passage of a weather front; these winds may reach 25 mph. The rather high frequency of N winds noted here, and to a lesser extent the NE flow, primarily results from dry Santa Ana wind circulation, common to this area during the period from about mid-October to mid-April. Associated speeds occasionally average 30 mph with some gusts reaching 40 mph. This special wind flow lasts from 24 to 72 consecutive hours and is accompanied by exceptionally low relative humidity, usually less than 10%.

J. ECOLOGY

The vegetation of the SSFL site is chaparral interspersed with grassland and remnant oak woodland communities. Chamise (Adenostama fasciculatum) and laurel sumac (Rhus laurina) are the dominant shrubs, with various species of Ceanothus as subdominants. The 1970 fire at SSFL burned most of the vegetation so that current vegetation is approaching maturity. As succession continues, sage (Salvia spp), deer weed (Lotus scoparius), and brush monkey flower (Mimulus longiflorus) will continue to be subdominant plants. The percent cover of the two latter plants will decrease as buckwheat (Eriogonum fasciculatum) becomes more established.

California live oaks (Quercus agrifolia) are found along the perimeter of the few grasslands within the SSFL site and along the banks of some ephemeral streams. The oaks provide habitat for acorn woodpeckers and barn owls.

The oak woodland is the result of human actions. Repeated burning of the grassland area by Chumash Indians and subsequent grazing activities stemmed the invasion of brush and shrub species into the grassland areas. Current fire prevention activities on the SSFL site will allow some chaparral species to invade the grasslands.[9]

No rare or endangered plants are located at the SSFL.[10]

Fauna that have been identified on the SSFL site are listed in Appendix B. Although no rare or endangered species utilize the SSFL site on a permanent basis, two endangered bird species, the California condor and the American peregrine falcon, may utilize the site as transients. No nesting individuals or pairs have been sighted.

K. CULTURAL RESOURCES

There are no cultural resources on the leach field. The only cultural resource at the SSFL consists of a major registered prehistoric Chumash Indian site. The resource consists of numerous rock shelters, pictographs, petroglyphs, bedrock mortars, cupules, assorted artifacts, and large areas covered with midden. The major site consists of a formerly intensely occupied area of approximately 14 acres and is estimated to lie 5000 ft south of the leach field. Ongoing archeological research takes place at the site. There are also known pictographs located separate from the major site. The closest two of these are located approximately 2000 ft and 3000 ft, respectively, from the leach field. It is estimated that the site was occupied from approximately 500 to 1800 A.D.

IV. ENVIRONMENTAL CONSEQUENCES

A. ENVIRONMENTAL EFFECTS OF PROPOSED ACTION AND ALTERNATIVES

Decontamination procedures have already been performed at the leach field. Therefore, an examination of the alternatives is no longer pertinent.

1. Direct Effects

a. Direct External Radiation

No significant increase in the surface dose rate, above that naturally occurring, will result from radioactivity remaining in the leach field. The material used to backfill the site, after excavation and disposal of the contaminated soil and gravel bed, was removed surface soil taken from the general area of SSFL. Surface samples taken across the leach field indicated natural levels of radioactivity. The average concentrations of Sr-90 and Cs-137 in these samples were 1.0 and 0.3 pCi/g, respectively. The beta activity associated with these nuclides would not contribute to the whole body dose received by an occupant of this site.

The gamma radiation associated with the Cs-137 would result in a whole body dose of less than 0.0003 mrem per year to a maximum exposed individual. This value is calculated as follows:

$$\text{Dose} = 100{,}000 \text{ pCi/m}^2 \times \text{dose factor} \times \text{residential shielding factor.}$$

The dose factor and residential shielding factor used are 4.2E-9 and 0.7, respectively.[11,12] The dose factors for Cs-137 and Sr-90 used to calculate first year radiation doses due to chronic exposure were derived from the formulas shown in Appendix D. These dose conversion factors were developed by J. K. Soldat of Pacific Northwest Laboratories for estimating exposures due to routine operations (NUREG-0172).

No direct external exposure will result due to elevated levels of Sr-90 contamination found in cracks of the underlying bedrock. These cracks are covered by 10 ft of soil. The soil provides adequate shielding from the beta emissions associated with Sr-90. It is not considered probable that the soil overburden would be displaced by an act of nature (e.g., earthquake or landslide). Since the leach field lies near the base of the arroyo, it is more probable that landsliding or an earthquake would result in a movement of material down from the canyon slopes that would further bury and shield the remaining contamination.

Excavation into the crack area of the leach field would not add to the whole body dose from external radiation. Contamination in these cracks is primarily beta activity from Sr-90. No significant gamma radiation was detected during the decontamination operations. Again, the beta activity associated with Sr-90 would not contribute to the whole body dose.

b. Atmospheric Resuspension of Soil Radioactivity

Resuspension of soil particles into the atmosphere from the leach field is likely. However, no discernible increase in atmospheric radioactivity will occur. Samples from the leach field overburden indicated an average gross beta activity of 21 pCi/g. An estimate of aerosol activity concentration can be calculated as follows (assumes average atmospheric dust content of 100 $\mu g/m^3$):[12]

$$\frac{21 \text{ pCi}}{\text{g}} \times \frac{10^{-6} \, \mu\text{Ci}}{\text{pCi}} \times \frac{10^{2} \, \mu\text{g}}{\text{m}^3} \times \frac{10^{-6} \text{ m}^3}{\text{cm}^3} \times \frac{10^{-6} \text{ g}}{\mu\text{g}} = 2.1 \times 10^{-15} \, \mu\text{Ci/cm}^3.$$

This calculated value, 2.1×10^{-15} $\mu Ci/cm^3$, is less than the general public (unrestricted area) continuous (168 h/week) MPC for all radioisotopes listed in Appendix A of the California Radiation Control Regulations.

The maximum dose would be received when all the activity is due to Sr-90. By calculating the dose to the critical organs for Sr-90, multiplying by a weight factor,[13] and summing the weighted doses, a whole body dose equivalent can be approximated and shown to be less than 0.0018 mrem per year. Table 6 summarizes this information.

TABLE 6

FIRST-YEAR WHOLE BODY DOSE EQUIVALENT FROM CHRONIC INHALATION OF Sr-90

Amount of Inhaled Radioactivity	Critical Organ	Dose Factor[11]	Critical Organ Dose (mrem)	Weighting Factor[13]	Whole Body Dose Equivalent
15.33 pCi/yr (Assumes an average inhalation of 20 m^3 of air per day)	GI-LLI	9.02E-5	0.0014	0.06	<0.0001
	Bone	1.24E-4	0.0019	0.15	0.0003
	Lung	7.02E-4	0.0108	0.12	0.0013
	Total Body	8.34E-6	0.0001	1.0	0.0001
					<0.0018

Excavation of the contaminated bedrock will not create a condition that would exeed the limit for airborne radioactivity. With the average concentration of radioactivity in the cracks being 300 pCi/g, it would require a dust content of 100,000 $\mu g/m^3$ to produce a condition that exceeds the limits. OSHA requires respiratory protection when the dust content exceeds 10,000 $\mu g/m^3$. A dust storm creates levels of about 1000 $\mu g/m^3$. Since the sandstone bedrock is well cemented, it is not likely that the dust generated from an excavation operation would even begin to approach these levels.

c. Ground Water Contamination

Visual inspection of the leach field at the time of decontamination suggested that cracks occupy about 1 to 10% of the area. Sampling of the cracks and of the material excavated from them indicated an average activity of 300 pCi/g (primarily Sr-90).

Using this information and an appropriate distribution coefficient, it is possible to estimate the amount of radioactivity that could possibly enter the ground water system. A distribution coefficient for a given nuclide refers to a state of equilibrium or quasi equilibrium, such as might be established when water percolates slowly through a sediment. The effective concentration of the nuclide sorbed onto the sediment reaches equilibrium with the concentration of the nuclide remaining in solution, and the ratio of these concentrations is the distribution coefficient K_d.[14] The coefficient in this case is 100 for strontium and 1000 for cesium.

Once they are sorbed on particle surfaces in the unsaturated (vadose) zone, the radionuclides can be depended on to remain fixed until water again moves through the soil and sediments. If the water movement is only temporary, say during a period of heavy rainfall, the sorbed ions would migrate a short distance and then become immobile.

Using the 300 pCi/g value for soil activity and the strontium distribution coefficient of 100, the maximum concentration of radioactivity for water taken from the most highly contaminated zone is estimated as 300 pCi/g ÷ 100 = $3 \times 10^{-6} \mu Ci/ml$.

It is unlikely that this level of radioactivity would ever be present in water moving through the leach field sediment. Water movement through the contaminated cracks would only be temporary, such as during a period of heavy rainfall, and the sorbed ions would migrate a short distance and then become immobile. This desorbing and resorbing of ions, as well as radioactive decay, will continually reduce the concentration of radioactivity. In addition, there is little or no percolation of surface water down to the water table due to the low porosity and low permeability of the underlying sandstone. Most of the surface water runs off; the small amount that does not is absorbed by the soil and then released to the atmosphere by evaporation and plant transpiration. Therefore, contamination of the ground water will not occur.

Surface water and vadose water from the leach field are not utilized at SSFL facilities in any manner that could provide a direct pathway for human exposure. In addition, as explained previously, the sandstone bedrock forms an impermeable barrier to the subterranean ground water. The ground water table existing at SSFL does not communicate directly with the water table existing in the populated valley floors below, which are ~1000 ft lower in elevation. Thus, the potential for human exposure via ground water contamination is nonexistent.

No recreational use or other potential exposure modes are of significance.

2. Indirect Effects

Ingestion of contaminated vegetation from the leach field presents the only potential for indirect exposure. This would be the case primarily if the site were to be utilized for agricultural purposes. But radioactivity is now near background levels and no concentration of radioactivity would occur in food crops grown on the site. Sampling of vegetation from the leach field and surrounding area indicated levels of radioactivity normally seen in the vegetation inhabiting this area.

The leach field soil contains an average of 1.0 pCi/g Sr-90 and 0.3 pCi/g of Cs-137 compared to 0.3 pCi/g Sr-90 and 1.6 pCi/g Cs-137 in the Los Angeles area. Using the leach field soil values, an estimated whole body dose equivalent from consumption of vegetables grown on the site can be calculated. The calculation makes use of the following assumptions:

- The average adult consumes 64 kg of green leafy vegetables a year
- The entire consumption is from vegetables grown on the site
- The soil-to-plant transfer factors are 1.72E-2 and 1.0E-2 for Sr-90 and Cs-137, respectively.[12]

The amount of ingested Sr-90 and Cs-137 would be 1088 pCi/yr and 192 pCi/yr. The total equivalent first-year whole-body dose from ingestion of vegetation grown on the site is $\sim$0.10 mrem. Table 7 summarizes the calculations.

Because the leach field and the surrounding region have poor soil and a limited water supply, agricultural activities would be extremely limited. If plant roots were to penetrate the crack access of the sandstone bedrock, the uptake of radioactivity by nonedible vegetation could be greater than estimated above. The only native plant with a root system capable of reaching to this depth is the chamise, which is slowly invading the site. The root system of the chamise is quite brittle and tends to follow such surface beds rather than forcing its way into cracks in rocks. Other plants suitable to this type of terrain and soil have shallow root systems that do not penetrate to this depth.[15-17]

Since vegetation is unlikely to become contaminated, foraging animals (deer, cattle, sheep) are also unlikely to become contaminated. Thus, no exposure would result from consuming meat from animals grazing on the leach field.

3. Total Dose

The total whole body dose equivalent is ~0.1 mrem and is calculated as the sum of the individual doses from each pathway. Table 8 summarizes this information.

4. Mitigation Measures

Contaminated soil was removed, packaged, and disposed of. The excavation was then covered with clean soil from elsewhere on the SSFL site. A few isolated cracks in the sandstone bedrock underlying the leach field contain material with specific activities ranging between 200 and 1000 pCi/g. During the decontamination, these cracks were sealed with a bituminous asphalt mastic to minimize the spread of contamination by permeation of water.

Sr-90 has a radioactive half-life of ~29 years, Cs-137 of ~30 years. Therefore, natural radioactive decay will reduce the levels of these two radioisotopes by about 2.4 and 2.3% per year, respectively, independent of any other reduction mechanisms. In 50 years, ~70% will have decayed; in 100 years, <10% will remain.

Recontamination of the leach field is unlikely. The septic system that fed the leach field has been removed and replaced by a waste water treatment system for the entire SSFL. In addition, several radioactive water processing facilities

TABLE 7

FIRST-YEAR WHOLE-BODY DOSE EQUIVALENT FROM CHRONIC INGESTION OF Sr-90 AND Cs-137 IN VEGETATION

Amount Ingested	Critical Organ	Dose Factor[11]	Critical Organ Dose (mrem)	Weighting Factor[13]	Whole Body Dose Equivalent (mrem)
1088 pCi/yr Sr-90	GI-LLI	2.19E-4	0.238	0.06	0.014
	Bone	1.68E-4	0.183	0.15	0.027
	Total Body	4.49E-5	0.049	1.0	0.049
					0.090
192 pCi/yr Cs-137	GI-LLI	2.11E-6	0.0004	0.06	<0.0001
	Bone	4.31E-5	0.0083	0.15	0.0012
	Liver	7.26E-5	0.0139	0.06	0.0008
	Lung	6.64E-6	0.0013	0.12	0.0002
	Kidney	3.09E-5	0.0059	0.06	0.0004
	Total Body	4.28E-5	0.0082	1.0	0.0082
					0.0109
				Total	0.1009

TABLE 8

TOTAL FIRST-YEAR WHOLE-BODY DOSE EQUIVALENT

Pathway	Dose (mrem/yr)
Direct exposure	0.0003
Inhalation	0.0018
Ingestion	
Water	0
Vegetation	0.1009
	0.1030

located along the north periphery of the RMDF have been removed. If an overflow of the present radioactive waste water processing system were to occur, it would flow toward the west end of the RMDF and not onto the leach field site. This system is equipped with sensitive alarms and turnoff controls in case of system failure.

It is anticipated that, for the foreseeable future, the property will remain as open space, which is consistent with Ventura County zoning laws.

B. RESOURCE COMMITMENT

The leach field is small in size and is located in an arroyo. When decommissioning was accomplished and contaminated dirt was removed, it was replaced with clean fill dirt. Rye grass was sown for erosion control, and the area is now being reclaimed by native vegetation. Animals, birds, and other fauna are as free to use the area as before. Thus, no natural or depletable resources have been affected. As chapparal species from the adjacent slopes invade the area, new habitats will evolve allowing for increased diversity and resiliency of the community.

C. ENERGY COMMITMENT

The release of the leach field for unrestricted use will not result in any additional energy requirements in the foreseeable future.

D. HISTORICAL AND CULTURAL EFFECTS OF ALTERNATIVES

Using the leach field under an unrestricted use classification as described in Section II will not in any way affect the historical or cultural aspects of the area. Prehistoric Chumash Indian sites previously mentioned in this assessment do not include any findings in the leach field area.

E. COORDINATION OF PROPOSED ACTION AND ALTERNATIVES WITH FEDERAL, STATE, AND LOCAL PLANS

The release of the leach field for unrestricted use will in no way affect federal, state, or local planning regarding land use. Current company thinking regarding the entire Santa Susana facility indicates that the site will remain an engineering test facility. In the event that, at some future date, the property is sold or transferred to residential building use, the terrain will require extensive grading with attendant environmental documentation. The leach field would probably be covered to a greater depth than it now is. The use of the property for grazing or agriculture is unlikely because the terrain is rugged, the soil poor, and water scarce.

V. CONTRIBUTORS

This environmental assessment was prepared by the Energy Systems Group Rockwell International Corporation for the San Francisco Operations Office of the U.S. Department of Energy. The ESG staff who contributed to this report are R. A. Kaldor (B.S. Environmental Engineering), J. V. Smith (B.A. Business), and P. S. Sonnenfeld (B.S. Geography-Ecosystems).

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APPENDIX A

LISTING OF FAUNA FOUND AT SSFL

BIRD SPECIES FOUND AT SSFL SITE AND HABITAT UTILIZED

Common Name	Scientific Name	Habitat
Red Winged Black Bird	Agelaius phoeniceus	Grasslands
Robin	Turdus migratorius	↓
Barn Owl	Tyto alba	
Golden Eagle	Aquila chrysaetos	
Western Kingbird	Tyrannus verticalis	
Western Meadowlark	Sturnella neglecta	
Cassin's Kingbird	Tyrannus vociferans	
Brewers Blackbird	Euphagus cyanocephalus	
Savannah Sparrow	Passerculus sandwichenis	
Lark Sparrow	Chondestes grammacus	↓
Mountain Quail	Oreorthyx picus	Chaparral
California Quail	Lophortyz california	↓
Allen's Hummingbird	Selasphorus sasin	
Anna's Hummingbird	Calypte anna	
Rufous-Sided Towhee	Pipilo erythrothalmus	
Bush Tit	Pasaltriparus minimus	
Wren Tit	Chamaea fasciata	
California Thrasher	Toxostoma redivivum	
Brown Towhee	Pipilo fuscus	
Nuttall's Woodpecker	Dendrocopus nuttallii	↓
Acorn Woodpecker	Melanerpeo formicivorus	Oak Woodland
Plain Titmouse	Parus inornatus	↓
Scrub Jay	Aphelocoma eoerulescens	
Red Tailed Hawk	Buteo jamaicensis	↓
Cooper's Hawk	Accipiter couperi	Cliffs and Canyons
Golden Eagle	Aquila chrysaetos	↓
Canyon Wren	Catherpes mexicanus	
California Condor	Gymnogyps californians	
Peregrine Falcon	Falco peregrinus	
Cliff Swallow	Petrochelidon pyrrhonota	↓

Source: D. W. Poole, P. C. Miller, Water Relations of Selected Species of Chaparral and Coastal Sage Communities," Ecology (56), 1975

MAMMALS FOUND AT SSFL AND HABITAT UTILIZED

Common Name	Scientific Name	Habitat
Mountain Loin	Felis concolor	Ridges/Slopes
Mule Deer	Odocoileus hemionus	Woodlands/Chaparral
Coyote	Canis latrans	↓
Skunk	Mephitis mephitis	
Woodrat	Neotoma SP	
Dusky Footed Woodrat	Neotoma fiscipes	
Gray Squirrel	Sciurus griseus	
Black-Tailed Rabbit	Lepus california	
Bush Rabbit	Slyvilagus bachmani	
Bobcat	Lynx rufus	Grasslands
California Ground Squirrel	Citellus beecheyi	↓
Deer Mouse	Peromyscus maniculatus	

REPTILES AT SSFL AND HABITAT UTILIZED

Common Name	Scientific Name	Habitat
Western Fence Lizard	Sceploporus occidentalis	Chaparral
Sagebrush Lizard	S. graciosus	↓
Coast Horned Lizard	Phrynosoma coronatum	
Gopher Snake	Pituophis melanoleucus	
Common King Snake	Lampropeltis getulu	
Western Skink	Emueces skiltonianus	Grasslands/Woodlands
Garter Snake	Thamnophis elegans	↓
Western Rattlesnake	Crotalus Viridus	All

APPENDIX B

PUBLIC EXPOSURE LIMITS

APPENDIX B
PUBLIC EXPOSURE LIMITS

Limitations of exposure for members of the public has been established by the regulatory agencies on the basis of limiting maximum individual exposures to 1/10 the occupational exposure limits. In addition, DOE has established dose limits for population groups that are further reduced to 1/3 of the maximum individual exposure limit. The DOE limits[B-1] are given in the table below.

ANNUAL DOSE EQUIVALENT OR DOSE COMMITMENT (rem)*

Type of Exposure	Based on Dose to Individuals at Points of Maximum Probable Exposure	Based on Average Dose to Suitable Sample of Exposed Population†
Whole body, gonads, or bone marrow	0.5	0.17
Other organs	1.5	0.5

*In keeping with DOE policy on lowest practicable exposure, as expressed in Chapter 0524-011b, exposures to the public shall be limited to as small a fraction of the respective annual dose limits as is practicable.

†See Paragraph 5.4 FRC Report No. 1 for discussion on concept of suitable sample of exposed population.

The NRC limits[B-2] for the public are defined for short-term exposures:

". . . no licensee shall possess, use or transfer licensed material in such a manner as to create in any unrestricted area from radioactive material and other sources of radiation in his possession:

(1) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems in any one hour, or

(2) Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of 100 millirems in any seven consecutive days

and make the assumption that the use of radioactive materials and sources of radiation, and the presence of an individual in an unrestricted area, will be such that the annual dose will be less than 0.5 rem."

The State of California[B-3] explicitly considers short-term and annual exposures:

"30268. Permissible Levels of Radiation in Uncontrolled Areas. (a) No user shall possess sources of radiation in such a manner as to create in any uncontrolled area, from such sources, radiation levels which could cause any individual to receive a dose to the whole body in excess of:

(1) Two millirems in any one hour; or
(2) One hundred millirems in any 7 consecutive days; or
(3) 0.5 rem in any one year."

Limitation of the doses received by the public resulting from internally deposited radioactive material is regulated by control of airborne and waterborne radioactivity concentrations.

These controls are derived from considerations of organ deposition and the resulting organ dose, which leads to establishment of maximum permissible body burdens. This, in turn, permits the establishment of annual limits of intake, which defines the maximum permissible concentrations.

As was done for the external exposure limits, the public limits are based on annual dose limits that are 1/10 the occupational exposure limits. However, the time of exposure for the public is assumed to be a factor of 3 greater than that for occupational exposure. This leads to limits on the radioactivity concentrations in air and water in uncontrolled areas that are 1/30 those for controlled areas. These limits are published by DOE,[B-1] NRC,[B-2] and the State of California.[B-3] An excerpt from the DOE manual is shown as an example in Table B-1.

TABLE B-1

MAXIMUM PERMISSIBLE CONCENTRATIONS IN AIR AND WATER ABOVE NATURAL BACKGROUND

Element (Atomic Number)	Isotope; Soluble (S), Insoluble (I)	Controlled Area		Uncontrolled Area	
		Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)	Column 1 Air (μCi/ml)	Column 2 Water (μCi/ml)
Actinium (89)	Ac 227 S	2×10^{-12}	6×10^{-4}	8×10^{-14}	2×10^{-6}
	I	3×10^{-11}	9×10^{-3}	9×10^{-13}	3×10^{-4}
	Ac 228 S	8×10^{-8}	3×10^{-3}	3×10^{-9}	9×10^{-5}
	I	2×10^{-8}	3×10^{-3}	6×10^{-10}	9×10^{-5}
Cesium (55)	Cs 137 S	6×10^{-8}	4×10^{-4}	2×10^{-9}	2×10^{-5}
	I	1×10^{-8}	1×10^{-3}	5×10^{-10}	4×10^{-5}
Cobalt (27)	Co 60 S	3×10^{-7}	1×10^{-3}	1×10^{-8}	5×10^{-5}
	I	9×10^{-9}	1×10^{-3}	3×10^{-10}	3×10^{-5}
Strontium (38)	Sr 90 S	1×10^{-9}	1×10^{-5}	3×10^{-11}	3×10^{-7}
	I	5×10^{-9}	1×10^{-3}	2×10^{-10}	4×10^{-5}

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APPENDIX C

RADIOLOGICAL SAMPLING AND ANALYTICAL TECHNIQUES USED FOR THE RMDF LEACH FIELD

APPENDIX C
RADIOLOGICAL SAMPLING AND ANALYTICAL TECHNIQUES USED FOR THE RMDF LEACH FIELD

SOIL SAMPLING

A grid of four evenly spaced transects was laid out along the length of the leach field area; each transect line had four sample points distributed at equal intervals along the line, for a total of 16 sample points across the leach field. In addition, four sample points were located in the drainage path south of the leach field along the north slope of the RMDF.

Four sample points were located in the ephemeral stream bed at the base of the arroyo. The points were selected by observation of places where natural pooling would occur during periods of heavy precipitation.

Samples were randomly taken at nine locations on the north and east slopes of the arroyo. One sample was taken at three locations away from the site. These locations were on the north facing slope of the ridge above the SRE, near Well 13, and near Rocketdyne Building 309 at the SSFL.

At each sampling location a surface sample was taken. This was done by pounding a 10-cm-diameter by 5-cm "cookie cutter" into the soil. Since a large volume of sample ($\sim$1 qt) was required for analysis, the cookie cutter was pounded into the soil five times in an area about 1 ft^2, once at each corner and once in the middle.

The leach field and watercourse locations were drilled with a hand held auger to a depth of about 3 ft unless bedrock, consolidated sandstone, or debris obstructed the drilling. At specified locations on the leach field core drilling was performed to obtain subsurface samples.

Each soil sample was assigned an identifier code. The codes used were LF for the leach field, WC (watercourse) for the ephemeral stream bed, HC for the high canyon areas, and B (background) for samples taken away from the site. Each sample was also assigned number of a letter-number combination. Therefore, LF A4 was a sample taken on the leach field at Point 4 of Transect A. In addition, the depth at which the sample was removed was noted. WC1 would mean watercourse sample Number 1 and HC1 would mean high canyon area sample Number 1.

A Ludlum Model 12 count rate meter with a pancake G-M probe was used as an indicator instrument only to detect gross radioactivity. Normal soil activity was considered to be in the range of 200-300 cpm. Areas which gave readings twice background were also sampled for analysis.

SOIL ANALYSIS

Analysis of the soil samples was performed by Energy Systems Group and by Teledyne Isotopes in Westwood, New Jersey. ESG analyzed the samples for gross alpha and gross beta only. The samples sent to Teledyne Isotopes were analyzed for the following:

1) gross alpha
2) gross beta
3) Sr-90
4) Cs-137
5) K-40
6) Tl-208
7) Pb-212
8) Bi-214
9) Pb-214
10) Ra-226
11) Ac-228
12) Co-60.

The ESG soil analysis technique consisted of removing about 2 g of soil from the gross sample, drying on an electric hotplate, sieving through a Gooch crucible (0.7-mm holes), and spreading thinly on a 2-in. planchet. The samples were counted for 10 min in a thin-window gas-flow proportional counter. Both gross alpha and gross beta were counted simultaneously. The beta calibration and self-absorption correction sample was K-40 in the form of KCl. The alpha calibration sample was Th-230 electrodeposited on a steel substrate having a geometry similar to the sample. The nominal beta background count rate was 30 cpm, and the efficiency factor averaged 3.6 dpm/cpm. The minimum detection level (MDL) is 4.2 pCi/g (three standard deviations above background). The nominal alpha background count rate was 1 cpm, and the efficiency factor averaged 3.7 dpm/cpm. The MDL for alpha is 0.8 pCi/g. The MDL for beta of 4.2 pCi/g is well below the natural activity of the soil in this locale, which is in the range of 15 to 30 pCi/g. The MDL for alpha of 0.8 pCi/g is about equal to the natural activity of the soil which is in the range of 0.5 to 0.8 pCi/g.

A total of 79 soil samples from the leach field were analyzed for radioisotopes. The average values for Sr-90 and Cs-137 were 1.0 pCi/g and 0.3 pCi/g, respectively.

APPENDIX D

CALCULATION OF FIRST-YEAR DOSE FACTORS FROM NUREG-0172

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CALCULATION OF FIRST-YEAR DOSE FACTORS FROM NUREG-0172

The first-year dose factors were calculated from the information provided in NUREG-0172 with the following corrections to equations provided by the author, J. K. Soldat, in a letter to R. J. Tuttle of Rockwell International on February 5, 1982. The letter states, "Equation A-2, Page A-1, and Equation A-3, Page A-2, are incorrect. They yielded correct answers in NUREG-0172 only because T_1 was 365 days in those calculations. The correct equations are:

$$K_{i1j} = 18.7 * f_w / \left[365 * T_1 * (\lambda_e^o)^2 \right] \quad \text{(A-2)}$$

$$I_{i2j} = 18.7 * f_a / \left[365 * T_1 * (\lambda_e^o)^2 \right] \quad \text{(A-3)}$$

Equation A-11, Page A-5, is missing a negative sign inside of the last parenthesis at the last exponent. It should be:

$$P_{4ipj} = . . . + EXP\ (-T_A * \lambda_e^o) \big] \quad \text{(A-11)"}$$

Table D-1, Summary Table of Equations, lists the equations used to calculate the first-year doses. Body organ mass and GI travel times data were taken from Table B.1, Appendix B, NUREG-0172. The balance of the required data was taken from Table B.5 of the same document.

TABLE D-1

SUMMARY TABLE OF EQUATIONS

Isotope	Organ	Pathway	NUREG-0172 Equations
Sr-90+D	Bone	Ingestion	(A-2) (A-11, T_A = 365 days)
Sr-90+D	Total body	Ingestion	(A-2) (A-11, T_A = 365 days)
Sr-90+D	GI-LLI	Ingestion	(A-20)
Sr-90+D	GI-LLI	Inhalation	(A-21)
Sr-90+D	Bone	Inhalation (insoluble)	(A-4) (A-18, T_A = 365 days)
Sr-90+D	Total body	Inhalation (insoluble)	(A-4) (A-18, T_A = 365 days)
SR-90+D	Lung	Inhalation	(A-3) (A-11, T_A = 365 days)
Cs-137+D	GI-LLI	Ingestion	(A-20)
Cs-137+D	Bone	Ingestion	(A-2) (A-11, T_A = 365 days)
Cs-137+D	Liver	Ingestion	(A-2) (A-11, T_A = 365 days)
Cs-137+D	Lung	Ingestion	(A-2) (A-11, T_A = 365 days)
Cs-137+D	Kidney	Ingestion	(A-2) (A-11, T_A = 365 days)
Cs-137+D	Total body	Ingestion	(A-2) (A-11, T_A = 365 days)

Calculation of Sr-90 Bone Dose Factor for Ingestion

$f_w = 0.0225$ $\lambda_e^o = \ln 2/6665$ days $= 1.040E-4$/day

$T_1 = 365$ days

Using Equation (A-2)

$$K_{i1j} = (18.7 \times 0.0225)/\left[365 \times 365 \times (1.04E-4)^2\right] = 292$$

$(\varepsilon/m)_A = 5.650/7000 = 8.071E-4$

$T_A = 365$ days

Using Equation (A-11)

$$P_{4ipj} = (\varepsilon/m)_A \times \left[T_1 \times \lambda_e^o - e^{-\left[(T_A - T_1) \times \lambda_e^o\right]} + e^{-(T_A \times \lambda_e^o)}\right] = 5.742 - 07$$

Using Equation (A-1)

$$D_{4ipj} = K_{i1j} \times P_{4ipj}$$

$= 292 \times 5.742E-7$

$= 1.677E-4$ mrem/pCi (first-year dose commitment)

Calculation of Sr-90 Total Body Dose Factor for Injestion

$f_w = 0.3$ $\lambda_e^o = \ln 2/5834 \text{ days} = 1.188E\text{-}4/\text{day}$

$T_1 = 365 \text{ days}$

Using Equation (A-2)

$$K_{i1j} = (18.7 \times 0.3) / \left[365 \times 365 \times (1.188E\text{-}4)^2\right] = 2983$$

$(\varepsilon/m)_A = 1.137/70{,}000 = 1.620E\text{-}5$

$T_A = 365 \text{ days}$

Using Equation (A-11)

$P_{4ipj} = 1.506E\text{-}8$

Using Equation (A-1)

$D_{4ipj} = 2983 \times 1.506E\text{-}8$

$= 4.491E\text{-}5$ mrem/pCi (first-year dose commitment)

Calculation of Sr-90 GI-LLI Dose Factor for Injestion

$f^* = 0.70$

$(\varepsilon/m)_A = 2.440/150 = 1.6267E-2$

$t_a' = 0.54$ days

$\tau_a' = 0.75$ days

$\lambda_R = \ln 2/(29 \times 365) = 6.548E-5/\text{day}$

Using Equation (A-20)

$$D_{4ipj} = 0.0256 \times 0.75 \times 0.70 \times 2.440/150 \times e^{-(0.54 \times 6.548E-5)}$$

$$= 2.186E-4 \text{ mrem/pCi (50-year and first-year dose commitment)}$$

Calculation of Sr-90 GI-LLI Dose Factor for Inhalation

$f^* = 1.0$ $\quad f_a = 0.62$ $\quad (\varepsilon/m)_A = 1.137/150 = 7.58E-3$

$\tau_a' = 0.75$ days $\quad t_a' = 0.54$ days

λ_R - ln 2/(29 x 365) = 6.548E-5/day

Using Equation (A-21)

$$D_{4ipj} = 0.0256 \times \tau_a' \times f^* \times f_a \times (\varepsilon/m)_A \times e^{-\lambda_R t_a'}$$

$$= 9.023E-5 \text{ mrem/pCi (50-year and first-year dose commitment)}$$

Calculation of Sr-90 Bone Dose Factor for Inhalation

λ_B^L = ln 2/120 = 5.776E-3/day

f_2' = 0.30 T_1 = 365 days

λ_e^0 = ln 2/6665 = 1.040E-4/day

λ_e^L = ln 2/118.7 = 5.839E-3/day

Using Equation (A-4)

K_{i3j} = (0.0064 x 5.776E-3 x 0.3)/[365 x (1.04E-4 - 5.839E-3)] = -5.298E-6

$(\varepsilon/m)_A$ = 5.650/7000 = 8.071E-4

T_A = 365 days

Using Equation (A-18)

P_{4i3j} = 2.350E+1

D_{4ipj} = (-5.298E-6) x (-2.350E+1)

= 1.245E-4 mrem/pCi (first-year dose commitment)

Calculations of Sr-90 Total Body Dose Factor for Inhalation

λ_B^L = 5.776E-3/day

f_2' = 1.0 T_1 = 365 days

λ_e^o = ln 2/5834 = 1.188E-4/day

λ_e^L = 5.839E-3/day

Using Equation (A-4)

K_{i3j} = -1.770E-5

$(\varepsilon/m)_A$ = 1.137/70,000 = 1.624E-5

T_A = 365 days

Using Equation (A-18)

P_{4i3j} = -4.710E-1

$D_{4i3j} = K_{i3j} \times P_{4i3j}$

D_{4i3j} = (-1.770E-5) x (-4.710E-1)

= 8.340E-6 mrem/pCi (first-year dose commitment)

Calculation of Sr-90 Lung Dose Factor for Inhalation

$f_A = 0.12 \quad T_1 = 365$ days

$\lambda_e^o = \ln 2/118.7$ days $= 5.839E\text{-}3$/day

Using Equation (A-3)

$$K_{i2j} = (18.7 * 0.12)/\left[365 \times 365 \times (5.839E\text{-}3)^2\right] = 0.494$$

$(\varepsilon/m)_A = 1.137/1000 = 1.137E\text{-}3$

$T_A = 365$ days

Using Equation (A-11)

$$P_{4i2j} = 1.137E\text{-}3 \left[(365 \times 5.839E\text{-}3) - e^{-(365-365)\times 5.839E\text{-}3} + e^{-(365\times 5.839E\text{-}3)}\right] = 1.421E\text{-}3$$

$$P_{4i2j} = K_{i2j} \times P_{4i2j}$$

$= 0.494 \times 1.421E\text{-}3$

$= 7.021E\text{-}4$ mrem/pCi (first-year dose commitment)

Calculation of Cs-137 GI-LLI Dose Factor for Ingestion

τ'_A = 0.75 days f^* = 0.05

$(\varepsilon/m)_A$ = 0.3290/150 = 2.193E-3

t'_A = 0.54 days

λ_R = ln 2/(30.1 x 365) = 6.309E-5/day

Using Equation (A-20)

$$D_{4i1j} = 0.0256 \times 0.75 \times 0.05 \times 2.193\text{E-}3 \times e^{-(6.309\text{E-}5 \times 0.54)}$$

= 2.106E-6 mrem/pCi (first-year of 50-year dose commitment)

Calculation of Cs-137 Bone Dose Factor for Ingestion

$f_w = 0.4 \quad T_1 = 365$ days

$\lambda_e^o = \ln 2/138.2$ days $= 5.016E\text{-}3$/days

Using Equation (A-2)

$$K_{i1j} = (18.7 \times 0.4)/\left[365 \times 365 \times (5.016E\text{-}3)^2\right] = 0.2232$$

$(\varepsilon/m)_A = 1.365/7000 = 1.950E\text{-}4$

$T_1 = 365$ days $\quad T_A = 365$ days

Using Equation (A-11)

$P_{4i1j} = 1.932E\text{-}4$

$D_{4i1j} = K_{i1j} \times P_{4i1j}$

$= 0.2232 \times 1.932E\text{-}4$

$= 4.313E\text{-}5$ mrem/pCi (first-year dose commitment)

Calculation of Cs-137 Liver Dose Factor for Ingestion

$f_w = 0.07 \qquad T_1 = 365$ days

$\lambda_e^o = \ln 2/89.27$ days $= 7.765E\text{-}3/\text{day}$

Using Equation (A-2)

$$K_{i1j} = (18.7 \times 0.07) / \left[365 \times 365 \times (7.765E\text{-}3)^2\right] = 0.1630$$

$(\varepsilon/m)_A = 0.40/1700 = 2.353E\text{-}4$

$T_A = 365$ days

Using Equation (A-11)

$P_{4i1j} = 4.454E\text{-}4$

$D_{4i1j} = 0.163 \times 4.454E\text{-}4$

$= 7.258E\text{-}5$ mrem/pCi (first-year dose commitment)

Calculation of Cs-137 Lung Dose Factor for Ingestion

$f_w = 0.003 \quad T_1 = 365$ days

$\lambda_e^o = \ln 2/138.2$ days $= 5.016E-3$/day

Using Equation (A-2)

$K_{i1j} = 1.674E-2$

$(\varepsilon/m)_A = 0.4/1000 = 4E-4$

$T_A = 365$ days

Using Equation (A-11)

$P_{4i1j} = 3.964E-4$

$D_{4i1j} = 1.674E-2 \times 3.964E-4$

$= 6.635E-6$ mrem/pCi (first-year dose commitment)

Calculation of Cs-137 Kidney Dose Factor for Ingestion

$f_w = 0.01 \quad T_1 = 365$ days

$\lambda_e^o = \ln 2/41.84$ days $= 1.657E-2$/day

Using Equation (A-2)

$K_{i1j} = 5.114E-3$

$(\varepsilon/m)_A = 0.359/300 = 1.197E-3$

$T_A = 365$ days

Using Equation (A-11)

$P_{4i1j} = 6.042E-3$

$D_{4i1j} = 5.114E-3 \times 6.042E-3$

$= 3.090E-5$ mrem/pCi (first-year dose commitment)

Calculation of Cs-137 Total Body Dose Factor for Ingestion

$f_w = 1.0 \quad T_1 = 365$ days

$\lambda_e^o = \ln 2/113.8$ days $= 6.091E-3$/day

Using Equation (A-2)

$K_{i1j} = 3.783$

$(\varepsilon/m)_A = 0.5940/70{,}000 = 8.486E-6$

$T_A = 365$ days

Using Equation (A-11)

$P_{4i1j} = 1.130E-5$

$D_{4i1j} = 3.783 \times 1.130E-5$

$= 4.275E-5$ mrem/pCi (first-year dose commitment)