VENTURA RIVER FLOOD OF FEBRUARY 1992: A LESSON IGNORED?

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ABSTRACT: *On February 12, 1992 a portion of the Ventura River, California, flowed through the Ventura Beach RV Resort which had recently been constructed across an historically active distributary of the Ventura River delta. State and local land-use planners recognized the flood hazards associated with the site, but decision-makers relied on analytical methods developed by the U.S. Army Corps of Engineers and flood-hazard categories developed by the Federal Emergency Management Agency which did not adequately reflect the mobile nature of the Ventura River channel and distributaries. A better understanding of the historical behavior of the Ventura River could have averted the flood damages experienced in 1992. Low intensity recreational, agricultural or habitat restoration use of the site would minimize potential flood damages and obviate the need for structural flood protection that would impact the river's natural resources. Continued operation of the recreational vehicle park could result in additional flood damages in the relatively near future; recognizing the limitations of the flood-modeling methodologies used for the Ventura Beach RV Resort could prevent similar miscalculations of flood potential in comparable situations.*

(KEY TERMS: river flooding; flood-hazard analysis; floodplain management; river history; southern California.)

INTRODUCTION

Those who cannot remember the past are condemned to repeat it
George Santayana, 1905

It is a commonplace that those who consistently ignore the lessons of the past, must bear the consequences when history repeats itself. While the age old question of cycles in human history is still actively debated, the repetitive nature of many natural phenomena such as floods is undisputed. The earth has a history, as much as a country or a community, and we argue that a better understanding of the historical behavior of a river can lead to improved environmental planning and reduce human tragedy stemming from natural physical processes.

On February 12, 1992 the Ventura River over-flowed its main channel near the City of San Buenaventura, California and ran through a private recreational vehicle park constructed on the delta of the river (Figure 1). The park is situated between two bridges constructed over a natural, historically active distributary channel of the lower river. The flood flow of February 12th had a recurrence interval of approximately 22 years. This was not an unusual event from a hazards/risk perspective. The probability of a 22-year flood occurring at least once in a 10-year period is approximately 37 percent. The probability of a 22-year flood occurring at least once in a 5-year period is approximately 21 percent.

The focus of this paper is the planning and political decisions that permitted the recreational vehicle park to be constructed in a hazardous area, ignoring or dismissing warnings from individuals and agencies concerning the flood hazard of the site; we have also provided hydrologic and geomorphic information to serve as a background for these decisions. With a better understanding of the circumstances leading to the construction of the Ventura Beach RV Resort the authors believe that similar decisions are less likely to be repeated in the future.

Figure 1. Path of February 12, 1992 flood flows on the lower Ventura River Delta, looking upriver from the "Second Mouth" at the Pacific Ocean. Head of distributary channel in upper left (agricultural field). Distributary channel passes to the left of Main Street Bridge; through the Ventura Beach RV Resort; over the U.S. Interstate Highway 101 "fairweather" crossing; through Emma Wood State Beach-Ventura Group Camp; and under the Southern Pacific Transportation Corporation Railroad Bridge over the Second Mouth of the Ventura River. Main Ventura River and the City of San Buenaventura area located to the right of the photograph. Aerial photography courtesy of Gary Phelps, aboard Aspin Helicopters.

VENTURA RIVER SYSTEM

The Ventura River watershed, with a drainage area of about 585 km^2 (226 mi^2), has its headwaters in the Santa Ynez Mountains north of the coastal City of San Buenaventura, California (U.S. Army Corps of Engineers, 1971). (Figure 2) The Ventura River system may be divided into three distinct zones (Schumm, 1977).

Zone 1 is characterized by the production of water and sediment and comprises the mountainous areas of the basin. The major tributaries include Matilija Creek with a drainage area of 141 km^2 (55 mi^2), North Fork Matilija Creek with a drainage area of 40 km^2 (16 mi^2), and San Antonio Creek with a drainage area of 133 km^2 (51 mi^2). The Matilija reservoir on Matilija Creek with a storage capacity of less than $1.2 \times 10^6 m^3$ (1000 acre feet), and the Robles Diversion on the upper Ventura River with a maximum capacity of 14 cms (500 cfs), play only a minor role in the control of major storm runoff. Coyote Creek and Santa Ana Creek, with a combined drainage area of 106 km^2 (41 mi^2), are also in zone 1 but the storm water runoff and sediment from this portion of the system are now partially controlled by Lake Casitas with a storage capacity of 31.3×10^7 m^3 (254,000 acre feet) (U.S. Geological Survey, 1970; California Department of Water Resources, 1983). Zone 2 of the Ventura River includes the main stem downstream from the confluence of Matilija Creek and the North Fork of Matilija Creek to the delta of the river at the Pacific Ocean. This zone is characterized by storage and transport of sediment along a broad floodplain with a short constriction below the confluence of Coyote Creek. Zone 3 of the Ventura River is characterized by shifting channels and deposition characteristic of a deltaic environment. The delta of the Ventura River is the result of the interaction between river processes and coastal processes, and is an arcuate-shaped landform that extends from the Pacific Ocean upstream for approximately 1.6 km (1 mi) and stretches along the coast approximately 3.2 km (2 mi).

Geologic evidence suggests that the Ventura River has slowly migrated to the west during the past 100,000 years, leaving a series of stream terraces which mark former locations of the channel and floodplain (Putnam, 1942; Rockwell et al, 1984). The river from Meiners Oaks downstream crosses numerous active geologic structures and near the City of San Buenaventura crosses the actively growing Ventura Avenue anticline which has had an uplift rate of about 1 cm/yr for the last several hundred thousand years (Rockwell et al, 1988).

The Ventura River is a mixed-load stream. As a result of rapid tectonic uplift it has the highest suspended and bedload yield per unit area of watershed in Southern California (Brownlie and Taylor, 1981; Taylor, 1983). Deltas of such rivers are characterized by channels that cannot be maintained in one location for extended periods. The land form is produced by a shifting locus of deposition similar to that which occurs on alluvial fans in inland areas; the arcuate shape testifies to this tendency of channels to migrate (Bull, 1968; Graf, 1988; Schumm, 1977). The multiple channels of the deltaic system, called distributary channels, are characteristically active for a period of time, then may become inactive, and then become active again at a later date. Early mapping of the Ventura River delta (Figure 3A) shows the main stem of the river near its present position, with numerous distributary channels. Approximately 0.4 km (0.25 mi) to the west of the main river channel is a prominent distributary channel identified over 100 years ago by the Southern Pacific Transportation Corporation as the "North Fork" of the Ventura River and is today known as the "Second Mouth" of the Ventura River.

The City of San Buenaventura is protected from natural flooding of the Ventura River by a rock levee constructed on the east side of the main river channel by the U.S. Army Corps of Engineers in 1948;

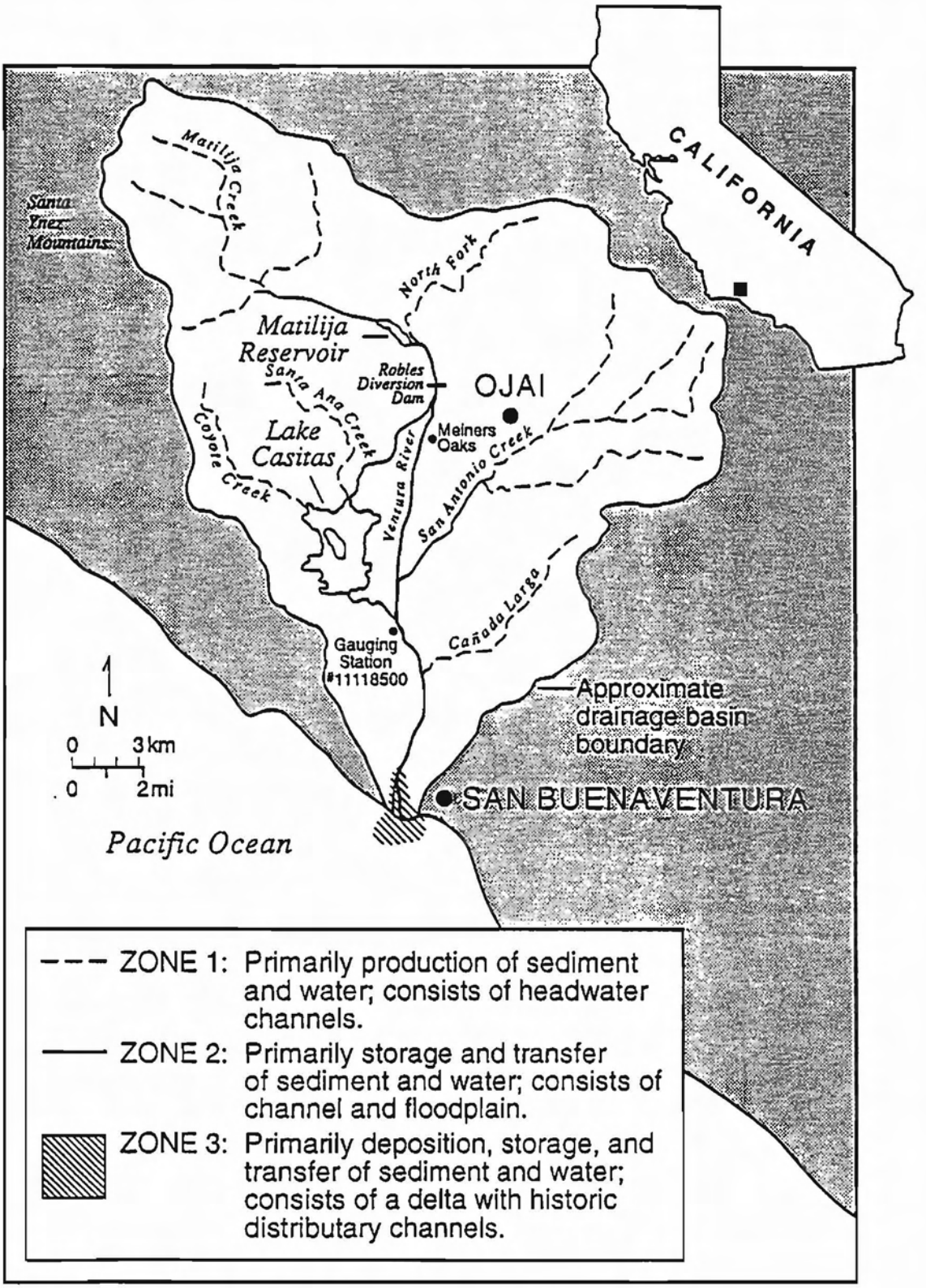

Figure 2. Ventura River watershed with zones of fluvial activity.

the levee is designed to contain a Standard Project Flood, which was originally rated at 4,248 cms (150,000 cfs), but has since been revised downward to 2,521 cms (89,000 cfs), primarily as a result of the construction of Lake Casitas (U.S. Army Corps of Engineers, 1967; Ventura County Public Works Agency 1984c). The levee effectively precludes development of distributary channels to the east of the present position of the main river channel. While this protects the City from flooding, it results in greater flooding activity in the main river channel and distributaries to the west. Figures 3B and 3C show the delta environment in 1945 and 1989. A major distributary channel to the west is still evident on both maps, and the recreational vehicle park constructed in 1987 is situated directly across the distributary channel.

VENTURA RIVER FLOODING: RECENT HISTORY

Coastal rivers in Southern California are characterized by extreme variability of flow as a result of the extreme variability in seasonal precipitation which is characteristic of the region's Mediterranean climate. The mean annual rainfall in the Ventura River drainage basin varies from approximately 6.6 cm (16 inches) near the river's mouth at the Pacific Ocean to over 16 cm (40 inches) in the mountainous headwaters. The concept of mean annual precipitation, however, has little significance in Southern California where the variability from the mean may be several hundred percent for a given year (Goodridge, 1982; Weaver, 1962). As a result, Southern California rivers tend to be "flashy", characterized by a sudden rise in discharge and "flash flooding". In regions such as the Eastern United States or Great Britain it is not uncommon for a 20-year flood to have a discharge of only 1 or 2 times the mean annual flood (the mean annual flood is a flood with a recurrence interval of approximately 2.33 years). However, for rivers in Southern California the discharge of the 20-year flood may be many times that of the mean annual event. For example, the discharge of a 20-year flood in the Ventura River is approximately 10 times that of the mean annual event. As a result, a 20-year flood in the Ventura River has the competency and capacity to cause greater scour and deposition than do floods of a similar recurrence interval that occur in Great Britain, where little change in the channel and floodplain occur (Lewin, 1981).

The Ventura River has a long history of flooding (U.S. Army Corps of Engineers, 1971, 1974a, 1974b; Ventura County Public Works Agency, 1983, 1990). Since 1938 there have been nine major floods (Table 1), the largest of which occurred in February 1978 with a peak discharge of 1,801 cms (63,600 cfs). This flow has an estimated recurrence interval of approximately 55 years.

The February 1992, flood with a discharge of approximately 1,322 cms (46,700 cfs), has a recurrence interval of approximately 22 years. Portions of the distributary channel which runs through the Ventura Beach RV Resort and discharges through the "Second Mouth" of the Ventura River were used to pass flood waters during the 1969, 1978, 1982, and 1992 flood events, an average of once every six years during the previous 25 years.

FEBRUARY 12, 1992 FLOOD

On February 12, 1992 the Ventura River overflowed its main channel several hundred meters above the Main Street Bridge near the apex of the Ventura River delta. The river reoccupied the distributary channel shown on Figures 3A, 3B, and 3C, flowing over the west end of Main Street, directly across the eastern end of the Ventura Beach RV Resort, over U.S. Interstate Highway 101, and into the Pacific Ocean after flowing beneath the Southern Pacific Transportation Corporation railroad bridge built over the "North Fork" or "Second Mouth" of the Ventura River.

The precise distribution of floodwaters which left the main channel of the Ventura River was influenced by developments on

Table 1. (A) Major Floods and Approximate Recurrence Intervals on the Ventura River Between 1938-1992; (B) Approximate Peak Discharge Levels for 5, 10, 25, 50, 100, and 200 Year Floods.

A.

Date		Peak Discharge* cms	(cfs)	Approximate Recurrence Interval (yrs)**
March	1938	1,110	(39,200)	14
January	1943	991	(35,000)	13
January	1952	835	(29,500)	9
January	1969	1,642	(58,000)	40
February	1969	1,133	(40,000)	15
February	1978	1,801	(63,600)	55
February	1980	1,073	(37,900)	14
March	1983	765	(27,000)	8
February	1992	1,322	(46,700)	22

B.

Peak Discharge* cms	(cfs)	Approximate Recurrence Interval (yrs)**
504	(17,816)	5
867	(30,622)	10
1,383	(48,832)	25
1,766	(62,364)	50
2,129	(75,184)	100
2,467	(87,105)	200

* Peak discharges are for the gaging station (#11118500) located about 2 km upstream from Canada Larga (Figure 2), with the exception of the February 1992 flood estimate, which represents peak flow to the ocean. Assuming that Canada Larga can carry several hundred cms during a 100-year flood, we estimate that the 100-year flood downstream at the delta to be about 2,265 cms (80,000 cfs).

** Caculated using the log-Pearson Type III distribution (United States Water Resources Council, 1981) and annual data (1933-1992) from the Federal Emergency Management Agency, 1985; the U.S. Geological Survey, 1987-1990, 1991-1992; and the Ventura County Public Works Agency, 1992d.

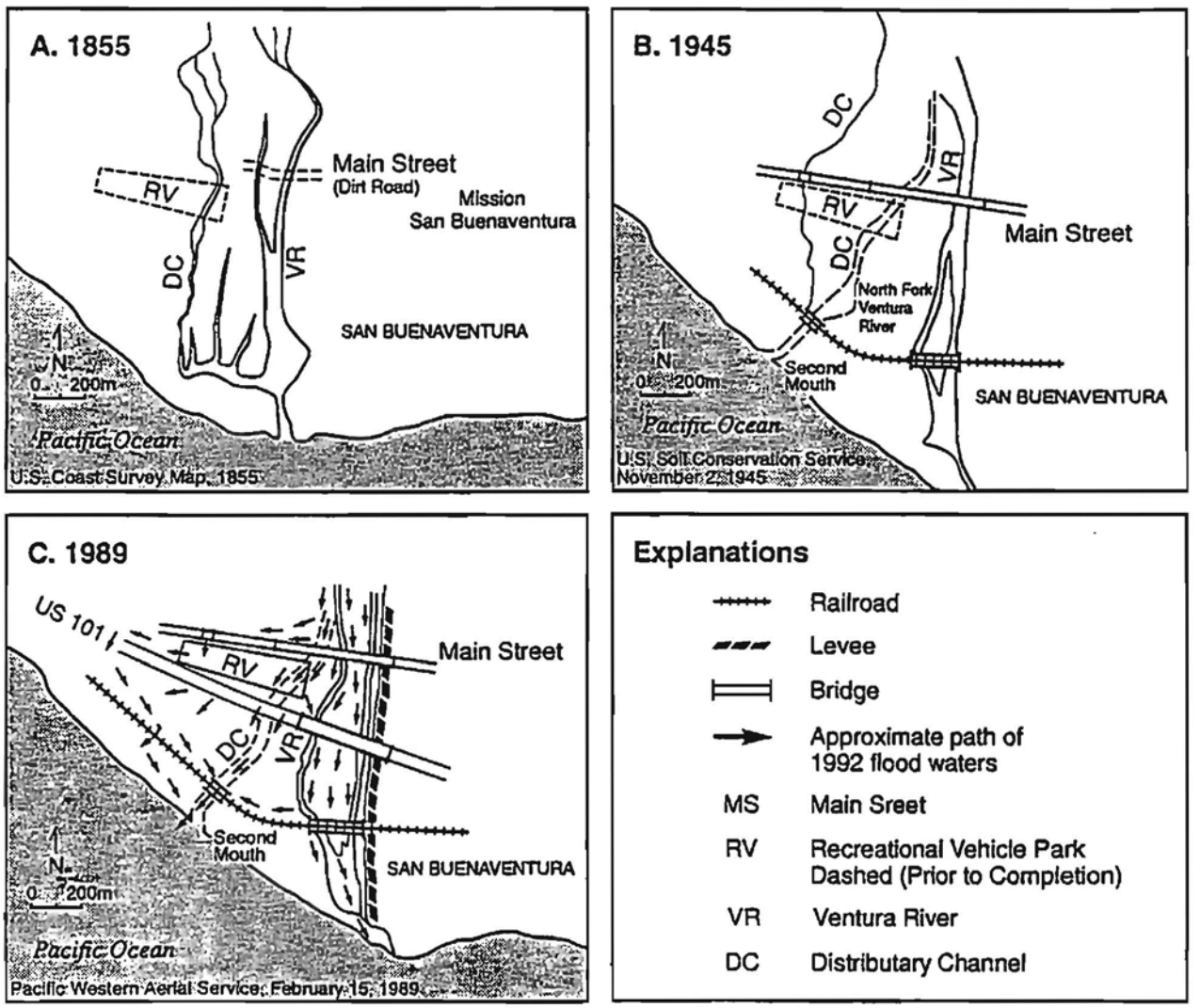

Figure 3. Historical and contemporary distributary channels on the Ventura River Delta.

the delta. While the major portion of the flood flows were directed down the main channel to the immediate east of the recreational vehicle park, a row of Eucalyptus trees planted as an agricultural wind break and an associated chain link fence constructed along the north side of the Main Street Bridge shunted shallow flood waters to the west and under a secondary bridge constructed in 1932 over a smaller distributary channel. This obstruction increased the backwater effect on the adjacent agricultural fields, but did not influence the breakout which occurred several hundred meters upstream and prior to the development of a backwater effect. Further, the construction of a concrete berm following the 1969 floods along the north side of the U.S. Interstate Highway 101 "fairweather crossing" by the California Department of Transportation acted as a dam, and as a result, increased the backwater effect upstream on the site of the recreational vehicle park (California Department of Transportation, 1981; Ventura County Public Works Agency, 1984a, 1984b). The increased backwater effect reduced flow velocity, but increased water depths in the recreational vehicle park, thus facilitating the flotation of recreational vehicles.

The flood on February 12 reached an estimated peak discharge of 1,322 cms (46,700 cfs) at approximately 10 a.m (Ventura County Public Works Agency, 1992a). The flood reportedly caused $1,000,000 in damages to the Ventura Beach RV Resort and approximately $40,000 in damages to the Emma Wood State Beach - Ventura River Group Camp (Kelley, 1992b; W. Deleu, California Department of Parks and Recreation, personal communication, 1992). The City of San Buenaventura expended an estimated $28,000 in immediate emergency services, and an additional $24,000 in post-flood clean-up and repairs. However, the bulk of the local emergency services (largely unreimbursable) were incurred by the Ventura County Sheriff and Fire Departments for police and helicopter rescue services (City of San Buenaventura, 1992b, 1992f; Kish, 1992).

At the time the Ventura River overflowed its main channel and reoccupied the western distributary, the recreational vehicle park was occupied by about 100 individuals in recreational vehicles. Many individuals had been living in their vehicles for extended periods, in violation of the conditions of the City's permit which limited the stay of the occupants to ensure the facility was used as a visitor-serving facility; as result, several vehicles had flat tires or were otherwise not in a condition to evacuate quickly (San Buenaventura, 1992e, 1992f, 1992g). The Emma Wood State Beach-Ventura River Group Camp was largely vacant because of the preceding several days of rain, and the few remaining campers had been evacuated earlier in the morning. The flows inundating the Ventura Beach RV Resort were of sufficient depth and velocity to pick up several of the larger recreational vehicles and carry them about 1 km to the ocean. Approximately 20 individuals were airlifted by helicopter from the tops of vehicles in the recreational vehicle park, and 10 stranded individuals from along the river channel. One homeless individual was drowned (Gruntfest and Taft, 1992; Kelley, 1992a; Reed, 1992; Reynolds, 1992; Ventura County Sheriffs Department, 1992).

The bulk of the rain fell early in the morning of February 12th; the river responded quickly with flow rising from less than 3 cms (100 cfs) to 1,322 cms (46,700 cfs) within about three hours. Although flash-flood warnings were issued the previous day, the very rapid response of the river made it difficult for floodplain evacuation to be effective (Fox Weather, 1992a, 1992b). The flood flows reached their peak during the mid-morning after the quickly moving storm center had passed, providing good visibility and making aerial rescue operations possible. Figure 4 shows the relationship between rainfall and the river flow on February 11 and 12, 1992.

The basic branching pattern of distributaries in the Ventura River delta had been previously recognized in the design of railroad and highway bridges constructed

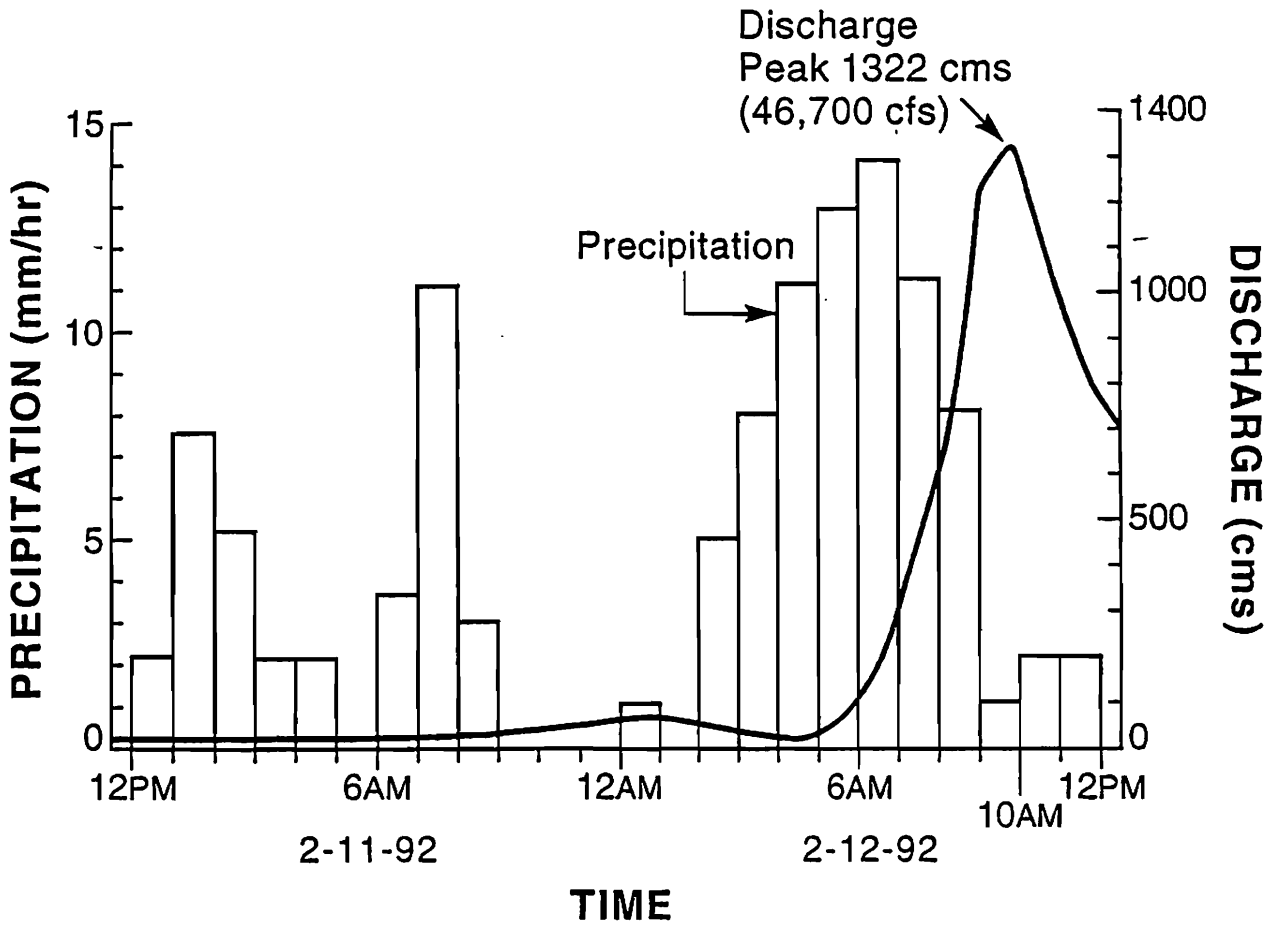

Figure 4. Rainfall and river flow during the February 11-12, 1992 flood on the Ventura River. (Ventura County Public Works Agency, 1992a.)

earlier in the century, as well as in the more recently constructed Emma Wood State Beach - Ventura River Group Camp, but was not recognized, or ignored in the development of the Ventura Beach RV Resort.

The Southern Pacific Transportation Corporation acknowledged that the western distributary channel, referred to as the "North Fork" of the Ventura River, was still active, and built a bridge in 1914 with two 46 m (150 ft) clear spans - adequate to allow passage of flood flows. As noted, this bridge was utilized in 1969, 1978, 1982, and 1992 to pass flood flows. (A portion of this bridge was removed in 1971.) When the original U.S. Interstate Highway 101 bridge (now Main Street) was constructed across the Ventura River in 1932, the design of the structure reflected the flood hazard posed by the distributary channels and provided a bridge which spanned the main river channel and distributary, as well as a smaller bridge further west to accommodate a minor distributary. (See Figure 3B.)

The current U.S. Interstate Highway 101 bridge was constructed in 1964 over the main river channel and included a large swale termed a "fairweather crossing" across the western distributary channel, as well as several box culverts further to the west. This 366 m (1200 foot) section of U.S. Interstate Highway 101 was originally designed to be inundated only during a 100-year flood, estimated by the California Department of Transportation at 2,407 cms (85,000 cfs) at the time of construction. As noted above, following the 1969 floods (estimated at less than a 50-year flood) which overtopped the "fairweather crossing", a small concrete berm (also referred to as a weir) was added along the north side of the roadway for the purpose of providing protection against flood flows (California Department of Transportation, 1981; Ventura County Public Works Agency, 1984a, 1984b). The 100-year flood (2,407 cms) projected by the California Department of Transportation is higher than the 2,129 cms we calculate using the log-Pearson type III distribution for the annual data (1933-1992) from the gauging station located about 2 km upstream of Cañada Larga (Figure 2). Due to the potential contribution of Cañada Larga, we estimate the discharge of the 100-year flood at the delta near the ocean to be about 2,265 cms (80,000 cfs). Significantly, the "fairweather" crossing" was inundated during the January 1969 flood with a discharge of 1,642 cms (58,000 cfs) and a recurrence interval of 40 years, and after the construction of the berm, during the 1992 flood with a discharge of 1,322 cms (46,700 cfs) and a recurrence interval of only 22 years.

Emma Wood State Beach-Ventura River Group Camp was constructed between U.S. Interstate Highway 101 and the Southern Pacific Transportation Corporation railroad line in 1981. Originally the plan included a 550 space recreational vehicle park within the flood easement of the Ventura County Flood Control District (California Department of Parks and Recreation, 1970). This element of the park was eliminated after questions were raised by the City of San Buenaventura and others regarding the placement of substantial improvements within the floodway; as a result, all park facilities were placed to the west of the Ventura County Flood Control District flood control easement (California Coastal Commission, 1978a, 1978b). A proposal to restore several acres of wetlands at the "Second Mouth" of the Ventura River as part of the Emma Wood State Beach improvements was also abandoned when a flood analysis performed by the U.S. Army Corps of Engineers indicated that the area would be subjected to inundation from a 10-year flood estimated by the Corps at 963 cms (34,000 cfs) (California Coastal Commission, 1978c; U.S. Army Corps of Engineers, 1978; California Department of Parks and Recreation, 1979).

The western distributary channels of the Ventura River delta have been irregularly, but relatively frequently used during major floods. Nevertheless, in 1987 the Ventura Beach RV Resort was constructed with one-third of the eastern end of the facility sited directly across the

Table 2. Critical Decisions Leading to the Development of the Ventura Beach RV Resort Across a Distributary Channel of the Ventura River Delta.

1968	Site of future Ventura Beach RV Resort annexed to the City of San Buenaventura;
1972	Site of future Ventura Beach RV Resort acquired for commercial development;
1975	Owner develops options for commercial use of the site of future Ventura Beach RV resort;
1978	Site stripped of secondary growth native riparian and chaparral vegetation and commercial ornamental flower-growing operation commenced; City approached with proposal to develop the site with recreational vehicle resort;
1981	Owner applies to the City of change of land use/zone designation from agriculture to commercial recreation;
1981	California Regional Coastal Commission approved City's Local Coastal Program (not including future RV site); California State Coastal Commission certified City's Local Coastal Program (not including future RV site);
1981	California State Coastal Commission certifies City Local Coastal Program with recreational land use designations and development standards for future RV site;
1985	San Buenaventura City Planning Commission certifies Final Environmental Impact Report (EIR) and approves 144 space recreational vehicle resort for site. Environmental groups appeal decision of City Planning Commission on 144 space recreational vehicle resort;
1985	San Buenaventura City Council rejects appeal of Planning Commission decision to approve recreational vehicle resort. Environmental groups appeal decision of San Buenaventura City Council to the California State Coastal Commission;
1985	California State Coastal Commission rejects appeal of San Buenaventura City Council decision to approve recreational vehicle resort;
1986	San Buenaventura City Council adopts floodplain ordinance which prohibits new recreational vehicle park uses within designated 100 year floodplain;
1987	Construction of Ventura Beach RV Resort completed;
1992	Ventura River inundates Ventura Beach RV Resort; San Buenaventura City Council votes to allow continuation of Ventura Beach RV Resort with no changes to original permit.

distributary channel spanned by the Main Street Bridge, the U.S. Interstate Highway 101 "fairweather" crossing and the Southern Pacific Transportation Corporation's railroad bridge over the "Second Mouth" of the Ventura River. The western third of the facility was sited across a remnant of a smaller distributary which was mistakenly characterized as a drainage channel carrying only local runoff.

The remainder of this paper focuses upon the series of local and State decisions that allowed the recreational vehicle park to be constructed in what many individuals and agencies considered to be a hazardous location and the limitations of the flood-modeling methodologies and insurance categories used to assess the flood potential of the site.

LAND USE HISTORY

Prior to its annexation to the City of San Buenaventura in 1968, the 7.3 ha (18 acre) site of the future Ventura Beach RV Resort, had been dry-farmed with various row crops through the early 1950's. The parcel had been fallow since the mid 1950's, and immediately prior to its purchase by the current owner in 1972, was covered with a mix of native coastal sage and riparian vegetation as a result of secondary plant succession. The parcel, however, remained zoned for agriculture, and under the City of San Buenaventura's Flood Plain Ordinance was not developable with structures. Table 2 lists the critical decisions that eventually led to the development of the Ventura Beach RV Resort.

In 1975 the current owner began developing options for the commercial use of the property which 12 years later culminated in the construction of the Ventura Beach RV Resort. Because the parcel lies within California's Coastal Zone (created with the passage of Proposition 20 in 1973) and is subject to the land-use polices of the California Coastal Act of 1976, clearing of the site's secondary growth of native chaparral and riparian vegetation to accommodate a non-agricultural commercial use posed potential conflicts with the Act's land-use policies. The Coastal Act contains specific policies providing for protection of environmentally sensitive habitat, including native plant communities, and the siting of development in areas subject to floods or other natural hazards (e.g., §30240, §30253). Removal of native vegetation for agricultural purposes, however, was excluded from the definition of development (See §30106) in the Coastal Act and therefore not subject to the permit requirements of the California Coastal Commission (California Legislature, 1976). Accordingly, in late 1978 the owner stripped the entire portion of the site outside the main channel of the river of all native vegetation and initiated an ornamental flower growing operation. At the same time the property owner approached the City of San Buenaventura with a proposal to develop a recreational vehicle park on the site (San Buenaventura, 1978a, 1978b).

The potential for flooding of the site was acknowledged from the outset of the planning for the Ventura Beach RV Resort, though the exact nature and extent of the flooding was not clearly understood. Consequently, in August of 1978 the City of San Buenaventura notified the Ventura County Flood Control District (which controls a flood easement across the eastern half of the property) of the owner's intention to develop a recreational vehicle park and requested the District's review and comments (San Buenaventura, 1978a). The District responded with a letter expressing concern about the flood hazards associated with the site, and indicating their opposition to the project. The District noted that the entire site was located within the floodplain and warned that "Flooding of the site could occur rapidly, thereby trapping users on the floodplain with no escape." The District also suggested, however, that recreational uses of floodplain areas are generally compatible with flood-hazard concerns, and recommended that if the applicant pursued the proposal, two conditions be applied to any permit for the development: (1) "No one should be permitted within the Flood Control District's easement.", and (2) "An adequate warning system should be

established that would lead to safe evacuation of the site." The District did not indicate what elements comprised an "adequate warning system": for example, how much time would be needed in advance of an inundating flood flow to evacuate the facility; how projections of potential flooding would be made; or who would be responsible for providing the necessary flood warning (Ventura County Public Works Agency, 1978).

While conducting the flower-growing operation, the owner applied to the City for a land use/zone change from agriculture to recreation in 1980. The City granted the land use/zone change without preparing an Environmental Impact Report (EIR) pursuant to the California Environmental Quality Act (CEQA), thereby committing the City to a more intense use of the site without having the benefit of an analysis of the direct and indirect impacts associated with a more intense, non-agricultural of the site. The City, however, but was unable to process the necessary Coastal Development Permit for the proposed commercial recreational vehicle resort until the land use/zone change and related development policies were certified as part of the City's Local Coastal Program (LCP) mandated by the California Coastal Act of 1976.

In December of 1980, the City submitted its proposed Local Coastal Program Land Use Plan (LCP/LUP) to the South Central Coast Regional Coastal Commission for approval. The plan included a recreational designation for the proposed recreational vehicle site, along with specific development policies dealing with flood hazards and the protection of the environmentally sensitive habitat which persisted on the eastern portion of the site. Because of the flooding potential on the site and the potential impacts to environmentally sensitive habitat issues, however, the Regional Coastal Commission, and subsequently the State Coastal Commission, initially refused to certify a recreational land use designation and set of development policies for the site (California Coastal Commission, 1981a, 1981b).

Potential flooding was a major issue at several hearings held by the Regional and State Coastal Commission's on the City's LCP/LUP between 1981 and 1984. The Commissions' planning staffs noted that the site of the proposed recreational vehicle park was situated on the delta of the Ventura River which contained several distributary channels, and had been subjected to repeated flooding, most recently in 1969 and 1978. The Commssions' planning staffs initially recommended against the recreational land use designation. (California Coastal Commission, 1981c) However, the project proponent's engineering consultant contended that a recent survey revealed there were "no defined distributaries meandering across the river delta since the construction of man-made improvements such as the freeway and Main Street." (Hawks & Associates, 1981b)

Furthermore, in a follow-up letter of October 21, 1981, written in response to the Commission staff's request for additional information, the Ventura County Flood Control District moderated its objection to the development of the site, and in particular dropped its objection to allowing individuals in the Flood Control District's easement; the District also reiterated its contention that "recreational uses of the floodplain are basically compatible with the [flood] hazard, subject to the condition that high value structures be protected either by elevation or by flood-proofing" (Ventura County Public Works Agency, 1981).

The District's analysis of the site's flooding potential relied on the Federal Emergency Management Agency (FEMA) National Flood Insurance Act insurance program to define acceptable levels of risk from future flooding. The FEMA program in turn relies on the U.S. Army Corps of Engineers HEC-2 flood-modeling methodology to determine flood elevations for mapping purposes. As discussed below, this methodology assumes a fixed river channel which limits its usefulness in many situations (U.S. Army Corps of Engineers, 1982). Further, the categories of

"floodway' and "floodway fringe" used by FEMA to delineate flood hazardous areas do not provide a realistic picture of potential flood patterns for rivers with mobile channels, or deltas with active distributaries. Nevertheless, both terms were used throughout the planning and decision making process to designate areas of the Ventura Beach RV Resort that would experience projected levels of flooding under specific levels of flow (California Coastal Commission, 1981a, 1981b; ENVICOM, 1984; Federal Emergency Management Agency, 1986a, 1986b; Hawks & Associates, 1982a, 1982b;). See Figure 5 for the application of these terms to the site of the Ventura Beach RV Resort.

The Regional and State Coastal Commissions ultimately deferred to the flood hazard analysis presented by the project proponent and to the revised evaluation prepared by the Ventura County Flood Control District (Ventura County Public Works Agency, 1981). Following several public hearings on the City's proposal for the site the State Coastal Commission finally certified the City's Local Coastal Program Land Use Plan (LCP/LUP) in December 1981. The certified LCP/LUP allowed recreational uses, including a recreational vehicle resort, on the project site; in addition, it established a number of development polices to address both environmentally sensitive habitat and flooding issues. The LCP/LUP also included general policies regarding development in all floodplains within the City's Coastal Zone. These policies allowed development in the designated "floodway" providing that such development did not reduce the cross-sectional area of the main channel, and the so called "overbank" areas, consistent with FEMA regulations. However, the policies which applied specifically to the Ventura Beach RV Resort site, also provided that "no permanent improvements (above grade improvements) would be allowed" in the designated "floodway" (California Coastal Commission, 1981a, 1981b, 1983; San Buenaventura, 1982).

Following the California Coastal Commission's certification of the City's LCP and the transfer of coastal permitting authority to the City, the property owner applied to the City for a Coastal Development and Development Plan Permit to construct a 144 space recreational vehicle resort on a 4.9 ha (12 acre) portion of the 7.3 ha (18 acre) site. The City determined that the project had the potential to adversely impact the environment and required the preparation of an EIR pursuant to the CEQA (ENVICOM, 1984). The flood-hazard analysis in the EIR relied upon a flooding analysis which used the HEC-2 methodology developed by the U.S. Army Corps of Engineers. As noted, this model for predicting the areal extent of flooding under a given magnitude of flow (expressed as a frequency of recurrence) assumes a stable cross-sectional channel area, and has limited applicability to watercourses with highly mobile channels (i.e., scour and/or fill during flow events) and distributaries such as are present on the delta of the Ventura River. Figure 6 illustrates the relative instability of the Ventura River channel based on the relationship between channel slope and bankful discharge developed by Leopold, et al.

On January 8, 1985, over the recommendation of denial of the project by the San Buenaventura City Planning staff, the City Planning Commission approved the EIR and a Coastal Development Permit in conjunction with a Planned Development Permit for a 144 space recreational vehicle resort on the site. Because the flood issue was perceived as a technical issue beyond the expertise of the planning staff, the formal basis for the recommendation for denial did not include the potential flood hazards associated with the site. Nevertheless, the Planning Commission's approval included several conditions intended to mitigate impacts from potential flooding identified in the EIR to a level of insignificance. These included modification of an existing distributary (characterized as a local drainage channel) across the western portion of the parcel to carry a 100-year flow; prohibition of grading in the designated floodway; and implementation of a flood-warning system. Significantly, the Planning Commission did not prohibit

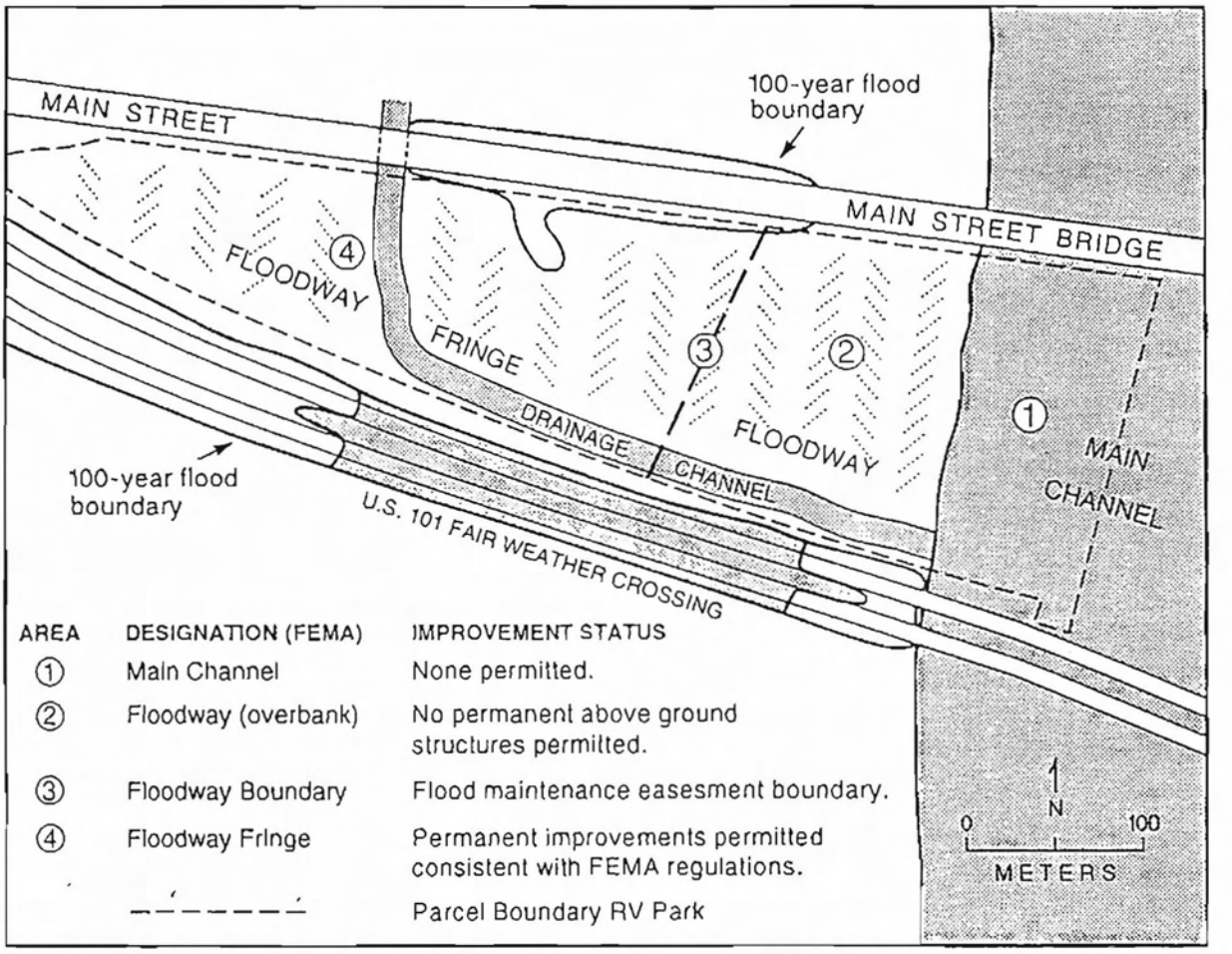

Figure 5. Federal Emergency Management Agency (FEMA) floodplain designations applied to the Site of the Ventura River Beach R Resort. Adapted from ENVICOM Corporation, 1984, and FEMA, 1986a.

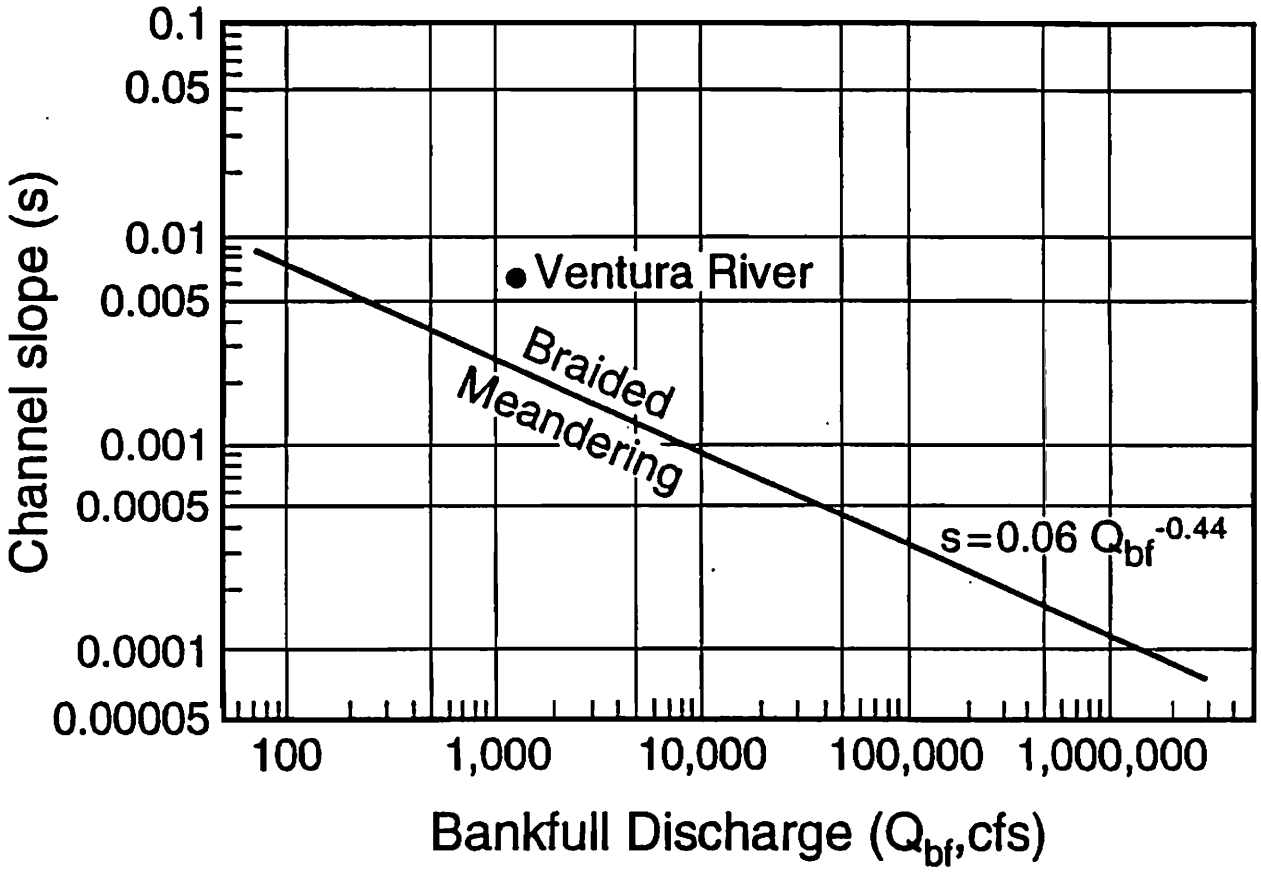

Figure 6. Threshold slope separating rivers with unstable braided channels from stable meandering channels. Adapted from Leopold, Wolman, and Miller, 1964.

the use of the floodway by individuals as originally stipulated by the Ventura County Flood Control District, or specify the exact nature of the flood warning system (San Buenaventura, 1985a).

The San Buenaventura City Planning Commission decision was appealed by several environmental organizations to the City Council. Again, because the flooding issue had been framed in technical engineering terms and had been resolved to the satisfaction of flood control professionals, the formal basis of the appeal did not rest on the potential flood hazards of the site. Instead, the appeal addressed more traditional land use issues, including the allowable uses in the buffer area adjacent to the main channel of the Ventura River, landscaping along U.S. Interstate Highway 101, hazards associated with bicycle and pedestrian traffic, and the density of the development (Audubon Society, 1985). On March 5, 1985, again over the recommendation of the City Planning staff, the San Buenaventura City Council voted to deny the appeal and uphold the Planning Commission's original approval of the proposed recreational vehicle park. However, in further recognition of the flood hazards associated with the site, the City Council added a condition which required the applicant to enter into an agreement with the City in which the applicant acknowledged the flood hazards associated with the project site, agreed to assume all risk, and to hold the City harmless from any liability for damages which could result from flooding (San Buenaventura, 1985b; Hubbard, 1987).

Following the City's final approval, the project was appealed by project opponents to the California Coastal Commission which had retained appeal authority over the eastern-most portion of the project which lay in the designated "floodway" adjacent to the main channel of the Ventura River. The appeal was based upon inconsistencies with the provisions of the City's certified LCP, including impacts to the adjacent Emma Wood State Beach, inadequate landscaping, inappropriate density, potential impacts to environmentally sensitive habitats of the Ventura River, and alteration of landforms for site preparation and flood control (Environmental Coalition of Ventura County, 1985). The Coastal Commission staff recommended that the Commission find that the appeal raised no substantial issue with respect to the project's consistency with the City's certified LCP and the Commission concurred with the staff's recommendation (California Coastal Commission, 1985). While the project was the subject of several more hearings at the local level for minor amendments to the originally approved plan, the planning and public review process had, after almost 12 years, come to an end. The applicant commenced construction of the facility and completed the project in time for the beginning of the 1988 summer season. The facility was in operation for only four years before being struck by the flood of February 12, 1992.

DISCUSSION & CONCLUSIONS

The staffs of the Ventura County Flood Control District, City of San Buenaventura, and the California Coastal Commission initially recommended against development of a recreational vehicle park on the Ventura River delta on the grounds that it was subject to severe flood hazards. Similar concerns were also raised by the U.S. Army Corps of Engineers, private individuals and environmental groups in numerous public hearings. In the face of strong counter-arguments advanced by private flood control professionals, and the moderation of the Ventura County Flood Control District's initial opposition, however, these flood hazard concerns were overridden.

Arguments in favor of the Ventura Beach RV Resort centered around its economic and visitor-serving potential (Kelley, 1992). The project proponents asserted that it would contribute approximately $100,000 a year to the City of San Buenaventura's economy and enhance coastal access - a major goal of the California Coastal Act. Actual revenues generated by the park amounted to

$159,462 over the four year period from 1988 through 1992, an annual average of $40,000 per year, or less than half of the annual projected revenues (San Buenaventura, 1992a). A portion of these revenues were subsequently offset when the City expended approximately $28,000 on immediate emergency rescue, and an additional sum (only partially reimbursable) on post-flood clean-up and repair (San Buenaventura, 1992b, 1992f). Regarding the provision of additional coastal access, it is significant that the California Coastal Commission had previously limited the size of the facilities at the adjacent Emma Wood State Beach-Ventura River Group Camp in order to protect the area's environmentally sensitive habitats, including wetlands, coastal dunes, and intertidal cobble fields (California Coastal Commission, 1978a, 1978b). Furthermore, State park records indicate that the day-use parking facilities at the Emma Wood State Beach-Ventura Group Camp have been rarely used to capacity, and that the Ventura Beach RV Resort has not been used as a regular staging area to gain access to the adjacent beach (California Department of Parks and Recreation, 1992).

Nevertheless, the project proponents were ultimately successful in persuading City and State decision-makers to allow the site to be used for a high-density recreational vehicle park. An independent flood evaluation funded by the developer supported the contention that flooding was not likely to be a major problem at the site, or could be mitigated with proper engineering (Hawks & Associates 1981a, 1981b, 1982a, 1982b). All engineering studies to evaluate the site's flood-hazards utilized the standard HEC-2 computer model developed by the U.S. Army Corps of Engineers. As previously noted, the model assumes a constant channel cross-section that remains stable during floods. This assumption is not appropriate for the main stem of the Ventura River or the delta because of the mobility of the channel resulting from sediment transport and avulsion- clogging of the active channel with sediment and diversion of water to alternative distributary channels.

The limitations of the HEC-2 studies were compounded by reliance on the flood hazard categories used by the FEMA and applied to the project site. The FEMA flood insurance program employs the terms "floodway" and "floodway fringe" to characterize flood patterns and flood potential for determining eligibility for flood insurance. The term "floodway" is a technical term used by FEMA to designate a *lateral* area into which a discharge from a 100-year flood can theoretically be compressed without increasing the *vertical* height of the flood flow more than 0.3 m (one ft). This term was not intended to describe those areas which will be inundated only during a 100-year flood. The term "flood fringe" is a technical term used to designate that portion of the natural 100-year floodplain that would be theoretically left dry after compressing the 100-year flood flow into the "floodway". It does not describe that portion of the floodplain which is necessarily less prone to flooding (Federal Emergency Management Agency, 1985b)

Both terms are artificial; neither were intended or purport to describe the natural pattern or extent of flooding, but rather areas into which flood flows may be artificially channeled. They specifically were not intended to describe the pattern of flooding in either braided channels or on deltas with a system of distributary channels such as the Ventura River. The FEMA standards are minimum requirements developed primarily for insurance purposes, and local agencies may adopt stricter regulations. The February 12, 1992 flood underscores the problem of relying exclusively on standard flood-modeling methodologies, and FEMA flood regulations which focus on the 100-year flood rather than on the discharge level where inundation of overbank areas may actually begin. In retrospect, the Ventura County Flood Control District has recognized that stricter requirements are probably justified for the Ventura River delta where a braided channel pattern and a system of

delta distributary channels complicate flood hazard evaluation (J. Weikel, Ventura County Flood Control District, personal communication, 1992).

Fluvial geomorphologists have long recognized the special behavioral characteristics of rivers and streams in arid and semi-arid regions with highly variable discharges. Radical short-term variations in discharge can generate a channel morphology that is suited to high flow, but that is not in equilibrium with subsequent low flows (Schumm and Lichty, 1963). Graf has pointed out (1988) that the radical spatial and temporal changes in channel form which occur abruptly are not accommodated by general mathematical models of channel behavior. Knowledge of prior floods is also critical to an understanding of the channel configuration observed at any given time. Consequently, a statistical summary of floods such as a flood-frequency analysis that does not account for the order of occurrence of floods is likely to be unrealistic and even misleading.

Flooding on alluvial fans or deltas is particularly difficult to predict. Researchers have identified a number of contributing factors. The distributaries formed upon the surface of an alluvial fan by a major flood event are modified and filled in during subsequent smaller flood events. As a result, a subsequent major flood "does not necessarily follow the path of a previous event." (Dawdy, 1979) Another uncertainty results from the variably in the amount of sediment delivered to an alluvial fan by a particular flood event. A sediment rich event will carry more sediment to the apex than the flow can transport across the fan causing channel avulsions. A sediment deficient event will tend to generate erosion in the vicinity of the apex and create a channel which will carry sediment away from the alluvial fan. (Dawdy, 1979; Dawdy and Hill, 1987; Hill and Dawdy, 1987).

As as result of these variables, Dawdy (1979) has argued that the probability with which a flood occurs at the apex of an alluvial fan does not alone determine the probability of a flood or flood depth at any point on an alluvial fan below the apex. The most recently revised FEMA Guidelines have recognized these characteristics of alluvial fans and note that "Below the apex of the fan . . . the channel will occur at random locations at any place on the fan surface; under natural conditions, it is not more likely to follow a preexisting flowpath than it is to follow a new flowpath." (Federal Emergency Management Agency, 1985a) Graf (1988) has also concluded that "Present geomorphological theory does not provide for the calculation of the probability that any particular distributary channel will receive flow. On natural fan surfaces the flood hazard is therefore largely indeterminate." (See also, Cooke 1984; Dawdy, 1984; Dawdy, et al, 1989; Edwards and Thielmann, 1984; Hill, et al, 1989; National Research Council, 1982)

An engineering perspective, such as characterized the flood hazard analysis of the Ventura Beach RV Resort site, is particularly limited in arid and semi-arid regions where rivers are characterized by highly mobile beds and unstable banks that can change configuration during major floods. These behavioral characteristics can limit the usefulness of fixed cross-sectional surveys and the basic assumptions upon which the HEC-2 methodology relies. The inadequacy of the HEC-2 computer modeling was tragically demonstrated when the Ventura Beach RV Resort was inundated with a 1,322 cms (46,700 cfs) flow, while the model, as applied by the owner's engineering consultant, predicted that a majority of the site was above the elevation of a 100+ year flood with an estimated 2,209 cms (78,000 cfs) discharge (Hawks & Associates, 1982a).

A geomorphic perspective, which includes an historical component, can provide additional insight into the possible future behavior of a river system, though predicting the precise timing of such behavior remains an art more than a science. What was ignored, dismissed, or not recognized in the case of the February 1992 flood on the Ventura River was the

history of the river system itself. None of the flood analyses of the river discussed the delta environment in which the Ventura Beach RV Resort was to be situated, or recognized that distributary channels had been active in the recent past. As noted, the consulting flood control engineer for the project reported no defined distributaries on the Ventura River delta. While recent evidence of such distributaries may have been obscured as a result of the intensive manipulation of the land for agricultural and other purposes, historical aerial photographs reveal clearly demarked distributary channels and patterns of riparian vegetation which trace temporarily abandoned distributaries. (See Figures 3A and 3B.)

Conventional (and in this case inadequate) engineering analysis suggested that the Ventura Beach RV Resort site would likely only be flooded by a 100+ year flood, and that in the event of an inundating flood, a flood-warning system would be adequate for evacuation. Both of these assessments proved to be incorrect.

Current Situation

Ironically, the City of San Buenaventura has allowed the Ventura Beach RV Resort to reopen, without even the original flood-warning system provided by the Ventura County Flood Control District in place (San Buenaventura, 1992c, 1992d; Ventura County Public Works Agency, 1992c). The Ventura County Flood Control District is presently working to develop a new flood-warning system for the Ventura Beach RV Resort. Major new objectives and elements under consideration for an improved flood-warning system include (Ventura County Pubic Works Agency, 1992e; Ventura County Sheriff's Department, 1992; J. Weikel, personal communication 1992):

- Improve the Ventura County Flood Control District's existing Flood Warning System by adding an automated self-reporting stream gage on Cañada Larga and refining the National Weather Service forecast model for the Ventura River.

- Ascertain the minimum time necessary to evacuate a fully occupied recreational vehicle resort and utilize a more conservative threshold for issuing flood warnings.

- Install a computer terminal and modem hookup at the recreational vehicle park to receive current Ventura County Flood Control District flood advisories, as well as a radio receiver to receive National Weather Service Flood Warnings.

- Develop an evacuation protocol and install a public address system to enable the management of the recreational vehicle resort to provide clear instructions to occupants in the event of a flood.

- Establish a formal written agreement between the Ventura County Flood Control District and the owners/operators of the recreational vehicle resort which embodies a comprehensive flood detection, warning, and evacuation program.

An improved flood-warning system may provide greater response time than the previous system which allowed only about 45 minutes for evacuation during the February 12, 1992 flood. However, while these provisions may provide additional protection to the users of the Ventura Beach RV Resort, they also underscore the inherent flood-hazards associated with the site. The Ventura County Flood Control District has prudently cautioned against too heavy a reliance on warning systems to reduce risks, noting that the "flood warning is only as good as the data that we get -- any reliance on any kind of forecasting should be very, very carefully considered" (Ventura County Public Works Agency, 1992b).

The residents of the City of San Buenaventura are at a cross-roads concerning the management of the Ventura

River. Currently, the City is developing a management plan for the lower Ventura River that is intended restore and manage the natural resources of the lower river (San Buenaventura, 1990; Wetlands Research Associates, et al 1991). At the same time, it is being pressured to support additional flood control to protect the continuance of the Ventura Beach RV Resort.

The flood on February 12th flood occurred after 5 years of below normal rainfall which prevented the natural annual scouring of the main Ventura River channel; as a consequence, some have suggested that the flooding was the result of riparian vegetation that piled up in several locations causing a backwater effect that facilitated overbank flow and reoccupation of the distributary channel (Hawks & Associates, 1992; Ventura County Sheriffs Department, 1992; Taylor, 1992; U.S. Army Corps of Engineers, 1992b). While some riparian vegetation was dislodged during the flood, and did pile up at a number of locations including bridges and fences, the presence of riparian vegetation can not account for the basic branching behavior of the flows across the Ventura River delta which was exhibited during the February 12, 1992 flood. As noted, the dislodging of vegetation is a natural process by which river channels are cleared of choking vegetation. In the case of the February 12th flood a majority of this vegetation was passed to the ocean during the flood event as evidenced by the considerable vegetative debris which accumulated on local beaches (U.S. Army Corps of Engineers, 1992b). Major debris piles did accumulate on the Main Street, U.S. 101, and Southern Pacific Railroad bridges; however, these structures are all situated several hundred meters below the head of the branching distributary which caused the flooding of the Ventura Beach RV Resort.

Should the Ventura County Flood Control District or other agencies periodically clear the riparian vegetation, important elements of the Ventura River environment (e.g., riparian habitat, pool/riffle channel morphology) will be degraded or lost (Keller, 1976, 1977, 1989). Elimination of periodic discharges through distributaries would also reduce the ability of the Ventura River to maintain historic wetlands which were originally created by and are dependent upon periodic scour to remove the natural build-up of sediment. This process of wetland rejuvenation was demonstrated during the February 12th flood when the reactivated "North Fork" of the Ventura River re-excavated the wetland at the "Second Mouth" of the river which had been almost completely filled in as a result of natural and artificial accumulation of sediments. Further, removal of vegetation would tend to destabilize channel banks by removing root systems which add to the shear strength of the loosely consolidated bank material, rendering channel banks even more likely to erode and shift during smaller floods (Keller and Swanson, 1979).

Radical channelization that would include additional levees or perhaps even concrete lining of the lower Ventura River is another option. This would contain all but the very largest floods and would allow for additional floodplain encroachment. However, there is increasing resistance to radical channelization that transform the Ventura River into a small version of the concrete lined Los Angeles River, extensive sections of which function more like an hydraulic flume than a river system. Additional flood constraints on the west side of the river would also place added stress on the existing Ventura River levee which serves to protect the urbanized portion of the City of San Buenaventura (U.S. Army Corps of Engineers, 1981). Increased flood elevations on the west side of the levee could also adversely affect the operation of a series of storm drains which serve the residential and commercial community on the east side of the Ventura River levee.

Land uses compatible with the dynamic, unpredictable nature of flood flows on the Ventura River delta, and which would not necessitate the modification of the riverine environment for flood protection, include use of the western portion of the site as a summer campground with minimal structural development; returning a portion of the site to agricultural use; and

restoration of historic riparian wetlands and coastal sage scrub habitat. Amortization of the current high-intensity recreational use and public acquisition of the site would create opportunities for uses compatible with both the inherent hazards and resources values of the site and the adjacent lower Ventura River and Ventura River estuary. Such uses would be consistent with the original recommendations of U.S. Army Corps of Engineers as well as the recommendations recently developed by the Federal Interagency Hazard Mitigation Team.

During the initial review of the proposed recreational vehicle park the U.S. Army Corps of Engineers advised that "Passive recreation would be most compatible with the resource values in the floodway. Another acceptable alternative could be restoration of the floodway to natural habitat and allowing camping and/or day use, but no vehicles in selected parts of the floodway. Use should be restricted to the season when no flood hazard exists." (U.S. Army Corps of Engineers, 1981) Following the February 1992 floods in Southern California, the Federal Interagency Hazard Mitigation Team developed similar recommendations for all recreational vehicle parks in floodways: "Floodways should be maintained in a manner that ensures unrestricted downstream movement of water, therefore, development and use of floodways for any recreational purpose should be prohibited. Exceptions are made for open field recreation, trails and other like activities, restricted to day use only, that do not obstruct the water flow during any rainfall and do not experience significant damage." (Federal Emergency Management Agency, 1992).

Future Prospects

If the history of the Ventura River system continues to be ignored or dismissed, the flooding experienced in February 1992 will be repeated. The probability of at least a 22-year flood occurring in the next ten years is relatively high at about 37 percent. The probability of the 1992 flood event reoccurring at least once in the next five years is approximately 21 percent. History reveals that the Ventura River has previously occupied the distributary channel across the Ventura Beach RV Resort, and that it is likely that it will again in the relatively near future.

Finally, the experience of the Ventura Beach RV Resort is not an isolated instance of an unsuccessful effort by consultants, planners, and decision-makers using standard flood-modeling methodologies and flood insurance categories to accurately predict and assess the flood potential on a development site. While proposed development in flood-prone areas in the United States is generally reviewed using accepted flood-modeling methodologies, the total national annual flood-related damages continues to rise (Federal Emergency Management Agency, 1992a; U.S. Army Corps of Engineers, 1992a; U.S. Department of Commerce, 1990). Significantly, the FEMA's Nation-Wide Flood Insurance Program is based upon flooding projections which rely on the same flood-modeling techniques which were utilized to predict and assess the flooding potential on the Ventura Beach RV Resort site.

The Ventura Beach RV Resort experience dramatically illustrates the need for a more critical approach to the application of standard flood-modeling methodologies such as the U.S. Army Corps of Engineers' HEC series. These models have provided a valuable tool for predicting the areal extent of flooding under specified flow conditions for planning, designing, and management purposes. However, where rivers or sections of rivers have highly mobile channels or are characterized by high sediment yields, such models must be used with caution, and preferably supplemented with a fluvial geomorphic analysis which takes into account the historic behavior of the watercourse; this is especially critical for development proposed on alluvial fans or deltas. While the practitioners of flood modeling are cognizant of the model's limitations, those relying on the models to make discretionary decisions may not be fully aware of these limitations. This may be particularly true of land-use planning staffs, as well as appointed or

elected decision-makers who frequently lack sufficient technical training to independently evaluate the models, and who must therefore rely on the judgements of those responsible for developing and applying the flood-prediction models. Failure to fully appreciate the historical dimensions of rivers and streams as well as the limitations of current flood-modeling methodologies, or to adequately inform decision-makers of these dimensions and limitations, invites repetition of the tragedy which struck the Ventura Beach RV Resort.

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REFERENCES CITED

Audubon Society. 1985. Appeal of the Local Coastal Development Permit and Planned Development Permit CDP-46/PD-406, approved by the City of San Buenaventura Planning Commission, to the San Buenaventura City Council, January 16, 1985.

Brownlee, W. R. and B. D. Taylor. 1981. Ventura River Basin. *In:* Sediment Management for Southern California Mountains, Coastal Plains and Shoreline. Part C. Coastal Sediment Delivery by Major Rivers in Southern California. (EQL Report No. 17-C) Environmental Quality Laboratory, California Institute of Technology, Pasadena, California, pp. C26-C58.

Bull, W. B. 1968. Alluvial Fans. Council on Education in the Geological Sciences, American Geological Institute. (Short Reviews -9) Washington, D.C., pp. 101-106

California Legislature. 1976. The California Coastal Act of 1976, as amended (Public Resources Code, Division 20, §30000-30900). Sacramento, California.

California Coastal Commission. 1978a Staff Report and Recommendation on Emma Wood State Beach, Application No. 150-24.

California Coastal Commission. 1978b. Staff Report and Recommendation on Appeal of Regional Commission Decision on Emma Wood State Beach, Appeal No. 25-78.

California Coastal Commission. 1978c. Letter from Eric Metz, Coastal Program Analyst, to Tim Yeh, U.S. Army Corps of Engineers, September 29, 1978.

California Coastal Commission. 1981a. South Central Coast Regional Commission Staff Report on City of San Buenaventura Local Coastal Program Land Use Plan, June 19, 1981.

California Coastal Commission. 1981b. State Commission Staff Report on City of San Buenaventura Local Coastal Program Land Use Plan, November 19, 1981.

California Coastal Commission. 1981c. Transcript of Hearing Before the California Coastal Commission Regarding the City of San Buenaventura Local Coastal Program Land Use Plan (Hubbard Property), December 19, 1981.

California Coastal Commission. 1983. Letter from Philip J. Mees, Chief Planner, South Central Coast District, California Coastal Commission, to Ann Chaney, Planning Division, City of San Buenaventura, September 2, 1983.

California Coastal Commission. 1985. Staff Report on Appeal: Regular Calendar Appeal No. A-4-BVC-85-195, April 8, 1985.

California Department of Parks and Recreation. 1970. Emma Wood State Beach General Development Plan. Drawing No. 12179, November 9, 1970. Sacramento, California.

California Department of Parks and Recreation. 1979. Letter from Richard A. May, Chief Development Division, California Department of Parks and Recreation, to Michael L. Fischer, Executive Director, California Coastal Commission, January 3, 1979.

California Department of Parks and Recreation. 1992. Vehicle Count at Emma Wood State Beach, 1982-1991. Sacramento, California.

California Department of Transportation. 1981. Letter from J. E. Kenan, Senior Transportation Engineer, California Department of Transportation, to Charles Hilsmann, Hawks & Associates, December 7, 1981.

California Department of Water Resources. 1988. Dams Within the Jurisdiction of the State of California. Bulletin No. 17-88. Sacramento, California.

Cooke, R. U. 1984. Geomorphological Hazards in Los Angeles: A Study of Slope and Sediment Problems in a Metropolitan County. Allen & Unwin, London.

Dawdy, D. R. 1979. Flood Frequency Estimates on Alluvial Fans. Journal of Hydraulics Division, American Society of Civil Engineers. 105:1407-1413.

Dawdy, D.R. 1984. Mud Flood, Mudslide and Alluvial Fan Hazards. *In:* Improving the Effectiveness of Floodplain Management in Western State High-Risk Areas: Alluvial Fans, Mudflows, Mud Floods. Workshop, Palm Springs, California, February 15-16, 1984, pp. 39-41.

Dawdy, D. R. and J. C Hill. 1987. Interpretation of FEMA Alluvial Fan Maps for Planning and Regulation. *In:* Realistic Approaches to Better Floodplain Management. Eleventh Annual Conference of the Association of State Floodplain Managers, Seattle, Washington, June 8-13, 1987, pp. 259-262.

Dawdy, D. R., J. C. Hill, and K. C. Hanson. 1989. Implementation of FEMA Guidelines on Alluvial Fans. *In:* Proceedings of the 1989 National Conference on Hydraulic Engineering, New Orleans, Louisiana, August 14-18, 1989, pp. 64-69.

Edwards, K. L. and J. Thielmann. 1984. Alluvial Fans: Novel Flood Challenge. Civil Engineering. November 1984, pp. 66-68.

Environmental Coalition of Ventura County. 1985. Appeal of Environmental Coalition of Ventura County of Local Coastal Development Permit, CDP-46, approved by the San Buenaventura City Council, to the California Coastal Commission, March 19, 1985.

ENVICOM Corporation. 1984. Final Environmental Impact Report Hubbard Recreational Vehicle Park, Ventura, California (EIR #1055, SCH #83122101). Prepared for City of San Buenaventura. Calabasas Park, California.

Federal Emergency Management Agency. 1985a. Flood Insurance Study Guidelines and Specifications for Study Contractors. (September 1985) Federal Insurance Administration. Washington, D.C.

Federal Emergency Management Agency. 1985b. Flood Insurance Study Ventura County, California, Vol. I. (October 1985) Federal Emergency Management Agency. Washington, D.C.

Federal Emergency Management Agency. 1986a. National Flood Insurance Program. Floodway Flood Boundary and Flooway Map, City of San Buenavenutra, California, Ventura County. Panel 5 of 10, Community Panel Number 060419-0005. (September 29, 1986) Federal Emergency Management Agency. Washington, D.C.

Federal Emergency Management Agency. 1986b. National Flood Insurance Program. FIRM, Flood Insurance Rate Map, City of San Buenavenutra, California, Ventura County. Panel 5 of 10, Community Panel Number

060419-0005-B. (September 29, 1986) Federal Emergency Management Agency. Washington, D.C.

Federal Emergency Management Agency. 1989. Flood Insurance Program: Flood Studies and Surveys Historical Statistics. (September 1989) Washington, D.C.

Federal Emergency Management Agency. 1992. Principal Threats Facing Communities and Local Emergency Management Coordinators: A Report to the United States Senate Committee on Appropriations. (April 1992) Washington, D.C.

Fox Weather, Inc. 1992a. Narrative Satellite Rainrate Analysis, 1845 PST, Tuesday, February 11, 1992. Fox Weather Inc. Oxnard, California.

Fox Weather, Inc. 1992b. Weather Forecast for Ventura County Public Works Agency, 0530 PST, Wednesday, February 12, 1992. Fox Weather, Inc. Oxnard, California.

Goodridge, J. D. 1982. Historical Extreme Annual Rainfall Data in California. *In:* Storms, Floods, and Debris Flows in Southern California and Arizona 1978-1980. National Academy Press, Washington, D.C., pp. 54-77.

Graf, W. L. 1988. Definition of Flood Plains Along Arid-Region Rivers. *In:* Flood Geomorphology, Victor R. Baker, R. Craig Kochel and Peter C. Patton (Editors). John Wiley & Sons, New York.

Gruntfest, E. and V. Taft. 1992. What We Can Learn from the February 1992 Floods in Ventura County, California. Quick Response Report #50. Natural Hazards Research and Applications Information Center, University of Colorado. Boulder, Colorado. May 29, 1992.

Hawks & Associates. 1981a. Letter from Chuck Hilsmann to Arnold Hubbard, re: "Local Coastal Program (Hubbard Property)", September 23, 1981.

Hawks & Associates. 1981b. Memorandum from Chuck Hilsmann, Hawks & Associates to Lee Evans, Arnold Hubbard representative, re: "November 9, 1981 California Coastal Commission Staff Report", December 10, 1981.

Hawks & Associates. 1982a. Hydraulic Analysis of the Ventura River in the Vicinity of the Hubbard Property. (June 1982) Prepared for Hubbard Development Company. Hawks & Associates. San Buenaventura, California.

Hawks & Associates. 1982b. Memorandum from Charles Hilsmann to California Coastal Commission re: "Hubbard Property", December 17, 1982.

Hawks & Associates. 1992. Flooding Investigation Report, Ventura Beach RV Resort, Ventura California. (August 1992) Prepared for the Hubbard Trust. San Buenaventura, California.

Hill, J. C. and D. R. Dawdy. 1987. Criteria for Alluvial Fan Management. *In:* Realistic Approaches to Better Floodplain Management, Dante Accurti (Editor). Eleventh Annual Conference of the Association of State Floodplain Managers, Seattle, Washington, June 8-13, 1987, pp. 259-262.

Hill, J. C., D. R. Dawdy, and G. K. Lutes. 1989. Alluvial Fan Management: Maps, Regulations, and Planning. *In:* Proceedings of the Conference of Arid West Floodplain Management, Las Vegas, Nevada, October 19-21, 1988, pp. 181-186.

Hubbard, A. 1987. Agreement between the Arnold Hubbard Trust and the City of San Buenaventura, December 3, 1987. Recorded Official Records County of Ventura, 87-197303.

Keller, E. A. 1976. Channelization: Environmental, Geomorphic, and Engineering Aspects. *In:* Geomorphology and Engineering, D. K. Coates (Editor). Dowden, Hutchinson, and Ross, Inc., Stroudsburg, Pennsylvania, pp. 115-140.

Keller, E. A. 1977. The Fluvial System: Selected Observations *In:* Riparian Forests in California: Their Ecology and Conservation, Anne Sands (Editor). Institute of Ecology, Publication No. 1, University of California, Davis, pp. 39-46.

Keller, E. A. 1989. "Physical Setting" *In:* Ecology of Riparian Habitats of the Southern California Coastal Region: A Community Profile. U.S. Fish and Wildlife Service. Biological Reports 85(7.27), Washington, D.C., pp. 5-19. .

Keller, E. A. and F. Swanson. 1979. Effects of Large Organic Material on Channel Form and Fluvial Processes. Earth Surface Processes 4(4): 361-380.

Kelley, D. 1992a. "RV Dwellers Lose Homes With No Warning", Los Angeles Times, February 13, 1992. Ventura County Edition, pp. Bl, B4.

Kelley, D. 1992b. "Planners Cited Flooding Risks Before RV Park Won Approval", Los Angeles Times, February 23, 1992. Ventura County Edition, pp. B1, B9.

Kish, A.. 1992. Memorandum from Andrew Kish, Accountant, County of Ventura Sheriff's Department, to Steve Offerman, Administrative Assistant, Ventura County Board of Supervisors, re: "R.V. Park Police Services, Flood 1992", May 20, 1992.

Lewin, J. 1981. Contemporary Erosion and Sedimentation. *In:* British Rivers, J. Lewin (Editor). George Allen & Unwin, London, pp. 35-58.

Leopold, L. B., M. G. Wolman, and J. P. Miller. 1964. Fluvial Processes in Geomorphology. W. H. Freeman and Co, San Francisco.

National Research Council. 1992. Storms, Floods, and Debris Flows in Southern California and Arizona, 1978 and 1980. National Academy Press, Washington, D.C.

Putnum, W. C. 1942. Geomorphology of the Ventura Region, California. Geological Society of America Bulletin 53: 691-754.

Reed, M. 1992. "Killer Floods Ravage Ventura", Los Angeles Times, February 13, 1992. Ventura County Edition, pp. A1, A4.

Reynolds, C. 1992. "City Aware of Potential for Flood at Trailer Park", Los Angeles Times, February 13, 1992. Ventura County Edition, pp. B1, B4.

Rockwell, T. K., E. A. Keller, Clark, M. N. Clark, and D. L. Johnson. 1984. Chronology and Rates of Faulting of Ventura River Terraces, California. Geological Society of America Bulletin 91:1466-1474.

Rockwell, T. K., E. A. Keller, and G. R. Embroff. 1988. Quaternary Rate of Folding of the Ventura River Anticline, Western Transverse Ranges, Southern California. Geological Society of America Bulletin 100: 850-858.

San Buenaventura. 1978a. Letter from Deborah Meares, Planning Division, City of San Buenaventura, to W. G.

Frank, Division Engineer, Ventura County Flood Control District, August 11, 1978.

San Buenaventura. 1978b. Letter from Shelly Jones, Acting Chairman EIR Committee, City of San Buenaventura, to Arnold Hubbard, re: "EIR-643/MP-28 Overnight Recreational Vehicle Park", September 5, 1978.

San Buenaventura. 1982. Local Coastal Program: Land Use Plan. Department of Community Development, Planning Division. San Buenaventura, California.

San Buenaventura. 1985a. Planning Commission Resolution No. 5990. Granting a Planned Development Permit Case No. CDP-46/PD-406, January 8, 1982.

San Buenaventura. 1985b. City Council Resolution No. 85-26. A Resolution of the City Council of the City of San Buenaventura Upholding a Decision of the Planning Commission Granting a Coastal Development Permit/Planned Development Permit No. CDP-46/PD-406, February 25, 1985.

San Buenaventura. 1990. Request for Proposals: Ventura River Estuary. San Buenaventura, California.

San Buenaventura. 1992a. Historical Revenue Data - Ventura Beach RV Resort, as of February 1992. San Buenaventura, California.

San Buenaventura. 1992b. Summary List of Direct City Costs Relating to 800 W. Main Street (RV Park) for February 1992 Flood, as of April 8, 1992. San Buenaventura, California.

San Buenaventura. 1992c. Administrative Report from Everett Millais, Director of Community Development, to John Baker, City Manager, re: "Ventura Beach Recreational Vehicle Park", February 27, 1992.

San Buenaventura. 1992d. Administrative Report from Everett Millais, Director of Community Development, to John Baker, City Manager, re: "Ventura Beach Recreational Vehicle Park", April 14, 1992.

San Buenaventura. 1992e. Letter from Everett Millais, Director of Community Development, to Nancy Hubbard, June 9, 1992.

San Buenaventura. 1992f. Cost of February 1992 Flood Controls. Direct Services Report, July 24, 1992. (935-DR-CA) San Buenaventura, California.

San Buenaventura. 1992g. Letter from Everett Millais, Director of Community Development, to Charles W. Cohen, Cohen, Alexander & Clayton, re: "Ventura Beach Recreational Vehicle Park", August 28, 1992.

San Buenaventura. 1992h. Hazard Mitigation Plan for 1992 Floods; Annex for State Hazard Mitigation Plan, FEM-935-DR-CA Disaster, September 21, 1992.

Schumm, S. A. 1977. The Fluvial System. John Wiley & Sons, New York.

Schumm, S. and R. W. Lichty. 1963. Channel Widening and Floodplain Construction Along Cimarron river in southwestern Kansas. *In:* U.S. Geological Survey Professional Paper 352-D, pp. 71-88.

Taylor, B. D. 1983. Sediment Yields in coastal Southern California. American Society of Civil Engineers Journal of Hydrological Engineering 109(1): pp. 71-85.

Taylor, D. 1992. Floods in Ventura County: The Computer is Not Always Right. Natural Hazards Observer, May 1992, pp. 4-5.

U.S. Army Corps of Engineers. 1967. Water Resources Development by U.S. Army Corps of Engineers in California. South Pacific Division, Corps of Engineers. San Francisco, California.

U.S. Army Corps of Engineers. 1971. Flood Plain Information: Ventura River (Including Coyote Creek), Ventura County, California. U.S. Army Corps of Engineers, Los Angeles District. Los Angles, California.

U.S. Army Corps of Engineers. 1974a. Report of Engineering Aspects: Floods of January and February 1969 in Southern California. U.S. Army Corps of Engineers, Los Angeles District. Los Angeles, California.

U.S. Army Corps of Engineers. 1974b. Report on Flood of January and February 1969. Appendix C. U.S. Army Corps of Engineers, Los Angeles District. Los Angeles, California.

U.S. Army Corps of Engineers. 1978. Letter from Norman Arno, Chief Engineering Division, U.S. Army Corps of Engineers, to Eric Metz, Coastal Program Analyst, California Coastal Commission, December 6, 1978.

U.S. Army Corps of Engineers. 1981. Letter from Norman Arno, Chief Engineering Division, U.S. Army Corps of Engineers, to Nyna Dolby, Coastal Program Analyst, California Coastal Commission, November 6, 1981.

U.S. Army Corps of Engineers. 1982. HEC-2: Water Surface Profiles: Program User's Manual, 723-X6-L202A. U.S. Army Corps of Engineers, Hydrologic Engineering Center. Davis, California.

U.S. Army Corps of Engineers. 1992a. U.S. Army Corps of Engineers Annual Flood Damage Report to Congress for Fiscal Year 1991. (February 1992) Washington, D.C.

U.S. Army Corps of Engineers. 1992b. Hydrology Report On February 1992 Floods: Five Counties of Southern California. (September 1992) U.S. Army Corps of Engineers, Los Angeles District. Los Angeles, California.

U.S. Department of Commerce. 1990. Environmental Science Services Administration Climatological Data, National Summary. Washington, D.C.

U.S. Geological Survey. 1970. Water Resources Data for California, Part 1. Surface Waters Records. Vol. 1: Colorado River Basin, Southern Great Basin, and Pacific Slope Basins, excluding Central Valley. Ventura River Basin. Guages 11115000, Matilija Creek At Matilija Hot Springs; 11116000, North Matilija Creek At Matilija Hot Springs; 11117500, San Antonio Creek At Casitas Springs; 11118000, Coyote Creek and Santa Ana Creek Near Oak View, California.

U.S. Geological Survey. 1987-1990. Water Resources Data for California, Part 1. Surface Waters Records. Vol. 1: Colorado River Basin, Southern Great Basin, and Pacific Slope Basins, excluding Central Valley. Ventura River Basin. Gauge 11118500, Ventura River Near Ventura, California.

U.S. Geological Survey. 1991-1992. Unpublished preliminary data. Ventura River Basin, 11118500,

Ventura River Near Ventura, California.

U.S. Water Resources Council. 1981. Guidelines for Determining Flood Flow Frequency. Bulletin No. 17B of the Hydrology Committee (revised September 1981). Washington, D.C.

Ventura County Public Works Agency. 1978. Letter from W. G. Frank, Division Engineer, Ventura County Flood Control District, to Deborah Meares, Associate Planner, City of San Buenaventura, August 21, 1978.

Ventura County Public Works Agency. 1981. Letter from W. G. Frank, Principal Engineer, Ventura County Flood Control District, to Nyna C. Dolby, Coastal Analyst, California Coastal Commission, October 28, 1981.

Ventura County Public Works Agency. 1983. Report of 1983 Flood. Flood Control and Water Resources Department. San Buenaventura, California.

Ventura County Public Works Agency. 1984a. Letter from W. G. Frank, Principal Engineer, Ventura County Flood Control District, to Don Asquith, ENVICOM Corporation, May 2, 1984.

Ventura County Public Works Agency. 1984b. Letter from W. G. Frank, Principal Engineer, Ventura County Flood Control District, to Paul V. Berlant, Environmental Impact Report Committee, City of San Buenaventura, May 3, 1984.

Ventura County Public Works Agency 1984c. Letter from W.G. Haydon, Senior Engineer, Ventura County Flood Control District, to Col. Paul Taylor, U.S. Army Corps of Engineers, May 15, 1984.

Ventura County Public Works Agency. 1990. Quadrennial Report of Hydrologic Data: 1984-85, 1985-86, 1986-87, 1987-88. Surface Water Section, Flood Control Department. San Buenaventura, California.

Ventura County Public Works Agency. 1992a. Hydrographs for Ventura River February 12, 1992. Unpublished preliminary data, Surface Water Section, Flood Control Department. San Buenaventura, California.

Ventura County Public Works Agency. 1992b. Transcript of Testimony of Alex Sheydayi, Deputy Director, Ventura County Flood Control District, to the San Buenaventura City Council regarding February 12, 1992 floods, March 2, 1992.

Ventura County Public Works Agency. 1992c. Letter from Alex Sheydayi, Deputy Director, Ventura County Flood Control District, to Arnold Hubbard, March 9, 1992.

Ventura County Public Works Agency. 1992d. Flood Flow Frequency Analysis, Ventura River Near Ventura, 1933 - 86. Unpublished preliminary data, Surface Water Section, Flood Control Department. San Buenaventura, California.

Ventura County Public Works Agency. 1992e. An Agreement to Participate in a Flood Warning System for the Ventura Beach Recreational Vehicle Resort: Agreement Number FC NO. 1-93-2A. San Buenaventura, California.

Ventura County Sheriff's Department 1992. Advance Warning Enhancement of Ventura Beach R.V. Park. *In:* Ventura County Hazard Mitigation Plan for the Floods of 1992 (August 4, 1992), pp. 9-11. San Buenaventura, California.

Weaver, R. L. 1962. Meteorology of Hydrologically Critical Storms in California. U.S. Weather Bureau, Hydrometerological Report No. 37.

Wetlands Research Associates, Philip Williams and Associates, Ltd, Hyden and Associates, Lawrence Hunt, and Paul Lehman. 1991. Ventura River Estuary Enhancement Plan: A Proposal. San Rafael, California.