# SECTION 8: FLOODS

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## Why are Floods a Threat to the City of Glendale?

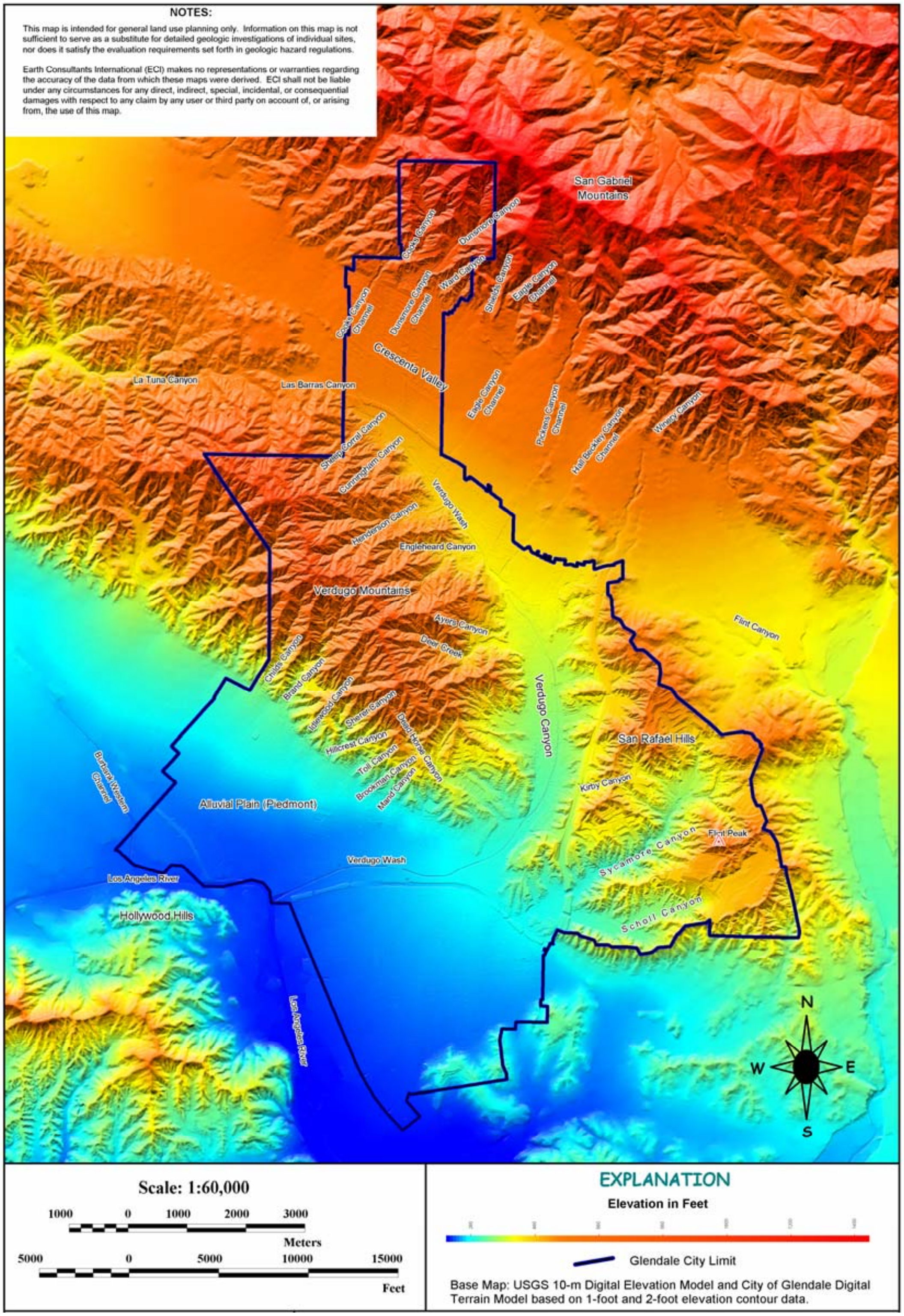
Floods are natural and recurring events that only become hazardous when man encroaches onto floodplains, modifying the landscape and building structures in the areas meant to convey excess water during floods. Unfortunately, floodplains have been alluring to populations for millennia since they provide level ground and fertile soils suitable for agriculture, access to water supplies, and transportation routes. These benefits come with a price – flooding is one of the most destructive natural hazards, responsible for more deaths per year than any other geologic hazard. Furthermore, average annual flood losses (in dollars) have increased steadily over the last decades as development in floodplains has increased. In short, flooding poses a threat to life and safety, and can cause severe damage to public and private property.

The city of Glendale and surrounding areas are, like most of southern California, subject to unpredictable seasonal rainfall. Most years, the scant winter rains are only enough to turn the hills green for a few weeks, but every few years the region is subjected to periods of intense and sustained precipitation that result in flooding. Flood events that occurred in 1969, 1978, 1980, 1983, 1992, 1995, and 1998 have caused an increased awareness of the potential for public and private losses as a result of this hazard, particularly in highly urbanized parts of floodplains and alluvial fans. As the population in Los Angeles County increases, there is an increased pressure to build on flood-prone areas, and in areas upstream of already developed areas. With increased development, there is also an-increase in impervious surfaces, such as asphalt. Water that used to be absorbed into the ground becomes runoff to downstream areas. If the storm drain systems are not designed or improved to convey these increased flows, areas that may have not flooded in the past may be subject to flooding in the future. This is especially true for developments at the base of the mountains and downstream from canyons that have the potential to convey mudflows.

Glendale is drained by the south-, southwest-, and west-flowing Verdugo Wash and its tributaries (see Map 8.1). The Verdugo Wash ultimately drains onto the larger Los Angeles River at the city's western boundary. Several streams are tributary to the Verdugo Wash. From north to south in Glendale, these include Cooks Canyon, Dunsmore Canyon, and Ward Canyon. Streams or channels that flow out of the San Gabriel Mountains, through the La Crescenta and La Cañada – Flintridge areas and into Verdugo Wash include Shields Canyon, Eagle Canyon, Pickens Canyon, Hall Beckley Canyon, and Winery Canyon. Several streams emanate from the north and east sides of the Verdugo Mountains and make their way into Verdugo Wash as well. These include, again from north to south, La Tuna, Las Barras, Sheep Corral, Cunningham, Henderson, Engleheard, Deer and Dead Horse Canyons.

In the western portion of the city, the Burbank Western Channel extends through a small portion of Glendale on the channel's final stretch before emptying into the Los Angeles River. Other canyons draining off the south flank of the Verdugo Mountains include, from west to east, Childs, Brand, Idlewood, Sherer, Hillcrest, Toll, Brookman and Mand Canyons. Several small and two large canyons drain the western and southwestern

**Map 8.1: Geomorphic Map of Glendale Showing the Canyons Referred to in the Text**




portions of the San Rafael Hills. Most of the small canyons in the northwestern portion of the San Rafael Hills are unnamed, except for Kirby Canyon. The two large ones are Sycamore Canyon and Scholl Canyon. There are also a few unnamed streams in the San Rafael Hills whose headwaters are in Glendale but drain to the east, toward Arroyo Seco. Several of the canyons in the San Gabriel and Verdugo Mountains have debris basins that were built for flood protection purposes. Most of the streams off the San Gabriel Mountains have been channelized through the La Cañada Valley for flood-protection purposes. Similarly, Verdugo Wash is channelized through Glendale.

## History of Flooding in the City of Glendale:

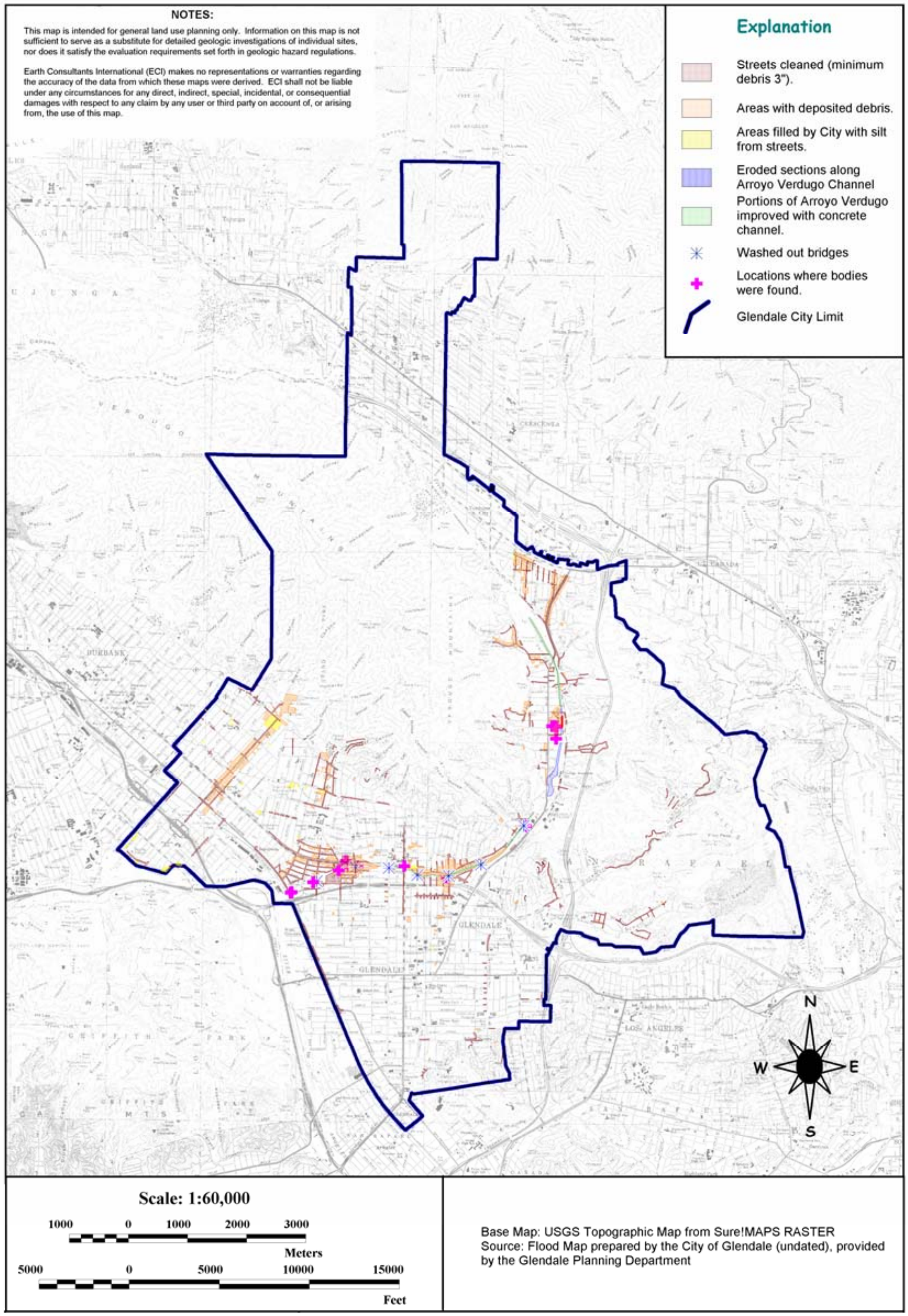
Floods of consequence to the city of Glendale are typically of the flash flood type, of short duration, but with high peak volumes and high velocities. This type of flooding occurs in response to the local geology and geography and the built environment (human-made structures). The mountains in and north of the city consist of rock that is predominantly impervious to water so little precipitation infiltrates the ground; rainwater instead flows along the surface as runoff. When a major storm moves in, water collects rapidly and runs off quickly, making a steep, rapid descent from the mountains onto the alluvial fans and ultimately into Verdugo Wash.

The most severe flood recorded in Glendale occurred in 1934. Intense precipitation on New Year's Eve, 1933 occurred locally in the La Cañada-Flintridge area, causing the Verdugo Wash to swell and overflow its then natural channel. Extensive areas of the drainage basin had burned earlier, in November 1933, causing large amounts of debris. The debris was carried by the storm waters down the mountains, and into the alluvial valleys, where several roads were choked. Damage was not confined to Verdugo Wash, but extended to several of the canyons draining the eastern and southern flanks of the Verdugo Mountains, and also in Sycamore and Scholl Canyons. More than 40 people died, several bridges were washed out, and erosion and sedimentation damaged more than 400 properties (see Map 8.2). Verdugo Wash and most of its tributaries through the La Crescenta area were channelized in response to the 1934 flood.

Several canyons near the Glendale area have also flooded in the past, impacting developments within the canyons or areas downstream. For example, during the storms of 1969, the Verdugo Hills and the city proper were impacted by debris flows and flood flows when tributary streams reportedly overtopped their debris basins, causing damage (Waananen, 1969).

Stream gage records show that maximum daily peak flows in the lower reaches of Verdugo Wash are typically less than about 400 cubic feet per second (cfs), with many years actually measuring peaks of considerably less than 100 cfs. However, maximum daily peak flows have occasionally exceeded 1,000 cfs (in 1937-38, 1942-43, 1965-66, 1968-69, 1977-78, 1982-83, 1994-95, 1995-96, and 1996-97). In the decades between 1930 and 1990, maximum daily peak flows exceeding 1,000 cfs generally occurred only once in a decade, but in the1990s there were three consecutive years when this channel had maximum daily peak flows exceeding 1,000 cfs (and in the 1997-98 water year, the maximum daily peak flow was 966 cfs, also high for the area). The records show that annual discharges in the last decades are overall higher than the measurements for the previous four decades. This may indicate that climate has been wetter in the last few decades (possibly as a result of global warming), or it could mean that with increased development in the Verdugo drainage area, the Verdugo Wash receives more runoff.

**Map 8.2: Effects of the 1934 Flood in Glendale**




The highest peak flow recorded in Verdugo Wash is for the water year of 1968-69, with a maximum daily peak flow of 1,850 cfs. However, there are two years for which there are no records, in 1933-34, and 1983-84. The lack of data for 1933-34 is probably the result of the gage being washed out during the worst flood recorded for Verdugo Wash, as discussed above.

Similarly, the winter storms in 1983-84 caused considerable damage in southern California, and may have also washed out the gage.

The City of Glendale most recently experienced some destruction during the 2005 floods. Residents and business owners who were impacted by flooding and the rain storms were able to receive disaster assistance through the Federal Emergency Management Agency and the City. On February 4, 2005, President Bush declared that a major disaster existed in California and ordered Federal aid to supplement State and local recovery efforts.

## Historic Flooding in Los Angeles County:

There are several rivers in the southern California region, but the river with the best-recorded history is the Los Angeles River. The flood history of the Los Angeles River is generally indicative of the flood history of much of southern California. Records show that since 1811, the Los Angeles River has flooded 30 times, roughly about once every 6 years. But averages are deceiving, for the Los Angeles basin goes through periods of drought and then periods of above-average rainfall. For example, between 1868 and 1884, a period of 16 years, there were no major floods, but this was followed by a series of wet years with floods in 1885, 1886, 1889 and 1891. A similar cluster of wet years was recorded in the 1990s, as discussed above.

**Table 8-1: Historical Floods in Los Angeles County**

| Year | Comments |
|---|---|
| 1770-1771 | Great flooding on the L.A. River recorded by Father Juan Crespi. River overflowed its channel. |
| 1771-1772 | Flooding recorded by Spanish Mission Fathers. San Gabriel Mission crops destroyed. |
| 1775-1776 | Due to heavy flooding, San Gabriel Mission was moved about 6 miles back from the river. |
| 1779-1780 | Flooding recorded by Spanish Mission Fathers. Flows filled riverbed and flooded the lowlands where wheat and barley had been planted. |
| 1811 | Flooding reported, although records are sparse. |
| 1815 | Flooding washes away the original Plaza in L.A. River changes course at Alameda and 4th Street to cut west and join Ballona Creek. From there it emptied into Santa Monica Bay. |
| 1822 | A great flood on the L.A. River "covered all the lowlands and reached a greater height than was ever known before." |
| 1824-25 | The greatest of the earlier recorded floods. L.A. River changed its course back from the Ballona wetlands to San Pedro. Before this storm, the river would spread over the entire area, filling depressions at the surface and forming lakes, ponds and marshes, rarely discharging its waters into the sea. The 1825 floods cut a riverway to the ocean, draining the marshlands and causing the forests to disappear. |
| 1832 | Heavy flooding caused the drainage near Compton to change so that many lakes and ponds that "had been permanent, became dry a few years thereafter." Drainage of these ponds and lakes completed the destruction of the forests that used to cover a large part of southern L.A. County. |
| 1849 – 1860 | Floods of various magnitudes occurred in 1849-1850, 1851-1852, and 1859-1860. |

| Year | Comments |
|---|---|
| 1861-62 | The "great flood" or the "Noachian deluge of California." Fifty inches of rain fell during December and January. The entire valley from Los Angeles to the ocean was a great lake. Part of the river split and drained into Ballona Creek. San Gabriel River also overflowed its banks and started a new channel. |
| 1867-68 | Floods spill over river channel and create a large, temporary lake out to Ballona Creek. San Gabriel River breaks out of its channel and washes thousands of acres of land. |
| 1884 | Two periods of intense rainstorms separated by 6 to 8 days. The first storms caused little damage. The second washed all but one of the bridges across the L.A. River, washed away many houses, and drowned several people. Parts of Los Angeles flooded 3 to 4 feet deep. |
| 1886-87 | A good part of Los Angeles was inundated. The levees were damaged and railway communication was impossible for 2 to 3 weeks. |
| 1889 | Flood on Christmas Day caused much damage; bridges and levees washed away; the old San Gabriel, new San Gabriel and L.A. Rivers joined near Downey and formed one body. L.A. River overtopped its channel. |
| 1914 | Heavy flooding in January and February. Great damage to L.A. harbor. |
| 1916-1938 | Flooding in 1916. Minor floods causing damage in certain areas reported in 1918, 1921-1922, 1926, 1927, 1931, 1932, 1934, 1936, and 1937. |
| 1934 | Moderate to severe flooding starting January 1. Over 40 dead in La Cañada – Glendale area. Debris flow killed 12 people who had taken shelter in the Montrose Legion Hall. |
| 1938 | Series of storms beginning December 1937. March floods exceeded all previous floods for which records were available. Large tracts inundated; bridges, highways and railroads severely damaged. 87 people killed, over $78 Million (1938 dollars) in damage. |
| 1941-1944 | Los Angeles River floods five times. |
| 1952 | Moderate flooding. |
| 1969 | Recurrent precipitation during January and February nearly approached the largest total since 1884. Nearly 40 people died as direct result of the floods in southern California, and more than 10,000 had to be evacuated. |
| 1978 | Two moderate floods. |
| 1979 | Los Angeles experiences severe flooding and mudslides. |
| 1980 | Flood tops banks of river in Long Beach. Sepulveda Basin spillway almost opened. |
| 1983 | Flooding kills six people. |
| 1992 | 15-year flood. Motorists trapped in Sepulveda basin. Six people dead. |
| 1994-1995 | Heavy flooding throughout the State. The total damages are estimated at $2 billion. |
| 1997-98 | The 1997 floods caused extensive damage in 48 California counties, including Los Angeles County. Total damages were estimated at $1.8 billion. The 1998 El Niño storms also caused damage, but this was less than it could have been because many had taken measures to reduce their risk following the 1997 storms. |
| 2003-2004 | The rains followed the extensive fires of 2003; in many areas, canyons chocked with ashes and debris caused debris flows that did substantial damage downstream. |
| 2004-05 | The second-wettest year on record in the Los Angeles Basin; the rains caused extensive damage in some areas, triggering landslides and debris flows. |

## What Factors Create Flood Risk?

### *Climate:*

Flooding occurs when climate, geology, and hydrology combine to create conditions where water flows outside of its usual course. In the city of Glendale, geography and climate may combine to create seasonal flooding conditions. The Santa Monica, Santa Susana, and Verdugo Mountains, which surround three sides of the San Fernando valley, seldom reach heights above three thousand feet. The western San Gabriel Mountains, in contrast, have elevations of more than seven thousand feet. These higher ridges often trap east-moving winter storms. Although downtown Los Angeles averages just fifteen inches of rain a year, some mountain peaks in the San Gabriel Mountains receive more than forty inches of precipitation annually.

Naturally, this rainfall moves rapidly down stream, often with severe consequences for anything in its path. Storm events are likely to generate debris flows in the upper reaches of the watershed. In extreme cases, flood-generated debris flows will roar down a canyon at speeds near 40 miles per hour with a wall of mud, debris and water tens of feet high. Debris flows, such as those that impacted Glendale in 1934, often occur in areas recently burned by wildfires, where vegetation has not yet formed a protective ground cover that helps keep the soil in place. Furthermore, the oils in the plants native to southern California, when burned, react with the soils, making them water repellant. As a result, less rainwater than usual infiltrates the ground, and instead makes its way downslope as runoff, carrying ashes and other burned debris with it.

Average yearly precipitation in the downtown Glendale area is about 17 to 18 inches, whereas the northern reaches of the city, near La Crescenta, receive 23 to 24 inches per year, on average. In general, areas closer to the San Gabriel Mountains receive higher precipitation rates than areas farther south from the mountains. This is because, as explained above, the mountains often capture precipitation from strong, east-moving Pacific storms. The mountains therefore separate the semi-arid environment to the west, within the Los Angeles basin, from the dry desert environment to the east, in the Mojave Desert.

"Averages" are not particularly representative of rainfall in the southern California area, as illustrated with the following discussion about downtown Los Angeles: the average annual rainfall in Los Angeles for the last 125 years is 14.9 inches, but rainfall during this time period has ranged from only 4.35 inches in 2001-2002 to 38.2 inches in 1883-1884. In fact, in only fifteen of the past 125 years has the annual rainfall been within plus or minus 10 percent of the 14.9-inch average, and in only 38 years has the annual rainfall been within plus or minus 20 percent of the average value. This makes the Los Angeles basin a land of extremes in terms of annual precipitation.

There are three types of storms that produce precipitation in southern California: winter storms, local thunderstorms, and summer tropical storms (or monsoons). These are described below.

- **Winter Rainfall:** Winter storms are characterized by heavy and sometimes prolonged precipitation over a large area. These storms usually occur between November and April and are responsible for most of the precipitation recorded in southern California. The storms originate over the Pacific Ocean and move eastward (and inland). The mountains, such as the San Gabriel and San Bernardino Mountains, form a rain shadow, slowing down or stopping the eastward movement of this moisture. A significant portion of the moisture is dropped on the mountains as snow. If large storms are coupled with snowmelt from these mountains, large peak discharges can be expected in the main watersheds at the base of the mountains. Some of the severe winter storm seasons that have historically impacted the southern California area have been related to

El Niño events.

El Niño is the name given to a phenomenon that starts every few years, typically in December or early January, in the southern Pacific off the western coast of South America, but whose impacts are felt worldwide. Briefly, warmer than usual waters in the southern Pacific are statistically linked with increased rainfall in both the southeastern and southwestern United States, droughts in Australia, western Africa and Indonesia, reduced number of hurricanes in the Atlantic Ocean, and increased number of hurricanes in the Eastern Pacific. Two of the largest and most intense El Niño events on record occurred during the 1982-83 and 1997-98 water years. [A water year is the 12-month period from October 1 through September 30 of the second year. Often a water year is identified only by the calendar year in which it ends, rather than by giving the two years, as above.] These are also two of the worst storm seasons reported in southern California.

- **Thunderstorms and Monsoons:** Another relatively regular source of heavy rainfall, particularly in the mountains and adjoining cities, is from summer tropical storms. Tropical rains or monsoons are infrequent, and typically occur in the summer or early fall. These storms originate in the warm, southern waters off Baja California, in the Pacific Ocean, and move northward into southern California. Tropical storms that have dropped significant rainfall in the southern California area in the last 100 years or so are listed in Table 8-2 below. Thunderstorms can occur at any time, but are usually more prevalent in the higher mountains during the summer. Thunderstorms usually impact relatively small areas.

**Table 8-2:**
**Tropical Storms That Affected Southern California During the 20th Century**

| Month- | Date(s) | Area(s) Affected | Rainfall |
|---|---|---|---|
| July 1902 | 20th & 21st | Deserts and southern mountains | up to |
| Aug. 1906 | 18th & 19th | Deserts and southern mountains | up to |
| Sept. 1910 | 15th | Mountains of Santa Barbara County | 2" |
| Aug. 1921 | 20th & 21st | Deserts and southern mountains | up to |
| Sept. 1921 | 30th | Deserts | up to |
| Sept. 1929 | 18th | Southern mountains and deserts | up to |
| Sept. 1932 | 28th - Oct | Mountains and deserts, 15 fatalities | up to 7 |
| Aug. 1935 | 25th | Southern valleys, mountains and deserts | up to |
| Sept. 1939 | 4th - 7th | Southern mountains, southern and eastern deserts | up to 7 |
| | 11th & 12th | Deserts, central and southern mountains | up to |
| | 19th - 21st | Deserts, central and southern mountains | up to |
| | 25th | Long Beach, with sustained winds of 50 MPH | 5" |
| | | Surrounding mountains | 6 to 12" |
| Sept. 1945 | 9th & 10th | Central and southern mountains | up to 2" |
| Sept. 1946 | 30th - Oct | Southern mountains | up to |
| Aug. 1951 | 27th - 29th | Southern mountains and deserts | 2 to 5" |
| Sept. 1952 | 19th - 21st | Central and southern mountains | up to |
| July 1954 | 17th - 19th | Deserts and southern mountains | up to |
| July 1958 | 28th & 29th | Deserts and southern mountains | up to |
| Sept. 1960 | 9th & 10th | Julian | 3.40" |
| Sept. 1963 | 17th - 19th | Central and southern mountains | up to |
| Sept. 1967 | 1st - 3rd | Southern mountains and deserts | 2" |
| Oct. 1972 | 6th | Southeast deserts | up to |
| Sept. 1976 | 10th & 11th | Central and southern mountains. Ocotillo was destroyed, 3 fatalities | 6 to 12" |
| Aug. 1977 | n/a | Los Angeles | 2" |
| | | Mountains | up to |
| Oct. 1977 | 6th & 7th | Southern mountains and deserts | up to 2 |
| Sept. 1978 | 5th & 6th | Mountains | 3" |
| Sept. 1982 | 24th - 26th | Mountains | up to |
| Sept. 1983 | 20th & 21st | Southern mountains and deserts | up to |
| http://www.fema.gov/nwz97/eln_scal.shtm | | | |

## *Geography and Geology:*

The local mountains are very steep and consist of rock types that are fairly impervious to water. Consequently, little precipitation infiltrates the ground; rainwater instead flows across the surface as runoff, collecting in the major drainages that pass through the city. When a major storm moves in, water collects rapidly and runs off quickly, making a steep, rapid descent from the mountains into man-made and natural channels within developed areas. Because of the steep terrain, scarcity of vegetation, and the constant shedding of debris from mountain slopes (primarily as dry ravel and rock falls), flood flows often carry large amounts of mud, sand, and rock fragments. Sheet flow occurs when the capacities of the existing channels (either natural or man-made) are exceeded and water flows over and into the adjacent areas.

The greater Los Angeles Basin has been shaped by erosion and sedimentation for millennia. Most of the mountains that ring the valleys and coastal plain have and are being uplifted along movement on faults; this movement has fractured the bedrock, allowing for their brittle slopes to be readily eroded. Rivers and streams have then carried boulders, rocks, gravel, sand, and silt down these slopes to the valleys and coastal plain. Over time, these sediments have collected in the valley bottoms, so that locally these sediments are as much as twenty thousand feet thick. This sediment generally acts as a sponge, absorbing vast quantities of water received as precipitation in those years when heavy rains follow a dry period. But like a sponge that is near saturation, the same soil fills up rapidly when a heavy rain follows a period of relatively wet weather. So, in some years of heavy rain, flooding is minimal because the ground is relatively dry. The same amount of rain following a wet period, when the ground is already saturated, can cause extensive flooding.

***Built Environment:***

The greater Los Angeles basin is essentially built out. This leaves precious little open land to absorb rainfall. This lack of open ground forces water to remain on the surface and accumulate rapidly. If it were not for the massive flood control system that has been built over the years, with its concrete lined rivers and stream beds, flooding in the Los Angeles basin would be a much more common occurrence. And the tendency is towards even less and less open land. In-fill building is becoming a much more common practice in many areas: Developers tear down older homes, which typically cover up to 40% of the lots that they sit on, and replace each of them with three or four town homes or apartments, which may cover 90-95% of the lot. This increase in impervious surfaces (including concrete walkways, and roofs) results in a direct increase in runoff.

Another potential reason for recurrent storm flooding in developed areas is “asphalt creep.” The street space between the curbs of a street is a part of the flood control system. Water leaves the adjacent properties and accumulates in the streets, where it is directed towards the underground portion of the flood control system. The carrying capacity of a given street is determined by the width of the street and the height of the curbs along the street. Often, when streets are being resurfaced, a one- to two-inch layer of asphalt is laid down over the existing asphalt. This added layer of asphalt subtracts from the rated capacity of the street to carry water. Thus the original engineered capacity of the entire storm drain system is marginally reduced over time. Subsequent re-paving of the street will further reduce its engineered capacity.

## How Are Flood-Prone Areas Identified:

The Federal Emergency Management Agency (FEMA) is mandated by the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 to evaluate flood hazards. To promote sound land use and floodplain development, FEMA provides Flood Insurance Rate Maps (FIRMs) for local and regional planners. Flood risk information presented on FIRMs is based on historic, meteorological, hydrologic, and hydraulic data, as well as topographic surveys, open-space conditions, flood control works, and existing development.

Rainfall-runoff and hydraulic models are utilized by the FIRM program to analyze flood potential, adequacy of flood protective measures, surface-water and groundwater interchange characteristics, and the variable efficiency of mobile (sand bed) flood channels. It is important to realize that FIRMs only identify potential flood areas based on the conditions at the time of the study, and do not consider the impacts of future development. To prepare FIRMs that illustrate the extent of flood hazards in a flood-prone community, FEMA conducts engineering studies referred to as Flood Insurance Studies (FISs). Using information gathered in these studies, FEMA engineers and cartographers delineate Special Flood Hazard Areas (SFHAs) on FIRMs. SFHAs are those areas subject to inundation by a "**base flood**" which FEMA sets as a 100-year flood (see definitions below).

The NFIP also reduces flood losses through regulations that focus on building codes and sound floodplain management. In the city of Glendale, the NFIP and related building code regulations went into effect on August 31, 1984 (City ID No. – 065030). NFIP regulations (44 Code of Federal Regulations (CFR) Chapter 1, Section 60, 3) require that all new construction in floodplains must be elevated at or above base flood level.

## Flood Terminology

### *Floodplain:*

A floodplain is a land area adjacent to a river, stream, lake, estuary, or other water body that is subject to flooding. This area, if left undisturbed, acts to store excess floodwater. The floodplain is made up of two sections: the floodway and the flood fringe.

### *100-Year Flood:*

The 100-year flooding event is the flood having a one percent chance of being equaled or exceeded in magnitude in any given year. Contrary to popular belief, it is not a flood occurring once every 100 years. The 100-year floodplain is the area adjoining a river, stream, or watercourse covered by water in the event of a 100-year flood. A **100-year flood** is defined by looking at the long-term average period between floods of a certain size, and identifying the size of flood that has a 1 percent chance of occurring during any given year. This base flood has a 26 percent chance of occurring during a 30-year period, the length of most home mortgages. However, a recurrence interval such as "100 years" represents only the long-term average period between floods of a specific magnitude; rare floods can in fact occur at much shorter intervals or even within the same year.

### *Floodway:*

The floodway is one of two main sections that make up the floodplain. Floodways are defined for regulatory purposes. Unlike floodplains, floodways do not reflect a recognizable geologic feature. For National Flood Insurance Program (NFIP) purposes, floodways are defined as the channel of a river or stream, and the overbank areas adjacent to the channel. The floodway carries the bulk of the floodwaters downstream and is usually the area where water velocities and forces are the greatest. NFIP regulations require that the floodway be kept open and free from development or other structures that would obstruct or divert flood flows onto other properties.

Glendale regulations prohibit all development in the floodway. The NFIP floodway definition is "the channel of a river or other watercourse and adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than one foot." Floodways are not mapped for all rivers and streams but are generally mapped in developed areas.

### *Flood Fringe:*

The flood fringe refers to the outer portions of the floodplain, beginning at the edge of the floodway and continuing outward. Generally, the flood fringe is defined as "the land area which is outside of the stream flood way but is subject to periodic inundation by regular flooding."

This is the area where development is most likely to occur, and where precautions to protect life and property need to be taken.

***Development:***
For floodplain ordinance purposes, development is broadly defined as "any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation, or drilling operations located within the area of special flood hazard." The definition of development for floodplain purposes is generally broader and includes more activities than the definition of development used in other sections of local land use ordinances.

***Base Flood Elevation (BFE):***
The term "Base Flood Elevation" refers to the elevation (normally measured in feet above sea level) that the base flood is expected to reach. Base flood elevations can be set at levels other than the 100-year flood. Some communities choose to use higher frequency flood events as their base flood elevation for certain activities, while using lower frequency events for others. For example, for the purpose of storm water management, a 25-year flood event might serve as the base flood elevation, whereas the 500-year flood event may serve as base flood elevation for the tie down of mobile homes. The regulations of the NFIP focus on development in the 100-year floodplain.

## Storm Flooding Characteristics

Three primary types of flooding have historically affected the southern California area, including the city of Glendale: riverine flooding, urban flooding, and debris flows (see descriptions below). (Areas near the coastline are also susceptible to coastal flooding, but given that the city of Glendale is located inland, this type of flooding will not be discussed herein).

- **Riverine Flooding:** Riverine flooding is the overbank flooding of rivers and streams. This process in a natural environment adds sediment and nutrients to the flooded area, cyclically enhancing the fertility of the soils, which is why floodplains have been the breadbaskets of civilizations through the ages. However, large floods have the potential to cause significant damage to man-made structures and causing significant loss of life. Flooding in large river systems typically results from large-scale weather systems that generate prolonged rainfall over a wide geographic area, causing flooding in hundreds of smaller streams, which then drain into the major rivers.

  Shallow area flooding is a special type of riverine flooding. FEMA defines shallow flood hazards as areas that are inundated by the 100-year flood with flood depths of only one to three feet. These areas are generally flooded by low velocity sheet flows of water.

- **Urban Flooding:** As land is converted from agricultural fields or woodlands to roads and parking lots, it loses its ability to absorb rainfall. Urbanization of a watershed changes the hydrologic systems of the basin. Heavy rainfall collects and flows faster on impervious concrete and asphalt surfaces. The water moves from the clouds, to the ground, and into streams at a much faster rate in urban areas. Adding these elements to the hydrological systems can result in floodwaters that rise very rapidly and peak with violent force. The flooding of developed areas often occurs when the amount of water generated from rainfall and runoff exceeds the storm water system's capability to remove it.

  Over 50 percent of the Glendale area has a high concentration of impervious surfaces that either collect water, or concentrate the flow of water in channelized or man-improved channels. During periods of urban flooding, streets can become swift moving rivers and basements can fill with water. Storm drains may also back up with vegetation and debris causing additional, localized flooding.

- **Debris Flows:** Another flood related hazard that can affect certain parts of the southern California region is debris flows. Debris flows most often occur in mountain canyons and at the foothills of the large mountains that serve as backdrop to the area. However, any hilly or mountainous area with intense rainfall and the proper geologic conditions may experience one of these very sudden and devastating events.

  Debris flows, sometimes referred to as mudslides, mudflows, or debris avalanches, are common types of fast-moving landslides that generally occur during periods of intense rainfall or rapid snow melt. They usually start on steep hillsides as shallow landslides that liquefy and accelerate to speeds that are typically about 10 miles per hour, but can exceed 35 miles per hour. The consistency of debris flows ranges from watery mud to thick, rocky mud that can carry large items such as boulders, trees, and cars. Debris flows from many different sources can combine in channels, and their destructive power may be greatly increased. They continue flowing down hills and through channels, growing in volume with the addition of water, sand, mud, boulders, trees, and other materials. When the flows reach flatter ground, the debris spreads over a broad area, sometimes accumulating in thick deposits that can wreak havoc in developed areas.

## Dam Failure Flooding

Seismically induced inundation refers to flooding that results when water retention structures (such as dams) fail due to an earthquake. Failure of these structures can also result from other causes, such as overtopping, foundation problems, or construction errors. Statutes governing dam safety are defined in Division 3 of the California State Water Code (California Department of Water Resources, 1986). These statutes empower the California Division of Dam Safety to monitor the structural safety of dams that are greater than 25 feet in dam height or have more than 50 acre-feet in storage capacity.
Dams under State jurisdiction are required to have inundation maps that show the potential flood limits in the remote, yet disastrous possibility, that a dam is catastrophically breached. Inundation maps are prepared by dam owners to help with contingency planning; these inundation maps in no way reflect the structural integrity or safety of the dam in question. Because dam failure can have severe consequences, FEMA requires that all dam owners develop Emergency Action Plans (EAP) for warning, evacuation, and post-flood actions. Although there may be coordination with county officials in the development of the EAP, the responsibility for developing potential flood inundation maps and facilitation of emergency response is the responsibility of the dam owner. Dam owners are also required to prepare and submit emergency response plans to the State Office of Emergency Services, the lead State agency for the State dam inundation-mapping program. Cities and counties are required by State law to have in place emergency procedures for the evacuation and control of populated areas within the limits of dam inundation. In addition, recent legislation requires real estate disclosure upon sale or transfer of properties in the inundation area (AB 1195 Chapter 65, June 9, 1998; Natural Hazard Disclosure Statement).

There have been a total of 45 dam failures in California since the 19th century. The most significant dam failures in southern California are listed in Table 8-3, and the two most significant dam failures, St. Francis Dam in 1928 and the Baldwin Hills Dam in 1963, are described further below.

**Table 8-3: Dam Failures in Southern California**

| Dam Name | Location | Year | Failure Mechanism |
|---|---|---|---|
| Sheffield | Santa Barbara | 1925 | Earthquake slide |
| Puddingstone | Pomona | 1926 | Overtopping during construction |
| Lake Hemet | Palm Springs | 1927 | Overtopping |
| Saint Francis | San Francisquito Canyon | 1928 | Sudden failure at full capacity through foundation, 426 deaths. |
| Cogswell | Monrovia | 1934 | Breaching of concrete cover |
| Baldwin Hills | Los Angeles | 1963 | Leak through embankment turned into washout, 3 deaths. |

St. Francis Dam, built in 1926 in the San Francisquito Canyon near Saugus, was 180 feet high and 600 feet long. Its failure, and the resulting loss of over 400 lives in the path of a roaring wall of water, was a scandal that resulted in the almost complete destruction of the reputation of its builder, William Mulholland. Mulholland was an immigrant from Ireland who rose up through the ranks of the Los Angeles City water department to the position of chief engineer. It was he who proposed, designed, and supervised the construction of the Los Angeles Aqueduct, which brought water from the Owens Valley to the city.

St. Francis dam gave way on March 12, 1928, three minutes before midnight. Its waters swept through the Santa Clara Valley toward the Pacific Ocean, about 54 miles away. Sixty-five miles of valley were devastated before the water finally made its way into the ocean between Oxnard and Ventura. At its peak, the wall of water was said to be 78 feet high; by the time it hit Santa Paula, 42 miles south of the dam, the water was estimated to be 25 feet deep. Almost everything in its path was destroyed: livestock, structures, railways, bridges, and orchards. By the time it was over, parts of Ventura County lay under 70 feet of mud and debris. Over 400 people were killed and damage estimates topped $20 million.

The Baldwin Hills dam, an earthen dam that created a 19-acre reservoir to supply drinking water to West Los Angeles residents, failed on December 14, 1963 at 3:38 in the afternoon. This is one of the first disaster events documented in a live helicopter broadcast - the live telecast of the collapse from a KTLA-TV helicopter is considered the precursor to airborne news coverage that is now routine everywhere. As a pencil-thin crack widened to a 75-foot gash, 292 million gallons surged out. "The Baldwin Hills Dam collapsed with the fury of a thousand cloudbursts, sending a 50-foot wall of water down Cloverdale Avenue and slamming into homes and cars . . . Five people were killed. Sixty-five hillside houses were ripped apart, and 210 homes and apartments were damaged." The flood swept northward in a V-shaped path roughly bounded by La Brea Avenue and Jefferson and La Cienega boulevards.

It took 77 minutes for the impounded reservoir to empty, but it took a generation for the neighborhood below to recover, illustrating the severe, long-term impact of these disasters. Furthermore, failure of this tank foreshadowed the end of urban-area earthen dams as a major element of the Department of Water and Power's water storage system. It also prompted a tightening of Division of Safety of Dams control over reservoirs throughout the State.

***Flooding due to Failure of Above-Ground Water Storage Tanks:***

Seismically induced inundation can also occur if strong ground shaking causes structural damage to above-ground water tanks. If a tank is not adequately braced and baffled, sloshing water can lift a water tank off its foundation, splitting the shell, damaging the roof, and bulging the bottom of the tank (elephants foot) (EERI, 1992). Movement can also shear off the pipes leading to the tank, releasing water through the broken pipes. These types of damage occurred during southern California's 1992 Landers, 1992 Big Bear, and 1994 Northridge earthquakes. The Northridge earthquake alone rendered about 40 steel tanks non-functional (EERI, 1995), including a tank in the Santa Clarita area that failed and inundated several houses below. As a

Baldwin Hills Dam - Dark spot in upper right hand quadrant
shows the beginning of the break in the dam.

result of lessons learned from recent earthquakes, new standards for design of steel water tanks were adopted in 1994 (Lund, 1994). The new tank design includes flexible joints at the inlet/outlet connections to accommodate movement in any direction. All of Glendale's water steel tanks have been retroffited with flexible expansion joints to allow for movement during earthquakes.

Water lost from tanks during an earthquake can significantly reduce the water resources available to suppress earthquake-induced fires. Damaged tanks and water mains can also limit the amount of water available to residents. Furthermore, groundwater wells can be damaged during an earthquake, also limiting the water available to the community after an earthquake. Therefore, it is of paramount importance that the water storage tanks in the area retain their structural integrity during an earthquake, so water demands after an earthquake can be met. In addition to evaluating and retrofitting to meet current standards, this also requires that the tanks be kept at near full capacity as much as practical.

## The Effect of Development on Floods:

When structures or fill are placed in the floodway or floodplain, water is displaced. Development raises the river levels by forcing the river to compensate for the flow space obstructed by the inserted structures and/or fill. When structures or materials are added to the floodway or floodplain and no fill is removed to compensate, serious problems can arise. Flood waters may be forced away from historic floodplain areas. As a result, other existing floodplain areas may experience flood waters that rise above historic levels. *Local governments must require engineer certification to ensure that proposed developments will not adversely affect the flood carrying capacity of the Special Flood Hazard Area (SFHA).* Displacement of only a few inches of water can mean the difference between no structural damage occurring in a given flood event, and the inundation of many homes, businesses, and other facilities. Careful attention should be given to development that occurs within the floodway to ensure that structures are prepared to withstand base flood events.

In highly urbanized areas, increased paving can lead to an increase in volume and velocity of runoff after a rainfall event, exacerbating the potential flood hazards. Care should be taken in the development and implementation of storm water management systems to ensure that these runoff waters are dealt with effectively.

### ***How Building Codes Address Building In Known Flood Prone Areas:***

Flood Insurance Rate Maps (FIRM) and Flood Insurance Studies (FIS) Floodplain maps are the basis for implementing floodplain regulations and for delineating flood insurance purchase requirements. A Flood Insurance Rate Map (FIRM) is the official map produced by FEMA which delineates SFHA in communities where NFIP regulations apply. FIRMs are also used by insurance agents and mortgage lenders to determine if flood insurance is required and what insurance rates should apply.

Water surface elevations are combined with topographic data to develop FIRMs. FIRMs illustrate areas that would be inundated during a 100-year flood, floodway areas, and elevations marking the 100-year-flood level. In some cases they also include base flood elevations (BFEs) and areas located within the 500-year floodplain. Flood Insurance Studies and FIRMs produced for the NFIP provide assessments of the probability of flooding at a given location. FEMA conducted many Flood Insurance Studies in the late 1970s and early 1980s. These studies and maps represent flood risk at the point in time when FEMA completed the studies. However, it is important to note that not all 100-year or 500-year floodplains have been mapped by FEMA.

FEMA flood maps are not entirely accurate. These studies and maps represent flood risk at the point in time when FEMA completed the studies, and does not incorporate planning for floodplain changes in the future due to new development. Although FEMA is considering changing that policy, it is optional for local communities. There is no FIRM map for the City of Glendale.

### ***Flood Mapping Methods and Techniques:***

Although many communities rely exclusively on FIRMs to characterize the risk of flooding in their area, there are some flood-prone areas that are not mapped but remain susceptible to flooding. These areas include locations next to small creeks, local drainage areas, and areas susceptible to man-made flooding.

In order to address this lack of data, jurisdictions can take efforts to develop more localized flood hazard maps. One method that has been employed includes using high-water marks from flood events or aerial photos, in conjunction with the FEMA maps, to better reflect the true flood risk. The use of GIS (Geographic Information System) is becoming an important tool for flood hazard mapping. FIRM maps can be imported directly into GIS, which allows for GIS analysis of flood hazard areas.

Communities find it particularly useful to overlay flood hazard areas on tax assessment parcel maps. This allows a community to evaluate the flood hazard risk for a specific parcel during review of a development request. Coordination between FEMA and local planning jurisdictions is the key to making a strong connection with GIS technology for the purpose of flood hazard mapping.

FEMA and the Environmental Systems Research Institute (ESRI), a private company, have formed a partnership to provide multi-hazard maps and information to the public via the Internet. ESRI produces GIS software, including ArcViewC9 and ArcInfoC9 . The ESRI web site has information on GIS technology and downloadable maps. The hazards maps provided on the ESRI site are intended to assist communities in evaluating geographic information about natural hazards. Flood information for most communities is available on the ESRI web site. Visit www.esri.com for more information.

# Hazard Assessment

## Hazard Identification:

Hazard identification is the first phase of flood-hazard assessment. Identification is the process of estimating: 1) the geographic extent of the floodplain (i.e., the area at risk from flooding); 2) the intensity of the flooding that can be expected in specific areas of the floodplain; and 3) the probability of occurrence of flood events. This process usually results in the creation of a floodplain map. Floodplain maps provide detailed information that can assist jurisdictions in making policies and land-use decisions.

### *Flood Hazard Mapping for the City of Glendale:*

On May 7, 1976 the Federal Insurance Administration (FIA) issued a Flood Hazard Boundary map for the City of Glendale. However, a study of Verdugo Wash conducted in 1978 for the Los Angeles County Department of Public Works (LACDPW) showed that the channel could accommodate the estimated peak flows everywhere, except in the area immediately north of where Verdugo Wash joins the Los Angeles River. In fact, this area is known to flood regularly during winter storms (refer to following sections for further information on this). Based on the information provided by the LACDPW, stating "that for all practical purposes no part of the community would be inundated by the base flood; that is, a flood having a one percent chance of being equaled or exceeded in any given year," and therefore, that the entire community would be classified as Zone C (area of minimal flood hazards where the purchase of flood insurance is not mandatory), the Flood Hazard Boundary Map was rescinded by FIA on November 15, 1979.

On a letter dated August 31, 1984, FEMA again informed the City that no Special Flood Hazard Areas were present within the corporate limits of the city at that time, and thus that the City was placed in Zone D, which has no mandatory flood insurance purchase requirements. As a result, there are no flood insurance rate maps for the city of Glendale, and Glendale is not listed in FEMA's Community Rating System. [The Community Rating System (CRS) is a system for crediting communities that implement measures to protect the natural and beneficial functions of their floodplains, as well as managing their erosion hazard.] Although, there are no FIRM maps for the city, and Glendale is not currently listed in FEMA's CRS of cities, the City of Glendale has participated as a regular member in the NFIP since August 31, 1984 (City ID No. – 065030). Since the City is a participating member of the NFIP, flood insurance is available for individuals to purchase voluntarily. There is, however, a 30-day wait period after the policy is issued before the coverage becomes effective.

Since these analyses were conducted, however, there has been substantial development in the hills of Glendale, increasing runoff into the city's storm drains and flood-conveyance system. The studies also did not consider the impacts that debris flows could have on the city. During the past 80 years, the Los Angeles County Department of Public Works (LACDPW) and the US Army Corps of Engineers have constructed several detention or debris basins in the San

Gabriel Mountains, in or above Glendale, including debris basins in Cooks, Dunsmore, Shields, Eagle, Pickens and Hall Beckley Canyons. At least three other debris basins have been built in the Verdugo Mountains, above the populated areas of the city. The LACDPW also has made channel alterations consisting primarily of concrete side-slopes and linings for most of the major channels in the area. These flood control structures are presently owned and operated by the LACDPW, which has jurisdiction over the watercourses in the Glendale area, as well as the regional flood control system in the Los Angeles County. All of these structures help regulate flow in the Verdugo Channel, holding back some of the flow during intense rainfall periods that could otherwise overwhelm the storm drain system in the area.

These storm drain facilities generally provide the city with adequate protection from a major storm except some isolated minor localized inundation. This type of localized inundation may mean that on major storms, a portion of the street may be flooded but the water level will be contained within the curbs. No flooding of private properties occurs unless there is a backup of local storm drains.

**Localized Flooding:** One area in the city that may sporadically flood is at the terminus of Woodland Avenue. This street was cut with the construction of the Verdugo Wash, and is now a dead-end residential street that is serving only 12 residential homes. A lateral of the Verdugo Wash Channel was also constructed which terminated at the terminus of Woodland Avenue. Because of grade, three (3) 36-inch flap gates were installed at the end of that lateral. Under severe storm conditions, the flap gates close and runoff from the street is retained within the street temporarily until the flow can be taken into the channel.

***Inundation due to Catastrophic Failure of Water Storage Structures:*** Loss of life and damage to structures, roads, and utilities may result from a dam failure. Economic losses can also result from a lowered tax base and lack of utility profits. These effects would certainly accompany the failure of one of the major dams in the city of Glendale.

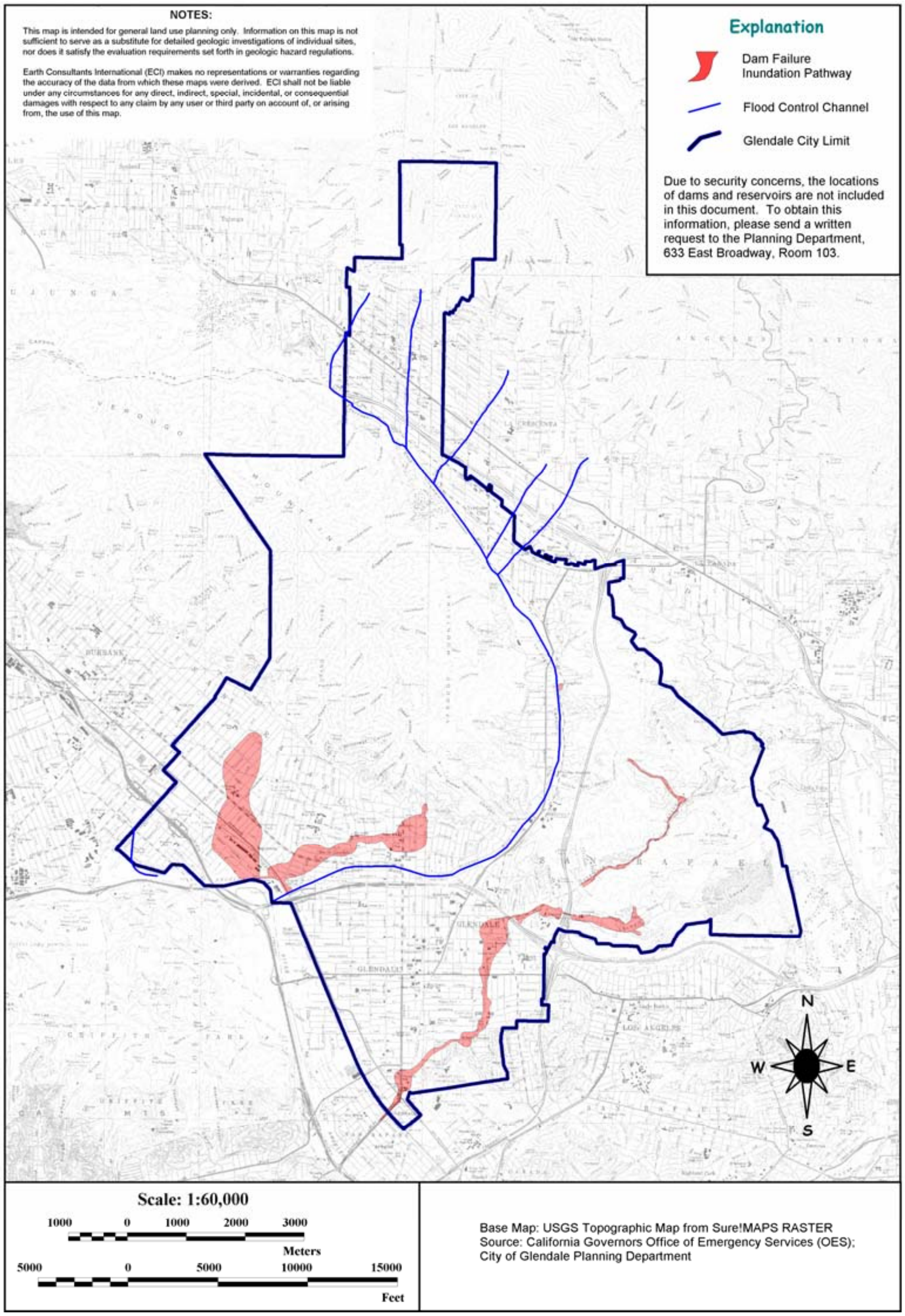
There are seven dams in the Glendale area that fall under State jurisdiction. These dams are owned by the city of Glendale and retain small reservoirs in the Verdugo Mountains and San Rafael Hills. From west to east, they include the 10th and Western, Brand Park, and Diederich dams in the Verdugo Mountains, and the Glorietta East, Chevy Chase 1290, Glenoaks 968 and Chevy Chase 968 dams in the San Rafael Hills. Areas in Glendale within the dam inundation areas identified by the State are shown on Map 8-3 (and Plate H-10). All of these seven concrete reservoirs have inundations maps approved by the State Office of Emergency Services. These maps are included in the Dam Evaluation Plan for the City of Glendale. Two of the reservoirs, Brand Park and Chevy Chase 968, reportedly would empty in uninhabited areas or directly into a flood control channel. As a result, failure of these two dams would not create a need for evacuation of areas downgradient from the dams (Glendale Water and Power written communication, 2006).

There are several other, smaller debris basins in the Glendale area that are not subject to State regulations because they are too small. These debris basins, and other flood control improvements, such as canals, culverts, and levees, may crack and suffer structural damage during an earthquake, especially in areas prone to ground failure, such as that due to liquefaction or slope instability. These facilities could pose an inundation hazard to areas downstream if they contain water at the time of the seismic event, or if they are not repaired prior to the next winter storm season.

There are thirteen steel water storage tanks in the city of Glendale. Tanks located near the fault hazard management zones (identified in Section 6 of this report, see Plate H-4) are especially vulnerable to rupture due to ground deformation, strong ground shaking and even surface fault rupture. While most water tanks in the Glendale area are not located near fault management zones, three tanks near the base of the San Gabriel Mountains are located within the State mandated Alquist-Priolo Earthquake Fault Zone for the Sierra Madre fault. Because these water tanks have a heightened risk of rupturing catastrophically during an earthquake on the Sierra Madre fault, their inundation paths should be identified to evaluate whether or not habitable structures are located within the floodway. The evaluation should also address whether these water reservoirs are self-contained. In the event of a catastrophic breakage, will the water be contained within the site, or will it be discharged to a storm drain or channel or will it pose a hazard to properties downstream?

Because the entire city of Glendale is susceptible to strong seismic ground motion, all water tanks should incorporate new earthquake resistant designs, including flexible pipe joints. According to Glendale Water and Power, all steel water tanks in Glendale have been fitted with flexible joints that can accommodate some movement during seismic events, reducing the potential for breakage of the pipes, leading to accidental releases of water.

**Map 8.3: Dam Inundation Areas in the City of Glendale**




## Vulnerability Assessment:

Vulnerability assessment is the second step of flood-hazard assessment. It combines the floodprone areas identified previously with an inventory of the property within those areas. Understanding the population and property exposed to this hazard can assist in reducing risk and preventing loss from future events. Because site-specific inventory data and inundation levels are not available for Glendale (according to FEMA there are no flood-prone areas in the city), calculating the community's vulnerability to flood events is difficult. Typically, vulnerability assessments of flooding hazards involve assessing the amount of property in the floodplain, as well as the type and value of structures on those properties. Once that is done, then a working estimate for potential flood losses can be calculated. The HAZUS software has a component to estimate losses due to flooding. Input to the program can include FEMA flood inundation zones, or site-specific engineering studies of flood potential prepared by others rather than FEMA. Since there are no FEMA maps available for Glendale, nor are there more recent and city-specific studies that identify potential flooding areas, this loss estimation analysis was not conducted for this report. Should data be developed in the future to more fully map this hazard, loss estimation analyses based on that mapping can then be conducted.

# Community Flood Issues:

## What is Susceptible to Damage During a Flood Event?

The largest impact on communities from flood events is the loss of life and property. During certain years, property losses resulting from flood damage are extensive. Property loss from floods strikes both private and public property. Although there has been no significant flooding in Glendale since at least 1969, as described above, localized flooding does occur sporadically. Furthermore, storm damage in the form of drips into structures, amounting to considerable amount of money in the form of repairs, have been reported as recently as with the storms of 2005.

***Property Loss Resulting from Flooding Events:*** The type of property damage caused by flood events depends on the depth and velocity of the floodwaters. Faster moving floodwaters can wash buildings off their foundations and sweep cars downstream. Pipelines, bridges, and other infrastructure can be damaged when high waters combine with flood debris. Extensive damage can be caused by basement flooding and landslide damage related to soil saturation from flood events. Most flood damage is caused by water saturating materials susceptible to loss (i.e., wood, insulation, wallboard, fabric, furnishings, floor coverings, and appliances). In many cases, flood damage to homes renders them unlivable.

## Risk Analysis:

Risk analysis is the third and most advanced phase of a hazard assessment. It builds upon the hazard identification and vulnerability assessment. A flood risk analysis for the city of Glendale should include two components: 1) the life and value of property that may incur losses from a flood event (defined through the vulnerability assessment); and 2) the number and type of flood events expected to occur over time. Within the broad components of a risk analysis, it is possible to predict the severity of damage from a range of events. Flow velocity models can assist in predicting the amount of damage expected from different magnitudes of flood events.

The data used to develop these models is based on hydrological analysis of landscape features. Changes in the landscape, often associated with human development, can alter the flow velocity and the severity of damage that can be expected from a flood event. Using GIS technology and flow velocity models, it is possible to map the damage that can be expected from flood events over time. It is also possible to pinpoint the effects of certain flood events on individual properties. At the time of publication of this Plan, data was insufficient to conduct a risk analysis for flood events in the city of Glendale.

However, the current mapping projects will result in better data that will assist in understanding risk. This Plan includes recommendations for building partnerships that will support the development of a flood risk analysis in the City of Glendale

***Manufactured Homes:***

Statewide, the 1996 floods destroyed 156 housing units. Of those units, 61 percent were mobile homes and trailers. Many older manufactured home parks are located in floodplain or low-lying areas. Manufactured homes have a lower level of structural stability than stick-built homes, and must be anchored to provide additional structural stability during flood events (and for earthquake preparedness, also). Because of confusion in the late 1980s resulting from multiple changes in NFIP regulations, there are some communities that do not actively enforce anchoring requirements.

***Business/Industry:***
Storm-flooding events impact businesses by damaging property and by interrupting business. Flood events can cut off customer access to a business as well as close a business for repairs. Roof leaks can impact the contents; in extreme cases, leaks can cause damage to sensitive electrical equipment, with the potential to cause the affected business thousands of dollars in material losses and potential loss of revenue. A quick response to the needs of businesses affected by flood events can help a community maintain economic vitality in the face of flood damage. Responses to business damages can include funding to assist owners in elevating or relocating flood-prone business structures, and loans to make building improvements, such as new roofs.

***Public Infrastructure:***
Publicly owned facilities are a key component of daily life for all citizens of Los Angeles County, including Glendale residents. Damage to public water and sewer systems, transportation networks, flood control facilities, emergency facilities, and offices can hinder the ability of the government to deliver services. Government can take action to reduce risk to public infrastructure from flood events, as well as craft public policy that reduces risk to private property from flood events.

***Roads:***
During natural hazard events, or any type of emergency or disaster, dependable road connections are critical for providing emergency services. Roads systems in the city of Glendale are maintained by multiple jurisdictions. Federal, State, county, and city governments all have a stake in protecting roads from flood damage. Road networks often traverse floodplains and floodway areas. Transportation agencies responsible for road maintenance are typically aware of roads at risk from flooding.

***Bridges:***
Bridges are key points of concern during flood events because they are important links in road networks, river crossings, and they can be obstructions in watercourses, inhibiting the flow of water during flood events. Scour at highway bridges involves sediment-transport and erosion processes that cause streambed material to be removed from the bridge vicinity. Nationwide, several catastrophic collapses of highway and railroad bridges have occurred due to scouring and a subsequent loss of support of foundations. This has led to a nationwide inventory and evaluation of bridges (Richardson and others, 1993).

Scour processes are generally classified into separate components, including pier scour, abutment scour, and contraction scour. ***Pier scour*** occurs when flow impinges against the upstream side of the pier, forcing the flow in a downward direction and causing scour of the streambed adjacent to the pier. ***Abutment scour*** happens when flow impinges against the abutment, causing the flow to change direction and mix with adjacent main-channel flow, resulting in scouring forces near the abutment toe. ***Contraction scour*** occurs when flood-plain flow is forced back through a narrower opening at the bridge, where an increase in velocity can produce scour. ***Total scour*** for a particular site is the combined effects from all three components. Scour can occur within the main channel, on the flood plain, or both. While different materials scour at different rates, the ultimate scour attained for different materials is similar and depends mainly on the duration of peak stream flow acting on the material (Lagasse and others, 1991).

The State of California participates in the bridge scour inventory and evaluation program and a state-designated inspector must inspect all state, county, and city bridges every two years. The inspections are rigorous, looking at everything from seismic capability to erosion and scour. The bridges in the city of Glendale are State, county, city, or privately owned. To date, we have not found any records to indicate that the bridges in the Glendale area have been evaluated. Nevertheless, since the Verdugo Wash is channelized in the city, the potential for bridge scour to occur along the Verdugo Wash is considered low to nil. The most significant, although unlikely concern regarding bridge scour is if unusually high surface water flows in the Sycamore and Scholl Canyons were to reach the Glendale (2) Freeway, impacting the bridges at Chase Drive and Glenoaks Boulevard. Privately owned bridges are not inspected, so those bridges extending across unlined creeks could be at risk of failure due to scour.

***Storm Water Systems:***

As indicated above, drainage problems are known to occur sporadically in some specific areas of Glendale. However, the City does not consider these drainage issues more than a nuisance, and has pumping equipment to deal with flooding in these low spots when necessary.

Inadequate maintenance can also contribute to the flood hazard in urban areas. As long as the City conducts a regular inspection of culverts and storm drains to remove debris that may obstruct the flow of water during storms, most areas should not be impacted by flooding.

***Water/Wastewater Treatment Facilities:***

The city of Glendale is a part of the Sanitation Districts of Los Angeles County. The Sanitation Districts are a confederation of independent special districts serving about 5 million people in Los Angeles County. There are no wastewater treatment facilities in Glendale.

***Water Quality:***

Environmental quality problems include bacteria, toxins, and pollution. "Out of sight, out of mind" has traditionally been a common approach to dealing with trash, sediment, used motor oil, unused paint and thinner, and other hazardous substances that people dump into the sewer or storm drains. What we often forget is that these substances eventually make their way into the rivers and oceans, where they can sicken surfers and swimmers, and endanger wildlife. The Clean Water Act of 1972 originally established the National Pollutant Discharge Elimination System (NPDES) to control wastewater discharges from various industries and wastewater treatment plants, known as "point sources." Point sources are defined by the EPA as discrete conveyances such as pipes or direct discharges from businesses or public agencies. Then, in 1987, the Water Quality Act amended the NPDES permit system to include "nonpoint source" pollution (NPS pollution). NPS pollution refers to the introduction of bacteria, sediment, oil and grease, heavy metals, pesticides, fertilizers and other chemicals into our rivers, bays and oceans from less defined sources. These pollutants are washed away from roadways, parking lots, yards, and other areas by rain and dry-weather urban runoff, entering the storm drains, and ultimately the area's streams, bays and ocean. NPS pollution is now thought to account for most water quality problems in the United States. Therefore, strict enforcement of this program at the local level, with everybody doing his or her part to reduce NPS pollution, can make a significant difference.

The National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point and nonpoint sources that discharge pollutants into waters of the United States. The City of Glendale is a member of the Los Angeles County Stormwater Program. This program regulates and controls storm water and urban runoff into the Los Angeles River, San Gabriel River, Santa Clara River, tributaries to these rivers, and ultimately, the Pacific Ocean. The Los Angeles County Stormwater Program is the local enforcer of the NPDES program. In the Glendale Area, NPDES permits are filed with the California Regional Water Quality Control Board, Los Angeles Region. This permit was required by all counties with a storm drain system that serves a population of 100,000 or more. On October 29, 1999, Phase II of NPDES was signed into law. Under this phase of NPDES, areas with 50,000 or more residents, and construction sites one acre or more in size, must file for and obtain an NPDES permit. Under NPDES, the local regulator is responsible for the following control measures:

- Public education and outreach on storm water impacts,
- Public involvement/participation,
- Illicit discharge detection and elimination,
- Construction of site storm water runoff control,
- Post-construction storm water management in new development and redevelopment, and
- Pollution prevention/good housekeeping for municipal operations.

The NPDES permit area that includes Glendale is 3,100 square miles in area, with a population of 11.4 million. In conformance with the Federal requirements listed above, one of the major tasks of the Los Angeles County Stormwater Program is to educate the local population about keeping the water that flows into our rivers and ocean clean by eliminating discharges of hazardous materials into storm drains and other point sources. Signs are typically painted by storm drains that drain to the local rivers and ultimately into the Pacific Ocean to encourage people from not disposing motor oil or other potentially hazardous substances into the drains.

### ***Existing Flood Mitigation Activities:***
Flood mitigation activities listed here include current mitigation programs and activities that are being implemented by the City of Glendale agencies or organizations.

The City of Glendale uses building codes, zoning codes, and various planning strategies to address the goals which aim at restricting development in areas of known hazards, and applying the appropriate safeguards.

### ***Acquisition and Protection of Open Space in the Floodplain:***
Current efforts to increase public open space in the southern California area been paired with the need to restore and preserve natural systems that provide wildlife habitat and help to mitigate flood events. Public parks and publicly owned open spaces can provide a buffer between flood hazards and private property.

### ***Water Districts:***
Many water districts in the region are in the process of replacing old cast iron pipes with more ductile iron pipes, which will be more resilient in disaster situations. Water districts in the region are committed to working together during a disaster to provide water to the area's residents as soon as possible in the event that the water distribution system fails locally. For example, Glendale's Department of Water and Power has built inter-ties with the Metropolitan Water District for emergency situations.

### ***Stormwater Systems:***
There are several surface water management providers in the county that manage water quality and storm water runoff from new development. The primary one, and the one that provides flood control services for the city of Glendale is the Los Angeles County Department of Public Works.

***Flood Management Projects:***
Flood management structures can assist in regulating flood levels by adjusting water flows upstream of flood-prone areas. The main flood control systems in the Glendale area include the Verdugo Wash Flood Control Channel and Sycamore Canyon Channel. In addition, there are several detention or debris basins in the San Gabriel Mountains, in or above Glendale that provide flood protection.

***Verdugo Wash Flood Control Channel:*** The city of Glendale is primarily served by the Verdugo Wash Flood Control Channel. This Channel was designed for a 100-year capital storm to carry the storm water run-off from the hillsides at the northern portion of the city (in the La Crescenta area), and outlets into the Los Angeles River. Other tributaries of the Verdugo Wash include: Halls Canyon Channel, Pickens Canyon Channel, Eagle Shields Canyon Channel, Cooks Canyon Channel and the Dunsmuir Canyon Channel. A debris basin was also constructed across the Verdugo Wash Channel downstream from all the tributary channels to filter debris that could potentially clog the channel and reduce its capacity.

***Sycamore Canyon Channel:*** The eastern portion of the city is served by the Sycamore Canyon Channel. This channel was built during the 1930s. Although many developments have occurred within its drainage area, it is generally adequate for storm water protection, except for a small portion of the "Adams Hill Area," where there is a dip on Cottage Grove Avenue, between Palmer Street and Green Street. This dip acts as drainage channel, and during heavy rains, this dip may be subjected to minor flooding. However, private properties are not adversely affected.

## Community Issues Summary:

Flooding issues in Glendale are considered minor, however, recent storms have shown that storm damages to structures and businesses can cost thousands if not millions of dollars to repair. In most cases, these loss estimates do not even include lost revenue due to business interruption.

The city of Glendale works to address its localized flooding problems as they arise. However, given that some areas in Glendale appear to be more susceptible to flooding issues, due in great part to urban run off and modification of the natural environment, proactive measures that address the issues before flooding occurs could be implemented.

# Flood Mitigation Action Items

The flood mitigation action items provide direction on specific activities that organizations and residents in the city of Glendale can undertake to reduce risk and prevent loss from flood events. Each action item is followed by ideas for implementation, which can be used by the steering committee and local decision makers in pursuing strategies for implementation.

### Short Term – Flood #l:

**Action Item:** Analyze each repetitive flood property within the City of Glendale and identify feasible mitigation options.

**Ideas for Implementation:**

- Identify appropriate and feasible mitigation activities for identified repetitive flood properties. Funding may be available through FEMA' s Hazard Mitigation Grant and Flood Mitigation Assistance Programs and the Pre-disaster Mitigation Program.

- Contact repetitive loss property owners to discuss mitigation opportunities, and determine interest should future project opportunities arise.

- Explore options for incentives to encourage property owners to engage in mitigation.

| | |
|---|---|
| **Coordinating Organization:** | Hazard Mitigation Advisory Committee |
| **Timeline:** | 1-2 years |
| **Plan Goals Addressed:** | Protect Life and Property, Partnerships and Implementation |
| **Constraints:** | Pending Funding and Available Personnel |

**<u>Short Term – Flood #2:</u>**
**Action Item:** Recommend revisions to requirements for development within the floodplain, where appropriate.

**Ideas for Implementation:**

- Evaluate elevation requirements for new residential and nonresidential structures in the unincorporated floodplain area.

- Explore raising the base elevation requirement for new residential construction to two or three feet above base flood elevation, or greater. An increased elevation standard is one activity the county can engage in to receive credit from the NFIP Community Rating System Program.

- Identify opportunities to upgrade Federal Insurance Rate Map, and arrange for Cooperative Technical Partnership mapping upgrades for select areas.

- Identify alternatives to reduce development in the floodplain.

| | |
|---|---|
| **Coordinating Organization:** | Public Works, County Department of Transportation, Information Services |
| **Timeline:** | 2 years |
| **Plan Goals Addressed:** | Protect Life and Property |
| **Constraints:** | Pending Funding and Available Personnel |

**<u>Short Term – Flood #3:</u>**
**Action Item:** Develop better flood warning systems.

**Ideas for Implementation:**

- Coordinate with appropriate organizations to evaluate the need for more stream gauges.

- Distribute information regarding flooding to the general public efficiently.

| | |
|---|---|
| **Coordinating Organization:** | County Emergency Management, County Public Works, County Department of Transportation |
| **Timeline:** | 2 years |
| **Plan Goals Addressed:** | Protect Life and Property, Emergency Services |
| **Constraints:** | Pending Funding and Available Personnel |

## Long Term – Flood #1:

**Action Item**: Enhance data and mapping for floodplain information within the county, and identify and map flood-prone areas outside of designated floodplains.

**Ideas for Implementation:**

- Apply for FEMA's cooperative technical partnership using the 2-foot contour interval floodplain mapping data acquired by the City of Glendale GIS.
- Use WES inventory and mapping data to update the flood-loss estimates for the city of Glendale.
- Encourage the development of floodplain maps for all local streams not currently mapped on Flood Insurance Rate Maps or county maps, with special attention focused on mapping rural and unincorporated areas. The maps should show the expected frequency of flooding, the level of flooding, and the areas subject to inundation. The maps can be used for planning, risk analysis, and emergency management.

| | |
|---|---|
| **Coordinating Organization:** | County Geographic Information Services, County Department of Transportation, County Public Works |
| **Timeline:** | 3 years (as funding allows) |
| **Plan Goals Addressed:** | Protect Life and Property |
| **Constraints:** | Pending Funding and Available Personnel |

## Long Term – Flood #2:

**Action Item**: Encourage development of acquisition and management strategies to preserve open space for flood mitigation, fish habitat, and water quality in the floodplain.

**Ideas for Implementation:**

- Develop a comprehensive strategy for acquiring and managing floodplain open space in the City of Glendale.
- Explore funding for property acquisition from federal (e,g" FEMA Hazard Mitigation Grant Program), state, regional, and local governments, as well as private and non-profit organizations, trails programs, fish programs as well as options for special appropriations.
- Develop a regional partnership between flood mitigation, fish habitat, and water quality enhancement organizations/programs to improve educational programs.
- Identify sites where environmental restoration work can benefit flood mitigation, fish habitat, and water quality.
- Work with landowners to develop flood management practices that provide healthy fish habitat.
- Identify existing watershed education programs and determine which programs would support a flood education component.

| | |
|---|---|
| **Coordinating Organization:** | County Department of Transportation, County Public Works |
| **Timeline:** | 5 years |

**Plan Goals Addressed:** Natural Systems, Protect Life and Property
**Constraints:** Pending Funding and Available Personnel

**Long Term – Flood #3:**
**Action Item**: Identify surface water drainage obstructions in the city of Glendale.

**Ideas for Implementation:**

- Map culverts in the city.
- Prepare an inventory of culverts that historically create flooding problems and target them for retrofitting.
- Prepare an inventory of major urban drainage problems, and identify causes and potential mitigation actions for urban drainage problem areas.

**Coordinating Organization:** County Public Works, County Geographic Information Systems
**Timeline:** 5 years
**Plan Goals Addressed:** Protect Life and Property
**Constraints:** Pending Funding and Available Personnel

**Long Term – Flood #4:**
**Action Item:** Establish a framework to compile and coordinate surface water management plans and data throughout the City.

**Ideas for Implementation:**

- Develop surface water management plans for areas that are not currently within surface water management plan boundaries.

**Coordinating Organization:** County Public Works, County Planning Division, Geographic Information Systems
**Timeline:** 5 years
**Plan Goals Addressed:** Protect Life and Property, Partnerships and Implementation
**Constraints:** Pending Funding and Available Personnel

# Flood Resource Directory

The following resource directory lists the resources and programs that can assist county communities and organizations. The resource directory will provide contact information for local, county, regional, State and Federal programs that deal with natural hazards. For additional information, refer to Appendix A.

## County Resources:

**Los Angeles County Public Works Department**
900 S. Fremont Ave.
Alhambra, CA 91803
Ph: 626-458-5100

**Sanitation District of Los Angeles County**
1955 Workman Mill Road
Whittier, CA 90607
Ph: 562-699-7411 x2301

## State Resources:

**Governor's Office of Emergency Services (OES)**
P.O. Box 419047
Rancho Cordova, CA 95741-9047
Ph: 916 845- 8911
Fx: 916 845- 8910

**California Resources Agency**
1416 Ninth Street, Suite 1311
Sacramento, CA 95814
Ph: 916-653-5656

**California Department of Water Resources (DWR)**
1416 9th Street
Sacramento, CA 95814
Ph: 916-653-6192

**California Department of Conservation: Southern California Regional Office**
655 S. Hope Street, #700
Los Angeles, CA 90017-2321
Ph: 213-239-0878
Fx: 213-239-0984

## Federal Resources and Programs:

**Federal Emergency Management Agency (FEMA)**
FEMA provides maps of flood hazard areas, various publications related to flood mitigation, funding for flood mitigation projects, and technical assistance. FEMA also operates the National Flood Insurance Program. FEMA' s mission is to reduce loss of life and property and protect the nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response and recovery.

**Federal Emergency Management Agency, Region IX**
1111 Broadway, Suite 1200
Oakland, CA 94607
Ph: 510-627-7100

Fx: 510-627-7112

**Federal Emergency Management Agency, Mitigation Division**
500 C Street, S.W.
Washington, D.C. 20472
Ph: 202-566-1600

**FEMA' s List of Flood Related Websites**
This site contains a long list of flood related Internet sites from "American Heritage Rivers" to "The Weather Channel" and is a good starting point for flood information on the Internet.
Contact: Federal Emergency Management Agency, Phone: (800) 480-2520
Website: http://www.fema.gov/nfip/related.htm

**National Flood Insurance Program (NFIP)**
In southern California, many cities lie within flood zones as defined in FEMA Flood Maps. The City of Glendale is not a community within a designated flood zone. Nevertheless, flood insurance is available to citizens in communities that adopt and implement NFIP building standards. The standards are applied to development that occurs within a delineated floodplain, a drainage hazard area, and properties' within 250 feet of a floodplain boundary. These areas are depicted on federal Flood Insurance Rate Maps available through the county.
National Floodplain Insurance Program (NFIP)
500 C Street, S.W.
Washington, D.C. 20472
Ph: 202-566-1600

## Other National Resources:

**The Floodplain Management Association**
The Floodplain Management website was established by the Floodplain Management Association (FMA) to serve the entire floodplain management community. It includes full-text articles, a calendar of upcoming events, a list of positions available, an index of publications available free or at nominal cost, a list of associations, a list of firms and consultants in floodplain management, an index of newsletters dealing with flood issues (with hypertext links if available), a section on the basics of floodplain management, a list of frequently asked questions (FAQs) about the Website, and a catalog of Web links.
Floodplain Management Association
P.O. Box 50891
Sparks, NV 89435-0891
Ph: 775-626-6389
Fx: 775-626-6389

**The Association of State Floodplain Managers**
The Association of State Floodplain Managers is an organization of professionals involved in floodplain management, flood hazard mitigation, the National Flood Insurance Program, and flood preparedness, warning, and recovery. ASFPM fosters communication among those responsible for flood hazard activities, provides technical advice to governments and other entities about proposed actions or policies that will affect flood hazards, and encourages flood hazard research, education, and training. The ASFPM Web site includes information on how to become a member, the organization's constitution and bylaws, directories of officers and committees, a publications list, information on upcoming conferences, a history of the association, and other useful information and Internet links.
Contact: The Association of State Floodplain Managers
Address: 2809 Fish Hatchery Road, Madison, WI 53713 Phone: (608) 274-0123
Website: http://www.floods,org

**National Weather Service**

The National Weather Service provides flood watches, warnings, and informational statements for rivers in the City of Glendale.

National Weather Service
520 North Elevar Street
Oxnard, CA 93030
Ph: 805-988- 6615

**Office of Hydrology, National Weather Service**

The National Weather Service s Office of Hydrology (OH) and its Hydrological Information Center offer information on floods and other aquatic disasters, This site offers current and historical data including an archive of past flood summaries, information on current hydrologic conditions, water supply outlooks, an Automated Local Flood Warning Systems Handbook, Natural Disaster Survey Reports, and other scientific publications on hydrology and flooding.

National Weather Service, Office of Hydrologic Development
1325 East West Highway, SSMC2
Silver Spring, MD 20910
Ph: 301-713-1658
Fx: 301-713-0963

**National Resources Conservation Service (NRCS), US Department of Agriculture**

NRCS provides a suite of federal programs designed to assist state and local governments and landowners in mitigating the impacts of flood events. The Watershed Surveys and Planning Program and the Small Watershed Program provide technical and financial assistance to help participants solve natural resource and related economic problems on a watershed basis. The Wetlands Reserve Program and the Flood Risk Reduction Program provide financial incentives to landowners to put aside land that is either a wetland resource, or that experiences frequent flooding. The Emergency Watershed Protection Program (EWP) provides technical and financial assistance to clear debris from clogged waterways, restore vegetation, and stabilizing riverbanks. The measures taken under EWP must be environmentally and economically sound and generally benefit more that one property.

National Resources Conservation Service
14th and Independence Ave., SW, Room 5105-A
Washington, DC 20250
Ph: 202-720-7246
Fx: 202-720-7690

**USGS Water Resources**
This web page offers current US water news; extensive current (including real-time) and historical water data; numerous fact sheets and other publications; various technical resources; descriptions of ongoing water survey programs; local water information; and connections to other sources of water information.
USGS Water Resources
6000 J Street Placer Hall
Sacramento, CA 95819-6129
Ph: 916-278-3000
Fx: 916-278-3070

**Bureau of Reclamation**
The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The Bureau provides leadership and technical expertise in water resources development and in the efficient use of water through initiatives including conservation, reuse, and research. It protects the public and the environment through the adequate maintenance and appropriate operation of Reclamation's facilities and manages Reclamation's facilities to fulfill water user contracts and protect and/or enhance conditions for fish, wildlife, land, and cultural resources.
Mid Pacific Regional Office
Federal Office Building
2800 Cottage Way
Sacramento CA 95825-1898
Ph: 916- 978-5000
Fax 916- 978-5599
http://www.usbr.gov/

**Army Corps of Engineers**
The Corps of Engineers administers a permit program to ensure that the nation's waterways are used in the public interest. Any person, firm, or agency planning to work in waters of the United States must first obtain a permit from the Army Corps of Engineers. The Corps is responsible for the protection and development of the nation's water resources, including navigation, flood control, energy production through hydropower management, water supply storage and recreation.
US Army Corps of Engineers
P.O. Box 532711
Los Angeles CA 90053- 2325
Ph: 213-452- 3921

**American Public Works Association**
2345 Grand Boulevard, Suite 500
Kansas City, MO 64108-2641
Ph: 816-472-6100
Fx: 816-472-1610

## Publications:

**NFIP Community Rating System Coordinator's Manual**
**Indianapolis, IN.**
This informative brochure explains how the Community Rating System works and what the benefits are to communities. It explains in detail the CRS point system, and what activities communities can pursue to earn points. These points then add up to the "rating" for the community, and flood insurance premium discounts are calculated based upon that "rating." The brochure also provides a table on the percent discount realized for each rating (1-10). Instructions on how to apply to be a CRS community are also included.
Contact: NFIP Community Rating System
Phone: (800) 480-2520 or (317) 848-2898
Website: http://www.fema.gov/nfip/crs

**Floodplain Management: A Local Floodplain Administrator's Guide to the NFIP**
This document discusses floodplain processes and terminology. It contains floodplain management and mitigation strategies, as well as information on the NFIP, CRS, Community Assistance Visits, and floodplain development standards.
Contact: National Flood Insurance Program Phone: (800) 480-2520
Website: http://www.fema,gov/nfip/

**Flood Hazard Mitigation Planning: A Community Guide, (June 1997).**
**Massachusetts Department of Environmental Management.**
This informative guide offers a 10-step process for successful flood hazard mitigation. Steps include: map hazards, determine potential damage areas, take an inventory of facilities in the flood zone, determine what is or is not being done about flooding, identify gaps in protection, brainstorm alternatives and actions, determine feasible actions, coordinate with others, prioritize actions, develop strategies for implementation, and adopt and monitor the plan.
Contact: Massachusetts Flood Hazard Management Program Phone: (617) 626-1250
Website: http://www.magnetstate.ma.us/dem/programs/mitigate

**Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials, (February 1987), FEMA-116.**
This guidebook offers a table on actions that communities can take to reduce flood losses. It also offers a table with sources for floodplain mapping assistance for the various types of flooding hazards. There is information on various types of flood hazards with regard to existing mitigation efforts and options for action (policy and programs, mapping, regulatory, non-regulatory). Types of flooding which are covered include alluvial fan, areas behind levees, areas below unsafe dams, coastal flooding, flash floods, fluctuating lake level floods, ground failure triggered by earthquakes, ice jam flooding, and mudslides.
Contact: Federal Emergency Management Agency Phone: (800) 480-2520
Website: http://www.fema,gov