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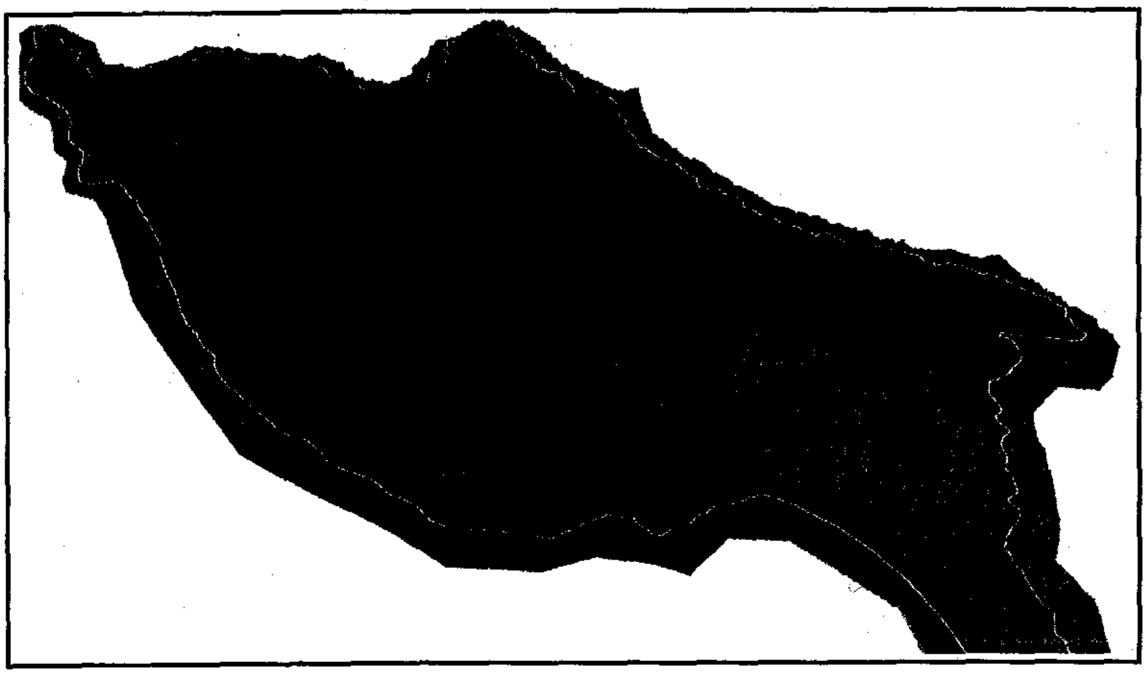
U.S. Environmental Protection Agency

NUTRIENT CRITERIA DEVELOPMENT



U.S. EPA Region IX Demonstration Project: Ecoregion II Rivers and Streams

Tetra Tech, Inc.

March 2000

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Prepared For:

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1.0 INTRODUCTION AND OVERVIEW

The EPA National Nutrient Criteria Program has prepared guidance documents for the development of waterbody-specific nutrient criteria. One of the goals of this project was to demonstrate the use of the EPA criteria guidance to derive nutrient criteria (Total N, Total P, chlorophyll-a, and turbidity) ranges for selected waterbodies within EPA Region IX. Another goal of this work assignment was to identify issues and solutions to those issues associated with the application of the nutrient criteria development procedures. The lessons learned that are described in this report could facilitate the development of nutrient criteria in other regions. If the Regional Technical Advisory Group approves the data and procedures used in this project the recommended ranges for nutrient criteria could be proposed for the ecoregional documents.

EPA Region IX includes three of the fourteen draft aggregations of Level III ecoregions for nutrient criteria (Figure 1-1). The project team consulted with the Work Assignment Manager and EPA Region IX to select rivers and streams in nutrient Ecoregion II – Western Forested Mountains for this demonstration project. The decision to select Ecoregion II rivers and streams was based on several factors including:

- The *Nutrient Criteria Technical Guidance Manual: Rivers and Streams (DRAFT 1999)* was available to provide guidance to the Tetra Tech project team;
- A review of the data collected in EPA Region IX as part of Work Assignment 1-51 indicated that there was an abundance of monitoring station reports available throughout Ecoregion II;
- The geographic area within Ecoregion II was believed to include many waterbodies that could be considered minimally impacted; and
- Ecoregions I and III present special challenges that would not be able to be addressed within the scope and schedule for this work assignment.

The project strategy used by the Tetra Tech project team is illustrated in Figure 1-2. The strategy requires the development and analysis of two primary datasets:

1. Regional STORET Dataset: EPA Headquarters provided this database. The dataset includes stations reported to STORET that have been quality assured for location and analytical techniques. There is no attempt to distinguish between impacted and unimpacted waterbodies. Frequency distributions developed from this dataset are assumed to be representative of the range of conditions of waterbodies within EPA Region IX. Tetra Tech extracted the data for rivers and streams within Ecoregion II from this dataset.

2. Reference Condition Dataset: Tetra Tech collected information on all waterbody types from a wide range of agencies and institutions throughout EPA Region IX. The water quality monitoring information included in the Reference Condition Dataset has not been reported to STORET. The waterbodies included in this dataset were screened to ensure that they are minimally impacted by anthropogenic sources of nutrients. The information for streams and rivers was extracted from this dataset. The frequency distributions

developed from this dataset are assumed to represent background or reference conditions for streams and rivers within Ecoregion II.

This report includes detailed descriptions of the procedures used to collect information, select waterbodies, review QA/QC, characterize the stations, analyze the water quality data (e.g., sub-classification distributions – flow, geologic type, gradient, land use) as well as a comparison of the Regional STORET and Reference Condition datasets. Section 2 describes the data collection process, the overall database, and the Ecoregion II databases for rivers and streams. Section 3 presents an analysis of the EPA Region IX database, which includes both the EPA STORET and Ecoregion II reference datasets. The final section of this report provides information on lessons learned and recommends next steps for nutrient criteria development that could be useful for other waterbody classifications in Region IX and other EPA Regions.

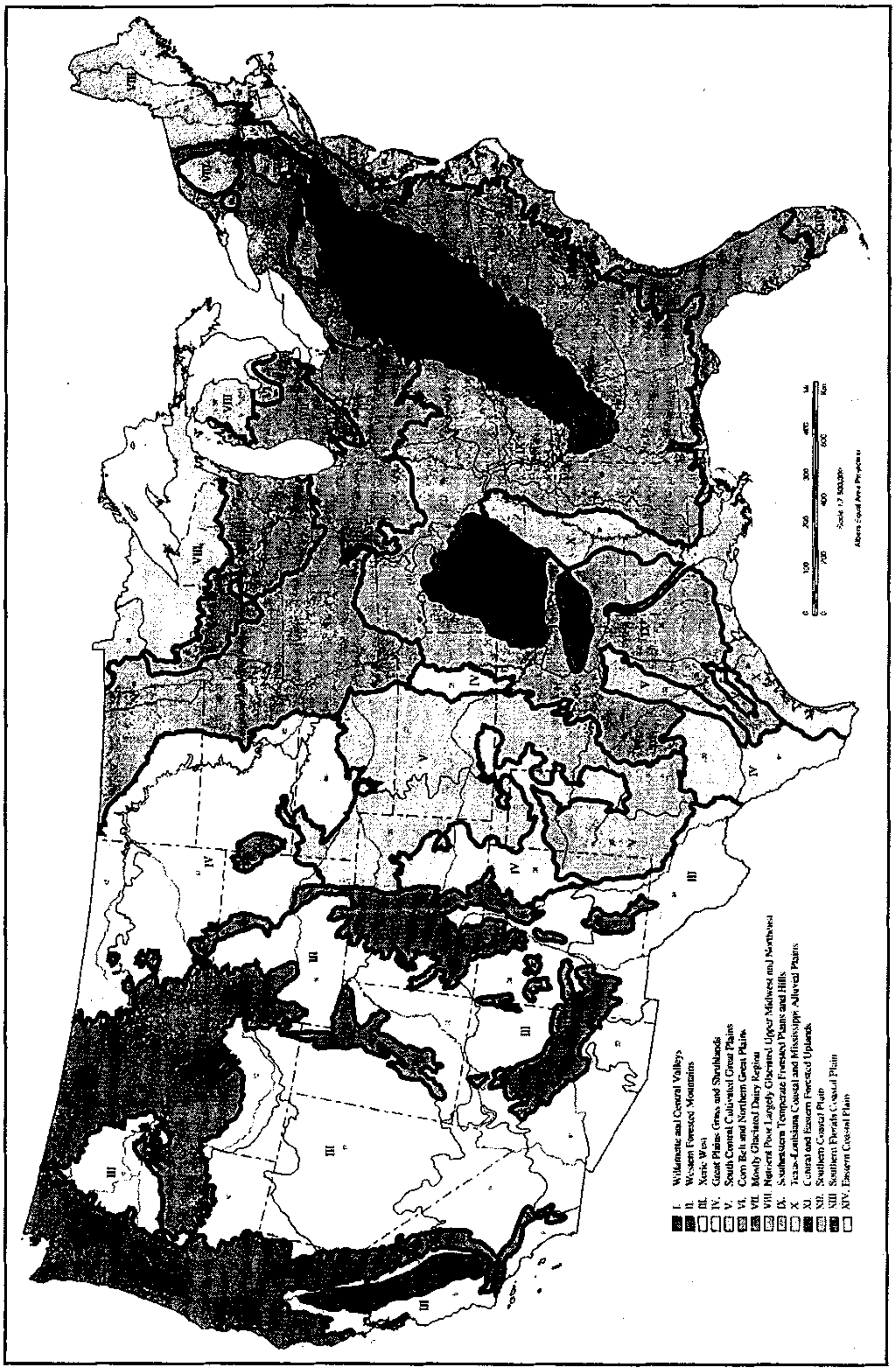

Figure 1-1. Draft Aggregations of Level III Ecoregions for the National Nutrient Strategy.

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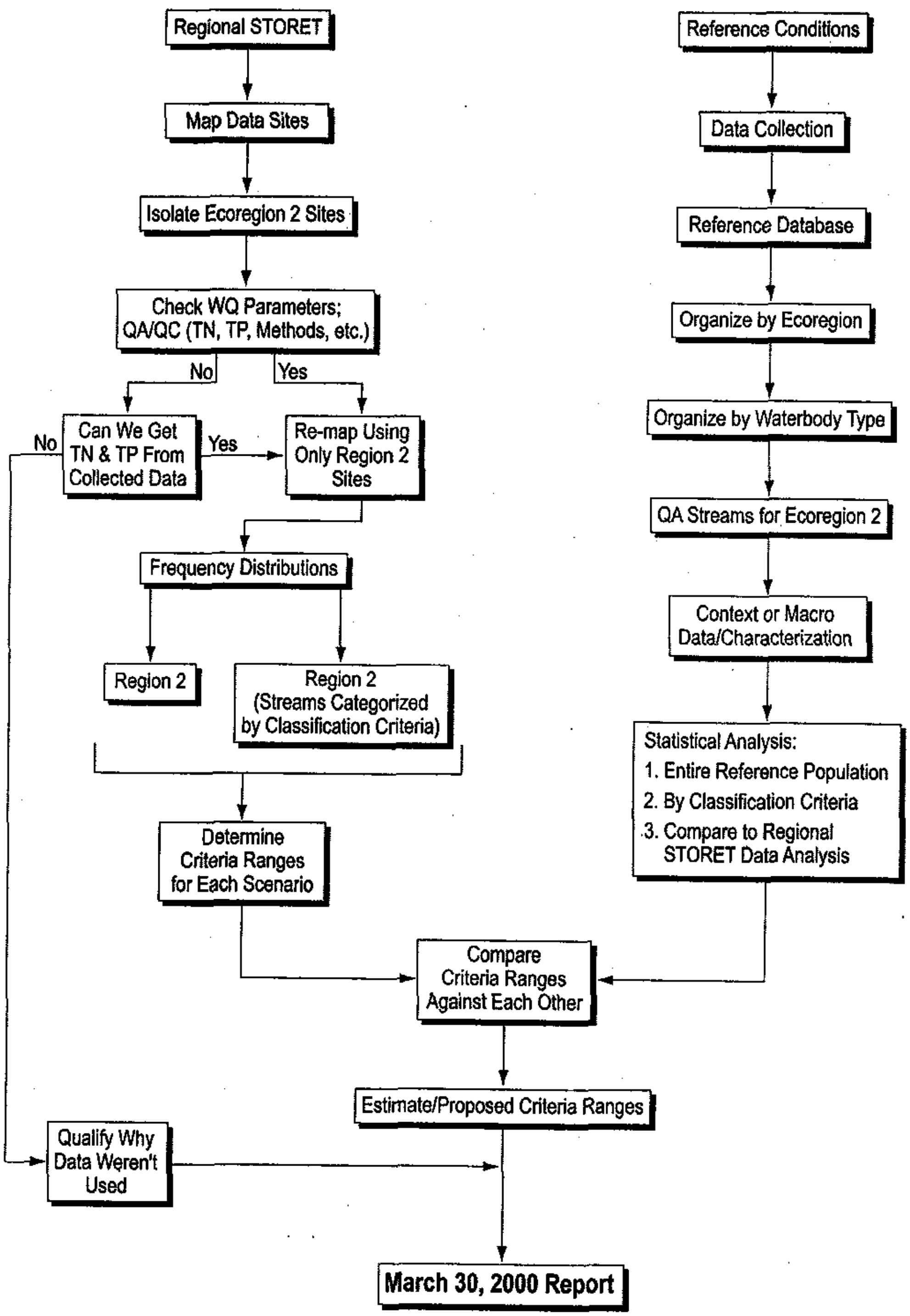

Figure 1-2. EPA Region 9 Pilot Study Process for ecoregion-based nutrient criteria development.

2.0 DESCRIPTION OF DATABASE

2.1 Data Collection Process

The process of collecting nutrient related water quality data involved personal interviews, phone interviews, on-line database searches and site visits. Phone interviews were the most common method of discovering and acquiring data. Contact information for prospective data sources was acquired through contacts made at conferences, recommendations from personnel at Tetra Tech, web searches, and referrals from contacts made during the data collection process. The following statements and questions were used during the phone and personal interviews:

- Introduction and brief description of the EPA National Nutrient Criteria development effort, including a description of the ecoregions. Explain that the development of nutrient criteria will likely be based on the model of a comparison to 'reference' conditions for each waterbody type in each ecoregion.
- Do you have nutrient water quality data for surface waters from the 1990 to present including all forms (species) of nitrogen and phosphorous, that are **not currently in the EPA STORET database and representative of reference conditions?**
- Is the data available in an electronic format?
- If nutrient concentration data were available, the following questions/requests were posed.
- Please include the location of every sampling station using latitude and longitude if possible or a map and description of locations.
- Please include a description of the waterbody and watershed that contributes to the sample stations water quality. We are trying to categorize whether each sample comes from a 'reference' waterbody, (*i.e.*, one that has no known anthropogenic or natural sources of elevated nutrient contributions). The emphasis is on collecting water quality data from 'reference' waterbodies. However, if you have high quality data from a non-reference waterbody please describe and/or include a description of the nutrient sources, which make the waterbody non-reference quality.
- Do you have supporting water quality data which will help us to interpret the nutrient concentration data such as: QA/QC, flow (if a river or stream), secchi depth, turbidity, TSS, DO, pH, chlorophyll-a, or biological sampling data (*e.g.*, macroinvertebrates).
- Please include a description of the sample collection and processing methodology as well as description of the QA/QC procedures that were used.

Contact Table

A contact list was generated that contained the names of potential data sources. This list contained 135 names from 103 separate source agencies. Each contact was placed into one of the following categories: sent data, will send data, provided contact information, not contacted, call back later or, no data. The definitions for each category are as follows:

Sent data – The contact sent data either in electronic or hardcopy format and Tetra Tech received the data.

Will send data – The contact has indicated that they have data and it will be sent.

Provided contact info. – The contact did not have the requested data but provided the name and contact information for someone who might have the type of data requested.

Not contacted – The majority of the names in this category were not contacted after it became apparent from other sources that the person did not have the requested data or that someone else within their organization had already sent the data that had been requested.

Call back later – The person was not available, did not respond to voice mail or email, was on vacation, or requested that we call back later when they had more time available.

No data – The person did not have data or contact information and was not likely to be helpful on this project.

A summary of the responses is provided in Table 2-1. These responses could be broken down into two distinct categories (positive and negative). The positive responses (*i.e.*, call back later, provided contact information, sent data, and will send data) totaled approximately 67%, while the negative responses (*i.e.*, no data and not contacted) approximated 33% of the total.

The actual list of contacts, the agency that they represent, and their response is provided in Appendix A to this report.

Table 2-1
Summary of Nutrient Data Contact Responses

Response	Quantity	Positive/Negative
Sent Data	31	Positive
Will Send Data	2	Positive
Provided Contact Information	31	Positive
Not Contacted	24	Negative
Call Back Later	27	Positive
No Data	20	Negative

Issues

A number of issues were encountered during the data collection phase, which affected the speed at which data could be acquired or the quality of the data itself:

- Water quality data were not sorted and stored in a central location or database that could facilitate easy retrieval;
- No one at the source agency knew where to look for the data;

- Data was not in an electronic format, (*i.e.* it was contained in hardcopy data sheets, micro-fiche/film, or reports only);
- Contacts did not return calls or e-mails in either a timely manner or at all;
- Contacts were busy conducting their normal duties and did not make processing our data requests a high priority (*e.g.*, did not have a strong incentive to help EPA draft new regulation since many people were already swamped with TMDL related work);
- Nutrient water quality samples were not regularly collected, may have been occasional grab samples to answer a specific question, or not part of a regular monitoring program;
- Very few sampling stations had either latitude/longitude coordinates;
- Some sampling stations had inadequate descriptions of site location and, if we couldn't locate a site, the data were deemed unusable;
- Supporting data for nutrient water quality samples were not collected (*e.g.*, no flow, DO, pH, or turbidity measurements were collected with the nutrient data;
- Contacts did not agree with the approach that the EPA was proposing to develop nutrient criteria (*e.g.*, many contacts felt that their particular waterbody or region was unique and would not be adequately addressed at the ecoregion scale);
- Nutrient water quality data tended to be collected in waterbodies that had a perceived nutrient related water quality problem, not much data was available for 'reference' waterbodies;
- Personnel at the contacted organization were not available to locate and send water quality data, which necessitated a visit to the site by Tetra Tech staff;
- Although supporting water quality data, sampling station locations, and laboratory methods were explicitly requested, contacts often just sent the most recent annual water quality report for their region, which usually did not contain much of the requested information;
- Upon receipt of data sets without supporting information, it was necessary to re-contact people and explicitly request the additional information; and
- It was not unusual for the source agency to not provide any QA/QC results, either because they didn't have them, they were not performed, or they couldn't locate them.

2.2 Data Screening

The data that were received from the various source agencies were screened for consistency prior to being included in the EPA Region IX Nutrient Database. This screening process selected data that met the following criteria:

- Data must have latitude/longitude coordinates or a description of the sample site that allowed us to locate it on a regional map;
- Data must have either a numerical value or a non-detect value for requested parameters. Data where concentrations or values (except flow) were listed as 0.0 were excluded; and

- Data must have been generated using EPA approved methodologies. Those data that were generated using other methods were not used unless it could be determined that the methods were compatible with those approved by the EPA.

Initially, each of the datasets was to be screened for appropriate QA/QC, with the data that failed to meet standard QA/QC protocols being excluded. This step was eliminated because the paucity of QA/QC data that were available would have severely reduced the size of the database.

2.3 EPA Region IX Nutrient Database

The EPA Region IX nutrient database is composed of two separate datasets for each of the three ecoregions of EPA Region IX (U.S. EPA STORET and the Reference) and includes nutrient water quality data for each of the water body types being assessed by the National Nutrient Criteria Program. These water body types include rivers and streams; lakes and reservoirs; wetlands; and coastal/estuary/marine within the states of California, Arizona, and Nevada.

To date, the nutrient water quality database contains more than 86,000 discreet water quality values collected from more than 1,500 stations within Ecoregions I, II, and III (Table 2-2), with the majority of values and stations occurring within the rivers and streams waterbody classification. The wetlands category contains the least amount of data values and stations, with three samples collected from two stations.

Table 2-2
Summary of Nutrient Water Quality Database

Ecoregion	Lakes/Reservoirs		Rivers/Streams		Coastal/Estuary/Marine		Wetland	
	# Stations	# Samples	# Stations	# Samples	# Stations	# Samples	# Stations	# Samples
				EPA STORET Dataset				
1	0	0	62	8,843	0	0	0	0
2	5	388	246	16,219	0	0	0	0
3	64	1,297	601	39,970	17	2,187	0	0
				Reference Dataset				
1	0	0	67	2,563	0	0	0	0
2	40	2,914	121	3,097	0	0	0	0
3	43	5,940	295	3,492	25	299	2	3
Total	**152**	**10,539**	**1,392**	**74,184**	**42**	**2,216**	**2**	**3**

2.4 Database for Ecoregion II

The primary focus of this pilot study is to determine reference conditions for waterbodies within Ecoregion II, specifically looking at rivers and streams. A query of the Ecoregion II river and stream data (Table 2-2) indicates that the EPA STORET dataset contains over 16,000 discreet water quality nutrient values collected from more than 240 stations within the states of California, Arizona, and Nevada. Figure 2-1 presents a graphical display of the STORET monitoring locations within Ecoregion II.

The reference dataset (Table 2-2) contains more than 3,000 discreet water quality nutrient values that have been collected from over 120 stations within the states of California and Arizona. The monitoring stations included in the reference dataset for Ecoregion II have been presented graphically (Figure 2-2). Figure 2-2 shows that the coverage of Ecoregion II occurs in three main clusters (Northern California, Lake Tahoe Basin, and mountainous areas of Arizona), with smaller levels of representation occurring in the Central and Southern Sierras and in the Santa Cruz Mountains. None of the reference data collected from the state of Nevada were within Ecoregion II.

2.5 Characterization of Ecoregion II Streams and Rivers Databases: Classification Criteria

The technical guidance manual recommends a stream system classification approach that is based on natural physical factors. Several factors were identified due to their influence on background nutrient loading and on stream ecological processes. The classification factors are believed to affect periphyton and plankton biomass levels in stream systems. The guidance document identifies several classification criteria to evaluate the effects of hydrology and channel morphology, flow, and parent geology on algal growth within stream systems. The streams and rivers classification recommended in the guidance document include:

- Fluvial geomorphology
- Rosgen stream classification
- Stream order
- Hydrology and morphology
- Flow conditions
- Underlying geology

It will not be possible to evaluate all of the classification factors listed above because few of the monitoring stations included information on these factors. With this in mind, the project team performed an extensive review of the available literature and modeling techniques to ascertain what classification factors could be used to characterize the EPA Region IX reference dataset. The reference dataset lent itself to six levels of classification:

- Land-use;
- Flow;
- Stream/river size;

- Stream gradient;
- Stream order; and
- Underlying geology.

Each of these classification factors was further sub-divided into categories, which provided additional levels of 'fine-tuning' the dataset. The sources, methods, classifications, and categories are provided in the following section.

2.5.1 Characterization Sources, Methods, and Sub-Classifications

Flow – Stream flow data was downloaded from the United States NWIS-W data retrieval website: (http://waterdata.usgs.gov/nwis-w/US/). Flow data were available for 19 streams in the dataset, 14 of which had nutrient water quality data collected during the same time period (January 1978 – September 1998). Stream flow was characterized using the categories presented in Smith, *et al.* (1997). The authors classify streams into three different flow regimes (low, mid, and high):

- Low flow: <28.3 m^3/sec, or 1,000 cfs;
- Mid-sized flow: 28.3 – 283 m^3/sec; and
- High flow: >283 m^3/sec, or 10,000 cfs.

Stream/River Size - Stream and river size classifications were based on those used by the Ohio EPA (1999), which use watershed drainage area to differentiate the different size classes into headwater streams; wadeable streams; small rivers; and large rivers:

- Headwater streams: 0 – 20 square miles;
- Wadeable streams: 20 – 200 square miles;
- Small rivers: 200 – 1,000 square miles; and
- Large rivers: > 1,000 square miles.

Stream Gradient - Stream gradient was determined using a 1:250,000 scale Digital Elevation Model (DEM). Slope as a percent of grade was calculated from the DEM. The gradient value for each station was calculated from the average slope values along a set of evenly distributed points running approximately 2 miles upstream. Slope characteristic classifications were those used by Rosgen (1994) and include such categories as very steep; steep; riffle dominated; and gentle gradient:

- Very steep: >10%;
- Steep: 4 – 10%;
- Riffle dominated: 2 – 4%;
- Gentle gradient: <2%

Very steep slopes were characterized as having frequently spaced vertical drops and pools as bed features, with high debris transport. Steep slopes were characterized as having steep, cascading steps and pools as bed features. Riffle dominated streams and rivers had characteristic rapids and infrequently spaced scour pools at bends or areas of constriction. Those streams and rivers

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classified as having a gently slope had characteristically gently slopes with riffles and pools as bed features.

Stream Order - Stream order information was obtained from ARC/INFO (ESRI 1994) grid commands and uses the method proposed by Strahler in 1952. Using this method, stream order only increases when streams of the same order intersect. Thus, the intersection of a first order and second order stream will remain a second order stream rather than create a third order stream (ESRI 1994). All streams having no tributaries were assigned an order of 1, and are referred to as first order. When two first order streams intersect, the downslope stream is assigned an order of 3, and so on. Only when two streams of the same order intersect will the order increase.

Land Use Area – Calculations for land use area were provided by BASINS 2 land cover data. Detailed land use distributions were derived using the "Land use distribution report" wizard in BASINS 2.

Underlying Geology – Underlying geological data was acquired from a website offering online GIS coverages of US geology. The USGS department of mineral resources produced the original coverage. (http://minerals.usgs.gov/kb/kb.html).

2.5.2 Characterization Descriptions

Each stream or river in the reference dataset was characterized according to the classification factors and associated categories (Table 2-3). All of the stream and river characterization categories are represented in the reference dataset, except for high flow, large, first order streams or rivers. The majority of the dataset is composed of wadeable, very steep, third and fourth order streams having flows less than 1,000 cfs (Table 2-3). Almost 98% of the land usage surrounding the reference stream and river dataset is composed of forest (79%), rangeland (17.5%) and reservoirs (1.2%). All of the other land use categories were less than 1% each. It should be noted, that a substantial number of streams and rivers in the dataset could not be characterized according to flow, with 50% of the dataset being classified as 'unknown'.

Table 2-3
Stream Characterization Summary

Classification	Percentage of Dataset	Number of Streams
Median Flow		
Low (<1,000 cfs)	45	10
Mid (1,000 – 10,000 cfs)	5	1
High (>10,000 cfs)	0	0
Unknown	50	11
Stream/River Size		
Headwater (<20 sq. miles)	14	3
Wadeable (20 – 200 sq. miles)	59	13
Small River (200 – 1,000 sq. miles)	27	6
Large River (>1,000 sq. miles)	0	0
Stream Gradient		
Very Steep (>10%)	36	8
Steep (4 – 10%)	23	5
Riffle Dominated (2 – 4%)	18	4
Gentle Gradient (<2%)	23	5
Stream Order		
1	0	0
2	14	3
3	36	8
4	36	8
5	14	3
Land Use		
Urban	0.85	18 of 22
Agricultural	0.4	12 of 22
Forest	79.1	22
Rangeland	17.5	20 of 22
Water (Reservoirs)	1.2	11 of 22
Barren Land	0.8	16 of 22
Tundra	0.007	2 of 22
Wetland	0.09	5 of 22
Perennial snow or Ice	0.1	1 of 22

Frequency distributions were developed for each of the stream sub-sets and compared to those derived from both the U.S. EPA STORET and the entire EPA Region IX Reference datasets. Section 3 provides a discussion of these comparisons.

A characterization packet for each of the watersheds is provided in Appendix B to this report.

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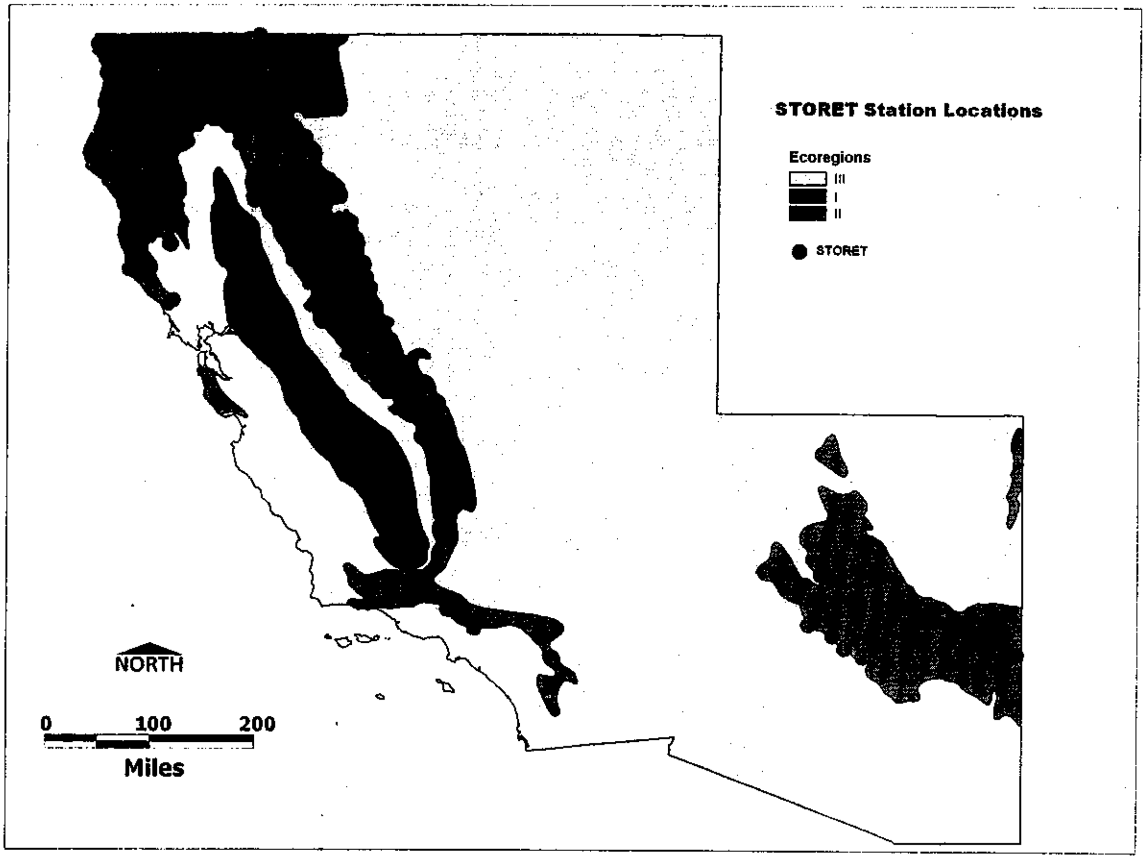

Figure 2-1. Ecoregion II Coverage by EPA STORET Data

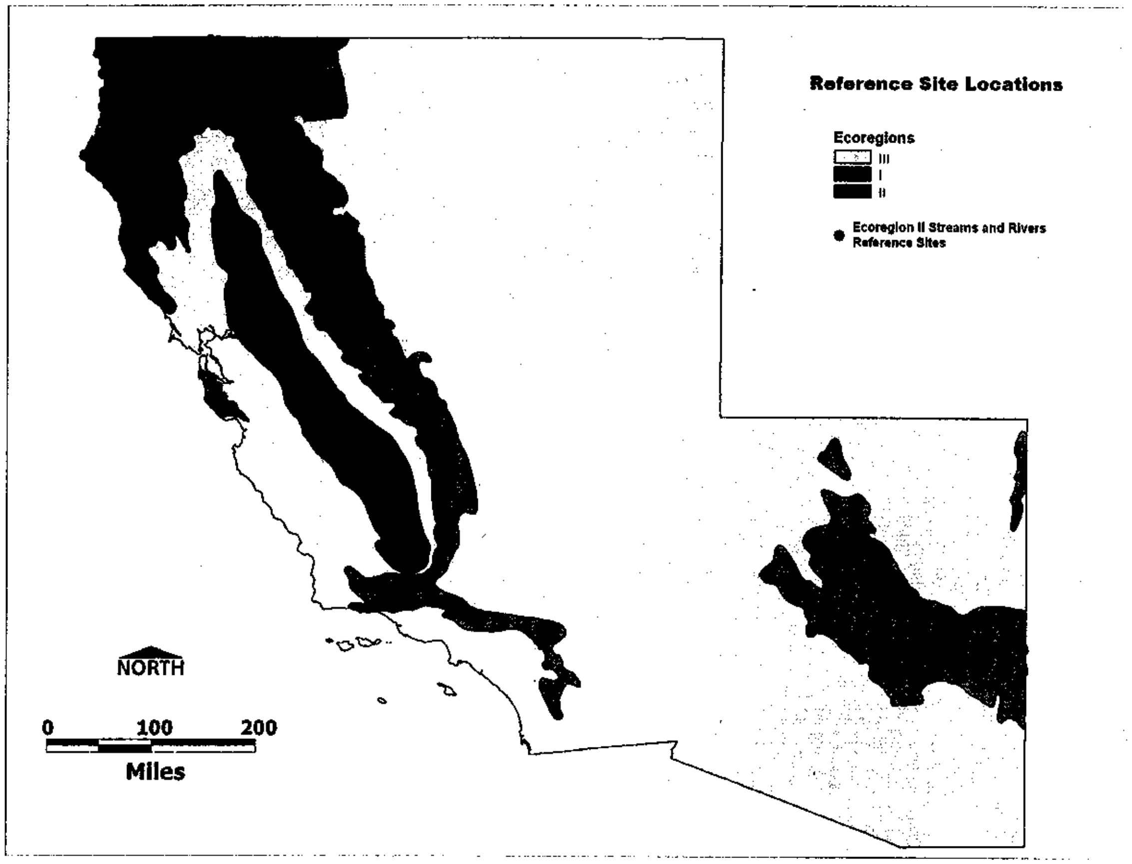

Figure 2-2. Ecoregion II Coverage by the Reference Dataset.

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3.0 DATA ANALYSIS

Preliminary analysis was performed using the STORET data set for rivers and streams in Ecoregion II. The key variables examined were total phosphorus and total Kjeldahl nitrogen because data on them is reported most frequently in the STORET data set for Ecoregion II . Other chemical parameters of interest such as total nitrogen, specific nitrogen species (such as nitrate, nitrite, and ammonia) were not analyzed at this time because of the relatively low frequency with which these data were sampled in Ecoregion II. No data on phosphorus species (such as orthophosphate, or dissolved organic phosphorus) were present in the STORET data set for Ecoregion II.

Total Kjeldahl nitrogen (TKN) was used as a surrogate for total nitrogen (TN) in our analysis because of the significantly larger number of reported values of TKN in Ecoregion II: there were roughly seven times as many TKN measurements as TN measurements. For the limited number of stations where TN and TKN had been measured simultaneously (approximately 740 points), we found that the two values were closely related, with slope of a regression line only slightly greater than unity (Figure 3-1). This is not surprising because TKN is the sum of organic nitrogen and ammonia nitrogen, which are major components of stream nitrogen. For subsequent analysis, we therefore felt that TKN was a good representation of TN.

The first step in the data analysis was to compare the concentrations of TKN and TP where they had been measured simultaneously. As shown in Figure 3-2 and 3-3, TP and TKN are positively correlated, although the relationship is noisy. Interestingly, a plot of the Redfield ratio (on a mass basis) on Figure 3-3 indicates that a majority of the streams in Ecoregion II have excess phosphorus. The Redfield ratio corresponds to the amount of phosphorus and nitrogen in biological matter. When the N:P ratio in water on a mass basis is near 7:1, both nitrogen and phosphorus are present in amounts that are sufficient for growth and neither nutrient is limiting. On the other hand when the Redfield ratio is greater that 7:1, this indicates that excess nitrogen is present and phosphorus is limiting. Similarly, when the ratio is less than 7:1, that is points that fall below the straight line in Figure 3-3, the water body has excess phosphorus. These points are also illustrated in Figures 3.4 and 3.5 where the frequencies and cumulative frequencies of the TKN/TP ratio are plotted. Both plots show that the majority (about 75%) of the sampling points indicate excess phosphorus over nitrogen.

The next step in the data analysis was to study the frequency distributions of total phosphorus and total Kjeldahl nitrogen for Ecoregion II streams as a whole, and by state and season (wet and dry). This follows the approach outlined in Section 7.2 of the Draft Nutrient Criteria Technical Guidance Manual for Streams and Rivers (Figure 9, page 78). By plotting data from all streams in an Ecoregion (reference streams as well as impacted streams) as a frequency distribution, one can estimate a criterion value as a percentile of the distribution. For example, the criterion value could be the limit of the bottom 25th percentile of nutrient values from all streams in an Ecoregion. Cumulative frequency plots can be used to estimate the criterion values corresponding to any percentile. Plots of frequency and cumulative frequency are presented as Figures 3.6 to 3.21. Figures 3.6 and 3.7 show the total phosphorus values in Ecoregion II. The x-axis in these plots indicates the upper limit of a phosphorus or nitrogen range--for example 20 refers to all samples that fall between 15 and 20 ppb. The cumulative plot shows that roughly 25% of the samples fall below 20 ppb of TP. Figures 3.8 and 3.9 show the distributions of TKN.

These plots indicate that roughly 25% of the samples are lower than 100 ppb. The TP distribution in the dry months (Figures 3.10 and 3.11) is similar to that for all dates, although the frequency distributions indicate the greater occurrence of higher phosphorus values. In the wet months (Figure 3-12 and 3-13) the concentrations of TP are slightly lower. Note that all TP plots show the presence of a fair number of samples (roughly 8%) at high concentrations, greater than 150 ppb. The TKN trends for season are similar to that for TP and are shown in Figures 3-14 and 3-15. When data for Ecoregion II are considered by state (Figure 3-16 and 3-17), California shows a slightly lower 25th percentile for TP than the Ecoregion as a whole (15 ppb compared to 20 ppb). This is not true for TKN values: the 25th percentile is comparable to that for the Ecoregion as a whole (Figures 3-18 and 3-19). The 25th percentile of TKN for Arizona is lower than for the Ecoregion as a whole (Figures 3-20 and 3-21).

Another area of data analysis that we touched on briefly was the relationship between nutrients and biological parameters. We found practically no data for chlorophyll a, but there were some measurements of turbidity and dissolved oxygen that could be used as surrogates of biological activity. The relationship of turbidity to TP and to TKN is shown in 3-22. The relationship is noisy, even though it has been plotted on a log-log scale. It does appear that higher turbidity values are associated with higher TP values, although this is not true of the relationship with TKN. The relationship of DO to TP and TKN shows no trends at all (Figure 3-23).

3.1 Data Quality

The usefulness of any dataset depends upon many factors. These factors include the care that was used while the data were being collected and analyzed, the consistency in the sampling techniques and analytical methodologies used, as well as accuracy and variability. All of these factors had to be considered and a set of guidelines developed while examining the various water quality datasets.

The set of guidelines that were developed allowed us to assess the quality of the individual datasets; since these data were generally collected from studies whose objectives did not necessarily include setting a regional nutrient water quality criterion. These guidelines allowed us to combine data that were generated independent from each other into a single nutrient based dataset.

The guidelines allowed us to focus on only those datasets that contained the following:

- Same water quality parameters (e.g., total nitrogen, total phosphorous, and chlorophyll-a);
- Same reporting units of measurement;
- Same analytical methods; and
- Data that were generated relatively recently (e.g., 1990 to present).

Sorting the data using these guidelines proved to be relatively simple. When we attempted to tighten the guidelines by requiring the presence of QA/QC information (e.g., blanks, duplicates, and spikes) the quantity of data dropped off precipitously. Quality assurance/quality control data were seldom included with the collected datasets and we were unable to obtain these data from the reporting sources since QA/QC data were rarely collected. Therefore, the QA/QC data requirement was not included in the abovementioned list of guidelines.

In general, the database contains adequate nitrogen and phosphorus data, however there was a paucity of chlorophyll-a data (both benthic and water column) as well as other biological data (e.g., benthic invertebrate populations). Additionally, secondary water quality data (e.g., dissolved oxygen, pH, TSS) were provided for the majority of the individual datasets.

3.2 Reference Station Nutrient Data

Water quality data were obtained from 215 stations in Ecoregion II that had been identified by the data collection agencies (local and state water bodies) as being relatively unimpacted and suitable for use as reference stations. The different parameters monitored and the total number of datapoints for each parameter in the reference database are shown in Table 3-1. Replicate measurements made at a station on the same date were averaged to produce this table. Table 3-1 shows that there were 530 total phosphorus datapoints and 470 total Kjeldahl nitrogen datapoints. Measurements of dissolved oxygen and chlorophyll-a were less frequent. Turbidity data were measured more often, and are represented by about 400 datapoints. In the analysis below, our principal goal was to compare the distributions of total phosphorus and total Kjeldahl nitrogen values at the reference stations with Ecoregion II stations from the STORET database. We did not plot the response variables (DO, chlorophyll-a, and turbidity) with respect to nutrient concentrations because of the limited availability of data. This is because all biological data present in the database cannot be used in plotting a relationship with nutrients because the number of co-located nutrient and biological measurements is significantly smaller than the total number of these datapoints. This limitation also applies to total phosphorus and total Kjeldahl nitrogen measurements which were not correlated in this analysis.

Nutrient data collected at reference stations was compared with the distribution of nutrient concentrations found for the STORET dataset and reported in the previous section. We used STORET data only from the California stations, because all the reference stations were located in California. As with the STORET database, we found that data on total phosphorus and total Kjeldahl nitrogen were the most commonly measured parameters for the reference stations. We therefore used only these two parameters for comparison.

The cumulative frequency distributions of the data from the reference stations and the STORET stations for TP and TKN are shown in Figure 3-24 and 3-25. We see that the concentration distributions of TP and TKN show that the reference stations have *higher* values than the data from the STORET stations. This result is the opposite of what would be expected from relatively unimpacted stations. The Nutrient Criteria Guidance document presents a schematic on page 78 that implies reference stations will have lower nutrient concentrations than the general population of stations. The surprising result that we have found points to the need of looking in greater detail at individual reference stations and identifying features such as their geology, flow, slope, and habitat that could explain the differences between these stations and the STORET stations.

As the first step in this analysis, we performed detailed characterization of a limited number of reference stations (discussed in detail in Section 2.5.5). Based on the detailed characterization, we divided the streams according to their flow, slope, stream order, and drainage area to identify the differences in nutrient concentration that result from these features. An overview of the classification methodology is presented in Table 2-5. The results of looking at the stream data using these classifications are shown in Table 3-2. We found significant differences in average nutrient concentrations (TP, TKN, and PO_4) for the different stream classifications. However, there were insufficient data points to make any strong conclusions about the effect of stream properties from the subset of the stations that we have currently looked at. The effects of stream properties can be evaluated more fully when we have characterization information for as many of the 215 reference stations as possible. We should point out that some information, particularly flow data, may not be available for all stations.

Table 3-1
Number of datapoints associated with different parameters in the Reference Station Database

Parameter	Datapoints*
Chl-a	29
DO	102
FLOW	244
NH_3	530
NH_3+Org N	56
NH_4	4
NO_2 (dissolved)	55
NO_2 + NO_3	451
NO_3 (dissolved)	134
Organic N	5
Ortho-PO_4	97
P (total)	530
pH	108
pH (field)	375
PO_4 (total)	17
TDS (lab)	14
TKN	470
TN	34
TSS	378
Turbidity	38
Turbidity (field)	359

* Number of unique station-date pairs (replicates on some dates were averaged)

Table 3-2
Summary of Stream Data by Stream Classifications

Average Values

By Flow rate

Parameter	Low	Mid	High
PO4	0.015	0.016	0.019
TKN	0.228	0.811	0.334
TP	0.032	0.105	0.087

By Drainage Area

Parameter	Head Water Stream	Large River	Small River	Wadeable Stream
PO4	0.031	0.073	0.016	0.012
TKN	0.328		0.749	0.245
TP	0.064	0.144	0.042	0.040

By Slope

Parameter	Gentle Gradient	Riffle Dominated	Steep	Very Steep
PO4	0.026	0.016	0.012	0.073
TKN	0.408	0.360	0.226	0.342
TP	0.234	0.035	0.024	0.097

By Stream Order

Parameter	2	3	4	5
PO4	0.031	0.012	0.016	0.015
TKN	0.378	0.235	0.432	0.383
TP	0.063	0.037	0.057	0.027

Number of Datapoints

Low	Mid	High
303	11	40
248	8	39
306	19	60

Head Water Stream	Large River	Small River	Wadeable Stream
1	14	68	271
5		7	283
5	14	75	291

Gentle Gradient	Riffle Dominated	Steep	Very Steep
21	46	273	14
12	2	245	32
15	48	272	46

2	3	4	5
1	254	48	25
5	270	13	3
5	263	59	28

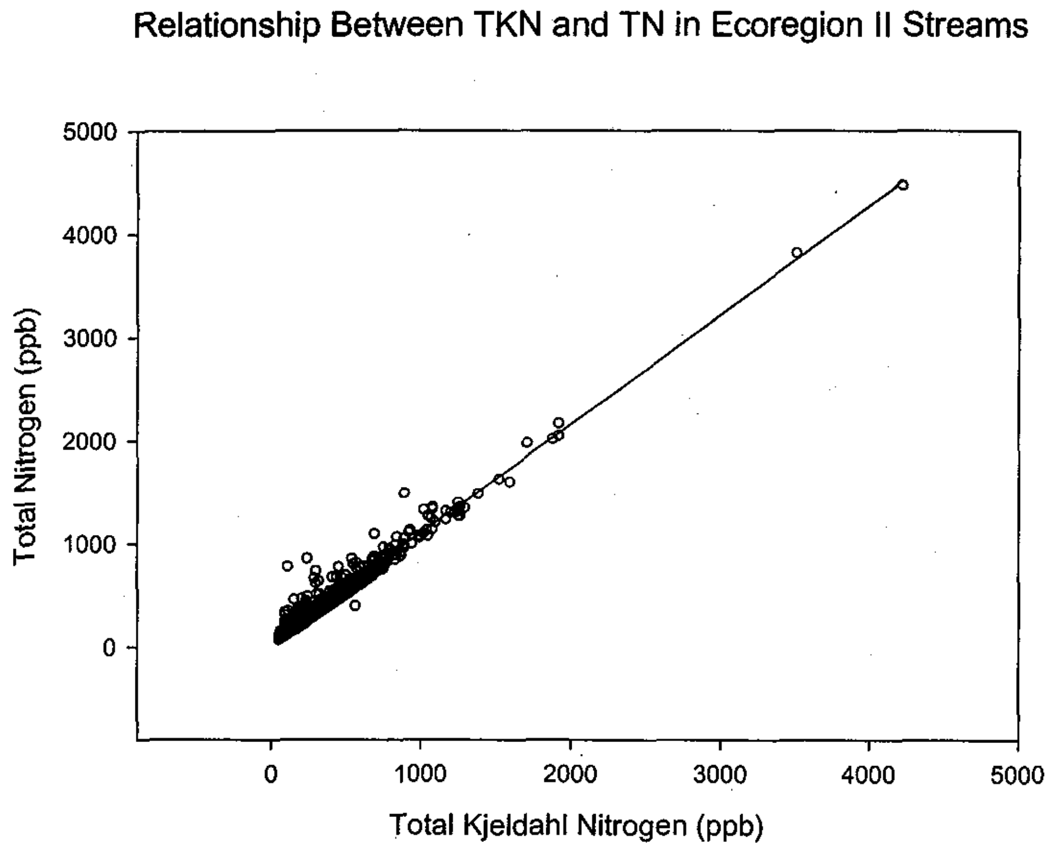


Figure 3-1. Relationship between TKN and TN in Ecoregion II Streams.

18064

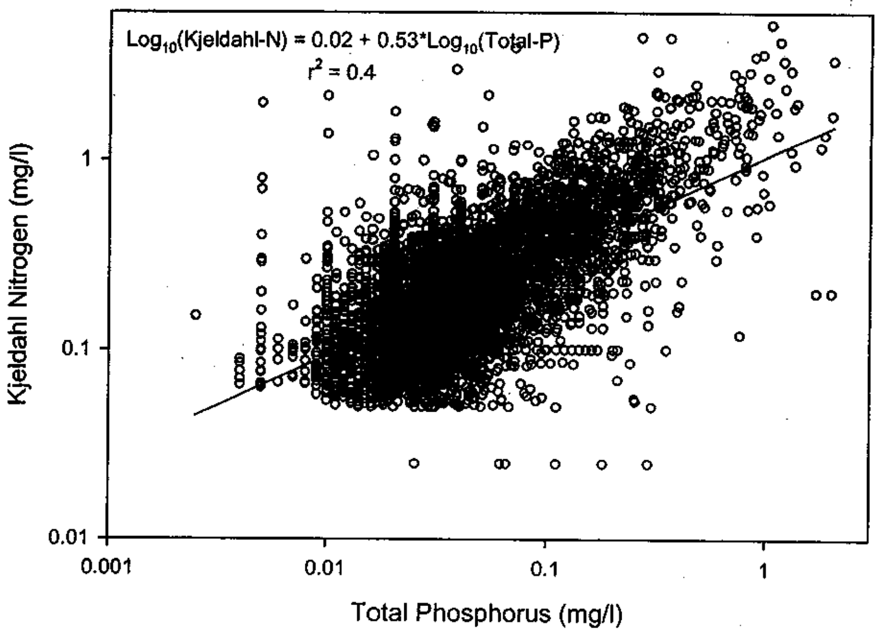


Figure 3-2. STORET Data: Ecoregion II Streams.

18065

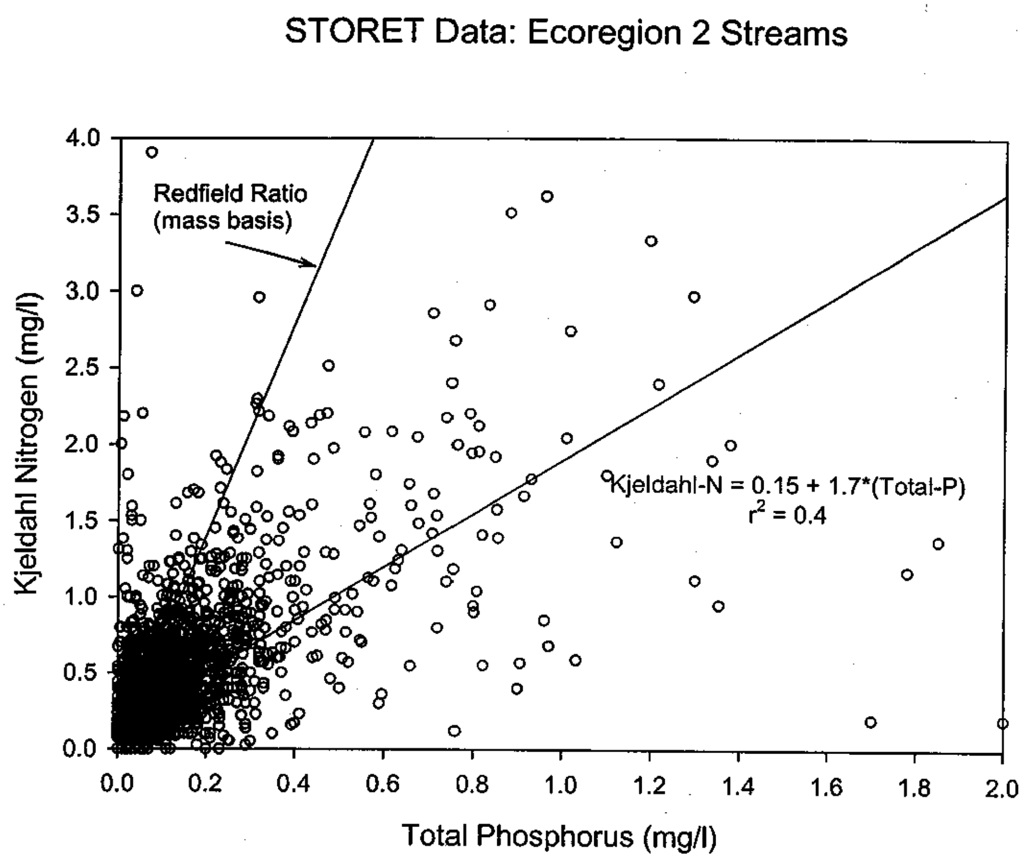


Figure 3-3. STORET Data: Ecoregion II Streams.

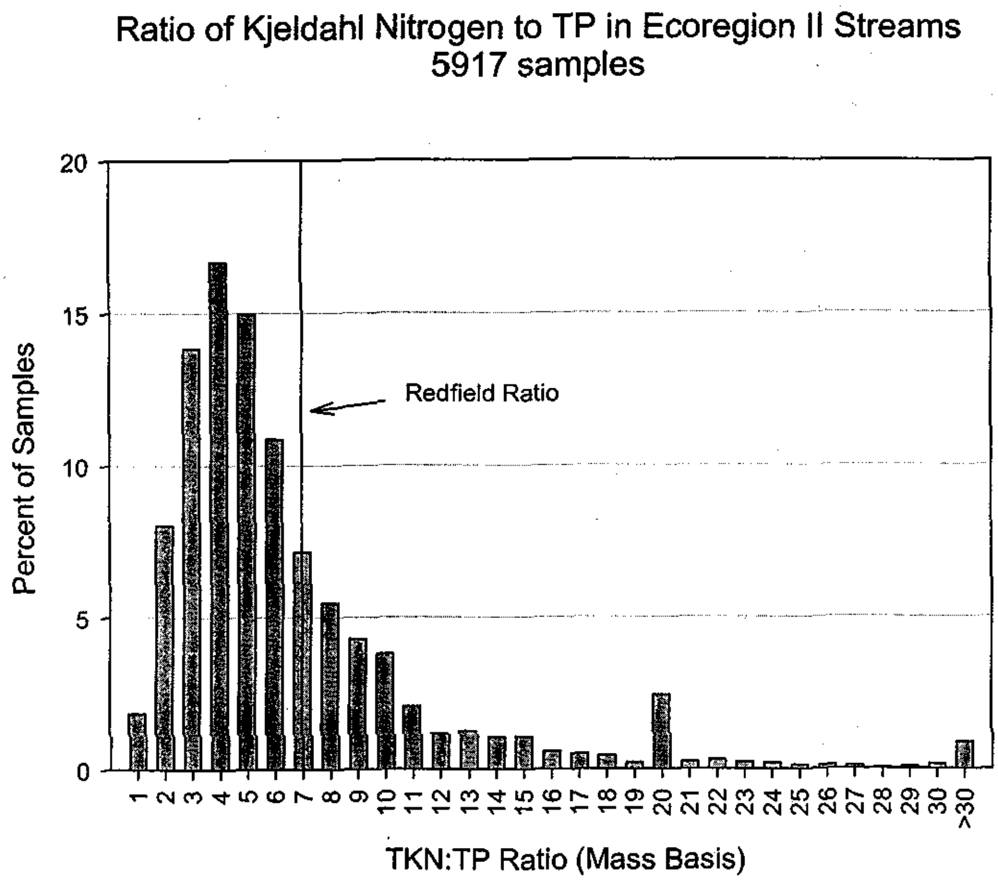


Figure 3-4. Ratio of Kjeldahl Nitrogen to TP in Ecoregion II Streams 5917 samples.

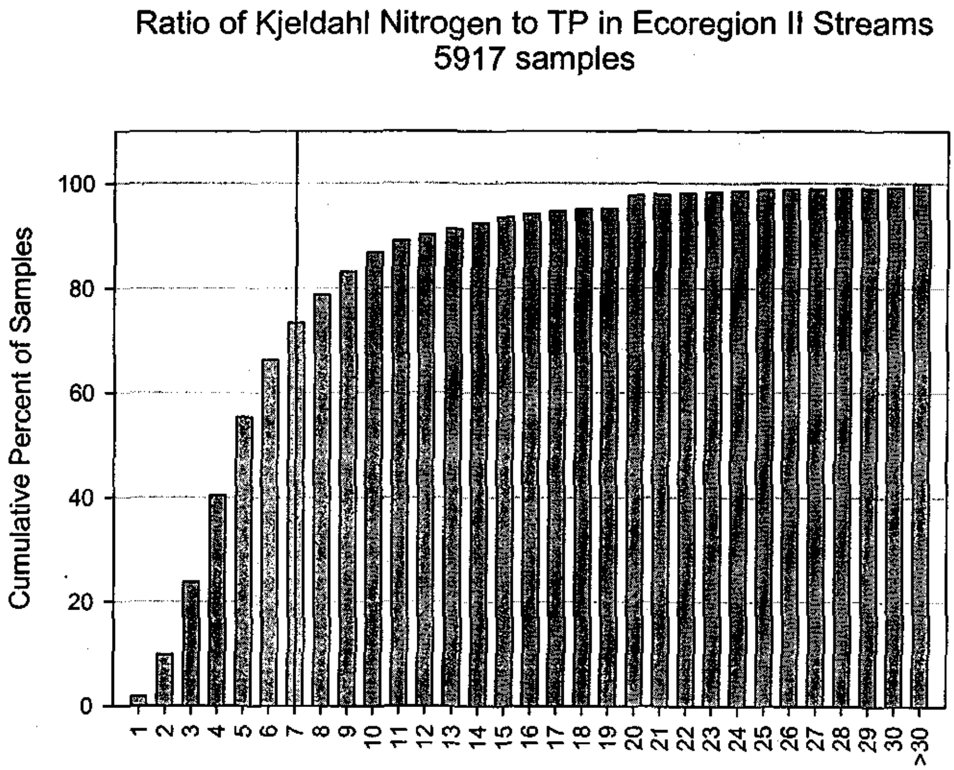


Figure 3-5. Ratio of Kjeldahl Nitrogen to TP in Ecoregion II Streams 5917 samples.

18068

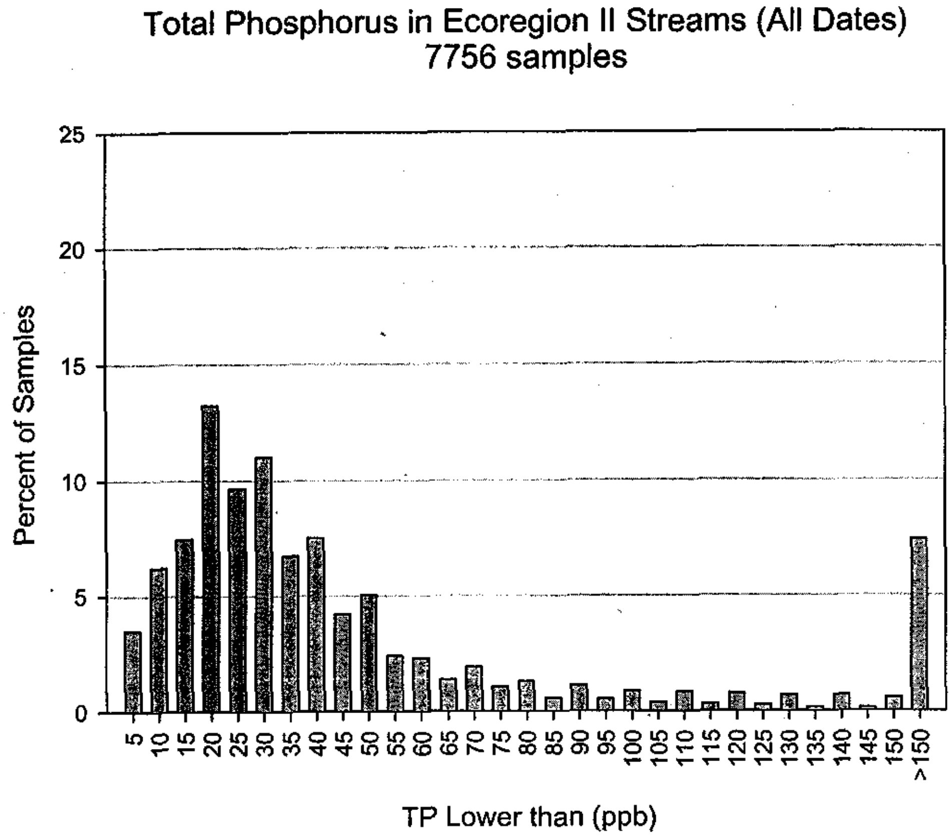


Figure 3-6. Total Phosphorus in Ecoregion II Streams (all dates) 7756 samples.

18069

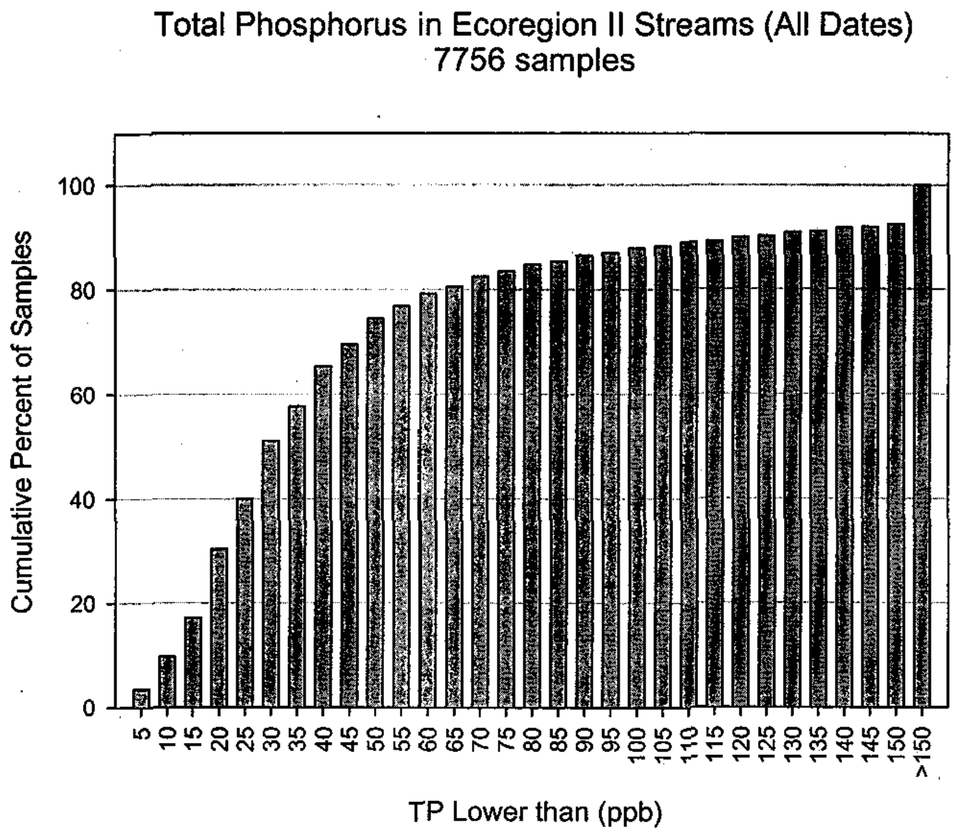


Figure 3-7. Total Phosphorus in Ecoregion II Streams (all dates) 7756 samples.

18070

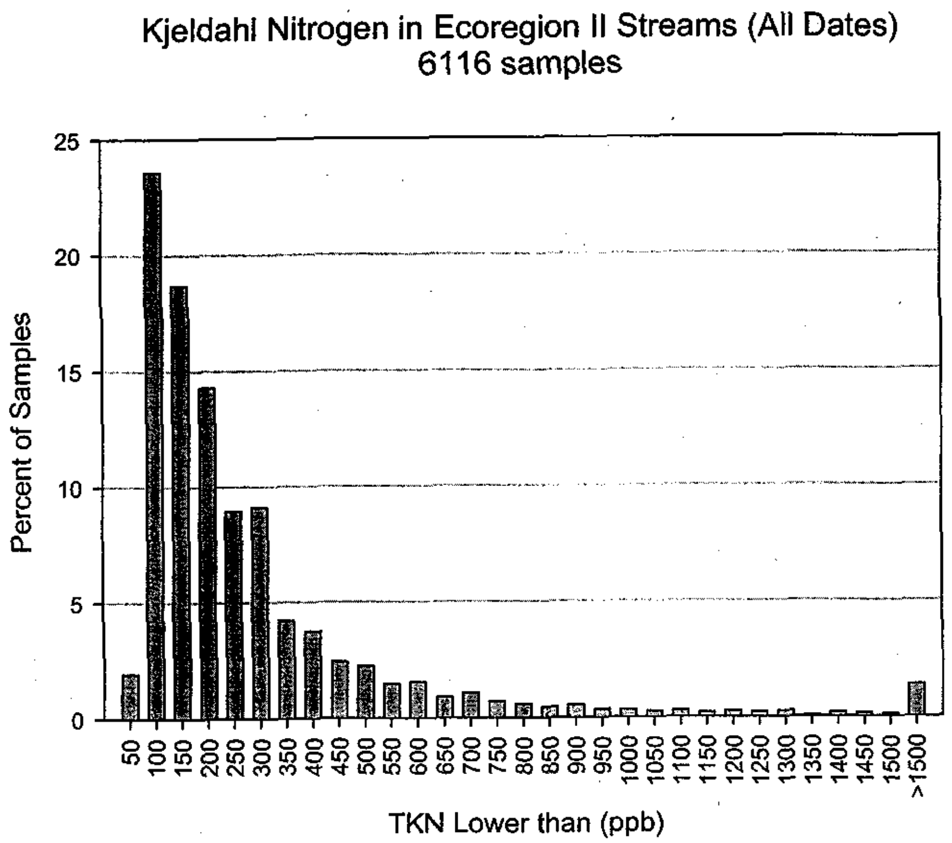


Figure 3-8. Kjeldahl Nitrogen in Ecoregion II Streams (all dates) 6116 samples.

18071

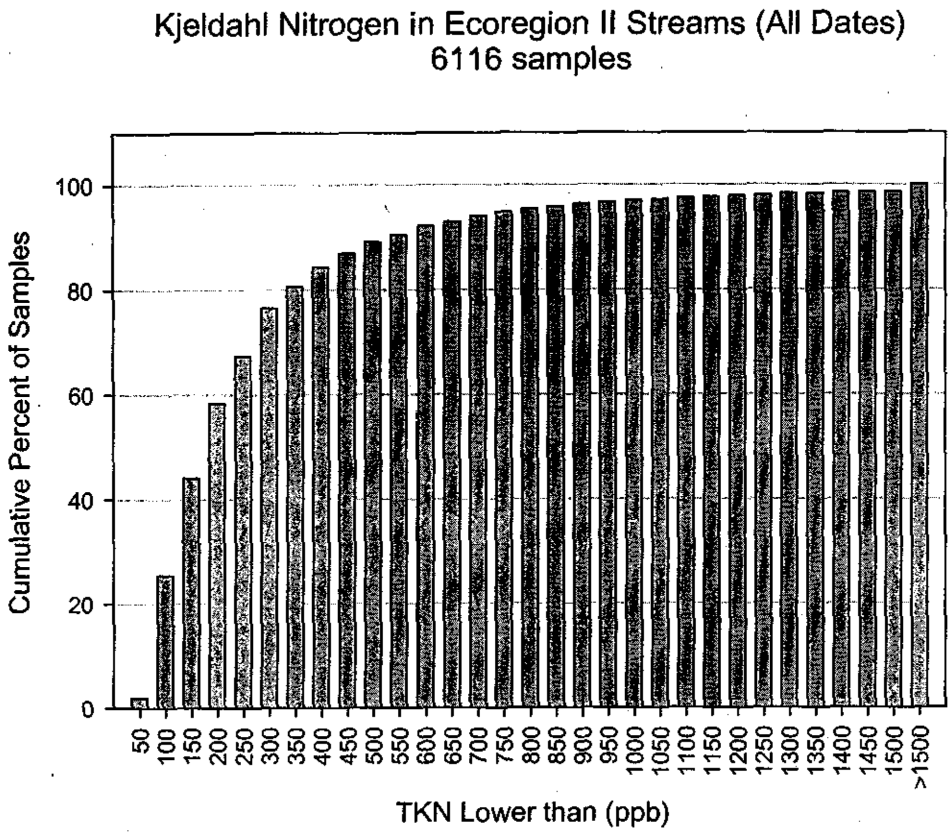


Figure 3-9. Kjeldahl Nitrogen in Ecoregion II Streams (all dates) 6116 samples.

18072

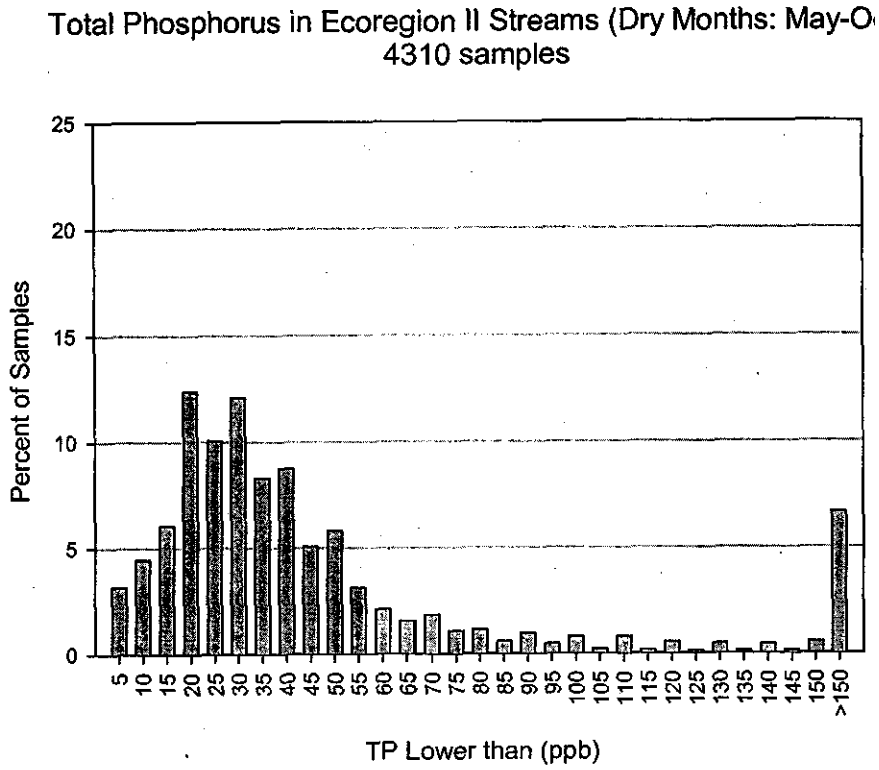


Figure 3-10. Total Phosphorus in Ecoregion II Streams (dry months: May-Oct) 4310 samples.

18073

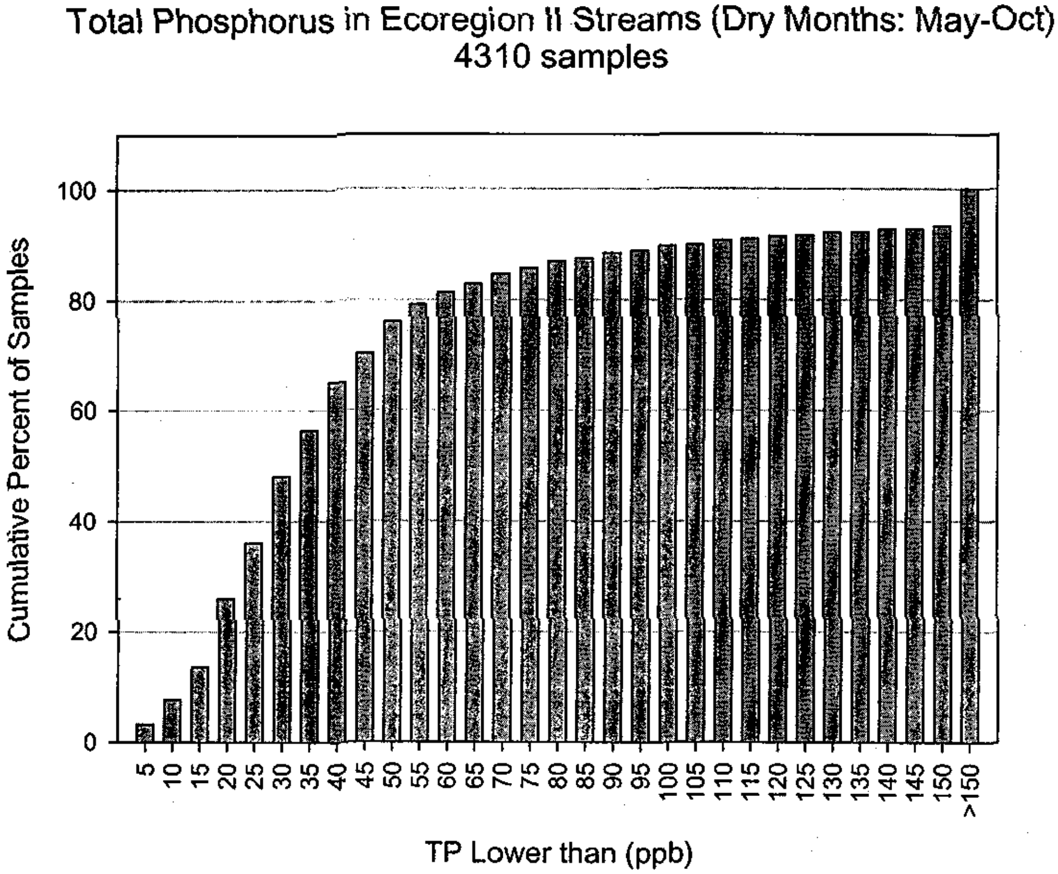


Figure 3-11. Total Phosphorus in Ecoregion II Streams (dry months: May-Oct) 4310 samples.

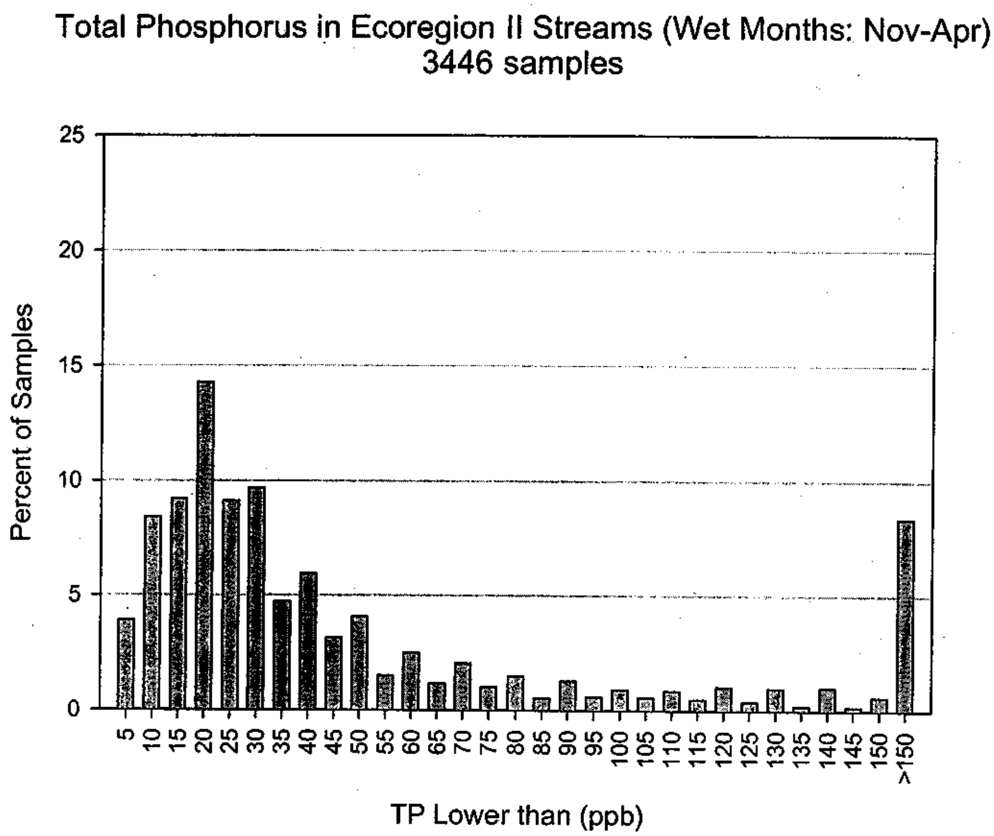


Figure 3-12. Total Phosphorus in Ecoregion II Streams (wet months: Nov-Apr) 3446 samples.

18075

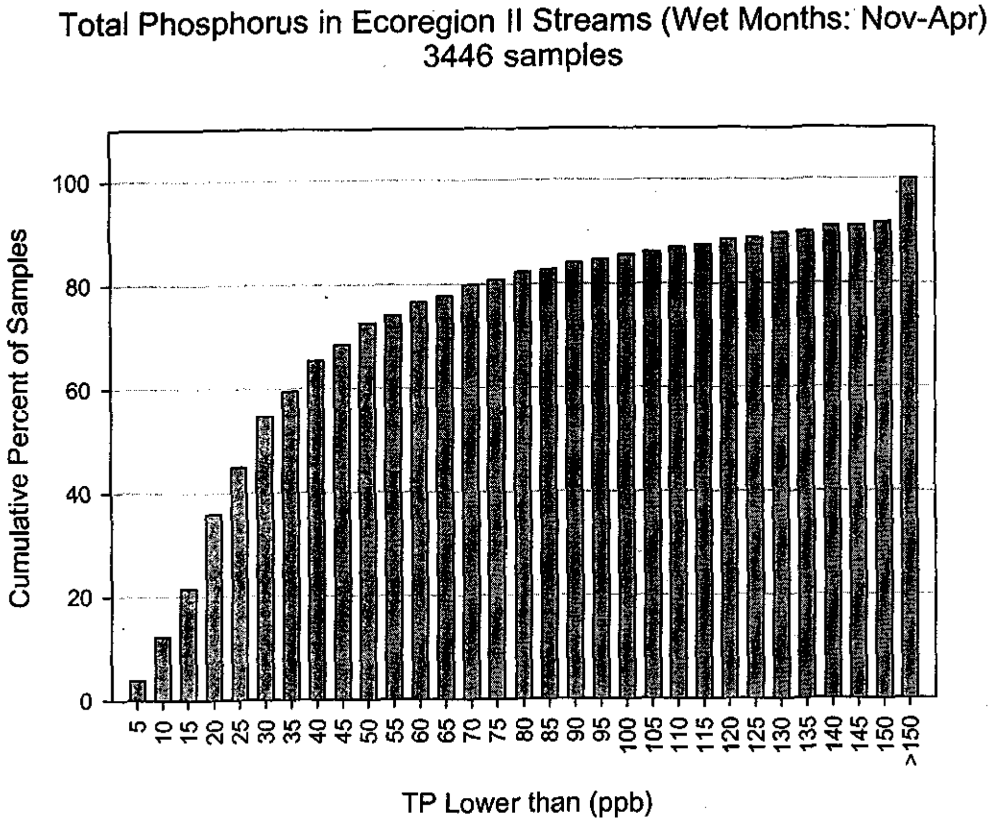


Figure 3-13. Total Phosphorus in Ecoregion II Streams (wet months: Nov-Apr) 3446 samples.

18076

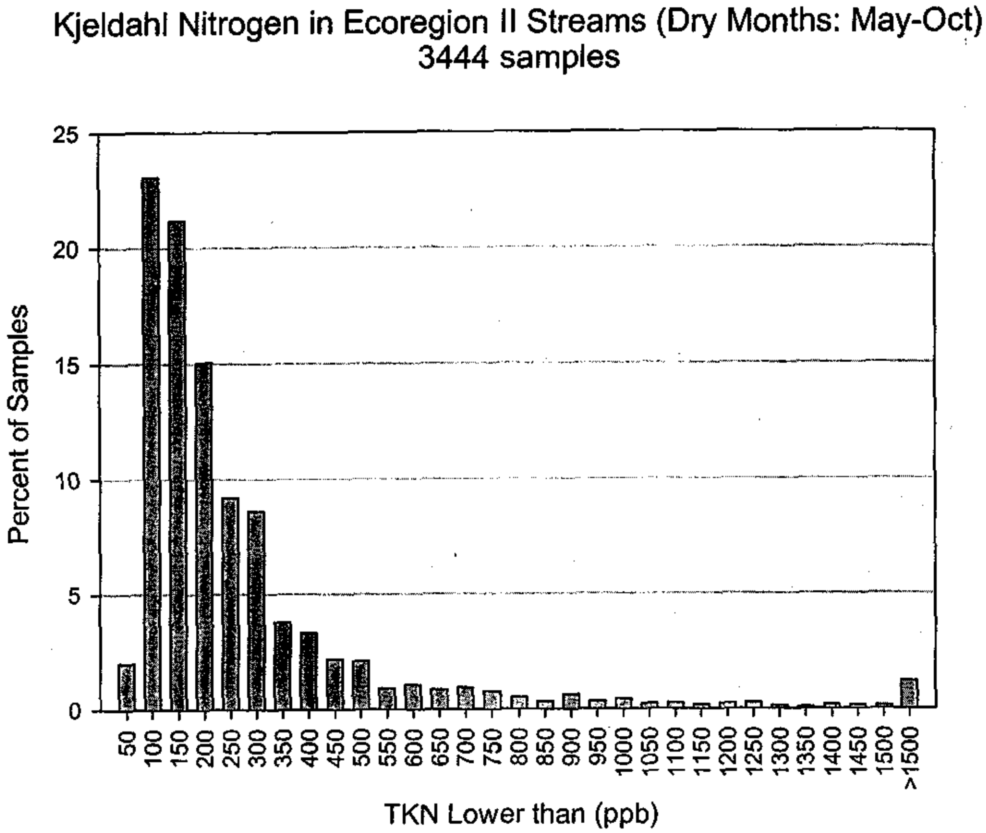


Figure 3-14. Kjeldahl Nitrogen in Ecoregion II Streams (dry months: May-Oct) 3444 samples.

18077

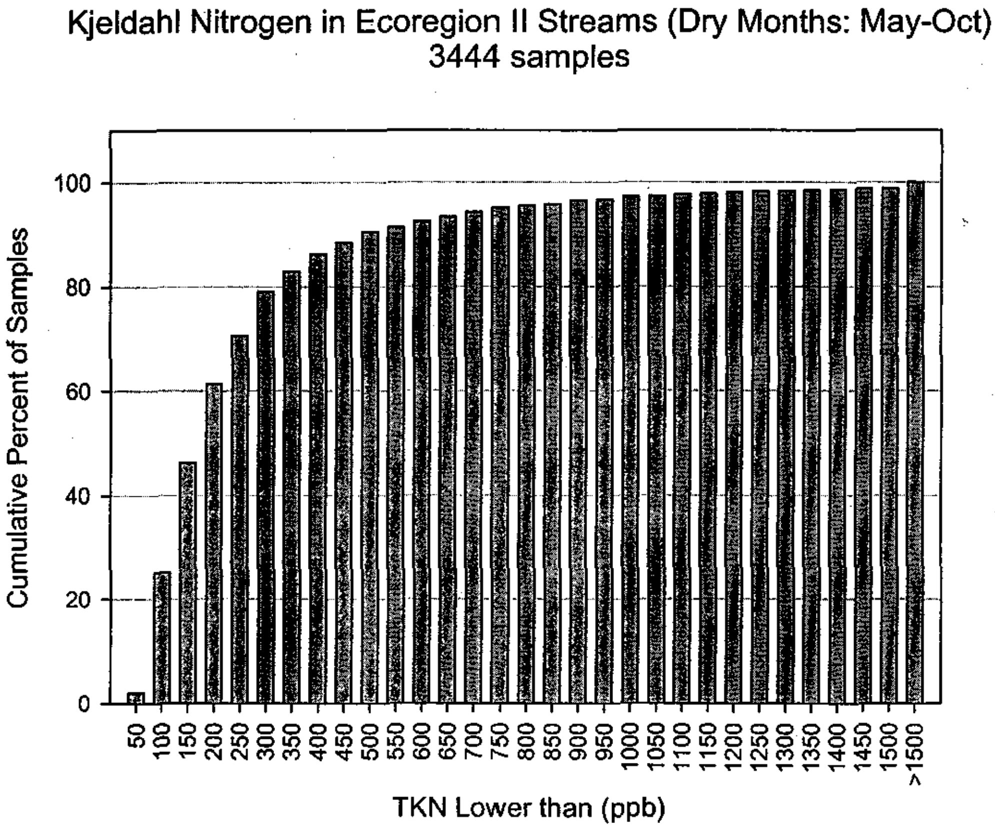


Figure 3-15. Kjeldahl Nitrogen in Ecoregion II Streams (dry months: May-Oct) 3444 samples.

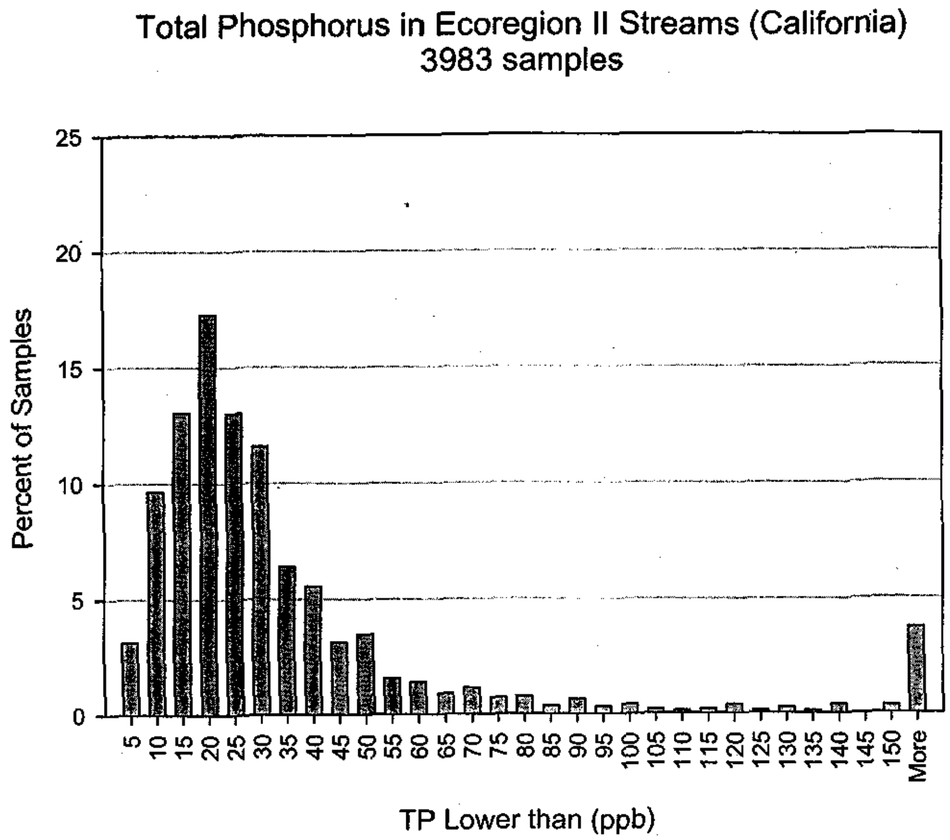


Figure 3-16. Total Phosphorus in Ecoregion II Streams (California) 3983 samples.

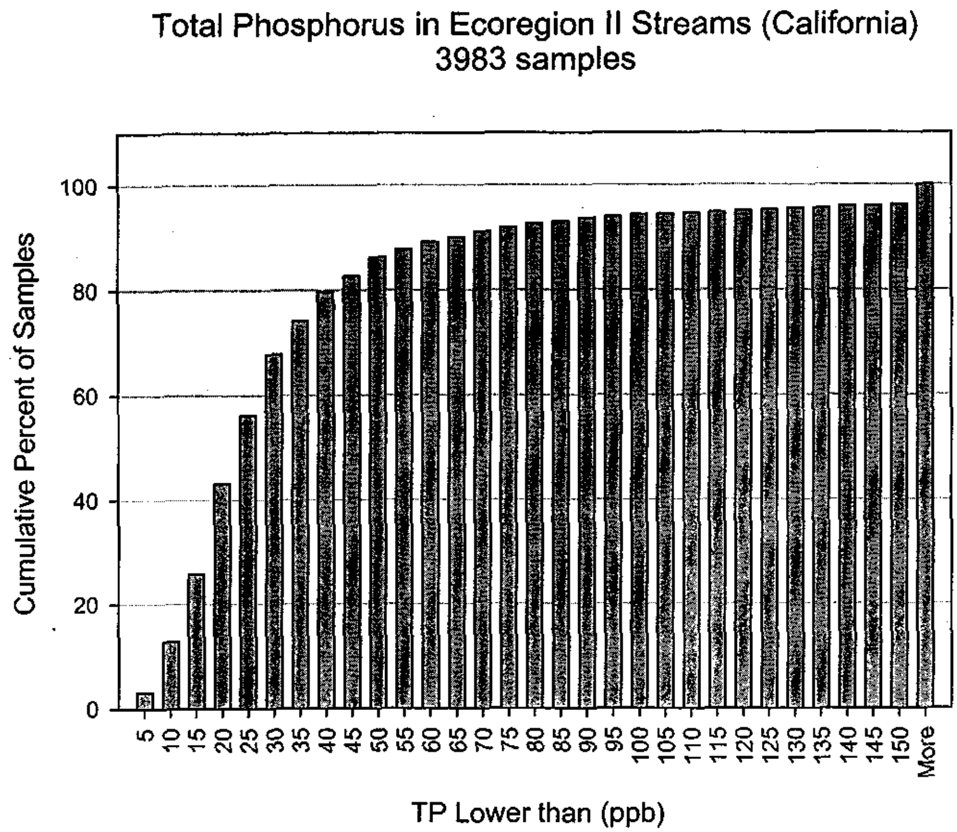


Figure 3-17. Total Phosphorus in Ecoregion II Streams (California) 3983 samples.

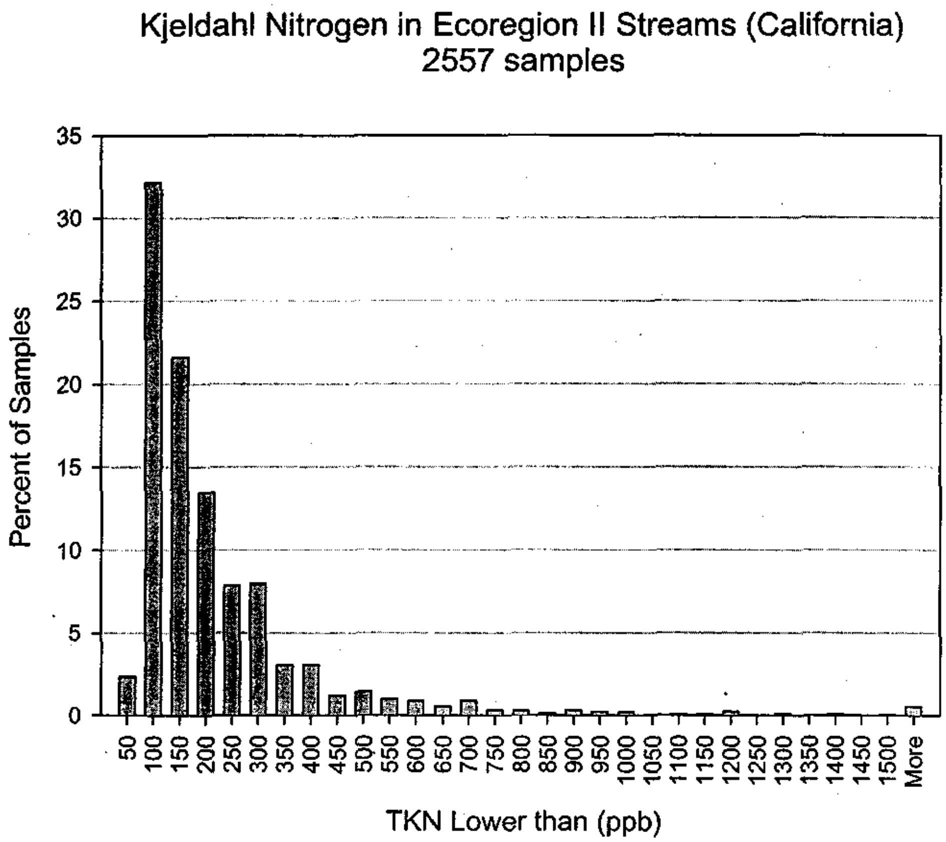


Figure 3-18. Kjeldahl Nitrogen in Ecoregion II Streams (California) 2557 samples.

18081

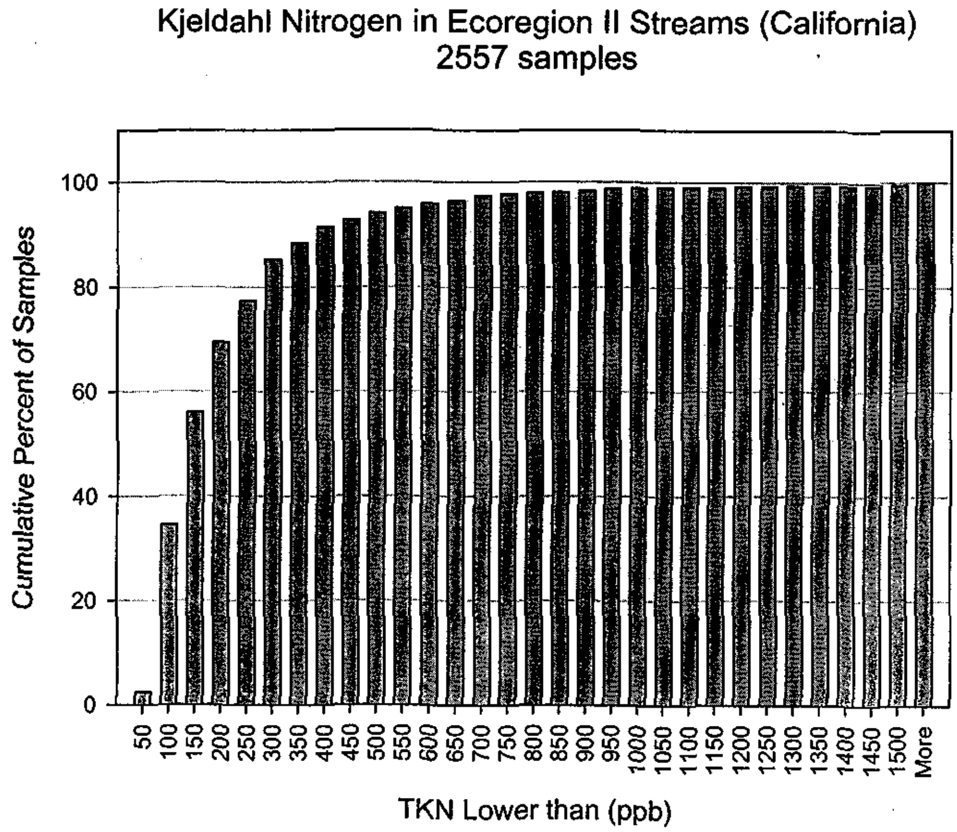


Figure 3-19. Kjeldahl Nitrogen in Ecoregion II Streams (California) 2557 samples.

18082

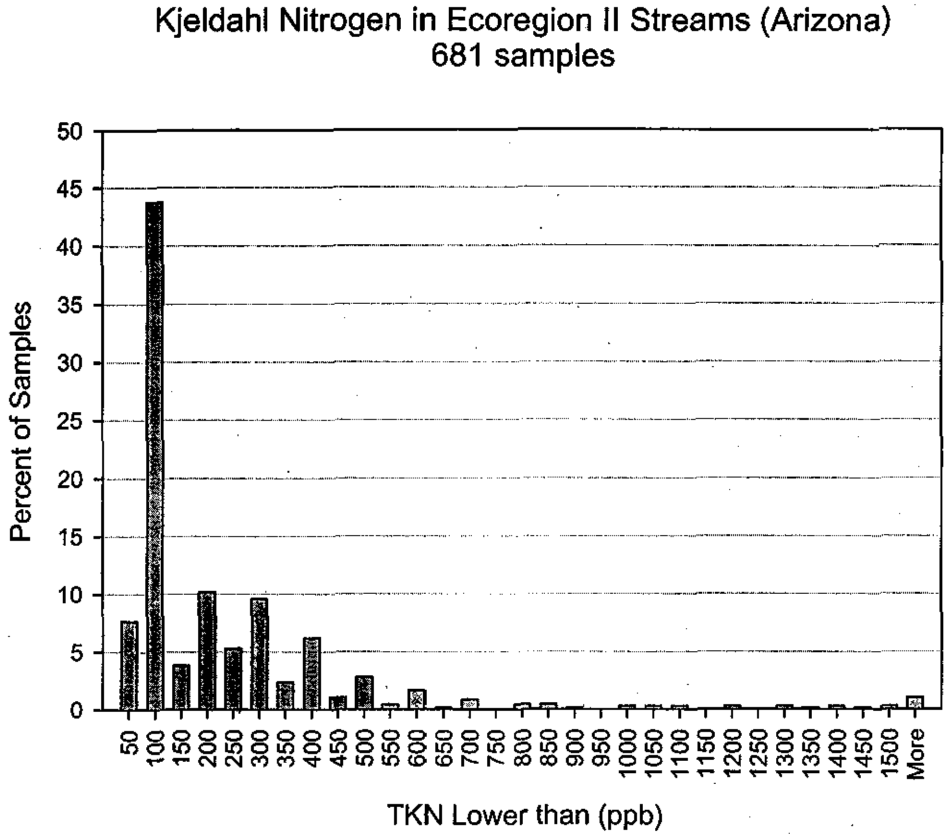


Figure 3-20. Kjeldahl Nitrogen in Ecoregion II Streams (Arizona) 681 samples.

18083

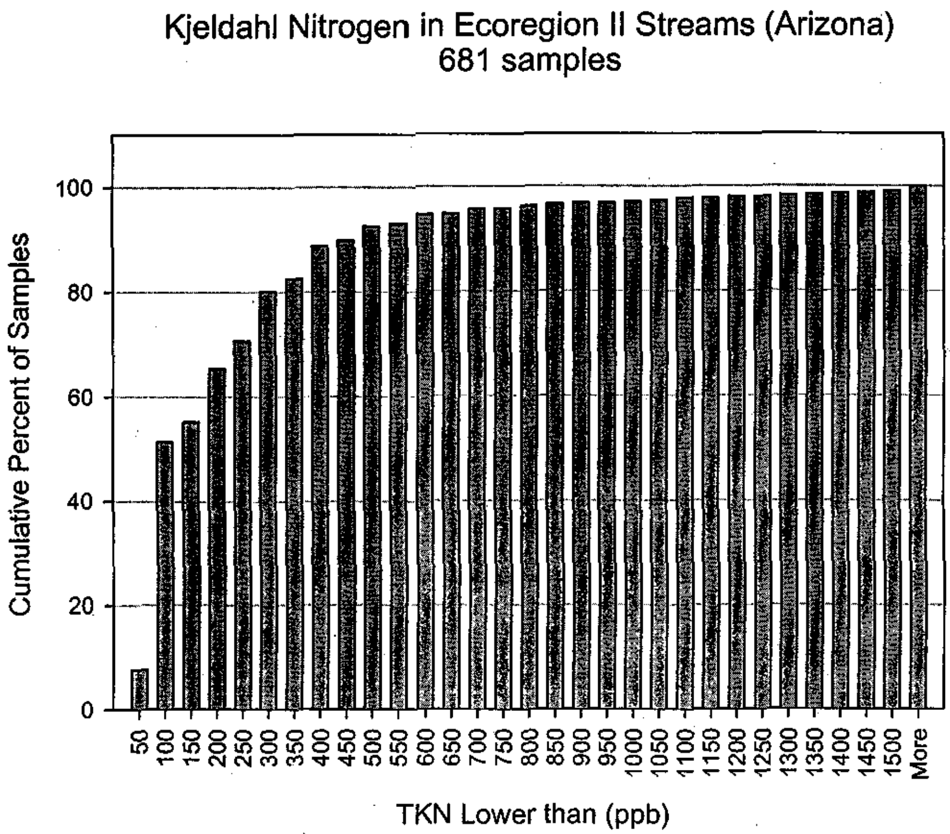


Figure 3-21. Kjeldahl Nitrogen in Ecoregion II Streams (Arizona) 681 samples.

18084

TURBIDITY, HACH TURBIDIMETER (FORMAZIN TURBIDITY UNITS)
Ecoregion II Streams, 968 Data Points

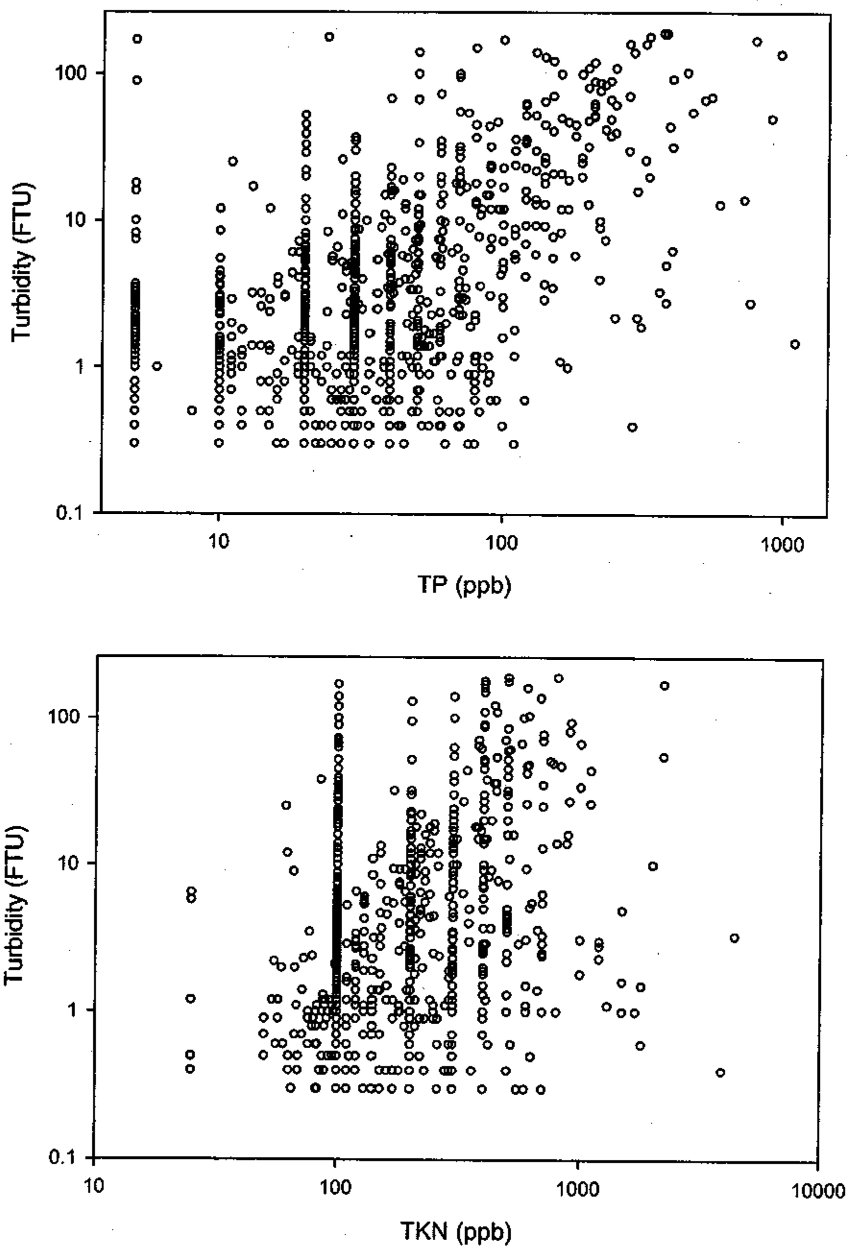
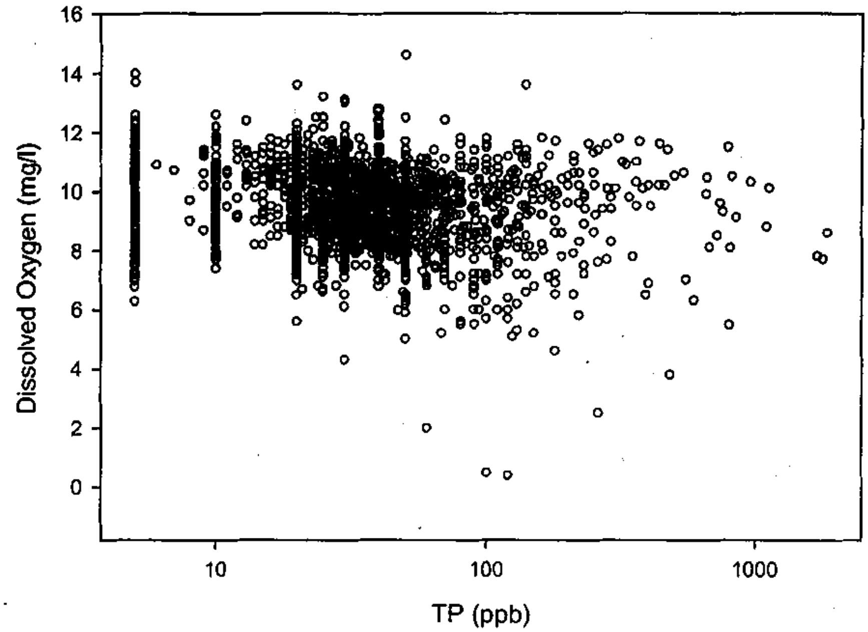


Figure 3-22. Turbidity, Hach Turbidimeter (formazin turbidity units) Ecoregion II Streams, 968 data points.



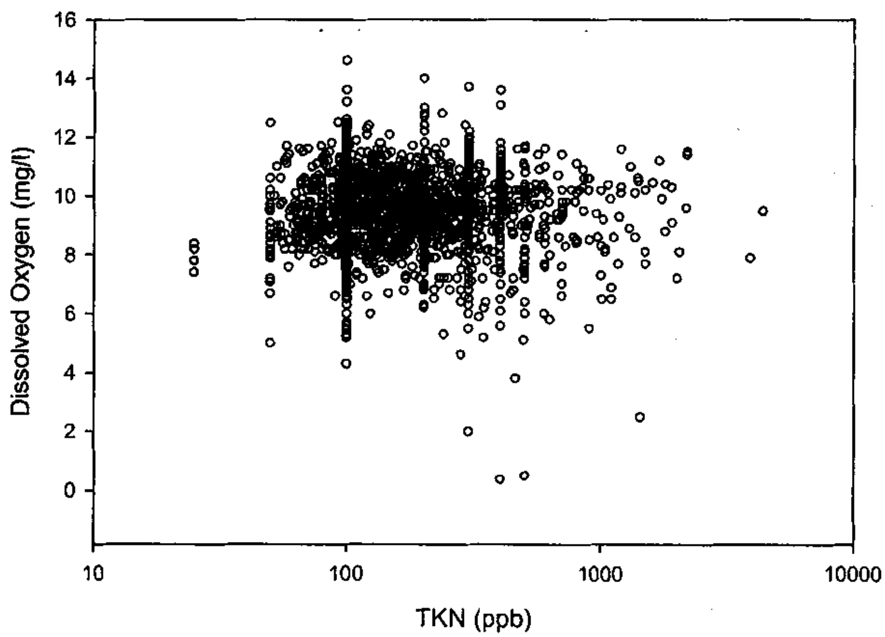


Figure 3-23. Dissolved Oxygen (mg/l) Ecoregion II Streams, 1985 data points.

18086

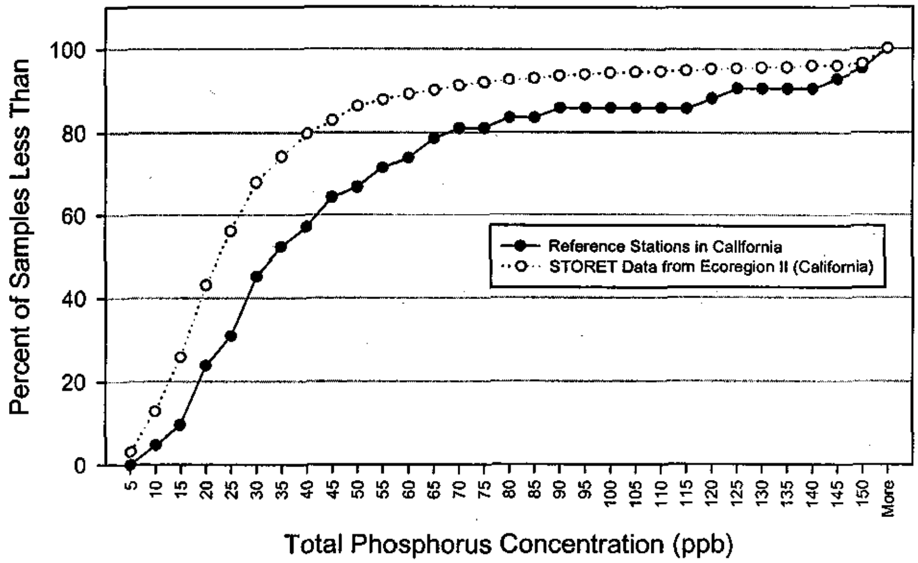


Figure 3-24. Comparison of STORET total phosphorus concentrations (California) with reference streams in Ecoregion II

18087

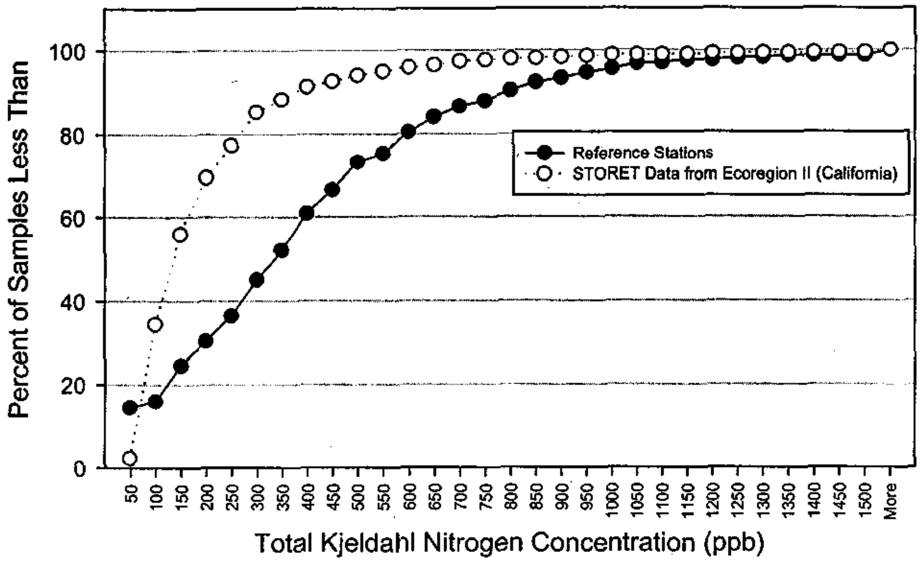


Figure 3-25. Comparison of STORET total Kjeldahl nitrogen concentrations (California) with reference streams in Ecoregion II

18088

4.0 LESSONS LEARNED AND NEXT STEPS

This study is a pilot project and, by its very own nature, becomes a learning process. Over the course of the project certain issues have arisen that will be useful in future efforts. These lessons fall into three main categories (data acquisition, data quality, and data quantity) and are presented below:

- Data availability differed greatly between and within source agencies. In some cases, the data were available electronically while in many cases; the agencies simply did not have the person power to input all of their hardcopy data into an electronic format. Nor did they have the resources to make copies of hardcopy data and send it to us (e.g., Lahontan RWQCB 6). This added copious amounts of time to the collection process.

- Some source agencies (EBMUD and PG&E) have intensive internal approval processes that had to be met before any dataset could be released.

- Geo-referenced data were a rarity. Many datasets contained sample site descriptors such as (50 feet north of Tom's place), while others had only a site number with no reference as to the location. Without some kind of geo-referencing, it was impossible to locate some of the monitoring stations and use the data. This meant that additional time had to be spent contacting the source agency to find out exactly where the station is located. This took time (few minutes to several weeks to "we don't know where that site is").

- QA/QC data were rarely collected and hardly ever reported. It could not be assumed that these data would automatically be sent with the rest of the data.

- Not all reporting agencies used the same or similar analytical methodologies. For example, the Hoopa Tribe EPA used a visual colorimetric method to determine nutrient concentration, while other agencies used more accurate analytical methods. The methods used must always be asked for and compared to accepted EPA methods.

- Since many of the studies were not designed to measure trophic condition, only the basic nutrient values were collected (e.g., nitrate and/or phosphate). These data could not be used in a quantitative manner since the EPA nutrient criteria program requires that nutrient criteria be set using <u>total</u> nitrogen and total phosphorus concentrations.

- Biological information was very scarce. There was a paucity of chlorophyll-a information, with benthic chlorophyll-a concentrations being rarely reported even though chlorophyll-a concentrations provide important information regarding waterbody trophic level. Even more rare were other biological data (e.g., benthic community structure and dynamics).

- The comparison of reference station nutrient data with those observed at the STORET stations showed that the reference stations actually had <u>higher</u> nutrient concentrations. This result was the opposite of what had been expected, and highlights the need for looking at additional stream properties (not just ecoregion) to determine appropriate background concentrations. For Ecoregion II, it is clear that a simple comparison of nutrient concentrations at reference stations and all stations will not yield a numeric nutrient criterion.

- Classification of stream stations by different properties (stream flow, drainage area, slope, and order) was possible, albeit it was a time-intensive process. Twenty-five (out of 215) stations were characterized in this manner. Nutrient data from these stations were insufficient to make strong conclusions about the extent that stream properties influence nutrient concentrations.

Additional Data Needs:

This pilot study focused on Ecoregion II and on the issues surrounding data collection from streams and rivers in this ecoregion. The data collected for Ecoregion II appears to be clustered, with the three largest clusters appearing in the northern region of California, around the Lake Tahoe Basin, and in the mountainous regions of Arizona. The remainder of Ecoregion II is represented by small amounts of data collected from streams and rivers in the Santa Cruz Mountains and in the Central and Southern Sierras. Unless additional data can be found or generated for these areas, they will be underrepresented in the final analysis.

In addition, seasonal data is limited in number. Storms, winter snowmelt, and hot dry summers influence many of the streams and rivers located in Ecoregion II. These extreme environmental conditions increase the importance of addressing seasonal water quality characteristics of the rivers and streams located in Ecoregion II.

Next Steps

Nutrient concentrations at reference stations and the general population of stations must be compared at the ecoregion level for other water bodies and other ecoregions in a manner similar to what has been presented here. If it is shown that the total nutrient concentrations at reference stations are not statistically significantly lower at the ecoregion level for other data sets, it follows that (1) criteria may have to be developed at the sub-ecoregion level, e.g., for high-flow streams in Ecoregion II, or (2) criteria must be based not on the distribution of nutrient concentrations but on the response of some biological metric that is valuable to protect, such as dissolved oxygen concentrations or the index of Biological Integrity. Both options present practical difficulties. In the first case, we may end up with a large number of numeric criteria for different locations, which may be difficult to manage. In the second case, data on biological responses to nutrients may be very difficult to get.

If the goal is to develop nutrient criteria based on water body properties (e.g., for streams relevant properties may be the flow or the stream order), we may discover that we do not have adequate data for every classification for example, we may have sufficient reference station data for streams with steep slopes, but not for gentle slopes. To develop criteria for different water body classifications, some specially targeted monitoring may have to be performed to obtain reliable estimates of background nutrient levels. In this pilot study, although extensive efforts were made to obtain reference station data from streams in Ecoregion II, many stream classifications had very little nutrient monitoring data available.

Classification data for sampling stations are not part of the database. In several cases, these data may be obtained from public data sources, although this may be a very time consuming process, especially where hundreds of stations are involved. Future database development efforts must consider the possibility of including water body characterization information in one location.

5.0 REFERENCES

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U.S. Geological Survey. 2000. GIS Coverages of US Geology website: http://minerals.usgs.gov/kb/kb.html

Appendix A
EPA Nutrient Criteria Contacts List

First Name	Last Name	Company Name	Work Phone	Status
Patti	Armison	Tahoe Research Group (TRG)	(530) 756-7679	call back later
Jeffrey	Armstrong	Orange County Sanitation District	(714) 593-7455	call back later
Jeanique	Artiola	University of Arizona	(520) 621-3516	call back later
Brenda	Begay	White Mtn. Apache Tribe	(520) 338-4346	call back later
Bryan	Bennon	Gila River Indian Community	(520) 562-2234	call back later
Michael	Carlan	City of San Francisco Public Water Utilities	(415) 554- 8987	call back later
Jay	Cass	CA RWQCB Lahontan, south office	(760) 241-7404	call back later
Robert	Gearheart	HSU, Env. Resource Engineering Dept.	(707) 826-3135	call back later
Nancy	Grimm	AZ. State University		call back later
Matt	Hegemann	US Park Service	(970) 225-3535	call back later
Terry	Knight	NV Nature Conservancy	(702) 737-8744	call back later
Kevin	Kratt	Ameritech (Performing nutrient TMDL's)	kkratt@ameritech.net	call back later
John Paul	Kyle	Tahoe Regional Planning Agency	(775) 588-4547	call back later
Liz	Lewis	Marin County Flood Control Dist.	(415) 499-7226	call back later
Chris	Maxwell	Lahontan RWQCB - Southern District Region 6	(760) 224-1741	call back later
Glenn	Miller	UNR, Environmental Resources Program	(775) 784-4108	call back later
Brian	Niewinski	Pyramid Lake Fisheries	(775) 476-0426	call back later
MJ	Oliveri	City of Santa Rosa, Public Works	(707) 543-3854	call back later
Patti	Orozco	City of Santa Rosa, water quality	(707) 543-3825	call back later
John	Reuter	UC Davis	(530) 752-9525	call back later
Glenn	Stark	Gila River Indian Community	(520) 562-2234	call back later
Lynette	Stevens	Navajo EPA	(520) 871-7690	call back later
Mark	Sylvestor	USGS Menlo Park	(650) 329-4415	call back later
Karen	Thomas	USGS	(775) 887-7672	call back later
Dean	Tucker	US Park Service	(970) 225-3516	call back later
Roland	Williams	AZ Dept. of Environmental Quality	(602) 207-4506	call back later
Iris	Yamagata	CDEC- DWR Fresno	(559) 230- 3327	call back later
Victor	Baker	University of Arizona	(520) 621-7120	no data
Marie	Barry	Washoe Tribe of NV and CA	(775) 265-4191	no data
Judy	Bloom	EPA Region IX	(415) 744-1829	no data
Val	Connor	Central Valley RWQCB	(916) 255-3111	no data
Mike	Deas	UC Davis	(530) 759-8227	no data
Terry	Flemming	US EPA Region IX	(415) 744-1939	no data
John	Johnston	Calif. State University, Sacramento	(916) 278 - 7939	no data
Cindy	Larkin	City of Eureka	(707) 441-4363	no data
Jack	Lewis	Redwood Science Lab	(707) 825-2929	no data

Appendix A (continued)
EPA Nutrient Criteria Contacts List

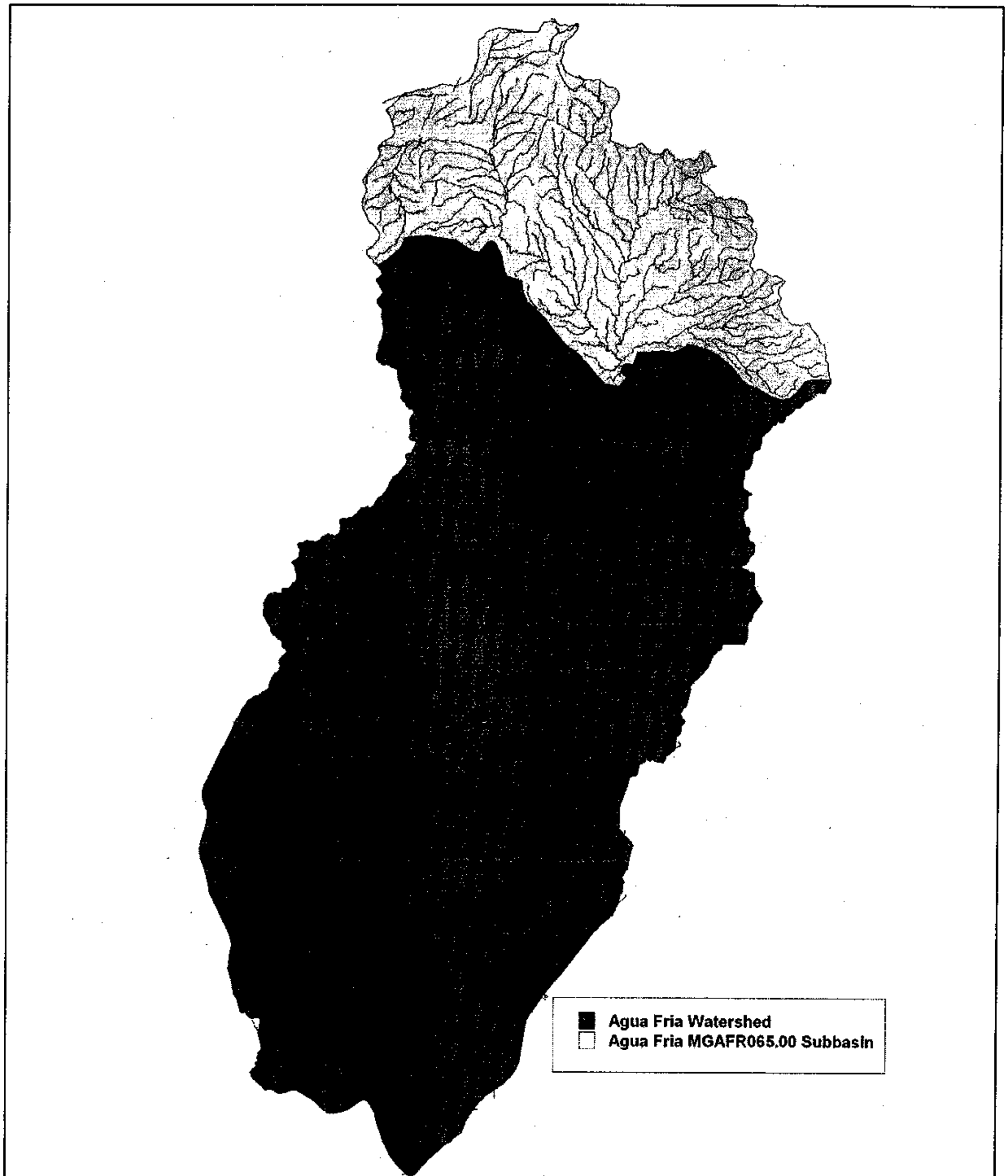
First Name	Last Name	Company Name	Work Phone	Status
Geoff	Powers	County of Sonoma, Stormwater	(707) 527-2036	no data
Tina	Rhom	US EPA	(715) 344-5454	no data
Larry	Roundtree	Bureau of Health Protection	(702) 687-4750	no data
Stewart	Schillenger	City of Tucson, Dept. of Water Quality	(520) 791-5256	no data
Nancy	Vacinich	Pyramid Lake Fisheries	(775) 476-0426	no data
Sean	White	Sonoma Co. Water Agency	(707) 547-1908	no data
Mike	Young	Prescott Water Treatment	(520) 776-6247	no data
Mike	Young	City of Prescott	(520) 776-6247	no data
		Arizona Water Resources Research Center	(520) 792-9591	no data
		Natural Resources, Division of Water Planning	(702) 687-3600	no data
		Carson River Advisory Committee	(702) 887-2100	no data
Dave	Bogner	CA DWR Central Valley Region		not contacted
Richard	Brock			not contacted
Gale	Cordy	USGS NAWQA	(520) 670-6671	not contacted
Jennifer	Davis	Scott River CRMP	(530) 467-3798	not contacted
Marie	deAngelis	HSU Oceanography Dept.		not contacted
Steve	Dollar			not contacted
Niel	Dubrovsky	USGS NAWQA	(916) 278-3078	not contacted
Tom	Galier	City of Tempe	(602) 350-2625	not contacted
Gregory	Gearheart	CA EPA, CA RWQCB SF Bay Region	(510) 622-2320	not contacted
Bob	Hollander	City of Phoenix	(602) 262-4992	not contacted
Bob	Klamt	CA Regional Water Quality CB, North Coast Region	(707) 576-2693	not contacted
Mark	Larkin	Friends of Santa Cruz River	(520) 398-9093	not contacted
Ed	Laws			not contacted
Mike	Lico	USGS NAWQA	(775) 887-7626	not contacted
Alan	Martindale	City of Mesa	(602) 644-3481	not contacted
Gene	Michael	City of Glendale	(602) 930-3877	not contacted
Barbara	Oliveri	City of Scottsdale	(602) 312-5673	not contacted
Carol	Rische	Humboldt Bay Municipal Water Supply	(707) 443-5018	not contacted
Kathleen	Ruttenberg	Woods Hole Oceanographic Institution		not contacted
Pat	Sampson	City of Chandler	(602) 786-2391	not contacted
Jeffrey	Stoner	USGS		not contacted
William	Taylor	City of Gilbert	(602) 503-6470	not contacted
Ken	Velutz	USGS NAWQA	(619) 637-6850	not contacted
Stan	Wiemeyer	USFW Reno	(775) 861-6326	not contacted
Adele	Basham	Nevada Department of Env. Protection	(775) 687-4670	provided contact info.
Bob	Berger	EBMUD	(510) 287 - 1219	provided contact info.
Martha	Conklin	University of Arizona	(520) 621-5829	provided contact info.
Scott	Dawson	Santa Ana RWQCB	(909) 782 - 4493	provided contact info.
Richard	Engel	Humboldt Water Resources	(707) 826-2869	provided contact info.

Appendix A (continued)
EPA Nutrient Criteria Contacts List

First Name	Last Name	Company Name	Work Phone	Status
Marilyn	Ethelbah	Ft. McDowell Indian Community	(480) 816-7141	provided contact info.
Theresa	Foglesong	USGS	(775) 887-7649	provided contact info.
Jill	Geist	City of Arcata	(707) 822-8184	provided contact info.
Chris	Hepe	US EPA Region IX	(707) 825-2311	provided contact info.
David	Herbst	Sierra Nevada Aquatic Research	(760) 935-4536	provided contact info.
Hans	Krock	University of Hawaii (?)		provided contact info.
Michael	Lyons	Region 4 RWQCB (LA)	(213) 576 - 6600	provided contact info.
Mary	Madison	UC ICE	(530) 752-5678	provided contact info.
Pat	Mariella	Gila River Indian Community	(520) 562-2234	provided contact info.
Diana	Marsh	Arizona Dept. of Environmental Quality	(602) 207-4545	provided contact info.
Alan	Miller	CA RWQCB Region 6	(530) 542-5400	provided contact info.
Al	Olsen	USFS	(530) 842-6131	provided contact info.
Bernadette	Reed	CA RWQCB, North Coast Region	(707) 576-2678	provided contact info.
Lynn	Small	City of Santa Rosa	(707) 543-3350	provided contact info.
Gordon	Smith	Hawaii DOH		provided contact info.
Debbie	Smith	Region 4 RWQCB (LA)	(213) 576 - 6600	provided contact info.
Hope	Smyth	Santa Ana RWQCB	(909) 782-4493	provided contact info.
Jeff	Stuck	ADEQ, Drinking Water Division	(602) 207-4617	provided contact info.
Mark	Sylvestor	USGS NAWQA	(650) 329-4415	provided contact info.
Evelyn	Thompkins	DWR Southern District	(818) 543- 4600	provided contact info.
Judith	Unsicker	CRWQCB Region 6, Lahontan	(530) 542-5417	provided contact info.
Erwin	VanNigewonhuyse	USF&WS Stockton	(209) 946-6400	provided contact info.
Dave	Webb	Shasta RCD	(530) 926-2460	provided contact info.
Rita	Whitney	Tahoe Regional Planning Agency	(775) 588-4547	provided contact info.
Mike	Wilson	Humboldt Water Resources	(707) 826-2869	provided contact info.
Robert	Ziemer	USFS PSW Redwood Sciences Laboratory	(707) 825-2936	provided contact info.
Shirley	Birosik	Region 4 RWQCB (LA)	sbirosik@rb4.swrcb.ca.gov	sent data
Jerry	Boles	CA Department of Water Resources, N. District	(530) 529-7326	sent data
Lorrie	Bundy	Siskiyou RCD	(530) 467-3975	sent data
James	Carter	USGS Menlo Park	(650) 329-4439	sent data
Greg	Crawford	HSU Oceanography Dept.	(707) 826-3466	sent data
Randy	Dahlgren	UC Davis, Dept. of Land, Air and Water Resources	(530) 752-2814	sent data
Larry	Dugan	Bureau of Reclamation	(541) 883-6935	sent data
Greg	Elliott	Salt River Project	(602) 236-5545	sent data
Susan	Fitch	AZ DEQ, Clean Lakes Program	(602) 207-4521	sent data
Sid	Fong	Bright Chemical Laboratories	(916) 375-6008	sent data
Gary	Gilbreath	DWR Southern District	(818) 543- 4600	sent data
Bruce	Gwynn	CA Regional Water Quality CB, North Coast Region	(707) 576-2661	sent data
Robert K.	Hall	US EPA Region IX	(415) 744-1936	sent data

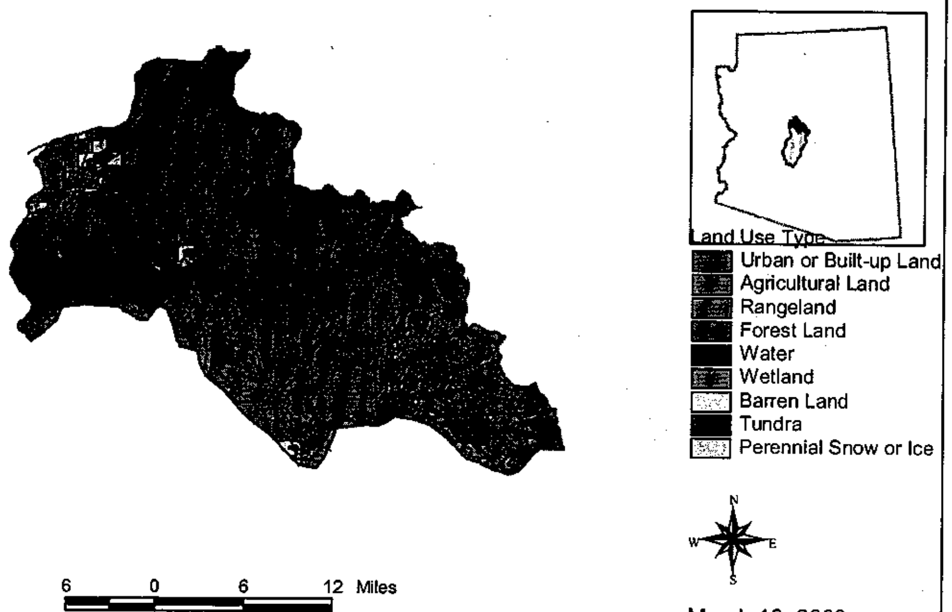
Appendix A (continued)
EPA Nutrient Criteria Contacts List

First Name	Last Name	Company Name	Work Phone	Status
Mark	Harvey	CA Regional WQCB, Central Valley Region	(530) 224-4856	sent data
John	Heggeness	NV Dept. Env. Protection	(775) 687-4670	sent data
Rodney	Jung	EBMUD	(510) 287-1219	sent data
Perry	LeBeouf	CA DWR	(530) 529-7394	sent data
Alan	McKay	Desert Research Institute	(775) 673-7384	sent data
John	Munn	US Forest Service	(916) 653-5843	sent data
Mike	Napolitano	Region 2 RWQCB (San Francisco)	(510) 622-2397	sent data
James	Omernik	US EPA		sent data
Peter	Otis	CA Regional Water QCB N. Coast Region	(707) 576-2662	sent data
Sam	Rector	AZ Dept. of Env. Quality	(602) 207-4536	sent data
Amanda	Ryan	AZ Dept. of Environmental Quality	(602) 207-4521	sent data
Tom	Scott	Lake Merry Water Treatment Plant	(520) 774-0262	sent data
Patti	Spindler	AZ Dept. of Environmental Quality	(602) 207-4543	sent data
Ron	Stillwell	City of Williams	(520) 635-4451	sent data
Richard	Svetich	Tahoe Truckee Sanitation Agency	(530) 587-2525	sent data
Judith	Unsicker	Lahontan RWQCB - Northern District region 6	(530)542- 5417	sent data
Pavlova	Vitale	Santa Ana RWQCB	(909) 782 - 4493	sent data
Brian	White	Los Angeles Dept of Power and Water	(213) 367 - 3419	sent data
Rich	Breuer	DWR Central District	(916) 327 - 1725	will send data
Kevin	McKernan	Hoopa Tribe	(530) 625-5515	will send data



Station: MGARF065.00
Basin: Agua Fria
Site: Agua Fria River Below Gaging Station

Agua Fria MGARF065.00 Subbasin Land Use

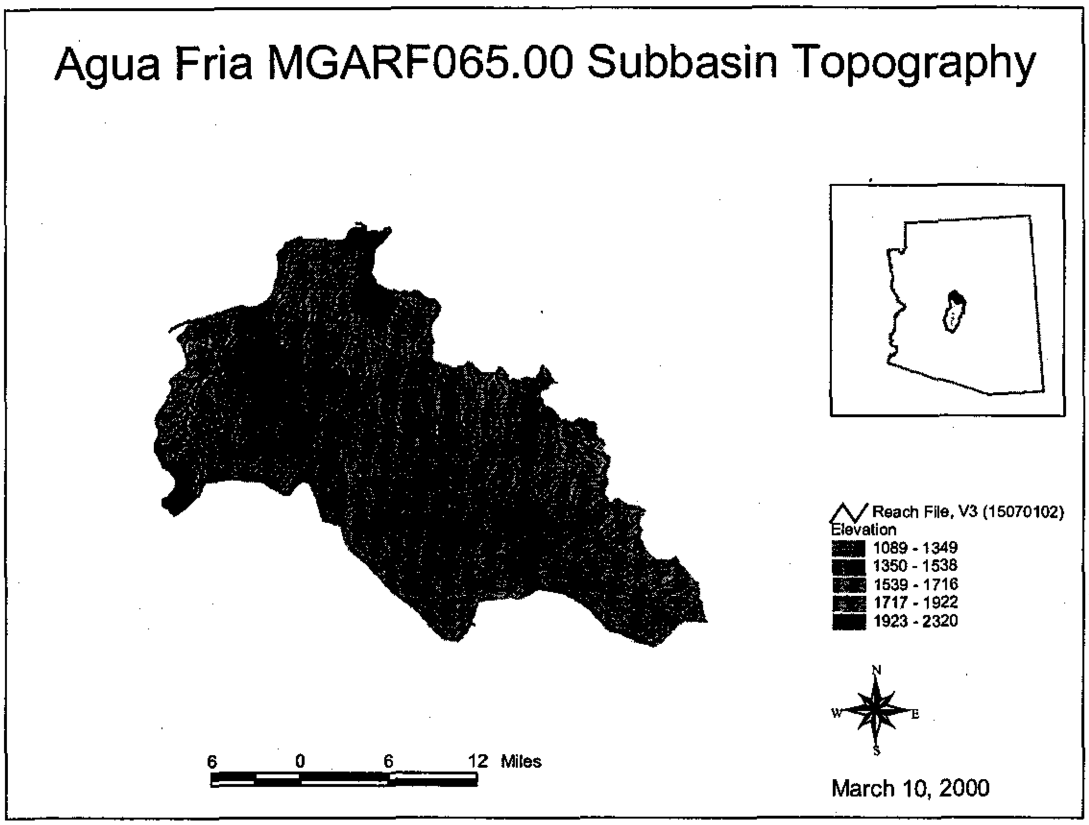


March 10, 2000

Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	4364
COMMERCIAL AND SERVICES-12	324
INDUSTRIAL-13	108
TRANS, COMM, UTIL-14	1961
MXD URBAN OR BUILT-UP-16	296
OTHER URBAN OR BUILT-UP-17	176
Subtotal	7229
Agricultural Land	
CROPLAND AND PASTURE-21	1442
OTHER AGRICULTURAL LAND-24	124
Subtotal	1566
Forest Land	
EVERGREEN FOREST LAND-42	112611
Subtotal	112611
Range Land	
SHRUB & BRUSH RANGELAND-32	172470
MIXED RANGELAND-33	36801
Subtotal	209271

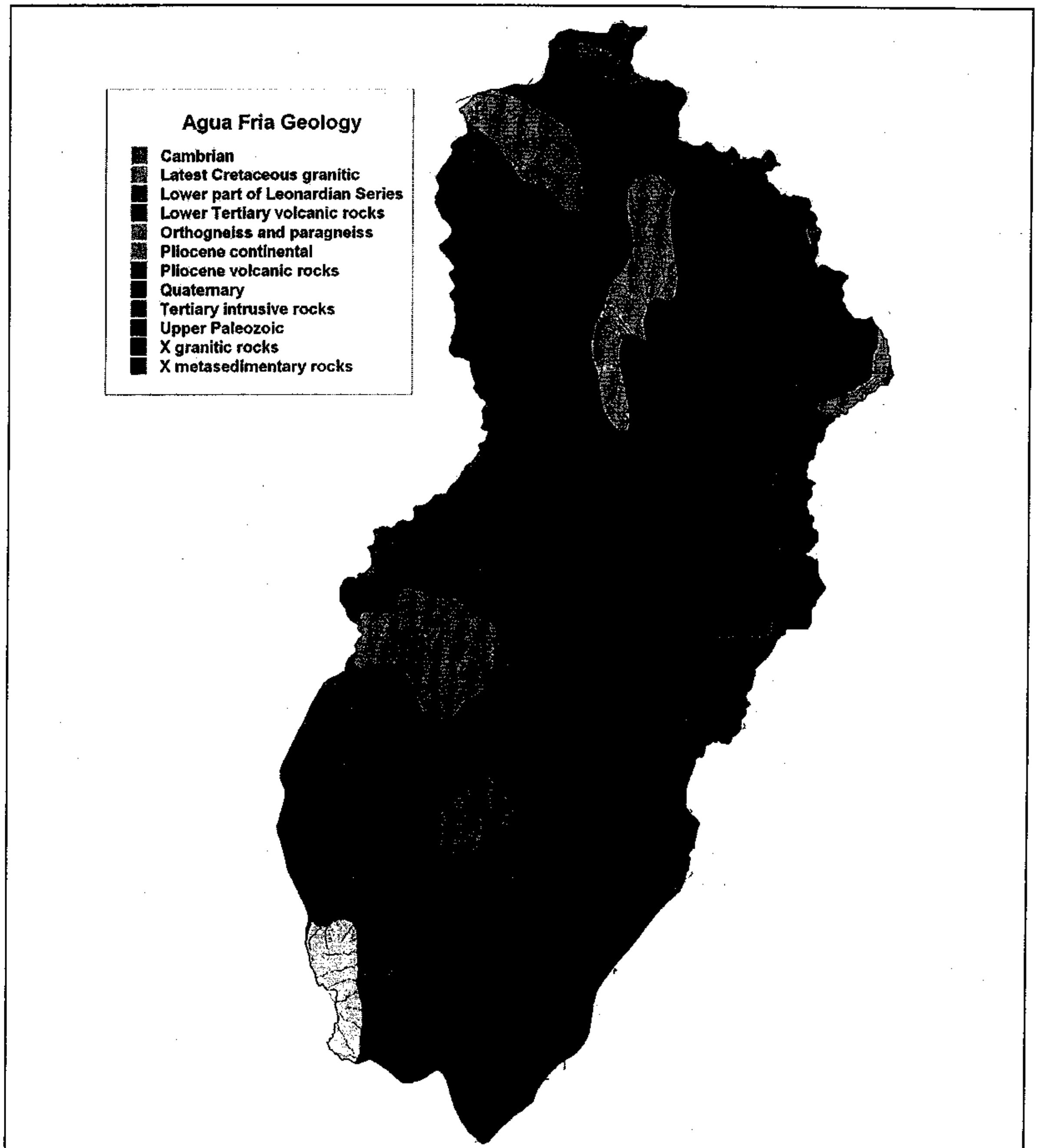
18098

Water	
RESERVOIRS-53	192
Subtotal	192
Barren Land	
STRIP MINES-75	1272
TRANSITIONAL AREAS-76	4469
Subtotal	5741
============================	
Total	336610



Min. Elevation: 1089
Max. Elevation: 2320
Mean Elevation: 1535.31
Median Elevation: 1523
Std. Deviation: 233.294

Average Stream Gradient: 0.38259



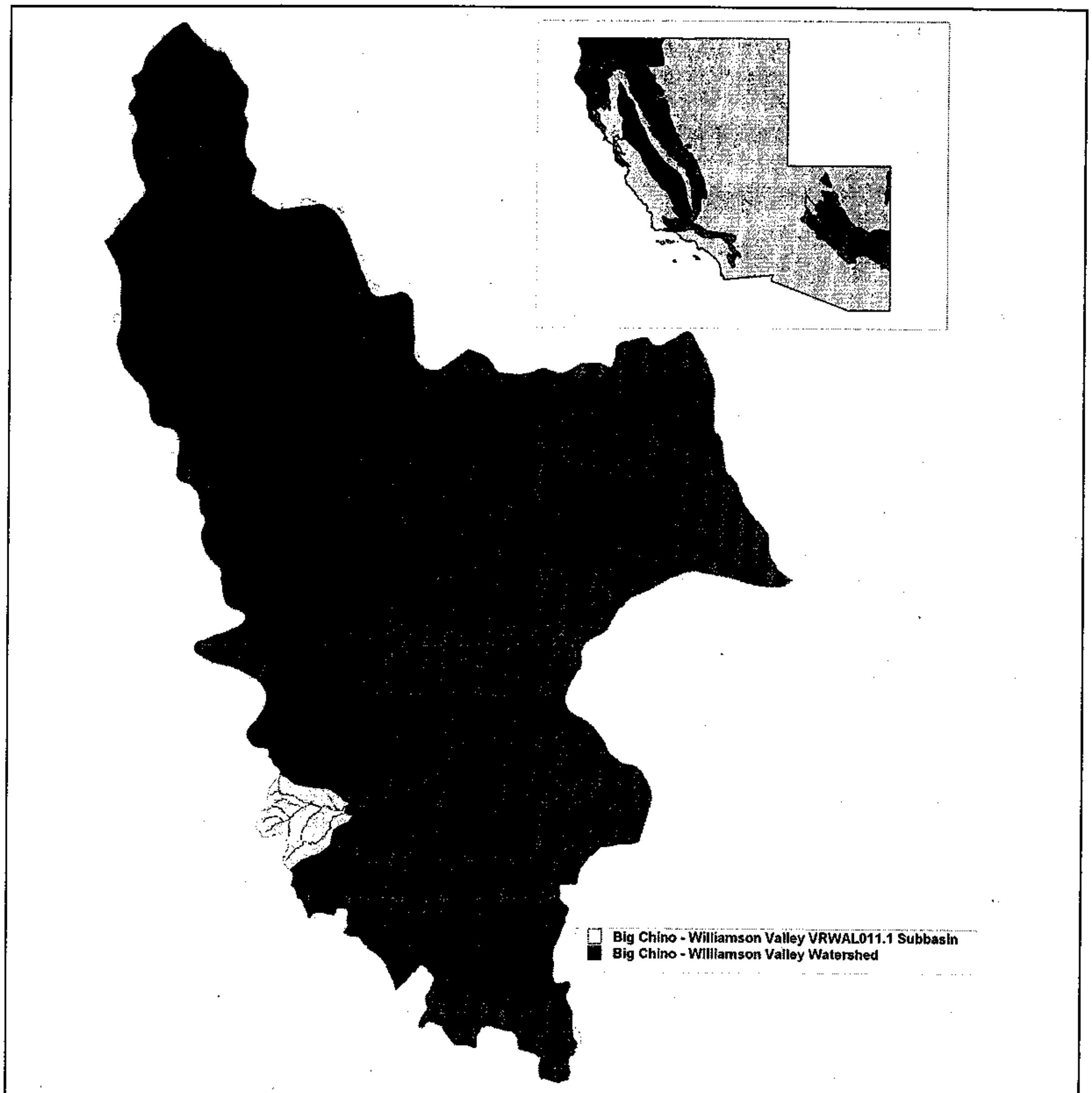
Geology in Agua Fria MGAFR065.00 Subbasin:

ROCKDESC	Acres
Cambrian	8810.13
X metasedimentary rocks	99819.87
Lower part of Leonardian Series	1666.92
Quaternary	8526.34

18100

X granitic rocks	28272.03
Upper Paleozoic	7773.88
Pliocene continental	60107.69
Pliocene volcanic rocks	120297.81

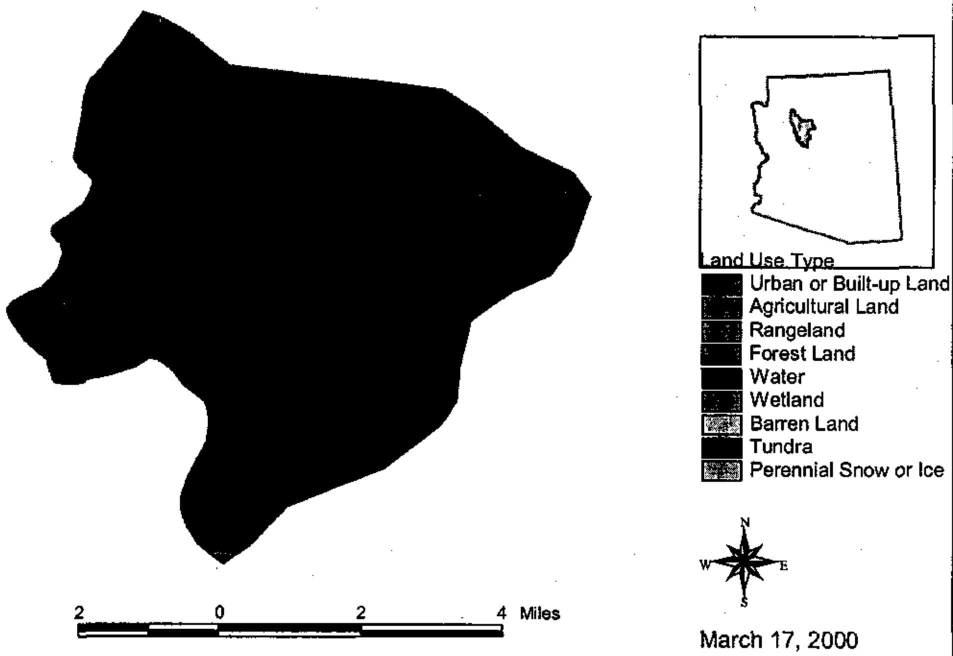
Drainage Area	523.9 sq mi
Stream Order	5
Flow Characteristics	1978 - 1998 Median: 4.50 cfs



Station: VRWAL011.1
Basin: Big Chino - Williamson Valley
Site: Walnut Creek Above Forest Service Road #95

18102

Big Chino VRWAL011.1 Subbasin Land Use

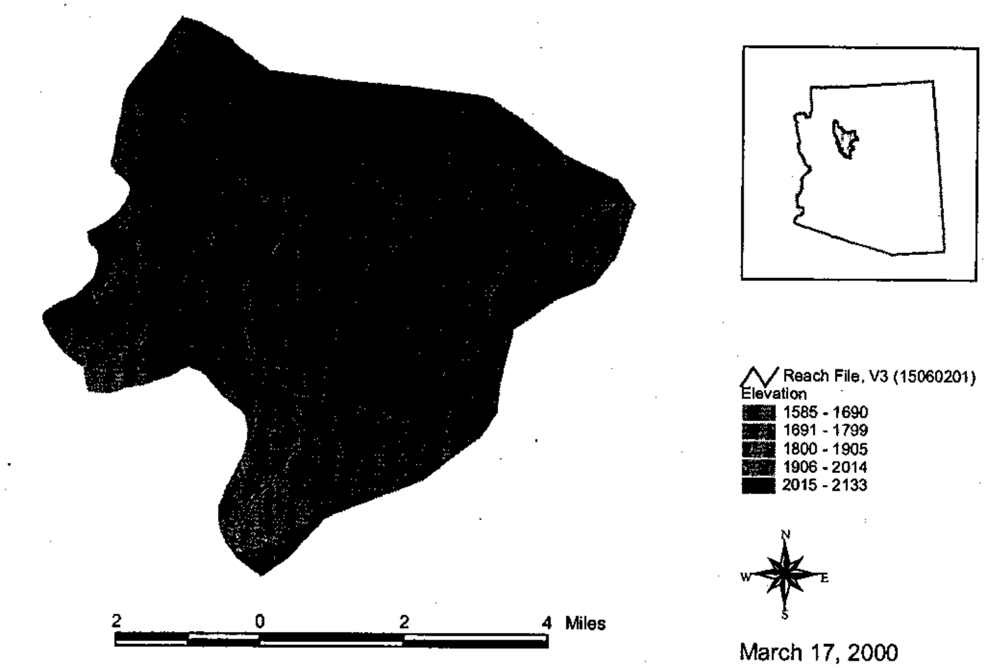


March 17, 2000

Land Use Name and Code	Area (acres)
Forest Land	
EVERGREEN FOREST LAND-42	22260
Subtotal	22260
Range Land	
SHRUB & BRUSH RANGELAND-32	198
Subtotal	198
Total	22458

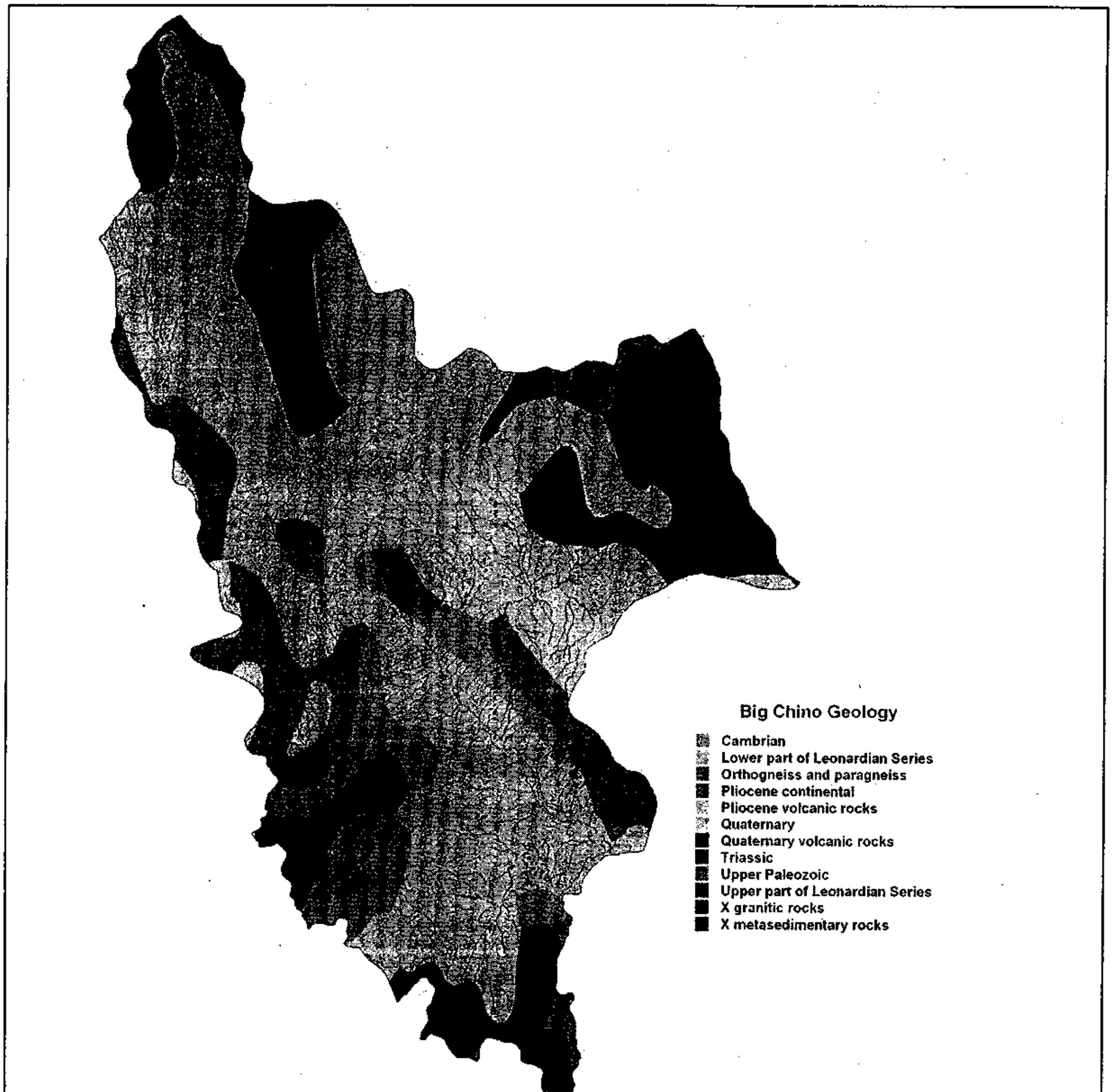
18103

Big Chino VRWAL011.1 Subbasin Topography



Min. Elevation: 1585
Max. Elevation: 2133
Mean Elevation: 1834.64
Median Elevation: 1873
Std. Deviation: 138.037

Average Stream Gradient: 2.19021

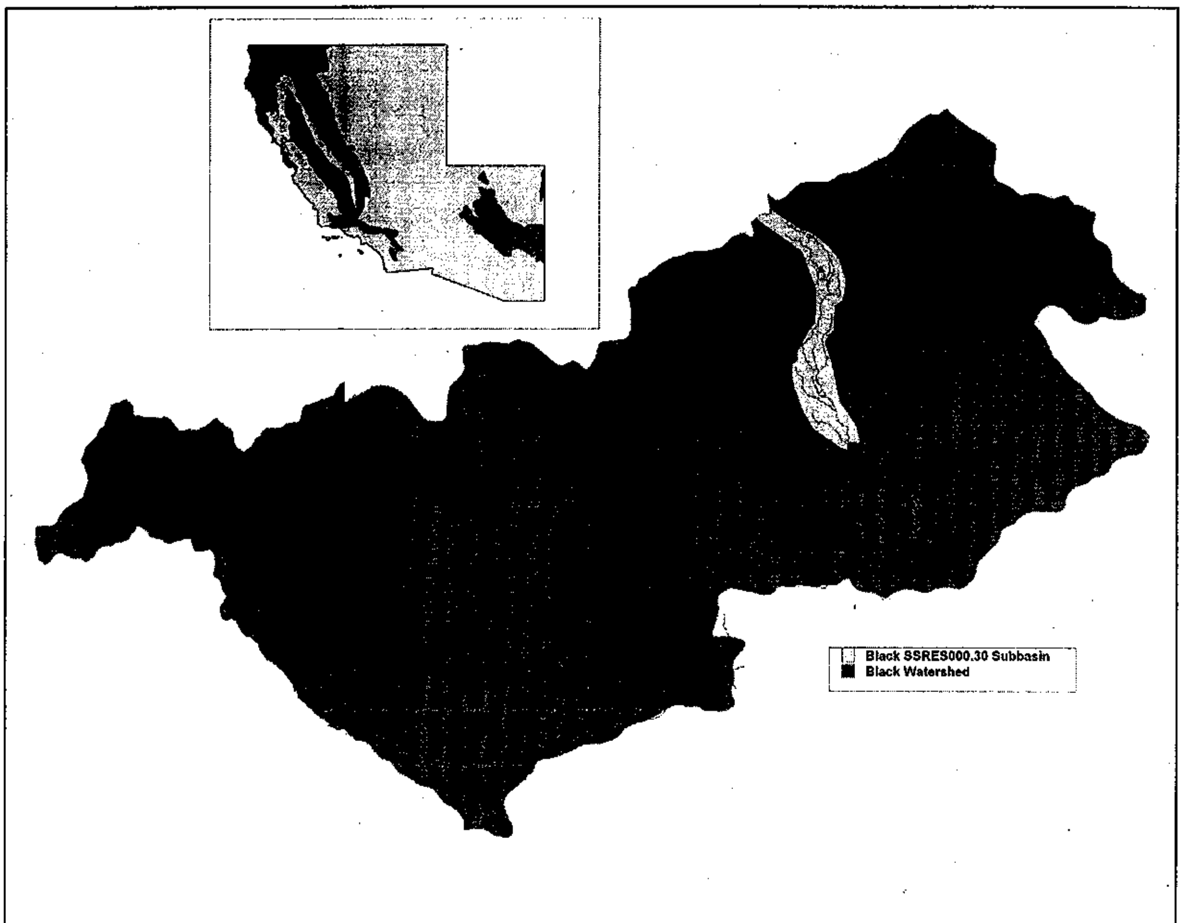


Geology in Big Chino VRWAL011.1 Subbasin:

ROCKDESC	Acres
Orthogneiss and paragneiss	556.355
Pliocene volcanic rocks	62.5875
Upper Paleozoic	157.875
X granitic rocks	15735.17
Cambrian	5889.07

18105

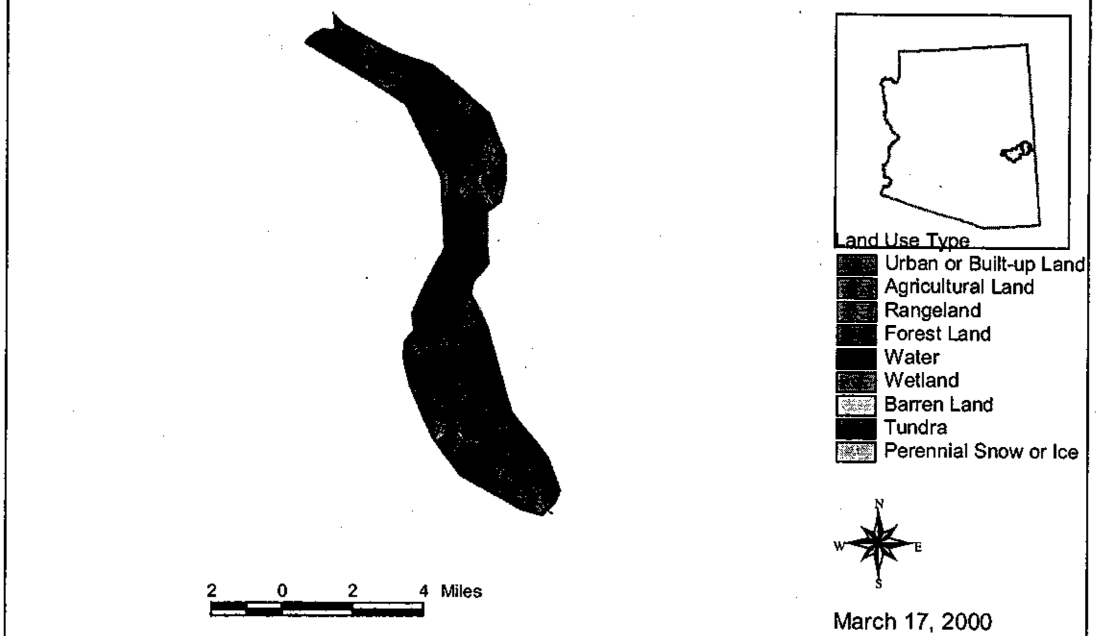
Drainage Area	35.00 sq mi
Stream Order	3
Flow Characteristics	Not available



Station: SRRES000.30
Basin: Black
Site: Reservation Creek Above Black River Confluence

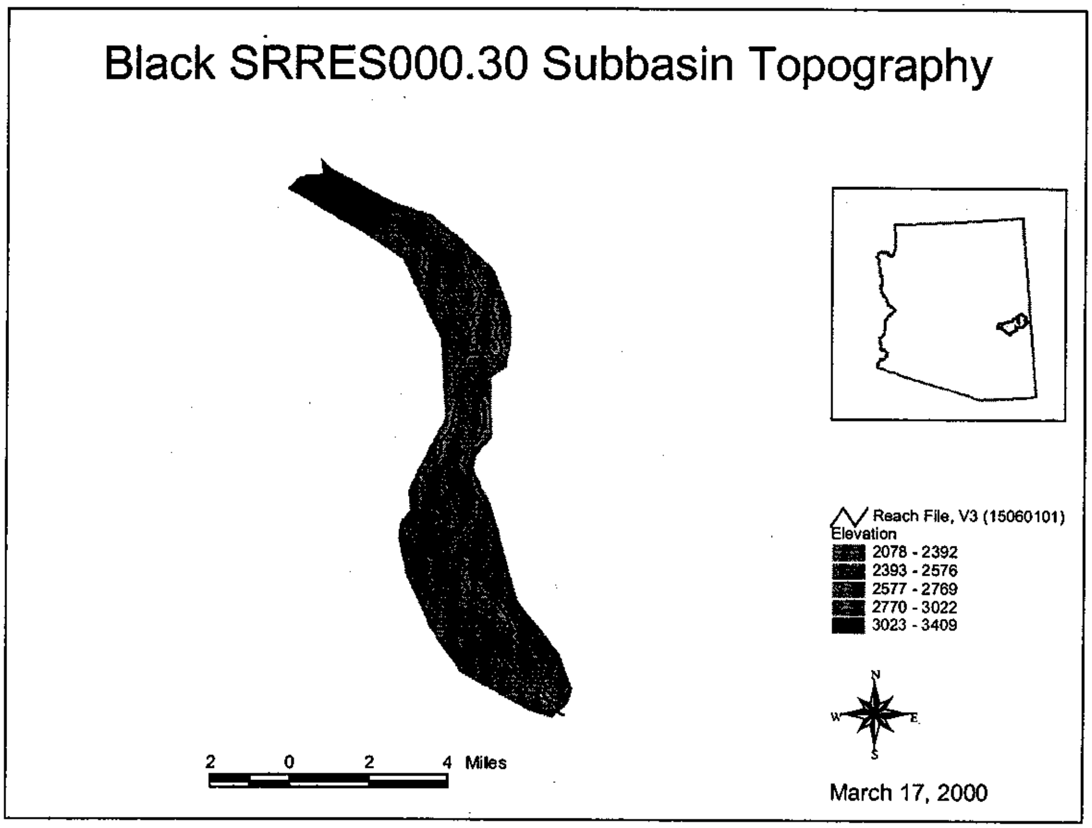
18107

Black SRRES000.30 Subbasin Land Use



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
OTHER URBAN OR BUILT-UP-17	219
Subtotal	219
Agricultural Land	
OTHER AGRICULTURAL LAND-24	9
Subtotal	9
Forest Land	
DECIDUOUS FOREST LAND-41	660
EVERGREEN FOREST LAND-42	8661
MIXED FOREST LAND-43	6590
Subtotal	15911
Range Land	
SHRUB & BRUSH RANGELAND-32	536
MIXED RANGELAND-33	723
Subtotal	1259
Water	
RESERVOIRS-53	322
Subtotal	322

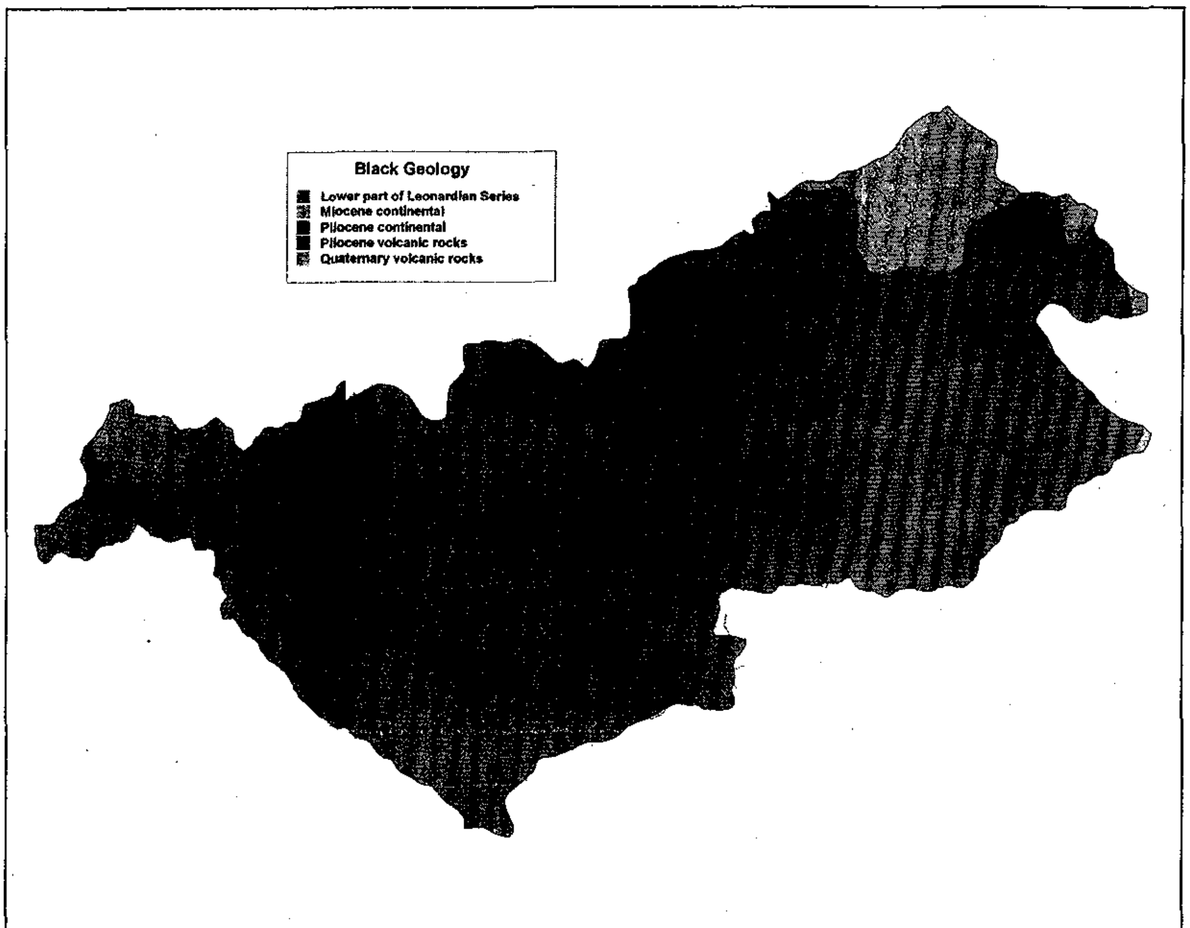
WetLand	
NONFORESTED WETLAND-62	143
Subtotal	143
==	
Total	17863



Min. Elevation: 2078
Max. Elevation: 3409
Mean Elevation: 2647.57
Median Elevation: 2583
Std. Deviation: 296.683

Average Stream Gradient: 17.2117

18109



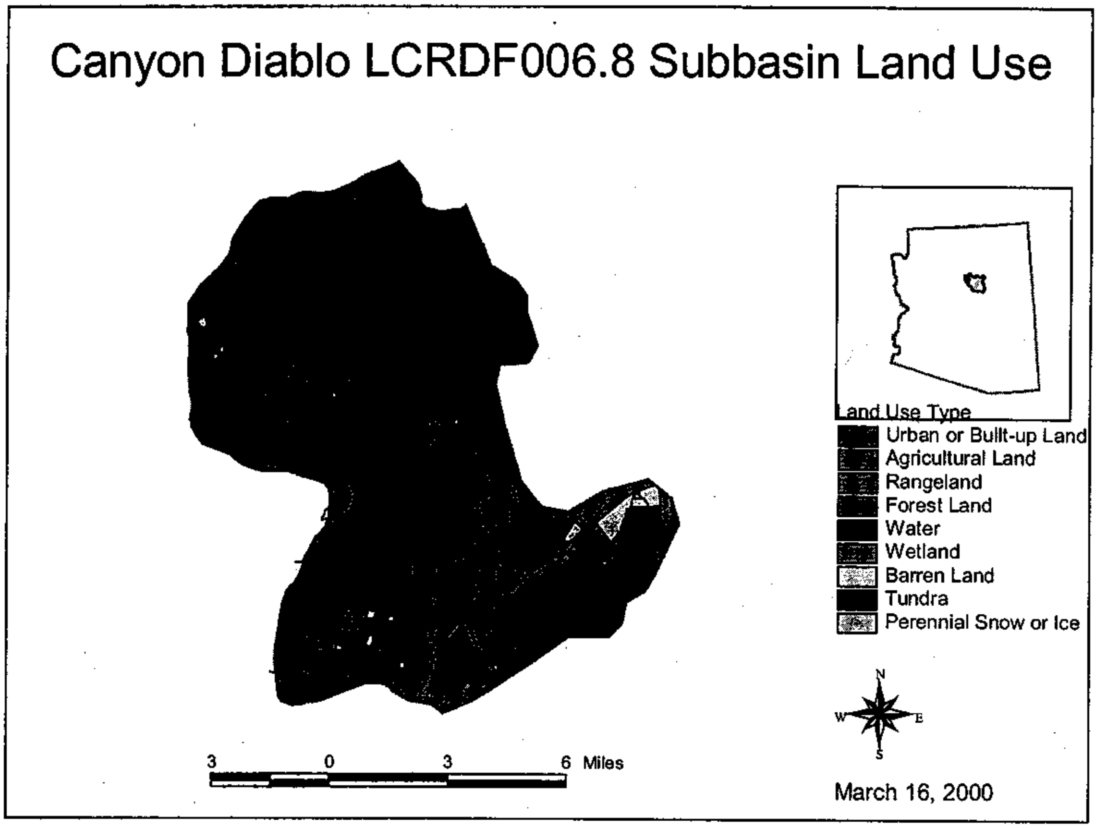
Geology in Black SSRES000.30 Subbasin:

ROCKDESC	Acres
Pliocene volcanic rocks	17671.9

Drainage Area	27.61 sq mi
Stream Order	2
Flow Characteristics	Not available

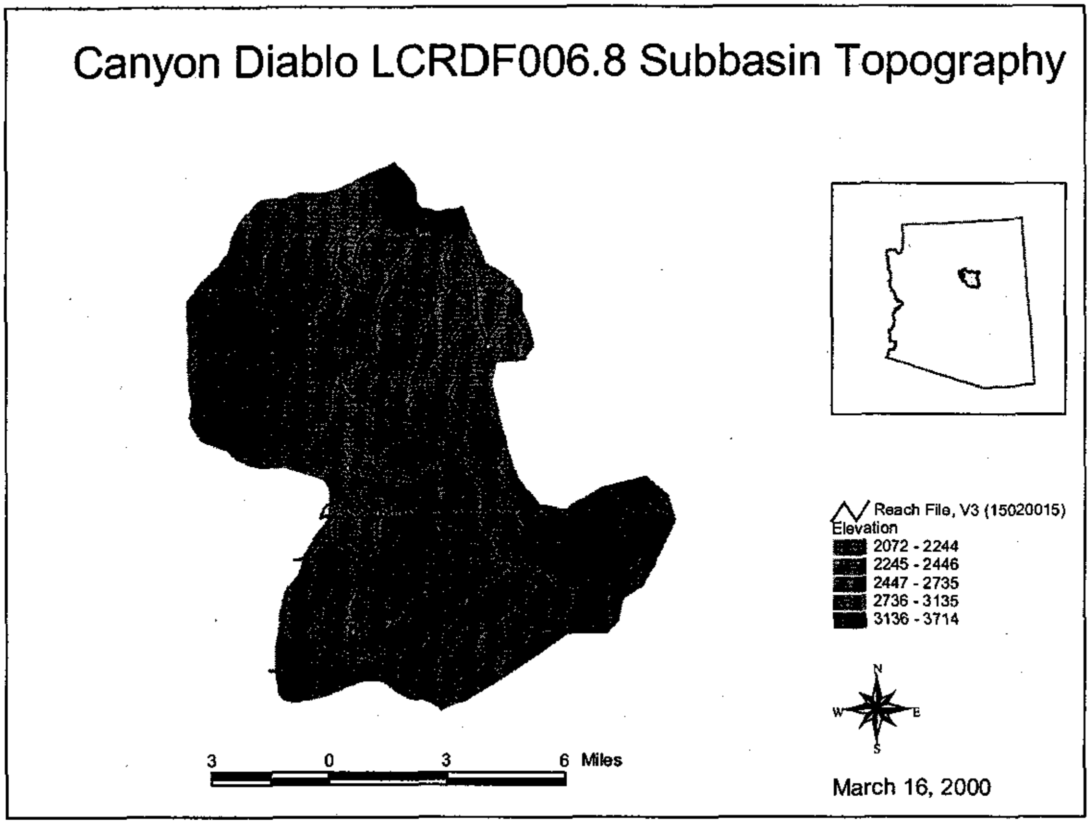
Station: LCRDF006.8
Basin: Canyon Diablo
Site: Rio De Flag Below Flagstaff

18111



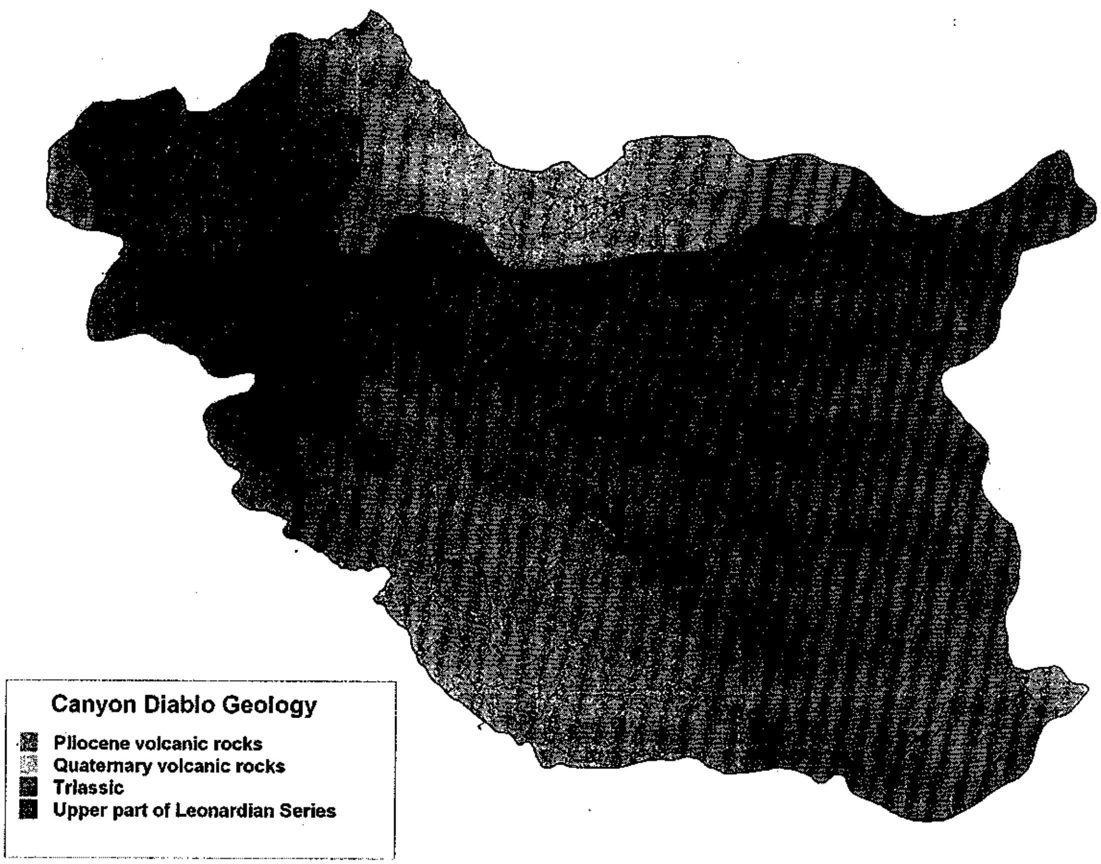
Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	1999
COMMERCIAL AND SERVICES-12	609
INDUSTRIAL-13	108
TRANS, COMM, UTIL-14	1356
MXD URBAN OR BUILT-UP-16	2261
OTHER URBAN OR BUILT-UP-17	374
Subtotal	6707
Agricultural Land	
CROPLAND AND PASTURE-21	483
Subtotal	483
Forest Land	
EVERGREEN FOREST LAND-42	48544
MIXED FOREST LAND-43	4696
Subtotal	53240
Range Land	
MIXED RANGELAND-33	2542
Subtotal	2542

Water	
RESERVOIRS-53	11
Subtotal	11
Barren Land	
STRIP MINES-75	185
TRANSITIONAL AREAS-76	618
Subtotal	803
Tundra	
MIXED TUNDRA-85	155
Subtotal	155
===	
Total	63941



Min. Elevation: 2072
Max. Elevation: 3714
Mean Elevation: 2386.1
Median Elevation: 2333
Std. Deviation: 289.063

Average Stream Gradient: 0.635612

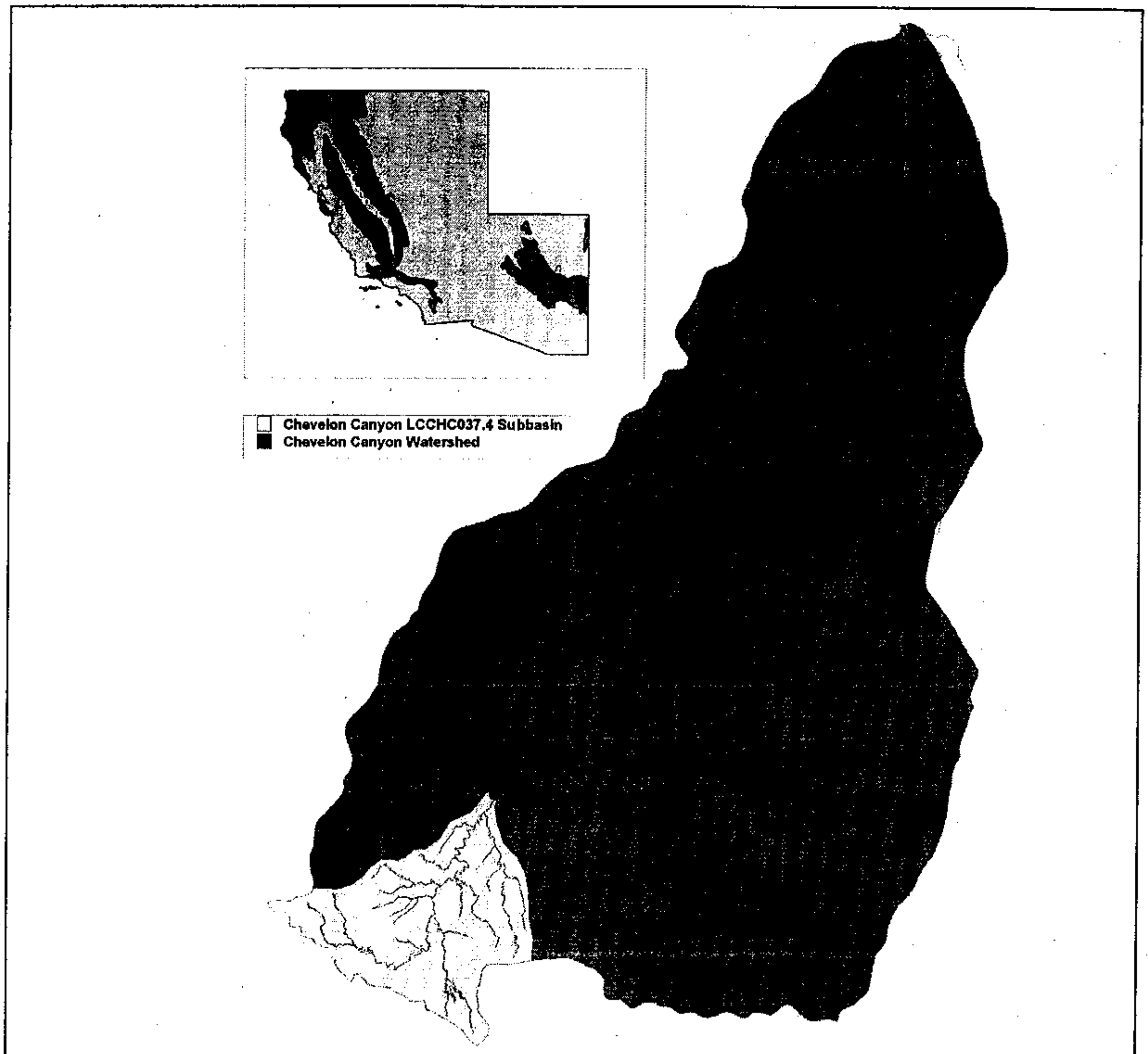


Geology in Canyon Diablo LCRDF006.8 Subbasin:

ROCKDESC	Acres
Quaternary volcanic rocks	4674.18
Pliocene volcanic rocks	40189.35
Upper part of Leonardian Series	18761.77

Drainage Area	99.41 sq mi
Stream Order	3
Flow Characteristics	Not available

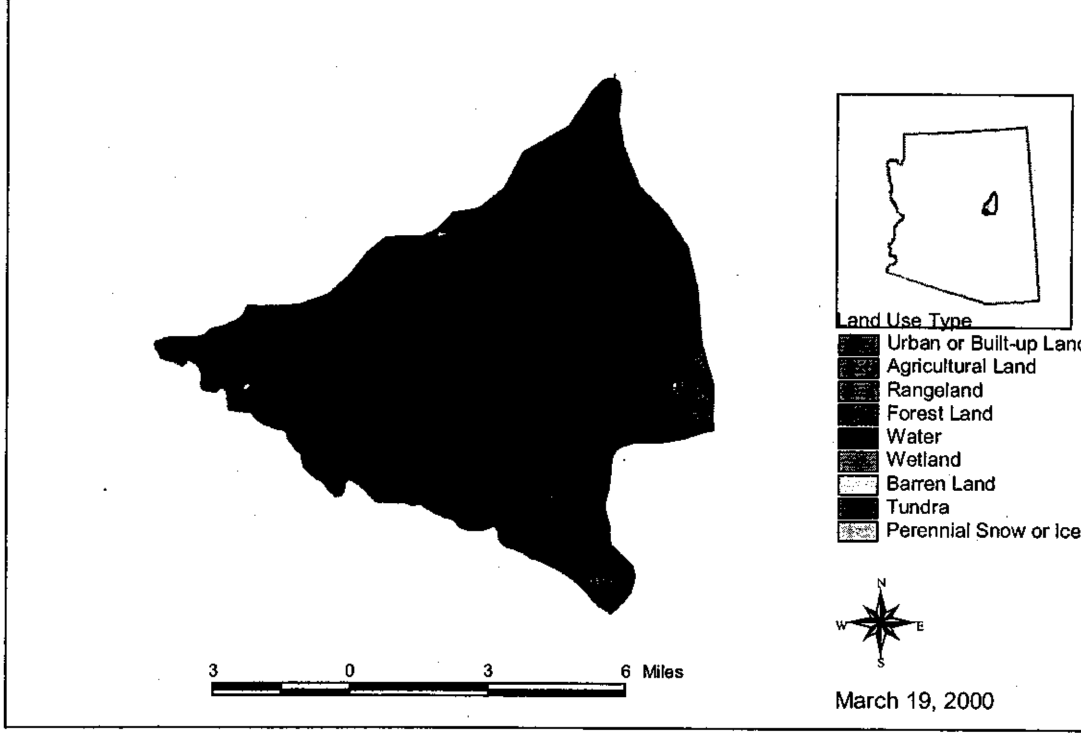
18114



Station: LCCHC037.4
Basin: Chevelon Canyon
Site: Chevelon Canyon Creek At Telephone Ridge

18115

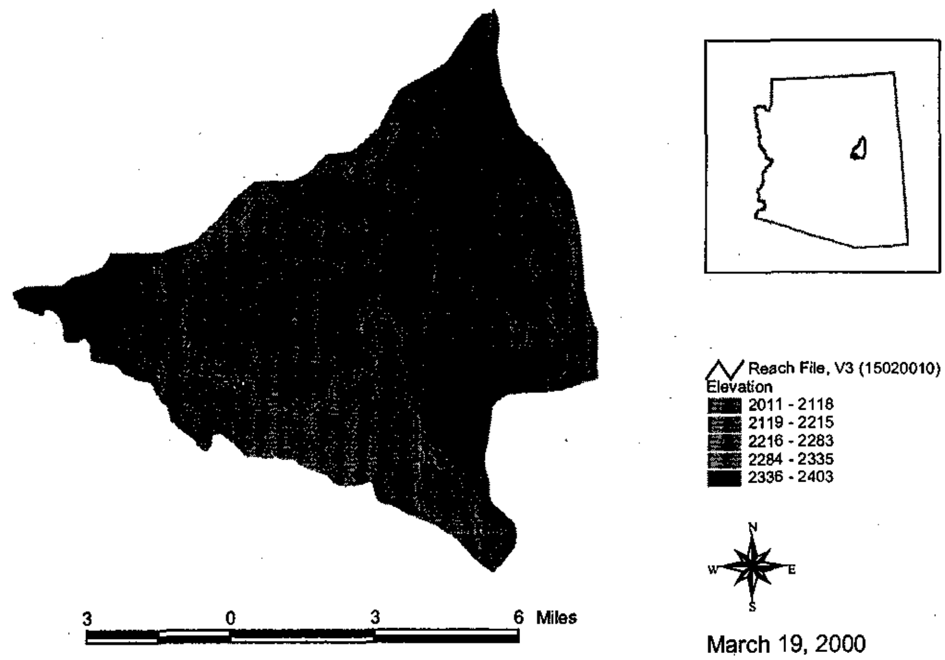
Chevelon Canyon LCCHC037.4 Subbasin Land Use



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	338
Subtotal	338
Forest Land	
EVERGREEN FOREST LAND-42	41038
Subtotal	41038
Water	
RESERVOIRS-53	151
Subtotal	151
Barren Land	
STRIP MINES-75	49
Subtotal	49
Total	41576

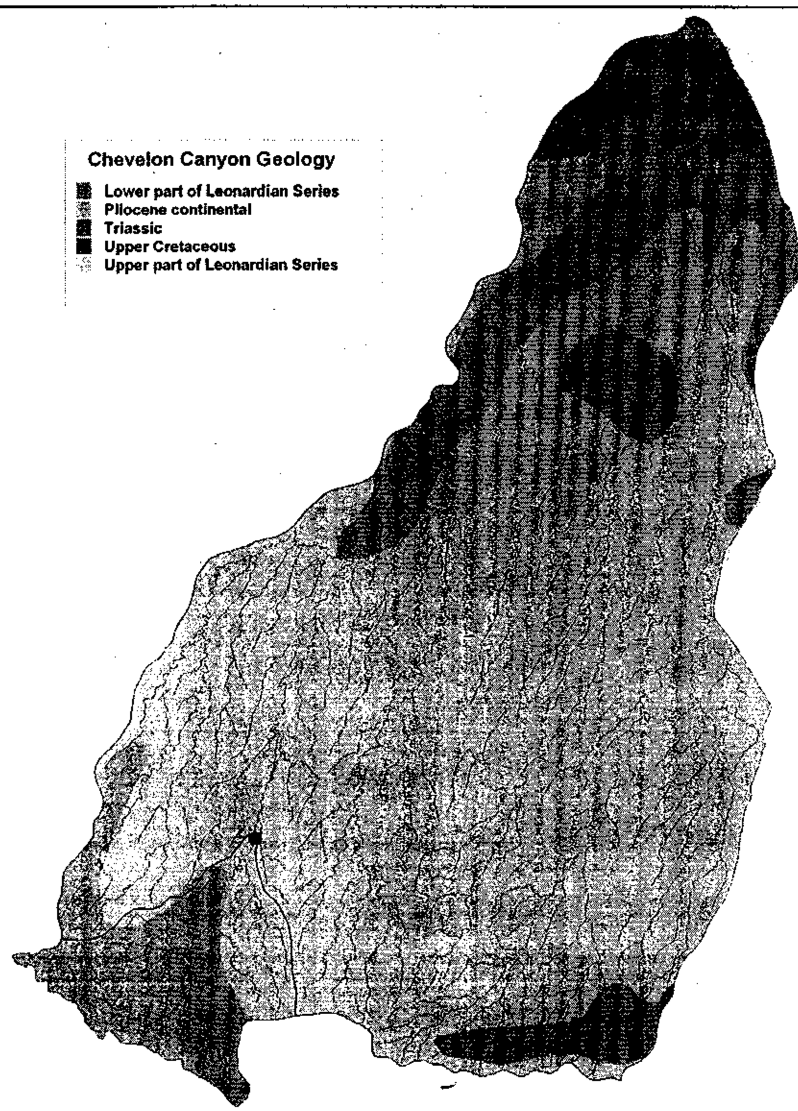
18116

Chevelon Canyon LCCHC037.4 Subbasin Topography



Min. Elevation: 2011
Max. Elevation: 2403
Mean Elevation: 2253.88
Median Elevation: 2328
Std. Deviation: 78.4516

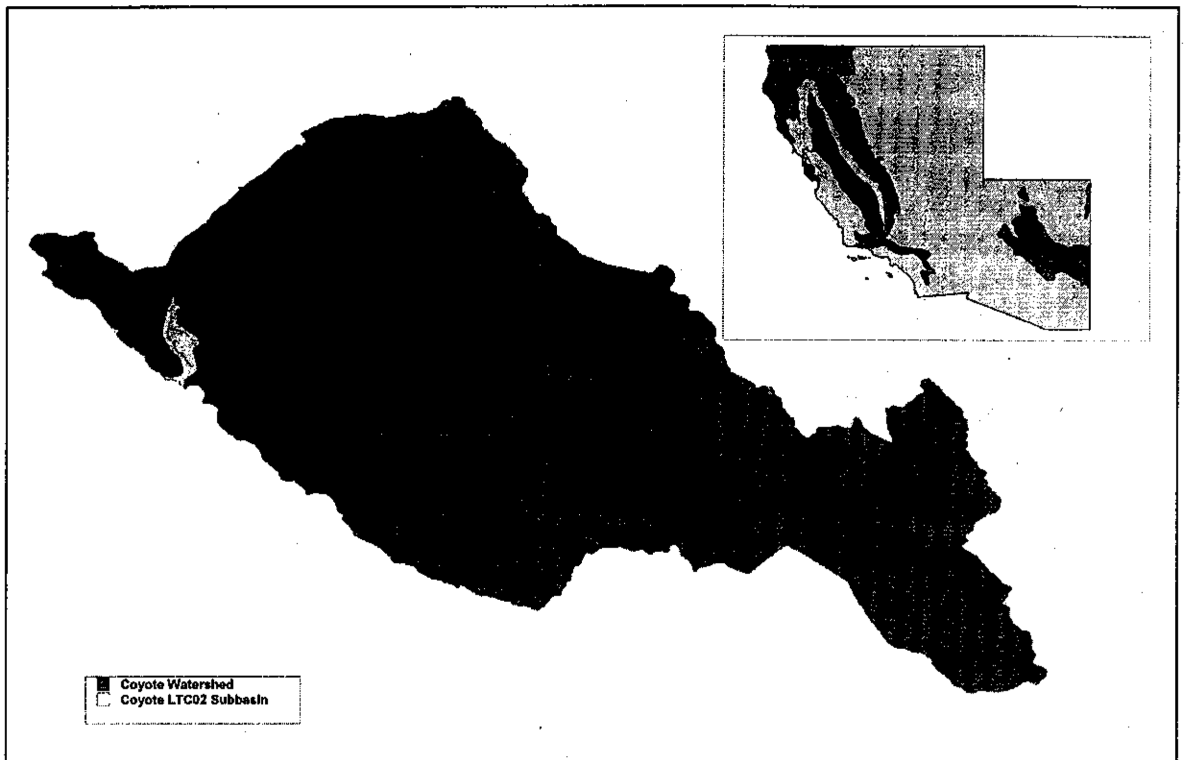
Average Stream Gradient: 16.1798



Geology in Chevelon Canyon LCCHC037.4 Subbasin:

ROCKDESC	Acres
Lower part of Leonardian Series	29571.57
Upper part of Leonardian Series	11725.25

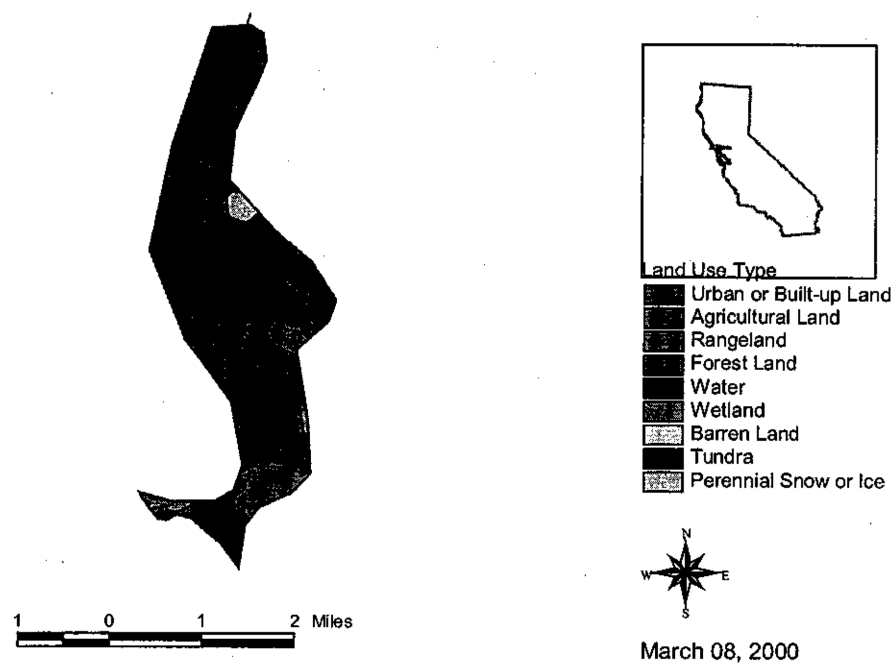
Drainage Area	64.53 sq mi
Stream Order	3
Flow Characteristics	Not available



Station: LTC02
Basin: Coyote
Site: Los Trancos Ck

18119

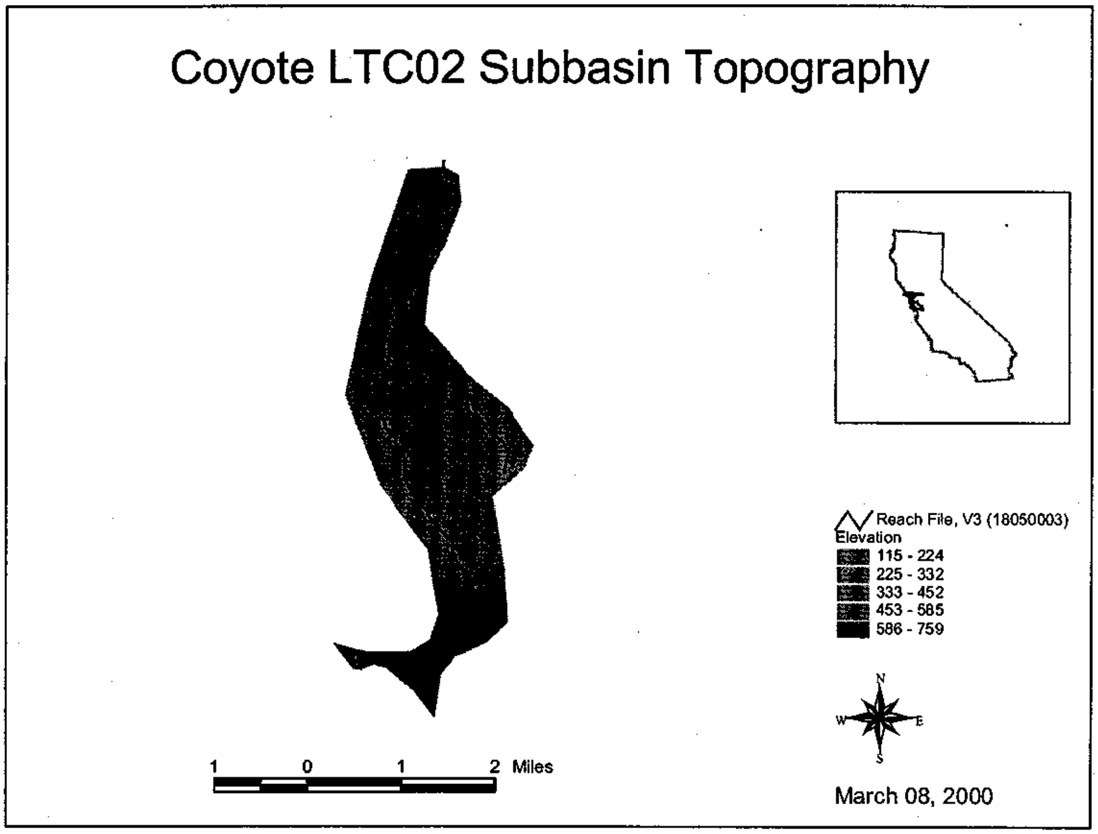
Coyote LTC02 Subbasin Land Use



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	547
COMMERCIAL AND SERVICES-12	16
MXD URBAN OR BUILT-UP-16	64
OTHER URBAN OR BUILT-UP-17	2
Subtotal	629
Agricultural Land	
OTHER AGRICULTURAL LAND-24	11
Subtotal	11
Forest Land	
EVERGREEN FOREST LAND-42	2471
Subtotal	2471
Range Land	
HERBACEOUS RANGELAND-31	228
SHRUB & BRUSH RANGELAND-32	111
Subtotal	339
Barren Land	
STRIP MINES-75	48

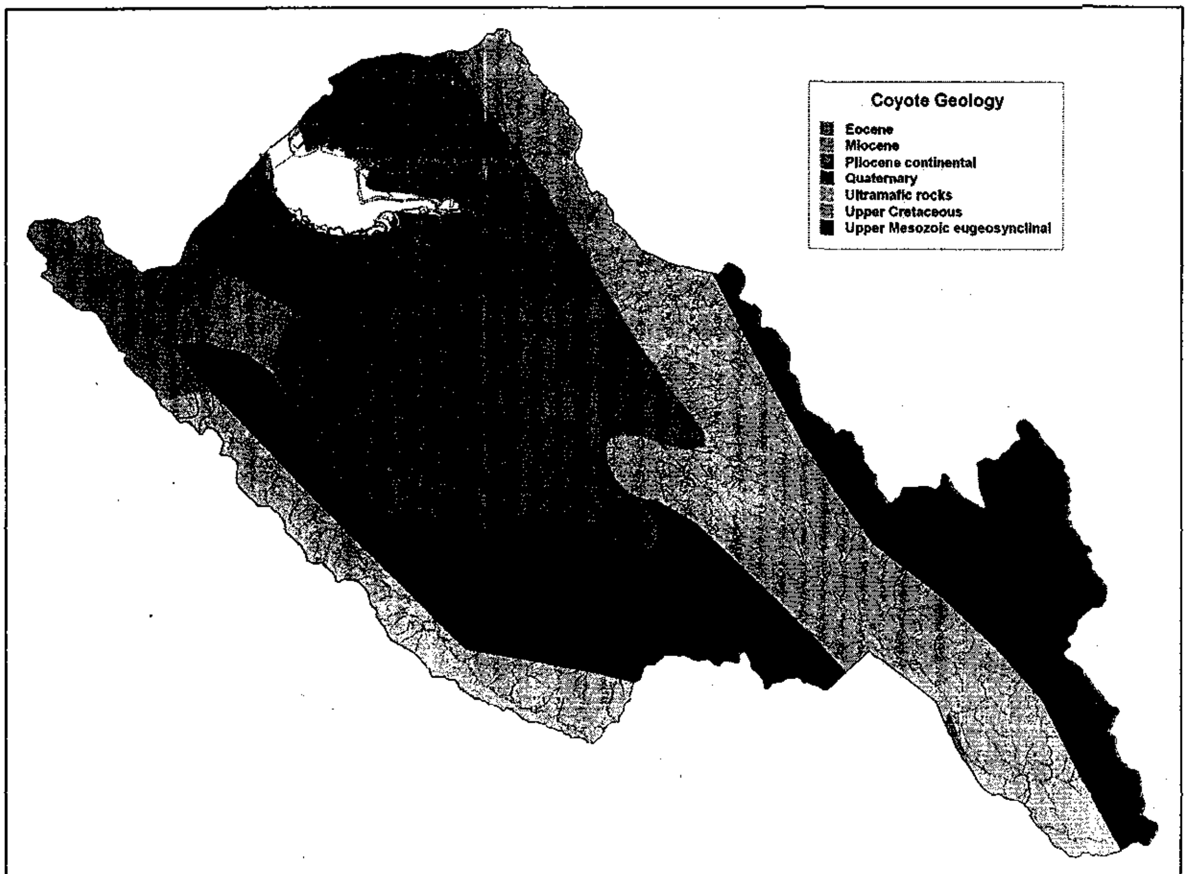
18120

Subtotal	48
===	
Total	3498



Min. Elevation: 115
Max. Elevation: 759
Mean Elevation: 388.314
Median Elevation: 366
Std. Deviation: 184.952

Average Stream Gradient: 1.90673

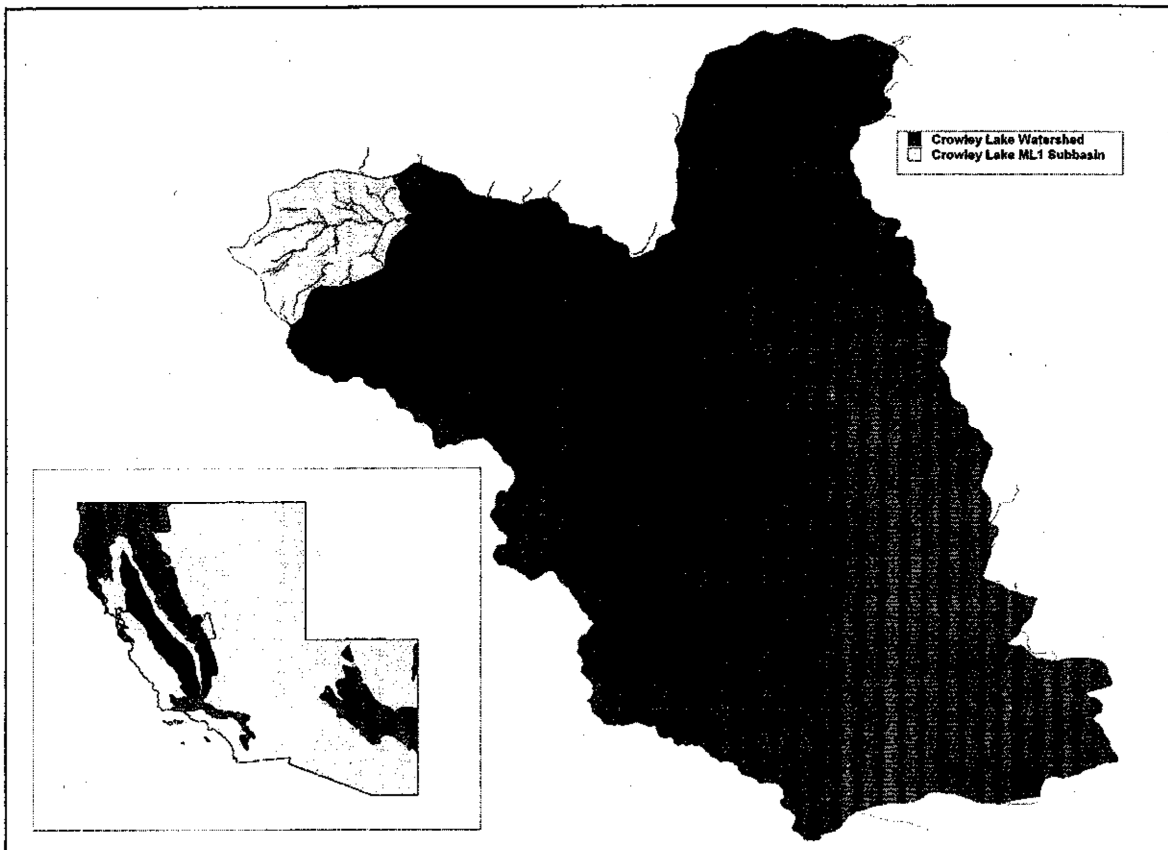


Geology in Coyote Creek LTC02 Subbasin:

ROCKDESC	Acres
Miocene	809.858
Eocene	1508.53
Upper Mesozoic eugeosynclinal	1162.04

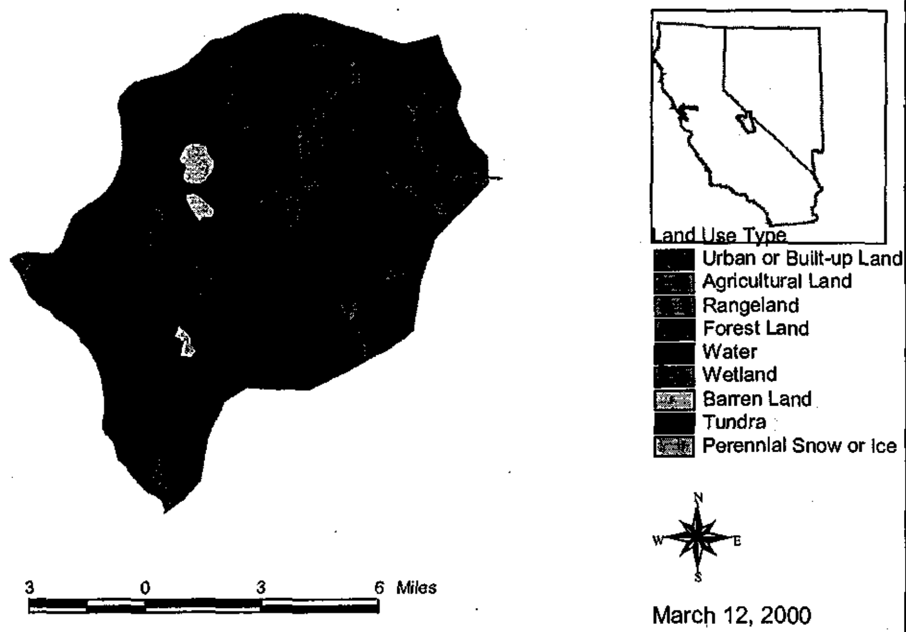
Drainage Area	5.438 sq mi
Stream Order	2
Flow Characteristics	Not available

18122



Station: ML1
Basin: Crowley lake
Site: Picked off map

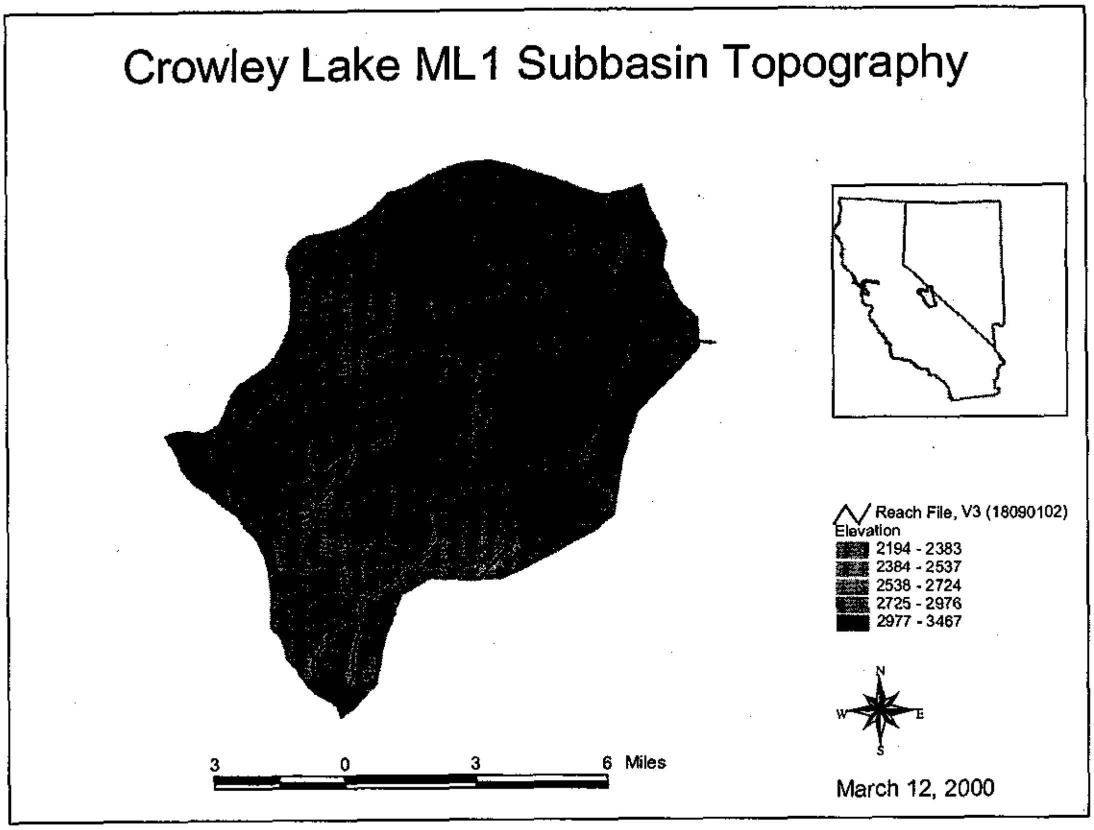
Crowley Lake ML1 Subbasin Land Use



March 12, 2000

Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	17
COMMERCIAL AND SERVICES-12	26
Subtotal	43
Forest Land	
EVERGREEN FOREST LAND-42	47682
Subtotal	47682
Range Land	
SHRUB & BRUSH RANGELAND-32	6644
MIXED RANGELAND-33	643
Subtotal	7287
Barren Land	
BARE EXPOSED ROCK-74	926
Subtotal	926
Tundra	
SHRUB AND BRUSH TUNDRA-81	214
Subtotal	214

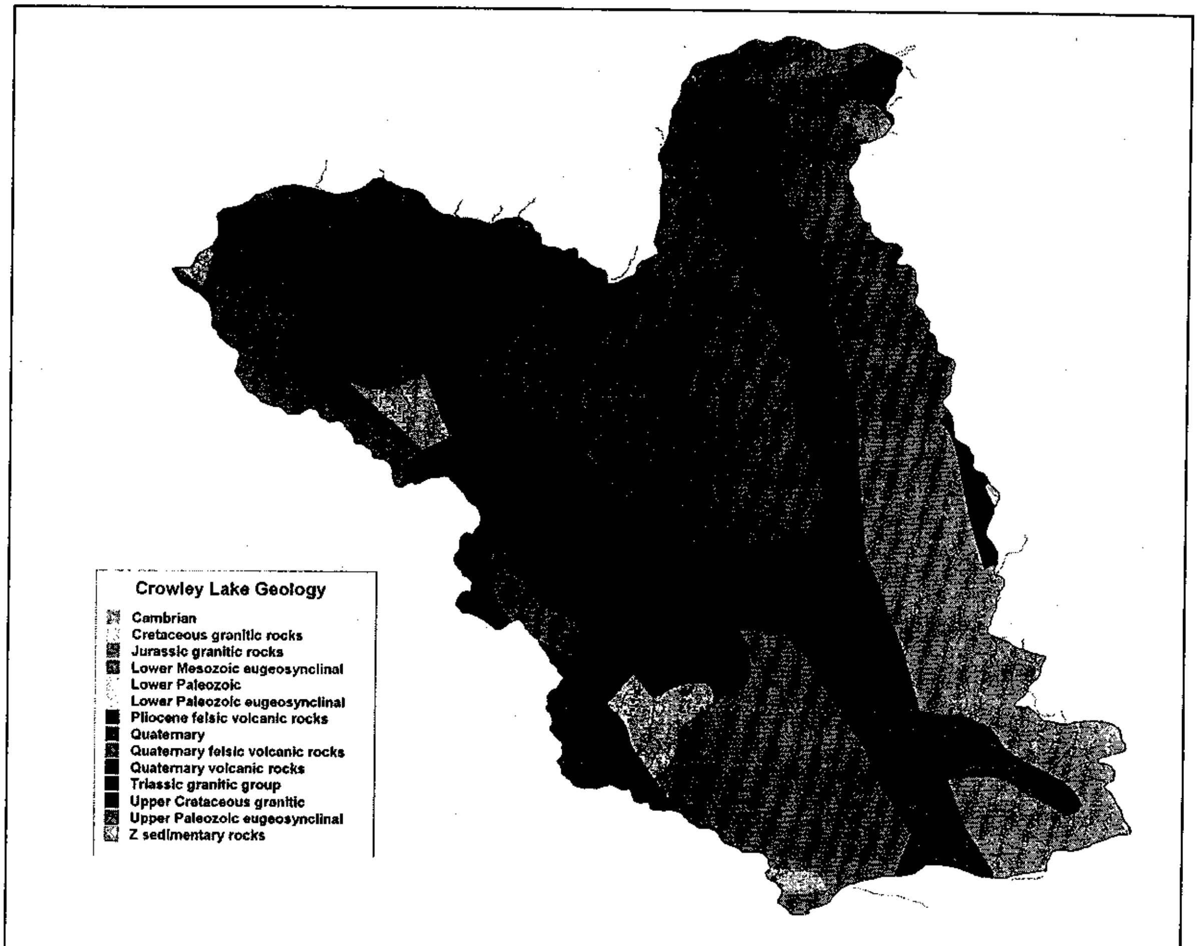
```
=======================================================
Total                                  56152
```




```
Min. Elevation: 115
Max. Elevation: 759
Mean Elevation: 388.314
Median Elevation: 366
Std. Deviation: 184.952
```

```
Average Stream Gradient:  0.183692
```


18125

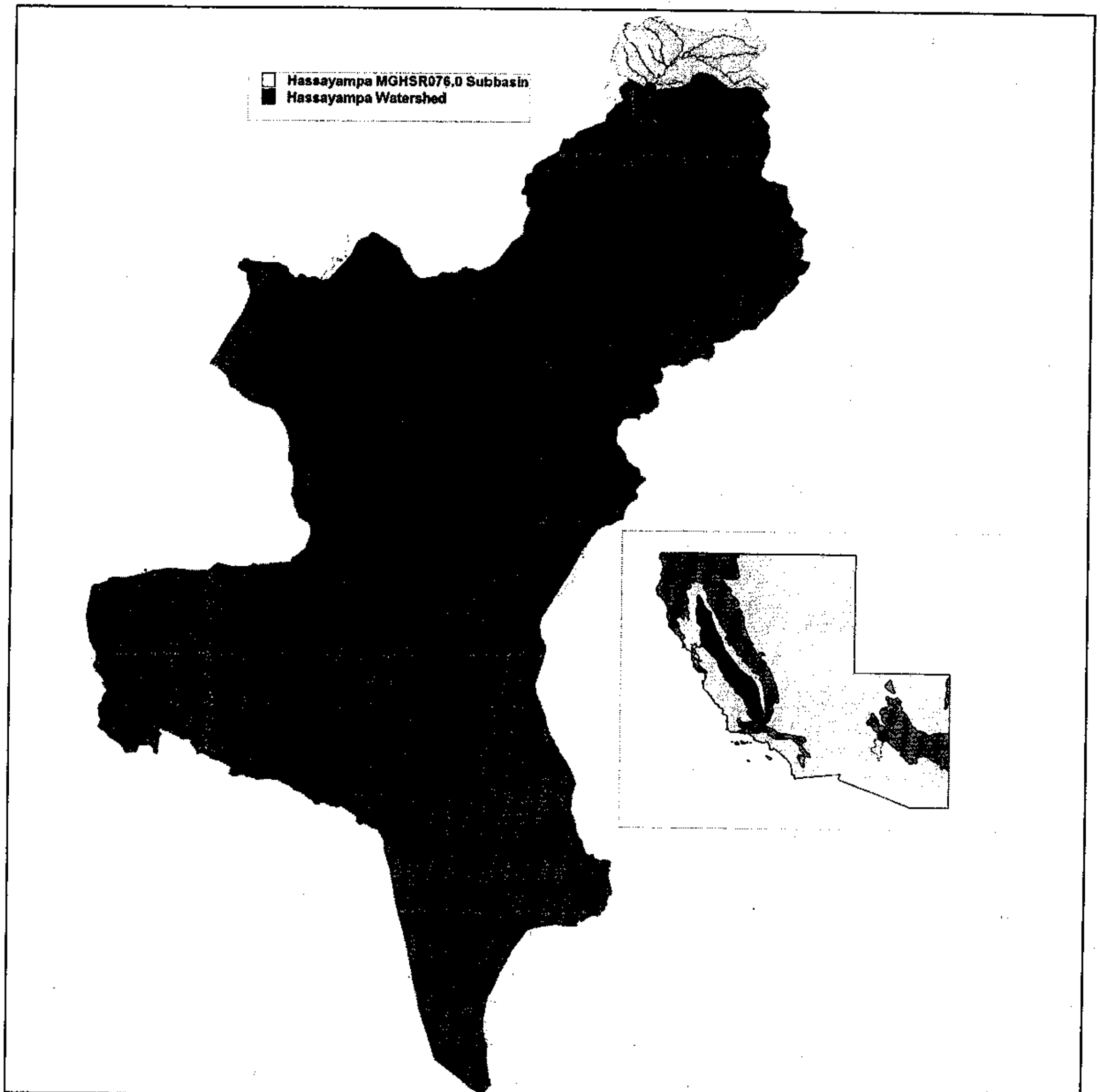


Geology in Crowley lake ML1 Subbasin:

ROCKDESC	Acres
Triassic granitic group	236.397
Quaternary	2705.57
Upper Paleozoic eugeosynclinal	908.157
Quaternary felsic volcanic rocks	50502.82
Lower Paleozoic eugeosynclinal	1770.69

Drainage Area	87.69 sq mi
Stream Order	3
Flow Characteristics	Not available

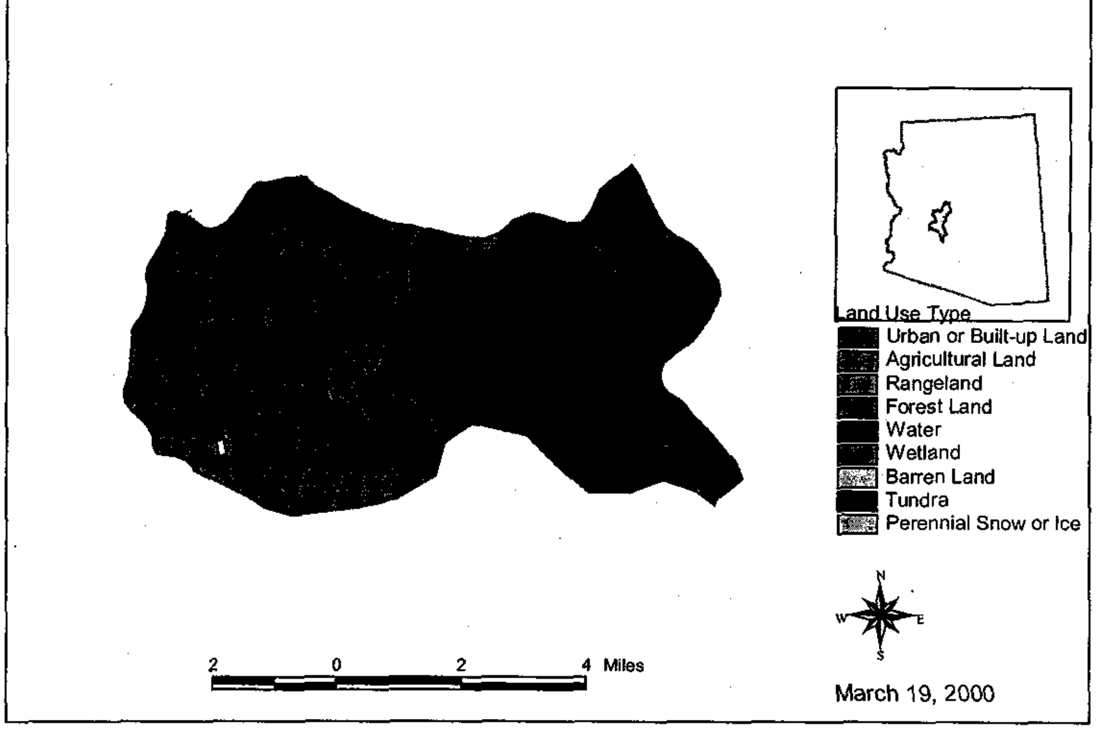
18126



Station: MGHSR076.0
Basin: Hassayampa
Site: Hassayampa River Below Board Creek Confluence

18127

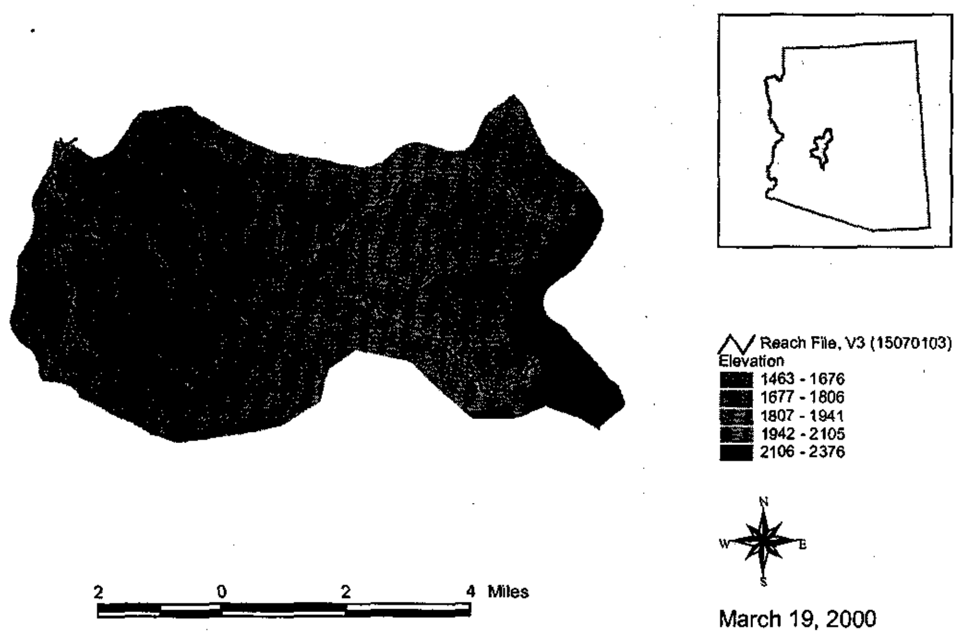
Hassayampa MGHSR076.0 Subbasin Land Use



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	327
Subtotal	327
Forest Land	
EVERGREEN FOREST LAND-42	16034
Subtotal	16034
Range Land	
SHRUB & BRUSH RANGELAND-32	8642
Subtotal	8642
Barren Land	
STRIP MINES-75	20
Subtotal	20
Total	25023

18128

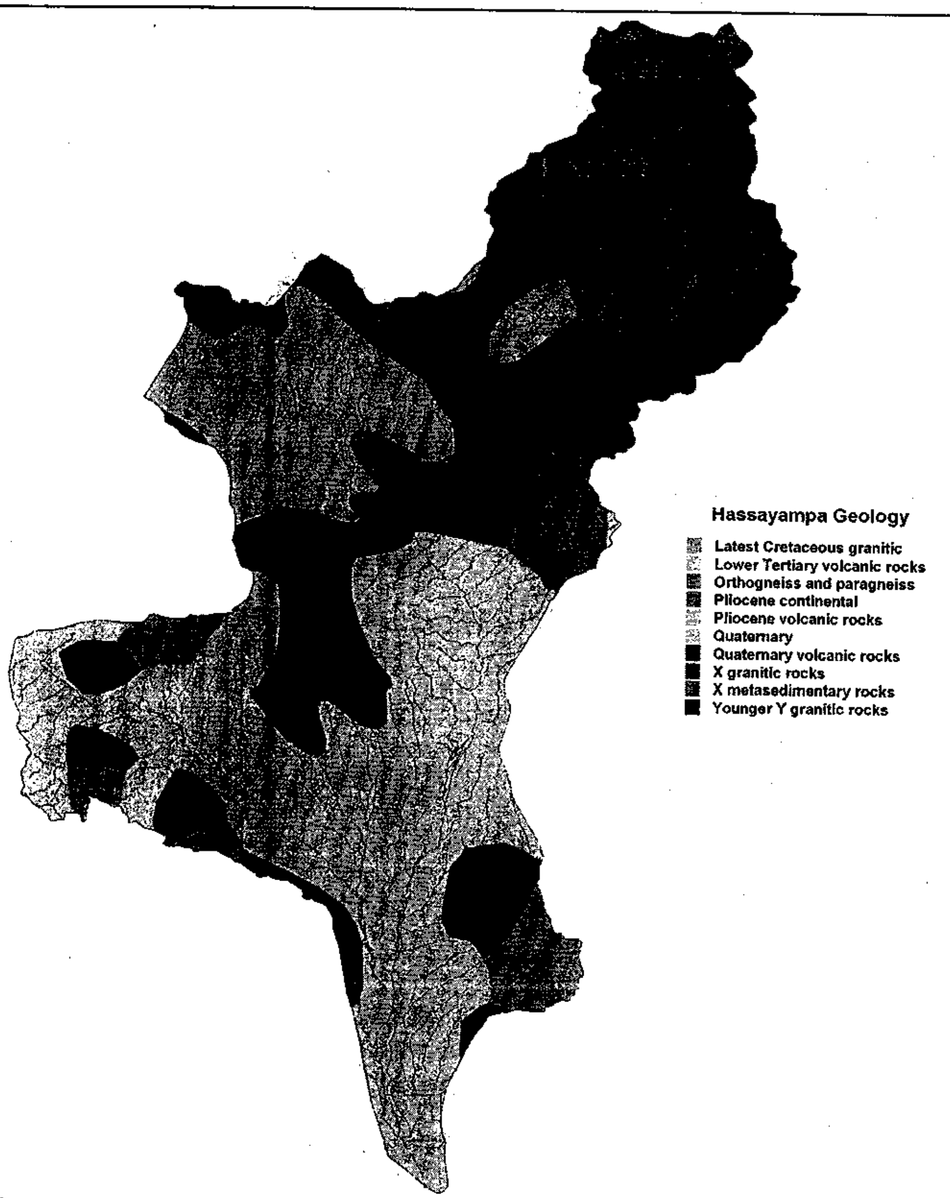
Hassayampa MGHSR076.0 Subbasin Topography



March 19, 2000

Min. Elevation: 1463
Max. Elevation: 2376
Mean Elevation: 1868.58
Median Elevation: 2172
Std. Deviation: 176.411

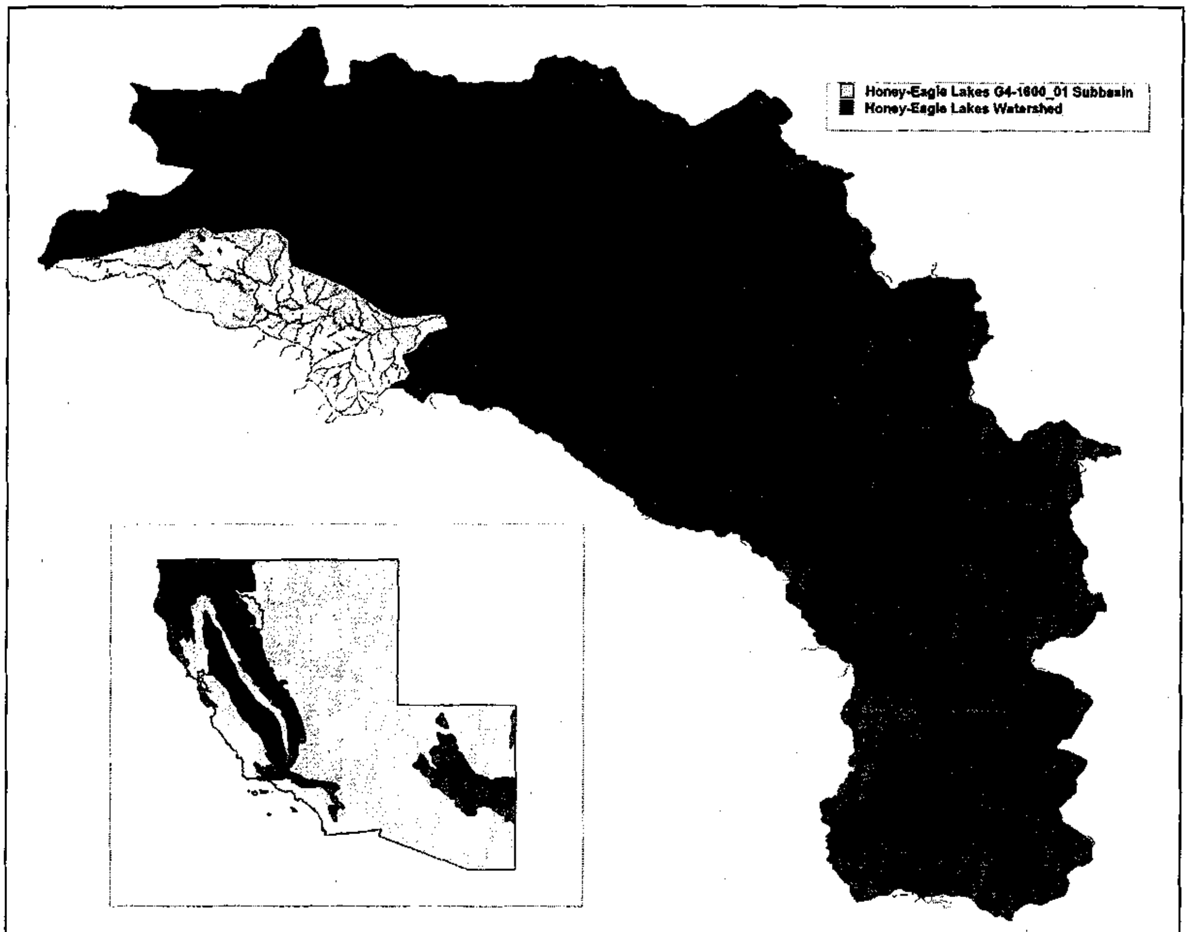
Average Stream Gradient: 18.591



Geology in Hassayampa MGHSR076.0 Subbasin:

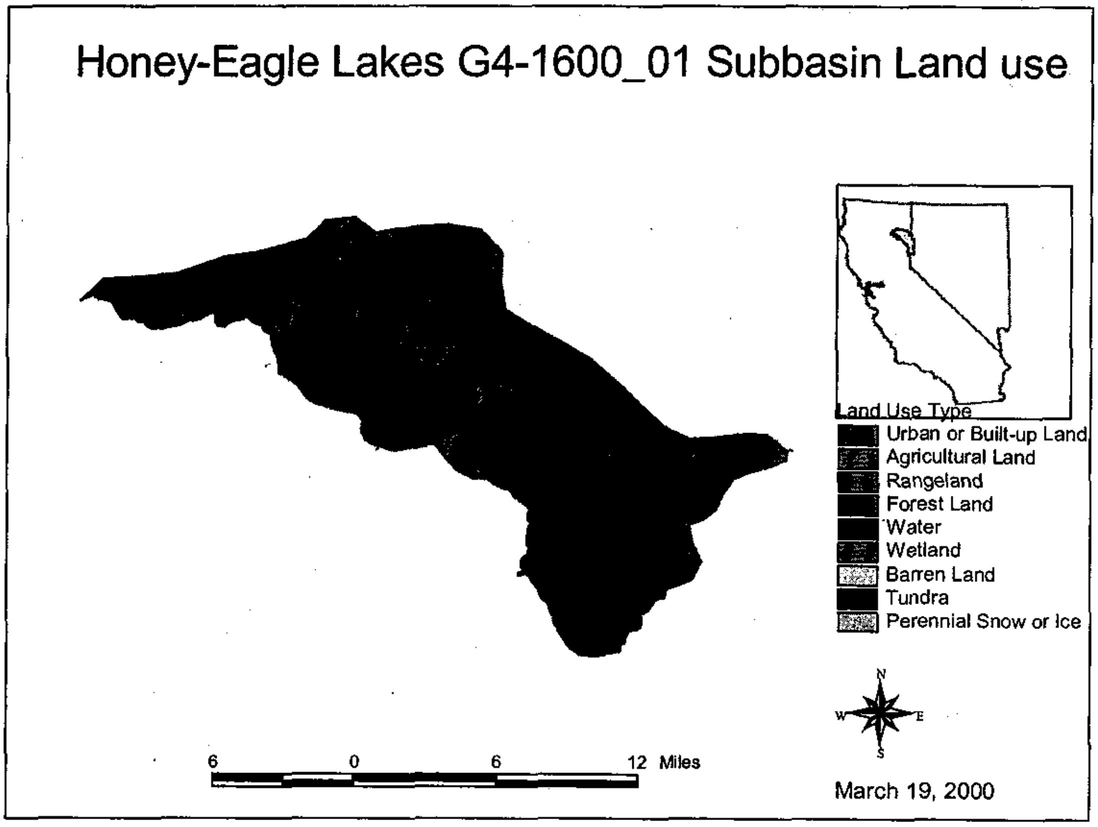
ROCKDESC	Acres
X metasedimentary rocks	17884.24
X granitic rocks	7057.17

Drainage Area	38.97 sq mi
Stream Order	3
Flow Charateristics	Not available



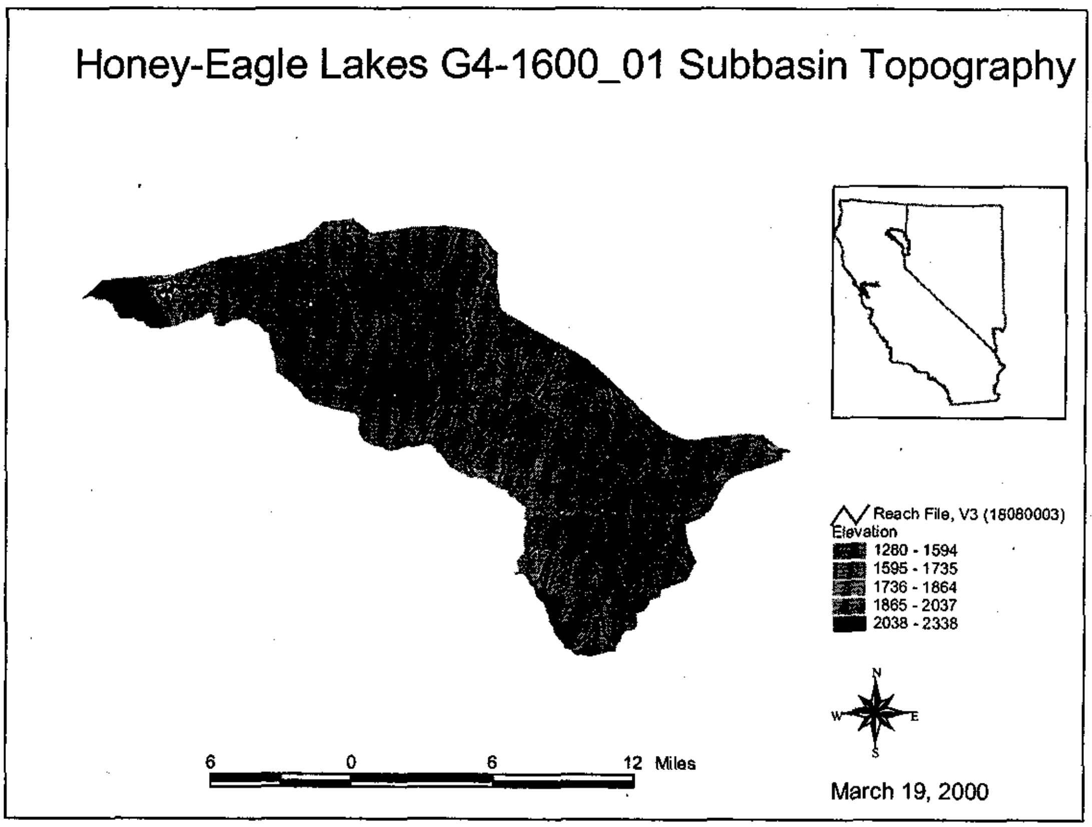
Station: G4-1600.01
Basin: Honey-Eagle Lakes
Site: Susan R at Lassen St Bridge

18131



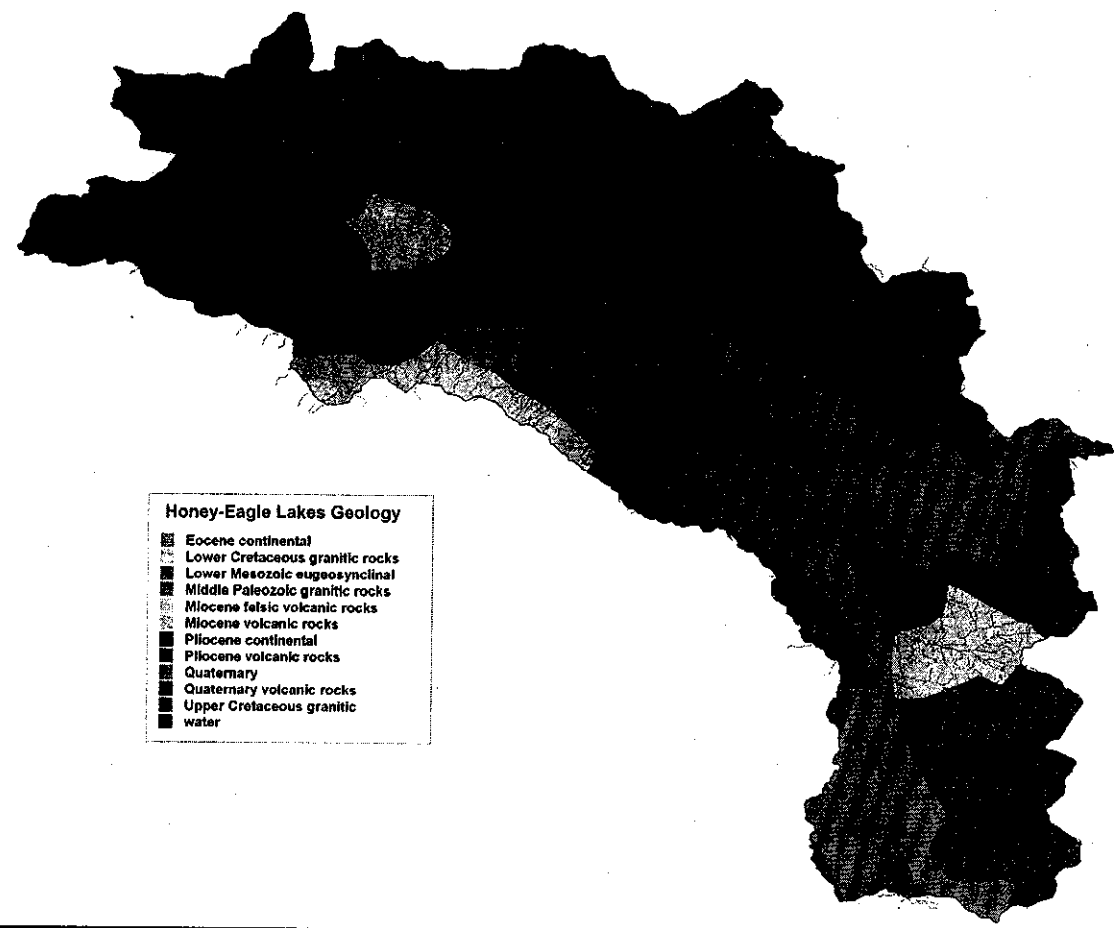
Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	143
COMMERCIAL AND SERVICES-12	42
Subtotal	185
Agricultural Land	
CROPLAND AND PASTURE-21	182
Subtotal	182
Forest Land	
EVERGREEN FOREST LAND-42	117820
Subtotal	117820
Range Land	
HERBACEOUS RANGELAND-31	767
SHRUB & BRUSH RANGELAND-32	2796
MIXED RANGELAND-33	269
Subtotal	3832
Water	
STREAMS AND CANALS-51	82

LAKES-52	448
RESERVOIRS-53	25
Subtotal	555
WetLand	
NONFORESTED WETLAND-62	658
Subtotal	658
Barren Land	
STRIP MINES-75	50
Subtotal	50
===	
Total	123282



Min. Elevation: 1280
Max. Elevation: 2338
Mean Elevation: 1757
Median Elevation: 1678
Std. Deviation: 168.676

Average Stream Gradient: 2.16707

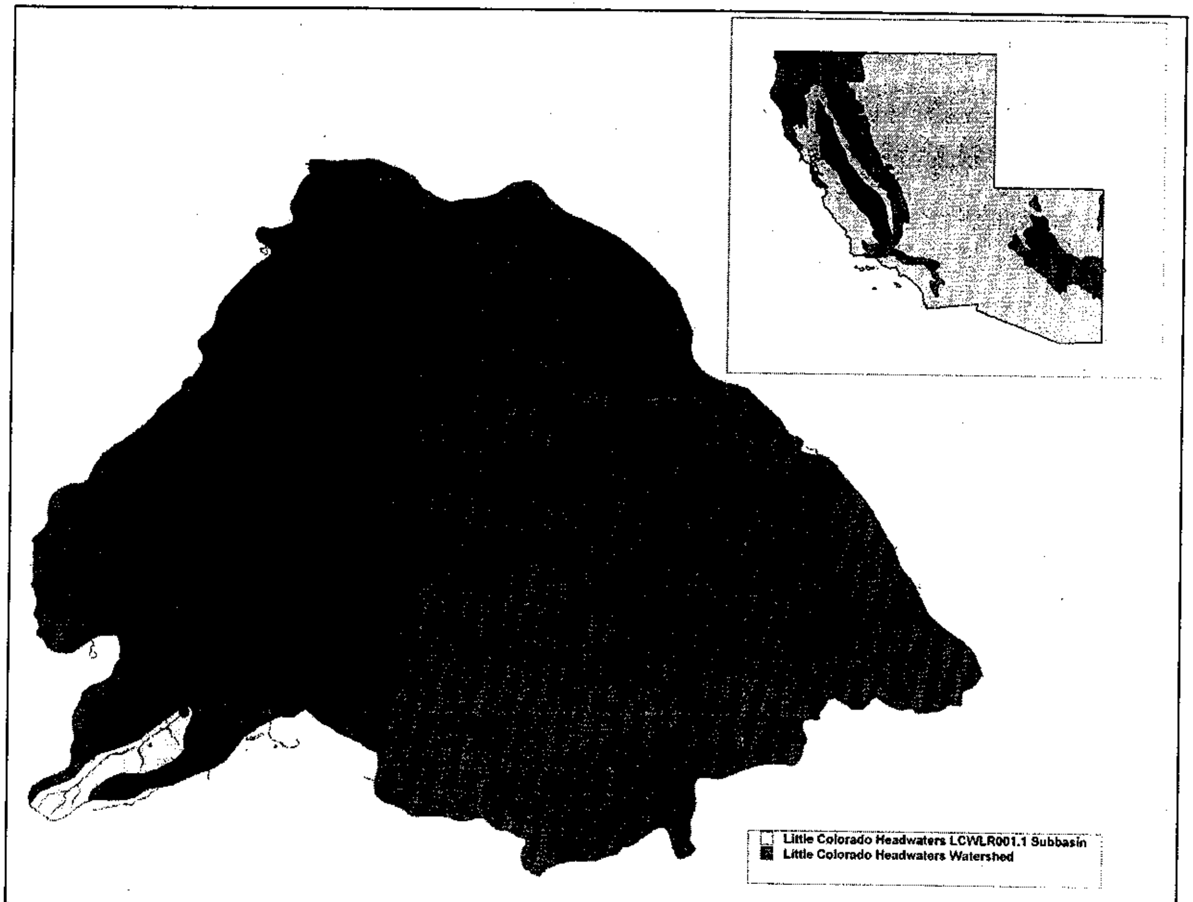


Geology in Honey-Eagle Lakes G4-1600_01 Subbasin:

ROCKDESC	Acres
Pliocene volcanic rocks	23130.09
Miocene volcanic rocks	2654.94
Eocene continental	11092.1
Lower Cretaceous granitic rocks	177.611
Quaternary volcanic rocks	85847.84

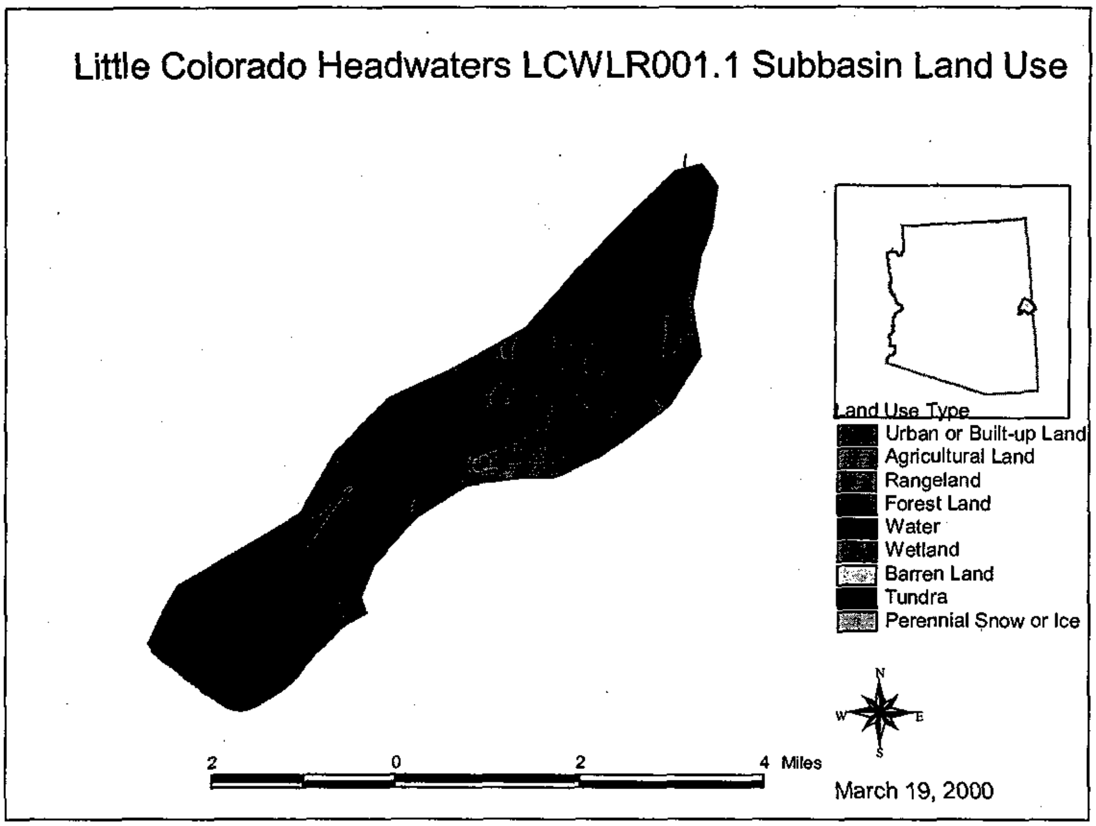
Drainage Area	192.0 sq mi
Stream Order	4
Flow Characteristics	1978 - 1998 Median: 19.00 cfs

18134

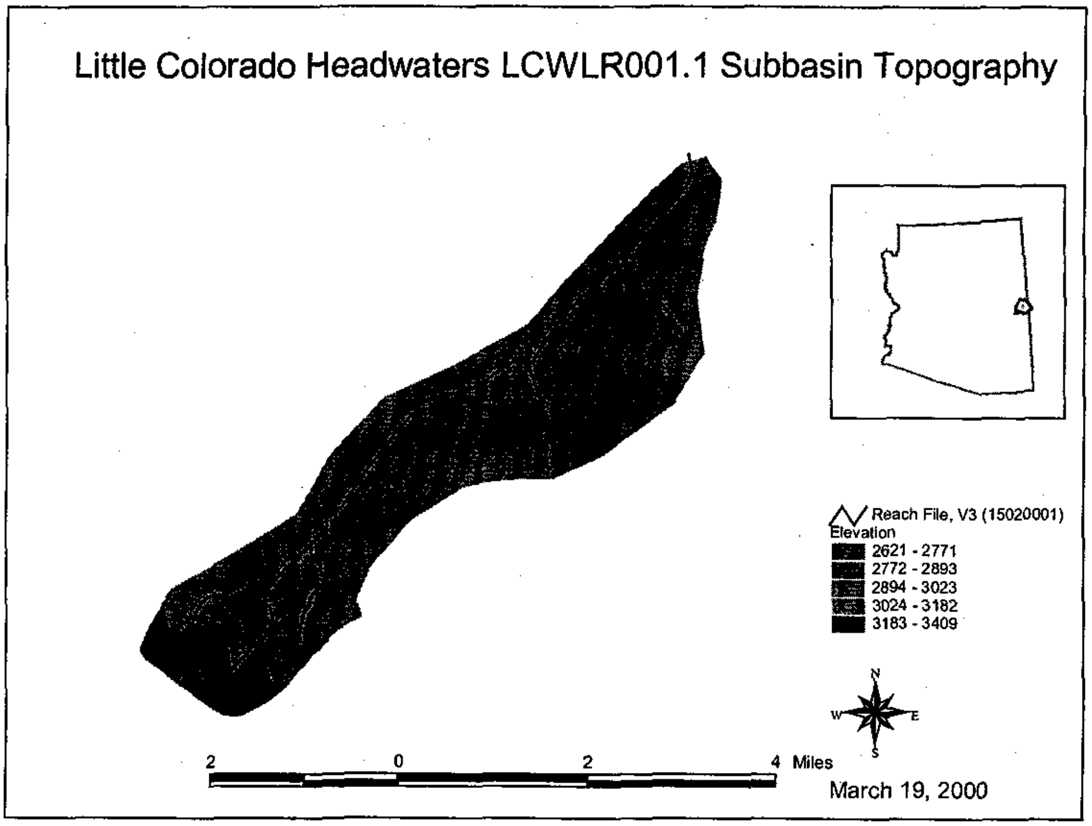


Station: LCWLR001.1
Basin: Little Colorado Headwaters
Site: West Fork Little Colorado River Above Government Springs

18135

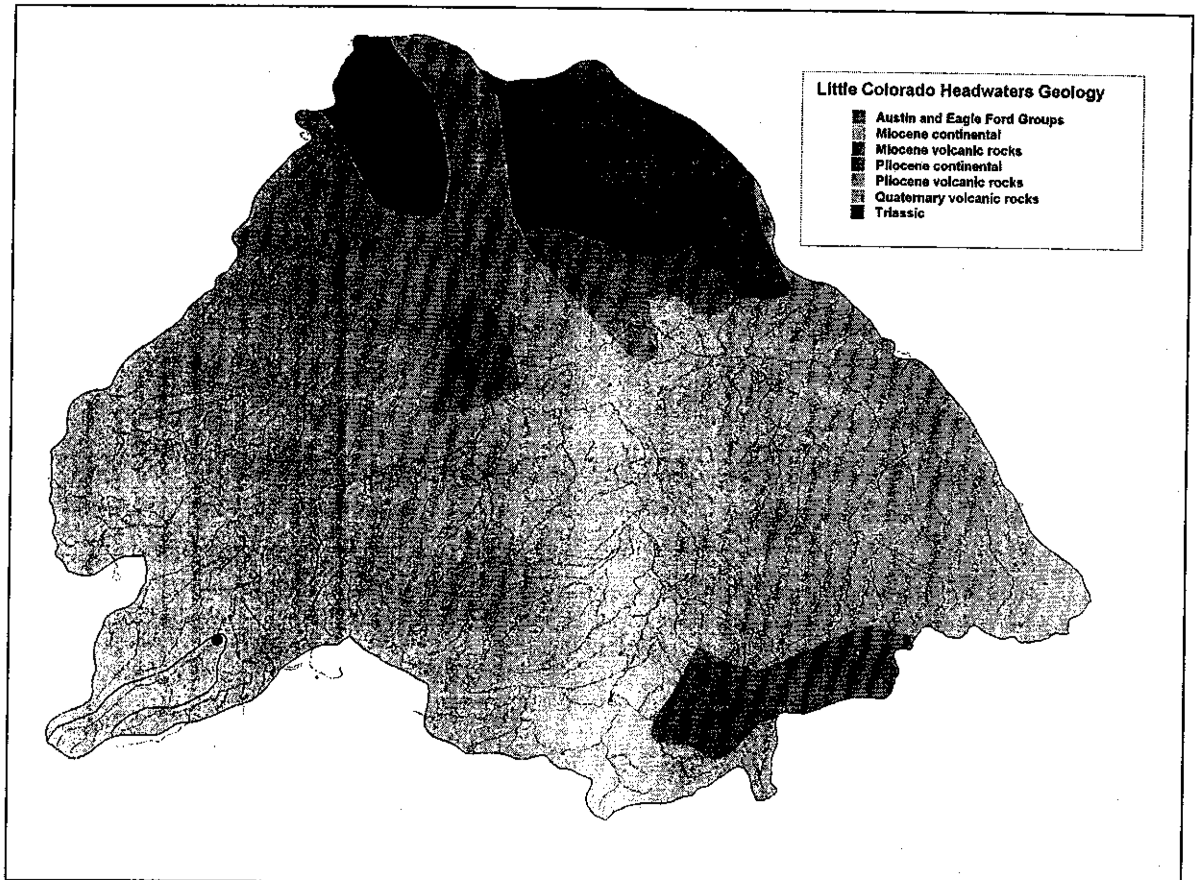


Land Use Name and Code	Area (acres)
Urban or Built-up Land	
OTHER URBAN OR BUILT-UP-17	52
Subtotal	52
Forest Land	
EVERGREEN FOREST LAND-42	4283
MIXED FOREST LAND-43	1283
Subtotal	5566
Range Land	
SHRUB & BRUSH RANGELAND-32	113
MIXED RANGELAND-33	1040
Subtotal	1153
Total	6771



Min. Elevation: 2621
Max. Elevation: 3409
Mean Elevation: 2940.78
Median Elevation: 2865
Std. Deviation: 171.632

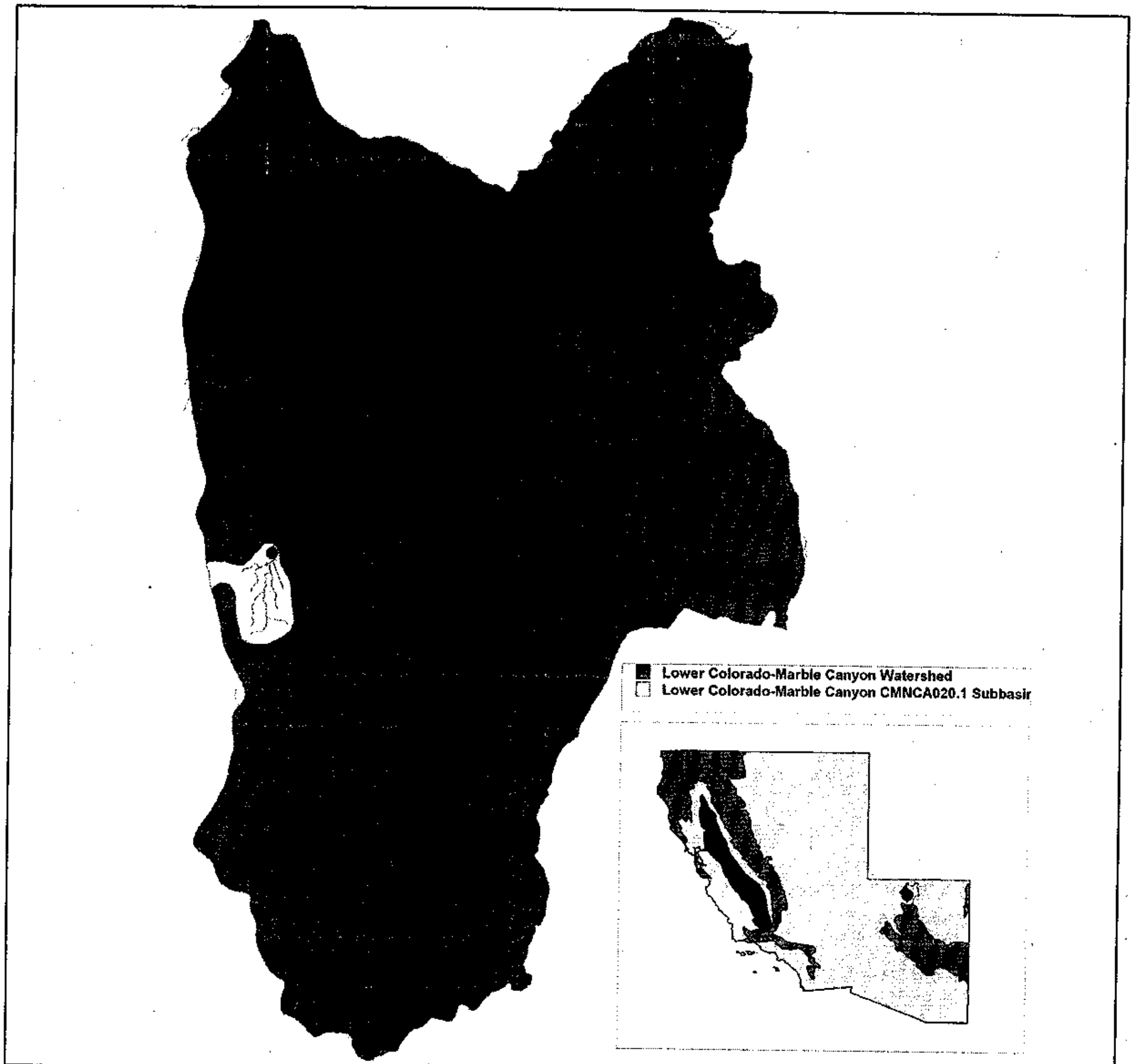
Average Stream Gradient: 12.8479



Little Colorado Headwaters LCWLR001.1 Subbasin:

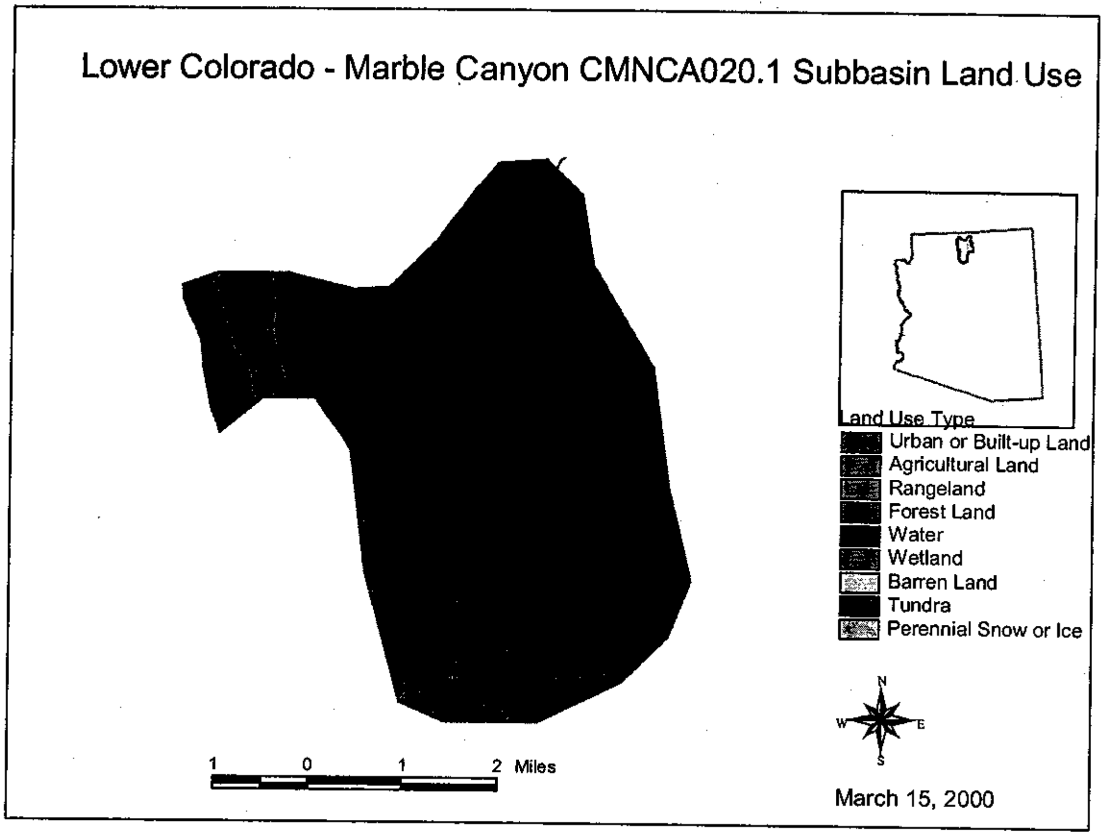
ROCKDESC	Acres
Pliocene volcanic rocks	1129.93
Quaternary volcanic rocks	5568.9

Drainage Area	10.47 sq mi
Stream Flow	2
Flow Characteristics	Not available



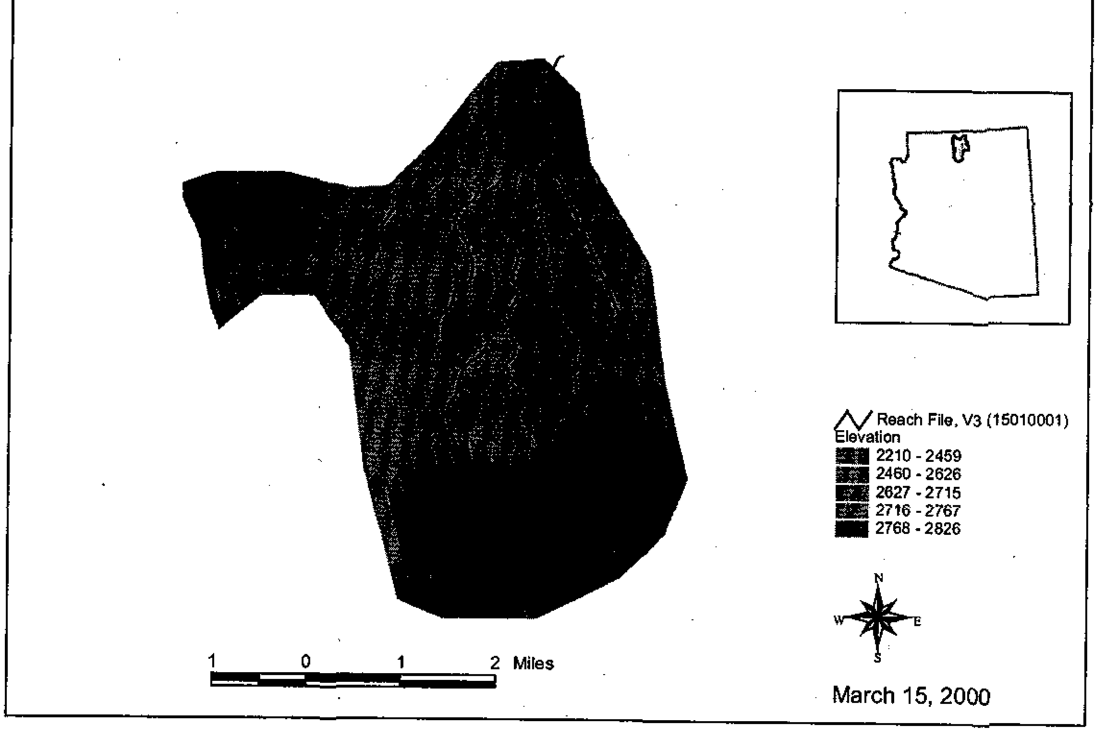
Station: CMNCA020.1
Basin: Lower Colorado - Marble Canyon
Site: North Canyon Creek Below North Canyon Spring

18139



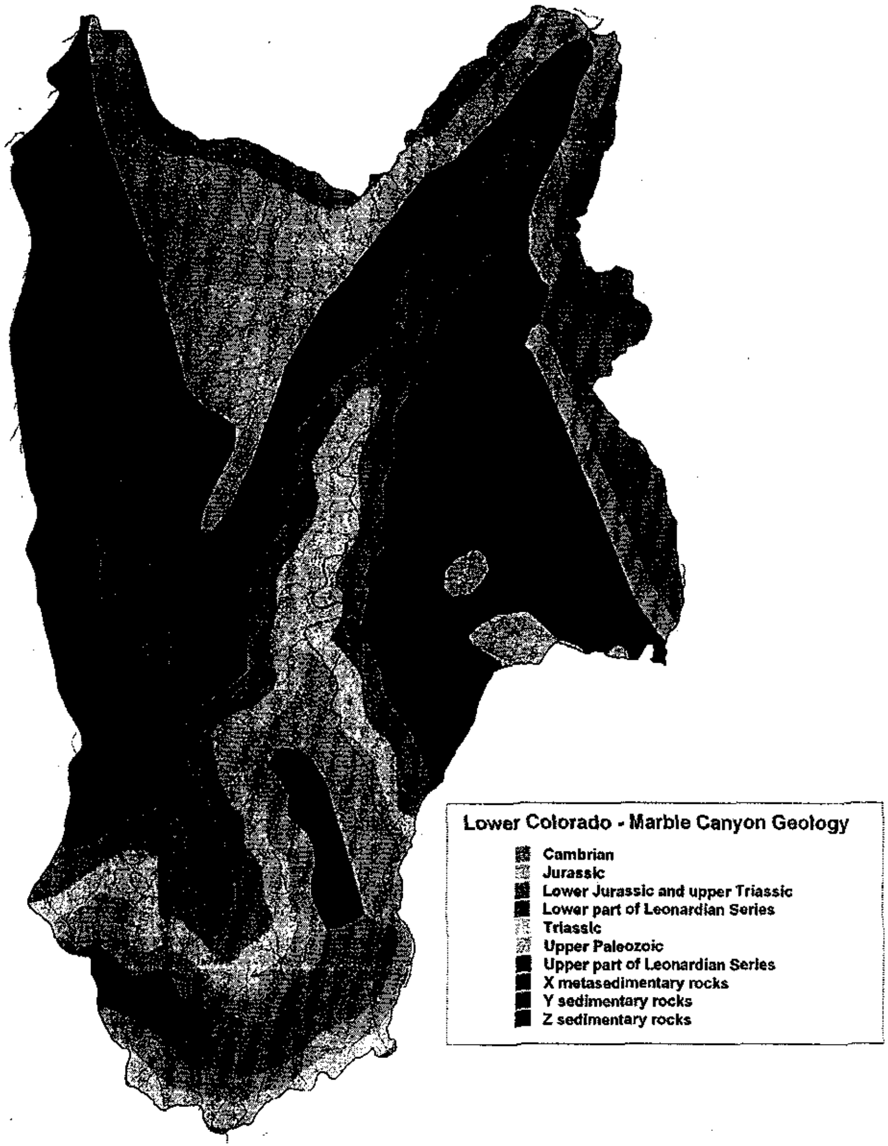
Land Use Name and Code	Area (acres)
Forest Land	
EVERGREEN FOREST LAND-42	11278
Subtotal	11278
Range Land	
HERBACEOUS RANGELAND-31	2756
Subtotal	2756
Total	14034

Lower Colorado - Marble Canyon CMNCA020.1 Subbasin Topography



Min. Elevation: 2210
Max. Elevation: 2826
Mean Elevation: 2700.54
Median Elevation: 2771
Std. Deviation: 114.525

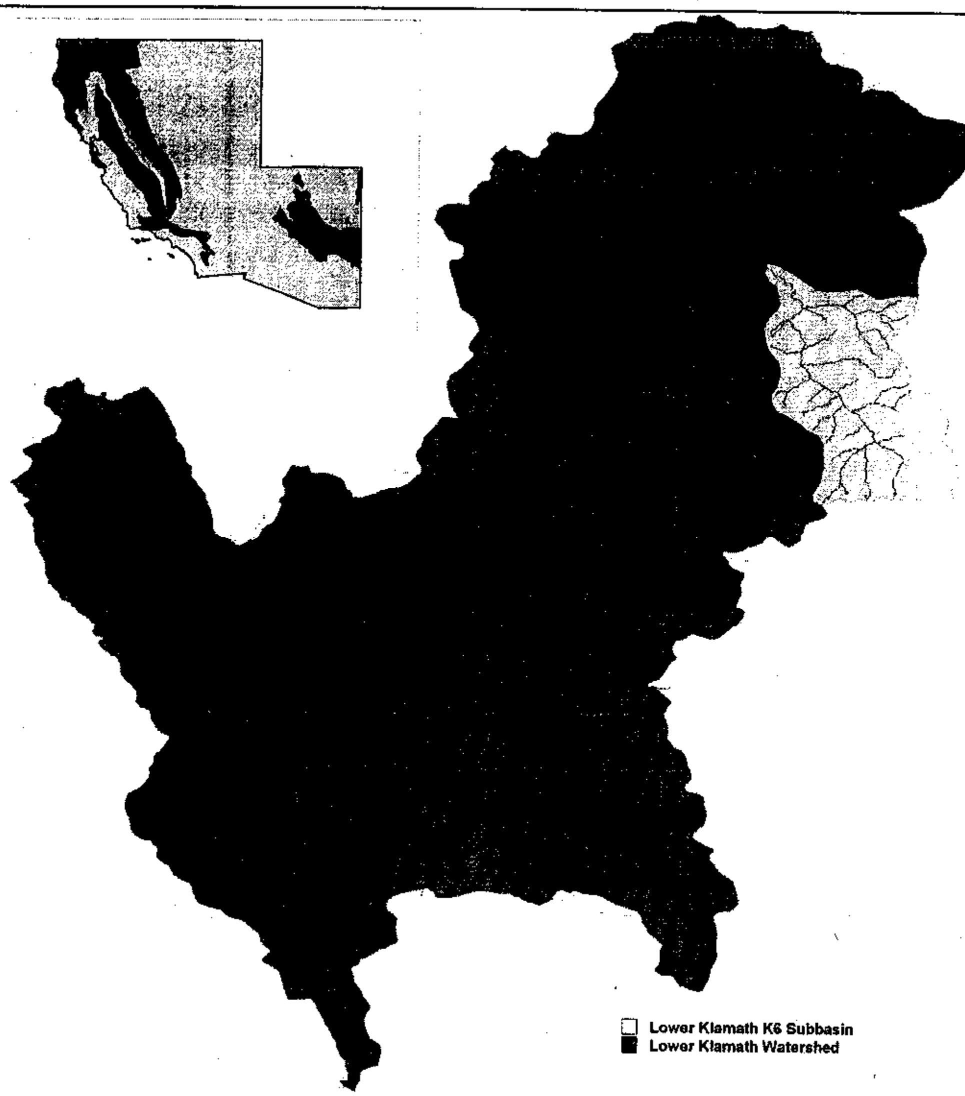
Average Stream Gradient: 23.4661



Geology in Lower Colorado - Marble Canyon CMNCA020.1 Subbasin:

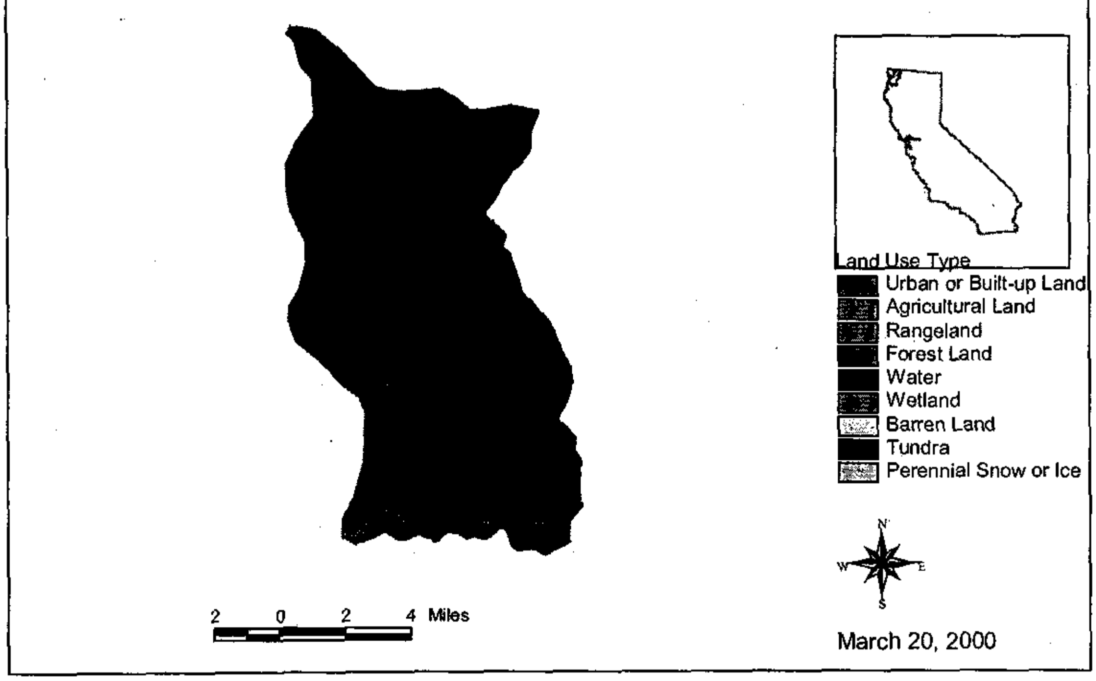
ROCKDESC	Acres
Lower part of Leonardian Series	1161.15
Upper part of Leonardian Series	10513.66

Drainage Area	18.24 sq mi
Stream Order	3
Flow Characterization	Not available



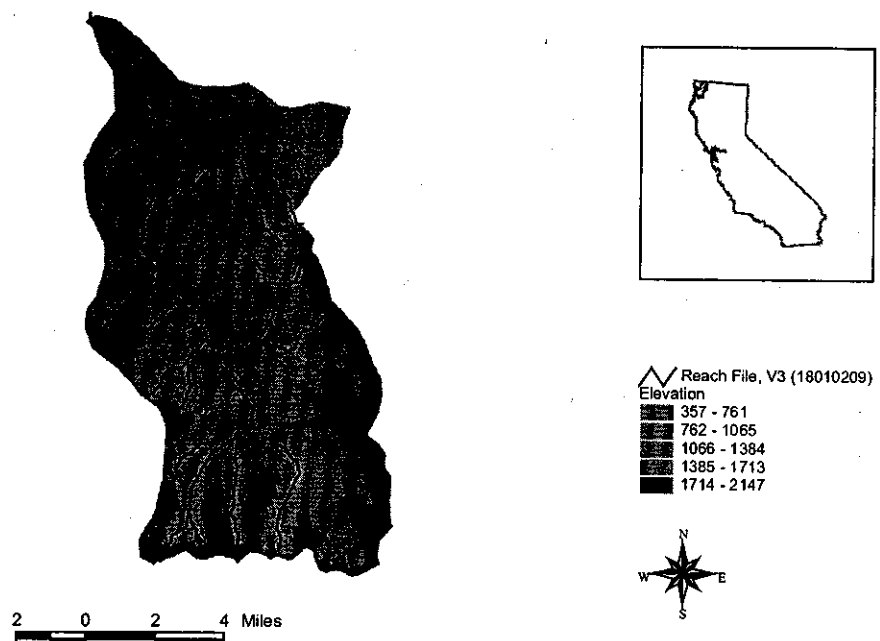
Station: K6
Basin: Lower Klamath
Site: Klamath River d/s Elk Creek

Lower Klamath K6 Subbasin Land Use



Land Use Name and Code	Area (acres)
Forest Land	
EVERGREEN FOREST LAND-42	61228
Subtotal	61228
Total	61228

Lower Klamath K6 Subbasin Topography

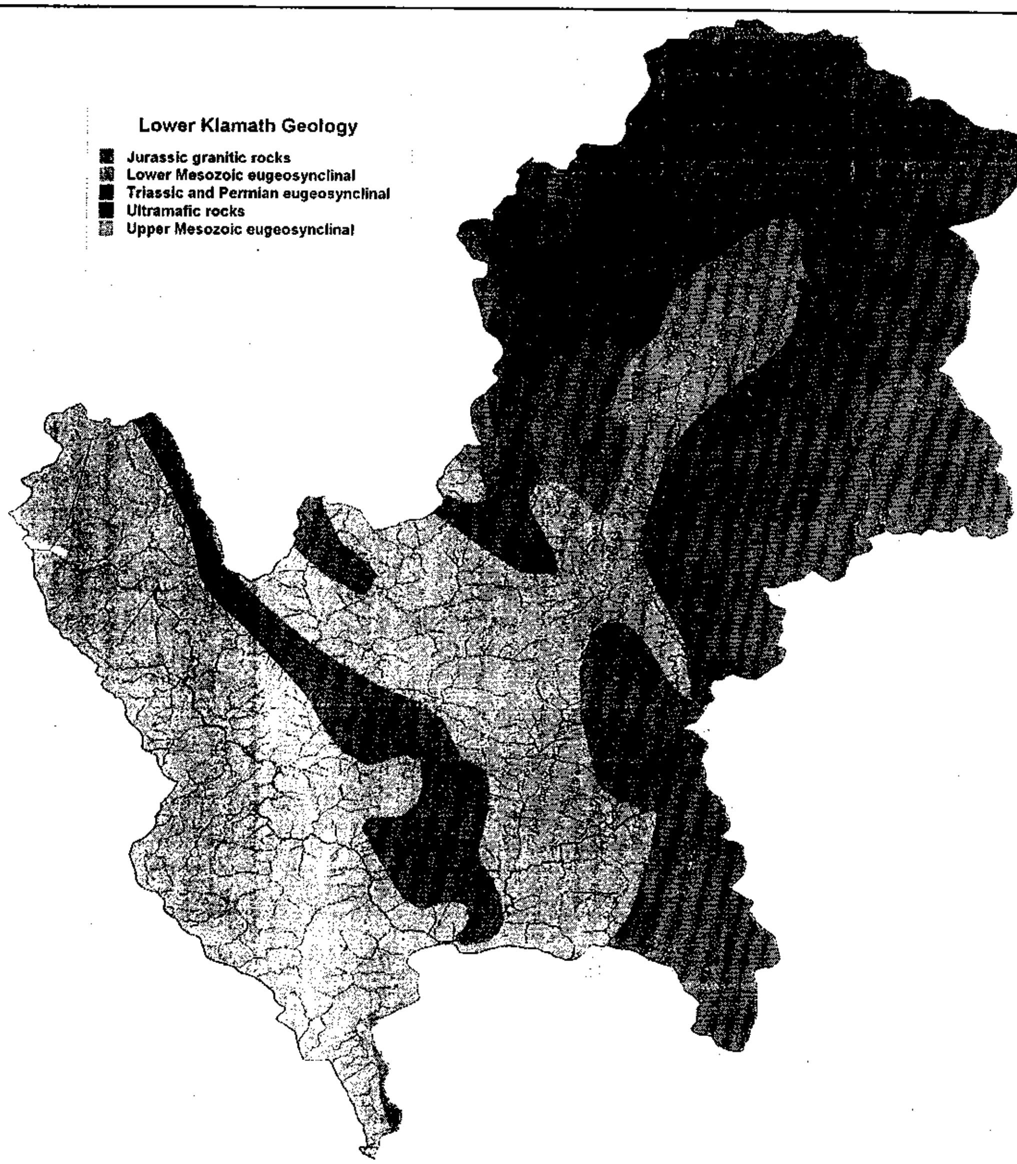


March 20, 2000

Min. Elevation: 357
Max. Elevation: 2147
Mean Elevation: 1243.85
Median Elevation: 1435
Std. Deviation: 443.461

Average Stream Gradient: 12.4118

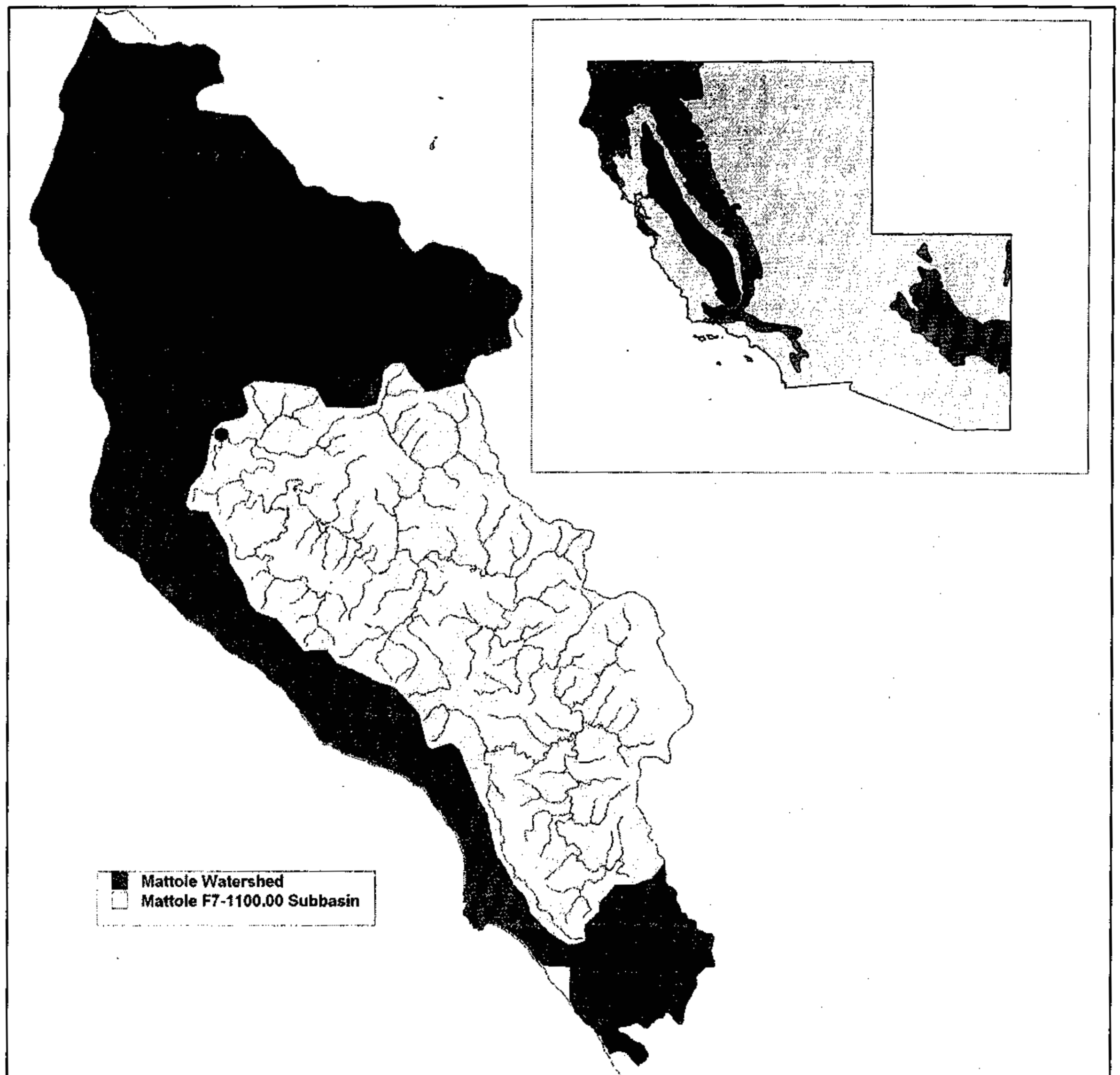
18145



Geology in Lower Klamath K6 Subbasin:

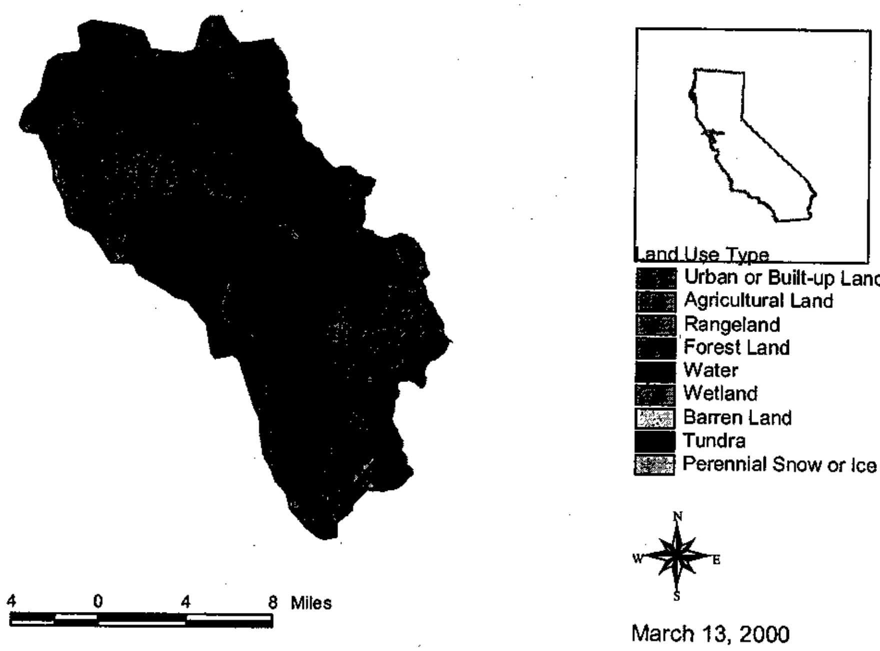
ROCKDESC	Acres
Ultramafic rocks	4556.14
Jurassic granitic rocks	16269.66
Triassic and Permian eugeosynclinal	39886.12
Lower Mesozoic eugeosynclinal	63.7077

Drainage Area	94.96 sq mi
Stream Order	4
Flow Characteristics	Not available



Station: F7-1100.00
Basin: Mattole
Site: Mattole R at Petrolia

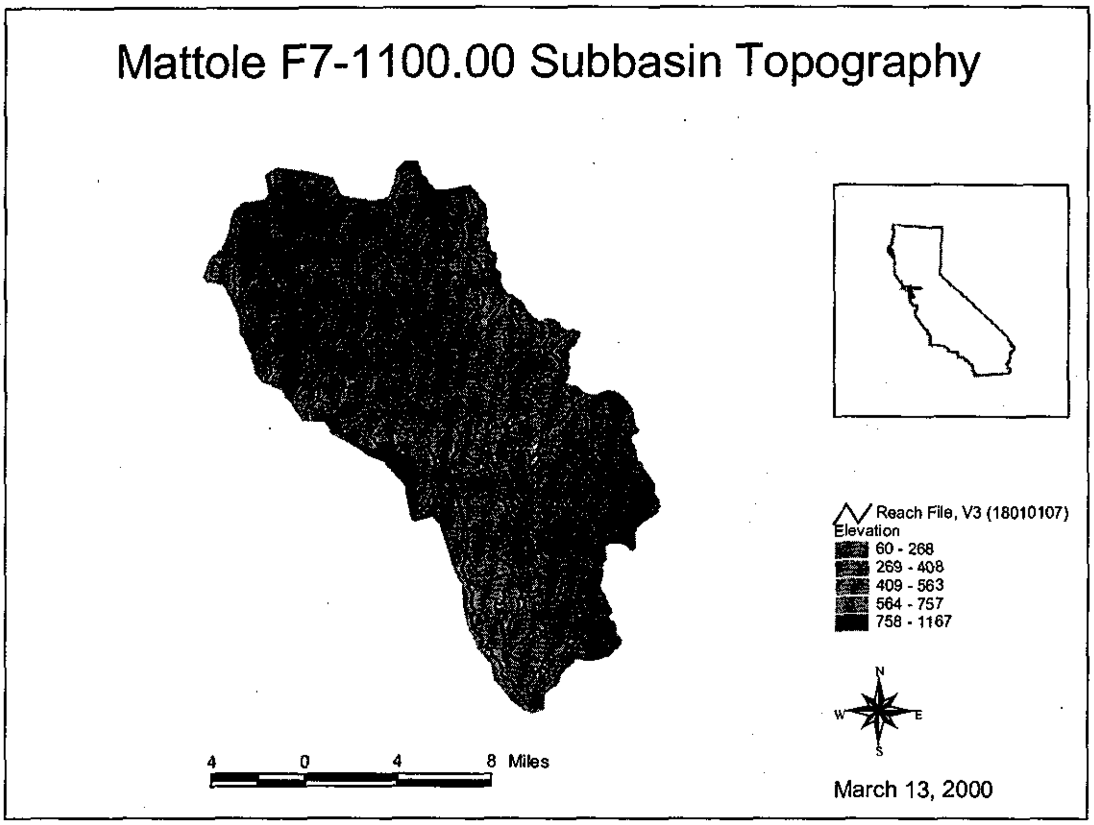
Mattole F7-1100.00 Subbasin Land Use



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
COMMERCIAL AND SERVICES-12	47
Subtotal	47
Agricultural Land	
CROPLAND AND PASTURE-21	982
Subtotal	982
Forest Land	
DECIDUOUS FOREST LAND-41	132
EVERGREEN FOREST LAND-42	119449
MIXED FOREST LAND-43	839
Subtotal	120420
Range Land	
HERBACEOUS RANGELAND-31	11621
SHRUB & BRUSH RANGELAND-32	7502
MIXED RANGELAND-33	4413
Subtotal	23536
Barren Land	

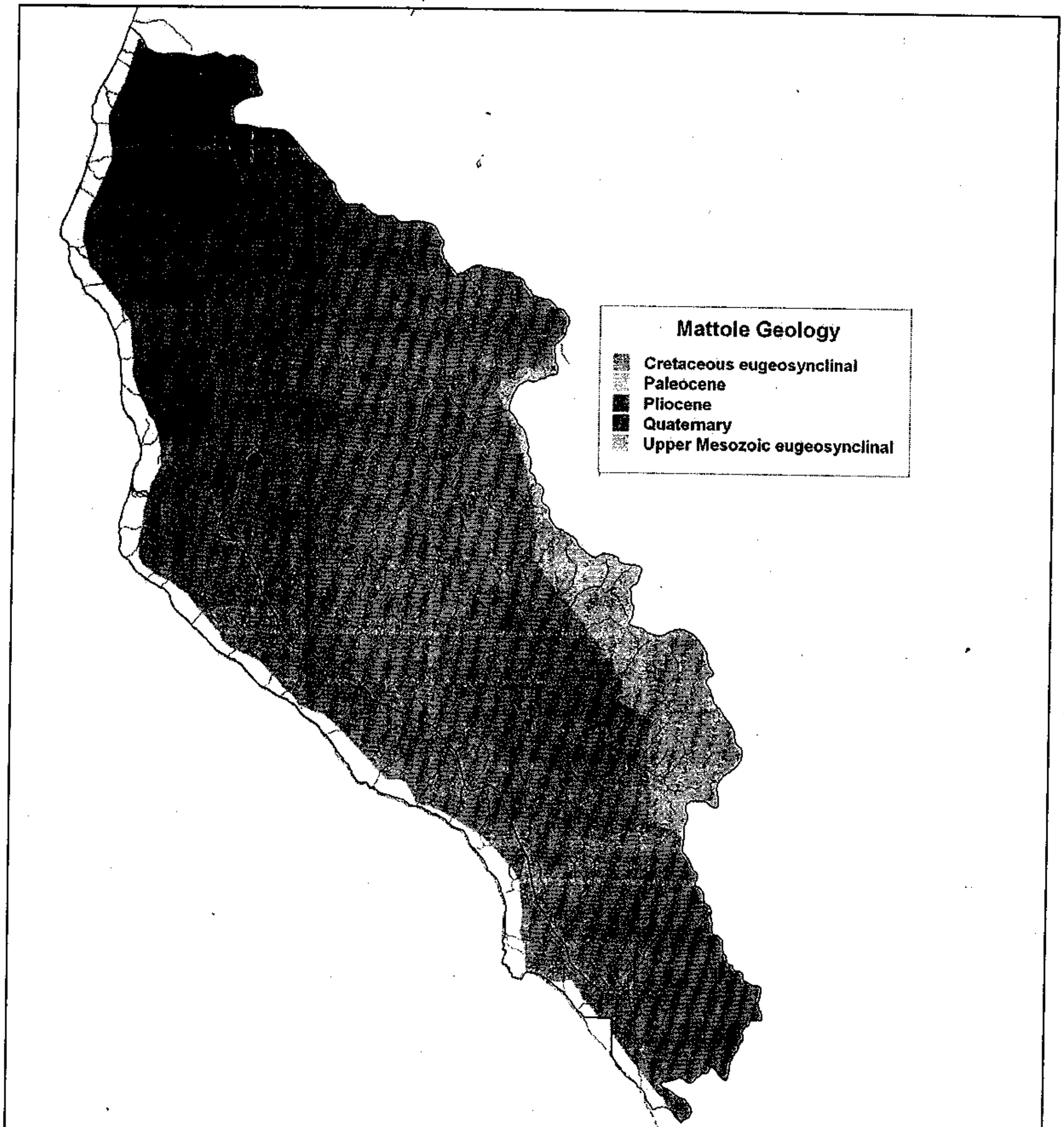
18149

STRIP MINES-75	26
TRANSITIONAL AREAS-76	32
Subtotal	58
==	
Total	145043



Min. Elevation: 60
Max. Elevation: 1167
Mean Elevation: 433.702
Median Elevation: 574
Std. Deviation: 189.716

Average Stream Gradient: 2.27385

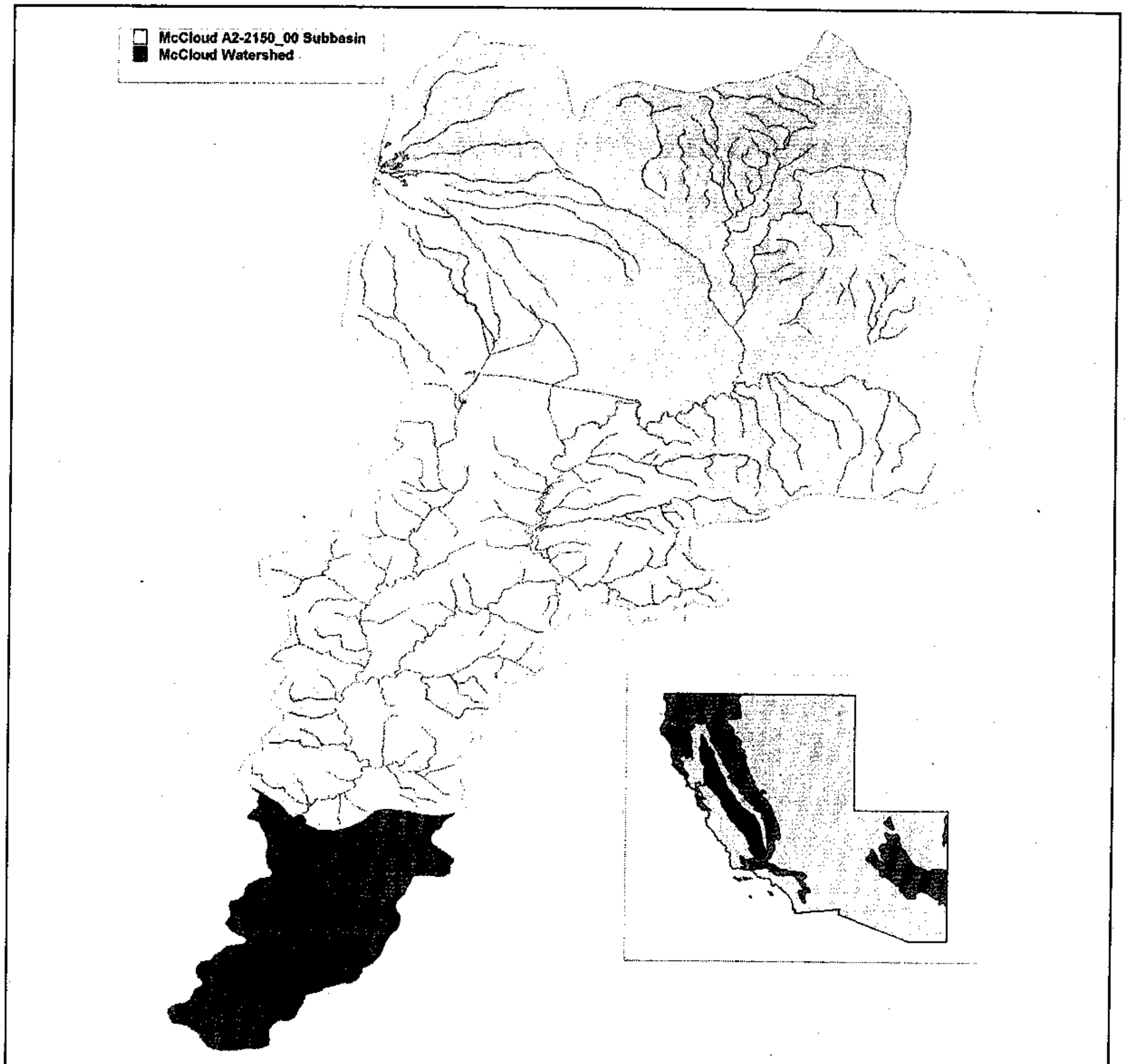


Geology in Mattole F7-1100.00 Subbasin:

ROCKDESC	Acres
Paleocene	17976.07
Upper Mesozoic eugeosynclinal	4251.07
Cretaceous eugeosynclinal	121477.92

18151

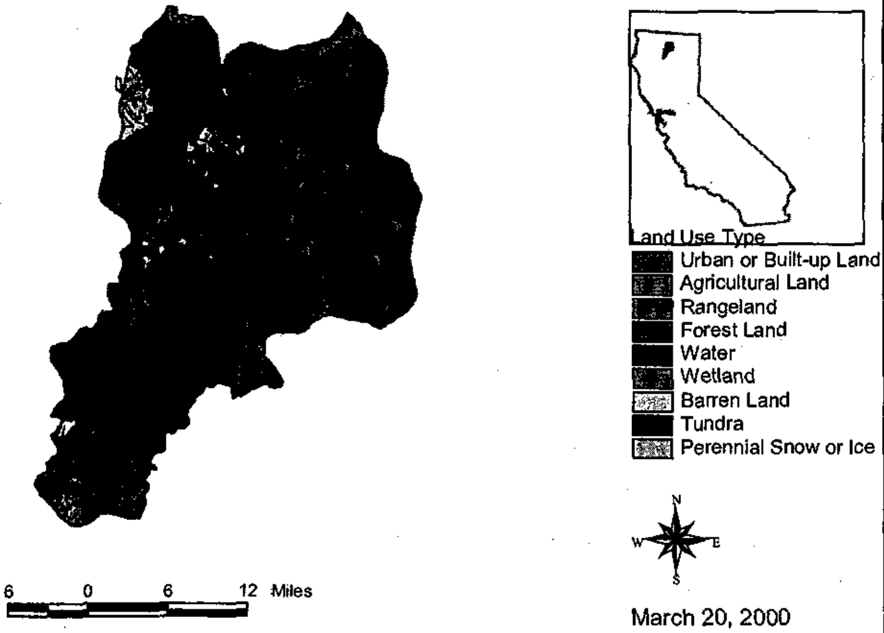
Drainage Area	224.5 sq mi
Stream Order	4
Flow Characteristics	1978 - 1998 Median: 253.0 cfs



Station: A2-2150.00
Basin: McCloud
Site: McCloud R above Shasta Lake

18153

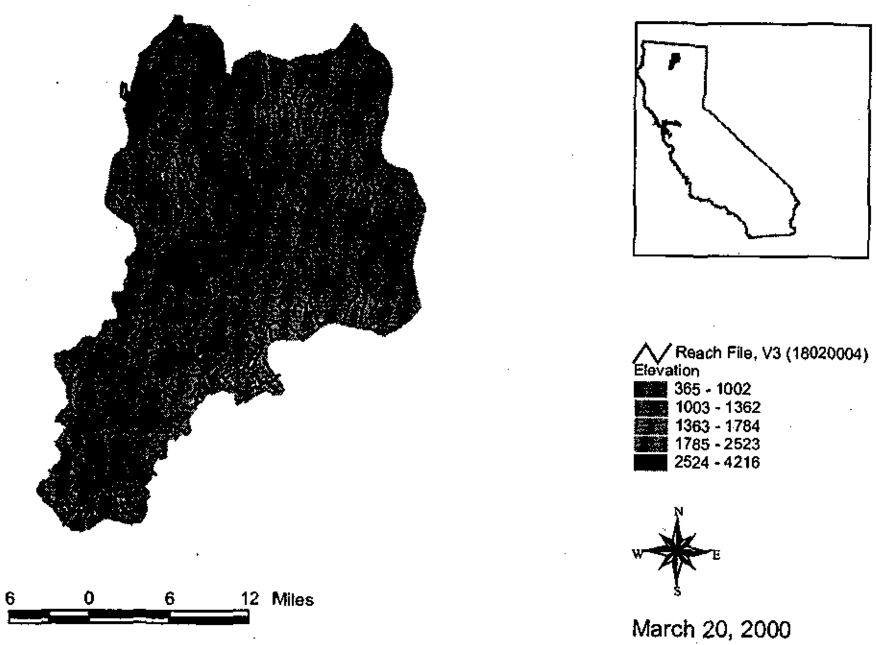
McCloud A2-2150_00 Subbasin Land Use



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	311
COMMERCIAL AND SERVICES-12	49
INDUSTRIAL-13	331
TRANS, COMM, UTIL-14	26
OTHER URBAN OR BUILT-UP-17	32
Subtotal	749
Agricultural Land	
CROPLAND AND PASTURE-21	103
Subtotal	103
Forest Land	
EVERGREEN FOREST LAND-42	372060
Subtotal	372060
Range Land	
HERBACEOUS RANGELAND-31	1191
SHRUB & BRUSH RANGELAND-32	10882
MIXED RANGELAND-33	664
Subtotal	12737

Water	
RESERVOIRS-53	266
Subtotal	266
WetLand	
FORESTED WETLAND-61	349
Subtotal	349
Barren Land	
BARE EXPOSED ROCK-74	4243
STRIP MINES-75	49
TRANSITIONAL AREAS-76	4986
Subtotal	9278
Perennial Snow or Ice	
PERENNIAL SNOWFIELDS-91	3069
Subtotal	3069
==	
Total	398611

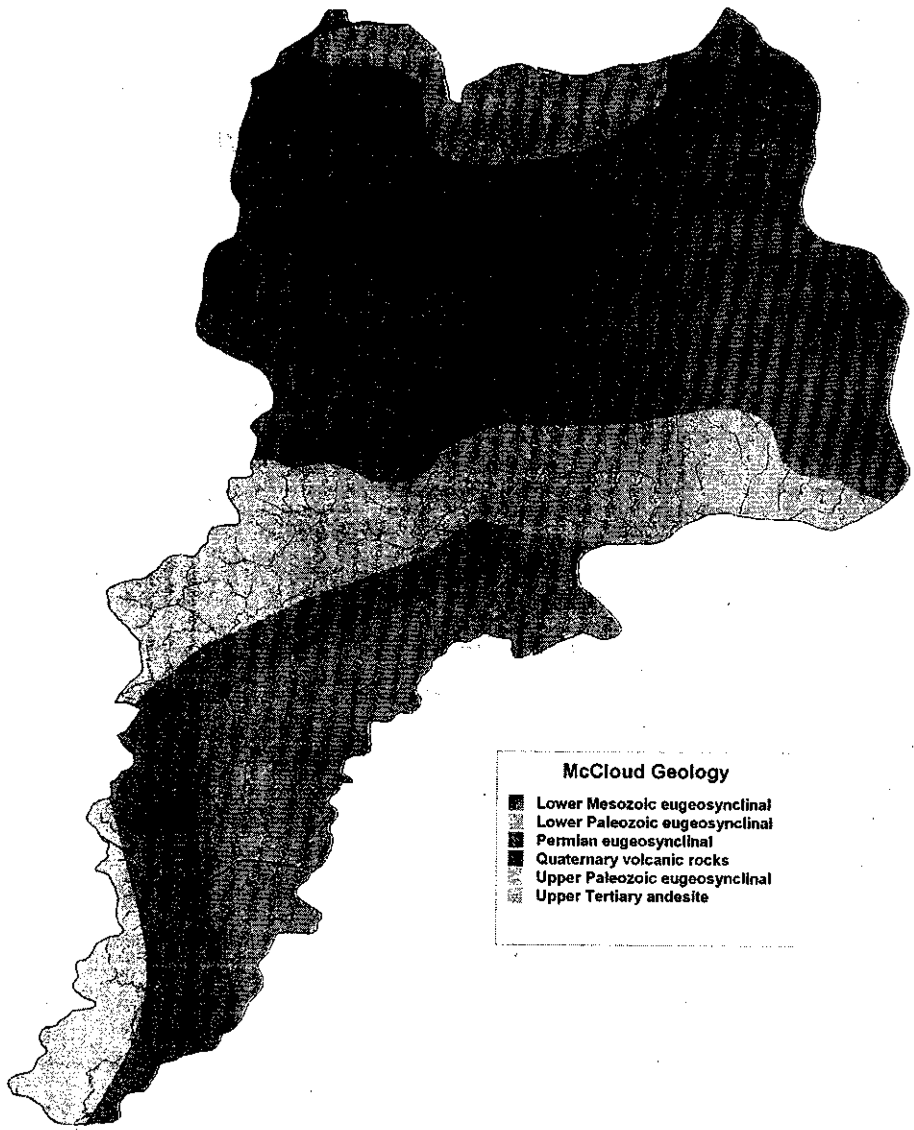
McCloud A2-2150_00 Subbasin Topography



Min. Elevation: 365
Max. Elevation: 4216
Mean Elevation: 1349.4
Median Elevation: 1065
Std. Deviation: 453.526

Average Stream Gradient: 9.6732

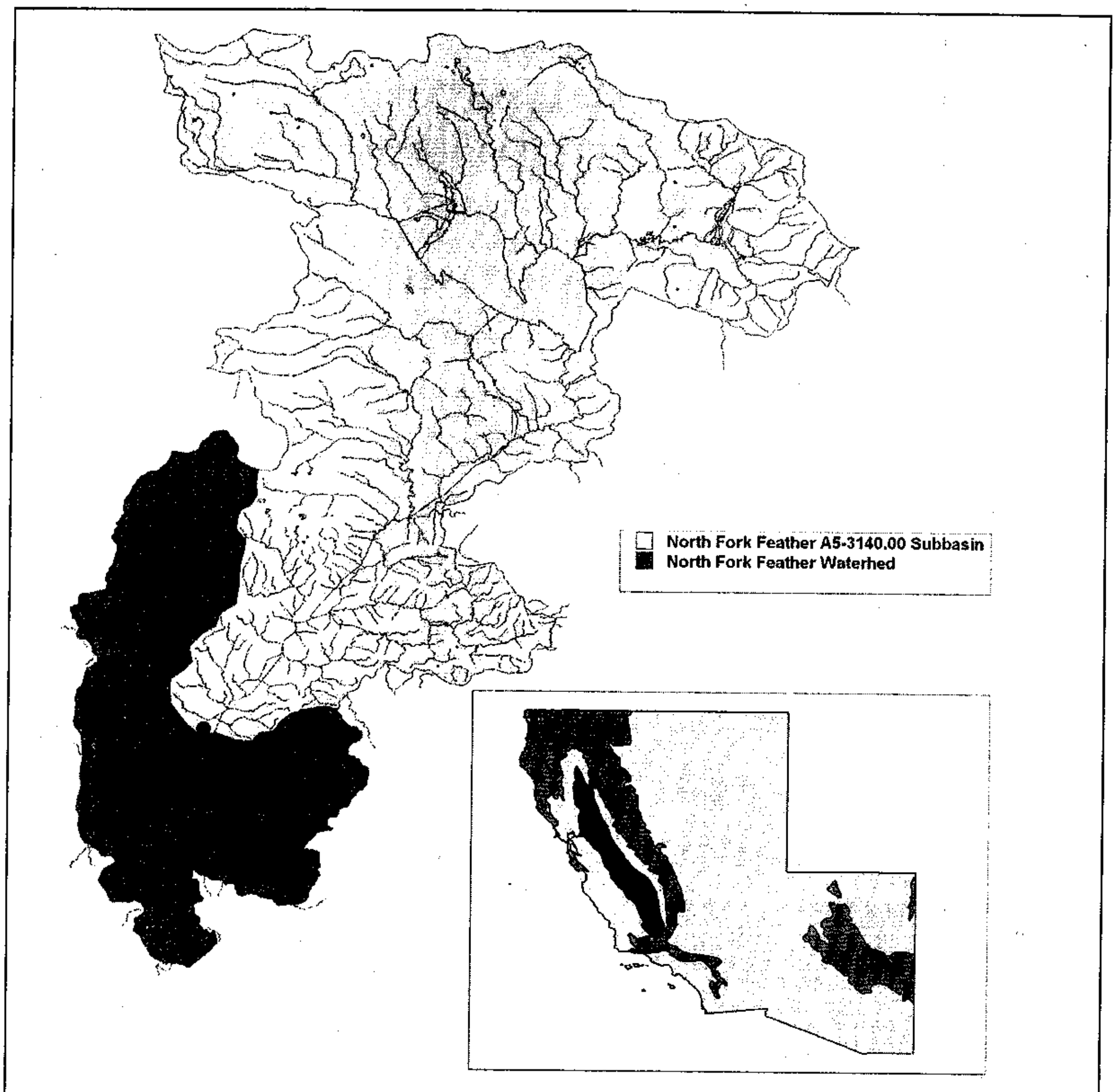
18156



Geology in McCloud A2-2150_00 Subbasin:

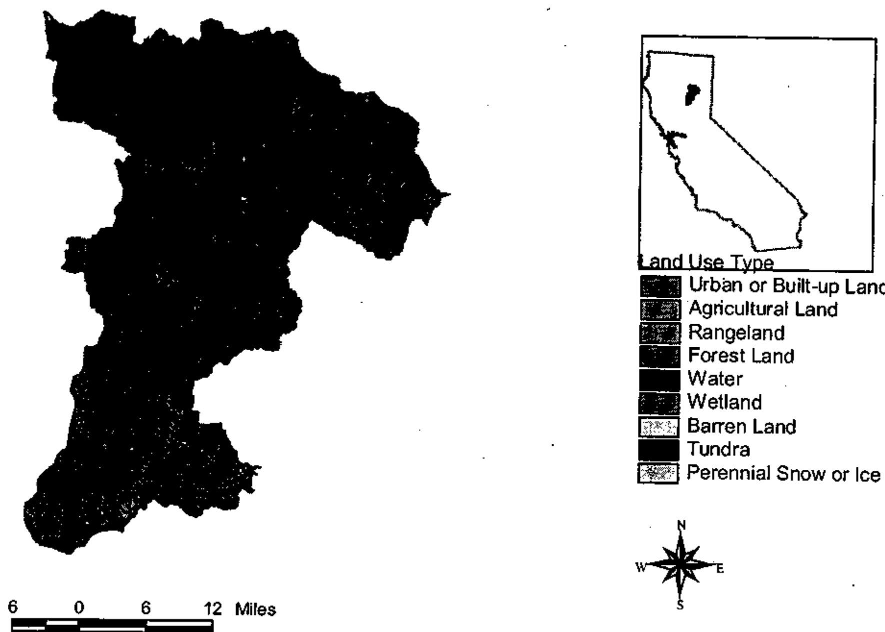
ROCKDESC	Acres
Lower Paleozoic eugeosynclinal	1606.16
Upper Tertiary andesite	59061.03
Quaternary volcanic rocks	216346.04
Permian eugeosynclinal	32235.67
Upper Paleozoic eugeosynclinal	38994.83
Lower Mesozoic eugeosynclinal	48403.92

Drainage Area	619.8 sq mi
Stream Order	5
Flow Characteristics	Not available



Station: A5-3140.00
Basin: North Fork Feather
Site: Feather R NF at Pulga

North Fork Feather A5-3140.00 Subbasin Land Use



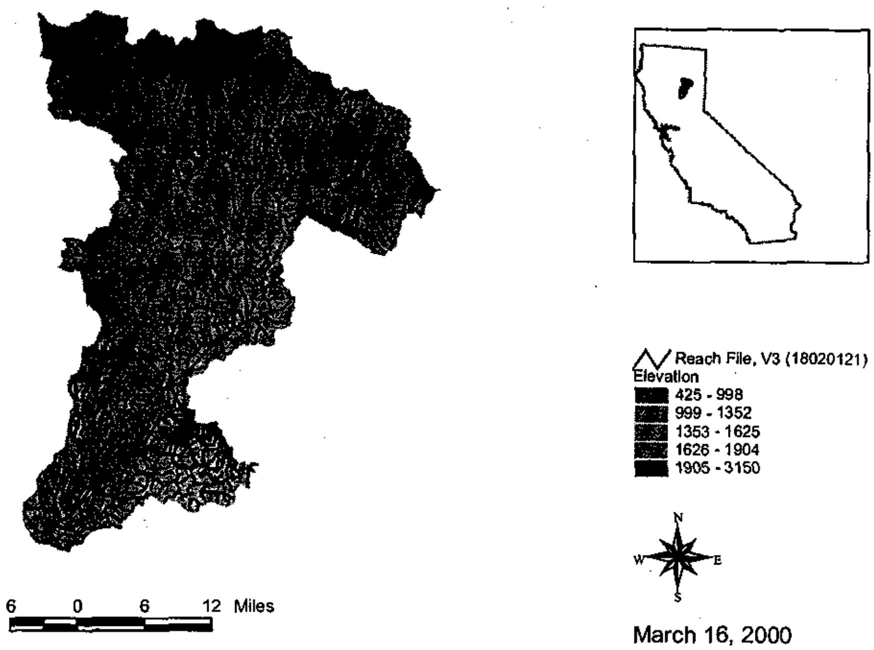
March 16, 2000

Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	3138
COMMERCIAL AND SERVICES-12	246
INDUSTRIAL-13	159
TRANS, COMM, UTIL-14	214
MXD URBAN OR BUILT-UP-16	10
OTHER URBAN OR BUILT-UP-17	209
Subtotal	3976
Agricultural Land	
CROPLAND AND PASTURE-21	121
Subtotal	121
Forest Land	
DECIDUOUS FOREST LAND-41	448
EVERGREEN FOREST LAND-42	522324
MIXED FOREST LAND-43	2495
Subtotal	525267
Range Land	
HERBACEOUS RANGELAND-31	9446

18160

SHRUB & BRUSH RANGELAND-32	14994
MIXED RANGELAND-33	609
Subtotal	25049
Water	
LAKES-52	2782
RESERVOIRS-53	29457
Subtotal	32239
WetLand	
NONFORESTED WETLAND-62	356
Subtotal	356
Barren Land	
BARE EXPOSED ROCK-74	508
STRIP MINES-75	481
TRANSITIONAL AREAS-76	582
Subtotal	1571
================================	
Total	588579

North Fork Feather A5-3140.00 Subbasin Topography

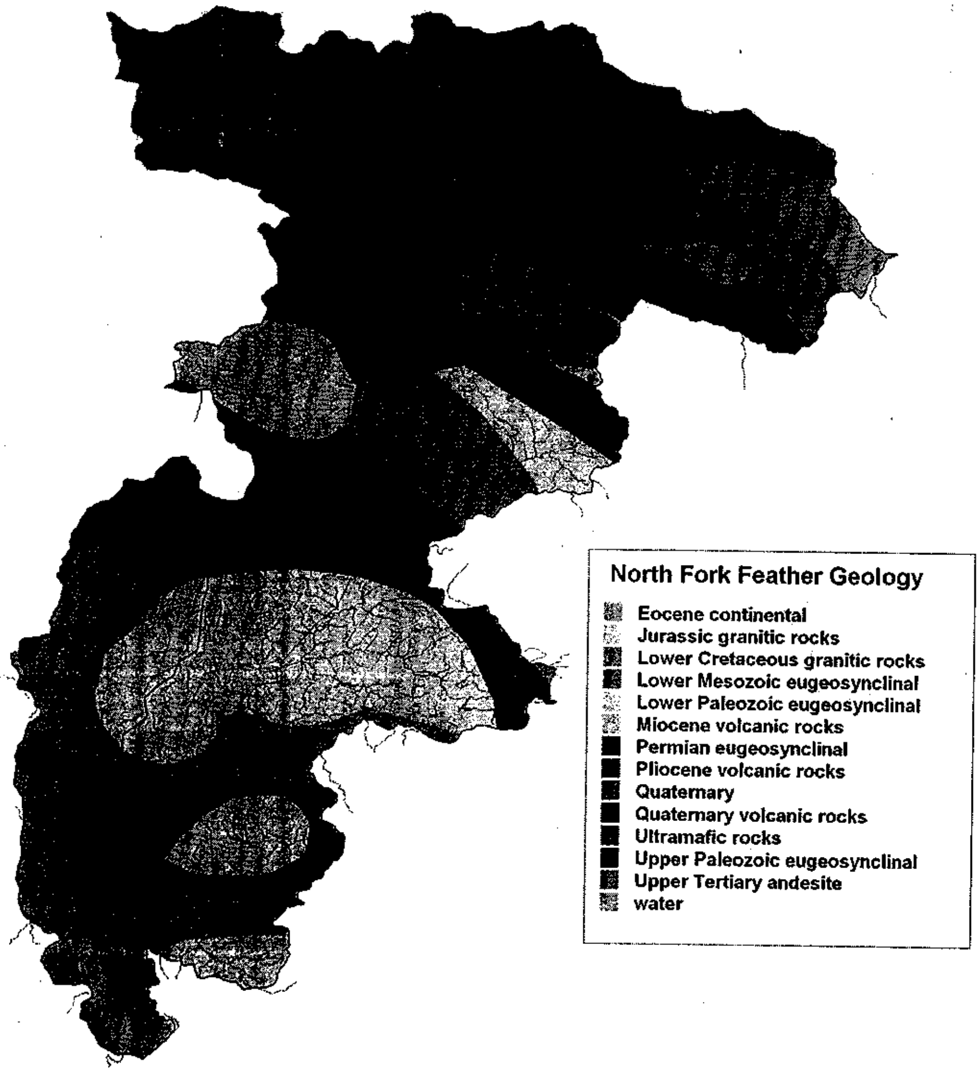


March 16, 2000

Min. Elevation: 425
Max. Elevation: 3150
Mean Elevation: 1612.52
Median Elevation: 1773
Std. Deviation: 329.904

Average Stream Gradient: 4.42869

18162



Geology in North Fork Feather A5-3140.00 Subbasin:

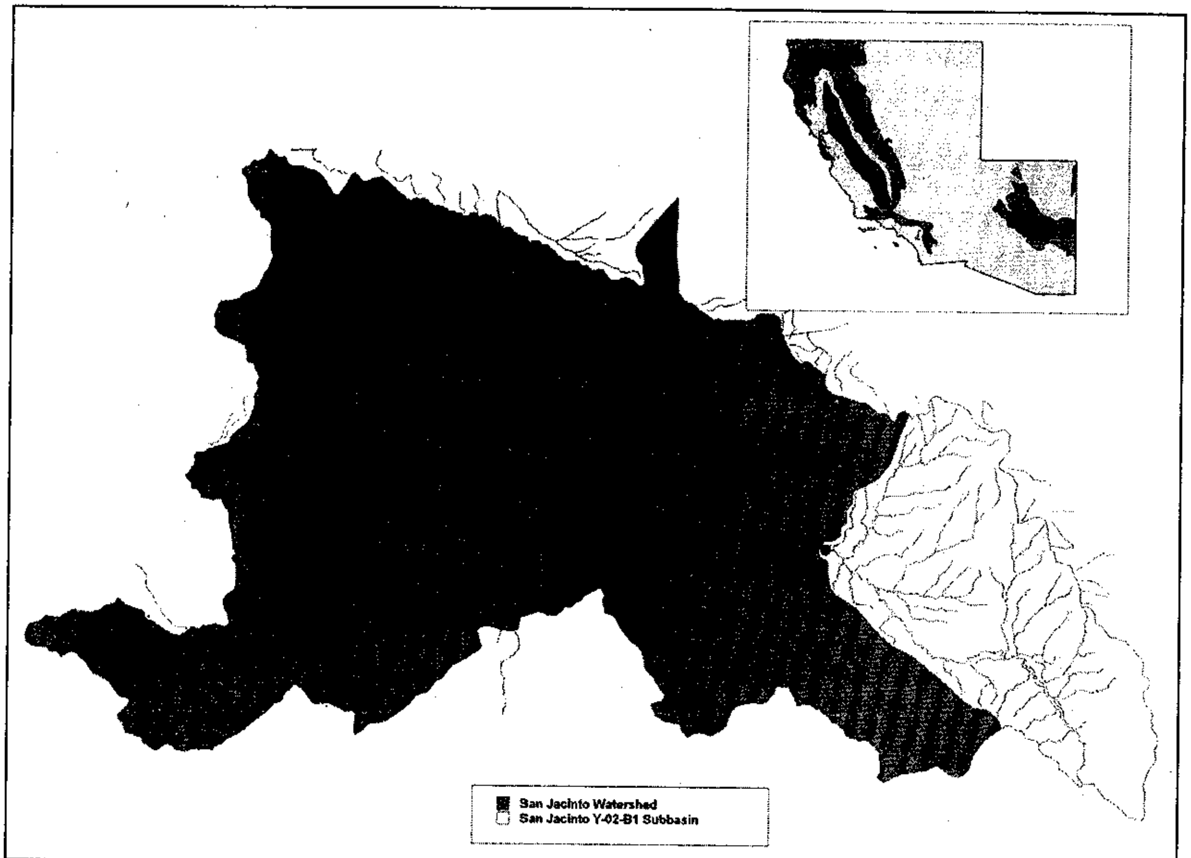
ROCKDESC	Acres
Upper Tertiary andesite	39230.12
Pliocene volcanic rocks	111866.89
Quaternary	37761.39
Miocene volcanic rocks	31850.76
water	4209.08
Lower Cretaceous granitic rocks	16059.25
Eocene continental	6648.03
Permian eugeosynclinal	28943.19
Lower Mesozoic eugeosynclinal	56028.38
Lower Paleozoic eugeosynclinal	15124.72

18163

Upper Paleozoic eugeosynclinal	37927.81
Quaternary volcanic rocks	108021.38
Jurassic granitic rocks	81029.49
Ultramafic rocks	11832.46

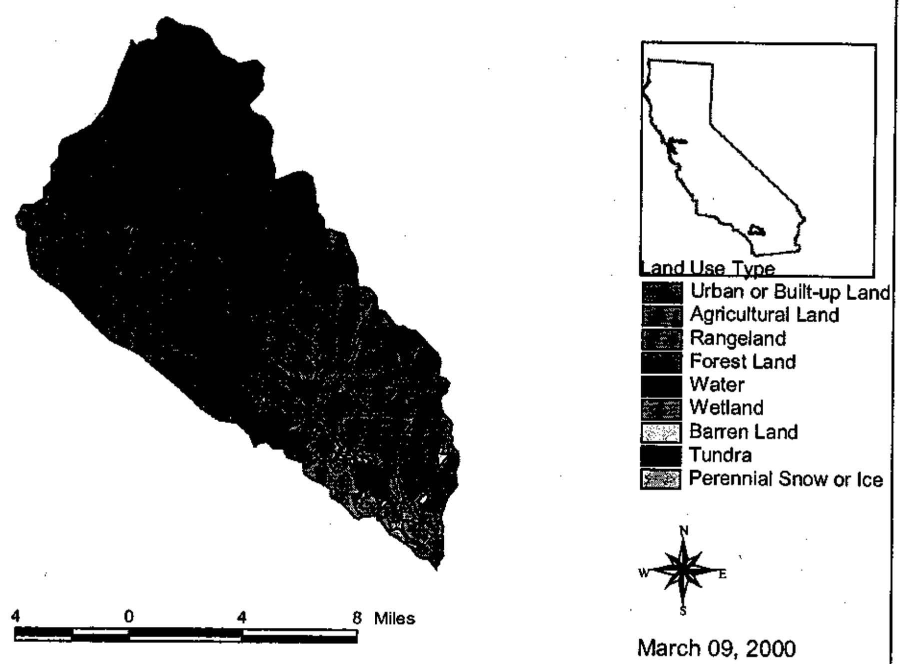
Drainage Area	916.5 sq mi
Stream Order	4
Flow Characteristics	1978 - 1998 Median: 65.00 cfs

18164



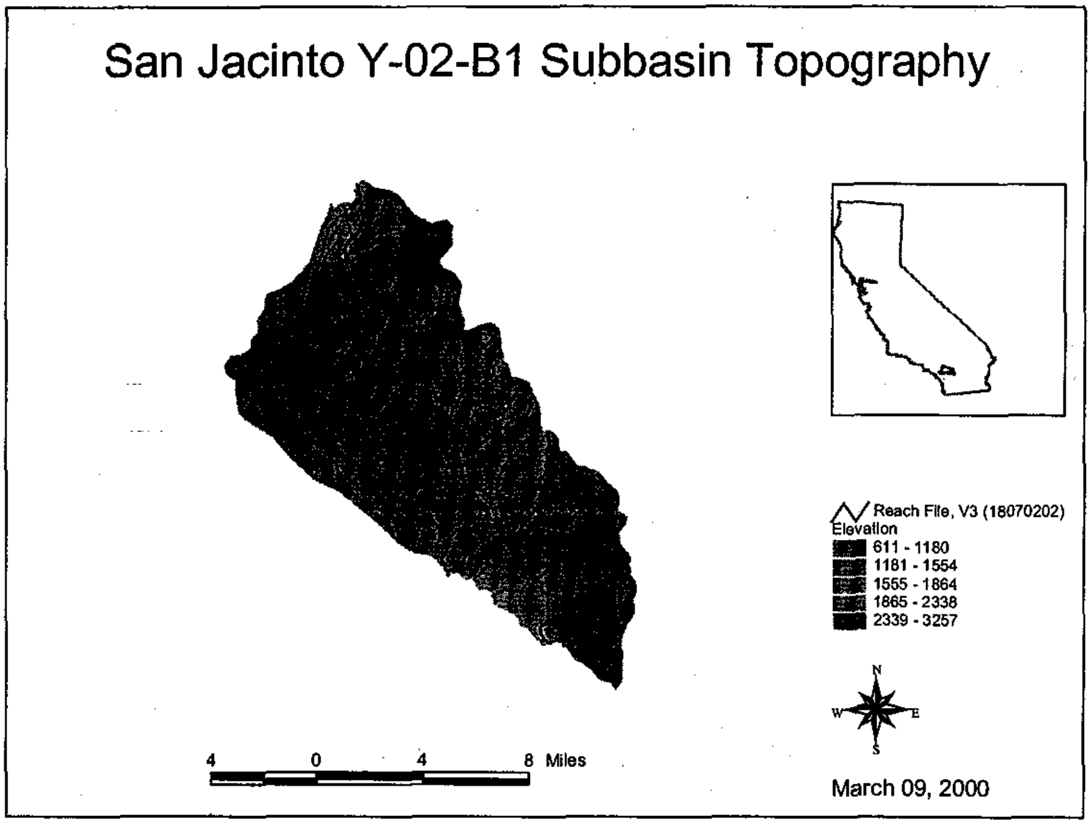
Station: Y-02-B1 Y9 1450.00
Basin: San Jacinto
Site: San Jacinto River nr San Jacinto

San Jacinto Y-02-B1 Subbasin Land Use



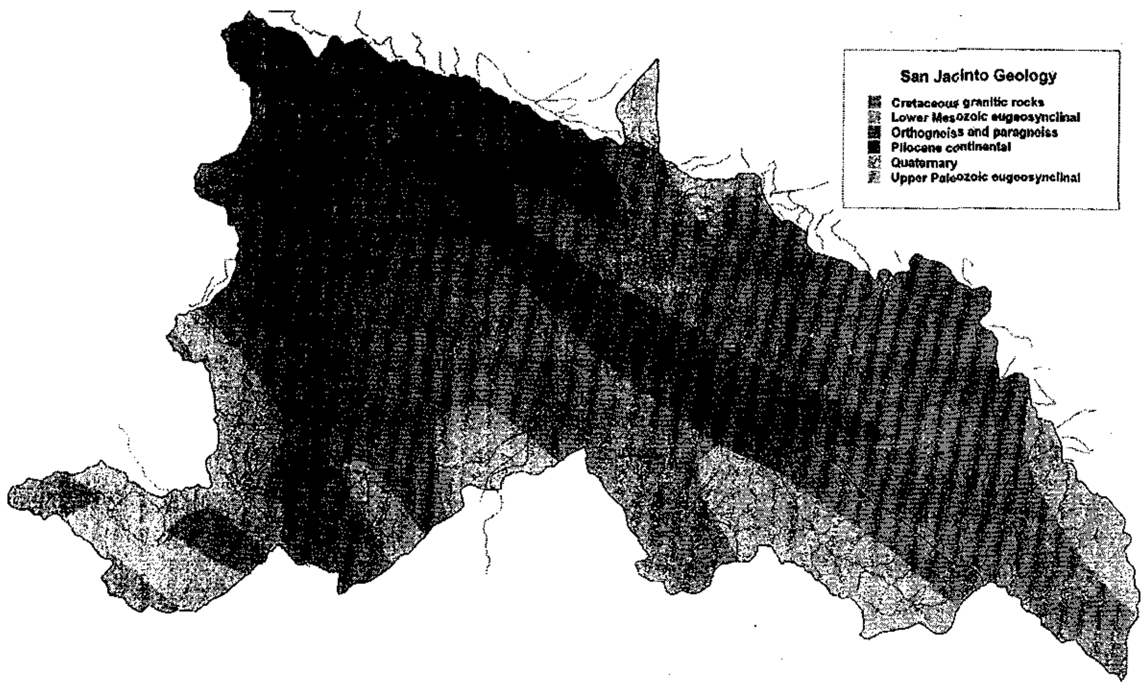
Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	1899
COMMERCIAL AND SERVICES-12	96
MXD URBAN OR BUILT-UP-16	134
Subtotal	2129
Agricultural Land	
CROPLAND AND PASTURE-21	852
OTHER AGRICULTURAL LAND-24	23
Subtotal	875
Forest Land	
EVERGREEN FOREST LAND-42	44982
MIXED FOREST LAND-43	1633
Subtotal	46615
Range Land	
SHRUB & BRUSH RANGELAND-32	36397
MIXED RANGELAND-33	1254
Subtotal	37651

Water	
RESERVOIRS-53	363
Subtotal	363
WetLand	
NONFORESTED WETLAND-62	1245
Subtotal	1245
Barren Land	
BARE EXPOSED ROCK-74	52
TRANSITIONAL AREAS-76	118
Subtotal	170
==	
Total	89048



Min. Elevation: 611
Max. Elevation: 3257
Mean Elevation: 1632.34
Median Elevation: 1224
Std. Deviation: 404.103

Average Stream Gradient: 5.47142

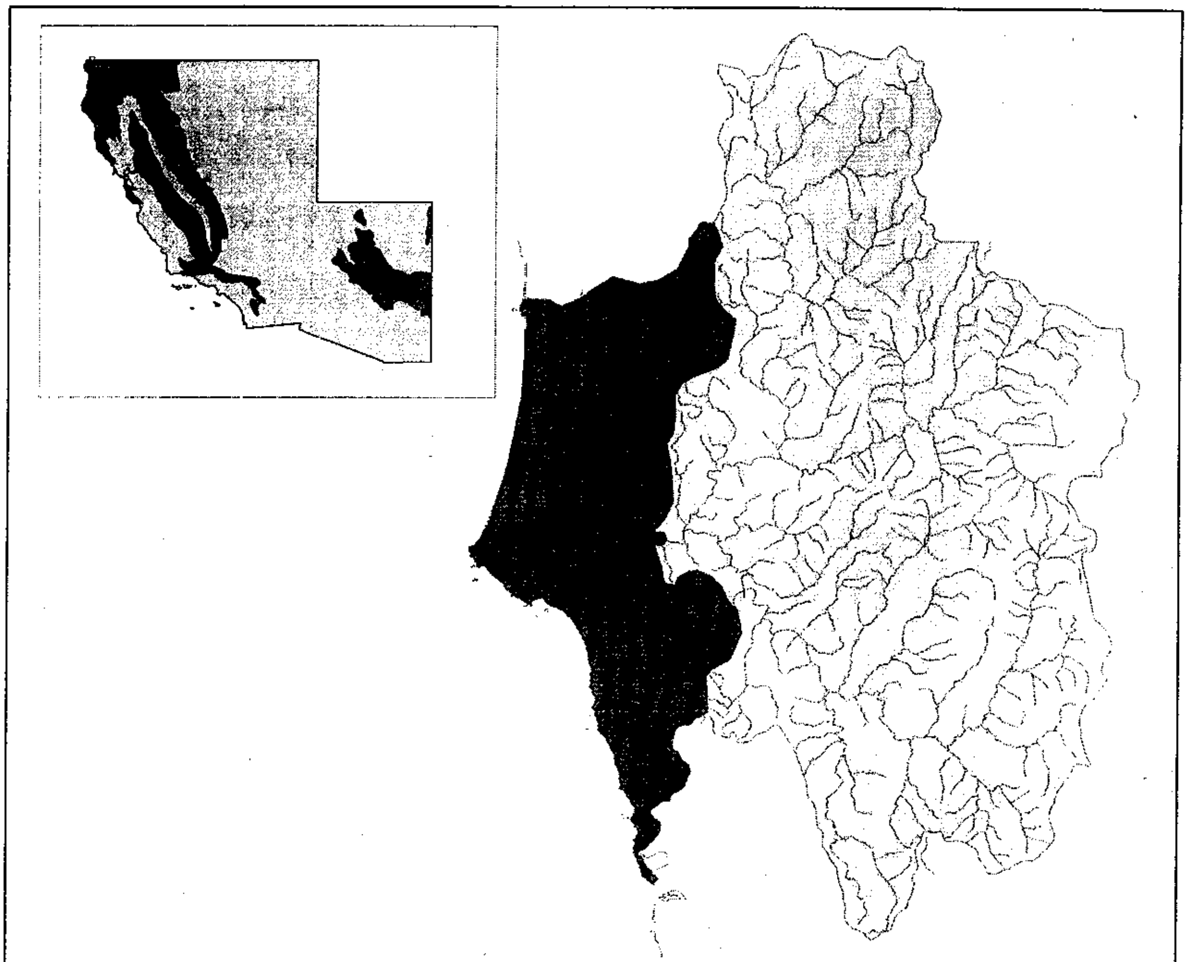


Geology in San Jacinto Y-02-B1 Subbasin:

ROCKDESC	Acres
Pliocene continental	3611.62
Upper Paleozoic eugeosynclinal	11605.28
Cretaceous granitic rocks	73930.89

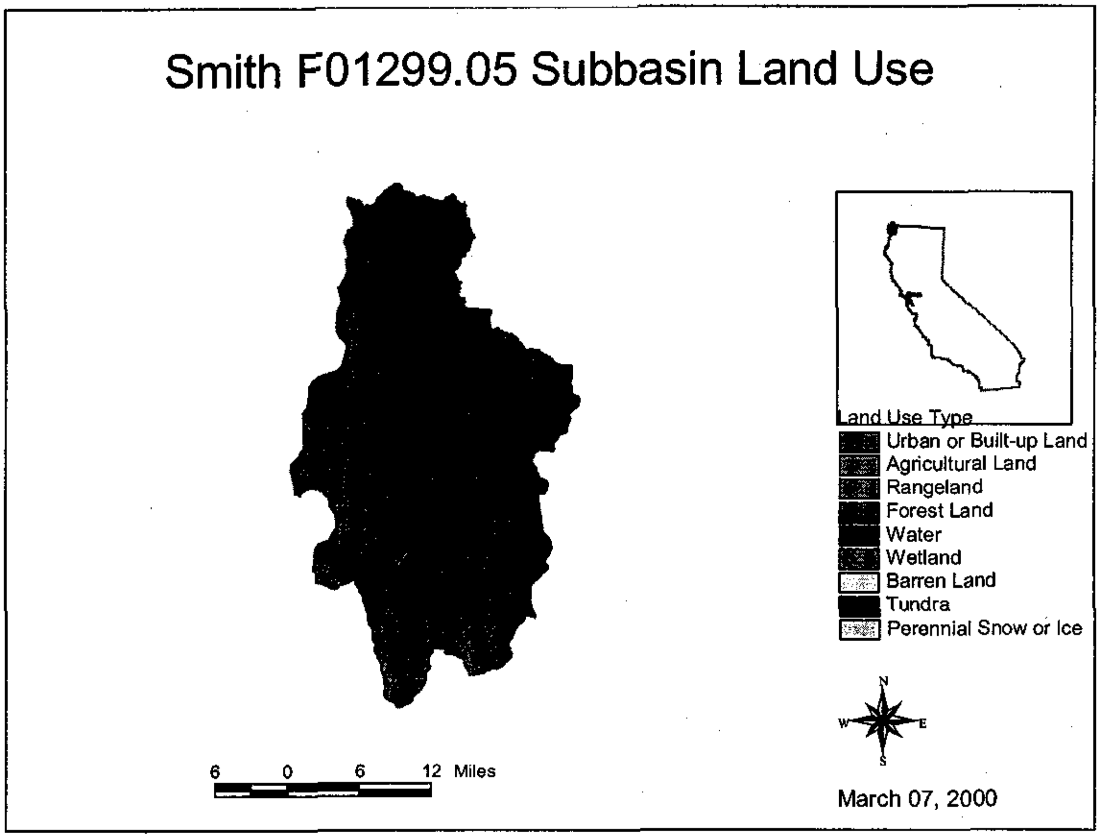
Drainage Area	139.3 sq mi
Stream Order	4
Flow Characteristics	1978 - 1998 Median: 2.60 cfs

18168



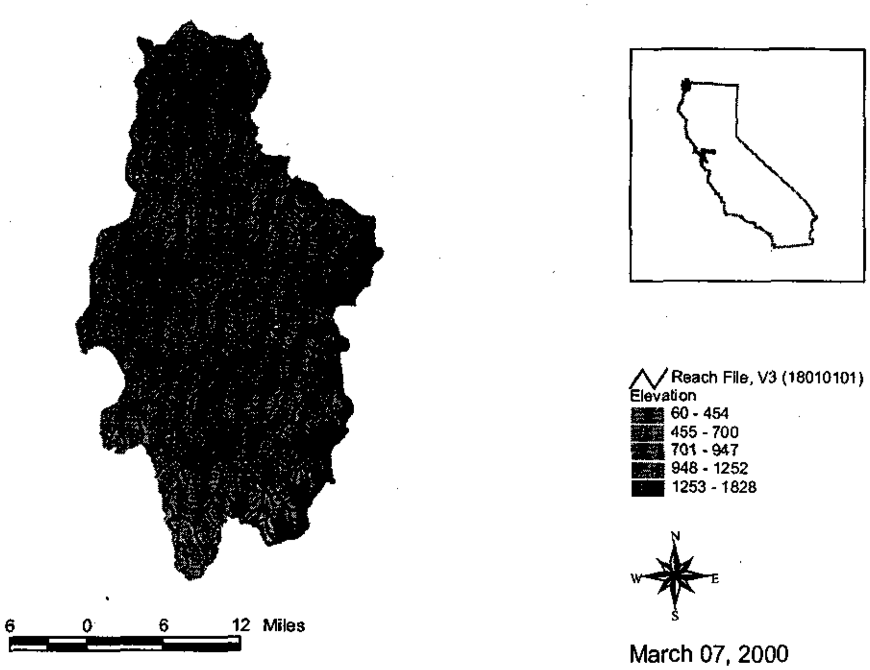
Station: F0-1299.05
Basin: Smith
Site: Smith R at Hiouchi

18169



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	175
MXD URBAN OR BUILT-UP-16	73
Subtotal	248
Forest Land	
EVERGREEN FOREST LAND-42	390947
MIXED FOREST LAND-43	2721
Subtotal	393668
Range Land	
HERBACEOUS RANGELAND-31	406
SHRUB & BRUSH RANGELAND-32	707
Subtotal	1113
Total	395029

Smith F0-1299.05 Subbasin Topography

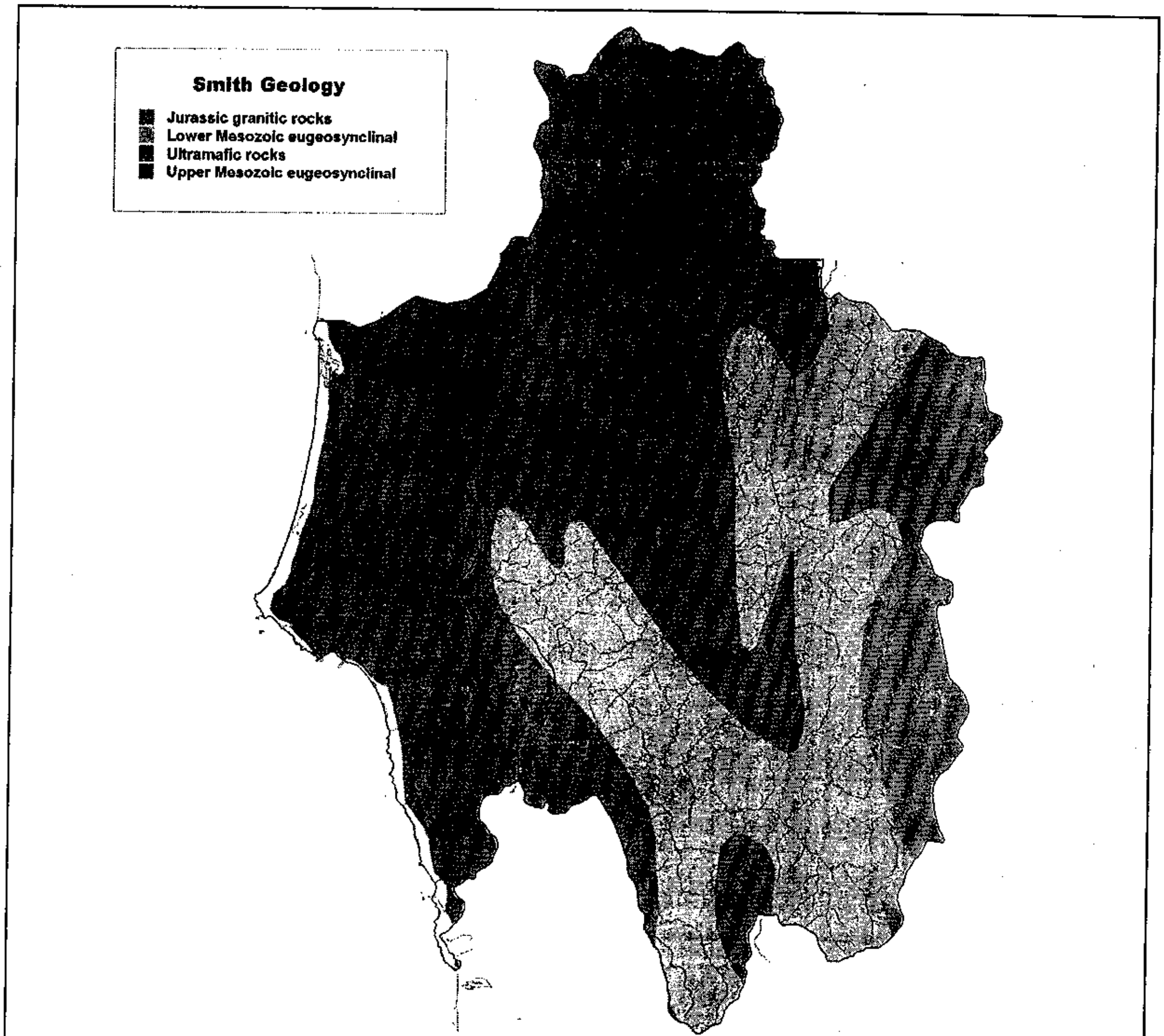


March 07, 2000

Min. Elevation: 60
Max. Elevation: 1828
Mean Elevation: 776.44
Median Elevation: 606
Std. Deviation: 328.901

Average Stream Gradient: 0.555654

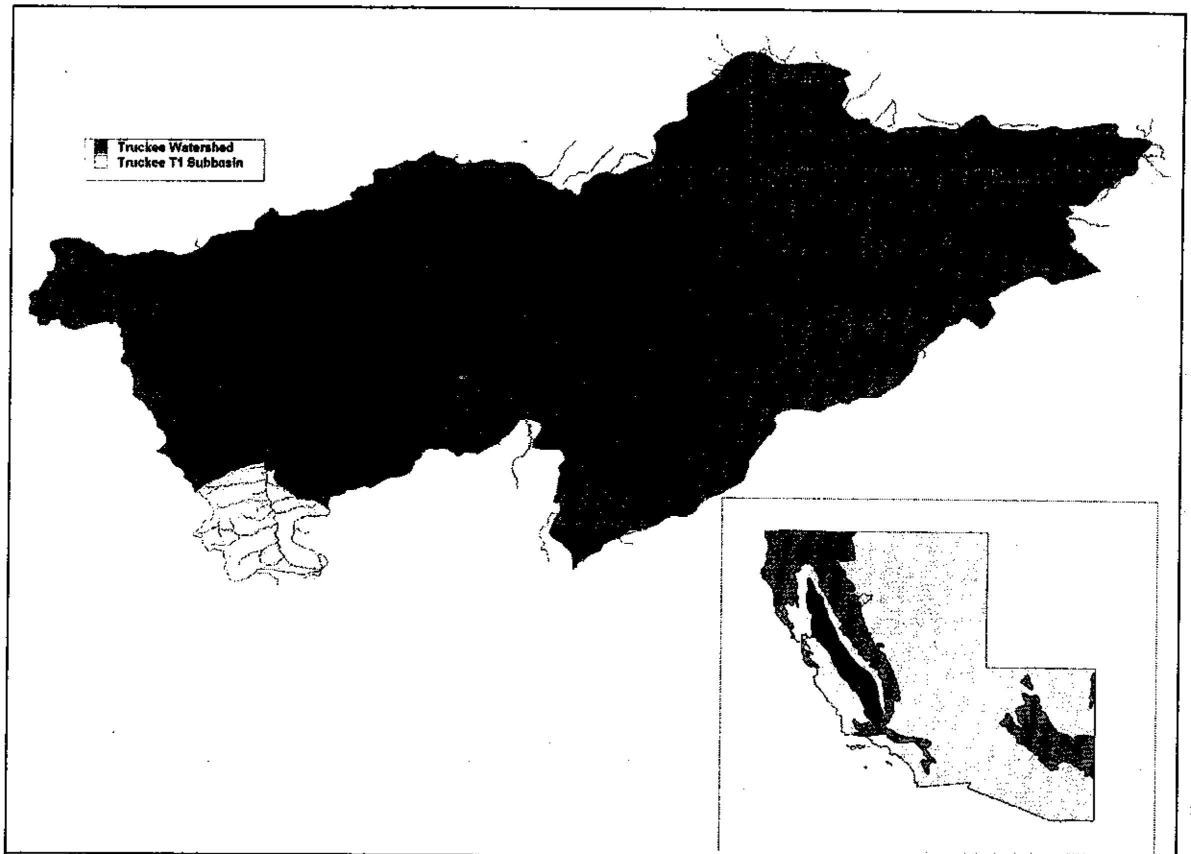
18171



Geology in Smith FO-1299.50 Subbasin:

ROCKDESC	Acres
Ultramafic rocks	207373.52
Jurassic granitic rocks	29160.92
Upper Mesozoic eugeosynclinal	3136.85
Lower Mesozoic eugeosynclinal	151919.14

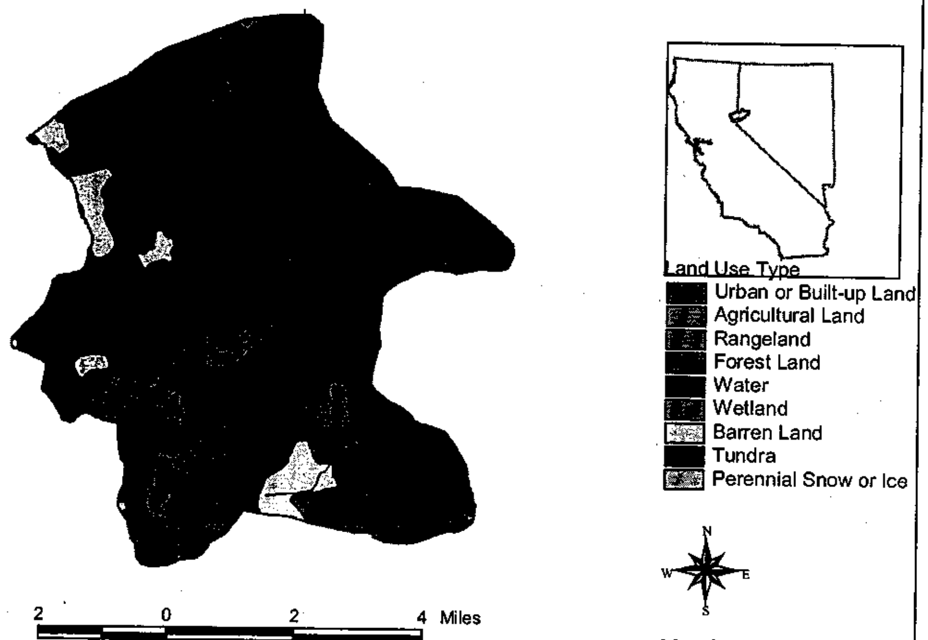
Drainage Area	611.9 sq mi
Stream Order	5
Flow Characteristics	1978 - 1998 Median: 1510.00 cfs



Station: T1
Basin: Truckee
Site: Truckee R Nr Truckee

18173

Truckee T1 Subbasin Land Use

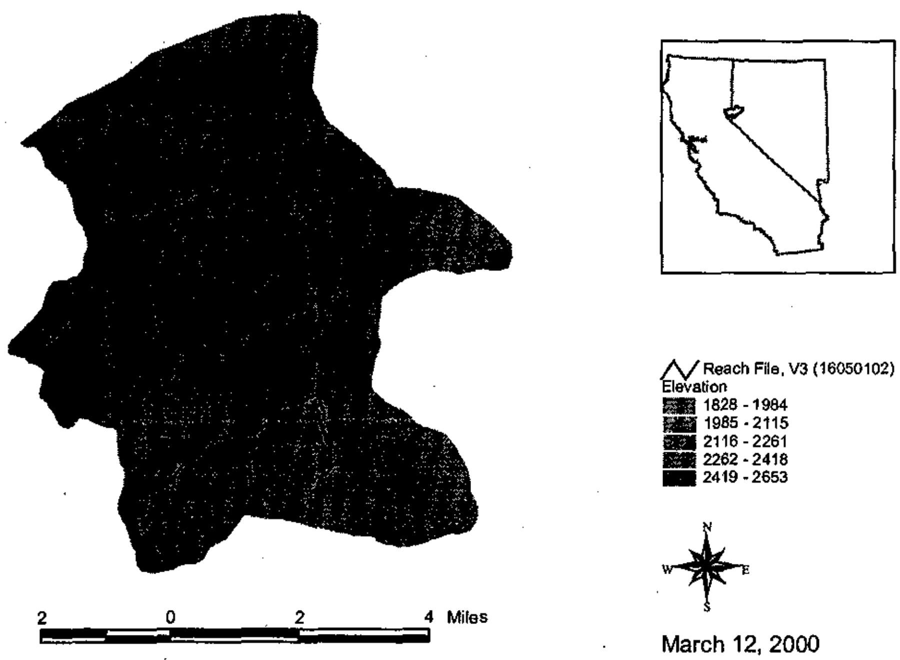


March 12, 2000

Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	359
COMMERCIAL AND SERVICES-12	155
INDUSTRIAL-13	7
OTHER URBAN OR BUILT-UP-17	278
Subtotal	799
Forest Land	
EVERGREEN FOREST LAND-42	22929
Subtotal	22929
Range Land	
HERBACEOUS RANGELAND-31	221
SHRUB & BRUSH RANGELAND-32	916
MIXED RANGELAND-33	100
Subtotal	1237
Barren Land	
BARE EXPOSED ROCK-74	695
TRANSITIONAL AREAS-76	511
Subtotal	1206

Total	26171

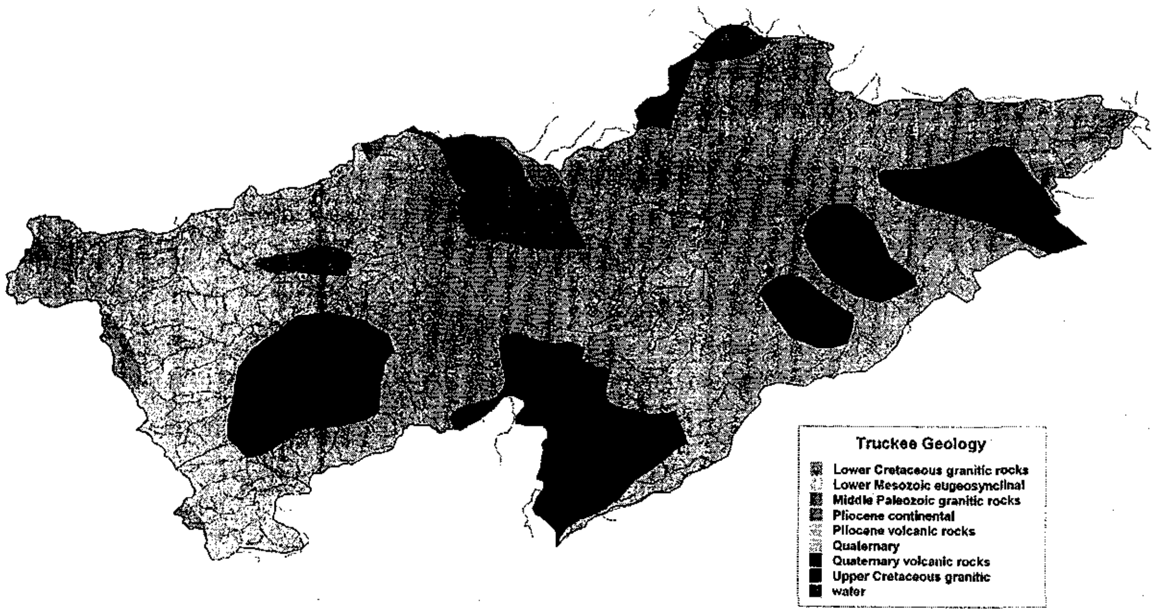
Truckee T1 Subbasin Topography



Min. Elevation: 1828
Max. Elevation: 2653
Mean Elevation: 2178.19
Median Elevation: 2464
Std. Deviation: 185.93

Average Stream Gradient: 7.99206

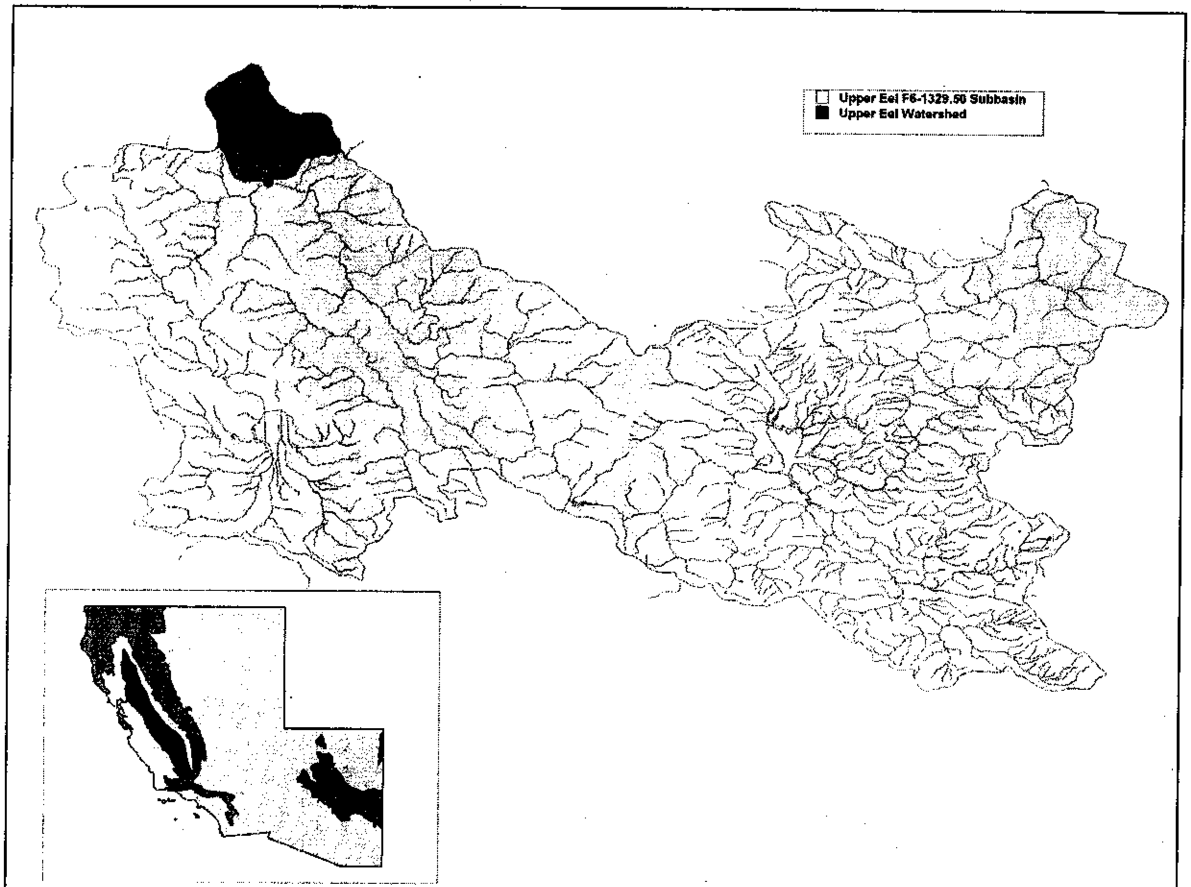
18175



Geology in Truckee T1 Subbasin:

ROCKDESC	Acres
Lower Cretaceous granitic rocks	1361.13
Quaternary volcanic rocks	689.668
Lower Mesozoic eugeosynclinal	0.00273478
Pliocene volcanic rocks	24068.24

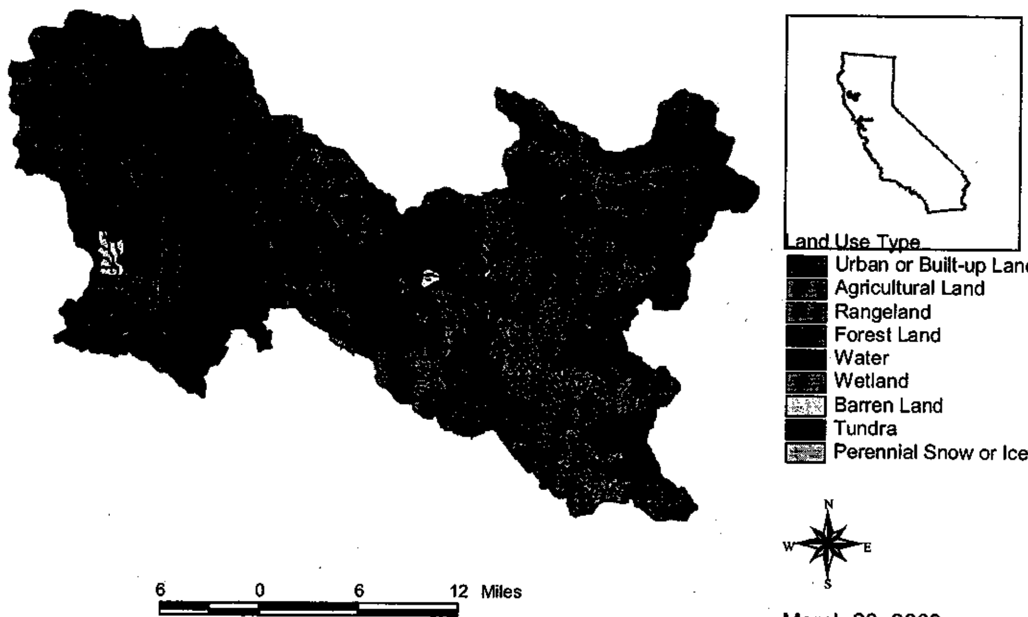
Drainage Area	40.81 sq mi
Stream Order	3
Flow Characterization	1978 - 1998 Median: 190.00 cfs



Station: F6-1329.50
Basin: Upper Eel
Site: Eel R above Outlet Cr nr Dos Rios

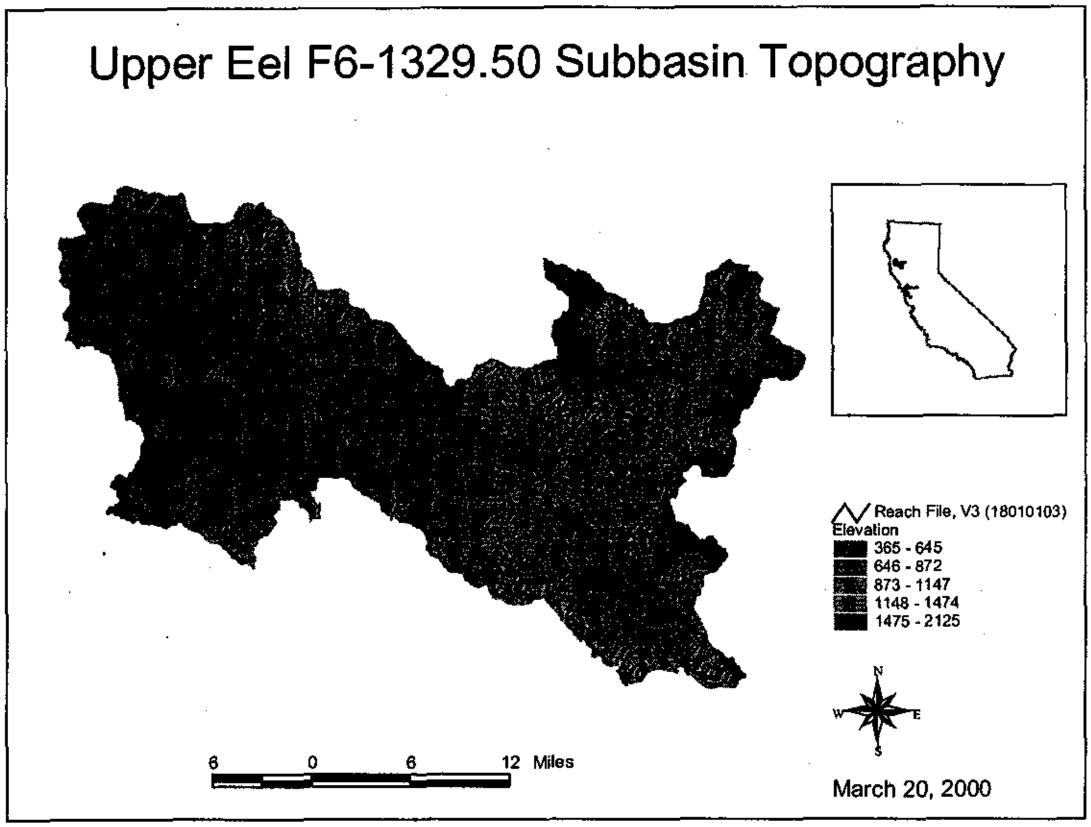
18177

Upper Eel F6-1329.50 Subbasin Land Use



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	1102
COMMERCIAL AND SERVICES-12	308
INDUSTRIAL-13	129
TRANS, COMM, UTIL-14	757
OTHER URBAN OR BUILT-UP-17	142
Subtotal	2438
Agricultural Land	
CROPLAND AND PASTURE-21	7003
Subtotal	7003
Forest Land	
DECIDUOUS FOREST LAND-41	314
EVERGREEN FOREST LAND-42	307100
Subtotal	307414
Range Land	
HERBACEOUS RANGELAND-31	17798
SHRUB & BRUSH RANGELAND-32	78693
MIXED RANGELAND-33	22493

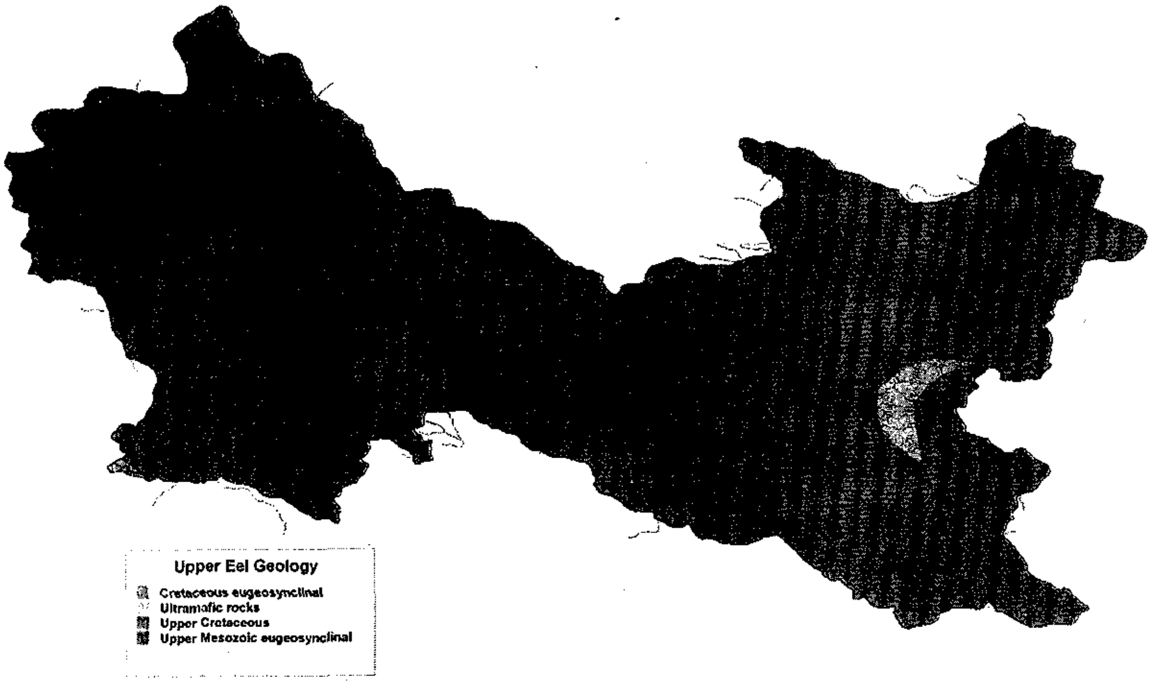
Subtotal	118984
Water	
LAKES-52	106
RESERVOIRS-53	1908
Subtotal	2014
Barren Land	
SANDY AREA (NON-BEACH)-73	284
TRANSITIONAL AREAS-76	2906
Subtotal	3190
===	
Total	441043



Min. Elevation: 365
Max. Elevation: 2125
Mean Elevation: 910.011
Median Elevation: 913
Std. Deviation: 349.046

Average Stream Gradient: 3.43159

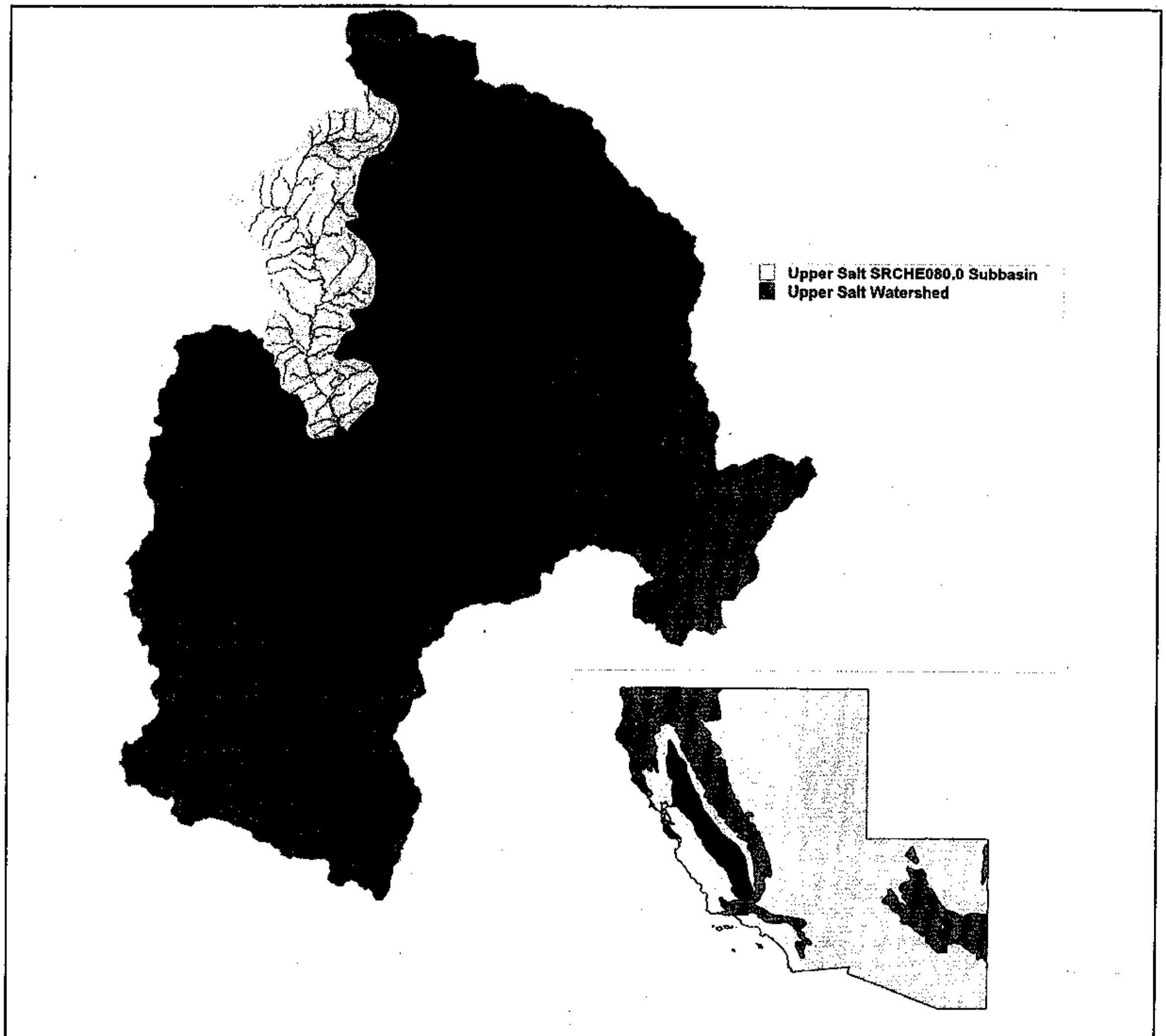
18179



Geology in Upper Eel F6-1329.50 Subbasin:

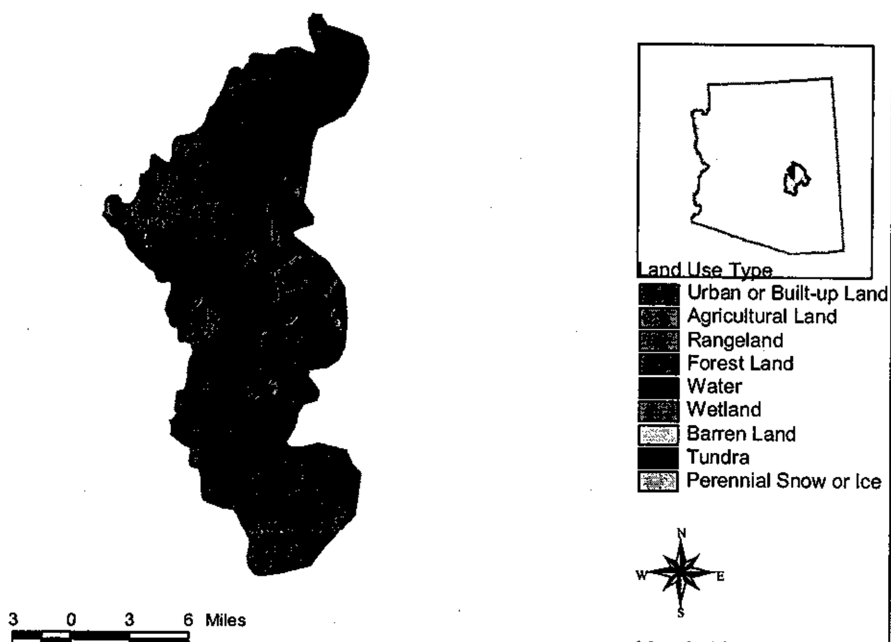
ROCKDESC	Acres
Upper Cretaceous	18734.4
Ultramafic rocks	4866.07
Upper Mesozoic eugeosynclinal	413958.61
Cretaceous eugeosynclinal	450.109

Drainage Area	684.4 sq mi
Stream Order	4
Flow Characteristics	1978 - 1998 Median: 69.00 cfs



Station: SRCHE080.0
Basin: Upper Salt
Site: Cherry Creek Above Confluence With Devils Chasm

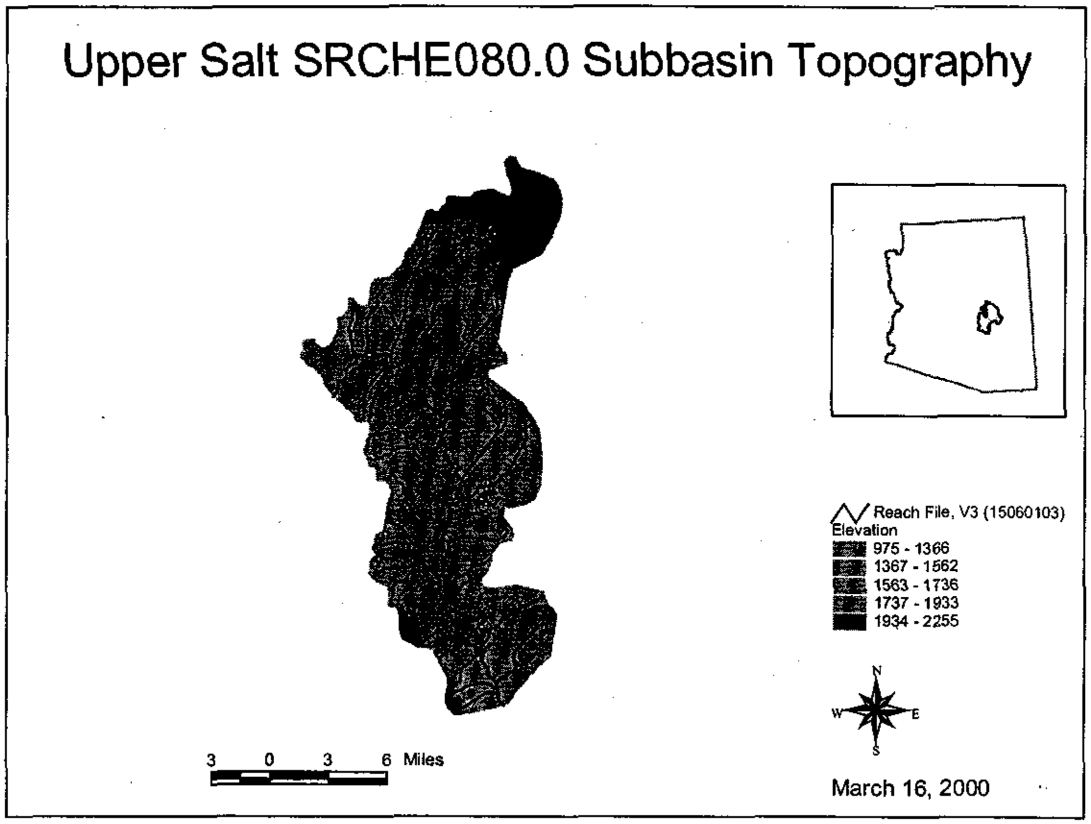
Upper Salt SRCHE080.0 Subbasin Land Use



March 16, 2000

Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	140
COMMERCIAL AND SERVICES-12	12
Subtotal	152
Agricultural Land	
CROPLAND AND PASTURE-21	271
Subtotal	271
Forest Land	
EVERGREEN FOREST LAND-42	116879
MIXED FOREST LAND-43	85
Subtotal	116964
Range Land	
HERBACEOUS RANGELAND-31	3128
SHRUB & BRUSH RANGELAND-32	3293
MIXED RANGELAND-33	4920
Subtotal	11341
Barren Land	

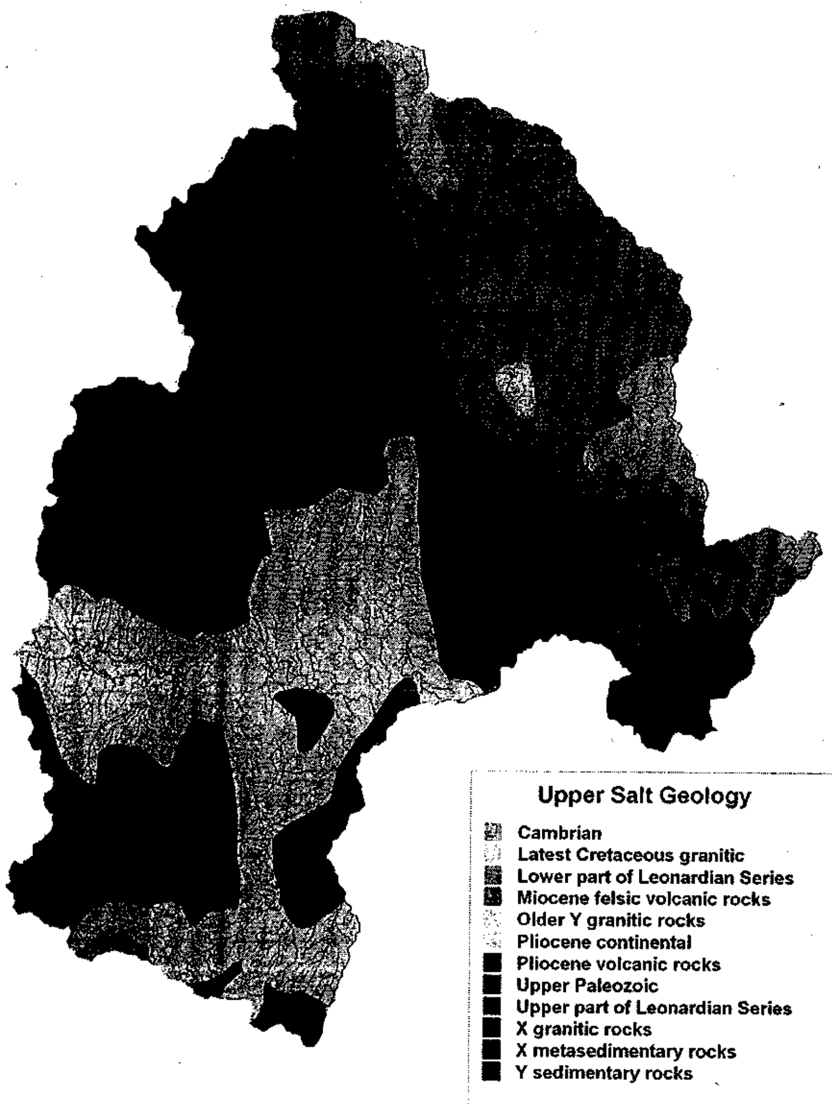
STRIP MINES-75	21
Subtotal	21
==	
Total	128749



Min. Elevation: 975
Max. Elevation: 2255
Mean Elevation: 1675.85
Median Elevation: 1622
Std. Deviation: 210.268

Average Stream Gradient: 23.8664

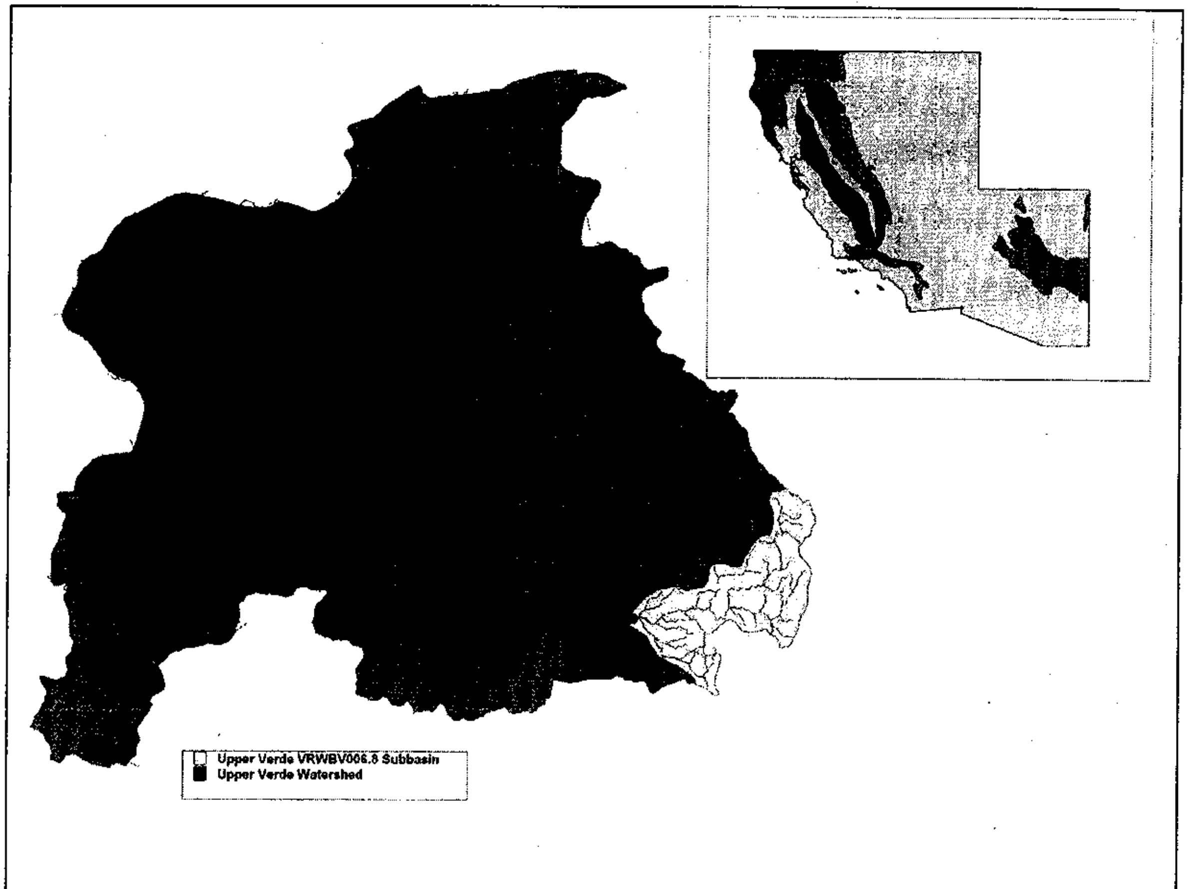
18183



Geology in Upper Salt SRCHE080.0 Subbasin:

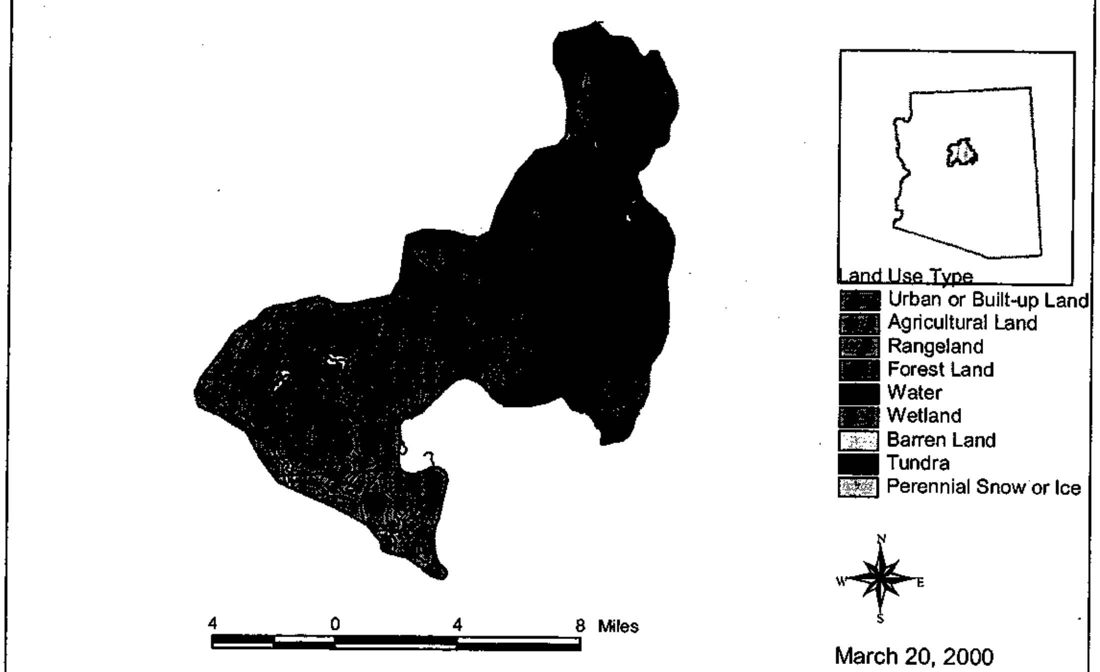
ROCKDESC	Acres
X granitic rocks	29415.36
Lower part of Leonardian Series	75.5415
Y sedimentary rocks	87410.24
Upper Paleozoic	11009.73

Drainage Area	199.9 sq mi
Stream Order	3
Flow Characteristics	1978 - 1998 Median: 10.00 cfs

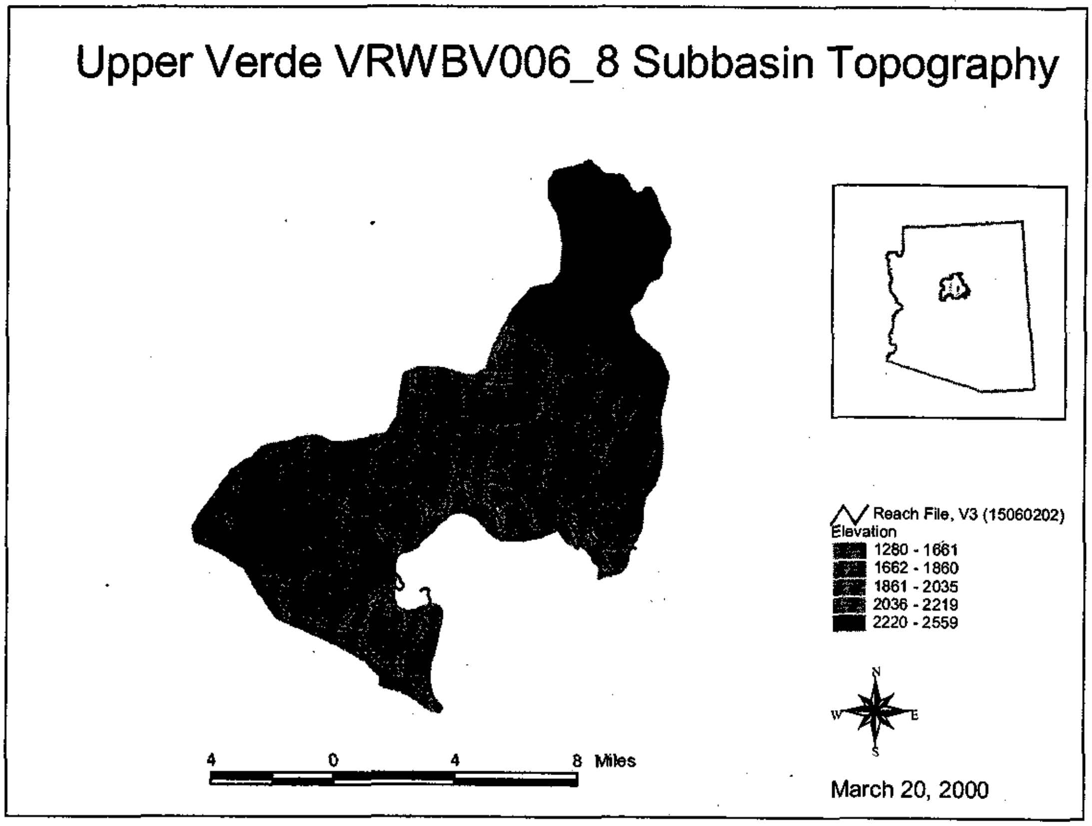


Station: VRWBV006.8
Basin: Upper Verde
Site: Wet Beaver Creek Above Usgs Gage

Upper Verde VRWBV006_8 Subbasin Land Use



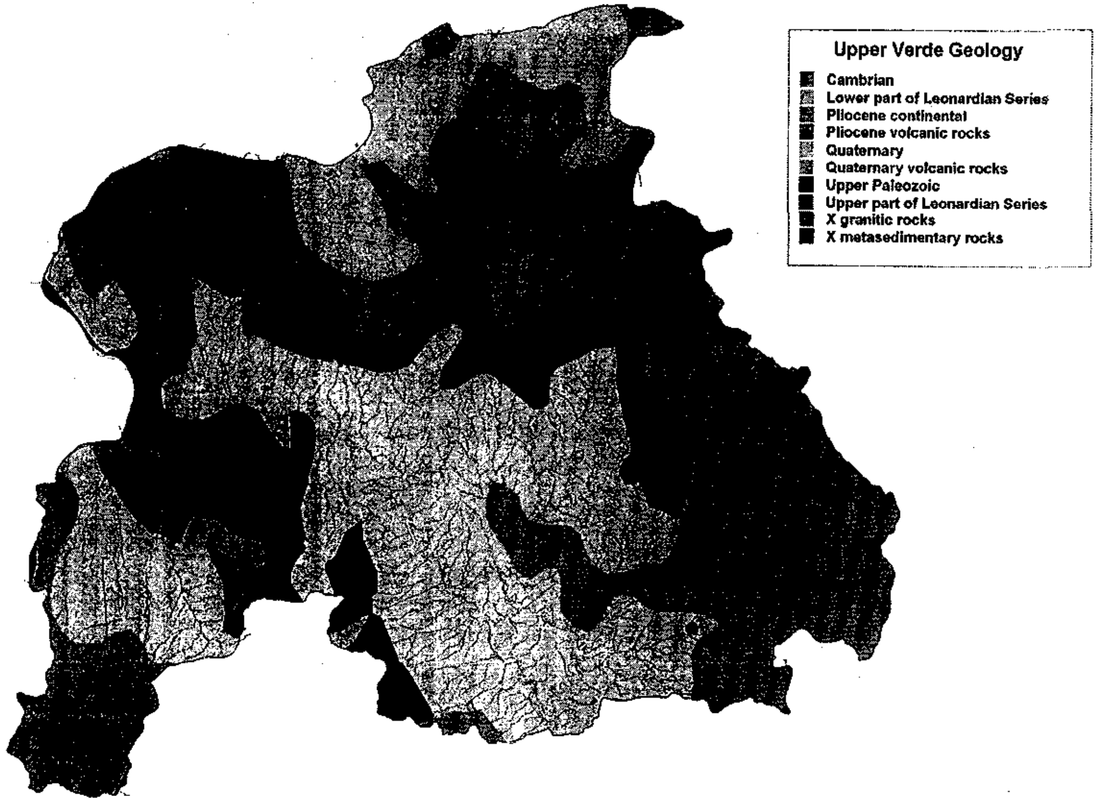
Land Use Name and Code	Area (acres)
Forest Land	
EVERGREEN FOREST LAND-42	36586
MIXED FOREST LAND-43	2459
Subtotal	39045
Range Land	
SHRUB & BRUSH RANGELAND-32	22440
MIXED RANGELAND-33	12432
Subtotal	34872
Water	
LAKES-52	40
Subtotal	40
Barren Land	
SANDY AREA (NON-BEACH)-73	329
STRIP MINES-75	49
Subtotal	378
Total	74335



Min. Elevation: 1280
Max. Elevation: 2559
Mean Elevation: 1987.01
Median Elevation: 2025
Std. Deviation: 241.212

Average Stream Gradient: 17.366

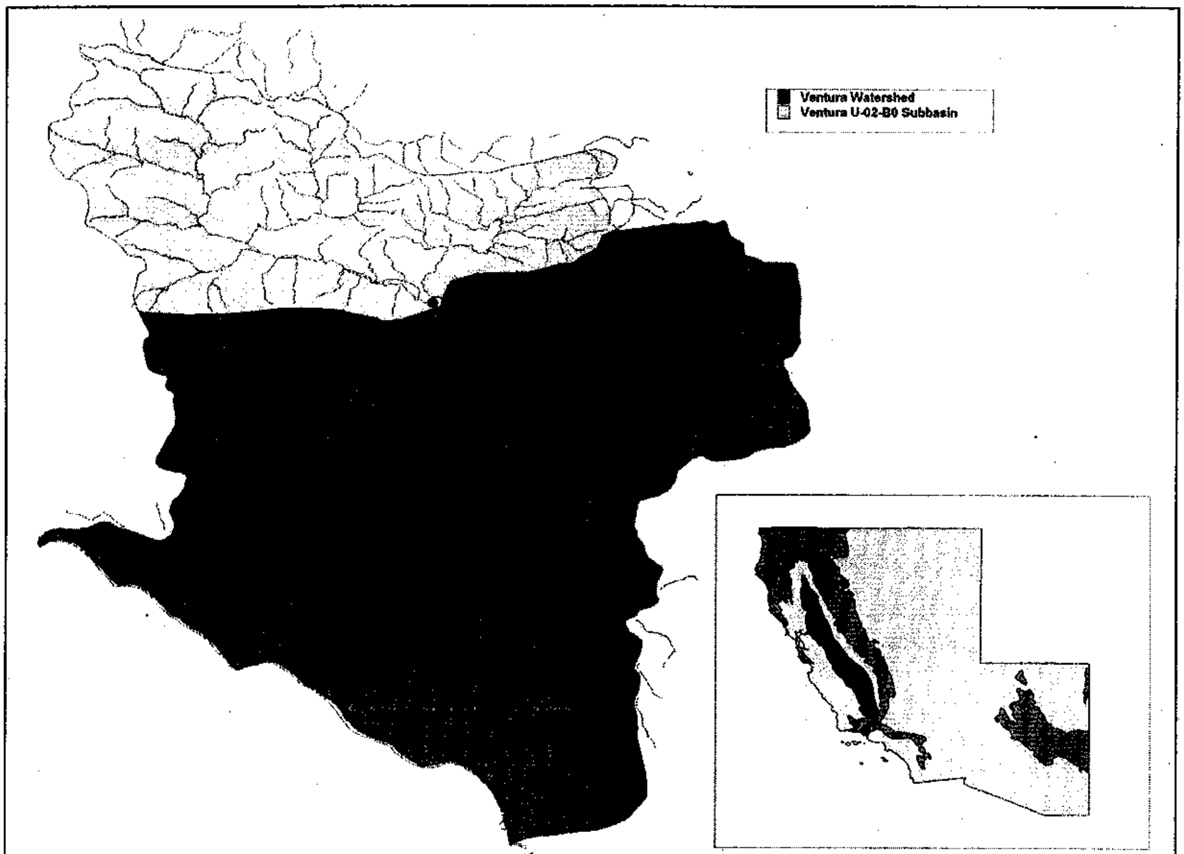
18187



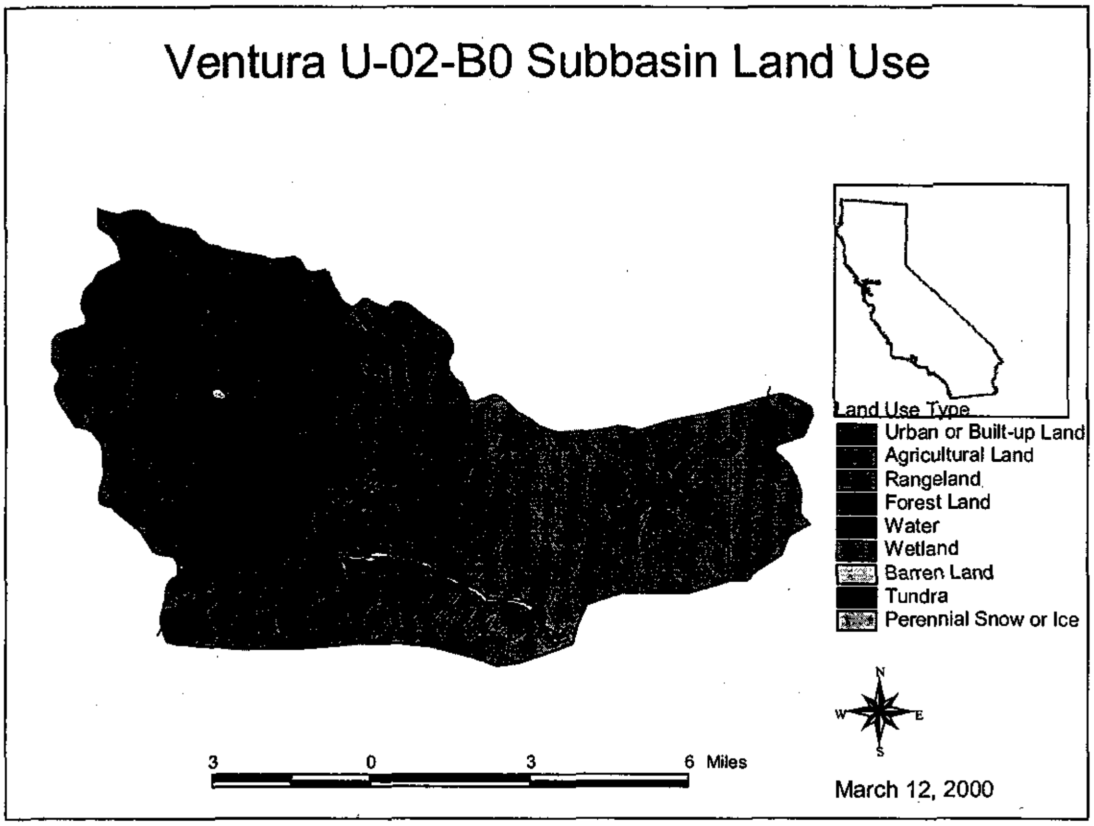
Geology in Upper Verde VRWBV006.8 Subbasin:

ROCKDESC	Acres
Lower part of Leonardian Series	1987.11
Pliocene volcanic rocks	71954.78

Drainage Area	115.5 sq mi
Stream Order	4
Flow Characteristics	1978 - 1998 Median: 7.20 cfs

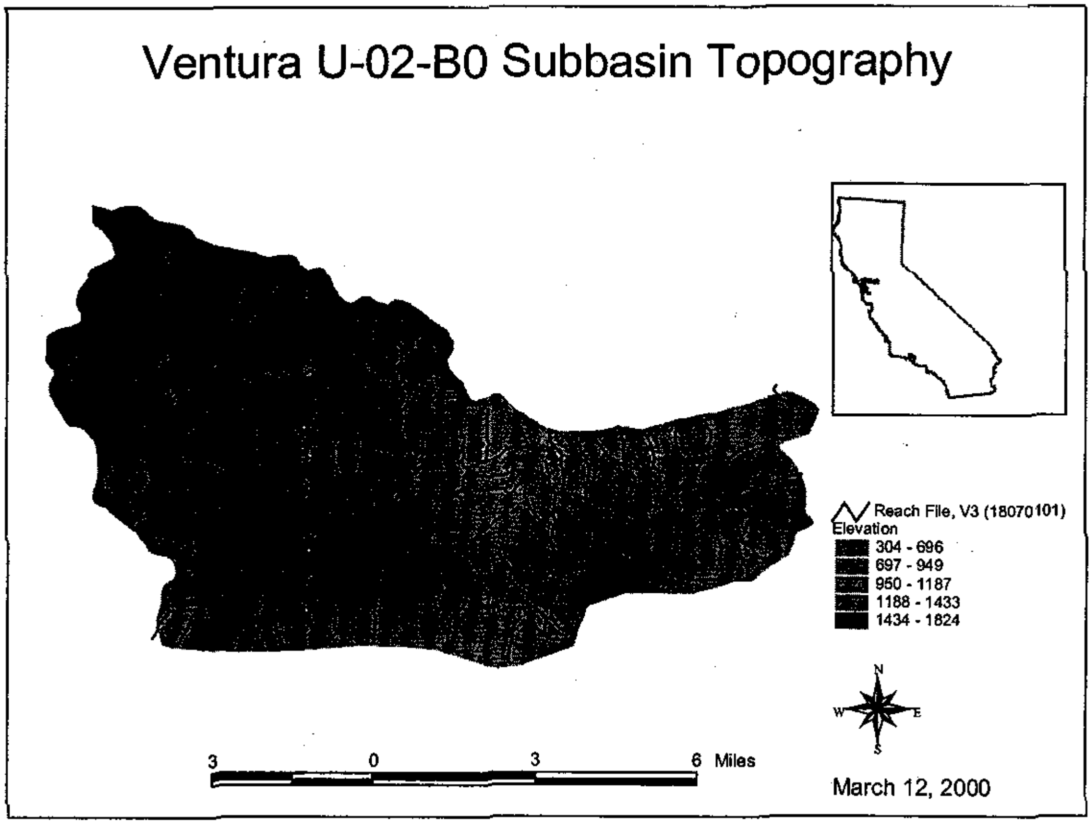


Station: U-02-B0 Z1 5150.00
Basin: Ventura
Site: Matilija Creek nr Matilija Hot Springs



Land Use Name and Code	Area (acres)
Urban or Built-up Land	
RESIDENTIAL-11	120
Subtotal	120
Agricultural Land	
ORCH,GROV,VNYRD,NURS,ORN-22	13
Subtotal	13
Forest Land	
EVERGREEN FOREST LAND-42	5161
Subtotal	5161
Range Land	
SHRUB & BRUSH RANGELAND-32	40517
MIXED RANGELAND-33	124
Subtotal	40641
Water	
RESERVOIRS-53	46
Subtotal	46

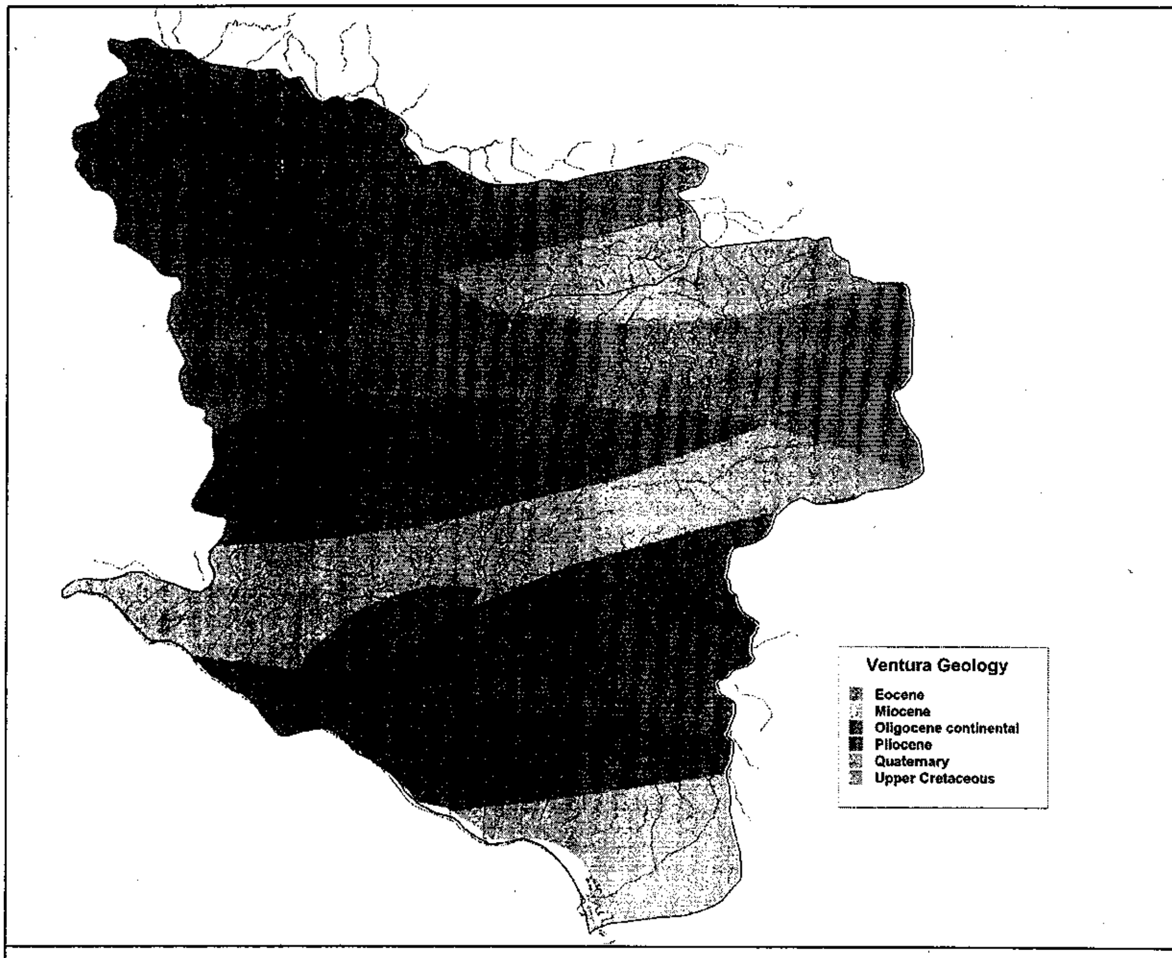
Barren Land	
SANDY AREA (NON-BEACH)-73	184
BARE EXPOSED ROCK-74	29
Subtotal	213
====================================	====================
Total	46194



Min. Elevation: 304
Max. Elevation: 1824
Mean Elevation: 1081.01
Median Elevation: 919
Std. Deviation: 338.351

Average Stream Gradient: 5.9781

18191



Geology in Ventura U-02-B0 Subbasin:

ROCKDESC	Acres
Upper Cretaceous	5057.3
Miocene	2.2706
Eocene	41125.42

Drainage Area	72.16 sq mi
Stream Order	4
Flow Characteristics	1978 - 1998 Median: 6.10 cfs

18193