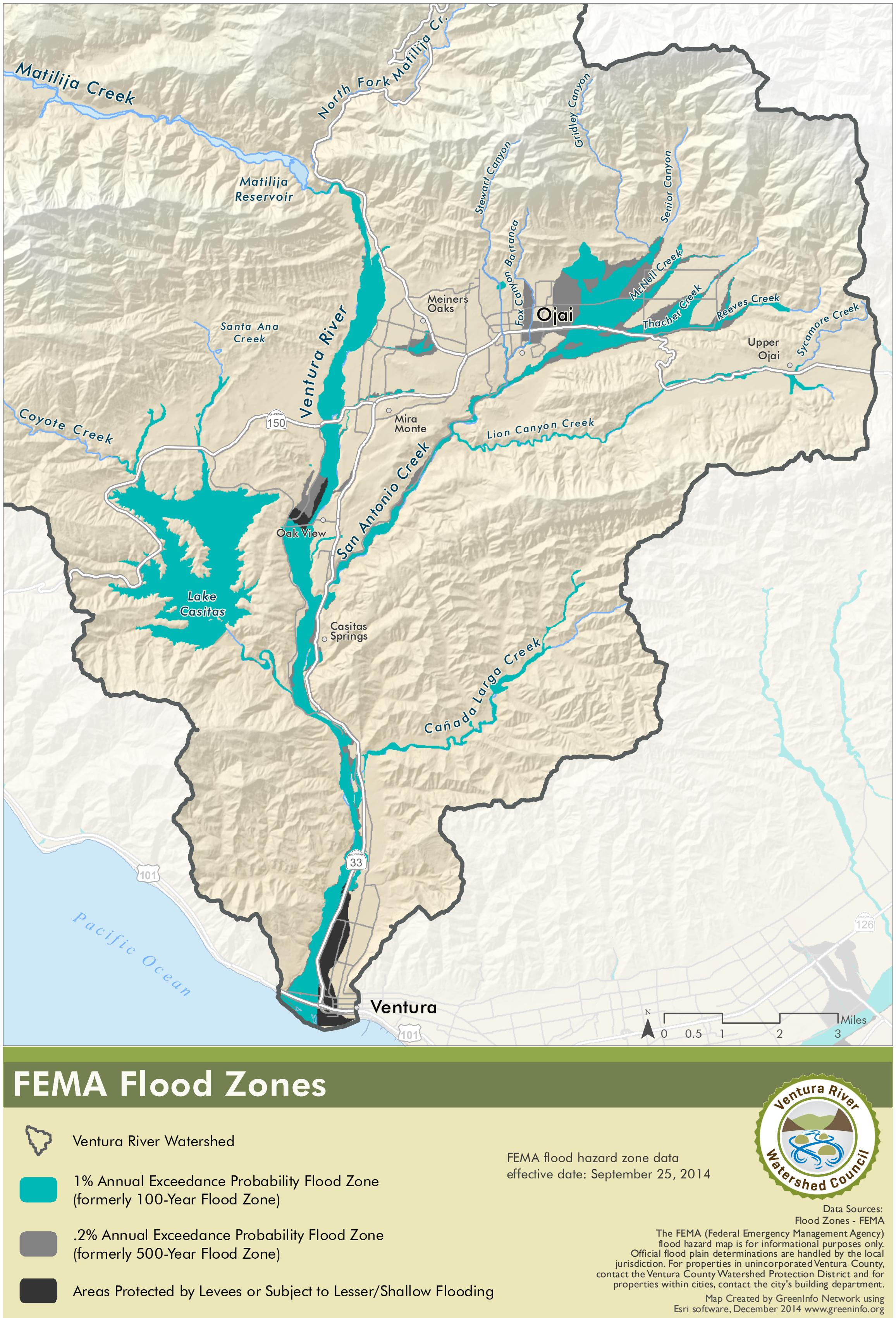


Figure 3.3.2.2.2 Flood Hazard Zone Map

3.3.2.3 Types of Floods and Where They Occur

The Ventura River watershed experiences several distinct types of flooding, including riverine flooding, alluvial fan flooding, coastal flooding, and urban drainage flooding; it also has the potential for dam failure flooding.

Riverine Floods

Definition: Floodplain

A floodplain is the area adjacent to a watercourse or other body of water that is naturally subject to recurring floods.

Riverine flooding occurs when a stream or river channel receives so much water that the excess water flows over its banks and onto the adjacent floodplain. The periodic inundation of floodplains is a natural and important ecosystem function that renews nutrients and triggers cycles of successive vegetation. As described in "3.3.1 Surface Water Hydrology," a long list of factors influence streamflows. Two important factors that strongly influence the nature of riverine flooding in the watershed are the steepness of the terrain and the intensity of rain events.

In the flood of 1992, the rate of flow of the Ventura River rose from less than 100 to 46,700 cubic feet per second—an increase of 46,600%—within about three hours.

The steep terrain of the Ventura River watershed is carved by a network of streams that discharge water in a very short distance. The distance from the headwaters to the ocean is only 33.5 miles. Stormflows move fast in such a steep environment which, when coupled with the intense downpours that can occur in the upper watershed, results in streamflows that sometimes cannot be contained by their banks.

Floods in these conditions are called "flashy" because floodwaters tend to rise and fall in a matter of minutes. In the flood of 1992, as an extreme example, the rate of flow of the Ventura River rose from less than 100 to 46,700 cfs—an increase of 46,600%—within about three hours. The Ventura can be a fiercely flashy river.

Ventura River Rescue, 1992 Flood

Photo courtesy of Ventura County Star

Ventura River Preserve Swimming Hole, Dry and During 2005 Flood
Flood photo courtesy of David Magney

City of Ventura's Nye Well 1A, 2005 Flood. The City's Nye Well 1A replaced Nye Well 1, lost in a previous flood. The February 2005 flood took out the rest of its replacement.
Photo courtesy of Ventura Water, City of Ventura

San Antonio Creek, 2005 Flood
Photo courtesy of Paul Jenkin

Casitas Springs, 2005 Flood
Photo courtesy of Ventura County Watershed Protection District

Overflowing Manhole in San Antonio Creek, 2005 Flood. Stormwater caught in the sewer system flows out the manhole.
Photo courtesy of Ojai Valley Sanitary District

Live Oak Acres, 1969 Flood
Photo courtesy of Ventura County Star

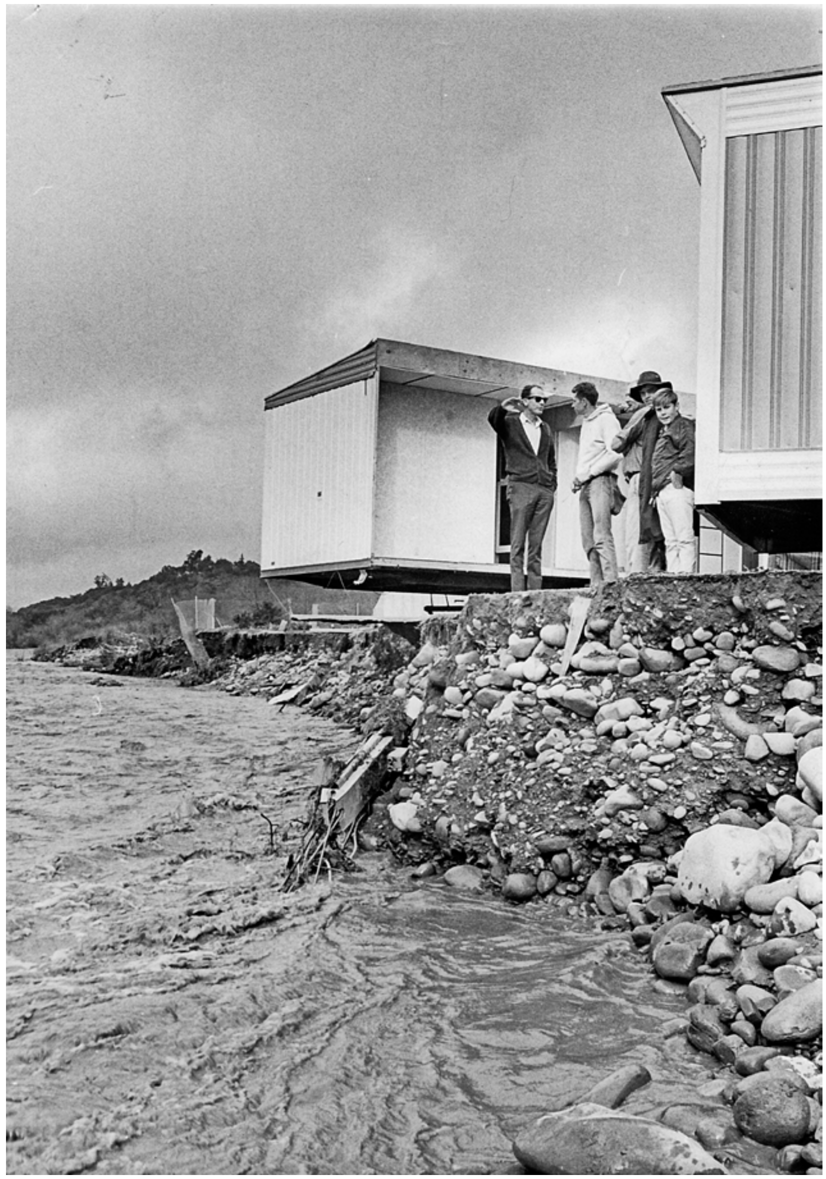
In addition to the risks associated with water overflowing its banks, riverine floods also pose risks related to erosion. Properties adjacent to streams and rivers can be scoured and undercut during floods, threatening homes, roads, and infrastructure. The floods of 1969 and 2005 both washed out a number of sewer mainlines along the edges of San Antonio Creek and the Ventura River. In the 2005 flood, this caused raw sewage mixed with stormwater to spill into the river for several days.

Cañada Larga Creek, Looking Upstream, 2005 Flood
Photo courtesy of Ventura County Watershed Protection District

Coyote Creek, 2005 Flood
Photo courtesy of Ventura County Watershed Protection District

Rancho Trailer Park, Casitas Springs, 1969 Flood

Photo courtesy of Ventura County Star



The high sediment load carried and deposited by local streams is a very significant factor in local riverine flood risks.

The high sediment load carried and deposited by local streams is a very significant factor in local riverine flood risks. Deposited rocks and sediment readily fill established channels which, if not cleaned out, can cause channel overflow and exacerbate flooding.

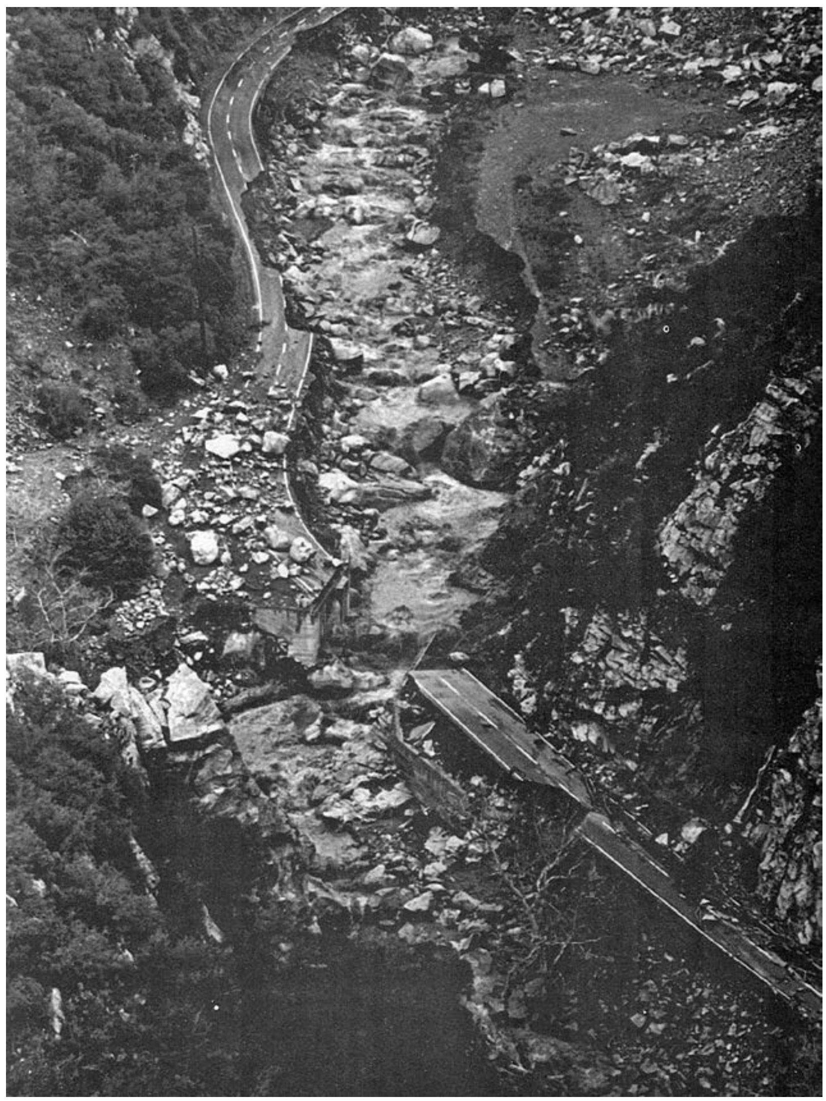
The wildland fires that occur in the forest and chaparral habitats that frame the watershed are also important contributors to flooding. After an intense fire, a waxy substance from the burning of brush and trees can be left on the soil, which makes the soil repel water. These "hydrophobic" soils decrease infiltration and increase runoff. A pattern of floods following fires within watersheds has been closely observed for more than 90 years in southern California (Earp 2007).

The Flood of 1969: The Watershed's Most Damaging Flood

The most damaging riverine flood recorded in the Ventura River watershed occurred in 1969. The watershed above Ojai received a staggering 43 inches of rain in nine days between January 18 and January 27. The floodwaters and associated debris rolled down out of the mountains, flooding homes in Casitas Springs and Live Oak Acres. Much agricultural land, primarily citrus groves, was seriously damaged or destroyed. All over Ventura County, transportation facilities, including roads, bridges, and railroad tracks, were damaged. The wastewater treatment plant below Foster Park was severely damaged and dumped raw sewage into the Ventura River. In addition, sewer trunk lines were broken along the Ventura River and San Antonio Creek. Untreated sewage polluted the river and beach (VCPD 2011a). The capacity of the Matilija reservoir was significantly reduced by siltation from the flood (USACE 2004). See "4.4 Appendices" for a more detailed description of the 1969 flood.

Highway 33 Destroyed at North Fork Matilija Creek, 1969

Photo courtesy of Ventura County Star



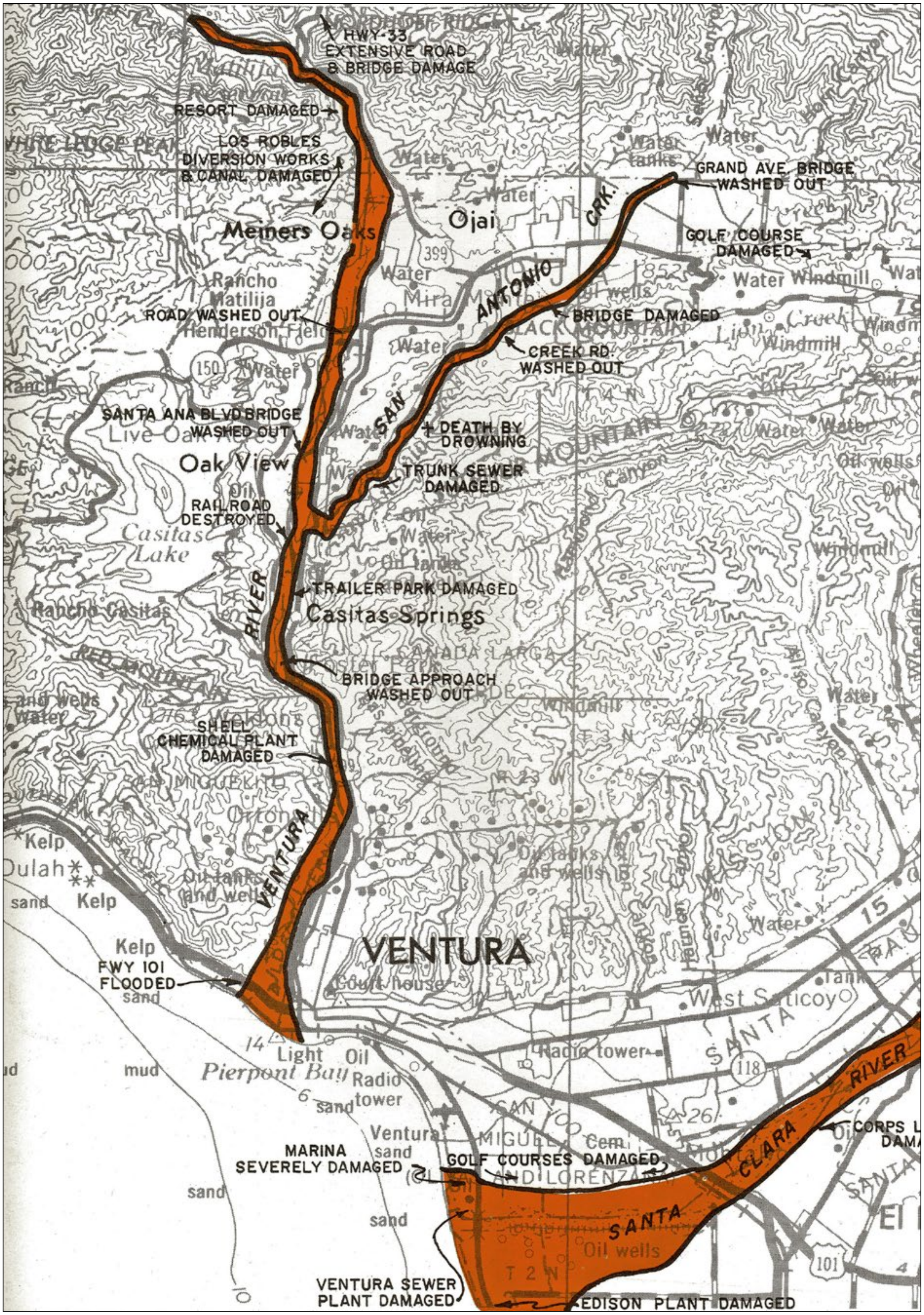


Figure 3.3.2.3.1 1969 Flood Damages Map

Source: Ventura County Flood Control District

Alluvial Fan Floods

Alluvial fans are the fan-shaped deposits of rock and sediment that accumulate on valley floors at the mouths of canyons in steep erosive mountains, typically in dry climates. The stream channels associated with alluvial fans are shallow and poorly defined, and their path is unpredictable. During heavy rains, water runs off the steep mountains above alluvial fans very quickly and with tremendous erosive force. The water picks up sediment, rocks, and boulders that can easily fill the shallow stream channels and cause floodwaters to spill out, spread out, and cut new channels. Alluvial fan floods can cause significant damage due to the high velocity of water flow, the amount of debris carried, and the broad area affected.

East Ojai Avenue, 1969 Flood
The stream channels associated with alluvial fans are shallow and poorly defined, and their path is unpredictable.
Photo courtesy of *Ventura County Star*

Soule Park Golf Course, 2005 Flood
Photo courtesy of Ventura County Watershed Protection District

Siete Robles Neighborhood after 2005 Flood. The Siete Robles neighborhood is located on the active depositional area of the alluvial fans in Ojai's East End.

Photo courtesy of Ventura County Watershed Protection District

A significant area of the Ojai Valley's East End appears on FEMA floodplain maps because of alluvial fan flood risk. Three alluvial fans occur in this area: Thacher Creek Alluvial Fan, San Antonio Creek Alluvial Fan, and Dron-Crooked Canyon Alluvial Fan (VCWPD 2009).

San Antonio, Thacher, McNell, Reeves, and Dron Creek-Crooked Creeks are associated with the alluvial fan flooding on the East End of Ojai. These creeks have some of the highest erosion rates in Ventura County (Hawks & Associates 2005). This area of the watershed is dominated by citrus orchards, and flooding of the creeks can cause erosion and damage to the orchards, as well as to homes and roads. Residential neighborhoods built in these areas have a history of repeated flood damage. The Siete Robles neighborhood on Ojai's East End, located directly on the "active" or depositional area of the alluvial fans, has seen severe flooding over the years.

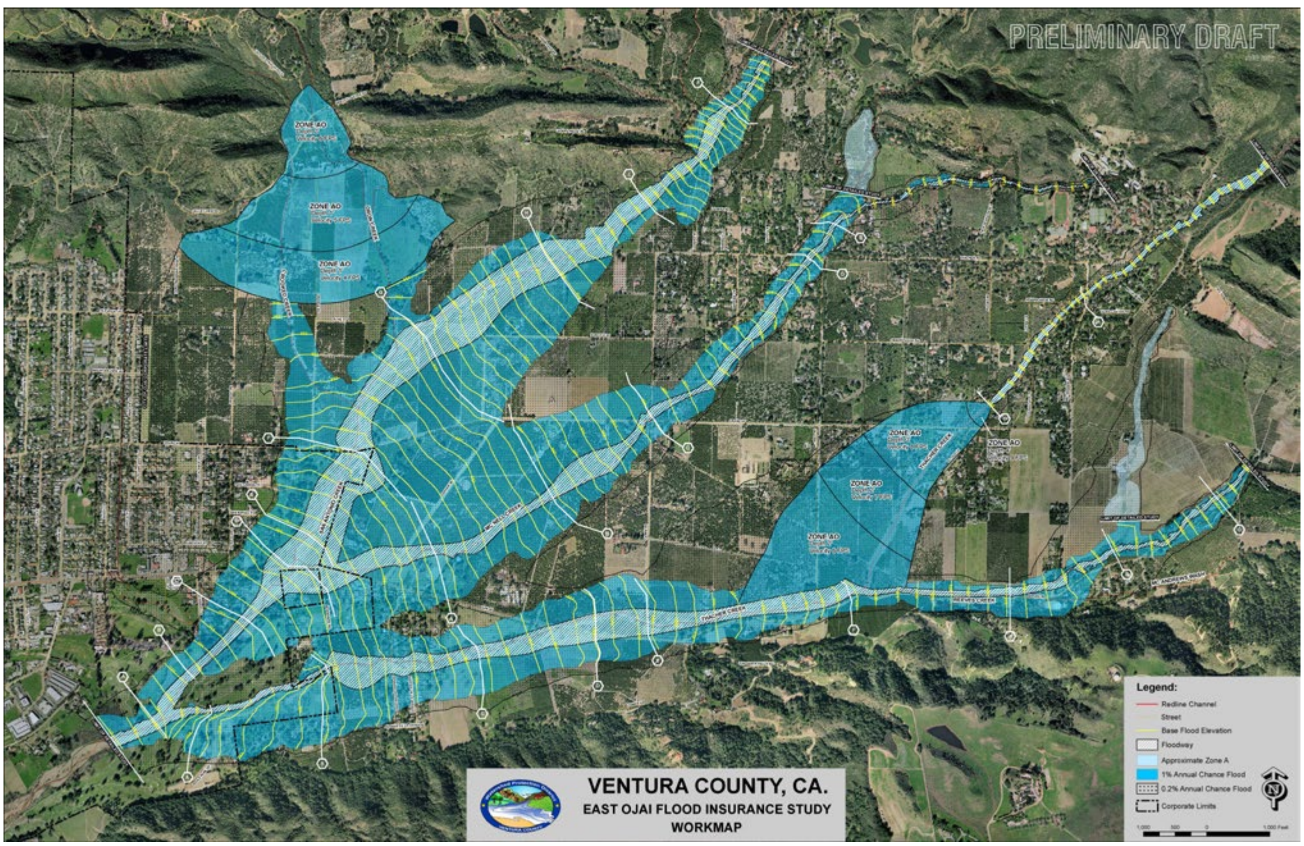


Figure 3.3.2.3.3 East Ojai 100-Year (1% AEP) Floodplain Map. In a Cooperative Technical Partnership with FEMA, Ventura County Watershed Protection District performed a comprehensive floodplain study of the east Ojai area, which culminated in 2011 with a proposal to FEMA to revise the floodplain map of this area. The revised map, which is very different than the old map, became effective in September of 2014.

Source: Addendum to East Ojai Alluvial Fan Flood Insurance Study, Technical Support Data Notebook (VCWPD 2012a).

Coastal Floods

Coastal flooding occurs when water from the ocean is driven onto land by storm surges, storm-generated wind, tides and waves, or tsunamis.

Coastal flooding may cause damaging erosion of the coast, beaches, and structures along the coast, and this hazard is exacerbated by the reduction in the natural transport of sand and gravel to replenish local beaches. Rising sea level from climate change also presents a potential coastal flooding hazard. Backwater flooding at the river mouth, where the flow of the river to the ocean is "backed up" by exceptionally high ocean water or sand berms, is a type of flooding that is possible under conditions of higher sea level. Backwater flooding regularly occurs at the drainage to the coast on San Jon Road in Ventura, just outside of the watershed.

Backwater Flooding at San Jon Road, Ventura

Photo courtesy of Paul Jenkin

A tsunami is a series of sea waves generated by an earthquake, landslide, volcanic eruption, or other large disruption to the ocean. These sea waves can move more than 500 miles per hour and their destructive power can be enormous when they hit land. Damaging tsunamis have occurred infrequently in California, but they are a possibility that must be considered in coastal regions (CGS 2013).

The tsunami from an earthquake in Alaska in 1964 caused approximately $35,000 of damage to the marinas in Ventura County. A major earthquake off the coast of Chile in 2010 generated a tsunami that caused over $200,000 in damages to structures and vessels in Ventura Harbor. The worst recorded tsunami to hit California was in 1812, when an earthquake occurred in the Santa Barbara Channel; the resulting waves were probably 15 feet or higher above sea level at Ventura (VCPD 2011a).

Definition: Flood

FEMA's official definition of "flood" includes: "Collapse or subsidence of land along the shore of a lake or similar body of water as a result of erosion or undermining caused by waves or currents of water exceeding anticipated cyclical levels that result in a flood." (FEMA 2013a)

Ventura Pier 1998
Photo courtesy of Paul Jenkin

Coastal flooding often occurs at the same time that riverine flooding occurs because both are associated with major storms, but this is not always the case. Sometimes powerful storms can flood or significantly erode the coast but not drop enough water to cause significant riverine flooding.

Coastal flooding often occurs at the same time that riverine flooding occurs because both are associated with major storms, but this is not always the case.

The boundaries of the watershed at the coast extend from the upper end of the City of Ventura's Seaside Wilderness Park adjacent to Emma Wood State Beach to just west of the tall Crowne Plaza Hotel at California Street. Coastal development in this area consists primarily of the 62-acre Ventura County Fairgrounds, several apartment complexes, and the Ventura Promenade.

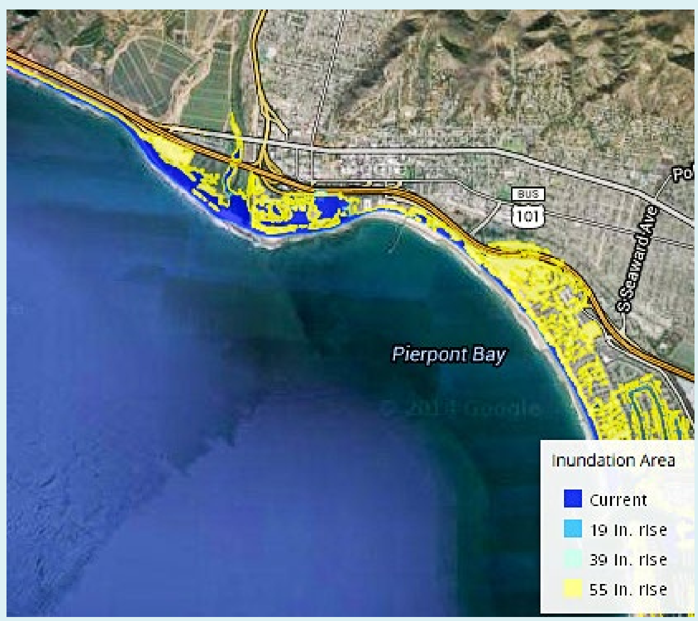
Relative to other parts of the coastline, this area is sheltered from ocean storm swells by both Point Conception and the Channel Islands (BEACON 2009). Nonetheless, Emma Wood State Beach and the Ventura Promenade in front of the Ventura County Fairgrounds—both located on the river's delta—have experienced repeated coastal flooding and erosion damage over the years. Emma Wood State Beach is eroding at a rate of about 0.6 feet annually, and past storms have caused extensive damage and led to its temporary closure (VCPD 2011a).

A reduction in the natural flow of sediment and sand to the beach is one of the reasons the ocean has been able to cause so much erosion here. The natural supply of sediment to the beaches in this region of the coast is principally from the steep gradient mountain creeks of the Santa Ynez and Topatopa Mountains. Over half of this natural sand and gravel supply is now blocked from reaching the beach, largely by Matilija Dam, but also by other dams, diversions, and debris basins (Beller et al. 2011).

Erosion of the coastal bluffs northwest of the Ventura River delta has historically contributed sediment to local beaches, but this natural process has also been modified. The Rincon Parkway, the 17-mile stretch of coastline above the mouth of the Ventura River, is almost entirely protected with either seawalls or revetments installed to protect the railroad, freeway, and development from erosion and the impact of waves (BEACON 2009).

Sea Level Rise

California's Cal-Adapt website states that "Global models indicate that California may see up to a 55 inch (140 cm) rise in sea level within this century given expected rise in temperatures around the world." The map below from the website shows the latest projections for sea level rise at the watershed's coastline. These data were developed by scientists from the USGS and Pacific Institute (Cal-Adapt 2014).



Projected Sea Level Rise Map
Source: Cal-Adapt 2014

The City of Ventura is a beach town; its inviting and accessible beaches are a central part of its cultural identity, and the health and maintenance of these beaches and coastal habitats are strongly supported by watershed stakeholders. A well-used promenade and bike path runs along the coast, east of the river mouth in front of the fairgrounds, and connects to paths up and down the coast, as well as up the river. This area of the coast is a highly regarded surfing spot, a point break known as "Surfers' Point." Erosion of the beach in this area is a significant issue of concern in the watershed. The bike path and parking area eroded more than 60 feet back in some places since originally installed. See "3.2.3 Geomorphology and Sediment Transport" for a discussion on the innovative "managed retreat" project being implemented in this location to address the loss of beach sand.

Surfers' Point in Front of Ventura County Fairgrounds, 1995
Photo courtesy of Paul Jenkin

Surfers' Point Wave Run-Up, 1995
Photo courtesy of Paul Jenkin

Urban Drainage Floods

Storm drain infrastructure can be overwhelmed by storm flows and cause urban flooding.

Storm drain infrastructure (systems of ditches, culverts, pipes, and lined channels designed to quickly move storm flows out of urban areas) can be overwhelmed by storm flows and cause urban flooding. These systems may be undersized or poorly designed, become damaged, or get clogged by debris, resulting in flooding in areas outside the expected flood zone. Urban drainage problems can also result in areas protected by levees because the natural flow towards the river is blocked by the levee itself. Urban drainage flooding is primarily nuisance flooding since significant flows are not usually involved. This type of flooding does not generally pose a serious threat to life and property.

Development in natural wetlands is another reason for urban drainage flooding in the watershed. Springs, vernal ponds, and other types of wetlands are commonly associated with geological faults. The highly folded and faulted Ventura River watershed, one of the most tectonically active uplifting regions of the world, comprises several fault-associated wetlands scattered throughout the area (Ferren 2004). Some areas in the watershed have a very high water table, which can also present urban drainage flooding problems.

Ojai Meadows Preserve Flood Management Wetland. The restoration of the Ojai Meadows Preserve in Meiners Oaks by the Ojai Valley Land Conservancy is addressing a historic urban drainage problem by re-establishing the natural wetland drainage in that area.

Photo courtesy of Rick Wilborn

Stormwater Infiltration Infrastructure

Impervious surfaces—rooftops, roadways, and parking lots—in urban areas exacerbate flood flows because water flowing over these surfaces cannot infiltrate or evapotranspire; it simply flows off—fast. The result is that both peak streamflow rates and runoff volumes can be increased by impervious surfaces. Groundwater recharge is also diminished. Impervious surfaces also accumulate pollution and sediment, which increases nutrients, bacteria, and other pollutant concentrations in local channels, rivers, and the ocean.

As a result of these impacts to water quality, state and local regulators have developed stormwater "best management practice" (BMP) programs and requirements to increase the retention and infiltration of stormwater onsite, so that the amount and quality of water leaving the site during storms more closely matches that of predevelopment conditions. These BMPs include bioswales, rain gardens, vegetated filter strips, small neighborhood retention basins, and other types of infiltration systems (and curb cuts that direct runoff into these infiltration systems), as well as pervious pavements, green roofs and other systems. The photos below illustrate some of these systems installed in the watershed.

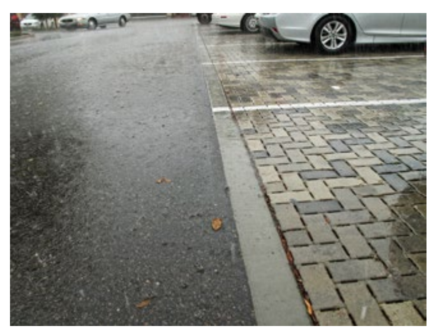
Bioswale, Oak Street Parking Lot, Ventura

Bioswale, Surfers' Point, Ventura

Bioswale, Hwy 33, Mira Monte

Bioswale, Downtown Ventura Parking Lot

Pervious Parking Lot, Ojai
Photo courtesy of Lisa Brenneis



Pervious Pavers, Oak Street Parking Lot, Ventura

Dam Failure Floods

Flooding as a result of dam failure is another type of flooding that could potentially occur in the watershed. Dam failure can result in severe flooding because the flows that would result would be much larger than the capacity of the downstream channels. Four dams are of sufficient size to be regulated for safety in the watershed: Casitas Dam, Matilija Dam, Senior Canyon Dam, and the dam associated with Stewart Canyon Debris Basin. Because of the size of Lake Casitas, the Casitas Dam poses the greatest flooding potential. Depending on whether a dam is federally or locally owned, dams are under the regulatory jurisdiction of either an agency of the Federal government, as is the case for Casitas Dam, or under the California Division of the Safety of Dams (DSOD), as is the case for Matilija Dam, Senior Canyon Dam, and Stewart Canyon Debris Basin (USACE 2004b). Table 3.3.2.3.1 summarizes the four dams in the watershed.

Table 3.3.2.3.1 Regulated Dams in the Ventura River Watershed

Dam	Owner	Regulatory Jurisdiction	Capacity (acre-feet)	Flood Route
Casitas Dam	U.S. Bureau of Reclamation	U.S. Bureau of Reclamation	254,000	Coyote Creek, Ventura River
Matilija Dam	Ventura County Watershed Protection District	California DSOD[1]	500	Matilija Creek, Ventura River
Senior Canyon Dam	Senior Canyon Mutual Water Company	California DSOD	78	Senior Canyon, San Antonio Creek
Stewart Canyon Debris Basin	Ventura County Watershed Protection District	California DSOD[1]	64.6	Stewart Canyon Creek Channel, Stewart Canyon Creek, San Antonio Creek

1: California Division of the Safety of Dams

Data Sources: URS 2005; Cardno-Entrix 2012; USACE 2004 and 2004b, Magney 2005

The Casitas Dam is located in an area of high seismicity, which presents a potential hazard to the dam's integrity, as described in the following excerpt:

> Casitas Dam is located in an area where the earth's crust is being compressed rapidly (on a geologic time scale). As a result, the area surrounding the dam contains numerous active faults, including the Red Mountain thrust fault less than 2 miles from the dam. A peer-reviewed study shows this fault to be capable of producing an earthquake of approximate magnitude $M_w 7$. The resulting accelerations could exceed 0.7 times the earth's gravity (0.7 g). A seismic hazard assessment was performed considering the Red Mountain Fault as well as other nearby faults. This evaluation

> concluded that there is from 1 chance in 100 to 1 chance in 300 in any given year of accelerations exceeding 0.6 g. This probability is unusually high, even for California.
>
> —*Design Summary, Casitas Dam Modification* (USBR 2001)

Much of the embankment of the dam bears upon stream-channel alluvial substrate (USBR 2001), a material that is susceptible to liquefaction during earthquakes (URS 2005a). Liquefaction occurs when ground shaking causes loose, saturated soil to lose cohesive strength and act as a viscous liquid for several moments (VCPD 2011a).

Modifications to Casitas Dam were designed to alleviate concerns about the potential liquefaction of the alluvium substrate under the dam in a severe earthquake. These upgrades to the facility, including stabilization of the downstream slope and modification of the crest to accommodate instability of the upstream slope, were implemented in 2001 (USBR 2007). At the crest, the earth filled Casitas Dam originally measured 40 feet from lakeside to the face of the dam. The foot of the dam was 1,750 feet thick. This seismic retrofit increased the thickness of the dam by 110 feet (CMWD 2013).

Casitas Dam
Photo courtesy of US Bureau of Reclamation

Dam Failure Response

In Ventura County, disaster coordination and planning is the responsibility of the Sheriff's Office of Emergency Services (OES). The OES serves as the depository for Ventura County's Dam Inundation Maps and is charged with ongoing maintenance of the County's Dam Failure Response Plan (VCPD 2011a).

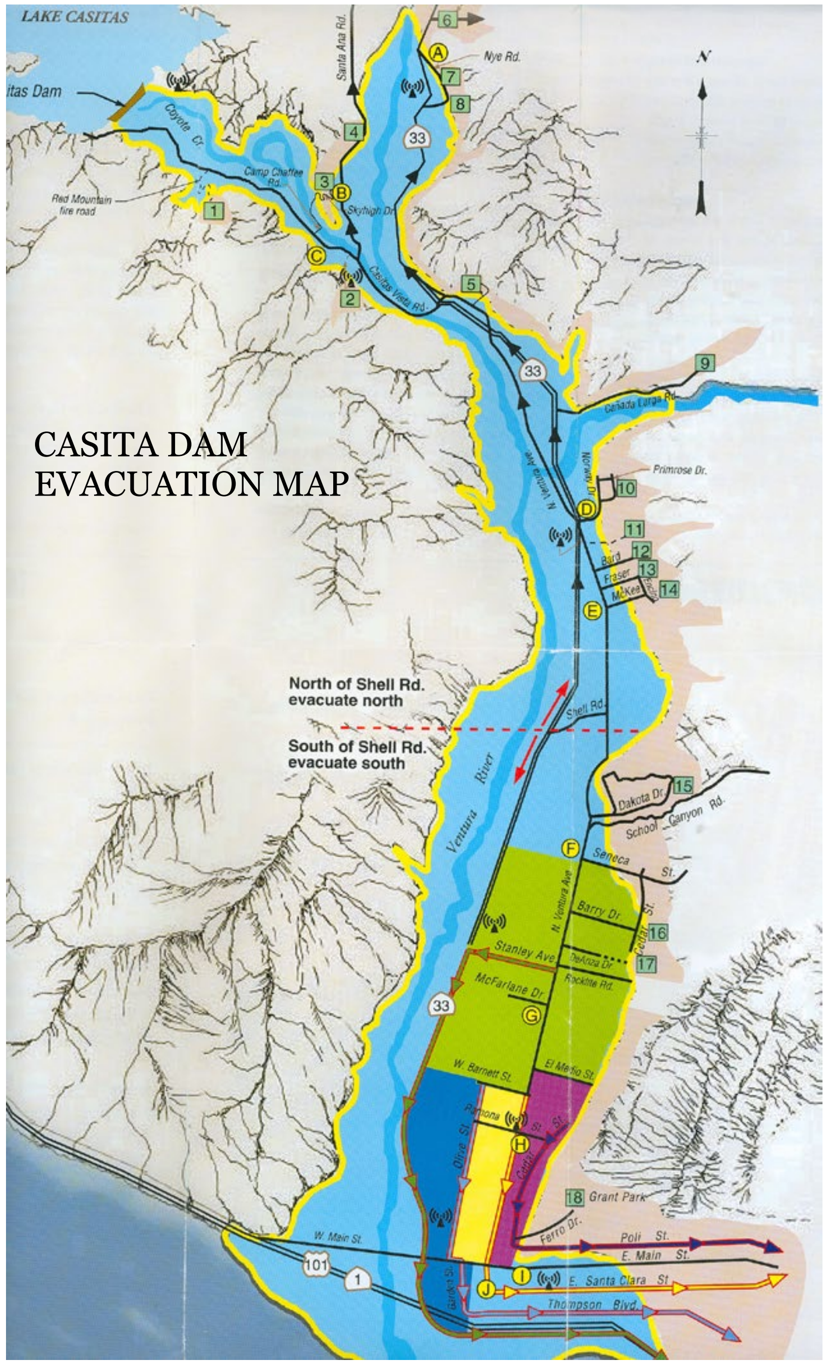


Figure 3.3.2.3.4 Casitas Dam Evacuation Map. For the complete map, with legend and instructions, go to http://readyventuracounty.org/pdf/CasitasDamEvacuationMap.pdf

Source: Casitas Dam Evacuation Route (VCOES 2013)

3.3.2.4 Flood Protection Infrastructure

The primary flood control infrastructure in the watershed consists of levees; debris basins; stormwater channels, pipes and culverts; and bank revetments such as riprap. Dams and reservoirs can also provide some potential flood control functions. Most of the flood management infrastructure in the watershed is designed, managed, and maintained by the Ventura County Watershed Protection District.

Most of the flood management infrastructure in the watershed is designed, managed, and maintained by the Ventura County Watershed Protection District.

Levees

There are three major levees along the Ventura River, all owned and operated by the Ventura County Watershed Protection District. Of the 16.23 miles of the mainstem of the Ventura River, 4.93 miles (30%) of the length of the river have a levee on one side.

Channel Meandering vs. Channel Hardening

Levees are embankments built to prevent the overflow of a body of water, such as a river. Levees are a conventional "bricks and mortar" approach to flood control. While such structures have become essential in some areas to protect urban developments, they are inconsistent with and counteract the natural tendency of rivers to erode and deposit sediments. Channel meandering is a natural process by which a river dissipates its energy during floods. Channel straightening and hardening of banks tend to increase the energy of the river during floods and potentially create accelerated erosion at other locations. Flood control agencies have come to understand this, and are now attempting to integrate more nonstructural approaches to flood management that combine natural and man-made alternatives.

Federal regulations administered by FEMA, the federal agency that offers flood insurance, require levee owners and operators to certify that their levees will continue to provide a barrier to the base flood (generally the 1% AEP flood) in order for FEMA to accredit such flood protection levels on Digital Flood Insurance Rate Maps (DFIRMs). In November of 2009, the Ventura County Watershed Protection District completed the mandated engineering evaluations for the levees in the watershed. The three levees in the watershed were found to have deficiencies such that they could not be certified as fully meeting federal standards by the November 2009 compliance deadline.

Consequentially, property owners behind the non-certified levees would be in a flood hazard zone, when new FEMA flood hazard maps are created. At that time, property owners with federally backed mortgages would be subject to mandatory federal flood insurance requirements. FEMA's DFIRMs do not get updated often, and a number of studies and

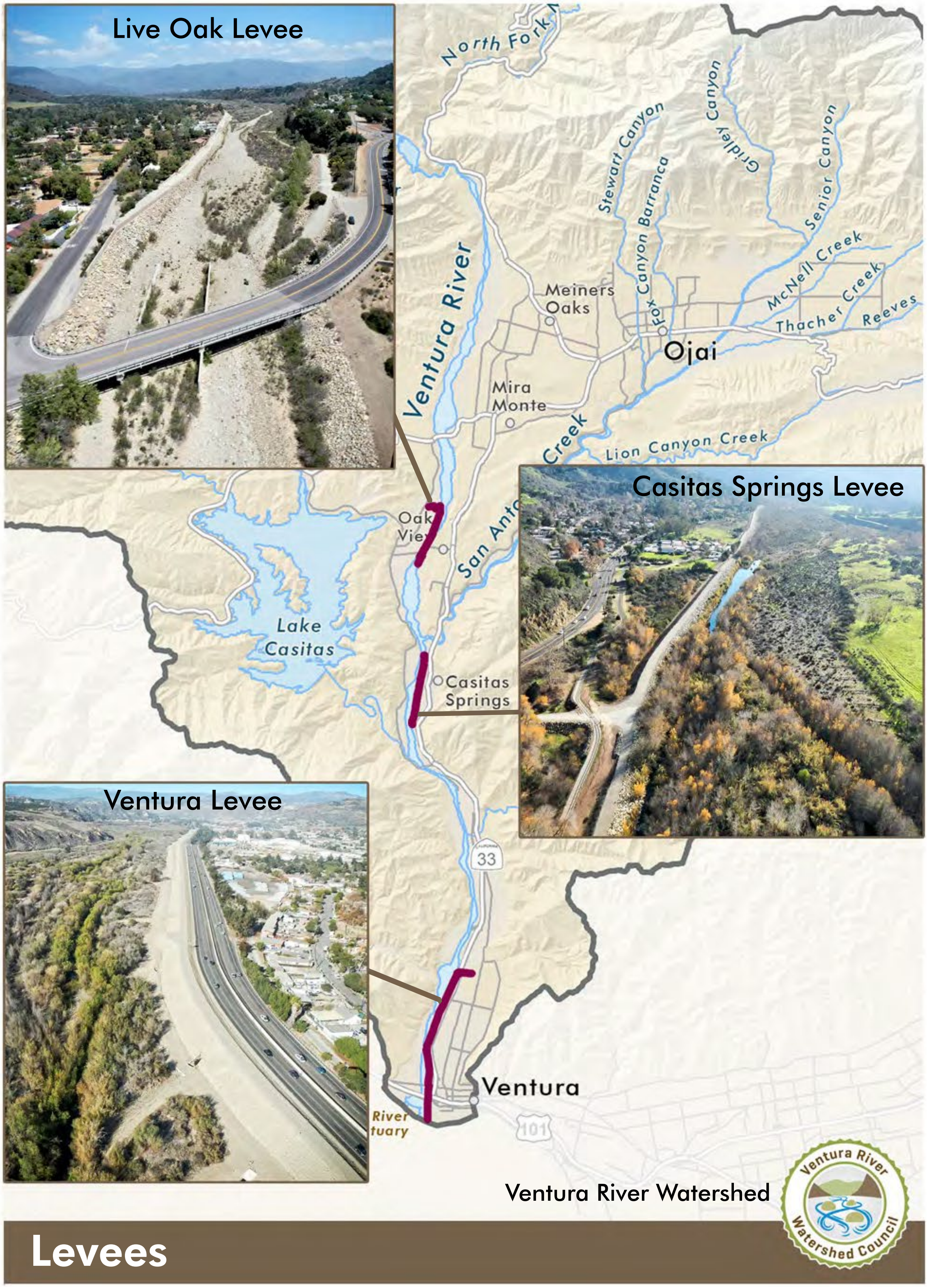


Figure 3.3.2.4.1 Levees in the Ventura River Watershed Map

Table 3.3.2.4.1 Levees in the Ventura River Watershed

Levee	Year Built	Location[1]	Length (miles)	Built to Protect
Ventura River Levee	1948	From Pacific Ocean to Canada de San Joaquin, City of Ventura	2.65	City of Ventura
Live Oak Levee	1978	From Santa Ana Blvd. Bridge to the Live Oak Diversion (near the junction of Riverside and Burnham Roads), Oak View	1.28	Live Oak Acres
Casitas Springs Levee	1979	From Santa Ana Blvd north to Riverside Rd., Casitas Springs	1	Casitas Springs

1: See Levees Map, Figure 3.3.2.4.1

Data Source: Cardno Entrix 2012; USACE 2004b

steps are required before they are updated for the Ventura River watershed. FEMA has not yet released an official date to issue new DFIRMs for the watershed. The projected earliest release date for new DFIRMs for the areas protected behind the three levees would be sometime during 2016 (VCWPD 2013d).

The Matilija Dam removal project, called the Matilija Dam Ecosystem Restoration Project, involves installing and upgrading a number of flood control structures in the river, including enhancing the Casitas Springs and Live Oak levees, as well as constructing a new levee at Meiners Oaks. Design work is already in process, and if sufficient construction funding can be secured for these levee rehabilitation projects, federal levee certification requirements should be met for these two levees.

For the Ventura River levee, the Ventura County Watershed Protection District is engaged in preliminary reconnaissance and feasibility work in support of levee retrofit and/or enhancement projects required to certify the levee, and is researching possible sources of funding.

Limited Flood Management Funding

It is the mission of the Ventura County Watershed Protection District to protect life, property, watercourses, watersheds, and public infrastructure from the dangers and damages associated with floods and stormwaters in Ventura County. The District has four service areas that roughly correspond to the major river systems in the County; the district's Zone 1 comprises the Ventura River watershed and adjacent coastal drainages.

Ongoing funding for the District's activities comes from property taxes, benefit assessments, and land development fees. In addition, supplemental funding from grants, cost-share programs, and other funding sources has become increasingly important to the District's ability to complete large, capital-intensive flood protection projects.

The relative amount of funding available for flood management in each of the District's zones differs because of how the District is funded. Benefit assessment monies collected from each zone are dedicated to support operations and maintenance and NPDES (National Pollutant Discharge Elimination System) permit activities within that zone. Property tax monies raised within a zone are spent on construction projects and to support District planning studies within that zone (VCWPD 2005).

Due to the limited development in the Ventura River watershed, revenues from property taxes, land development fees, and benefit assessment fees in Zone 1 are significantly lacking, and are much less than in zones comprising the County's other two major watersheds. Annual revenues available for flood management projects in Zone 1 have averaged less than $2 million a year.

Debris and Detention Basins

Debris basins are a very important component of flood control systems in areas where streams carry high sediment loads. Typically placed at canyon mouths, debris basins capture the sediment, gravel, boulders, and vegetation that are washed out of canyons during storms. The basins capture the material and allow the water to flow into downstream drainage channels. Removing sediment and debris helps prevent blockage of channels and associated flooding. One of the drawbacks of debris basins is that by removing the sediment from the water, the flowing water becomes "hungry" for sediment and as a result increased erosion and scour downstream of debris basins has been observed (VCWPD 2013a).

Typically placed at canyon mouths, debris basins capture the sediment, gravel, boulders, and vegetation that are washed out of canyons during storms.

There are four functioning debris basins that collect sediment from drainages before they enter the mainstem of the Ventura River: Dent, Live Oak, McDonald Canyon, and Stewart Canyon. All of these basins are owned and operated by the Ventura County Watershed Protection District.

An earth and rock debris basin was built on San Antonio Creek in 1986 as an emergency structure in response to the Wheeler Fire that had burned the watershed in 1985. It served its purpose, accumulating 26,600 cubic yards of debris during the first year of operation. The basin has been damaged and filled over the years and is no longer functioning as a debris basin (Hawks & Associates 2005).

Some basins have been designed specifically as "detention basins," which detain large volumes of water during the early phases or peak of a storm event, then slowly release the water over time. Detention basins reduce the peak downstream flows, which reduces flooding, but they also act to retain debris. Similarly, basins designed primarily as debris basins also help to attenuate peak flow, depending on their storage capacity.

Table 3.3.2.4.2 Debris Basins in the Ventura River Watershed

Basin	Year Built	Location[1]	Watershed Area (acres)	Maximum Debris Storage Capacity (cubic yards)	Expected Debris Production for 1% AEP[2] Flood (cubic yards)
Dent Debris Basin	1981	Ventura, behind De Anza Middle School	19	4,100	1,624
Live Oak Diversion Dam	2002	Oak View, west of Burnham Rd. between Santa Ana Rd. and Hwy 150	794	28,700	20,952
McDonald Canyon Detention Basin	1998	Meiners Oaks, east of Hwy 33/ Fairview Rd junction	573	23,400	20,179
Stewart Canyon Debris Basin	1963	Ojai, at north end of Canada St.	1,266	328,300	209,000

1: See Dams and Debris Basins Map, Figure 3.3.2.4.2

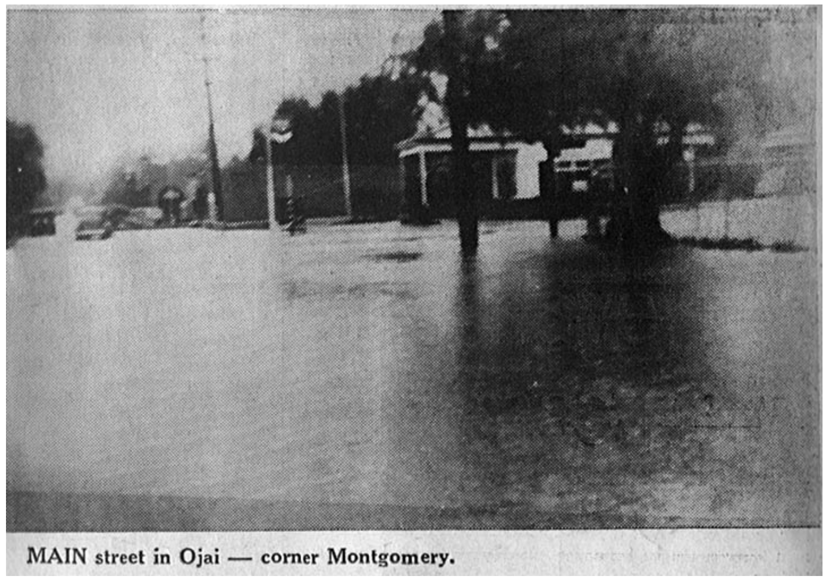
2: Annual Exceedance Probability

Data Sources: VCWPD 2005a; Cardno-Entrix 2012

Figure 3.3.2.4.2 Dams and Debris Basins Map

Stewart Canyon Debris Basin

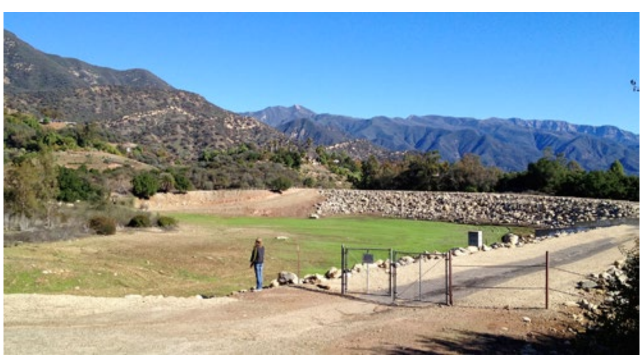
The Stewart Canyon Debris Basin is worth special mention. It is so massive that it stands out in aerial photos of the City of Ojai. The basin sits at the base of Stewart Canyon, one of the primary drainages off of Nordhoff Peak. Stewart Canyon naturally drains through the center of the City of Ojai, and in the flood of 1938 this became a big problem. A 1938 newspaper stated, "The Arcade was awash from a cascade down Montgomery Street and Signal Street. Lion and Aliso were also completely flooded as water raced down Stewart Canyon." (OVN 1969)



Downtown Ojai Before Stewart Canyon Debris Basin was Built, 1938 Flood

Photo courtesy of Ojai Valley News

This flood provided motivation for the construction of the Stewart Canyon Debris Basin, which is credited with saving the City of Ojai from major property damages and loss of lives. It is estimated that over 200,000 cubic yards of material were deposited in the basin during the storms in January and February of 1969 (City of Ojai 1991).



Stewart Canyon Debris Basin, Dry

Stewart Canyon Debris Basin Map. Stewart Canyon debris basin is the large brown area in the upper center of the image.

Map photo courtesy of Google Earth, 2013

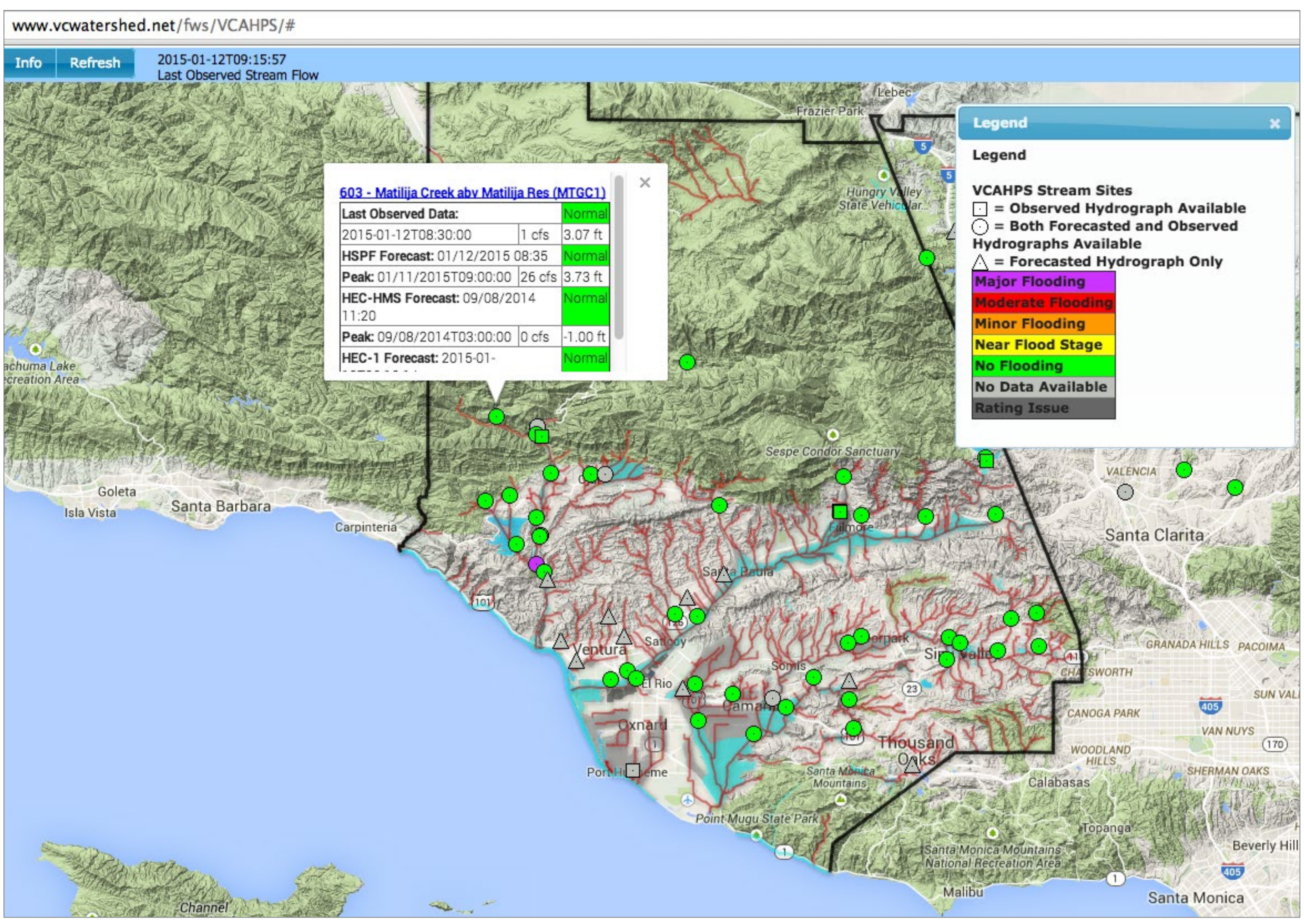
Dams and Reservoirs

The Matilija Reservoir no longer serves a significant flood control function because it is largely full of sediment. The capacity at Lake Casitas (if available) provides attenuation of flood flows downstream of the dam, as the stormwater from upper Coyote Creek and Santa Ana Creek flows into the lake. The exception to this is if the lake is full. Additionally, up to 500 cfs can be diverted from Ventura River to Lake Casitas; however, this diversion has little effect on large Ventura River peak flows (Entrix & URS 2004). See "3.3.1 Surface Water Hydrology" for more information on the watershed's dams and reservoirs.

3.3.2.5 Flood Monitoring

The Ventura County Watershed Protection District maintains a Google Maps interface that provides current (almost real-time) streamflow observations. The monitoring location icons are color-coded to indicate the current flooding status. Clicking on a specific monitoring location icon opens a window with last observed flow data and forecast information. The monitoring location link within this window provides access to more detailed information on flood flow categories and potential flood impacts for that location. Website: www.vcwatershed.net/fws/VCAHPS/#.

Figure 3.3.2.5.1 VCWPD's Advanced Hydrologic Prediction System Website. See "3.3.1 Surface Water Hydrology" for a summary of the other streamflow monitoring programs in the watershed.



3.3.2.6 Key Data and Information Sources/ Further Reading

"4.4 Appendices" contains additional information on flooding in the watershed, including the following documents:

Ventura River Mainstem Flood Risk Areas

1969 – Our Most Damaging Flood

Past Floods in Brief

Table of Storm Event Peak Flows, Foster Park (Station 608), 1933–2013

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

The Ventura County Watershed Protection District's websites (http://portal.countyofventura.org/portal/page/portal/PUBLIC_WORKS/Watershed_Protection_District and www.vcfloodinfo.com) have considerably more information on the topic of flooding.

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

Coastal Regional Sediment Management Plan (BEACON 2009)

Design Summary, Casitas Dam Modification (USBR 2001)

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

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

Flood Histories of the Counties in the Alluvial Fan Task Force Study Area (Earp 2007)

Flood Mitigation Plan for Ventura County, California (URS 2005)

Hydrologic Data Server, Foster Park Gauge. Includes info on flood flow categories, potential flood impacts by flow, and flooding hot spots. (VCWPD 2013b) www.vcwatershed.net/fws/VCAHPS/php/ahps.php?gage=608

Hydrologic Data Server, San Antonio Creek Gauge. Includes info on flood flow categories and potential flood impacts by flow (VCWPD 2013c) www.vcwatershed.net/fws/VCAHPS/php/ahps.php?gage=608

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

Levee Certification Public Safety Project website. www.vcwatershed.com/levee/ (VCWPD 2013d)

Acronyms

AEP—Annual Exceedance Probability (flood)

BMP—best management practice

cfs—cubic feet per second

DFIRM—Digital Flood Insurance Rate Map

DSOD—California Division of the Safety of Dams

FEMA—Federal Emergency Management Agency

OES—Office of Emergency Services

NPDES—National Pollutant Discharge Elimination System

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

San Antonio Creek Debris Basin Feasibility and Upper San Antonio Creek Deficiency Study (Hawks & Associates 2005)

Tsunamis website of the California Geological Survey: www.consrv.ca.gov/cgs/geologic_hazards/tsunami/pages/about_tsunamis.aspx (CGS 2013)

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

Ventura County Open Pacific Coast Study (FEMA 2011)

Ventura River Watershed Protection Plan Report (Cardno-Entrix 2012)

Ventura River Watershed Design Storm Modeling Final Report (VCWPD 2010)

3.3.3 Groundwater Hydrology

This section summarizes the physical location, capacity, and dynamics of the Ventura River watershed's major groundwater systems. These groundwater systems form essential water storage and transport functions in the watershed. For the water quality aspects of groundwater in the watershed, see "3.5.2 Groundwater Quality," and for the water supply aspects of groundwater in the watershed, see "3.4 Water Supplies and Demands."

Water that falls on the earth is disposed of in three ways. It evaporates into the air, it sinks into the ground, or it runs off the surface of the earth…Water on the land surface is visible in lakes, ponds, rivers, and creeks or surface water. What is not seen is the important water that is out of sight—called groundwater. It is convenient to refer to surface and groundwater separately in describing the location of the water, even though they are not different kinds of water. Both come from precipitation.

—*Luna B. Leopold,* Water, Rivers and Creeks

The watershed's groundwater basins generally lie within geologic depressions that have filled with alluvium, layered sediments primarily deposited by streams over long periods of time. The deposited material includes coarse deposits, such as sand and gravel that form the aquifers where water is stored and can flow, and finer-grained deposits, such as clay and silt that form the aquacludes, barriers to groundwater movement.

The boundaries of the groundwater basins are essentially defined by the alluvium that fills the basins and overlies low-permeability rock or, in a few cases, large geologic fault blocks (VCFCD 1971). When groundwater basins are full, the water table often occurs at relatively shallow depths—sometimes at, or just a few feet below ground surface—with depths varying depending on location.

There are four groundwater basins of significance in the Ventura River watershed: Ojai Valley Basin, Upper Ventura River Basin, Lower Ventura River Basin, and Upper Ojai Basin.

There are four groundwater basins of significance in the Ventura River watershed: Ojai Valley Basin, Upper Ventura River Basin, Lower Ventura River Basin, and Upper Ojai Basin. Some sources consider the Upper and Lower Ventura River Basins to be sub-basins of one large Ventura River Basin. A fifth small basin, the San Antonio Creek Basin, was identified as a separate basin in the extensive 1971 study prepared by the Ventura County Flood Control District (now Watershed Protection District) (Entrix 2001), but this small, shallow basin is now considered part of the Upper Ventura River Basin by the State of California (CDWR 2003) and the Ventura County Watershed Protection District.

Groundwater: Water in the Saturated Zone

The pores, fractures, and other voids that are present in the sediments and rocks that lie close to the earth's surface are partially to completely filled with water. In most locations, an unsaturated zone in which both water and air fill the voids exists immediately beneath the land surface. At greater depths, the voids become fully saturated with water. The top of the saturated zone is referred to as the water table, and the water within the saturated zone is groundwater.

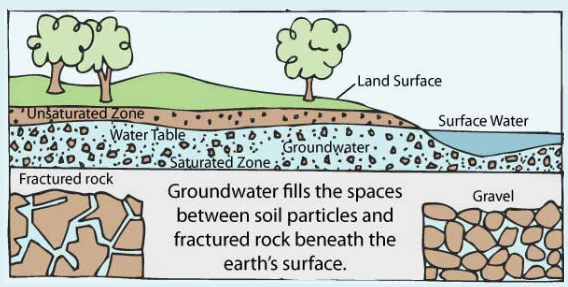


Figure 3.3.3.1 Groundwater Illustrated
Image courtesy of The Groundwater Foundation

Although voids beneath the water table are filled with water, the ability of subsurface materials to store and transmit water varies substantially. The term aquifer refers to subsurface deposits and geologic formations that are capable of yielding usable quantities of water to a well or spring, whereas a confining layer (or confining bed) refers to a low-permeability deposit or geologic formation that restricts the movement of groundwater. An aquifer can refer to a single geologic layer (or unit), a complete geologic formation, or groups of geologic formations.

—*Streamflow Depletion by Wells: Understanding and Managing the Effects of Groundwater Pumping on Streamflow* (Barlow & Leake 2012)