CHAPTER 3: FLOOD HAZARDS

Safety Elements of General Plans must assess the impact of flooding from storm activity such as the 100-year and 500-year flood events. Smaller-scale flooding generally associated with overburdened storm drain and canal systems may also damage property and hinder emergency activities such as fire department access or evacuation. Therefore, small-scale flooding is also addressed if there are available data. The State of California Government Code Section 65302 (g) also requires local governments to assess the potential impact that failure of dams or other water retention structures might have on their community. This chapter reviews published flood data and a directory of dams showing inundation limits in the Glendale area. The results of this study indicate that several areas in Glendale may be impacted by the catastrophic failure of reservoirs and water tanks.

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.

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 will be 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.

3.1 Storm Flooding

3.1.1 Hydrologic Setting

The City of Glendale is drained by the south-, southwest-, and west-flowing Verdugo Wash and its tributaries. 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 (see Plate 3-1). From north to south, in the City of 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.

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

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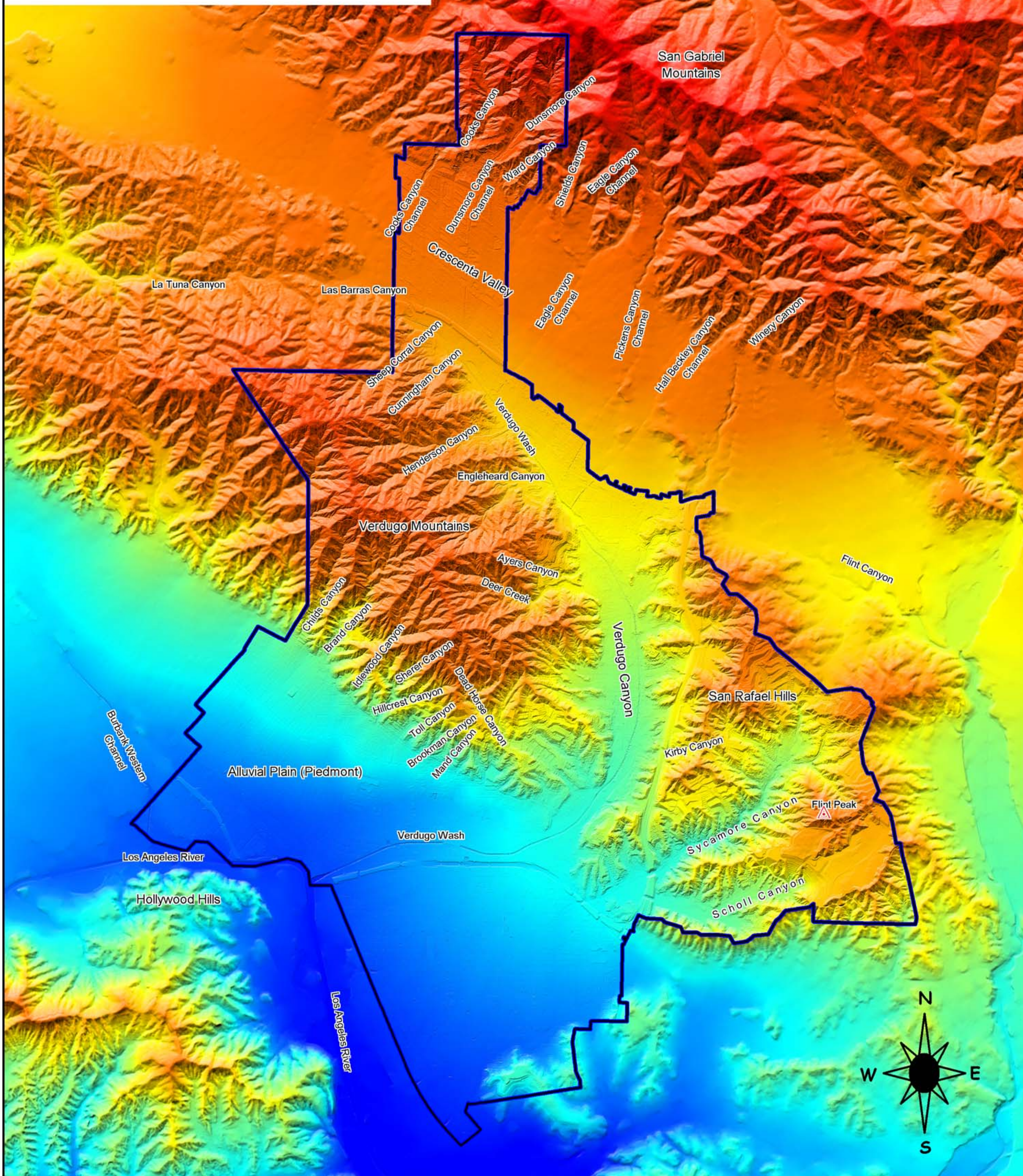

Scale: 1:60,000

1000 0 1000 2000 3000

Meters

5000 0 5000 10000 15000

Feet

EXPLANATION

Elevation in Feet

200 400 600 800 1000 1200 1400

Glendale City Limit

Base Map: USGS 10-m Digital Elevation Model and City of Glendale Digital Terrain Model based on 1-foot and 2-foot elevation contour data.

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Project Number: 2103

Date: July, 2003

Geomorphic Map

Glendale, California

Plate 3-1

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 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 also have been channelized through the La Cañada Valley, also for flood-protection purposes. Similarly, Verdugo Wash is channelized through Glendale.

3.1.2 *Meteorological Setting*

Average yearly precipitation in the downtown Glendale area is about 17 to 18 inches (see Table 3-1), while rainfall in the northern reaches of the City is better represented by rainfall data for the La Crescenta area (Table 3-2). These tables show that areas closer to the San Gabriel Mountains receive higher precipitation rates, on average, than areas farther south from the mountains.

Table 3-1: Average Annual Rainfall by Month for the Glendale Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	3.9	3.8	2.5	1.5	0.2	0.1	0.0	0.0	0.3	0.4	2.0	3.0	**17.6**

Data based on 40 complete years between 1941 and 1971.
Source: http://www.worldclimate.com/

Table 3-2: Average Annual Rainfall by Month for the La Crescenta Area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Inches	4.5	5.4	4.0	1.7	0.4	0.1	0.0	0.2	0.5	0.8	2.3	3.6	**23.5**

Data based on data from 60 complete years between 1931 and 1995.
Source: http://www.worldclimate.com/

Not only does rainfall vary significantly from one location to the next, often within short distances, but rainfall in southern California is extremely variable from year to year. For example, in the 1999-2000 water year, the County of Los Angeles Department of Public Works rain gage station at Brand Park recorded 10.72 inches of rain for the year, while the rain gage at Scholl Landfill reported 17.62 inches of rain during the same period (http://www.dpw.co.la.us/wrd/report/9900/precip/stations.cfm). Data reviewed for this study also suggest that southern California has experienced more wet years in the last 20 to 30 years than in the 50 years prior.

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

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. This is illustrated by the data on Tables 3-1 and 3-2. 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.

Local thunderstorms can occur at any time, but usually cover relatively small areas. These storms are usually prevalent in the higher mountains during the summer (FEMA, 1986). Tropical rains 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.

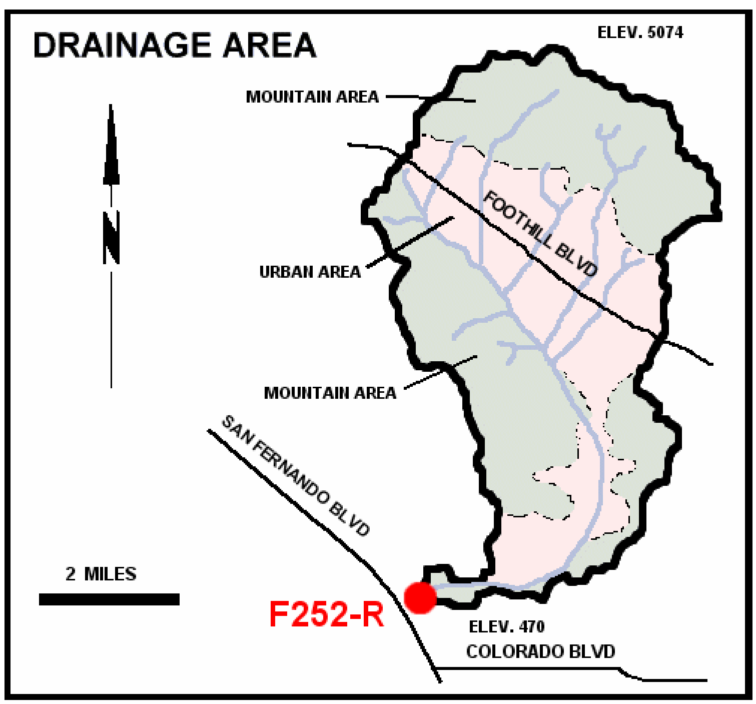
3.1.3 Historical Flows and Past Floods

The streams in the Glendale area are typical of the majority of the streams that emanate from the San Gabriel and San Bernardino Mountains in southern California. Stream flow is negligible other than during and immediately after rains because climate and basin characteristics are not conductive to continuous flow. In the Los Angeles Basin, including the Glendale area, flooding is difficult to predict, and thus plan for, because as mentioned previously, rainfall in the area is extremely variable. It can be said that 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 U.S. Geological Survey does not maintain any stream gages on the Verdugo Wash, but the County of Los Angeles Public Works Department has over the years manned at least one, and occasionally two, stream gages in the Verdugo Wash drainage area. One of these, Gage Station F252-R on Estelle Avenue, near the southwestern end of the Verdugo Wash, has been operated continuously since December 2, 1935 (its location is shown on Figure 3-1), although sporadic measurements date back to 1928. These provide a relatively long-term record of flow discharge and peak flows that can be used to describe the flooding history and future flooding potential of the Glendale area. The drainage area for Station F252-R, which is 26.80 square miles in size, is shown on Figure 3-1.

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 (see Table 3-3). 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). Notice that in the decades between 1930 and 1990, maximum daily peak flows exceeding 1,000 cfs generally occurred only once in a decade, but that in the 1990s, 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 highest peak flow recorded at this stream gage 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. As discussed further below, 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. Similarly, the winter storms in 1983-84 caused considerable damage in southern California, and could be related to the lack of data for the stream gage in Verdugo Wash for the 1983-84 water year.

Figure 3-1: Drainage Area for Stream Gaging Station F252-R in Glendale



Source: Los Angeles County Department of Public Works, at
http://www.dpw.co.la.us/wrd/runoff/dispimg.cfm?showimg=graphics/d252.gif

Table 3-3: Peak Flow Records for Station F252-R at Estelle Avenue in Glendale

Season	Daily Peak (cfs)			Total Runoff (Acre-feet)	Peak Inflow	
	Maximum	Minimum	Mean		Date	cfs
1928-29	15.0	0.0	*	140*	4/4	56*
1929-30	14.0	0.0	0.4	274.0*	5/3	80
1930-31	8.4	+	0.2	145.0	4/26	46
1931-32	39.0	0.1	1.0	713.0	2/9	145
1932-33	42.0	0.1	0.4	295.0	1/19	391
1933-34	No Record					
1934-35	85.0*	0.0	*	620.0	1/5	1,020*
1935-36	33.0	0.0	0.6	463.0	3/30	1,100*
1936-37	*	0.0	*	1,560	12/27	768
1937-38	1,500.0	0.0	7.5	5,450	3/2	4,400E
1938-39	78.0	0.0	2.0	1,420	1/5	520
1939-40	60.0	+	2.0	1,430	1/8	533
1940-41	357.0	+	10.2	7,370	2/19	1,120
1941-42	81.0	0.8	3.0	2,160	12/10	440
1942-43	1,020.0	0.3	12.0	8,690	1/23	3,570
1943-44	998.0	0.2	7.0	5,040	2/12	3,160
1944-45	181.0	0.6	2.8	2,010	2/2	1,520
1945-46	135.0	0.3	2.7	1,930	12/22	816
1946-47	234.0	0.0	2.7	1,940	12/25	1,860
1947-48	41.0	0.0	0.5	382.0	3/24	573
1948-49	35.0	0.0	0.6	433.0	12/16	202
1949-50	69.0	0.0	0.9	638.0	2/6	467
1950-51	41.0	0.0	0.5	383.0	1/11	960
1951-52	422.0	0.0	7.8	5,630	1/16	2,920
1952-53	100.0	0.0	1.3	968.0	11/15	1,520
1953-54	227.0	0.0	2.7	1,920	2/13	1,300
1954-55	134.0	0.0	2.0	1,480	1/18	784
1955-56	550.0	0.0	2.5	1,840	1/26	1,940
1956-57	184.0	0.0	1.9	1,400	2/23	2,960
1957-58	236.0	0.0	5.2	3,770	2/19	1,700
1958-59	232.0	0.0	2.0	1,440	2/16	2.080
1959-60	56.0	0.0	1.2	862.0	2/11	533
1969-61	98.0	+	0.9	667.0	11/5	676
1961-62	592.0	0.0	6.8	4,830	2/12	1,880
1962-63	370.0	+	2.0	1,460	2/9	2,180
1963-64	192.0	0.0	2.1	1,510	1/21	1,640
1964-65	249.0	+	3.8	2,780	4/8	1,480
1965-66	1,030.0	0.1	12.2	8,830	12/29	3,480
1966-67	422.0	0.5	10.4	7,530	1/22	3,230
1967-68	606.0	0.2	9.3	6,730	3/8	3,460
1968-69	1,850	1.8	36.1	26,120	1/25	5,050
1969-70	261.0	2.0	8.4	6,090	2/28	2,500
1970-71	931.0	1.8	10.6	7,690	11/29	5,330
1971-72	476.0	1.2	14.8	4,570	12/24	1,960
1972-73	897.0	1.0	12.8	9,280	1/18	4,010
1973-74	671.0	1.8	10.2	7,380	1/7	2,390
1974-75	373.0	0.7	7.7	5,590	12/4	3,390

Table 3-3 (Continued)

Season	Daily Peak (cfs)			Total Runoff (Acre-feet)	Peak Inflow	
	Maximum	Minimum	Mean		Date	cfs
1975-76	180.0	0.5	6.4	4,560	3/1	1,190
1976-77	210.0	0.3	6.0	4,318	1/23	2,100
1977-78	1,700.0	+	34.2	24,739	2/10	9,820
1978-79	*	*	*	*	3/27	*
1979-80	440.0	1.2	18.1	13,000	2/16	6,420
1980-81	266.0	1.5	12.0	8,706	1/29	2,870
1981-82	333.0	1.0	12.5	9,083	4/1	1,960
1982-83	1,260.0	2.0	37.0	26,750	3/1	6,714
1983-84	No Record					
1984-85	279.0	1.0	9.2	6,686	12/19	2,430
1985-86	437.0	1.2	12.1	8,737	3/8	1,620
1986-87	158.0	1.5	5.0	3,635		ND
1987-88	688.0	2.3	19.3	14,042	2/1	4,150
1988-89	301.0	0.3	9.1	6,262	12/16	1,700
1989-90	474.0	+	5.7	4,120	2/17	1,820
1990-91	544.0	0.2	11.1	8,017		ND
1991-92	636.0	0.0	20.1	14,621	2/10	4,110
1992-93	733.0	1.7	32.5	23,520	6/5	4,320
1993-94	265.0	0.0	10.4	7,543	11/30	2,220
1994-95	1,710.0	1.0	46.5	33,700	1/10	4,460
1995-96	1,260.0	0.8	18.6	13,520	2/21	3,460
1996-97	1,140.0	1.9	23.3	16,860	12/22	3,010
1997-98	966.0	3.9	22.3	16,150	2/7	5,550
1998-99	117.0	3.6	10.0	7,250	11/28	1,390
1999-2000	289.0	2.9	11.7	8,470	2/16	2,700

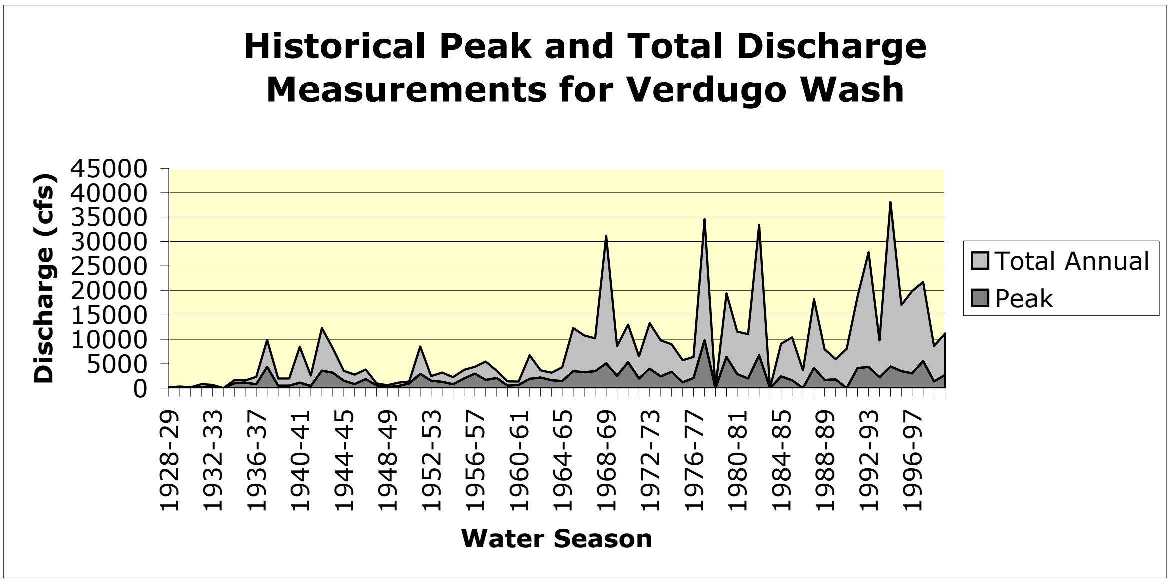
* = Record Incomplete E = Estimate ND = Not Determined
+ = Less than 0.05 acre-feet or less than 0.05 cfs, but greater than 0
Source: http://www.dpw.co.la.ca.us/wrd/report/9900/runoff/peak.cfm

Figure 3-2 illustrates the total annual and peak annual discharge measurements for Verdugo Wash. The graph clearly illustrates that the annual discharges in the last decades, since the late 1960s, are overall higher than the measurements for the previous four decades. The annual peak discharge measurements also have increased in the last few decades, but not as much as the total annual measurements. This may indicate that the climate indeed has been wetter in the last few decades, or it could mean that with increased development in the Verdugo drainage area, the Verdugo Wash receives more runoff.

Several canyons near the Glendale area have 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).

The most severe flood recorded in Glendale occurred in 1934. Intense precipitation on New Year's Eve, 1933 occurred locally in the La Canada 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. Several people died, several bridges were washed out, and erosion and sedimentation damaged property. The damage caused by this storm was carefully documented by an unknown official or employee of the City. The map showing the damage is reproduced here, as Plate 3-2. Verdugo Wash and most of its tributaries through the La Crescenta area were channelized in response to the 1934 flood.

Figure 3-2:



Source: Los Angeles County Department of Public Works, Annual Hydrological Report 1999-2000, at http://www.dpw.co.la.us/wrd/report

3.1.4 National Flood Insurance Program

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.

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

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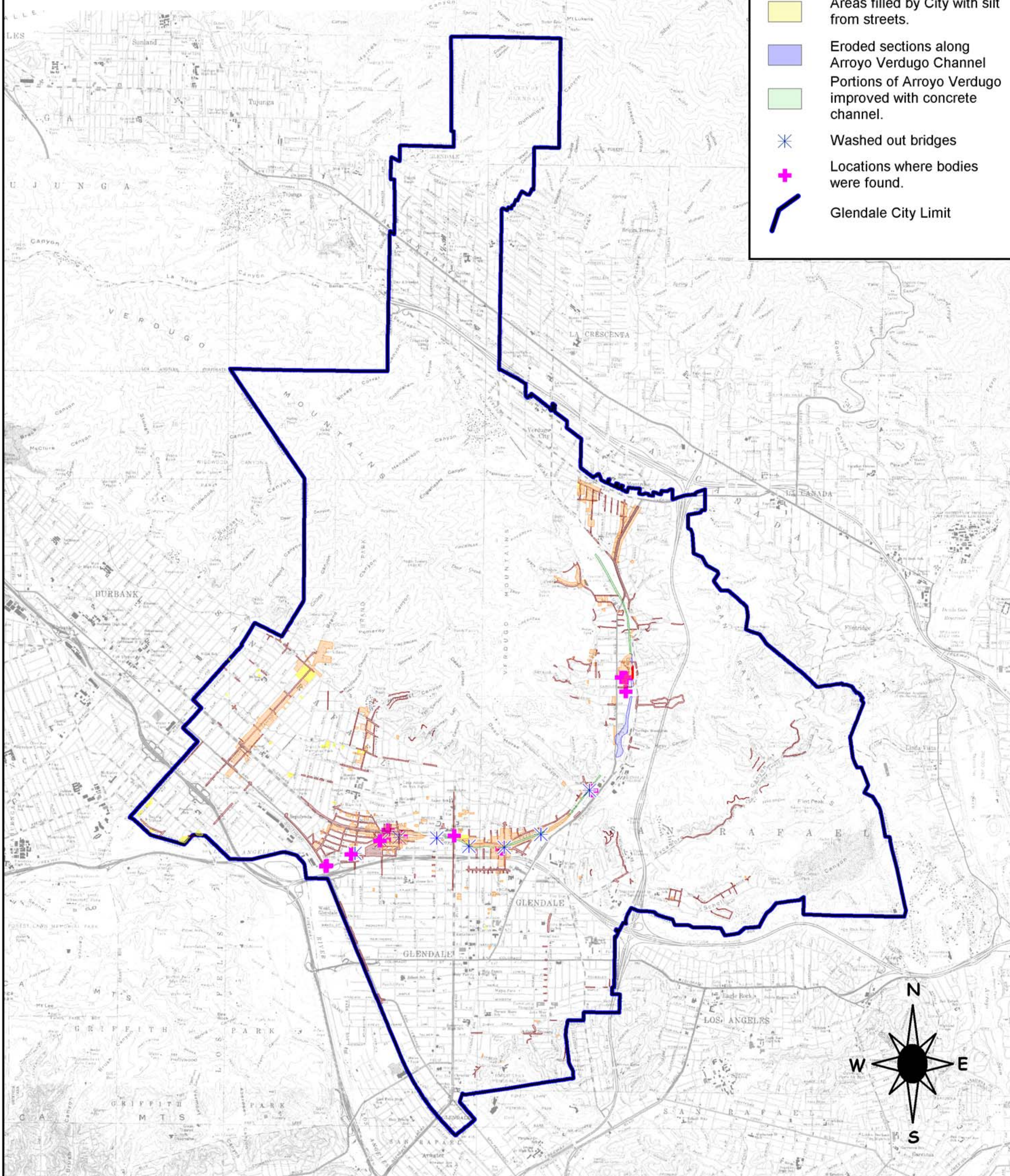


Scale: 1:60,000

1000 0 1000 2000 3000

Meters

5000 0 5000 10000 15000

Feet

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: Flood Map prepared by the City of Glendale (undated), provided by the Glendale Planning Department

Earth Consultants International

Project Number: 2103
Date: July, 2003

Damage Caused by the January 1, 1934 Flood

Glendale, California

Plate 3-2

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. 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.

On May 7, 1976 the Federal Insurance Administration (FIA) issued a Flood Hazard Boundary map for the City of Glendale. However, this map was rescinded by FIA on November 15, 1979, because information provided to them indicated "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." (letter from Gloria M. Jimenez, FIA, stamped November 29, 1979). In addition, the Federal Emergency Management Agency, in a letter to the City of Glendale, dated August 31, 1984 "determined that no Special Flood Hazard Areas exist, at this time, within the corporate limits of your community. Therefore, no map will be published."

The base flood is a regulatory standard used by the National Flood Insurance Program (NFIP) as the basis for insurance requirements nationwide. The Flood Disaster Protection Act requires owners of all structures in identified SFHAs to purchase and maintain flood insurance as a condition of receiving Federal or federally related financial assistance, such as mortgage loans from federally insured lending institutions.

The base flood is also used by Federal agencies, as well as most county and State agencies to administer floodplain management programs. The goals of floodplain management are to reduce losses caused by floods while protecting the natural resources and functions of the floodplain. The basis of floodplain management is the concept of the "**floodway**". FEMA defines this as the channel of a river or other watercourse, and the adjacent land areas that must be kept free of encroachment in order to discharge the base flood without cumulatively increasing the water surface elevation more than a certain height. The intention is not to preclude development, but to assist communities in managing sound development in areas of potential flooding. The community is responsible for prohibiting encroachments into the floodway unless it is demonstrated by detailed hydrologic and hydraulic analyses that the proposed development will not increase the flood levels downstream.

The NFIP is required to offer federally subsidized flood insurance to property owners in those communities that adopt and enforce floodplain management ordinances that meet minimum criteria established by FEMA. The National Flood Insurance Reform Act of 1994 further strengthened the NFIP by providing a grant program for State and community flood mitigation projects. The act also established the Community Rating System (CRS), a system for crediting communities that implement measures to protect the natural and beneficial functions of their floodplains, as well as managing the erosion hazard. *The City of Glendale has participated as a regular member in the NFIP since August 31, 1984 (City ID No. – 065030) however, there are no FIRM maps for the City, and Glendale is not currently listed in FEMA's CRS of cities*. 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.

3.1.5 Bridge Scour

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; however, 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.

3.1.6 Existing Flood Protection Measures

(The information in this section was provided by the City of Glendale Engineering Department in a memo dated April 17, 2003).

Most storm drains within the City are maintained by the County of Los Angeles. For other problem areas, the City has provided the County a “Drainage Deficiency Report” for their evaluation. It is anticipated that the Los Angeles County Department of Public Works will address these conditions as funds become available.

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 (se Plates 3-1). 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.

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 (La Crescenta), 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.

These storm drain facilities 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 Inundation: Another area that could potentially be subjected to localized inundation is the area 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 would close and runoff from the street will be retained within the street temporarily until the flow can be taken into the channel.

Sycamore Canyon Channel: The eastern portion of the City is served by the Sycamore Canyon Channel. This channel was built during the 1930's. 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.

3.1.7 Future Flood Protection

As development projects in the hillsides of Glendale are considered, it is important that hydrologic studies be conducted to assess the impact that increased development may have on the existing development down gradient. These studies should quantify the effects of increased runoff and alterations to natural stream courses. Such constraints should be identified and analyzed in the earliest stages of planning. If any deficiencies are identified, the project proponent needs to prove that these can be mitigated to a satisfactory level prior to proceeding forward with the project, in accordance with CEQA guidelines. Mitigation measures typically include flood control devices such as catch basins, storm drain pipelines, culverts, detention basins, desilting basins, velocity reducers, as well as debris basins for protection from mud and debris flows.

The methodology for analysis and design is set forth in several manuals published by the Los Angeles County Department of Public Works (LACDPW). Future responsibilities for operation of regional flood control facilities will be with the LACDPW, while the local storm drain network outside of the regional system will be with the City of Glendale. Therefore, both agencies must be involved in the planning and approval of mitigation measures, to assure compatibility.

Across the United States, substantial changes in the philosophy, methodology and mitigation of flood hazards are currently in the works. For example:

- Some researchers have questioned whether or not the current methodology for evaluating average flood recurrence intervals is still valid, since we are presently experiencing a different, warmer and wetter climate. Even small changes in climate can cause large changes in flood magnitude (Gosnold et al., 2000).

- Flood control in undeveloped areas should not occur at the expense of environmental degradation. Certain aspects of flooding are beneficial and are an important component of the natural processes that affect regions far from the particular area of interest. For instance, lining major channels with concrete reduces the area of recharge to the ground water, and depletes the supply of sand that ultimately would be carried to the sea to replenish our beaches. Thus there is a move to leave nature in charge of flood control. The advantages include lower cost, preservation of wildlife habitats and improved recreation potential.

- Floodway management design in land development projects can also include areas where stream courses are left natural or as developed open space, such as parks or golf courses. Where flood control structures are unavoidable, they are often designed with a softer appearance that blends in with the surrounding environment.

- Environmental legislation is increasingly coming in conflict with flood control programs. Under the authority of the Federal Clean Water Act and the Federal Endangered Species Act, development and maintenance of flood control facilities has been complicated by the regulatory activities of several Federal agencies including the U.S. Army Corps of Engineers, the Environmental Protection Agency, and the U.S. Fish and Wildlife Service. For instance, FEMA requires that Los Angeles County and its incorporated cities maintain the carrying capacity of all flood control facilities and floodways. However, this requirement can conflict with mandates from the U.S. Fish and Wildlife Service regarding maintaining the habitat of endangered or threatened species. Furthermore, the permitting process required by the Federal agencies is lengthy, and can last several months to years. Yet, if the floodways are not permitted to be cleared of vegetation and other obstructing debris in a timely manner, future flooding of adjacent areas could develop. Zappe (1997) argues that reform of environmental laws is necessary to ease the burden on local governments, and ensure the health and safety of the public. In particular, Zappe calls for a categorical exemption from the Federal laws for routine maintenance and emergency repair of all existing flood control facilities.

3.1.8 Flood Protection Measures for Property Owners

Property owners can make modifications to their houses to reduce the impact of flooding. FEMA has identified several flood protection measures that can be implemented by property owners to reduce flood damage. These include: installing waterproof veneers on the exterior walls of buildings; putting seals on all openings, including doors, to prevent the entry of water; raising electrical components above the anticipated water level improvements; and installing backflow valves that prevent sewage from backing up into the house through the drainpipes. Obviously, these changes vary in complexity and cost, and some need to be carried out only by a professional licensed contractor. For additional information and ideas, refer to the FEMA webpage at www.fema.gov. Structural modifications require a permit from the City's Building Department. Refer to them for advice regarding whether or not flood protection measures would be appropriate for your property.

3.2 Seismically Induced Inundation

3.2.1 Dam Inundation

Seismically induced inundation refers to flooding that results when water retention structures (such as dams) fail due to an earthquake. 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 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. 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. Areas in Glendale within the dam inundation areas identified by the State are shown on Plate 3-3.

The City of Glendale is 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).

Seven dams located in the Glendale area 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 10^{th} and Western, Brand Park, and Diederich dams in the Verdugo Mountains, and the East Glorietta, Chevy Chase 1290, Glenoaks and Chevy Chase 980 dams in the San Rafael Hills.

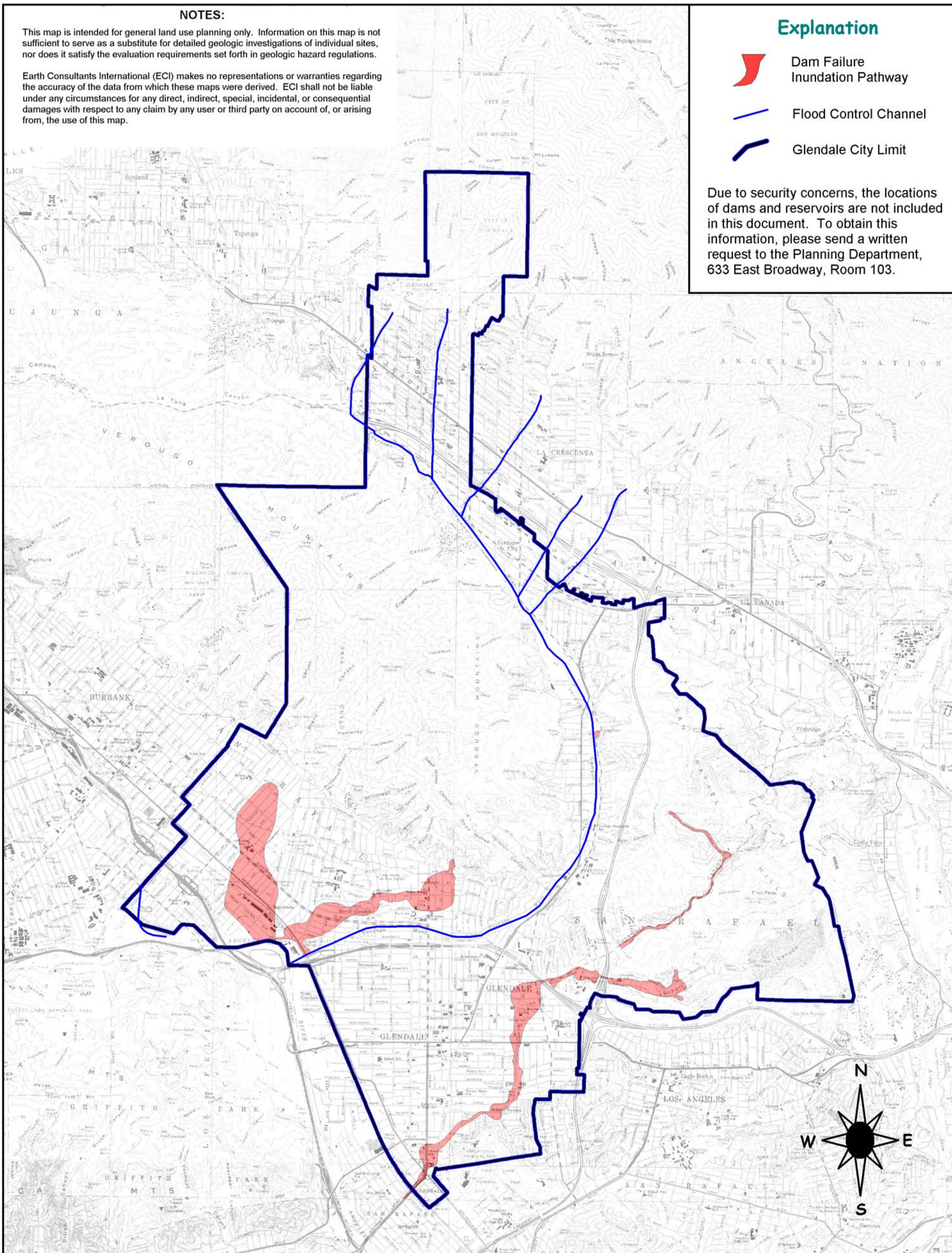
(For security purposes, the locations of dams and reservoirs are not included in this document. In order to obtain this information please send a written request to the Planning Department, 633 East Broadway, Room 103.)

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.

NOTES:

This map is intended for general land use planning only. Information on this map is not sufficient to serve as a substitute for detailed geologic investigations of individual sites, nor does it satisfy the evaluation requirements set forth in geologic hazard regulations.

Earth Consultants International (ECI) makes no representations or warranties regarding the accuracy of the data from which these maps were derived. ECI shall not be liable under any circumstances for any direct, indirect, special, incidental, or consequential damages with respect to any claim by any user or third party on account of, or arising from, the use of this map.



Scale: 1:60,000

1000 0 1000 2000 3000 Meters

5000 0 5000 10000 15000 Feet

Base Map: USGS Topographic Map from Sure!MAPS RASTER
Source: California Governors Office of Emergency Services (OES); City of Glendale Planning Department

Earth Consultants International

Project Number: 2103
Date: July, 2003

Dam Inundation Pathways

Glendale, California

Plate 3-3

3.2.2 Inundation From Above-Ground Storage Tanks

(For security purposes, the locations of above-ground storage tanks are not included in this document. In order to obtain this information please send a written request to the Planning Department, 633 East Broadway, Room 103.)

Seismically induced inundation can also occur if strong ground shaking causes structural damage to aboveground 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 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. Flexible joints have been installed at most of Glendale's larger steel tanks.

There are thirteen steel water storage tanks in the City of Glendale. Tanks located near the fault hazard management zones (identified in Chapter 1 of this report) 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. Many water tanks have already been retrofitted with these improvements; however, the Glendale Heights, Allen, San Luis Rey, and especially Cooks Canyon water tanks still need to be updated.

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.

3.3 Summary of Issues and Planning Opportunities

According to the Federal Emergency Management Agency, the City of Glendale is not vulnerable to flooding associated with the Verdugo Wash and its tributaries, or the Los Angeles River. Although there are no FIRM maps for the Glendale area, FEMA does provide National Flood Insurance for property owners in the City of Glendale. Many of the claims that FEMA processes are for structures located outside the 100-year flood zone. FEMA's National Flood Insurance Program (FEMA, 2001) also includes inundation by "mudslides," coverage that may be of interest to property owners at the base of the San Gabriel and Verdugo Mountains, or the San Rafael Hills, especially if near the mouth of a small canyon or drainage.

Future planning for new developments must consider the impact on flooding potential as well as the impact of flood control structures on the environment, both locally and regionally. Flood control should not be introduced in undeveloped areas at the expense of environmental degradation. Land development planning should consider leaving watercourses natural wherever possible, or developing them as parks, nature trails, golf courses or other types of recreation areas that could withstand inundation.

Several of the reservoirs and water tanks in the City are located within or adjacent to a fault zone. If an earthquake occurs on either the Sierra Madre or Verdugo faults, several reservoirs and water tanks may be damaged. The catastrophic release of water from these tanks has the potential to impact large areas in the City, including critical facilities located within the inundation zones. Critical facilities should not be permitted in floodplains unless they are elevated above the projected inundation depths and/or otherwise protected. Two of the largest reservoirs in the City, have the potential to inundate several facilities that use or store hazardous materials. Facilities using, storing, or otherwise involved with substantial quantities of onsite hazardous materials should not be permitted within these inundation zones unless all standards of elevation, anchoring, double containment and flood proofing have been satisfied, and the hazardous materials are stored in watertight containers that will not float.

Above-ground water storage tanks in the City of Glendale need to be reviewed, and retrofitted as necessary, to prevent them from rupturing catastrophically during an earthquake, which could have severe consequences on down slope structures and properties. Retrofitting measures should be in accordance with the latest water tank design guidelines, which were amended based on experience in recent southern California earthquakes. The evaluation should also address whether or not a water reservoir is self-contained, so that in the event of catastrophic breakage, the water is contained within the site.