APPENDIX A

WATERSHED MODELING ANALYSIS

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1. INTRODUCTION

1.1 BACKGROUND

Las Virgenes Creek is located within Los Angeles County and Ventura County of the State of California. McCoy Creek and Dry Canyon Creek are located entirely within Los Angeles County. Las Virgenes Creek is located in the Malibu Creek Watershed, while McCoy Creek and Dry Canyon Creek are situated within the Los Angeles River Watershed. Portions of all three creeks run through the City of Calabasas (City), which is shown in Figure 1.1.

Existing beneficial uses of Las Virgenes Creek identified by the Los Angeles Regional Water Quality Control Board (LARWQCB) in the 1994 Basin Plan include water contact recreation, non-contact water recreation, warm freshwater habitat, wildlife habitat, rare species habitat, and wetland habitat (LARWQCB, 1994). Potential beneficial uses include municipal and domestic supply, cold freshwater habitat, migration of aquatic organisms, and spawning, reproduction and/or early development of fish. Existing beneficial uses of McCoy and Dry Canyon Creeks include groundwater recharge (intermittent), water contact recreation (intermittent), non-contact water recreation (intermittent), warm freshwater habitat (intermittent), and wildlife habitat. Potential beneficial uses of these two creeks include only municipal and domestic supply. All three creeks are listed under Section 303(d) of the Clean Water Act (CWA) for multiple pollutants that impair these beneficial uses. The schedule established by the LARWQCB for development of the nutrient total maximum daily load (TMDL) for all three creeks is December 2003.

The City received a grant from the U.S. Environmental Protection Agency (EPA) under Section 205(j) of the CWA to prepare a master restoration plan (Restoration Plan) for the three creeks as part of an overall watershed approach to improving water quality with a focus on meeting TMDL objectives. In July 2002, EDAW, Inc. (EDAW) was selected by the City to prepare the Restoration Plan. In addition to improving water quality, the Restoration Plan lays out alternatives to increase recreational opportunities, provide educational facilities, and enhance wildlife habitat.

A significant component of the study needed to prepare the Restoration Plan was the use of a numerical watershed model to simulate the flow of water and corresponding transport of contaminants. EDAW retained Everest International Consultants, Inc. (Everest) to perform the watershed modeling component of the study. The watershed modeling study is summarized in this document, which was prepared as an appendix to the Restoration Plan.

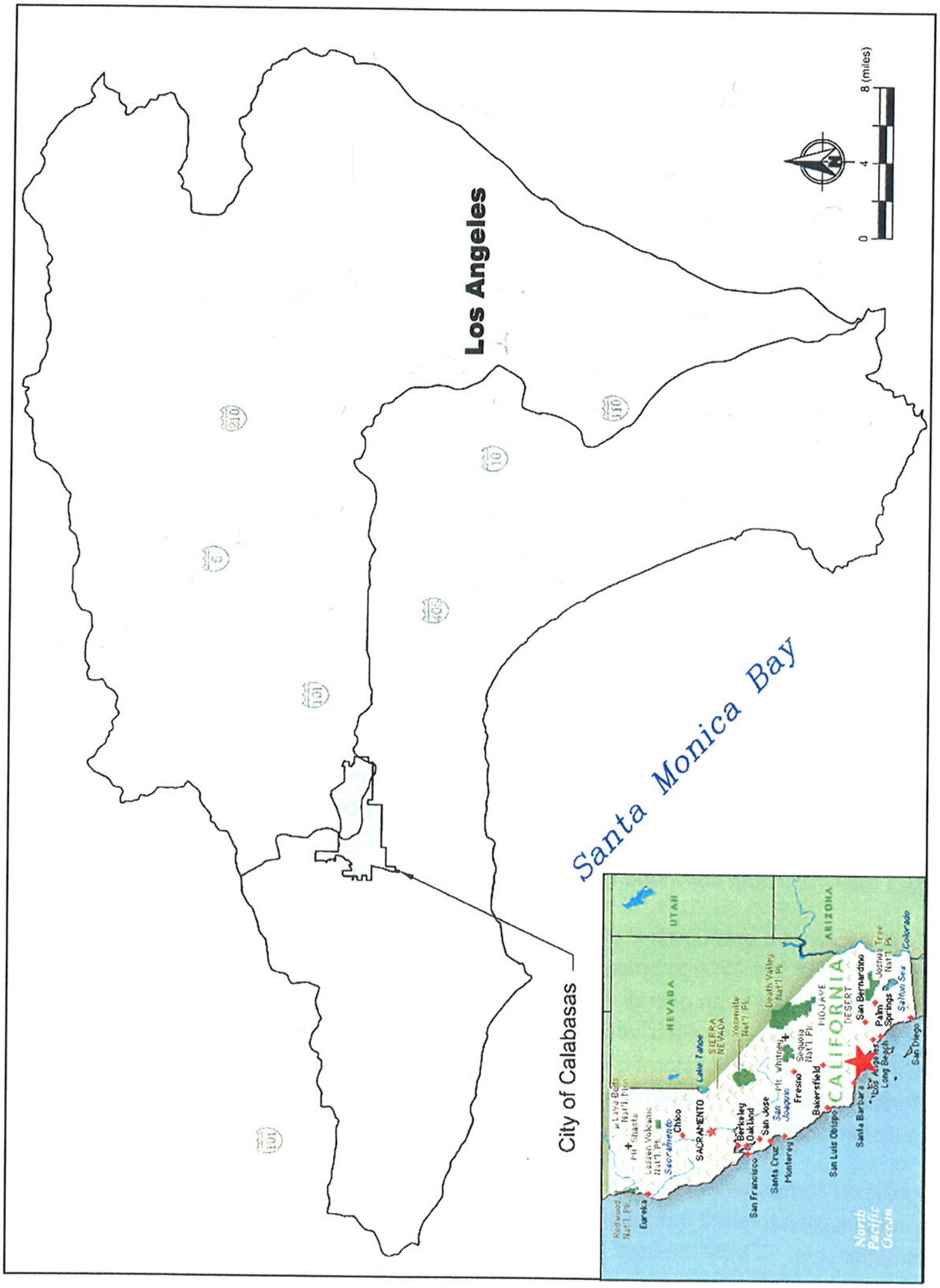

Figure 1.1 Location Map

1.2 PURPOSE AND OBJECTIVES

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 the restoration measures.

1.3 SCOPE OF STUDY

The scope of the watershed modeling study was limited to an analysis of watershed hydrology and nutrients. Existing, available information and data were used for the modeling study as funding was not available to perform additional field work. The nutrient model simulations were focused on the portion of the creeks that flow through the City 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 were insufficient for model calibration; therefore, the scope was modified to allow the use of an uncalibrated watershed model for alternative development and evaluation. The implication of this change in scope is discussed in Section 2.3.

2. WATERSHED MODELING APPROACH

A 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 two 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.

2.1 WATERSHED MODEL SELECTION

The EPA 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 CWA. 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 (HUC). 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 (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 LARWQCB to establish the TMDL allocations for nutrients and bacteria within the Malibu Creek Watershed.

2.2 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. Figure 2.1 illustrates graphically the hydrologic components of a typical hydrologic cycle.

For a given watershed with known characteristics (e.g., 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.

<u>Watershed Characteristics</u>

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

<u>Creek Characteristics</u>

- 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

<u>Hydrology</u>

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

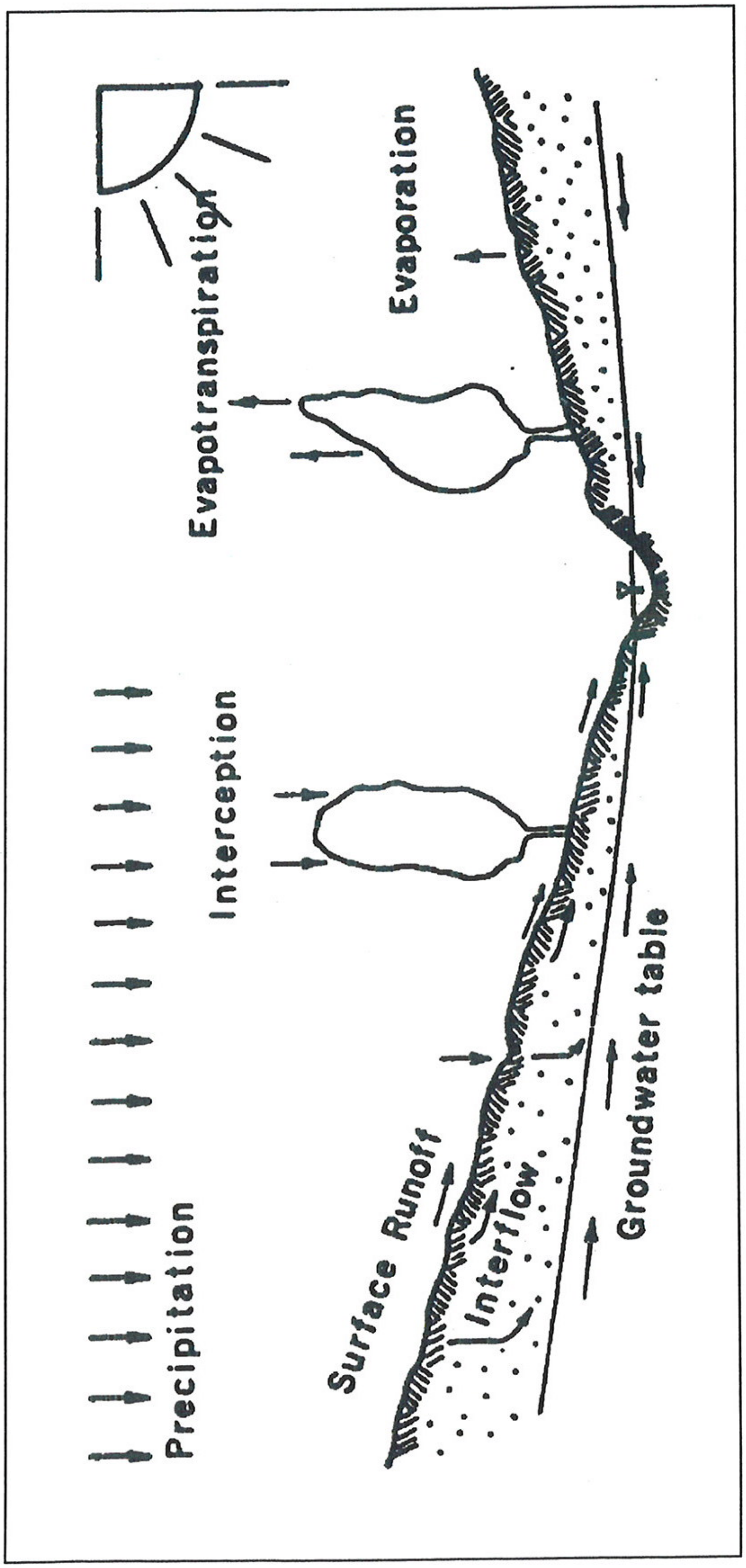

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Figure 2.1 Hydrologic Cycle

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

2.3 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 throughout the City were usually collected; however, no continuous flow measurements were collected as part of the program. Given that no simultaneous, continuous measurements of flow and water quality constituents were made 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 still useful in providing a relative comparison for the watershed analysis. The conceptual model was verified against analytical methods in flow estimates, as well as comparison with other studies in the region for pollutant loadings. More detailed information regarding the conceptual model setup is provided in the next chapter.

3. CONCEPTUAL WATERSHED MODEL SETUP

The BASINS suite provides a compilation of regional environmental data for the major watersheds of the United States according to HUC. The regional data includes weather, topography, soil type, land use, and point sources of pollutant discharge. In addition, the National Hydrography Dataset (NHD) provides a spatial definition of water bodies within each major watershed of the U.S.

Las Virgenes Creek is located within the Santa Monica Bay Watershed, shown in Figure 3.1, which is designated as HUC-18070104. The Santa Monica Bay Watershed is composed of the Malibu Creek and Ballona Creek Watersheds. A segment of Las Virgenes Creek flows through the western edge of the City of Calabasas, while the upper portion of the Las Virgenes Creek is located within Ventura County. Las Virgenes Creek joins with Malibu Creek just below the downstream boundary of the City. McCoy and Dry Canyon Creeks are part of the Los Angeles River Watershed designated as HUC-18070105. Both creeks originate within the City and join to form Arroyo Calabasas which then flows into the Los Angeles River. Watershed data from the BASINS database, USGS, and NHD were obtained for the watersheds of the three creeks by cross-referencing with the corresponding HUC.

In addition to the data obtained above, meteorological and water quality data were needed to conduct the HSPF modeling. Several available sources were identified to obtain these data and the sources are summarized in Table 3.1. Precipitation data were obtained from the Los Angeles County Department of Public Works (LACDPW) Monte Nido rainfall station (Station No. 435) located just south of Calabasas. Evaporation data was obtained from the closest LACDPW pan evaporation station at Pacoima Dam (Id 33-A). The monthly minimum and maximum temperatures from the National Oceanic and

Table 3.1 Summary of Available Site Specific Data

DATA	LOCATION	RECORD	SOURCE
Precipitation	Monte Nido	10/01/1996 – 9/30/2001	LADPW – Rainfall Station 435
Evaporation	Pacoima Dam	10/01/1996 – 9/30/2001	LADPW – Station Id 33-A
Temperature	Ojai	1/01/1990 – 6/30/2000	NOAA – Station 046399
Land Use	Las Virgenes Creek	1993	SCAG - Malibu Watershed Management Area Plan
Nitrate Ammonia Phosphate	Las Virgenes, McCoy, and Dry Canyon Creeks	Periodically 2001-2002	City of Calabasas
Nitrate Ammonia Phosphate	Las Virgenes Creek	Periodically 1998-2002	Heal the Bay

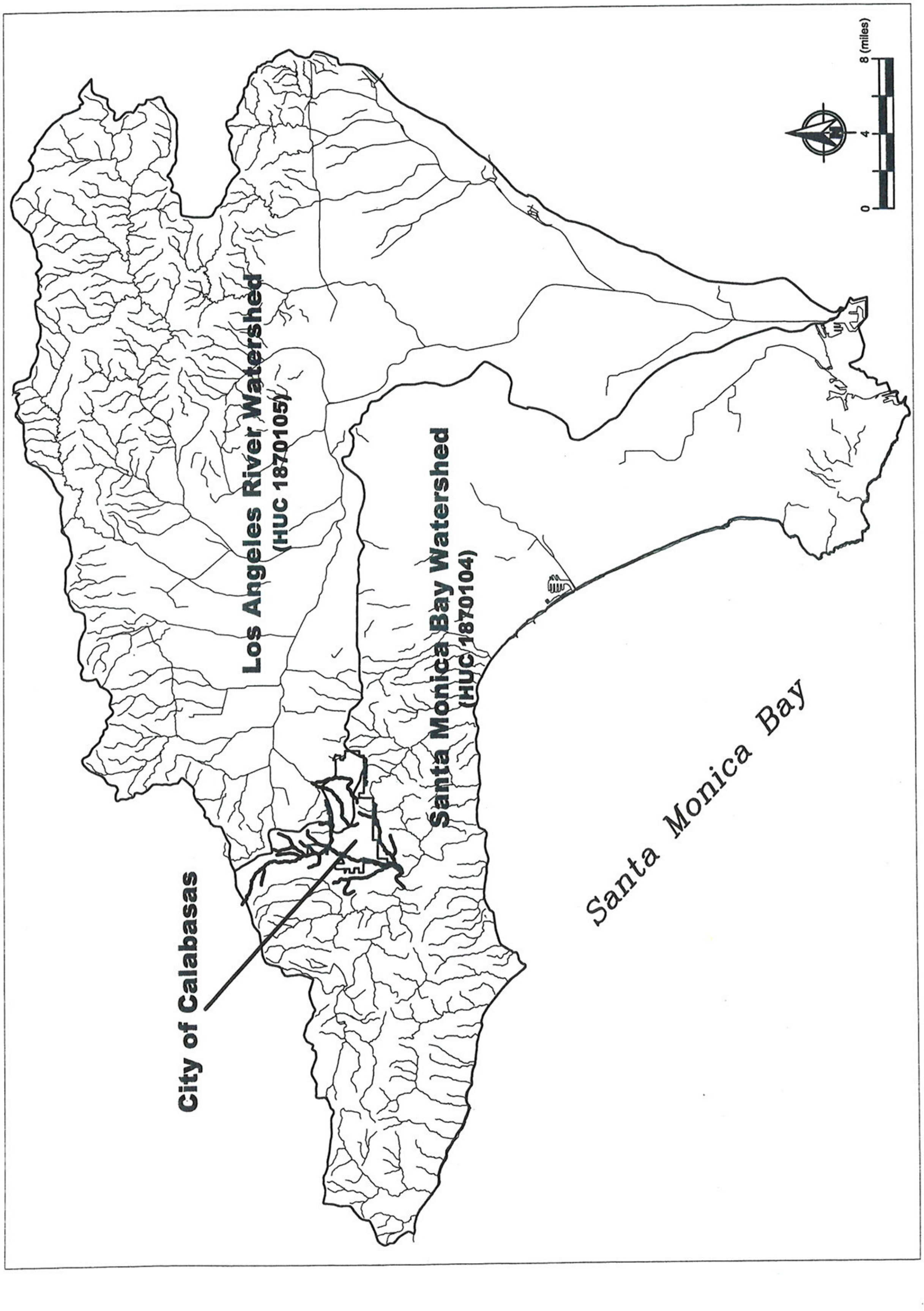


Figure 3.1 Santa Monica Bay and Los Angeles River Watersheds

Atmospheric Administration (NOAA) station in Ojai (Station 046399-06) were used to compute the potential evapotranspiration using a computer program based on the Hamon method (EPA, 2001b).

3.1 WATERSHED SETUP

The watershed boundaries for Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek were delineated based on regional topographic data provided from the BASINS database. The conceptual watershed model for Las Virgenes Creek extends downstream from the upper watershed to the discharge point into Malibu Creek. Figure 3.2 shows the eight subwatersheds used to define the HSPF model area. Las Virgenes Creek flows through the City boundaries in Subwatersheds 2, 3, and 4. The conceptual model extends beyond the area of interest to allow for comparison of the model results with available flow and water quality data at the outlet of Las Virgenes Creek into Malibu Creek (end of Subwatershed 7).

The conceptual watershed model for McCoy Creek is shown in Figure 3.3. McCoy Creek originates within Subwatershed 2 and flows in the northeast direction towards Subwatershed 1.

Dry Canyon Creek flows in a northerly direction from Subwatershed 2 to Subwatershed 1 as shown in Figure 3.4. Dry Canyon Creek exits the city limits at the downstream end of Subwatershed 2.

Land uses within the watersheds were obtained from the National Spatial Data Infrastructure and these data were refined with data from the Malibu Watershed Management Area Plan (WMAP) GIS Database. The land uses were grouped into three general categories (open space, urban, and agricultural). Open space included undeveloped area and rangeland. Urban lands comprise all developed areas including residential, commercial, and transportation areas. Agriculture lands are composed of agricultural and animal husbandry areas. Tables 3.2 through 3.4 summarize the areas and land use compositions within individual subwatersheds for Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek, respectively.

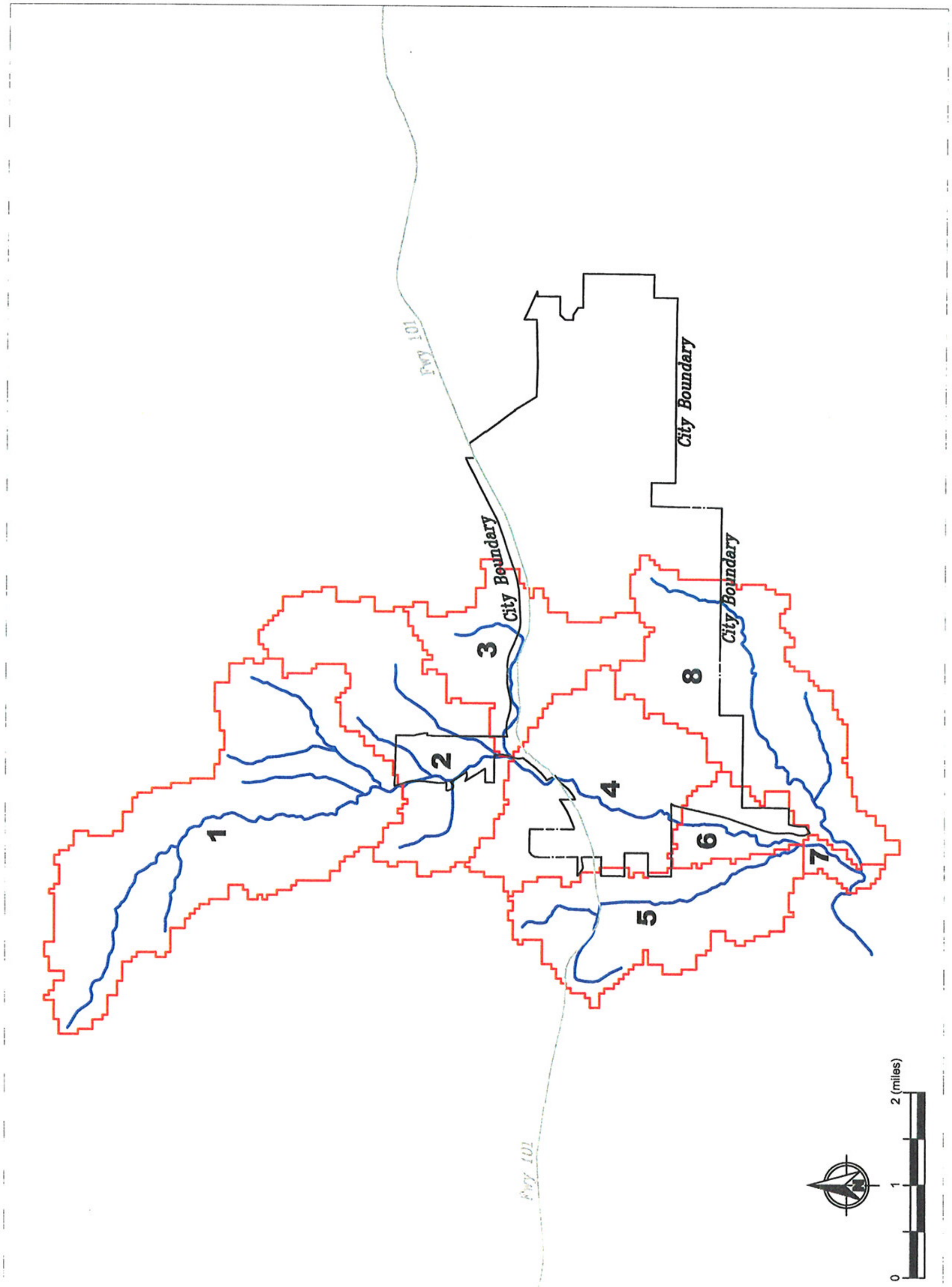


Figure 3.2 Conceptual Model Setup for Las Virgenes Creek

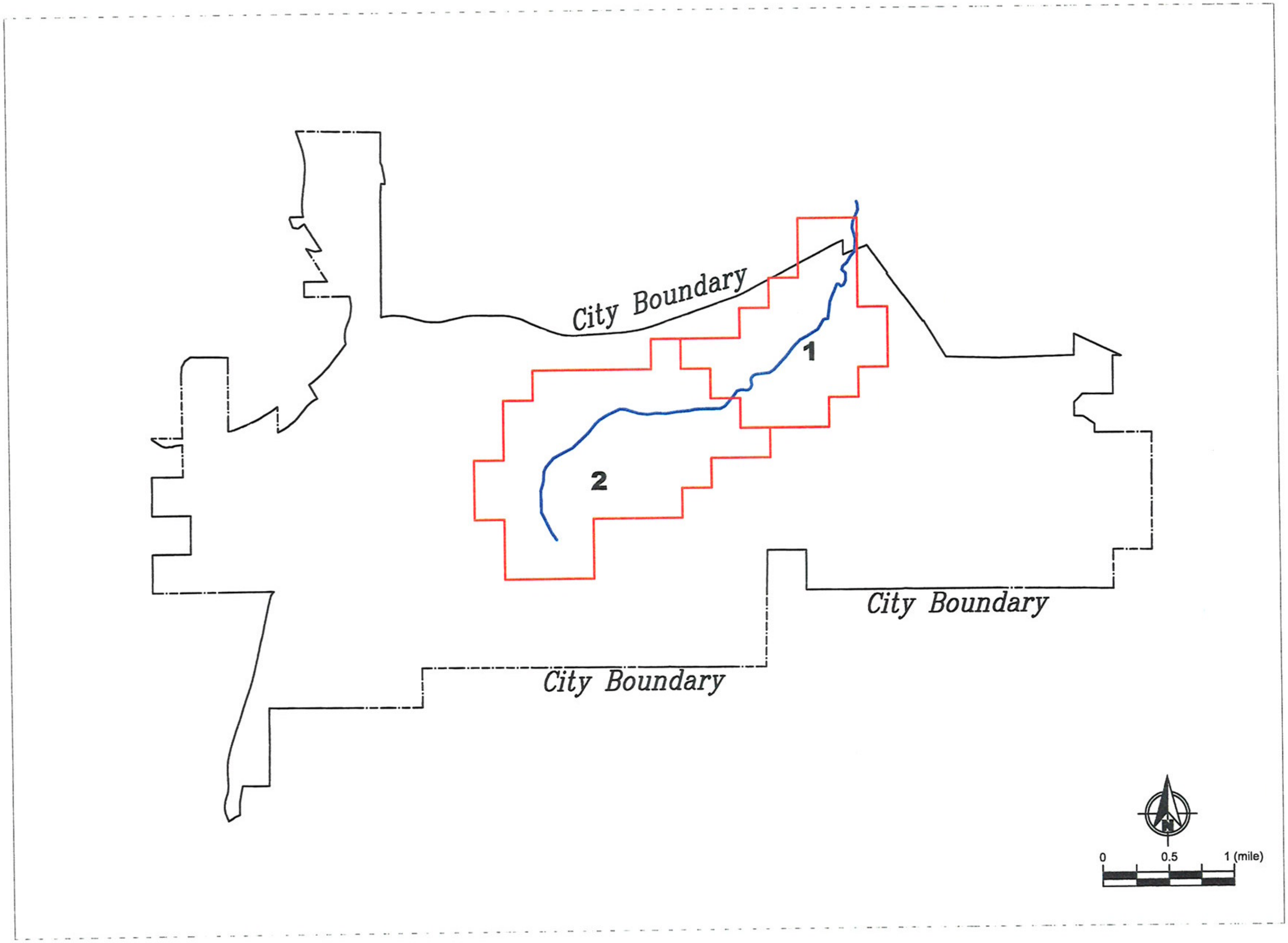


Figure 3.3 Conceptual Model Setup for McCoy Creek

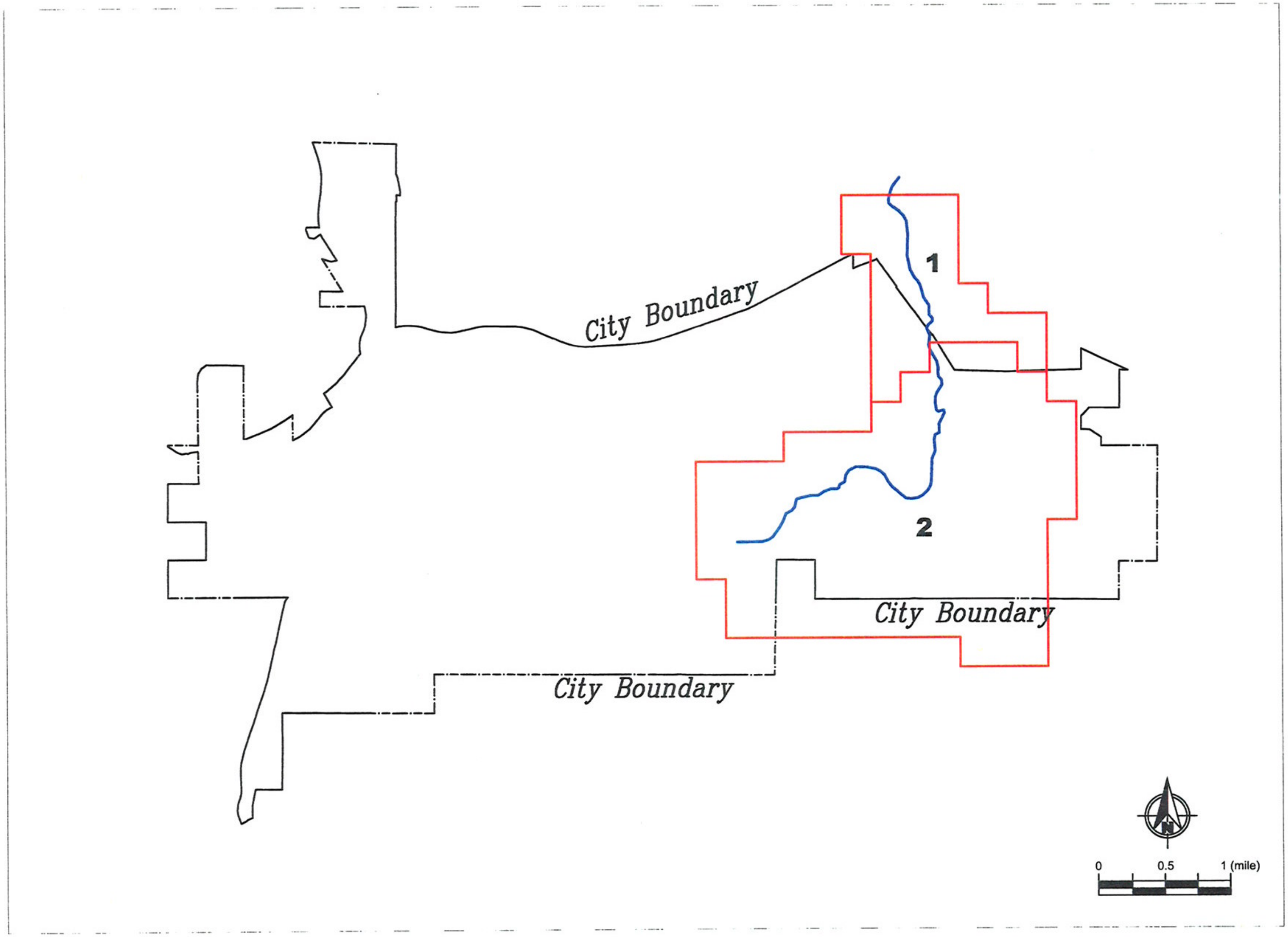


Figure 3.4 Conceptual Model Setup for Dry Canyon Creek

Table 3.2 Las Virgenes Creek Subwatersheds

SUBWATERSHED	AREA (ACRE)	LAND USE		DESCRIPTION
		TYPE	PERCENT OF SUBWATERSHED (%)	
1	4396	Open Space Urban	99.8 0.2	Outflow to Calabasas from undeveloped area of Ventura County
2	2465	Open Space Urban	82.0 18.0	Concrete section of Las Virgenes Creek
3	1616	Open Space Urban Agricultural	83.2 16.3 0.5	Tributary
4	2453	Open Space Urban Agricultural	73.4 24.3 2.3	Outflow from Calabasas
5	1940	Open Space Urban Agricultural	87.3 12.3 0.4	Liberty Canyon tributary
6	609	Open Space Urban Agricultural	92.0 2.0 6.0	Open section outside Calabasas
7	171	Open Space Urban Agricultural	99.0 0.5 0.5	Outflow to Malibu Creek
8	2845	Open Space Urban Agricultural	92.0 4.0 4.0	Stokes Creek tributary

Table 3.3 McCoy Creek Subwatersheds

SUBWATERSHED	AREA (ACRE)	LAND USE		DESCRIPTION
		TYPE	PERCENT OF SUBWATERSHED (%)	
1	646	Open Space Urban	59.3 40.7	Outflow from Calabasas to Los Angeles River
2	1076	Open Space Urban	88.9 11.1	Outflow from golf course

Table 3.4 Dry Canyon Creek Subwatersheds

SUBWATERSHED	AREA (ACRE)	LAND USE		DESCRIPTION
		TYPE	PERCENT OF SUBWATERSHED (%)	
1	598	Open Space Urban	16.0 84.0	Outflow to Los Angeles River
2	2393	Open Space Urban	83.0 17.0	Outflow from Calabasas

The Las Virgenes Creek and McCoy Creek watersheds are relatively undeveloped with open space accounting for 88.5% and 77.8% of the watersheds, respectively. It should be noted that the land use distribution for McCoy Creek watershed does not include the New Millennium Project in full build out. The Dry Canyon Creek watershed is substantially urbanized with only 30.4% open space. While open space and agriculture lands were assumed to be entirely pervious, urban lands were considered to have both pervious and impervious areas. The values of percent impervious land for urban land uses assumed for the present study were taken from LACDPW (1994) and the information is summarized in Table 3.5.

Table 3.5 Portion of Impervious Area

URBANIZED DESIGNATION	PERCENT IMPERVIOUS
Single Family	42
High Density	42
Multifamily Residential	70
Transportation	90
Commercial	89

Source: LACDPW, 1994

Soil characteristics within the watersheds were obtained from the State Soil Geographic (STATSGO) Data Base (NRCS, 1995a), which identifies the distribution of hydrologic soil groups based on soil map unit. The percentages of the soil groups identified within the watersheds were used to calculate the weighted averages of infiltration capacity index for the watersheds based on ranges shown in Table 3.6.

Table 3.6 Soil Groups and Infiltration Capacities

SCS Hydrologic Soil Group	Infiltration Capacity Index Estimate		Soil Characteristics	Runoff Potential
	IN/HR	MM/HR		
A	0.4 – 1.0	10.0 – 25.0	Deep sand, deep loess, aggregated silts	Low
B	0.1 – 0.4	2.5 – 10.0	Shallow loess, sandy loam	Moderate
C	0.05 – 0.1	1.25 – 2.5	Clay loams, shallow sandy loam, low in organic content, high in clay	Moderate to High
D	0.01 – 0.05	0.25 – 1.25	Swell significantly when wet, heavy plastic clays, certain saline soils	High

Source: USEPA, 2000

Stream characteristics including cross sections and roughness conditions were estimated from observations made during field visits in February 2003. A representative cross section was assumed for each stream reach within each subwatershed of the three creeks.

3.2 METEOROLOGY

Meteorological conditions in the region that drive the hydrological processes in the watersheds were represented by long-term records of precipitation, temperature, and evaporation from stations maintained by LACDPW and NOAA. Table 3.7 lists the data periods and sources. The monthly minimum and maximum temperatures from the NOAA station were used to produce a record of potential evapotranspiration for the same period using WDMUtil, a meteorological data processor, based on the Hamon method (EPA, 2001b).

Table 3.7 Meteorological Data

Data	Location	Record Period	Source
Precipitation	Monte Nido	10/1/1996-9/30/2001	LADPW Rainfall Station 435
Evaporation	Pacoima Dam	10/1/1996-9/30/2001	LADPW Evaporation Station 33A
Temperature	Ojai	1/1/1990-6/30/2000	NOAA Station 046399

3.3 NUTRIENT SOURCE LOADINGS

Primary nutrient sources within the three watersheds were identified based on information provided by local agencies, published values from prior studies, as well as observations during site visits. Table 3.8 lists the primary nutrient sources.

Table 3.8 Primary Nutrient Sources

WATERSHED	PRIMARY NUTRIENT SOURCES
Las Virgenes Creek	• Atmospheric deposition • Reclaimed water irrigation • Livestock • Septic system
McCoy Creek	• Atmospheric deposition • Reclaimed water irrigation • Golf course fertilization
Dry Canyon Creek[1]	• Atmospheric deposition • Reclaimed water irrigation

[1] At the time modeling was completed there were no data available indicating the presence of septic systems in Dry Canyon Creek; therefore, it was assumed that there were no septic systems in Dry Canyon Creek. After completion of the modeling analysis, information became available indicating the presence of several septic systems within the Dry Canyon Creek watershed but the locations of those septic systems are still unknown.

Graphical representations of the nutrient sources for Las Virgenes, McCoy, and Dry Canyon Creeks are shown in Figures 3.5, 3.6, and 3.7, respectively. The atmospheric deposition rates of nitrate nitrogen (NO_3-N) and ammonia nitrogen (NH_4-N) were estimated from data obtained from the National Atmospheric Deposition Program/National Trends Network (NADP/NTN) Station CA42 in Tanbark Flat, CA to the east of Los Angeles. The nitrogen (N) deposition rates were input as wet deposition (precipitation-associated) and allowed to vary seasonally. The deposition rate of phosphate phosphorous (PO_4), which is not monitored by NADP/NTN, was assumed to be comparable to the nationwide average rate provided by Graham and Duce (1979). The total phosphorous (P) deposition rate (wet and dry) was input to the model as dry (or total) deposition and assumed constant throughout the year. Loadings from atmospheric deposition were applied uniformly to the entire watershed for all three creeks.

The loading rates from reclaimed irrigation water within the watersheds were determined based on effluent flow rates as well as nitrogen (N) and phosphorous (P) concentrations in the effluent from the Tapia Water Reclamation Facility (EPA/RWQCB, 2002). Since irrigation occurs most extensively within the City, the loadings were applied to all subwatersheds with a portion located within the City limits. For each subwatershed affected by irrigation, the total mass loads of nitrogen and phosphorous forms were computed based on the area of Calabasas contained within the subwatershed and divided by the total area of the subwatershed to provide loading rates of nitrogen and phosphorous from irrigation for the subwatershed.

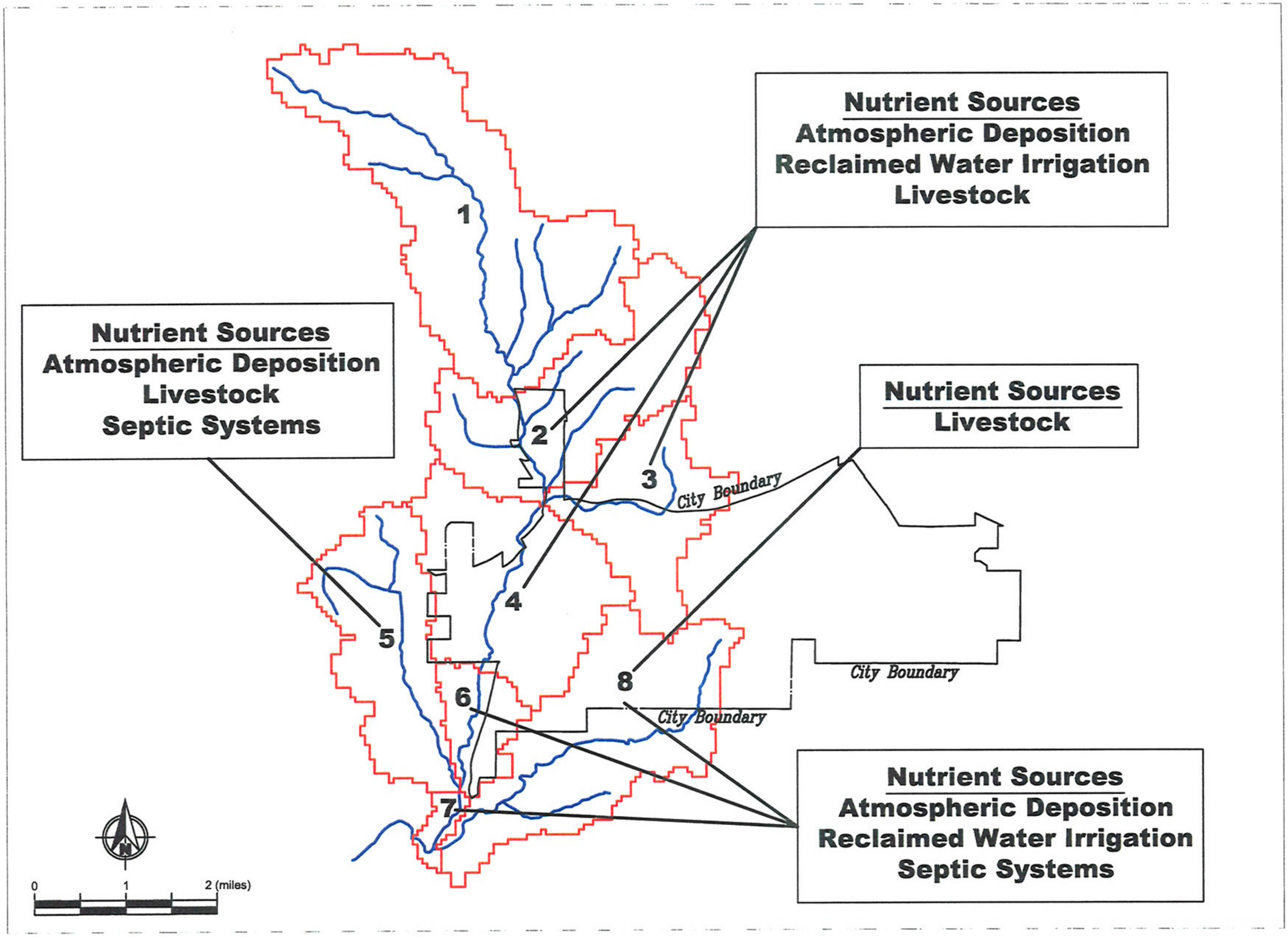


Figure 3.5 Nutrient Sources for Las Virgenes Creek

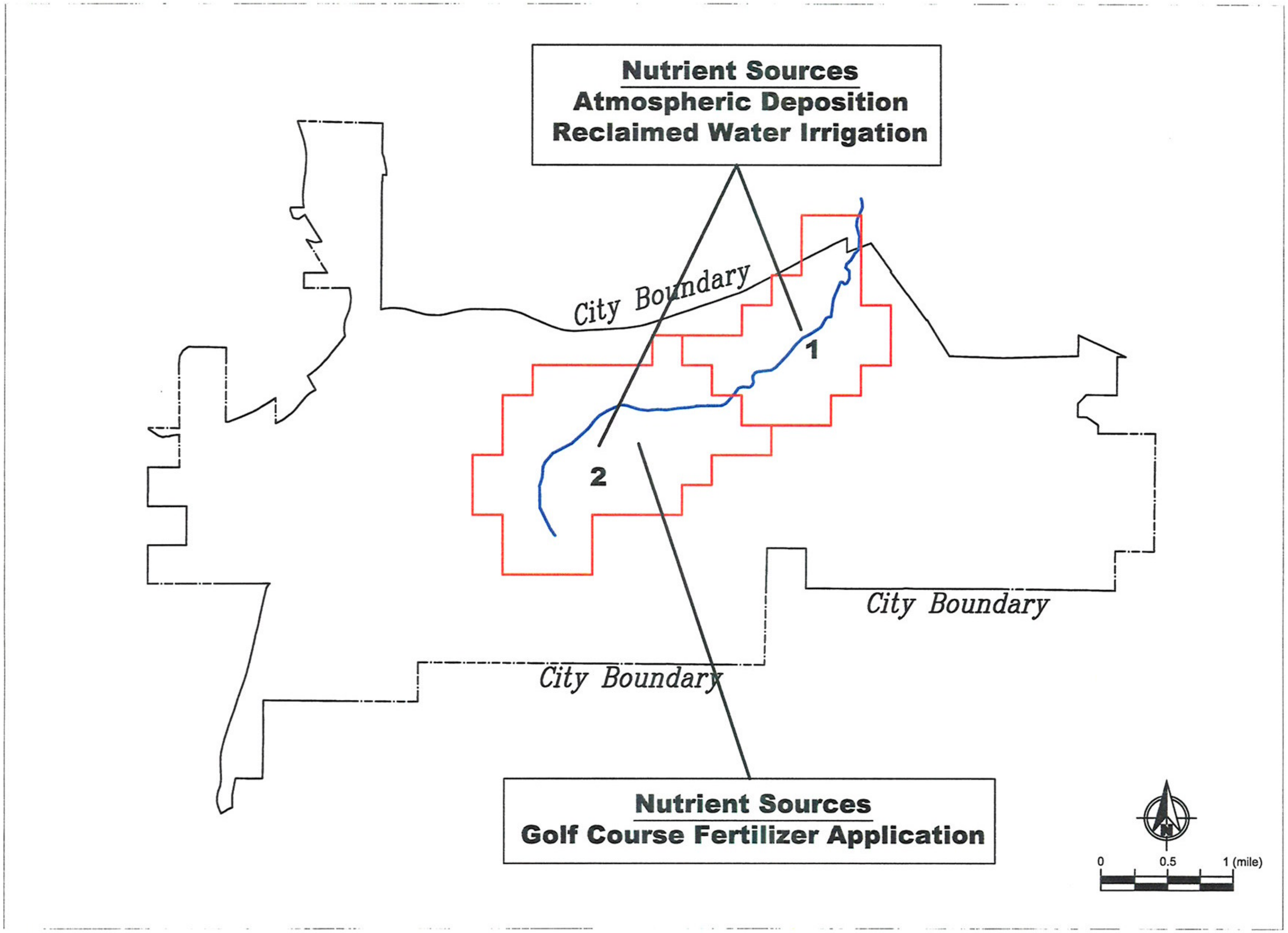


Figure 3.6 Nutrient Sources for McCoy Creek

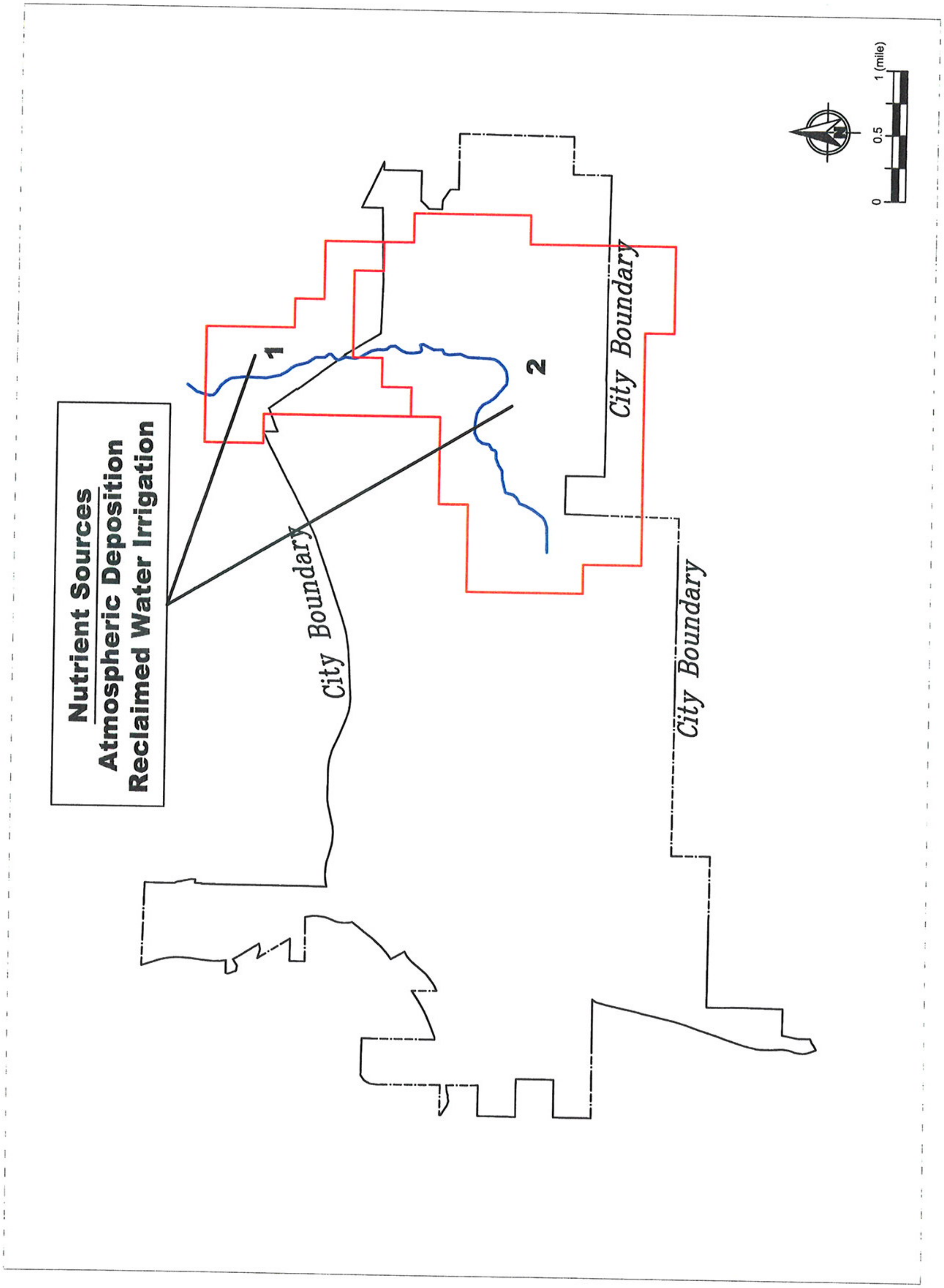


Figure 3.7 Nutrient Sources for Dry Canyon Creek

The loading rates from livestock, septic systems, and golf course fertilization were estimated from information provided in EPA/RWQCB (2002). Loadings from these sources were applied to subwatersheds containing animal farming activities, rural residential land use, and golf courses, respectively. For each subwatershed affected by livestock, the total mass loads of nitrogen and phosphorous forms were computed based on the density and types of the animal population in the subwatershed and divided by the total area of the subwatershed to provide loading rates of nitrogen and phosphorous from livestock for the subwatershed. Similarly, for each subwatershed affected by septic systems and golf courses, the total mass loads of N and P phosphorous forms were computed based on the areas of rural residential land use and golf course contained within the subwatershed, respectively, and divided by the total area of the subbasin to provide loading rates of nitrogen and phosphorous from these sources for the subwatershed.

3.4 CONCEPTUAL MODEL VERIFICATION

Detailed calibration of the HSPF model set up for the three watersheds was not conducted for lack of site-specific water quality data at a level that would permit full calibration of the model. 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 simultaneous, continuous measurement of flow and water quality constituents were made, the data were insufficient to conduct a meaningful calibration of the HSPF model.

Instead of full calibration, the model was qualitatively compared against the results of analytical estimates of flows within Las Virgenes Creek and total loadings provided in EPA/RWQCB (2002). Verification was based on loading per acre of watershed with the ranges of nutrient loadings for the Malibu Creek watershed (LACDPW, 2000; Stenstrom et al., 1993; UCLA, 2000; NRCS, 1995b). The nutrient loading trends were also compared to water quality data from the City. The model was found to provide reasonable results given the limited amount of data.

Hydrology

The conceptual watershed model for Las Virgenes Creek was used to check the hydrologic component of the watershed model setup. The conceptual model predicted peak flow rate for existing condition over a 24-hour period are compared with those calculated based on a commonly used analytical method (Rational Method) in Table 3.9. As shown in the table, the conceptual model predicted flow rates at each subwatershed match well with the Rational Method predictions.

Table 3.9 Comparisons of Conceptual Model and Rational Method Flows

SUBWATERSHED	**FLOWS (CFS)**	
	RATIONAL METHOD	**CONCEPTUAL METHOD**
1	64	73
2	132	160
3	42	62
4	253	331
5	45	63
6	262	345
7	360	497
8	50	87

Nutrient Loadings

The conceptual model predicted general trends of the nutrient loadings were compared to available monitoring data obtained from the City. An analysis of these data revealed that there is an increase in nutrient concentrations along Las Virgenes Creek moving from upstream to downstream through the City limits. The conceptual watershed models predicted the same general trend of increase in nutrient loadings along the creek through the City. As shown in Table 3.10, the model predicted nutrient loadings compared reasonably well to the values presented in the draft Malibu Creek watershed study (EPA/RWQCB, 2002) report for three separate locations (see Figure 3.8) within the Las Virgenes Creek watershed.

Table 3.10 Average Annual Nutrient Loading Comparisons

LOCATION	**NUTRIENT**	**AVERAGE ANNUAL LOADING (LB/YR)**	
		LAS VIRGENES CREEK CONCEPTUAL MODEL	**DRAFT MALIBU CREEK WATERSHED STUDY**
1	Nitrogen	23,075	19,300
	Phosphorus	8,060	2,075
2	Nitrogen	42,901	43,200
	Phosphorus	16,775	4,340
3	Nitrogen	20,184	14,460
	Phosphorus	3,341	1,640

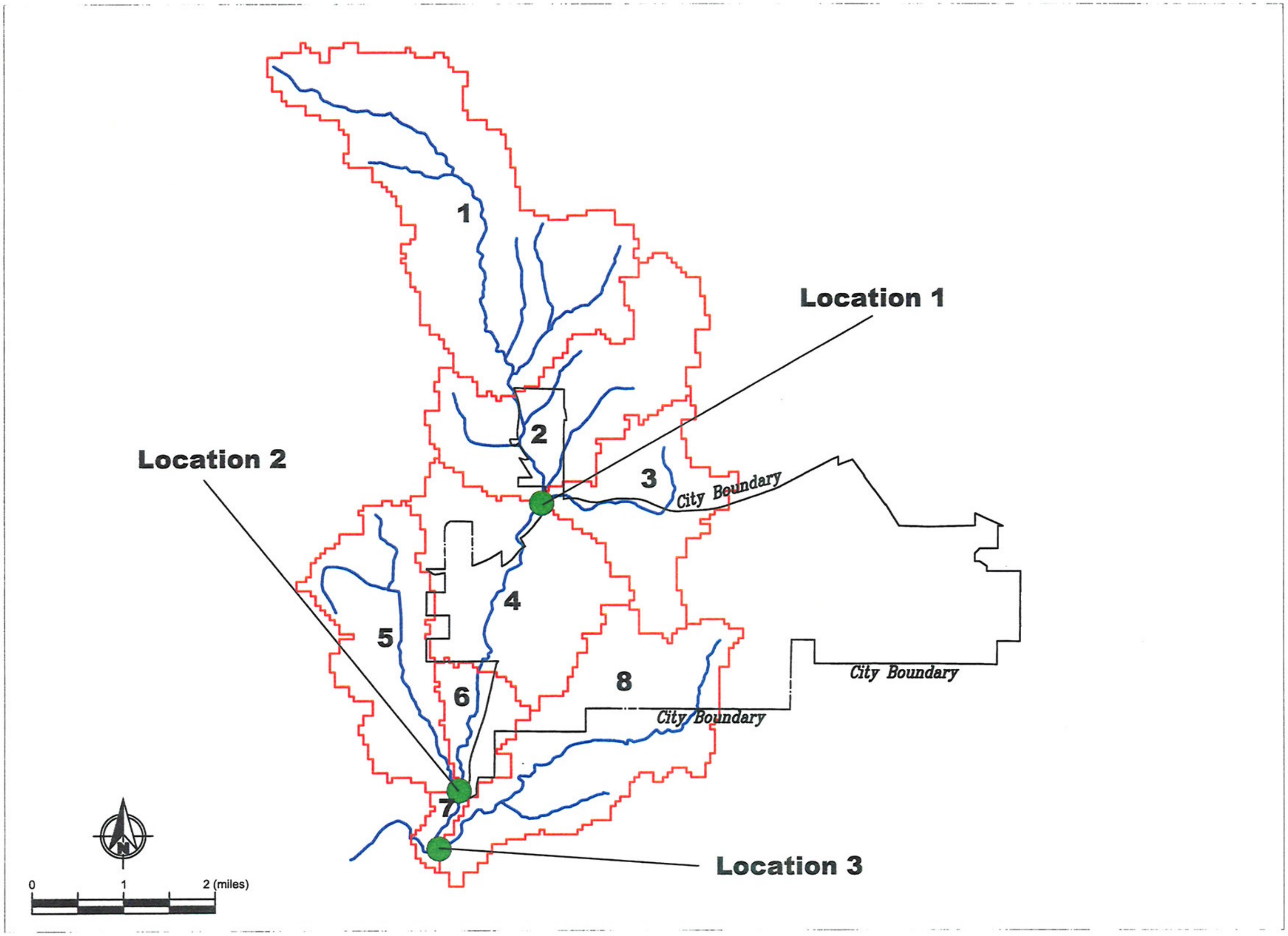


Figure 3.8 Locations for Nutrient Loading Comparison

Loading Sensitivity

Two simulations for each creek were conducted to determine the model sensitivity to the input nutrient loadings. For the sensitivity test, the total loading for each nutrient was increased by 50% and decreased by 50% from the existing condition. The model results were then compared based on percent changes in loading from the existing conditions. Table 3.11 summarizes the percent change for the sensitivity analysis.

Table 3.11 Nutrient Loading Sensitivity Analyses

NUTRIENT	SENSITIVITY CHANGE	PERCENT CHANGE (%)		
		LAS VIRGENES CREEK	MCCOY CREEK	DRY CANYON CREEK
Nitrate	50% Increase	46	33	38
	50% Decrease	46	33	35
Ammonia	50% Increase	23	12	16
	50% Decrease	23	10	9
Phosphate	50% Increase	39	24	38
	50% Decrease	38	24	38

The sensitivity test results show that an increase and a decrease in the input nutrient loadings result in similar percent changes from existing conditions. The nitrate sensitivity change resulted in relatively close changes for Las Virgenes (46%), McCoy Creek (33%), and Dry Canyon Creek (37%).

The results indicate that the absolute nutrient loading is sensitive to the input nutrient loading. The percent change in loading was similar regardless of whether or not the input nutrient loading was increased or decreased. Therefore, the model should only be used to compare relative changes in nutrient loading between alternatives and not to evaluate changes in absolute values. This illustrates the need for model calibration if the model results are to be used on an absolute basis (i.e., actual loading or concentration).

4. ALTERNATIVE DEVELOPMENT

4.1 OBJECTIVE

Nutrient levels in receiving waters are dependent on source loadings in the watershed, transformations on the watershed surface and in the soil environment, runoff intensity, and physical, chemical, and biological interactions within the aquatic environment of the receiving water. Water quality improvement can be achieved by altering these processes. Decreasing the nutrient source within the watershed lowers the nutrient loading. Limiting irrigation or preventing runoff from reaching the receiving water reduces the transport of nutrients. Increases in biological and chemical processes increase removal of nutrients within the watershed also.

Alternative restoration measures were developed to achieve these objectives, thereby reducing nutrient loading to the creeks. The alternative restoration measures were divided into three groups based on the primary mechanism for achieving reductions in nutrient loadings. Alternative restoration measures implemented within the creek (creek restoration) were developed to improve water quality primarily through habitat restoration and creek flow modification. Implementation of structural best management practices (BMPs) within the watershed were analyzed as a class of alternative restoration measures to reduce nutrient loading through methods focused primarily on trapping nutrients prior to entering the creeks (e.g., sedimentation trap, CDS units, and treatment wetlands/bioswales). Finally, source control methods were identified as a class of alternative restoration measures focused primarily on reducing nutrient loading at the generation source (e.g., recycled irrigation water use changes).

4.2 ALTERNATIVE DEVELOPMENT

To facilitate the development of watershed modeling alternatives, improvement goals were established that focused on nutrient reductions and reductions in secondary processes that affect nutrients (e.g., soil erosion). The goals are presented in Table 4.1, along with the corresponding control mechanisms and watershed restoration measures required to achieve each goal.

Table 4.1 Water Quality Improvement Goals, Control Mechanisms, and Watershed Restoration Measures

GOAL	CONTROL MECHANISM	WATERSHED RESTORATION MEASURE
Reduce Fertilizer Runoff	Transport	Structural BMPs
Decrease Husbandry Runoff	Transport	Structural BMPs
Reduce Septic System Failure	Source	Source Control
Modify Reclaimed Water Use	Source	Source Control
Reduce Erosion	Flow	Creek Restoration or Land Use Modification
Increase Vegetative Uptake	Removal	Creek Restoration or Land Use Modification

Since it is possible to implement various combinations of the alternative watershed restoration measures presented above, a clear methodology was needed to cost-effectively analyze the full range of options within a limited number of model simulations.

This was done by combining all the restoration measures for each group into one alternative, thereby resulting in three alternatives for model simulation (Creek Restoration, Structural BMPs, and Source Control). To provide a baseline for comparison, a fourth alternative was developed based on the historical land uses that were thought to exist prior to the arrival of European man (i.e., open space/natural). This alternative (Historical Land Use) establishes an upper limit on the amount of improvement that can be achieved through watershed restoration since it reflects a watershed condition absent human influence.

4.3 HISTORICAL LAND USE

The Historical Land Use Alternative was developed to establish nutrient loadings in the absence of human activities. Urbanization impacts the watershed characteristics and increases nutrient loadings associated with anthropogenic sources. By eliminating urbanization, this alternative establishes the maximum possible improvement that can be achieved for the watershed. The alternative was based on the existing watershed without urban land use and with atmospheric deposition being the only nutrient input to the watershed.

4.4 CREEK RESTORATION

The Creek Restoration Alternative was developed to reduce erosion and increase vegetative uptake of nutrients through stream modifications. The alternative addresses all of the creek restoration opportunities, which included erosion control, channel modifications, and wetland restoration actions as identified in Table 4.2. These stream

Table 4.2 Creek Restoration Opportunities

RESTORATION OPPORTUNITIES	STREAM MODIFICATIONS
Erosion Control	Stabilize bank and channel
Channel Modifications	Cease vegetation clearing
	Remove concrete and rip-rap
	Stabilize banks with bioengineering techniques
	Remove or improve flow restrictions (e.g. – weirs or culverts)
	Pull back banks
	Enhance floodplain
Wetland Restoration	Remove eucalyptus, vinca, tamarisk, and other exotics
	Create and restore riparian wetlands

modifications do not impact the nutrient loadings from the watershed that enters the creek, but the modifications were modeled for completeness. In addition, nutrient uptake resulting from habitat restoration is insignificant compared to the other nutrient removal processes because the steep gradients of the creeks do not allow sufficient time for substantial nutrient uptake and the total area of restored habitat was small.

Specific restoration actions for Las Virgenes Creek were identified along the main stem defined by the green segment in Figure 4.1. Creek characteristics were modified in Subwatersheds 2, 4, and 6. The concrete channel along the majority of the Subwatershed 2 and along the top of Subwatershed 4 will be removed. Modifications to stabilize the creek bank and channel were identified along the entire segment. Multiple wetland restoration sites were identified in Subwatersheds 2, 4, and 6. Restoration actions were identified for the entire length of McCoy Creek as shown in Figure 4.2. Restoration opportunities for Dry Canyon Creek were also identified along the entire creek. Figure 4.3 indicates the primary restoration actions for Dry Canyon Creek.

The Creek Restoration Alternative was simulated by adjusting channel characteristics to reflect stream modifications for erosion control and channel modifications. Improvement of vegetative uptake due to wetland restoration was determined to be relatively localized and insignificant on a watershed scale; therefore, vegetative uptake improvements were not modeled.

4.5 WATERSHED MANAGEMENT ALTERNATIVE 1 – STRUCTURAL BMPS

Watershed Management Alternative 1 was developed to reduce nutrients from runoff by treating runoff on site within the watershed using structural BMPs before it reaches the creeks. Four general types of BMPs were identified to be applicable based on land use: detention basins, biofilters, infiltration basins, and pervious concrete. Detention basins capture runoff for treatment through sedimentation. Biofilters utilize vegetation to treat runoff and reduce surface runoff. Infiltration basins reduce surface runoff by increasing percolation into the ground and provide removal of contaminants. Similarly, pervious concrete reduces the runoff from impervious urban areas by promoting infiltration and contaminant removal.

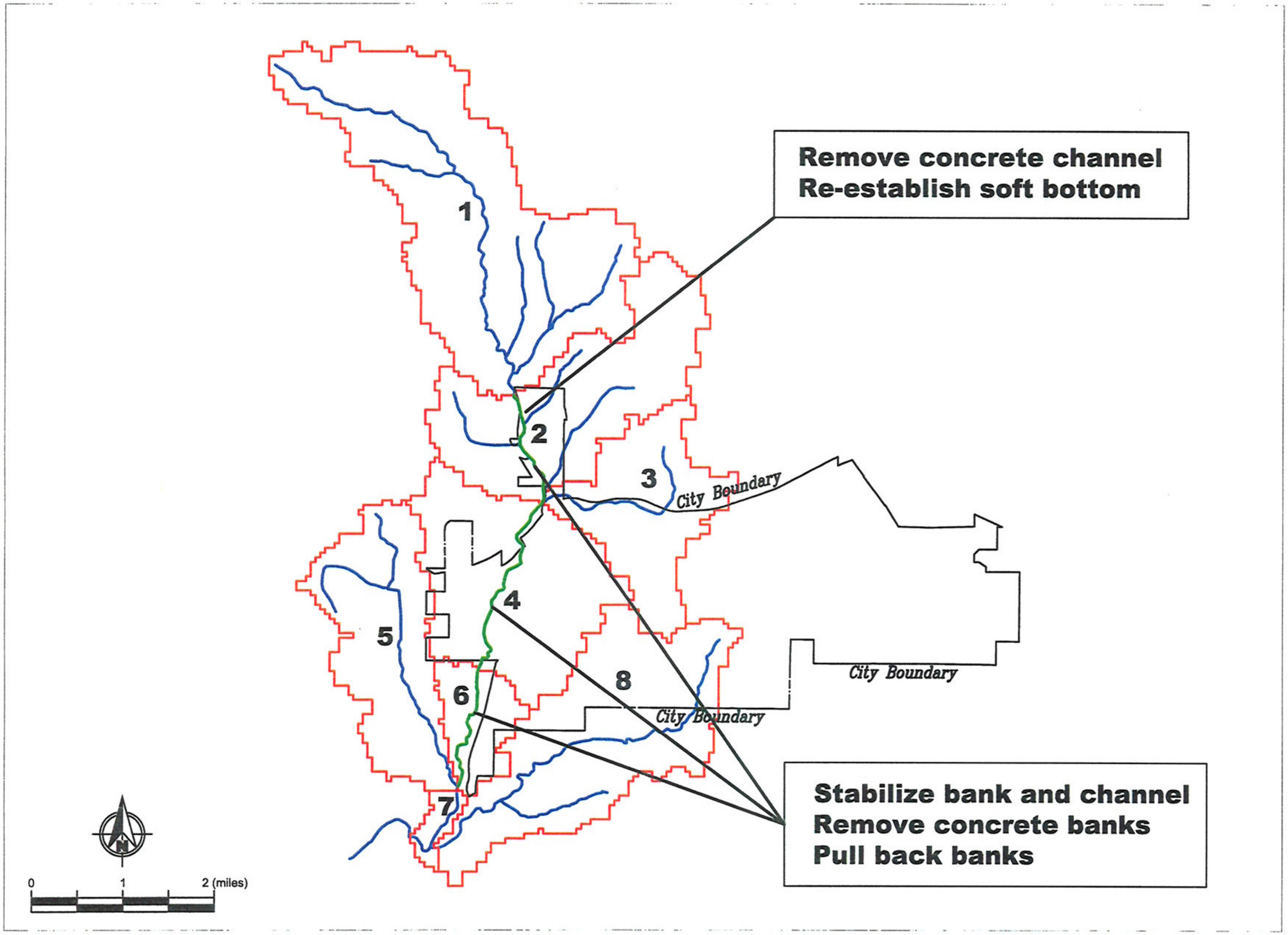
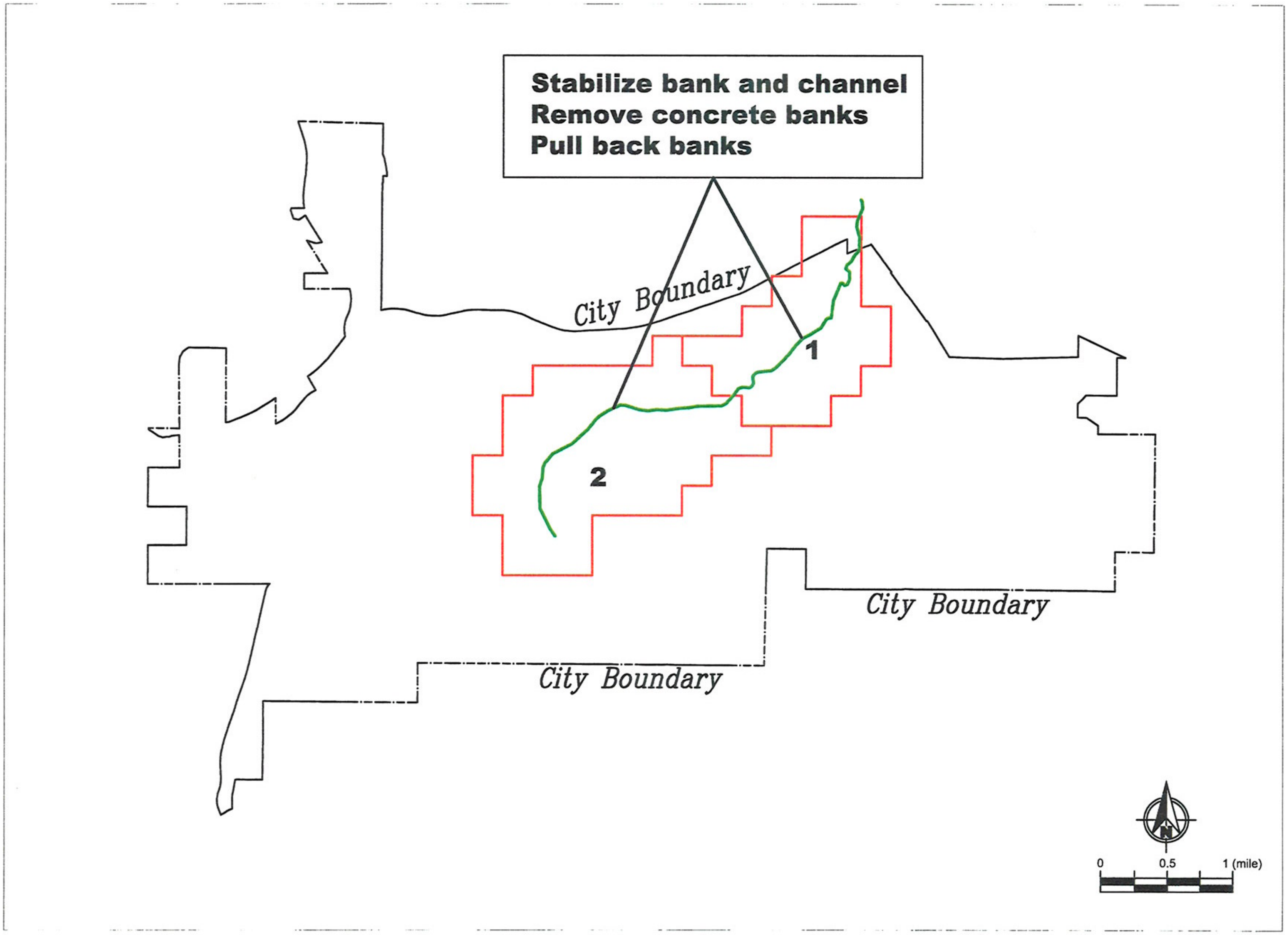


Figure 4.1 Creek Restoration Alternative for Las Virgenes Creek



Stabilize bank and channel
Remove concrete banks
Pull back banks

Figure 4.2 Creek Restoration Alternative for McCoy Creek

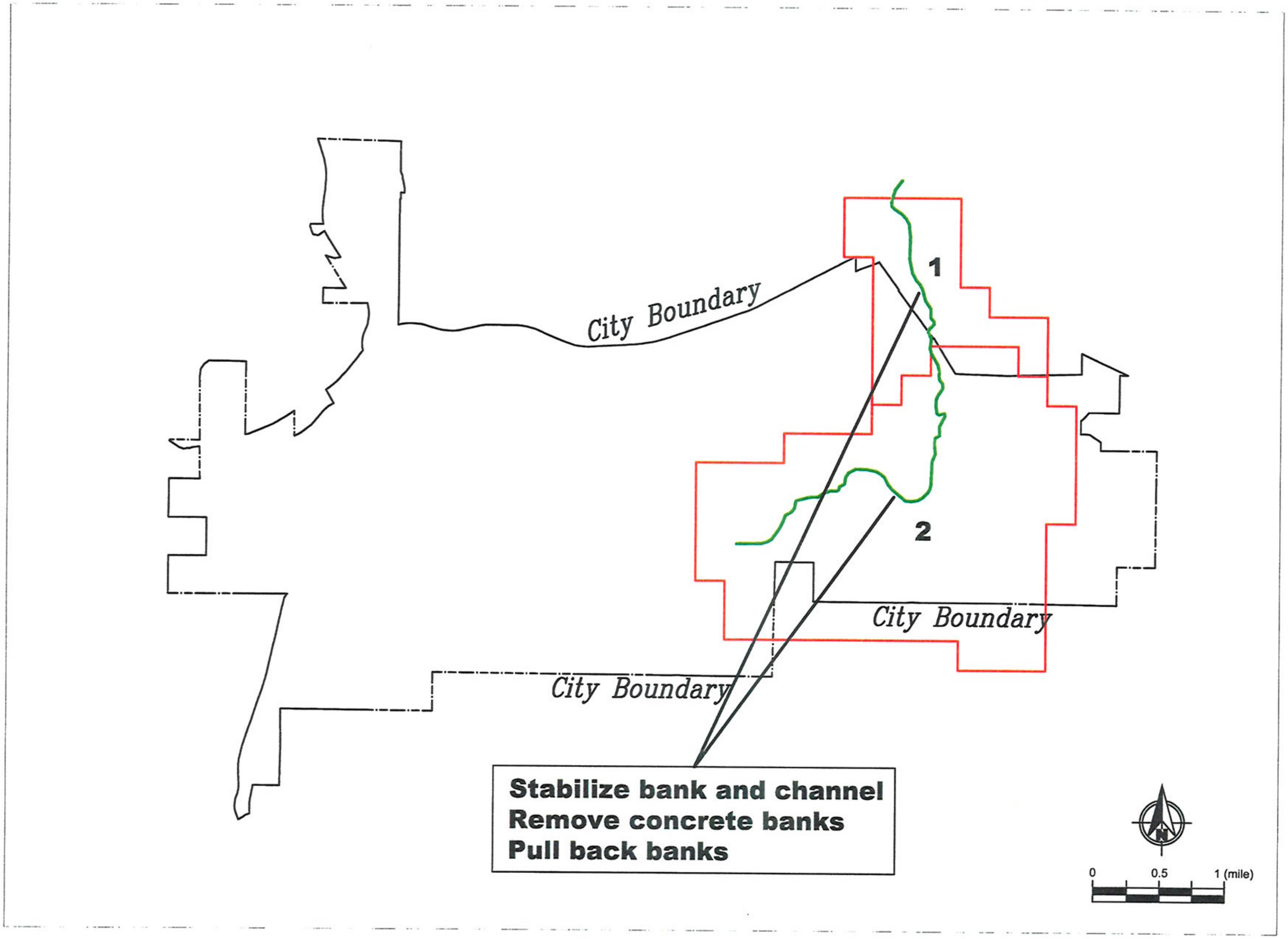


Figure 4.3 Creek Restoration Alternative for Dry Canyon Creek

Table 4.3 shows the typical values of removal efficiency for the BMPs considered for this alternative. The removal efficiencies were calculated based on average literature values (EPA, 1993; SWQTF, 1993; EPA, 1999; EPA, 2002; CASQA, 2003). The nitrogen and phosphorus removal efficiencies were similar for each type of BMP. These values were used to calculate the reduction of the nitrogen and phosphorus species by the BMPs. The nitrogen removal efficiency was assumed to be applicable for both nitrate and ammonia. The phosphorus removal efficiency was assumed to be applicable for phosphate.

Table 4.3 Average Removal Efficiencies of BMPs

TYPE OF BMP	AVERAGE REMOVAL EFFICIENCY (%)		APPLICABLE LAND USE
	NITROGEN	PHOSPHORUS	
Detention Basins	37.5	37.5	Agricultural and Husbandry
Biofilters	51.0	53.0	Agricultural, Husbandry, Residential, and Commercial
Infiltration Basins	70.5	70.5	Residential and Commercial
Pervious Concrete	80.0	60.0	Residential

Source: EPA, 1993; SWQTF, 1993; EPA, 1999; EPA, 2002; CASQA, 2003

The average removal efficiencies presented in Table 4.3 are based on complete treatment of all runoff and successful performance of each structural BMP. To account for the potential range in runoff trapping and poor performance of some structural BMPs, two scenarios were developed to represent Alternative 1. Alternative 1A was based on the assumption that the structural BMPs were successful at treating 50% of the runoff, while Alternative 1B was based on the assumption that the structural BMPs were successful at treating 100% of the runoff.

The use of structural BMPs is limited based on land use. In some cases, multiple BMPs can be implemented within the same land use. For land uses with two applicable BMPs, the efficiency was calculated based on the assumption that the BMPs would be linked in series such that the efficiency of the second BMP was applied to the output of the first BMP. For example, biofilters and infiltration basins were utilized in pervious residential and commercial land use areas. The biofilters can remove 51% of nitrate leaving behind 49% of nitrate assuming the biofilters are 100% effective. Infiltration basins were then linked to the biofilters to remove 70.5% of the nitrate remaining, thereby leaving 29.5% of the nitrate after biofilter treatment. Multiplying the portion remaining after biofilter treatment (49%) by the portion remaining after infiltration basin treatment (29.5%) yields an overall remaining nitrate of 14.5%. Therefore, the sequence of biofilters and infiltration basins has an overall removal efficiency of 85.5% (i.e., 100% - 14.5%).

The overall efficiency of each BMP for each land use within each subwatershed was applied to the nutrient loadings determined from existing conditions. The BMPs applicable to this alternative can be utilized only within the agricultural, residential, and commercial land uses; therefore, the loadings for these three land uses were reduced through application of the BMPs. This process is illustrated in Figure 4.4 as an example flow chart. The flow chart outlines the nitrate loading from the pervious urban area in Las Virgenes Creek Subwatershed 4 under Alternative 1A. The pervious urban area is composed of residential, commercial, and transportation land uses with the transportation land uses accounting for 26.4%. The structural BMPs of biofilters and infiltration basins can be utilized for the residential and commercial land uses; therefore, only 73.6% of the loading can be directed to the structural BMPs. The other 26.4% from the transportation land use enters the creek directly (i.e., no treatment). Based on the assumption of Alternative 1A, 50% of the nitrate loading bypasses the structural BMPs and enters the creek, while the other 50% is captured for treatment by the structural BMPs. Based on the overall removal efficiency discussed above, 85.5% of the treated loading is removed. Thus, 14.5% of the treated nitrate loading enters the creek. This process was applied for each land use in each subwatershed.

The areas that BMPs can be used within the Las Virgenes Creek watershed are shown in Figure 4.5. The gray areas indicate the residential and commercial land uses and yellow indicates agricultural or husbandry land uses. As shown in the figure, BMPs can only be applied to a limited portion of the entire watershed.

The residential and commercial areas for the McCoy Creek watershed are shown in Figure 4.6. The gray areas indicate the portion of the watershed that BMPs could be implemented.

Figure 4.7 indicates the areas where structural BMPs can be implemented for Dry Canyon Creek. Again, the gray areas indicate the portion of the watershed that BMPs could be implemented.

4.6 WATERSHED MANAGEMENT ALTERNATIVE 2 – SOURCE CONTROL MEASURES

Watershed Management Alternative 2 was developed to reduce nutrient loading through reductions in sources. Based on information presented in Section 3.3, the four most significant nutrient sources in the watershed were determined to be atmospheric deposition, septic systems, reclaimed irrigation water use, golf course fertilization, and livestock. It was not considered feasible to reduce atmospheric deposition of nutrients as part of this study because atmospheric deposition occurs on a regional basis, which is beyond the geographic limits (watershed) of the study. Septic systems within the Las Virgenes Creek watershed occur downstream of the area of interest (City limits); therefore, changes in septic systems were not addressed in the current study since those changes would not have any effect on the portion of the creek that flows through the City. Septic systems within the Dry Canyon Creek watershed were not simulated because there were no available data indicating the presence of septic systems in the Dry Canyon Creek

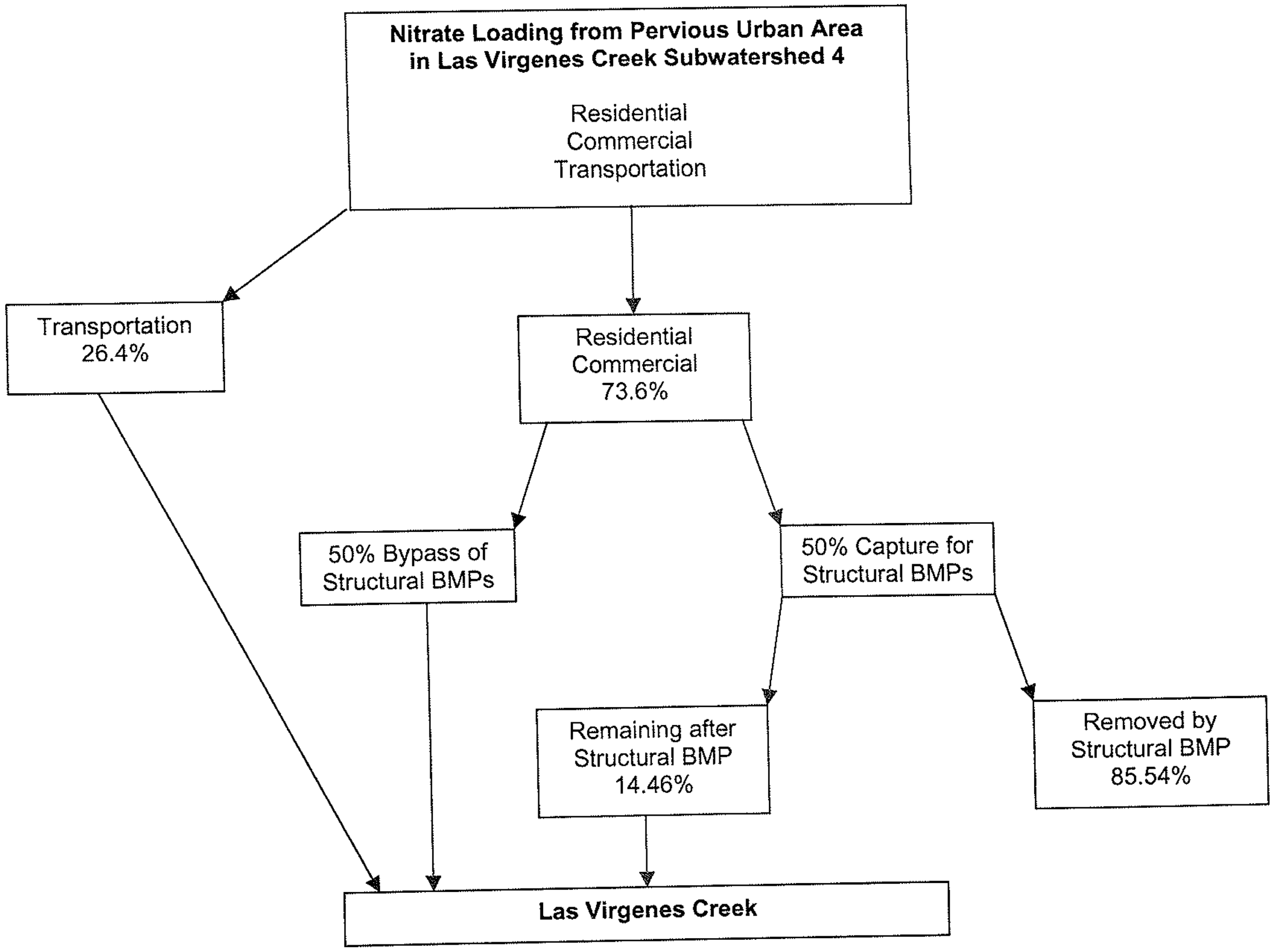


Figure 4.4 Example Flow Chart for Watershed Management Alternative 1A - Structural BMPs

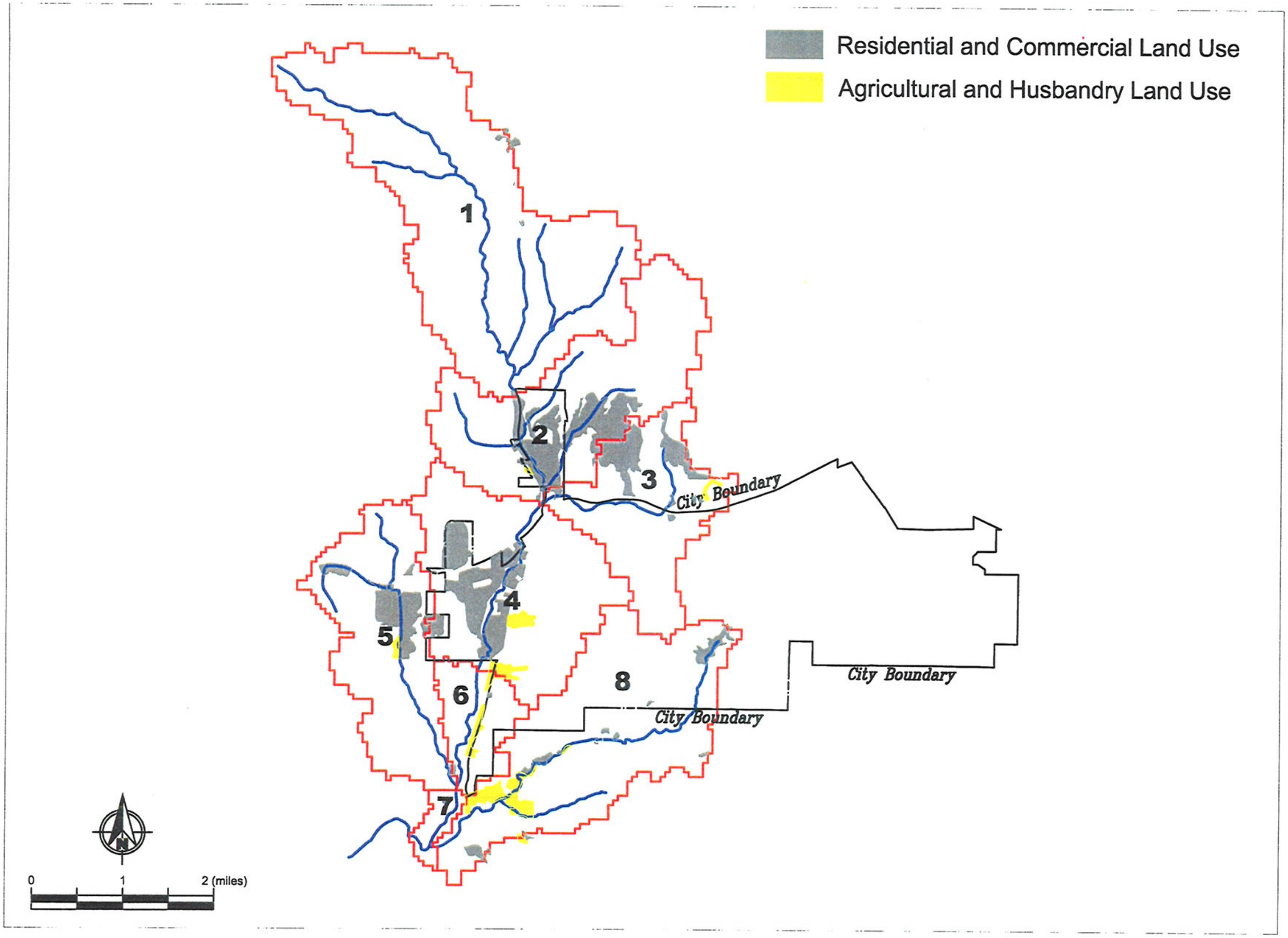


Figure 4.5 Watershed Management Alternative 1 - Structural BMPs for Las Virgenes Creek

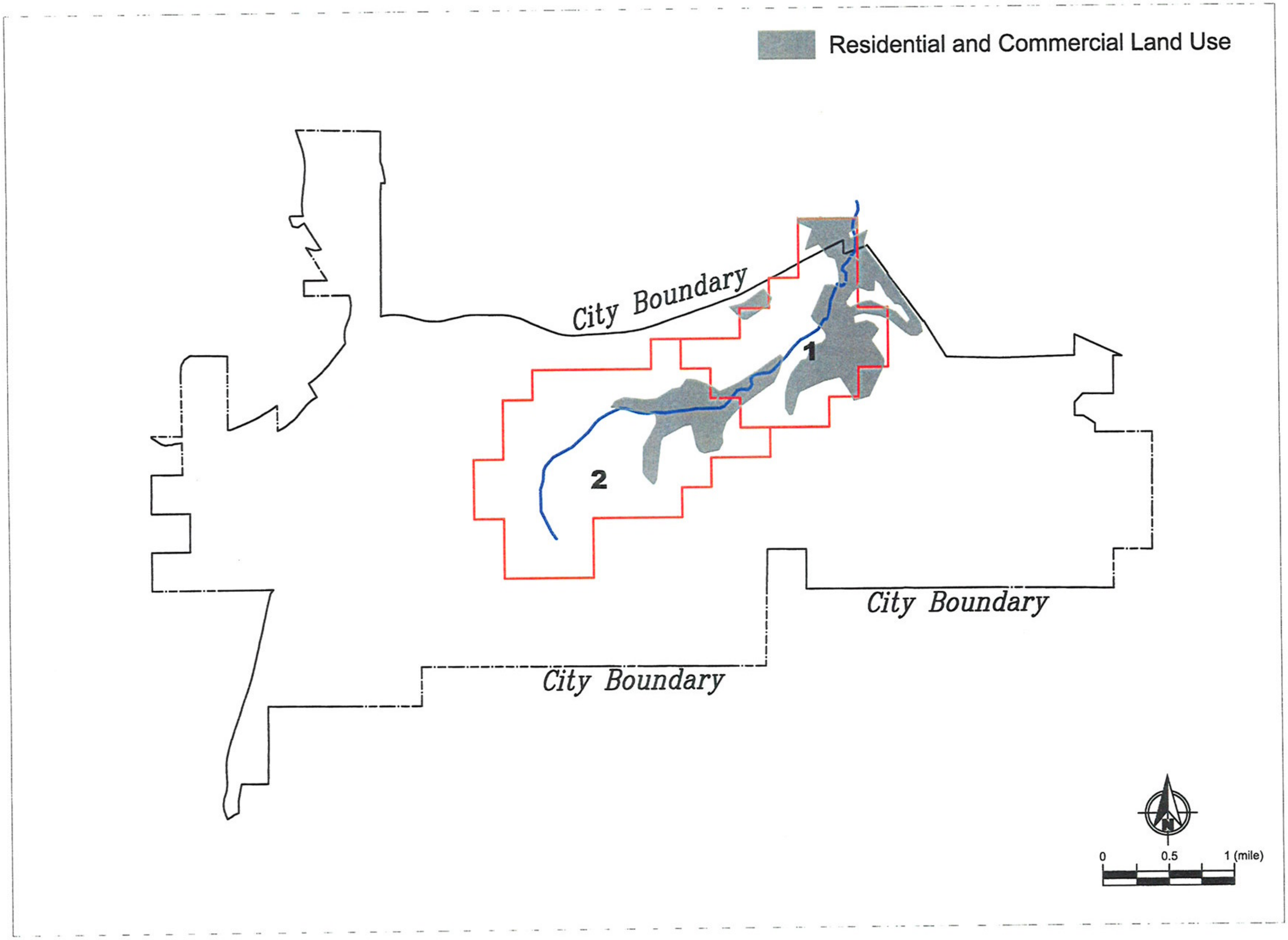


Figure 4.6 Watershed Management Alternative 1 - Structural BMPs for McCoy Creek

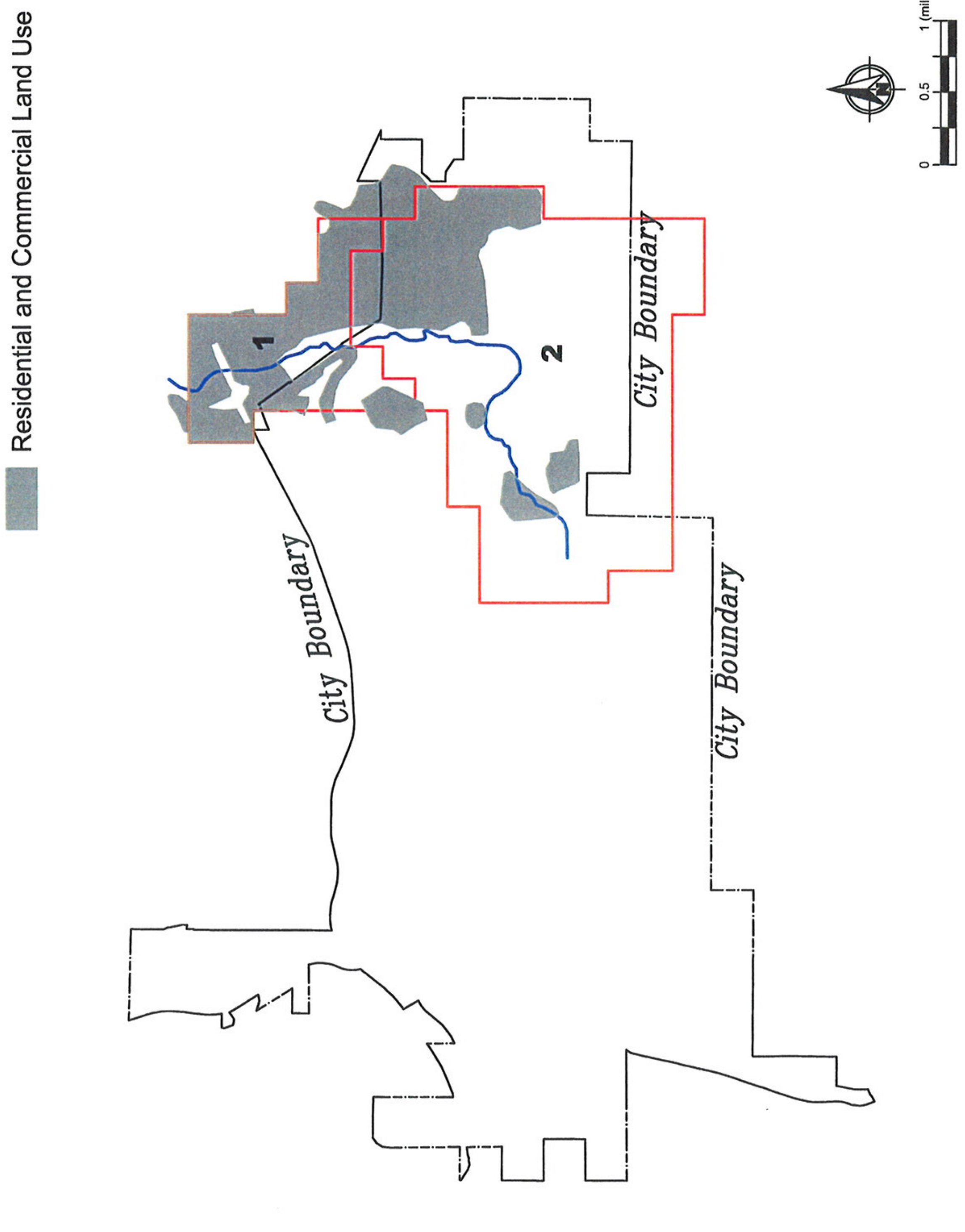


Figure 4.7 Watershed Management Alternative 1 - Structural BMPs for Dry Canyon Creek

watershed at the time the modeling analysis was conducted. The remaining sources of nutrients that were analyzed for control as part of the study were reclaimed irrigation water use, golf course fertilization, and livestock.

A reduction factor (percent) in nutrient loading was applied for each of the controllable sources within each watershed. Figure 4.8 illustrates the nutrient source reductions that were applied to different subwatersheds of the Las Virgenes Creek watershed. For McCoy Creek watershed, the reclaimed water irrigation and golf course fertilizer source reductions were applied as shown in Figure 4.9. Figure 4.10 shows the only source reduction being considered for Dry Canyon Creek is reclaimed water irrigation.

Similar to Alternative 1, two scenarios were developed for the Watershed Management Alternative 2. Alternative 2A was based on the assumption that the source control measures would be effective in achieving a 25% reduction in reclaimed water irrigation and livestock sources. Alternative 2B was based on the assumption that the source control measures would be effective in achieving a 50% reduction in nutrients. The nutrient load reduction factor (percent) was applied for nitrate, ammonia, and phosphate.

A summary of the watershed model alternatives is given in Table 4.4.

Table 4.4 Summary of Watershed Model Simulations

ALTERNATIVE	DESCRIPTION
Historical Land Use	No urban land uses and sources; open space only
Creek Restoration	Implementation of all creek restoration opportunities
Alternative 1A	Structural BMPs – 50% Runoff
Alternative 1B	Structural BMPs – 100% Runoff
Alternative 2A	Source Control Measures – 25% Source Reduction
Alternative 2B	Source Control Measures – 50% Source Reduction

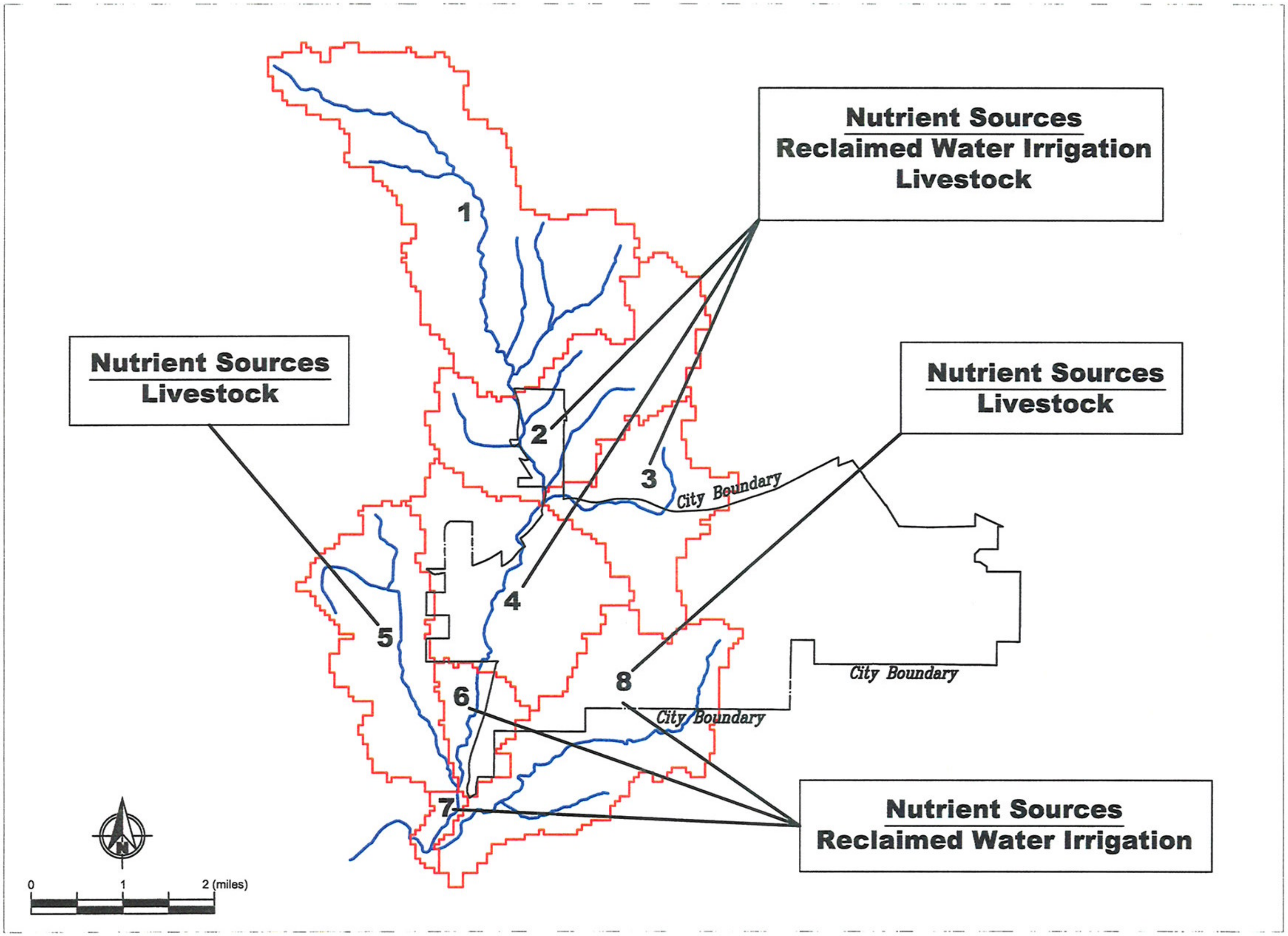


Figure 4.8 Watershed Management Alternative 2 - Source Control Measures for Las Virgenes Creek

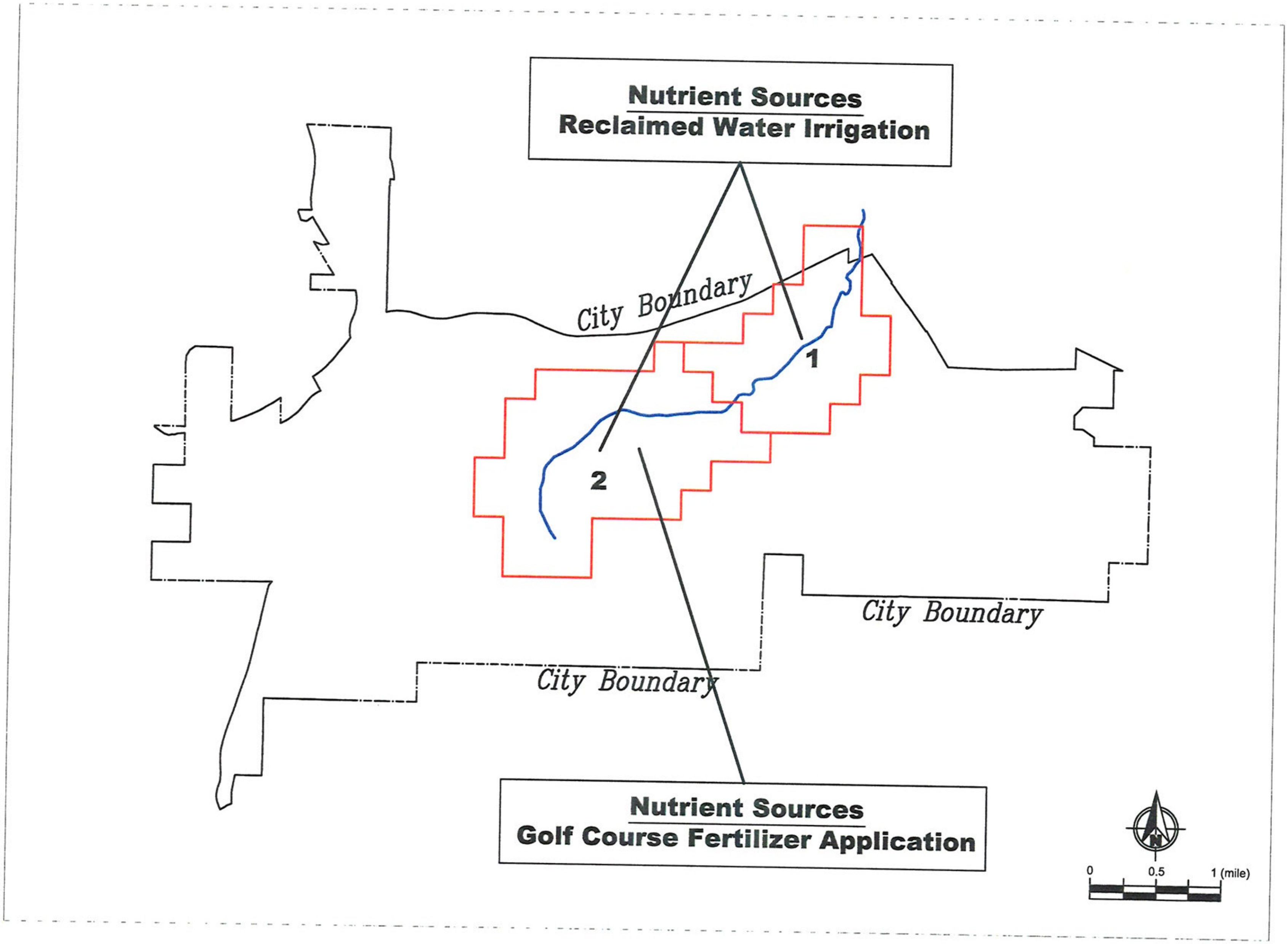


Figure 4.9 Watershed Management Alternative 2 - Source Control Measures for McCoy Creek

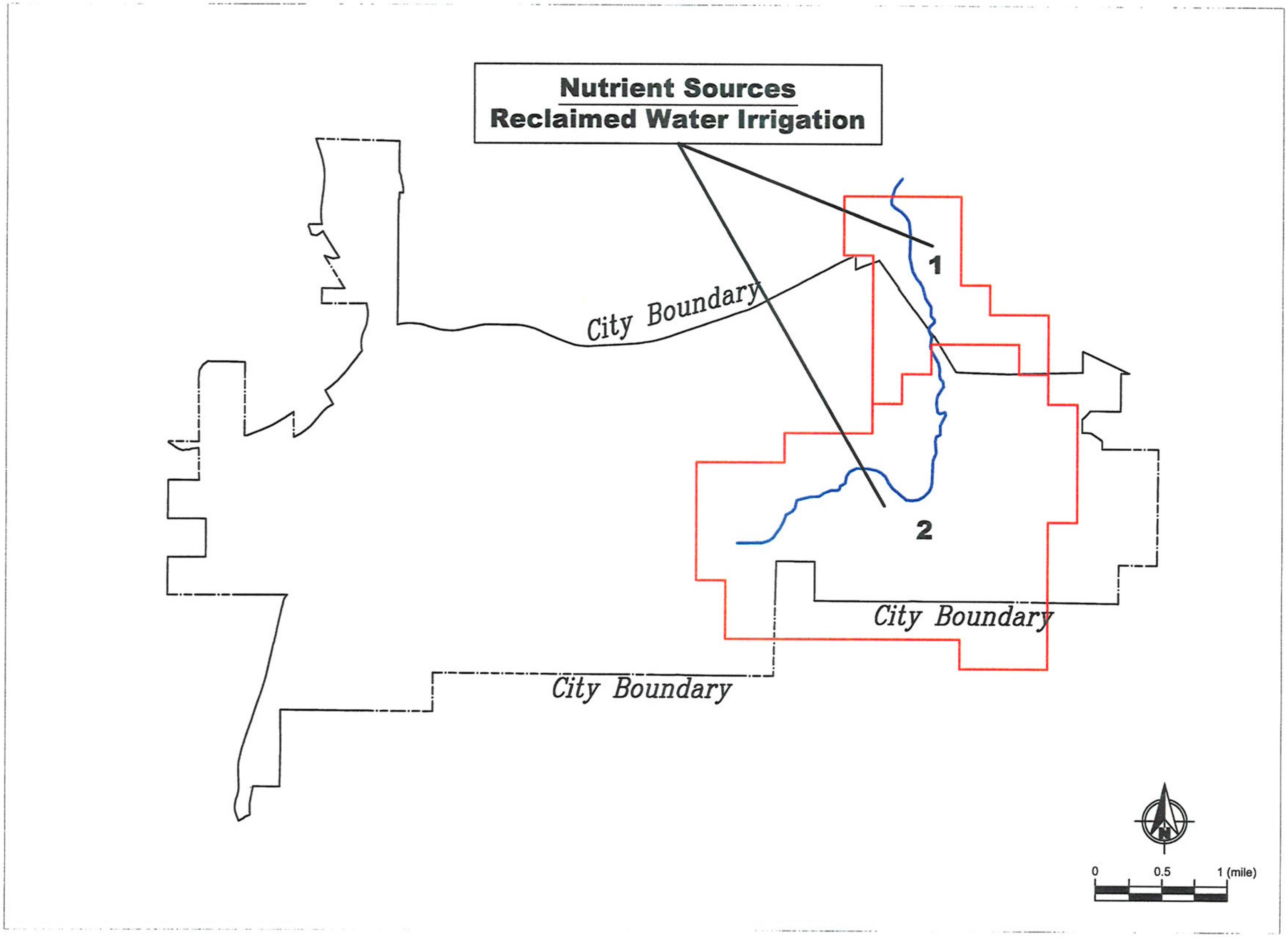


Figure 4.10 Watershed Management Alternative 2 - Source Control Measures for Dry Canyon Creek

5. WATERSHED MODELING RESULTS

As discussed previously in Section 3.2, each alternative was simulated for a 3.75-year time period (October 1996 – June 2000). HSPF produced the nutrient loadings from the watershed over the entire simulation period. The results from the first year were not used to allow adequate time for the numerical model to reach a dynamic equilibrium. Therefore, nutrients were evaluated based on the average annual load (lbs/yr) over the last 2.75 years of the model results.

The nutrient loading under existing conditions was established for each creek at the downstream City limit. Figures 5.1, 5.2, and 5.3 show the three output locations for Las Virgenes, McCoy, and Dry Canyon Creek, respectively. The output location for Las Virgenes Creek is located at the downstream end of Subwatershed 4, thus the results reflect alternative restoration measures located upstream of the output location. Results for McCoy Creek were determined from the entire watershed (downstream end of Subwatershed 1). The City limits for Dry Canyon Creek are located at the downstream end of Subwatershed 2.

The reduction in average annual loading (expressed as a percentage) at each output location presented above was determined for each alternative and then compared to the loading under existing conditions. The results are shown as a percent reduction in loading from existing conditions instead of the absolute loading (lbs/yr) or change in loading (change in lbs/yr). As discussed in Section 3.3, comparison of the actual values of simulated loadings is not meaningful because the model was not calibrated. An uncalibrated model is most appropriately used to compare alternatives against a baseline condition (e.g., existing conditions) or against one another to determine relative effect.

The results of the model simulations for each creek are presented below in Sections 5.1 to 5.3. The results of the model simulations for all three creeks are summarized in Section 5.4.

5.1 LAS VIRGENES CREEK

The nitrate, ammonia, and phosphate reductions for Las Virgenes Creek are summarized in Table 5.1. The percent reduction for each alternative reflects the changes upstream of the output location (i.e., Subwatersheds 1 – 4) as shown in Figure 5.1.

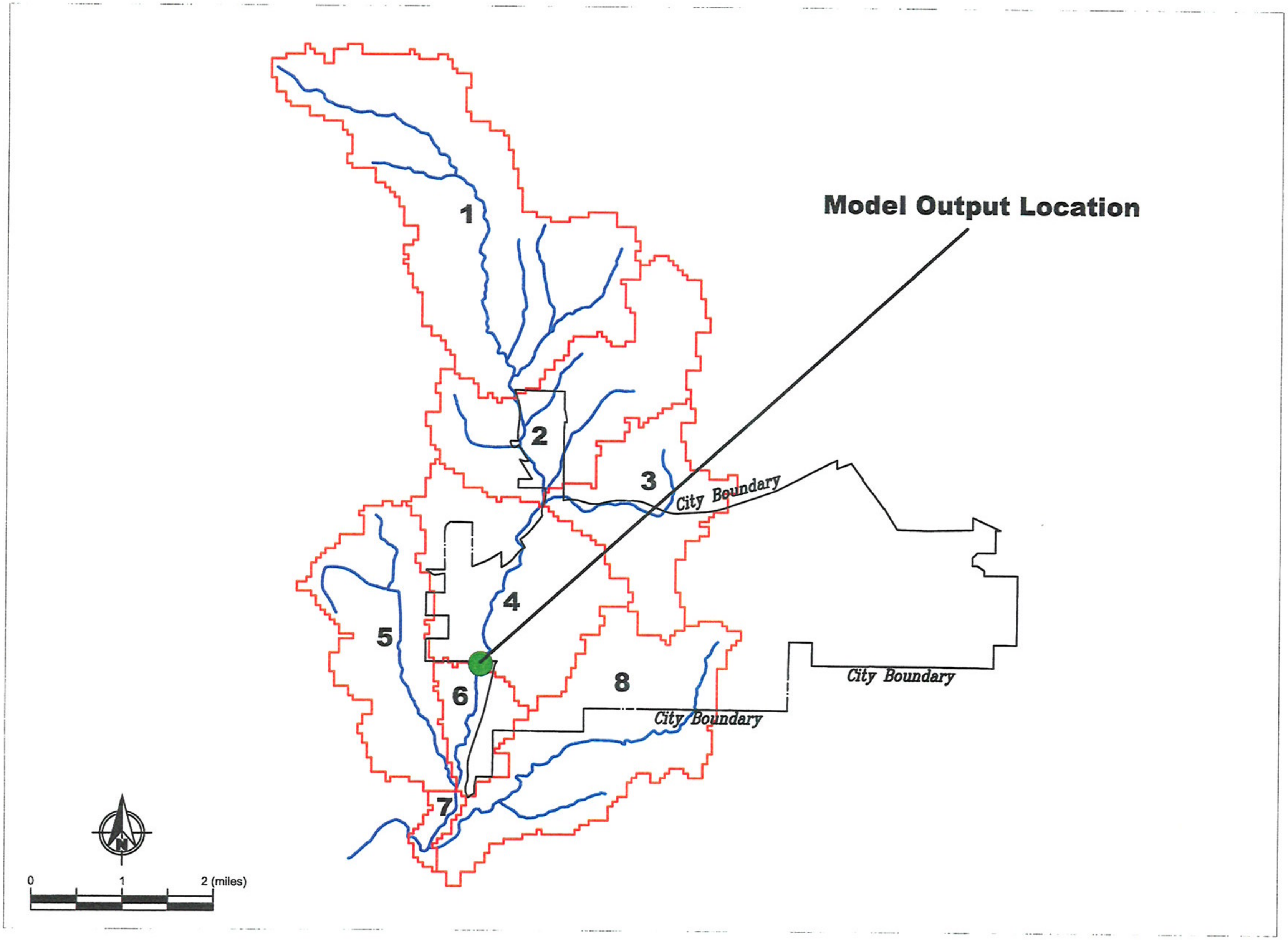


Figure 5.1 Model Output Location for Las Virgenes Creek

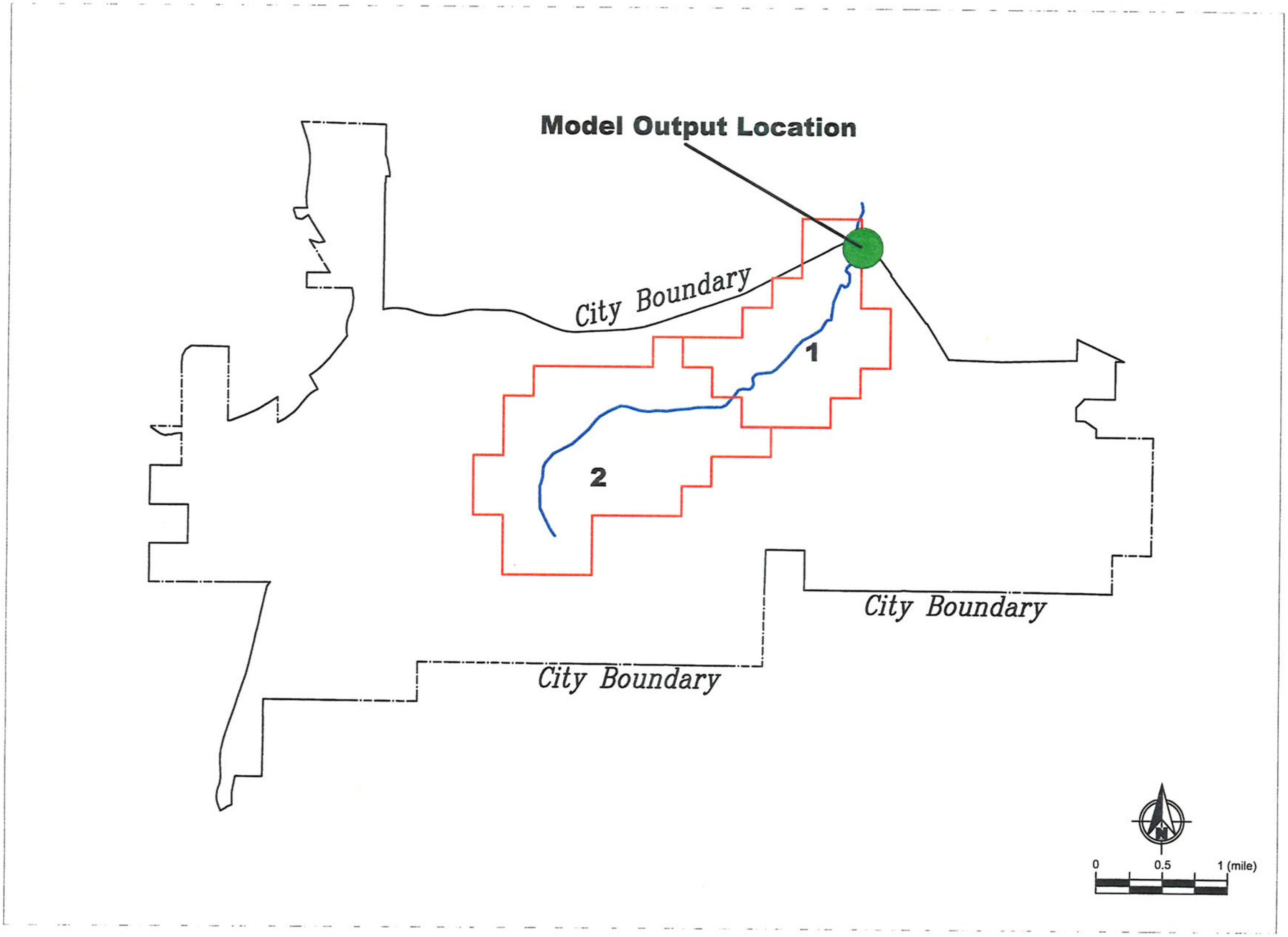


Figure 5.2 Model Output Location for McCoy Creek

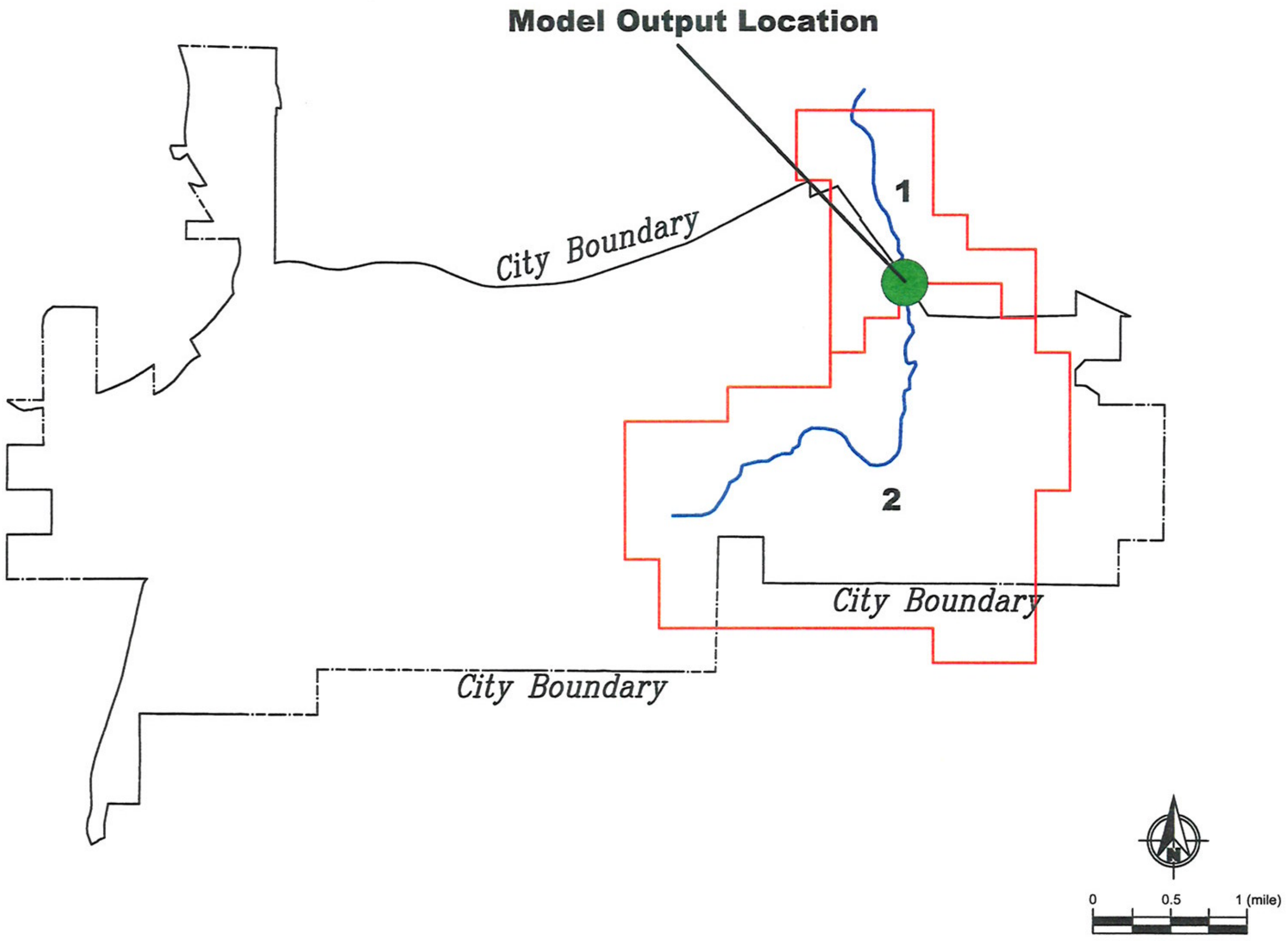


Figure 5.3 Model Output Location for Dry Canyon Creek

Table 5.1 Nutrient Loading Reductions for Las Virgenes Creek

Watershed Alternative	Percent Reduction (%)		
	Nitrate	Ammonia	Phosphate
Historical Land Use	91	86	86
Creek Restoration Alternative	0	0	0
Alternative 1A	4	19	16
Alternative 1B	7	39	32
Alternative 2A	21	5	4
Alternative 2B	41	10	7

The Historical Land Use Alternative shows a significant reduction of 86-91% for nutrients. The potential reduction indicates that the major contribution of nutrients for the watershed is from human sources and urban land uses. The results also indicate that there is a natural nutrient loading attributable to natural source (e.g., soil erosion and wildlife). Therefore, to achieve a 100% reduction in nutrients would require reductions in loading attributable to natural as well as human sources.

The Creek Restoration Alternative was found to have no detectable impact on nutrient loading. This is because the modifications to the hydrological parameters associated with implementation of this alternative do not have any measurable impacts to nutrient loadings of the watershed. Meaningful reductions in nutrient loading within the watershed require restoration measures that focus on the water quality parameters (i.e., structural BMPs and source control).

As shown in the results of Alternative 1A, implementation of structural BMPs results in a 4%, 19%, and 16% loading reduction in nitrate, ammonia, and phosphate, respectively. The corresponding reductions are 7%, 39%, and 32% for Alternative 1B. The results indicate that structural BMPs are more effective in reducing ammonia and phosphate loading than nitrate loading. However, since structural BMPs can only be used in a limited portion of the watershed (see Figure 4.5), the overall nutrient reduction for the watershed is relatively low.

The model results show that implementation of source control measures under Alternative 2A would reduce loading of nitrate, ammonia, and phosphate by 21%, 5%, and 4% respectively. Implementation of Alternative 2B would reduce nitrate loading by 41%, ammonia loading by 10%, and phosphate loading by 7%. As discussed in Section 4.6, the source control measures were only applied to nutrient sources associated with reclaimed water irrigation use and livestock. These results indicate that source control would be more effective in reducing nitrate loading compared to ammonia loading and phosphate loading. Since reclaimed water irrigation use is the dominant source of nitrate, source control measures show a greater impact on nitrate loading compared to implementation of structural BMPs. There is still a relatively substantial contribution of ammonia loading and phosphate loading due to atmospheric deposition that is not addressed under any of the alternatives investigated as part of this study.

5.2 MCCOY CREEK

Similar to Las Virgenes Creek, the results of McCoy Creek were determined at the downstream City limit (Figure 5.2). The nitrate, ammonia, and phosphate loading reductions of each alternative for McCoy Creek are shown in Table 5.2.

Table 5.2 Nutrient Loading Reductions for McCoy Creek

WATERSHED ALTERNATIVE	PERCENT REDUCTION (%)		
	NITRATE	AMMONIA	PHOSPHATE
Historical Land Use	98	96	98
Creek Restoration Alternative	0	0	0
Alternative 1A	2	13	7
Alternative 1B	4	26	14
Alternative 2A	16	3	8
Alternative 2B	33	6	15

The Historical Land Use shows a 98%, 96%, and 96% reduction in nitrate, ammonia, and phosphate loading compared to existing conditions. The potential reduction indicates a greater contribution of nutrients from human sources and urban land uses compared to Las Virgenes Creek.

As with Las Virgenes Creek, the Creek Restoration Alternative showed no detectable reductions in nutrient loading. As explained previously, the creek modifications were limited to the hydrologic parameters, thus the changes did not affect nutrient loading. Alternative 1A resulted in a 2% nitrate loading reduction, 13% ammonia loading reduction, and 7% phosphate loading reduction. Implementation of Alternative 1B would yield a reduction in nitrate, ammonia, and phosphate loading of 4%, 26%, and 14%, respectively. The reductions for both alternatives are similar to the simulated reductions for Las Virgenes Creek. Structural BMPs are more effective in reducing ammonia loading and phosphate loading compared to nitrate loading.

The model simulations revealed that implementation of Alternative 2A would result in a reduction in nitrate, ammonia, and phosphate loading of 16%, 3%, and 8%, respectively. Implementation of Alternative 2B approximately doubles the reductions attributed to Alternative 2A resulting in nitrate, ammonia, and phosphate loading reductions of 33%, 6%, and 15%, respectively. Implementation of source control measures would be more effective at reducing nitrate loading compared to ammonia loading and phosphate loading.

5.3 DRY CANYON CREEK

Figure 5.3 shows the location at the downstream end of Subwatershed 2 where the average annual load for Dry Canyon Creek was determined. Table 5.3 summarizes the nitrate, ammonia, and phosphate loading reductions for Dry Canyon Creek.

Table 5.3 Nutrient Loading Reductions for Dry Canyon Creek

WATERSHED ALTERNATIVE	PERCENT REDUCTION (%)		
	NITRATE	AMMONIA	PHOSPHATE
Historical Land Use	98	98	93
Creek Restoration Alternative	0	0	0
Alternative 1A	5	28	21
Alternative 1B	9	55	42
Alternative 2A	17	2	2
Alternative 2B	35	4	5

Similar to McCoy Creek, implementation of the Historical Land Use Alternative indicates high nutrient loading reductions with a 98% reduction in nitrate and ammonia as well as a 93% reduction in phosphate. These results reflect the fact that a significant portion of the Dry Canyon Creek watershed is urbanized and these urban uses result in substantial impacts to nutrient loading.

Similar to the results for Las Virgenes Creek and McCoy Creek, implementation of the Creek Restoration Alternative will not result in any detectable reduction in nutrient loading for Dry Canyon Creek.

The model simulations indicated that implementation of Alternative 1A would yield a 5%, 28%, and 21% loading reduction in nitrate, ammonia, and phosphate, respectively. Implementation of Watershed Management Alternative 1B would lower nitrate, ammonia, and phosphate loadings by 9%, 55%, and 42%, respectively. The results suggest that implementation of structural BMPs would yield the greatest reductions in ammonia loading, followed by phosphate loading and nitrate loading. However, since additional data made available after completion of the modeling analysis revealed the presence of septic systems in Dry Canyon Creek and septic systems are a source of nutrients, implementation of structural BMPs may not be as effective for ammonia reduction in Dry Canyon Creek if a significant number of septic systems were present in the watershed because structural BMPs do not reduce septic system contributions. This underscores the importance of identifying the number and location of septic systems within the Dry Canyon Creek watershed.

Implementation of Watershed Management Alternative 2A would result in a 7% reduction in nitrate loading and a 2% reduction in loading attributed to ammonia and phosphate. The results indicated that implementation of Alternative 2B would reduce nitrate loading by 35% while reducing ammonia loading and phosphate loading by 4% and 5%, respectively. Implementation of the source control measures were found to have the greatest impact on reducing nitrate loading with less effectiveness at reducing ammonia loading and phosphate loading. Source control measures could be more effective at reducing ammonia if septic systems were determined to be a significant contributor of ammonia.

5.4 SUMMARY OF LOADING REDUCTION BY ALTERNATIVE

The results of the watershed modeling for nutrient loading are presented in Table 5.4 for all three creeks and all simulation alternatives. For the Historical Land Use Alternative, all three creeks show significant reductions in loading ranging from 86% to 98% for all three nutrients. McCoy and Dry Canyon showed the greatest reduction in nutrient loading; hence, greater potential for restoration measures to lower nutrient levels.

As discussed previously, the Creek Restoration Alternative was not expected to reduce nutrient loadings. The simulations were based on implementation of all identified creek restoration opportunities within each creek, including bank stabilization, concrete removal, and vegetation clearing. Since the creek restoration opportunities focused primarily on hydrologic and/or habitat changes within the creek channel, neither the nutrient loadings from the watershed nor the water quality processes within the creek were substantially modified through implementation of the creek restoration measures. The model results of restoration alternatives for all three creek indicated that nutrient loading would not be meaningfully affected through implementation of these measures.

Watershed Management Alternative 1 simulated nutrient loading reductions based on the treatment of runoff using structural BMPs. Alternatives 1A and 1B provide a range of reduction based on the amount of runoff treated and the effectiveness of the various BMPs. The quantity of runoff treated with structural BMPs directly impacts the nutrient reduction such that nutrient loading is reduced in proportion to the volume of treated runoff. The percent reductions for Alternative 1B are approximately twice that of Alternative 1A, which corresponds to the treatment of twice as much runoff in Alternative 1B compared to Alternative 1A. The results for all three creeks show the greatest loading reduction in ammonia and phosphate compared to nitrate.

Table 5.4 Nutrient Loading Reductions by Alternative

ALTERNATIVE	CREEK	PERCENT REDUCTION (%)		
		NITRATE	AMMONIA	PHOSPHATE
Historical Land Use	Las Virgenes Creek	91	86	86
	McCoy Creek	98	96	98
	Dry Canyon Creek	98	98	93
Creek Restoration Alternative	Las Virgenes Creek	0	0	0
	McCoy Creek	0	0	0
	Dry Canyon Creek	0	0	0
Alternative 1A	Las Virgenes Creek	4	19	16
	McCoy Creek	2	13	7
	Dry Canyon Creek	5	28	21
Alternative 1B	Las Virgenes Creek	7	39	32
	McCoy Creek	4	26	14
	Dry Canyon Creek	9	55	42
Alternative 2A	Las Virgenes Creek	21	5	4
	McCoy Creek	16	3	8
	Dry Canyon Creek	17	2	2
Alternative 2B	Las Virgenes Creek	41	10	7
	McCoy Creek	33	6	15
	Dry Canyon Creek	35	4	5

Alternatives 2A and 2B provided a range in nutrient reductions associated with implementation of a range in nutrient source control measures. Alternative 2A was based on a 25% reduction of the nutrient loading associated with reclaimed water irrigation and livestock sources and Alternative 2B was based on a 50% reduction in nutrient loading. Doubling the source control reduction (25% to 50%) approximately doubled the nutrient loading reduction. For example, the results for Las Virgenes Creek indicated a 21% and 41% reduction in nitrate loading for Alternative 2A and Alternative 2B, respectively. The ammonia loading reduction increased from 5% to 10% with an increase in source control for Alternative 2A and Alternative 2B, respectively. The 4% phosphate loading reduction of Alternative 2A was increased to a 7% phosphate loading reduction under implementation of Alternative 2B. The results for McCoy and Dry Canyon Creek followed the same trend. The source control measures are the most effective for nitrate reduction and less effective at reducing the loading for ammonia and phosphate.

A comparison of Alternative 1 and Alternative 2 revealed that Alternative 2 reduced nitrate loading more than Alternative 1. This indicates that source control measures were more effective at reducing nitrate loading than removing ammonia and phosphate from runoff within this watershed. Structural BMPs were more effective at reducing ammonia loading and phosphate loading than source control measures.

6. CONCLUSIONS

Watershed modeling was conducted for Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek, which run through portions of the City of Calabasas. The modeling was useful in developing and assessing restoration measures for the three creeks aimed at improving water quality with a focus on nutrient reduction. Although available data were insufficient for calibrating the watershed model, the data were sufficient to develop and apply an uncalibrated model to the three creeks. The application of this model was used to gain an understanding of the dominant processes related to nutrient loading of the receiving water (i.e., creeks). The following conclusions were developed from the results of this study.

1. A review of the available, existing data revealed that the data were insufficient to perform a calibration of the model parameters. This limits the usefulness of the model because the accuracy of the model output values is unknown. The uncertainty in the model output means that the model results cannot be used to determine the effectiveness of restoration measures relative to absolute metrics such as the LARWQCB water quality standards. However, the uncalibrated model is useful for comparing the effectiveness of alternatives relative to a baseline condition (e.g., existing conditions) and against one another.

2. The results of the modeling revealed that human influences account for the majority of nutrient loading to the three creeks. The loading of nutrients (nitrate, ammonia, and phosphate) leaving the City limits under existing conditions with recent human influence was substantially higher than the loading under historical conditions without human influence. This conclusion supports the development of restoration measures as a means to improve water quality through nutrient reductions since these measures tend to focus on human influences.

3. The results suggest that it is possible to exceed the LARWQCB water quality standards (TMDL) in the absence of human influence. For example, based on the modeling simulations, the concentration of nitrates within the three creeks under historical conditions sometimes exceeded the water quality standard. Since the model was not calibrated it is not possible to draw a definitive conclusion; however, these results, coupled with the results of the sensitivity analysis (see Conclusion 4), reveal

the importance of model calibration and input data quality.

4. The results of the sensitivity analysis revealed that increases and decreases in nutrient loading would result in significant changes in the model results. A 50% change (+/-) in nitrate loading resulted in an average change of approximately 46%, 33%, and 36% in Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek, respectively. A 50% change (+/-) in ammonia loading resulted in an average change of approximately 23%, 11%, and 12% in Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek, respectively. A 50% change (+/-) in phosphate loading resulted in an average change of approximately 38%, 24%, and 38% in Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek, respectively. This level of sensitivity indicates the need to conduct calibration of the model if the results are to be used to provide absolute values of contaminant loadings.

5. Implementation of all the restoration measures identified for creek restoration will not result in meaningful reductions in nutrient loading. This is because the creek restoration alternatives will only change the hydraulics/hydrology of the creek and not the nutrient sources or processes.

6. Implementation of structural Best Management Practices (BMPs) would probably not be effective at reducing nutrient loading associated with nitrates. The results revealed that implementation of all the identified structural BMPs within Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek would only reduce nitrate loading by 4% to 9% compared to existing conditions. This is primarily because the structural BMPs can only be implemented over a relatively small portion of the watershed due to space, land use, or slope limitations; therefore, the overall reduction in nitrate loading attributed to the combined effects of these measures is relatively small.

7. The results of the modeling indicated that implementation of structural BMPs could be effective at reducing nutrient loading attributed to ammonia and phosphate. The results revealed that implementation of all the identified structural BMPs within Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek would reduce ammonia loading by 13% to 55% and phosphate loading by 7% to 42% compared to existing conditions. Structural BMPs may not be as effective for ammonia reduction in Dry Canyon Creek if septic systems were determined to be a significant contributor of ammonia, since structural BMPs do not reduce septic system contributions.

8. The results of the modeling revealed that source control could be effective at reducing nutrient loading attributed to nitrate. The results revealed that implementation of all the identified source control measures within Las Virgenes Creek, McCoy Creek, and Dry Canyon Creek would reduce nitrate loading by 17% to 41% compared to existing conditions. Source control measures could increase the ammonia reduction in Dry Canyon Creek if septic systems were determined to be a significant contributor of ammonia.

9. The results of this study indicate that substantial reductions in nutrient loading defined as reductions in nitrate, ammonia, and phosphate loading will require implementation of a comprehensive approach involving strategic implementation of structural BMPs and source control measures throughout the watersheds of the three creeks.

7. RECOMMENDATIONS

The following recommendations are provided to improve the water quality of the three creeks related to nutrient loading.

1. Pursue implementation of structural BMPs throughout the watersheds of the three creeks to reduce nutrient loadings attributed to ammonia and phosphate.
2. Pursue source control measures related to recycled water use within the watershed to reduce nutrient loadings attributed to nitrate to the three creeks. The following actions should be considered for implementation.
    a. Reduce nutrient levels in reclaimed water.
    b. Conduct a public outreach program to reduce fertilizer use.
    c. Reduce the use of reclaimed water to lower associated runoff; however, this action is probably not feasible since it would probably result in an increase in the use of imported water.
    d. Pursue implementation of irrigation control measures to reduce the volume of runoff from areas irrigated with reclaimed water (e.g., computerized irrigation control devices with moisture sensors).
    e. Conduct research to determine the uptake rate of nutrients associated with different types of grasses for the purpose of developing an integrated program of reclaimed water use for various turf types.
3. Pursue source control measures related to equestrian management and operational practices within the watershed to reduce nutrient loadings to the three creeks.
4. Conduct a survey of septic systems within the watersheds to determine the quantity, location, and condition of septic systems located within the study area to verify the assumptions used in the modeling study presented in this report and/or to update the modeling based on any significant changes in the assumptions.
5. Conduct a monitoring program to provide the data needed to calibrate the HSPF model for the site-specific conditions within the watersheds of the three creeks.

6. Calibrate and verify the HSPF model using data collected from Recommendation 5.
7. Perform updated modeling of the restoration alternatives with the calibrated and verified HSPF model developed under Recommendation 6.
8. Conduct modeling of other constituents of concern (e.g., bacteria) to develop restoration measures for those constituents.
9. Develop a field and/or literature program to verify the applicability of the regional contaminant loading rates to the two watersheds. If the regional rates are found to be not applicable, then develop watershed-specific contaminant loading rates.
10. Overlay results, develop integrated alternatives, and simulate the alternatives to determine the effectiveness at improving overall water quality to eliminate single-objective alternatives focused only on one or two constituents (e.g., trash or bacteria). This effort should include a cost-effectiveness analysis to optimize multiple objective alternatives.

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