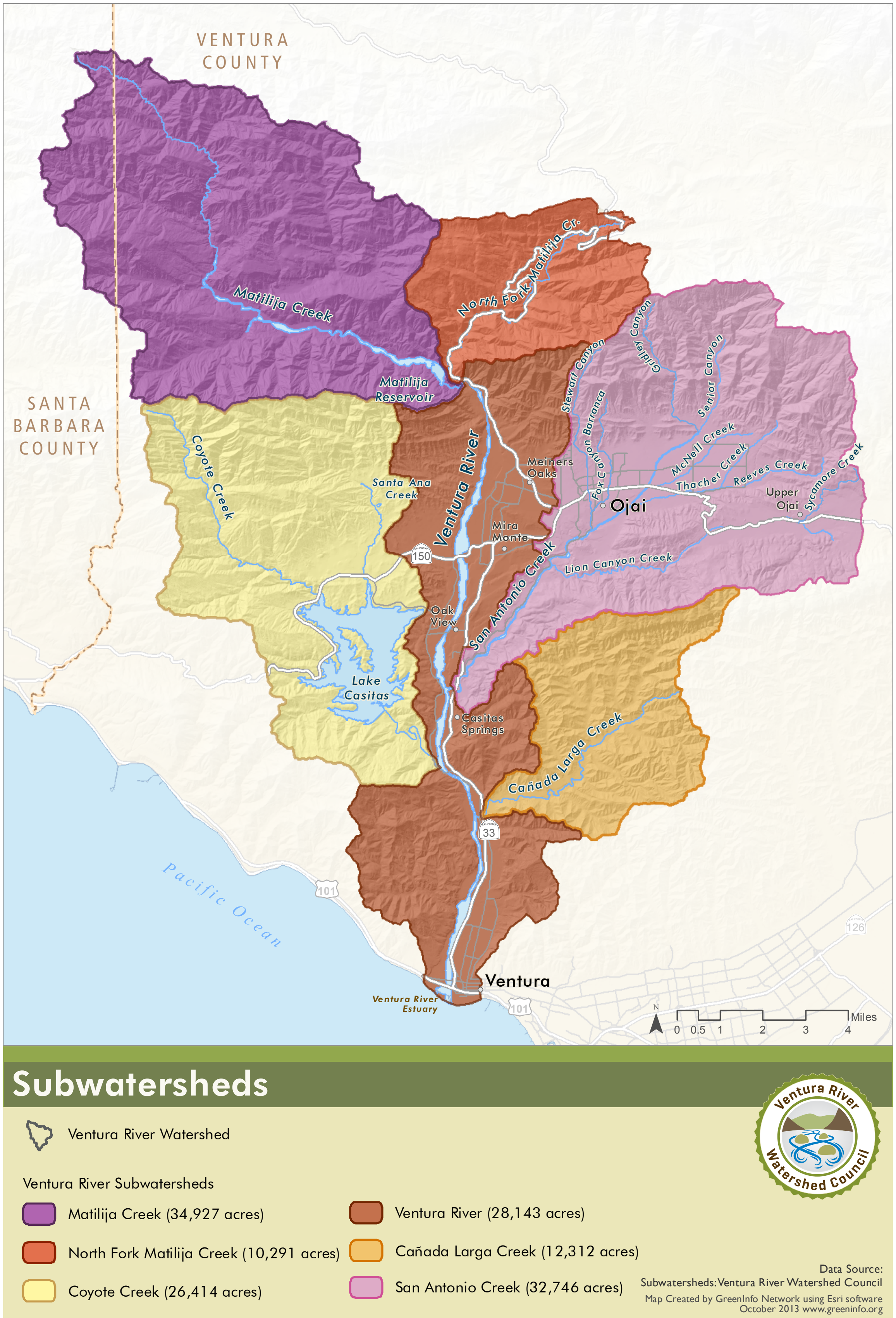


Figure 3.1.1.2 Subwatersheds Map

Land Use and Demographics: Conditions in the watershed remain natural and undeveloped, with 57% of its land area in protected status. Most of the watershed's primary streams and drainages are unchannelized, though two dams—Casitas and Matilija Dams—and three levees—Ventura River, Casitas Springs, and Live Oak—have modified natural hydrologic patterns.

The northern half of the watershed lies within Los Padres National Forest. The watershed's southern half includes two cities and a number of unincorporated communities. The population is approximately 44,140, which represents just 5.4% of Ventura County's population of 823,318 residents (as of 2010 Census). The City of Ojai lies entirely within the watershed, 13 miles inland at an elevation of 746 feet. Thirteen percent of the City of Ventura lies within the watershed, adjacent to the coast and the lower stretch of the Ventura River. The population of the watershed is relatively small and the rate of growth low.

Thacher Creek, January 2005
Photo courtesy of Michael McFadden

Developed land (excluding grazing) comprises only about 13% of the total land area in the watershed. Agriculture is the dominant land use. Citrus and avocados are the primary irrigated crops grown, and a significant area of land is used for cattle grazing.

Lower Ventura River Watershed Land Uses: Urban, Oil Extraction, Agriculture

Photo courtesy of Brian Hall, by way of Santa Barbara Channelkeeper and LightHawk

Water Quality: Surface water quality is good compared with more developed watersheds in the region and has improved notably in recent decades. Despite relatively good water quality, all of the watershed's major waterbodies are on the Clean Water Act Section 303(d) list of impaired waterbodies. Between these waterbodies there are 14 different types of impairments.

Because the annual amount of rainfall received is highly variable, water supplies must be managed with caution.

Water Supply: Unlike most all of its neighbors in southern California, the Ventura River watershed truly depends upon its watershed to "shed" water. All of the water used in the watershed falls from the sky. Lake Casitas serves as the major surface water supply reservoir in the watershed and groundwater is heavily relied upon. On average, surface water comprises about 55% of the water recovered from the watershed and groundwater comprises about 45%.

Cycles of drought and flooding occur regularly. Annual rainfall in downtown Ojai has ranged from a low of seven inches to a high of 49 inches—a sevenfold variation. Because the annual amount of rainfall received is highly variable, water supplies must be managed with caution.

Ventura River, Upstream from Main Street Bridge

Photo courtesy of Santa Barbara Channelkeeper

Two small coastal watersheds—the North Ventura Coastal Streams watershed and the Buenaventura watershed—flank the Ventura River watershed's lower section and are dependent on its water. Water from the Ventura River watershed is used to irrigate avocado orchards in the North Ventura Coastal Streams watershed and serves a significant population in a portion of the Buenaventura watershed that lies within the City of Ventura.

Two small coastal watersheds flank the Ventura River watershed's lower section and are dependent on its water.

Flooding: The steep terrain of the Ventura River watershed, coupled with intense downpours that can occur in its upper portions, result in flash flood conditions where floodwaters rise and fall in a matter of hours. Major or moderate floods have occurred once every five years on average since 1933.

Habitat and Species: The watershed's rugged topography, largely undeveloped status, and Mediterranean climate combine to make for an area of exceptional biodiversity. It supports a diverse array of natural habitats, including grassland, coastal sage scrub, chaparral, oak woodlands and savannas; coniferous woodlands; riparian scrub, woodlands and wetlands; alluvial scrub; freshwater aquatic habitats; estuarine wetlands; and coastal cobble, dune and intertidal habitats. The Ventura River estuary, at the mouth of the Ventura River, is an exceptionally valuable wetland habitat and ecological resource in the watershed.

White Pelicans, Lake Casitas
Photo courtesy of Allen Bertke

The watershed is home to numerous protected species and habitats, including 137 plants and animals protected at either the federal, state, or local level. The federally endangered southern California steelhead is of particular importance, given the watershed's often dry and always variable climate. Removing Matilija Dam, in part to return access to the steelhead to spawning habitat, is a major project that is underway in the watershed. The watershed is also challenged by invasive, non-native species, such as *Arundo donax*.

Ventura River Estuary

Photo courtesy of Santa Barbara Channelkeeper

The watershed is a recreation destination for hikers, walkers, bikers, surfers, campers, fishermen, boaters, backpackers, equestrians, and birders, as well as artists, spiritual seekers, and students of natural history. Many local organizations are committed to providing the public with access to nature and nature-based recreation opportunities.

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.

Kishu Mandarins After a Freezing Night
Photo courtesy of Lisa Brenneis

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).

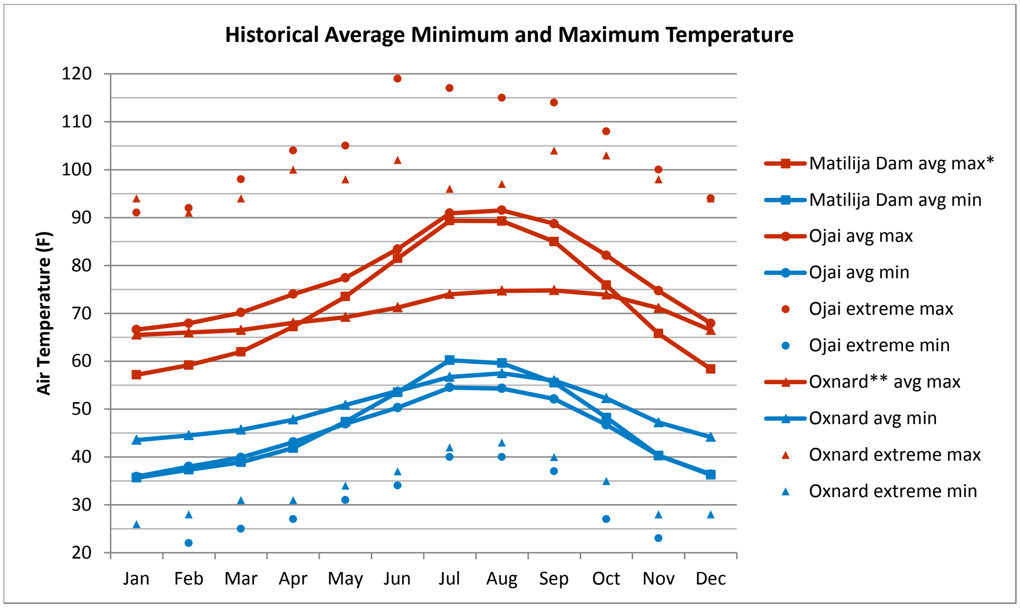


Figure 3.2.1.2.1 Historical Average Minimum and Maximum Temperature
Dates: Matilija Dam - 1905–2011, Ojai - 1905–2012, Oxnard - 1923–2003.

* 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												
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.

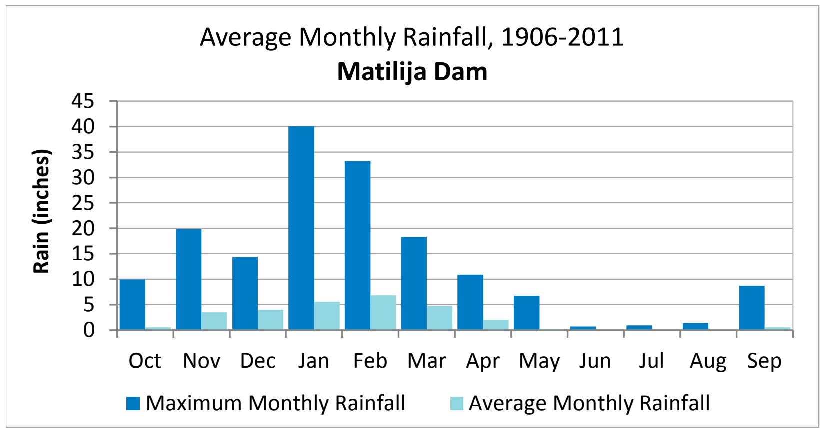
Table 3.2.1.3.1 Rainfall Average and Median (inches/year)

	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

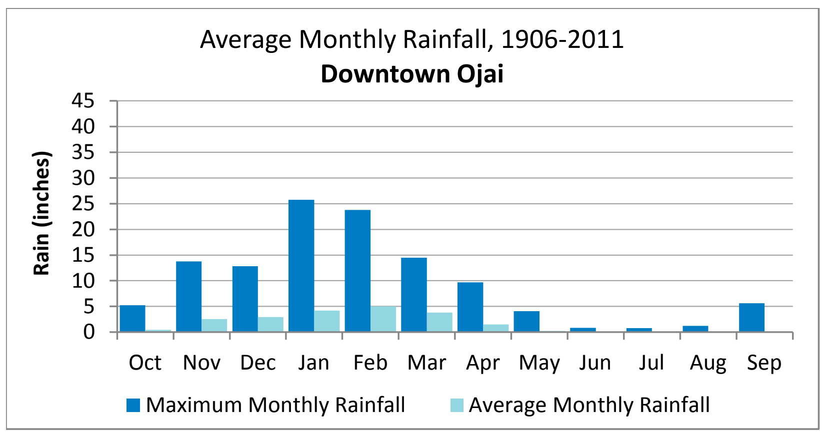
Data Source: VCWPD Hydrologic Data Server (VCWPD 2013)

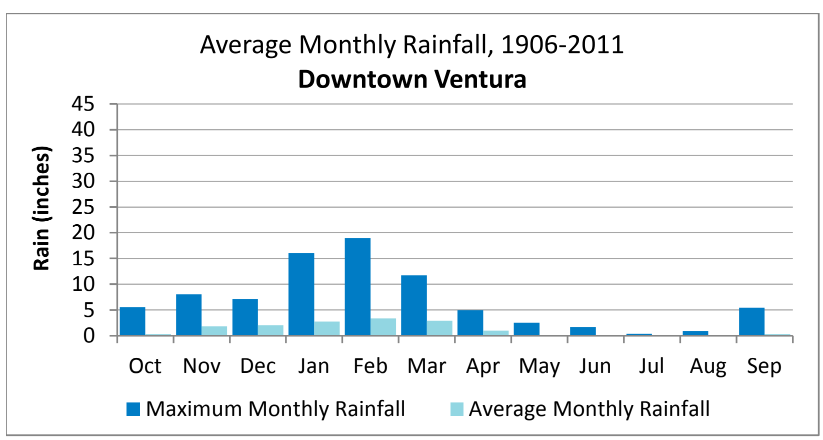
Figure 3.2.1.3.1 Average Monthly Rainfall, 1906–2011 (Matilija Dam, Ojai, Ventura)

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.

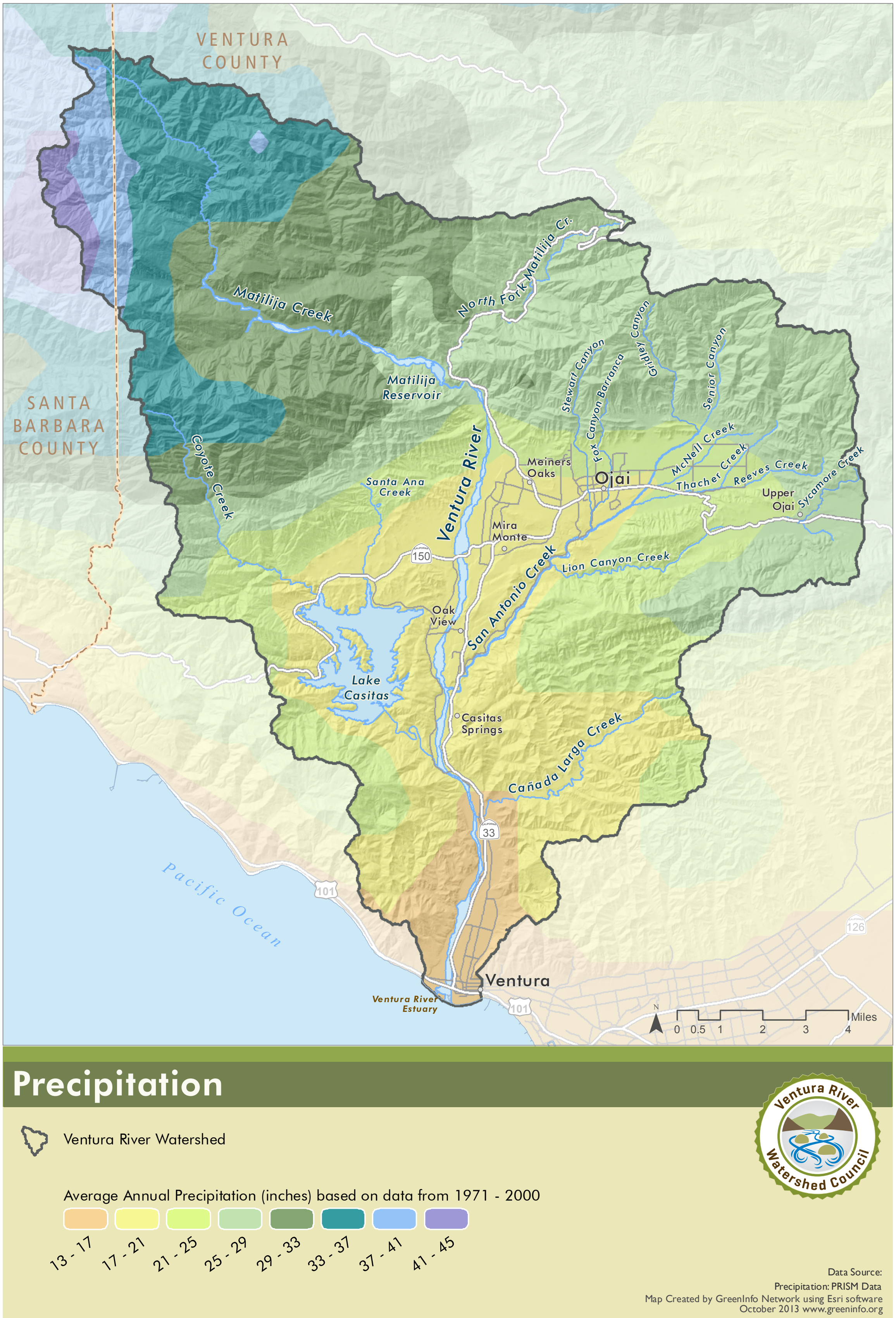


Figure 3.2.1.3.2 Precipitation Map

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).

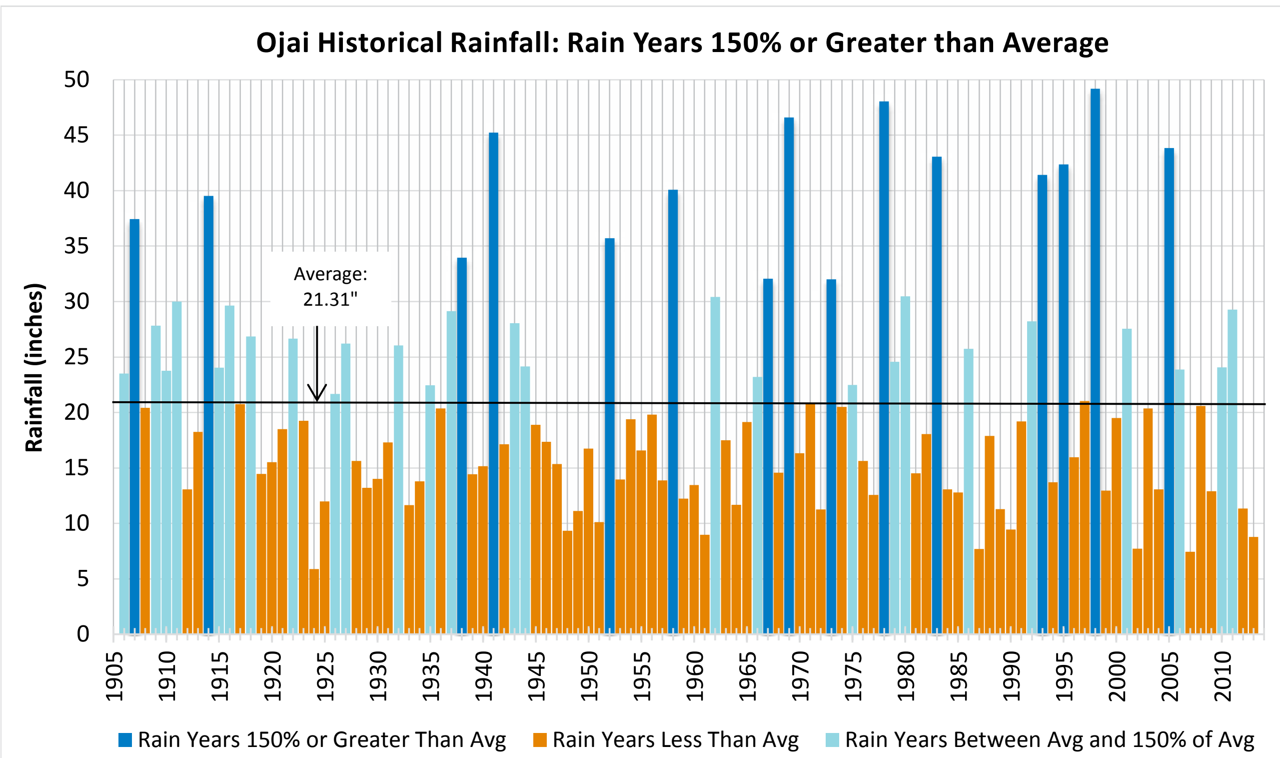


Figure 3.2.1.3.3 Ojai Historical Rainfall: Rain Years 150% or Greater than Average. Since 1906, there have been 15 years of significantly high rainfall (at least 150% of average—or greater than 32 inches) in downtown Ojai. This is an average of once every seven years. Average rainfall in downtown Ojai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

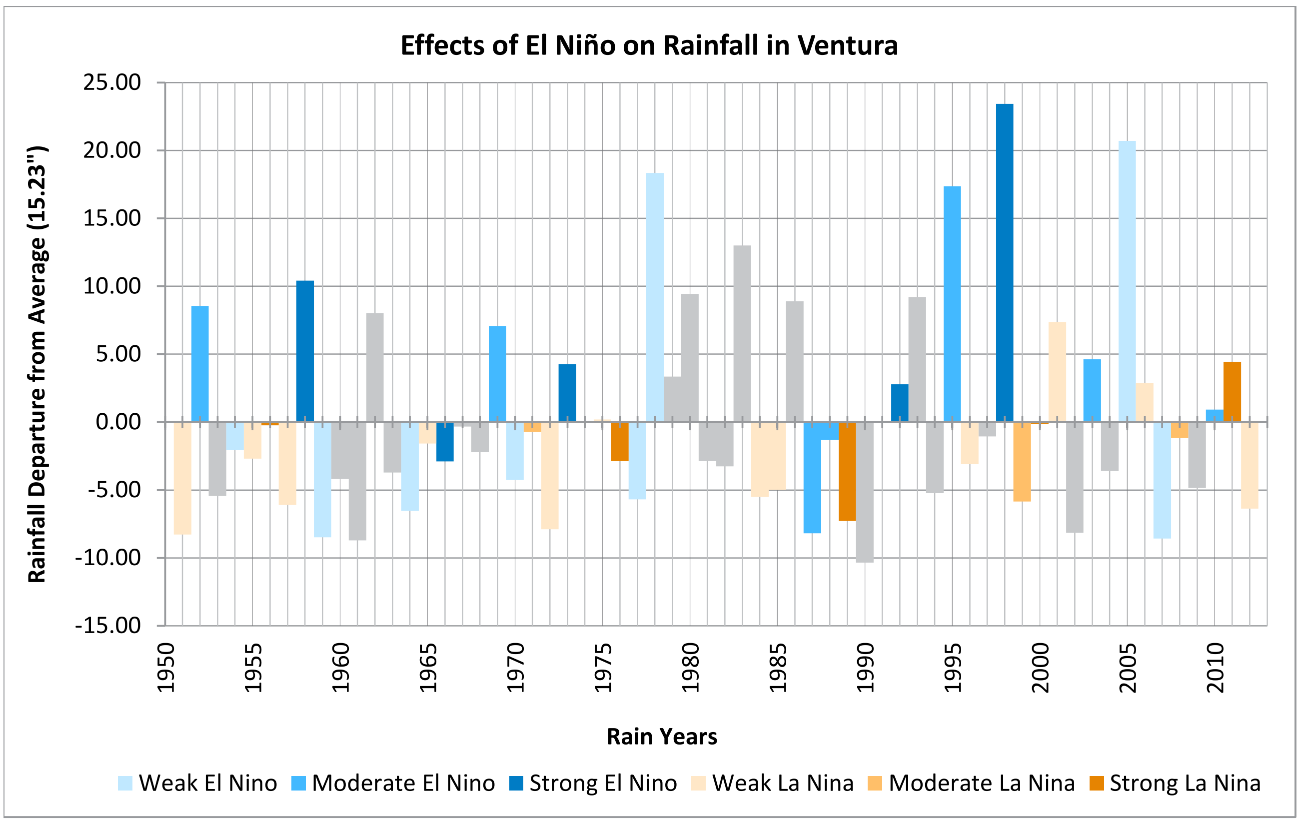


Figure 3.2.1.3.4 Effects of El Niño on Rainfall in Ventura. Average rainfall (15.23 inches) is represented as zero on this chart. Rainfall numbers below zero indicate less than average rainfall, and numbers above indicate greater than average.

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)

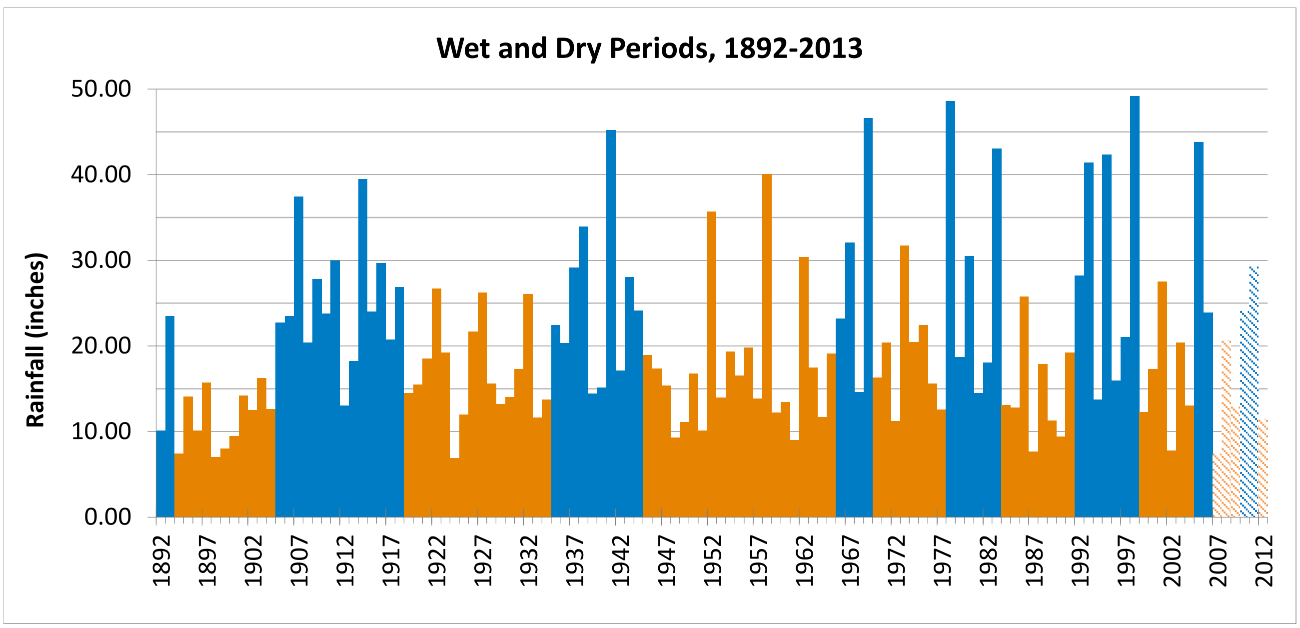


Figure 3.2.1.3.5 Wet and Dry Periods in the Ventura River Watershed, 1892–2013. Blue bars indicate wet periods and orange bars indicate dry periods. Hatched bars indicate that the long-term wet or dry trend is not yet clear. These periods were determined by analyzing how the annual rainfall of each year 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

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

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).

Acronyms Used in this Section

NOAA - National Oceanic and Atmospheric Administration

VCWPD - Ventura County Watershed Protection District

WRCC - Western Regional Climate Centers

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)

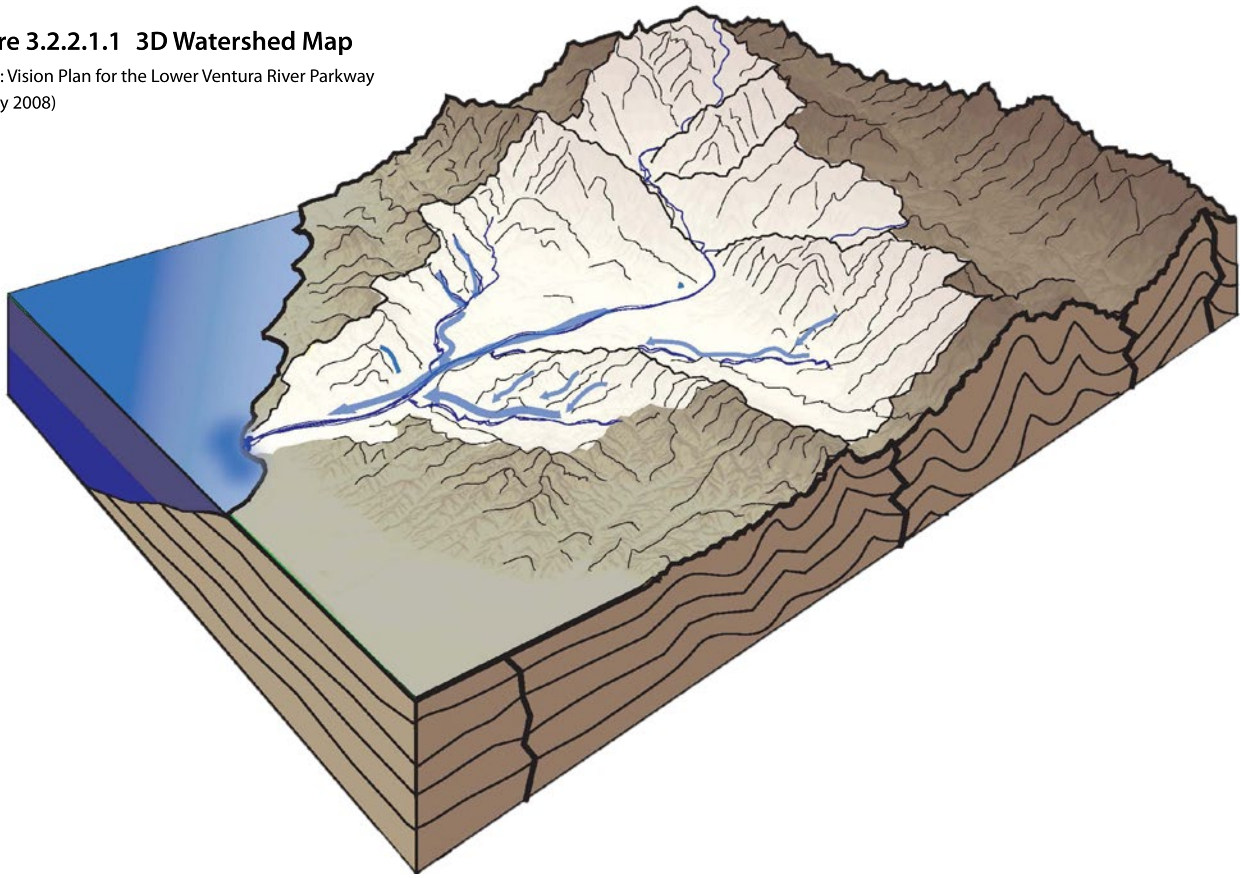
Mountains and foothills dominate the watershed. Only 35 square miles (15%) of the watershed are flat (with a slope of 10% or less). This includes the broad valley floors where most of the residences and farms are concentrated, and the coastal zone. The coastal zone includes the delta and coastline, the 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

Elevation

Ventura River Watershed

Elevation in Feet

6,000 4,000 2,000 1,000 750 500 250

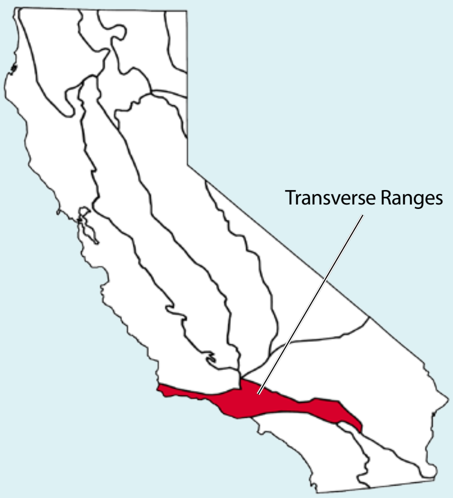
Ventura River Watershed Council

Data Source:
Elevation: USGS National Elevation Dataset
Map Created by GreenInfo Network using Esri software
October 2013 www.greeninfo.org

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

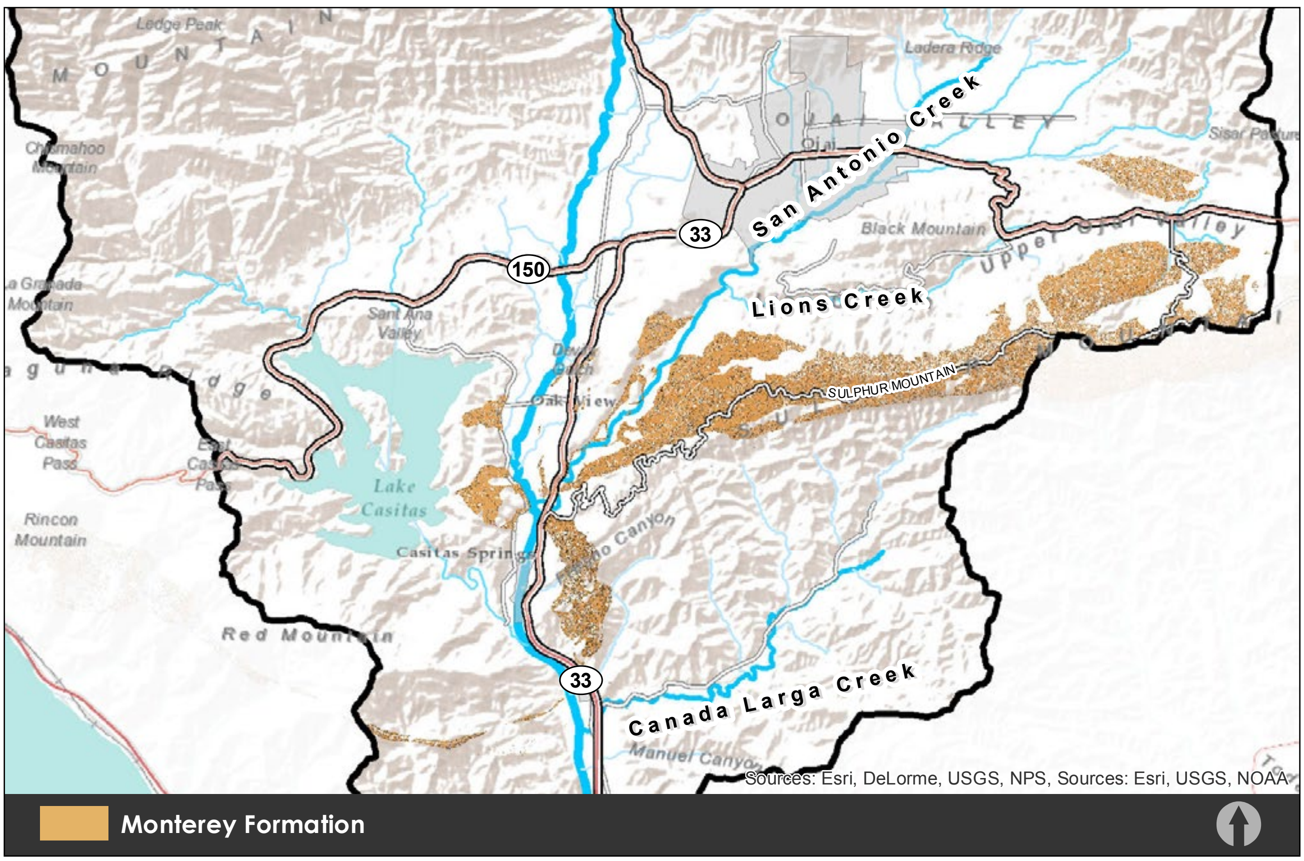


Figure 3.2.2.1.4 The Monterey Formation Map. The "Monterey Formation," often referred to as "Monterey Shale," is a geologic formation that is a major petroleum source and host rock in California. There has been some discussion in the watershed, and in nearby Malibu Creek watershed, about whether this 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.

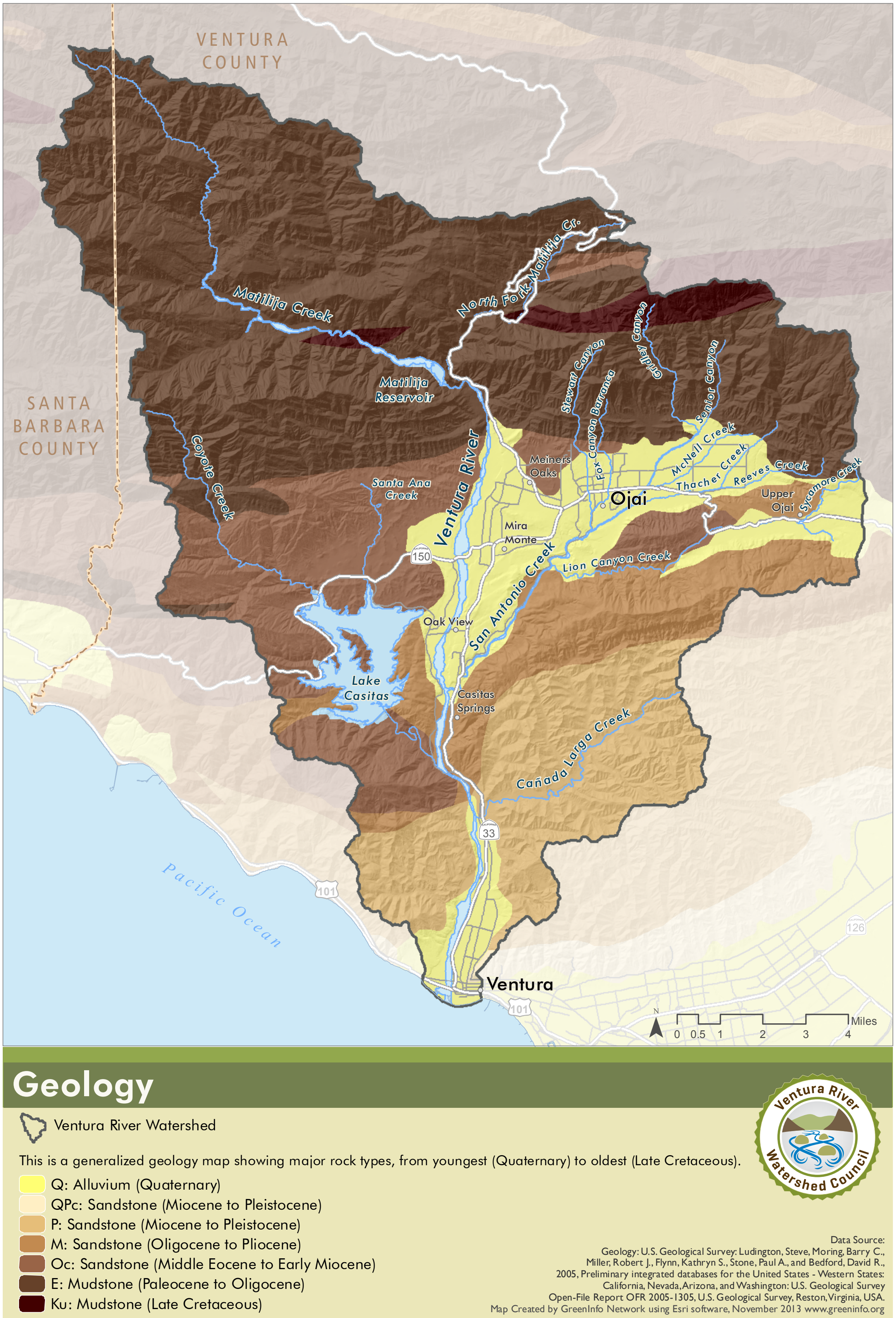


Figure 3.2.2.1.5 Geology Map. The major groundwater basins of the Ventura River watershed are located in the alluvial fill valleys.

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 floodwaters 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.