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LOCKHEED BEAUMONT NO. 1 SITE
REMEDIAL ACTION PLAN
(Submitted pursuant to Health & Safety Code, Section 25356.1)

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1.0 INTRODUCTION

This Remedial Action Plan (RAP) summarizes the results of remedial investigations conducted at the Lockheed Beaumont No. 1 site, and describes the remedial action (cleanup) strategy to mitigate and control contamination at the site. Previous activities included an historical review; remedial investigations (RIs), which describe the type and extent of contamination; a health risk assessment; and treatability and feasibility studies (FS), which evaluate various remedial action alternatives to clean up the site. This document also provides an overview of the burn pit removal action, and a justification of no further remedial action for the radioactive waste and landfill areas.

The strategy for remediation will be to treat those areas where both soil vapor and groundwater contain the greatest mass of contaminants, thereby reducing the risk for contaminant migration. The implementation of this strategy will also reduce the existing and future health risks described in the *Health Risk Assessment* for the Lockheed Beaumont No. 1 site (Radian, 1992c).

Remediation of the Beaumont No. 1 site will use the "observational" approach, focusing on the technologies that will address the highest levels of contamination most effectively in the shortest amount of time. The effectiveness of these technologies will be monitored during operation, and the system will be modified as necessary to optimize the effect of the remedial action.

1.1 Purpose of the Remedial Action Plan

The purpose of a RAP is to compile and summarize data gathered in the RI and the FS, and to identify and subsequently design, plan, and implement a final remedial action program. Public review of the RAP provides the public with an opportunity to participate in the approval of the remedial action for the site.

1.2 Site Identification

The Lockheed Beaumont No. 1 facility is located south of Beaumont, California. It was used from 1961 until 1974 by Lockheed Propulsion Company for mixing and testing solid rocket motor propellant, ballistics testing, and open burning of waste propellant. The location of the facility is shown in Figure 3-1 (see Section 3.2.9).

1.3 Scope of Information

Information in this RAP is based on the RI/FS documents listed in Table 1-1. The RAP was prepared in accordance with the guidance and outline provided by the California Environmental Protection Agency Department of Toxic Substances Control.

Table 1-1

Lockheed Beaumont Documents

Title	Major Report	Date [a]
Historical Report	✓	September 1986
Preliminary Remedial Investigation		December 1986
Source and Hydrogeologic Investigation	✓	February 1990
Burn Pit Removal Action Plan	✓	April 1991
Burn Pit Excavation Management Plan		March 1991
Treatability Study	✓	February 1992
Health Risk Assessment	✓	March 1992
Feasibility Study	✓	March 1992
Community Relations Plan		November 1989
Two public factsheets		1990; 1991

[a] Dates indicate final submittal to regulatory agencies.

2.0 EXECUTIVE SUMMARY

This Remedial Action Plan (RAP) summarizes all previous activities that led to the selection of a cleanup method for the Lockheed Beaumont No. 1 site. This site is the larger of two former Lockheed Propulsion Company solid rocket motor test facilities located in Beaumont, California. Initial investigations of the Beaumont No. 2 facility have found no contamination, as addressed in separate reports.

2.1 Consistency with State and Federal Requirements

On June 14, 1989, Lockheed Corporation and the California Department of Health Services, now known as the Department of Toxic Substances Control (DTSC), signed a Consent Order that requires Lockheed to prepare and implement a Remedial Investigation/Feasibility Study (RI/FS) and a RAP for the two Beaumont sites. The purpose of the Consent Order was to identify and remediate any soil, surface water, or groundwater contamination that occurred at the two properties, in accordance with the standards and requirements set forth in the Health and Safety Code Section 25356.1. Lockheed has retained Radian Corporation to implement the requirements of this Consent Order.

As required by the Consent Order, Radian has prepared this RAP for the Beaumont No. 1 site, which, when implemented, will significantly reduce or eliminate the major contamination at the site.

2.2 Concise Summary of the History of the Site and Site Contamination

Lockheed used the Beaumont No. 1 site from 1961 to 1974 as a rocket motor test facility. Activities included rocket propellant mixing and testing, ballistics testing, and the open burning of waste propellant. The facility was closed in 1974. Since then, the land has been used for grazing sheep, for training operators of heavy construction equipment, and for a survey school.

Contamination at the Beaumont No. 1 site was caused by the following activities:

- Open burning of waste rocket propellant and other materials used in the production of rocket motors;
- Operations in the rocket motor production area (including cleaning of rocket motor casing);
- A one-time burial of low-level radioactive waste;
- A one-time spill of transformer oil containing polychlorinated biphenyls (PCBs); and
- A spill from an underground storage tank that was punctured during removal.

Activities at the burn pit area have caused halogenated volatile organic compounds (VOCs) to migrate to the soil vapor and the groundwater. The groundwater has, in turn, contaminated a small, artificial pond where groundwater is exposed at the surface. Surface soils in the burn pit area and most of the burned waste have been found to be nonhazardous; only a few specific wastes that may be hazardous remain in the burn pit area. Subsurface soils tested were also found to be nonhazardous.

The PCB spill and buried low-level radioactive waste were cleaned up as they were discovered. The spill from the punctured underground storage tank was cleaned up immediately after it occurred. An additional potential source of contamination, a permitted landfill, was shown to be not contaminated. None of these four areas require any further remedial action.

Therefore, this document primarily addresses the remedial alternatives relating to contamination emanating from open burning of waste rocket propellant and other material, and from operation in the rocket motor production area.

2.3 Concise Description of the Selected Alternative

The first step in remediating the Beaumont No. 1 site will be a removal action of the burned propellant and other debris from the burn pit area in the eastern portion of the site. After the material has been removed and properly disposed off site, the burn pit area will be restored to its natural condition.

The selected soil vapor and groundwater remediation strategy is intended to focus the cleanup in the areas of highest contaminant mass, i.e., the burn pit area and the rocket motor production areas. Removing contaminants at these areas will reduce the potential health risks and prevent contaminants from migrating further while treatment proceeds. The design of the treatment system is intended to be flexible in order to respond to decreases in the concentrations of contaminants as treatment proceeds. The results of treatment will be closely monitored, and the system will be modified as necessary to maximize the removal of contamination.

Contaminated soil vapor and groundwater will be extracted from both the burn pit and rocket motor production areas. The soil vapor from the burn pit area will be treated using a catalytic oxidation system to destroy the contaminants. Soil vapor from the rocket motor production area will be treated in a vapor-phase carbon adsorption system. Groundwater from both areas will be treated by air stripping to remove halogenated VOCs; the effluent gas from the air stripping system will be passed through a vapor-phase carbon adsorption system.

After treatment, contaminant levels in the effluent vapor will be below the concentrations specified in the South Coast Air Quality Management District

(SCAQMD) air permits for the catalytic oxidation and carbon units. The treated effluent vapor will be released to the atmosphere. Treated groundwater will be injected into the aquifer downgradient of the rocket motor production area, where it is intended to create a barrier to reduce migration of the higher contaminated groundwater into the areas with low or no contamination. Treated groundwater may also be injected near the burn pit to flush contaminants toward the extraction wells. In the western area of the site, groundwater is expected to be evapotranspired by the vegetation along the streambanks. The nitrates in groundwater will be used as fertilizer by the plants, so no treatment of nitrates is planned.

2.4 Concise Summary of the Preliminary Allocation of Financial Responsibility

Lockheed Corporation accepts financial responsibility for the implementation of remedial actions at the Lockheed Beaumont No. 1 site.

2.5 Applicable or Relevant and Appropriate Requirements

Applicable or relevant and appropriate requirements (ARARs) are other environmental laws that may be either "applicable" or "relevant and appropriate."

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

Five ARARs have been identified for the Beaumont No 1 site. The ARARs, and the steps being taken to address them are:

- SCAQMD Rule 1150 for the excavation and removal of burn pit wastes. A permit to excavate was issued on 24 July 1991, and an extension to this permit was granted on 30 March 1992.

- Waste Discharge Requirements (WDR) from the Santa Ana Regional Water Quality Control Board (RWQCB) for the discharge of treated groundwater into the groundwater aquifer. An application for WDR was filed with the RWQCB on 22 July 1992.

- SCAQMD air quality permits for the catalytic oxidation system, the air stripper/activated carbon system, and the mobile vacuum extraction trailer. The permit application for the trailer was submitted to SCAQMD on 4 August 1992. The permit for the permanent systems will be submitted as soon as final design specifications have been completed.

- Permission to trap and relocate the endangered Stephens kangaroo rats living in the burn pit area. A tentative agreement has been reached with the U.S. Fish and Wildlife Agency. Final written approval is currently being prepared. The burn pit removal action will not be started until complete authorization has been obtained.

- Maximum Contaminant Levels (MCLs) for groundwater. Based on the Regional Water Quality Control Board (RWQCB) Resolution 88-63, the groundwater beneath the Lockheed Beaumont Site No. 1 is defined in the Water Quality Control Plan as potentially suitable for municipal or domestic water supply. The Department of Toxic Substances Control (DTSC) will require MCLs to be used as the cleanup goals for remediation of the groundwater aquifer beneath the Lockheed Beaumont Site No. 1. This requirement by the DTSC will be reviewed on an annual basis as site-specific groundwater monitoring data become available, with a comprehensive review after 5 years.

3.0 DETAILED DESCRIPTION OF SITE CHARACTERISTICS

3.1 Site History

Until the 1950s, the 9,100-acre Beaumont No. 1 site was used for ranching. In the 1950s, the property was purchased by the Grand Central Rocket Company, which became a wholly owned subsidiary of the Lockheed Propulsion Company in 1961. Sometime after June 1961, Lockheed dismantled the ranch structures and began using the Beaumont No. 1 site for solid rocket propellant mixing and testing, ballistics testing, and open burning of waste propellant. These operations continued until 1974, when the facility was closed. A complete discussion of the Lockheed Beaumont historical site activities is documented in the *Historical Report* (Radian, 1986a).

From 1975 until 1991, the site was used by the International Union of Operating Engineers as a surveying and heavy equipment training area. Since the facility was closed in 1974, all of the flat portions of the site (2,300 acres), including the burn pit area (4 acres), have been used for dryland farming (barley) and pasture (sheep grazing).

3.1.1 Location

The Beaumont No. 1 site is located in a semiarid region approximately 70 miles east of Los Angeles, in the foothills of the San Jacinto Mountains (Figure 3-1 in Section 3.2.9).

3.1.2 Nature of Business

Lockheed Propulsion Company (LPC) was formerly a wholly owned subsidiary of the Lockheed Corporation. Lockheed is an aerospace manufacturer that used the Beaumont site for mixing and testing solid rocket motor propellant. Rockets tested included a 13-foot diameter motor, which was the largest rocket motor in the world in the early 1960s, and the Lunar Escape Module.

3.1.3 Length of Operation

Lockheed acquired the Beaumont No. 1 site from Grand Central Rocket in 1960, and used it until 1974. Aerial photographs taken in June 1961 show that, at that time, the site had not yet been used for testing activities.

3.1.4 Types of Chemicals Used at the Beaumont No. 1 Site

The solid propellants used by LPC consisted of fuel (polymeric binder and aluminum), oxidizer made of ammonium perchlorate and, occasionally, a burn rate modifier. Ignition of the fuel and oxidizer mixture generated heat and pressure that continued until the propellant was consumed. The burn rate modifier helped to control the rate of combustion.

After the solid rocket motors were manufactured and cast, they were x-rayed to detect cracks, voids, or foreign materials in the propellant. If a defect was found, the rocket motor propellant was scrapped. However, because the metal casings were expensive, the propellant was removed so the casings could be reused. A 1,000 pounds per square inch (psi) water jet was used to force the solid propellant out of the metal casings in a process known as "motor washout." The solid residue was then collected, put in barrels, and taken to the burn pit area to be burned.

As shown in Figure 3-2 (in Section 3.2.9), the 4-acre burn pit area is in a broad valley in the southeastern portion of the 9,100-acre Beaumont No. 1 site. The burn pits were operated from 1962 until 1974 and used to burn waste propellant and other materials used in the production of rocket motors (Table 3-1). Waste materials

Table 3-1

List of Waste Materials Disposed of at the Burn Pit Area

Ammonium perchlorate (too finely ground and/or not meeting specifications)
Wet propellant (generated from rocket motor washout activities)
Test propellant (cast and cured in small containers and used in various studies)
Propellant that did not meet specifications (prepared at the mix station)
Various adhesives (used to attach insulation material to rocket motor casings)
Resin curatives such as PBAN (polybutadiene acrylonitrile/acrylic acid copolymer)
Burn rate modifiers (e.g., ferrocene)
Pyrotechnic and ignition components
Packaging materials (metal drums, plastic bags, and paper drums)
Solvents, including trichloroethene (TCE) primarily from the Lockheed Propulsion Company Redlands plant
Cyclotetramethylene tetranitramine (HMX) (one-time disposal brought in by an employee of McCormick Self)

were placed in the pits, ammonium perchlorate oxidizer or diesel fuel was added to facilitate combustion, and the materials were ignited with an electric match. The propellant material reportedly burned completely; however, insulation and liner material from inside of the rocket casings often would not burn. Any unburned materials were saved for subsequent burns.

3.1.5 Release of Chemicals

Chemical releases include a spill of oil containing polychlorinated biphenyls (PCBs), a spill from an underground storage tank punctured during excavation, the burial of low-level radioactive waste, and releases resulting from the open burning of wastes. The open burning caused contamination of the groundwater and soil vapor under the burn pits. The PCB spill and underground storage tank spill were cleaned up immediately, and are discussed in Section 3.1.8 under Interim Remedial Measures. Other chemical releases are discussed in more detail in Section 4.0, Summary of Remedial Investigation Findings.

3.1.6 Chronology of Site Contamination, Investigation, and Remedial Activities

Table 3-2 provides an overview of the chronology of the contamination, investigation, and cleanup at individual locations of the Beaumont No. 1 site.

3.1.7 Previous Studies

Previous investigations, including hydrogeologic (remedial) investigations, the health risk assessment, and the feasibility study, are listed in Table 1-1.

Table 3-2

Chronology of Site Contamination, Investigation, and Cleanup at Individual Locations of the Beaumont No. 1 Site

Site	Date Occurred	Dates Cleanup Occurred
PCB transformer vandalized	April 1984	July–August 1984
Removal of three underground storage tanks	1984	All tanks removed in 1984
One-time burial of low-level radioactive waste	Approximately 1971	1989 [a]
Permitted landfill	Operated late 1960s to early 1974 under annually renewed permit from California Department of Forestry	No contamination detected in this area
Burn pits	1961–1974	Burn Pit Removal Action Plan[b]
Soil vapor	1960s–1974	Remedial Action Plan[c]
Groundwater	1960s–1974	Remedial Action Plan[c]

[a] All of the material discovered at the radioactive burial site was used up during the sampling and analysis program.

[b] The burn pit will undergo a removal action to remove burn pit wastes and soils after permitting for the Stephens kangaroo rat has been approved.

[c] Remediation of soil vapor and groundwater contamination is the subject of this Remedial Action Plan.

3.1.8 History of Interim Remedial Measures Implemented by Potentially Responsible Parties (PRPs) or the Department

Interim remedial measures completed at the Beaumont No. 1 site include cleanup of a PCB spill, removal of all underground storage tanks, and the investigation/ removal of the low-level radioactive material at a one-time burial site. A Removal Action Plan for the burn pit area has been submitted to the Department of Toxic Substances Control (DTSC) for approval.

PCB Spill

In April 1984, the site security guard discovered that a transformer containing PCBs had been vandalized. The transformer was located about 50 feet west of the Betatron building, as shown in Figure 3-2 (in Section 3.2.9). The drain valve had been opened and liquid was discharged to the transformer pad and surrounding soil; about 60 gallons of the transformer oil could not be accounted for when the transformer was inspected. The PCBs had contaminated the soil adjacent to the transformer pad, and some PCBs had been transported downslope by rainwater runoff.

On July 30, 1984, Lockheed submitted a cleanup plan to both the Riverside County Department of Environmental Health and the California Regional Water Quality Control Board (RWQCB), Santa Ana Region. All PCB-contaminated soil was excavated and transported to the Casmalia Class I disposal facility in Santa Barbara County, California. Resampling in the area revealed that PCB-contaminated soil had been adequately removed. In August 1984, Lockheed removed and properly disposed of all remaining transformers at the Beaumont No. 1 site. Both Riverside County and the RWQCB approved of the cleanup of the PCB spill (County of Riverside Department of Health, 1986; California Regional Water Quality Control Board, 1986).

Underground Tank Removal

In November 1984, Lockheed removed three underground fuel storage tanks from the Beaumont No. 1 facility. During excavation, one tank was perforated, which caused some fuel to spill into the soil. This soil was removed, and soil samples were collected from around all three tanks and from background locations. In response to the cleanup activities and laboratory results, the Riverside County Department of Health stated that "none of the levels were in a range which would warrant further remedial cleanup action" (County of Riverside Department of Health, 1985). The excavations were then backfilled and compacted.

Low-Level Radioactive Burial

The 1989 investigation of the one-time, low-level radioactive burial site included collecting samples of the buried materials. All of the radioactive materials at the burial site were collected for sampling and consumed in analysis. The low levels of radioactivity detected were well below regulatory levels. No further action is required in this area. The radioactive burial area is discussed in more detail in Section 4.1.3.

Burn Pit Removal Action

Lockheed submitted a *Burn Pit Removal Action Plan* to DTSC in April 1991. Although most of the wastes remaining in the burn pits, and the soil surrounding the pits, have been classified as nonhazardous, the plan calls for the removal and proper disposal off site of the burn pit residue. Lockheed is in the process of obtaining the necessary permits from the U.S. Fish and Wildlife Service for the endangered Stephens kangaroo rat (SKR) (*Dipodomys stephensi*), which inhabits this area, before the removal action can proceed. A detailed discussion of the burn pit area can be found in Section 4.1.3.

3.1.9 Other Significant Information

During the remedial investigation, Radian became aware of the presence of the SKR on the property. Since the SKR is a federally listed endangered species and a California-listed threatened species, proper permitting will be required before any activities, such as the Remedial and Removal Actions. Failure to do so would be in violation of Section 9 of the Federal Endangered Species Act and Section 2080 of the California Endangered Species Act. Lockheed and DTSC are presently discussing SKR issues with the U.S. Fish and Wildlife Service.

3.2 Physical Description

The Beaumont No. 1 site consists of 9,100 acres of semiarid land approximately 70 miles east of Los Angeles, in the foothills of the San Jacinto Mountains (see Figure 3-1 in Section 3.2.9). The facility is either fenced or bordered by very rugged terrain (see Figure 3-2 in Section 3.2.9). Access gates are locked at all times, and a security guard patrols the facility during normal working hours and on weekends.

3.2.1 Topography

The Beaumont No. 1 site is located in a broad valley in the western foothills of the San Jacinto Mountains, and is surrounded by gently rolling hills and rugged mountains. Elevations on the site range from 3,700 feet on the southern ridges, to 1,500 feet in Massacre Canyon in the southwestern corner of the site. Potrero Creek bisects the site in a northeast to southwest direction, and flows in a southerly direction through Massacre Canyon and into the San Jacinto Valley. The soils in the area are alluvial (floodplain) soils and are generally well drained.

3.2.2 Areal Extent of Contamination

Soil Contamination

In general, no significant levels of soil contamination were identified during the remedial investigations. The burn pit residues themselves contain low concentrations of volatile and semivolatile organic compounds, acetone, and chlorinated solvents. Analysis of soils immediately beneath the burn pit residue found very low levels of chlorinated volatile organic compounds (VOCs). These residues and soils have been classified as nonhazardous, with the exception of a few specific wastes, which were not classified, but which will be treated as hazardous for purposes of implementing the Burn Pit Removal Action. The Burn Pit Removal Action is discussed in more detail in Section 7.0.

The only deep soil contamination found at the Beaumont No. 1 site consisted of very low levels of chlorinated VOCs in one sample each from two borings in the burn pit area, at depths of 75 and 80 feet. The low concentrations in the soil are probably the result of migrating soil vapors and not direct contamination at the boring location, because these two locations are located away from the known source areas.

No soil contamination was discovered in samples taken at the radioactive waste burial site, the sanitary landfill, or the rocket motor production area.

Soil Vapor Contamination

Contamination in the soil vapor extends from the burn pit area northwest for approximately 1 mile. The distribution of chlorinated VOCs in soil vapor is shown in Figure 3-3 (in Section 3.2.9). The highest concentrations are beneath the burn pits, where concentrations in the shallow soil vapor reach 8,000 parts per billion by volume (ppbv); beneath the rocket motor production area, shallow soil vapor concentrations range up to 840 ppbv.

Beneath the burn pit area, soil vapor contamination increases with depth. Average concentrations are about 250,000 ppbv, with the highest concentrations of contaminants in the soil vapor occurring in the Mount Eden Formation near the water table. Approximately 75% of the total-mass of soil vapor contaminants lie within the 1,000 ppbv contour in the burn pit area (see Figure 3-4 in Section 3.2.9).

Groundwater Contamination

Chlorinated VOCs--Groundwater contaminated with chlorinated VOCs occupies an L-shaped area approximately 10,000 feet long and 500 to 1,700 feet wide (Figure 3-5 in Section 3.2.9). The contaminant plume generally follows the shape of the valley, flowing westerly (downgradient) from beneath the source at the burn pit. The highest concentrations of contaminants in the groundwater occur in the Mount Eden Formation beneath the burn pits. In general, the concentrations of contaminants in the water decrease with depth. Approximately 55% of the total mass of groundwater contaminants lie within the 1,000 micrograms per liter (g/L) contour in the burn pit area, as shown in Figure 3-6 (in Section 3.2.9).

Nitrates--Nitrate concentrations in groundwater generally range from less than 1 to 50 milligrams per liter (mg/L) nitrate expressed as nitrogen (Figure 3-7 in Section 3.2.9). A single result from one well indicated nitrate at 118 mg/L.

Perchlorates--Perchlorates were used by Lockheed to manufacture propellant at the Beaumont No. 1 site. Concentrations of perchlorates in groundwater range from below detectable levels to 9.1 mg/L, as shown in Figure 3-8 (in Section 3.2.9). The distribution of perchlorates is similar to the chlorinated VOC plume; however, the perchlorate plume is much smaller. No federal water quality standards exist for perchlorates. Since perchlorates were not consistently detectable during the treatability study extraction, no treatment of perchlorates is recommended.

3.2.3 Description of Buildings, Structures, and Current Uses on the Property

The primary structure on the Beaumont No. 1 property is a large concrete block building, known as the Betatron building, which formerly housed the x-ray machine used to inspect rocket motors. This building is currently used as the office for the security guard. Several small, one-room, concrete block structures also exist, which were once used to simulate different weather conditions. Several bunkers that were built into hillsides were used to hold instruments during the test-firing of rockets. These buildings are now empty and locked.

A large test stand made of concrete block was built into the side of a hill. This structure was formerly used to test-fire the large rocket motors that were built at the site.

The International Union of Operating Engineers has four or five trailers, which they used as offices during training activities. These are presently only used occasionally by the survey school classes.

The western portion of the site is currently used as sheep pasture.

3.2.4 Description of Outlying Area

The land immediately to the north of the Beaumont No. 1 site is hilly and steep (see Figure 3-2 in Section 3.2.9). Two miles north of the property boundary, just to the south of Beaumont and Banning, the land becomes relatively flat and has been developed primarily for residential and commercial uses. Terrain to the east, south, and west of the site consists of rugged hills and mountains that are uninhabitable.

3.2.5 Demography

The nearest population centers are the cities of Banning and Beaumont, California, located to the north of the site. According to the 1990 census, 22,000 people live in Banning, and 10,000 in Beaumont. The closest residential areas in these cities are recently constructed subdivisions on Highland Springs Road, located approximately 2 miles north of the burn pits.

To the south and east of the site, rugged, uninhabited mountains separate the site from the San Jacinto and Coachella Valleys. The closest population center in these directions is the town of San Jacinto, which lies approximately 5 miles south of the burn pits. The hills to the north and west are sparsely inhabited by ranchers. The nearest residence in these areas is a ranch located approximately 2 miles northwest of the burn pits.

Currently, the only employee on the site is the security guard, who divides his time between this and another property. Contractors involved with the site investigation make irregular visits to the site for variable durations. Basque sheep herders and, occasionally, survey school trainees also work on the site.

3.2.6 Location and Distance to Neaby Biological Receptors

The Beaumont No. 1 site supports a variety of habitats and wildlife. Habitats include chaparral, Riversidian sage scrub, disturbed/non-native grassland, riparian woodland, riparian scrub, freshwater marsh, and oak woodland. Because of the habitat diversity, the site also supports a variety of wildlife populations. Many bird species use the vegetation in the riparian areas for food and cover. A variety of rodent species inhabit the disturbed grasslands, sage scrub, and chaparral. These rodent populations in turn support a variety of reptilian, avian, and mammalian species.

The sensitive biological resources that occur on the site include:

- Habitats:
  - -- Riparian woodland. South Coast Riparian Woodland occurs on the site, primarily in the central and southwestern portions of the property in a band along Potrero Creek.
  - -- Coast live oak woodland. Approximately 30 acres of this habitat occur on the site, mainly on the north-facing slopes south of Potrero Creek.
- Animals:
  - -- Several sensitive animal species are known to occur in the area, including bobcat (*Lynx rufus*), mountain lion (*Felix concolor*), red-tailed hawk (*Buteo jamaicensis*), golden eagle (*Aquila chrysaetos*), American kestrel (*Falco sparverius*), and federally endangered Stephens kangaroo rat (*Dipodomys stephensi*).

3.2.7 Climatology

The climate in the region of the site is semiarid. Rainfall averages 20 inches per year across the northeast boundary, decreasing to approximately 14 inches per year at the southwestern boundary. Most rainfall occurs between November and April (California Department of Water Resources, 1978).

General temperature patterns in the area south of the city of Beaumont indicate a mean maximum January temperature of about 62°F and a mean minimum of 38°F. In July, these means are 96°F and 58°F, respectively (National Oceanic and Atmospheric Administration, 1978). The predominant wind direction is from the west at 6.1 miles per hour (California Air Resources Board [ARB], 1984).

3.2.8 Location of Nearest Water Well and Population Served by Well

There are presently no production wells drawing water from the contaminated aquifer. The nearest residence that may have a well is located approximately 1 mile from the site, in a direction that is upgradient and possibly in a different aquifer. Other residential supply wells may exist in a rural residential area approximately 2 miles upgradient. The nearest municipal supply well is located approximately 4 miles north of the burn pit area and is screened in an aquifer separate from the contaminated aquifer.

Wells at these locations would be isolated from the contaminated aquifer by relatively impermeable material (the Mt. Eden and San Timoteo formations and granitic rock). These impermeable formations completely surround the contaminated aquifer, and thus prevent the spread of contamination to other aquifers.

One Lockheed well, located downgradient of the area of groundwater contamination, has a pump installed in it. This well is only used to supply water to a fire control storage tank. The pump switch and the electric power supply are both locked.

Approximately 75 groundwater or soil vapor monitoring wells are located across the site.

3.2.9 Map of Property and Off-Site Areas

Figures 3-1 through 3-8 at the end of this section show the property, off-site areas, and the areal extent of contamination at the Beaumont No. 1 site.

The ruggedness of the hills surrounding the San Jacinto Nuevo y Potrero Valley can be seen on photographs taken of a physical model of the Lockheed Beaumont No. 1 site (Figure 3-9). The model allows the viewer to see into the formation, by removing layers of the model. The first photo (Figure 3-9a) shows the valley floor, the riparian vegetation along Potrero and Bedsprings creeks, and the burn pit area (in the lower right of the valley alluvium) viewed from the south. Each contour on the model represents 10 vertical feet. The blue area in the center of the alluvium is where the artificial pond was constructed; on the model, it represents an area where the water table reaches within 10 feet of the surface, or less than one contour interval. The black lines on the alluvium represent roads. Figure 3-9e shows a close-up of the burn pit area in the southeast of the valley.

In the second photo (Figure 3-9b), the alluvial soils above the groundwater have been removed to reveal the groundwater table surface and the corresponding gradient of groundwater flow. Black lines show contours of groundwater contamination; these contours correspond to those shown in Figure 3-5. Groundwater flow is generally to the west (left), toward Massacre Canyon. In the model, the groundwater layer ends where available data about the water table surface end. However, all groundwater flow in the San Jacinto Nuevo y Potrero Valley is believed to be evapotranspired by the vegetation in the valley; none currently flows into Massacre Canyon.

In the third photo (Figure 3-9c), the groundwater has been removed to show the subsurface contours of the bedrock underlying the valley, including the relatively impermeable Mt. Eden Formation.

In Figure 3-9d, the model has been reassembled. This view from the west clearly shows the ruggedness of the hills and the gentle slope of the alluvial valley as it narrows and approaches Massacre Canyon.

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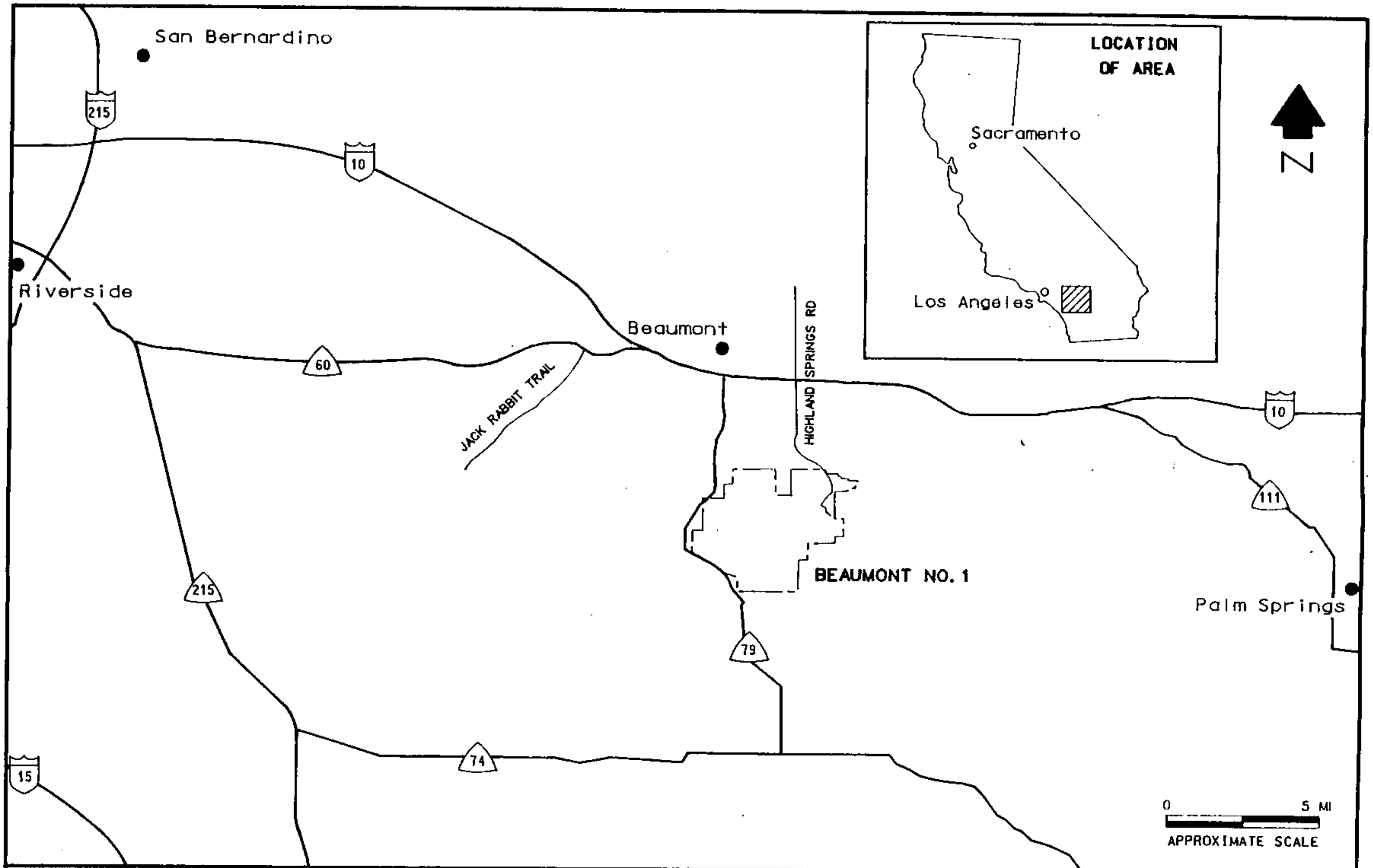

Figure 3-1. Location of Lockheed Beaumont No. 1

LOCK6 LCB1-2 2/14/92

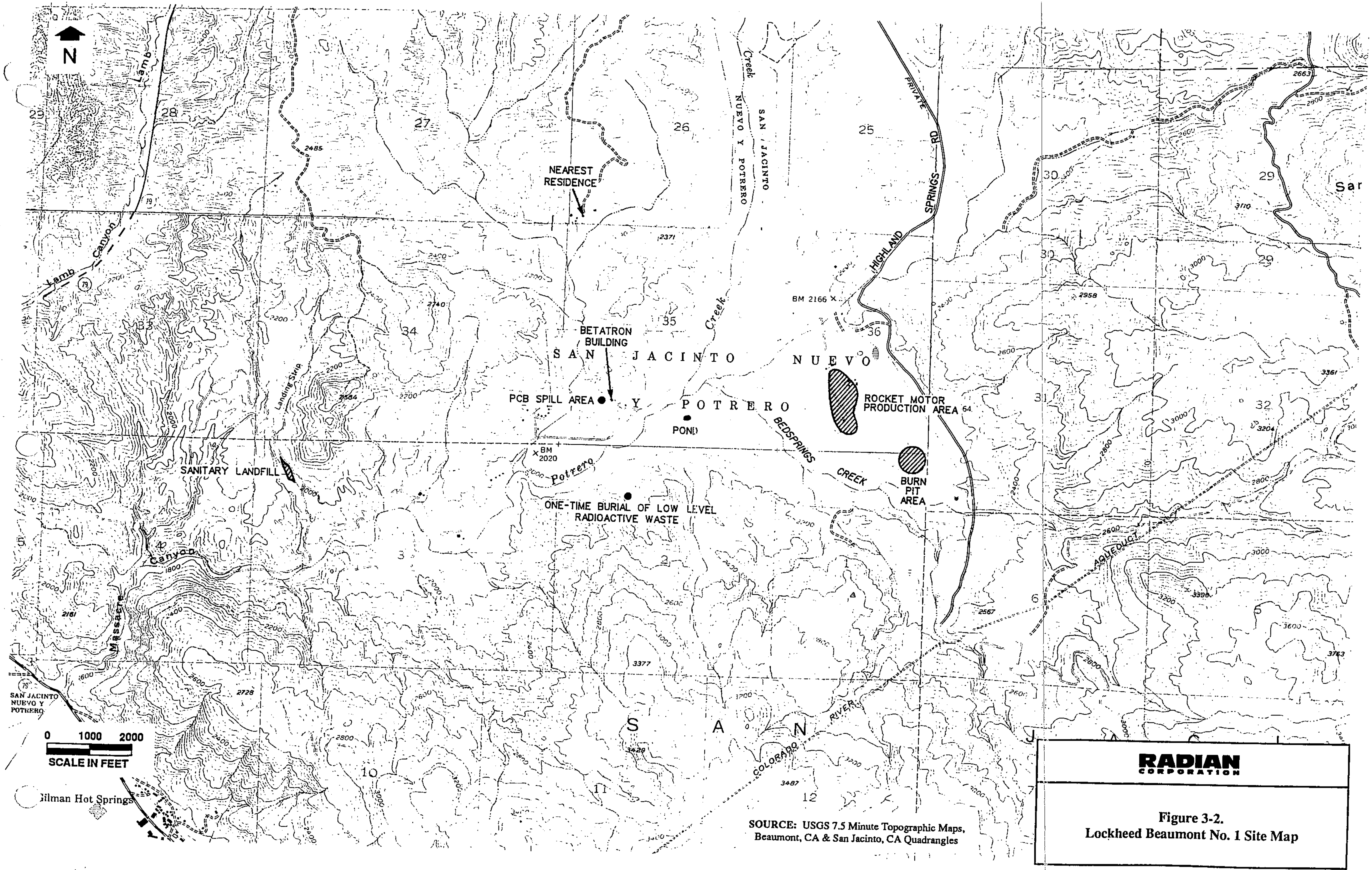

Figure 3-2.
Lockheed Beaumont No. 1 Site Map

SOURCE: USGS 7.5 Minute Topographic Maps, Beaumont, CA & San Jacinto, CA Quadrangles

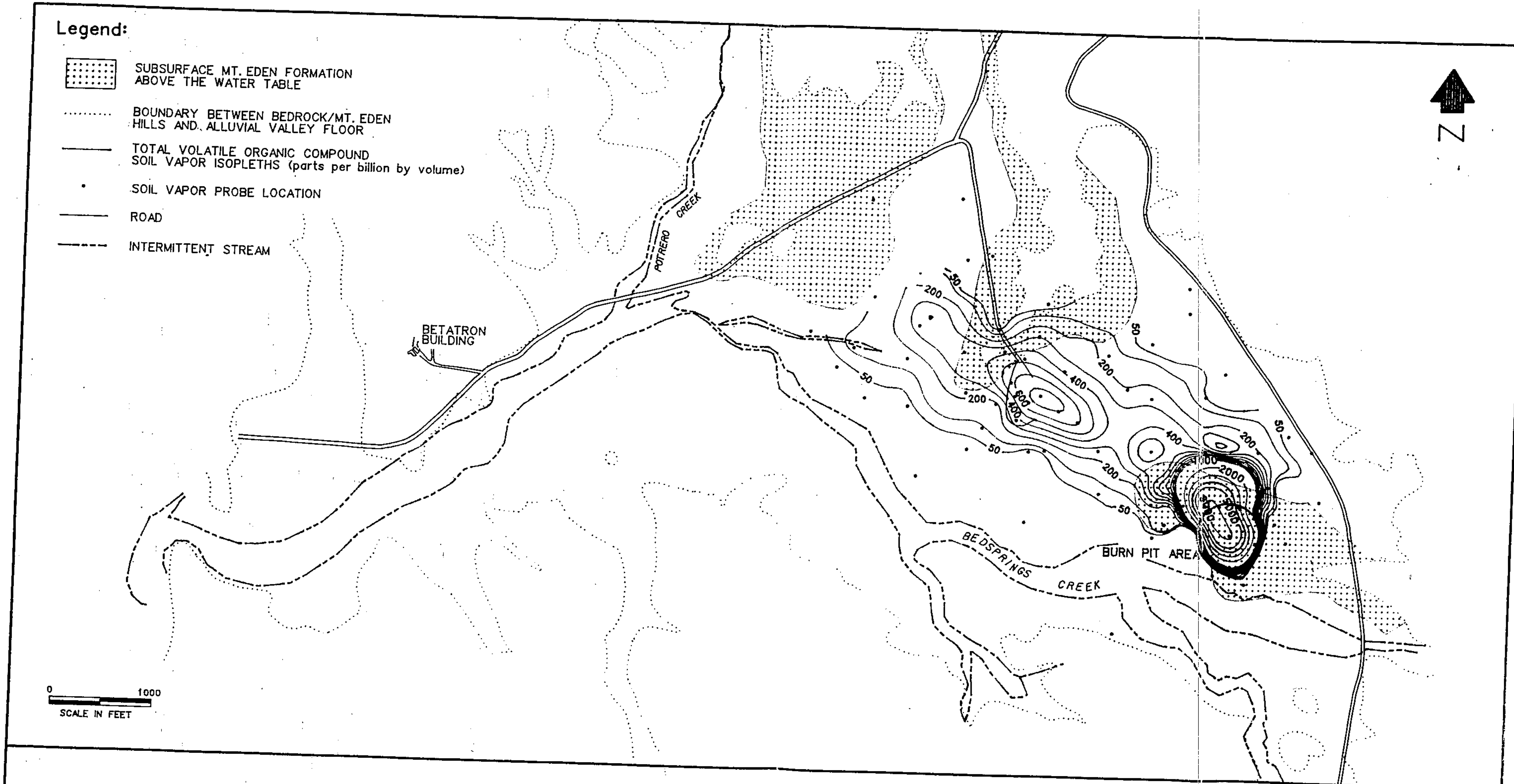

Figure 3-3.
Lockheed Beaumont No. 1
Soil Vapor Contamination

LOCK6 RAP TOT 04/30/92

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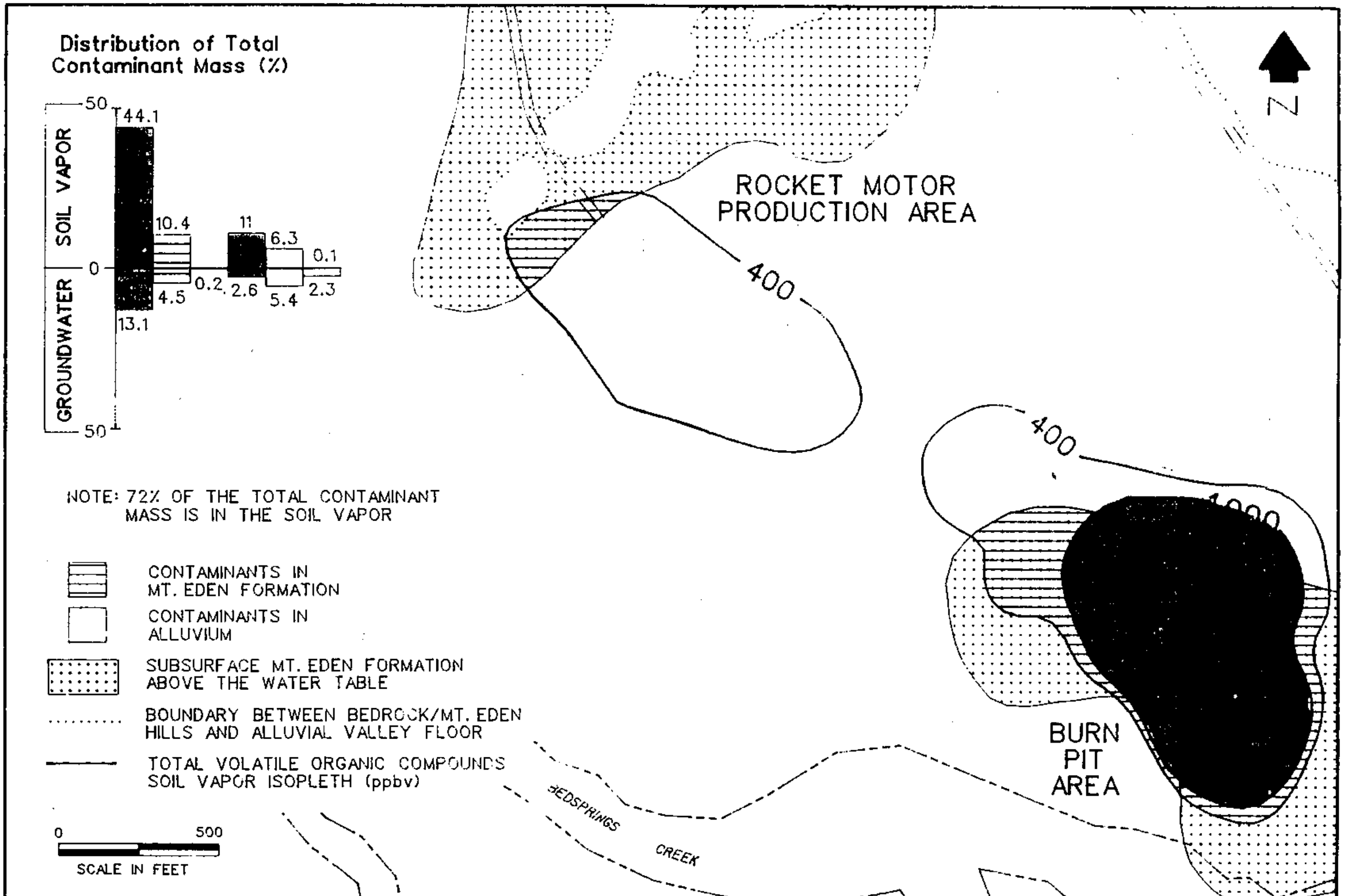

Figure 3-4. Lockheed Beaumont No. 1 Distribution of Contaminant Mass in Soil Vapor

VRL RAP SVMASS 5/04/92

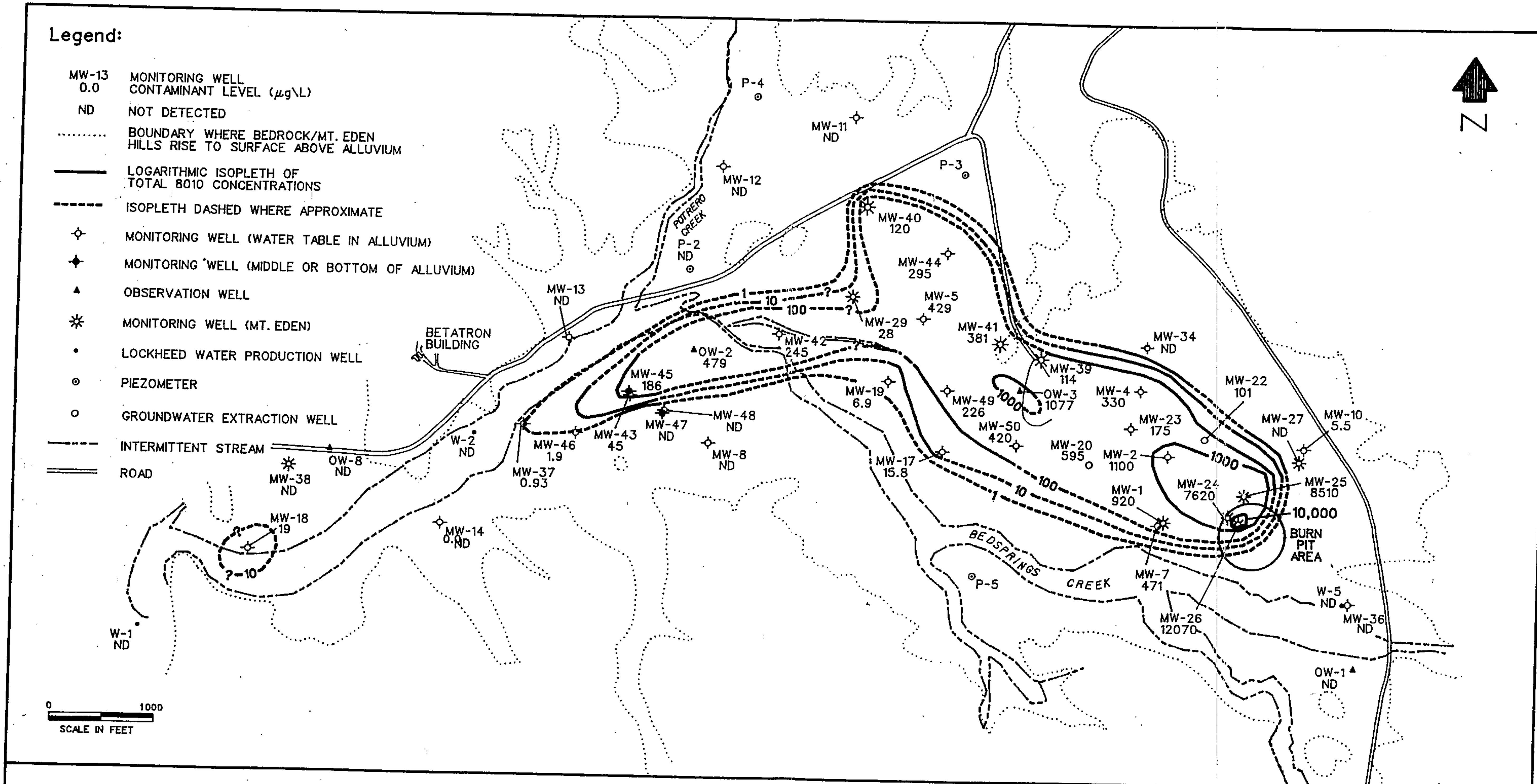

Figure 3-5.
Lockheed Beaumont No. 1
Total Volatile Organic Compound Concentrations in Groundwater

LOCKB RAP 8010A 04/29/92

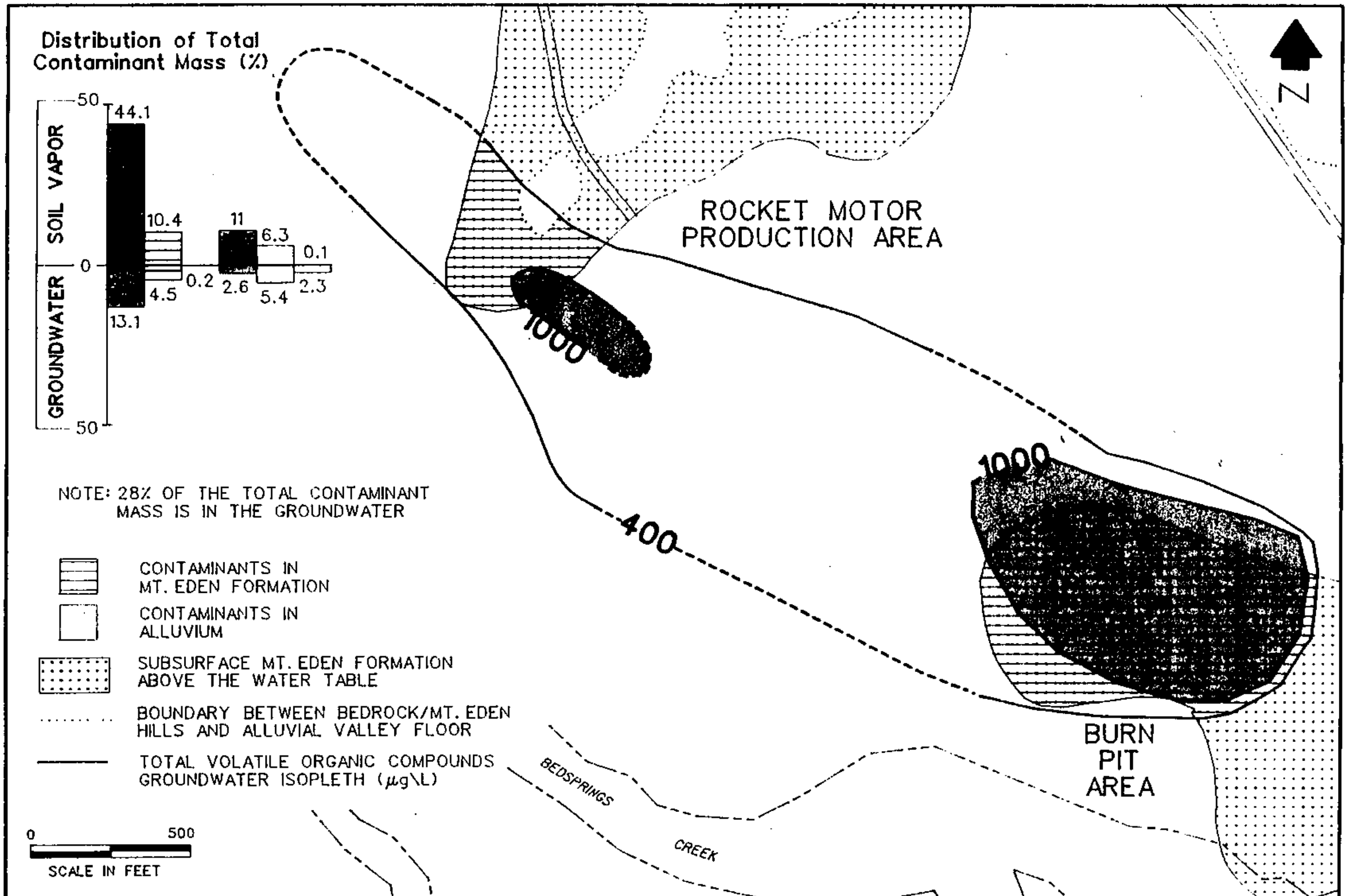

Figure 3-6. Lockheed Beaumont No. 1 Distribution of Contaminant Mass in Groundwater

VRL RAP GWMASS 5/04/92

RADIAN CORPORATION

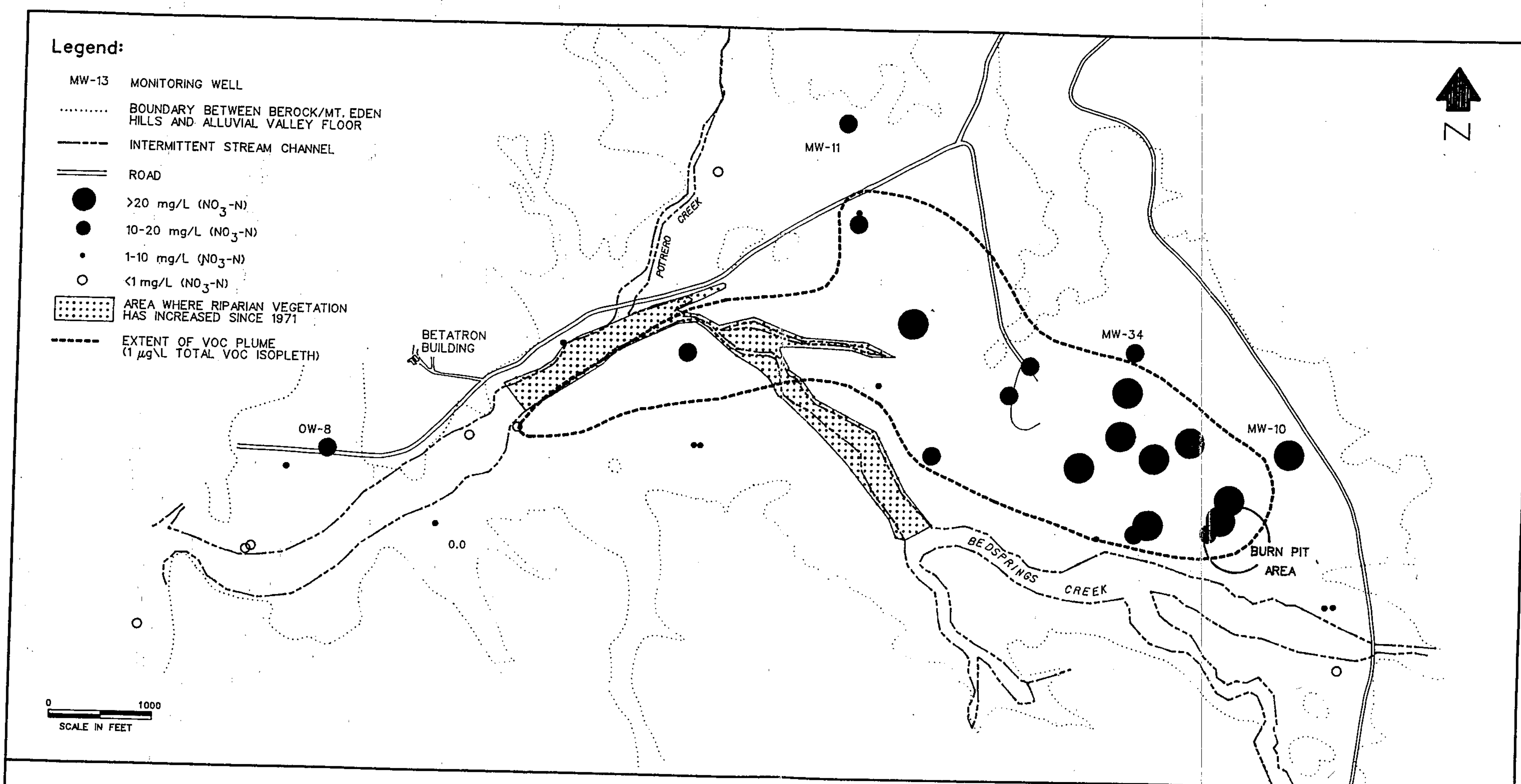

Figure 3-7.
Lockheed Beaumont No. 1
Nitrate Contamination
in Groundwater

LOCK8 RAP HRANIT 04/29/92

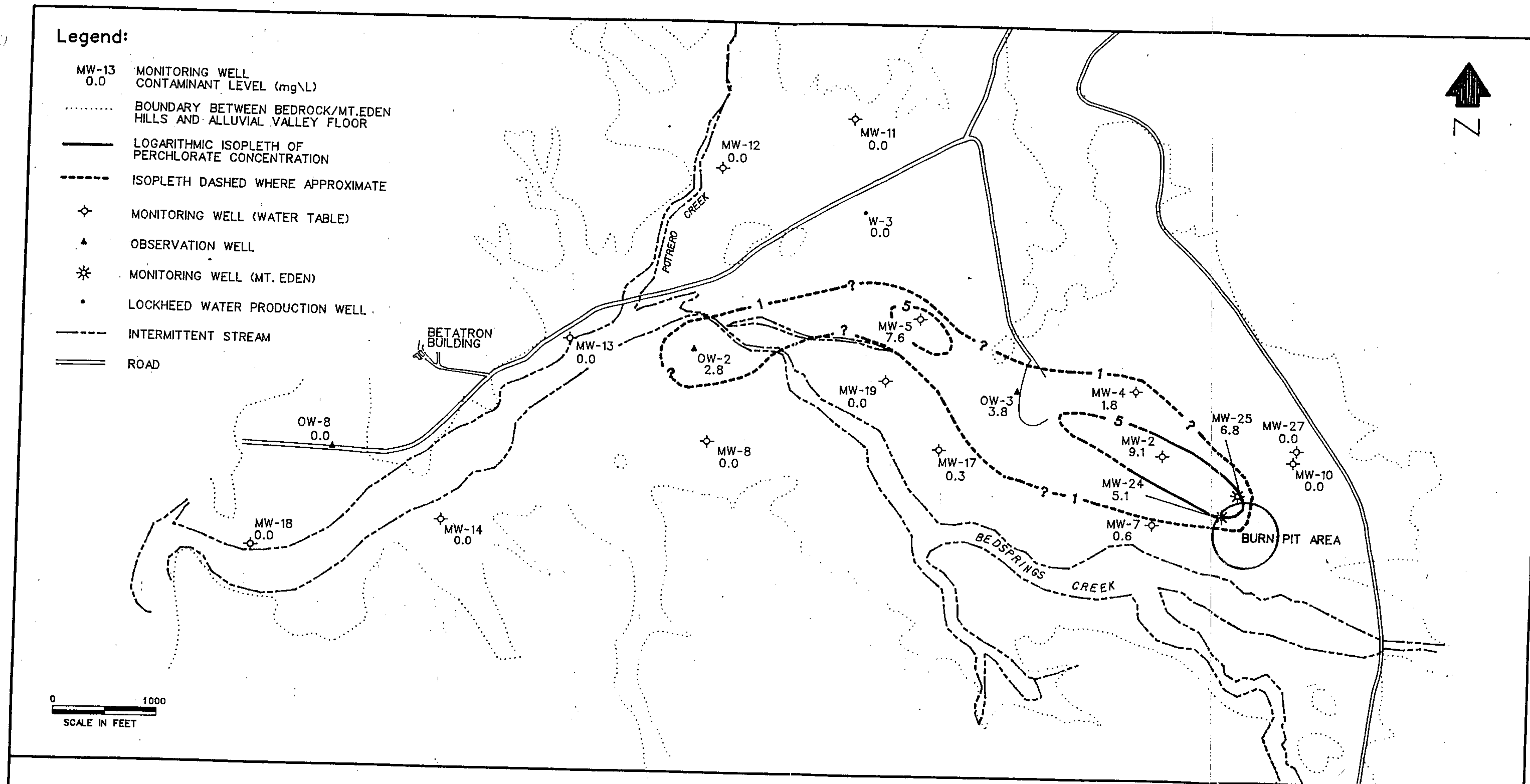

Figure 3-8.
Lockheed Beaumont No. 1
Perchlorate Concentrations in
Shallow Groundwater (Spring 1991)

LOCK6 RAP PERCH 04/29/92

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D. View of San Jacinto Nuevo y Potrero Valley from the West

N

LEGEND:
Green = Riparian Habitat
Lavender = Underlying Bedrock
Tan = Alluvial Valley

E. Closeup of Burn Pit Area

N

Figure 3-9. (continued) Model of Lockheed Beaumont No. 1 Site

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A. Surface Features

B. Groundwater Table Surface

C. Underlying Bedrock (including Mt. Eden Formation)

LEGEND:

N

Green = Riparian Habitat

Lavender = Underlying Bedrock (including Mt. Eden Formation)

Blue = Groundwater/Water Table (black lines are logarithmic contours of groundwater contamination)

Tan = Alluvial Valley (Burn Pit in lower right corner)

Figure 3-9. Model of Lockheed Beaumont No. 1 Site

4.0 SUMMARY OF REMEDIAL INVESTIGATION (RI) FINDINGS

The investigations performed at the Lockheed Beaumont No. 1 site (see Table 1-1) have delineated four areas of interest: the site of a one-time burial of low-level radioactive waste, the sanitary landfill site, the rocket motor production area, and the burn pit area. Of those areas, the sanitary landfill area was determined to contain no contamination. The radioactive burial site was found to have radioactivity that was well below reportable regulatory levels; all of the buried material was used up while being analyzed. Contaminants from the burn pit area (and to a lesser extent, the rocket motor production area) were found to have migrated to the soil vapor and to groundwater beneath the site.

4.1 Geological Investigation of Site and Adjacent Area

The information discussed below is described in more detail in the *Lockheed Propulsion Company, Beaumont Test Facilities, Source and Hydrogeologic Investigation* (Radian, 1990) and the *Hydrogeologic Investigation* (Radian, pending).

4.1.1 Types of Soils/Rocks

The Lockheed Beaumont No. 1 site is located in a small valley in the northwestern foothills of the San Jacinto Mountains. This valley trends southwesterly, and extends approximately 12 miles from the San Gorgonio Pass on the north to the San Jacinto Valley (see Figure 3-1). The valley floor loses approximately 1,000 feet in elevation in this distance. A large portion of the Beaumont No. 1 facility is located in the wide part of a flat valley known as San Jacinto Nuevo y Potrero. Southwest of San Jacinto Nuevo y Potrero, the valley steepens toward Massacre Canyon and descends more rapidly to the San Jacinto Valley.

The soils at the site can roughly be divided into upland soils and alluvial (floodplain) soils. The upland soils are well drained, and include the Cienega, Escondido, Fallbrook, Friant, and San Timoteo series. Cienega soils form in coarse-grained igneous rock. Escondido soils originate from metamorphosed sandstone and mica schist. Fallbrook soils originate from granodiorite and tonalite, Friant soils from weathered mica schist, and San Timoteo soils from calcareous marine sediment and weak sandstone (Westec Services, Inc., 1988).

The alluvial and floodplain soils include the Hanford, Gorgonia, Grangeville, Tujunga, San Emigdio, Metz, and Ramona series. The first four series are well drained soils of granitic origin. The last three series are well drained and characterized by slow to medium runoff (Westec Services, Inc., 1988).

4.1.2 Site Geology

The regional stratigraphy in the vicinity of the site, from oldest to youngest, consists of:

- The basement complex of late Paleozoic to middle Mesozoic age metasedimentary rocks and Mesozoic granitic rocks;
- Sedimentary deposits of the Pliocene age to Pleistocene age Mount Eden Formation overlain by the sedimentary San Timoteo Formation; and
- Quaternary alluvium, which is divided into Older and Recent.

The metasedimentary rocks of the basement complex chiefly consist of foliated, gray, micaceous schists and pink to gray gneiss. The basement complex includes the intrusive rocks that underlie and flank the San Jacinto Nuevo y Potrero Valley. These granitic rocks are exposed in the southern and western hills surrounding the valley, adjacent to metasedimentary rocks, or occur as boulders flanking intrusive outcrops.

Sedimentary rocks of continental origin, which overlie the basement rocks, are divided into the Mount Eden Formation and the overlying San Timoteo Formation. The Mount Eden Formation is the most widespread unit outcropping around and underlying the San Jacinto Nuevo y Potrero Valley. The Mount Eden Formation is of early Pliocene age, and is chiefly composed of red to dark brown arkosic sandstones and conglomerates with silty and clayey sand horizons (Fraser, 1931). The unit is well cemented and, in outcrop, appears as a deep red or gray, hard, resistant sandstone or conglomerate. Where it is exposed, the Mount Eden Formation forms rounded, steep-sided ridges.

The San Timoteo Formation, of Upper Pliocene or Pleistocene age, occurs only in the northern portion of the site (i.e., for the most part, north of the area where the soil and groundwater have been contaminated). The San Timoteo Formation is primarily composed of poorly indurated, greenish-gray interbedded sandstone, siltstone, shale, claystone, and minor conglomerates. The San Timoteo Formation crops out at higher elevations north of the San Jacinto Nuevo y Potrero Valley.

In the center of the San Jacinto Nuevo y Potrero Valley, relatively permeable alluvial deposits overlie the Mount Eden Formation. These deposits were left as the result of erosion of the surrounding hills and mountains. Alluvial deposits consist of older alluvium (Pleistocene age) and recent alluvium. The older alluvium is generally found flanking the southern part of Potrero Creek above the entrance to Massacre Canyon. Recent age alluvium overlies the older alluvium within the San Jacinto Nuevo y Potrero Valley and is the main water-bearing unit in the area. North of the creek, the source of alluvium is the finer grained San Timoteo Formation; south and east of the creek, the sources of alluvium are the coarser grained Mount Eden Formation and granitic rock.

At the site, the alluvial deposits are approximately 50 to 90 feet thick. The alluvium is less than 15 feet thick near the margins of the valley and along the section of

Potrero Creek where the valley narrows to a canyon, southwest of the permitted landfill. The maximum thickness of the alluvium measured in a borehole is 134 feet. Figure 4-1 shows a generalized cross-sectional view of the deposits underlying the Beaumont No. 1 site.

Locally, the Mount Eden Formation is found at quite shallow depths even in the central portion of the valley. In portions of the site, notably the burn pit and rocket motor production areas, ridges of the Mount Eden Formation extend outward into the valley beneath the surface of the alluvium (Figure 4-2). These buried ridges or hills appear to have shapes similar to exposed portions of the Mount Eden Formation in that they often occur as round-topped ridges with relatively steep sides. The presence of these features is significant in that they influence the movement of contaminants in soil vapor and groundwater.

No wells drilled by Radian encountered the granitic bedrock, other than at two locations north and west of the burn pit area. Although these boreholes are located close to the granitic source rock, it is possible that a granitic boulder may have been embedded in the Quaternary alluvium.

4.1.3 Contaminant Assessment

Four areas at the Lockheed Beaumont No. 1 site have been investigated for soil contamination: the site of a one-time burial of low-level radioactive waste, the permitted landfill, the burn pit area, and the rocket motor production area. The results of these investigations are discussed separately below.

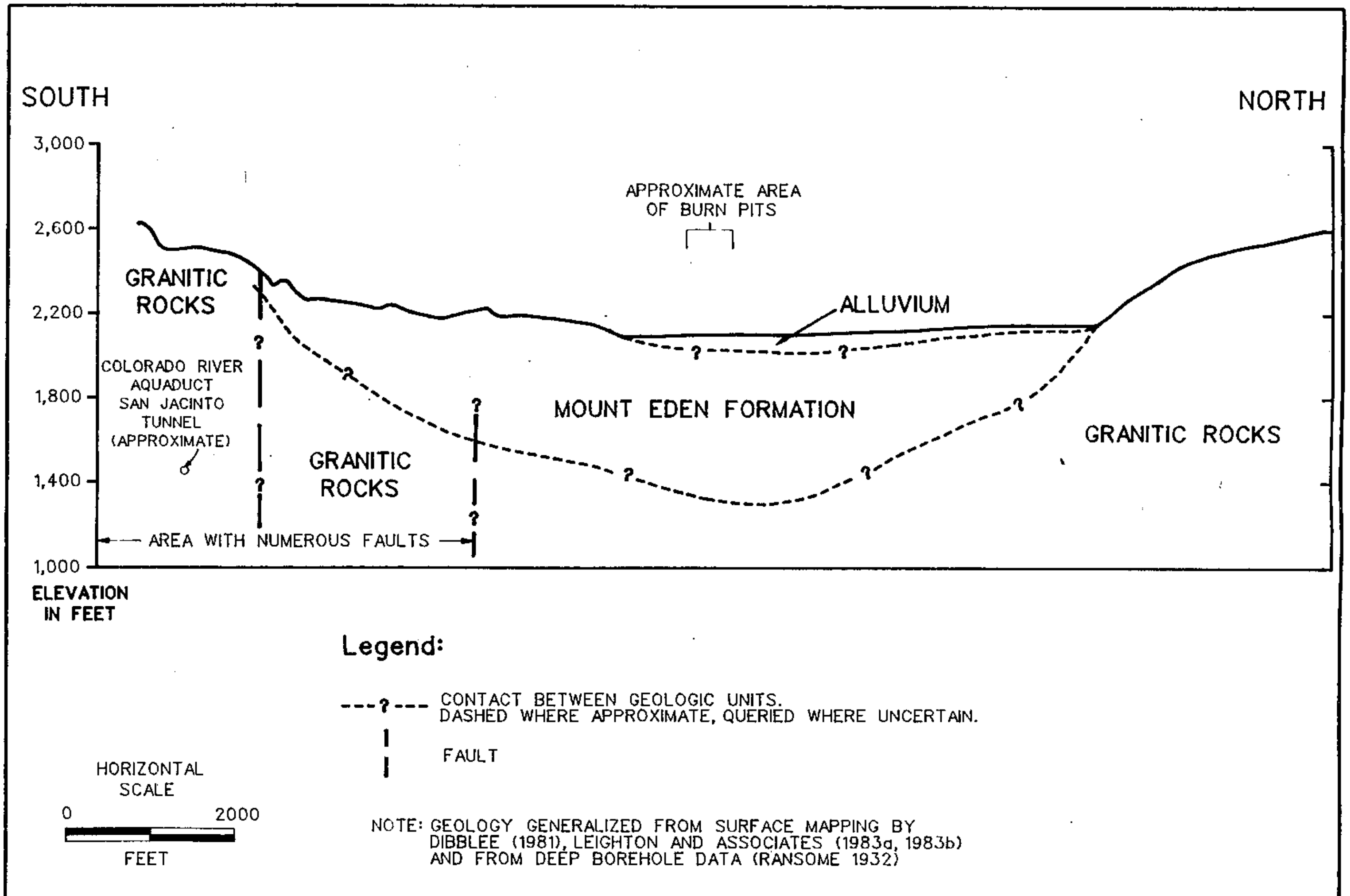

Figure 4-1. Generalized Cross Section of Lockheed Beaumont No. 1

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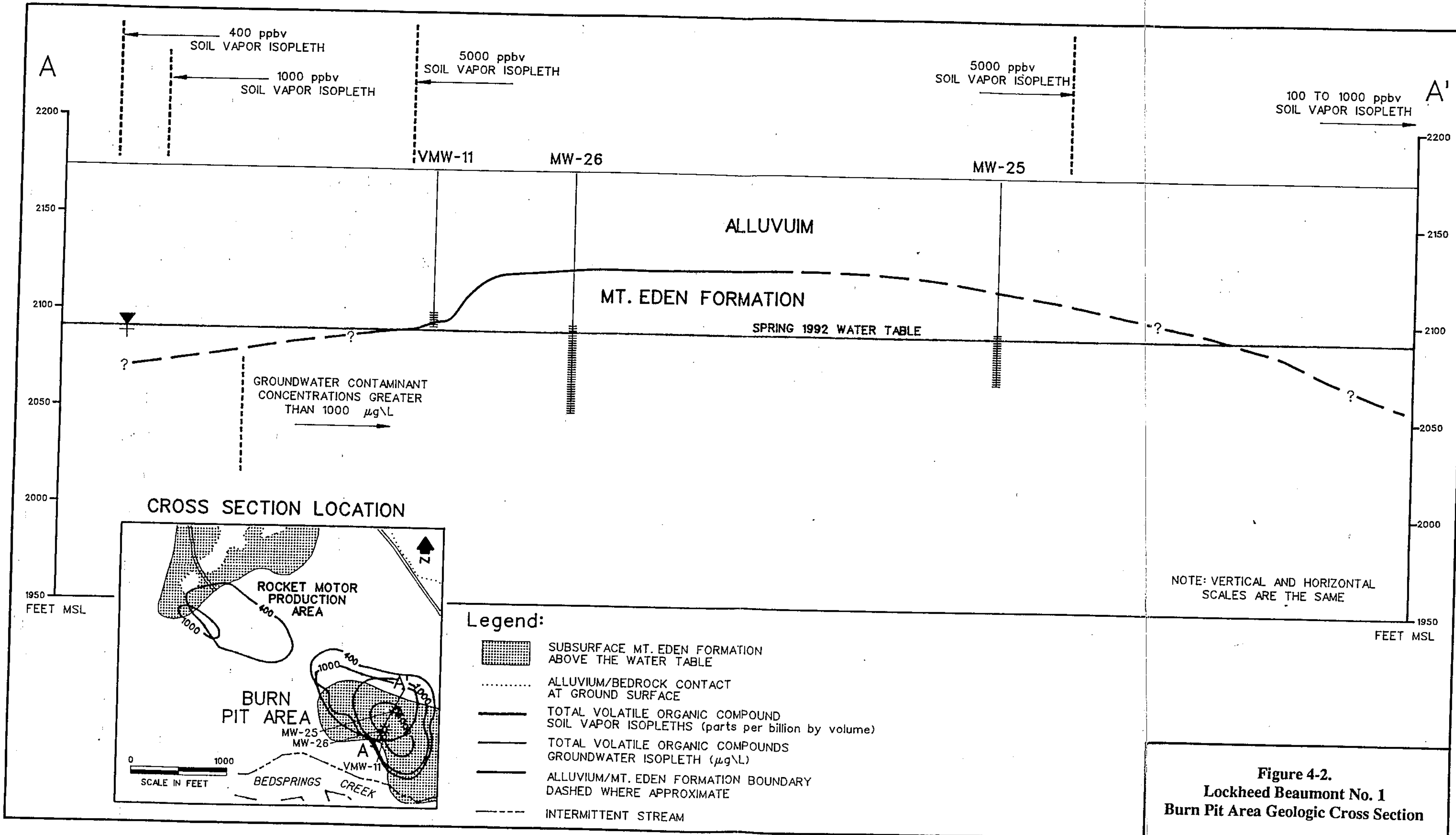

Figure 4-2.
Lockheed Beaumont No. 1
Burn Pit Area Geologic Cross Section

VRL RAP BPXSEC 5/01/92

Low-Level Radioactive Waste Burial Area

During a single incident in 1971, a small amount of low-level radioactive material in glass containers was buried in one of the side canyons southeast of the Betatron building at the Lockheed Beaumont No. 1 site. The material was reportedly laboratory glassware and water or acid used to wipe down the counters during cleanup of the Lockheed Propulsion Company (LPC) Redlands chemistry laboratory (Radian, 1990). The laboratory used small quantities of weak beta radiation emitters as tracer compounds during solid rocket propellant test burns. These compounds reportedly were carbon 14 (C^{14}), tritium (H^3), and sulfur 35 (S^{35}). When the laboratory was dismantled, this tracer material was collected and sent to a proper radioactive waste disposal site. The cleaning liquids used to wipe down the laboratory counters as part of final cleanup were placed in glass jars and buried at the Beaumont facility.

Radian attempted to determine the location of the buried radioactive wastes using several methods, including: site visits by former Lockheed employees, aerial photographic interpretation, radiation monitoring with Geiger counters, and geophysical surveys using ground-penetrating radar and magnetometry.

The collective information from several former Lockheed employees indicated that the containerized waste was buried in a location that had an unobstructed view of the Betatron building, a steep red-rock cliff to the east, and a ditch to the west. Based on this information, four canyons were identified as potential burial sites.

After the geophysical investigation was completed, further inspection toward the head of one canyon, which became narrow and quite brushy, revealed a small side canyon to the east with an unnatural mound in the center. The mound was too far away from the steep canyon wall to have been caused by slumping and looked as though it had been graded to direct water to run off on either side. A hole dug into the mound showed homogeneous soil to a depth of 3 feet; similar holes dug nearby indicated clearly differentiated soil horizons. A 3-foot deep creek drainage was close by to the west. The Betatron building was clearly visible down the main canyon. An old tree stump that was upside down on the mound indicated that the area had been disturbed. A former safety officer who was present during the burial indicated that the site looked familiar and closely resembled the typical grading pattern used by the bulldozer operators.

The area was investigated by carefully trenching the mound while continuously monitoring with radiation detecting equipment. The waste was found at an approximate depth of 4 feet below land surface (BLS) at the southeast corner of the mounded area. The following types of wastes were found in an area approximately 2 feet long by 2 feet wide by 1 foot deep:

- Two broken 5-gallon glass jars with metal lids.
- Approximately 20 broken or empty 10-milliliter to 50-milliliter plastic and glass vials.
- Four small, unopened vials containing an orange or white solid material (possibly tracer materials).
- Two broken 1-gallon amber glass jars.
- A 1-quart jar containing a small amount of white powder.
- One open, empty 1-quart jar.
- Assorted pipettes and broken laboratory volumetric flasks, tubes, vials, etc.
- A small amount (less than one-half cubic foot) of laboratory trash including aluminum trays, plastic bags, etc. (this material was the only waste that had a Geiger-Müller reading slightly higher than background).
- A 1-gallon clear glass jar with a yellow plastic cap (a reused sulfuric acid container) approximately three-quarters full of a green fluid marked "Radioactive Waste Cl..." ("Cl" possibly stands for cleaner, but the rest of the label was unreadable.)

The fluid in the jar did not register any reading on either the photoionization detector (PID) or the Geiger-Müller detector. The fluid was transferred into two 1-liter sample jars and shipped, along with the rest of the buried waste found in the excavation, to the Radian Austin Laboratory for analysis. All of the discovered material fit into a single 30-quart cooler. Approximately one-half cubic yard of soil surrounding the buried material was stockpiled on plastic, sampled, and covered. The backhoe then deepened and enlarged the excavation area until native soil was encountered on all sides. No additional waste or evidence of trenching was discovered. All of the waste reportedly buried at the site was accounted for and was removed for analysis. All of the sampled material was used up during the laboratory analysis.

Analysis of the green fluid in the unbroken jar and the contents of tracer vials confirmed the reports that the buried waste consisted of low-level beta radiation emitters, C^{14} and H^3, used at the Redlands facility. All of the isotopes detected in the green fluid were detected at very low levels, well below both the soluble and the insoluble release limits specified under Title 17 California Code of Regulations (CCR), Section 30355.

The vials containing orange and white solid materials were analyzed for gross alpha and beta radiation only. The analytical results indicated the presence of low-energy beta emitters, such as C^{14}, consistent with the interview reports of the former employees, which indicated the use of C^{14} as a tracer material.

Although S^{35} was also used as a tracer material, this radionuclide has a half-life of 87.1 days and, if present, would have decayed to below detectable levels in the 18 years after it was buried (approximately 75 half-lives).

Radiochemical analysis was also performed on four soil samples from above, around, and below the buried material. The soil samples were analyzed for gross alpha, gross beta, and gamma radioactivity. The concentrations of gamma-emitting isotopes in the samples of soil above the waste, around the broken glass, and below the glass indicate that all radioactivity levels are essentially equal, given the inherent errors in measurement techniques. The radioactivity levels of potassium (K^{40}) and radium (Ra^{226}) detected in the burial site soil were within the range of naturally occurring gamma-emitting radionuclide concentrations, and are exempt from regulatory requirements under Title 17 CCR, Section 30180 (c)(1).

All of the radioactive liquid and material in the tracer vials was completely used up during the laboratory analysis; none was left to dispose. The soils at the burial site did not indicate measurable concentrations of radioactivity above naturally occurring levels. Therefore, no further action is required at the burial site.

Permitted Landfill

The permitted landfill is located on the western side of the Beaumont No. 1 site overlooking a deeply incised intermittent stream channel. The 3-acre landfill was permitted during the late 1960s and early 1970s by the California Department of Forestry. The permit allowed Lockheed to dispose of trash, such as paper, scrap metal, concrete, and wood. According to interviews with former employees (Radian, 1986a), the landfill received trash generated by routine operations at the Beaumont No. 1 facility. Lockheed policy strictly dictated that hazardous materials were not to be discarded in this landfill. Former employees and visual observation indicated that trenches were dug using bulldozers, filled with trash, covered with soil, and leveled. Pieces of metal, tires, wood, and empty 55-gallon drums are currently visible on the surface, indicating the locations of some of the trenches.

To identify the lateral extent of the landfill, the historical photographs and magnetometry data collected for the *Preliminary Remedial Investigation* (Radian, 1986b) were reviewed during the *Source and Hydrogeologic Investigation* (Radian, 1990).

Patterns of low-lying or depressed soils indicative of subsurface disturbance were also used to identify potential trench locations.

In September 1989, 23 trenches of various lengths were dug at the landfill area with a large tracked excavator. Trash was found in 11 trenches; the other 12 were clean. When trash was found, the trench was continued vertically and horizontally until soil without any debris was encountered.

The trash consisted of two types of material: general waste and scrap metal. General waste included paper, wood debris, plastic bags and sheeting, and rubber scrap. Food cans and other household wastes were only occasionally uncovered during the excavation, indicating that very little municipal garbage was placed in the landfill. Scrap metal waste included empty drums, wire, welding rods, and spent rocket casings. The depth of buried waste varied from 4 to 10 feet BLS. Soil samples were taken below the waste at four different locations selected to represent different types of waste found in the trenches.

Soil Sample Analyses--Soil samples from all four locations were analyzed for volatile organic compounds (VOCs) and semivolatile organic compounds by gas chromatography/mass spectroscopy (GC/MS). Tentatively identified compounds (TICs) were reported for both analyses. TICs are compounds that are not on the analyte list for VOCs or semivolatile organic compounds but which can be identified, if requested, using additional chemical library databases to interpret the GC/MS data. Samples were also analyzed for priority pollutant metals and for nitrates.

The analytical results for the samples collected at the sanitary landfill did not show any significant levels of priority pollutants. All metals concentrations were less than 10 times the soluble threshold limit concentrations (CCR, Title 22). The concentration of nitrates found ranged from 2.1 to 19 parts per billion (ppb). These values fall within the naturally occurring range for nitrate concentrations in soils from non-agricultural lands in the California Central Valley. No significant levels of VOCs or semivolatile organic compounds in the soils were found.

Soil Vapor Analyses--Soil vapor samples were also collected in the area of the permitted landfill. Analytical results showed concentrations of 1,1,1-trichloroethane (1,1,1-TCA) and trichloroethene (TCE), all at concentrations below 10 parts per billion by volume (ppbv). These levels were almost indistinguishable from the background instrument response. Based on these results, the soil vapor investigation at the landfill was concluded.

Groundwater Analyses--A groundwater monitoring well was installed downgradient of the landfill. Groundwater samples were analyzed for VOCs, phenolic compounds, and metals. No compounds were detected at concentrations of concern.

These results were consistent with Lockheed's policy of strictly prohibiting the disposal of hazardous materials in the landfill. No further action is recommended for the landfill.

Rocket Motor Production Area

The rocket motor production area, located to the northwest of the burn pit area, was used from 1961 until 1966, and once very six months from 1970 until 1974, for the manufacture of solid rocket propellant. Facilities included a fuel slurry station, propellant mixing station, a motor cast and cure station, and a motor casing washout area.

Solid propellant rocket motors are simple units with no moving parts. Propellant formulas by Lockheed consisted of the dry oxidizer, aluminum, liquid fuel ingredients, and burn rate modifiers.

Solid propellant combustion required such large amounts of oxygen that the propellant contains much more oxidizer than fuel (up to 90% of the propellant by weight). The most widely used oxidizer was ammonium perchlorate, a colorless crystalline salt, which was ground to a fine powder. All oxidizer grinding was done at the Redlands facility; oxidizer proportions and particle sizes were precisely controlled because of the profound effect they exerted on the rate the propellant burned.

The fuel itself consisted primarily of aluminum. The liquid ingredients consisted mostly of butadiene, which caused the propellant to cure to a rubber-like material. Ignition of the fuel and oxidizer mixture generated heat and pressure that continued until the propellant was consumed. The burn rate modifiers, which consisted mostly of iron, helped to control the rate of combustion. The various propellant formulations differed mainly by the type of burn rate modifier used. Flame temperatures of burning propellant ranged from 5,000 to 6,000°F.

The production of solid rocket motors involved several steps. First, the metal chambers that held the propellant were insulated with either a rubber sheet or liquid mastic, lined with a rubber-based material, and set up for casting.

Next, the fuel and burn rate modifier ingredients were carefully weighed and formally accepted for use. The weights were verified to help ensure that each propellant batch met required specifications and had nearly identical properties. The fuel and modifier ingredients were premixed as a fuel slurry before being transported to the propellant mix station.

The fuel slurry and oxidizer were combined in a large, vertical mixing machine into a homogeneous fluid. The dry oxidizer was hoisted above the mixer and dropped in at a controlled rate while blades within the mixer blended it with the liquid ingredients. Mix operations were controlled from a nearby bunker built into the side of a hill. The propellant mix cycle took about eight hours, including cleanup, which involved scraping and wiping down all containers and mixing equipment to remove any remaining propellant.

After mixing, the thick, viscous propellant was poured under vacuum into the insulated and lined metal casings. The cast propellant was then cured by heating it to 140°F for several days; curing resulted in a solid, rubbery mass bonded to the insulation. Casting and curing was done at a stand located a short distance to the south of the mix station.

Lockheed had detailed quality control and safety procedures established for propellant mixing, and required the procedures to be followed precisely throughout the manufacturing cycle. Batches of propellant that did not meet specifications, and cleaning material (including the paper used for wipedown) were taken to the burn pits for incineration.

During plant closure in 1974, all usable parts from the mix station were dismantled and taken off site to be sold. The concrete foundations of the mix and slurry stations remain today, as does the mix station bunker. No adverse environmental impacts appear to exist at the propellant mixing area as a result of past activities. Lockheed required that the site be kept clean during all operations, and that all propellant waste be taken to the burn pit for disposal.

Soil samples collected from borings at the rocket motor production area showed no contamination. Soil vapor and groundwater samples indicated that the production area was a secondary source of contamination, much less significant than the burn pit area. Soil vapor and groundwater remediation strategies for this area are discussed in Sections 8.0 and 9.0.

Burn Pit Area

The burn pit area covers 4 acres of a broad valley in the southeastern portion of the Beaumont No. 1 site (see Figure 3-2). The burn pits were operated from 1962 until 1974 for the disposal and subsequent burning of waste propellant and other materials used in the production of rocket motors (see Table 3-1). Historical information about the burn pit area operation was gathered from several sources, including interviews with former Lockheed employees, review of historical photographs, and observations made during site visits and investigations. According to former Lockheed employees, the burn pits were excavated with a bulldozer and generally measured 50 to 100 feet long, 6 to 8 feet wide, and 4 to 6 feet deep. As many as 20 burn pits were excavated, and some pits were used more than once. Waste materials were placed in the pits, ammonium perchlorate oxidizer or diesel fuel was added to facilitate combustion, and the materials were ignited with an electric match. The resulting fire was occasionally hot enough to melt sand (2,300°F); temperatures of the flames may have been higher. The propellant material reportedly burned completely; however, insulation and liner material from inside of the rocket casings often would not burn. Any unburned materials were saved for subsequent burns. Operation of the burn pits was suspended in 1974.

Aerial photographs from 1961, 1972, 1974, and 1980 confirm the reported north-south orientations of most of the burn pits and also indicate that the burn pits were primarily located in the immediate vicinity of the two currently existing north-south oriented mounds. Figure 4-3 is a compilation of burn pit locations identified from the available aerial photographs and sampling activities.

In 1986, Radian conducted a geophysical investigation of the burn pit area using terrain conductivity and magnetometry techniques (Radian, 1986b). In September 1989, a remedial investigation was conducted to identify the waste materials and contaminant source areas within the burn pit area (Radian, 1990). In the burn pit area,

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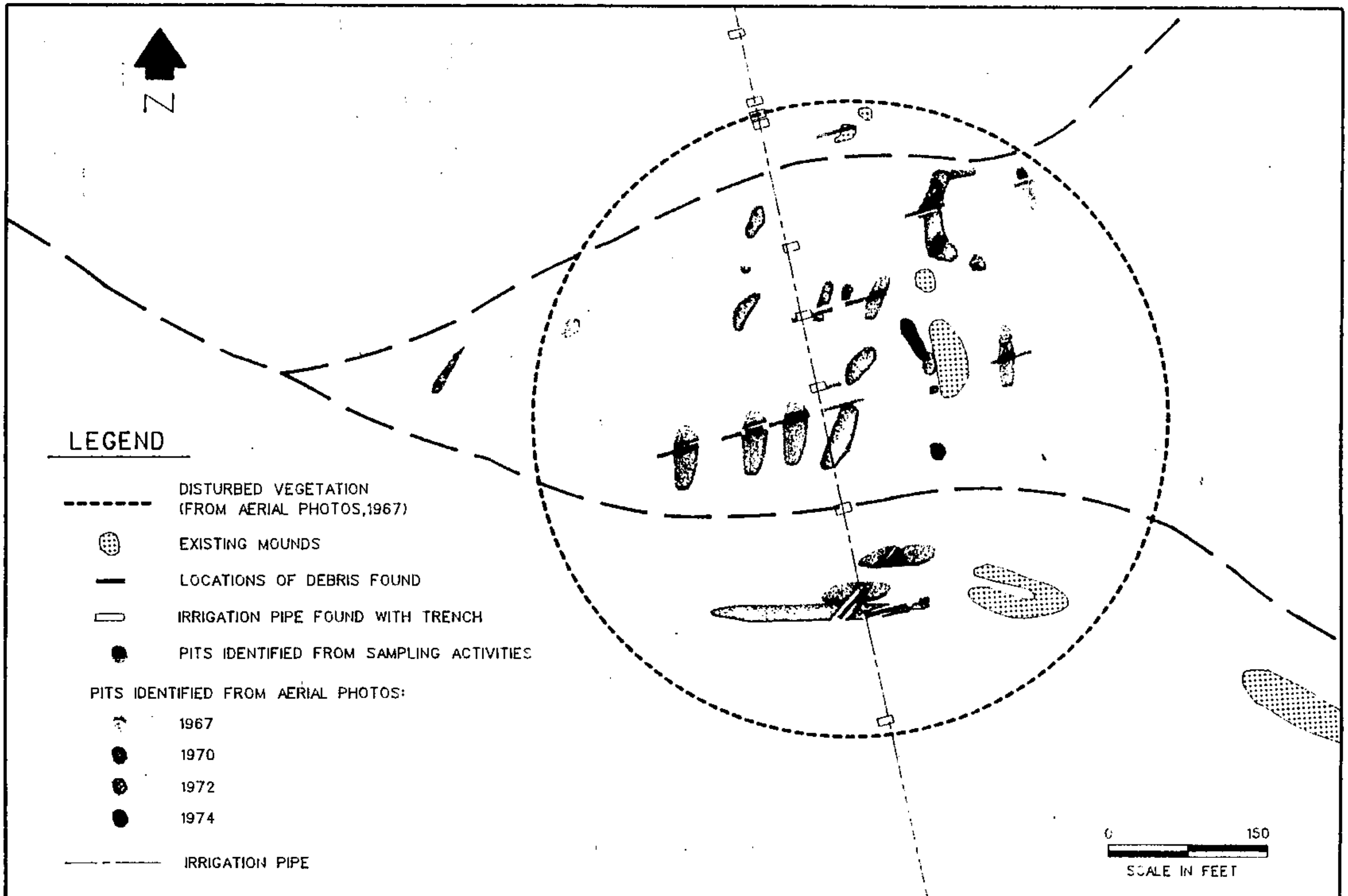

Figure 4-3. Burn Pit Area at Lockheed Beaumont No. 1

VRL RAP 204-BP 03/18/92

a 1- to 3-foot thick layer of burned material was found at a depth of 2 to 3 feet BLS. The burn pits contain a variety of materials, including: drums; wood; spent rocket motor liners; and hard, black burn residue. The burn pit area contains very small isolated pockets of specific waste material (unburned rocket propellant, ferrocene, and what is suspected to be ammonium perchlorate). This material is easily identifiable by visual inspection. Discrete samples of these specific wastes were collected during the remedial investigation in February 1990. A detailed discussion of the results is available in the *Burn Pit Area Removal Action Plan* (Radian, 1991b). General results are discussed below.

Rocket Propellant Sample--Rocket propellant is a gray solid that is initially jelly-like and very pliable, but which hardens with age. One plastic bag of unburned propellant was found during the trenching investigation. Volatile organic compound analysis of the propellant indicated the presence of low levels of several halogenated organics, mostly at less than quantifiable levels (less than five times the method detection limit). Analytical results indicated an elevated level (9.4% by weight) of aluminum, which is consistent with propellant ingredients; aluminum is the fuel that oxidizes when propellant burns.

Ferrocene Sample--A fist-sized chunk of very visible orange-red powder was collected and identified as the propellant burn-rate modifier ferrocene. Analytical results indicated that the powder is 54% iron, as would be the case for ferrocene. The only organic compounds detected in this sample were probably laboratory contaminants.

Ammonium Perchlorate Sample--Solid propellant combustion required large amounts of oxygen; the most widely used oxidizer was ammonium perchlorate, a colorless crystalline salt, which was specially ground to a size of 6 to 8 microns. Ammonium perchlorate that was not ground to the correct size was burned. Ammonium perchlorate is very soluble in water, and quickly leaches out of propellant when exposed to water. Propellant with perchlorate leached out of it burns similarly to a tire.

The third discrete sample, a white crystalline material, was tentatively identified in the field as weathered ammonium perchlorate. The sample was analyzed for metals; analytical results indicated 18% magnesium. Analysis for chloride and ammonium indicated low levels of both, suggesting that this was not a sample of ammonium perchlorate, but a magnesium salt.

Classification of Material as Nonhazardous--In 1990, as part of the start-up of field activities for the treatability study, Radian resampled the areas where the highest organic compound levels were found to conclusively determine whether the burn zone material and underlying soil would be classified as nonhazardous waste. The classification of the burn zone residue and underlying soil is based on analysis of these samples and samples taken during the 1989 remedial investigation. A summary of the analytical results and characteristic criteria for the nonhazardous determination are provided in Table 4-1.

The burn zone residue does not exhibit any of the characteristics of a hazardous waste as defined by state or federal law. A detailed waste analysis discussing the applicable regulatory criteria is provided in the *Excavation Management Plan* (Radian, 1991a). Based on these criteria, the burn zone residue is classified as nonhazardous.

Because the chemical analysis of the soil underlying the burn zone waste showed lower levels of VOCs than the burn zone waste, the underlying soil is also classified as nonhazardous.

The unburned specific wastes (ferrocene, ammonium perchlorate, and propellant) exist in the form of an occasional buried barrel or bag of material. Due to the low volume (conservatively estimated to be 50 yd^3 out of the total volume of 3,500 yd^3) of specific wastes and the high analytical costs associated with classifying each

Table 4-1

Summary of Analytical Results and Characteristic Criteria for Nonhazardous Determination of Burn Zone Wastes

Test or Criteria	Result	Regulatory Citation	Discussion
Listed Hazardous Waste	Not listed	40 CFR 261, Title 22 CCR, Article 9	Operations at the burn pits are not listed under nonspecific or specific industrial sources referenced under the U.S. EPA or state programs.
Toxicity Criteria			
TCLP	Negative	40 CFR 261.24	TCLP extracts did not exceed regulatory limits for U.S. EPA toxicity characteristic constituents.
TTLC	Negative	Title 22 CCR, Section 66261	Total concentrations of CA-DHS toxicity characteristic constituents were below regulatory limits.
STLC	1 Positive	Title 22 CCR, Section 66261	One sample exceeded STLC limits for lead by 3 mg/L. All other sample concentrations were below regulatory limits.
Aquatic Toxicity Test	Negative	Title 22 CCR, Section 66261	Aquatic bioassay test results on fat head minnows showed no mortality after 96 hours for concentrations ≤ 500 mg/L. One sample showed 5% mortality at 750 mg/L.
Carcinogen Containing Waste	Not listed	Title 22 CCR, Section 66261.24(a)(5)	The burn zone material does not contain any of these carcinogens.
Ignitability	Negative	40 CFR 261.21, Title 22 CCR, Section 66261	The burn zone material does not exhibit the characteristic of ignitability.
Corrosivity	Negative	40 CFR 261.22, Title 22, Section 66261.21	When mixed with equal weight of water, pH measurements show that the material has an average pH of 7.2.
Reactivity	Negative	40 CFR 261.23, Title 22, Section 66261.23	The burn pit operations did not involve the use of cyanides or sulfides. The material does not exhibit any characteristics of reactivity.

CFR = Code of Federal Regulations
CCR = California Code of Regulations
TCLP = Toxicity Characteristic Leaching Procedure
TTLC = Total Threshold Limit Criteria
STLC = Soluble Threshold Limit Criteria

specific waste, all specific wastes will be assumed to be hazardous and will be treated as such.

The removal action for the burn pit area is discussed in Section 7.0.

4.2 Hydrogeological Investigation

The Lockheed Beaumont No. 1 facility is located in an area between the San Jacinto Groundwater Basin and the Coachella Valley Groundwater Basin. The groundwater conditions at the site are described in detail in the *Lockheed Propulsion Company Beaumont Test Facilities, Source and Hydrogeologic Investigation* (Radian, 1990) and in the *Lockheed Propulsion Company Beaumont Test Facilities Hydrogeologic* Investigation (Radian, pending). Locations of groundwater monitoring wells and piezometers are shown in Figure 4-4.

4.2.1 Groundwater Depth and Direction of Flow

Groundwater in the alluvium occurs as deep as 85 feet BLS in the upgradient portion of the valley near the burn pits. As one moves downgradient from the hills to the valley floor, the depth to water generally decreases to approximately 3 feet BLS.

Recharge to the groundwater aquifer in the alluvium occurs from direct infiltration of rainfall and infiltration of surface drainage through stream channels. Recharge occurs primarily in the eastern portion of the valley where coarser, more permeable sediments are present at the surface. In the western and lower portions of the valley, direct recharge may be limited by the presence of fine-grained, low permeability sediments in the upper portion of the alluvium. Groundwater recharge to the alluvial aquifer may also occur from subsurface inflow from adjacent or underlying

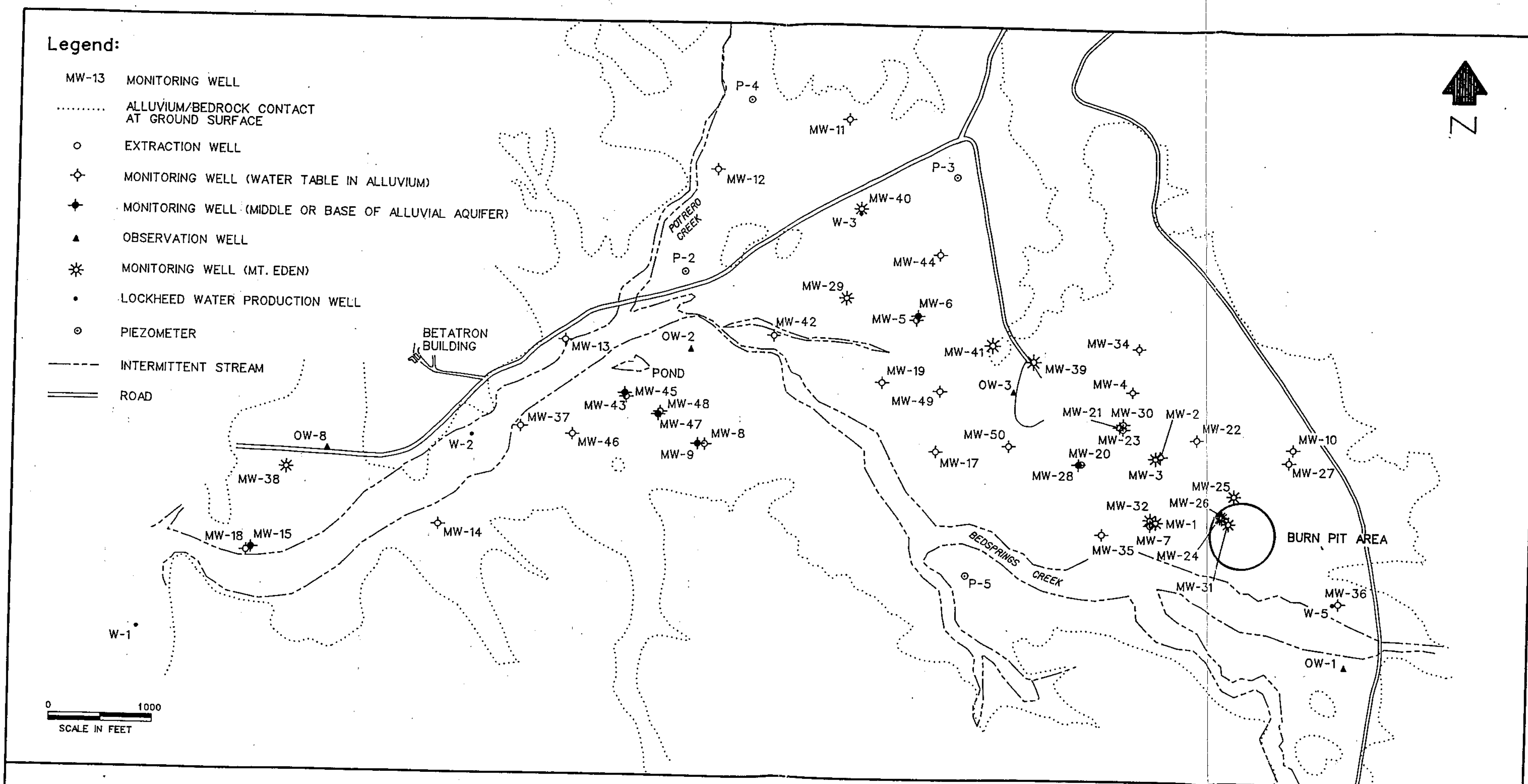

Figure 4-4.
Lockheed Beaumont No. 1
Monitoring Well Locations

LOCK6 RAP WELLSYMC 03/10/92

geologic units. However, subsurface inflow is thought to be a relatively minor contributor to groundwater in the alluvium.

Artesian flow has occurred from OW-2 and MW-43, located in the central-eastern portion of the valley. Artesian conditions in this area may be the result of a groundwater barrier (possibly a fault in the alluvium), the constriction of the alluvium as the valley narrows, and/or confining clay and silt layers.

A review of historical water-level data for the site from 1983 to the present indicates that water levels in the alluvium have declined as much as 58 feet in the last six to seven years. Water levels in the eastern portion of the valley have dropped more rapidly than in the western portion.

Groundwater Flow

As shown in Figure 4-5, groundwater in the alluvium generally flows toward the northwest from the burn pit area, past the rocket motor production area, and then southwesterly down the valley toward Massacre Canyon. In this area, the slope of the water table generally parallels the valley floor. The alluvial aquifer gradually disappears as it approaches Massacre Canyon due to very shallow or non-existent alluvium and water uptake by riparian vegetation. Groundwater rarely flows out of the valley through Massacre Canyon in the alluvium.

The low inflow of water into the boreholes penetrating the Mount Eden Formation suggests that the conductivity of the unit is very low. These low hydraulic conductivity values and the thickness of the Mount Eden Formation (500 to 600 feet) indicate that the Mt. Eden Formation retards, but does not prevent, the flow of groundwater. This observation is supported by the occurrence of artesian flow from deep bedrock boreholes drilled for the San Jacinto Tunnel, which suggests that the groundwater in the granitic bedrock was confined by the Mount Eden Formation.

RADIAN CORPORATION

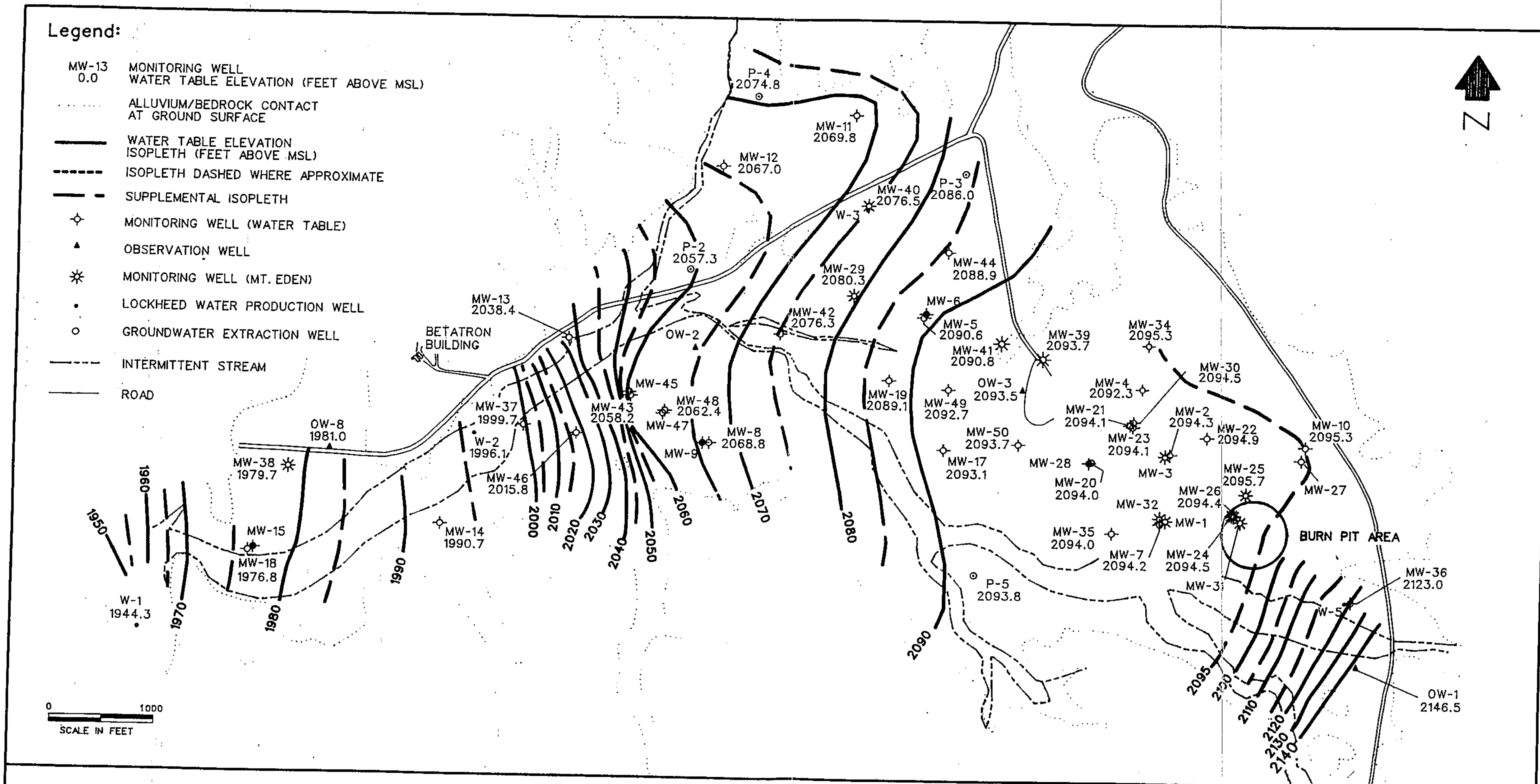

Figure 4-5.
Lockheed Beaumont No. 1
Water Table Elevations
13 January 1992

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4.2.2 Surface Water Conditions and Beneficial Uses

The watershed area that includes the San Jacinto Nuevo y Potrero Valley extends over approximately 35 square miles. The valley itself is roughly triangular in shape and covers about 2,000 acres (see Figure 3-2).

The valley is predominantly drained by Potrero Creek, an intermittent or seasonal stream that flows through the valley from north to south before turning southwest to pass through Massacre Canyon toward its confluence with the San Jacinto River. The creek is fed by local tributary drainage and storm runoff from the city of Beaumont in the San Gorgonio Pass area and other ephemeral streams (Bedsprings Creek) located in the southeast area of the site.

Before the construction of the San Jacinto Tunnel, to the southeast of the site, the valley area had numerous springs. After construction of the tunnel, the number of springs was greatly reduced, including those that fed a former lake. Data collected by the Metropolitan Water District during and after construction of the San Jacinto Tunnel indicate that surface runoff from the Potrero Creek watershed through Massacre Canyon totaled 16,380 acre-feet in the 1936-1937 water year (October-September), then dropped to between 1,900 and 400 acre-feet in subsequent water years (1938-1941).

The only occurrences of surface water on the site are the ephemeral streams, and a small artificial pond, across the stream from the Betatron building. This pond was constructed by the International Union of Operating Engineers equipment operators in the mid-1970s, in an area of shallow groundwater, to provide water for dust and fire control. The historical decline in groundwater levels, combined with the recent drought, has caused the pond to become almost dry. A temporary pond, constructed by the engineers in the lower streambed by Potrero Creek, was washed away by heavy rains in the spring of 1991.

4.2.3 Subsurface Water Conditions and Beneficial Uses

Currently, no water is being withdrawn from the contaminated aquifer. The relatively impermeable Mt. Eden Formation isolates the contaminated aquifer from the surrounding aquifers. Water for the sheep is pumped from W-1, which is 0.75 mile downgradient of the contamination; contamination has never been detected in water from W-1. This well is also used to fill a fire supply tank.

The local water districts, which provide water to the cities of Banning and Beaumont, pump water from an aquifer beneath those cities that is hydraulically independent of the contaminated aquifer (Butcher, 1991). Ranches in the area are either connected to the city water supplies or have their own wells, which draw water from areas of the aquifer well separated from the contamination.

The Santa Ana Regional Water Quality Control Board (RWQCB) Basin Plan does not specify any beneficial use designation for groundwater beneath the Lockheed Beaumont Site No. 1; however, based on the RWQCB Basin Plan and State Water Resources Control Board Resolution No. 88-63, the groundwater beneath the site is considered a potential source of drinking water.

4.2.4 Contaminant Assessment

Chlorinated VOCs--Contaminants in the groundwater occur over an L-shaped area approximately 10,000 feet long and ranging from about 500 to 1,700 feet wide (see Figure 3-4). The plume of contaminants generally follows the shape of the valley, flowing from beneath the burn pits downgradient to an area southwest of the Betatron building.

The five main contaminants are: trichloroethene (TCE), 1,1-dichloroethene (1,1-DCE), 1,1,1-trichloroethane (1,1,1-TCA), 1,1-dichloroethane (1,1-DCA), and

1,2-dichloroethane (1,2-DCA). The most commonly detected compounds are TCE and 1,1-DCE, which occur at concentrations exceeding California Department of Toxic Substances Control and U.S. Environmental Protection Agency (U.S. EPA) Primary Maximum Contaminant Levels (PMCLs) for drinking water.

Concentrations of contaminants are higher in samples collected from wells near the burn pits (> 1,000 μg/L for 1,1-DCE) than elsewhere on the site, which confirms that the burn pits are a primary source of groundwater contamination. However, these highest levels are one thousand times less than the saturation levels of the contaminants (1,100,000 μg/L for TCE), so it is very unlikely that any dense, nonaqueous phase liquid is present. A secondary source of contamination is the rocket motor production area.

The highest concentrations of contaminants in the groundwater occur in the Mount Eden Formation directly beneath the burn pits. In this area, concentrations are high not only because the area is near the source, but also because the Mount Eden Formation transmits less water, which limits the ability of the contaminants to disperse and dilute with time.

Mass balance calculations made during the *Feasibility Study* (Radian, 1992b) indicate that the greatest mass of contaminants in the groundwater--almost 56%--lies within the 1,000 μg/L surface contour (Table 4-2). About 91% of the groundwater contaminants lie within the 400 μg/L contour. However, these calculations also indicate that the mass of groundwater contaminants represents only 28% of the mass of all the contaminants at the site; 72% of the contaminant mass is in the soil vapor (see Figures 3-4 and 3-6).

Several faults in the area have displaced the granitic and Mt. Eden rocks. Based on previous geologic studies (Woodward-Clyde Consultants, 1989), the faults are not thought to extend beneath the burn pits and, when considered with the results of

Table 4-2

Distribution of Contaminant Mass in Groundwater

Surface Isopleth Boundary[b]	Formation	Volume[c] (million gallons)	Total Mass of HVOC (lb)	Mass Ratio (lb/million gallons)	% Mass of Groundwater Contamination (cumulative)	% of Total Mass of Contamination
1000 µg/L	Mt. Eden	10.5	840	80.2	46.4	13.1
	Alluvium	20.1	170	8.3	9.4	2.6
	Total	30.6	1010	33.0	55.8	15.7
400 µg/L	Mt. Eden	70.3	1130	16.0	62.4	4.5
	Alluvium	93.8	520	5.5	28.7	5.4
	Total	164.1	1650	10.0	91.2	10.1
1 µg/L	Mt. Eden	115	1150	10.0	63.5	0.3
	Alluvium	336	660	2.0	36.57	2.2
	Total	451	1810	4.0	100.0	2.5
TOTAL percent of contaminant mass in groundwater						28.1

[a] The volume and mass numbers presented here are cumulative (i.e., the 400 ppbv numbers are a subset of the 1 ppbv numbers).

[b] This analysis excludes groundwater in the downgradient portion of the 1 ppbv isopleth. The total volume of the 1 ppbv isopleth for the whole site is 950 million gallons and contains an estimated 2,160 pounds of halogenated VOCs.

[c] Volume calculations assume a porosity of 20 percent.

µg/L = micrograms per liter.

HVOC = Halogenated volatile organic compounds.

groundwater sampling, probably have little or no direct effect on the movement of contaminated groundwater. The groundwater plume appears to have no distinctive features or breaks in concentration that would indicate disruption in flow or migration.

Nitrates--Nitrate nitrogen (NO_3-N) has been reported in one groundwater well at a level of 120 milligrams per liter (mg/L); the second highest measurement was 50 mg/L. As shown in Figure 3-7, the highest nitrate concentrations were found in the area north and northwest of the burn pits, and east-southeast of the rocket motor production area. West of this area, nitrate levels in the aquifer gradually decrease. The two potential sources of nitrate on the site are sheep urine and ammonium perchlorate, the oxidizer used in rocket motor propellant.

The current U.S. EPA maximum contaminant level (MCL) for NO_3-N in drinking water is 10 mg/L. The results of the health risk assessment indicate that, under current conditions, nitrate does not pose any health risks because the affected aquifer is not used as a source of drinking water. Additionally, since the higher nitrate concentrations are localized, it is likely that continued pumping would produce water with nitrate levels at, rather than above, the MCL. This would be due to dilution by the cleaner water present just below the water surface.

The nitrate in the groundwater has had a positive effect on the riparian vegetation on the site. Nitrate, an essential nutrient for plants, is used in the production of amino acids, DNA, and chlorophyll. Nitrate is the preferred form of nitrogen for plants (they can also use ammonium) and is actively absorbed by roots. Nitrogen is one of the three main ingredients in plant fertilizers. A common liquid plant fertilizer (Schultz-Instant) is applied with a total nitrogen concentration of approximately 50 mg/L (NO_3-N). Measurements in the groundwater underlying the riparian areas ranged from <0.02 to 15 mg/L (NO_3-N).

In dry riparian woodlands with well drained soils, nitrogen is often a limiting factor for plant productivity (Nilsen et al., 1984). The soils on the site consist of well drained alluvial sand and gravel deposits that contain very little organic material. An analysis of aerial photographs taken in 1961, 1970, 1974, and 1991 indicates that most of the riparian vegetation did not exist before 1974. The site was used for sheep grazing after 1974 when Lockheed discontinued operations. As shown in Figure 3-7, the most obvious changes have occurred on the lower one-half mile of Bedsprings Creek and a one-half mile segment downstream of the junction of Bedsprings and Potrero Creeks. Most of the recent growth has occurred in the stream channel, which has an average width of 500 meters in these areas. The 1961 and 1970 photographs indicate that the stream channel was barren and unvegetated except for a few scattered trees and shrubs. The 1974 photograph shows a slight increase in vegetation in areas that now contain dense stands of riparian vegetation.

It is likely that this increase in riparian vegetation has occurred as a result of the increase in the groundwater nitrate concentration. Because the groundwater levels in the area of new growth have declined slightly since monitoring began in 1983 (Radian, 1990), an increase in water availability is probably not responsible for the increase in riparian vegetation. In addition, sections of Potrero Creek that do not have elevated levels of nitrate in the underlying groundwater are barren in all of the photographs.

Therefore, based on the beneficial effects of nitrates on the riparian habitat and the very low probability that the groundwater will be used as a source of drinking water, it is not necessary to remove nitrates from the groundwater as part of the treatment process.

4.3 Air Investigation (including Surface and Subsurface Vapors)

Soil vapor data were collected during the remedial investigation (RI) (Radian, 1990), a waste classification study (Radian, 1991a), the treatability study (Radian, 1992a), and the health risk assessment (Radian, 1992c).

4.3.1 Description of Ambient Air Qualities

Ambient air was sampled during the soil and waste sampling activities performed as part of the remedial investigation and the waste classification study; no VOCs were detected in ambient air samples.

4.3.2 Investigation of Subsurface Vapor

Soil vapor samples collected during the investigations of the Lockheed Beaumont No. 1 site and discussed below include surface vapor emission samples, shallow soil vapor samples (3.5 to 7 feet), and deep soil vapor samples (borings to 89.5 feet).

4.3.3 Contaminant Assessment

Surface vapor emissions--Samples of vapor emissions on the land surface were collected during the hydrogeologic investigation (Radian, 1990) by removing approximately 4 inches of surface soil and placing a sampling chamber over the area to collect samples. Analytical results ranged from 1 to 23 ppbv of chlorinated VOCs. These concentrations are considered very low and often were not discernable from background signals on the analytical instrument. Vapor emissions from the undisturbed ground surface (rather than 4 inches deep) were even lower.

Shallow soil vapors--Shallow soil vapor samples were collected in 1990 from approximately 120 locations at depths of 3.5 to 7 feet. Analytical results ranged from 7 to 10,500 ppbv total VOCs. Locations of contaminated soil vapor are shown in Figure 3-3. The compounds that comprise this total value include 1,1-DCE, 1,1-DCA, trans-1,2-DCE, 1,1,1-TCA, TCE, tetrachloroethene (PCE), and 1,1,2,2-tetrachloroethane (1,1,2,2-PCA). More detailed information on these analysis can be found in the *Source and Hydrogeologic Investigation* (Radian, 1990).

In 1991, the highest concentrations detected in the shallow soil vapor from the same area were 6,400 ppbv; all but one sample contained concentrations of less than 3,000 ppbv. The reasons for the apparent decline in vapor concentrations has not been determined. Potential factors include differences in barometric pressure, a drop in the underlying water table, variations in previous rainfall, and different ambient temperatures at the time of sampling.

Deep soil vapors--Deep soil vapor samples were collected at 34 locations at depths ranging from 7 to 89.5 feet. The primary compounds detected in the soil vapors were TCE, 1,1-DCE, and 1,1,1-TCA. In the rocket motor production area, the maximum concentrations of total VOCs were 184 and 163 ppbv, at depths of 3.5 and 15 feet, respectively. At greater than 15 feet, concentrations declined to near ambient levels.

In the burn pit area, the detected concentrations increased with depth, reaching a maximum concentration in the alluvium of 1,000,000 ppbv total VOCs at 80 feet, 5 feet above the water table. In the *Treatability Study* (Radian, 1992a), the highest concentrations observed averaged 25,000,000 ppbv in one vapor monitoring well screened at 75.5 to 78 feet in the Mount Eden Formation, just above the surface of the water table. Although the contamination originated in the burn pits, which are buried in the alluvium, concentrations are higher in the Mount Eden Formation because the vapors in the Mount Eden Formation disperse more slowly than the vapors in the more permeable alluvial material.

The mass balance calculation made during the *Feasibility Study* (Radian, 1992b) indicate that the greatest mass of soil vapor contaminants--about 76%--lies within the 1,000 ppbv contour (Table 4-3). About 99.9% lies within the 400 ppbv contour. These calculations also indicate that the mass of contaminants in the soil vapor represents 72% of the mass of all the contaminants at the site; 28% is in the groundwater (see Figures 3-4 and 3-6).

4.4 Biological Investigation

No field studies have been performed to determine the impact of the contamination on the Stephens kangaroo rat (SKR) or other vegetation and wildlife on the site. During the remedial investigation, all ground-disturbing activities (i.e., wells) were located so as to avoid disturbing SKR burrows.

The assessment of ecological impact in the health risk assessment described the potential pathways by which biota could be exposed to contamination. Because the main contaminants of concern do not tend to bioaccumulate, biomagnification in the food chain is not expected to be significant. A semiquantitative evaluation indicated that soil vapor inhalation may present some adverse health effects to SKRs that inhabit the immediate burn pit area.

Before the planned excavation of the burn pits, the U.S. Fish and Wildlife Service will have to grant approval to allow the disturbance of SKR habitat in that area. All other future ground-disturbing activities will be located to minimize impacts to the SKR.

Table 4-3

Distribution of Contaminant Mass in Soil Vapor[a,b]

Surface Isopleth Boundary[c]	Formation	Volume (million gallons)	Total Mass of HVOC (lb)	Mass Ratio (lb/million gallons)	% Mass of Groundwater Contamination (cumulative)	% of Total Mass of Contamination
1000 ppbv	Mt. Eden Alluvium	2.7 6.8	2830 710	1048 104	61.3 15.3	44.1 11.0
	Total	9.5	3540	373	76.6	55.0
400 ppbv	Mt. Eden Alluvium	4.3 23.1	3500 1115	814 48	75.8 24.1	10.4 6.3
	Total	27.4	4615	168	99.9	16.8
200 ppbv	Mt. Eden Alluvium	4.3 42.9	3500 1120	814 26	75.8 24.2	0 0.1
	Total	47.2	4620	98	100.0	0.1
TOTAL percent contaminant mass in soil vapor						71.8

[a] This analysis includes only those halogenated VOCs; within the 200 ppbv isopleth to represent the total mass in the soil vapor. Data for lower concentrations (at shallow depths) were not considered adequate or reliable for the mass balance.

[b] The volume and mass numbers presented here are cumulative (i.e., the 1,000 ppbv numbers are a subset of the 400 ppbv number).

[c] See Figure 3-3.

ppbv = Parts per billion by volume.

HVOC - Halogenated volatile organic compounds.

5.0 HEALTH AND SAFETY RISKS POSED BY THE CONDITIONS AT THE SITE

Current and potential future adverse health effects posed by the Beaumont No. 1 site were evaluated in a *Health Risk Assessment* (HRA) (Radian, 1992c). The HRA evaluated the potential for health risks under two scenarios: current conditions at the site, and a hypothetical on-site residential usage. The worst-case health risks were assumed to be posed by the unremediated site to residents in the hypothetical scenario.

Because of the small size of the contaminated aquifer, it is not realistic to expect it to be used as a drinking water supply for residential use. However, a special-case analysis--using the contaminated groundwater as a water supply ("with-water scenario")--was included in the hypothetical scenario along with the more likely case of the aquifer not being used for water supplies ("without-water"). The incremental (above background) lifetime risk of developing cancer and the likelihood of significant chronic health effects were the toxicological endpoints that were evaluated in each scenario.

Although contamination in the burn pit area, which has been identified as the major source of groundwater and soil vapor contamination (Radian, 1990), is scheduled to be removed as an interim remedial action, it was included in the current scenario, but not in the future scenarios.

The primary chemicals of potential concern were halogenated volatile organic compounds (VOCs) (primarily trichloroethene [TCE], 1,1-dichloroethene [1,1-DCE], 1,1,1-trichloroethane [1,1,1-TCA], and 1,1-dichloroethane [1,1-DCA]) that were detected in groundwater, surface water, soil vapor, and surface flux emissions (Radian, 1990). Nitrates and several metals were also identified as chemicals of potential concern in groundwater. The following primary exposure pathways were evaluated:

- Inhalation of soil vapor emissions;
- Inhalation of chemicals volatilized from surface water;
- Consumption of contaminated drinking water; and
- Inhalation and dermal absorption of chemicals from contaminated shower water.

Because of the great uncertainty about the carcinogenicity of 1,1-DCE, results were presented for two cases: in the first, 1,1-DCE is considered carcinogenic; in the other, it is not.

Uncertainty is unavoidable in quantifying health impacts. Many parameters used in the calculations are not well known (cancer slope factors) or contain significant variability (contaminant concentrations in groundwater vary by several orders of magnitude at the site). Health risk assessments account for this uncertainty by using either average or intentionally biased values to represent uncertain parameters in the calculations. Intentionally biased values are chosen so that risks are never underestimated and the assessment will be health-conservative. However, if several intentionally biased valued are multiplied or divided, the resulting value will be biased to a much greater degree than the individual values used to calculate it. This is called compound bias. Because numerous health-conservative biases were used in the HRA, actual risks are most likely less than the reported risks.

5.1 Assessment of Current and Potential Risks

The HRA results indicate that, even if 1,1-DCE is assumed to be carcinogenic, there are not likely to be any carcinogenic or chronic non-carcinogenic health impacts to site workers, given the current on-site conditions and land uses.

The results for the future residential scenario indicate that, if contaminated groundwater is not used, there are not likely to be any chronic noncarcinogenic effects;

the cancer risk from soil vapor emissions are above one-in-a-million only if 1,1-DCE is considered carcinogenic. In the unlikely event that the contaminated groundwater were used as a drinking water supply, carcinogenic and chronic noncarcinogenic effects would occur.

The HRA also included an evaluation of the contamination's potential impacts on plants and wildlife, with emphasis on the endangered Stephens kangaroo rat (*Dipodomys stephensi)* (SKR) and riparian vegetation. The screening-level evaluation concluded that the SKR may be affected by the contaminated soil vapor, but only in the immediate vicinity of the burn pits. The amount of riparian vegetation on the site appears to have increased due to the elevated nitrate level in the groundwater.

Finally, the HRA estimated the cancer risks for the hypothetical residential scenario after partial remediation of the groundwater and/or soil vapor (residual risk). If groundwater is not used as the drinking water supply, the residual risk is proportional to the residual concentration of VOCs in the soil vapor. This residual contamination in the soil vapor is expected to be substantially reduced during the first year of remediation. If groundwater is used as a potable water supply, the residual risk is proportional to the residual concentration of VOCs in groundwater.

6.0 EFFECTS OF CONTAMINATION UPON RESOURCES

6.1 Present Uses of Land/Water

At the present time, the Lockheed Beaumont property is used only for sheep grazing (to the west of the contaminated areas) and for a survey training school.

The areas north of the site and south of Beaumont and Banning contain scattered ranches and much undeveloped land with native vegetation. The closest residential development is located approximately 3.5 miles north of the burn pits on the east side of Highland Springs Road. Most of the medium and high density residential areas in Beaumont and Banning occur to the north of Highway 10, which is approximately 4.5 miles north of the burn pits at its closest point.

The rugged land south, east, and west of the site is primarily undeveloped. The closest developed area in these directions is in the San Jacinto Valley, located approximately 4 miles southwest of the burn pits. The only notable feature in this area is the Colorado River Aqueduct, which runs in a tunnel 700 feet below the surface in deep granite. At its closest point, the aqueduct is approximately 1 mile southeast of the burn pits.

Currently, no water is being withdrawn from the contaminated aquifer. The relatively impermeable Mt. Eden Formation isolates the contaminated aquifer from the deeper and surrounding aquifers. Water for the sheep is pumped from well W-1, which is located in a non-contaminated area. The local water districts, which provide water to the cities of Banning and Beaumont, pump water from an aquifer that is located beneath these cities and is hydraulically independent of the contaminated aquifer (Butcher, 1991). Ranches in the area (the closest is 1 mile away) are either connected to the city water supplies or use their own wells, which draw water from areas of the aquifer well separated from the contamination.

6.2 Consideration of Future Potential Uses

There are currently several possibilities for future use of the site, including a residential development, a water reservoir, wildlife preserve, and the existing land use. Lockheed is currently considering using the property for a large residential development, and has retained a developer to begin planning. The Metropolitan Water District has considered purchasing the site for use as a water reservoir or wildlife preserve. The site is currently designated a "study area" under the Riverside County Short-Term Habitat Conservation Plan for the endangered Stephens kangaroo rat (*Dipodomys stephensi*) and may be selected as a permanent reserve.

The relatively flat areas, primarily to the north of the site and south of Beaumont and Banning, are continuing to be developed primarily for residential and commercial uses. Rugged terrain is likely to prevent development of many areas to the east, south, and west of the site.

The small volume of water, low well yields, and low permeability of the contaminated aquifer cause it to be unsuitable for use as a supplementary municipal drinking water supply.

7.0 SUMMARY OF THE BURN PIT AREA REMOVAL ACTION

As discussed in Section 3.0, the 4-acre burn pit area is in a broad valley in the southeastern portion of the facility. The burn pits were used from 1961 until 1974 for disposal and subsequent burning of waste propellant and other materials used in the production of rocket motors. The burn pits are believed to have been the major source of the soil vapor and groundwater contamination at the Beaumont No. 1 site. However, the burn pits have been exposed since 1961, and the analytical data indicate that the material has been almost completely leached of contaminants. The contaminants of interest include low levels of halogenated volatile organic compounds (VOCs) and a few metals. The materials found in the burn pits have been separated into three categories:

- Burn zone material or residue;
- Specific wastes existing as discrete bags of unburned propellant, ferrocene, and suspected ammonium perchlorate; and
- Soil underlying the burn zone.

The maximum concentrations of the compounds detected in the burn zone material and specific wastes were used to help classify the material. As shown in Table 4-1, most of the burn zone residue, with an estimated volume of 3,500 cubic yards (yd^3), is classified as nonhazardous. The unburned specific wastes, conservatively estimated to be 50 yd^3, is all assumed to be hazardous because of its low volume and because of the high costs associated with analyzing and classifying each specific waste.

The results of the geophysical and remedial investigations and the aerial photography were used to determine the limits of the burn pit area. Collectively, the individual burn pits cover approximately 4 acres (see Figure 4-3). There are no buildings or structures on the burn pit site. The private dwelling that is nearest to the burn pit is approximately 1.8 miles to the north. The burn pit area has been cultivated and grazed, so most of the area is disturbed grassland.

The removal action that is planned for the burn pit area includes:

- The removal and stockpiling of top soil;
- The excavation and off-site disposal of the burn zone residue and specific wastes; and
- Site restoration.

The project duration is estimated to last approximately 60 days, with actual material excavation to take place in a four-week period. Lockheed will notify the Department of Toxic Substances Control (DTSC) prior to excavation and removal of any soil and waste materials.

A *Burn Pit Removal Action Plan* (Radian, 1991b) has been submitted to the state regulatory agencies for review. Staff from DTSC have indicated that they are waiting for the U.S. Fish and Wildlife Service to grant approval for disturbing the endangered Stephens kangaroo rat before approving the Removal Action Plan. A landfill excavation permit has been issued to Lockheed by the South Coast Air Quality Management District (SCAQMD).

This section summarizes the feasibility study which led to the selection of the removal action and describes the planned removal of the burn zone material and specific wastes from the former burn pit area at the Beaumont No. 1 facility. More specific details can be found in the *Burn Pit Removal Action Plan* (Radian, 1991b), or the *Excavation Management Plan* (Radian, 1991a) prepared as a requirement for the SCAQMD landfill excavation permit.

7.1 Alternative Remedial Actions

A focused feasibility study was performed to identify possible cleanup technologies and to evaluate cleanup alternatives for the burn pits. These studies are briefly summarized in the following subsections.

7.1.1 Technology Identification

Table 7-1 lists the possible cleanup technologies that were evaluated following a review of site characterization data for burn zone material and specific wastes, available literature, and information from equipment vendors. These technologies were grouped into general response actions that include:

- No action;
- Containment; and
- Excavation/treatment.

As part of a screening review, each technology was categorized according to one of the following criteria:

1) The technology merits further consideration (Rank 1);
2) The technology was inappropriate for the types of waste or concentrations of contaminants at the site (Rank 2); and
3) The technology would not achieve permanent cleanup (Rank 3).

Technologies that were classified as meriting further consideration were carried onto the next step of the evaluation process.

Table 7-1

Waste and Contaminated Soil Control Technologies

Technology	Evaluation Rank
No Action	3
Containment	
Capping	
Clay	3
Asphalt	3
Synthetic membranes	3
Concrete	3
Fly ash mixtures	3
Soil cement/clay mixtures	3
Barriers	
Slurry walls	3
Diaphragm walls	3
Grout curtains	3
Steel sheet piling	3
Grout bottom sealing	3
Clay liners	3
Synthetic liners	3
Excavation	
Removal and Off-Site Disposal	1
Removal and On-Site Disposal	1
Treatment	
Solidification/Stabilization/Fixation	
Cement-based pozzolanics	1
Thermoplastic	1
Organic polymer	1
Vitrification (in situ)	2
Thermal Destruction	
Infrared incineration	2
Rotary kiln incineration	2
Fluidized-bed incineration	2
Multiple hearth incineration	2
Pyrolysis	2
Other Treatments	
Biological degradation	2
Water/solvent flushing, collection, and treatment (in situ)	2
Soil venting	2
Reduction	2
Sulfide precipitation	2
Neutralization	2
Polymerization	4

Ranking

1. Technology merits further consideration.
2. Technology is inappropriate for the type of waste or concentration of contaminants.
3. Technology would not achieve permanent cleanup.

7.1.2 Alternative Evaluation

The objective of this evaluation was to select the most cost-effective remedial alternative that is consistent with unrestricted future land use. The viable remedial technologies were combined into five remedial action alternatives:

1) No action;
2) Disposal on site;
3) Disposal off site;
4) Biodegradation; and
5) Batch solidification/disposal on site.

Table 7-2 lists the advantages and disadvantages of the viable alternatives for remediation of the burn zone material and specific wastes. The conceptual costs associated with each of these alternatives are shown in Table 7-3. The selected alternative, shown in bold lettering in Table 7-2, is described in greater detail in the following section.

7.2 Recommended Final Removal Action

Disposal of the burn zone material and specific wastes off site is the only alternative that will meet the criterion for unrestricted land use and is, therefore, the recommended alternative. The no action and on-site disposal alternatives all involve leaving the burn zone material and specific wastes in place and, therefore, are not compatible with all potential land uses.

The excavation of the burn zone material will begin by removing the top 1 to 3 feet of clean soil with a bulldozer or scraper and exposing the horizontal limits of individual burn pits. In order to expose all burn pits, the limit of the excavation will

Table 7-2

Summary of Advantages and Disadvantages of Remedial Action Alternatives for the Burn Pit Area

Response Action	Technology	Advantages	Disadvantages
No Action		No disturbance of kangaroo rat habitat.	Current condition may affect kangaroo rat and the area may not be suitable for unrestricted future land use.
Excavation	**Removal**	Permanently remove contamination from site.	Temporarily disrupt Stephens kangaroo rat habitat.
Treatment	Waste/Soil Separation	May be able to dispose of some waste at a lower class (II or III) disposal site.	Will need to test segregated waste to determine appropriate disposal site or pretreatment.
	Solidification	Proven technology (batch). Commercially available.	Duration of effectiveness is unknown. In situ solidification not possible due to large size and heterogeneity of materials. Not necessary for majority of burn pit material (nonhazardous).
	Biodegradation		Costs increase with decreasing contaminant concentration. Metal debris and burn pit material will not degrade.
Disposal	On site	Lowest disposal cost.	Not compatible with all potential future land uses.
	Off-site: Class I	Applicable to specific wastes.	Highest disposal fee. Potential long-term liability at disposal facility.
	Off-site: Class III	Lowest off-site disposal fee.	Applicable to nonhazardous wastes only (burn zone material).
Site Restoration		Restore kangaroo rat habitat.	None identified.

Table 7-3

Costs For Remedial Action Alternatives for the Burn Pit Area

Remedial Action Alternatives for Burn Zone Material and Specific Waste	Cost[1] ($)
1 No action	---
2 Disposal on site	$125,380
3 Disposal off site[2]	$600,000
4 Biodegradation	$675,000 - $1,350,000
5 Batch solidification/disposal on site	$1,004,680

1 All options except no action include costs for excavation of waste and site restoration (replace topsoil); costs are estimated ±50%. Costs do not include oversight, reporting, or confirmation sampling.

2 Burn zone material would be disposed at Class III landfill, specific waste at Class I landfill.

extend approximately 200 feet beyond the perimeter of the burn pits, as defined from aerial photographs and the 1989 Remedial Investigation (Radian, 1990). The total disturbed area is estimated to be approximately 9.5 acres. An estimated 13,000 yd^3 of topsoil will be stockpiled for later use during site restoration. The excavation will be performed in stages to minimize dust emissions, and all disturbed soils will be watered as needed during soil removal activities.

Since the limits of the burn zone are easily identified, visual observation will be used to determine the limit of burn zone residue removal. It is anticipated that a track excavator will be used to selectively remove the estimated 3,500 yd^3 of debris and burn zone material. The material will be loaded into 20 yd^3 dump trailers, covered securely with plastic tarps to minimize payload losses, and hauled off to an approved off-site disposal facility.

Due to the small quantity of specific wastes (conservatively estimated at 50 yd^3), the occasional drum or bag of these materials will be selectively excavated and stockpiled in a closed container. This material will be transported to an approved Class I disposal facility after all burn pits have been excavated and all the specific wastes have been collected.

Following the removal of the burn zone waste, the topsoil will be replaced and the area will be graded to promote good drainage.

The estimated average VOC emission rate has been calculated to be approximately 1.6 pounds of VOCs emitted per day of exposed excavation, or approximately 33 pounds of VOCs emitted during the excavation project. The excavated waste and the breathing zone in the excavation area will be monitored for organic vapors using a photoionization detector. All measurements of organic vapor emissions from the waste have been less than 10 parts per million (ppm); all measurements in the breathing zone have not detected any organic vapors.

A landfill excavation permit (Rule 1150) has been obtained from the SCAQMD for the burn pit removal action. This permit includes the provision that all construction activities will cease immediately if the SCAQMD indicates that a public nuisance has occurred as defined by SCAQMD Rule 1150(b)(3). Any mitigation measures which the SCAQMD Executive Officer deems appropriate will be implemented immediately to eliminate any situation which is creating a public nuisance.

A complete health and safety plan for the removal action at the burn pit area has been prepared and is included as part of the Removal Action Plan.

Lockheed will notify DTSC prior to starting the removal action. However, the soils removal action at the burn pit area cannot begin until the DTSC approves the plan, and all necessary permits for the removal are obtained. Department staff have indicated that they will not approve the plan until approval to disturb the Stephens kangaroo rat is obtained from the U.S. Fish and Wildlife Service.

8.0 SUMMARY OF REMEDIAL ACTION FEASIBILITY STUDY -- SOIL VAPOR CONTAMINATION

Any remedial action implemented at the Lockheed Beaumont No. 1 site must address both soil vapor and groundwater contamination. To be most effective in evaluating and developing a remedial action strategy, it is necessary to look at the partitioning of the contaminants, or the phase in which they are found, as well as the location of the majority of the contamination. Approximately 72% of the mass of the contamination at the site is in the soil vapor phase, and 28% is in the groundwater. Approximately 77% of the soil vapor contaminant mass (and 44% of the total contaminant mass) was calculated to be within the 1,000 parts per billion by volume (ppbv) isopleth in the burn pit area (see Figure 3-4 in Section 3.2.9); greater than 99% of the soil vapor contaminant mass (71.8% of the total) lies within the 400 ppbv isopleth (Radian, 1992b).

Because of the large size of the Beaumont No. 1 site, and the physical and technical limitations of pump-and-treat systems, treating all groundwater contamination that exceeds Maximum Contaminant Levels (MCLs) would not be possible. Therefore, the initial strategy for remediation will be to treat those areas where both soil vapor and groundwater contain the greatest mass of contaminants, thereby removing the source and reducing the risk for further migration of contaminants. The strategy will also reduce both existing and future health risks as described in the *Health Risk Assessment* (HRA) (Radian, 1992c).

The "observational approach" strategy will be used to remediate the Beaumont No. 1 site. Remediation will focus on the proven technologies that will most effectively address the highest concentrations of contaminants in the shortest amount of time. The effectiveness of these technologies will be closely monitored during operation, and the system will be modified, if necessary, to optimize the remediation effort.

8.1 Remedial Actions for Soil Vapor Contamination

In 1990, an initial screening of alternatives to control and mitigate soil vapor contamination was conducted. A treatability study was performed in early 1991 to test the effectiveness of the most promising technologies at the site. In late 1991 and early 1992, a detailed analysis of alternatives was conducted that included innovative technologies, as well as the results of the treatability study.

8.1.1 Identification of Alternative Remedial Actions

Remedial actions for soil vapor have three components: extraction, treatment, and disposal. Options for each component were evaluated and assembled into remedial action alternatives.

Each remedial action alternative was evaluated by the following criteria: long-term effectiveness; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability (suitability of the technology), which included time for construction; and costs. The results of the evaluation are shown in Table 8-1. For a more detailed discussion of each alternative, and each combination of extraction and treatment systems, see the *Lockheed Beaumont No. 1 Treatment Design Feasibility Study* (Radian, 1992b).

Extraction

Before the contaminated soil vapor can be treated, it must be extracted from the soil. Two extraction systems were evaluated in the feasibility study: a dual-phase (groundwater and soil vapor) high-vacuum system, and a conventional soil vapor vacuum extraction system.

Table 8-1

Comparison Matrix For Soil Vapor Alternatives

Technology	Processes	Long-Term Effectiveness	Reduction of Toxicity, Volume, or Mobility	Short-Term Effectiveness	Implementability	Cost	Total
Extraction							
Dual-Phase, High Vacuum	Xerox®	3	4	3	2	4	16
Conventional	Various	3	2	2	5	2	14
Treatment							
No Action	N/A	1	1	2	5	5	14
Vapor-Phase Oxidation	Nulite, Ultrox	4	4	3	1	3	15
Catalytic Oxidation	CATOX	4	5	4	3	4	20
Carbon Adsorption	Various	3	4	4	5	2	18

5 = Superior
4 = Better Than Average
3 = Average
2 = Worse Than Average
1 = Inferior

N/A = Not Available

The dual-phase system extracts both groundwater and soil vapor from each well by applying a high vacuum (typically greater than 18 inches of mercury [Hg] vacuum) through a central lift pipe that extends down the well to just above the water level. The high vacuum pulls both soil vapor and droplets of groundwater into the pipe. One advantage of simultaneous groundwater pumping and soil vapor extraction is that the water table is depressed around the well, which creates a hydraulic gradient for water to flow toward the well. It also exposes more of the vadose zone close to the water table, where contaminant concentrations are highest.

The conventional system uses conventional downhole groundwater pumping and a vacuum pump for soil vapor extraction. Soil vapor is extracted through soil vapor extraction wells using a vacuum pump (2 inches Hg vacuum versus a high-vacuum pump at 18 inches Hg vacuum) and is transported to the treatment unit via a soil vapor pipeline. Groundwater is pumped from each groundwater or dual-phase well to a feed tank for treatment via a groundwater transport pipeline.

Treatment

Four technologies were considered in the initial screening for the treatment of soil vapor contamination. The four alternatives were:

- Carbon adsorption of organic compounds from vacuum-extracted soil vapor. Carbon adsorption is a process in which the vapor stream containing organic compounds is brought into contact with activated carbon. The organic compounds in the air stream are selectively adsorbed onto the surfaces of the carbon granules.
- Co-treatment of soil vapor with groundwater by hydrogen peroxide/ozone/ultraviolet (UV) light (UV oxidation) or air stripping/carbon adsorption.
- Venting vacuum-extracted soil vapor to the atmosphere (on the assumption that low levels of vapor contaminants would be below

mass emission limits imposed by the South Coast Air Quality Management District [SCAQMD]).

- Thermal incineration of extracted soil vapor.

Several processes that had not been developed enough for consideration in the initial screening were evaluated in the *Feasibility Study* (Radian, 1992b). These processes included:

- Catalytic oxidation preheats contaminated vapor and then passes it over a proprietary catalyst specific to halogenated volatile organic compounds (VOCs) to oxidize the organic material at lower temperatures than typically used in thermal incineration. Systems are being successfully used for removal of chlorinated hydrocarbons from soil vapor in Irvine and Saugus, CA.

- Nulite™ catalytic oxidation with titanium oxide oxidizes contaminants in water and vapor using a selected band of light to excite a titanium oxide catalyst and cause the formation of the hydroxyl radical. This hydroxyl radical attacks and breaks down the hazardous contaminants. Development of the catalyst began four years ago and is complete, but the engineering of the system is not completed. Five systems are operating in Japan and others are being field tested in North America.

  Nulite™ is not entirely commercially developed -- current status of the technology is to run a small trial reactor at the site for three months to determine the best operating conditions before scaling up. This system destroys contaminants in groundwater and soil vapor effectively and requires primarily electricity as a utility; however, it may not be developed enough for application.

- Ultrox UV oxidation (vapor-phase) has been used to reduce benzene contamination by 40 to 50%. Accurate predictions of chlorinated hydrocarbon reduction were not readily available, but it is suspected to be similar to benzene reduction. An acid gas scrubber is needed to remove hydrochloric acid before exhaust gases are vented to the atmosphere. Ultrox currently has only a bench-scale model running, with plans to start a pilot-scale demonstration plant in early 1992.

- Methanotrophic trichloroethene (TCE) biodegradation (Gas Research Institute) biologically changes chlorinated hydrocarbons, methane, and oxygen into carbon dioxide and hydrochloric acid. Trichloroethene levels have been reduced from 10 parts per million (ppm) to 50-100 parts per billion (ppb). The final concentration can be reduced further with this process, but it is more economical to use activated carbon to achieve final low concentrations. The Gas Research Institute and Radian may have a pilot-scale groundwater treatment system and a large-scale vapor treatment plant in place by 1992.

Additionally, the no action alternative was evaluated.

Disposal

For all but one alternative, disposal of the treated soil vapors includes discharging the treated effluent to the atmosphere. The concentrations of contaminants allowed in the effluent vapor is dictated by the air permit requirements for the treatment equipment. It is Lockheed's intent to meet these requirements.

One alternative considered in the initial screening included venting untreated soil vapors directly to the atmosphere.

8.1.2 Purpose, Objective, and Scope

The purpose of the remedial action is to restore the property to allow unrestricted land use. As stated above, the initial action will be to treat the most contaminated soil vapors and groundwater because they contain the greatest mass of contaminants. The remediation of soil vapor and groundwater in the burn pit area will also reduce the level of contaminants in the surface soil vapor and lower any future health risks, as described in the HRA for the site (Radian, 1992c).

8.1.3 Cost-Effectiveness

The feasibility study concluded that catalytic oxidation (CATOX) of contaminated soil vapor is more cost-effective than carbon adsorption if the concentration of the contaminants is high. In a carbon adsorption system, the VOCs are not destroyed, but are retained on the carbon beds. When sufficient VOCs have adhered to the carbon, the beds need to be regenerated and the VOCs disposed of properly. High concentrations of VOCs necessitate frequent replacement and regeneration of the carbon beds; hence, high operation and maintenance (O&M) costs.

Ultrox UV oxidation, Nulite™ catalytic oxidation, and methanotrophic TCE biodegradation are currently only developed on the bench or pilot scales. The costs to develop these innovative technologies to the commercial scale are unknown and can only be projected. Cost-effectiveness of these technologies, therefore, cannot be accurately determined at this time. Consequently, these technologies were rejected based on lack of commercially available systems for timely remediation of soil vapor at the Lockheed Beaumont No. 1 site.

8.1.4 Estimate of Time to Carry Out Each Alternative

Remediation time for alternatives that included venting to the atmosphere, thermal incineration, or biodegradation were not estimated because the alternatives were either unacceptable or not yet proven to be effective. Remediation time for the UV oxidation alternative was similarly not calculated because the technology proved unsuitable for the Beaumont No. 1 site in the treatability study.

Remediation time for the extraction and catalytic oxidation or carbon adsorption alternatives is a function of treatment capacity and the amount of times the contaminated subsurface must be flushed to remove all contaminants. Table 8-2

Table 8-2

Soil Vapor Remediation Time

Treatment Capacity = 200 scfm				
Isopleth Boundary (ppbv)	Volume of Soil Vapor[a] (million scf)	Remediation Time[b] (years)		
		1 PV[c]	10 PV	50 PV
1000[d]	9.5	0.1	1.0	5.0
400[d]	27.4	0.3	3.0	15.0

[a] Volume includes vapor in alluvium and Mt. Eden formations.
[b] Remediation time assumes an operating factor of 90 percent.
[c] PV = pore volume (e.g., 10 PV = 10 pore volumes).
[d] The 1,000 ppbv is the burn pit area; the 400 ppbv area includes the burn pit and the rocket motor production area.

ppbv = parts per billion by volume.
scf = standard cubic feet.
scfm = standard cubic feet per minute.

compares the remediation time for soil vapor within the 1,000 ppbv and the 400 ppbv isopleths (near the burn pit area), assuming a treatment capacity of 200 standard cubic feet per minute (scfm). In the table, a pore volume is the amount of fluid--in this case, soil vapor--that is present in a defined volume of ground (i.e., within a certain concentration isopleth and above the water table). One pore volume of soil vapor within the 1,000 ppbv isopleth is approximately 9.5 million scf.

Contaminants in the subsurface are present in the soil vapor, but they also adhere to soil particles. Therefore, estimates of remediation time must take into consideration the number of times that volume must be flushed to remove contaminants that have adhered to soil particles. An analogy would be to rinsing soap from a sponge: not all the soap comes out of the sponge on the first rinse, and several (many) rinses may be necessary to remove all the soap. Currently, no methods exist to reliably predict this time frame. Estimates range from 0.1 years to remove and treat one pore volume from within the 1,000 ppbv isopleth, to 15 years to remove and treat 50 pore volumes from within the 400 ppbv isopleth. Therefore, the effectiveness of the extraction methods will be closely monitored using the observational approach and modified as necessary to minimize the remediation time.

8.1.5 Effect of Each Alternative Measure on Groundwater

All of the vapor extraction and treatment alternatives would have a beneficial effect on the groundwater beneath the contaminated soil vapor, because each would remove contaminants before they could migrate to groundwater. The vadose (or unsaturated) zone extends as deep as 80 feet below ground surface, and contains a high percentage of the contaminant mass present at the site. Since the groundwater level is currently low due to the past five years of drought, the unsaturated zone extends considerably deeper than normal. The extraction of contaminated vapors will, therefore, be an effective method to remove a large mass fraction of the contaminants present. To be most effective, however, rapid implementation of soil vapor remediation is essential, in case normal rainfall partially restores the groundwater levels, and covers the now-exposed unsaturated zone.

Soil vapor extraction has been also shown to be effective in removing contaminants from the groundwater by disturbing the equilibrium in the vapor above the water table. As contaminated soil vapor is extracted, the volatile contaminants evaporate from the groundwater into the soil vapor, where they, too, are extracted. Extraction of soil vapors will also significantly reduce the risk due to inhalation of vapors rising from the ground surface.

Operation of the CATOX system will generate a very small quantity of brine solution, containing approximately 6% (by weight) sodium chloride and 2% (by weight) sodium bicarbonate; this solution will be mixed with treated groundwater and injected into the aquifer.

The no action alternative would not benefit the environment or remove the contaminants from the soil vapor, and thus would not prevent them from migrating either to the groundwater or to the surface.

8.1.6 Potential for Adverse Change on the Environment

None of the alternatives have a high potential for adversely changing the environment of the site; the treatment units are small and would not require the disruption of large areas of land. Rather, by removing contaminants from the near-surface soil vapor, these alternatives would have a beneficial effect on the environment.

8.1.7 Justification for Rejected Alternatives

The observational approach that is proposed for remediating the Beaumont No. 1 site allows Lockheed to reevaluate the remediation system and to make modifications as they become necessary. These modifications may include substituting soil vapor treatment processes (e.g., carbon adsorption for CATOX) when the contaminant concentrations in extracted soil vapor decline as remediation progresses.

The no action alternative was rejected because it would not meet the remedial action objectives of reducing health risks and remediating the site for unrestricted land use. Venting contaminated soil vapors to the atmosphere was rejected as being unacceptable to the agencies and the public. Incineration was rejected because a fuel source is unavailable at the site, and because of high maintenance costs. Methanotrophic TCE biodegradation was rejected due to high costs.

Ultraviolet oxidation was rejected because of the complexity of operation, potential problems concerning treatment of unreacted ozone and organic vapors, and lack of cost-effectiveness. However, UV oxidation processes that do not use ozone may overcome some of the potential problems (e.g., the RAYOX® process uses UV light, hydrogen peroxide, and proprietary additives), and will be examined further if more large-scale operating data become available before the process design is finalized. Acquisition of these data is essential to demonstrate performance of these new processes since, in the treatability study, the presence of ozone was shown to be important for high oxidation efficiency.

8.2 Recommended Final Remedial Action

The final remedial action for soil vapor will be undertaken in conjunction with the remedial action for groundwater.

8.2.1 Remedial Action Alternative Identification

The recommended remedial action for soil vapor contamination at the Beaumont No. 1 site is to extract the contaminated vapors from the unsaturated zone, treat the soil vapor with catalytic oxidation, and discharge the treated effluent to the atmosphere. The area with the highest concentrations of contaminants in the soil vapor (greater than 1,000 ppbv) will be addressed first (see Figure 3-9 in Section 3.2.9), because potentially more halogenated volatile organic compounds can be removed by processing relatively low volumes of soil vapor and groundwater from these areas.

In practice, the contaminant concentrations will decline exponentially at a presently unknown rate, so carbon adsorption will eventually become economically more attractive as the required frequency of regeneration decreases. Therefore, a carbon adsorption system will be installed for treatment of low concentration vapors and as a backup to a catalytic oxidation unit for air permit compliance.

Based on this evaluation of extraction and treatment technologies and their assembly into a process configuration, the following steps are proposed for implementing the initial remedial action as soon as practicable:

- Investigate the feasibility of increasing the permeability of the Mt. Eden Formation and implement selected technologies to improve extractability of the most contaminated regions of soil vapor and groundwater;
- Prepare specifications for a 200 scfm catalytic oxidation unit to be physically located in the burn pit area; and
- Install the catalytic oxidation unit, vapor recovery wells, and the required piping network as a first priority to extract and treat soil vapor from beneath the burn pit area.

Placement of the extraction wells is discussed in Section 9.2.1. The soil vapor remediation system will initially be operated for six months. Estimates indicate that theoretically two pore volumes within the 400 ppbv VOC soil vapor isopleth will be removed after the operating period. During this six-month period, extraction rates and contaminant concentrations will be observed. Then, based on the results, the soil vapor remediation strategy will be reviewed and revised as necessary.

8.2.2 Description of Mitigation Measures

The proposed remedial action will have no significant or potentially significant adverse impacts on the environment. The only exception would be the potential impact on the Stephens kangaroo rat (SKR) if the relatively impermeable Mt. Eden Formation requires either dense well spacing or the use of a technology to increase the subsurface permeability (such as blasting) to adequately remove contaminated soil vapor and groundwater. All other treatment alternatives were evaluated with the objective of minimizing the effect on the SKR, and should have no significant effect. No other alternatives or mitigation measures to avoid or reduce any significant impacts to the environment have been proposed.

8.2.3 Evaluation of Consistency with Federal Regulations

The evaluation of remedial action alternatives was conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The selected action is, therefore, consistent with federal regulations.

8.2.4 Substantive Technical and Administrative Requirements of the Resource Conservation and Recovery Act (RCRA) Program

Operation of the catalytic oxidation unit (and associated air scrubber) will entail the storage and handling of hazardous materials. Therefore, RCRA requirements for storage and disposal of those materials may apply. Operation of the carbon adsorption unit will generate hazardous waste in the form of the contaminated carbon beds. The spent carbon may be classified as hazardous under the RCRA ignitability or leachability characteristics and, therefore, will need to be handled, transported, and regenerated in accordance with RCRA treatment, storage, and disposal facility (TSDF) regulations, or the equivalent.

8.2.5 CERCLA Section 101 (24) Requirements

The selected remedial action -- catalytic oxidation of contaminated soil vapors -- is more cost-effective than other alternatives when considered over the life of the project, as long as the concentrations of the contaminants remain high. After the concentrations drop below a certain level, carbon adsorption becomes more cost-effective, and the system will be modified accordingly.

The remedial actions at the Beaumont No. 1 site are being undertaken to reduce the health risks of exposure to contaminated soil vapor and groundwater. Removing these relatively high concentrations from the surface soil vapor will reduce both existing and future health risks, as described in the *Health Risk Assessment* (Radian, 1992c).

8.2.6 Health and Safety Plan

A health and safety plan for the construction and operation of the extraction and treatment system will be prepared before any work begins.

9.0 SUMMARY OF REMEDIAL ACTION FEASIBILITY STUDY -- GROUNDWATER CONTAMINATION

Any remedial action implemented at the Lockheed Beaumont No. 1 site must address both soil vapor and groundwater contamination. To be most effective in evaluating and developing a remedial action strategy, it is necessary to look at the partitioning of the contaminants, or the phase in which they are found, as well as the location of the majority of the contamination. Approximately 72% of the mass of the contamination at the site is in the soil vapor phase, and 28% is in the groundwater. Approximately 56% of the groundwater contaminant mass (and 16% of the total contaminant mass) was calculated to be within the 1,000 micrograms per liter (μg/L) isopleth (see Figure 3-6 in Section 3.2.9); greater than 91% of the groundwater contaminant mass (25.6% of the total mass) lies within the 400 μg/L isopleth.

Because of the large size of the Beaumont No. 1 site, and the physical and technical limitations of pump-and-treat systems, treating all groundwater contamination that exceeds Maximum Contaminant Levels (MCLs) would not be possible. Therefore, the initial strategy for remediation will be to treat those areas where both soil vapor and groundwater contain the greatest mass of contaminants, thereby removing the source and reducing the risk for further migration of contaminants. The strategy will also reduce both existing and future health risks as described in the *Health Risk Assessment, Lockheed Propulsion Company Beaumont Site No. 1* (Radian, 1992c).

The "observational approach" strategy will be used to remediate the Beaumont No. 1. Remediation will focus on the proven technologies that will most effectively address the highest concentrations of contaminant in the shortest amount of time. The effectiveness of these technologies will be closely monitored during operation, and the system will be modified, if necessary, to optimize the remediation effort.

9.1 Remedial Actions for Groundwater Contamination

As with the soil vapor contamination, the initial screening of alternatives to control and mitigate groundwater contamination was performed in 1990. A treatability study was conducted in early 1991 to test the effectiveness of the most promising technologies at the site. In late 1991 and early 1992, a detailed analysis of alternatives was conducted, which included innovative technologies, as well as the results of the treatability study.

9.1.1 Identification of Alternative Remedial Actions

Remedial actions for groundwater have three components: extraction, treatment, and disposal. Options for each component were evaluated and assembled into remedial action alternatives.

Each remedial action alternative was evaluated by the following criteria: long-term effectiveness; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability, which included time for construction; and costs. The results of the evaluation are shown on Table 9-1. For a more detailed discussion of each alternative, and each combination of extraction and treatment systems, see the *Lockheed Beaumont No. 1 Treatment Design Feasibility Study* (Radian, 1992b).

Extraction Alternatives

Two extraction systems were evaluated in the feasibility study: a dual-phase (groundwater and soil vapor) high-vacuum system, and a conventional groundwater pumping system.

The dual-phase system extracts both groundwater and soil vapor from each well by applying a high vacuum through a central lift pipe that extends down the well to

Table 9-1

Comparison Matrix for Groundwater Alternatives

Technology	Processes	Long-Term Effectiveness	Reduction of Toxicity, Volume, or Mobility	Short-Term Effectiveness	Implementability	Cost	Total
Extraction							
Dual-Phase, High Vacuum	Xerox ®	3	4	3	2	4	16
Conventional	Various	3	2	2	5	2	14
Treatment							
No Action	N/A	1	1	2	5	5	14
Carbon Adsorption	Various	3	4	4	5	2	18
Air Stripping	Various	5	4	4	4	4	21
Ultraviolet Oxidation	Ultrox, Rayox ®	4	5	4	3	1	17
Biodegradation	GRI, Other research groups	4	3	2	1	4	14

5 = Superior
4 = Better than average
3 = Average
2 = Worse than average
1 = Inferior
N/A = Not applicable

just above the water level. The high vacuum pulls both soil vapor and groundwater droplets into the pipe. This system has the added benefit of effectively air stripping the volatile contaminants out of the water droplets while they are still in the well, thereby reducing the concentrations in the groundwater that must be treated at the surface. Another advantage of simultaneous groundwater pumping and soil vapor extraction is that the water table is depressed around the well, creating a hydraulic gradient for water to flow toward the well. It also exposes more of the vadose zone close to the water table, where contaminant concentrations are highest.

The conventional system of groundwater extraction uses downhole pumps. Groundwater is pumped from each extraction well to a feed tank for treatment via a groundwater transport pipeline. If soil vapor extraction is performed in the same well, a separate vacuum pump will be used.

Treatment

Six technologies were considered in the initial screening of alternatives for treatment of groundwater contamination:

- Oxidation of organics with hydrogen peroxide/ozone/ultraviolet (UV) light (UV oxidation). Organics are oxidized to water and carbon dioxide, reducing the need for air pollution controls. The ultraviolet light acts as a catalyst that causes the oxidants to split and form free hydroxyl radicals; these hydroxyl radicals react with organics more rapidly than ozone or hydrogen peroxide alone. Unreacted ozone requires additional control systems, but no other air emissions are produced when liquid is treated.

- Liquid-phase carbon adsorption of organics from groundwater on granular activated carbon. Carbon adsorption is a process in which a water or vapor stream containing organic compounds is brought into contact with activated carbon. The organic compounds in the water or the air stream are selectively adsorbed onto the surfaces of the carbon granules. Because each carbon granule contains a very high surface area-to-volume ratio, large quantities of organic compounds can be adsorbed.

The effectiveness of the carbon system depends on the solubility of the organics in water, contact time within the carbon bed, type of carbon used, the size of the carbon granules, and the affinity of the carbon for the compounds of interest. A liquid-phase system requires considerable operator attention during sampling and analysis to ensure that the carbon is replaced when organics break through the carbon bed.

- Air stripping/carbon adsorption of volatile organic contaminants (VOCs). Air stripping first transfers organic compounds from the groundwater to an air stream. A vapor-phase activated carbon system then removes contaminants from the air stream. Further treatment (carbon regeneration or incineration) is required to destroy the adsorbed contaminants. The effectiveness of the air stripping system depends on the solubility of the organics in water, vapor pressure of the organics, height of the tower, type of packing material, and temperature of the water and air.

- Steam stripping/off-site disposal of contaminants with low volatility. Steam, rather than air, removes organics from the groundwater. The contaminated steam is condensed and decanted, which separates the organic and aqueous phases. The condensed organics are incinerated, recycled, or treated off site.

- Air stripping/incineration of contaminants with high volatility. After air stripping, contaminated air is passed through an incinerator to thermally destroy the contaminants.

- Evaporation of the organics from the untreated water containing low concentrations of contaminants. Groundwater is pumped to holding ponds or tanks and/or spray irrigated over the site to evaporate the organics. Spray irrigation would be similar to air stripping and would be particularly effective during the hot summers in the Beaumont area. Ultraviolet sunlight would also act to photochemically destroy the halogenated contaminants.

Two additional technologies were considered, but not evaluated as alternatives. Pumping groundwater to a publicly owned treatment facility (POTW) was not evaluated as an alternative because of the long distance to a sewer connection and because the nearest facilities would not accept the discharge. In situ bioremediation of the groundwater was not evaluated as a treatment option because of the large area of the site and the relatively fine-grained soil material.

These six technologies were ranked using the same methodology that was used to rank soil vapor technologies. Of the six technologies screened, UV oxidation and liquid-phase carbon adsorption ranked the highest. Evaporation was eliminated from further consideration because of its limited applicability and the probable inability to obtain an air permit.

The feasibility study also ranked additional groundwater treatment technologies. These innovative technologies became available commercially only after the initial screening of alternatives. The additional alternatives are:

- Nulite™ catalytic oxidation with titanium oxide oxidizes contaminants in water and vapor using a selected band of light to excite a titanium oxide catalyst causing the formation of the hydroxyl radical. This hydroxyl radical attacks and breaks down the hazardous contaminants. Development of the catalyst began four years ago and is complete, but the engineering of the system is not quite perfected. Five systems are operating in Japan; others are being field tested in North America.

  Nulite™ is not entirely commercially developed -- current practice is to run a small trial reactor at the site for three months to determine the best operating conditions before scaling up. This system destroys contaminants in groundwater and soil vapor effectively and requires primarily electricity as a utility; however, it may not be developed enough for application.

- RAYOX® oxidation, marketed by Solarchem, cleans groundwater using UV light, hydrogen peroxide, and a proprietary catalyst. Systems are operating in Carson City, NV (benzene from 17,000 parts per million [ppm] to 5 parts per billion [ppb]), and in Riverside, Santa Barbara, and Bakersfield (Superfund site), CA. Current designs treat 2 to 600 gallons per minute (gpm).

- Wet-air oxidation involves liquid-phase oxidation by dissolving oxygen in water at high temperatures (300-400°C) and very high pressures (1,500 to 3,000 psi). Three or four companies sell the process in North America, and at least one system operates in California. Compressing air to the high operating pressures entails very high operating costs.

- Anoxic liquid-phase fluidized bed biological treatment uses bacteria that grow in a liquid-fluidized sand bed reactor to degrade contaminants. The process is not expected to work well on chlorinated contaminants because the bacteria do not survive well. Researchers are still running bench-scale tests of the process.

- Fixed film bioreactor tests show a 60% reduction of trichlorethene (TCE) for concentrations exceeding 1,000 micrograms per liter (μg/L), greater than 90% reduction of TCE and trichloroethane (TCA) in vapor and 35-40% reduction in alkylbenzenes in soil. The process uses methane, butane, and natural gas as a substrate for bacteria. However, only bench-scale tests have been completed.

- Other bioremediation technologies which destroy, rather than transfer toxics from one medium to another, may be preferable to most other traditional treatments. However, few bacteria are capable of degrading chlorinated hydrocarbons. Both aerobic and anaerobic degradations of TCE are being researched and have potential, but only the technologies mentioned above have currently progressed enough for consideration.

- The Cascade-packed tower air stripper is generally the most efficient air stripper design for contacting air and water. The cascade air stripper uses the same basic design as traditional packed tower air strippers, except air is injected at graduated levels rather than all at the bottom. It has been tested for three weeks at 400 gpm with reduction of TCE levels from 500 μg/L to 10 μg/L, and may cost up to 10 times less than a traditional air stripper, even if an activated carbon filter system is added. The design seems to be an academic rather than commercial development, because there are currently no vendors for such a system.

- Cooling towers may be more cost-effective, easier to maintain, and easier to operate than standard towers for high flow rate (>1000 gpm) designs. In one example, reducing TCE from 25 μg/L to <5 μg/L (80% reduction) at 1000 gpm could be accomplished with either a \$50,000 to \$60,000 standard air stripper or a \$20,000 cooling tower. However, since flow rates less than 1000 gpm are anticipated in this project, cooling towers are not an appropriate technology.

- Diffused aeration tanks may be a better choice for removing volatile organic compounds (VOCs) from streams containing high concentrations of inorganic compounds. Utility costs will be higher, but capital costs are lower and the added utility cost may be less than the expenses from changing fouled packing. Since groundwater at the Beaumont No. 1 site does not contain high levels of inorganics, these tanks are not relevant to this project.

A final alternative is the no action alternative, in which the contaminated groundwater would be left in the aquifer.

Disposal

Disposal alternatives include pumping the treated water to a POTW, or injecting the cleaned groundwater into wells located on the downstream side of the rocket motor production area. Downgradient of this area, contaminant concentrations in the groundwater drop significantly; injection of treated water would further dilute these concentrations.

Injection of the groundwater assumes that the aquifer will never be used as a source of drinking water. As groundwater flows downgradient, it appears to be completely evapotranspired by the vegetation along the present stream bed. This assumption is based on the fact that the alluvial aquifer gradually disappears as it approaches Massacre Canyon.

9.1.2 Purpose, Objective, and Scope

The purpose of the remedial action is to restore the Beaumont No. 1 property to allow unrestricted land use. The scope of the remediation is based on the assumption that the aquifer will never be used as a drinking water source. Rather, the initial action will be to treat contaminated groundwater within the 1,000 $\mu g/L$ isopleth, because this is where the greatest mass of contaminants lies. Removing these higher concentrations will reduce both existing and future health risks, as described in the *Health Risk Assessment, Lockheed Propulsion Company Beaumont Site No. 1* (Radian, 1991c).

9.1.3 Cost Effectiveness

The feasibility study concluded that the dual-phase extraction system, which air strips the contaminated groundwater in the well, followed by activated carbon polishing is the most cost-effective treatment method for the higher contaminated groundwater. In areas of lower contamination, or where the aquifer permeability is too high for the dual-phase system to work effectively, an air stripping tower is most cost-effective. Vapors will be treated by catalytic oxidation or activated carbon.

The need to provide equipment for ozone generation and the need to destroy unreacted ozone and organics causes the UV/oxidation process to be less cost-effective for groundwater treatment.

Wet air oxidation has very high operating costs, due to the need to compress air to very high operating pressures; the process is, therefore, not cost-effective at this site.

Cooling tower air strippers are most cost-effective at flow rates greater than 1,000 gpm; flow rates for the Beaumont No. 1 site are anticipated to be 100 gpm. Therefore, a cooling tower air stripper is not cost-effective at this site.

9.1.4 Estimate of Time to Carry Out Each Alternative

Since several of the alternatives are not commercially available, time to carry out these alternatives was not estimated. Similarly, time to carry out biodegradation alternatives was not estimated because these technologies are unsuitable for treating chlorinated contaminants, such as those found at the Beaumont No. 1 site.

Remediation time for the extraction and catalytic oxidation or carbon adsorption alternatives is a function of treatment capacity and the number of times the contaminated subsurface must be flushed to remove all contaminants. Table 9-2 compares the remediation time for groundwater within the 1,000 μg/L and the 400 μg/L isopleths (near the burn pit area), assuming a treatment capacity of 100 gpm. In the table, a pore volume is the amount of fluid--in this case, groundwater--present in a defined volume of the ground (i.e., within a certain concentration isopleth and a measured aquifer thickness). One pore volume equals the volume of groundwater within the isopleth. One pore volume of groundwater within the 1,000 μg/L isopleth is approximately 30.6 million gallons.

Contaminants in the subsurface are present in the groundwater, but they also adhere to soil particles. Therefore, estimates of remediation time must take into consideration the number of times that volume must be flushed, or rinsed, with fresh formation water to remove contaminants that have adhered to soil particles. An analogy would be rinsing soap from a sponge: not all the soap comes out of the sponge on the first rinse, and several (many) rinses may be necessary to remove all the soap.

Currently, no reliable methods exist to predict this timeframe. Estimates range from 0.65 years to remove and treat one pore volume from within the 1,000 μg/L isopleth, to 175 years to remove and treat 50 pore volumes from within the 400 μg/L isopleth. The length of time predicted is indicative of why groundwater pump-and-treat methods have been shown to be less than effective in remediating groundwater

Table 9-2

Groundwater Remediation Time

Treatment Capacity = 100 gpm				
Isopleth Boundary (μg/L)	Volume of Groundwater (million gallons)	Remediation Time (years)		
		1 PV[a]	10 PV	50 PV
1000[b]	30.6	0.65	6.5	32.5
400[b]	164.1	3.5	35	175

[a] PV = pore volume (e.g., 10 PV = 10 pore volumes).
[b] The 1,000 μg\L area is in the burn pit area; the 400 μg/L area includes the burn pit and the rocket motor production areas.

gpm = gallons per minute.

μg/L = micrograms per liter.

contamination. Therefore, the effectiveness of the extraction methods will be closely monitored using the observational approach. This will allow the extraction and treatment system to be modified as necessary to minimize the remediation time and continually focus the remediation on the most contaminated areas.

9.1.5 Effect of Each Alternative Measure on Groundwater

All of the pump-and-treat alternatives would remove contaminants from the aquifer, with varying levels of effectiveness.

The no action alternative would have no effect on the groundwater; contaminant levels and, therefore, potential health risks would not be reduced and contaminants would continue to migrate downgradient. However, since it is assumed this aquifer will not be used as a source of drinking water, no drinking water supplies would be affected by this or any other alternative.

Disposal of the extracted groundwater to a POTW would have the long-term effect of removing water from the aquifer, so less water would be available for the riparian habitats in lower parts of the canyon. Injection of treated water downgradient of the areas of highest contamination would accomplish three things:

- It would form a hydraulic barrier to minimize the flow from highly contaminated areas to areas of low contamination (hydraulically induced containment);
- It would disperse the already low concentrations of contaminants remaining in the downgradient portion of the contaminant plume; and
- It would not reduce the amount of groundwater available in the lower portions of the canyon.

9.1.6 Potential for Adverse Change in the Environment

None of the other alternatives evaluated present significant potential for adverse impact on the environment. Impacts of construction are not considered to be significant.

9.1.7 Justification Statement for Rejected Alternatives

Alternatives were rejected for the following reasons:

- The no action alternative was rejected because it would not meet the remedial action goal of making the site available for unrestricted land use.
- The UV oxidation alternatives that use ozone were rejected because of low cost effectiveness, the complexity of operation, and potential problems concerning treatment of unreacted ozone.
- Nulite™ catalytic oxidation with titanium oxide was rejected because it is not developed enough for application.
- The biodegradation and biological treatment alternatives were rejected because they are unsuitable for treating chlorinated contaminants, the primary contaminants of concern at the Beaumont No. 1 site.
- Wet air oxidation was rejected because of its high operating costs.
- The cascade-packed tower air stripper was rejected because it is not commercially available.
- The cooling tower air stripper and diffused aeration tank alternatives were rejected as inappropriate for this site because anticipated flow rates were not high enough.
- Air stripping/incineration was rejected because of unavailability of a fuel source, high maintenance costs, and the extensive permitting process required.
- Evaporation of untreated groundwater was rejected as unacceptable.

The Rayox® process does not use ozone and may be examined further before the process design is finalized if more large-scale operating data become available.

9.2 Recommended Final Remedial Action

Groundwater remediation will take place in two areas: extraction and treatment of the most contaminated groundwater beneath the burn pit area, and extraction and treatment of groundwater with lesser contamination from beneath the rocket motor production area. This dual focus will effectively contain the most contaminated portions of the aquifer (burn pit area) and minimize the further migration of contaminants (rocket motor production area).

9.2.1 Remedial Action Alternative Identification

Extraction System

The extraction system recommended for the Beaumont No. 1 site is a combination of dual-phase, high vacuum (Xerox®) extraction wells and conventional groundwater extraction wells. Although the estimated costs of the dual-phase system are approximately 50% of those for a conventional extraction system (because downhole groundwater pumps and associated pipelines are not required), the dual-phase system is not capable of lifting the larger volumes of groundwater produced by wells in high permeability areas of the alluvial aquifer.

The combination of techniques will allow the groundwater extraction system to be designed to match the permeability and contaminant levels of specific extraction wells. The most effective use of the two extraction systems will be determined as the extraction wells are installed and the actual well production rates and contaminant levels are determined in the field. The number of wells required will be determined by evaluating the individual well production rates and comparing them with the design criteria developed during groundwater modeling activities. Enough wells will be installed to provide for extraction of a sufficient volume of water to adequately capture and control the contaminants. Possible locations of the extraction well network are shown on Figure 9-1.

Treatment System

The recommended groundwater treatment system will involve the use of three treatment methods, as shown on Figure 9-2. These methods are:

- Air stripping of groundwater during the dual-phase extraction process;
- An air stripping column to treat water not extracted by the dual-phase extraction system; and
- Liquid-phase carbon adsorption.

In the areas where the dual-phase extraction system is implemented (areas of the aquifer with low permeability), contaminants will be stripped from the groundwater as the water is brought to the surface. Liquid-phase carbon adsorption is the most cost-effective alternative to perform the final polishing of the groundwater required to achieve waste discharge requirements.

In areas where conventional extraction pumps are used (areas of high permeability), contaminants will be removed using an aboveground air stripping column. Air stripping was demonstrated in the treatability study to provide a cost-effective solution that meets waste discharge requirements for the treated groundwater before it is injected back into the aquifer. It is anticipated that the air stripper will be located in the vicinity of the rocket motor production area. Off-gas from the air stripper will be routed

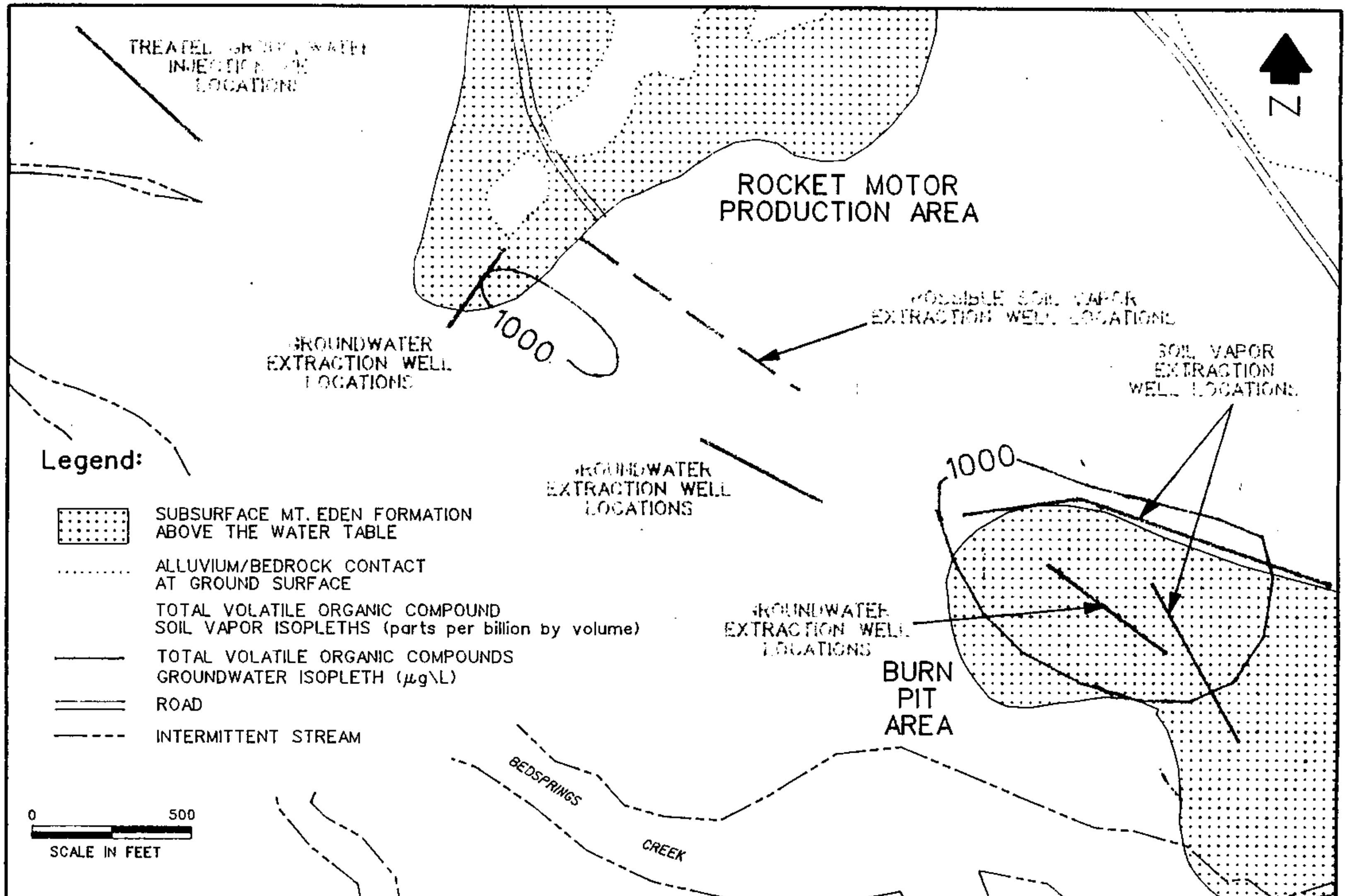

Figure 9-1. Locations of Groundwater and Soil Vapor Extraction Wells at Lockheed Beaumont No. 1

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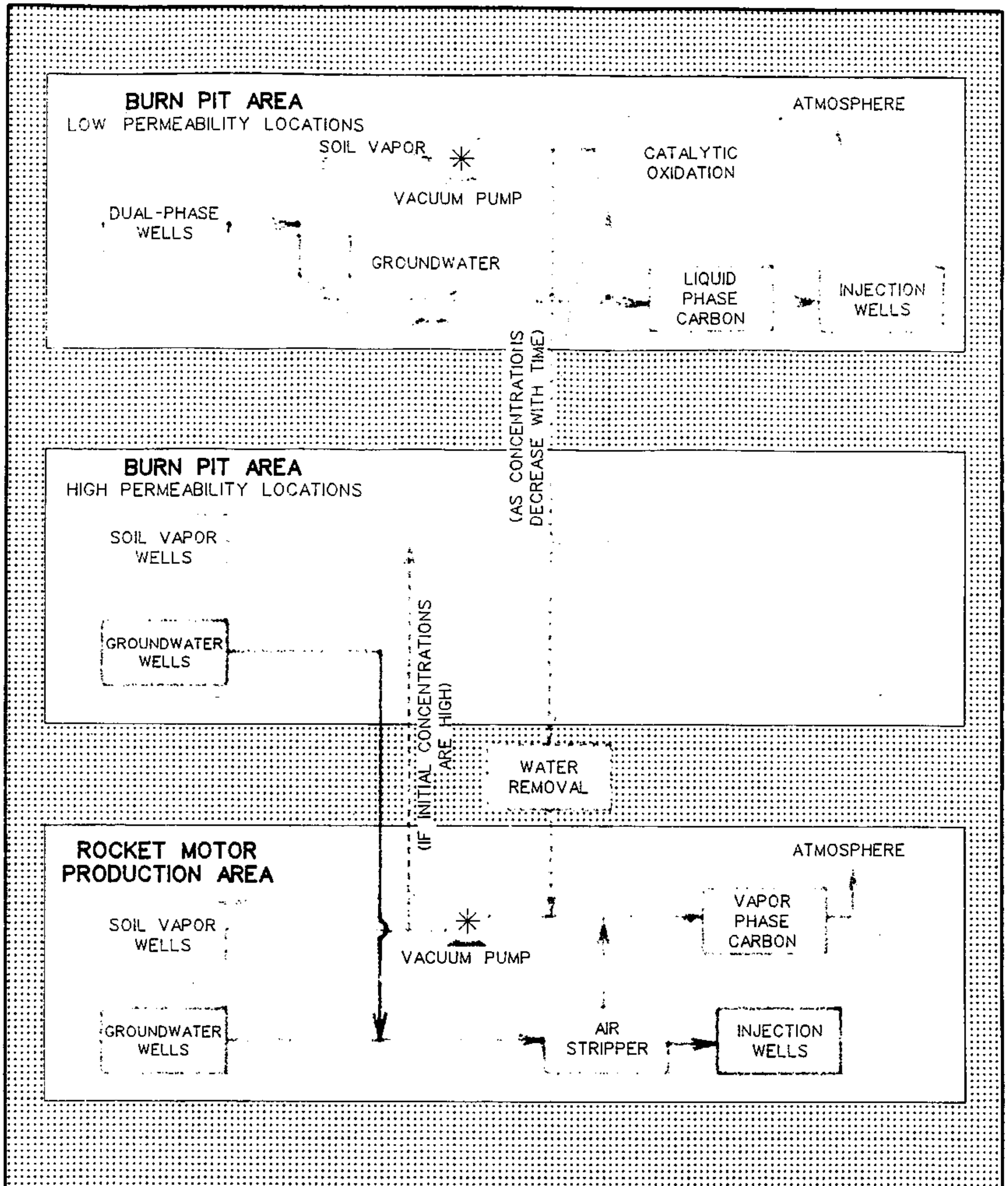

Figure 9-2. Process Configuration of Proposed Remedial Action Alternative

LOCKTRNS FLOWLS 4/13/92

through a vapor-phase carbon adsorption system before release to the atmosphere. If it is necessary to extract soil vapors from the rocket motor production area (which are expected to be of relatively low concentration), then these vapors will be combined with the vapor stream leaving the air stripper and treated with the activated carbon.

Based on the beneficial effects of nitrates on the riparian habitat and the very low probability that the groundwater will be used as a source of drinking water, and per agreement by the Santa Ana Regional Water Quality Control Board (RWQCB, 1992), nitrates will not removed from groundwater as part of the treatment process.

Disposal

Treated groundwater will be injected into the aquifer downgradient (downstream) of the rocket motor washout area, subject to the waste discharge requirements of the Santa Ana Regional Water Quality Control Board. Downgradient groundwater is anticipated to be completely evapotranspired by the vegetation along the present stream bed, since no groundwater appears to leave the site through Massacre Canyon.

The groundwater remediation system will be operated for approximately two years, during which time the extraction rates and contaminant concentrations will be observed. Then, based on the initial results, the groundwater remediation strategy will be reviewed and modified as necessary. In particular, the rates of concentration decline will be monitored; this may prompt a change in which extraction wells are operated and/or the cycle of operation that is necessary to accelerate the progress of remediation.

9.2.2 Description of Mitigation Measures

Although the proposed remedial action will have no significant or potentially significant adverse impacts on the environment, mitigation measures will be taken to comply with federal, state, and local regulations as stated in the Mitigated Negative Declaration.

9.2.3 Evaluation of Consistency with Federal Regulations

The evaluation of remedial action alternatives was conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The selected action is, therefore, consistent with federal regulations.

9.2.4 Substantive Technical and Administrative Requirements of the Resource Conservation and Recovery Act (RCRA) Program

The carbon adsorption until will generate hazardous waste in the form of the contaminated carbon beds. The spent carbon may be classified under the RCRA ignitability or leachability characteristic and, therefore, will need to be handled, transported, and regenerated in accordance with RCRA treatment, storage, and disposal facility (TSDF) regulations. Therefore, RCRA requirements for storage and disposal of those materials may apply.

9.2.5 CERCLA Section 101 (24) Requirements

The selected remedial action--catalytic oxidation of contaminated soil vapors combined with air stripping and carbon adsorption of groundwater--is more cost-effective than other alternatives when considered over the life of the project, and as long as the concentrations of the contaminants remain high. After the concentrations drop below a level at which carbon adsorption for soil vapors becomes more cost-effective, the system will be modified accordingly.

The remedial actions at the Beaumont No. 1 site are being undertaken to reduce the health risks of exposure to contaminated soil vapor and groundwater. Removing the relatively high concentrations from the subsurface soil vapor will reduce both existing and future health risks, as described in the *Health Risk Assessment* (Radian, 1992c).

9.2.6 Health and Safety Plan

A Health and Safety Plan for the installation of wells has been prepared as part of the *Draft Hydrogeologic Investigation Work Plan* (October 1989). This plan will be followed when extraction wells are installed at the site and during construction of the treatment system. In addition, a health and safety plan for the operation of the extraction and treatment system will be prepared before the system is operational.

A Health and Safety Plan for the Burn Pit Removal Action was included as part of the *Burn Pit Removal Action Plan* (April 1991).

10.0 IMPLEMENTATION SCHEDULE

The remedial action described in this report cannot begin until the following have been obtained:

- Approval of this Remedial Action Plan by the Department of Toxic Substances Control (DTSC), California Environmental Protection Agency; and
- Proper permitting to alter habitat occupied by the Stephens kangaroo rat (SKR).

Once the permits and approvals are received, remedial activities can begin. The schedule for these activities is as follows:

Approval of Remedial Action Plan by DTSC	September 30, 1992
Well Installation Plan Approval by DTSC	August 14, 1992
Installation of Extraction Wells	August 1992-January 1993
SKR Approval by U.S. Fish & Wildlife	October 31, 1992
Burn Pit Removal Action Implementation	December 1992-March 31, 1993
Treatment System Design Plan	October 31, 1992
Waste Discharge Requirements from Regional Water Quality Control Board	October 31, 1992
Air Quality Permits from South Coast Air Quality Management District	October 31, 1992
Treatment System Construction	November 1992-May 31, 1993

11.0 NON-BINDING PRELIMINARY ALLOCATION OF FINANCIAL RESPONSIBILITY

Lockheed Corporation accepts financial responsibility for all remedial actions.

12.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Applicable or relevant and appropriate requirements (ARARs) are other environmental laws that may be either "applicable" or "relevant and appropriate."

Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) site.

Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site.

Five ARARs have been identified for the Beaumont No 1 site. The ARARs, and the steps being taken to address them are:

- South Coast Air Quality Management District (SCAQMD) Rule 1150 for the excavation and removal of burn pit wastes. A permit to excavate was issued on 24 July 1991, and an extension to this permit was granted on 30 March 1992.
- Waste Discharge Requirements (WDR) from the Santa Ana Regional Water Quality Control Board (RWQCB) for the discharge of treated groundwater into the groundwater aquifer. An application for WDR was filed with the RWQCB on 22 July 1992.

- SCAQMD air quality permits for the catalytic oxidation system, the air stripper/activated carbon system, and the mobile vacuum extraction trailer. The permit application for the trailer was submitted to SCAQMD on 4 August 1992. The permit for the permanent systems will be submitted as soon as final design specifications have been completed.

- Permission to trap and relocate the endangered Stephens kangaroo rats living in the burn pit area. A tentative agreement has been reached with the U.S. Fish and Wildlife Agency. Final written approval is currently being prepared. The burn pit removal action will not be started until complete authorization has been obtained.

- Maximum Contaminant Levels (MCLs) for groundwater. Based on the Regional Water Quality Control Board (RWQCB) Resolution 88-63, the groundwater beneath the Lockheed Beaumont Site No. 1 is defined in the Water Quality Control Plan as potentially suitable for municipal or domestic water supply. The Department of Toxic Substances Control (DTSC) will require MCLs to be used as the cleanup goals for remediation of the groundwater aquifer beneath the Lockheed Beaumont Site No. 1. This requirement by the DTSC will be reviewed on an annual basis as site-specific groundwater monitoring data become available, with a comprehensive review after 5 years.

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