Multi-Hazard Mitigation Plan
4.0 Risk Assessment

44 CFR 201.6(c)(2)(ii): "The risk assessment shall include…A description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section. This description shall include an overall summary of each hazard and its impact on the community".

Risk from natural hazards is a combination of hazard and exposure. The risk assessment process identifies relevant hazards and the exposure of lives, property, and infrastructure to the hazards. The goal of the risk assessment is to measure the potential loss to a community, including loss of life, personal injury, property damage, and economic injury from a hazard event.

The risk assessment process allows a community to better understand their potential risk and associated vulnerability to natural hazards. This information provides the framework for a community to develop and prioritize mitigation strategies and plans to help reduce both the risk and vulnerability from future hazard events. This risk assessment for the Sutter County Planning Area followed the methodology described in the FEMA publication 386-2 Understanding Your Risks – Identifying Hazards and Estimating Losses (FEMA, 2002) and was based on a four-step process:

(1) Identify Hazards,
(2) Profile Hazard Events,
(3) Inventory Assets, and
(4) Estimate Losses.

This risk assessment covers AMEC's Planning Step 4: Assess the Hazard and Planning Step 5: Assess the Problem. It also includes a third component, Existing Mitigation Capabilities, in which the risk and vulnerability are analyzed in light of existing mitigation measures such as building codes, warning systems and floodplain development regulations.

Risk Assessment Methodology

The HMPC relied on a variety of sources to identify and profile the natural hazards affecting the Sutter County Planning Area. Utilizing existing data and plans available from participating jurisdictions as well as input from planning meetings, the HMPC agreed upon a list of those natural hazards of concern to the participating communities. Historical data from FEMA, the National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center (NCDC), CA-OES and other sources were also examined to profile and confirm the significance of these hazards to the planning area. The natural hazards evaluated as part of this plan include those that have either historically caused or have the future potential to cause significant human

and/or monetary losses. Only the more significant hazards have a more detailed hazard profile and are analyzed further in Section 4.2, Vulnerability Assessment.

Hazard Identification/Profiles (Section 4.1)

Section 4.1 of the Risk Assessment identifies and profiles natural hazards affecting the Sutter County Planning Area. This section begins with an overview of the declared disasters in Sutter County and leads to a hazard profile for the identified hazards. The purpose of this section is to profile all the natural hazards that affect, or could affect, Sutter County and its participating jurisdictions. This sets the stage for the following section (Section 4.2, Vulnerability Assessment), where the risk to Sutter County is quantified for each of the significant hazards. Where the hazards and risk vary across the Planning Area or from jurisdiction to jurisdiction, the differences are noted in both Section 4.1 (Hazard Identification) and Section 4.2 (Jurisdictional Elements) of this plan. The following format is used to profile the hazards:

Hazard/Problem Description
This section gives a description of the hazard and associated problems, followed by details on the hazard specific to the Sutter County Planning Area. Where known, this includes information on the hazard extent, seasonal patterns, speed of onset/duration, and magnitude and/or any secondary affects.

Past Occurrences
This section contains information on historic incidents, including impacts where known. The extent or location of the hazard within or near the Sutter County Planning Area is also included here. A historic incident worksheet was used to capture information from participating jurisdictions on past occurrences. Information provided by the HMPC is integrated here with information from other data sources. This is the next step in defining where hazard impacts vary across the Planning Area.

Frequency/Likelihood of Future Occurrence
The frequency of past events is used in this section to gauge the likelihood of future occurrences. Based on historical data, the likelihood of future occurrences is categorized into one of the following classifications:

Highly Likely*: Near 100% chance of occurrence in next year, or happens every year.*

Likely*: Between 10 and 100% chance of occurrence in next year, or has a recurrence interval of 10 years or less.*

Occasional*: Between 1 and 10% chance of occurrence in the next year, or has a recurrence interval of 11 to 100 years.*

Unlikely*: Less than 1% chance of occurrence in next 100 years, or has a recurrence interval of greater than every 100 years.*

The frequency, or chance of occurrence, was calculated where possible based on existing data. Frequency was determined by dividing the number of events observed by the number of years

and multiplying by 100. This gives the percent chance of the event happening in any given year. An example would be 3 droughts occurring over a 30 year period which equates to 10% chance of that hazard occurring any given year.

Significant Hazards

Once the hazards have been identified and profiled, this methodology includes an initial assessment at the end of Section 4.1 of the significance of each identified hazard. The objective is to identify those hazards requiring further evaluation during the vulnerability assessment in Section 4.2. Significance of an identified hazard to the community was measured in general terms using the hazard profile, focusing on key criteria such as frequency and resulting damage, including deaths/injuries and property, crop, and economic damages to a community. Those hazards that occur infrequently or when they do occur, damages are minimal or non-existent are determined to be insignificant to the Planning Area. This assessment is used by the HMPC to prioritize those hazards of significance to the Planning Area; thus focusing resources on priority hazards.

Vulnerability Assessment (Section 4.2)

Section 4.2 of the risk assessment, consists of a vulnerability assessment to describe the impact that each significant hazard identified in Section 4.1 would have upon the Sutter County Planning Area. The vulnerability assessment was conducted based on the significance of the hazard utilizing best available data. This assessment is an attempt to quantify assets at risk, by jurisdiction where possible, to further define populations, buildings, and infrastructure at risk to natural hazards.

Data to support the vulnerability assessment was collected and compiled from the following sources:

- County GIS data (hazards, base layers, and assessor's data);
- Statewide GIS datasets compiled by CAL-OES to support mitigation planning;
- FEMA's HAZUS-MH MR 2 GIS-based inventory data (January 2005)
- Written descriptions of inventory and risks provided by participating jurisdictions;
- Existing plans and studies; and
- Personal interviews with planning team members and County and City staff.

Vulnerability is measured in general, qualitative terms, and is a summary of the potential impact based on past occurrences, spatial extent, and damage and casualty potential:

> ***Extremely Low:*** *The occurrence and potential cost of damage to life and property is very minimal to non-existent.*
>
> ***Low****: Minimal potential impact. The occurrence and potential cost of damage to life and property is minimal.*

***Medium**: Moderate potential impact. This ranking carries a moderate threat level to the general population and/or built environment. Here the potential damage is more isolated and less costly than a more widespread disaster.*

***High**: Widespread potential impact. This ranking carries a high threat to the general population and/or built environment. The potential for damage is widespread. Hazards in this category may have already occurred in the past.*

***Extremely High:** Very widespread and catastrophic impact.*

The scope of the vulnerability assessment is to describe the risks to the county as a whole. Data from each jurisdiction was also evaluated and is integrated here in the jurisdictional elements, and noted where the risk differs for a particular jurisdiction across the Planning Area.

Jurisdictional Elements (Section 4.3)
DMA regulations require that the HMPC evaluate the risks associated with each of the hazards identified through the planning process. For multi-jurisdictional plans, the regulations also require that the risks be further evaluated where a jurisdiction's risks vary from the risks facing the entire planning area. This section of the plan presents a summary, where data permits, of the possible impacts of identified hazards by participating jurisdiction. Note that data is provided only where the risk or impacts vary from those previously identified as impacting the entire Planning Area. If no additional data is included, it should be assumed that the risk and impacts to the affected jurisdiction would be similar to that previously described for the county.

Capability Assessment (Section 4.4)
This risk assessment has identified the natural hazards posing a threat to the Sutter County Planning Area and described and quantified the vulnerability of the County and communities to these risks. This capability assessment identifies what loss prevention mechanisms are already in place to reduce the planning area's risk and vulnerability to identified hazards... Doing so provides the planning area's "net vulnerability" to natural disasters and more accurately focuses the goals, objectives and proposed actions of this plan.

The HMPC took two approaches in conducting this capability assessment. First, an inventory of existing policies, regulations and plans was made. These policy and planning documents were collected and reviewed to determine if they contributed to reducing hazard related losses, or if they inadvertently contributed to increasing such losses. Second, an inventory of other mitigation activities was made through the use of a matrix. The purpose for this effort was to identify activities and actions beyond policies, regulations and plans that were either in place, needed improvement, or could be undertaken, if deemed appropriate.

Summary
This risk assessment for the Sutter County Planning Area, includes all incorporated communities, and covers the entire geographical extent of the county. Where the hazards and risks vary across the planning area, the differences are noted. Thus, the risk assessment for the

Sutter County Planning Area includes and directly corresponds to Sutter County and the following incorporated communities and districts:

- City of Yuba City
- City of Live Oak
- Gilsizer Drainage District
- Reclamation District 1001
- Reclamation District 1500
- Reclamation Districts 70 & 1660

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4.1 Hazard Identification

The Sutter County HMPC conducted a Hazard Identification study to determine what hazards threaten the Planning Area. This section of the plan provides a description of the hazard/problem and documents the previous occurrences of identified hazards and the likelihood of their recurrence. This Hazard Identification follows the methodology previously described in Section 4.0 and addresses steps 1 and 2 of FEMA's four-step process for conducting risk assessments:

(1) Identify Hazards,
(2) Profile Hazard Events,
(3) Inventory Assets, and
(4) Estimate Losses.

In alphabetical order, the natural hazards identified and investigated for the Sutter County multi-jurisdictional plan include:

- Agricultural Hazards
- Dam Failure
- Drought
- Earthquakes
- Floods
- Landslides
- Severe Weather
    - Extreme Temperatures
    - Fog
    - Winterstorms: Heavy Rains/Thunderstorms/Hail/Lightning/Wind
    - Tornadoes
- Soil Hazards
    - Erosion
    - Expansive Soils
    - Land Subsidence
- West Nile Virus
- Wildfires
- Volcanoes

Also discussed by the HMPC, the natural hazards listed below were eliminated from further consideration in this risk assessment because: (1) they either occur rarely or not at all, and (2) when they do occur, they are very limited in magnitude—no or very limited damages are sustained.

- Avalanches
- Dust Storms

In order to understand how natural hazards affect the Sutter County Planning Area, the Disaster Declaration History for the County is summarized, followed by a discussion of each natural hazard. Identified natural hazards start with severe weather, which is the driving force behind most all natural hazards affecting Sutter County, and then followed by the big three natural hazards in California: flood/dam failure, wildfire, and earthquake. The remaining natural hazards are then addressed alphabetically.

DISASTER DECLARATION HISTORY

One method to identify hazards based upon past occurrence is to look at what events triggered federal and/or state disaster declarations within the Sutter County Planning Area. Disaster declarations are granted when the severity and magnitude of the event's impact surpass the ability of the local government to respond and recover. Disaster assistance is supplemental and sequential. When the local government's capacity has been surpassed, a state disaster declaration may be issued, allowing for the provision of state assistance. Should the disaster be of sufficient magnitude and severity that both the local and state government's capacity are exceeded, a federal disaster declaration may be issued, allowing for the provision of federal disaster assistance.

The federal government may issue a disaster declaration through the U.S. Department of Agriculture (USDA) and/or the Small Business Administration (SBA), as well as through FEMA. The quantity and types of damage are the determining factors. A USDA declaration will result in the implementation of the Emergency Loan Program through the Farm Services Agency (FSA). This program enables eligible farmers and ranchers in the affected county as well as contiguous counties to apply for low interest loans. A USDA declaration will automatically follow a Presidential declaration for counties designated major disaster areas and those counties that are contiguous to a declared county - including counties that are across state lines. As part of an agreement with the USDA, the Small Business Administration (SBA) offers low interest loans for eligible businesses that suffered economic losses in declared and contiguous counties that have been declared by the Secretary of Agriculture. These loans are referred to as Economic Injury Disaster Loans (EIDL

Declared Disaster History Analysis

Details on federal (i.e., FEMA) and state disaster declarations were obtained by the HMPC, FEMA, and CA-OES and compiled, in chronological order in the table below. A review of state and federal declared disasters indicate that within the Sutter County Planning Area there were 20 state declarations from 1950 through 2006 for Sutter County, 11 of which also qualified as federal disaster declarations. 18 of the 20 state declarations were associated with severe winter storms, heavy rains and flooding. The other two were declarations for drought and freeze. USDA declarations for the planning area are discussed in the agricultural hazard section of this plan.

This disaster history (combined FEMA and state) equates to a major event worthy of a disaster declaration every 2.8 years or a 35.7% chance of a disaster declaration any given year. Every historical declared disaster event resulted directly or indirectly from extreme weather conditions. The declared disaster data demonstrates that injuries to people and damages to property and crops are a result of severe weather conditions in the Sutter County Planning Area.

Sutter County State and Federal Disasters Declaration
1950-2006

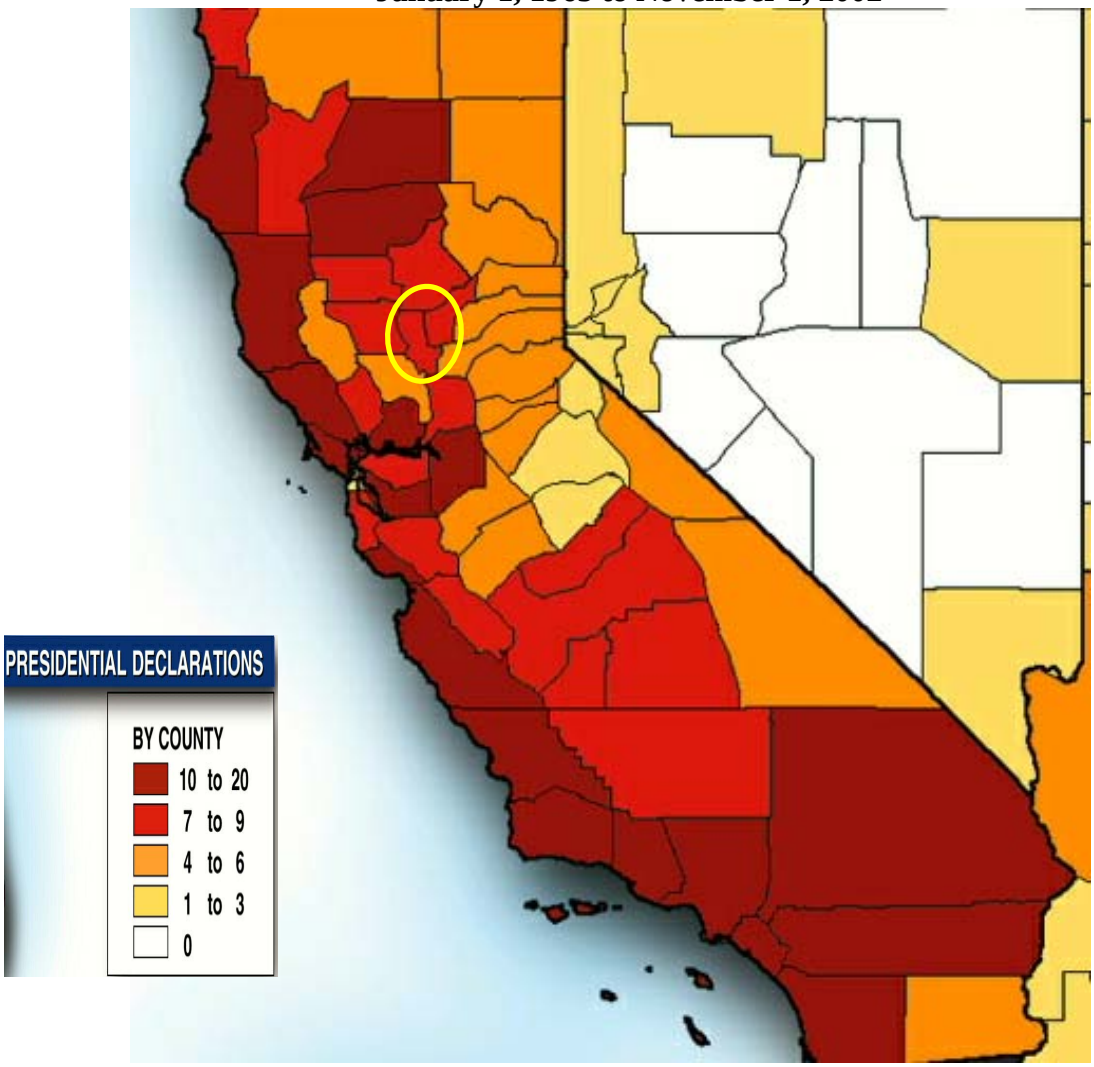
Hazard Type	Disaster Name	Disaster #	Year	State Declaration	Federal Declaration Type/Date	Location	Damages*
Flood	Floods	CDO 50-01	1950	11/21/50	State 11/21/50	Sutter County (statewide)	9 deaths; $32,183,000
Flood	Floods	DR-47	1955	12/22/55	Federal 12/23/55	Sutter County (statewide)	74 deaths; $200,000,000
Severe Storm, Economic	Unseasonal and Heavy Rainfall	N/A	1957	5/20/57 (Cherry-producing)	State 5/20/57	Sutter County (other cherry producing areas)	2 injuries; $6,000,000
Flood	Storm & Flood Damage	CDO 58-03	1958	2/26/58	State 2/26/58	Sutter County (and 36 other counties)	Not available
Flood	Storm & Flood Damage	N/A	1958	4/2/58	82	Sutter County (statewide)	13 deaths $24,000,000
Severe Storm	Unseasonal and Heavy Rainfall	N/A	1959	9/17/59	State 9/17/59	Sutter County (other Tokay grape producing areas)	2 deaths $100,000
Flood	Flood and Rainstorm		1962	10/17/1962, 10/25/62, 10/30/62 & 11/4/62	Federal 138 (10/24/62)	Sutter County (and 11 other counties)	$4,000,000
Severe Storm, Flood	Abnormally Heavy and Continuous Rainfall	N/A	1963	2/14/64	State 2/14/64	Sutter County (and 50 other counties)	Not Available
Flood	1964 Late Winter Storms	Unknown	1964	12/22/64, 12/23/64, 12/28/64, 1/5/65, & 1/1/65	Federal 12/29/64	Sutter County (and 25 other counties)	$213,149,000
Flood	Northern California Flooding	Unknown	1970	1/26/70, 2/3/70, 2/10/70, 3/2/70	Federal 2/16/70	Sutter County (and 17 other counties)	$27,657,478
Severe Storms	Severe Weather Conditions	N/A	1972	9/3/72	State 9/3/72	Sutter County	$2,004,300
Flood	Storms and Floods	N/A	1973	2/28/73	State 2/28/73	Sutter County (and 5 other counties)	$1,864,000
Drought	Drought	N/A	1976	2/9/76, 2/13,76,	State 2/9/76,	Sutter County (and 30 other	$2,664,000,000

Hazard Type	Disaster Name	Disaster #	Year	State Declaration	Federal Declaration Type/Date	Location	Damages*
				2/24/76, 3/26/76, 7/6/76	2/13,76, 2/24/76, 3/26/76, 7/6/76	counties)	
Flood, Severe Storm	1982-83 Winter Storms	DR-677	1982	1982, 1983	Federal 2/9/83	Sutter County (and 43 other counties)	$523,617,032
Severe Storm	Storms	DR-758	1986	2/18-86 - 3/12/86	Federal 2/18/86	Sutter County (and 38 other counties)	13 deaths; $407,538,904
Freeze	Freeze	DR-894	1990	12/19/90-1/18/91	Federal 2/11/91	Sutter County (and 32 other counties)	$856,329,675
Severe Storm	Severe Winter Storms	DR-1044	1995	1/6/95 - 3/14/95	Federal 1/13/95	Sutter County (and 44 other counties)	11 deaths $741,400,000
Severe Storm, Flood	Late Winter Storms	DR-1046	1995		Federal 1/10/95	Sutter County (and all other counties except Del Norte)	17 deaths; $1,100,000,000
Flood	January 1997 Floods		1997	1/2/97 - 1/31/97	State 1/2/97 - 1/31/97	Sutter County (and 46 other counties)	8 injuries; $1,800,000,000
	Severe Storms, Flooding, Mudslide, and Landslides	DR-1628	2006		Federal 2/3/06	Sutter County (and 28 other counties)	

(Sources: CA-OES, Draft Multi-Hazard Mitigation Plan, 2004; http://www.fema.gov/news/disasters_state.fema?id=6)
*Note: Damage amount reflects totals for all impacted Counties

The following map, from the FEMA Website, displays the number of Presidential Disaster Declarations within Sutter County between 1965 and 2002. Clearly, Sutter is among the many counties in California that are susceptible to disaster.

PRESIDENTIAL DISASTER DECLARATIONS MAP
January 1, 1965 to November 1, 2002



(Source: www.fema.gov)

SEVERE WEATHER

Severe weather is generally any destructive weather event, but usually occurs in the Sutter County Planning Area as localized storms such as heavy rains, winter storms, and strong wind events. Severe weather conditions generally occur on an annual basis throughout Sutter County; however, it appears that many of these events go unreported.

The NOAA NCDC has been tracking severe weather events since 1950. Their database tracks wildfire, flood, thunderstorms, wind, heavy snow, tornadoes, and funnel clouds, dense fog, extreme temperatures, hail, lightning, and mircrobursts. This database only identified 12 severe weather events occurring in Sutter County between January 1, 1950 and May 31, 2006, and these occurred during the 1993 to 2006 timeframe.

The NCDC database was supplemented with data from another source for disaster events called the SHELDUS database, produced by the Hazard Research Lab at the University of South

Carolina. SHELDUS is a county-level data set for the U.S. on 18 different natural hazard event types along with property and crop losses, injuries, and fatalities for the period 1960-2000. This database is a combination of information from several sources and can be searched by county. From 1960 to 1995, only those events that generated more than $50,000 in damages were included in the database. For events that covered multiple counties, the dollar losses, deaths, and injuries were equally divided among the counties (e.g., if 4 counties were affected, then each was given ¼ of the dollar loss, injuries, and deaths). From 1995 to 2000 all events that were reported by the NCDC with a specific dollar amount are included in the database.

The two databases were downloaded from the Internet, merged into one, and presented in the table below. Based on the combined NCDC/SHELDUS data bases, there have been 38 documented severe weather events resulting in $42,492,942.21 in property damage and $13,030,040.34 in crop damage since 1950 associated with events occurring in Sutter County. These events have also directly or indirectly caused 1.29 deaths and 16.98 injuries within the same timeframe. These sums do not likely represent the entire costs, as it is difficult to capture all the costs associated with an event. These events are discussed further in the hazard profiles that follow.

NCDC/SHELDUS
Severe Weather Reports
Sutter County 1950-2006

Type	Location	Date	Property Loss	Crop Loss	Deaths	Injuries	Data Source
Winter Weather	Sutter County	02/11/1992	$892.86	$0	0	0	SHELDUS
Winter Weather	Sutter County	02/16/1992	$862,068.97	$0	.12	.22	SHELDUS
Flooding, Winter Weather	Sutter County	02/13/1992	$11,627.91	$0	0	0	SHELDUS
Flooding, Winter Weather	Sutter County	02/16/1992	$9,090.91	$0	0	0	SHELDUS
Wind, Winter Weather	Sutter County	12/09/1992	$2,631.58	$0	0	0	SHELDUS
Funnel Cloud	E. Nicolaus	03/26/1993	$0	$0	0	0	NCDC
Wildfire, Wind	Sutter County	10/31/1993	$36,777,777.78	0	0	9.89	SHELDUS
Winter Weather	Sutter County	12/11/1993	$3,448.28	$0	0	0	SHELDUS
Winter Weather	Central Valley	02/21/1994	$1,282.05	$0	0	0	SHELDUS
Downburst	Sutter County	01/10/1995	$0	$0	0	0	NCDC
Gustnado	Sutter County	01/10/1995	$0	$0	0	0	NCDC
Flooding, Severe	Statewide	03/31/1995	$0	$11,241,379.31	0	0	SHELDUS

Type	Location	Date	Property Loss	Crop Loss	Deaths	Injuries	Data Source
Storm, Thunderstorm							
Flooding	Sutter County	12/31/96	$2,857.14	$0	0	0	SHELDUS
Fog	Countywide	12/11/1997	$300,000	$0	1	5.2	SHELDUS
Heavy Rain	Countywide	01/12/1998	$0	$0	0	0	NCDC
Heavy Rain	Countywide	01/18/1998	$0	$0	0	0	NCDC
Flooding	Sutter County	02/28/1998	$3362337.66	$1637662.34	0	0	SHELDUS
Wind	Sutter County	02/07/1998	$17,647.06	$0	0	0	SHELDUS
Wind	Sutter County	06/16/1998	$1000	$0	0	0	SHELDUS
Wind	Sutter County	10/16/1998	$9,090.91	$0	0	0	SHELDUS
Wind	Sutter County	11/07/1998	$41,176.47	$0	0	0	SHELDUS
Fog	Sutter County	12/18/1998	$83,333.33	$0	.17	1.67	SHELDUS
Winter Weather	Sutter County	12/29/1998	$0	$141,176.47	0	0	SHELDUS
Wind	CAZ015>17	02/07/1999	$3,846.15	$0	0	0	SHELDUS
Wind	CAZ016	02/09/1999	$7,000	$0	0	0	SHELDUS
Wind	CAZ016>19	04/03/1999	$1,333.33	$2,600	0	0	SHELDUS
Wind	CAZ015-17-19	04/23/1999	$1,538.46	$0	0	0	SHELDUS
Flooding	Southern Sacramento Valley, CAZ017	01/24/2000	$4,166.67	$0	0	0	SHELDUS
Wind	CAZ015>017-019-067	02/14/2000	$555.56	$2,222.22	0	0	SHELDUS
Wind	CAZ015>017-019-063>064-066>069	10/23/2000	$1,739.13	$0	0	0	SHELDUS
Wind	Sacramento Valley, Carquinez Strait and Delta	02/07/2001	$1,500	$0	0	0	SHELDUS
Tornado: F0	Yuba City	03/29/2005	$0	$0	0	0	NCDC
Funnel Cloud	Yuba City	04/17/2005	$0	$0	0	0	NCDC
Funnel Cloud	Yuba City	05/09/2005	$0	$0	0	0	NCDC

Type	Location	Date	Property Loss	Crop Loss	Deaths	Injuries	Data Source
Tornado: F0	Yuba City	05/09/2005	$85,000	$5,000	0	0	NCDC
Funnel Cloud	Yuba City	05/09/2005	$0	$0	0	0	NCDC
Heavy Rain	Countywide	12/17/2005	$0	$0	0	0	NCDC
Flood	Countywide	01/01/2006	$900,000	$0	0	0	NCDC

The table above summarizes severe weather events occurring in Sutter County. Although identified as a severe weather events by these various data sources, only a few of the events identified above actually resulted in state and federal disaster declarations as previously detailed. It is further interesting to note that different data sources capture different events during the same time period, and often, different information specific to individual events. Recognizing that these inconsistencies are inherent to using existing data sources, the value of this data is in the "big picture" aspect of the story it tells, not in the individual details.

As previously described, all of Sutter County's state and federal disaster declarations have been a result of extreme weather conditions. For this plan, severe weather is discussed in the following subsections:

- Extreme Temperatures
- Fog
- Winterstorms: Heavy Rains/Thunderstorms/Hail/Lightning/Wind
- Tornadoes

Extreme Temperatures

Hazard/Problem Description

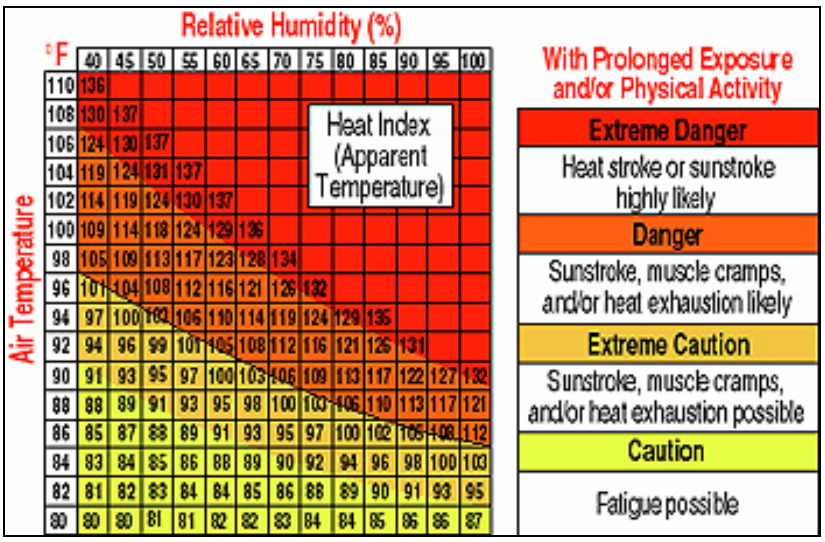
Extreme temperature events, both hot and cold, can have severe impacts on human health and mortality, natural ecosystems, agriculture and other economic sectors.

Extreme Heat

According to information provided by the FEMA website, extreme heat is defined as temperatures that hover 10 degrees or more above the average high temperature for the region and last for several weeks. Heat kills by taxing the human body beyond its abilities. In a normal year, about 175 Americans succumb to the demands of summer heat. According to the NWS, among natural hazards, only the cold of winter -- not lightning, hurricanes, tornadoes, floods, or earthquakes -- takes a greater toll. In the 40-year period from 1936 through 1975, nearly 20,000 people were killed in the United States by the effects of heat and solar radiation. In the heat wave of 1980, more than 1,250 people died.

Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating, or a chemical (salt) imbalance caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and heat-related illness may develop. Elderly persons, small children, chronic invalids, those on certain medications or drugs, and persons with weight and alcohol problems are particularly susceptible to heat reactions, especially during heat waves in areas where

moderate climate usually prevails. The following graphic illustrates the relationship of temperature and humidity to heat disorders.



Note: Since HI values were devised for shady, light wind conditions, exposure to full sunshine can increase HI values by up to 15°F. Also, strong winds, particularly with very hot, dry air, can be extremely hazardous.
(Source: National Weather Service, 2004)

The NWS has in place a system to initiate alert procedures (advisories or warnings) when the Heat Index (HI) is expected to have a significant impact on public safety. The expected severity of the heat determines whether advisories or warnings are issued. A common guideline for the issuance of excessive heat alerts is when the maximum daytime HI is expected to equal or exceed 105°F and a nighttime minimum HI of 80°F or above for two or more consecutive days.

Extreme Cold

Extreme cold often accompanies a winter storm or is left in its wake. Prolonged exposure to cold can cause frostbite or hypothermia and can become life-threatening. Infants and the elderly are most susceptible. Pipes may freeze and burst in homes or buildings that are poorly insulated or without heat.

In 2001, NWS implemented an updated Wind Chill Temperature (WTC) index. This index was developed by the NWS to describe the relative discomfort/danger resulting from the combination of wind and temperature. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature.

The NWS will issue a wind chill advisory for the central valley when it gets to be 25 degrees below 0 for 3 hours or more.

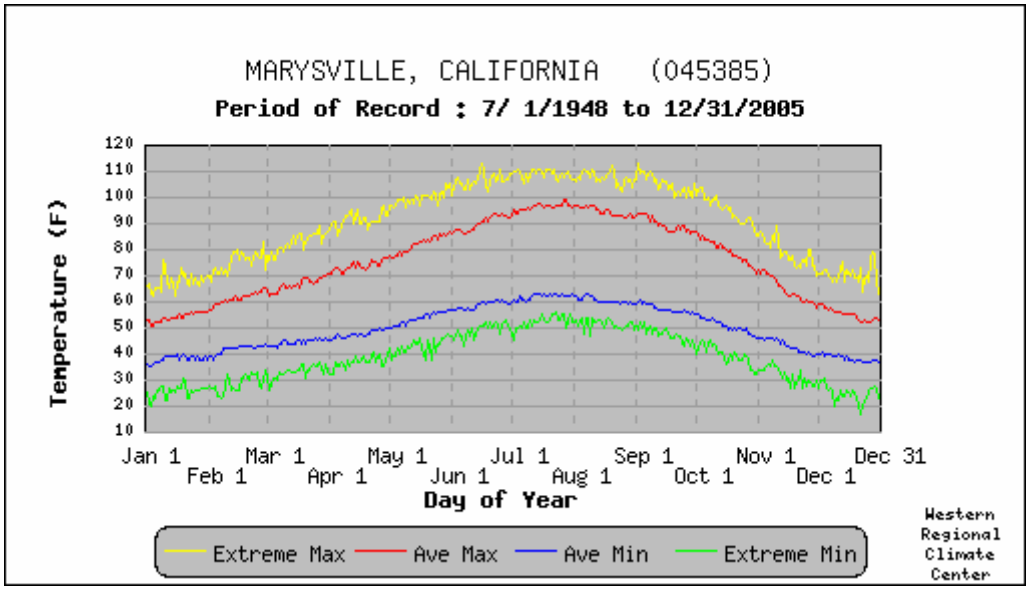
Past Occurrences

An analysis of extreme temperature ranges in the Sutter County Planning Area is provided below using data obtained from the Western Regional Climate Center from the Marysville Weather

Station. This weather station sits on the Sutter County/Yuba County border and was used based on its location and the completeness of available data.

Sutter County (Marysville Weather Station -Period of Record 1948 to 2006)

In Sutter County, monthly average maximum temperatures in the warmest months (May through October) range from the high 70's to the high 90's. Monthly average minimum temperatures from November through April range from the high 30's to the high 40's. The highest recorded daily extreme is 113 degrees Fahrenheit (°F) on June 16, 1961. The lowest recorded daily extreme is 17°F on December 22, 1990. For the period of record (POR) for maximum temperature extremes (on an annual basis), 94.2 days exceeded 90°F and no days were less than 32°F. For the POR for minimum temperature extremes (on an annual basis), 14.6 days were less than 32°F and no days were less than 0°F.



- Extreme Max. is the maximum of all daily maximum temperatures recorded for the day of the year.
- Ave. Max. is the average of all daily maximum temperatures recorded for the day of the year.
- Ave. Min. is the average of all daily minimum temperatures recorded for the day of the year.
- Extreme Min. is the minimum of all daily minimum temperatures recorded for the day of the year.

(Source: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca5385)

The HMPC was not aware of any specific deaths, injuries or damages related to extreme temperatures.

Likelihood of Future Occurrences

Highly Likely: Temperature extremes are likely to continue to occur annually in the Sutter County Planning Area.

Fog

Hazard/Problem Description

Fog results from air being cooled to the point where it can no longer hold all of the water vapor it contains. One of the most dangerous aspects of the Sacramento Valley during the rainy season is the Tule fog. Tule fog is a thick ground fog that settles in the San Joaquin Valley and Sacramento Valley areas of California's Central Valley. Tule fog generally forms during the late fall and winter (November through March) after the first significant rainfall. The tule fog is a radiation fog, which condenses when there is a high relative humidity, typically after a heavy rain, calm winds, and rapid cooling during the night. The longer nights during the winter months creates this rapid ground cooling and results in a pronounced temperature inversion at a low altitude creating a thick ground fog. Above the cold, foggy layer, the air is typically warm and dry. Once the fog has formed, turbulent air is necessary to break through the inversion. Daytime heating can also work to evaporate the fog in some areas.

Tule fog is quite dense and visibility can vary and change rapidly. Visibility is usually less than an eighth of a mile, although, it can be less than 10 feet. Accidents caused by the tule fog are one of the leading causes of weather-related casualties in California. In addition to accidents, severe fog incidents can close roads and impair the effectiveness of emergency responders.

Past Occurrences

Only two incidents of severe fog were identified in the NCDC/SHELDUS database search for Sutter County. These two events, occurring in December of 1997 and 1998 collectively resulted in $383,333 in property damage and were responsible for 6.87 injuries and 1.17 deaths.

According to the HMPC, severe fog is a reoccurring problem within the Planning Area often resulting in car accidents, especially around intersections on some of the major two-lane roads.

Likelihood of Future Occurrences

Occasional: Using the Sheldus data, two major fog incidents over a 56 year period equates to a major fog event occurring every 28 years and a 3.57% chance of a major fog event any given year. However, based on input from the HMPC, it is likely that minor fog events will continue to occur annually in the Sutter County Planning Area.

Winterstorm: Heavy Rain/Thunderstorms/Hail/Lightning/Wind

Hazard/Problem Description

Winterstorms in the Sutter County Planning Area are generally characterized by heavy rains often accompanied by strong winds, and sometimes lightning, and hail. Tornadoes and funnel clouds can also occur during these types of storms. Thunderstorms can produce a strong rush of wind known as a downburst, or straight-line winds which may exceed 120 miles per hour. These storms can overturn mobile homes, tear roofs off of houses and topple trees.

Approximately 10 percent of the thunderstorms that occur each year in the United States are classified as severe. A thunderstorm is classified as severe when it contains one or more of the following phenomena: (1) Hail, three-quarters inch or greater; (2) Winds gusting in excess of 50 knots (57.5 mph); or (3) A tornado.

High winds often accompany thunderstorms. High winds can result in property damage and injury. Strong gusts can rip roofs from buildings, snap power lines, shatter windows, down trees, and sandblast paint from cars. Other associated hazards include utility outages, arcing power lines, debris blocking streets, dust storms, and an occasional structure fire from this natural hazard.

Hail is formed when water droplets freeze and thaw as they are thrown high into the upper atmosphere by the violent internal forces of thunderstorms. Hail is usually associated with severe winter storms which occur throughout Sutter County Planning Area. Hailstones are usually less than 2 inches in diameter and can fall at speeds of 120 mph. Severe hailstorms can be quite destructive causing damage to roofs, buildings, automobiles, vegetation, and crops.

Lightning is defined as any and all of the various forms of visible electrical discharge caused by thunderstorms. Thunderstorms and lightning are usually (but not always) accompanied by rain. Cloud-to-ground lightning can kill or injure people by direct or indirect means. Objects can be directly struck and this impact may result in an explosion, burn, or total destruction. Or, damage may be indirect when the current passes through or near an object, generally resulting in less damage.

Given the near sea level elevation of the area, snow within the limits of the Planning Area is extremely rare and limited to the occasional dusting of the Sutter Buttes at an elevation of 1,600 to 2,100 feet above msl.

According to the HMPC, short-term, heavy storms can cause both wide spread flooding as well as extensive localized drainage issues. With the increased growth of the area, the lack of adequate drainage systems has become more of an issue. In order to properly drain excess water from these intense storms, the southern part of the County must drain first, followed by the central portion and then the northern portion of the County. Inadequate drainage in one area can severely impact drainage in another.

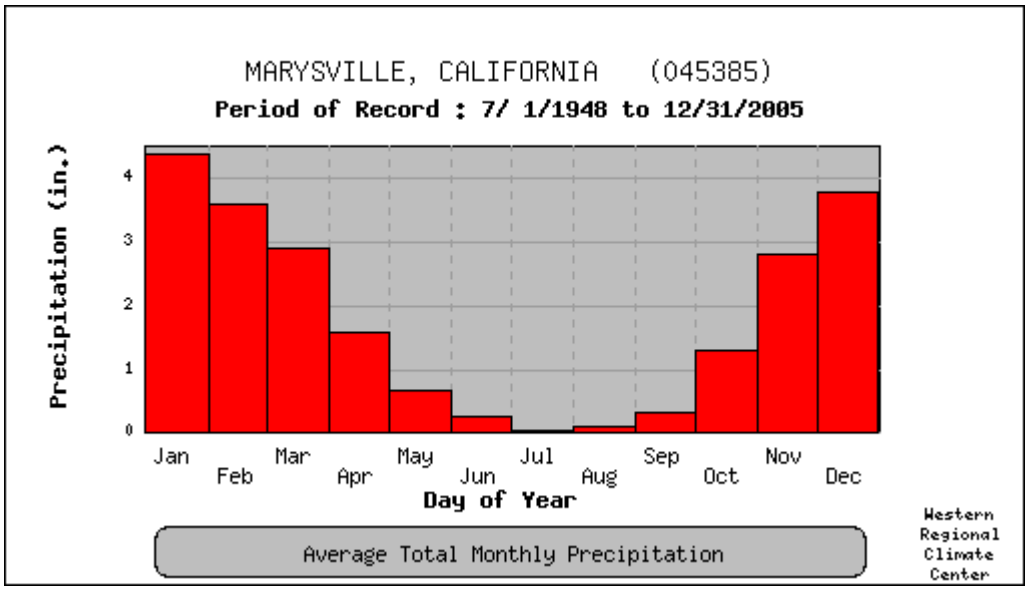
In addition to the flooding that often occurs during these storms, strong winds when combined with saturated ground conditions often result in the downing of very mature trees throughout the Planning Area.

Past Occurrences

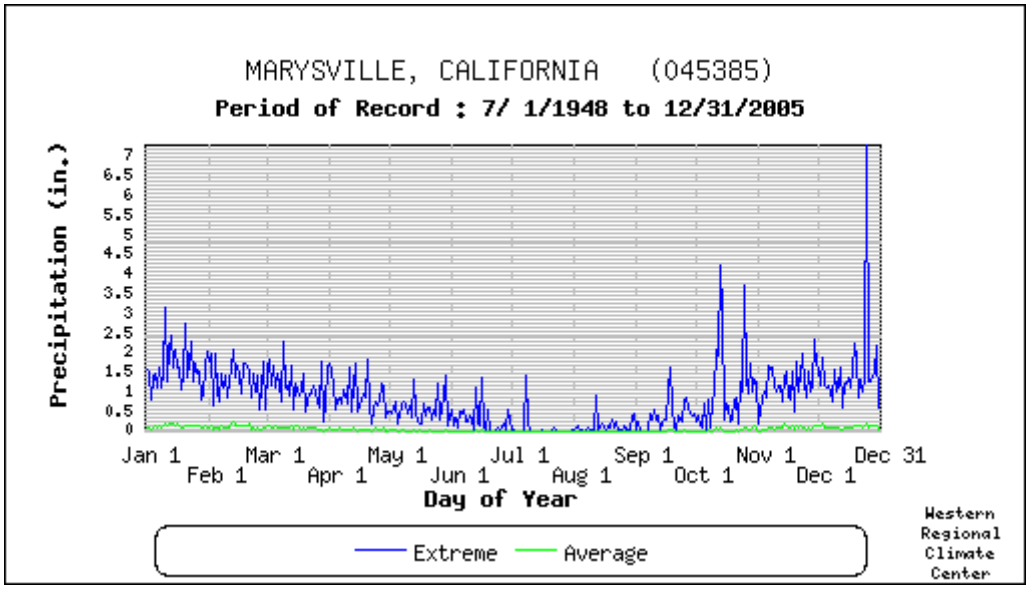
Heavy rains and severe storms occur in the Sutter County Planning Area primarily during the late fall, winter and spring seasons. According to the Sutter County General Plan, 88% of the average annual rainfall occurs between November and April. Annual average rainfall varies for the county, ranging from 17 to 21 inches and increases across the area from the southwest to the northeast.

Information obtained from the Marysville weather station is summarized below.

Sutter County (Marysville Weather Station -Period of Record 1948 to 2006)
Average annual precipitation in Sutter County is 21.59 inches per year. The highest recorded annual precipitation for Sutter County is 46.26 inches in 1983; the highest recorded precipitation for a 24-hour period is 7.29 inches on December 25, 1983. The lowest annual precipitation total is 7.41 inches in 1976.



- Average precipitation recorded for the month.



- Extreme is the greatest daily precipitation recorded for the day of the year.
- Average is the average of all daily precipitation recorded for the day of the year.
(Source: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca5385)

Extreme weather events associated with Heavy Rain/Thunderstorms/ Hail/Lightning/Wind include those specific events listed in the previous tables included in this severe weather section.

Likelihood of Future Occurrences

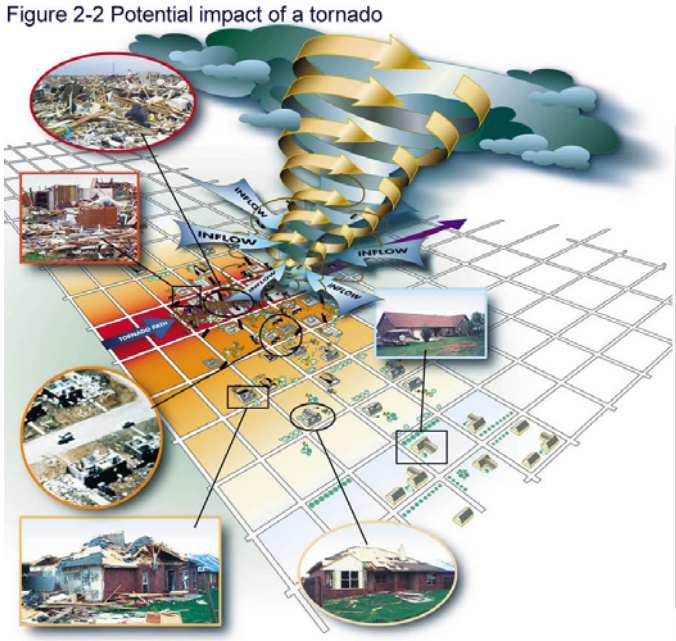
Highly Likely: Severe weather, including thunderstorms, heavy rain, hail, and lightning is a well documented seasonal occurrence that will continue to occur annually in the Sutter County Planning Area.

Tornadoes

Hazard/Problem Description

Tornadoes are another weather-related event that occurs within the Sutter County Planning Area, primarily during the rainy season. Tornadoes are rotating columns of air marked by a funnel-shaped downward extension of a cumulonimbus cloud whirling at destructive speeds of up to 300 mph, usually accompanying a thunderstorm. Tornadoes are the most powerful storms that exist. They can be comprised of the same pressure differential that fuels 300-mile wide hurricanes across a path only 300 yards wide or less.

Figure 2-2 Potential impact of a tornado



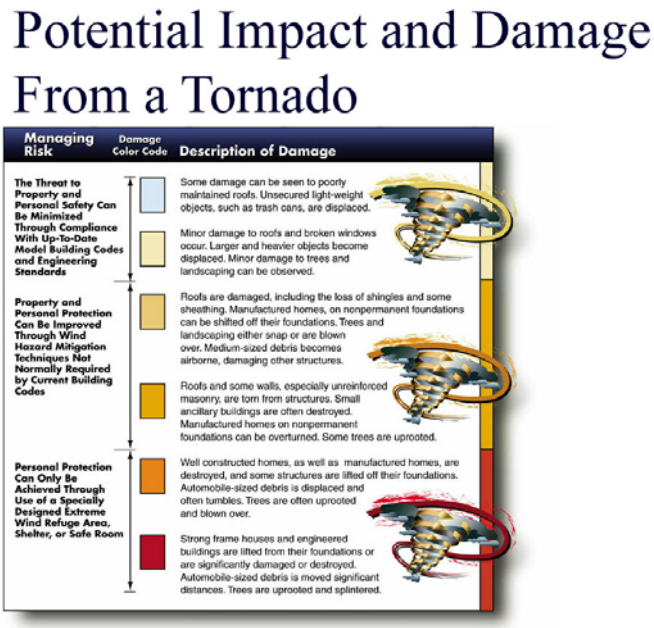


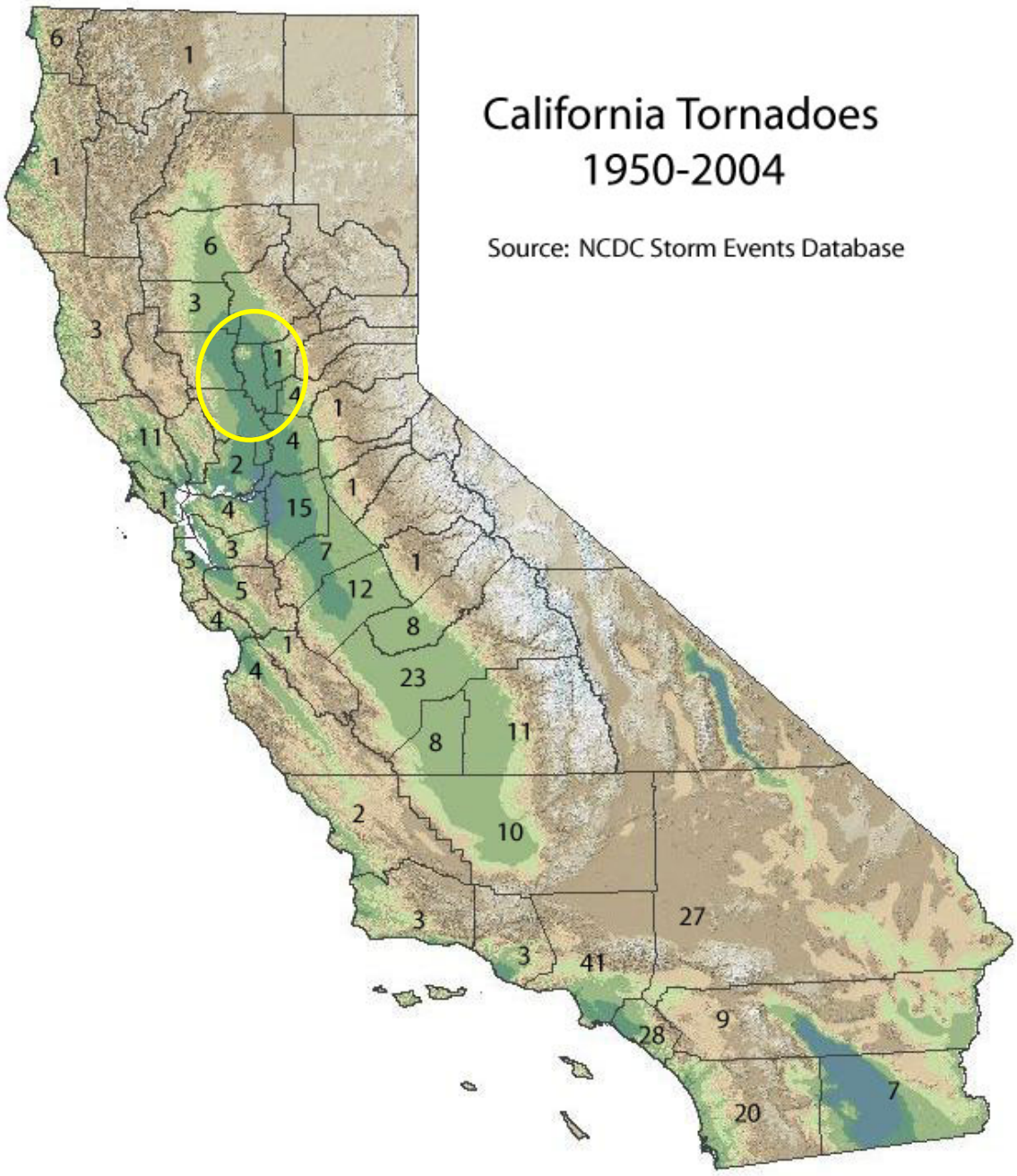
Figure 2-2 Potential damage table for impact of a tornado

Tornado magnitude is ranked according to the Fujita scale listed as follows:

<u>Fujita Tornado Scale</u>
F0: 40 - 72 mph (35-62 kt)
F1: 73-112 mph (63-97kt)
F2: 113-157 mph (137-179 kt)
F3: 158-206 mph (137-179 kt)
F4: 207-260 mph (180-226 kt)
F5: 261-318 mph (227-276 kt)

Past Occurrences

Based on data from 1950 – 1995, California ranks 32 of 50 (compared to other states) for frequency of tornadoes, ranking 36 for injuries and 31 for cost of damages. When compared to other states by the frequency per square mile, California ranks number 44 for the frequency of tornadoes, 44th for injuries per area and 40th for costs per area. The following map shows tornado frequency by California county using NCDC data from 1950 to 2004. It was not until 2005 that the NCDC database had any recorded tornado events in Sutter County.



(Source: http://ggweather.com/ca-tornado.jpg)

According to the HMPC, during the rainy season the Sacramento Valley is prone to relatively strong thunderstorms, sometimes accompanied by funnel clouds and tornadoes. While they do occasionally occur, most often they are of F0 or F1 intensity. Documented incidents of tornadoes in the Sutter County Planning area include the following events, all occurring in 2005:

- 03/29/2005 – F0 tornado, no damages or injuries (NCDC)
- 04/17/2005 – Funnel Cloud (NCDC)
- 05/09/2005 – F0 Tornado, 50-60- plum trees destroyed ($500,000); roof and deck damaged; (NCDC/NWS)
- 05/09/2005 – 3 Funnel Clouds (NCDC/NWS)

Likelihood of Future Occurrences

Occasional: Recent tornado activity within the planning area indicates that the area will likely continue to experience the formation of funnel clouds and low intensity tornadoes during adverse weather conditions.

FLOOD

Hazard/Problem Description

Floods can be among the most frequent and costly natural disaster in terms of human hardship and economic loss, and can be caused by a number of different weather events. Floods can cause substantial damage to structures, landscapes, and utilities as well as life safety issues. Certain health hazards are also common to flood events. Standing water and wet materials in structures can become a breeding ground for microorganisms such as bacteria, mold, and viruses. This can cause disease, trigger allergic reactions, and damage materials long after the flood. When floodwaters contain sewage or decaying animal carcasses, infectious disease is of concern. Direct impacts such as drowning can be limited with adequate warning and public education about what to do during floods. Where flooding occurs in populated areas, warning and evacuation will be paramount to reduce life and safety impacts with any type of flooding.

The area adjacent to a channel is the floodplain. Floodplains are illustrated on inundation maps, which show areas of potential flooding and water depths. In its common usage, the floodplain most often refers to that area that is inundated by the 100-year flood, the flood that has a one percent chance in any given year of being equaled or exceeded. The 100-year flood is the national minimum standard to which communities regulate their floodplains through the National Flood Insurance Program (NFIP). The potential for flooding can change and increase through various land use changes and changes to land surface, resulting in a change to the floodplain. A change in environment can create localized flooding problems in and outside of natural floodplains by altering or confining natural drainage channels. These changes are most often created by human activity.

The Sutter County Planning Area is susceptible to four types of floods: localized flooding, riverine (slow rise) flooding, levee failure/overtopping, and dam failure floods.

Localized Flooding. Localized flooding problems are often caused by flash flooding, severe weather, or an unusual amount of rainfall. Flooding from these intense weather events usually

occurs in areas experiencing an increase in runoff from impervious surfaces associated with development and urbanization as well as inadequate storm drainage systems. The term "flash flood" describes localized floods of great volume and short duration. In contrast to riverine flooding, this type of flood usually results from a heavy rainfall on a relatively small drainage area. Precipitation of this sort usually occurs in the winter and spring. Flash floods often require immediate evacuation within the hour.

Riverine (Slow Rise) Flooding. Riverine flooding, defined as when a watercourse exceeds its "bank-full" capacity, generally occurs as a result of prolonged rainfall, or rainfall that is combined with already saturated soils from previous rain events. This type of flood occurs in river systems whose tributaries may drain large geographic areas and include one or more independent river basins. The onset and duration of riverine floods may vary from a few hours to many days. Factors that directly affect the amount of flood runoff include precipitation amount, intensity and distribution, the amount of soil moisture, seasonal variation in vegetation, snow depth, and water-resistance of the surface due to urbanization. In the Sutter County Planning Area, slow rise riverine flooding predominantly occurs caused by heavy and continued rains, sometimes combined with snow melt, increased outflows from upstream dams, and heavy flow from tributary streams. These intense storm events can overwhelm the local waterways within the Planning Area as well as the integrity of the levee system. The warning time associated with slow rise floods will assist in life and property protection. According to the 2006 Sutter County Operational Area Emergency Operations Plan (EOP), slow rise flooding is a well-established and potentially large-scale threat to the area.

Levee Failure/Overtopping. Generally, levees fail due to overtopping or collapse due to seepage, subsidence, erosion, or any combination thereof. A catastrophic failure resulting from collapse can occur very quickly with relatively little warning. Levee failure usually occurs when the levee is saturated from high flows or there is an inherent defect in the levee. Floodwater will flow in a relatively shallow path and collect in low-lying areas. Slow rise flooding in the Sutter County Planning Area can lead to a more catastrophic flood event due to the potential for a levee overtopping or failing.

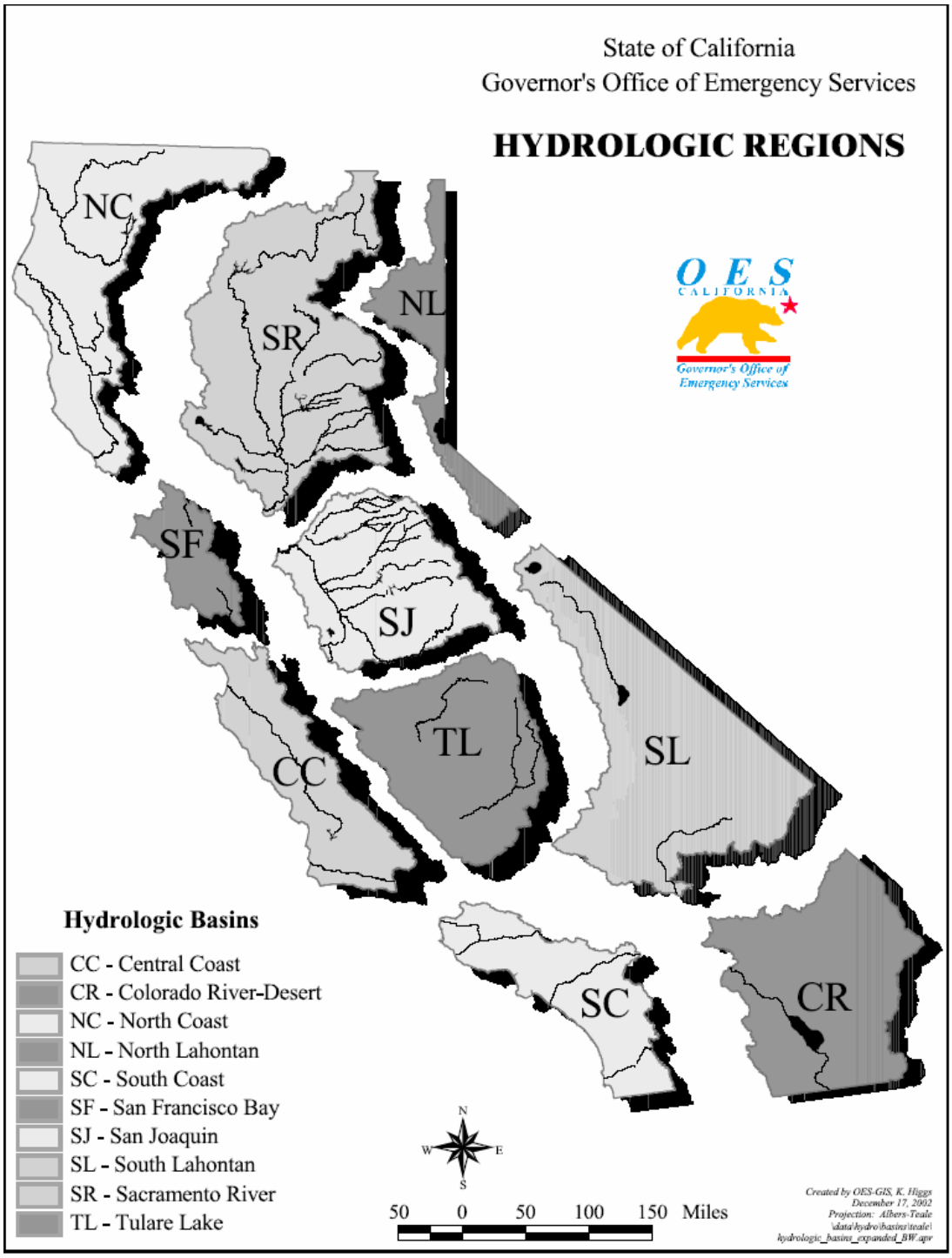
Dam Failure. Flooding from failure of one or more upstream dams is also a concern to the Sutter County Planning Area. A catastrophic dam failure could easily overwhelm local response capabilities and require mass evacuations to save lives. Impacts to life safety will depend on the warning time available and the resources to notify and evacuate the public. Major loss of life could result and there would be associated health concerns as well as problems with the identification and burial of the deceased. Dam failure impacts in the Planning Area are addressed further in a separate section following this section on floods.

Sutter County Hydrology

California has 10 hydrologic regions. The Sutter County Planning Area sits in the Sacramento River hydrologic region. This region encompasses the northern half of the Central Valley bounded by the Sierra Nevada Mountains, the Coast Range, the Cascade Range, and the Trinity Mountains. This region is predominantly agricultural, but has experienced increased urbanization in recent years. The primary cause of flooding in the region is due to runoff from major winter storm events and/or snowmelt. Levee systems and dams built throughout the area have significantly reduced the historic flood hazards in this region. However, the area remains

vulnerable to flooding hazards due to an aging levee system combined with the increase urbanization of the County.

A map of the California's hydrological regions is provided below.



The Sutter County Planning Area is located in the east-central part of the Sacramento Valley. The 2006 Sutter County Operational Area EOP describes the Sacramento Valley as forming the northern half of the Central Valley, which surrounded by mountains, creates a "bathtub effect,

with the Sacramento Valley, San Joaquin Delta, and San Francisco Bay forming the drain to the ocean. The lowest areas of the Central Valley, which includes Sutter County, are at the bottom of the bathtub and generally receive the brunt of any flooding.

More specifically, the topography of the Sutter County planning area is a relatively flat alluvial plain with the exception of the Sutter Buttes and the surrounding rolling terrain. The eastern part of the county is an alluvial terrace with elevations of 35 to 80 feet. This terrace generally drains to the southwest into the lower Sutter and American Basins, which are at 10-40 feet in elevation. Flooding is a common occurrence in areas adjacent to and in the lowlands of waterways in the Sutter County Planning Area.

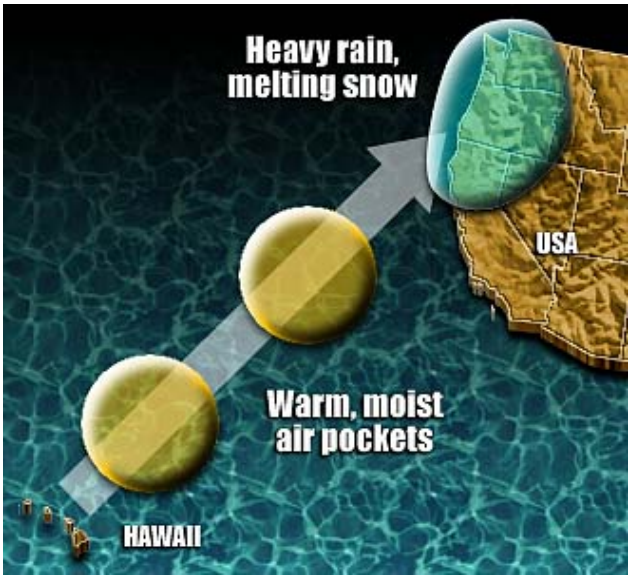
Historically, the Sutter County Planning Area has always been at risk to flooding because of its high annual percentage of rainfall, the watercourses that bound the County, and the location of development adjacent to flood-prone areas. Drainage and stormwater runoff, in addition to natural and manmade waterways, all contribute to potential flooding in the Sutter County Planning Area.

Further contributing to the flooding issue within the Planning Area, are the reduced flow capacity of many of the natural channels. Some factors contributing to this reduced flow include the increased sedimentation from historic upstream mining operations, in addition to the presence of bridges, overgrowth, debris, reduced cross sectional areas and limited or no banks to contain the water.

Also a factor in the flooding potential of the area, a weather pattern called the "Pineapple Express" frequents the Planning Area as described below.

'Pineapple express' brings warm air, rain to West. A relatively common weather pattern brings southwest winds to the Pacific Northwest or California, along with warm, moist air. The moisture sometimes produces many days of heavy rain, which can cause extensive flooding. The warm air also can melt the snow pack in the mountains, which further aggravates the flooding potential. In the colder parts of the year, the warm air can be cooled enough to produce heavy, upslope snow as it rises into the higher elevations of the Sierra Nevada or Cascades. Forecasters and others on the West Coast often refer to this warm, moist air as the "Pineapple Express" because it comes from around Hawaii where pineapples are grown.

(Source: USA TODAY research by Chad Palmer http://www.usatoday.com/weatherwpinappl.htm)



The Sutter County Waterway System

Positioned on an alluvial plain between the Sacramento River on the west and the Feather River on the east, the Sutter County Planning Area lies entirely within the Sacramento River watershed and within the Sutter and Butte Drainage basins. In the southeastern portion of the county lies another alluvial plain situated south of the Bear River and east of the Feather River. These alluvial plains were geologically formed by water running over the stream banks during naturally occurring historic floods.

The Sutter County Planning Area includes both natural and manmade waterways. In addition to the Sacramento, Feather, and Bear Rivers, natural waterways include Coon Creek, Pleasant Grove Creek, Markham and Auburn Ravines in the southeastern portion of the County, the Snake River on the east side of the Sutter Buttes, and other smaller streams and sloughs located throughout the county. Manmade waterways form an extensive network and are used for flood control as well as to convey irrigation water and to provide drainage channels from the croplands. Manmade waterways include the Sutter and Tisdale Bypasses, the Natomas Cross Canal, the Natomas East Main Drainage Canal, and Gilsizer Slough. Drainage and stormwater runoff, in addition to natural waterways, all contribute to potential flooding in the Sutter County Planning Area.

The more notable of these waterways are described in further detail below.

Sacramento River. The Sacramento River, the largest river in the state, extends for approximately 70 miles along the western border of Sutter County. Historically, the river has carved out a wide floodplain outside of its existing banks. The river provides drainage for all of Sutter County and the Sacramento Valley through a system of levees and bypasses completed in the 1920s. The final outlet of the water is the Delta and eventually, the San Francisco Bay. The river supports various recreational and boating activities, agricultural irrigation and diverse wildlife habitats. No communities in Sutter County use the river as a source of domestic or municipal water supply.

The State Department of Water Resources, Division of Water Resources (DWR) established the Sacramento River Flood Control Project to implement flood protection programs for the river and its tributaries. The upper portion if the river is controlled by Shasta Dam, Whiskeytown Dam and Keswick Dam.

Feather River. The Feather River extends approximately 45 miles through Sutter County, forming part of the east Sutter County boundary. The Feather River reaches its confluence with the Sacramento River at the southern county boundary near Verona. Similar to the Sacramento River, the Feather River provides for recreational activities, agricultural irrigation and a diverse wildlife habitat. The river is listed as navigable below the City of Yuba City; however, due to siltation caused by past mining practices in the Sierra Foothills and lack of maintenance, only small boats can pass. The City of Yuba City obtains a large part of its annual water supply for municipal and domestic use from the river.

The Feather River is also part of the Sacramento River Flood Control Project managed by the State DWR. Upstream the river is controlled by the Oroville Dam in Butte County.

Bear River. The Bear River roughly parallels about 11 miles of the eastern county boundary, entering the county from Placer County and crossing the boundary at several points. The river flows in a south-southwest direction until it joins the Feather River about one mile north of the town of Nicolaus. Although smaller than either the Sacramento or Feather Rivers, the Bear River also provides recreational opportunities, agricultural irrigation water and a diverse wildlife habitat. River flows are controlled by the Camp Far West Reservoir in Yuba County.

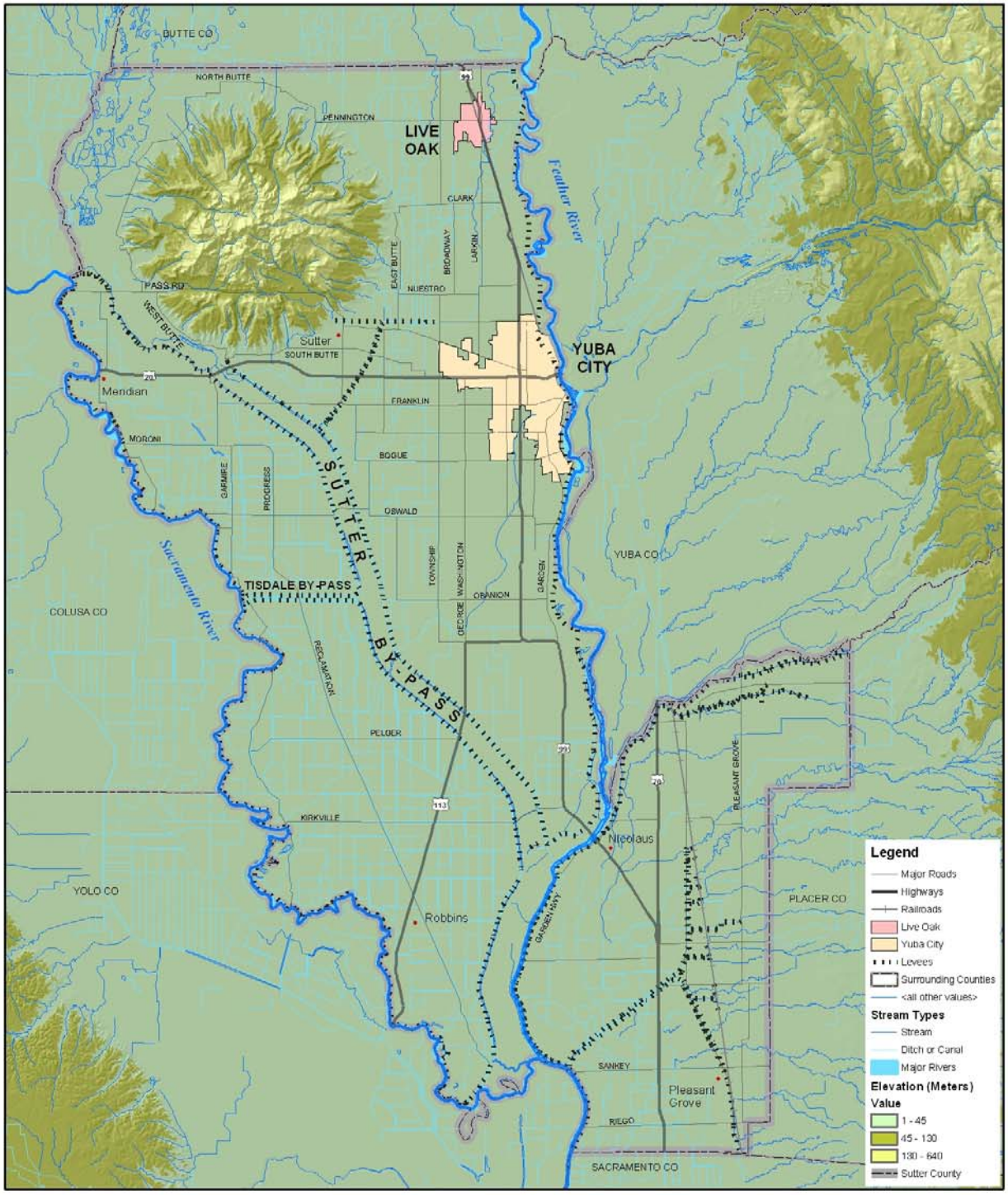
Sutter Bypass. The Sutter Bypass, part of the Sacramento Flood Control Project, is an artificial flood control corridor approximately 3/4 mile wide, bordered by two parallel channels. The Bypass extends from the Sacramento River in the northwest portion of the County, north of Pass Road, and proceeds west of the Sutter Buttes continuing generally in a south-southeast direction for approximately 27 miles where it intercepts the Feather River about three miles south of Nicolaus. The Sutter Bypass collects flood overflow water from the Sacramento River after passing through Butte Slough and the Butte Sink.

Sutter Bypass
(Source: AMEC Earth & Environmental)

Tisdale Bypass. The Tisdale Bypass, another flood control corridor, extends for approximately four miles due west from the Sutter Bypass.

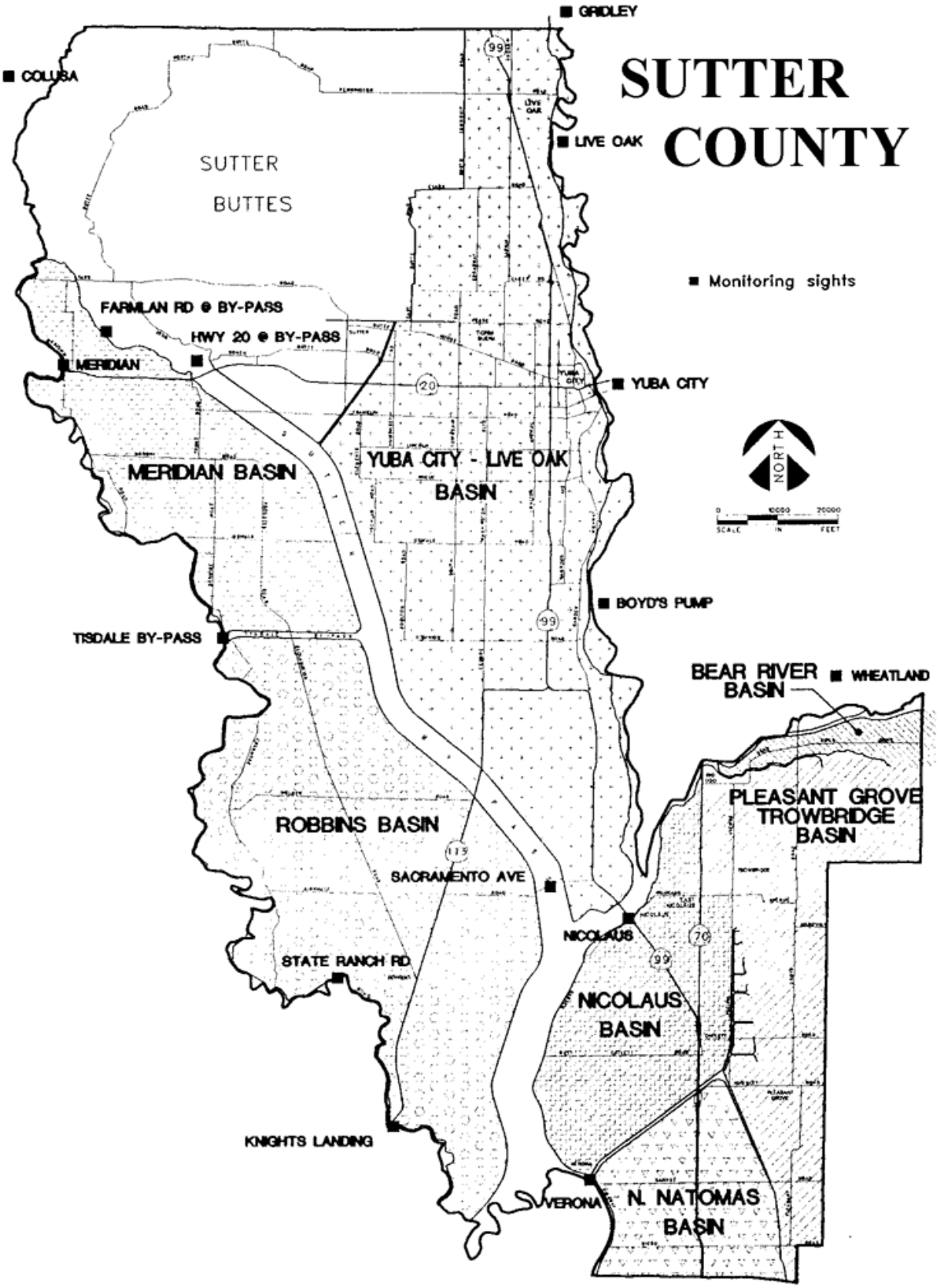
The following figure illustrates natural and manmade waterways in the planning area.

Sutter County Drainage / Flood Control Map



Sutter County is divided into four primary basins: Yuba City/Live Oak Basin, Meridian Basin, Robbins Basin and the Southeast Sutter County Basin (consisting of the Nicolaus, Bear River, Pleasant Grove/Trowbirdge, and North Natomas Basins.) The following map taken from the Sutter County Operational Area EOP, Annex 5 – Floods and Dam Failure, illustrates the locations of these basins.

Sutter County Basins



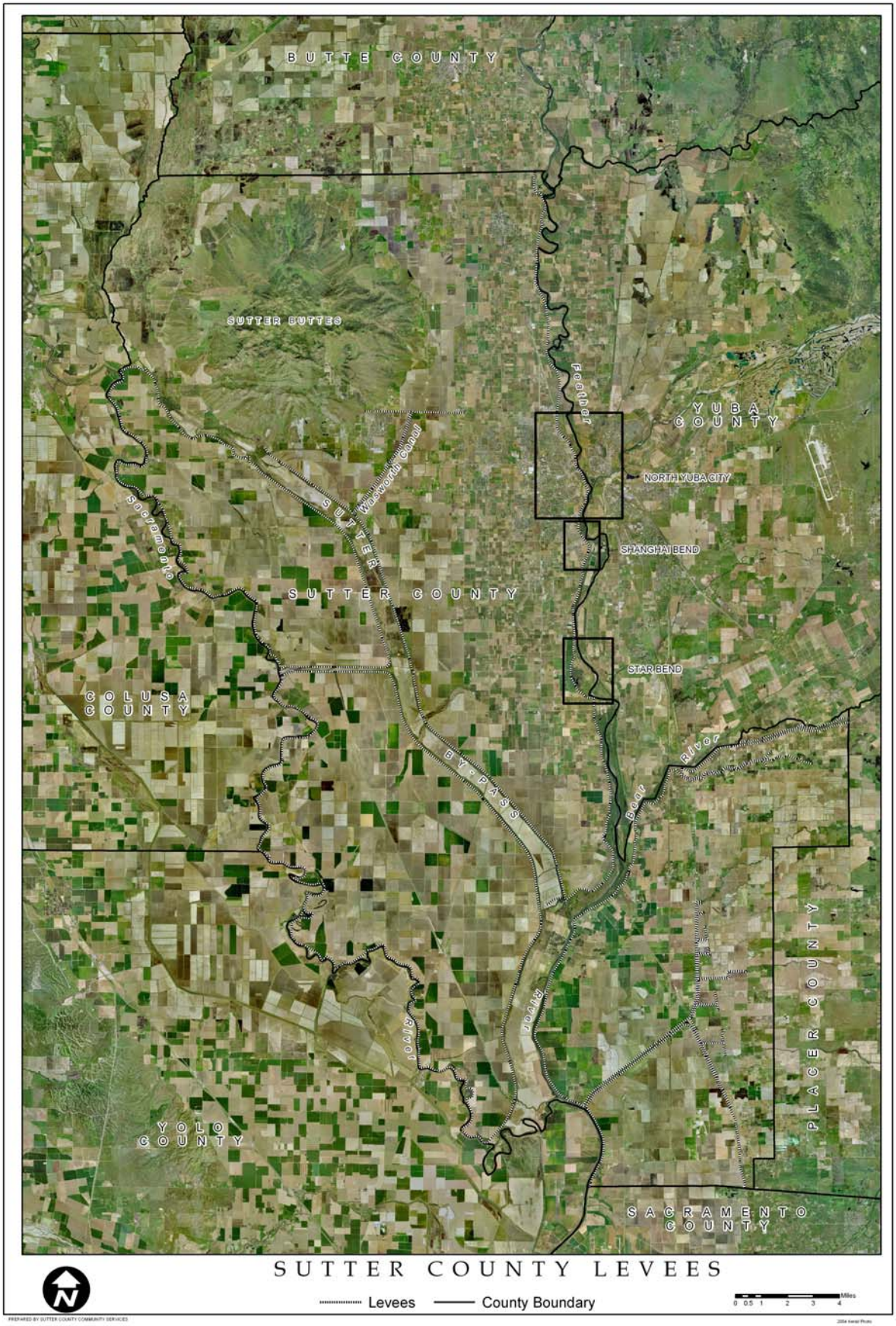
County-Wide Flood Control Measures

The principal method of flood protection for the Sutter County Planning Area is structural, consisting of reservoirs (dams), levees and bypasses completed between the 1920s and 1960s. Most of the levees were constructed as parts of federal flood control projects and then, on completion, were turned over to local interests for operation and maintenance. Levees along the Sacramento River, Sutter Bypass, Feather River Yankee Slough, Wadsworth Canal, Cross Canal, and Tisdale Bypass are part of the Sacramento River Flood Control Project which was authorized by the Flood Control Act of 1917. According to the Flood Insurance Study (FIS) for unincorporated Sutter County (1998), the original project designs and later improvements to the Sacramento River Basin Flood Control System provided a 100-year level of protection. However, as discussed later in this section, more recent studies evaluating the levee system have identified several deficiencies which reduce the current level of protection of most area levees to below the 100-year level.

All of the reservoirs are located outside of the Planning Area. Within the Planning Area, the Sacramento and Feather Rivers rely primarily on a system of levees or earthen embankments to contain high river flows. Other flood control structures include bypasses. The bypasses, such as the Sutter Bypass, are auxiliary channels used to pass floodwater. Because the potential high flow of floodwaters within the Planning Area is larger than existing channel capacities, bypass systems have been developed to create additional capacity during critical peak flows. These bypass systems are needed only during major floods; as such, much of the lands reserved for this purpose can be used for agriculture, wildlife management, recreation or other compatible uses.

As the Sacramento River flows southward from Shasta Dam, natural overflow areas and two fixed weirs, Moulton and Colusa, permit floodwater to escape from the river into the Butte Basin. The Butte Basin is a natural flowage area that has not been drained and developed as have other basins in the area. Waters in the Butte Basin then flow into the upstream end of the Sutter Bypass. At the Tisdale Weir, additional water can be diverted from the Sacramento River directly into the Sutter Bypass. Draining the east side of the Sacramento Valley, flows from the Feather River enter the Sutter Bypass directly. The Sutter Bypass and the Sacramento River join just above the Fremont Weir. This weir divides the joint flow of the river-bypass system, limiting flow into the Sacramento River channel to its capacity and permitting the excess flow to cross the river and enter the Yolo Bypass. Near Sacramento, the Sacramento Weir provides the final escape route from the river to the Yolo Bypass. Also considered part of the flood control system within the Planning Area is a system of pumping plants which collect drainage waters and pumps the waters back into adjacent canals and rivers.

The map on the following page depicts the levee system within Sutter County.


BUTTE COUNTY
SUTTER BUTTES
Feather
YUBA COUNTY
NORTH YUBA CITY
Wadsworth Canal
SUTTER
Sacramento
SHANGHAI BEND
SUTTER COUNTY
STAR BEND
COLUSA COUNTY
BY-PASS
Bear
River
PLACER COUNTY
Joaquin
River
YOLO COUNTY
SACRAMENTO COUNTY
SUTTER COUNTY LEVEES
Levees
County Boundary
Miles
0 0.5 1 2 3 4

While this system of levees and bypasses certainly provide a level of flood protection to the Planning Area, recent studies (e.g., Sacramento River Flood Control System Evaluation initial Appraisal Report – Marysville/Yuba City Area, 1990) have identified several deficiencies in the structural integrity of the levees along the Feather River. According to this study as summarized in the Sutter County General Plan:

"…the levee system contains a number of structurally deficient segments that are susceptible to seepage problems and do not provide the design levels of flood protection. Without the remedial repairs recommended in the report cited above, the levels of flood protection are well below the 100 year recurrence interval that the system was designed to provide. The U. S. Army Corps of Engineers is in the process of reconstruction efforts along the most critical areas of the levee system. Table 10.7-1 depicts the different segments of the rivers and their level of protection with and without the recommended remedial repairs." (Source: Sutter County General Plan 2015: Background Report, November 1996. Pg. 10-17.)

Table 10.7-1 is reproduced in part below:

Sutter County Planning Area
Levels of Levee Protection*
With and Without Remedial Repairs

Levee Reach	Recurrence Interval Without Improvements	Recurrence Interval With** Improvements
Feather River upstream from Honcut Creek	50 years	200+ years
Feather River between Honcut Creek and Jack Slough	50 years	175+ years
Feather River between Jack Slough and Yuba River	60 years	150+ years
Feather River between Yuba River and Bear River	70 years	150+ years
Feather River between Bear River and Sutter Bypass	65 years	150+
Yuba River upstream of mouth	30 years	100 years
Bear River upstream from mouth	65 years	100+ years
Sutter Bypass between Tisdale Bypass and Feather River	20 years	150+ years

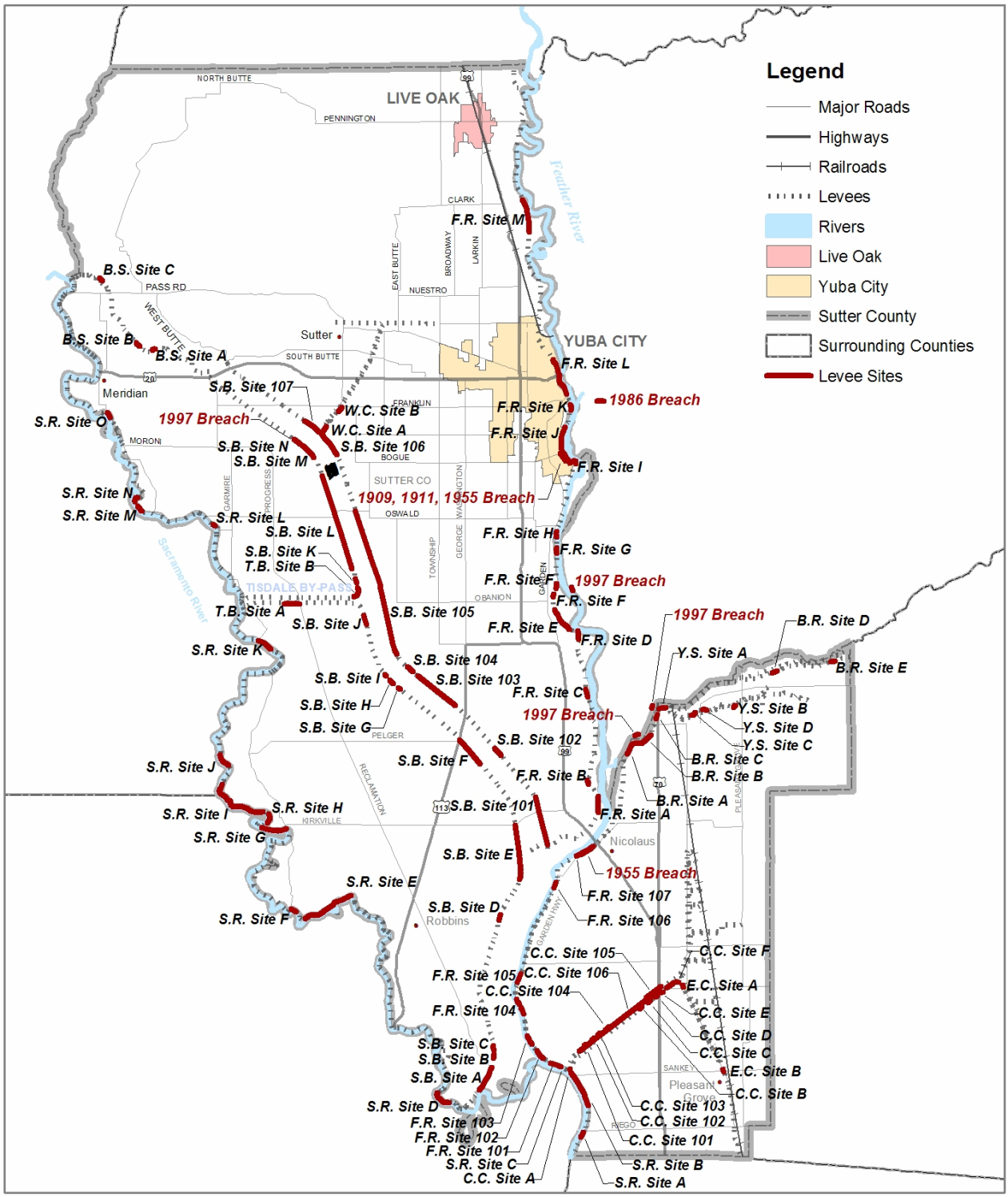
* Recurrence intervals are based on the assumption that no levee breaches occur upstream. In reality, if a levee break occurred upstream, downstream levee reaches would have a higher level of flood protection than those shown above.

** Levels of flood protection with remedial repairs are based on a minimum of 3 feet freeboard in a specified levee reach.

The above table and statements from the Sutter County General Plan provide an assessment of the levee system prior to the 1997 floods. Since then, while concerns with the levees remain, many improvements to the levees have been implemented. More recent evaluations and studies

of the existing levee system provide more comprehensive information on the status of the levee system in the Sutter County Planning Area. Summarizing the most significant issues with the levee system as well as identifying the various types of improvements, the following map and associated text identify locations and provide historical details on the status of the levees as of 2002.

Sutter County Historical Levee Information



SUTTER COUNTY AND YUBA CITY
HISTORICAL LEVEE INFORMATION 2002

Feather River, Right (West) Levee

F.R. Site A: This site is located between Sacramento Avenue and Laurel Avenue between approximate river miles 10.2 and 11.1 (levee mile 2.3 and 3.3). Excessive seepage occurs at this site during high water.

F.R. Site B: This site is located near Laurel Avenue at approximate river mile 11.6 (levee mile 3.7). A landside boil occurred in a landside drainage ditch near the levee toe during the 1986 flood. During the 1997 flood, the drainage ditch was sloughing and heavy but clear seepage was entering the ditch. During the flood, an emergency stability berm was constructed of sandbags placed on a geotextile within the drainage ditch. Later that year, the ditch was converted to a pervious toe drain. In 1998, a permanent seepage/stability berm was constructed at this site under the Marysville/Yuba City Levee Reconstruction Project.

F.R. Site C: This site is located 2.4 miles south of Star Bend at approximate river mile 14.7 (levee mile 1.5). During the 1986 flood, a crack formed in the levee. During the 1997 flood, seepage occurred at this site. A pervious toe drain and seepage/stability berm have been constructed at this site under a PL 84-99 action.

F.R. Site D: This site is located just south of Star Bend at approximate river mile 17.8 (levee mile 3.8). During the 1986 flood, boils carrying soil formed near the landside toe of the levee in a half-mile stretch. The ground to approximately 100 feet away from landside toe was very soft and wet. The peak floodwater was 5-6 feet below the top of the levee at this location. LD 1 personnel constructed sandbag rings around three of the worst boils. Seepage also occurred during the 1997 flood. In 1998 the levee was raised 1 foot and a pervious toe drain and seepage/stability berm was installed at the landside levee toe under the Marysville/Yuba City Levee Reconstruction project.

F.R. Site E: This site is located between Star Bend Road and Abbot Road at approximate river mile 18.1 to 19.0 (levee mile 4.1 to 5.0). During 1995, clear seepage exited the levee toe and the ground beyond the levee toe while the river level was approximately 12 to 15 feet below the top of levee. During the 1997 flood, numerous boils occurred in a 200 linear foot stretch. Sandbag rings were constructed around the boils that were moving material. The following day, the sandbagged boils were flowing clear. In 1997 the Corps of Engineers installed relief wells in this area to reduce seepage and instability of the levee under a PL 84-99 contract.

F.R. Site G: This site is located near Messick Road at approximate river mile 21.2 (levee mile 7.3). Waterside bank erosion is encroaching on the levee section.

F.R. Site H: This site is at the Boyd Pump Boat Ramp at levee mile 8, between Messick Road and Oswald Avenue at approximate river mile 21.7. During the 1986 flood, portions of the boat ramp parking lot and subgrade and portions of the levee toe were eroded. In 1998 the Corps raised the levee 1 foot and

installed a pervious toe drain and seepage/stability berm at this site under the Marysville/Yuba City Levee Reconstruction project.

F.R. Site J: This site is located between Shanghai Bend and the Yuba City Airport between approximate river miles 25.1 and 26.5 (levee miles 11.0 and 12.4). The levee broke in this area during 1909, 1911, and 1955. In 1957, the Corps of Engineers reconstructed the levee to the landside of it's previous location and installed a row of relief wells near the landside levee toe. Water from the relief wells is pumped to the Feather River. During the 1986 flood, volunteers sandbagged several boils in this area. In 1990 the City of Yuba City installed a seepage interceptor system in the southern part of this site. The interceptor system consists of a perforated pipeline and filter 12-18 feet below ground surface to extract shallow seepage, and relief wells placed between the 1957 relief wells to extract deeper seepage. All water collected is pumped into the Feather River separately from the water collected by the 1957 relief wells. In 1993, an inspection of the shallow drain perforated pipeline discovered unacceptable deflections over large portions of the pipeline. The deformed plastic pipeline was removed and replaced with a

perforated clay pipeline. In 2000 or 2001 the Corps of Engineers rehabilitated the original 1957 relief wells under a PL 84-99 contract.

F.R. Site K: This site is located near the Yuba City airport at approximate river mile 27.0 (levee mile 13.6). Seepage occurs at this site during high water. An impermeable cutoff wall has been constructed in this area. The cutoff wall slightly overlaps the relief wells and deep seepage interceptor system at F.R. Site J, extends through this site, and ends 800 feet upstream of the Fifth Street Bridge in F.R. Site L. The southern portion of the cutoff wall was constructed under the Marysville/Yuba City Levee Reconstruction project. The northern portion of the cutoff wall was constructed under a PL 84-99 contract.

F.R. Site L: This site is located in Yuba City from Garden Highway north to the Drive In Cinema between approximate river miles 27.4 to 29.3 (levee miles 14.0 to 15.5). During the 1955 flood seepage was observed near the Tenth Street Bridge. During the 1986 flood the landside slope became saturated and unstable and bulged slightly in the area of the Corporation Yard. Water also flowed up through cracks in the parking lot pavement and the floor slab of an auto body shop on Teegarden Avenue. Erosion of the waterside levee toe occurred in the areas immediately upstream and downstream of the Fifth Street Bridge. Yuba City constructed a berm along the landside toe as an emergency action. A permanent seepage/stability berm was later constructed from the 5th Street Bridge extending northward to about 2500 feet beyond the 10th Street Bridge. An impermeable cutoff wall was also constructed in this area (see F.R. Site K). In 1998 rock protection was added to the waterside eroded area around the Fifth Street Bridge.

F.R. Site M: This site is located in the area around Koch Lane between approximate river miles 35.6 and 37.6 (levee miles 3.9 and 5.3) in LD 9. During high water, seepage and boils occur near the landside levee toe. The Corps relocated an open drainage ditch away from the toe of the levee at the north end of this site under the Marysville/Yuba City Levee Reconstruction project. A consultant to L.D. 9 recommended installing a pervious toe drain over the entire site to control seepage, but no improvements have been made.

Sutter Bypass East Levee

S.B. Site 101: This site is located between Pumping Station #1 and the confluence of the Feather River between river miles 66.2 to 68.5 (levee miles 20 to 22.37). During 1986 a 3,000 foot length of the

waterside levee north of the confluence with the Feather River was repaired under a PL 84-99 action. Wavewash and county maintenance equipment had resulted in erosion near the waterside toe and halfway
up the waterside slope. Both areas were repaired using nearby materials. During the 1997 flood, the 1,000 linear foot segment immediately upstream of the Feather River exhibited seepage, boils, and a sinkhole on the landside berm. This landside berm is an abandoned railroad berm. A landside pervious toe drain was constructed at this site in 2001 under a cost-shared PL 84-99 action.

S.B. Site 102: This site is located between Pump Station #1 and Highway 113, at approximately river mile 70.1 (levee mile 17.6). During the 1997 flood seepage occurred at this site. A seepage/stability berm with a pervious toe drain was constructed at this site in 2001 under a cost-shared PL 84-99 action.

S.B. Sites 103 and 104: These sites are located between Highway 113 and Gilsizer Slough at approximately river miles 72.3 to 73.7 and 74.4 respectively (levee miles 14.1 to 15.5 and 13.4 respectively). Seepage occurred at these sites during high water. As part of the Mid Valley Phase III Levee Reconstruction project, seepage/stability berms have been constructed at both of these sites.

S.B. Site 105: This site is located between Hughes Road (upstream of Tisdale Bypass) and Gilsizer Slough, between river miles 75.0 and 80.1 (levee miles 7.5 and 12.6). Part of this site is upstream of the Tisdale Bypass and part of the site is downstream of the Tisdale Bypass. Boils occur near the landside levee toe during high water events at this site. In 1958 a landside pervious toe drain was installed from McClatchey Road to Gilsizer Slough.

S.B. Site 106: This site is located between Lincoln Road and McClatchy Road, immediately downstream of the Wadsworth Canal, between approximately river miles 82.8 and 83.7 (levee miles 4.4 and 5.4). During the 1997 flood, heavy seepage occurred in this area. During 2001 a pervious toe drain and seepage/stability berm was constructed at this site under a cost-shared PL 84-99 action.

S.B. Site 107: This site is located between Pump House #3 and the right bank of the Wadsworth Canal between approximately river miles 83.8 and 84.4 (levee miles 3.7 and 4.3). During the 1997 flood heavy seepage and soil heaving occurred at this site. A pervious toe drain and seepage/stability berm was constructed during 2001 under a cost-shared PL 84-99 action.

Wadsworth Canal, Left (Southeast) Levee.

W.C. Site A: This site is located where the Wadsworth Canal joins the Sutter Bypass (the Dean Property), river and levee miles 0 to 0.5. Seepage frequently occurs at this site during high flows. During 1997 and 1998 small boils were observed at the landside levee toe. In 2002 the Corps of Engineers recommended a slurry cutoff wall be constructed at this site under a cost-shared PL 84-99 action.

W.C. Site B: This site is located just downstream of Franklin Road, river and levee miles 1.0. During the 1997 flood heavy seepage occurred at this site. The water surface was observed to be about 5 feet below the levee crest. In 2001 the Corps of Engineers constructed a pervious toe drain at the landside toe of the levee under a cost-shared PL 84-99 action.

Floodplain Mapping

FEMA established standards for floodplain mapping studies as part of the NFIP. The NFIP makes flood insurance available to property owners in participating communities adopting FEMA approved local floodplain studies, maps and regulations. Floodplain studies that may be approved by FEMA include federally funded studies, studies developed by state, city and regional public agencies, and technical studies generated by private interests as part of property annexation and land development efforts. Such studies may include entire stream reaches or limited stream sections depending on the nature and scope of a study. A general overview of floodplain mapping is provided in the following paragraphs. Details on the NFIP program, flood studies and mapping specific to each participating jurisdiction are provided in the jurisdictional elements of this plan.

Flood Insurance Study (FIS)

The FIS develops flood-risk data for various areas of the community that will be used to establish flood insurance rates and to assist the community in its efforts to promote sound floodplain management. The current Sutter County FIS is dated July 6, 1998. A new, preliminary FIS for Sutter County (August 9, 2006) is currently under review. FEMA has never published any FISs for the Cities of Yuba City or Live Oak.

Flood Insurance Rate Map (FIRM)

The FIRM is designed for flood insurance and floodplain management applications. For flood insurance, the FIRM designates flood insurance rate zones to assign premium rates for flood insurance policies. For floodplain management, the FIRM delineates 100-and 500-year floodplains, floodways and the locations of selected cross sections used in the hydraulic analysis and local floodplain regulation. Current FIRM map panels for each jurisdiction are identified in the jurisdictional elements of this plan.

Letter of Map Revision (LOMR) and Map Amendment (LOMA)

LOMRs and LOMAs represent separate floodplain studies dealing with individual properties or limited stream segments that update the FIS and FIRM between periodic FEMA publications of the FIS and FIRM.

Digital Flood Insurance Rate Map (DFIRM)
FEMA has begun the process of converting paper FIRMS to digital FIRMs. The end product is called the DFIRM. This is part of FEMA's Map Modernization program. The primary goals of the DFIRM are to:

- Incorporate the latest updates (LOMRs and LOMAs),
- Utilize community supplied data,
- Verify the currency of the floodplains and refit them to community supplied basemaps,
- Upgrade the FIRMs to a GIS database format to set the stage for follow on updates and to enable support for GIS analyses and other digital applications, and
- Solicit community participation.

In August of 2005, FEMA Headquarters' issued Memo 34, *Interim Guidance for Studies Including Levees.* This memo recognizes the risk and vulnerability of communities with levees. The memo mandates the inclusion of levee evaluations for those communities that are undergoing map changes such as the conversion to DFIRMs. No maps could become effective without an evaluation of all levees within a community against the criteria set forth in 44 CFR 65.10 *Mapping of Areas Protected by Levee Systems.*

As previously described, recent evaluations of the levee system in the Sutter County Planning Area have identified numerous deficiencies in the structural integrity of these levees. Additional evaluation and repairs to identified deficiencies in accordance with FEMA levee certification requirements are required before the levees can be properly certified. As a result, FEMA is in the process of issuing DFIRMs for the Planning Area that do not recognize the levees as providing protection from the 100-year flood. Specifically, FEMA is completing new flood studies and developing DFIRMS for the Sutter County Planning Area in two phases:

Lower Feather River Study. The Amended Draft of the Lower Feather River Floodplain Mapping Study, Revised February 17, 2005 (LFR Study), prepared by the U.S. Army Corps of Engineers (USACE) Sacramento District, was conducted, in part, to support the DFRIM mapping efforts within the Sutter County Planning Area. Generally, the LFR Study addresses flooding from the Feather River downstream of the Yuba River confluence to the mouth of the Feather River at the Sacramento River. It also addresses flooding from the Bear River downstream of Highway 65 and several tributaries to the Bear River. New hydrologic data and hydraulic models were developed as part of this study.

The LFR study was performed in compliance with current FEMA technical guidelines requiring certification of levees before crediting the levees with providing protection from the 1% annual event. According to the LFR study, at the time the study began, none of the levees in the study area were certified. And, most of the levees were "grand-fathered" as providing 100-year flood protection based on Flood Plain Information Reports performed in the 1960's by USACE. No new flood insurance studies had been conducted on either the Yuba or Feather Rivers since the 1986 or 1997 flood events and levee failures.

FEMA levee certification requirements include evaluations of freeboard, geotechnical stability and seepage, bank erosion potential due to currents and waves, closure structures, operations and maintenance, and wind set and wave run-up. The LFR Study, basing its assessment on only three of these requirements (i.e., freeboard, geotechnical stability and seepage, and bank

erosion), concluded that no levees within the study area could be certified in accordance with the requirements of 44 CFR 65.10. As a result of this finding, the new DFIRMs developed from this LFR study do not recognize the levees as providing 100-year flood protection.

According to the LFR Study, FEMA requires that a levee not be recognized on new maps if not certified for determination of flood insurance rate zones. New flood insurance rate zones were identified by considering: depth of flooding, nature of flow pattern, and whether the hydraulic computation method was considered detailed or approximate. Based on this Study, the following criteria were applied to the determination of flood insurance rate zones for the new DFIRMs:

- Areas of deep ponding, such as behind levees, were mapped as AE zones. The 1% water surface elevation for these areas is well defined as the water is typically ponded behind a levee of know height.
- Areas of shallow (less than one foot) overland flow were mapped as X zones.
- Areas of overland flow, ranging from 1 to 3 feet deep, were mapped as AO zones.
- Areas of deeper overland flow were mapped as A zones.

The resulting DFIRMs are discussed further in the Jurisdictional Elements of this plan.

Upper Feather River Study (UFR Study). Similar in scope to the LFR Study, the UFR Study will cover the portions of the Sutter County Planning Area, not included in the LFR Study. It is anticipated that the UFR Study will reach the same conclusions with respect the inability to certify the levees within that study area resulting in new DFIRMs that do not recognize the levees as providing a 100-year level of flood protection. The UFR study and new DFIRMs are anticipated to be out in draft form sometime in 2008-2009.

Major Sources of Flooding/Problem Areas

Floodwaters are a common occurrence for communities adjacent to and in the lowlands of rivers in Sutter County. Normally, wintertime storm floodwaters are kept within defined limits by levees, dykes, and open lowlands and cause no damage. Dams located outside Sutter County boundaries such as Oroville, Bullards Bar, and Shasta also help control floodwaters. But, occasionally, a combination of frequent storms, extended heavy rain, and melting snow results in floodwaters exceeding normal high-water boundaries and causing damage.

Given their location relative to the county, the Feather and Sacramento Rivers and associated tributaries present the greatest flood potential to the Sutter County Planning Area. The following table provides a record of peak water levels at several key monitoring stations on both the Feather and Sacramento Rivers.

Sutter County River/Stream Historic Levels

River/Stream	Forecast Point	MONITORING STATION	Top of Levee Elevation	Peak Level of Record
Feather River	**Yuba City**	Feather River @ 5th Street Bridge (YUB)	83.5'	**82.4'** 12/24/1955
Feather River	**Nicolaus**	Feather River @ Nicolaus (NIC)	60.3'	**51.6'** 12/23/1955
Sacramento River	**Colusa Weir**	Sacramento River @ Colusa Weir (CLW)	74.8'	**70.6'** 3/1/1940
Sacramento River	**Colusa**	Sacramento River @ Colusa Bridge (COL)	73.0'	**69.2'** 2/8/1942
Sacramento River	**Tisdale Weir (Robbins Basin)**	Sacramento River @ Tisdale Weir (TIS)	57.0'	**53.3'** 3/1/1940
Sacramento River	**Knight's Landing (Robbins Basin)**	Sacramento River @ Knights Landing (KNL)	47.5'	**41.8'** 2/8/1942
Sacramento River	**Below Wilkins Slough (SE County Basin)**	Sacramento River @ Wilkins Slough	56.1'	**52.8'** 3/1/1940
Sacramento River	**Fremont Weir (SE County Basin)**	Sacramento River @ Fremont Weir	45.4'	**39.7'** 12/23/1955
Sacramento River	**Verona (SE County Basin)**	Sacramento River @ Verona	46.0'	**41.2'** 3/1/1940
Sutter By-Pass	**Meridian Basin**	Sutter By-Pass @ Long Bridge (LNB)	61.8'	**57.7'** 3/1/1940
Yuba River	**Englebright Dam**		527.0'*	**546.1'** 12/22/1964

All elevations are United States Engineering Datum (USED)
*Spillway crest elevation.
(Source: Sutter County Operational Area Emergency Operations Plan, Annex 5 – Floods and Dam Failure)

Flooding during periods of excessive rainfall can occur anytime in the Planning Area during the rainy season from November through April. Prolonged heavy rainfall contributes to a large volume of runoff resulting in high peak flows of moderate duration. Flooding is more severe when previous rainfall has created saturated ground conditions. According to the 1998 FIS for the county, the severity of flooding is often intensified by backwater conditions between stream systems. This occurs when floodwater elevations are increased in lower portions of tributary streams due to the backwater effect from main streams reducing hydraulic gradients and flow-storage areas. The 1998 FIS identified several areas where the high flow of floodwaters cause backwater conditions on other channels:

- High flows on the Sacramento River generate backwater conditions on the lower reach of the American River and the Cross Canal.
- The American River peak 100-year flows induce backwater conditions in the lower reach of the Natomas East Main Drainage Canal.
- High flows on the Natomas East Main Drainage Canal cause backwater conditions on the lower reaches of Arcade and Dry Creeks.
- High flows on Cross Canal create backwater conditions on Pleasant Grove Creek Canal.

Localized flooding also occurs throughout the County with several areas of primary concern. According to the Sutter County Department of Public Works, numerous roads throughout the county are subject to flooding in heavy rains. In addition to flooding, damages to these areas during heavy storms include pavement deterioration, washouts, landslides/mudslides, debris areas, and downed trees. The amount and type of damage or flooding that occurs varies from year to year, depending on the quantity of runoff. These areas and the types of damages are presented in the following table. Photos and descriptions of these areas during flood conditions are included in Appendix F

Unincorporated Sutter County
Localized Flooding Areas and Related Impacts

No.	Road Name	Flooding	Pavement Detoriation	Washouts	Landslide Or Mudslides	Debris	Downed Trees
1	Pass Rd	x	x	x	x	x	
2	West Butte Rd.	x	x	x		x	
3	North Butte Rd.	x	x	x		x	x
4	East Butte Rd.	x	x	x		x	x
5	South Butte Rd.	x	x	x		x	x
6	Powell Rd.	x	x	x		x	x
7	Pennington Rd.	x	x	x		x	x
8	Butte House Rd.	x				x	x
9	Kellogg Rd.	x	x	x	x	x	x
10	Lower Pass Rd.	x	x	x		x	x
11	Almond Orchard Rd.	x				x	
12	Hagaman Rd.	x					
13	Metterr Rd.	x	x				
14	Fifield Rd	x		x	x	x	
15	Keyes Rd.	x	x	x			
16	Catlett Rd.	x		x		x	
17	Howsley Rd.	x	x			x	
18	Pleasant Grove Rd.	x	x	x		x	
19	Brewer Rd.	x	x	x		x	x
20	Sacramento Ave.	x	x	x		x	x
21	Reclamation Rd.		x		x		
22	Subaco Rd..		x	x	x		
23	Hicks Rd.	x	x			x	x
24	Hughes	x	x			x	x
25	Oswald	x	x			x	x

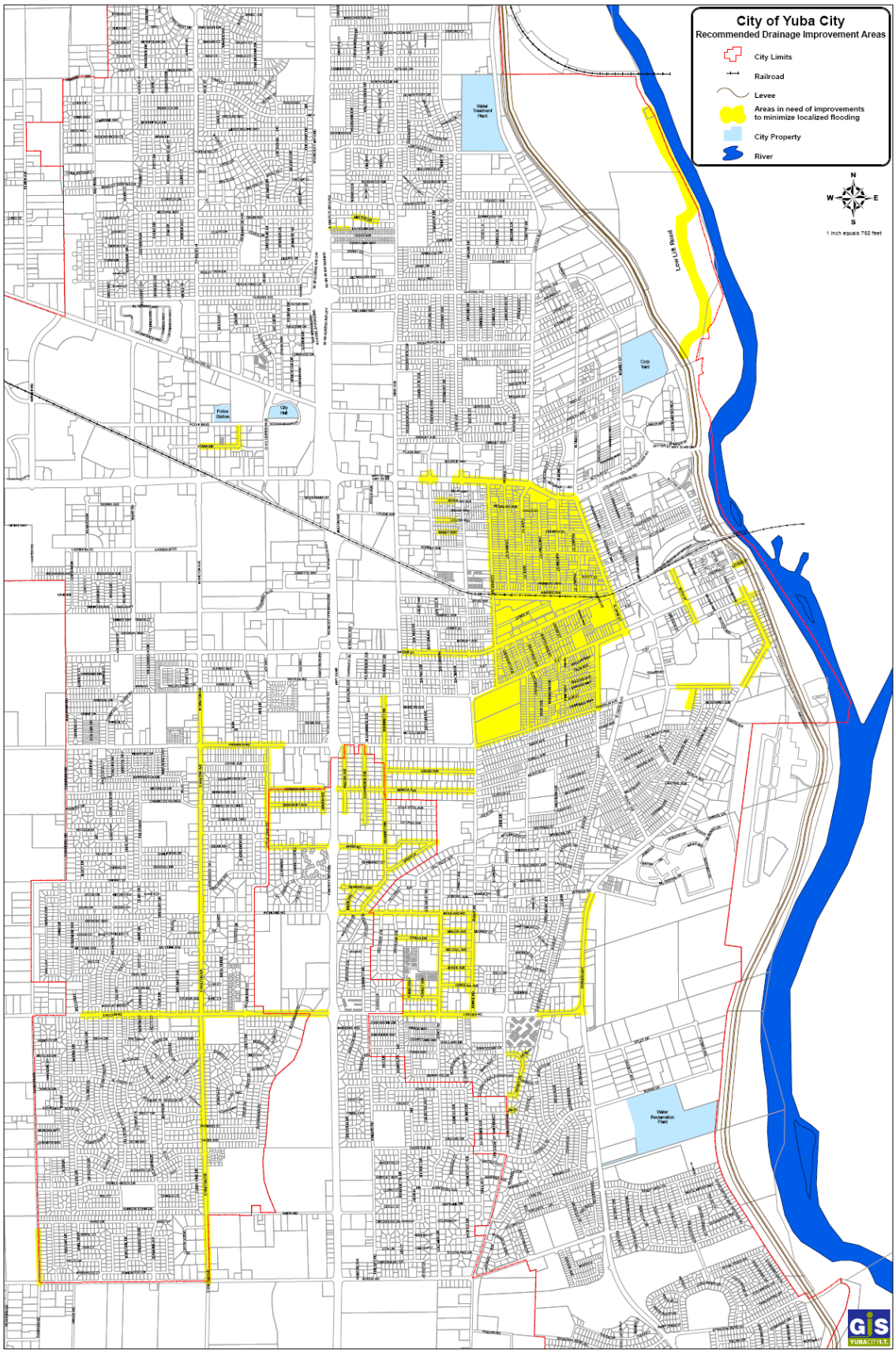
(Source: Sutter County Public Works)

Also of concern to the County is the Live Oak Canal area between Pease Road and Schlag Road. The Live Oak canal drains approximately 1/3 of the Yuba City Area and approximately ½ of the Yuba City rural area. Most of the problems are caused by heavy rains combined with inadequate pipe capacity due to increased development in the Yuba City rural area.

Yuba City Urban Area - The area of the county with the greatest potential to be impacted by drainage and flooding problems is the Yuba City Urban Area. The greatest potential threat to the Yuba City Urban Area is flooding resulting from failure of levees along the Feather River. In addition to a damaging flood resulting from a dam or levee failure, the urban area is highly susceptible to flooding from stormwater runoff. As development continues to occur in the urban

area, the increase in impervious surfaces will result in increased overall run-off at an accelerated rate. Ongoing improvements to the drainage infrastructure are being designed and constructed to accommodate this increase in run-off; however, removing run off and flood waters from the urban area does not in itself resolve drainage issues. Lack of downstream channel maintenance and limited flow capacity within the Sutter Bypass can backup flood waters and also contributes to localized flooding issues within the urban area. A map detailing recommended drainage improvement areas within the City of Yuba City is provided on the following page.

City of Yuba City Recommended Drainage Improvement Areas



(Source: City of Yuba City, Departments of Public Works/GIS)

Past Occurrences

Historically, flooding has been an ongoing problem throughout the Planning Area. The most notable major flood events occurred in 1955, 1986, 1995, and 1997 as described in detail below. Primary damages were to property and agricultural crops. These damaging floods were generally the result of failures of the levee systems rather than the levees being overtopped. Other lesser flooding events have also occurred in other years. A brief summary table is also included below that presents a timeline of past flooding events.

Historic Timeline of Past Flooding Events in Sutter County and Surrounding Areas.

Date	Description
1805	Great Flood. Information from early settlers indicated the entire valley was inundated. Many lives were lost and villages destroyed.
1846-47	More data from early settlers indicated the loss of life and villages.
1852-53	More data from early settlers indicated the loss of life and villages.
1861	Dec. 10th. Marysville Appeal Newspaper described the entire town under water. All that was seen was the "roofs of houses and floating animals"
1862	Jan. 11th. Water was 6" higher than 1861. Farmers lost ¾ of herds.
1867-68	Extensive property and levee damage. 1/5th of levees were washed away.
1870	Large levee constructed in Colusa county penned in water in Sutter County. Meridian and Kirksville were submerged.
1875	Jan. 19. Levees in Yuba City and Maryville broke and flooded both cities. Volume and height of water unprecedented.
1907	Three weeks of heavy rain and March snowfall led to levees breaking in District 1 & 2 in mid-March. Flood wave sustained 200 miles. Damage amounted to $1000.
1937	Levee break in E. Biggs. Water flowed over Hwy 20. Nicolaus bridge was damaged.
1940	Flood in Meridian from Sutter Bypass. After this flood the Shasta Dam was built to control the Sacramento River.
1942	Break in Sutter Bypass flooded Sutter/Robbins Basin.
1944	Break in the Bear River flooded Sutter County.
1948	Break in Bear River flooded Rio Oso/Nicolaus Basin.
1950	Nov. 19th break in Yankee Slough flooded Sutter County.
1955	Dec. All time record flow. Worst flood in Northern California history.
1986	Linda levee broke. Flooded 30 square miles. Emergency declared by Governor.
1995	Flooding caused by two direct downpours which created major surface drainage back-ups at numerous locations throughout the county. More than $850,000 in damages to county facilities.
1997	Flood in Yuba County, Plumas Lake area. 80,000 evacuated. Meridian basin floods from a break in the Sutter Bypass Levee.

Taken directly from the 2006, Draft Sutter County Operational Area EOP, Annex 5 - Flood and Dam Failure, the following paragraphs provide a short synopsis of the most significant past flooding disasters occurring in the Sutter County Operational Area:

1955 Flooding

This was the most devastating of all the floods to this area. A break in this levee south of Yuba City occurred at about midnight on December 23rd. The initial of surge water spread westerly through Gilsizer Slough to the Sutter Bypass and northerly into Yuba City. Within less than 24 hours, the heart of Sutter County was flooded from the Feather River on the east and south to the Bypass on the west and southwest. To the north, the water spread north of Colusa Avenue (Highway 20) in several areas, including some west of Walton Avenue.

Nearly 100,000 acres were flooded and resulted in 38 deaths, injuries to 3,200 people, and nearly $40 million in property damage. The bridge over the Feather River at 5th Street was washed out and telephone service was lost south of Colusa Avenue.

Downtown Yuba City December 1955
(Seepage Related Levee Break in Upper Center) View Southerly
(Source: Yuba City Public Library)

1986 Flooding

While the most severe flooding occurred in neighboring Yuba County, Sutter County did experienced flooding. The most serious problems were located in the southern area of the county which is sparsely populated. The county was fortunate not to have a break in the levee but did experience slumping in the Robbins area. In the southeast area of the county, surface flow from Placer County led to extensive ponding. This coupled with

two failures of minor levees, flooded numerous rural residences and agricultural facilities.

1995 Flooding

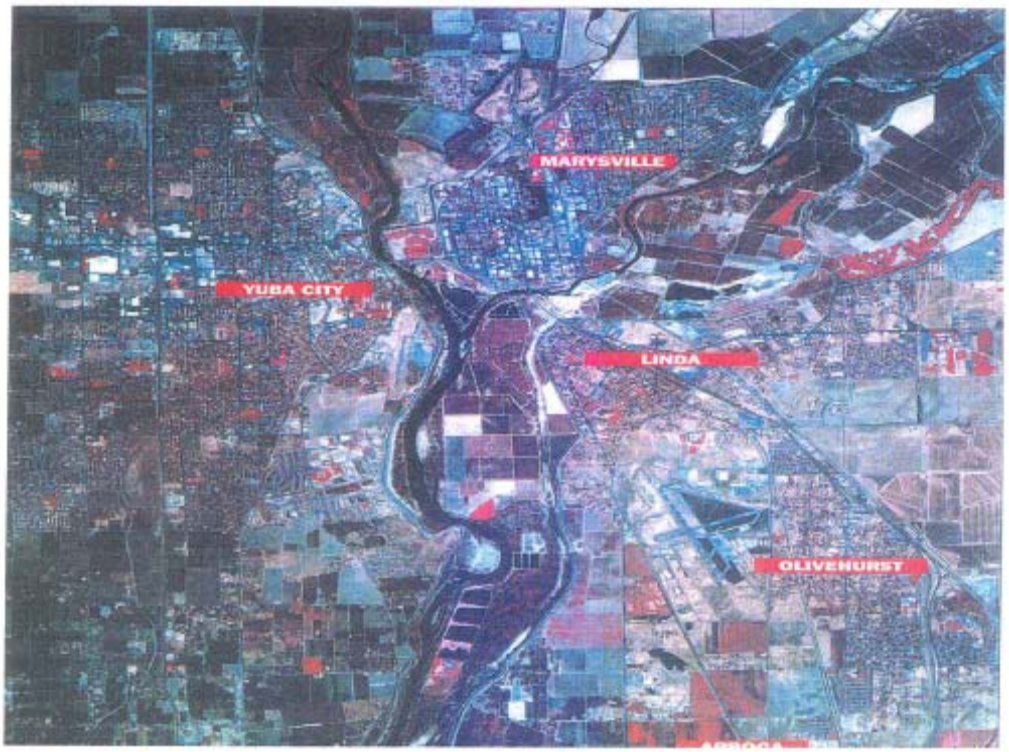
The 1995 floods were caused by two direct downpours which created major surface drainage back-ups at numerous locations throughout the county. Most of the water simply was on the wrong side of the levees. The storms were accompanied by high winds which also contributed significantly to the damage. The two separate events occurred in January and March and resulted in more than $850,000 in damage to county facilities.

1997 Flooding

A series of storms generated by the "Pineapple Express" dumped warm, heavy rains onto a nearly double than average snow pack in the Sierra Nevada Mountains in late December. Runoff was filling the Shasta, Oroville, and New Bullards Bar Dams. Sutter County was notified by Oroville Dam that uncontrolled releases of huge proportions within the next 24 hours were possible. Sutter County declared an emergency on New Years Day at 11 a.m. and advised residents of voluntary evacuation. As the river continued to rise, the Sutter County Board of Supervisors directed a mandatory evacuation of the Nicolaus area and of all areas east of the Sutter Bypass and south of Pease Road. A break in the levee occurred at Arboga in Yuba County and it brought inundation to southwestern Yuba County. The mandatory evacuation was extended to Pleasant Grove and Robbins was added to the list on January 4th due to dangerous levee conditions evolving on the south side of Tisdale Weir. The mandatory evacuation was lifted when the conditions stabilized and residents were allowed to return to the Yuba City area but the levee experienced a massive break in the Sutter Bypass. The town of Meridian was under a mandatory evacuation order and over the next three days earthen berms were constructed on the east and south sides of town which successfully protected it from being flooded. Meridian was the hardest hit area of Sutter County with approximately 50 square miles under water. Virtually every facility in the basin was destroyed or damaged including nearly 100 homes and a school standing in 4 feet of water. A second break in the levee was made at the south end of the basin to allow the waters to return to the Bypass. The mandatory evacuation order was lifted on January 22nd and the basin was not dry until June. Even though Sutter County did not experience loss of lives with this flood, the estimated financial losses to individuals and businesses were about $18 million and agricultural losses exceeded $5 million, not including long term damage to orchard trees. Losses sustained by public agencies within the county amounted to about $10 million.

Illustrating the extent of flooding, a before and after aerial photo of the flooding of 1997 is included on the following page.

1997 Flood Event
(Before)



1997 Flood Event
(After)

(Source: Sutter County Public Works)

Localized Flooding

In addition to the major historic flood events described above, as previously described, the Sutter County Planning Area remains at risk to annual localized flooding. Flood Damage Assessment reports for the 2005-2006 winterstorms/heavy rains illustrates the impacts of some of these localized flooding issues as well as impacts associated with riverine flooding.

A listing of those areas impacted by the 2005-2006 winterstorms include the following sites provided by the Sutter County Department of Public Works:

- Site No. 1: Sacramento Avenue
- Site No. 2: Keys and Natomas Road
- Site No. 3: Fifield Road
- Site No. 4: Howsely Road
- Site No. 5: East Catlett Road
- Site No. 6: Pleasant Grove Road
- Site No. 7: Pleasant Grove Road
- Site No. 8: Nicolaus Avenue
- Site No. 9: Brewer Road
- Site No. 10: Sabaco Road
- Site No. 11: Pennington Road
- Site No. 12: North Butte Road
- Site No. 13: West Butte
- Site No. 14: Kellog Road
- Site No. 15: Pass Road (Segment 1)
- Site No. 16: Pass Road (Segment 2)
- Site No. 17: Pass Road (Segment 3)
- Site No. 18: West Butte Road
- Site No. 19: Robbins Wastewater Treatment Plant
- Site No. 20: Yuba City Boat Ramp
- Site No. 21: Yuba City Boat Ramp Debris Removal

Yuba City also incurred damage as a result of high water events occurring during the 2005-2006 winterstorms from December 17, 2005 through January 3, 2006. Of primary concern to the city was damage associated with two city-owned properties:

- Damage to six effluent percolation ponds on the east side of the Feather River, southeast of the City's Wastewater Treatment Facility. The ponds, composed of graded earthen fill, are an integral part of the wastewater treatment process. Heavy rains and severe storms caused the Feather River to flood its banks, overtopping the adjacent percolation ponds and causing damage to the structure of each of the six ponds. The damages sustained include silt debris deposits, scour along the pond levee slopes and pond bottoms, tearing/displacement of the fabric lining of the ponds, washout of rip rap and fill along the pond slopes, and erosion damage and washout of fill around the concrete spillways of each pond. Similar damages occurred in previous high water events in 1986, 1995, and 1997.
- Damage to the Low Lift Station Access Road which runs along the banks of the Feather River. The roadway, shoulders and embankments are composed of graded and

compacted aggregate base and backfill. Severe storms caused the Feather River to flood over its banks and resulted in major roadway flooding that washed out the roadway, roadway shoulders and integral ground of both along sections of the Low Lift Station Access Road.

Past Occurrences Affecting Other Nearby Communities

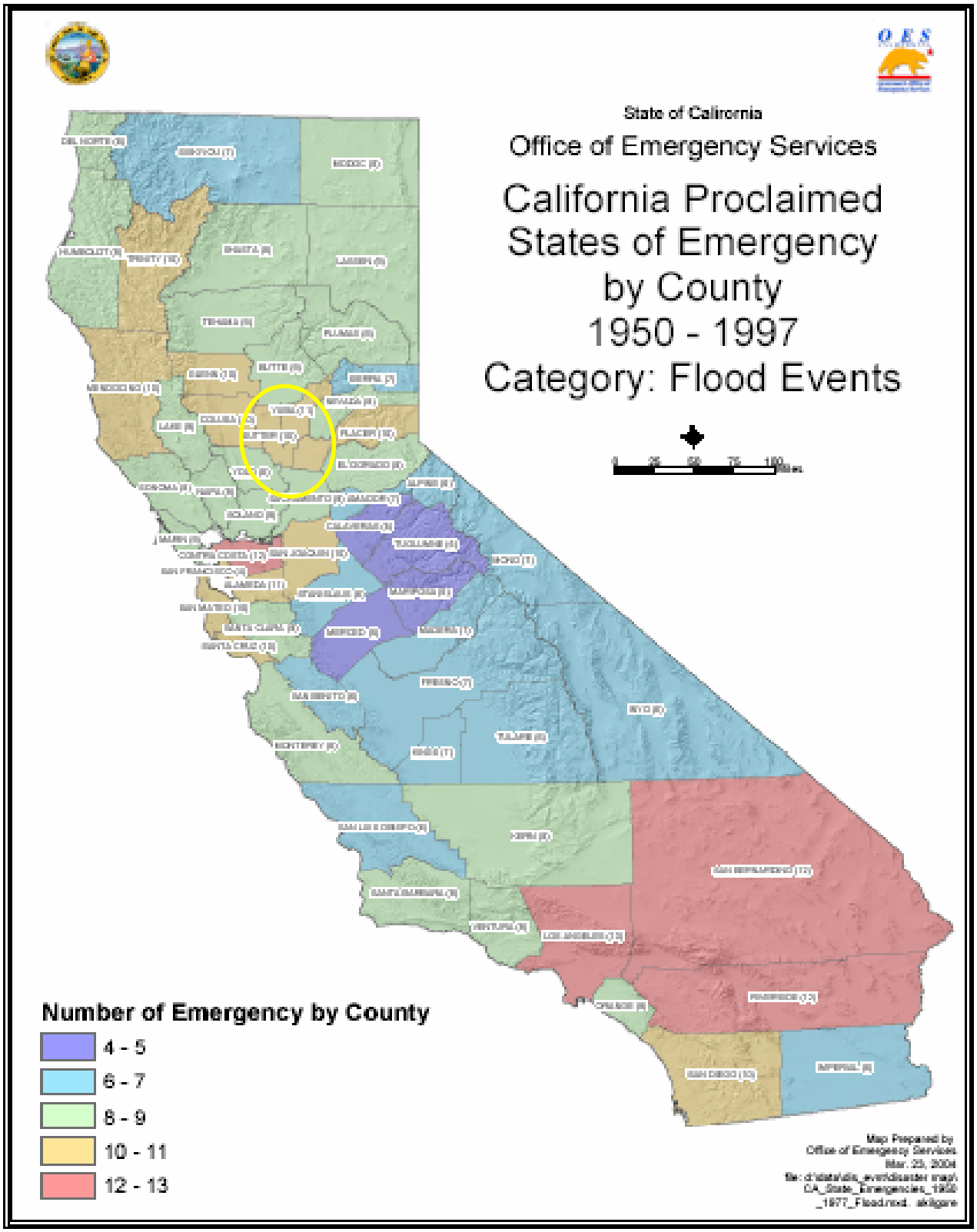
Although primarily affecting adjacent Yuba County, the 1986 and 1997 floods were the most significant flooding to occur since the completion of the Oroville Dam in 1964. This historical flood data is important to the Sutter County Planning Area as extreme flood conditions resulted in the failure of a levee that is part of the overall levee system protecting the Planning Area. Under slightly different circumstances, these same flood conditions could have resulted in a levee failure with more of a direct impact to the Sutter County Planning Area. As it was, in addition to the flooding it received, the Planning Area was also impacted through its efforts in assisting with evacuations and in providing shelter to those most affected from neighboring Yuba County. The affects of these flood events on neighboring Yuba County are described briefly below:

1986 Flooding
The left levee of the Yuba River failed just upstream of the Feather River confluence (RD 784). The communities of Linda and Olivehurst were inundated, resulting in one death, 895 destroyed homes, and 150 destroyed businesses.

1997 Flooding
The left levee of the Feather River failed near Arboga (RD 784), killing one person, destroying 180 homes and businesses, and prompting evacuation of about 15,000 people from Linda and Olivehurst.

Flood Data: California Multi-Hazard Mitigation Plan, 2004

According to the 2004 Draft California Multi-Hazard Mitigation Plan, Sutter County has experienced 10-11 California proclaimed states of emergency for flood events between 1950 and 1997 as evidenced in the map on the following page. Also, according to the state plan, between 1955 and 2002, Sutter County has experienced 5 federally declared flood disasters.



(Source: Draft California Multi-Hazard Mitigation Plan, 2004)

The state plan also summarized past flood damage to Sutter County by program or claim type. Taken from the state plan, this information is detailed below.

Hazard Mitigation Grant Program. Based on data included in the state plan, in response to flood disaster #SW404, Sutter County and Gilsizer County Drainage District, applied for Hazard Mitigation Grant Funds for elevation and flood control projects. In total, three grants were submitted for a total of $8,050,500; no monies were obligated in response to these grants. A breakdown of the grants is provided below:

- Sutter County – 2 grants
  - $6,000,000 (Elevation Project)
  - $1,312,500 (Flood Control Project)

- Gilsizer County Drainage District – 1 grant
  - $738,000 (Flood Control Project)

Individual Assistance Claims. Individual Assistance (IA) flood damage claims include both residential and small business flood damage sites where either state or federal assistance was requested. The state plan indicates that Sutter County has an estimated 758 IA damage location properties (with 64 of these falling within the 100-year floodplain). This equates to only 8.44% of all IA flood damage occurring in the 100-year floodplain within Sutter County over the last 10 years.

Public Assistance Claims. Under the Public Assistance (PA) Program, FEMA reimburses, on a 75-25 cost share, state and local governments and certain non-profit agencies for disaster response and recovery activities. The state plan identifies 540 Sutter County PA applicants associated with historic floods, with PA eligible funds totaling $11,974,730.

Repetitive Loss Properties. Repetitive loss (RL) refers to those properties insured by the NFIP incurring damages resulting in two or more claims greater than $1,000 each in a ten year period. The state plan indicates that Sutter County has nine NFIP RL properties; of these eight RL properties are located within the incorporated portions of the county.

Likelihood of Future Occurrences

100-year flood – Occasional: The 100-year flood is the flood that has a one percent chance in any given year of being equaled or exceeded.

<100-year flood/Outside the 100-year floodplain – Highly Likely: Based on historic data, flooding events less than a 100-year flood and those outside of the 100-year floodplain occur frequently during periods of heavy rains.

Historically, the current levee system has provided the Sutter County Planning Area with a certain degree of protection from major flood events (i.e., these levees were initially designed to provide protection from the 100-year flood). However, with the recent evaluations and review of levee certifications being conducted as part of the new floodplain mapping, new data is bringing into question the structural integrity and certification of these levees. Until the new DFIRMs have been developed and finalized for the entire Sutter County Planning Area and additional

evaluation and repairs to both the levees and local drainage systems have been completed, it is difficult to exactly predict the nature and extent of future flooding within the Planning Area. Although, one thing is for certain, seasons of prolonged heavy rainfall will continue to occur throughout the Planning Area creating a wide range of flooding conditions.

DAM FAILURE

Hazard/Problem Description

Dams are man-made structures built for a variety of uses including flood protection, power, agriculture, water supply, and recreation. When dams are constructed for flood protection, they usually are engineered to withstand a flood with a computed risk of occurrence. For example, a dam may be designed to contain a flood at a location on a stream that has a certain probability of occurring in any one year. If a larger flood occurs, then that structure will be overtopped. Overtopping is the primary cause of earthen dam failure in the United States. Failed dams can create floods that are catastrophic to life and property as a result of the tremendous energy of the released water. A catastrophic dam failure could easily overwhelm local response capabilities and require mass evacuations to save lives. Impacts to life safety will depend on the warning time available and the resources to notify and evacuate the public. Major loss of life could result and there could be associated health concerns as well as problems with the identification and burial of the deceased.

Dams typically are constructed of earth, rock, concrete, or mine tailings. Three factors that influence the potential severity of a full or partial dam failure include:

- The amount of water impounded,
- The density, type, and value of development and infrastructure located downstream, and
- The onset/speed of failure.

Dam failures can result from any one or a combination of the following causes:

- Prolonged periods of rainfall and flooding, resulting in overtopping flows,
- Earthquake,
- Inadequate spillway capacity, resulting in overtopping flows,
- Internal erosion caused by embankment or foundation leakage or piping,
- Improper design,
- Improper maintenance,
- Negligent operation, and/or
- Failure of upstream dams on the same waterway.

There is only one dam located within Sutter County which is under the jurisdiction of the California, DWR, Division of Safety of Dams (DSD). This is Steidlmayer #3 dam which is located in the northwest interior of the Sutter Buttes. It is relatively small in size and a failure of this dam would result in minimal property damage. There are however, 10 larger dams located outside the county which, if they fail, can impact the people and resources in the Sutter County

Planning Area. According to information included in the Sutter County Background Report to the General Plan, a break in any one of the dams detailed in the following table could cause significant flooding in Sutter County. These dams have been designed and constructed for a variety of purposes with a wide range of capacities.

Dams under State Jurisdiction with Potential to Flood Sutter County				
Dam	**Owner**	**Stream**	**Type**	**Capacity (Acre Feet)***
Oroville Dam	State DWR	Feather River	Earth	3,537,577
New Bullards Bar Dam	Yuba County Water Agency	Yuba River	Variable Radius Arch	969,600
Camp Far West Dam	South Sutter Water District	Bear River	Earth & Rock	103,000
Lake Almanor Dam	Pacific Gas & Electric	Feather River	Hydraulic Fill	1,308,000
Thermalito Afterbay Dam	State DWR	Feather River	Earth	57,041
Thermalito Forebay Dam	State DWR	Feather River	Earth	11,768
Shasta Dam	US Bureau of Reclamation	Sacramento River	Gravity	4,552,000
Whiskeytown Dam	US Bureau of Reclamation	Clear Creek (Sacramento River)	Gravity	241,100
Folsom Dam	US Bureau of Reclamation	American River	Gravity	1,010,000
Englebright Dam	Corps of Engineers	Yuba River	Variable	70,000

(Source: Sutter County General Plan Background Report)
*One Acre Foot=326,000 gallons

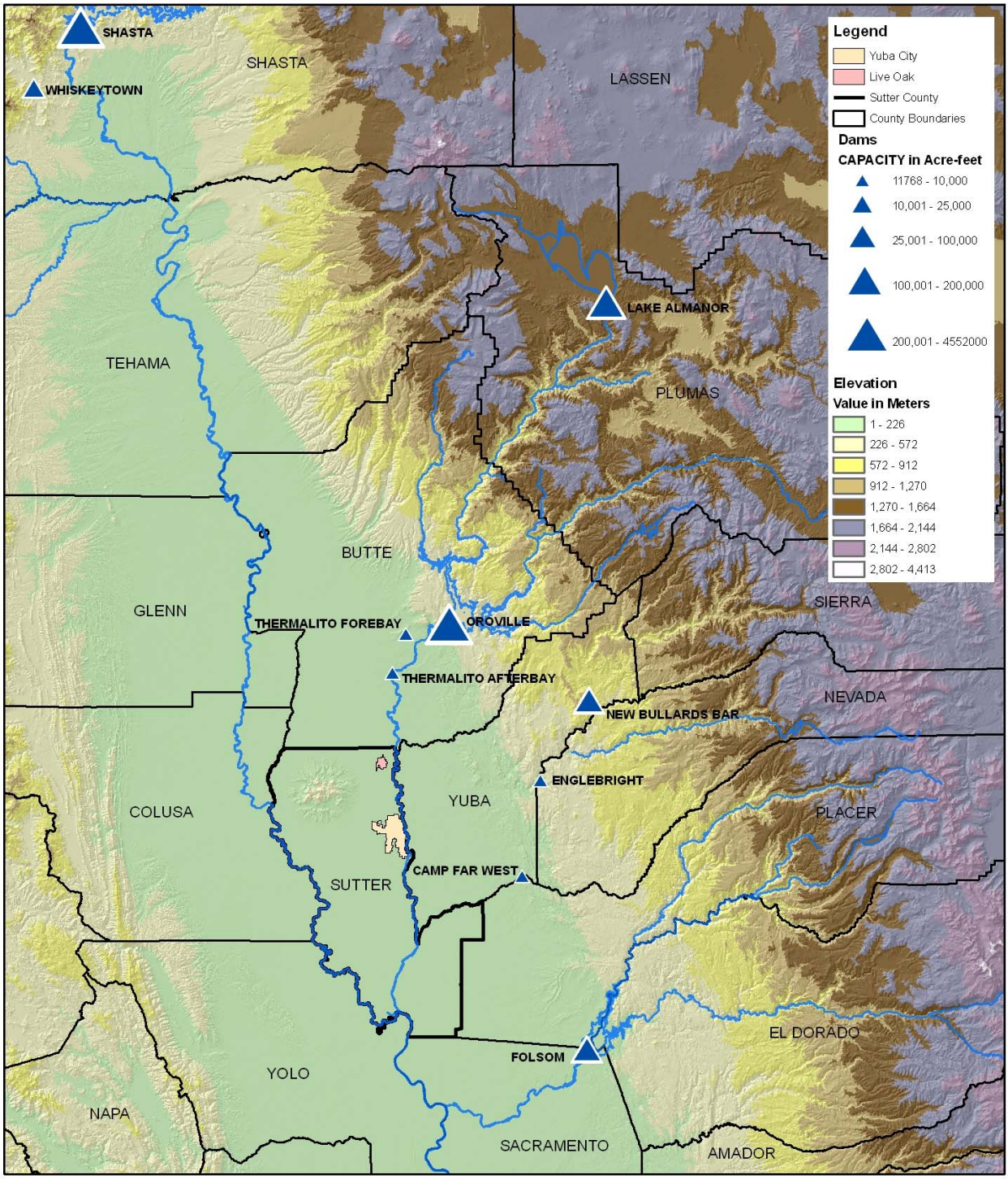
The Draft 2006 Sutter County Operational Area EOP, Annex 5 – Floods and Dam Failure refines this analysis further. According to the 2006 EOP, a catastrophic failure of four of these 10 dams would have a significant impact on Sutter County and the Sutter County Planning Area.

- Shasta
- Oroville
- Bullards Bar
- Camp Far West

The EOP indicates that with a failure of any one of these dams, "complete devastation could occur in and along the river bottoms to up their banks several hundred feet above normal river levels at a point from the dams themselves down river to near the ocean where the rivers widen. Water levels could be many times higher than those recorded in the worst floods." (2006 EOP, p. 12.)

The following map illustrates the locations of identified dams of concern within and surrounding Sutter County.

Dams of Concern to Sutter County



amec

Map Compilation: AMEC 10/19/06
Data Source: Sutter County, CA OES

0 5 10 20 30 40 50 Miles

Past Occurrences

According to the HMPC, there have been no dam failures within or affecting the Yuba-Sutter Planning Area. However, during the winterstorms and flooding of 1996 and 1997, the Oroville Dam reportedly came very close to overtopping.

Likelihood of Future Occurrences

Unlikely: Historically, there have been no dam failure flood events in the Yuba-Sutter Planning Area. The 2006 EOP notes that, "All area dams have performed well during past disasters and are expected to exceed their design limits during future events." (2006 EOP, p. 12) However, the county remains at risk to dam failures from numerous dams under a variety of ownership and control and of varying ages and conditions. As a result, the potential exists for future dam failures in the Yuba-Sutter Planning Area.