CHAPTER 1.0
INTRODUCTION

1.1 BACKGROUND

Calabasas (City) has three main creeks that flow through its boundaries: Las Virgenes Creek in the Malibu Creek watershed, and Dry Canyon and McCoy Creeks, in the Los Angeles River watershed (Figure 1.1). Both watersheds, Malibu Creek and Los Angeles River, are areas of regional prime concern. The Malibu Creek watershed is important because of its prominent wildlife corridor and significant planning areas within the Santa Monica Mountains National Recreation Area (SMMNRA). McCoy and Dry Canyon Creeks confluence to form Calabasas Creek, also referred to as Arroyo Calabasas, which is one of the two creeks forming the headwaters of the Los Angeles River. Being situated in the headwaters presents a great challenge and opportunity to protect and enhance the Los Angeles River watershed from its source.

Two corridors for wildlife movement have been identified within the Malibu Creek watershed, and for this reason the watershed provides a key function for habitat linkage to the surrounding natural areas of the Santa Monica Mountains, Simi Hills, Santa Susana Mountains, and beyond. As one of the dual headwaters of the Los Angeles River, McCoy, and Dry Canyon Creeks provide an opportunity for coordination with the Santa Monica Mountains Conservancy's Los Angeles River projects, as well as habitat for wildlife. This study is envisioned to provide a specific, detailed implementation plan with which to direct efforts to protect and enhance these creeks.

The Las Virgenes Creek watershed is approximately 89 percent undeveloped, although the stream has been altered considerably below the Ventura County-Los Angeles County jurisdictional line. Below the county jurisdictional line to Agoura Road, the creek has been straightened, riprapped, relocated, and given other treatments typical of an urbanizing area. This has caused accelerated water flow velocity below the concrete reach.

Previous studies of the Malibu Creek watershed have provided some baseline information for its tributary, Las Virgenes Creek. However, Dry Canyon and McCoy Creeks have gone largely unstudied. Dry Canyon and McCoy Creeks have both been adversely affected by urbanization similar to the effects on Las Virgenes Creek. Large segments of these two creeks flow through gated communities and private properties. Also, the flood control systems take the creeks

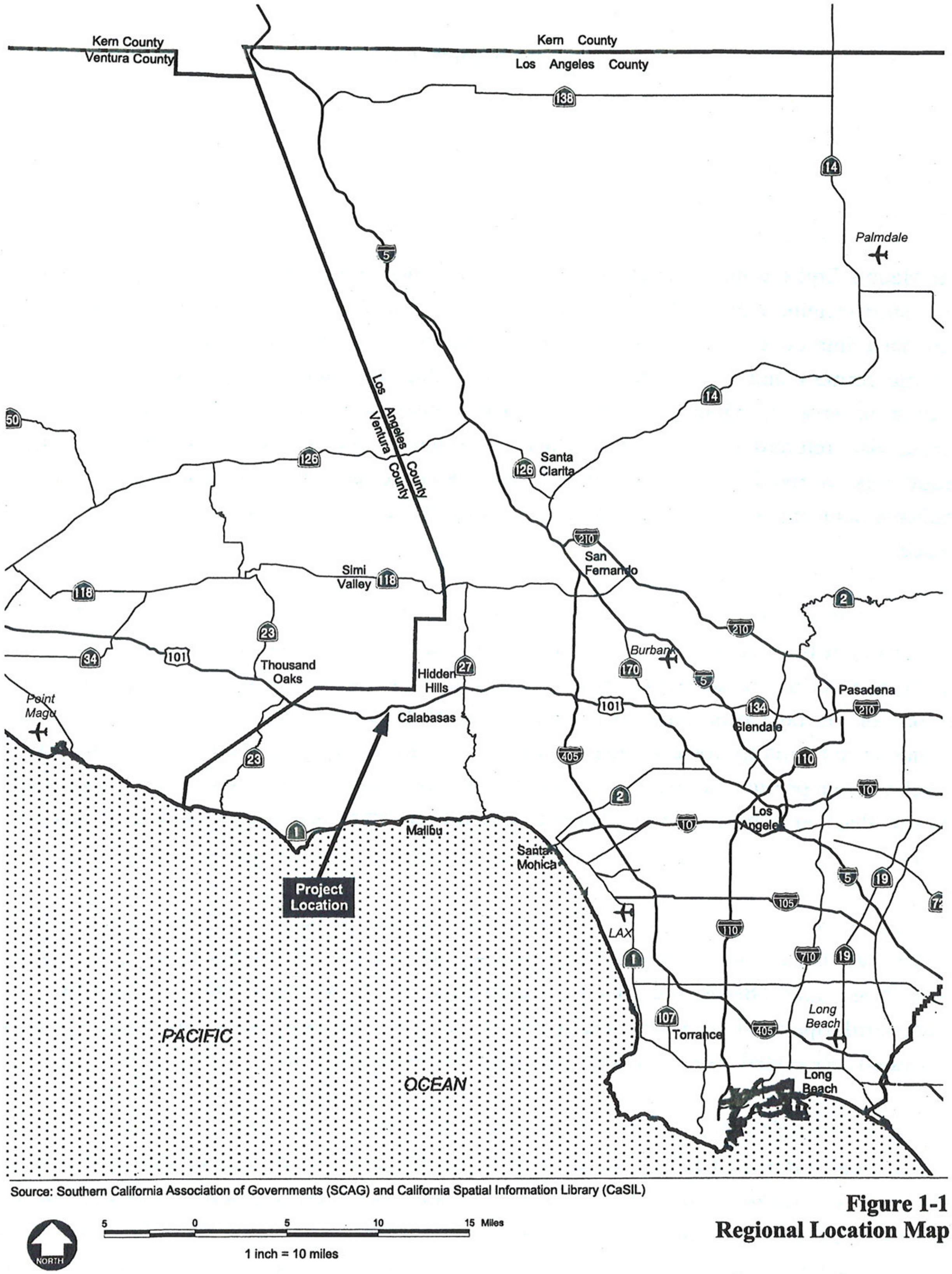


Figure 1-1
Regional Location Map

underground for some stretches. These developments have largely ignored the creek as a resource, and many areas are inaccessible to the public. This inaccessibility is due to several factors: fencing of concrete-lined areas, steep slopes, and ravines created by erosion; lack of resource information; and virtually no trails around the riparian area to accommodate human use. Finding good access points to the creeks, with the least amount of disturbance for outdoor education and increased appreciation of the creek's resource is a major goal of this study.

The three creeks pass through Calabasas serving to convey storm water flows to the lower watershed during the wet season, typically October to April. Smaller flows associated with rare summer storm runoff, irrigation runoff, industrial/commercial runoff and natural seeps and springs pass through the creeks on the way to Malibu Creek and the Los Angeles River. In addition to conveying water from the upper watershed, the three creeks also transport contaminants. The results of local monitoring programs indicate that Las Virgenes Creek has elevated levels of nutrients, selenium, coliform, scum, and trash, while Dry Canyon Creek and McCoy Creek have elevated levels of nutrients, coliform, and trash.

In 1999, the City submitted a 205(j) grant application to the State Water Resources Control Board (SWRCB) to prepare a management plan for Las Virgenes, Dry Canyon and McCoy Creeks, within the City boundaries. The grant was subsequently approved in the fall of 1999. The 205(j) grant program is a federally funded program focusing on water quality planning for local public agencies. Funded projects under the 205(j) program may include broad-based watershed planning or plans aimed at resolving specific water quality concerns. The U.S. Environmental Protection Agency (EPA) grants the funds annually to the SWRCB, which distributes the funds competitively to public agencies and administers the grants. With the increasing water-related regulations applicable to the City, it is desirable to have a master plan document addressing these regulations and ways to achieve compliance.

1.2 GOAL

The overall goal of the project is to create a road map of opportunities for improving the natural environment, with an emphasis on water quality, within the City's boundaries. This project goal coincides with the goals outlined in the Calabasas General Plan. The goal of the Conservation, Environmental Design, and Open Space Element of the General Plan is to:

- Preserve significant environmental features within Calabasas and the City's General Plan study area, and provide for their wise management;
- Define limits on the natural resources needed to support urban and rural life within Calabasas and the City's General Plan study area, and to ensure that those resources are used wisely, and not abused, and

- Maintain an open space system that will conserve natural resources, preserve scenic beauty, promote a healthful atmosphere, provide space for a variety of active and passive recreational activities and protect public safety.

1.3 OBJECTIVES

The overall purpose of the restoration master plan is to describe specific projects that should be implemented throughout the watersheds of the three creeks in a phased approach that will primarily improve water quality as well as enhance habitat, increase recreational facilities, and provide educational opportunities. The following are the overall objectives of the master plan:

- Establish baseline environmental conditions of the existing habitat within the three creeks.
- Evaluate historical land use and vegetation changes within the watersheds.
- Define opportunities and constraints for improving water quality parameters targeting specific Total Maximum Daily Load (TMDL) contaminants for the three creeks.
- Define opportunities and constraints for improving water quality to enhance existing creek habitat for species such as arroyo chub and steelhead trout.
- Define opportunities and constraints to restore creek and riparian habitat.
- Define opportunities and constraints to improve recreational facilities/features within the study area.
- Define opportunities and constraints to provide educational facilities/features within the study area.

1.4 METHODS

1.4.1 Pre-field Survey Evaluation of Existing Data

1.4.1.1 Previous Projects Conducted in the area

Prior to conducting the field survey, previous project reports for work conducted within the study area were reviewed. With Dry Canyon and McCoy Creeks being located at the top of the Los Angeles River watershed, there has been little emphasis placed on studying their features and characteristics. Therefore, very little information was available for these two creeks. As Las Virgenes Creek is located in the Malibu Creek Watershed, slightly more information was available in the way of previous studies. However, much of this information is for Malibu Creek itself, with limited focus on Las Virgenes Creek.

A Protection and Revitalization Plan for Las Virgenes Creek (2001)

One of the previous studies that focused exclusively on Las Virgenes Creek was a graduate study conducted by Bradley Owens, completed in 2001. This study, A Protection and Revitalization Plan for Las Virgenes Creek, was envisioned to be "used by the community as a reference and inspiration for stewardship, and to create plans that include 'big ideas' that positively influence the area for many generations."

With that goal in mind, the study compared quantity and duration of storm water runoff from the predevelopment era to the development within the Las Virgenes Watershed in 1999. As expected, the analysis shows that as development (impervious surfaces) of the watershed increased, the peak flows within the creek also increased. Mr. Owens also identified areas of the creek that were concrete lined and determined that the combination of increased flow with the increase in velocity from the concrete lining would increase erosion downstream of the concrete areas. In addition to the flow studies conducted by Mr. Owens, he also qualitatively identified habitat improvement areas, areas to enhance wildlife corridors, and potential areas to increase public access to Las Virgenes Creek.

The Malibu Creek Watershed: A Framework for Monitoring Enhancement and Action (1998)

The Malibu Creek Watershed: A Framework for Monitoring Enhancement and Action was completed in 1998, by the Graduate Department of Landscape Architecture, California State Polytechnic University, Pomona. The study was prepared for Heal the Bay and the California State Coastal Conservancy. The stated purpose of the project was to design a citizen-monitoring program to evaluate the water quality of the entire Malibu Creek watershed and target areas for future studies, protection restoration, and enhancement.

The report provides an overview of the Malibu Creek watershed and the geologic and hydrologic processes taking place within the watershed. One of the main discussion points of the report is what processes change in an urbanizing watershed and how urbanization can change erosion and sedimentation as well as water quality. In addition, the report provides a lengthy discussion about citizen monitoring and the importance of organizing the data collection.

1.4.1.2 Water Quality Data

Water quality data are collected by various agencies and organizations within both the Malibu Creek watershed and the Los Angeles River watershed. However, there are limited monitoring stations within Calabasas (Figure 1.2). The two main groups that complete the monitoring within the project area are the City with the Adopt-a-Creek Program and Heal the Bay's Stream Team. The Ventura County Department of Public Works also has one monitoring station on Las Virgenes Creek, near the Los Angeles County-Ventura County jurisdictional line. Water quality data collected for this project are presented in Appendix C, including data on nutrients, dissolved oxygen, temperature, pH, fecal coliform, and other consituents from the three creeks.

City of Calabasas Adopt-a-Creek Program

The Adopt-a-Creek Program uses City staff teamed with volunteers to conduct quarterly monitoring at a total of 10 stations: 6 along Las Virgenes Creek and 2 each for McCoy and Dry Canyon Creeks. At each station a total of 9 parameters are measured in the field and 42 parameters are assessed by laboratory analysis (Table 1.1). The overall results are sent to the Regional Water Quality Control Board – Los Angeles Region (RWQCB-LA) periodically.

Heal the Bay – Stream Team

Heal the Bay sponsors the Stream Team, which is a group of volunteers who conduct water quality monitoring throughout the Malibu Creek watershed. Under the leadership of Heal the Bay staff, these volunteers have also conducted habitat assessments within the watershed. The Stream Team conducts monthly monitoring at three stations along Las Virgenes Creek. At each station, 17 parameters are measured in the field, and 1 parameter is determined by laboratory analysis. In addition to the constituent analysis, the Stream Team also evaluates the Index of Biological Integrity (IBI) for discrete stream segments. The IBI evaluations use benthic macroinvertebrates to determine long-term vitality of the specific stream based on the community of invertebrates identified.

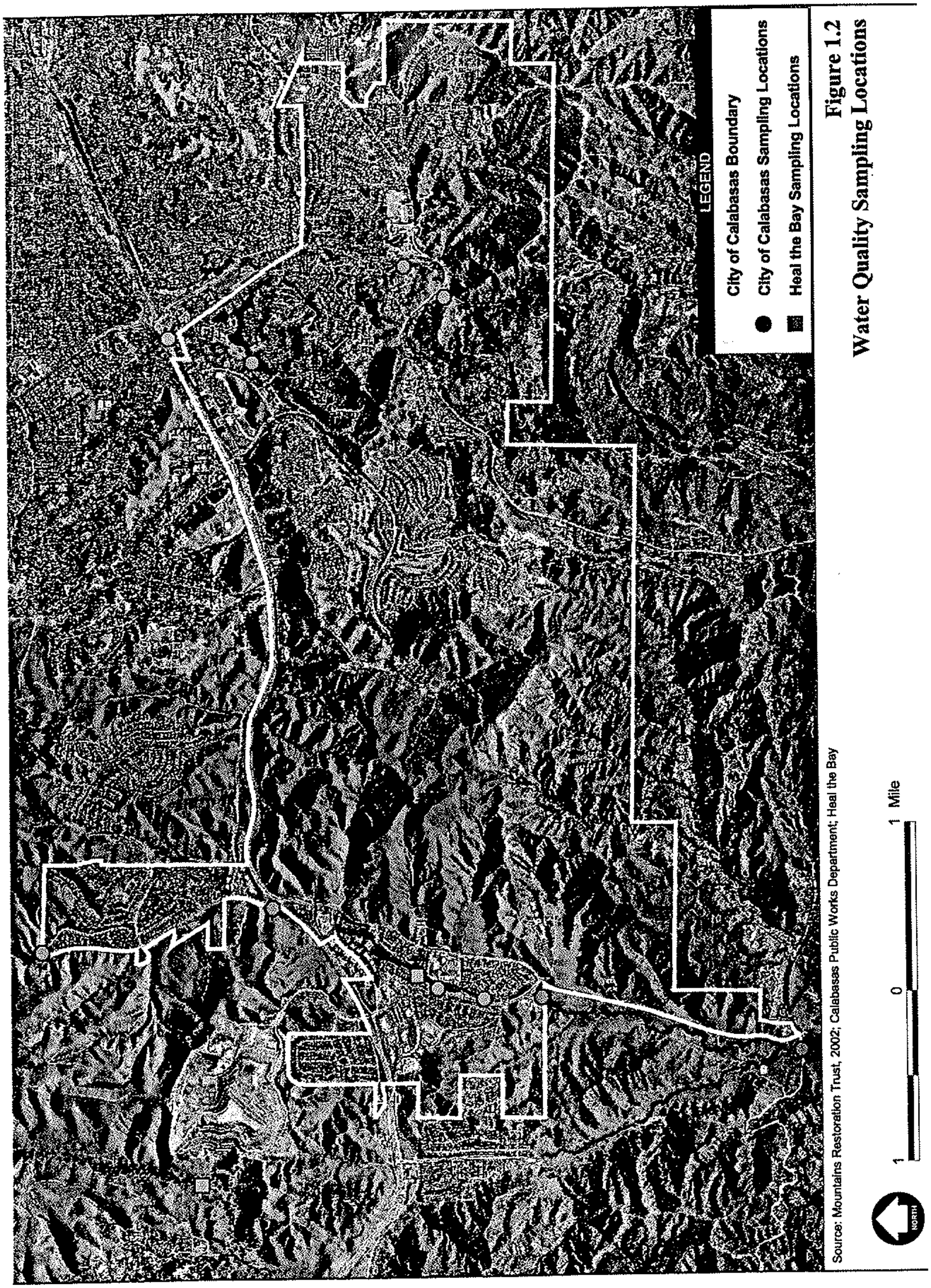


Figure 1.2
Water Quality Sampling Locations

Table 1.1. Overview of the Water Quality Analysis Conducted in the Las Virgenes Creek Watershed

Constituents Sampled	Adopt-a-Creek	Analysis Method	Stream Team	Analysis Method	Ventura County	Analysis Method
Air Temperature	X	Thermometer	X			
Water Temperature	X	LaMotte DO 4000 Meter	X	YSI 55 or 550		
Water Clarity	X	Visual	X	Visual		
Water Color	X	Visual	X	Visual		
Odors	X		X			
Floatables	X	Visual	X	Visual		
Biological Floatables	X	Visual	X	Algae protocol		
Turbidity, NTU			X	LaMotte 2020 Turbidimeter		
pH	X	pH Tester2	X	Cole Parmer pH Testr2	X	na
Flow	X	Global Flow Probe	X	Flowmate II		
Chloride (Cl-), mg/l					X	na
Phosphorus, Dissolved, mg/l					X	na
Phosphorus (P) Total, mg/l	X	EPA 365.2			X	na
Phosphate (P04)			X	Ascorbic acid reduction	X	na
Ammonia Nitrogen (NH3-N), mg/l	X	EPA 350.2	X	LaMotte SMART Colorimeter	X	na
Nitrate Nitrogen (NO3-N), mg/l	X	EPA 353.3 and Cadmium reduction method	X	LaMotte SMART Colorimeter		
Nitrate (mg/l)					X	na
Nitrite Nitrogen (NO4-N), mg/l						
N03+N02+N ppm			X	Cadmium reduction method		
Total Kjeldahl Nitrogen (TKN), mg/l					X	na
Biological Oxygen Demand (BOD), mg/l					X	na
Chemical Oxygen Demand (COD), mg/l					X	na
Total Organic Carbon (TOC), mg/l					X	na
Dissolved Oxygen	X	Winkler Method, La Motte, EPA 4500-G, EPA 360.1	X	YSI Model 55 or 550		
Total Suspended Solids (TSS), mg/l					X	na
Total Dissolved Solids (TDS)	X	TDSTester 20	X		X	na

Constituents Sampled	Adopt-a-Creek	Analysis Method	Stream Team	Analysis Method	Ventura County	Analysis Method
Conductivity			X (mS)	19830-00 Cole Parmer or YSI 30	X (umhos/cm)	na
Total Hardness, mg/l	X	EPA 130.2			X	na
Coliform, Total, mpn/100ml	X	EPA 9221		IDEXX Quanti-tray 2	X	na
Coliform, Fecal, mpn/100ml	X	EPA 9221		IDEXX Quanti-tray 2	X	na
Enterococcus, Fecal, mpn/100ml	X	EPA 9230B	X	IDEXX Quanti-tray 2		
Streptococcus, Fecal, mpn/100ml					X	na
Arsenic, (As), Dissolved, µg/l					X	na
Arsenic, (As), Total, µg/l					X	na
Cadmium (Cd), Dissolved, µg/l					X	na
Cadmium (Cd), Total, µg/l					X	na
Chromium (Cr), Dissolved, µg/l					X	na
Chromium (Cr), Total, µg/l					X	na
Copper (Cu), Dissolved, µg/l	X	EPA 200.8			X	na
Copper (Cu), Total, µg/l	X	EPA 200.8			X	na
Lead (Pb), Dissolved, µg/l					X	na
Lead (Pb), Total, µg/l					X	na
Mercury (Hg), µg/l					X	na
Mercury (Hg), Dissolved, ng/l					X	na
Mercury (Hg), Total, ng/l					X	na
Nickel (Ni), Dissolved, µg/l					X	na
Nickel (Ni), Total, µg/l					X	na
Selenium (Se), Dissolved, µg/l					X	na
Selenium (Se), Total, µg/l	X	EPA 200.8			X	na
Silver (Ag), Dissolved, µg/l					X	na
Silver (Ag), Total, µg/l					X	na
Zinc (Zn), Dissolved, µg/l	X	EPA 200.8			X	na
Zinc (Zn), Total, µg/l	X	EPA 200.8			X	na
Aldrin	X	EPA 508				
Chlordane-alpha	X	EPA 508				
Chlordane-gamma	X	EPA 508				
Clorneb	X	EPA 508				
Chlorthalonil	X	EPA 508				
DCPA	X	EPA 508				

Constituents Sampled	Adopt-a-Creek	Analysis Method	Stream Team	Analysis Method	Ventura County	Analysis Method
4,4'-DDD	X	EPA 508				
4,4'-DDE	X	EPA 508				
4,4'-DDT	X	EPA 508				
Dieldrin	X	EPA 508				
Endosulfan I	X	EPA 508				
Endosulfan sulfate	X	EPA 508				
Endrin	X	EPA 508				
Endosulfan II	X	EPA 508				
Etridiazole	X	EPA 508				
HCH-alpha	X	EPA 508				
HCH-beta	X	EPA 508				
HCH-delta	X	EPA 508				
HCH-gamma	X	EPA 508				
Heptachlor	X	EPA 508				
Heptachlor epoxide	X	EPA 508				
Hexachlorobenzene	X	EPA 508				
Methoxychlor	X	EPA 508				
cis-Permithrin	X	EPA 508				
Propachlor	X	EPA 508				
Trifluralin	X	EPA 508				
Diazinon, μg/l	X	EPA 507				
Chlorpyrifos, μg/l	X	EPA 507				
Macroinvertebrates			X	IBI Method		
Toxicity (TIE)					X	na

mg/l = milligrams per liter
μg = micrograms per liter
NTU = nephelometric turbidity unit
DCPA= dicyclopentenyl acrylate
na = not available

1.4.1.3 Aerial photographs

Aerial photographs were used to identify both existing and historic conditions within the watersheds.

Historic

Historical aerial photographs of the area were reviewed from the collection located at California State University Northridge. The photographs reviewed were from 1960, 1975, and 1989 (see Figures 1.3, 1.4a, 1.4b and 1.5). Figure 1.3, from 1960 (unknown scale), shows primarily the McCoy Creek watershed with Mulholland Highway near the bottom of the photograph. Figure 1.4a, and 1.4b, from 1989 (unknown scale), show the study area. The Las Virgenes Creek watershed is shown in Figure 1.4a, and the McCoy and Dry Canyon Creek watersheds shown in 1-4b. Figure 1.5 from 1975 (unknown scale) show the entire study area with Las Virgenes Creek on the left and McCoy and Dry Canyon Creek shown on the right of the photograph. The evaluation of these photographs was used to determine the land use history of the watersheds (see Section 2.1, Land Use).

Current

A recent aerial photograph (2002) for the project area was supplied by Mountains Restoration Trust. This photograph was used to evaluate current land use within the study area and for use in developing field and report maps.

1.4.1.4 Cooperating Organizations

The following organizations were contacted and supplied information for this study:

- Las Virgenes Municipal Water District
- Mountains Restoration Trust
- Los Angeles County Department of Public Works – Watershed Division
- Heal the Bay
- Resource Conservation District of the Santa Monica Mountains
- California Department of Parks – Malibu Creek State Park
- Regional Water Quality Control Board, Los Angeles Region

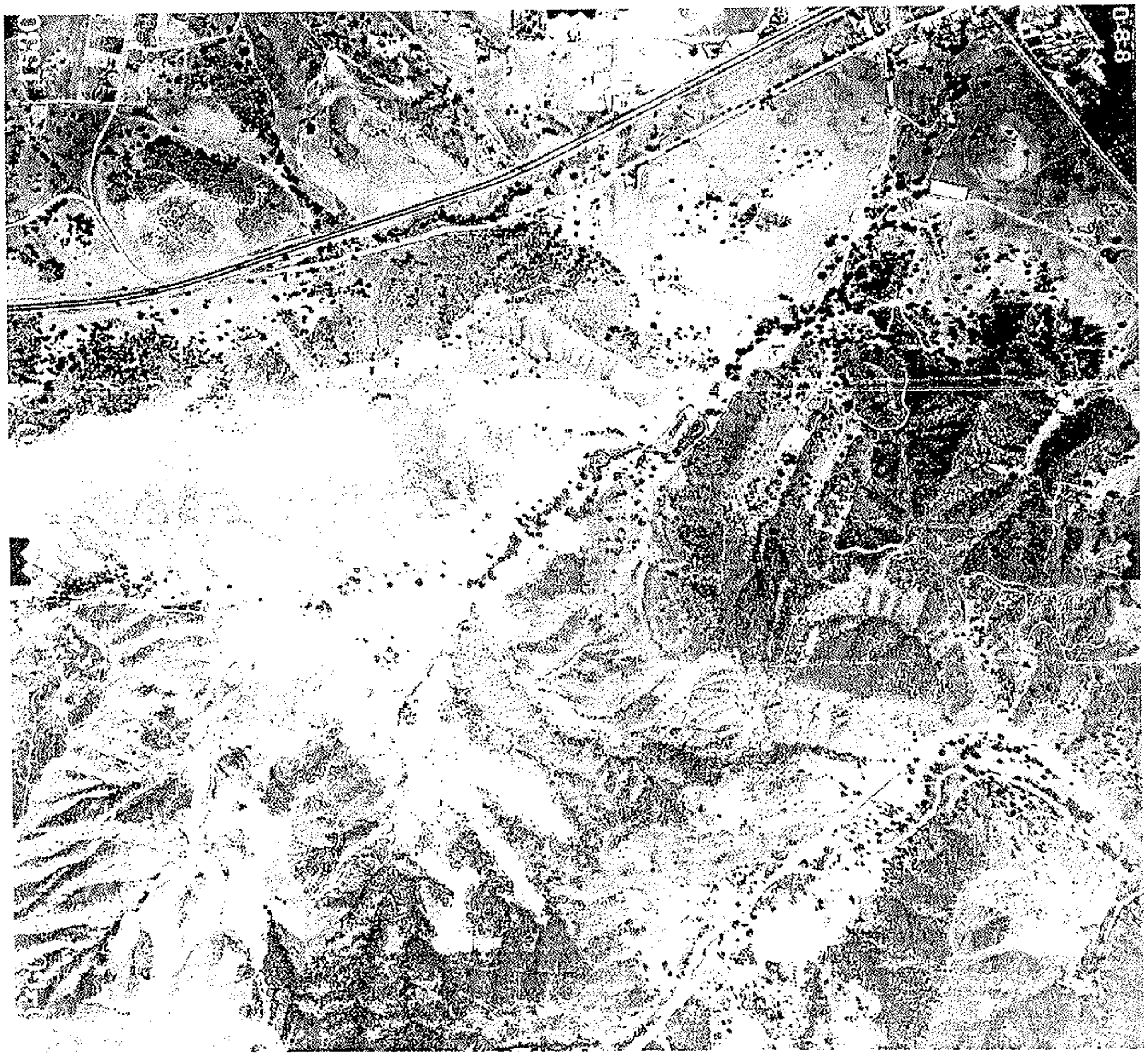


Figure 1.3
Historical Aerial Photograph
May 20, 1960

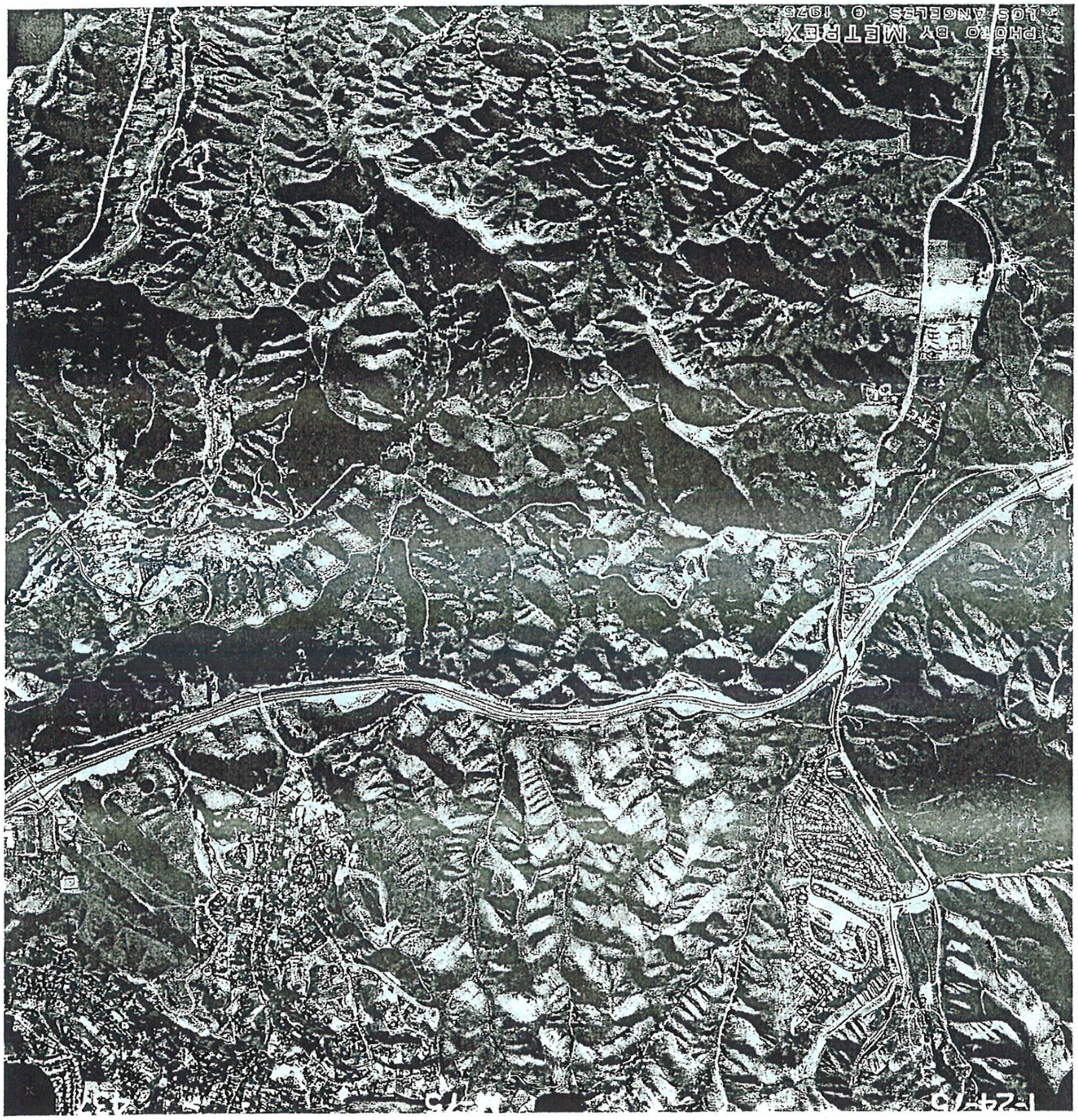
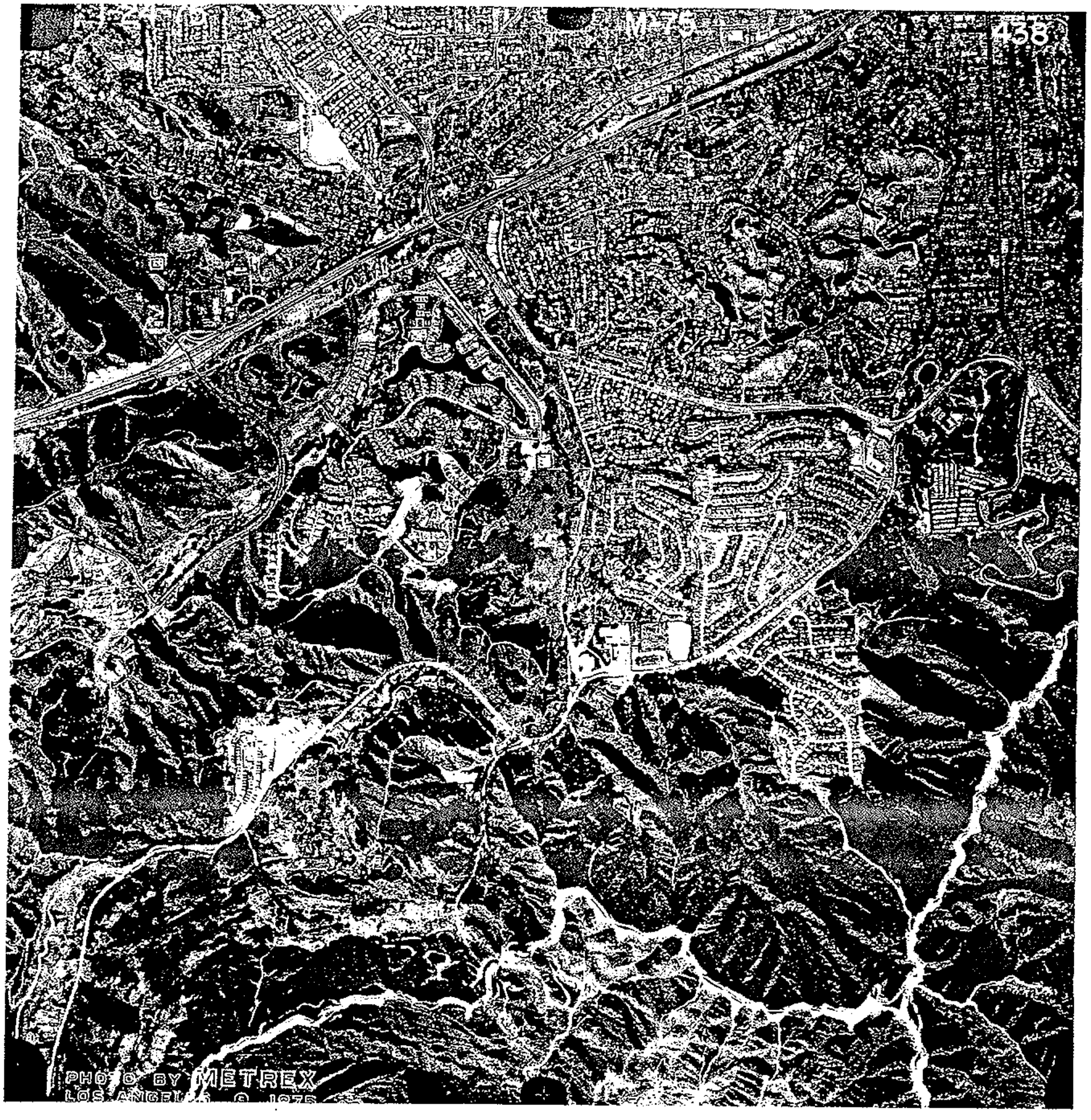


Figure 1.4a
Historical Aerial Photograph
January 24, 1975

NORTH



NORTH

Figure 1.4b
Historical Aerial Photograph
January 24, 1975

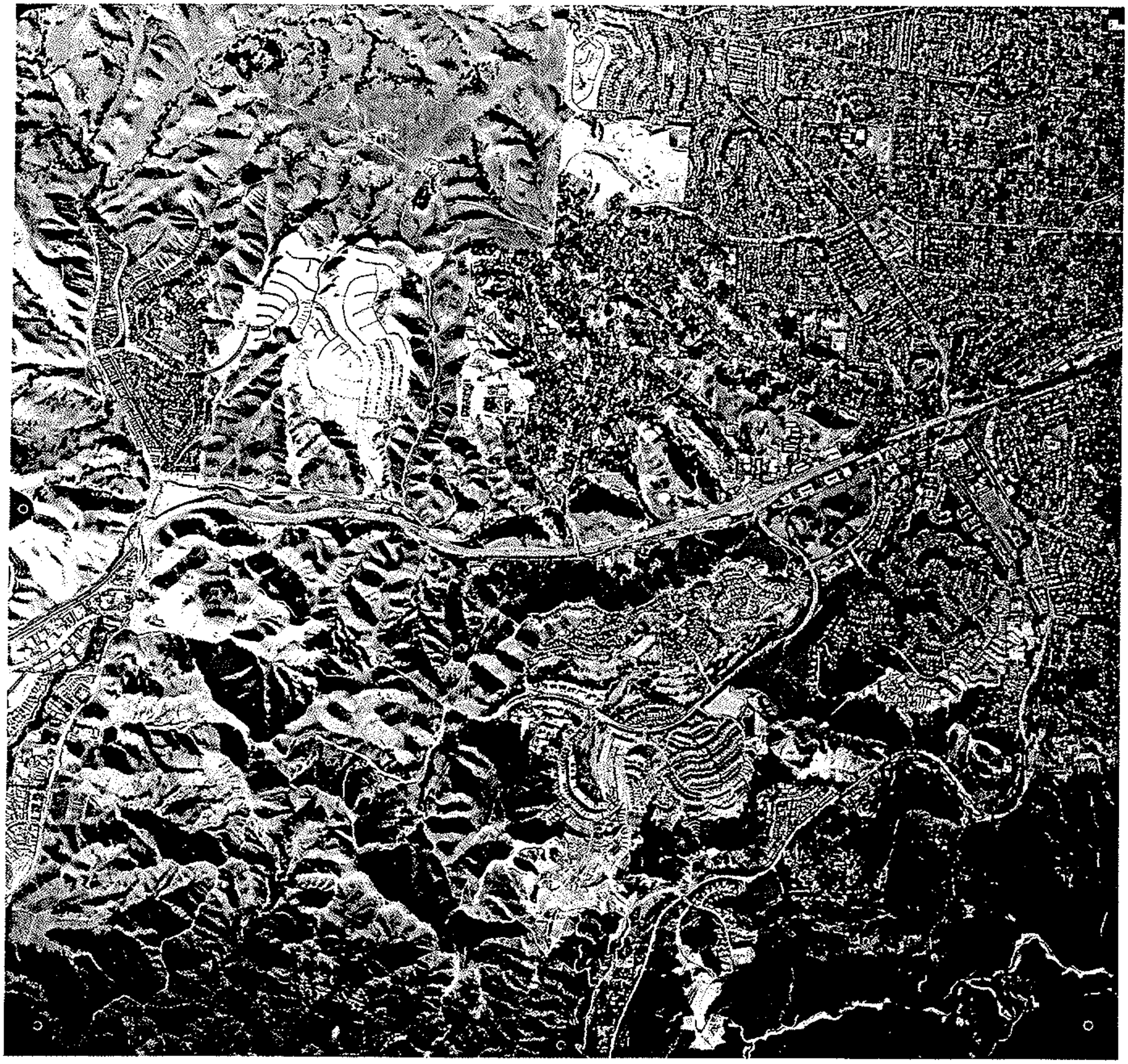


Figure 1.5
Historical Aerial Photograph
December 12, 1989

1.4.2 Field Survey Evaluation

1.4.2.1 Watershed Survey

A driving survey was conducted for each of the three watersheds to evaluate land use practices, storm water program controls, approximate location of storm drain outlets, appropriate potential signage locations, and identification of potential park, education, and recreation facility locations.

1.4.2.2 Stream Walk (Habitat Assessment)

Baseline conditions for Las Virgenes, Dry Canyon, and McCoy Creeks were assessed during field visits performed in January and March 2003. The riparian assessment procedure developed for this project evaluated physical and hydrological properties of stream reaches, presence of plant and animal species, and adjacent vegetation communities and land uses. Each stream was walked from the upper reaches to lower, and unique characteristics were photographed and documented on field maps. This information was then used to identify potential areas for habitat restoration as described in Chapter 4.0.

1.4.3 Modeling

The watershed modeling was completed by Everest International Consultants (Everest) (Appendix A). Everest, as part of the EDAW team, worked collaboratively with the City to develop restoration measures and the model was then used to simulate the corresponding flow and water quality conditions.

The purpose of the watershed modeling study was to develop restoration measures and assess the effectiveness of those measures, at improving water quality within the creeks. The following objectives were developed to achieve this purpose:

- Select appropriate watershed model.
- Acquire information needed to conduct watershed modeling.
- Identify any data gaps related to the scope of work.
- Develop conceptual models of the two watersheds.
- Perform watershed modeling to establish existing/baseline conditions.

- Develop restoration measures aimed at improving water quality.
- Conduct watershed modeling to analyze and evaluate measures.

Scope of Modeling Study

The scope of the watershed modeling study was limited to an analysis of watershed hydrology and nutrients. Existing, available water quality and flow information and data were used for the modeling study as resources were not available to conduct additional data collection for these parameters. The nutrient model simulations were focused on the portion of the creeks that flow through the City's boundaries, along with the corresponding watershed areas. The original intent of the study was to conduct the watershed modeling using a calibrated model. However, an initial review of the available data revealed that the data are insufficient for model calibration; therefore, the scope was modified to allow the use of an uncalibrated watershed model for alternative development and evaluation. The uncalibrated model was used to perform a relative comparison for nutrient reductions between different model simulations.

Approach

The study approach based on the application of a numerical watershed model was developed to meet the study objectives. Potential models were reviewed and a suitable model was selected that met the purpose and objectives of the study. Conceptual models of the three sub-watersheds under existing conditions were developed, and the model was used to establish existing conditions. The results of the existing condition simulations were used to establish baseline values for subsequent comparison with the various restoration measures. The EDAW team worked collaboratively with the City to develop restoration measures, and the model was then used to simulate the corresponding flow and water quality conditions. The results of the model simulations conducted with the restoration measures were compared to the baseline results to determine the effectiveness of the various restoration measures at improving water quality. The results of the various alternatives were also compared against one another to gauge the effectiveness of the restoration measures. This last step provided useful information in the development of the overall restoration alternatives for the creeks.

<u>Watershed Model Selection</u>

The EPA has developed a suite of numerical models and a graphical user interface that can be used to analyze watershed hydrology and water quality. This system, known as the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), is a multipurpose environmental analysis system designed for the application of watershed approaches to improve water quality. The BASINS system supports the development of TMDLs as required by Section

303(d) of the Clean Water Act. The BASINS suite allows for flexible analysis at varying geographic scales and it includes a compilation of environmental data from various government agencies migrated into a geographic information system (GIS) framework. Environmental data are available for watersheds as defined by hydrologic unit codes (HUCs). BASINS allows for manipulation of watershed characteristics to delineate watershed boundaries and calculate setup parameters for the component simulation models that comprise the BASINS system.

The Hydrological Simulation Program – Fortran (HSPF) model, a component of the BASINS system, was selected for this study for the following three reasons. First, HSPF is a component of BASINS and BASINS is one of the models currently accepted for use by the EPA for loading allocation determination as part of the TMDL program. Second, the model was capable of meeting all the technical requirements of the study purpose, including simulation of watershed hydrology, stream flows, and contaminant loading. The model also allows for relatively easy incorporation of watershed restoration measures such as best management practices (BMPs) (e.g., CDS units), land use changes (e.g., conversion of urban areas to open space), and source control (e.g., reclaimed water use changes). Third, HSPF is currently being used by the RWQCB-LA to establish the TMDL allocations for nutrients and bacteria within the Malibu Creek watershed.

HSPF Model Description

HSPF is a comprehensive watershed modeling package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. It is the only comprehensive model of watershed hydrology and water quality that allows the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulics, water temperature, sediment transport, nutrient, and sediment-chemical interactions (EPA 2001a).

HSPF simulates the movement of water, sediment, and contaminants over the land surface and through the soils of a watershed; computes resultant flows, sediment transport, and contaminant concentrations in the collecting streams; and provides water discharge, sediment discharge, and contaminant loading to the receiving waters. In summary, HSPF simulates all the hydrological processes within the hydrologic cycle.

For a given watershed with known characteristics such as land uses, vegetative cover, and soil conditions, HSPF computes the transport of water, sediment, and contaminants throughout the watershed on a continuous basis under continuous meteorological forcing such as precipitation, temperature changes, and evaporation. HSPF permits complex physical and chemical interactions and transformations of contaminants in the watershed and streams, thereby providing relatively accurate estimates of contaminant loading into the receiving water. The model outputs simulation results in the form of time histories of runoff flow rate, sediment load, and contaminant concentrations at any point of interest within the watershed.

Given the long-term periods of analysis and the comprehensive nature of the processes being simulated, HSPF requires extensive hydrology and water quality data for successful application. Data are needed to characterize the watershed, creek, hydrology, meteorology, and water quality. In addition, for optimal accuracy of the modeled output, the input data should cover the same period of record, or the various data records should be verified to make sure all data are representative of the period being modeled. The data required to conduct watershed modeling using HSPF are listed below.

Watershed Characteristics

- Topography
- Land use
- Soil characteristics
- Water table depth

Creek Characteristics

- Thalweg elevation profiles
- Cross-section geometries for main channel and overflow planes
- Bottom conditions (earth, vegetation type, rock types)
- Creek rating curve for depth versus flow
- Seasonal variation of creek characteristics

Hydrology

- Continuous precipitation records for local area at hourly interval and corresponding creek flow at multiple locations for each creek (Las Virgenes Creek 5 to 10 locations; McCoy and Dry Canyon Creeks 1 to 3 locations per creek)
- Groundwater data, including flow and water table depths

Meteorology

- Evapotranspiration
- Temperature (minimum and maximum) and dew point
- Wind
- Solar radiation
- Cloud cover

Water Quality

- Location, type, and concentration of point sources of contaminants
- Location, type, and concentration of nonpoint sources of contaminants

HSPF Model Calibration Discussion

As with any numerical model, HSPF requires calibration to provide accurate estimates of the various model outputs for a given watershed. Typically, the model will be calibrated by first performing simulations over a given period and then comparing the output to measured values of flow, contaminant loading, and contaminant concentrations. The various model parameters (e.g., initial contaminant storage, atmospheric deposition, and friction) will then be adjusted within accepted limits until the model results match the measured values within an acceptable limit. Therefore, successful calibration requires simultaneous, continuous flow and water quality constituent measurements across the watershed at a level sufficient to resolve the expected variation of these parameters.

The City has been monitoring water quality since 1998 as part of the Adopt-A-Creek Program. The monitoring program consists of instantaneous measurements of various water quality constituents accomplished through direct measurements as well as grab sample collection and subsequent analysis. Instantaneous flow measurements were usually collected; however, no continuous flow measurements were collected as part of the program. Given that no continuous flow or water quality constituent measurements were made within the portion of the three sub-watersheds located within Calabasas, the data were insufficient to conduct a meaningful calibration of the HSPF model for this study. Hence, instead of using a fully calibrated HSPF model, a conceptual model built upon literature values was used for this study. Nevertheless, the conceptual model was verified against analytical methods in flow estimates, as well as comparison with other studies in the regions for pollutant loadings. Details about the conceptual model setup are provided in section 3 of Appendix A.