3.2 Physical Features

Top of the Ventura River Watershed:
Highway 33 Runs Across the Steep Transverse Ranges

3.2 Physical Features

3.2.1 Climate

The Ventura River watershed has a two-season *Mediterranean climate:* a cool winter-spring wet season and a long summer-fall dry season without measurable rain.

3.2.1.1 Climate Zones

The watershed has three distinct climate zones: the low-lying coastal area within a few miles of the ocean; the inland, higher elevation valley floor area where most of the inland development and farming is located; and the mountainous area above the valley floor. The coastal area has smaller seasonal and daily variations in air temperature, cooler summer air temperatures, moister air and less rainfall than inland areas. It is subject to an inversion layer that traps cool, moist air at low elevations, producing fog or low clouds during the night and early morning hours. The inland areas have greater rainfall than coastal areas, along with drier air, and a greater range of daily and seasonal air temperature variation, with summer temperatures averaging 10° to 15°F hotter. The high elevation mountainous area receives the most rain.

3.2.1.2 Air Temperature

July and August are typically the hottest months in the watershed. From late September through March, the watershed can experience "Santa Anas," which are strong, warm, very dry winds that blow in from the deserts to the east and are associated with the rapid spread of wildfires. These winds are felt mostly in the coastal areas, although their drying effects extend inland.

In winter, the inland areas of the Ojai Valley experience an average of 31 days where the temperature drops below freezing; in the coastal zone, freezing temperatures are only reached an average of two days a year (WRCC 2013).

The highest temperature recorded in Ojai was 119°F, on June 16, 1917, and the lowest recorded temperature was 13°F on January 6, 1913 (WRCC 2013).

Kishu Mandarins After a Freezing Night
Photo courtesy of Lisa Brenneis

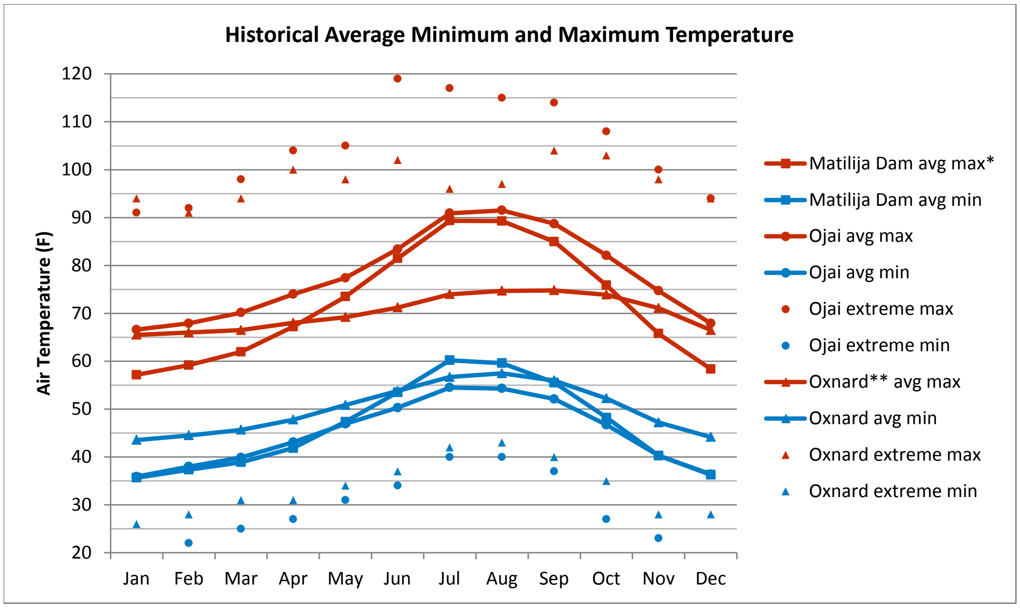


Figure 3.2.1.2.1 Historical Average Minimum and Maximum Temperature
Dates: Matilija Dam - 1905–2011, Ojai - 1905–2012, Oxnard - 1923–2003.

* Extreme maximum and minimum temperatures not available for this location.

** Oxnard data is a proxy for Ventura, as the weather is very similar and there is no weather station in Ventura.

Data sources: Matilija Dam - PRISM Climate Group 2013; Ojai and Oxnard - Western Regional Climate Center (WRCC 2013)

Table 3.2.1.2.1 Historical Average Minimum and Maximum Temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Matilija Dam 1905–2011												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
avg max temp (°F)	57.2	59.2	62.0	67.2	73.5	81.5	89.3	89.3	85.0	75.9	65.8	58.4
avg min temp (°F)	35.7	37.3	38.9	41.9	47.4	53.5	60.2	59.6	55.5	48.2	40.3	36.3
Downtown Ojai 1905–2012												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
avg max temp (°F)	66.6	67.9	70.2	74.0	77.4	83.4	90.9	91.5	88.7	82.1	74.7	67.9
avg min temp (°F)	35.9	38.0	39.9	43.1	46.9	50.3	54.5	54.3	52.1	46.7	40.3	36.4
Oxnard (Proxy for Ventura) 1923–2003												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
avg max temp (°F)	65.5	66.0	66.5	68.0	69.2	71.2	74.0	74.7	74.8	73.9	71.1	66.5
avg min temp (°F)	43.5	44.5	45.7	47.8	50.9	53.8	56.7	57.5	56.0	52.2	47.2	44.2

Data source: Matilija Dam - PRISM Climate Group 2013; Ojai and Oxnard - Western Regional Climate Center (WRCC 2013)

Table 3.2.1.2.2 Average Annual Temperature (°F)

Downtown Ojai (1905–2012)	61.37
Oxnard (Proxy for Ventura) (1923–2003)	60.11

Note: Average temperature data is not available for Matilija Dam
Data source: Western Regional Climate Center (WRCC 2013)

Aerial View of Fog in the River Valley. The climate of the watershed is also influenced by fog. From mid-May to mid-July, fog and low clouds commonly hug the coastline, typically retreating offshore by afternoon. Drizzle frequently falls in the morning when the fog is thickest. The fog conditions begin to decrease in intensity and duration from mid-July through mid-September. The fog is much more dominant at the coast, as in the interior valleys it is more readily dissipated by solar heating (VCAPCD 1998).

3.2.1.3 Rainfall

Rainfall is highly variable in the watershed—seasonally, and from year to year. Rainfall typically occurs in just a few significant storms each year, which can come any time between October 15 and April 1, with 90% of the rainfall occurring between November and April (VCWPD 2010). Snowfall is generally minimal and short-lived.

Definition: Water Year

A "water year" or "rain year" is defined as October 1 of the previous year through September 30. For example water year 2003 is from October 1, 2002, through September 30, 2003.

The Ventura River watershed's rainfall patterns are also variable geographically. The rainfall totals from the watershed's three climate zones shown in Table 3.2.1.3.1 illustrate that, on average, the watershed's upper area (Matilija Canyon) receives over twice as much rainfall, almost 20 inches more, as its lower areas (downtown Ventura). See "4.4 Appendices" for the annual rainfall data for the years 1873 to 2012.

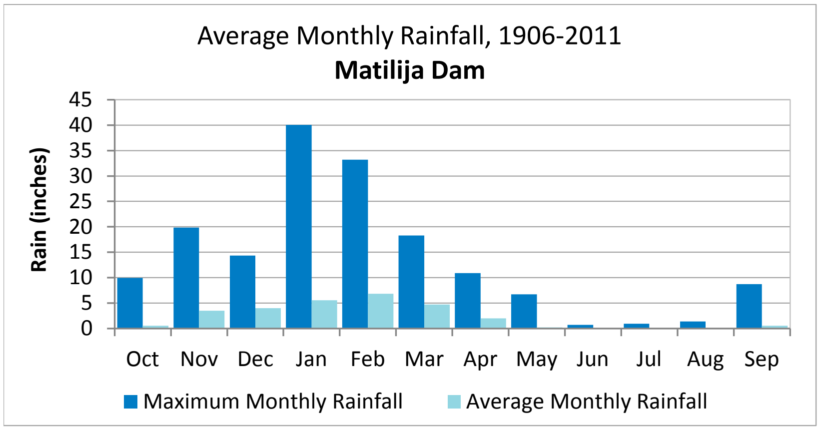
Table 3.2.1.3.1 Rainfall Average and Median (inches/year)

	Station #	Water Years	Average	Median	Min	Max
Matilija Canyon (upper watershed)	207	1960–2012	35.17	28.74	9.09	89.05
Downtown Ojai (middle watershed)	30	1906–2012	21.31	19.20	6.88	49.20
Downtown Ventura (lower watershed)	66	1873–2012	15.46	14.12	4.62	38.65

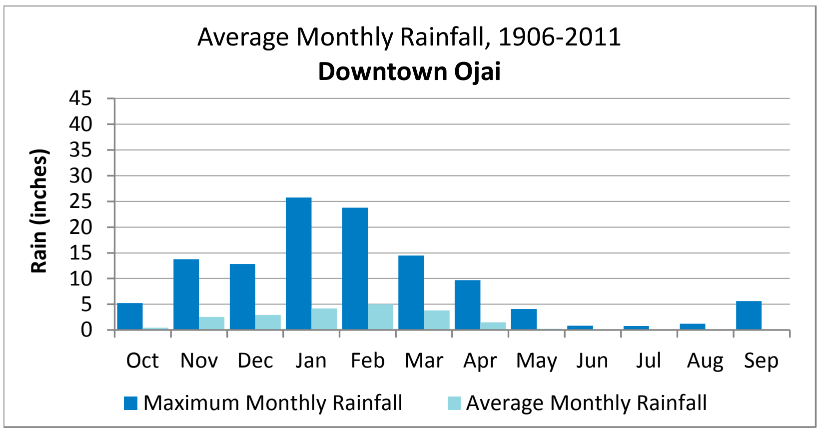
Data Source: VCWPD Hydrologic Data Server (VCWPD 2013)

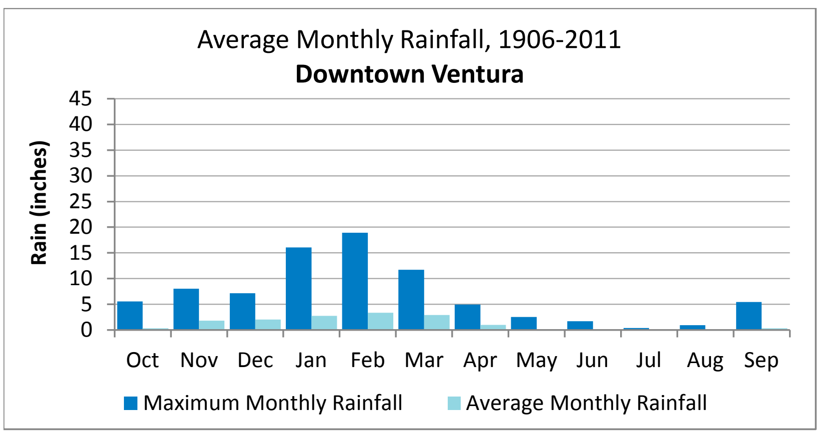
Figure 3.2.1.3.1 Average Monthly Rainfall, 1906–2011 (Matilija Dam, Ojai, Ventura)

Data Source: VCWPD Hydrologic Data Server (VCWPD 2013)



Since 1906, 67% of the years have had less than average rainfall in downtown Ojai.





Average annual rainfall does not adequately convey the reality of the rainfall situation, however. Very few years actually have average rainfall; most years are drier than average, and a relatively few very wet years heavily influence the average (Leydecker & Grabowsky 2006).

For example, rainfall data (Table 3.2.1.3.1.) collected since 1906 show that annual rainfall in downtown Ojai has ranged from a low of 6.88 inches in 1924 to a high of 49.20 inches in 1998; average rainfall over this period was 21.31 inches. Since 1906, 67% of the years have had less than average rainfall in downtown Ojai.

Very few years actually have average rainfall; most years are drier than average, and a relatively few very wet years heavily influence the average.

Since 1906, there have been 15 years of significantly high rainfall (at least 150% of the average—or greater than 32 inches) in downtown Ojai (in 1907, 1914, 1938, 1941, 1952, 1958, 1967, 1969, 1973, 1978, 1983, 1993, 1995, 1998 and 2005). This is an average of once every seven years.

Mean vs. Median

The use of "averages," also known as the "mean," to convey rainfall information can be misleading in a watershed with as much rainfall variability as the Ventura River watershed. The average yearly rainfall in the watershed is not equal to the rainfall that most typically occurs in the watershed, because the average rainfall figure is derived from more years that are dry and many fewer very wet years.

"Median" values give a truer picture of the actual experience of rainfall in the watershed in a typical year. A median rainfall value indicates that half the measurements (daily, monthly or annually) are above and half the measurements are below the median. An average rainfall value, on the other hand, averages all the measurements; average rainfall numbers end up higher than median numbers because of the really big rain years (called "outliers" in statistics). One extreme rain event will have less of an effect on a median value than an average value.

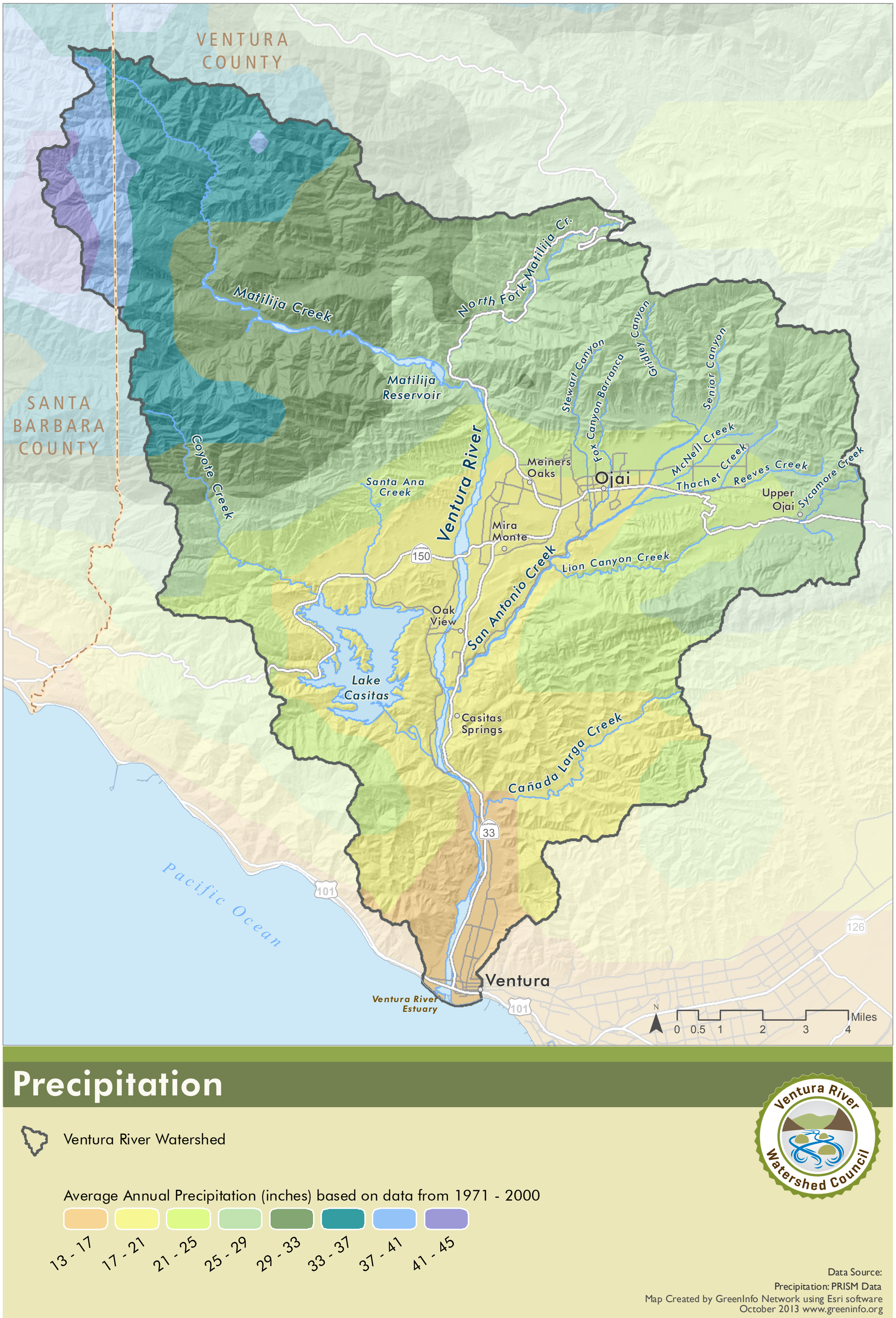


Figure 3.2.1.3.2 Precipitation Map

The Ventura River watershed receives more rainfall than other watersheds in Ventura County. The reason: a 5,560-foot elevation gain in just six miles, from downtown Ojai to the top of Chief Peak behind the city. This wall of vertical mountains near the coast causes what is called "orographic lift": air coming in from the ocean hits the mountains, rises up quickly, cools, condenses, and forms rain. This orographic lift can cause heavy-intensity rainfall events over the mountains of the watershed, most notably in the Matilija Creek subwatershed, the primary headwaters of the watershed. In 2005, 97 inches of rainfall was recorded on the Murrieta divide above Matilija Creek (Holder 2012). The peak historic rainfall intensity was approximately 4.04 inches per hour measured during a 15-minute period at the Wheeler Gorge gauge in the mountains adjacent to Ojai (VCWPD 2010).

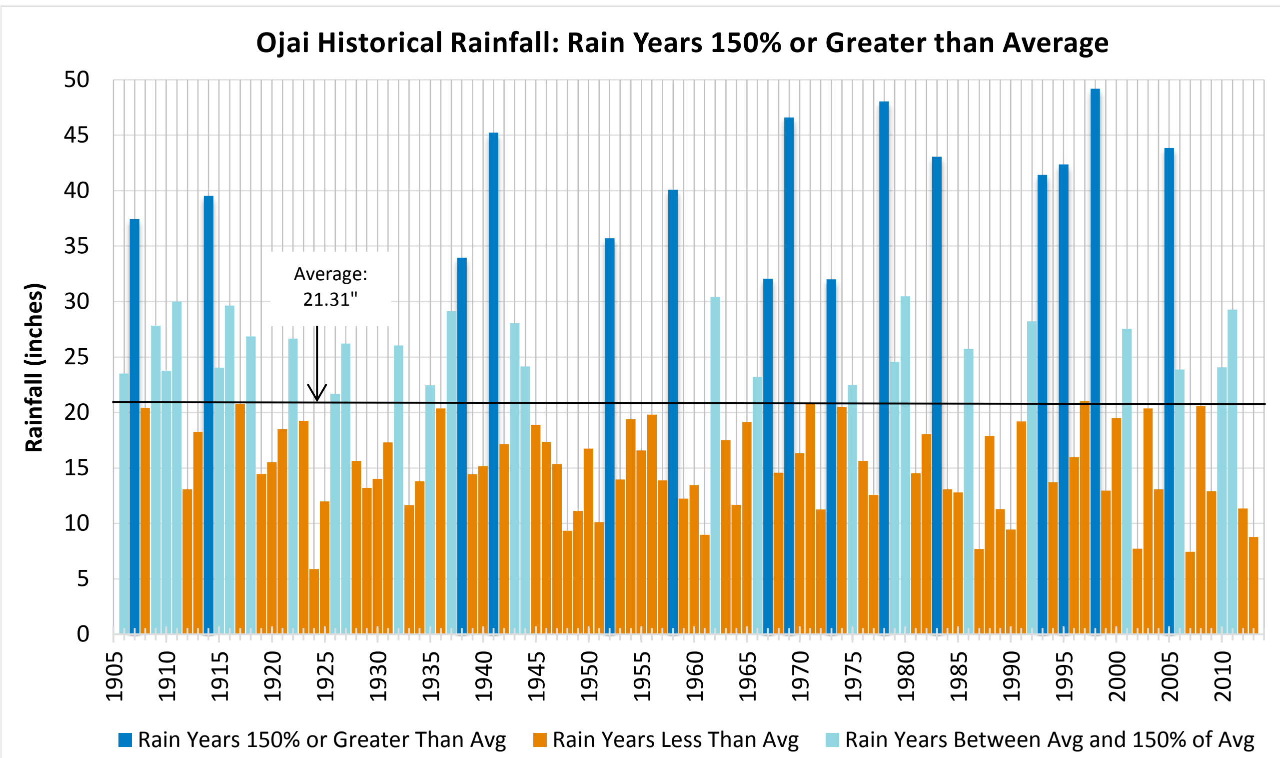


Figure 3.2.1.3.3 Ojai Historical Rainfall: Rain Years 150% or Greater than Average. Since 1906, there have been 15 years of significantly high rainfall (at least 150% of average—or greater than 32 inches) in downtown Ojai. This is an average of once every seven years. Average rainfall in downtown Ojai during this period was 21.31 inches.

Data Source: VCWPD Hydrologic Data Server (VCWPD 2013)

El Niño/La Niña Weather Cycle

The watershed is subject to an El Niño/La Niña weather cycle that can also affect winter precipitation amounts. In our area, the El Niño/La Niña weather pattern is characterized by warming and cooling cycles in the waters of the eastern equatorial Pacific Ocean, which typically have a 1.0- to 1.5-year duration and a 3- to 8-year recurrence interval. Elsewhere in southern California, El Niño years are generally characterized by relatively high rainfall intensities; La Niña years are generally characterized by lower than average rainfall. In the Ventura River watershed, however, the correlation between El Niño/La Niña events and rainfall amounts is somewhat weak, especially relative to the typical variability. As Figure 3.2.1.3.4 illustrates, rainfall amounts have been below average in moderate El Niños and above average in weak La Niñas. The most significant pattern is that strong El Niños bring above normal rainfall, sometimes substantially more than normal (Shaeffer 2013; Leydecker & Grabowsky 2006).

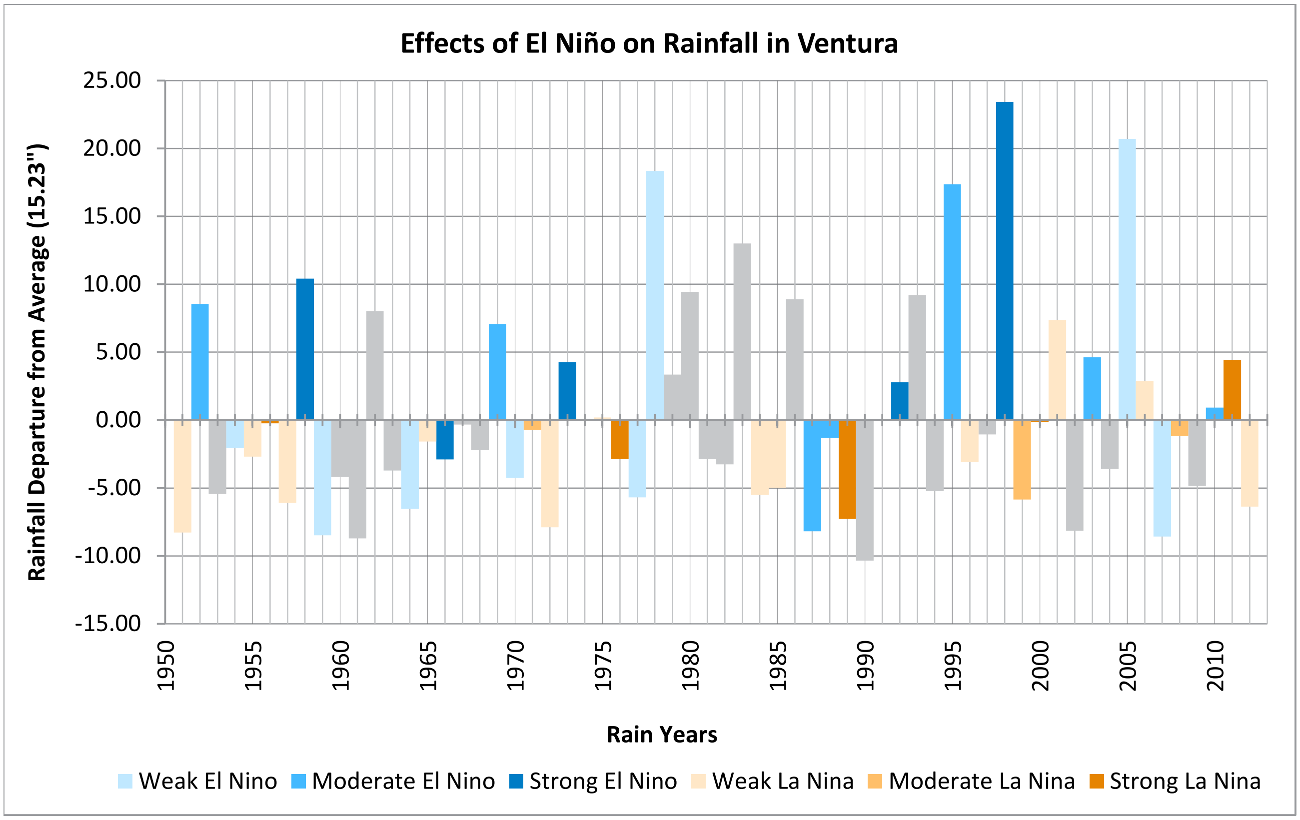


Figure 3.2.1.3.4 Effects of El Niño on Rainfall in Ventura. Average rainfall (15.23 inches) is represented as zero on this chart. Rainfall numbers below zero indicate less than average rainfall, and numbers above indicate greater than average.

Data Source: Golden Gate Weather Service 2013; VCWPD Hydrologic Data Server (VCWPD 2013)

Wet/Dry Cycles

The watershed typically experiences multi-year cycles of wetter years and drier years. Determining approximately when wet and dry groups of years have occurred in the past is helpful to understanding the relationships in the watershed between these wet/dry cycles and floods, fires, sediment transport, and other related factors. For example, major floods generally occur during wet periods, which is when most of the sediment is transported. Major fires tend to occur at the end of wet periods and the beginning of dry periods (Stillwater Sciences 2011).

> Most of California's moisture originates in the Pacific Ocean. During the wet season, the atmospheric high pressure belt that sits off western North America shifts southward, allowing Pacific storms to bring moisture to California. Atmospheric river storms—storms fueled by concentrated streams of water vapor from the Pacific Ocean—are big contributors to annual water supply conditions. A few major storms more or less shift the balance between a wet year and a dry one.
>
> —*Drought in California, Calif. Dept. of Water Resources Brochure* (CDWR 2012)

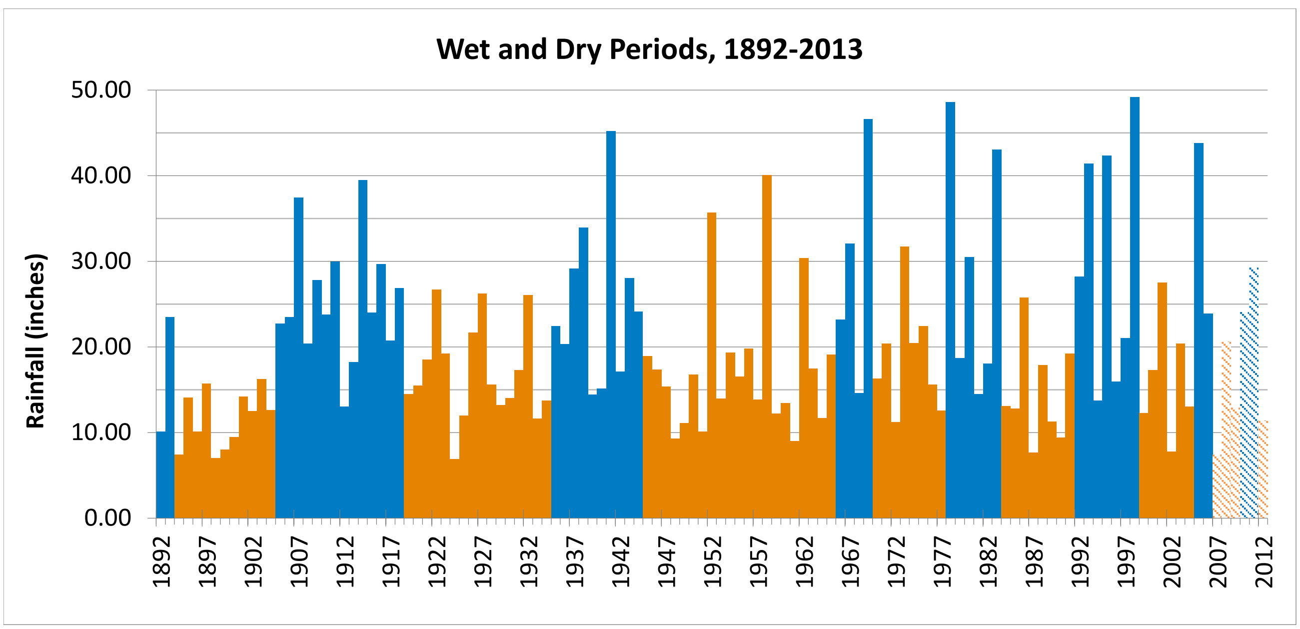


Figure 3.2.1.3.5 Wet and Dry Periods in the Ventura River Watershed, 1892–2013. Blue bars indicate wet periods and orange bars indicate dry periods. Hatched bars indicate that the long-term wet or dry trend is not yet clear. These periods were determined by analyzing how the annual rainfall of each year in the past departs from the long-term average annual rainfall—cumulatively, over time. Records from the City of Ojai were used since this location is central in the watershed; however, records from the City of Ventura go back in time a little further and were used for the years 1892 to 1905.

Data Source: VCWPD Hydrologic Data Server (VCWPD 2013)

Figure 3.2.1.3.5 illustrates the watershed's history of wet and dry periods since 1892. Dry periods include: 1984–1904, 1919–1934, 1945–1965, 1970–1977, 1984–1991, 1999–2004, and 2007–2013. (Note: these data are based on "water years" which run from October 1 of the previous year through September 30 of the year indicated.) While there were years of high rainfall during these dry periods, the predominance of dry years resulted in an overall long-term downward trend in rainfall, which is reflected in the ability of water reserves—groundwater basins and reservoirs—to replenish themselves.

Lake Casitas is managed to maintain water supplies during a repeat of the 21-year dry period from 1945 to 1965 (the longest drought on record at the time of design).

Drought and Floods—a Long History

A drought cycle started in the watershed in 1944, and didn't let up for 21 years. Throughout the late 1940s and early 1950s, residents and farmers struggled to obtain water. In the growing community of Oak View, wells went dry and residents had to truck in water (CMWD 2013).

Although official rainfall records are not available before 1892, historical records confirm a similar record of regular wet and dry periods. The following references to drought are from The San Francisco Estuary Institute's *Historical Ecology* (Beller et al. 2011) analysis of the Ventura River:

1776: Did not rain much this year … watering places gave out and the country was very dry and cracked …
— Font 1776, in Bolton et al. 1930

1809: It has not rained at all thus far this year. You can well imagine the inevitable hardship caused by the resulting lack of fodder and pasture, and the severe damage to our crops.
— Fray José Señán, April 4, 1809

1810: The year when V[entura] river had its great flood …
— Harrington 1986b

1828: [22-month drought] struck down thousands of the mission's animals …
— Smith 1972

1838–45: Greatest drought ever known.
— Ventura Free Press 1895

1839–40: The winter … was a severe one in California, an immense quantity of rain falling.
— Davis 1929

1861–62: Greatest storm in the written history of California …
— Engstrom 1996

1861–62: During the winter of 1861–62, there was an excessive amount of wet weather … all the land to a great depth was saturated and reeking; live stock was reduced almost to starvation, the animals dying in great numbers. Landslides were very frequent …
— Storke 1891

1864: Great drought. Thousands of cattle, horses, etc., starved to death.
— Ventura Free Press 1895

1867: Even higher water occurred in the Ventura River [than in 1861–62].
— Moore 1936

FINAL DRAFT

3.2.1.4 Local Climate Monitoring

Western Regional Climate Center (WRCC)

Regional Climate Centers deliver climate services at national, regional and state levels working with National Oceanographic and Atmospheric Administration (NOAA) partners in the National Climatic Data Center, National Weather Service, the American Association of State Climatologists, and NOAA Research Institutes. One station in Ojai provides temperature data to WRCC; Oxnard is the nearest coastal station for temperature data. WRCC also monitors precipitation data (WRCC 2013).

PRISM Climate Group

The PRISM Climate Group combines actual monitored temperature data with climate modeling techniques to produce spatial climate datasets to reveal short- and long-term climate patterns. The data covers the period from 1895 to the present. The PRISM Climate Group also monitors precipitation data (PRISM 2013).

Casitas Municipal Water District

The Casitas Municipal Water District maintains two weather stations, one in the recreation area and one at Casitas Dam. Evaporation, temperature, and rainfall are monitored.

Weather Station at Lake Casitas

Ventura County Watershed Protection District (VCWPD)

Historical Rainfall Data. VCWPD maintains 26 active rainfall gauges throughout the watershed, a number of which have been logging data since 1906. These gauges monitor daily observations, and some take hourly and 15-minute readings. Some have pan evaporation measurements as well. The gauges located in the Ventura River watershed are numbered as follows: 4A, 20B, 30D, 59, 64B, 66E, 85, 122, 134B, 140, 153A, 165C, 204, 207C, 218, 254, 264, 300, 301, 302, 303, 304, 305, 306, 307, 308. VCWPD makes the data available on their Hydrologic Data Server website, which provides rain, stream and evaporation data.

See "4.4 Appendices" for the annual rainfall data for the years 1873 to 2012.

www.vcwatershed.net/hydrodata/php/getstations.php?dataset=rain_hour&order=site_id

Current Rainfall Data. VCWPD also provides current (almost real-time) rainfall data at a website that is updated every 10 minutes. The site includes National Weather Service warnings.

www.vcwatershed.net/fws/gmap.html

3.2.1.5 Key Data and Information Sources/ Further Reading

Acronyms Used in this Section

NOAA - National Oceanic and Atmospheric Administration

VCWPD - Ventura County Watershed Protection District

WRCC - Western Regional Climate Centers

Ventura River Watershed Hydrology Model, Data Summary Report. The *Data Summary Report*—prepared for the Ventura County Watershed Protection District as part of development of a hydrology model for the watershed—contains a detailed analysis of precipitation, evaporation, and evapotranspiration in the watershed (Tetra Tech 2008).

Gaps in Data/Information

Temperature is monitored at only one inland location (in Ojai) and at no coastal locations in the watershed. The nearest coastal temperature monitoring location is in the City of Oxnard, so this is used as a proxy for the City of Ventura or coastal watershed temperatures.

3.2.2 Geology and Soils

3.2.2.1 Landform Zones

The Ventura River watershed has three distinct landform zones: the mountains and foothills of the Transverse Ranges, the broad valley floors, and the coastal zone. These zones define the watershed and influence its hydrology in many important ways, from how much and where it rains, to how much water it can store, to the biodiversity of its ecosystems.

Aerial View of Watershed Landforms

Photo courtesy of Brian Hall, Santa Barbara Channelkeeper & LightHawk (aerial support)

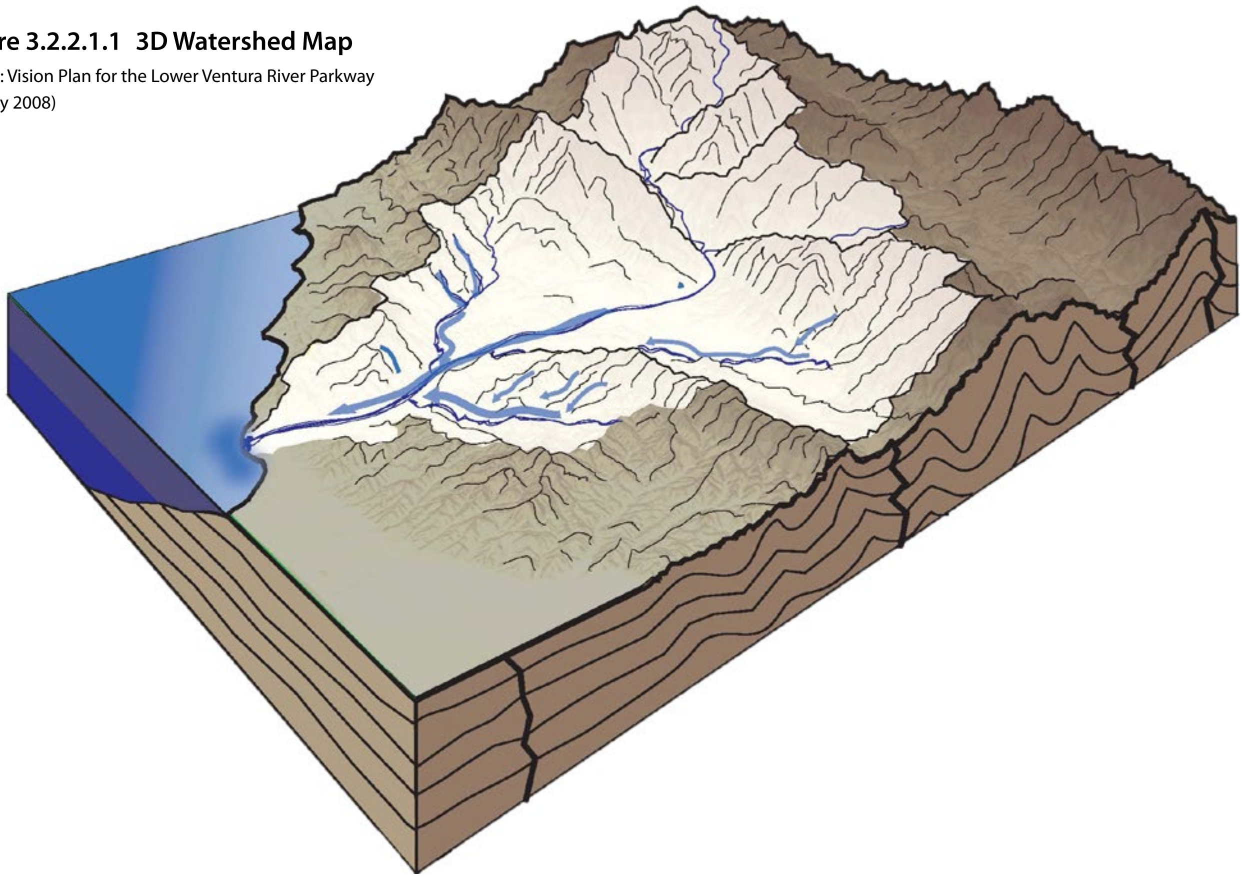
Mountains and foothills dominate the watershed. Only 35 square miles (15%) of the watershed are flat (with a slope of 10% or less). This includes the broad valley floors where most of the residences and farms are concentrated, and the coastal zone. The coastal zone includes the delta and coastline, the delta being the land at the mouth of the river formed over time by the deposition of sediments carried by the river. The delta surrounds and contains the Ventura River estuary, a dynamic zone of interaction between the fresh and salt waters of river and ocean and their hydrologic and biologic systems.

Mountains

Dramatically steep, folded and faulted, rocky and erodible: these are the notable geologic characteristics of the Ventura River watershed's mountains.

Figure 3.2.2.1.1 3D Watershed Map

Source: Vision Plan for the Lower Ventura River Parkway (CalPoly 2008)



In just 10 miles (as the crow flies), the land of the watershed rises from sea level to the top of Mount Arido at 6,010-foot elevation—a gain of 601 feet per mile. Even steeper is the elevation gain from downtown Ojai, at 746-foot elevation, to the top of Chief Peak at 5,560-foot elevation in just six miles—a gain of 802 feet per mile. These dramatically steep mountains of the watershed squeeze more water out of the air, but shed that water quite quickly, making for fast-moving, "flashy" storm flows.

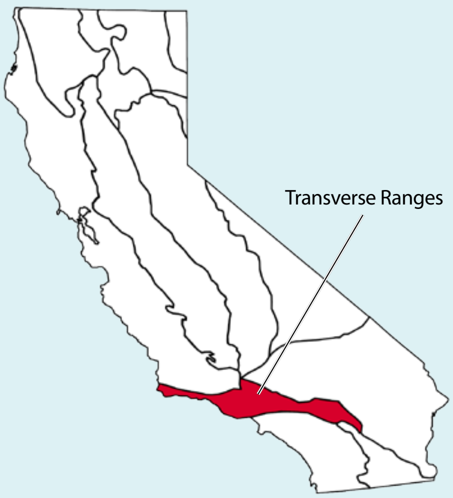
Folded and Erosive Mountains, Matilija Canyon

Photo courtesy of Michael McFadden

Figure 3.2.2.1.2 Elevation Map

Mountains and foothills make up 85% of the watershed, covering most of its north half and framing it on three sides. The watershed's Santa Ynez and Topatopa mountain ranges are part of the Transverse Ranges, which lie along an east-west axis, running from the Santa Barbara coast east to the Mojave and Colorado deserts.

Major peaks in the watershed are Mount Arido (6,010 ft.), Chief Peak (5,560 ft.), Old Man Mountain (5,538 ft.), White Ledge Peak (4,640 ft.) and Nordhoff Peak (4,485 ft.) (USFS 2005).



California's Transverse Ranges

The Ventura River watershed is located in the Transverse Ranges province, an east-west trending series of steep mountain ranges and valleys. The Transverse Ranges hold the distinction of being one of the fastest rising anticlines (a type of folded geologic structure) in the United States, with uplift rates as high as 0.2–0.4 inches per year. The Transverse Ranges started being uplifted, folded, and faulted about 1 million years ago (in the middle Pleistocene) and the distortion and rise continues today at the same rapid geologic rate (Ferren et al. 1990).

Figure 3.2.2.1.3 Transverse Ranges Map

Image source: California Geological Survey (CGS 2002)

Uplifted Land, Santa Ana Road, Ojai Valley

Geologically, the mountains are primarily comprised of 3- to 70-million-year-old (Tertiary) sedimentary rocks—sandstones, siltstones, conglomerates, and shales originally deposited in horizontal layers.

Although these bedrock sequences have been severely deformed by folding and faulting, they remain fairly well consolidated and have low permeability relative to the unconsolidated alluvial deposits of the valley floors (EDAW 1978). They are, however, highly erosive.

Definition: Alluvial Deposits

Alluvial deposits are loose, unconsolidated sediments that have been transported by and deposited from running water.

Conglomerate, San Antonio Creek, Camp Comfort

Foothills East of Lower Ventura River

Photo courtesy of Bruce Perry, Department of Geological Sciences, CSU Long Beach

Road Cut Exposing Upper Monterey Formation, at Old Creek Road Bridge

Photo courtesy of Rosalie Schubert

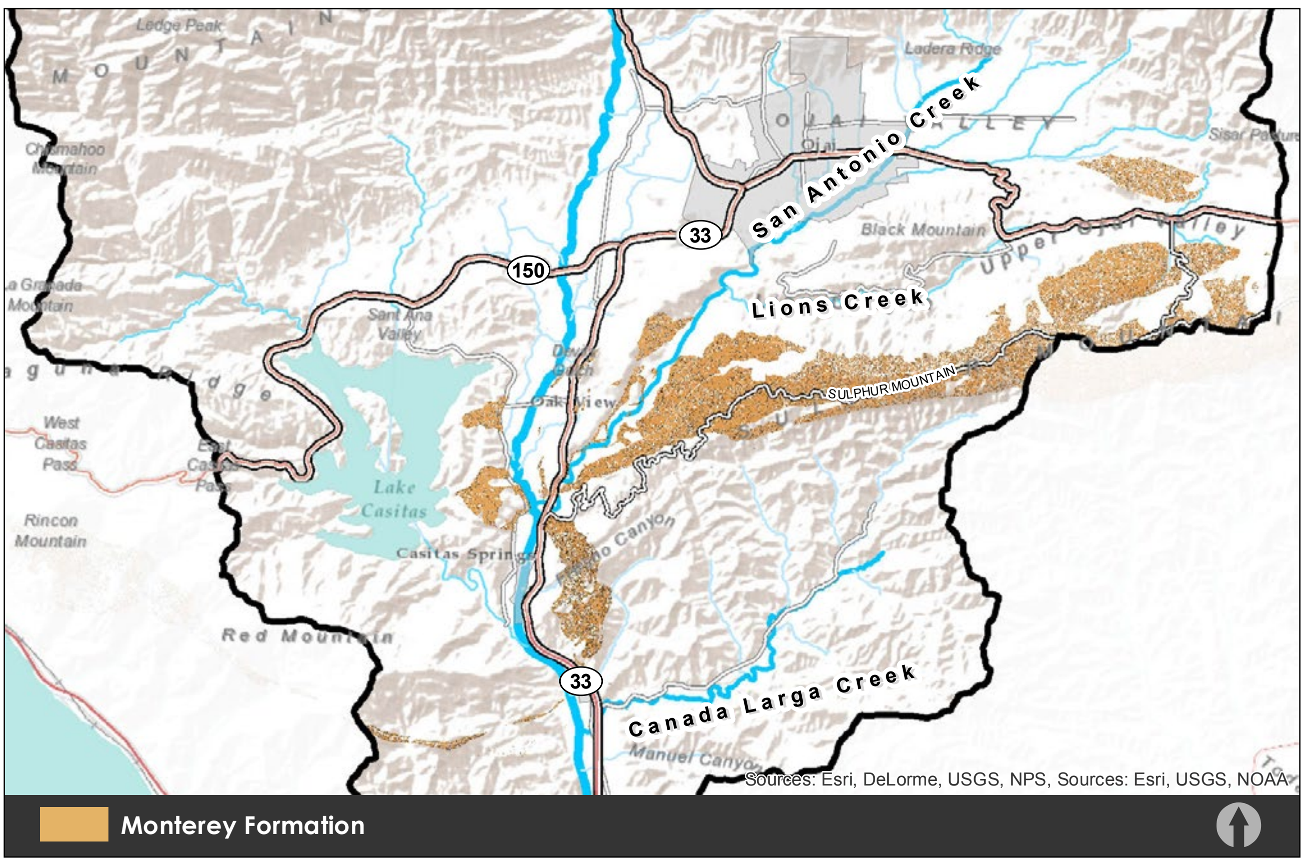


Figure 3.2.2.1.4 The Monterey Formation Map. The "Monterey Formation," often referred to as "Monterey Shale," is a geologic formation that is a major petroleum source and host rock in California. There has been some discussion in the watershed, and in nearby Malibu Creek watershed, about whether this rock formation may be contributing nutrients to the water (Orton 2009). This discussion is relevant to the regulatory mandates to reduce nutrient inputs in the watershed. The Monterey Formation forms the ridge top of Sulphur Mountain, contributing sediment to the valleys on each side, and crosses lower San Antonio Creek and the Ventura River.

Map courtesy of Ventura County CoLab. Data Source: Dibblee, Thomas JR. 1987–1988, Geologic maps of Ventura and Matilija Quadrangles, Ventura County, California: Dibblee Geological Foundation DF 21 and DF 12.

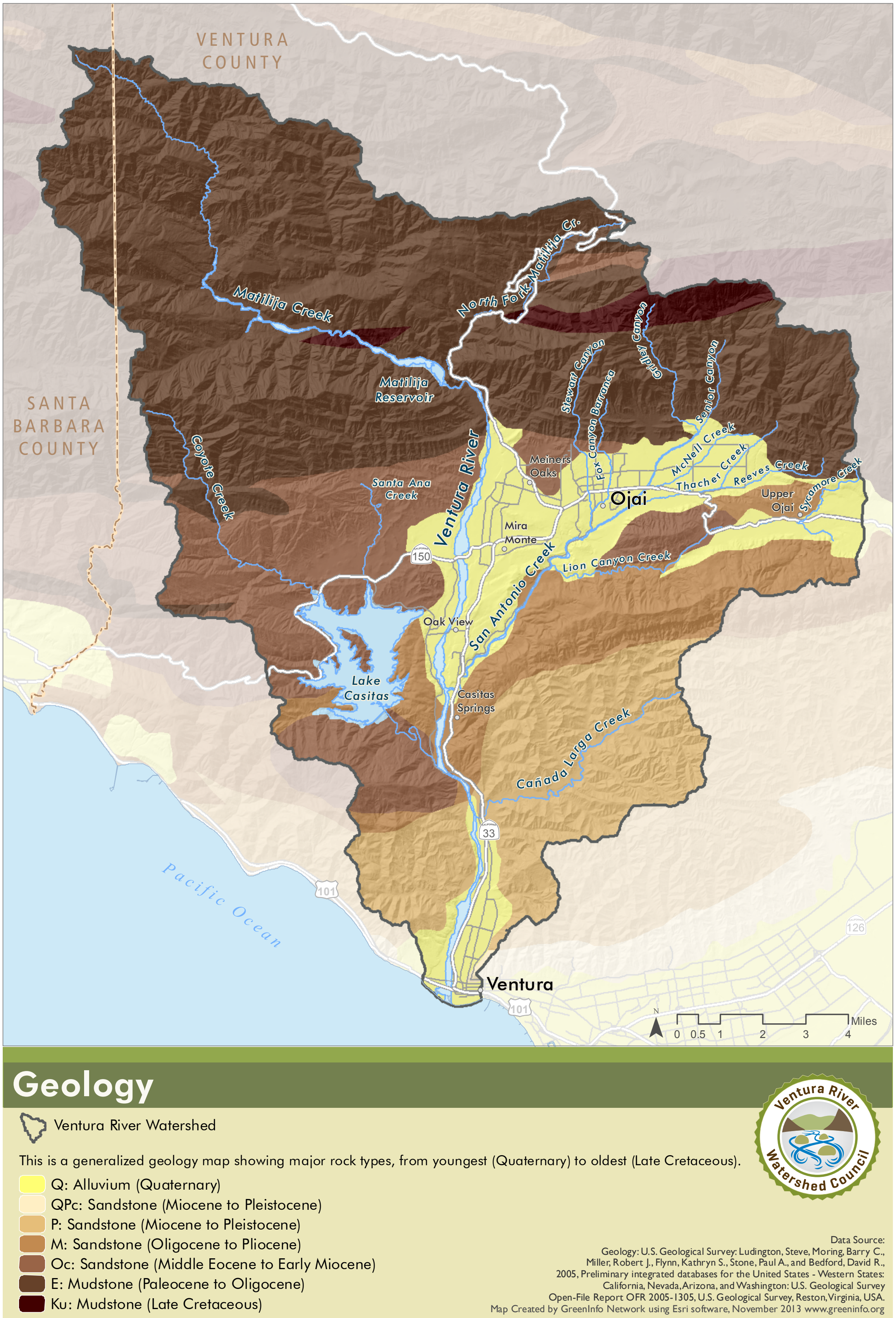


Figure 3.2.2.1.5 Geology Map. The major groundwater basins of the Ventura River watershed are located in the alluvial fill valleys.

See the Watershed Council's website Map Atlas for more detailed geology maps (7.5' Quadrangle Dibblee Maps).

Valley Floors

The 15% of the watershed that is relatively flat is found largely along the broad valley floors associated with the Ventura River, its stream channels, alluvial fans, and river terraces. This includes the area of the City of Ojai, the orchards of the Ojai Valley's East End, the valley floor of Upper Ojai, and the broad valley along the main stem of the Ventura River.

These broad, flat valley floors are largely filled with relatively shallow unconsolidated alluvial deposits of silt, sand, gravel, cobbles, and boulders eroded from the surrounding mountains over millions of years (EDAW 1978). The alluvial valley fills constitute the major groundwater aquifers, and the major groundwater basins of the Ventura River watershed are located in these valleys (Entrix & Woodward Clyde1997). Numerous terraces, caused by vertical uplift, are present along both the west and east sides of the Ventura River.

The East End, Ojai Valley Floor

Floodplain Terrace, Rancho Matilija

Photo courtesy of Rick Wilborn

The Avenue Area, Lower Ventura River Valley Floor

Photo courtesy of Stephanie Grumbeck, Brooks Institute of Photography

Coast

In the coastal zone, significant landforms include the Ventura River delta and the beach. The delta is the area of land where the Ventura River meets the Pacific Ocean. As fast-moving, sediment-filled flood-waters approach the ocean, they spread out and slow down, depositing boulders, cobble, and sediments. Over time, this deposition has built up a two-mile long, arc-shaped bulge in the coastline that extends from beyond Emma Wood State Beach above the river mouth to just short of the pier below.

Aerial View of Ventura River Delta, 1993

Intermixed Beach Cobble Substrate. The cobble substrate of the delta is intermixed with fine sediments derived from both the river and the longshore littoral (sand and rock) current (Capelli 2010). Submerged delta sediments also extend farther offshore.

The Ventura River delta is one of the few actively expanding deltas on the southern California coast.

Because of rapid tectonic uplift and high rates of erosion, the Ventura River delta is one of the few actively expanding deltas on the southern California coast (Entrix & Woodward Clyde 1997). Beaches for several miles south of the river depend on this sediment for new sand supply.

The delta allows the formation of the river's estuary, the exceptionally valuable wetland habitat where the fresh water riverine and saltwater ocean processes converge. Although relatively small in size, the estuary is a very important ecological resource in the watershed.

Ventura River Estuary, February 2014
Photo courtesy of Rick Wilborn

The Ventura River has two major dams (Matilija and Casitas) and a river diversion (Robles Diversion Facility) that inhibit the natural downstream flow of sediment from the mountains to the coast. Significant armoring of the coastline east of the Ventura River has further reduced the amount of sand delivered to the beaches through the longshore littoral current. Beach and delta erosion is an important watershed management concern. See "3.2.3 Geomorphology" for an expanded discussion of this topic.

3.2.2.2 Soils

Soils are classified by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) into one of four hydrologic soil groups—A, B, C, or D—based on the water infiltration rate when the soils are not protected by vegetation, are thoroughly wet, and are receiving precipitation from long-duration storms (Cardno-Entrix 2012). Finer-grained soils (clays) have very low water-infiltration rates but a high water holding capacity compared with larger-grained soils (sands and small gravels) that exhibit the opposite characteristics.

VCWPD Soil Classification System

The Ventura County Watershed Protection District (VCWPD) has developed a more detailed soil classification system for the purposes of hydrology studies and project design. That system groups soils into seven hydrologically homogeneous families. See the VCWPD Design Hydrology Manual for more information (VCWPD 2010a).

The map of the watershed's hydrologic soil groups (Figure 3.2.2.2.1) shows that the areas of significant infiltration of water into the soil are the alluvial fan heads—by Senior, McNell, Thacher, and San Antonio creeks, as well as in Upper Ojai—and on land under and adjacent to the Ventura River itself (Schnaar 2013). These areas, indicated as group "B" on the map, are generally composed of coarser sediments.

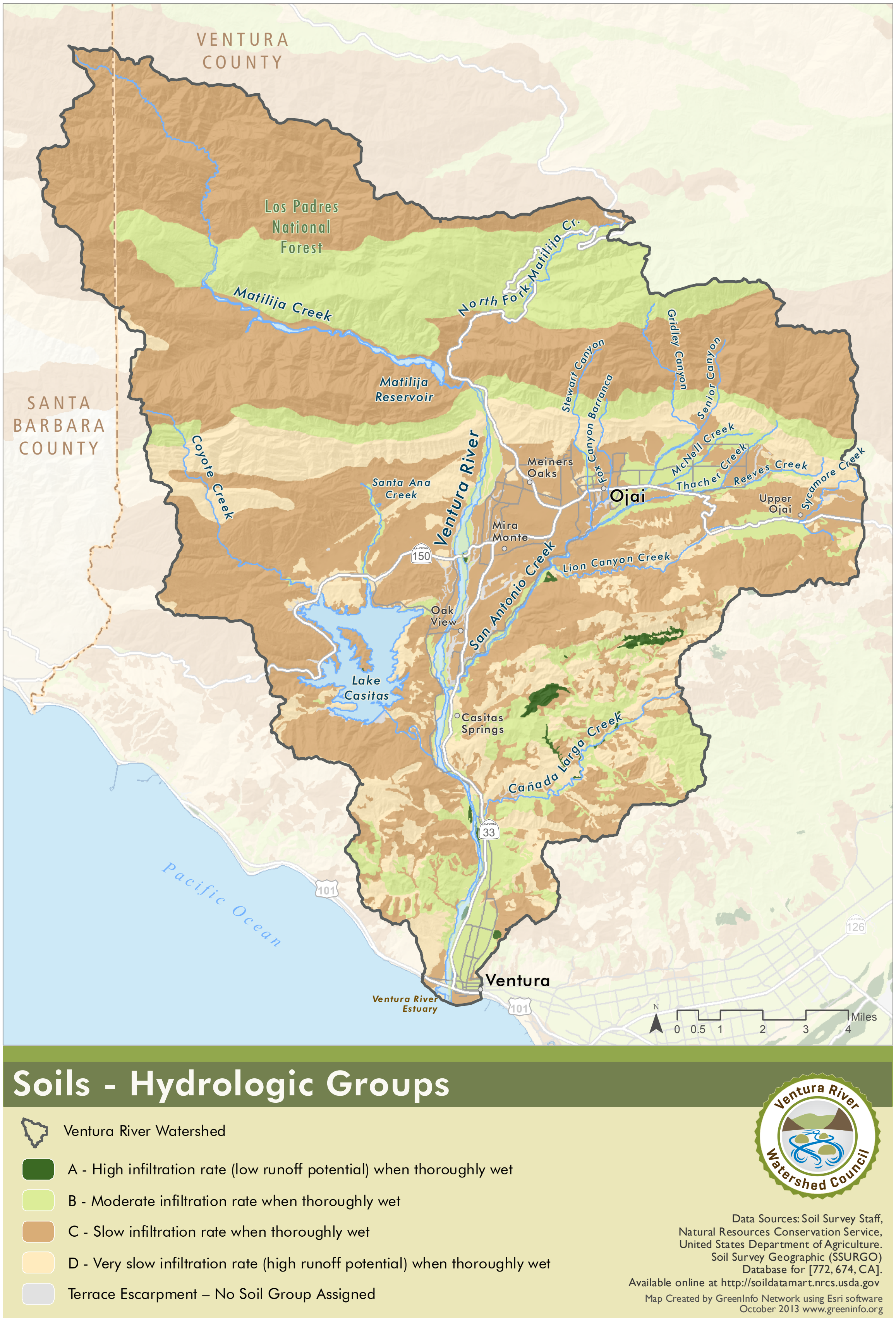


Figure 3.2.2.2.1 Soils – Hydrologic Groups Map

3.2.2.3 Petroleum

Tar Seep, Sulphur Mountain Road
Natural oil seeps and tar are found throughout the area.

The petroleum-rich sedimentary rocks of the Transverse Ranges, of which the watershed is a part, make this geologic province an important oil-producing area in the United States (CGS 2002).

The Ventura field is the watershed's major oil field, covering approximately 3,410 acres on both sides of Highway 33 near the coast. The Ojai Oil Field comprises 1,780 acres of small, active oil fields located primarily in the Upper Ojai areas of Sulphur Mountain and Sisar Creek, with smaller fields in the Lion Mountain area and in Weldon Canyon. Cañada Larga also has a small, 40-acre oil field (DOGGR 1992).

Ventura Oil Field. The Ventura Oil Field is the major oil-producing field in the watershed. The watershed contains several other smaller oil fields, the next most significant being the Ojai Oil Field, located mostly in Upper Ojai.

3.2.2.4 Faults

Intense tectonic forces have uplifted, twisted, and folded the watershed's mountains, creating multiple faults that crisscross the watershed. These faults influence the watershed in several important ways. For example, faults that cross streams can act like underground dams of bedrock that hold back or redirect streamflow, sometimes causing groundwater to surface as springs. Some of the favorite swimming holes in the watershed are upstream of such bedrock-surfacing occurrences.

Rock Outcrops at Ventura River Swimming Holes. Faults can sometimes cause the river channel pattern to abruptly bend around the faulted zone, often widening the upstream floodplain (Ferren, Fiedler & Leidy 1995).
Photo courtesy of Rick Wilborn

San Antonio Creek typically runs longer into the year than the upper Ventura River in part because it runs along a fault block and in places the creek bottom is bedrock. Some of the "walls" or boundaries of the watershed's groundwater basins are also formed by faults. The Santa Ana Fault, for example, forms the southern boundary of the Ojai Valley Basin (Kear 2005).

Bedrock in the San Antonio Creek Bottom
Photo courtesy of Santa Barbara Channelkeeper

Figure 3.2.2.4.1 Major Faults Map

Significant accumulations of accessible oil and gas deposits in the watershed are also associated with its fault structures. The large area of oil wells along Ventura Avenue and surrounding hills in the lower watershed is directly associated with the Ventura Avenue anticline.

> Many of the streams in the Oak View–Ojai area have a complex history that is intimately related to recent tectonics. When the Oak View terrace was being deposited (about 40,000 years ago) the watershed of the Ventura River included the Santa Paula Creek and Sisar Creek drainages, along with the upper Ojai Valley, which was continuous with the lower Ojai Valley. Santa Paula and Sisar Creeks were eventually captured by headward erosion of a tributary of the Santa Clara River. However, in view of activity of the faults in the area, it seems reasonable to speculate that tectonics probably were a significant factor in the drainage history. For example, after uplift along the Santa Ana fault, separating the upper and lower Ojai Valleys, and after capture of Santa Paula and Sisar Creeks by a tributary of the Santa Clara River, the drainage of the lower Ojai Valley was directed along the scarp of the Santa Ana fault.
>
> —*Tectonic Geomorphology and Earthquake Hazard, North Flank, Central Ventura Basin, California* (Keller et al. 1980)

3.2.2.5 Geologic and Seismic Hazards

Earthquakes

The Ventura River watershed is a dynamic landscape that is continually experiencing uplift, folding, and faulting, and with these powerful forces often come earthquakes. A number of faults within and near the watershed are capable of producing magnitude 7.0 earthquakes, and the nearby San Andreas Fault—the longest and most significant fault in California—is capable of producing a magnitude 8.3 earthquake along some of its segments (USACE 2004b).

A 2004 study of historical earthquakes, conducted as part of the Matilija Dam removal project, summarized earthquakes with a magnitude of 5.0 and greater that have occurred within a 50-mile radius around Matilija Dam between the years 1800 and 2000 (Table 3.2.2.5.1), and the magnitude seven and greater earthquakes that have occurred within a 100-mile radius of the dam (Table 3.2.2.5.2).

Table 3.2.2.5.1 Earthquake Magnitude and Exceedances within a 50-Mile Radius of Matilija Dam

Earthquake Magnitude	Number of Times Exceeded
5.0	49
5.5	21
6.0	10
6.5	5
7.0	4
7.5	1

Source: USACE 2004b

Table 3.2.2.5.2 Magnitude 7 and Greater Earthquakes within a 100-Mile Radius of Matilija Dam

Earthquake Date	Magnitude	Distance (miles)
12/08/1812	7.0	94.8
12/21/1812	7.0	34.2
09/24/1827	7.0	37.8
11/27/1852	7.0	39.7
01/09/1857	7.9	62.9
11/04/1927	7.5	84.1
07/21/1952	7.7	39.3

Source: USACE 2004b

Liquefaction

Liquefaction occurs when ground shaking causes loose, saturated soil to lose cohesive strength and act as a viscous liquid for several moments. Engineered structures including roads, bridges, dams, houses, and utility lines are subject to potential damage from liquefaction (VCPD 2011a).

Given the number of active faults in the area and the alluvial nature of the sediments, damage to the Casitas Dam from liquefaction has been a concern. Between 1999 and 2001, Casitas Dam underwent a major modification to prevent a liquefaction-induced failure from seismic activity. Seismic hazard evaluations conducted in the 1990s indicated that the potential earthquake loading was much higher than evaluations conducted in the 1980s indicated. Additionally, groundwater levels had also risen since the 1980s. To address this hazard, the liquefiable materials at the downstream toe of the dam were excavated and replaced, an overlying stability berm was constructed, and the crest of the dam was widened to provide additional protection (USBR 2001).

> Liquefaction has occurred in this area and can be expected to potentially occur again whenever an earthquake of sufficient intensity occurs. Areas with high liquefaction potential have had water table levels within 15 feet of the ground surface sometime in the last 50 years.
>
> —*Matilija Dam Ecosystem Restoration Project EIS/EIR* (USACE2004)

Areas where groundwater tables are more than 40 feet below the ground surface are typically not considered potential liquefaction zones (CGS 2003).

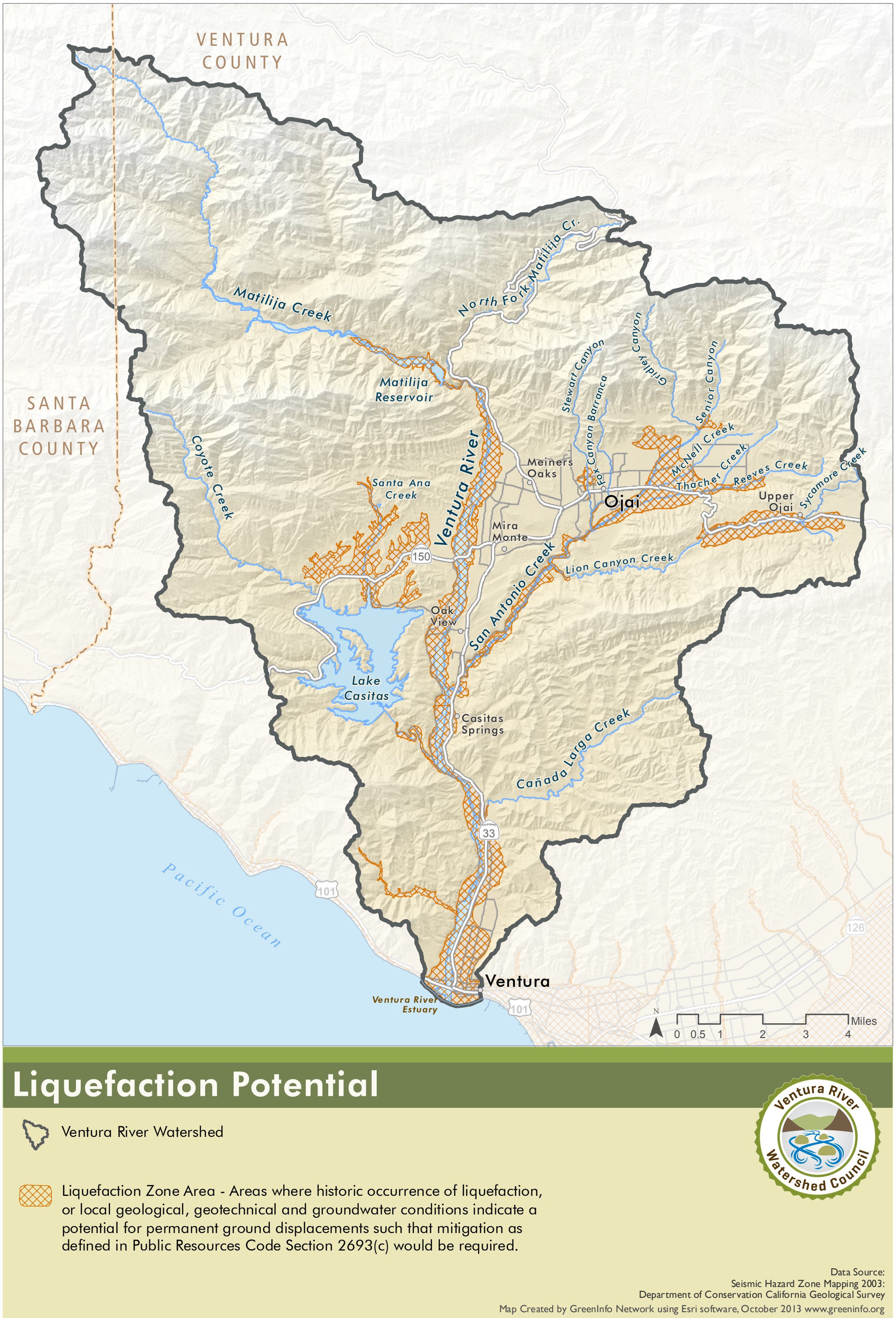


Figure 3.2.2.5.1 Liquefaction Potenial Map

Landslides and Debris Flows

Landslides and debris flows are types of "mass wasting." Mass wasting is the downward movement of soils and rock under gravity, and it requires source materials, a slope and a triggering mechanism. Source materials include fractured and weathered bedrock and loose soils. Triggering mechanisms include earthquake shaking, heavy rainfall and erosion (URS 2010).

The following discussion about landslide hazard is taken from the Ventura County General Plan:

> In general, the highest propensity for landsliding is found in weak rock formations along the more prominent fault zones, near anticlinal folds, and in areas of the younger geologic formations. It is apparent that the combination of these three factors has resulted in relatively intense areas of landsliding such as along the Rincon.
>
> Landslides and potentially unstable slopes are especially common in weak rock formations in hillside areas underlain by sedimentary bedrock of the Pico, Santa Barbara, Monterey/Modelo, and Rincon Formations. These formations are generally soft and contain abundant silt and clay strata.
>
> Many landslides are also associated with steep slopes that have been undercut by erosion and downslope inclination of bedding planes (such as in the Ventura Anticline area). The presence of subsurface water is also a contributing factor to slope instability in the great majority of landslide occurrences.
>
> Landslides and slope instability are widespread throughout the hillside areas. They are subject to potential renewal movement if triggered by poorly planned grading, earthquake ground motions, or increases in ground moisture by any one of numerous factors including, sewage disposal, irrigation, rainfall, etc.
>
> —*Ventura County General Plan, Hazards Appendix* (VCPD 2011a)

Rockslides from steep slopes are the most abundant type of earthquake-induced landslide. Less abundant are shallow debris slides on steep slopes, along with slumps and block slides on moderate to steep slopes (USACE 2004).

3.2.2.6 Key Data and Information Sources/ Further Reading

Below are some key documents that address geology in the watershed. See "4.3 References" for complete reference citations.

Botanical Resources at Emma Wood State Beach and the Ventura River Estuary, California: Inventory and Management (Ferren et al. 1990)

California Oil, Gas, and Geothermal Resources: An Introduction (Ritzius 1993)

Chronology and Rates of Faulting of Ventura River Terraces, California (Rockwell et al. 1984)

Design Hydrology Manual (VCWPD 2010a)

Draft Environmental Impact Statement/Environmental Impact Report for the Matilija Dam Ecosystem Restoration Project (USACE 2004)

Erosion and Sediment Yields in the Transverse Ranges, Southern California (Scott & Williams 1978)

Hydrology, Hydraulics and Sediment Studies of Alternatives for the Matilija Dam Ecosystem Restoration Project (USBR 2007)

Lake Casitas Final Resource Management Plan Environmental Impact Statement (URS 2010)

Matilija Dam Ecosystem Restoration Feasibility Study Final Report (Appendix C – Geotechnical Report) (USACE 2004b)

Quaternary rate of folding of the Ventura Avenue anticline, western Transverse Ranges, Southern California (Rockwell et al. 1988)

Seismic Hazard Zone Report for the Matilija 7.5-Minute Quadrangle, Ventura County, California (CGS 2003)

Status and Understanding of Groundwater Quality in the Santa Clara River Valley, 2007 – California GAMA Priority Basin Project: US Geological Survey Scientific Investigations Report (Burton et al. 2011)

Tectonic Geomorphology and Earthquake Hazard, North Flank, Central Ventura Basin, California (Keller et al. 1980)

The Monterey/Modelo Formation & Regional Water Quality (Orton 2009)

Ventura County General Plan, Hazards Appendix (VCPD 2011a)

Ventura River Flood of February 1992: A Lesson Ignored? (Keller & Capelli 1992)

Ventura River Steelhead Restoration and Recovery Plan (Entrix & Woodward Clyde 1997)

Wetlands of the Central and Southern California Coast and Coastal Watersheds: A Methodology for their Classification and Description (Ferren, Fiedler & Leidy 1995)

Acronyms Used in this Section

NRCS—Natural Resources Conservation Service

USDA—United States Department of Agriculture

VCWPD—Ventura County Watershed Protection District

3.2.3 Geomorphology and Sediment Transport

3.2.3.1 Sediment Production and Transport

The watershed's mountains are composed largely of geologically young marine sedimentary rock—sediments that were at the bottom of a sea floor not very long ago, geologically speaking. These weak, highly erodible rocks are set at very steep angles, causing the watershed to have exceedingly high rates of erosion. In fact, the Ventura River has the highest suspended load and bed load yield of sediment per unit area of any watershed in southern California (Keller & Capelli 1992).

The Watershed's Steep Mountains
Photo courtesy of Les Dublin

The headwaters and upper tributaries of the watershed—including Matilija Creek, North Fork Matilija Creek, Cozy Dell Creek, and streams on the East End of Ojai (e.g., Thacher and Senior Canyon creeks)—produce large amounts of cobble and sediments that flow downward and are deposited on the valley floors. These sediments form most of the alluvium that underlies the watershed's streams and comprises its groundwater basins in the flatter portions of the watershed.

As the river flows downstream, boulders become more rounded, coarse sands give way to finer sands, which eventually partially erode into silts and clays as the river nears the Pacific Ocean. Flash floods and heavy storm flows help to move larger material downstream, so cobbles and small boulders continue to be scattered throughout the river's path.

A number of geomorphic processes contribute sediment to the watershed's streams including sheet erosion (water flowing over land as a sheet rather than in distinct channels), dry land sliding, earthflows, and debris flows (Hill & McConaughy 1988). Wildfire intensifies all of these processes.

Headwater Boulders, Matilija Creek

Dry Landslide, Matilija Canyon

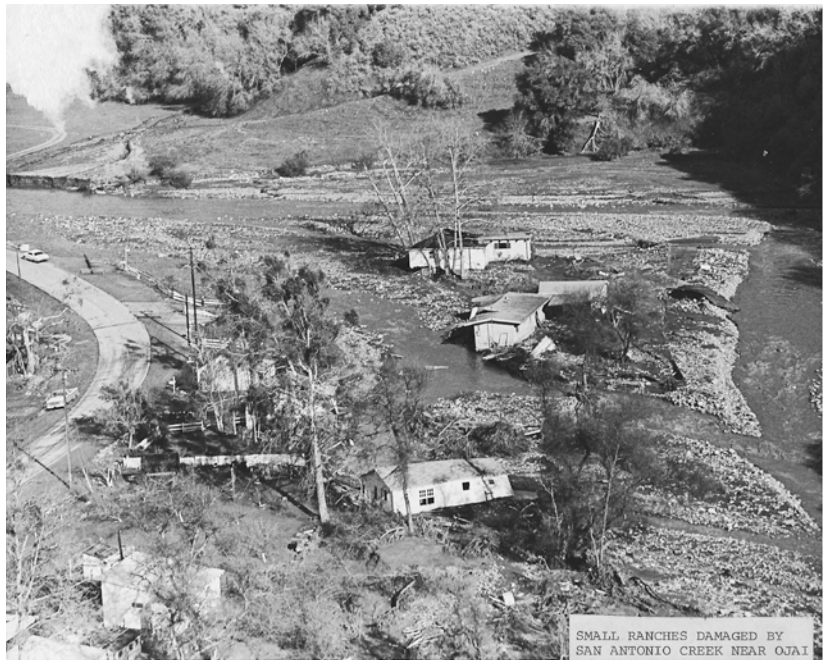
Sediment Transport in Ventura River at Highway 150 Bridge, Winter 2006

Photo courtesy of Scott Lewis

Ventura River, Scoured After 2005 Flood

Photo courtesy of Santa Barbara Channelkeeper

Sediment Transport and Deposition in San Antonio Creek, 1969
Photo by Dan Poush



It has been estimated that the sediment transported to the ocean by the Ventura and Santa Clara rivers during the 1969 floods was greater than all the sediment transported during the previous 25 years.

The vast majority of sediment transport, and the resulting changes to channel shape and location, occurs during relatively infrequent major storms. A 1988 analysis of sediment transport over a 12-year period found that 92% of the sediment transported in the Ventura River occurred during five storms averaging 10 days each (Entrix & URS 2004).

During periods without major storms, stream channels undergo more-or-less continuous fill; eroded sediments that have made their way into stream channels gradually build up. Then, during large storm events, these built up channel sediments are mobilized and channels undergo substantial scour (Scott & Williams 1978).

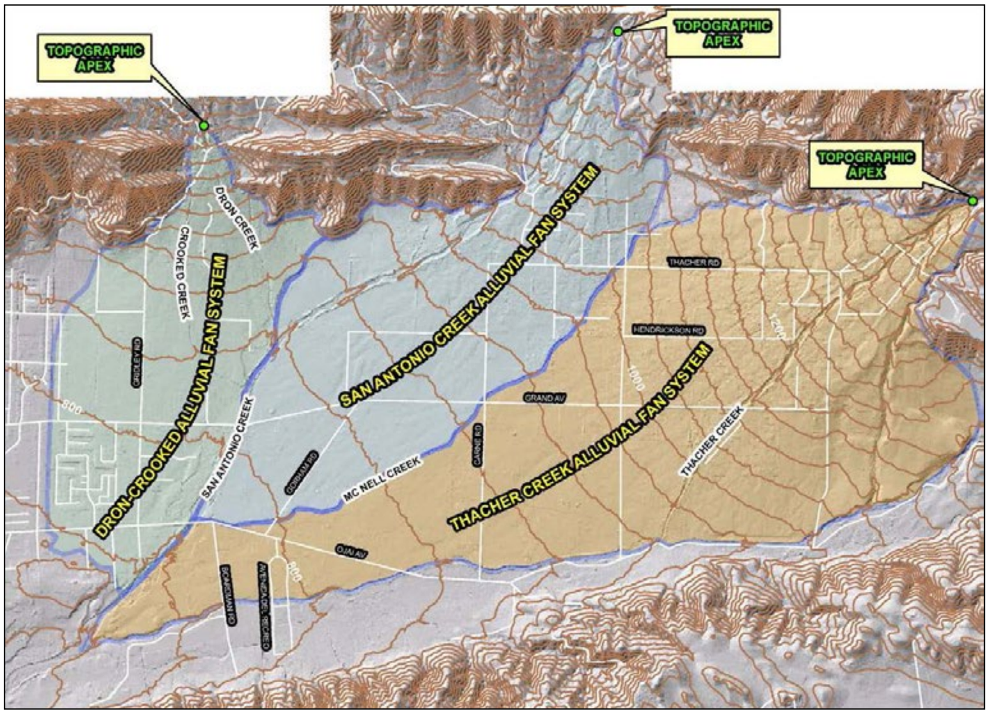
The difference between the movement of sediment during a "normal" year and during a winter dominated by very large storms cannot be exaggerated: it can be as large as 30:1. It has been estimated that the sediment transported to the ocean by the Ventura and Santa Clara rivers during the 1969 floods was greater than all the sediment transported during the previous 25 years (Inman & Jenkins 1999).

The high rates of erosion and landslides in the watershed present significant challenges to flood management and to protection of water and wastewater infrastructure.

Alluvial Fans

Alluvial fans are a significant geologic feature of the Ojai Valley formed by the transport of sediment by water. Alluvial fans are cone-shaped fans of rock and sediment that have built up at the mouths of mountain

Figure 3.2.3.1.1
Alluvial Fans Map, East Ojai Valley
Source: VCWPD 2009



and foothill canyons. Three distinct alluvial fans in the East End of Ojai have been identified: Dron-Crooked Creek Fan, San Antonio Creek Fan, and Thatcher Creek Fan (see Figure 3.2.3.1.1). As discussed more in "3.3.2 Flooding," alluvial fans present a special kind of flood hazard risk because the stream channels associated with alluvial fans are shallow and not well defined, and their movement is unpredictable.

Alluvial fans present a special kind of flood hazard risk because the stream channels associated with alluvial fans are shallow and not well defined, and their movement is unpredictable.

Following are excerpts from a 2009 study by the Ventura County Watershed Protection District on the alluvial fans on Ojai's East End:

> Active fans [where fan building is still active or potentially active] exist mostly in the floor of the valley where ground surface slopes become milder and channels lose their ability to carry sediments further downstream. The geological soil type in these parts of the fans is mainly fluvial deposits. Geological conditions indicate that most of the alluvial fans in East Ojai were formed during the last 12,000 years.
>
> Typical of alluvial fan flooding, flood water from relatively high mountain areas where slope is steep and energy is abundant, carries a large amount of sediment. Some of which are deposited in the channels at floors of alluvial fans. As a result, most of the channels at floors of alluvial fans are wide, shallow and unstable. Overbank flooding occurs frequently and can cause a significant amount of property damages. In fact, many parts of the East Ojai floodplain have been designated by FEMA as repetitive flooding areas.
>
> —*Alluvial Fan Floodplain Mapping, East Ojai FLO-2D Floodplain Study* (VCWPD 2009)

3.2.3.2 Fluvial Geomorphology – Rivers Sculpting Landform

Fluvial geomorphology is the study of the processes that operate in river systems and how they shape stream channels and other landforms overtime. Many factors play a role: tectonics, climate, geology, topography, wildfires, land use, and more.

The Ventura River watershed's fluvial geomorphic story is, in a word, dynamic. Steep, tectonically active mountains, intense storm flows, and erosive sediments all add up to stream channels that are moving and changing.

Floodplain Terrace, Meiners Oaks. Graphic examples of fluvial geomorphic processes at work are the series of floodplain terraces along the Ventura River in Meiners Oaks and near the river's mouth. These terraces were shaped by cycles of relatively rapid vertical uplift followed by downcutting of the river over the last 60,000–80,000 years (Ferren et al. 1990). These terraces also show that the river has migrated to the west over time.

The Braided Ventura River, 2005 Flood. Fluvial geomorphic processes have shaped the main stem of the Ventura River: it is a braided river (meaning numerous channels split off and rejoin each other to give a braided appearance) that flows through riverbed cobble and sometimes crosses bedrock and active geologic structures (Keller 2010).
Photo courtesy of David Magney

Ventura Riverbed Cobble

In its natural state, the Ventura River had a dynamic equilibrium wherein the river channel shape changed from flood to flood, and the river would yield major supplies of sand to the Ventura coastline (USACE 2004). The river's elevation rose between floods from sediment deposits, only to be scoured out during large floods. This natural state of the river has been modified, in part due to impediments to sediment transport as described later in this section.

Flood Scour and Cycles of Vegetation Growth, Ventura River at Main Street Bridge. The river's cycle of sediment buildup followed by scour influences many other processes, including the growth of riparian vegetation, aquatic plants, and algae, and the extent and adequacy of fish habitat. The left-hand photos show the river after big, scouring winters (top 2005, bottom 2008); algae is growing and aquatic plants are minimal. Gradually, without scouring winter flows, aquatic plants become dominant.
Source: Leydecker 2010b

A notable feature on maps of the Ventura River dating from the late 1800s is the presence of large, well-defined islands in the river—ranging in area from about one to over 35 acres. Contemporary accounts from the early 20th century mention residents camping during the summers on an island located between Coyote Creek and the Ventura River (Beller et al. 2011).

Fluvial geomorphic processes also directly influence the shape and extent of the river's delta. One characteristic of deltas formed by rivers carrying high loads of sediment is that their channels tend to migrate over time when deposited sediments interfere and redirect water flow (Keller & Capelli 1992).

These dynamic fluvial geomorphic processes significantly influence the land and watershed. They can directly affect flood control, water quality, habitat protection, land use, water supply, and many other aspects of watershed management.

Islands in the River

Ventura River Estuary, Second Mouth. Just west of the main channel of the Ventura River is a currently inactive channel called the "Second Mouth" of the Ventura River. The multiple channels of a delta system, called "distributary channels," may be active for a period of time, become inactive, and then become active again at a later date (Keller & Capelli 1992).

3.2.3.3 Impediments to Sediment Transport

While the general pattern of sediment buildup followed by flood scour persists today and still defines many river processes, in-channel and floodplain developments have constricted flow and reduced the availability of sediment.

The Ventura River watershed has two dams and a river diversion that inhibit the natural downstream flow of water and sediment: Matilija Dam (built in 1947) interferes with sediment flow from the Matilija Creek subwatershed and Casitas Dam (built in 1959) traps almost all of the sediment of the Coyote Creek subwatershed. The associated Robles Diversion Facility in the Ventura River (built in 1959) also interferes with sediment transport from watershed areas above the diversion.

Matilija Dam

Photo courtesy of Mark Capelli

Casitas Dam

Photo courtesy of Bruce Perry, Department of Geological Sciences, CSU Long Beach

Together these features block the natural drainage of about 37% of the watershed and thereby impede over half of all sediment delivery (Beller et al. 2011).

The Matilija Dam originally provided for 7,018 acre-feet of water storage. Rapid sedimentation, however, reduced this to only 500 acre-feet as of 2003 (Tetra Tech 2009). The vast majority of this sediment was deposited during a few big storm years; the floods of 1969 alone contributed a large proportion of the sediment (USACE 2004b).

> From 1947 to 1964, it is estimated that the [Matilija] dam trapped about 95% of the total sediments from the watershed. Today, it is estimated that the trapping efficiency has dropped to approximately 45% of the total sediment load from Matilija Creek, although the trap efficiency for sand sizes and greater is still practically 100%.
>
> —*Matilija Dam Ecosystem Restoration Feasibility Study Final Report* (USACE 2004b)

The following excerpt describes the impact that the dam has had on the river:

> Trapping sediment in the dam substantially reduces the sediment supply to the stream downstream of the dam. As a result, the stream, which still has a similar sediment transport capacity, makes up the difference by obtaining sediment for transport from the channel bank and bed. The removal of this sediment, without replacement by sediment from upstream, causes the bed elevation to drop over the long term, and increases the potential for bank erosion. In-stream structures such as bridges and utility crossings

Robles Diversion Facility

Stewart Debris Basin. Several debris basins at the base of foothills in the watershed trap sediment.

Photo courtesy of David Magney

> could be adversely affected, as could structures located adjacent to the stream. As the smaller-sized sediments in the channel bed are more easily transported than larger sediments, the channel bed composition would change to become more dominated by cobbles and boulders rather than sand. The delivery of sand to the beach would be reduced.
>
> —*Draft Environmental Impact Report for the Matilija Dam Ecosystem Restoration Project* (USACE 2004)

As stated in the excerpt below, the effect of the dam is significant, but no less significant than streamflow.

> Matilija Dam does not block all the sand from the Ventura River. San Antonio and North Fort Matilija still contribute large amounts of sand. However, it does block a significant portion of sand and its removal will increase the size of the beaches. How much is hard to tell, but the sand loads input into the Ventura River will be about 50% larger than they are now because Matilija Dam blocks about ⅓ of the total watershed area. Matilija Dam is still trapping almost all the sand that enters the reservoir. There is still sand being eroded from the bed of the Ventura River that currently replaces some of the sand that is trapped behind Matilija. However, the sand in the bed is of limited quantity and will eventually run out.
>
> It should be remembered that the biggest variable of beach sand is simply the flow in the river. Without river flows, the beaches erode. The beachline in 1947 (prior to Matilija Dam) is essentially identical to the beachline now because the 40s were relatively dry. Beaches will erode in this area with or without Matilija Dam if there is no rain.
>
> —*Blair Greimann, Hydraulic Engineer, Matilija Dam Ecosystem Restoration Project* (Greimann 2014)

3.2.3.4 Beach and Delta Sediments

Sand and other sediments get deposited on the beaches by both longshore drift and direct buildup from the Ventura River. A longshore current, called the Santa Barbara Littoral Cell, transfers sediment along beaches in the Santa Barbara Channel in a west-to-east direction from Ellwood Beach in Santa Barbara County to Point Mugu in Ventura County. This current is supplied with sediment from coastal cliff erosion and the floodwaters of streams and rivers, with steep-gradient creeks and rivers being the primary sources of sediment (BEACON 2009).

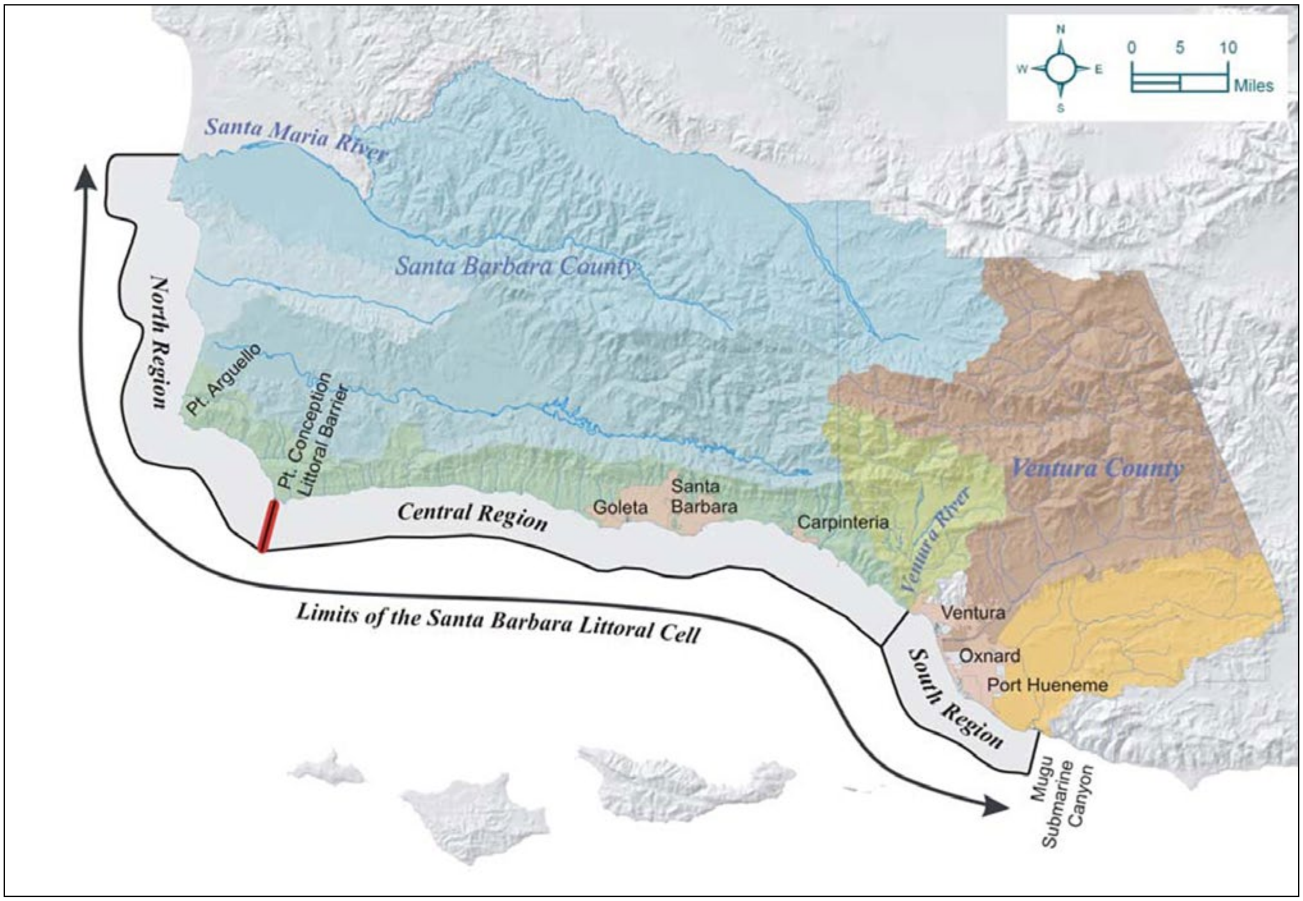


Figure 3.2.3.4.1 Santa Barbara Littoral Cell
Source: Coastal Regional Sediment Management Plan (BEACON 2009)

Beach Cobble Delta,
Seaside Wilderness Park

Sediment transport to the ocean from coastal southern California streams is highly episodic and correlated with flood flows, and this variability is reflected in the amount of beach that exists at any given time.

This natural cycle of sediment buildup and erosion has suffered from a lack of replenishment sediment, however, and this has resulted in growing erosion of beaches in the region (USACE 2004b). Another contributor to beach erosion is coastline armoring—the erection of seawalls and rock revetments (structures used to support embankments) to prevent erosion.

The Rincon Parkway, located between Rincon Point and the Ventura River delta, is one of the most fortified sections of coastline within the entire Santa Barbara Littoral Cell (BEACON 2009): 77% of this 17-mile stretch of coastline is armored with seawalls and revetments (CDBW & SCC 2002).

Rincon Parkway Armoring

Table 3.2.3.4.1 Estimated Sediment Supply Delivered to the Coast from Rivers and Streams of the Santa Barbara Littoral Cell

	Fluvial Delivery Volume (cubic yards/year)		
Watershed	**Pre-dam**	**Post-Dam**	**Reduction (%)**
Santa Maria River	811,000	261,000	68
San Antonio Creek	60,000	(no dams)	0
Santa Ynez River	713,000	347,000	51
Santa Ynez Mountains Watershed	195,000	(no dams)	0
Ventura River	216,000	102,000	53
Santa Clara River	1,634,000	1,193,000	27
Calleguas Creek	65,000	(no dams)	0

Data Source: Coastal Regional Sediment Management Plan (BEACON2009)

Such armoring has been documented to ultimately reduce beach widths via several mechanisms. For example, sediment from previously eroding coastal bluffs that would otherwise be available for transport and deposit by the littoral current is impounded by shoreline armoring.

Another mechanism is passive erosion:

> Whenever a hard structure is built along an eroding coastline, the shoreline will eventually migrate landward on either side of the structure. The effect will be gradual loss of the beach in front of the seawall or revetment as the water deepens and the shoreface profile migrates landward. This process is designated as *passive erosion* and has been well documented along many different shorelines. Passive erosion takes place regardless of the type of protective structure emplaced. This process is perhaps the most significant long-term effect of shoreline armoring.
>
> —*The Effects of Armoring Shorelines, The California Experience* (Griggs 2010)

Beach and delta erosion is a watershed management concern. The Matilija Dam removal project is an effort to return the river to more natural conditions, increasing sediment flow downstream, creating more alluvial floodplain habitat, and replenishing the sand-starved beaches along the coast. In concert with the Matilija Dam removal project, the Surfers' Point Managed Shoreline Retreat Project is designed to restore the beach profile to more natural and sustainable conditions (City of Ventura & Rincon Consultants 2003).

Surfers' Point Managed Shoreline Retreat Project

In 1992, winter storms eroded a new beachfront bike path, owned by the California Department of Parks and Recreation, and damaged the adjacent parking lot for the Ventura County Fairgrounds. Fairgrounds officials proposed the construction of a sea wall to stop further erosion. The local chapter of the Surfrider Foundation and the California Coastal Conservancy opposed the sea wall plan, which would have reduced the habitat and recreational value of the site and, by altering wave patterns, likely increased erosion rates on nearby beaches.

In 2001, the many parties with an interest in the site agreed on a managed retreat approach for the site. With leadership from Surfrider, funding assistance from the California Coastal Conservancy, a land contribution from the state of California's fairgrounds, and management by the City of Ventura, a progressive "managed retreat" project was designed and implemented at Surfers' Point in order to give the beach sand more room to behave like a natural seasonally growing and shrinking beach. Phase 1 construction, covering a 900-foot reach, was completed in 2011. Phase 2 is awaiting additional funding as of 2014.

(continues on next page)

Coastal Erosion, Surfers' Point

"Every Stone Helps" Sign, Surfers' Point

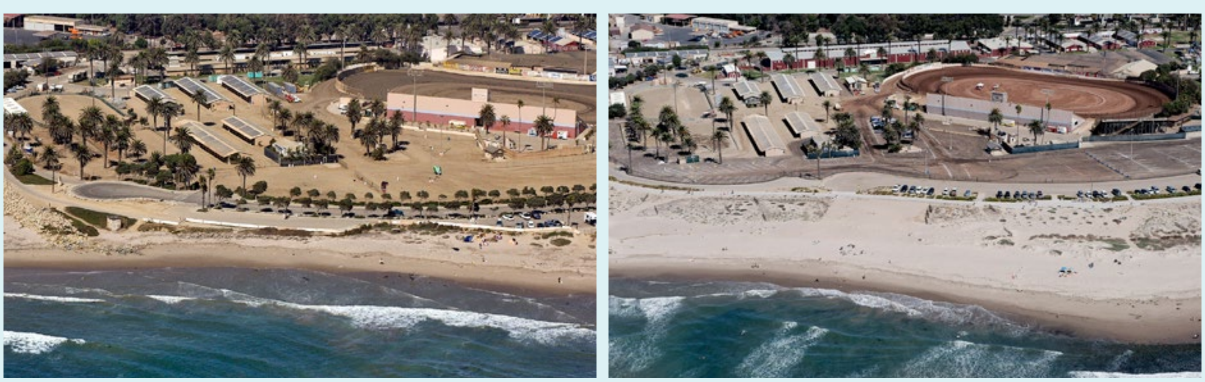
Surfers' Point Managed Shoreline Retreat Project *(continued)*

Features of this project include:

- Removing all existing improvements seaward of Shoreline Drive, including the damaged bike path and eroded public parking lot, and relocating them farther inland;
- Modifying Shoreline Drive to allow for retreat of the existing parking facilities and preserve public access to Surfers' Point;
- Improving parking by constructing two new "low impact development" parking lots that incorporate runoff treatment controls—including appropriate landscaping, permeable surfaces, and a stormwater treatment system—and installation of an entry kiosk and bicycle parking;
- Improving recreational amenities by constructing a new multi-use trail to replace the existing path, creating a new interpretive area, and expanding an existing picnic area; and
- Restoring the retreat zone and providing protection for the new improvements by recontouring the retreat area with natural beach materials and re-creating sand dunes.

Dune Restoration Sign, Surfers' Point

The Surfers' Point Managed Shoreline Retreat project is one of the first managed retreat projects to be implemented in California. Developed in response to coastal erosion, it serves as a model of sustainable shoreline management for other similar projects up and down the California coast. The project was featured at the California and the World Ocean Conference in 2006 and as a case study for managed retreat by NOAA's Office of Ocean and Coastal Resource Management. The California Coastal Commission has cited the project as an example for other locations including Goleta Beach and Pacific Beach (Jenkin 2013).


Before (2008) and After (2013) Managed Retreat Project, Surfers' Point

3.2.3.5 Key Data and Information Sources/ Further Reading

Below are some key documents that address geomorphology in the watershed. See "4.3 References" for complete reference citations.

Alluvial Fan Floodplain Mapping, East Ojai FLO-2D Floodplain Study (VCWPD 2009)

Botanical Resources at Emma Wood State Beach and the Ventura River Estuary, California: Inventory and Management (Ferren et al. 1990).

Channel Geomorphology and Stream Processes (Entrix 2001a)

Coastal Regional Sediment Management Plan (BEACON 2009)

Draft Environmental Impact Statement/Environmental Impact Report for the Matilija Dam Ecosystem Restoration Project (USACE 2004)

Draft Ventura River Habitat Conservation Plan (Entrix & URS 2004)

Erosion and Sediment Yields in the Transverse Ranges, Southern California (Scott & Williams 1978)

Historical Ecology of the lower Santa Clara River, Ventura River and Oxnard Plain: an analysis of terrestrial, riverine, and coastal habitats (Beller et al. 2011)

Hydrology, Hydraulics and Sediment Studies of Alternatives for the Matilija Dam Ecosystem Restoration Project (USBR 2007)

Matilija Dam Ecosystem Restoration Feasibility Study Final Report (USACE 2004b)

Sediment Loads in the Ventura River Basin, Ventura County, California, 1969–1981 (Hill & McConaughy 1988)

Surfer's Point Managed Shoreline Retreat Environmental Impact Report (City of Ventura and Rincon Consultants 2003)

The Effects of Armoring Shorelines—The California Experience (Griggs 2010)

Ventura River Flood of February 1992: A Lesson Ignored? (Keller & Capelli 1992)

Acronyms Used in this Section

NOAA—National Oceanic and Atmospheric Administration

Further Reading: Geomorphic Assessment of the Santa Clara River Watershed

In addition to the resources listed here, a comprehensive fluvial geomorphological study was undertaken on the Santa Clara River watershed, which is adjacent to the Ventura River watershed to the southeast. There are enough similarities between these watersheds that this study can be informative for the Ventura River watershed.

Stillwater Sciences. 2011. Geomorphic assessment of the Santa Clara River watershed: synthesis of the lower and upper watershed studies, Ventura and Los Angeles counties, California. Prepared by Stillwater Sciences, Berkeley, California, for Ventura County Watershed Protection District, Los Angeles County Department of Public Works, and the U.S. Army Corps of Engineers–L.A. District. April 2011

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