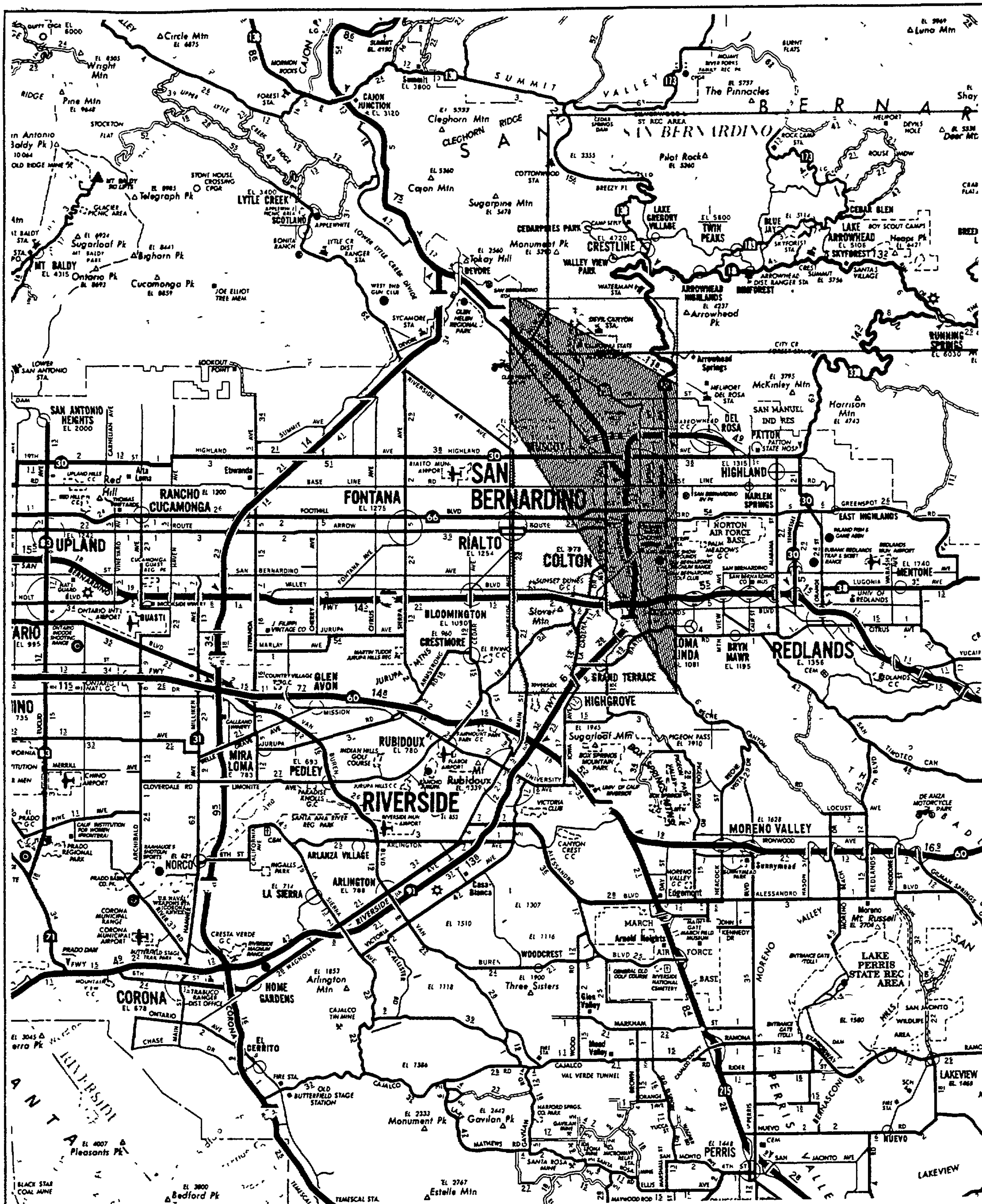

Figure 1-1
Study and Model Areas
Newmark Operable Unit RI/FS Report

Base Map: Automobile Club of Southern California, Los Angeles County and Vicinity, 1990

0 4 8
Scale in Miles

LEGEND

- Study Area
- Model Area

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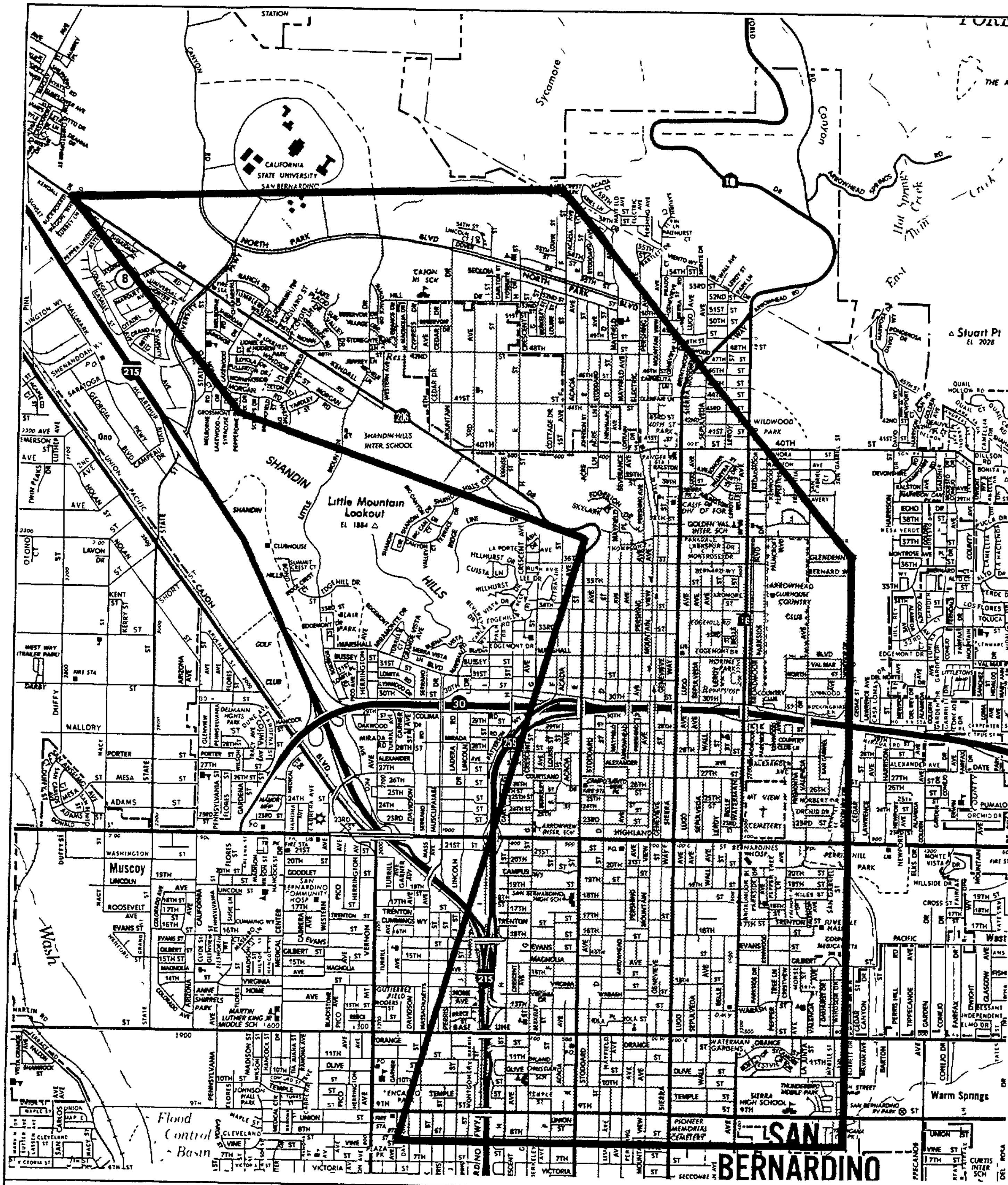


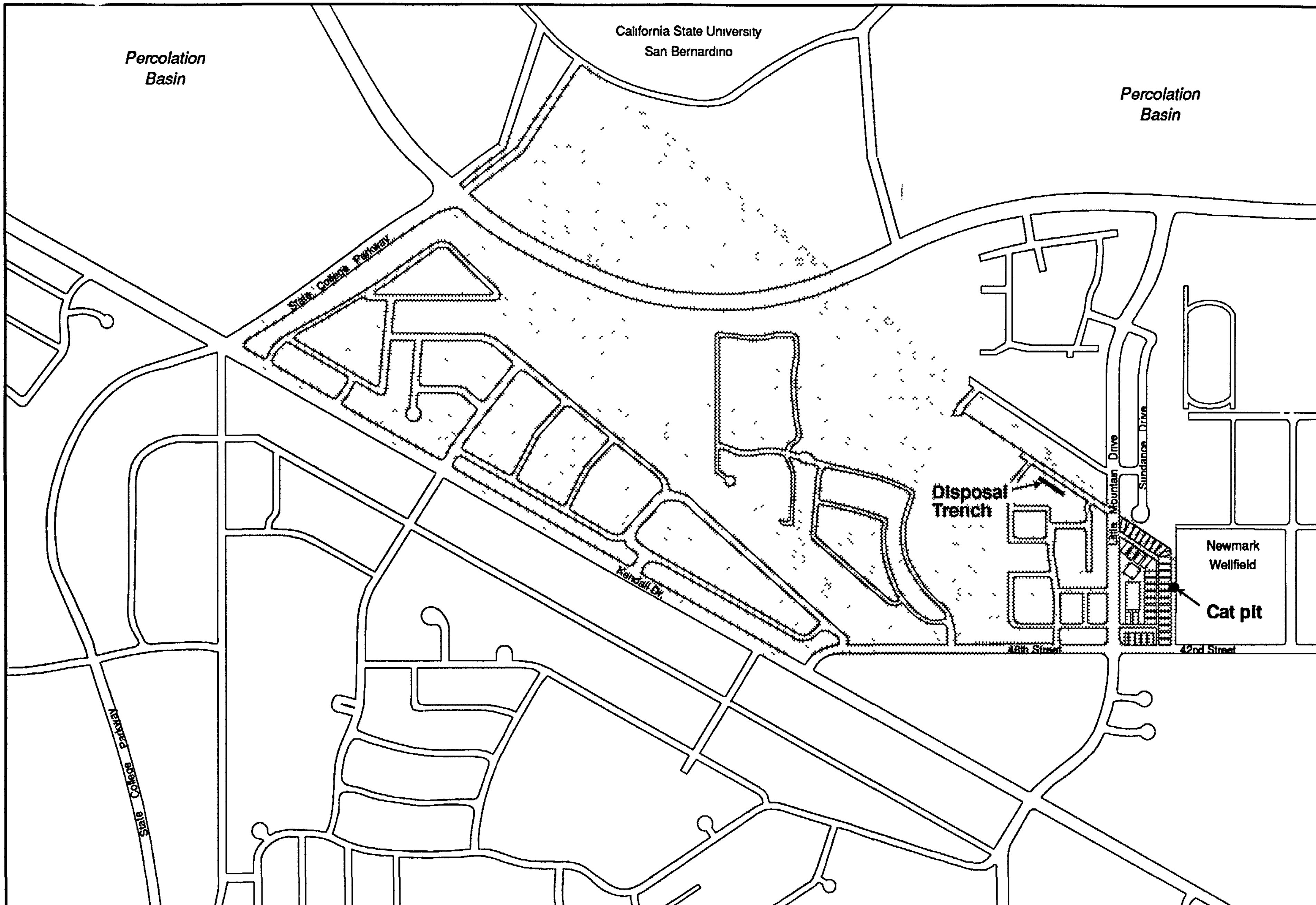
0 .5 1 1.5
Scale in Miles

Figure 1-2
Investigation Area
Newmark Operable Unit RI/FS Report

Base Map from Automobile Club of Southern California, San Bernardino-Redlands Area, 1990.

LEGEND

Investigation Area



N
Not to Scale

Figure 1-3
Suspected Source Area
Newmark Operable Unit RI/FS Report

LEGEND	
▒	Suspected Source Area (Old San Bernardino Airport)

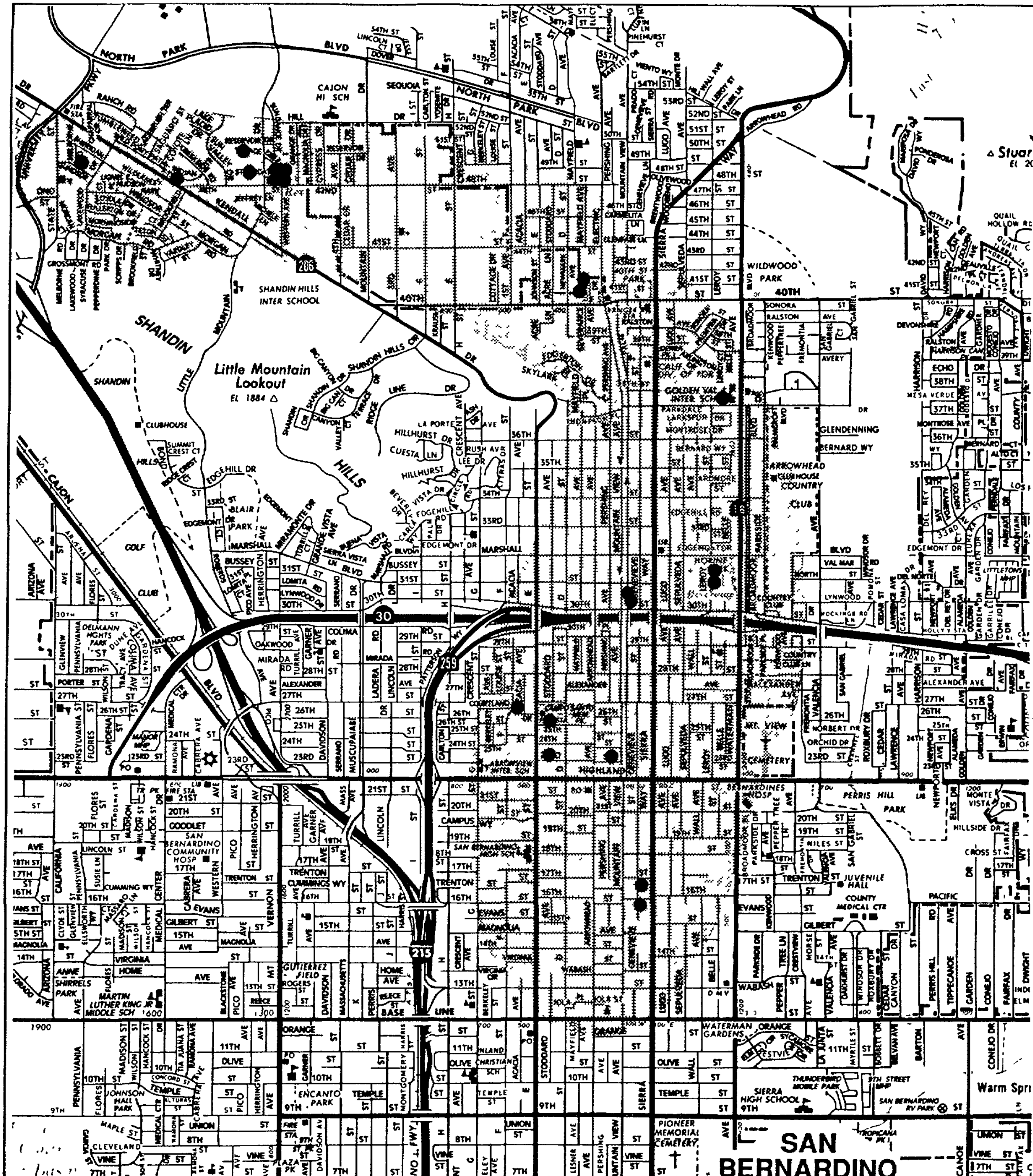


Figure 1-4

Plume Area

Newmark Operable Unit RI/FS Report

0 1 2
Scale in Miles

Base Map from Automobile Club of Southern California, 1990.

LEGEND

● = Affected Wells

= Plume Area

1.3 REPORT ORGANIZATION

The Newmark Groundwater Contamination Remedial Investigation/Feasibility Study Report is organized in accordance with "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA Interim Final, October 1988).

1.0 Introduction

2.0 Regional Setting

General description of physical and environmental conditions for study area; includes surface/subsurface features (geology/hydrogeology), climate, and demography.

3.0 Investigation Technique

Documentation of investigative field activities and field methodologies for construction and development of monitoring wells; includes analytical methods of data collection.

4.0 Investigation Area Characteristics

Focused description of physical characteristics (geology/hydrogeology) for suspected source and plume areas.

5.0 Nature and Extent of Contamination

Interpretation of data collected from soil and groundwater samples from suspected source and plume areas, and municipal wells; includes data from this RI/FS and previous investigations.

6.0 Contaminant Fate and Transport

Information on physical, chemical, and biological factors affecting contaminants; development of potential routes of contaminant persistence; evaluation of contaminant movement in groundwater through modeling; and a Risk Assessment, furnished by EPA.

7.0 Summary and Conclusions

Conclusions drawn from analytical data gathered from investigation activities, modeling, and other documents; summary of recommended remedial action objectives specifying contaminants of concern, exposure routes, and acceptable contaminant levels (MCLs).

8.0 Remedial Action Objectives

Detailed descriptions of remedial action objectives/target cleanup levels to provide a design basis for screening technologies. Applicable or Relevant and Appropriate Requirements (ARARs) and a summary of the baseline health risk assessment is provided. The ARARs and the baseline health risk assessment were furnished by EPA.

9.0 General Response Actions

Description of actions that fulfill remedial action objectives are grouped into four categories: No Action, Institutional Actions, Collection/Treatment/Disposal Actions, Containment Actions.

10.0 Identification and Initial Screening of Technologies and Process Options

Presentation of technologies and process options that potentially meet general response actions; evaluation and initial screening of options for further consideration.

11.0 Evaluation of Technologies and Process Options

Summary of final screening evaluation of technologies and process options based on effectiveness, implementation, and relative cost.

12.0 Development and Screening of Alternatives

Definition of remedial action alternatives; screening evaluation for effectiveness, implementation, and relative cost.

13.0 Detailed Analysis of Alternatives

Detailed analysis of alternatives remaining after screening, according to the nine EPA criteria that address effectiveness, implementation, and relative cost; comparison of alternatives with respect to each criterion.

2.0 REGIONAL SETTING

2.1 SURFACE FEATURES

The study area (see Figure 1-1) lies in the northwestern portion of the San Bernardino Valley at the base of the San Bernardino Mountains. The study area is comprised of a series of confluent alluvial fans (bajadas) derived from the San Gabriel Mountains to the northwest and the San Bernardino Mountains to the northeast to form the San Bernardino Valley. The alluvial fans are formed where the Santa Ana River, Mill, Lytle, Cajon, Devil Canyon, East Twin, and City Creeks leave the mountains and coalesce to form part of a broad alluvial plain in the central part of the San Bernardino Valley (Dutcher and Garrett 1963).

These mountains are drained by river channels and stream washes that flow southward to the valley floor below. With few exceptions, stream channels of the area are dry washes that support little or no vegetation and only contain appreciable runoffs for short periods during the wet winter months.

Several bedrock hills protrude above the alluvial fans. North of the Santa Ana River between the faults (San Jacinto and San Andreas), Shandin, Perris, Badger and Wiggins Hills rise 50 to 550 feet above the valley floor (Plate 1). All are believed to have been elevated by differential movement along faults in the bedrock (Dutcher and Garrett 1963). Well logs indicate similar bedrock hills exist at shallow depths beneath the valley floor. Several of these buried hills are significant in controlling the distribution and character of the older water-bearing alluvium.

In the area northwest and west of Colton, the surface of the older alluvium is concealed by relatively high hills and dunes of wind blown sand that support sparse vegetation. The crest of the dunes are as much as 40 feet above the general elevation of the alluvial plains.

Several northwestward trending faults, notably the San Andreas and San Jacinto Faults, form the boundary of the San Bernardino Valley (Plate 1). The dissected scarp of the San Andreas Fault rises above the valley edge to elevations ranging from about 2,700 feet at the mouth of Cajon Creek to more than 5,500 feet at the mouth of the Santa Ana River canyon. Ridges associated with the San Jacinto Fault are one of the major structural features in southern California. The San Jacinto Fault branches from the San Andreas Fault north of the study area and is the only major fault crossing the valley where topographic evidence of movement has been preserved. From the Fontana power plant of the Southern California Edison Company near Riverside Avenue to the Santa Ana River flood plain, scarps, terraces, and ridges are exposed along a discontinuous line as a result of differential movement along the San Jacinto Fault (Dutcher and Garrett 1963). Bunker Hill Dike, located between the cities of San Bernardino and Colton, consists of a series of subparallel ridges associated with the San Jacinto Fault and rises 15 to 40 feet above the adjacent alluvial plain.

Man-made features present in the study area include a series of percolation basins scattered throughout the area ranging in size from approximately 5,000 square feet to 20 million square feet (Plate 1). These basins are used to provide additional groundwater recharge in the area and substantially influence the surface water flow patterns originating in the San Bernardino Mountains to the north. Additionally, to handle the surface water run-off from abundant residential and commercial structures, concrete-lined drainage or flood canals were constructed throughout the northwest portion of the study area.

2.2 CLIMATE

The City of San Bernardino, located in the northeastern portion of the San Bernardino Valley, lies in a semi-permanent high pressure zone of the eastern Pacific, resulting in a Mediterranean-like climate characterized by long, hot summers and short, mild winters. This climate formation is interrupted infrequently by northeasterly Santa Ana winds.

The coolest months are January and December with a mean monthly minimum temperature of 39.4°F. The warmest month is July with a mean monthly maximum of 97.6°F. Average daily temperatures for the area range in the summer from the low 50s°F to the upper 90s°F, with occasional temperatures above 100°F; and in the winter from the upper 30s°F to the mid-60s°F, with occasional temperatures below 32°F. The sun is visible during 70-80% of the daylight hours annually (Woodruff and Brock 1980).

San Bernardino precipitation normal is 15.68 inches per year based on climatological records for a 30 year period from 1951 to 1980 (NOAA 1982). Approximately 90% of the annual rainfall occurs between November and April, with 50% of that rainfall occurring during the months between December and February. Historical climatological data collected from 1951 to 1990 indicate overall precipitation deviation from the previous year(s) has increased overall (Table 2-1). Recent precipitation deviation reflects current drought conditions being experienced throughout California.

Rainy days in the basin vary from 5 to 10% annually with the frequency increasing near the coast. Although the South Coast Air Basin has a semi-arid climate, the air near the ground surface is frequently humid because of the presence of a shallow marine layer on most days. Except for infrequent periods when Santa Ana winds enter the basin, the maritime air mass is dominant. Periods with heavy fog are frequent; and low stratus clouds, sometimes referred to as "high fog", are a characteristic climatic feature. Mean annual relative humidity is 70% at the coast and 57% inland (Envicom 1989).

Surface winds in the study area (located in the northeast region of the 6,600 square mile South Coast Air Basin) are portrayed by a diurnal reversal of direction. Breezes flow inland from the coast at approximately five miles per hour (mph) during the day. The directional changes of the evening breeze drain the interior land mass. The evening breezes flow from the northeast and east offshore at three to four mph. This typical wind scenario is interrupted during the occurrence of the Santa Ana winds. These intermittent winds are strong, very dry southerly winds that blow down from the Cajon Pass and the very narrow canyons, usually for irregular periods of several days each during the fall and winter months. Wind velocities for such periods can increase to over 60 mph.

The combination of the air basin's topography and climate create an area of severe air pollution problems. The air basin's high percentage of sunlight hours produces ozone through photochemical reaction with nitrogen oxides and reactive organic gases. During the summer months, dispersion of these pollutants is limited by the light winds and inversion layer (a warm air mass frequently formed over the cool, moist layer in the air basin).

Table 2-1

Summary of Annual Average Precipitation in San Bernardino 1951 to 1990 (inches)

Year	Precipitation[1]	Departure[1]
1951-1980	15.68	- .32
1981	11.51	-4.60
1982	22.92	6.81
1983	----	----
1984	8.93	-6.75
1985	10.90	-4.78
1986	15.52	- .16
1987	13.03	-2.65
1988	12.18	-3.50
1989	7.23	-8.45
1990	8.11	----

Source: Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days, 1951-1980, California (NOAA 1982).
Source: Climatological Data Annual Summary - NOAA (1981 through 1990)
---- Data missing.

[1] Normals represent arithmetic mean of climatological element over three consecutive decades. Effective 1 January 1983, the averaging period is 1951 to 1980.

Federal and state health-based ambient air quality standards have been established to protect the most sensitive persons from illness or discomfort with a margin of safety. The air basin exceeds four of the State and federal ambient air quality standards; carbon monoxide, nitrogen dioxide, ozone and fine particulate matter (PM_{10}). The air in the vicinity of San Bernardino exceeds the ambient air quality standards for ozone and PM_{10} (SCAQMD 1989). Table 2-2 presents the most recent available air quality data.

Table 2-2

STATE AND FEDERAL AMBIENT AIR QUALITY STANDARDS
SAN BERNARDINO
FOURTH STREET STATION NO. 203
1990

	Ozone			Particulate Matter (PM_{10})		
	Standard Hour	Maximum Hourly Concentration	Days Standard Exceeded	Standard (Hour)	Maximum Hourly Concentration	Days Standard Exceeded
Federal	0.12 ppm	0.29 ppm	78	150 $\mu g/m^3$	235 $\mu g/m^3$	2
California	0.09 ppm	0.29 ppm	129	50 $\mu g/m^3$	235 $\mu g/m^3$	35

Source: California Air Resources Board. California Air Quality Data - Summary of 1990 Air Quality Data. Volume XXII. Technical Support Division.

2.3 GEOLOGY

The model area lies between two major northwest-trending faults (San Andreas and San Jacinto) forming the San Bernardino Valley (Plate 1). The San Bernardino Valley is filled with water-bearing alluvial deposits derived from the San Gabriel Mountains to the northwest and the San Bernardino Mountains to the northeast. The valley floor underlying the alluvium consists of impermeable basement complex rocks (also referred to as bedrock). This bedrock is composed of pre-Tertiary igneous and metamorphic rocks. The San Gabriel Mountains, San Bernardino Mountains, and the various hills that are scattered throughout the study area are also composed of this bedrock material. The alluvium consists of boulders, gravel, sand, silt, and clay of late Tertiary and Quaternary age (Dutcher and Garrett 1963).

The region between the two major faults consists of a series of stair-stepping faults with bedrock hills protruding above the alluvium. The Loma Linda Fault is located approximately one mile northeast of the San Jacinto Fault and extends across the model area in a northwest/southeast trend. Fault K is located approximately one and one-half miles south of the San Andreas Fault and trends northwest/southeast. This fault has been mapped as extending from the vicinity of the Newmark Wellfield directly north of the Shandin Hills to the northwest, north of Wiggins Hill and out of the study area.

The confluent alluvial fans that fill the San Bernardino Valley formed at the base of mountains where erosion provided a supply of sediment. At time of deposition, sediments were deposited as channel or sheet deposits, depending upon the confining features present in the alluvial valley. Thin layers of coarse sediments, such as gravel and sand, are present at the base of mountains where the greater topographical relief resulted in increased flow velocities. Toward the valley center, where the topography is flatter and flow velocity is slower, the sediment layers are finer and thicker.

Alluvial thicknesses in the San Bernardino Valley area vary considerably, with maximum alluvial thickness occurring adjacent to the northeast side of the San Jacinto Fault (Fife et al., 1976; Hardt and Hutchinson 1980). Alluvial thicknesses increase from 400 feet at the Newmark Wellfield, near the base of the San Bernardino Mountains, to at least 2,100 feet at the Loma Linda/San Jacinto Fault zone near the center of the San Bernardino Valley (Youngs et al., 1981). Alluvial thicknesses are based on interpretation of drillers' logs. The northern portion of the study area, just south of the San Bernardino Mountains, consists predominantly of sand, gravel, and boulders with little or no clay. The drillers' log for the Waterman Avenue well (parallel to the southern edge of Shandin Hills) documents the northern most occurrence of a substantial amount of clay. Clay lenses increase in number and thickness toward the central and southern portion of the Valley.

2.4 HYDROGEOLOGY

Within the study area, ground- and surface-water issues are confined to the area occupied by the Bunker Hill groundwater basin, as described by Dutcher and Garrett (1963). This basin is bounded by the San Bernardino Mountains to the northeast, the Crafton Hills and the Badlands on the south, and by the San Jacinto fault on the southwest. Inflow into the basin is principally runoff from the San Bernardino Mountains with the bulk of the water from the Santa Ana River and Mill Creek. Water also enters the basin from the San Gabriel Mountains by way of Lytle Creek and Cajon Creek (Youngs, et al. 1981). The importation of Northern California water through the California aqueduct and subsequent inflow through the aforementioned percolation basins (constructed on the alluvial fans near the foot of the San Bernardino mountains, see Section 2.1), provide additional groundwater recharge.

In the 20-year period 1963 through 1982, recharge to the groundwater basin increased substantially. A sequence of wet years produced greater-than-average natural streamflow and greater percolation through the streambeds. In addition, water agencies upgradient in the basin, acting independently, have been recharging diverted natural streamflow and imported water from the California Aqueduct (Danskin and Freckleton 1989). From 1986 to present, the amount of recharge has decreased due to drought conditions. In 1973, the San Bernardino Valley Municipal Water District [(SBVMWD), organized in 1954 to provide supplemental water for the San Bernardino area] contracted with the California Department of Water Resources for a maximum entitlement of 48,000 acre-ft of imported water, increasing annually to 102,900 acre-ft by 1990 (Hardt and Hutchinson 1980).

The principal aquifer in the Bunker Hill basin is the older alluvium, saturated nearly everywhere it is overlain by younger alluvium. In general, the alluvium closer to the mountains is coarser but more poorly sorted than the alluvium farther from the mountain front. The better sorted zones of sand and gravel are more permeable and, where saturated, yield water freely to wells (Hardt and Hutchinson 1980).

Because hydrogeologic properties of younger and older alluvium differ from place to place, the alluvium within the study area has been divided into two aquifer systems separated by a zone consisting predominantly of discontinuous clay lenses. Interpretation of the 130 municipal and monitoring well logs collected from local and State water agencies indicated that the portion of the study area north of the Shandin Hills appears to contain few and discontinuous thin clay lenses; therefore, the aquifer in this area is considered to be an unconfined aquifer (or water-table aquifer) (Dutcher and Garret, 1963). South of the Shandin Hills the alluvium becomes interfingered with many clay and silt lenses. In this area, the aquifer is divided into two units: the upper aquifer which remains unconfined and a lower aquifer which is confined by the overlying zone of interfingered lower permeability silt and clay lenses. The identification of two aquifers to the south of the Shandin Hills was based mainly upon the recorded water levels and the placement of the well perforations during well installation and the interpretation of several driller logs. Hardt and Hutchinson (1980) also support this concept of one unconfined aquifer to the north of Shandin Hills and two aquifers to the south of Shandin Hills, with the lower aquifer being confined. Dutcher and Garret (1963) suggest that the lower aquifer is divided into three zones.

Groundwater movement in the study area follows the surface drainage pattern in the Bunker Hill basin. The basin groundwater generally moves southward with groundwater in Lytle Creek moving in a southeast direction. Once groundwater passes the Shandin Hills, the flows converge and continue south towards the Santa Ana River (Hardt 1987). Groundwater exits the basin beneath the Santa Ana River channel where it crosses the San Jacinto Fault.

Groundwater presence is also evident through the appearance of artesian-type wells. Where the potentiometric head (the groundwater level potential) is above the confining beds in this area, and the San Jacinto Fault ("Bunker Hill Dike") restricts lateral groundwater flow, groundwater is forced through and around the clay beds into the overlying strata and onto the land surface. Consequently, significant components of vertical flow are created in the groundwater flow regimen. Prior to 1945, potentiometric heads up to 75 feet above the land surface existed in the Warm Creek area adjacent to the north side of the San Jacinto Fault (Hardt and Hutchinson 1980). After 1945, potentiometric heads dropped below the land surface.

The significance of surface water within the study area is described by its importance in recharging the groundwater aquifer. Three main tributary streams -- the Santa Ana River, Mill Creek, and Lytle Creek -- contribute more than 60 percent of the recharge to the groundwater system. Streamflow originates in mountain areas contiguous to the groundwater basin. For the most part, streamflow that enters the valley is intermittent, averaging 123,000 acre-ft/yr. During storm periods, streamflow emerges from mountain canyons along the valley perimeter and moves down the alluvial fans, where a large part of the flow infiltrates through the permeable surfucial deposits on the fans. Some of the infiltrating water is evaporated and some is transpired by riparian vegetation. However, streamflow records indicate that over long periods of time about 90 percent of the streamflow that enters the valley recharges the groundwater basin (Danskin and Freckleton 1989).

2.5 STUDY AREA DEMOGRAPHY AND LAND USE

The study area is located within the City of San Bernardino's northern and eastern city limits. However, portions of the study area extend beyond the City of San Bernardino into the City of Rialto to the west and the Cities of Colton and Loma Linda to the south. The City of San Bernardino's eastern boundary follows irregular city limits shared with San Bernardino County and the adjacent cities of Highland, Redlands, and Loma Linda (see Figure 1-1).

The California State University is a major identifiable land use in the northern section of the city. The Santa Fe railyards, also a major land use, are located on the City's west side. South of the downtown area, the City is developed with commercial and industrial uses. Expansions in population and residential uses have developed outward from the downtown area with densities decreasing toward the foothills. Overall, the highest residential densities are found adjacent to the downtown area.

Residential uses within the study area include single and multiple-family dwellings. Existing single-family densities range from less than one to seven dwelling units per acre of land. Areas containing mobile home parks and two dwelling units on a lot are also classified in this category because their character and density is consistent with what is typically thought of as single-family residential. Multiple-family residential uses encompass those areas that contain three or more dwelling units per lot. This land use accounts for approximately 1/3 of the land uses in the City of San Bernardino (Envicom 1989).

Commercial uses encompass neighborhood, community, or regional retail and wholesale establishments, as well as administrative offices. Commercial use accounts for approximately 4.5 percent of the acreage in the City. Light industrial uses include warehousing and storage, transportation and distribution of goods, light manufacturing, research and development, and other similar activities. This land use accounts for approximately 1.5 percent of the acreage in the City. Heavy industrial uses, such as steel fabrication, railroad uses and concrete manufacturing, account for approximately one percent of the total land acreage in the City of San Bernardino (Envicom 1989).

The three golf courses within the City also provide for open space, one of which is privately owned. Shandin Hills Golf course is located on both sides of I-215 about one mile north of Highland Avenue. The City Municipal Golf Course lies immediately north of the Santa Ana River on Waterman Avenue. Although Arrowhead Country Club and Golf Course is a private facility, its location affords public view of private open space.

Public and quasi-public uses include such facilities as schools, hospitals, government buildings, utilities, and other public buildings. With the exception of two private hospitals, all are publicly owned. They are all widely scattered throughout the City and its planning area. These uses occupy approximately 9 percent of the total acreage within the City. Vacant lands include those which are undeveloped. Easements, rights-of-way for highways, roads, other infrastructures facilities, and under-utilized lands are excluded. Vacant land accounts for approximately 1/3 of the City.

Open space is predominantly used for, or in conjunction with, flood control uses. This land use type accounts for approximately 11 percent of the acreage in the City. Flood control use includes a large variety of facilities, such as wash areas, creeks and drainage channels, and detention and percolation basins. Flood control areas are concentrated in and around the Lytle Creek Wash and Santa Ana River as they pass through the city and its planning area. Four other major flood control areas are found along the foothills and include: the Cable Creek area; Devil Canyon; east Twin Creek; and City Creek. Cable and Devil Creek drain into Lytle Creek, while the Twin and City Creek empty into the Santa Ana River. A number of other minor flood control areas contribute flood waters to these four major drainages. Figure 2-1 provides an approximate delineation of the 100-year and 500-year flood zones, or floodplains, in the Investigation Area. The 100-year and 500-year floods are defined as streamflows

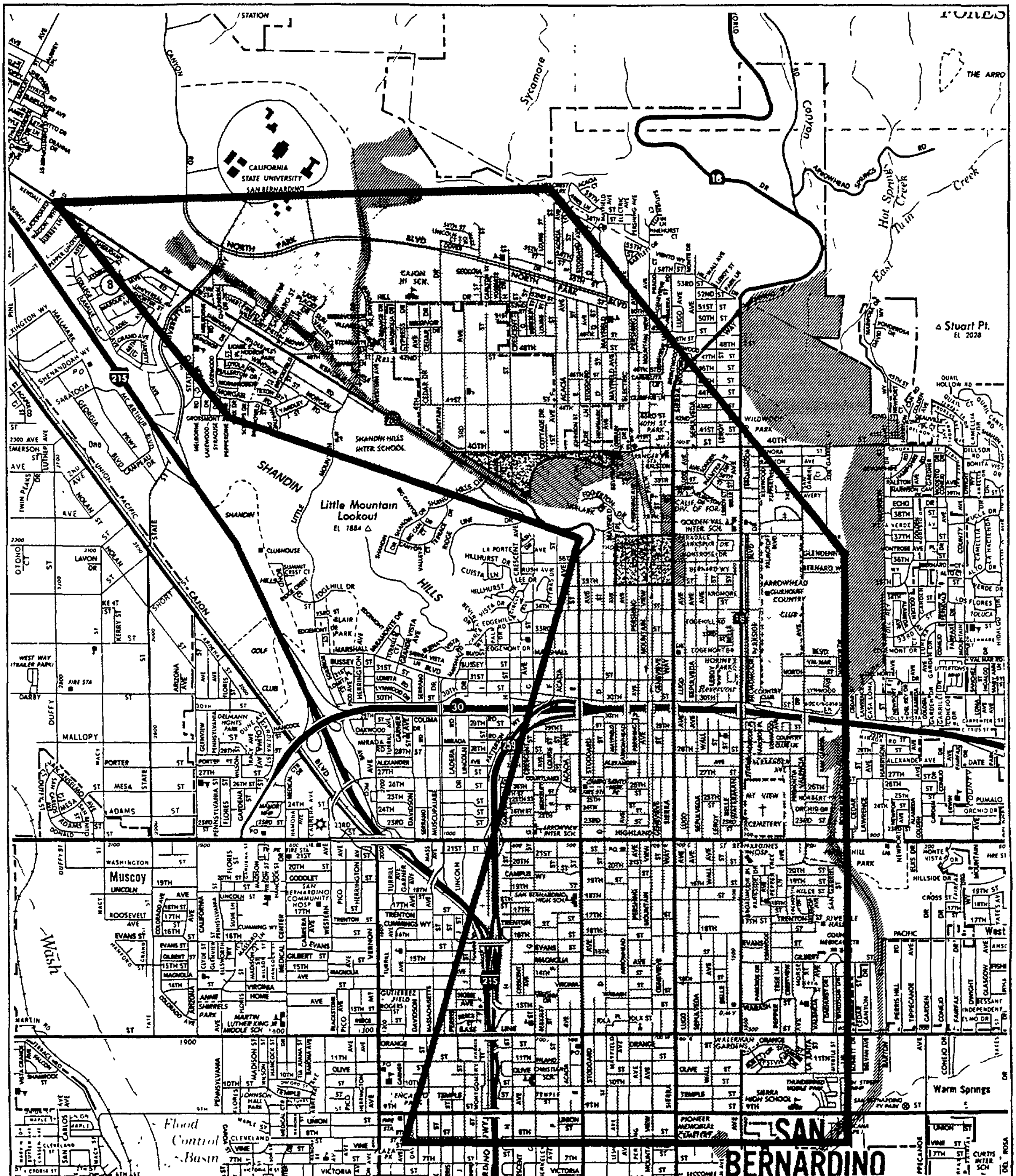


Figure 2-1

Investigation Area Flood Zones

Newmark Operable Unit RI/FS Report

Base Map from Automobile Club of Southern California, San Bernardino-Redlands Area, 1990.
Flood Zone Source: Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps: Community No. 060281# (1979 version)

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with a 1 percent and 0.2 percent respective probability of occurring in any given year. The criterion most often used to judge the adequacy of major flood control channels is the capacity to convey a 100 year flood.

Water services provided to the communities within the study area are supplied by municipal, mutual, and private water companies. The San Bernardino Valley Municipal Water District (the largest water supplier in the area, serving a population of approximately one-half million) is affected by the groundwater problem (E&E 1991). Groundwater supplies represent over 95 percent of the municipal water supply for the area. Alternative sources of drinking water (e.g., water imported from northern California) are already being used at near-maximum rates but represent less than 5 percent of the total supply. Another major supplier in the area is the City of Riverside Water Department. The Department has approximately 60,000 connections serving a population of about 200,000. Much of the Department's water supply comes from wells located along the Santa Ana River in the cities of San Bernardino and Colton.