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(ESG-DOE-13367)

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SODIUM REACTOR EXPERIMENT
DECOMMISSIONING
ENVIRONMENTAL EVALUATION REPORT

DOE Research and Development Report

Prepared for the United States
Department of Energy
Office of Nuclear Waste Management,
under Contract Number DE-AT03-76SF75008
with assistance
from the United States
Department of Energy,
San Francisco Operations Office

Rockwell International

Energy Systems Group

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SODIUM REACTOR EXPERIMENT DECOMMISSIONING ENVIRONMENTAL EVALUATION REPORT

Rockwell International

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CONTRACT: DE-AT03-76SF75008
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SUMMARY

The action assessed is the Department of Energy (DOE) release for unrestricted use of the Sodium Reactor Experiment (SRE) facility located at Rockwell International's Santa Susana Field Laboratory (SSFL) approximately 29 miles northwest of Los Angeles, California. The SRE was a 20-MWt sodium-cooled, graphite-moderated, thermal reactor. Initial operation of the SRE began in April of 1957. The facility was built and used as part of the U.S. nuclear energy research and development effort. After program completion, the SRE became excess to the DOE needs and was placed in a protective storage mode with routine surveillance. In 1974, a program was established to return the facility to Rockwell International for unrestricted use. Decontamination of the SRE began in 1976 and is near completion.

Environmental effects of the proposed action, release for unrestricted use, do not present any significant impacts. Contamination of ground water will not occur. Decontamination in various areas of the SRE has effectively reduced radioactivity in the soil. Contamination of water moving through these soils is highly improbable. Sampling of surface and subsurface water has indicated levels of radioactivity that are below allowable limits for unrestricted areas. The introduction of radioactivity into the food chain from this pathway will not occur.

Resuspension of radioactive materials into the atmosphere will not occur. Material near the surface which could become airborne contains very low levels of radioactivity and no significant dose will result from the inhalation of this material.

Contamination of vegetation growing on the SRE site will not occur. Only a very small portion of the SRE site contained soils with elevated levels of radioactivity and these sites have been or are being decontaminated. Therefore, no significant dose will occur to an individual as a result of consumption of vegetation grown on the site.

Direct external exposure from the SRE will not reflect an increase above that naturally occurring at the site.

Details of the SRE complex decommissioning will be available, upon completion of the effort, in the report "SRE Decommissioning Final Report."

There is no impact associated with this action to the cultural aspect of this site.

I. PURPOSE AND NEED FOR ACTION

This environmental evaluation report addresses the Sodium Reactor Experiment (SRE) Facility located at the Rockwell International Santa Susana Field Laboratory (SSFL) in the Santa Susana Mountains northwest of the San Fernando Valley and is a basis for consideration in recommending release for unrestricted use of the site.

The 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 SRE, are owned by the Federal Government on land leased with option to buy from Rockwell. Rockwell operates and maintains the Government facilities under contract to the Government.

Upon release of the SRE from federal control, health and safety issues would fall under the provisions of California law. The Public Health Sections of the California Administrative Code govern the use and handling of source and byproduct materials. The SRE site, an area of about an acre, falls into this category.

The Sodium Reactor Experiment is being radioactively decontaminated and decommissioned so that it may be returned to unrestricted, productive use. The facility was built and used during the period 1955 to 1964 as part of the U.S. nuclear energy research and development effort. After program completion, the SRE became excess to the DOE needs and was placed in a protective storage mode with routine surveillance. In 1974, a program was established in concert with the AEC, predecessor to the DOE, to plan the return of the facility to Rockwell International for unrestricted use. Decontamination of the SRE began in 1976 and is near completion.

II. DESCRIPTION OF PROPOSED ACTION AND ALTERNATIVES

A. PROPOSED ACTION

The proposed action is the release of the entire SRE complex for unrestricted use.

The SRE was a 20-MWt sodium-cooled, graphite-moderated, thermal reactor. Initial operation of the SRE began in April of 1957. Numerous testing programs were involved with the operation of the reactor. The reactor also delivered a supply of electricity sufficient to light the city of Moorpark beginning on November 14, 1957. The SRE did not operate as a nuclear plant after February 15, 1964. It generated more than 37 million kilowatt hours of electrical energy in over 27,300 reactor operating hours.

The radioactivity was produced by neutron activation of the material surrounding the test reactor and by the release of mixed fission products into the reactor primary sodium coolant system caused by a ruptured fuel element. Removal of the reactor internal components was accomplished under a water shield. Therefore, small quantities of mixed fission products which had remained on the surface of the reactor interior were dissolved or suspended in the shielding water. At various times during the removal of reactor internal components, it was necessary to lower the water level within the reactor vessel. This was accomplished by pumping the water from the vessel into a below-floor-level vault which had been coated to make its walls and floor impervious to water. During one prolonged period in which the vault was being used for the vessel water storage, it was noted that the decrease in water level was exceeding that which would have been expected by evaporation. Steel tanks were immediately prepared to line the vault and the water was transferred from the vault into the steel liners. Core borings were made in the surrounding area to collect subsurface water which was analyzed for radionuclides. Mixed fission products were found. Later excavation of the soil surrounding the vault indicated that the leakage had occurred from a pipe penetration in the vault wall. The pipe had been capped but water was able to slowly leak between the pipe and the concrete wall. Filtering by the soil prevented the mixed fission products from migrating more than 20 ft from the vault.

For purpose of decontamination, the SRE site was divided into ten (10) regions based on topographic factors and operations performed in each region (excludes the reactor building itself). Figure 1 shows this division. A brief narrative on the operations performed in each region and the decontamination performed or required follows.

Region I

Region I, located east of the main reactor complex, contained Facilities 723 and 724. Facility 723 is a 20 ft x 20 ft concrete pad used for sandblasting items and equipment that were determined to be free of radioactivity. Building 724 was the hot oil sodium cleaning facility, designed to be used for cleaning large pipes and assemblies for the secondary loop of the reactor. Decontamination of this area included the relocation of Building 724 to Region IV and the removal of contaminated concrete.

Region II

Region II is located along the main entranceway to the reactor complex and contains a portion of Building 163. A survey of this region indicated the area was never contaminated and as such no decontamination was required. The portion of Building 163 included in this area is used as a box fabrication shop.

Region III

Region III is a paved area adjacent to and between Buildings 163 and 143 (the reactor complex). The southwest end of Building 163 is used as a radioactively contaminated materials cleaning facility. Plans for decontaminating this region are being developed.

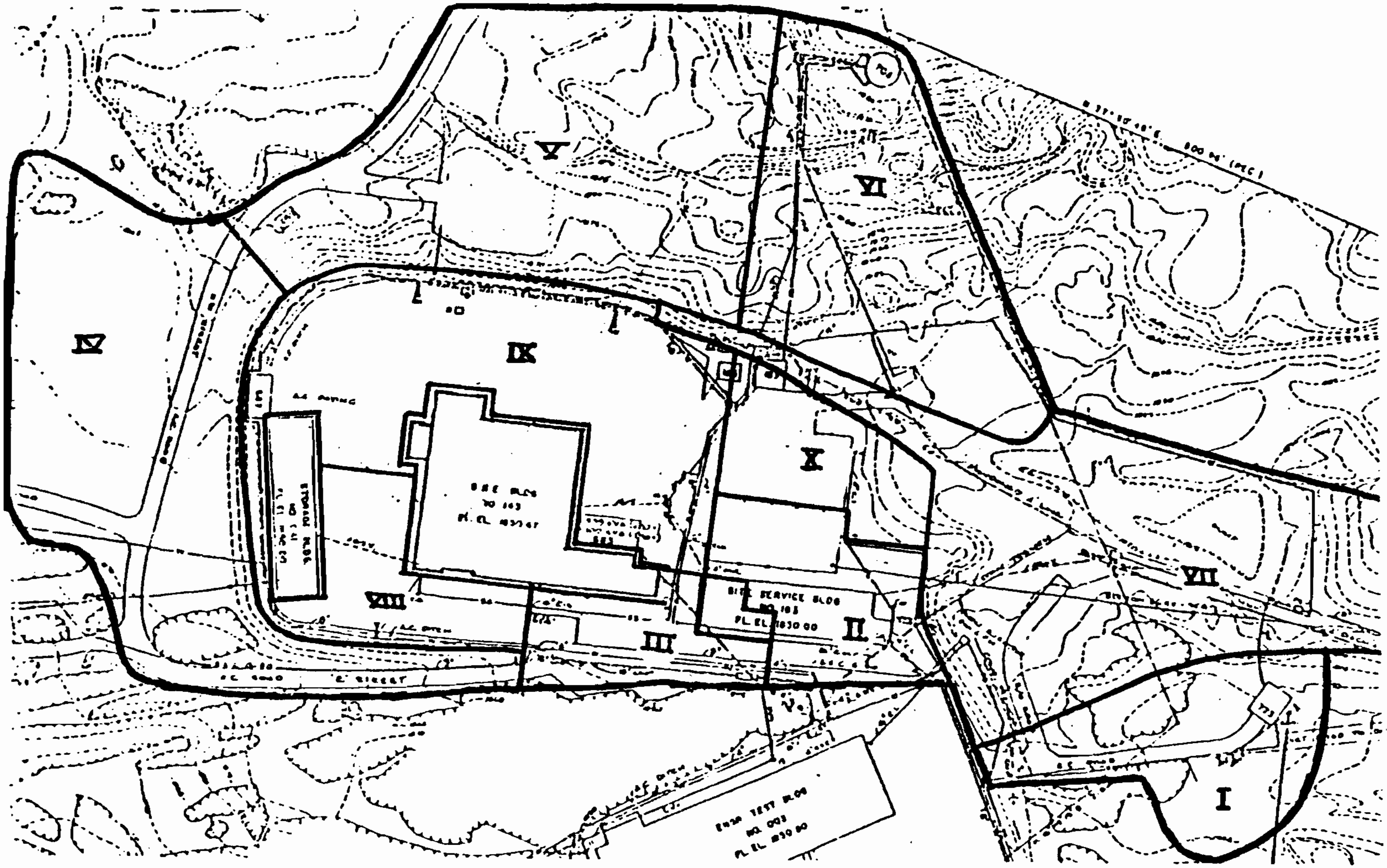

Figure 1. Regions of the SRE

Region IV

Region IV, located on a rise west of the reactor building, was part of an area originally used as an auxiliary parking area. During operation of the reactor, a fenced-in asphalt pad was laid at the south end of the area for use as a radioactive materials storage facility. Part of Region IV is currently used as a sodium disposal facility. This building is designated Building 133 and is the upper structure of 724, which was removed from Region I. Construction of the sodium facility required lowering the overall grade of the parking lot approximately 1 ft. Surveys made at that time did not indicate the presence of any significant contamination in the soil.

Region V

SRE Region V is located north of the main reactor building. Two facilities were located in this region as part of the reactor support system. They were identified as 686, a hot waste storage area, and 653, the interim radioactive waste vault. The hot waste storage area was a fenced asphalt pad used to store packaged core components. This area was one of the first facilities to be disposed of under the SRE decommissioning program.

The second facility, 653, contained buried gas and liquid holdup tanks. Along with the tanks were several concrete vaults that housed compressors and associated piping systems. Two auxiliary vaults contained gas decay tanks in addition to those in the ground. During the decontamination effort, the buried tanks and associated systems were removed. Contaminated soil detected between the tanks was removed, packaged, and shipped as radioactive waste to an NRC licensed burial site along with the pipes and valves from the tanks. Several inches of concrete had to be spalled away from the vaults to remove contamination detected on the concrete walls and floors. This material was also packaged and shipped as radioactive waste to the NRC licensed site. A large number of soil and concrete samples were used to determine that all contaminated material had been removed. At this point, the concrete that was left was used as backfill to help stabilize the hillside.

Region VI

SRE Region VI is made up mainly of sandstone formations several hundred feet high, northeast of the main reactor complex. The only manmade structure in this region was a large wooden water tank and access stairway. Both of these structures were destroyed by a brush fire several years ago. The water tank stored emergency cooling water for the Edison Company's steam generator portion of the Sodium Reactor program. Due to its inaccessibility, no other use was made of this region. During survey for surface radiation, all accessible locations were checked with particular attention to weeds that might conceal an unexpected radiation source. No contamination was found and as such no decontamination was necessary.

Region VII

Region VII is a low area to the east of the main SRE facility. The main feature of the region is a pond retained by an earth dam at the northeast end. The pond accepts drainage from most of the other SRE regions. During the summer of 1979, the retention pond was drained and a comprehensive survey was performed. Result of the survey indicated two locations containing slightly elevated levels of radioactivity. The soil from these locations was removed, packaged, and shipped for burial to the NRC licensed site. Resampling after decontamination showed that the contaminated soil had been effectively removed.

Region VIII

Region VIII is an asphalt parking area adjacent to the south corner of Building 143. It includes a portion of Building 041 which is used as a storage facility for packaged radioactive material. Plans for decontaminating this region are being developed.

Region IX

SRE Region IX is the predominantly paved area occupying the area north of and adjacent to the SRE building. It includes the remaining portion of Building 041. A large area next to the north corner of the SRE building has been excavated during decontamination of the SRE building.

Region X

SRE Region X is a partially paved area on the north corner of the main SRE lot. Clean dirt and rubble from the decontamination excavation currently occupy a portion of the area.

SRE Building 143

Extensive work has been performed in decontaminating this structure. Decontamination involved removing the reactor vessels and liners, the sodium systems, cooling systems, fuel handling systems, hot cells, the control room, and numerous other systems associated with an operating reactor. Contaminated soil in the building has been removed, packaged, and shipped for burial to either a DOE site or an NRC licensed site. In comparison to the decontamination already performed, only a small amount of effort remains to complete cleaning this facility.

1. Potential Impacts

a. Water Environment

Contamination of surface or ground water at the SRE is extremely unlikely. Sampling of surface and subsurface water indicated concentrations of radioactivity below Maximum Permissible Concentrations (MPC) adopted by the Department of Energy, Nuclear Regulatory Commission, and State of California for strontium-90, cesium-137, and cobalt-60. These radionuclides are considered to be the only significant ones remaining as a result of the operations at the SRE.

Decontamination procedures have effectively reduced soil radioactivity in several regions of the SRE and remaining radioactivity will be similarly reduced. Therefore, water moving through these soils will not become contaminated. No significant dose commitment would result due to consumption of the surface or ground water.

b. Air Environment

Atmospheric resuspension of soil from the SRE site will not result in airborne activity above the Maximum Permissible Concentration (MPC) allowed during continuous (168 hours/week) use for the general public in an unrestricted area as listed in Appendix A of the California Radiation Control Regulations. Only a small portion of the SRE site had soils with radioactivity above background. No significant dose will result from inhalation of suspended soil particles.

c. Terrestrial Environment

Since surface radioactivity will be at near background levels, direct exposure to the environment will not increase. Contamination of vegetation and wildlife from the SRE will not occur. No significant dose will result from consumption of food stuffs grown on the SRE site.

B. ALTERNATIVES

1. Restricted Use

This classification will result in the property being exempted from licensing requirements provided certain restrictions are followed. Examples of restrictions which could be applied to the SRE site are:

1) No grading of surrounding slopes.
2) No excavation in designated regions.
3) No drilling.
4) Development limitations.

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. With the site-specific activity levels being approximately equal to those of naturally occurring soil, no real benefit will be obtained by following this approach. Rockwell plans call for the conversion of the SRE to a fabrication facility.

2. <u>No Action</u>

Simply stated, this action proposes that the control of the property remain with DOE.

III. DESCRIPTION OF EXISTING ENVIRONMENT

A. LOCATION

The SRE area is located at Rockwell International's Santa Susana Field Laboratory (SSFL) which is operated by the Energy Systems Group and the Rocketdyne Division. The 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 2 and 3. Its distance from, and directional relationship to, various surrounding populated communities are:

Santa Susana	-	3 miles (5.0 km) north
Susana Knolls	-	3 miles (5.0 km) northeast
Simi	-	5 miles (8.3 km) northwest
Canoga Park	-	6 miles (10.0 km) east-southeast
Chatsworth	-	6 miles (10.0 km) east-northeast
Calabasas	-	7 miles (11.6 km) south
Woodland Hills	-	7 miles (11.6 km) southeast
Thousand Oaks	-	13.5 miles (22.7 km) 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 the Black Canyon road leading up from the Simi Valley.

ESG's operations are located at the west end of the field laboratory. All the decommissioning activity is entirely within the boundaries of the ESG operations. The SRE is located just north of Building 003 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. This is depicted in the aerial photograph shown in Figure 4.

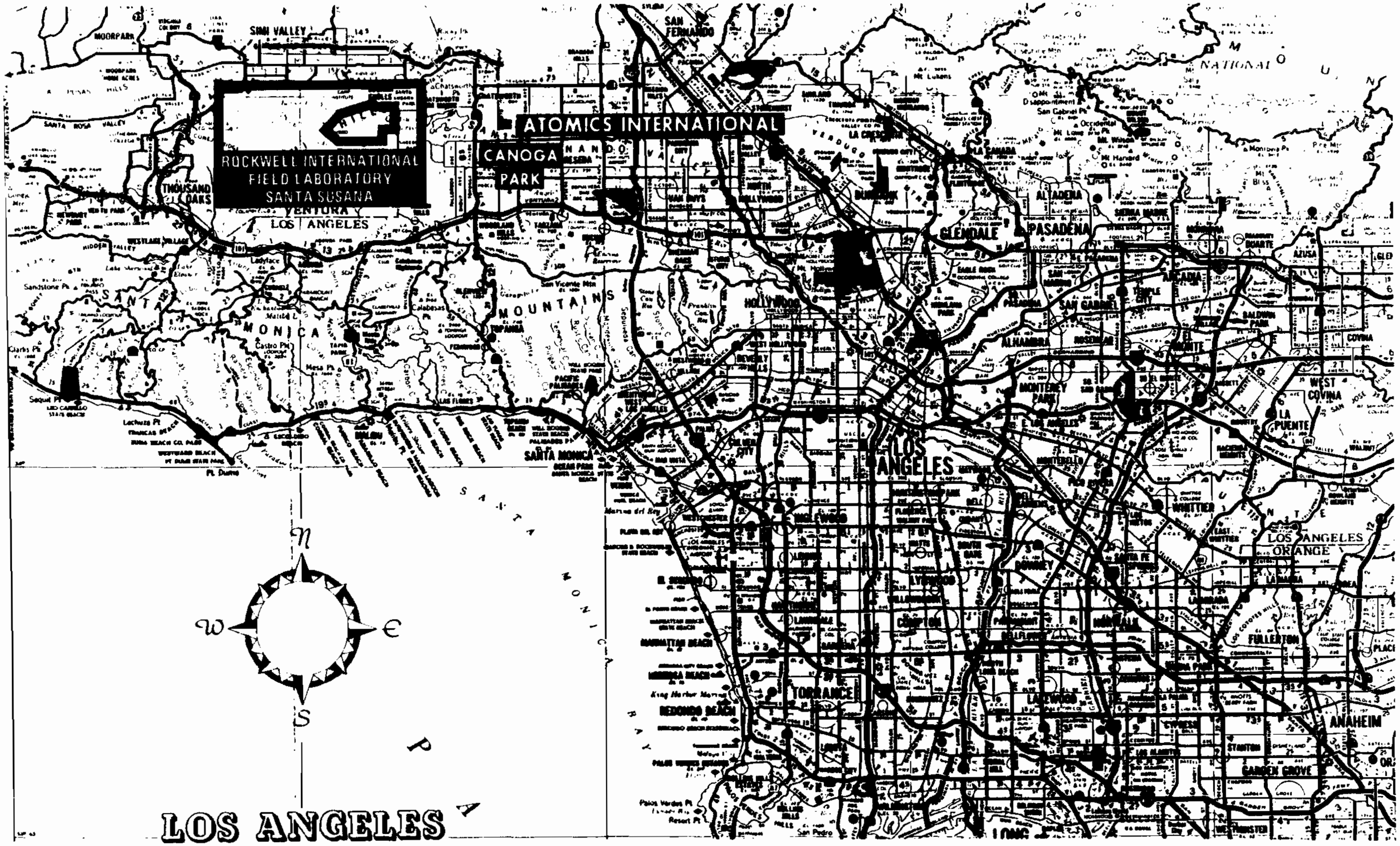

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Figure 2. Map of General Los Angeles Area (Copyright Automobile Club of Southern California. Reproduced by permission.)

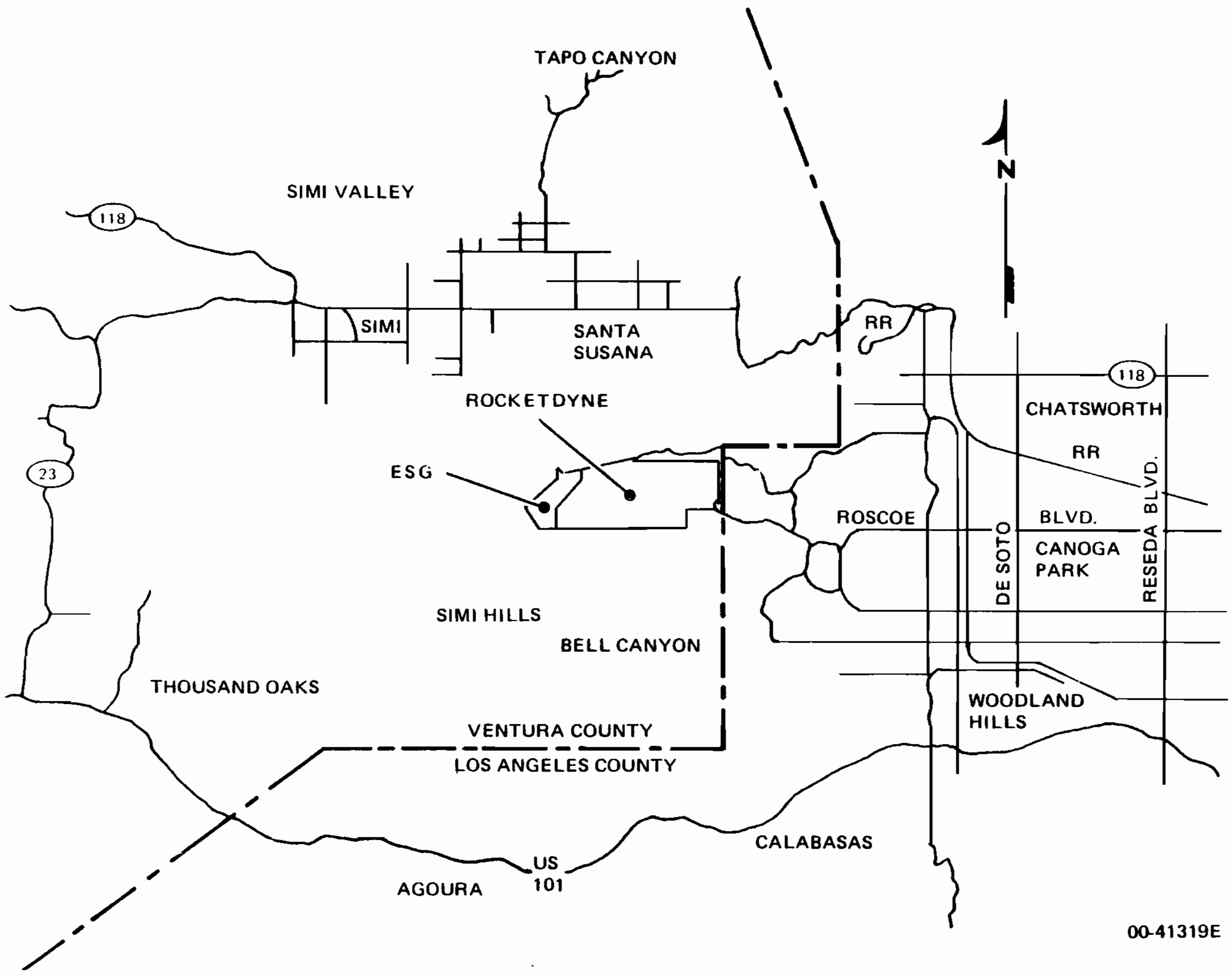

Figure 3. Location of the SSFL

Figure 4. Aerial View of SSFL

B. DEMOGRAPHY

1. Distribution

The greatest population density in areas near the SSFL occurs in the western San Fernando Valley area. This includes the communities of Canoga Park, Chatsworth, and Woodland Hills. All of these communities are at distances of at least 6 miles from the site.

The population of Simi Valley, north of the SSFL, increased rapidly during the mid-1960's. Since the late 1960's, the growth rate has slowed; however, the population of the valley continues to increase and is becoming more dense.(1) 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 and projected populations for areas relatively near the site are given in Table 1. The information was obtained from the Los Angeles City Planning Department, Los Angeles County Department of Regional Planning, Simi Valley Department of Environmental Affairs, Ventura County Planning Department, and the Chamber of Commerce of Chatsworth, Thousand Oaks, and Woodland Hills.

TABLE 1

POPULATION ESTIMATES FOR COMMUNITIES SURROUNDING THE SSFL

Area	Most Recent Estimate	1985	1990	1995	2000
Simi Valley*(2)	85,767	91,200	103,000	112,000	122,000
Woodland Hills - Canoga Park(3)	132,000	143,900	160,900	164,600	167,900
Chatsworth - Porter Ranch(3)	83,000	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

Due to the population density increase in the lower valleys, there has been greater development into canyon areas. There has been population growth in Bell Canyon to within 1-1/2 miles of the southern boundary of the SSFL. This area is planned for 979 residential lots. Assuming an average household size of 3 to 4 persons, this would account for a population of 2400 to 3200 people. Currently, 260 lots are occupied with 80 under construction. Development is also occurring in the Las Virgenes Canyon 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). An estimated 357 mobile home sites are located in the canyon of which 231 are occupied. These mobile home parks would account for a population of 1000 to 1400 people in the Woolsey Canyon area.

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

C. LAND USE

1. Land Use and Zoning

Located entirely within Ventura County, the 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 which regulate the use of buildings, structures, and land.(2)

In conformance with Ventura County's regional "open space" plan (Figure 5), 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 Exclusion (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) Mobile home parks have been constructed along the Woolsey Canyon Road, the closest of these being less than 3/4 mile from the entrance to the Rockwell facilities and ~3 miles from the decontaminated areas. Permits for the construction of the trailer parks were granted under a variance by the Los Angeles County Regional Planning Commission.

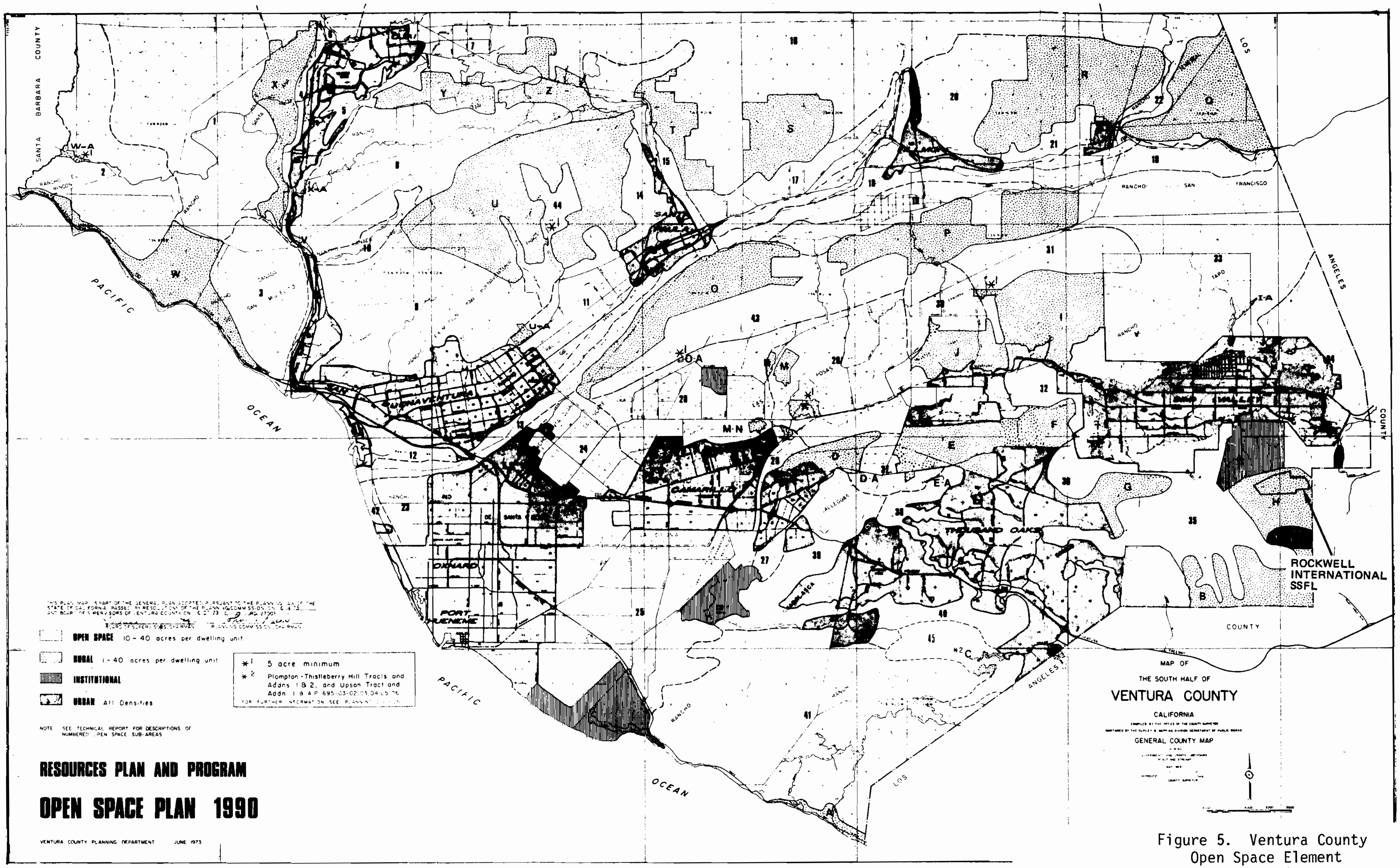

Figure 5. Ventura County Open Space Element

Figure 6 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. It should be noted that the vast majority of the land is still open space.

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 4 by use of NASA aerial photographs of Ventura County

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 purposes.

D. TOPOGRAPHY

The Santa Susana Field Laboratory 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.(5)

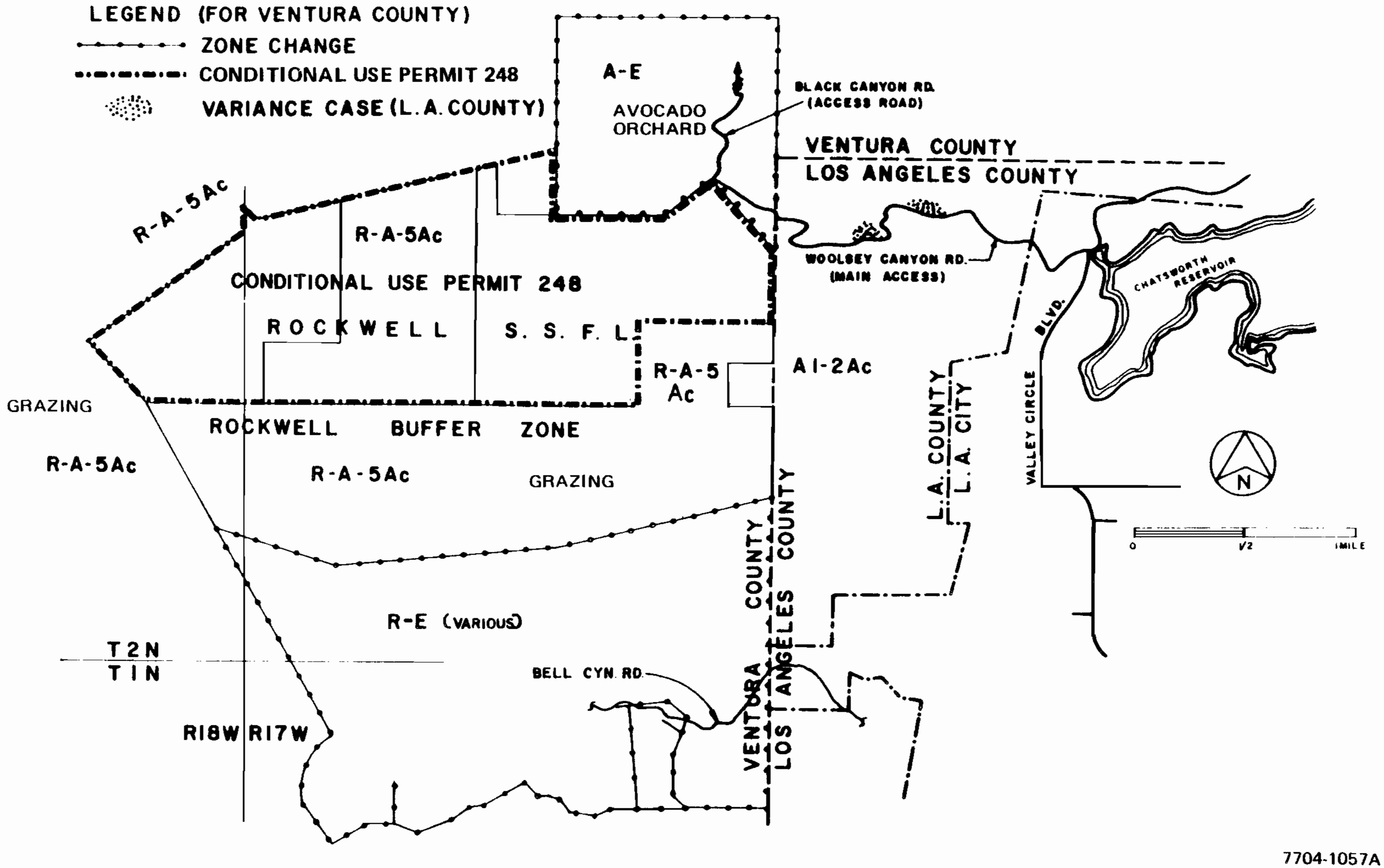

Figure 6. SSFL and Vicinity Zoning

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 to 2100 ft above sea level, with extremes of 1650 and 2250 ft.(6) The topographic map in Figure 7 indicates the rugged nature of the terrain surrounding the SSFL location.

The major drainage for this area is through Bell Canyon which drains to the south from the site and then to the east further down the canyon. The Las Virgenes Canyon also drains south but is separated from the site by a high ridge. Major drainage patterns to the north are through Meier Canyon and Runkle Canyon.

E. GEOLOGY AND SEISMOLOGY (See Figure 8)

1. Geology

a. General Geology

A major portion of the SSFL site is underlain by a bedrock unit formally 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.(5)

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.(7)

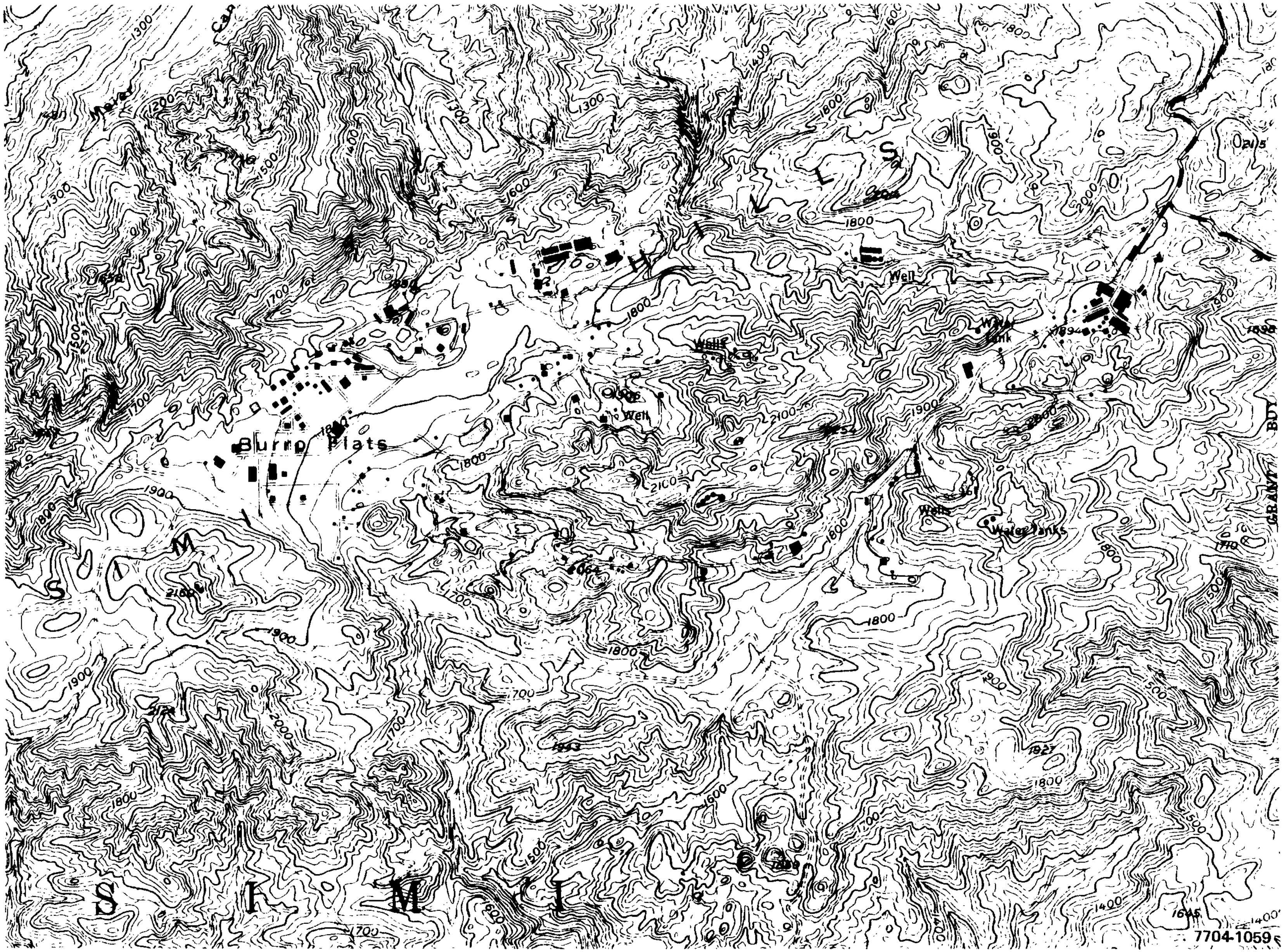

Figure 7. Topography of the SSFL, 25-ft Contour Intervals (From U.S. Geological Survey Topographic Map "Calabasas Quadrangle" 7.5-Minute Series, Revised 1967)

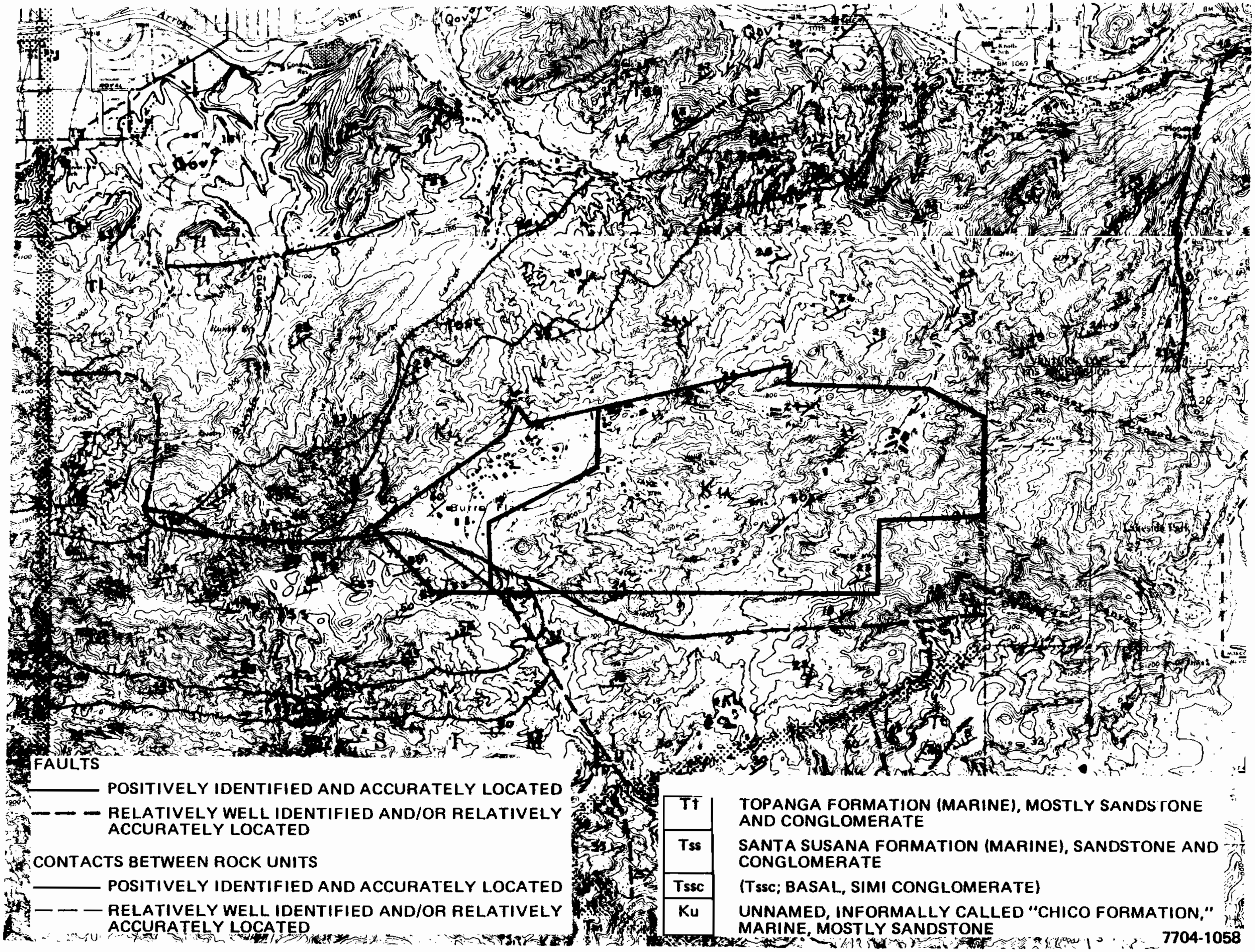

Figure 8. Geology of the SSFL

b. Faults

Numerous minor faults have been identified on the SSFL. One minor fault passes diagonally across the southwest portion of the ESG property. Some confusion appears to exist as to the name of this fault and its state of activeness. An arcuous east-northeast trending fault immediately north of the 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.

2. Seismology

The earthquake history of Ventura County, particularly the southern part, is dominated by small to moderate shocks.[8] Many of those shocks have been severe in their local epicentral areas, but regionally have caused only light damage. More serious than effects from local shocks have been the effects from relatively numerous moderate to large earthquakes whose epicenters are located outside of this area. The San Fernando earthquake of February 9, 1971, registered 6.6 with its epicenter (near the San Gabriel Fault) in the Newhall-Sylmar area about 20 miles east-northeast of the SSFL. Minor to severe damage along with landsliding and rockfalls was 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 away. 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 over 50 miles away, are believed to have been the strongest earthquakes, with magnitudes of 7.7.[5,6]

F. HYDROLOGY

1. Surface Water

Surface water at the SRE is essentially derived from two sources, rain and industrial waste, and is collected in the retention pond east of Building 143. The contents of this pond are routinely monitored to assure conformance with the State Water Resources Control Board (NPDES) permit (see Table 3). If the water is within acceptable limits, as defined by the permit, it is pumped into Rocketdyne release ponds. The water in these ponds is monitored by Rocketdyne technicians to assure that contamination levels are not exceeded. Overflow water is released into Bell Canyon Creek. Prior to release, another survey is made by an independent laboratory to validate the Rocketdyne analysis.

If the water in the SRE retention pond were found to be above acceptable levels, it would be treated by dilution or decontamination through filtration or an ion exchange process until the levels were reduced. After treatment, the water is pumped to Rocketdyne for release as before. It should be noted that it has never been necessary to treat the water in the SRE pond.

Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66-49 of September 21, 1966, a sampling station for evaluating environmental radioactivity in Bell Canyon was established in 1966. It is located approximately 2.5 miles downstream from the southern Rockwell International Corporation boundary. Samples, obtained and analyzed monthly, include stream bed mud, vegetation, and water. Comparison of the radioactivity concentrations in water from the ponds and from Bell Creek with that of the domestic water supply shows no significant variation in either alpha or beta activity.

2. Ground Water

The ground water supply underlying the SSFL site is completely contained by impervious barriers as a separate underground reservoir and is, therefore, not directly connected to the ground water in either the Simi Valley or the San Fernando Valley.[7]

TABLE 3

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD CRITERIA FOR DISCHARGING NONRADIOACTIVE CONSTITUENTS FROM ROCKETDYNE DIVISION, SSFL

NPDES NO. CA00-01309, EFFECTIVE SEPTEMBER 27, 1976

Constituent	Discharge Rate (lb/day)	Concentration Limit (mg/ℓ)	
	30-day Average	30-day Average	Maximum
Total dissolved solids	1,267,680	-	950
Chloride	200,160	-	150
Sulfate	400,320	-	300
Suspended solids*	66,720	50	150
Settleable solids*	-	0.1	0.3
BOD_5	26,690	20	60
Oil and grease	13,350	10	15
Chromium	6.67	0.005	0.01
Fluoride	1,340	-	1.0
Boron	1,340	-	1.0
Residual chlorine	-	-	0.1
Fecal coliform (MPN/100 mℓ)	-	-	23.0
Surfactants (as MBAS)	667	-	0.5
pH			6.0-9.0

*Not applicable to discharges containing rainfall runoff during or immediately after periods of rainfall.

The geologic structure which holds the water at 700 to 800 ft elevation above the surrounding valley floors is unique and quite unusual. The Cretaceous massive sandstone is bounded on the northwest, 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 the SSFL.

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

1) Along fault planes where movement has caused fracturing of the sandstone.
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 or water-producing formation. Most of the formation shows evidence of secondary cementation which has decreased the original porosity to a very low capacity. The majority of the porosity in which water occurs in the formation is very closely associated with the fault planes, fractures, and joints throughout the entire thickness of sediments.(7)

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. A study of the accumulated well data indicates that the ground water reserves are a limited asset and, unlike conventional aquifers, receive little or no replenishment through storm runoff. No relationship appears to exist between periods of heavy precipitation and well productivity.

All but four of the wells (see Figure 7) have been completely deactivated and only three of the wells are currently producing. The other one is currently on a standby status for use in emergency situations. The water from the three producing wells is for general plant use and is blended in the ratio of 25% well water to 75% purchased Ventura County water.

G. CLIMATOLOGY AND METEOROLOGY

1. Climatological Description

a. 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 season, 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 fog along the coastal sections, 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 which 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) Site Precipitation

Precipitation is extremely variable. The annual mean rainfall is 18.75 in. with over 93% of the total falling between the months of November and April. The occurrence of snowfall is a rarity but on occasion measurable amounts are received. The statistics for average and heaviest precipitation by months are given in Table 4.

(2) Site Temperatures

The elevation of the site, averaging about 1800 ft above sea level and 800 to 1000 ft above the surrounding valleys, provides a moderating influence on the temperature regime. In addition, the low latitude and ocean influence make for a relatively mild climate throughout the year. For 31 days of the year, the temperature exceeds 90°F with a recorded maximum of 108°F. It can usually be expected that for at least 1 day of the year, the temperature will drop below 32°F; the lowest annual minimum is about 28°F. Generally, SSFL experiences a somewhat higher minimum and lower summer maximum temperature than that which is recorded at the nearest National Weather Station in Van Nuys, on the San Fernando Valley floor. Temperature statistics for SSFL are also shown in Table 4.

Site information is from Rocketdyne Division meteorological stations and represents data collected over the period 1959 to 1980.

TABLE 4

SITE TEMPERATURES AND PRECIPITATION
(1959-1980)

Month	Temperature (°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

TABLE 5

SSFL SURFACE WIND CONDITIONS

	Summer	Winter
Prevailing Morning Direction	ESE	ESE
Prevailing Afternoon Direction	WNW	NW
Mean Daytime Speed	8 mph (13 km/h)	6 mph (10 km/h)
Mean Nighttime Speed	3 mph (5 km/h)	3 mph (5 km/h)

2. Meteorological Description

a. Site Meteorology

Average surface wind conditions for the SSFL site are depicted in Table 5. 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 6. 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 12:00 noon until sunset on 90% of the days in July to September and 80 percent of the time in early spring and early autumn. Sixty-four percent of the time wind speeds fall in the 5-to-11-miles-per-hour range. Those winds from the east to southeast prevail at night, from 11:00 p.m. to sunrise, on the average, with speeds less than 5 miles per hour. The remaining directions have a relatively low frequency and speeds associated with them are usually very light.

TABLE 6

SSFL UPPER WIND CONDITIONS

Elevation (ft)	Prevailing Wind Direction With Mean Speed in Prevailing Direction	
	Summer	Winter
3,250	SSE 5 mph (8 km/h)	N 5 mph (8 km/h)
9,750	SW 12 mph (19 km/h)	NW 15 mph (24 km/h)
16,500	SW 15 mph (24 km/h)	NNW 20 mph (32 km/h)

Wintertime windiness follows a similar pattern but is also less consistent. Northwest flow occurs 75% of the days during this period but speeds are lighter, with one exception, than observed in summer. The exception involves the northwest winds following a weather frontal passage, which may exhibit speeds as high as 25 miles per hour. It should also be noted that the rather high frequency of northerly winds noted here, and to a lesser extent the northeast flow, are primarily a result of the presence of dry Santa Ana wind circulation, common to this area during the period from about mid-October to mid-April. Associated speeds occasionally average 30 miles per hour with some gusts reaching velocities above 40 miles per hour. This special wind flow lasts from 24 to 72 consecutive hours and is accompanied by exceptionally low relative humidity, usually less than 10%. Table 6 indicates the average wind pattern at SSFL.

H. 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 the 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 invasion of brush and shrub species into the grassland areas. Current fire prevention activities on the SSFL site will allow invasion of the grasslands by some chaparral species.

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. It should be noted that no nesting individuals or pairs have been sighted.

I. CULTURAL RESOURCES

There are no cultural resources located on the SRE site. 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 SRE. 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 SRE. It is estimated that the site was occupied from approximately 500 A.D. to 1800 A.D.

IV. ENVIRONMENTAL CONSEQUENCES

A. ENVIRONMENTAL EFFECTS OF ALTERNATIVES

Decontamination procedures have already been undertaken at the SRE, as previously stated in this assessment. Therefore, environmental effects of each of the alternatives, i.e., unrestricted use, restricted use, or no action, will not differ, one from the other. These are expanded upon as follows.

1. Direct Effects

a. Direct External Radiation

No discernible increase in the surface dose rate above natural background is apparent at the SRE. Decontamination procedures have effectively reduced the amount of radioactivity in several areas of the SRE. Soil sampling across Regions I, IV, V, and VII after decontamination resulted in values of activity averaging 15-30 pCi/g, the background level for the area. Since similiar techniques will be employed in removing the remaining contamination, the entire site will contain essentially background levels of radioactivity after decontamination is complete.

As part of ESG's environmental monitoring program, thermoluminescent dosimeters have been placed at various locations at the SSFL to measure ambient radiation. One of the dosimeters is located near the retention pond in Region VII. Measurements taken at that location, when compared to those offsite (Table 7), do not indicate a significant elevation in ambient radiation due to the activities at the SRE. This data includes the natural background radiation component which exists as a consequence of cosmic radiation, radionuclides in the soil, and naturally occurring isotopes of radon in the atmosphere, in addition to radioactive fallout from nuclear weapons tests. One atmospheric test in the northern hemisphere was announced during 1980, and the effects are readily apparent in Table 7. Locally, this is approximately 135 mrem/year. The small variability

TABLE 7

TLD DATA FOR THE SRE SITE
(mrem)

Calendar Year	Quarter	SRE	Location		
			Northridge A	Simi	Northridge B
1980	4	48	55	59	58
	3	39	36	36	38
	2	37	32	32	32
	1	36	34	33	33
1979	4	43	32	37	36
	3	40	30	39	36
	2	44	32	38	35
	1	35	29	30	31
1978	4	42	32	34	40
	3	35	32	30	29
	2	39	32	33	37
	1	32	26	27	25
1977	4	40	30	29	29
	3	38	28	32	31
	2	31	24	28	20
	1	29	23	20	27
1976	4	27	22	26	22
	3	25	21	24	21
	2	31	22	27	23
	1	28	19	22	20

observed in the data is attributed to differences in elevation and geologic conditions at the various dosimeter locations.

b. Atmospheric Resuspension of Soil Radioactivity

Resuspension of soil particles into the atmosphere is likely in those regions of the SRE area with soils lacking vegetation. However, no discernible increase in atmospheric radioactivity will occur. Automatic air sampling is performed at the SRE as part of ESG's environmental monitoring program. Samples taken at this site over the last several years have been well below the MPC for air. The highest values, but still below MPC, resulted from nuclear fallout and were recorded after an announced detonation of a nuclear device in the atmosphere.

During the period 1975 through 1980, the highest monthly average value from air sampling was 0.541 pCi/m^3 beta activity. This encompasses the period when the major portion of the SRE decontamination was performed. A maximum dose would be received when all this activity is due to Sr-90. By calculating the dose to the critical organs for strontium-90, multiplying each organ dose by a weighting factor,[9] and summing the weighted doses, a whole-body dose equivalent can be approximated.

The dose factors for Sr-90 and for Cs-137 used later in this report 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 the Pacific Northwest Laboratories for estimating exposures due to routine operations (NUREG-0172).

If it is assumed that all of the above radioactivity is due to Sr-90 and an average person inhales 20 m^3 of air a day, 3950 pCi per year would be inhaled. The first-year whole-body dose equivalent from inhalation of this amount of Sr-90 would be 0.4607 mrem. Table 8 summarizes this information.

TABLE 8

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

Amount of Inhaled Radioactivity	Critical Organ	Dose Factor (10) (mrem/pCi)	Critical Organ Dose (mrem)	Weighting Factor(9)	Whole-Body Dose Equivalent (mrem)
3950 pCi/yr	GI-LLI	9.02E-5	0.356	0.06	0.0214
	Bone	1.24E-4	0.490	0.15	0.0735
	Lung	7.02E-4	2.773	0.12	0.3328
	Total Body	8.34E-6	0.033	1.0	0.033
Total					0.4607

c. Ground Water Contamination

Since it is not possible at this time to measure the soil radioactivity that will exist after the completion of the decontamination of the SRE complex, data from a similar contamination occurrence, decontaminated with the same practical guidelines for residual radioactivity, were used. Following decontamination of the RMDF sanitary leach field that had also been contaminated with water bearing activation products and old mixed fission products, cracks in the bedrock 10 ft below the surface contained material that 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.[11] 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 = 3×10^{-6} µCi/ml.

It is unlikely that this level of radioactivity would ever be present in water moving through the SRE soil. Water movement through the contaminated soil 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 SRE complex 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 SRE regions presents the only potential for indirect exposure. This would be the case primarily if the regions with arable soils were to be utilized for agricultural purposes. Decontamination efforts have effectively reduced radioactivity in several regions of the SRE such that the concentration of radioactivity in food crops grown on the site will not occur.

The soils in the SRE area are expected to contain less than 1 pCi/g of Sr-90 and 0.3 pCi/g of Cs-137 (see Appendix C —Expected Results). Using these values, an estimated first-year whole-body dose equivalent from consumption of vegetables grown on the site can be calculated. The calculation makes use of the following assumptions.

1) The average adult consumes 64 kg of green leafy vegetables a year.
2) The entire consumption is from vegetables grown on the site.
3) The soil-to-plant transfer factors are 1.72E-2 and 1.0E-2 for Sr-90 and Cs-137, respectively.[11]

The amount of ingested Sr-90 and Cs-137 is 1088 pCi/yr and 192 pCi/yr, respectively. The first-year whole-body dose equivalent from ingestion of vegetation grown on the site is ~0.10 mrem. Table 9 summarizes the dose calculations.

3. Total Dose

The total first-year whole-body dose equivalent is about 4.1 mrem per year and is calculated as the sum of the individual doses from each pathway. Table 10 summarizes the total dose.

4. Mitigation Measures

Sr-90 has a radioactive half-life of ~28 years, Cs-137 of ~30 years. Therefore, natural radioactive decay will reduce the levels of these two

TABLE 9

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

Amount Ingested	Critical Organ	Dose Factor[10] (mrem/pCi)	Critical Organ Dose (mrem)	Weighting Factor[9]	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
Subtotal					0.0109
Total					0.1009

TABLE 10

TOTAL FIRST-YEAR WHOLE-BODY DOSE EQUIVALENT

Pathway	Dose (mrem/yr)
Direct Exposure	0
Inhalation	0.46
Ingestion	
Vegetation	0.10
Total	0.56

radioisotopes by about 2.4% and 2.3% per year, respectively, independently of any other reduction mechanisms. In 50 years, about 70% will have decayed; in 100 years, less than 10% will remain.

The Rockwell International plan for the SRE area calls for its use as a research and development and nonnuclear manufacturing facility. Such activities preclude recontamination. All radioactive materials associated with the decontamination process will be shipped offsite for disposal at a DOE or NRC licensed site.

B. RESOURCE COMMITMENT

No new commitment of natural or depletable resources will result from the proposed action. In areas where soil was removed, it was replaced with clear fill dirt. Natural vegetation has reclaimed these areas. Animals, birds, and other fauna are free to use the area as before. The existing structures will be decontaminated and used as previously mentioned.

The commitment of resources has actually been decreased. The removal of structures located in several regions of the SRE has returned the areas to their natural state.

C. ENERGY COMMITMENT

The release of the SRE for unrestricted use will result in a small additional energy requirement in the future for productive purposes. R&D and manufacturing activities and the associated equipment will increase Southern California Edison's baseload in Ventura County negligibly.

D. HISTORICAL AND CULTURAL EFFECTS OF ALTERNATIVES

Use of the SRE area under an "unrestricted use" classification will not in any way affect the historical/cultural aspects of the area. Prehistoric Chumash Indian sites previously mentioned in this assessment do not include any findings in the SRE area.

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

The release of the SRE for unrestricted use will in no way affect federal, state, or local planning regarding land use. Rockwell plans for the SRE, as stated previously, are to utilize the facility for nonnuclear fabrication.

V. CONTRIBUTORS

This environmental assessment was prepared by the Energy Systems Group of 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

LIST OF FAUNA FOUND AT SSFL

BIRD SPECIES FOUND AT SSFL 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	Lophortyx 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	

MAMMALS FOUND AT SSFL AND HABITAT UTILIZED

Common Name	Scientific Name	Habitat
Mountain Lion	Felis concolor	Ridges/Slopes
Mule Deer	Odocoileus hemionus	Woodlands/Chaparral
Coyote	Canis latrans	↓
Skunk	Mephitis mephitis	↓
Woodrat	Neotoma SP	↓
Dusky Footed Woodrat	Neotoma fiscipes	↓
Grey 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	↓

APPENDIX B

PUBLIC EXPOSURE LIMITS

APPENDIX B
PUBLIC EXPOSURE LIMITS

Limitation 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:

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 water-borne 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 (μc/ml)	Column 2 Water (μc/ml)	Column 1 Air (μc/ml)	Column 2 Water (μc/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}

REFERENCES

B-1. "Radiation Protection Procedures," IAEA Safety Series No. 38, International Atomic Energy Agency, Vienna (1973)

B-2. "Standards for Radiation Protection," Chapter 0524 Appendix, ERDA Manual, U.S. Energy Research and Development Administration (1977)

B-3. "Standards for Protection Against Radiation," Code of Federal Regulations, Title 10, Chapter I, Part 20 (10 CFR 20), U.S. Government Printing Office, Washington (1978)

APPENDIX C

RADIOLOGICAL SAMPLING AND ANALYTICAL TECHNIQUES TO BE USED DURING THE FINAL RADIOLOGICAL SURVEY OF THE SRE COMPLEX

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RADIOLOGICAL SAMPLING AND ANALYTICAL TECHNIQUES TO BE USED DURING THE FINAL RADIOLOGICAL SURVEY OF THE SRE COMPLEX

RADIOLOGICAL SURVEY PROCEDURES

All areas with significant known contamination are surveyed during the process of decontamination or disposal. Data obtained during this work will provide the major record demonstrating that an area is below the limits for release to unrestricted use. Sampling and supplemental surveys will be performed to verify that levels of radioactivity are acceptable and that recontamination has not taken place.

Surveys will rely primarily on the following methods:

1) Search for contamination by use of a pancake-probe G-M instrument or other high-sensitivity survey meter.
2) Smear checks for removable contamination to show compliance with "Upper Contamination Limits for Surface Decontamination at the SRE." Smears will cover 100 cm^2 each, taken at approximately 1-m intervals.
3) Measurement of radiation exposure rate with the special CP-6M (CP-7) instrument to show compliance with the Upper Contamination Limits.
4) Counting of soil, concrete, and water samples to show compliance with a limit of 100 pCi/g for solids and 3×10^{-7} $\mu Ci/cm^3$ for water.

Any areas found to be above the applicable limits will be reworked by decontamination or disposal until the levels of radioactivity are reduced below those limits.

Upper Contamination Limits for Decontamination at the SRE

Beta Gamma Emitters:	Total = 0.1 mrad/h at 1 cm, with 7 mg/cm^2 absorber
	Removable = 100 dpm/100 cm^2
Alpha Emitters:	Total = 100 dpm/100 cm^2
	Removable = 20 dpm/100 cm^2

No significant contamination by highly active alpha emitters occurred at the SRE so that the described methods are adequate and the beta-gamma limits will be applied.

SOIL SAMPLING OF SRE EXCAVATION

The entire area to be surveyed at the SRE facility was 140 ft long and 65 ft wide with the floor approximately 20 ft below grade. This represented about 18,500 ft^2 of surface or 1700 m^2. Surveying each square foot or square meter of the area would represent an unreasonable task; therefore, a sampling plan was developed.

The area to be surveyed was defined on a drawing of the SRE. On this drawing was overlayed a 1-m^2 grid pattern covering the inside and outside below grade areas including all of the walls, columns, and the post and plank retaining wall on the south edge of the excavation. Each of the resulting 1-meter squares representing the total population was given a number. Fifty-four of these numbers were selected using a table of random numbers. These formed the unbiased or control samples.

A second independent group of 54 samples was identified on the meter squares. These were from specific locations selected because the history of operations or the previously run meter surveys suggested that they were areas of higher activity. Every attempt was made to make these 54 samples truly represent the areas of highest potential contamination.

All 108 sample locations were identified on the drawing of the SRE. Using the southwest corner (where the retaining wall meets the existing concrete wall) as the starting point, the sample locations on the SRE surfaces were established. Material samples, soil, rock, or concrete from the original structure were obtained and identified. In addition, the measurements used to establish the sample location were recorded with the rest of the sample information. A 1-meter square perimeter was placed on the surface at the sample location. Material samples for the 54 unbiased samples were obtained from any random location within the perimeter. For the 54 selected samples, however, it was necessary to measure the surface gamma radiation within the perimeter and obtain the sample from the area showing the highest reading. This reading was recorded with the other sample data.

The samples were carefully inventoried and submitted for analysis. Duplicates were selected by Argonne National Laboratory for independent analysis. The overcheck analysis and observation by Argonne personnel of the soil sampling was performed at the request of DOE.

SOIL ANALYSIS

Analysis of the soil samples will be performed by Energy Systems Group and by Teledyne Isotopes in Westwood, New Jersey. ESG will analyze the samples for gross alpha and gross beta only. The samples sent to Teledyne Isotopes will be analyzed for gross alpha, gross beta, and the radioisotopes Sr-90, Cs-137, K-40, Tl-208, Pb-212, Bi-214, Pb-214, Ra-226, Ac-228, and Co-60.

The ESG soil analysis technique consists of removing about 2 g of soil from the gross sample, drying it on an electric hotplate, sieving it through a Gooch crucible (0.7-mm holes), and spreading it thinly on a 2-in. planchet. The samples are counted for 10 min in a thin window gas-flow proportional counter. Both gross alpha and gross beta are counted simultaneously. The beta calibration and self-absorption correction sample is K-40 in the form of KCl. The alpha calibration sample is Th-230 electrodeposited on a steel substrate having a geometry similar to the planchet. The nominal beta background count rate is

30 cpm and the efficiency factor averages 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.

EXPECTED RESULTS

Since it is not possible at this time to measure the soil radioactivity that will exist after the completion of the decontamination of the SRE complex, data from a similar contamination occurrence, decontaminated with the same practical guidelines for residual radioactivity, were used. Following decontamination of the RMDF sanitary leach field that had also been contaminated with water bearing activation products and old mixed fission products, 79 soil samples plus three from adjacent areas were analyzed for Sr-90 and Cs-137. The average values for these two radionuclides were 1.0 pCi/g and 0.3 pCi/g, respectively. Since the circumstances of contamination and decontamination are quite similar in the leach field and the SRE, these values should serve as good estimates of the residual contamination to be expected to exist at the SRE following completion of the decontamination project.

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:

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

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

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

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

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 λ_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

$f_w = 0.3$ λ_e^o = ln 2/5834 days = 1.188E-4/day

T_1 = 365 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-5

T_A = 365 days

Using Equation (A-11)

P_{4ipj} = 1.506E-8

Using Equation (A-1)

D_{4ipj} = 2983 x 1.506E-8

= 4.491E-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

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

$\tau_a' = 0.75$ days $t_a' = 0.54$ 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 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^o = 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

$\lambda_B^L = 5.776E-3/day$

$f_2' = 1.0 \qquad T_1 = 365$ days

$\lambda_e^o = \ln 2/5834 = 1.188E-4/day$

$\lambda_e^L = 5.839E-3/day$

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)

$P_{4i3j} = -4.710E-1$

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

$D_{4i3j} = (-1.770E-5) \times (-4.710E-1)$

$= 8.340E-6$ 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)

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

= 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 $= 7.765E\text{-}3$/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)

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