Pajaro River Watershed Flood Prevention Authority

Phase 3 and 4a
Pajaro River Watershed Study

FEBRUARY 2005

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Glossary

Alternative Package – A group of individual flood protection projects that were combined to provide 100-year flood protection

Attenuate – To reduce peak magnitude through storage

Authority – The Pajaro River Watershed Flood Prevention Authority

Bypass – A parallel channel or pipeline that carries flow that exceeds the existing channel capacity

CEQA (California Environmental Quality Act) – CA state law that requires the protection of the environment

cfs (Cubic Feet per Second) – A measure of discharge where 1 cfs is approximately 450 gallons per minute

Corps – The Army Corps of Engineers

Detention – Temporary storage

ESA (Endangered Species Act) - The purpose of this act is to provide protections for the endangered and threatened species and the ecosystems upon which they depend

FEMA (Federal Emergency Management Agency) – A federal organization created to prepare for, respond to, recover from, and mitigate against disasters

Flood easement – A purchase of the permission to use a land area for flooding

Floodplain – The area of land that has historically been covered by water during floods

GIS (Geographic Information System) – A spatial database

Groundwater recharge – The addition of water to subterranean water bodies

Hydraulic roughness – The resistance to flow due to channel or overland characteristics

Hydrograph – A location specific graph showing the change in flow rate with respect to time.

Hydrologic condition – A measure of factors that impact surface runoff; used to determine the curve number

Impervious surface – A surface not allowing the absorption or seepage of water into the ground

Levee – An embankment constructed to prevent flooding outside of a confined space

Peak discharge – The greatest discharge value at a point during a water year

Pour point – Geographic location through which water from a watershed or subwatershed flows

PRWS (Pajaro River Watershed Study) – A study authorized by the Authority to determine the causes of flooding and identify methods of flood protection

Return period – The average amount of time between occurrences of an event of a given size

Riparian – Related to or situated on the bank of a river or other body of water

Stage – The height of a water surface above a given elevation

Subwatershed – A portion of a watershed

Thalweg – The lowest flowline within a channel

TM (Technical Memorandum) – Documents cataloging technical decisions, methods, and results in support of the PRWS

Watershed – The area upstream of a point through which all surface water within that area flows

Water year – The period from October 1 through September 30

Introduction

CHAPTER 1

CHAPTER 1

INTRODUCTION

This chapter introduces the Pajaro River Watershed Study Phase 3 and 4a Report. This phase of work incorporates two aspects of the State Water Resources Control Board (SWRCB) plan for the Pajaro River Watershed Study. In the Phase 3 aspect of the plan, the project is conceptually defined and documented according to California Environmental Quality Act (CEQA) regulations. The Phase 4a aspect of the plan addresses preliminary design requirements such as topography and aerial photography. This chapter also provides some background on the foundation of the Pajaro River Watershed Flood Prevention Authority and work that has already been completed in Phases 1 and 2.

Purpose of the Pajaro River Watershed Study: Phase 3 and 4a

Phase 2 identified and evaluated many alternatives throughout the Pajaro River Watershed to protect downstream properties and developments from flooding. A separate effort, the Lower Pajaro River Project led by the U.S. Army Corps of Engineers (Corps) and the counties of Monterey and Santa Cruz, identified a project that could provide 100-year protection and utilize federal funding at the same time. The focus of the Authority and Study therefore shifted to maintaining the predicted 100-year flows at current levels in the downstream reaches. This will ensure that the design capacity of the Corps Project is adequate to pass the design flood event safely to Monterey Bay.

One of the main conclusions from Phase 1 of the Study was the importance of Soap Lake in reducing the peak flood flows from the Upper Pajaro River. Phase 3 and 4a defines and documents the preferred method to maintain the Soap Lake attenuation and storage capacity, known as the Soap Lake Floodplain Preservation Project (Project). Soap Lake has been hydraulically modeled and the boundaries are defined, the impacts of flooding and land use preservation are examined, and the cost of the Project is estimated. This report summarizes and explains Phase 3 and 4a of the Pajaro River Watershed Study.

Study Background

Legal Authority

The Pajaro River Watershed Flood Prevention Authority (Authority) was established in July 2000 in order to "identify, evaluate, fund, and implement flood prevention and control strategies in the Pajaro River Watershed, on an intergovernmental basis."[1] As directed in the Assembly legislation, the Board of the Authority is comprised of one representative from each county and water district within the watershed. These include the following agencies:

- County of Monterey
- County of San Benito
- County of Santa Clara
- County of Santa Cruz
- Monterey County Water Resources Agency
- San Benito County Water District
- Santa Clara Valley Water District

[1] Keeley, "Assembly Bill 807: Pajaro River Watershed Flood Prevention Authority Act." October 10, 1999.

- Santa Cruz County Zone 7 Flood Control District

The Authority acts as a governing body through which each member organization can participate and contribute to developing a method to provide flood protection in the watershed and promote general watershed interests. In addition to flood protection, some identified benefits include:

- Municipal, agricultural, and industrial water supply
- Groundwater recharge
- Support of rare, threatened, or endangered species
- Migration and spawning of aquatic organisms
- Preservation of wildlife habitat[2]

Although efforts by individual agencies have been made in the past to protect against flooding, the ultimate solution may require coordination of structural and non-structural projects throughout the four counties that make up the watershed. Flooding throughout the lower Pajaro River reaches is a hazard to public and private property including residences, agriculture, highways, watercourses, and environmental resources. Recent floods have caused millions of dollars in damage.

As described in the enabling legislation State Assembly Bill 807, the goal of the Authority is to implement flood prevention and control strategies within the watershed. A further goal of the Authority is to identify strategies and projects that will provide multiple benefits, such as drinking water, ground water recharge, or environmental restoration and protection.

WATERSHED SETTING

The Pajaro River is the largest coastal stream between the San Francisco Bay and the Salinas Watershed in the County of Monterey.[3] The watershed is approximately 1,300 square miles and covers portions of Santa Cruz, Santa Clara, San Benito, and Monterey Counties. The large size contributes to the number of diverse environments, physical features, and land uses within the watershed. Tributaries to the Pajaro River, the largest of which is the San Benito River, serve as the major routes for flow and floods throughout the watershed. A relief map of the watershed showing major highways, cities, dams, and rivers is shown on Figure 1-1.

Prominent hydraulic features of the Pajaro River Watershed, in addition to the rivers and streams, include the storage locations. As will be described later in this chapter, the man-made reservoirs have played a significant role in reducing the peak flows in the Lower Pajaro River. The in-stream dams include Hernandez Dam, Pacheco Dam, Uvas Dam and Chesbro Dam. Soap Lake is an intermittent yet prominent storage feature of the watershed as well. It is the focus of Phase 3 of the Study as it significantly controls the magnitude and timing of the peak flows originating from the Upper Pajaro River Watershed. Soap Lake is described in greater detail in Chapter 2.

Development within the watershed, both urban and rural, is clustered around the major cities. The major urban centers are Watsonville, Gilroy, Morgan Hill, Hollister, and San Juan Bautista. Agriculture and grazing are the dominant land uses in these areas but represent a small portion of the total watershed land use. Other industries outside of the urban setting include mining and timber harvesting. The majority of the land cover is grassland, shrubland, and forest. Figure 1-2 shows the spatial distribution of the land uses.

[2] "Draft Water Quality Management Plan for the Pajaro River Watershed." Prepared for Association of Monterey Bay Area of Governments. March 1999.
[3] Ibid.

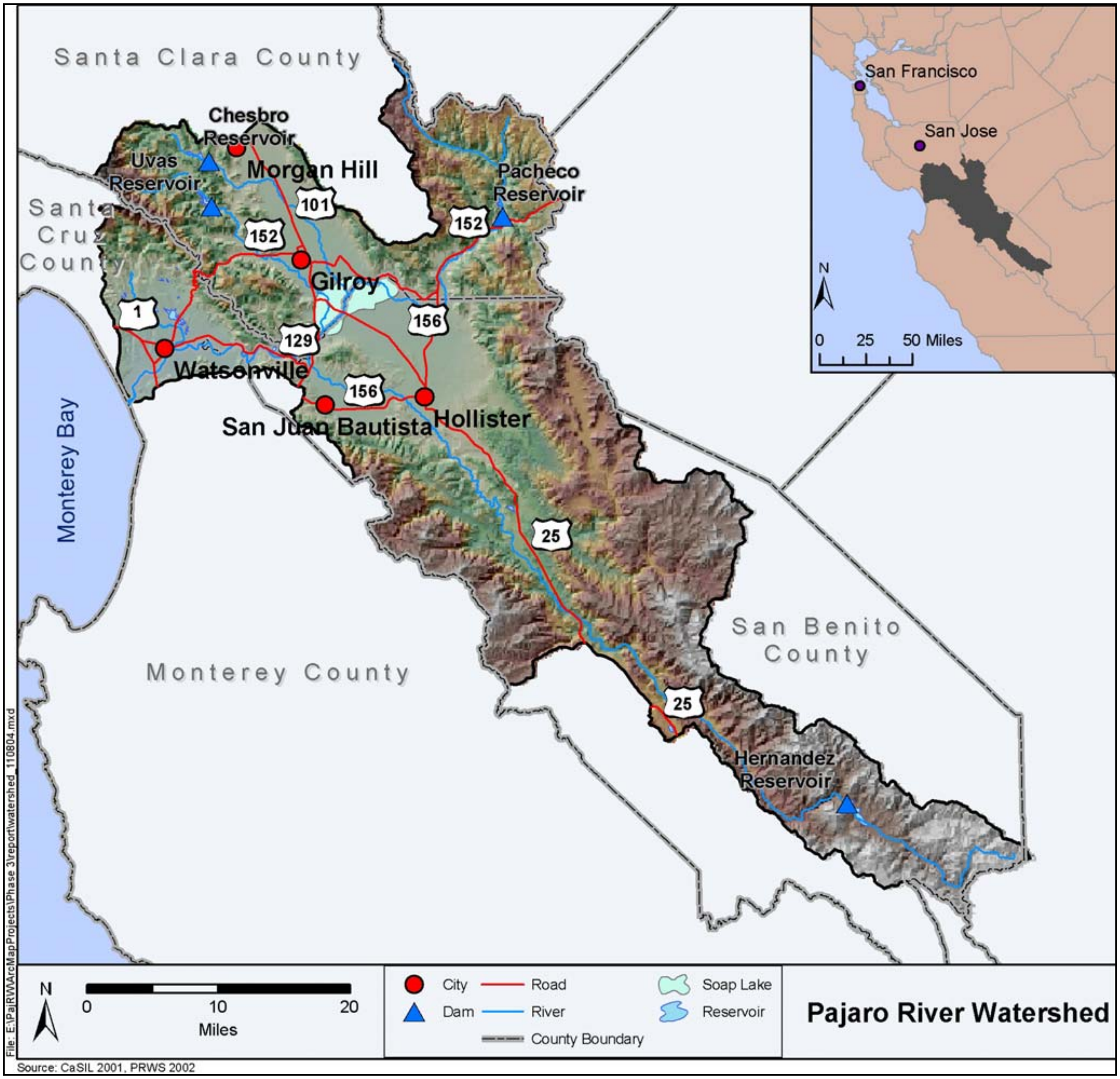

Figure 1-1: Relief map of the watershed showing major highways, cities, dams, and rivers.

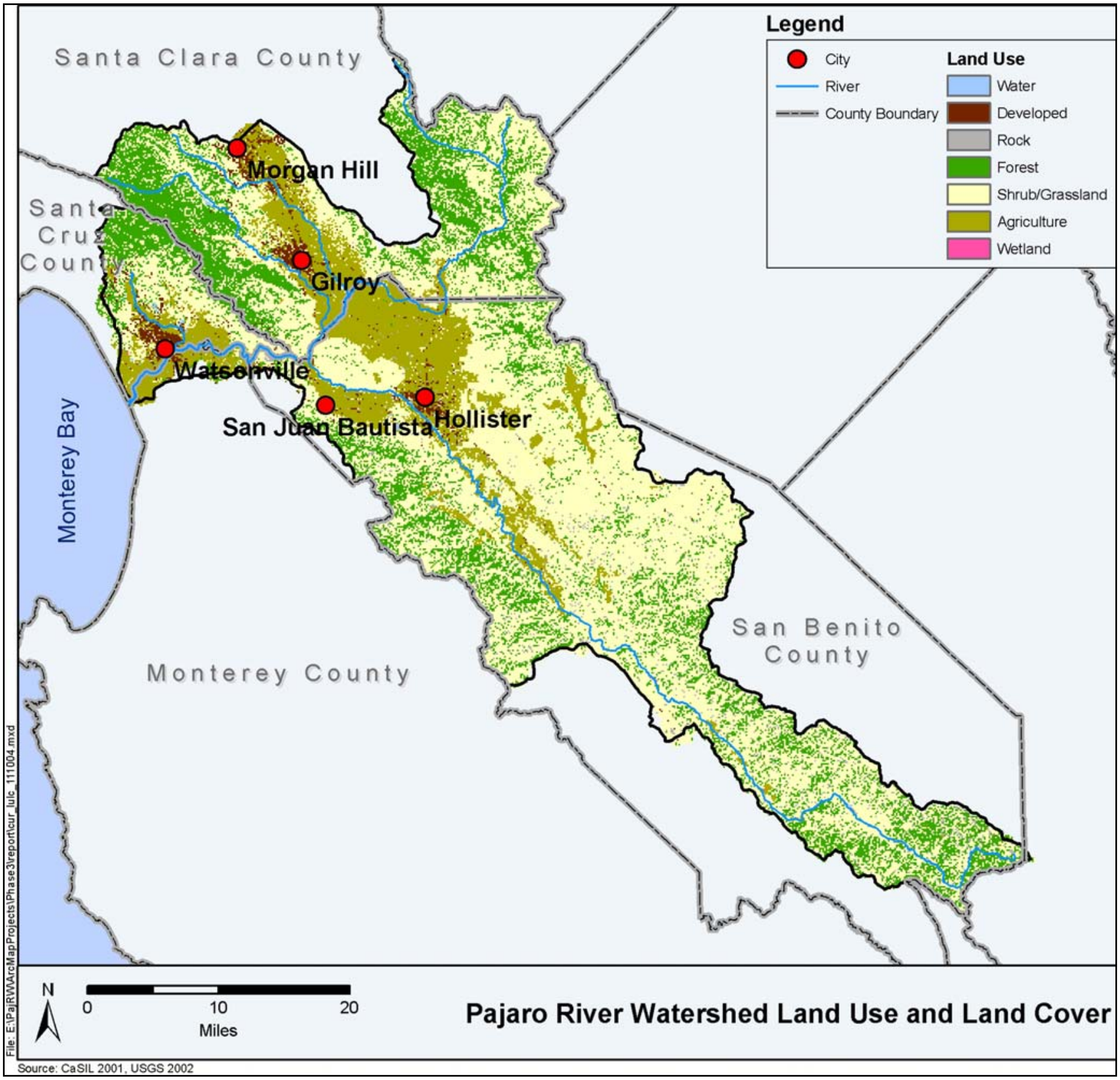

Figure 1-2: Major land use categories and locations within the watershed.

Over the recent years, rivers within the watershed have had significant water quality issues. They have been listed on the Clean Water Act 303d list for nutrients, sediments, fecal coliform, chloride, dissolved oxygen, sodium, and total dissolved solids. These pollutants limit the uses of the water and reduce the environmental benefits.

PHASE 1 SUMMARY

Objectives and Background

The scope of Phase 1 was designed to answer questions about the origins of flood waters and sediment. It was also important to the Authority to understand how sensitive the watershed is to changes in various types of land use, especially urban and agricultural areas.

In order to address these unknowns, the Authority created hydrologic models for the watershed and hydraulic and sediment generation and transport models for the Lower Pajaro River and Lower San Benito River. These models simulated peak and 3-day average flows for the 2-, 10-, 25-, 50-, 100-, and 200-year flood events. The models were calibrated at four points which characterized flows from the major subwatersheds. The locations and descriptions of these four points are:

- San Benito River Upstream of Pajaro River Confluence – Pour point for the entire San Benito River Watershed
- Soap Lake Outlet – Pour point for the Upper Pajaro River Watershed just upstream of Highway 101
- Chittenden Gage – Downstream of the Pajaro River and San Benito River confluence, this point captures flow from the entire upper watershed.
- Downstream of Salsipuedes – This calibrated node around Watsonville captures flow from the Pajaro River and all of its major tributaries.

Models simulating four other watershed conditions, based on the model calibrated for current conditions, were also created. Those watershed conditions are:

- **Historical Condition (1947)**: Provides insight into flooding conditions before the current Corps' levees, Hernandez Dam, Uvas Dam, or Chesbro Dam were in place.
- **General Plan Buildout Condition (2015-2020)**: Models the flood potential using the land use designations established by the individual city and county planning departments in their General Plans.
- **Ultimate Buildout (2050)**: This scenario is a worst case situation in terms of flooding. Urban growth is extrapolated to the year 2050 without regard to limits or regulations set forth in the General Plans.
- **Changes in Agriculture**: This scenario is intended to represent the worst case scenario, in terms of flooding, for agricultural changes. All agriculture present in the current condition is changed to row crops with a poor hydrologic condition. There is no timeframe associated with this scenario.

Results and Conclusions

Results from all four conditions can be found in Phase 1 documentation. However, the General Plan Buildout is particularly important to Phases 2 and 3 of the Study. The General Plan Buildout condition results are used in Phases 2 and 3 since it represents the best estimate of realistic, planned conditions, runoff, and flows within the watershed for a reasonable planning horizon. The results of this modeled condition can be found below in Table 1-1.

Table 1-1: Hydraulic Model Peak Flows Based on General Plan Buildout Conditions

Watershed Location	Peak Model Flow Rate (cfs)					
	2-Year Event	10-Year Event	25-Year Event	50-Year Event	100-Year Event	200-Year Event
San Benito River	1,280	10,800	18,800	26,200	31,600	44,700
Soap Lake Outlet on Pajaro River	4,020	15,300	21,600	27,400	30,700	35,600
Chittenden Gage on Pajaro River	3,610	17,300	29,300	38,400	44,400	58,200
Pajaro River downstream of Salsipuedes Creek	4,340	20,300	32,700	43,100	49,600	65,300

Figure 1-3 shows the four calibrated model points and the channel capacities in the lower reaches of the Pajaro River watershed. As listed in Table 1-1, the San Benito River 100-yr peak flow is 31,600 cfs and the Pajaro River 100-yr peak flow at the Soap Lake outlet is 30,700 cfs. However, due to the time difference between peak flows on each river, the cumulative peak discharge of these two rivers at Chittenden and the Murphy Road Crossing is a lower flow rate, about 44,400 cfs, than the two peaks added together. The channel capacity just downstream from Chittenden is about 19,000 cfs, based on the design channel size and levee conditions. However, the channel capacity certifiable by the Corps based on current channel and levee conditions could be much lower, at 9,000 cfs with 90% confidence. The design conditions of 19,000 cfs for channel capacity were used in this analysis. Flow from Salsipuedes Creek increases the peak discharge in the lower Pajaro River. The Pajaro River flow of 49,600 cfs just downstream from the Salsipuedes Creek confluence is the design flow for the 100-year flood event. The existing channel capacity in the lower reaches of Pajaro River is approximately 22,000 cfs, which is well below the expected 100-year flood event. Frequent flooding occurs in the region because of the lack of flood flow capacity in the river channel downstream of Chittenden.

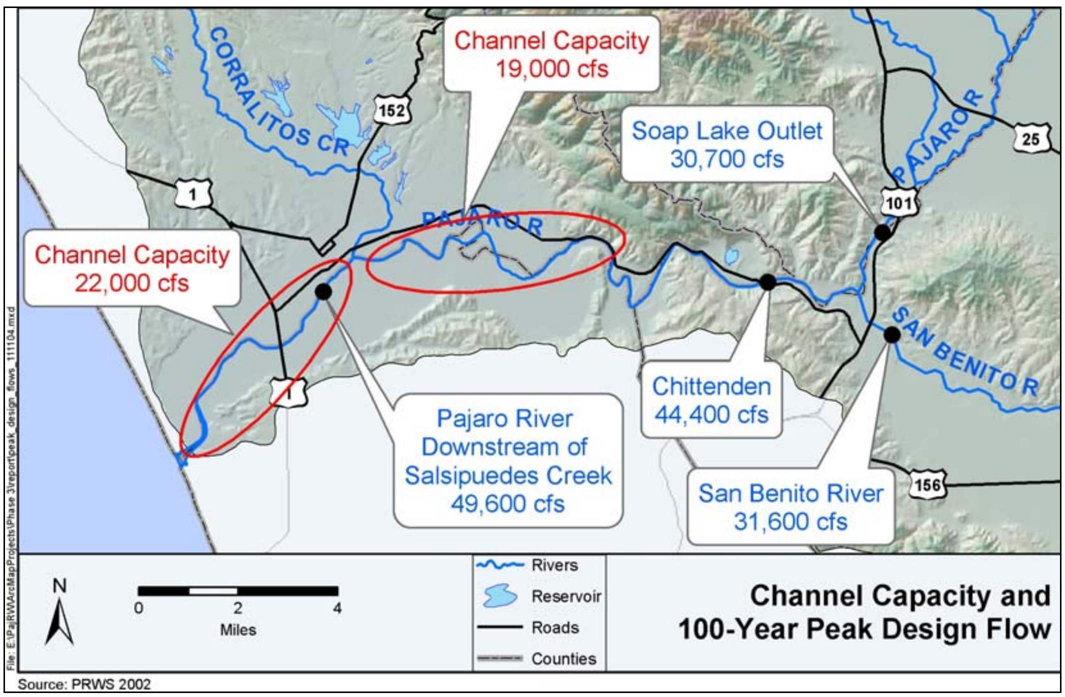

Figure 1-3: 100-Year Return Period Peak Design Flows on the Lower Pajaro River.

The following results and conclusions were based on the hydrologic modeling work:

- Since 1947, the construction of three reservoirs (Hernandez, Uvas, and Chesbro dams) reduced peak flood flows and the probability of flooding in the lower Pajaro River.
- Neither current agriculture conditions nor potential changes in agricultural conditions will cause significant changes in the design discharge or flood conditions.
- Urbanization will increase the runoff from smaller storm events with frequent return periods (2-year to 25-year), but causes little change in runoff from larger storms with longer return periods (50-year to 200-year).

- Flooding in the Soap Lake area provides peak flow attenuation of Pajaro River flows upstream of the San Benito River confluence, and this situation has been assumed to continue for the Corps peak flow design conditions.

The following results and conclusions were based on the sediment modeling work:

- Sediment conditions within the Pajaro River channel should not be significantly altered by the small, predicted changes in peak design discharges.
- Significant growth of shrubby vegetation could be expected to cause an increase in sediment deposition.
- Changes in sediment load may have localized impacts at the confluence of the San Benito and Pajaro Rivers, but do not affect the Lower Pajaro system as a whole.
- The flooding along Soap Lake limits sediment discharge from the Pajaro River upstream of the San Benito River confluence.

Since the results and conclusions of the sediment studies indicated that sediment conditions would not change significantly from existing conditions, the alternatives developed during Phase 2 were focused primarily on reduction of flooding risk within the lower Pajaro River. However, sediment management impacts were considered for alternatives with incidental effects on sediment conditions, such as reservoirs and detention basins.

Phase 2 Summary

The goal of Phase 2 was to identify flood control projects throughout the Pajaro River Watershed at a conceptual level that would provide protection to the general Watsonville area. Enough detail for each project was needed to generate quantification of potential flood reduction, other benefits and disadvantages, and cost. After evaluating all of the options, one or a few projects would be selected to carry on to Phase 3 of the Pajaro River Watershed Study. The Authority was able to utilize the models and conclusions of Phase 1 as well as significant coordination with the Corps' concurrent Lower Pajaro River flood control project to accomplish these goals.

A wide variety of flood protection projects throughout the watershed were considered. There are two general ways to protect against flooding: storage and conveyance. The purpose of storage is to detain or retain flood waters by either reducing the total amount of water included in the flood wave or attenuating the peak flows. The purpose of conveyance is to move the water out of an area as quickly as possible. Both types of projects were considered. Also, since upper and lower watershed agencies are involved in the Study, upper watershed projects are viable options to provide downstream flood protection. Figure 1-4 below shows a matrix of the projects considered based on the above two qualifications.

	Upper Watershed	Downstream
Conveyance	• None	• Open channel bypass • Flood channel • Underground bypass • Flood tunnel • Flood walls
Storage	• Land/Flood Easement at Soap Lake • Detention Basin in San Benito Watershed • Raise existing dams • New dam (various locations)	• Detention basin at College Lake

Figure 1-4: Matrix of flood control options considered in Phase 2.

Figure 1-5 highlights reasons why the pairings of downstream conveyance and upper watershed storage make more sense than the other pairings in Figure 1-4.

	Upper Watershed	Downstream
Conveyance	• Conveyance options would move the water to the downstream areas faster and allow less natural channel attenuation of peak flows.	• Proximity to river outlet (Monterey Bay) and limited available space make conveyance a good option • Uses less room than storage methods
Storage	• Rural and open space with varied topography lead to good storage opportunities. • Storage reduces the total volume of water or attenuates the peak flows.	• Lack of space and flat topography make storage difficult.

Figure 1-5: Matrix of conditions that create beneficial flood control pairings for the Pajaro River Watershed.

In addition to the projects in Figure 1-4, a concurrent flood protection process was reviewed and evaluated. Monterey and Santa Cruz counties are working with the U.S. Army Corps of Engineers to identify a 100-year flood protection project in the lower reaches of the Pajaro River. By identifying, permitting, and building a suitable project, the counties could save a significant portion of the cost through federal funding. At the time of the Phase 2 evaluation, the Corps was developing concepts that would provide 30- to 65-year protection through a combination of setback levees and floodwalls.

After analyzing all of the above projects, including the Study and Corps' projects, it was apparent that none of the more feasible projects would yield a complete flood protection solution, i.e. one that could provide 100-year protection. It was therefore necessary to group the individual projects to create packages. While the cost for the packages was higher than the individual projects, many additional benefits were realized in addition to providing the necessary flood protection. Depending on the package configuration, these benefits included additional water supplies, additional habitat, and additional recreational space.

At the time of the package evaluation, the Corps and downstream agencies had not yet arrived at their final proposed project. The Authority therefore took the position that the downstream project was considered to be the basis of the project packages and the additional projects identified in the Study would provide the additional flood protection up to a 100-year level. Figure 1-6 shows this concept graphically.

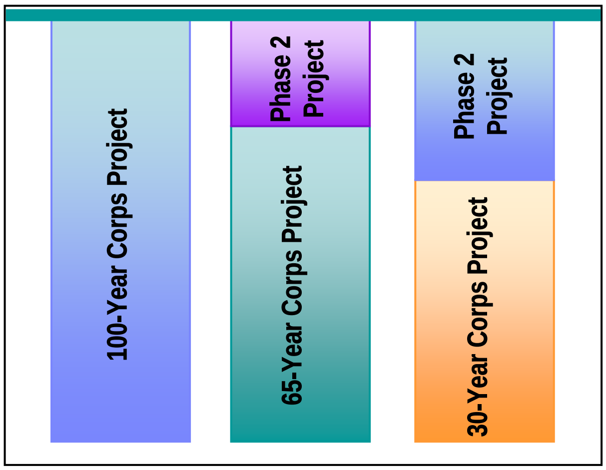

Figure 1-6: Combinations of projects yield 100-year protection.

The project packages that were preferred above all others were:

- Corps 65-year Project and New San Benito Dam
- Corps 65-year Project and Open Earthen Bypass Channel
- Corps 30-year Project and New San Benito Dam
- Corps 30-year Project and New Pacheco Dam and New San Benito Dam

All of the evaluated packages, including the four above, assumed that Soap Lake was functioning as it does currently.

After the conclusion of the analysis phase of work, the Corps selected a project capable of passing a 100-year flood event without any upstream projects. The focus of the Authority work shifted again to working to ensure that the flows passing through the Lower Pajaro River Project would not increase above the currently predicted levels. The most direct way to achieve this goal was to preserve Soap Lake and its attenuation capabilities. Therefore, the Soap Lake Floodplain Preservation Project became the focus of Phase 3 of the Authority's Study.

Should the Corps and downstream agencies choose a different project or if the protection level of the selected project is downgraded, it will be possible to reconsider the projects identified in Phase 2.

The Phase 3 work would still be applicable since Soap Lake would be an important part of any recommended project.

Characterizing the Soap Lake Floodplain

CHAPTER 2

CHAPTER 2

CHARACTERIZING THE SOAP LAKE FLOODPLAIN

This chapter provides some background on Soap Lake including a general description of the Lake location, how Soap Lake reduces incoming peak flows through attenuation, and the importance of continued flooding by comparing downstream peak flood flows with and without Soap Lake. The last section identifies the modeling efforts conducted to better define the location and boundaries of Soap Lake.

Soap Lake Location

Soap Lake is a natural detention basin, storing water and reducing peak flows that would otherwise increase flooding in the lower Pajaro River. Upper Soap Lake is also known as San Felipe Lake and is a permanent body of water. The Soap Lake floodplain lies along the Pajaro River within San Benito and Santa Clara Counties between Highway 152 and Highway 101. Figure 2-1 shows the location and approximate boundaries of Soap Lake during a 100-year flood event. The main land use is agriculture including row crops and pasture land. During significant rain events, the low-lying areas of the Soap Lake area become flooded and there is flow backup on the Pajaro River upstream of the San Benito River. Soap Lake disappears as the floodwaters recede and low-lying areas are drained.

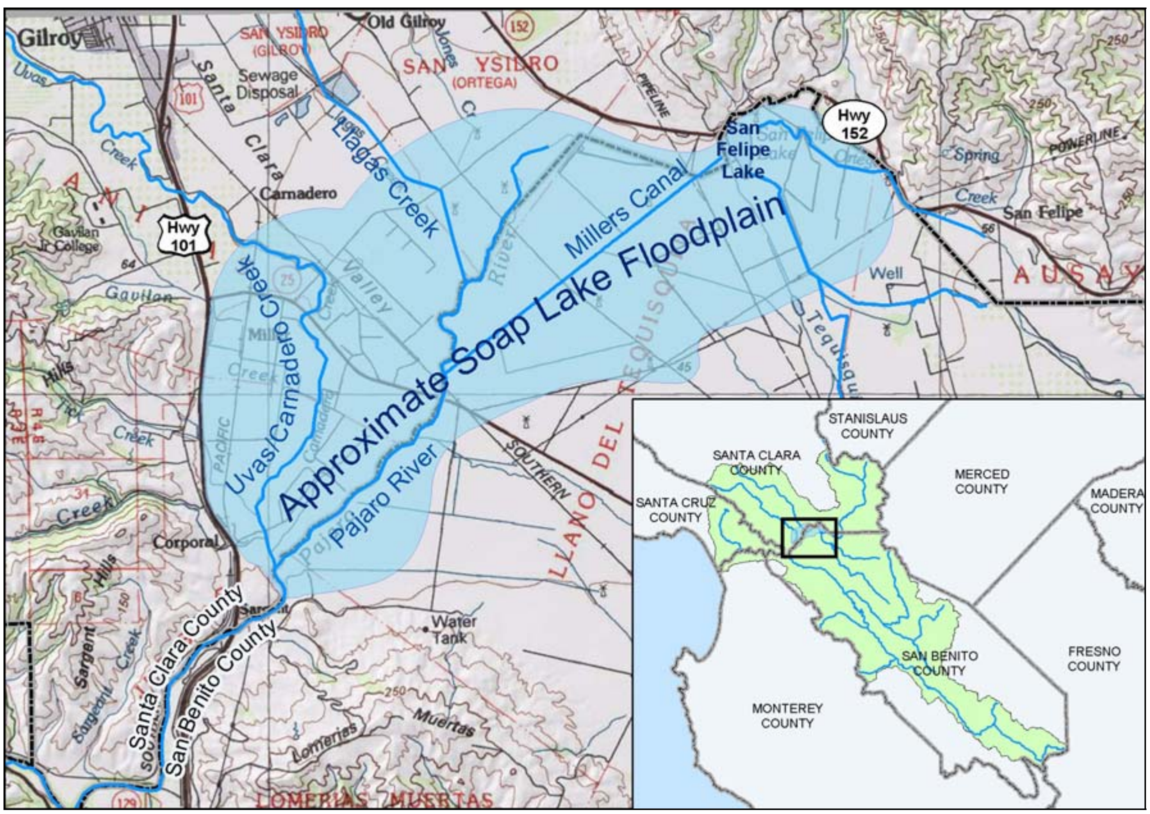

Figure 2-1: Soap Lake approximate floodplain area. The floodplain area is roughly the same as the FEMA approximate 100-year floodplain in this area.

Soap Lake Attenuation

As mentioned in the previous section, Soap Lake acts as a detention basin that fills during large flow events and slowly recedes after the flood wave has passed. The effect on flooding downstream of the basin is a reduction in the flood magnitude due to attenuation of the peak flows. The total volume of water leaving Soap Lake is nearly the same as the volume that enters but it has been spread out. Figure 2-2 shows an example of attenuation by depicting inflow versus outflow hydrographs. Without the storage and attenuation, the outflow hydrograph would be the same as the inflow hydrograph.

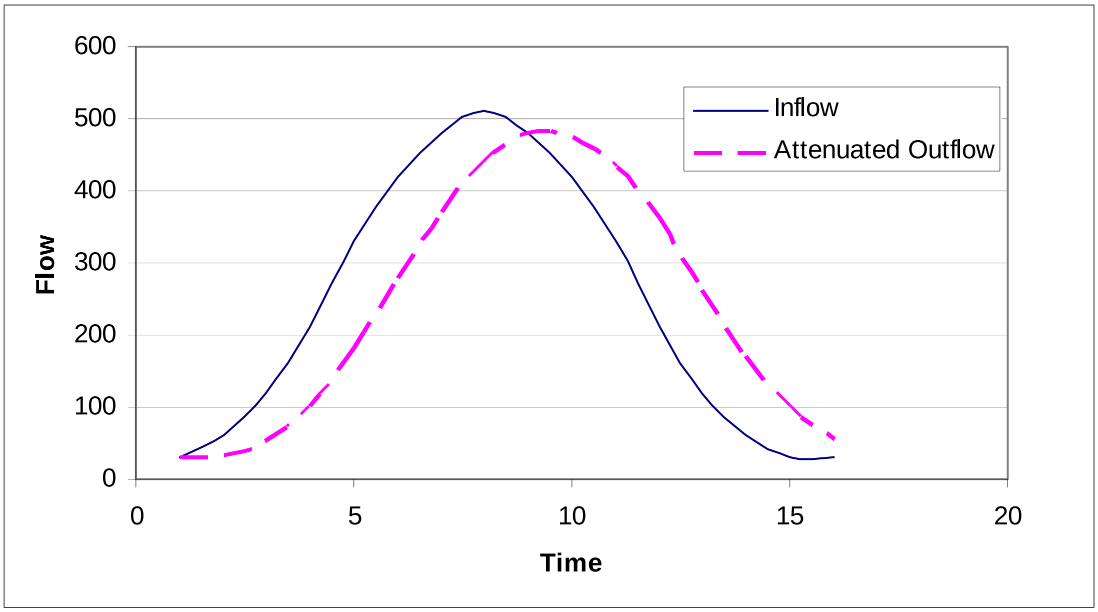

Figure 2-2: Example of attenuation impact on hydrograph.

Figure 2-3 shows modeled results of the peak flows downstream of Soap Lake during a 100-year event with and without attenuation. As can be seen in Figure 2-3, there is a significant difference in the peak flows for the attenuated outflow and the non-attenuated outflow. The lower peak translates into smaller required downstream flood control projects.

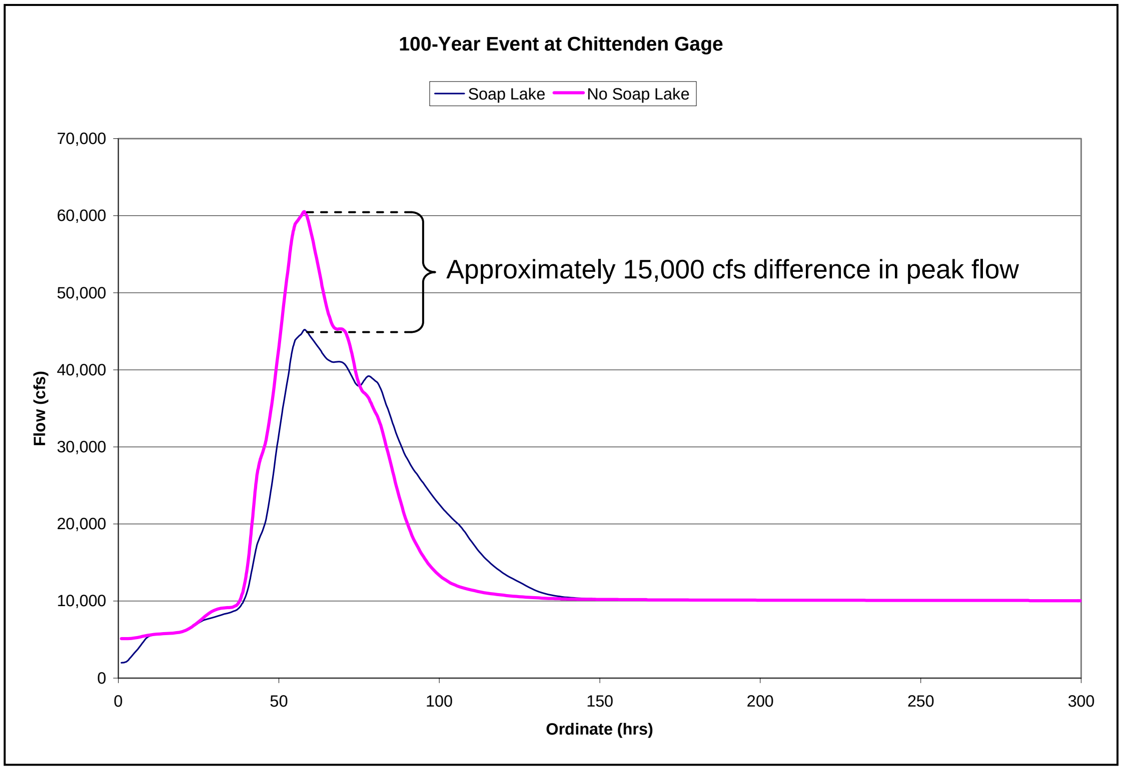

Figure 2-3: Model results of 100-year event flow at Chittenden Gage with and without Soap Lake attenuation.

Importance of Soap Lake

As demonstrated in Figure 2-3, Soap Lake can be considered a very important flood management feature for downstream areas in the Pajaro River watershed. HEC-1 modeling shows that the flood storage and attenuation within Soap Lake leads to a significant decrease in downstream peak flows. As can be seen in Table 2-1, attenuation in Soap Lake increases with event magnitude.

Table 2-1: Peak flows at Chittenden stream gage (Lat 36°54'01", Long 121°35'48") with and without Soap Lake attenuation.

Return Period (Yrs)	Flow with Soap Lake (cfs)	Flow without Soap Lake (cfs)	Peak Difference (cfs)
2	3,600	3,600	0
10	16,900	19,500	2,600
25	28,700	35,300	6,600
50	38,600	50,300	11,700
100	45,200	60,500	15,300
200	60,500	82,400	21,900

Figure 2-4 shows the data of the above table in a graphical format. One of the details that becomes apparent is the reduction in level of protection for the downstream areas if Soap Lake attenuation is removed. Existing or future flood protection projects assume that current storage levels are available. The 100-year flood flow at Chittenden is currently believed to be about 45,000 cfs. Without the Soap

Lake storage and attenuation, a 45,000 cfs flood flow would occur about every 37 years, instead of every 100 years.

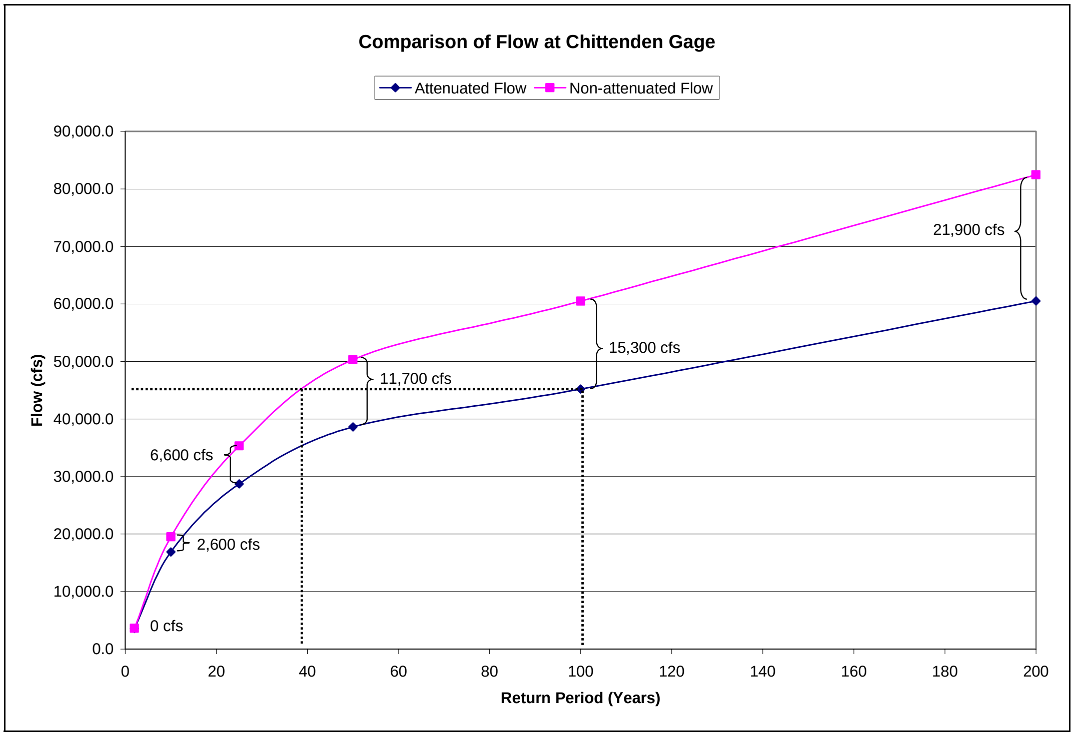

Figure 2-4: Effects of attenuation in Soap Lake on peak flows at Chittenden Gage.

Should Soap Lake be changed so that the floodplains no longer effectively attenuate peak flows, the downstream Lower Pajaro Project would be seriously impacted. A rough estimate of impacts was completed with the help of the Corps of Engineers. Raising the levees to accommodate the higher peak flows would have the following effects:

- **Additional levee cost**: The levees would cost approximately $60 million more than their current estimate of $112 million.
- **Additional land required**: As the levees are increased in height, their footprint is proportionally increased to maintain safe side slopes. Along the length of the levees, approximately 44 additional acres would need to be taken from the levee's neighboring land uses, agricultural and urban development.
- **Bridge modification**: The cost and land requirement increases do not account for impacts to bridges. The bridge and approach for Main Street in Watsonville would need to be rebuilt and the Highway 1 bridge and approach might need to be rebuilt. The railroad bridge would need to be significantly modified or abandoned to accommodate the additional levee height. Modification or rebuilding any of the bridges would be a significant additional cost and public nuisance.

Based on these impacts, the Lower Pajaro Project may not be feasible without the Soap Lake and its attenuation of large peak flows.

Extent of Soap Lake

In order to better define the Soap Lake floodplain and understand the flood protection benefits of the floodplain, it was necessary to perform detailed hydraulic modeling of the Soap Lake area and create floodplain maps based on the results of that modeling. Hydraulic models and maps were developed for the 2-, 10-, 25-, 50-, and 100-year flood events. Having some knowledge of how the floodplain changes during different flood events allows better understanding of how Soap Lake works (which features cause flooding, major storage areas, etc) and helps to identify areas most critical for preventing increased downstream flows. This section of Chapter 2 summarizes these efforts and results.

Soap Lake Hydraulic Model

The Soap Lake hydraulic model utilizes the Hydrologic Engineering Center River Analysis System (HEC-RAS) program to define water surface elevations throughout the Soap Lake area for the 2-, 10-, 25-, 50-, and 100-year flood events. The model output and floodplain maps are not intended to represent or replace the FEMA flood maps. They are instead a representation of potential future flood conditions to be used for this study's planning purposes.

HEC-RAS uses two types of input to calculate water surface elevation at individual cross sections. They are flow input, either peaks or hydrographs, and geographical data, which includes topography, stream paths, and ground roughness which simulates land use and land cover. The locations and lengths of cross sections are included in the geometry part of the model as well. Cross sections are slices of the topography where data is input into the HEC-RAS model. An example is shown in Figure 2-5. The following sections discuss these model inputs further.

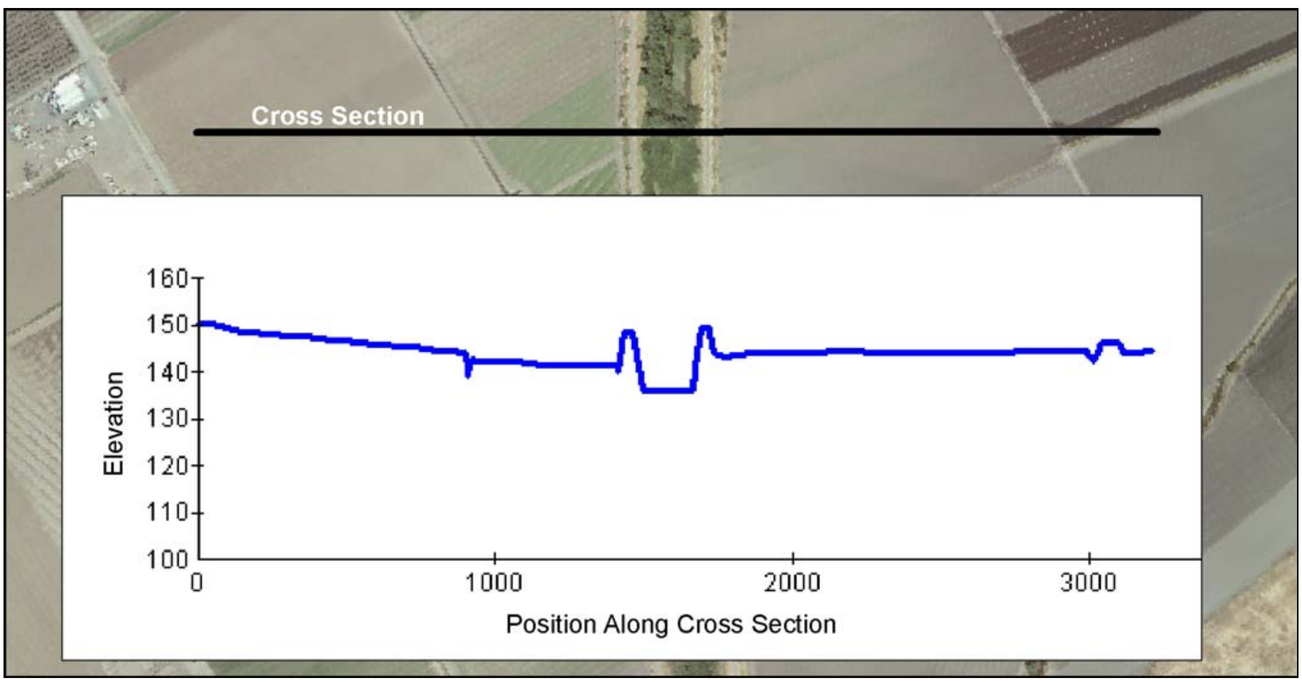

Figure 2-5: Example of cross section across Llagas Creek.

Model Input: Flow

The model utilizes results from the Phase 1 hydrologic model with General Plan Buildout conditions. As was described earlier in this report, this scenario was created in Phase 1 by incorporating future land use conditions from the General Plans of every county and major city within the watershed. The design rain storm was applied to the modeled surface. The resulting flood hydrograph represents the General Plan Buildout conditions.

Each of the model reaches shown on Figure 2-6 are assigned a flow based on HEC-1 model results. The HEC-1 model results include hydrographs at junctions and hydrograph routing in channel reaches. The hydrographs or combinations of hydrographs used for each reach are listed below. Hydrograph identifiers are given in parentheses.

- Millers Canal and Upper Pajaro River – Combined HEC-1 flows from San Felipe Lake Outlet (CP18R2) and subwatershed PJ-2 of Pajaro River are used for these two reaches. Millers Canal was not included in the Phase 1 models and therefore the flow is estimated for the Phase 3 hydraulic model. Total flow is divided and allocated between Upper Pajaro River and Millers Canal. In a 2-year event, the flow is split evenly between the two reaches. In all other events, 40 percent is allocated to the Upper Pajaro River and 60 percent was allocated to Millers Canal.
- Llagas Creek – HEC-1 flow from Llagas Creek at confluence with Upper Pajaro River (CP21C).
- Middle Pajaro River – Sum of Upper Pajaro River and Llagas Creek flows
- Lower Pajaro River - The flow rate in this reach is obtained from the HEC-1 flow for CP22DS. This reach includes combined flows from Upper Pajaro and Llagas Creek that merge at the Middle Pajaro reach and then combine with Millers Canal flows.
- Uvas/Carnadero Creek – HEC-1 flow from Uvas/Carnadero Creek at confluence with Lower Pajaro River (CP25C).
- Pajaro Outlet from Soap Lake – HEC-1 flow from a reach downstream of Highway 101 and upstream of the San Benito River confluence with Pajaro River (CP26R).
- Soap Lake Water Surface – Soap Lake stage from HEC-1 model (Soap Lake)

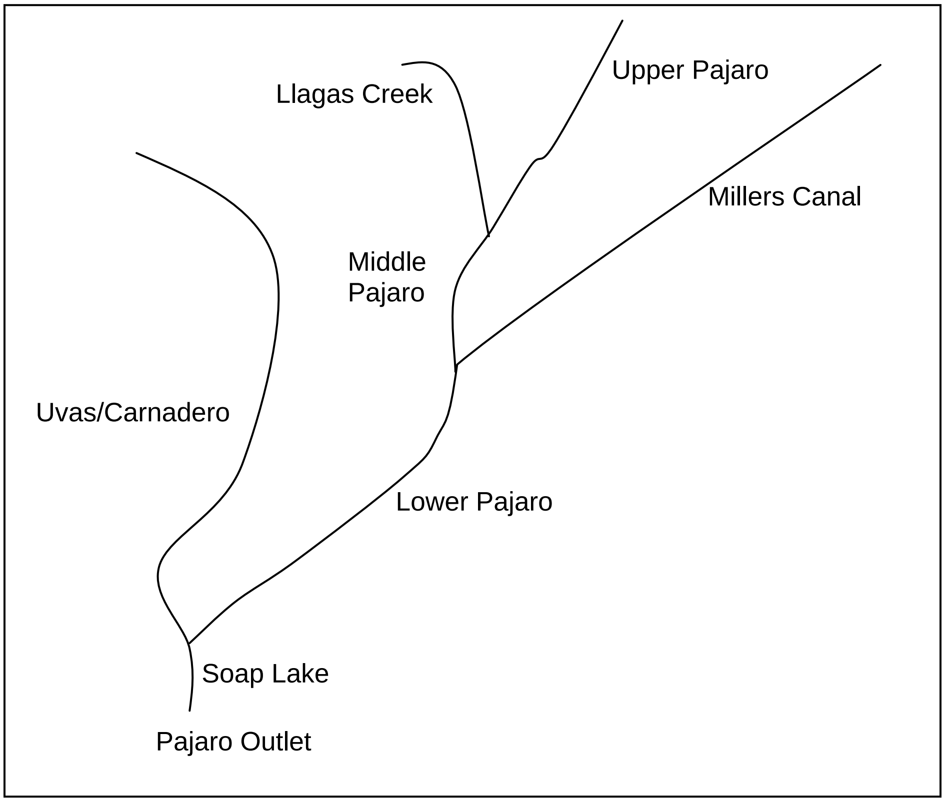

Figure 2-6: Schematic of reaches used in the Soap Lake hydraulic model.

The HEC-1 results include flow hydrographs that designate expected flows within the river system at given times. To determine peak flooding levels on the tributaries, the flow time period that included the peak flows on the tributary was modeled. The approximate time periods selected for the peak flow analyses in each of the return periods are listed in Table 2-2.

Table 2-2: Time of tributary peak flows.

Return Period	Time of Peak Flows in Storm Event (1)
2 Year	1/17 18:00 to 1/18 2:00
10 Year	1/18 20:00 to 1/18 23:00
25 Year	1/18 8:00 to 1/18 11:00
50 Year	1/18 8:00 to 1/18 10:00
100 Year	1/18 5:00 to 1/18 10:00

(1) Storm events begin at 12:00 AM, 1/16/2002

The peak flows within these time periods on each of the stream reaches were generally used for analysis of peak water levels along the reach. The peak water surface at Soap Lake generally occurred later, due to continued inflows that were greater than the outflow at the lake.

Input flows and downstream boundary conditions are summarized below in Table 2-3.

Table 2-3: HEC-RAS flows and downstream water surface elevations obtained from the Phase 1 HEC-1 general plan buildout model.

Location	2-Year Flow	10-Year Flow	25-Year Flow	50-Year Flow	100-Year Flow
Millers Canal	250 cfs	4,000 cfs	7,200 cfs	10,200 cfs	12,000 cfs
Upper Pajaro	250 cfs	2,600 cfs	4,800 cfs	6,800 cfs	8,000 cfs
Middle Pajaro	2,100 cfs	4,900 cfs	8,300 cfs	11,700 cfs	13,900 cfs
Lower Pajaro	2,200 cfs	8,800 cfs	15,200 cfs	21,700 cfs	25,300 cfs
Llagas	1,200 cfs	2,300 cfs	3,500 cfs	4,900 cfs	5,900 cfs
Uvas/Carnadero	900 cfs	3,900 cfs	6,300 cfs	8,300 cfs	9,800 cfs
Pajaro Outlet	3,100 cfs	11,100 cfs	15,000 cfs	17,900 cfs	19,500 cfs
Lake Surface Elevation*	126.5 ft	136 ft	140 ft	141.4 ft	142.5 ft

*Lake surface elevation is the water elevation at the outlet at the time of peak inflow to Soap Lake. It is not the maximum water surface of the lake nor is it constant throughout Soap Lake.

Model Input: Geographical

Geographical inputs to the model are generated through a GIS interface with the topographic and imagery data developed in Phase 3 Task 2. Streams and cross sections, among other features, are created in a GIS environment and translated into an ASCII format that HEC-RAS can import.

A GIS system was used to facilitate data entry for the geographic model. Using the GIS also made it possible to take advantage of the digital data and surfaces.

Data Input and Processing

Based on the relatively flat terrain through much of Soap Lake, 2-foot elevation contours are necessary for accurate modeling through the bulk of the Soap Lake area. The low flight level required for 2-foot contours corresponded with that needed for 6-inch pixel resolution of the aerial photography. High resolution data was collected for the entire Soap Lake area, as defined by the approximate FEMA floodplain, and a 1,000 foot buffer. Lower resolution data, 2-ft pixel photography with 10-foot contours, was available on the San Benito side of Soap Lake.

The Soap Lake area was divided into tiles to reduce individual file sizes and improve handling of smaller areas. Each tile has:

- A contour file with elevations based on NAVD 88
- Digital terrain model (DTM) and triangular irregular network (TIN) files
- 6” or 2’ pixel orthophotography

An example of each of the above data types is shown in Figure 2-7.

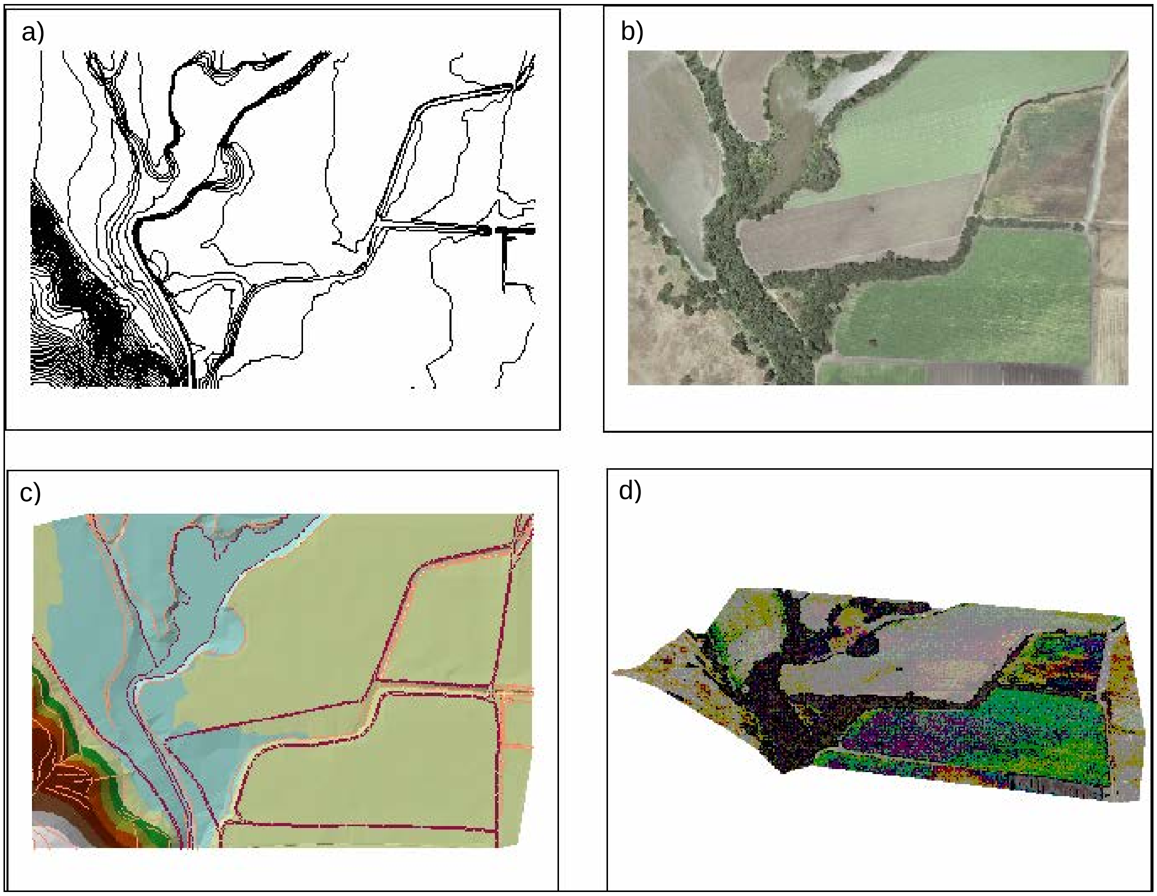

Figure 2-7: Examples of received data. The represented area is close to the outlet of Soap Lake. The data shown in this figure are: a) Contour lines b) Aerial photography c) Digital terrain model d) Synthesis of a), b), and c) with a vertical exaggeration of 5:1.

A Beta release of a program, HEC-GeoRAS, designed to facilitate information transfer between GIS data and HEC-RAS was used for data input and floodplain generation.

HEC-GeoRAS (GeoRAS) consists of two modules: one for preprocessing data for import to HEC-RAS and one for processing a HEC-RAS export file containing water surface elevations and profile boundary polygons. In the preprocessing stage, users create model features using GeoRAS in ArcGIS rather than in HEC-RAS. Once the geometric features have been created, HEC-RAS reads the import file and creates the geometry file of the model. Once modeling is complete within HEC-RAS, the user exports the profile water surface elevations back into a text file. GeoRAS can then interpret those results and delineate floodplains for steady-state modeling results. Figure 2-8 is a high level process flow diagram for the entire modeling process.

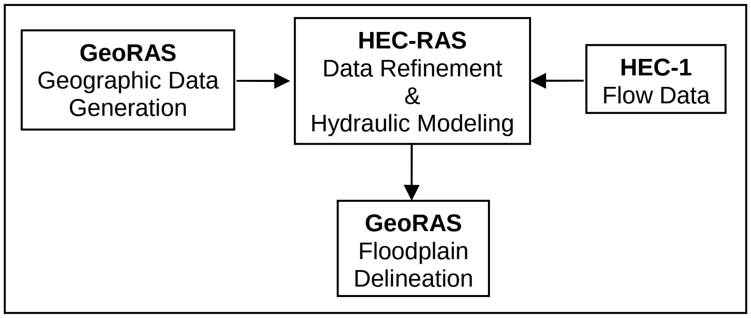

Figure 2-8: Flow diagram for the HEC-RAS modeling and floodplain delineation process using HEC-GeoRAS.

Feature Creation and Assumptions

As mentioned earlier, there are a number of features that were included in the Soap Lake hydraulic model. Below is a brief description of these features.

- **Stream Centerline**: Stream centerlines serve as the backbone of the stream system and for this model were assumed to be the deepest part of the channel. Stream centerlines were defined only for those waterways which were modeled as part of Phase 1 which include the Pajaro River, Llagas Creek, and Uvas/Carnadero Creek. Millers Canal was also modeled since it is a dominant feature in the study area. Figure 2-9 shows examples of the centerline definition based on the shape of the channel.

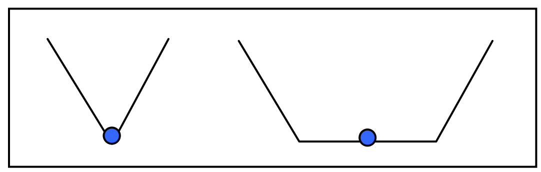

Figure 2-9: Examples of stream centerline delineation using the thalweg and the midpoint of the channel bottom.

- **Cross Sections**: Cross sections are the model's window into the geographical terrain and data. They are also the locations where water surface elevations are calculated. Cross sections were placed at approximately 500 foot intervals along each of the major waterways in the study area. Some locations were adjusted to meet local conditions. Others were added at bridge crossings to better define the land elevations and channel constrictions. The length of the individual cross section was defined by the study area topography. Figure 2-10 shows the locations of the Soap Lake cross sections.

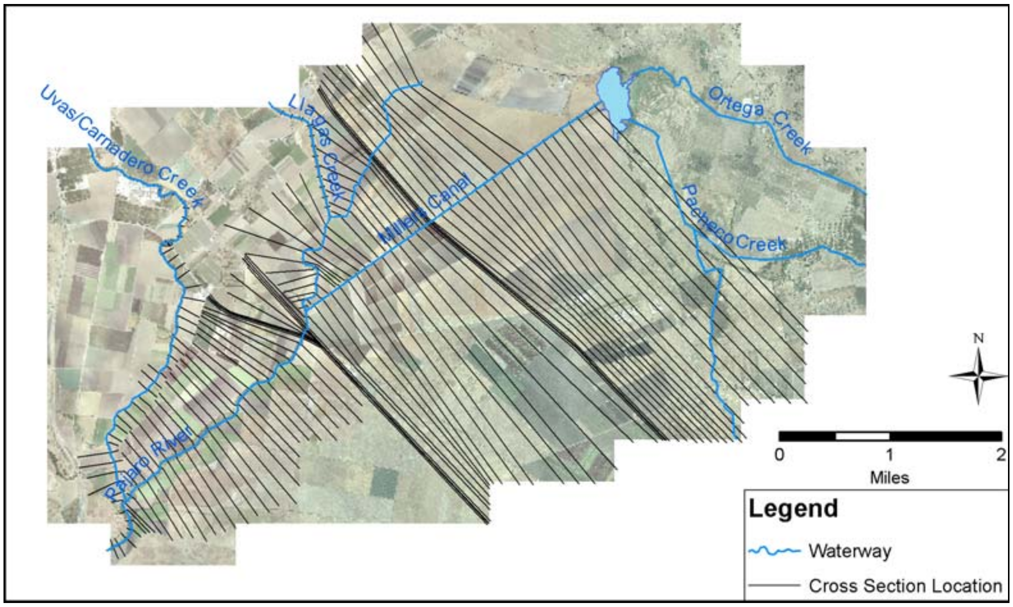

Figure 2-10: Cross section locations of the Soap Lake hydraulic model.

- **Bank Locations**: Bank location is used to define the left overbank, channel, and right overbank. This designation is used when determining the roughness, which translates to friction, that flowing water encounters. The roughness can be different for all three locations and is explained further below. Bank location was designated based on changes in land use cover visible in the aerial photography. Figure 2-11 below is an example of the bank delineation using land use change and designation of left and right overbanks and the channel.

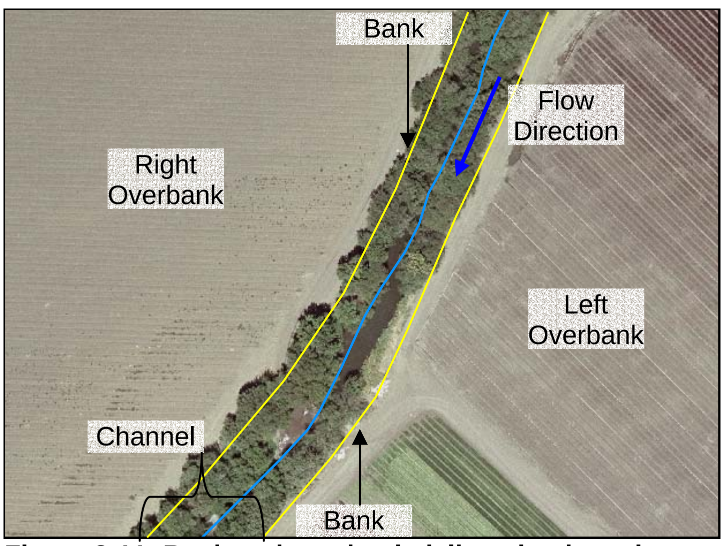

Figure 2-11: Bank and overbank delineation based on aerial photography.

- **Levee Locations**: Levees were used in the model to prevent flooding in low sections across the entire width of the cross section. Without the levees, the model would indicate flooding in any area lower than the water surface elevation along that cross section. With the levees in place, water was contained to between the channel and the levee. Once the water surface elevation increases above the levee elevation, the water is allowed to spread across the cross section as if no levee were present. Schematic cross sections are shown below in Figure 2-12 to demonstrate the effect of levees on containing inundated areas.

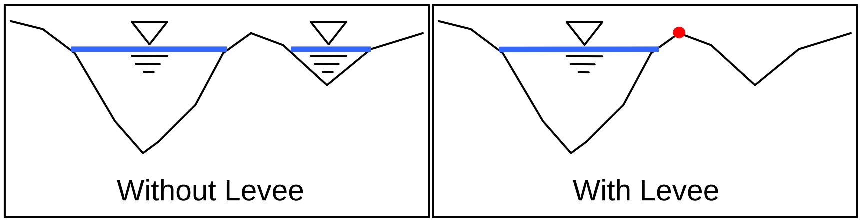

Figure 2-12: Schematic of water surface without and with a levee. The levee prevents overtopping before the water surface rises above a high point in the ground.

- **Bridges**: Oftentimes, bridges constrict flow during large flood events and are therefore important to include in a hydraulic model. For the Soap Lake model, bridges were modeled at five crossings: Millers Canal and Frazier Lake Road, Pajaro River and Frazier Lake Road, Pajaro River and the Railroad, Pajaro River and Highway 25, and Uvas/Carnadero Creek and Highway 25. A detailed crossing analysis was not made; instead, open span bridges with a bridge deck thickness of 2 feet were assumed. A sketch showing this arrangement is included as Figure 2-13. Surrounding terrain conditions were taken from only the available topographic GIS data. The width of the bridge was estimated from the aerial photography using GIS measuring tools.

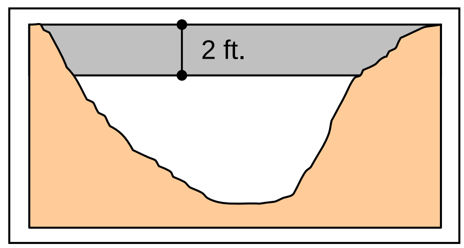

Figure 2-13: Bridge section schematic.

- **Ineffective Areas**: Ineffective areas are locations where water is being stored but not actively conveyed. The velocity of the water in these areas is close to or equal to zero. There was one ineffective area modeled within the Soap Lake study area, shown in Figure 2-14 below. This area is considered ineffective because of height of Highway 25 and the railroad. Except in major events, water is unable to flow over these structures. Water flowing under the railroad bridge is assumed to flow directly toward the Highway 25 bridge rather than conveyed in the riverbank area.

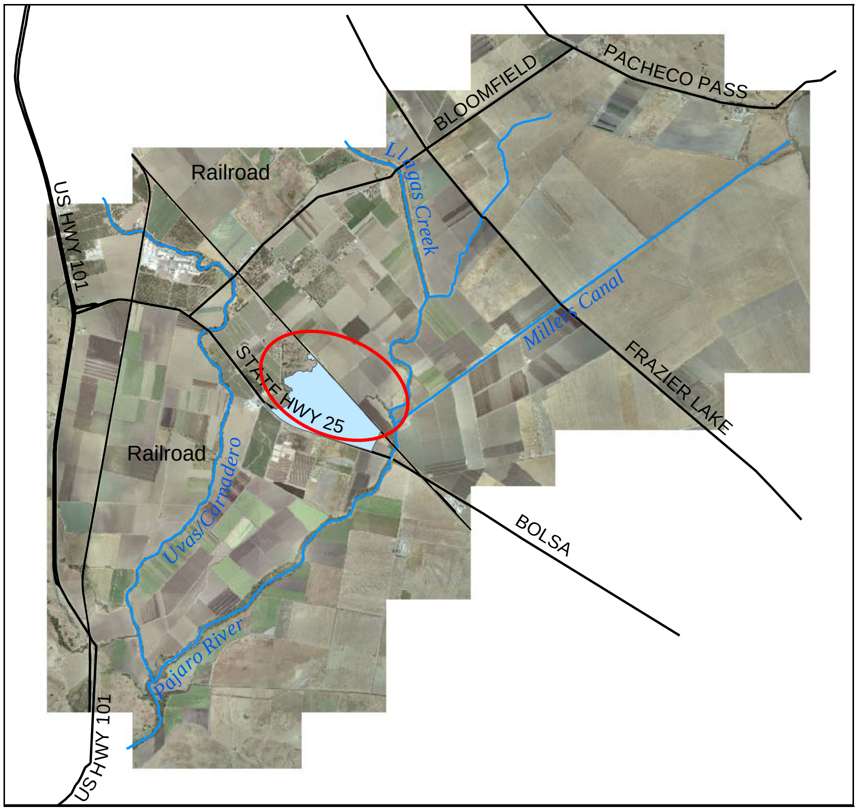

Figure 2-14: Ineffective flow area in the Soap Lake modeled area. The area is ineffective because of the high railroad and Highway 25.

- **Roughness Coefficients**: Mannings n roughness coefficients represent different types of land use and land cover. The higher values indicate a rougher surface for the water to travel over. The values used in the model are estimates based on the Phase 1 modeling and other models available for individual reaches of the streams included in the Soap Lake model. Table 2-4 summarizes the Mannings n values used in this model.

Table 2-4: Mannings n roughness coefficients used in the Soap Lake hydraulic model.

Location	Mannings n Value
Uvas Channel	0.050
Llagas Channel	0.055
Millers Canal Channel	0.025
Pajaro Channel Upstream of Hwy 25	0.050
Pajaro Channel Downstream of Hwy 25	0.060
All Overbank Areas	0.040

Model Synthesis

HEC-RAS combines the flow and geography models using one-dimensional steady and unsteady flow calculations to determine water surface elevations at the modeled cross sections. The Soap Lake hydraulic model utilizes the steady flow module to determine the water surface elevations since only peak flows were used. Modeled cross sections are limited to between San Felipe Lake and upstream of Highway 101. The floodplain due to Soap Lake may extend upstream of San Felipe Lake due to backwater effects but it was not hydraulically modeled in HEC-RAS. The floodplain model, explained in the next section, did some backwater analysis to approximate the effect of the most upstream cross section. The water surface elevation is assumed to be constant across the cross section. Any land points with an elevation below this water surface elevation are assumed to be submerged. The next section discusses delineating submerged areas, or floodplains, further.

Soap Lake Floodplain Model

Floodplain maps were developed using the hydraulic modeling results. The primary method for the floodplain mapping was using the post-processing module of the HEC-GeoRAS and GIS processes but other methods included split flow over a broad-crested weir, intersection between the water surface elevation and the ground elevation, and a stage-storage analysis. Each of these methods is described below. Also included in this section is a discussion of the limitation and applications of the final floodplain maps.

Floodplain Creation Methodology

To the extent of the modeled cross sections, the floodplains were created using a variation on the HEC-GeoRAS tool. There are areas outside the limits of the hydraulic model that are still considered within the Soap Lake study area. These areas were modeled using HEC-RAS results but applying different methodologies such as split weir flow where a new overland flow path was created and extending the water surface where the ground was flat but no channel or cross sections were available. Also, a later time-frame than that accounted for in the hydraulic model was simulated using a stage-storage analysis. These methodologies are explained further below.

- **HEC-GeoRAS**: Most of the Soap Lake study area was modeled using a combination of the HEC-GeoRAS post-processing tools and several GIS processes. HEC-RAS results, water surface elevations (WSE) at cross sections, are interpreted in a GIS environment and turned from lines with elevations into a surface. The elevation of the ground at a point is subtracted from the elevation of the water surface at the same point. If the difference is positive, the water surface is higher than the ground surface while if it is negative, the area would not be flooded. Figure 2-15 depicts this process in a profile view.

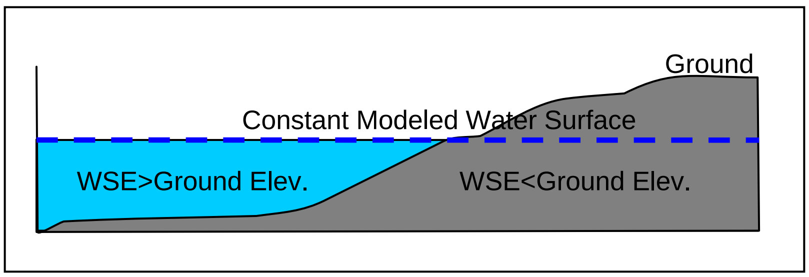

Figure 2-15: Logic test for flooding.

- **Split Weir Flow**: Topography in the left and right overbanks of Uvas/Carnadero Creek precluded modeling these areas the same way as the rest of the study area. The channel and channel walls for this creek are actually the high points in the region. Since HEC-RAS is a one dimensional model, it would assume that the water surface calculated for the channel would be extended to the limit of the study area or when the ground elevation was the same as the water surface elevation. This inherent assumption in the model would grossly over exaggerate the amount of flooding caused by overtopping. Figure 2-16 represents the effect of a slight overtopping with a one dimension assumption.

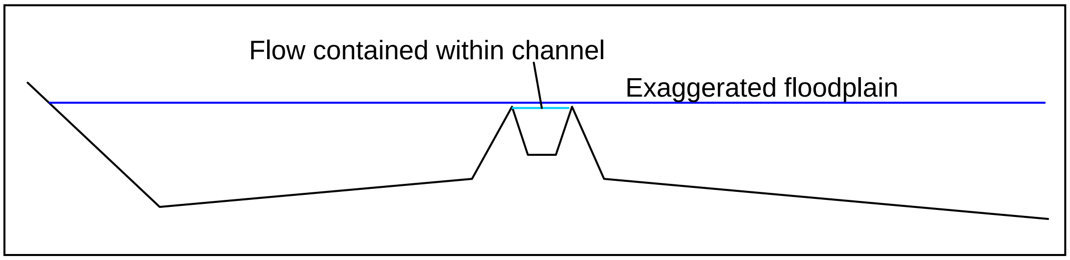

Figure 2-16: Representation of the effect of a one dimension assumption on model results. A slight increase in flow leads to massive predicted flooding and unreasonable results.

In order to more accurately represent the flooding caused by overtopping of the Uvas/Carnadero levees, the Uvas/Carnadero overbanks were not included in the HEC-RAS model. Instead, weir flow over the levees was assumed and an overland flow path was developed. Mannings equation and generalized cross sections were used to estimate the width of the flow path based on the amount of overflow.

- **Backwater Impact Area**: Portions of the study area near the upstream edges of the study area were not included in the hydraulic model due to model cross section layout. Since they were not included in the model, no flood level was calculated for these areas. However, these areas can become flooded under some conditions.

  A level water surface was created based on the elevation of the ground where it intersects the water surface of the most upstream cross section. The same flooding logic was described in the HEC-GeoRAS section above. Figure 2-17 shows this application for the area upstream of the Pajaro River. The backwater impact area was calculated for all areas upstream of the area modeled hydraulically.

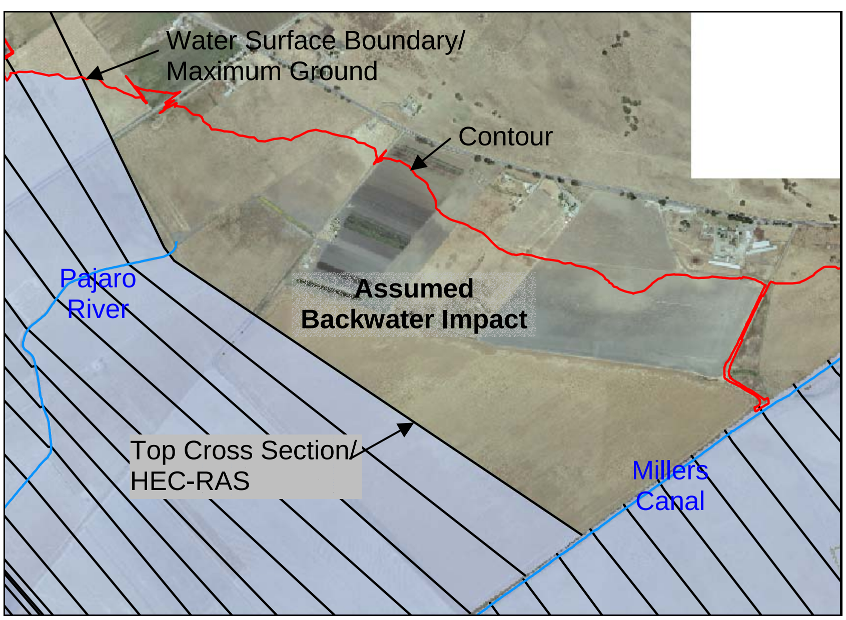

Figure 2-17: Demonstration of defining the assumed backwater impact area based on limit of flooding at the top cross section.

- **Soap Lake Peak Stage Analysis**: The hydraulic model and floodplains derived from its output are based on peak flows in each reach. At the time of peak inlet flows, the flow and water level at the outlet of Soap Lake is much lower than outlet peak values that will be reached later in the storm. This difference in the inflow and outflow causes the water surface in the lake to rise.

  To account for this effect, peak water surface levels are extracted from the model output and translated into level planes with an elevation equivalent to the highest water surface level. These water levels are shown in Table 2-5. The same flooding logic and methodology as described in the HEC-GeoRAS and backwater analysis sections above is applied to these water surfaces.

Table 2-5: Peak water surface elevations at Soap Lake outlet.

Event	Outlet WSE
2-Year	126.5 feet
10-Year	136.5 feet
25-Year	140.7 feet
50-Year	143.1 feet
100-Year	144.3 feet

The four floodplains generated by the above techniques are combined to create a single floodplain map representing both the peak inflows and the peak Soap Lake water surface elevation. The floodplain was checked for gaps and irregularities. Gaps occurred where there was insufficient cross section coverage, as shown in Figure 2-18, and were patched. Irregularities occurred where backwater assumptions would not apply (i.e. where there was a raised road that would block water) and were addressed.

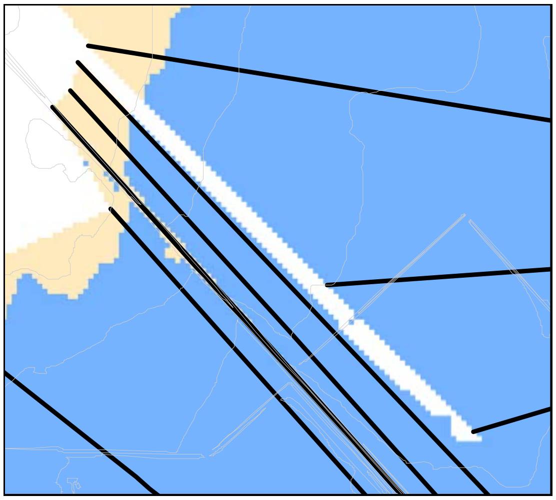

Figure 2-18: Example of data gap caused by cross section placement. The blue shading indicates flooding, the yellow shading indicates no flooding, and the white shading indicates no data. The thick black lines are cross section cut lines.

Soap Lake Floodplains

Based on the Soap Lake hydraulic and floodplain models, floodplain maps have been created for the 2-, 10-, 25-, 50-, and 100-year floodplains. These maps are included in this report as Figures 2-19 through 2-23. Following the maps is a discussion of the map limitations and intended applications. There is also a discussion of how the floodplain delineations are used to better define the Soap Lake Floodplain Preservation Project.

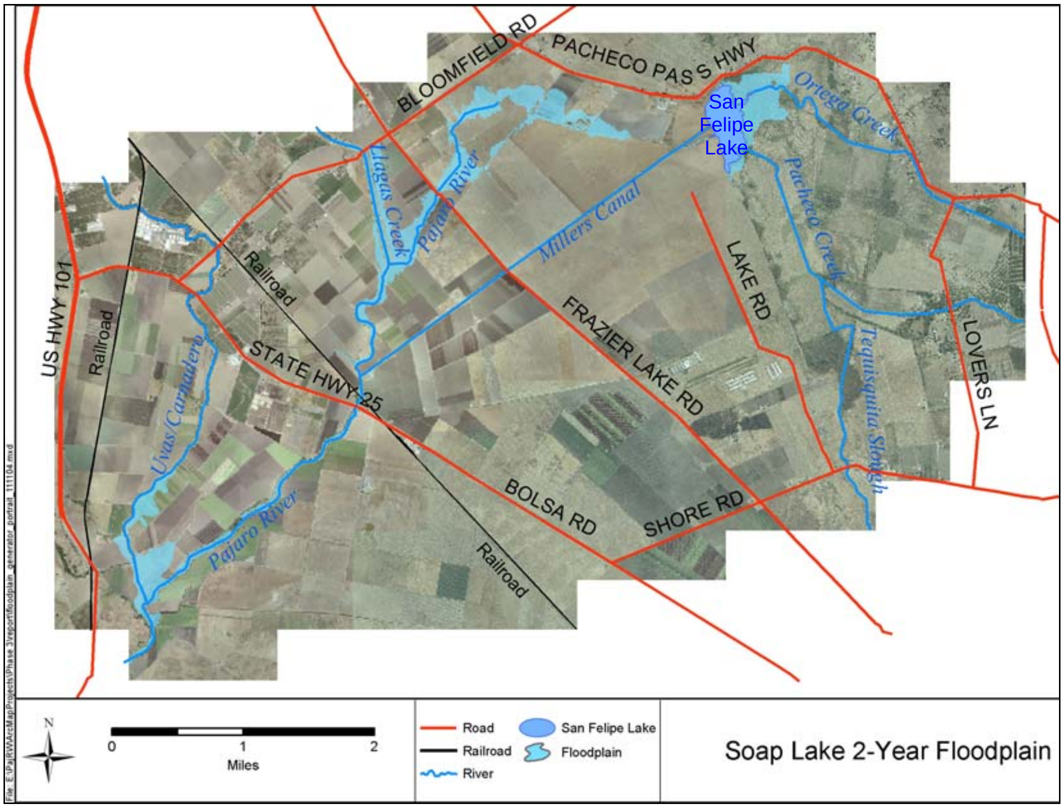

Figure 2-19: Soap Lake 2-year floodplain.

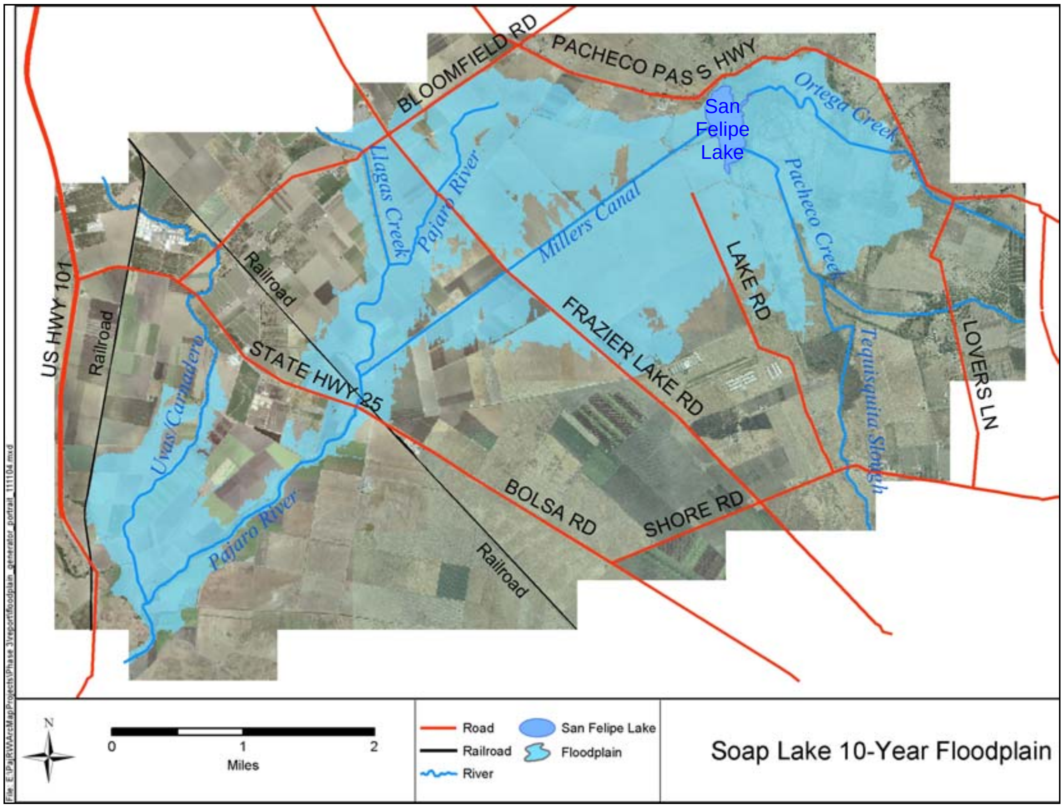

Figure 2-20: Soap Lake 10-year floodplain.

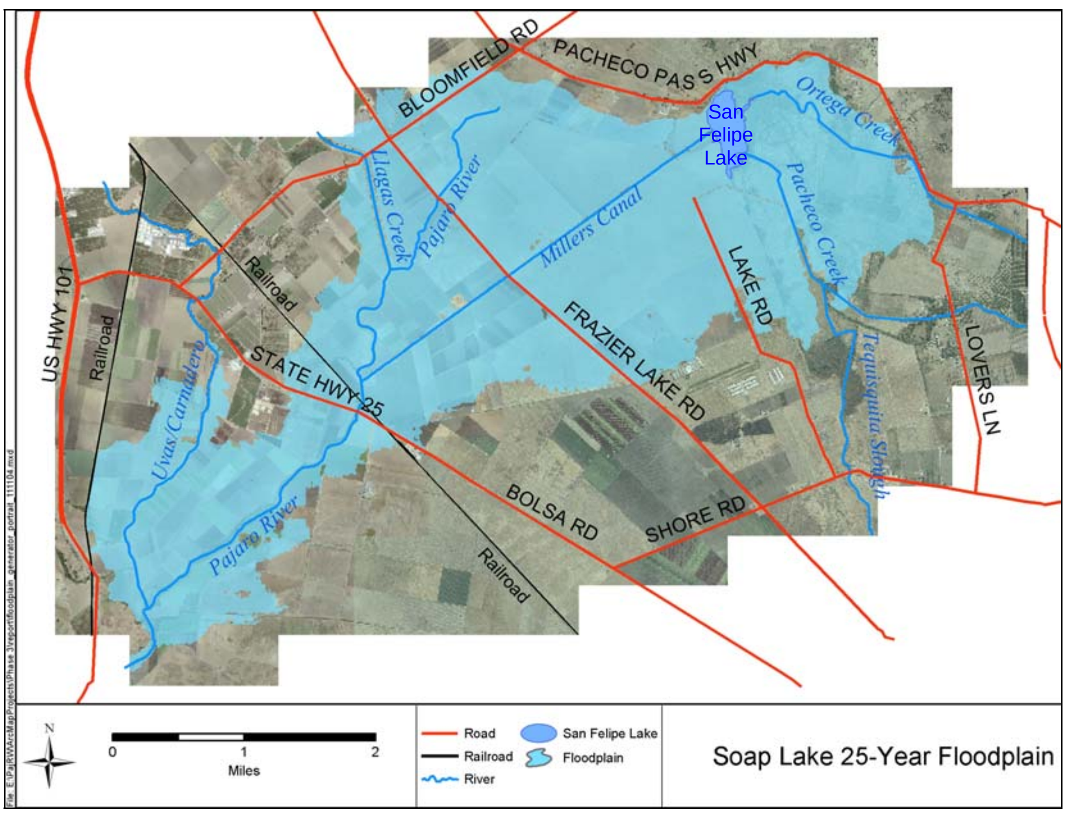

Figure 2-21: Soap Lake 25-year floodplain.

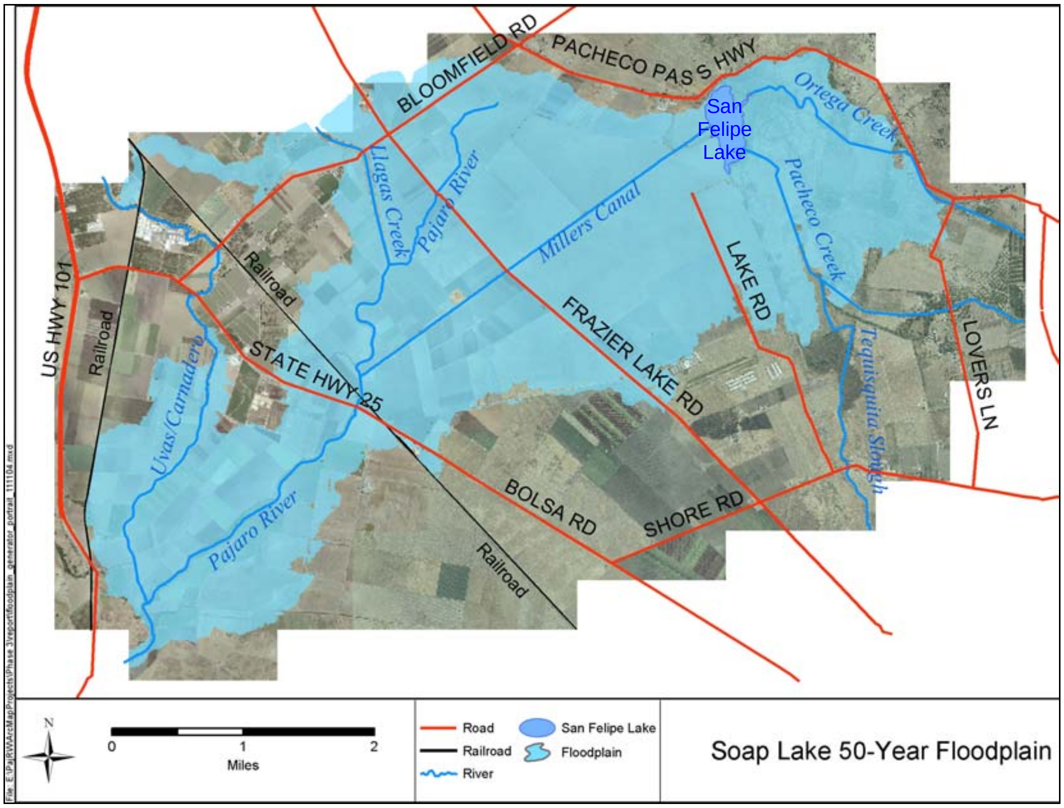

Figure 2-22: Soap Lake 50-year floodplain.

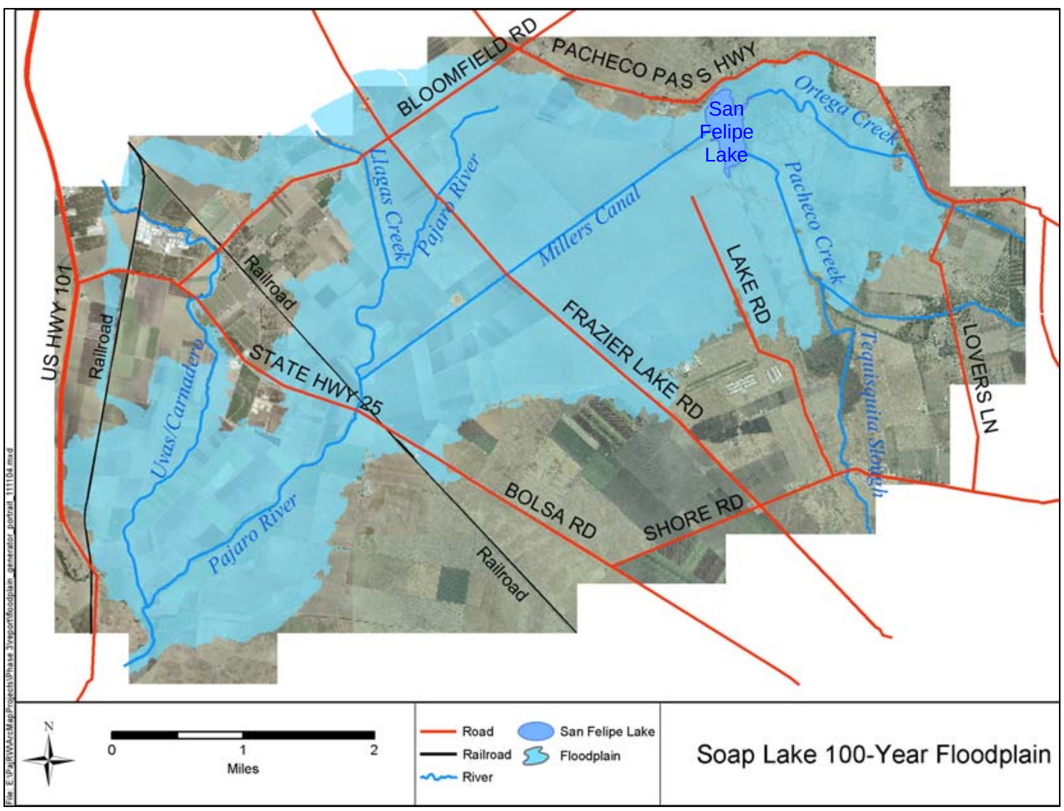

Figure 2-23: Soap Lake 100-year floodplain.

Applications of the floodplain maps should be limited to those within the Pajaro River Watershed Study. The maps are based on work performed for the Study and are graphical records of all of the assumptions built into the previous models. These assumptions include those made for the Phase 1 HEC-1 model and the Phase 3 HEC-RAS model. While they can be compared to FEMA flood maps, they are not intended to replace them at this time. Additional work would be required before they can be submitted as an official floodplain record.

It should also be recognized that the floodplain maps are the results of a one dimensional steady-state modeling. The extent of flooding shown can be considered a worst case scenario as it assumes that peak flows are constant and all tributary inputs coincide. Also, since the HEC-RAS modeling is steady-state, outflow hydrographs are not available from the model.

These floodplain delineations are a central aspect of the Soap Lake Floodplain Preservation Project as they define where preservation is necessary. Impacted parcels are identified based on these floodplain maps. The impacted parcels were used to notify land owners about the Soap Lake Floodplain Preservation Project. The floodplains and impacted parcels are also useful in determining the cost of the project. The floodplain delineations are used to quantify the impacts that various magnitudes of floods have on the Soap Lake area and identify sensitive resources that may be impacted by the project. The next chapter identifies these resource areas and potential impacts.

Facilities Impacted by Flooding

While flooding in Soap Lake prevents additional damage downstream, there are some facilities and resources that are impacted locally. The physical impacts of flooding were analyzed for a 2-, 10-, 25-, 50-, and 100-year flood event. A facility is considered to be impacted if it is at least partially within the floodplain limits. The facilities analyzed were limited to public or large structures and did not include residences or individual farms. Facilities included in the analysis included:

- Roads and Highways
- Bridges
- Railroads
- Utilities – Santa Clara Conduit and proposed Pajaro Valley Water Management Agency Import Pipeline
- Seismic Faults Special Structures – Significant structures not included in the above categories

Seismic faults, while not a physical structure, were identified as well because any development that might occur within the floodplains will need to be aware of the location of these faults.

The quantification of impact on the above facilities was calculated using available GIS information. The individual facility files were clipped to include only the portion of the facility within the floodplain boundary. The length, area, or count of the “flooded” facility was then calculated. Table 2-6 summarizes the physical impacts of a 100-year event on the above facilities. Figure 2-24 shows the locations of the impacted facilities. TM 3.5 of this Study, included in the appendix of this report, contains similar tables and figures for the other floodplains developed for Phase 3.

Table 2-6: 100-Year Flood Impacts in the Soap Lake area.

Facility Type	Impact	Length/Area of Impact	Examples
Highway/Roadways	Yes	89,100 ft; 1,580,000 sf	Hwy 25, Frazier Lake Rd, Bloomfield Rd, Bolsa Rd
Bridges	Yes	10 bridges	Bloomfield @ Llagas, Railroad @ Pajaro, Hwy 25 @ Pajaro, Bloomfield @ Carnadero, Hwy 25 @ Carnadero, Railroad @ Carnadero, Frazier Lake @ Pajaro, Frazier Lake @ Millers
Railroad	Yes	5,100 ft; 167,000 sf	Railroad bridges at Pajaro, Railroad at Tic, Railroad NW & SE of Pajaro bridge, Intersection of railroad lines
Utility	Yes	43,800 ft	Santa Clara Conduit, PVWMA Import Pipeline
Seismic Fault	Yes	12,200 ft	Sargent, Calaveras
Special Structures	Yes	2 sites	TriCal, Inc., Frazier Lake Airport Hangars

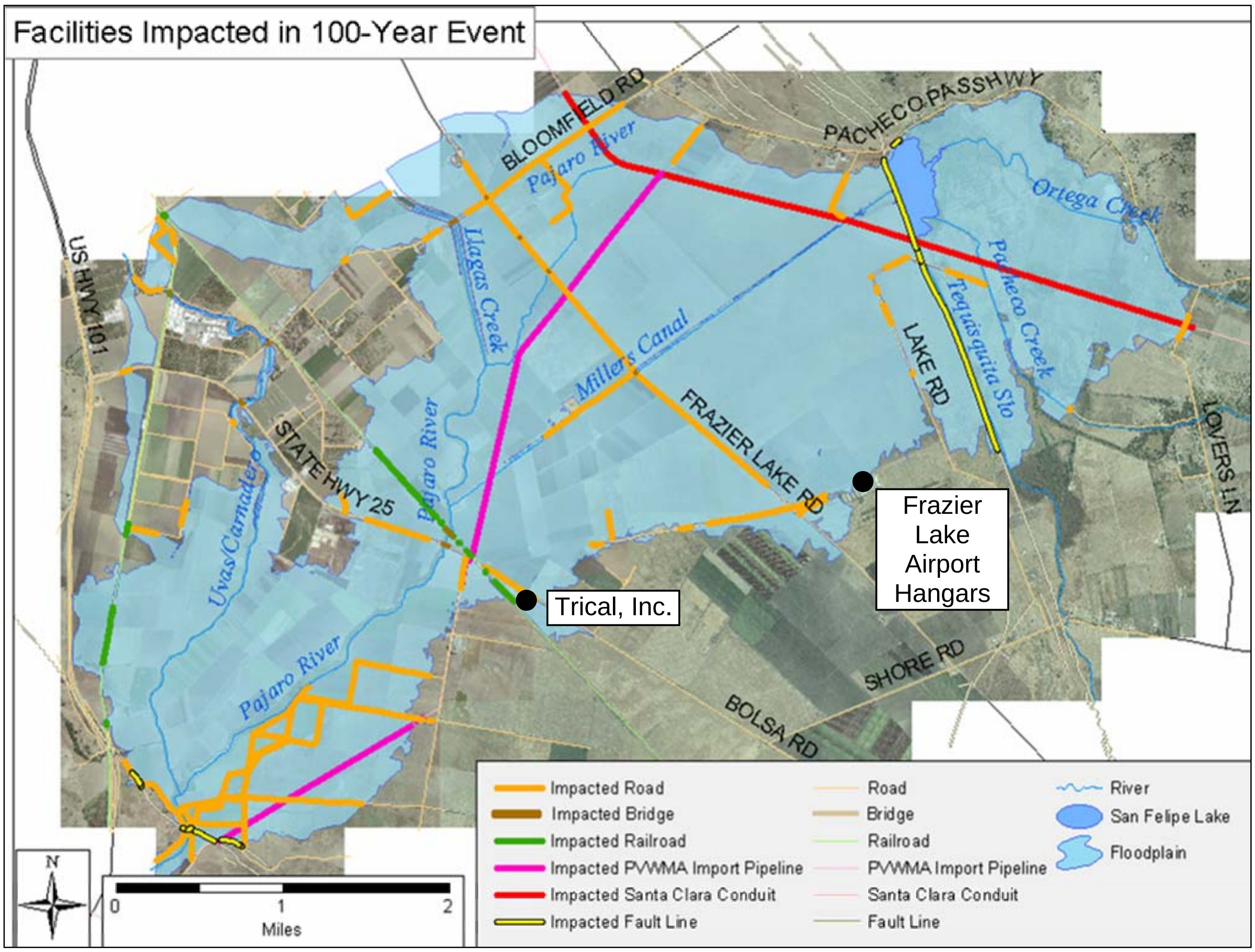

Figure 2-24: Facilities impacted by a 100-year flood event in the Soap Lake area.

In addition to the described facilities, there may be other utilities or proposed projects that were not included in the analysis due to lack of available information. One such project is the California High-Speed Train System. For this project, two route options are being explored that will traverse the Soap Lake project area at grade. Figure 2-25 shows the Draft EIR/EIS maps available for the high-speed rail project in this area. Another upcoming project that could impact or be impacted by flooding is the widening of Hwy 25 and construction of new bridges. It is important that agencies and organizations responsible for this and similar projects be aware of the critical nature of the Soap Lake floodplain and how their projects might impact flooding locally and downstream.

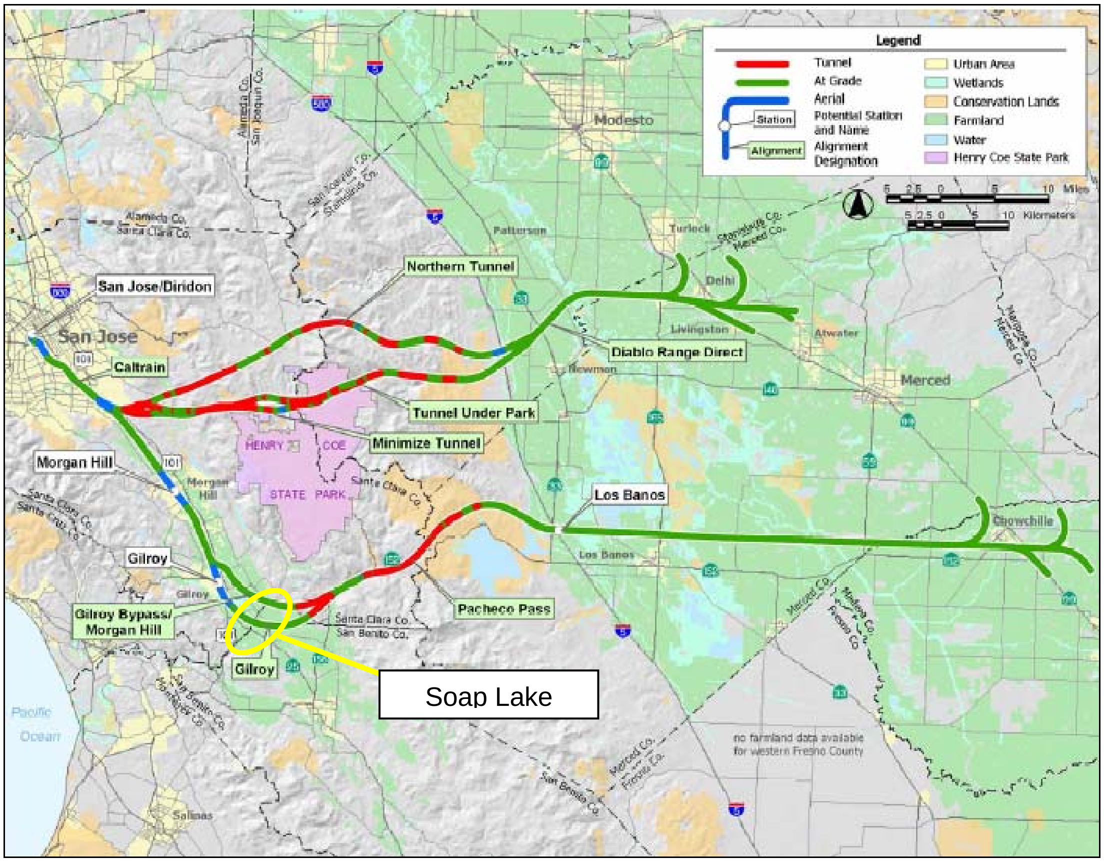

Figure 2-25: High-speed rail options between San Jose and the central valley. Map from the California High-Speed Rail Draft EIS/EIR.

Preserving the Soap Lake Floodplain

CHAPTER 3

CHAPTER 3

PRESERVING THE SOAP LAKE FLOODPLAIN

The Soap Lake Floodplain Preservation Project is the proposed CEQA project that would maintain the floodplain attenuation characteristics of Soap Lake with the fewest impacts to the area. The Authority recognizes that there are other ways to mitigate loss of storage and attenuation capabilities. Though this project does not include these other methods, it does not preclude them. This chapter defines the Soap Lake Floodplain Preservation Project by identifying:

- Viable methods of preservation
- Benefits of the project
- The boundaries of the project
- The impacts of the project
- The potential cost of the project

Project Description

Soap Lake has been determined to be one of the most important watershed features in providing downstream flood protection to the Watsonville area. Soap Lake, primarily agricultural land, acts as a natural detention basin during large rainstorms and reduces peak flood flow from the Upper Pajaro River watershed.

No structural facilities would be built; instead the proposed project would include either purchasing land or obtaining flood easements for the land within the Soap Lake floodplain. The objective is to maintain the current flood protection benefits provided by the Soap Lake floodplain by protecting the area from changes that would impact the flood protection properties of the floodplain. The purchase of land or floodplain easements would restrict development and preserve agriculture and open space.

The floodplain area is about 9,000 acres. The 100-year floodplain boundary was shown in Figure 2-23. The floodplains of the Uvas/Carnadero Creek, Llagas Creek, and Tequisquita Creek extend beyond the Soap Lake floodplain, but are not shown on Figure 2-23.

This project would maintain the current hydrologic and hydraulic conditions of the Soap Lake floodplain. The floodplain limits would not be changed. As flood frequency and magnitude increase due to urbanization elsewhere in the watershed, a protected Soap Lake would continue to provide the current level of flood protection afforded by this floodplain. The project would therefore minimize additional flood damage within the Soap Lake floodplain since new development would be restricted. The project would also minimize flood damage downstream since the peak flows are attenuated in the existing floodplain.

The proposed method to ensure preservation of the Soap Lake effect, and therefore maintain current flood flows, is to maintain the current land use and topography. There are multiple ways to achieve this goal through land acquisition and land use restrictions. These include:

- Land use policies (zoning, general plan, and floodplain ordinances)
- Incentive programs (Williamson Act, Farmland Security Zones, etc.)
- Purchase of land,
- Conservation easements, and
- Mitigation banking.

These preservation methods are explained below.

Zoning and General Plan Land Use Designation Changes

Agricultural zoning is a technique that allows municipalities to protect their rural and agricultural areas by establishing large minimum lot sizes. Both Santa Clara County and San Benito County already have designated the area within Soap Lake for agriculture with large lot sizes. Both counties also have policies in their General Plans promoting continued agricultural use of this land and it is recommended that these policies remain in place. One disadvantage of this method would be the possibility that these policies could be reversed in the future and may not be a permanent solution.

Floodplain Management Ordinance

A higher level of floodplain management could occur through greater regulatory requirements placed on development in the Soap Lake area. To do this, higher regulatory standards (ordinances) could be developed and adopted by the communities (Counties of Santa Clara and San Benito) which manage the Soap Lake floodplain through the Federal Emergency Management Agency (FEMA) National Flood Insurance Program (NFIP).

The NFIP is a mitigation program that lessens the impacts of flooding on communities (people and property) through damage prevention and flood insurance. To increase floodplain management strategies within the Soap Lake area, 100-year base flood elevations (BFEs) could be established. Establishing BFEs would provide an elevation to which local government can regulate construction practices to reduce flood losses. This is accomplished by establishing development and redevelopment policies that elevate residential structures, flood proof or elevate non-residential structures, and retrofit existing structures.

Participation in the Community Rating System (CRS) is a benefit of participating in the NFIP beyond the NFIP minimum standards. Participation in the CRS is voluntary and may reduce flood insurance premiums for the community's property owners once new flood mitigation, planning, and preparedness activities have been implemented and accepted by FEMA. The goals of the CRS are to reduce flood losses, facilitate accurate insurance ratings, and promote the awareness of flood insurance. These goals are achieved by activities relating to public information, mapping and regulations, flood damage reduction, and flood preparedness.

Incentive Programs

Various incentive programs are already in place within these counties to discourage development and maintain agricultural uses. These programs offer tax incentives to landowners through long-term contracts such as:

- Williamson Act Contracts – For land within designated Agricultural Preserve land – 10-20 year contracts, property tax based on income as opposed to full market value, with tax revenue subvention from state through Open-space Subvention Act Program.
- Farmland Security Zones – 20 year contracts, provides greater tax incentive than Williamson Act contracts (65% of WA valuation or 65% of Prop 13 valuation, whichever is lower), and also provides that the property cannot be annexed by City or taken by school districts for school facilities.

Although these programs are successful throughout California at preserving agricultural land, and are consistent with the proposed project goals, they too are not permanent solutions.

PURCHASE/LEASEBACK

Land would be acquired from a willing seller. The owner sells the property rights to the buying authority, and then the land is leased back to its original or a new owner. The buying authority then has control of the land use and no liability for damage claims, but allows a second party to maintain an acceptable land use. By allowing the land to be leased, some of the purchase price for the land can be recouped. Land acquisition is one of the options available to the Authority to provide flood protection to the lower Pajaro River.

FLOOD CONSERVATION EASEMENT

A flood easement is an agreement between the landowner and purchasing authority that land within a flood zone will be allowed to flood. The owner maintains the property rights and use. In this case, the land ownership would be retained by the existing owner, or sold to a new owner, with the purchase of an easement by a third party to allow third party control of land use in the area. The original land use, such as agriculture, can be continued while that area of land is not flooded.

The easement purchase would restrict the building of structures or facilities that could impede the flood attenuation benefits of the floodplain and that could be damaged by the flood or cause damage to the surrounding area. Examples of these structures include buildings, fill materials, and septic tanks.

Several conservation easements and land purchases have already been obtained within the Soap Lake project area totaling over 1,200 acres. In addition, funding has been secured to obtain another 1,200 acres. The easements and land obtained are described below and shown on Figure 3-1:

- Carnadero Preserve
- Silacci Property
- Helperin Property
- Wildlands Property

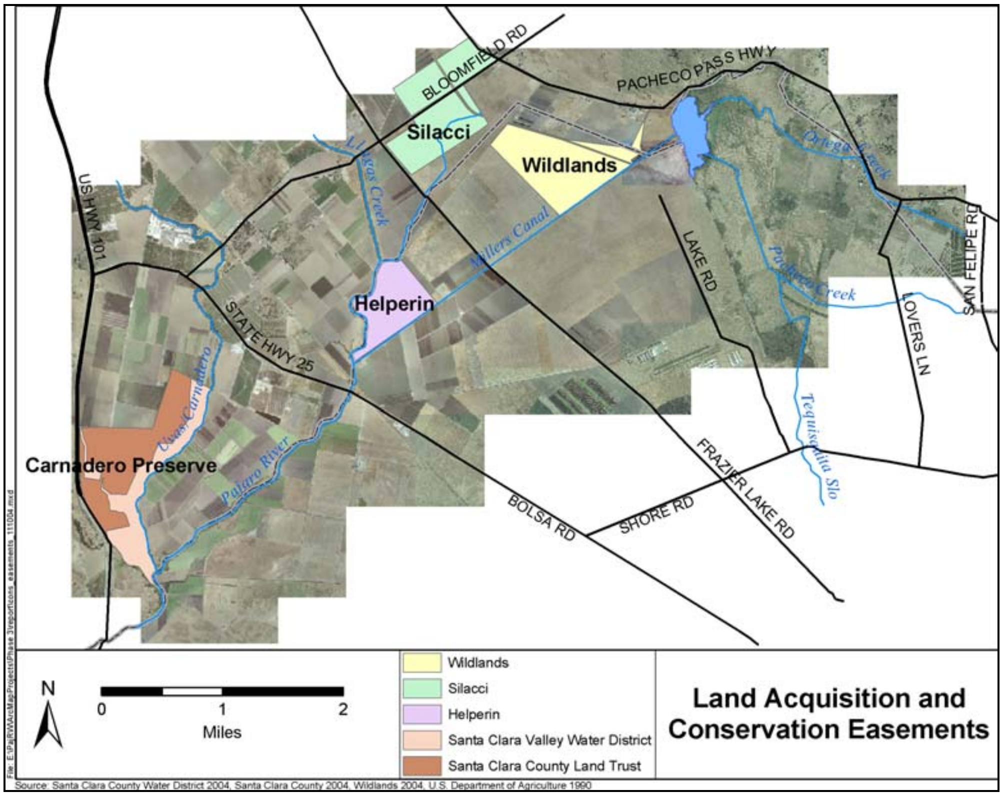

Figure 3-1: Land acquisitions and conservation easements within the Soap Lake floodplain.

Mitigation Banking

Agricultural land mitigation banking is a relatively new concept that allows developers to compensate for loss of agricultural land by paying for agricultural land that has been protected in other areas. Creating an agricultural mitigation banking program could be a complimentary preservation strategy in conjunction with conservation easements.

Eminent Domain

All of the above land acquisition options take place between a willing seller and buyer. Occasionally landowners are not willing to sell their land or right to use the land. When this happens and it has been shown that there is no other alternative, public agencies can take the land by eminent domain for the good of the public. This involves rigorous review of different options to solve the problem, study of environmental impacts, and court proceedings. The court forces the sale of the needed land at fair market value. Out of necessity, this is the last option to be considered and is therefore not likely to be considered.

Purchase/Condemn

This method is used when the successive land use will be completely different from its current land use. The former owner sells the property rights to the buying authority and has no further claim to the property. For example, a parcel within the 100-yr floodplain could be bought and any structure inhibiting flood flow removed. The land could then be returned to its natural state. Since maintaining the land for agricultural use is preferred, this alternative is not recommended for preserving the storage and attenuation characteristics of Soap Lake.

RECOMMENDED SOAP LAKE EFFECT PRESERVATION METHOD

The recommended method is a combination of the above methods with the exceptions of eminent domain and purchase/condemn. The primary method considered should be land acquisition through fee title purchase or flood conservation easements. Each property owner may want to take advantage of a different opportunity to preserve the property's land use and cover. Floodplain zoning changes and management ordinances could impact large portions of the floodplain or the entire floodplain. Incentive programs, conservations easements, and purchase options could provide capital for the land owners. Mitigation banking provides a similar opportunity but would allow development in another area not impacting the floodplain.

Project Benefits

There are many benefits associated with the Soap Lake Floodplain Preservation Project and are described in the following paragraphs.

As described earlier, Soap Lake serves as temporary storage for the Pajaro River. Without the floodplain, the 100-yr flood event is assumed to increase the peak downstream Pajaro River discharge by 15,600 cfs from 44,400 cfs to about 60,000 cfs. The Soap Lake Floodplain Preservation Project would therefore not reduce the magnitude of a flood flow, but would prevent increases in flood flow magnitude. Working in conjunction with the Corp's proposed levee project downstream, the proposed project would provide 100-year flood protection since the 100-year discharge would be expected to remain at 44,400 cfs between the Murphy Road Crossing and the Salsipuedes Creek confluence.

The project would not decrease expected average annual flood damage in the upper watershed. However, the project would prevent increases in average annual flood damages by preventing additional development on the floodplain. The land use would be maintained as primarily agriculture and open space and new development on the Soap Lake floodplain would be minimized or avoided. There would therefore be no additional assets that might be damaged during floods. Additional cost savings are realized since purchasing floodprone property or flood easements eliminates the need for structural flood protection improvements (such as bank stabilization, levees, etc.) that might otherwise be needed to protect these parcels.

Impacts to the environment are very important considerations when planning any project or developing an area. Threatened and endangered species such as the steelhead trout, the California red-legged frog, the tidewater goby, and the western pond turtle must be protected and their habitats preserved. A project like the Soap Lake Preservation Project at a minimum will be in compliance with the Endangered Species Act (ESA) but could go beyond simply complying by providing environmental enhancement opportunities, which would then maximize funding opportunities.

In addition to the ESA and biological environmental impacts, the Clean Water Act must be adhered to as well. For example, the Pajaro River was listed on the 303(d) list as a medium priority site for nutrients and sedimentation and as a low priority site for fecal coliform (impaired length is above Llagas Creek). Llagas Creek is listed for nutrients and sedimentation at a medium priority and for chloride, fecal coliform, low dissolved oxygen, PH, sodium and total dissolved solids at a low priority. San Benito River was listed as a medium priority for sedimentation and low priority for fecal coliform. Hernandez Reservoir is listed as a medium priority for mercury (Central Coast RWQCB 2004). The Soap Lake Floodplain Preservation Project, with careful planning and consideration, could provide the necessary flood protection benefits as well as the needed water quality improvements.

Other benefits of the Soap Lake Floodplain Preservation Project include open space preservation, riparian corridor protection, agricultural preservation, regulatory compliance, and maintenance of groundwater recharge. The open space and agricultural preservation are inherent parts of the proposed project. Also, the proposed project would prevent future encroachment near the riparian corridor. Where possible, some riparian corridors might be enhanced for environmental restoration. Regulatory compliance is possible since both San Benito and Santa Clara counties have language in their General Plans encouraging agricultural and open space preservation and discouraging development with detrimental effects downstream. Flooding of the Soap Lake floodplain will continue to provide percolation into the groundwater and recharging of the aquifer.

Project Extent

The project extent is limited to the area within the Soap Lake 100-year floodplain as shown in Figure 2-23. The portions of partially flooded parcels that are not inundated could also be preserved for benefits other than hydraulic reasons.

Floodplain Preservation Impacts on Resource Areas

Potential impacts to resources were evaluated at a programmatic level in compliance with CEQA. The Initial Study/Negative Declaration identified no significant adverse impacts and no mitigation measures are proposed at this time for the Soap Lake Floodplain Preservation Project. Potential impacts are summarized below. For further information about any of these impacts please refer to the Soap Lake Floodplain Preservation Project Initial Study and Negative Declaration at www.PajaroRiverWatershed.org.

- **Aesthetics** - The project would maintain existing views of agricultural lands and rangeland and would not substantially degrade the existing visual character or quality of the site and its surroundings. There are no designated scenic highways or scenic vistas within the project site.

- **Agriculture Resources** - The proposed project area is comprised almost entirely of agricultural lands and rangeland including Prime Farmland, Unique Farmland, and Farmland of Statewide Importance. Other potential land uses that could be compatible within a floodplain could include environmental restoration (such as riparian or wetland restoration), open space, or trails. Such conversion would place the land in open space use but would not change the ability of the land, in terms of soil or water, to be farmed in the future if needed. If a land purchase or conservation easement included conversion of agricultural land to non-agricultural uses such as environmental restoration, separate environmental documentation would be prepared as needed.

- **Air Quality -** The proposed project does not include any construction activities or any other actions that would generate air pollutant emissions. Since existing land uses would be maintained, air emissions from these uses would continue but would not increase. There are no sensitive receptors (schools, hospitals, etc.) located within the project area.

- **Biological Resources** – Threatened and endangered plant and wildlife species have been identified within the 100-year floodplain, however the proposed project would not directly or through habitat modifications, have an impact on these species. If future land acquisition or conservation easements included any ground disturbing activities or changes in land use that could affect special-status species, such as the creation of a trail or conversion of agricultural land, then additional environmental documentation would be required to assess these impacts and provide mitigation measures. Both San Benito and Santa Clara Counties are in the process of preparing Habitat Conservation Plans. The proposed project is not expected to conflict with these plans, and could perhaps be used to help the counties reach their conservation goals.

- **Cultural Resources** - There are 26 recorded Native American and historic-period cultural sites within the project area of which four sites have been determined eligible for the National Register of Historic Places. There is also the potential for paleontological (fossil) resources. Because the proposed action would not involve any ground-disturbing activities and would preserve the area by minimizing future development, no mitigation measures are recommended at this stage. If a future land acquisition or conservation easement included any changes to the landscape, further archival research and field study by an archeologist or paleontologist would be required. In addition, because of the number of historic buildings and structures (bridges, canals, etc) within the project area, any future land acquisition or easement should not include changes to these features until a qualified architectural historian assesses their historical value.

- **Geology and Soils** - Soils within the project area are rich agricultural soils underlain by alluvium. The project area is within a region of high seismic activity. The San Andreas Fault System is comprised of a series of northwest-trending faults including three active faults near the project site; the Sargent Fault, the San Andreas Fault, and the Calaveras Fault. The project would not have impacts to soils or seismic safety.

- **Hazards and Hazardous Materials** - There is one chemical facility that is located within the project's modeled 100-year floodplain. Trical's Bolsa facility is a fumigant formulation and packaging operation. If the facility is flooded, there could be a potential for hazardous materials to be released if the facility is not flood proofed. The project area is not included on the State's list of hazardous materials sites (Cortese List).

- **Hydrology and Water Quality** - The proposed Project would maintain existing drainage patterns, sedimentation rates, groundwater recharge and flooding conditions and could prevent worse flooding conditions downstream by restricting development in the project area. Access to the rivers and streams for continued maintenance activities would need to be provided for any conservation easements or land purchased along these water bodies.

- **Land Use and Planning** - The proposed project would not conflict with any local land use policies or ordinances. In fact the project would be consistent with the recently adopted agricultural mitigation policy by the City of Gilroy. That policy identifies portions of unincorporated Santa Clara County as their preferred location for agricultural mitigation, which includes a portion of the proposed Soap Lake project area.

- **Mineral Resources** - The majority of the project site appears to have not been classified for mineral resources. The proposed project would preclude development in the area, which would help preserve access to any mineral resources that may be located there.

- **Noise** - The proposed project would not change existing noise levels, would not result in any temporary or permanent increase in noise levels, or create any noise impacts in excess of established standards within the County Noise Ordinance. No sensitive noise receptors (schools, hospitals, etc) are located within the project area.

- **Population and Housing** - Since project implementation would reduce future development within the project area, this could indirectly contribute to development in other adjacent areas. If this development occurred within city boundaries, this would be consistent with Santa Clara County policies to develop incorporated areas rather than unincorporated areas.

- **Public Services** - Because the project would limit further development within the floodplain, it could decrease the burden on flood emergency services to repair or replace flood-damaged facilities that could otherwise be located there.

- **Recreation** - If conservation easements are obtained that include trail easements, there could be a beneficial impact by providing additional recreational opportunities. There are five proposed trail routes throughout the project area. Inclusion of trails in such easements would be consistent with county policies encouraging trail development but would need to be designed to avoid conflicts with other resources.

- **Transportation/Traffic** - The proposed project would not increase traffic, change levels of service, or disrupt transportation and circulation patterns. Roads, highways, bridges, and railroads would continue to be located within the floodplain and inundated during flood events. Roadways and highways that are flooded can restrict or block access for landowners, commercial traffic and emergency vehicles. This would continue to be an impact under the proposed project and existing conditions; however this risk would not be increased due to the project. Several transportation improvement projects have been completed or are proposed within the project area and some of these projects will raise the roadways due to floodplain conditions. The 100-year floodplain does cross a small portion of the Frazier Lake Airpark. However the runway and most areas of the airpark are not within the floodplain and the proposed Project would not interfere with any airport operations

- **Utilities and Service Systems** - A 96-inch underground water supply pipeline, the Santa Clara Conduit, provides water from the Central Valley Project to the Santa Clara Valley Water District and crosses the project area south of San Felipe Lake. Access points for the SCVWD to repair and maintain the pipeline are also within the project area. There is a risk to county water supply when the area is flooded and the district is unable to repair /maintain the pipeline. Also, the 100-year floodplain crosses an area proposed for the future expansion of the Gilroy Wastewater Treatment plant.

Land Acquisition Needs Assessment

The Soap Lake Floodplain Preservation Project consists, for the most part, of acquiring and preserving land. Before the land can be acquired and preserved though there needs to be an implementation strategy and an understanding of the project cost. A preliminary assessment of implementation strategies and project cost has been completed as part of Phase 3 and 4a. The following sections highlight the conclusion of this analysis.

IMPLEMENTATION STRATEGY

Two major parts of an implementation strategy were explored as part of this phase of work: determining the priority parcels for purchase and determining who the lead purchase agency should be.

Parcel Prioritization

A prerequisite in parcel acquisition is to have a willing seller. Should more than one parcel be available at a time though, parcel purchase priority is influenced by many factors. These include:

- **Flooding frequency**: The more frequently an area of land is flooded, the more frequently that area of land stores water and attenuates peak flows. Development in these areas would provide a pathway through the Soap Lake area that would not provide any storage or attenuation benefits.
- **Proximity to developed areas**: Large scale development generally takes place next to or near other development since necessary infrastructure, such as roads, water, sewer, and electricity, is already in place. Developing further away increases the costs since extensions to that infrastructure would be necessary.
- **Proximity to preserved areas**: Preserving parcels next to or near already preserved or acquired parcels provides additional benefits. Wildlife benefits from larger expanses of undeveloped land rather than smaller pockets or islands of habitat. Also, a larger or longer preserved area is more difficult for development to bypass or expand behind due to the costs of the extra infrastructure.
- **Other benefits and considerations**: Other benefits and considerations include things such as trails and wetlands. Providing regional trails and connectors through the Soap Lake floodplain is in accordance with the Santa Clara County and San Benito County general plans and is not contrary to the goal of the Soap Lake Floodplain Preservation Project. Recreation and alternative transportation opportunities, such as biking, provide additional benefit to the public and bring extra value to the project. Wetlands provide natural water treatment and could also enrich the biological diversity of the area. Another consideration would be meeting the goals of other land use policies such as the Gilroy Agricultural Mitigation Policy so long as those policies were in accordance with the goals of the Soap Lake Floodplain Preservation Project.

Lead Purchase Agency

The Authority is not the only body that should be considered as a potential owner of Soap Lake parcels. Other agencies such as counties, water districts, and private organizations are all currently easement and title holders of Soap Lake parcels and could all be owners of additional land or holders of easements. The different strengths and weaknesses of each agency or organization could make it more or less appropriate for a given purchase. There may also be more interest in particular parcels by particular agencies. Therefore it is important to reevaluate the most appropriate easement or title purchasing organization or agency for each purchase on a case-by-case basis.

When the Authority is not deemed to be the most suitable owner for a parcel, there are ways in which the Authority can maintain some degree of control over the easement language. For example, the Authority may be able to assist in obtaining funding for the purchase and/or maintenance costs of the parcel. If a grant is being pursued, the Authority could use its multi-agency, cooperative entity status and be a partner on the application or write letters of support for a grant applicant. In return, the Authority could request certain language be included in the easement or purchase contract or request some oversight in the management of the land.

COST

The cost of the Soap Lake Floodplain Preservation Project, since there is no actual construction, is limited to land acquisition cost and related preservation activities. An initial estimate to purchase the floodplains at the 2-, 10-, 25-, 50-, and 100-year event levels has been calculated based on unit cost per acre. The two primary acquisition methods are fee title purchase and flood/conservation easements and their unit costs are estimated to be $12,000/acre and $5,000/acre respectively. No analysis has been performed regarding which method might be more appropriate or applicable for any given piece of property. The acquisition cost was calculated for just the area of the floodplain and also for complete purchase of the entire impacted parcel, including the area outside of the floodplain. Table 3-1 summarizes the purchase price of the combinations of these two options for the 100-year floodplain.

Table 3-1: Purchase costs of 100-year floodplain.

100-Year Floodplain	Fee Title Purchase	Easement Purchase
Limited to flooding extent	$109 million	$45 million
Whole parcel	$175 million	$73 million

It is anticipated that the actual cost of the floodplain will be between the whole parcel fee title purchase cost ($175 million) and the easement purchases limited to the extent of the flooding ($45 million) since these two values are extremes. It is expected that the actual purchase pattern of the floodplain will include both easements and fee title purchases. It is also likely that some of the parcels at the fringe of the floodplain will be purchased in entirety while others will be divided. It should also be noted that land purchased in large tracts is generally available at a lower cost per acre. These discounts could also lower the total price.

Projects that provide multiple benefits maximize the opportunities for partnering and cost sharing. For example, the Soap Lake Preservation Project could satisfy mitigation requirements for the Corps Lower Pajaro River Project, thereby creating an opportunity to partner with the Corps and potentially receive federal funds. The Soap Lake preservation project, if developed to protect the natural flood attenuation characteristics as well as provide open space or habitat protection, could create opportunities for partnering with public and private resource agencies like Santa Clara County Open Space Authority, The Nature Conservancy, the Land Trust of Santa Clara County, California Department of Fish and Game, US Fish and Wildlife Services, and others. Any opportunity to partner with other agencies or organization maximizes the opportunities for cost sharing.

Conclusions and Recommendations

CHAPTER 4

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

The primary objectives of Phase 3 of the Pajaro River Watershed Study were to:

- Delineate the Soap Lake floodplain
- Evaluate alternatives for preserving the Soap Lake foodplain
- Complete the CEQA documentation for the preservation alternatives
- Identify land acquisition needs
- Enhance stakeholder outreach activities
- Integrate and coordinate with other watershed studies.

Conclusions and recommendations for each of these objectives are described below.

Floodplain Delineation

In Phase 3, the Authority delineated and documented the Soap Lake floodplain. To delineate the floodplain, a hydraulic model was created and applied to create floodplain maps for five different event magnitudes. The 2-year floodplain generally follows the water features closely. The floodplain is only about 750 acres. The 10-year floodplain is significantly larger and extends about 5,500 acres. The incremental difference in the 25-, 50- and 100-year floodplains is relatively small in comparison with the 100-year floodplain reaching over 9,000 acres. Table 4-1 shows each of these flood events and the corresponding acreage.

Table 4-1: Floodplain areas of the 2-, 10-, 25-, 50-, and 100-year flood events.

Event	Floodplain Area
2-Year	740
10-Year	5,480
25-Year	7,320
50-Year	8,450
100-Year	9,110

Facilities such as bridges, roads, and railroads within the floodplain were identified. These facilities would continue to be affected during flood events. Projected flood damages to existing facilities would therefore be maintained by this project. However since new development would be limited under the project, damage to new facilities would be limited.

Methods to Preserve the Soap Lake Floodplain

Potential methods to preserve the floodplain and maintain current levels of Soap Lake flood attenuation were explored and analyzed. The recommended alternative is land acquisition through fee title purchase or flood conservation easements. This method was selected because of the multiple benefits (agricultural and open space conservation, potential restoration benefits, and public acceptance) and permanence. A number of other methods could also be applied in the short term or in combination with land acquisition. These other alternatives include zoning and General Plan land use designation changes and enforcement, floodplain management ordinances, incentive programs, and mitigation banking. Maintaining the flood attenuation capability of Soap Lake can be achieved through other methods as well. The Soap Lake Floodplain Preservation Project does not include these alternate methods but does not preclude them either.

CEQA Documentation

Programmatic CEQA documentation for the Soap Lake Floodplain Preservation Project has been completed. CEQA "applies to projects proposed to be undertaken or requiring approval by State and local government agencies."[4] An initial study and negative declaration (IS/ND) was prepared documenting that there were no significant environmental impacts from the proposed project and no mitigation measures were proposed at this time. The IS/ND was circulated for public review and comment, and will be finalized in early 2005. In addition to placing notices in 4 newspapers and hosting a public meeting for the Project, a notice of availability of the IS/ND was mailed to over 300 agencies, individuals and organizations.

Many of the letters and comments received stated their support for the project and understand the importance of Soap Lake. At the time of this report the public comment period has closed with no comments of opposition. Several letters also requested that more specific information be included on how the Soap Lake Floodplain Preservation Project will be implemented and who will be responsible for it. These questions form the basis of some of the goals of the next phase of the Pajaro River Watershed Study.

Land Acquisition Needs

The Soap Lake Floodplain Preservation Project consists, for the most part, of acquiring and preserving land. There are three areas of land acquisition need that were explored generally in this phase of work:

- A strategy for land acquisition
- Identifying the most suitable buyer of land
- Estimating the cost of the parcel acquisitions

Prioritizing parcels for purchase involves balancing a number of different factors including flooding frequency, proximity to existing development, proximity to other preserved areas of land, and any other considerations such as proposed regional trails or wetlands. The most suitable land buyer will likely be determined on a case-by-case basis since different groups will have different priorities for parcel acquisition and different funding options and timelines. The envelope of floodplain costs is between about $45 million and $175 million though it is likely that the actual cost will be at the lower end of the estimate.

Stakeholder Consensus

Stakeholder consensus has been a key part of the success of the Pajaro River Watershed Study. Members, associate members, and interested groups have been consulted or have been involved in all decisions and the direction of the study. The public is invited to attend and take part in the Authority Board meetings. Special presentations have also been made to groups interested in learning more about the Authority's work.

[4] http://ceres.ca.gov/topic/env_law/ceqa/summary.html. November, 2004.

To increase the visibility of the Authority and facilitate distribution of information, a website has been developed. The site, www.PajaroRiverWatershed.org, provides an overview of the Authority structure and purpose and a centralized location for document downloads and public and contact information. This website is considered to be dynamic as it is able to develop and change as additional information and studies are developed.

Keeping the key stakeholders involved must be considered a priority of the Authority. Coordination among the agencies and organizations make the recommendations, work products, and actions of the Authority more significant and meaningful. Consensus will ultimately lead to better fulfillment of the Authority's mission of flood protection on a watershed basis.

Coordination with Other Studies

The Authority is in a prominent position to play a significant role in watershed activities. The most immediate opportunity is to continue supporting the Lower Pajaro River Project by maintaining flood levels. Implementing the Soap Lake Floodplain Preservation Project will continue to make the Lower Pajaro River Project feasible and allow the levees and floodwalls to contain the 100-year flood as they are designed to do. Depending on Corps of Engineers restrictions and timing of the work, there is also the possibility of leveraging the work performed and funds allocated for the Pajaro River Watershed Study as part of a Corps sponsored watershed study. The Corps watershed study would help to satisfy State and Federal regulatory and resource agencies' concerns about environmental impacts of the Lower Pajaro River Project. Should the Corps not be able to accept the Study work products and funds as a local match, the Authority should examine other ways to act as the local sponsor to the Corps watershed study.

Looking Forward

CHAPTER 5

CHAPTER 5

LOOKING FORWARD

Phase 3 of the Pajaro River Watershed Study defined the Soap Lake Floodplain Preservation Project alternatives. Phase 4 of the Study will include the following four tasks that contribute to or support flood protection for the Pajaro River Watershed:

- Develop the Soap Lake Floodplain Preservation Project Implementation Plan
- Create three Sediment Models
- Improve Flood Forecasting Capabilities
- Perform a Fisheries Study of San Felipe Lake

Soap Lake Floodplain Preservation Project Implementation Plan

The implementation plan for the Soap Lake Floodplain Preservation Project will define a recommended land acquisition strategy and will include the following elements:

- Land acquisition strategy: Identify purchase priority for parcels within the floodplain and which acquisition method is better suited for an area or condition.
- Refined cost estimate: Estimate land values for purchase and conservation easements.
- Standard conservation easement provisions: Develop standard flood easement provisions as a guide for future acquisitions.
- Land acquisition and management program administration recommendation: Develop a recommended strategy identifying what agency or organization could implement the program and if there will be lead roles and secondary roles.
- Agricultural mitigation bank guidelines: Develop guidelines for an agricultural mitigation banking program.
- Funding opportunities: Identify local, state and federal funding opportunities for the Soap Lake Floodplain Preservation Project.
- Recommendations for each county and water district: Develop list of recommendations for each member agency regarding the implementation of the Project.

Sediment Modeling

Three models will be created to better understand sediment transport and deposition in the Pajaro and San Benito Rivers.

- Sediment trap in the Pajaro River: Determine how feasible it would be to remove sediment from the river upstream of Watsonville.
- Two-dimensional model of benches in the Pajaro River: Determine the amount of deposition on the benches of the Lower Pajaro River.
- Sediment transport model for the San Benito River: Create a model that can be used to describe how sediment moves down the San Benito River.

Flood forecasting

There are four important aspects of flood forecasting that will be included in Phase 4.

- Rating Curve of Flow Gage of San Benito River at Highway 156: Evaluate current condition of the gage and provide recommendations as appropriate.
- Automated Local Evaluation in Real Time Gages: Evaluate existing ALERT stations and make recommendations for additional stations if necessary.
- Streamflow Time of Travel: Create time of travel curves for the Upper Pajaro River watershed.
- Pacheco Creek Streamflow Gage: Evaluate condition of the existing streamflow gage and make recommendations for rehabilitation, if necessary.

Fisheries Study of San Felipe Lake

A preliminary fisheries study of San Felipe Lake is necessary to document existing habitat conditions and species. This will help to provide some background information for future studies. Information that will be collected includes:

- Occurance of existing fish species, including size and class distribution.
- Limnological data appropriate to assess the status and quality of the lake's aquatic habitat.
- Temperature measurement at San Felipe Lake inlet and outlet.

Appendices

RMC

Pajaro River Watershed Flood Prevention Authority

APPENDICES

The following pages contain the technical memoranda prepared to support and document the work performed for Phase 3 and 4a of the Pajaro River Watershed Study. The TMs include:

- TM 3.3 and 3.4: Project Hydraulics and Operating Strategy; Floodplain Boundaries Mapping
- TM 3.5: Impacted Facilities Assessment
- TM 3.6: Land Acquisition Needs Assessment
- TM 3.7: Cost Estimating
- Value of Soap Lake

Pajaro River Watershed Flood Prevention Authority

PAJARO RIVER WATERSHED
FLOOD PREVENTION AUTHORITY
Phase 3: Conceptual Design of Soap Lake Preservation Project
Phase 4a: Design Level Mapping Technical Support

RMC
Raines, Melton & Carella, Inc.

Technical Memorandum Nos. 3.3 and 3.4

Task: **Project Hydraulics and Operating Strategy**
Floodplain Boundaries Mapping

To: **PRWFPA Staff Working Group**

Prepared by: **Tim Harrison**

Reviewed by: **Jeff Lewandowski**

Date: **August 18, 2004**

Reference: **0053-003.3, 0053-003.4**

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Introduction

This technical memorandum (TM) describes the work completed and the results obtained for Task 3.3 and 3.4: Project Hydraulics and Operating Strategy and Floodplain Boundaries Mapping of the Pajaro River Watershed Study. Discussion is provided regarding the location and characteristics of a large floodplain known as Soap Lake, located along the Pajaro River upstream of the confluence with the San Benito River. Comparisons are made between the floodplain model created for Task 3.3 and existing hydraulic models in order to highlight strengths and weaknesses of the floodplain model. The model inputs and floodplain delineation methodologies are discussed. The TM concludes with observations about the potential uses and limitations of the model as well as observations regarding the floodplains.

Phase 3 of the Pajaro River Watershed Study (Study) is a continuation of the Pajaro River Watershed Flood Prevention Authority's (Authority) efforts to provide flood protection to areas below the confluence of the Pajaro and San Benito rivers. Phase 1 of the Study consisted of hydrologic, hydraulic, and sediment modeling of the entire watershed. Model results of the 2-, 10-, 25-, 50-, and 100-year flows at critical locations on the Pajaro River were developed. Phase 2 of the Study consisted of developing flood protection alternatives and project packages to manage the modeled 100-year flows.

One of the most significant conclusions coming out of both Phase 1 and Phase 2 was the importance of the Soap Lake floodplain to the Pajaro Valley flood protection solution. Soap Lake, located along the Pajaro River between San Felipe Lake and upstream of Hwy 101, currently detains storm water flows from the Upper Pajaro River watershed upstream of the Pajaro River confluence with the San Benito River. Loss of this natural detention would increase the magnitude of flooding downstream of the confluence. Figure 1 shows the entire watershed highlighting the Upper Pajaro and San Benito subwatersheds as well as the location of Soap Lake.

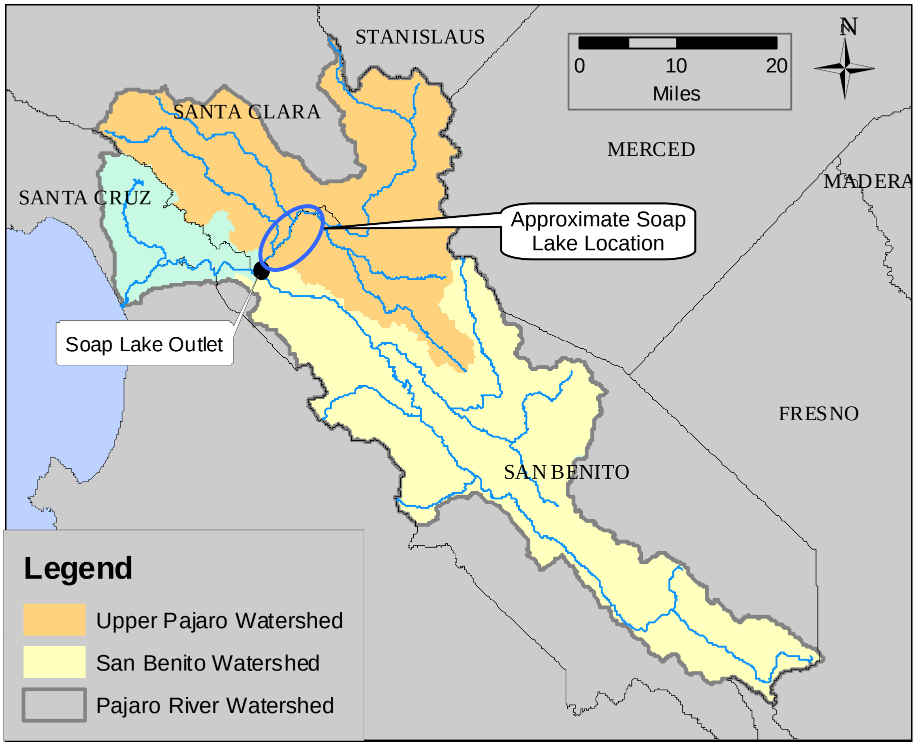


Figure 1: Upper Pajaro and San Benito subwatersheds.

Soap Lake

Soap Lake is a natural detention basin, storing water and reducing peak flows that would otherwise increase flooding in the lower Pajaro River. Upper Soap Lake is also known as San Felipe Lake and is a permanent body of water. The Soap Lake floodplain lies along the Pajaro River within San Benito and Santa Clara Counties between upstream of San Felipe Lake and the Highway 101 crossing (Figure 2). The main land use is agriculture including row crops and pasture land. During significant rain events, the low-lying areas of the Soap Lake area become flooded and there is flow backup on the Pajaro River upstream of the San Benito River. Soap Lake disappears as the floodwaters recede and low-lying areas are drained.

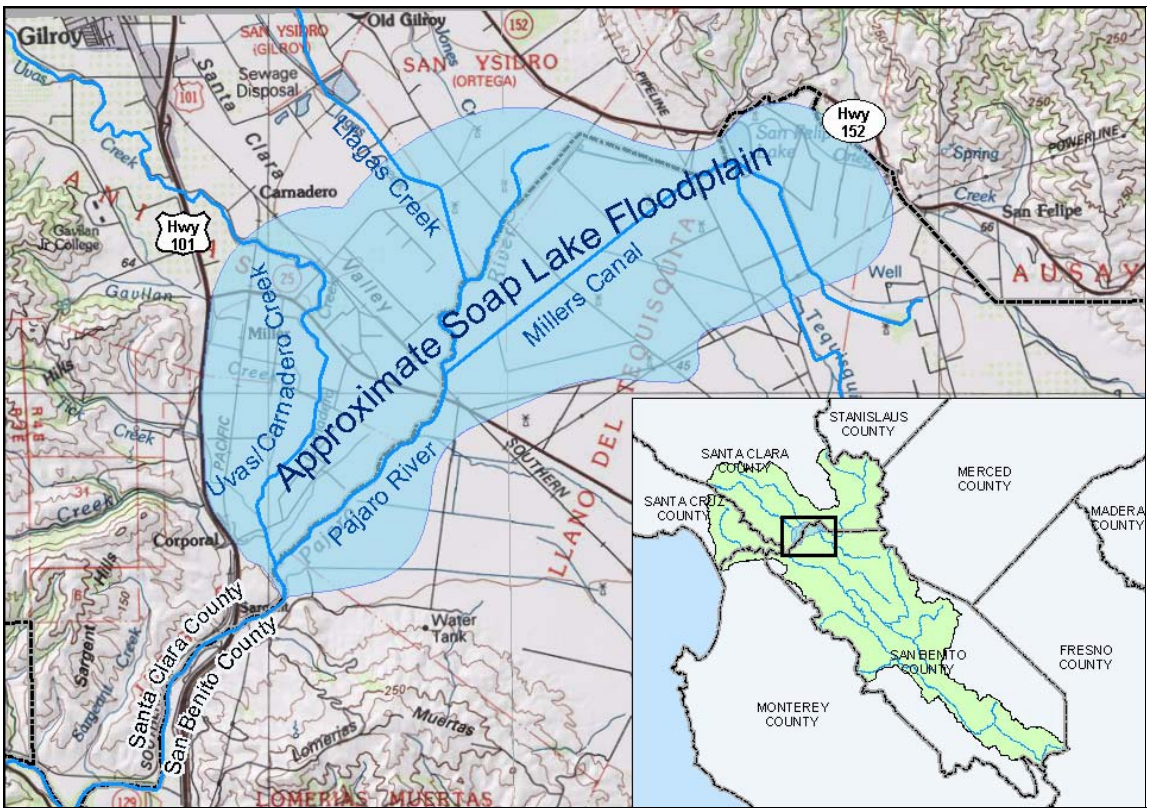


Figure 2: Soap Lake floodplain area. The floodplain area is roughly the same as the FEMA approximate 100-year floodplain in this area.

Importance of Soap Lake

Soap Lake can be considered a very important flood management feature for downstream areas in the Pajaro River watershed. HEC-1 modeling shows that the flood storage within Soap Lake leads to a significant decrease in downstream peak flows. As can be seen in Table 1, attenuation in Soap Lake increases with event magnitude.

Table 1: Peak flows at Chittenden stream gage (Lat 36°54'01", Long 121°35'48") with and without Soap Lake attenuation.

Return Period (Yrs)	Flow with Soap Lake(cfs)	Flow without Soap Lake (cfs)	Peak Increase (cfs)
2	3,600	3,600	0
10	16,900	19,500	2,600
25	28,700	35,300	6,600
50	38,600	50,300	11,700
100	45,200	60,500	15,300
200	60,500	82,400	21,900

Figure 3 shows the data of the above table in a graphical format. One of the details that becomes apparent is the reduction in level of protection for the downstream areas if Soap Lake attenuation is removed. Existing or future flood protection projects assume that current storage levels are available. The 100-year flood flow at Chittenden is currently believed to be about 45,000 cfs. Without the Soap Lake storage and attenuation, a 45,000 cfs flood flow would occur about every 37 years, instead of every 100 years.

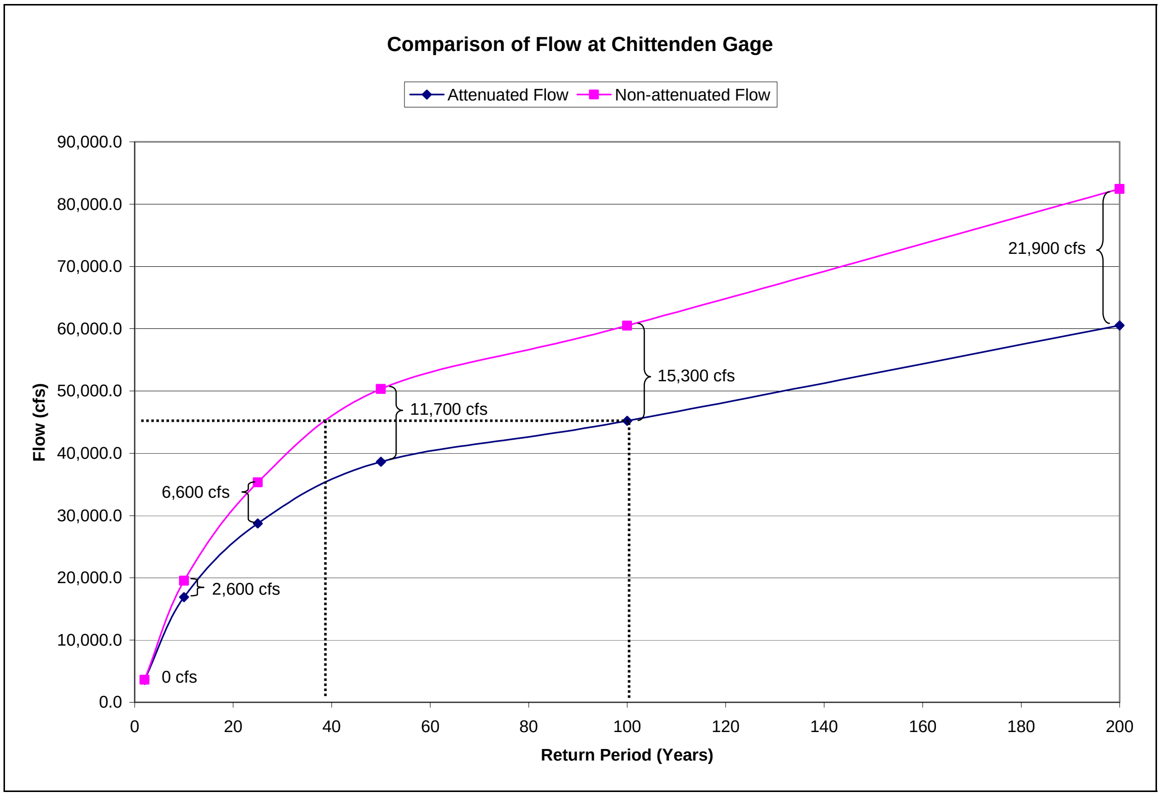


Figure 3: Effects of attenuation in Soap Lake on peak flows at Chittenden Gage.

Hydrographs for the 2-, 10-, 25-, 50-, 100-, and 200-year events can be found in Appendix A. These were generated using the HEC-1 models created for Phase 1 of the Study. The no attenuation scenario was created by removing the card that modeled Soap Lake storage. The HEC-1 models are described more fully later in this TM.

Natural Soap Lake Floodplain Storage Volume

A stage-storage curve was developed for the lower elevations of the Soap Lake study area to determine floodplain storage volume. In previous studies, Soap Lake was assumed to function like a reservoir. The updated topography was used to determine total available storage for comparison with previous study assumptions.

Methodology

The Soap Lake surface elevations were input into a GIS system that utilized the topographic data developed as part of Task 3.2 of Phase 3 of the Study. The GIS system allows the user to input a surface elevation which defines the level of a horizontal plane across and to the limit of the topographic data set. The GIS software will then calculate the 2- and 3-dimensional area and volume above and below that plane. For this stage storage elevation application, the volume underneath the plane and above the ground surface was calculated. The vertical datum of the elevation dataset is NAVD 88. The storage values are shown on Figure 4.

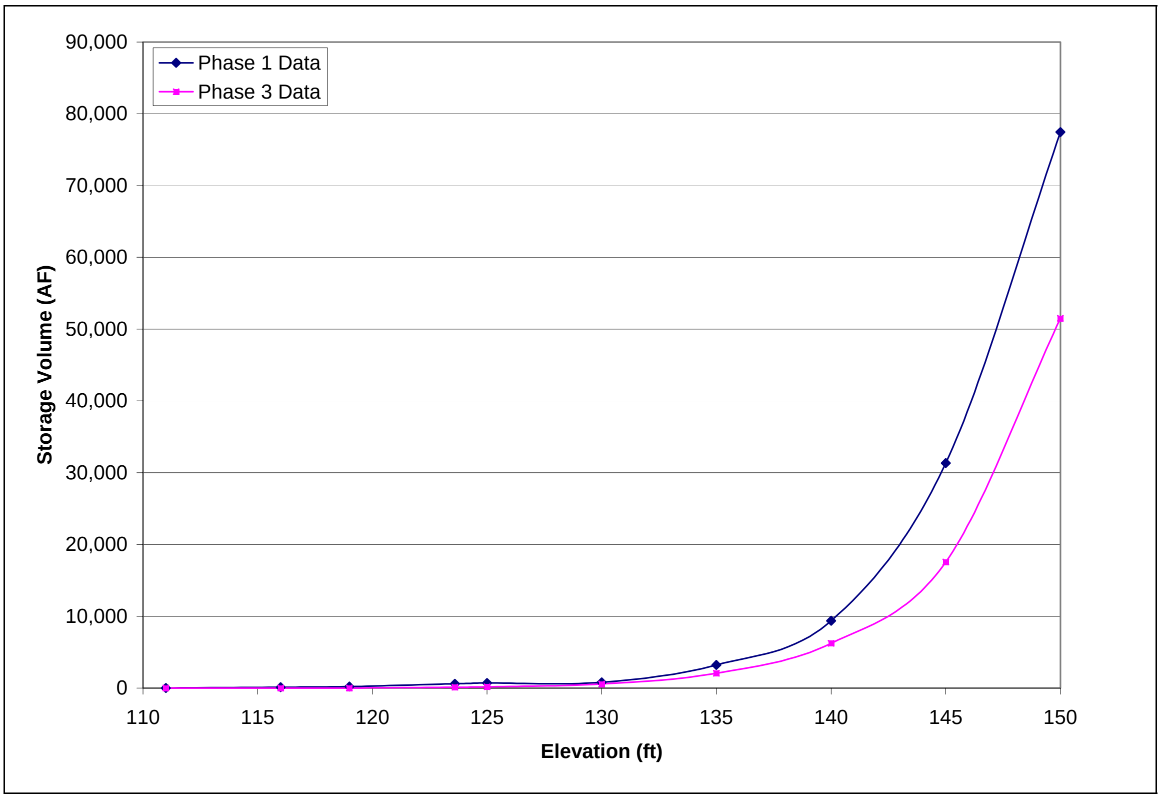


Figure 4: Stage storage curves for Phases 1 and 3 of the Study.

Discussion

The stage-storage curve developed for this study, shown in Figure 4, was developed using two different ground surface elevation datasets. The primary dataset, with a node density high enough to create 2-foot contours accurately, was the original dataset. Based on the model results though, it was apparent that the original floodplain extent was underestimated. The secondary dataset, with a node density high enough to create 10-foot contours, was obtained to reduce the floodplain overflow. The higher resolution data was not available for the extended area to the east and southeast of the original dataset. No additional data was available to the north where the limiting elevation is approximately El. 145 feet. The storage volumes were calculated for each elevation for both datasets and were summed to give a total storage volume.

One limitation of the volume calculation method is the extent of the upper bounding plane established by the user. The software assumes that it goes to the edge of the topographic data set. Because of this, if there are low points outside of the main channel there may be more storage volume calculated than would actually be available during a flooding event. Due to the topography of Soap Lake however, it is unlikely that this calculation method and assumption would create a significant error. The elevation generally increases with distance from the streambeds and there would be only minor channels or low points included in the volume calculation for a given flooding event. With the above considerations in mind, the stage storage elevations calculated for this task are good approximations.

As can be seen in Figure 4, there is a difference in the storage volumes used for Soap Lake in the Phase 1 HEC-1 model and the storage volumes established from the recent topography. The storage calculated for the recent topography is limited to the outlined study area. As can be seen in Table 2, the Phase 1 storage model starts at a lower elevation than the Phase 3 storage calculations. The lowest point in the Phase 1 model is between El. 111 ft. and 116 ft. and the lowest point in the Phase 3 dataset is ~ El. 117 ft. This indicates that the Phase 1 storage curve includes areas downstream of the Phase 3 study area. Future studies, potentially such as refined hydrologic modeling of the Pajaro River watershed, should use the stage-storage curves developed for the Study based on the quality of the source data and the additional information available regarding its development and coverage area.

Table 2: Elevations and storage volumes from different phases of work.

Elevation (ft)	Storage Volume (AF) Phase 1	Storage Volume (AF) Phase 3*
111	0	0
116	100	0
119	200	3
123.6	600	109
125	700	165
130	783	562
135	3,198	2,040
140	9,367	6,205
145**	31,344	17,560
150	77,461	51,507

*The storage volumes and elevations are samples. The dataset is not limited to these elevations.
**Approximate elevation at which geographic dataset becomes slightly restrictive.

The approximately 40,000 AF of storage previously identified in Phases 1 and 2 assumes a peak water surface elevation of 144.3 ft. It accounts for the storage described by Figure 4 and storage in the upstream floodplains.

Soap Lake Hydraulic Model

Overview

The Soap Lake hydraulic model utilizes HEC-RAS to outline the floodplains for the 2-, 10-, 25-, 50-, and 100-year flood events. These floodplain maps can then be used to determine the portions of the study area under future conditions most critical for preventing increased downstream flows. These floodplain maps are not intended to represent or replace the FEMA flood maps. They are instead a representation of potential future flood conditions and locations to be used for this study's planning purposes.

The model utilizes results from the Phase 1 hydrologic model with general plan buildout conditions. This scenario was created in Phase 1 by incorporating future land use conditions from the General Plans of every county and major city within the watershed. The design rain storm was applied to the modeled surface. The resulting flood hydrograph represents the general plan buildout conditions. Flows are modified in certain locations to better convert the general Phase 1 flows to meet topographical conditions.

Geographical inputs to the model are generated through a GIS interface with the topographic and imagery data developed in Phase 3 Task 2 of the Study. Streams and cross sections, among other features, are created in a GIS environment and translated into an ASCII format that HEC-RAS can import.

HEC-RAS combines the flow and geography models using one-dimensional steady and unsteady flow calculations to determine water surface elevations within the modeled cross sections. Modeled cross sections are limited to between San Felipe Lake and upstream of Highway 101. The floodplain due to Soap Lake may extend upstream of San Felipe Lake due to backwater effects but it was not hydraulically modeled. The Soap Lake hydraulic model utilizes the steady flow module to determine the water surface elevations. Input flow is constant and the water surface elevation is assumed to be constant across the cross section. Any land points with an elevation below this water surface elevation are assumed to be submerged. The Soap Lake hydraulic model takes advantage of certain techniques to limit flooding within reasonable boundaries. These techniques are described below. Model results can then be exported back to an ASCII format for use in post-processing of the floodplains.

Comparison to Existing Studies

Two previous model sets were examined when considering and developing the Soap Lake hydraulic model for Phase 3 of the Study. The hydrologic models (HEC-1) of Phase 1 provided the basis for the input flows and FEMA models were to have provided a comparison point for the current work.

Phase 1 Hydrologic Models

The Soap Lake hydraulic model uses peak flows and water surface elevations from the Phase 1 hydrologic models as inputs and boundary conditions for steady-state analysis. The Phase 3 work is therefore very dependent on the HEC-1 models. The results of the Phase 3 models are likewise impacted by the initial purpose and goals of the Phase 1 models and the methodology used to achieve those goals.

The goal of Phase 1 of the Study was to create a hydraulic model that could simulate flood flows at four key points in the watershed for four scenarios. The extent of the HEC-1 hydrologic model created as an input to this limited hydraulic model covered the entire watershed. Using methods described in the Phase 1 Report and TMs, the HEC-1 model was built to represent large-scale, general watershed conditions. To achieve the Phase 1 goals, calibration was only required for the four critical points. As a result, flow modeled for individual subwatersheds was not calibrated and is therefore not necessarily the best possible estimate for flow from that subwatershed. However, the combination of the subwatershed hydrographs does represent flows measured at gage stations at the four critical locations.

As mentioned above, the Soap Lake hydraulic model utilizes the Phase 1 hydrologic model as an input. None of the four calibrated points of the Phase 1 model is upstream of or is within the Soap Lake study area. The flows taken from the HEC-1 model may be quite different from other available models for the Soap Lake tributaries. These other models were not used as inputs for reasons described in a later section of this TM.

FEMA Models

As can be seen in Figure 5, the Soap Lake study area is mostly within an approximated FEMA 100-year floodplain. There are FEMA detailed study areas on Uvas/Carnadero and Llagas Creeks. RMC contacted a FEMA distribution agency to obtain the current detailed models to verify the flooding conditions shown on the Flood Insurance Rate Maps. No computer models were available for the Pajaro River and its tributaries in the Soap Lake study vicinity. One was available for the Pajaro River downstream of the study area and was not applicable to this study. Models were also obtained from Santa Clara Valley Water District but none were applicable to this study due to location, topographical changes since the model was created, and timeframe of the modeled conditions.

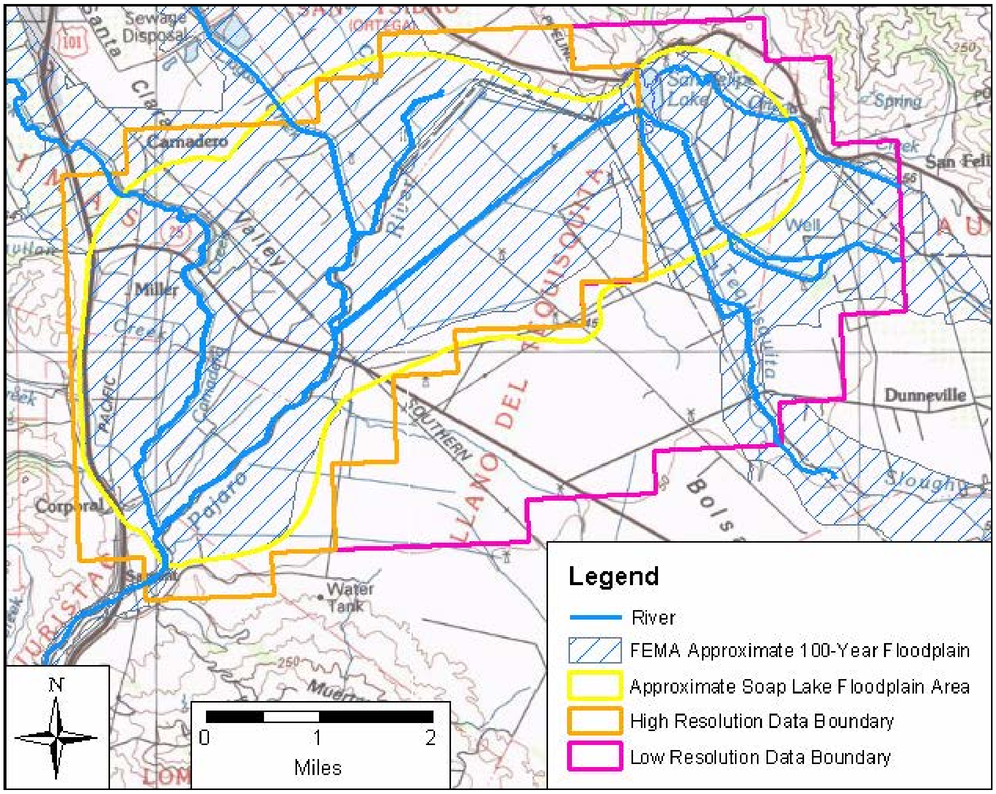


Figure 5: Relative locations between the FEMA 100-year floodplain, the Soap Lake floodplain area and the Soap Lake data boundaries.

A comparison between the Phase 1 project hydrology for existing conditions and the FEMA models was made based on the model print-out that was available for Uvas/Caradero Creek. Figure 6 shows the locational relationship between the FEMA model, the Phase 1 subwatersheds, and the Soap Lake study area of Phase 3. The FEMA model is close to the subwatershed border between a Uvas/Carnadero Creek and Llagas Creek subwatershed. The Uvas/Carnadero Creek subwatershed (UV2) is the better comparison though since it represents the appropriate creek. Since the HEC-1 from Phase 1 of the Study and HEC-2 from FEMA are different types of models, they utilize different types of data. Overlap includes flow and Manning's n roughness values. Table 3 summarizes these two sets of data from each model.

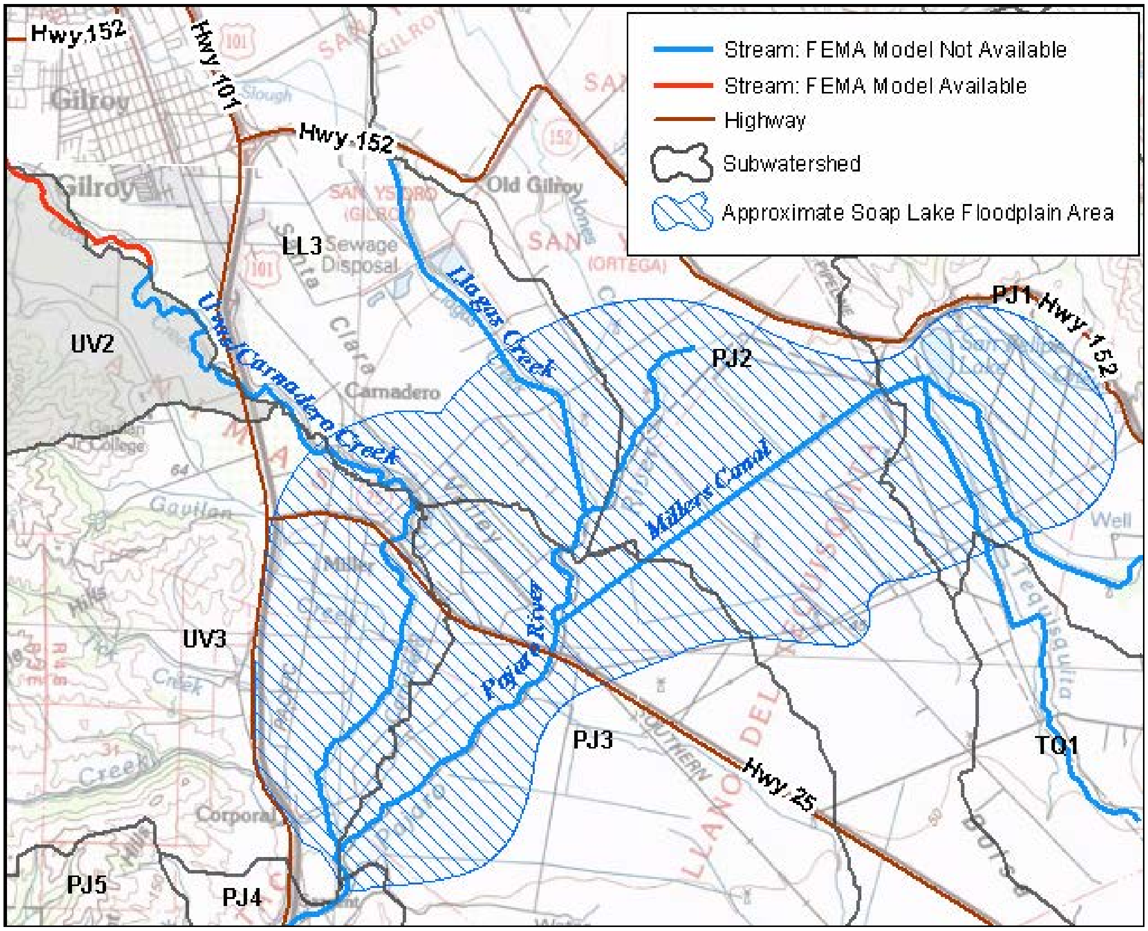


Figure 6: Spatial relationship between the FEMA model, Phase 1 hydrologic subwatersheds, and Phase 3 study area. Subwatershed UV2 best represents a similar area to the available FEMA model.

Table 3: Summary of flow and roughness data from the model for the Uvas Creek FEMA model and the corresponding Phase 1 subwatershed. Values are rounded to facilitate comparison. FEMA flows are given for the last cross section in the model. Shown FEMA roughness values are length-weighted averages.

		Flow (1,000 cfs)							Roughness (n)		
	Return Period (Years)	2	10	25	50	100	200	500	LOB*	Channel	ROB*
Model Unit	FEMA		5.58		11.7	14.0		19.7	0.031	0.036	0.031
	UV2	0.7	3.7	5.4	7.6	9.1	12.0		0.07	0.07	0.07

*LOB and ROB stand for left overbank and right overbank, respectively.

There are several possible explanations for the discrepancies between the two models. Based on Figure 6 above, it is clear that the downstream side of the FEMA model and the catch point for the UV2 subwatershed are not nearly in the same location. There are many opportunities for loss of flow and overland attenuation. As can be seen in Figure 7, a significant portion of the 100-year flow referenced in Table 3 has been diverted away from the channel and attenuated or lost. The 8,000 cfs shown in the figure is much closer to the value used in the HEC-RAS Soap Lake model.

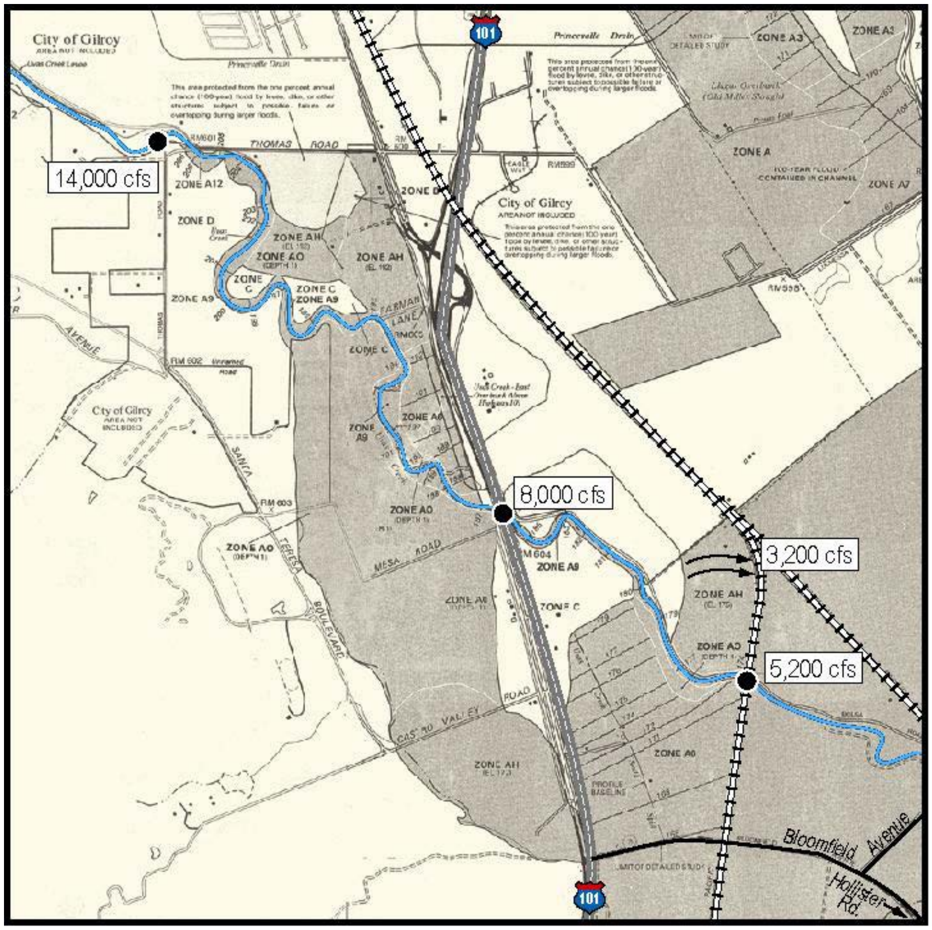


Figure 7: FEMA Flood Insurance Study 100-year flow values and locations on a FEMA Flood Insurance Rate Map.

The scale of the two models is also quite different. The FEMA HEC-2 model is used to determine water surface elevations, velocities and flooding extents. The model represents an area that is about four miles long and the widest cross section is only 2,700 feet wide. Most of the other cross sections are much narrower. Subwatershed UV2 has an area of about 41 square miles, or is approximately 20 times as large as the FEMA model, and is part of a larger model of about 1,300 square miles, approximately 640 times as large as the FEMA model. The HEC-2 model is also limited to the channel and left and right overbanks of the modeled reach. It is therefore possible to better match land use and ground cover with a specific roughness coefficient. The Phase 1 model, using HEC-1, must represent the entire subwatershed with a single roughness coefficient. This roughness coefficient must consider not only the channel and overbanks, but the largely rural and wooded uplands found in the subwatershed. In summary, the larger model has generalized flows and makes broader assumptions than the smaller model. Based on the purpose and scale of the Phase 1 model, it is unlikely that the HEC-1 model flows and roughness coefficients would match the HEC-2 model inputs.

Hydraulic Model Inputs

There are two primary types of information necessary for HEC-RAS to function: flow data and geographical data. Flow data includes the selected flow rate from the HEC-1 hydrograph and the boundary conditions for the model. Geographical data includes the delineation of the streams, banks, levees, bridges, ineffective flow areas, cross sections, and nearly any other physical feature or arrangement of features that would impact flow speed or direction. Connectivity between the reaches is also included in the geographical model.

Flow Model

This section of the TM summarizes the development of flows for HEC-RAS modeling of the Soap Lake study area. The flows are obtained from the HEC-1 analyses from the Phase 1 work. The General Plan Buildout hydrologic models are used to determine the flow rates. The next two sections describe which hydrograph was used and which value within that hydrograph was chosen as an input into the HEC-RAS model.

Hydrograph Sources for HEC-RAS Modeling

Each of the model reaches shown on Figure 8 are assigned a flow based on HEC-1 model results. The HEC-1 model results include hydrographs at junctions and hydrograph routing in channel reaches. The hydrographs or combinations of hydrographs used for each reach are listed below. Hydrograph identifiers are given in parentheses.

- Millers Canal and Upper Pajaro River – Combined HEC-1 flows from San Felipe Lake Outlet (CP18R2) and subwatershed PJ-2 of Pajaro River are used for these two reaches. Millers Canal was not included in the Phase 1 models and therefore the flow is estimated for the Phase 3 hydraulic model. Total flow is divided and allocated between Upper Pajaro River and Millers Canal. In a 2-year event, the flow is split evenly between the two reaches. In all other events, 40 percent is allocated to the Upper Pajaro River and 60 percent was allocated to Millers Canal.
- Llagas Creek – HEC-1 flow from Llagas Creek at confluence with Upper Pajaro River (CP21C).
- Middle Pajaro River – Sum of Upper Pajaro River and Llagas Creek flows
- Lower Pajaro River - The flow rate in this reach is obtained from the HEC-1 flow for CP22DS. This reach includes combined flows from Upper Pajaro and Llagas Creek that merge at the Middle Pajaro reach and then combine with Millers Canal flows.
- Uvas/Carnadero Creek – HEC-1 flow from Uvas/Carnadero Creek at confluence with Lower Pajaro River (CP25C).
- Pajaro Outlet from Soap Lake – HEC-1 flow from a reach downstream of Highway 101 and upstream of the San Benito River confluence with Pajaro River (CP26R).
- Soap Lake Water Surface – Soap Lake stage from HEC-1 model (Soap Lake)

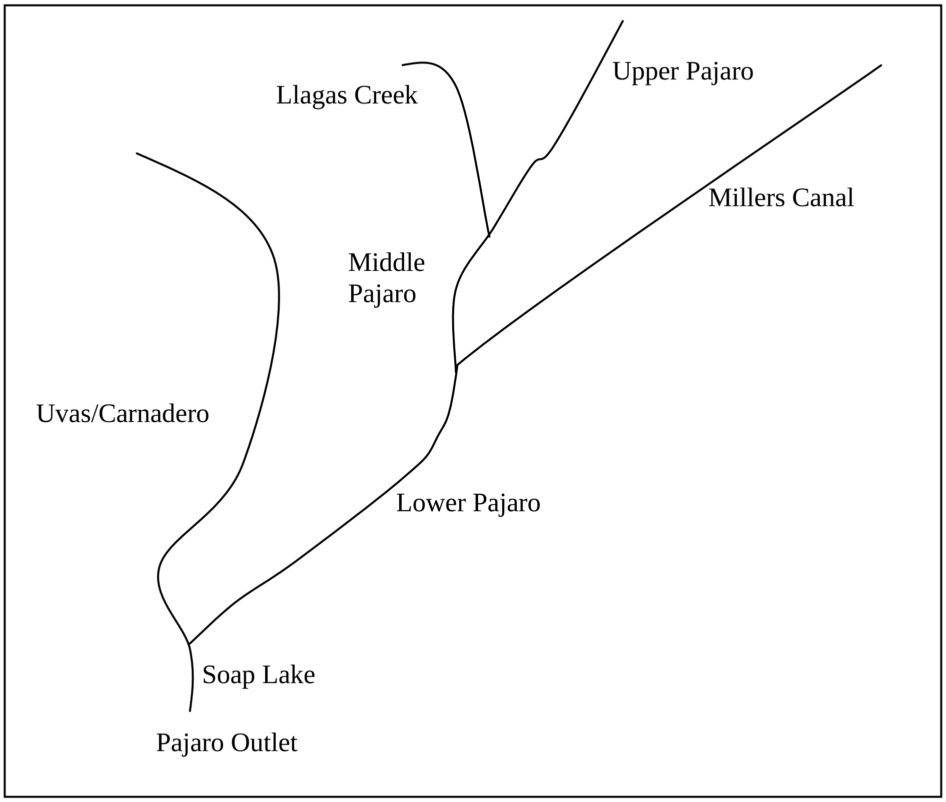


Figure 8: Schematic of reaches used in the Soap Lake hydraulic model.

Flow Selection for Steady State HEC-RAS Model

The HEC-1 results include flow hydrographs that designate expected flows within the river system at given times. To determine peak flooding levels on the tributaries, the flow time period that included the peak flows on the tributary was modeled. The approximate time periods selected for the peak flow analyses in each of the return periods are listed in Table 4.

Table 4: Time of tributary peak flows.

Return Period	Time of Peak Flows in Storm Event (1)
2 Year	1/17 18:00 to 1/18 2:00
10 Year	1/18 20:00 to 1/18 23:00
25 Year	1/18 8:00 to 1/18 11:00
50 Year	1/18 8:00 to 1/18 10:00
100 Year	1/18 5:00 to 1/18 10:00

(1) Storm events begin at 12:00 AM, 1/16/2002

The peak flows within these time periods on each of the stream reaches were generally used for analysis of peak water levels along the reach. The peak water surface at Soap Lake generally occurred later, due to continued inflows that were greater than the outflow at the lake.

Input flows and downstream boundary conditions are summarized below in Table 5.

Table 5: HEC-RAS flows and downstream water surface elevations obtained from the Phase 1 HEC-1 general plan buildout model.

Location	2-Year Flow	10-Year Flow	25-Year Flow	50-Year Flow	100-Year Flow
Millers Canal	250 cfs	4,000 cfs	7,200 cfs	10,200 cfs	12,000 cfs
Upper Pajaro	250 cfs	2,600 cfs	4,800 cfs	6,800 cfs	8,000 cfs
Middle Pajaro	2,100 cfs	4,900 cfs	8,300 cfs	11,700 cfs	13,900 cfs
Lower Pajaro	2,200 cfs	8,800 cfs	15,200 cfs	21,700 cfs	25,300 cfs
Llagas	1,200 cfs	2,300 cfs	3,500 cfs	4,900 cfs	5,900 cfs
Uvas/Carnadero	900 cfs	3,900 cfs	6,300 cfs	8,300 cfs	9,800 cfs
Pajaro Outlet	3,100 cfs	11,100 cfs	15,000 cfs	17,900 cfs	19,500 cfs
Lake Surface Elevation*	126.5 ft	136 ft	140 ft	141.4 ft	142.5 ft

*Lake surface elevation is the water elevation at the outlet at the time of peak inflow to Soap Lake. It is not the maximum water surface of the lake nor is it constant throughout Soap Lake.

Geography Model

This TM section describes the geographical model inputs and assumptions made regarding the methodology.

Methodology

A GIS system was used to facilitate data entry for the geographic model. Using the GIS also made it possible to take advantage of the digital data and surfaces.

GIS Data

The GIS data included in the hydraulic model is limited to the high resolution primary dataset described earlier. Based on the relatively flat terrain through much of Soap Lake, 2-foot elevation contours are necessary for accurate modeling. The low flight level required for 2-foot contours corresponded with that needed for 6-inch pixel resolution of the aerial photography. Data was collected for the entire Soap Lake area, as defined by the approximate FEMA floodplain, and a 1,000 foot buffer.

River line vector data was used as an initial estimate for the river thalweg location.

The mapping vendor provided the Soap Lake data as 77 individual tiles. Each tile has:

- 2’ contour file with elevations based on NAVD 88
- Digital terrain model (DTM) and triangular irregular network (TIN) files
- 6” pixel orthophotography

The tiles were mosaicked for purposes of this study. An example of each of the above data types is shown in Figure 9.

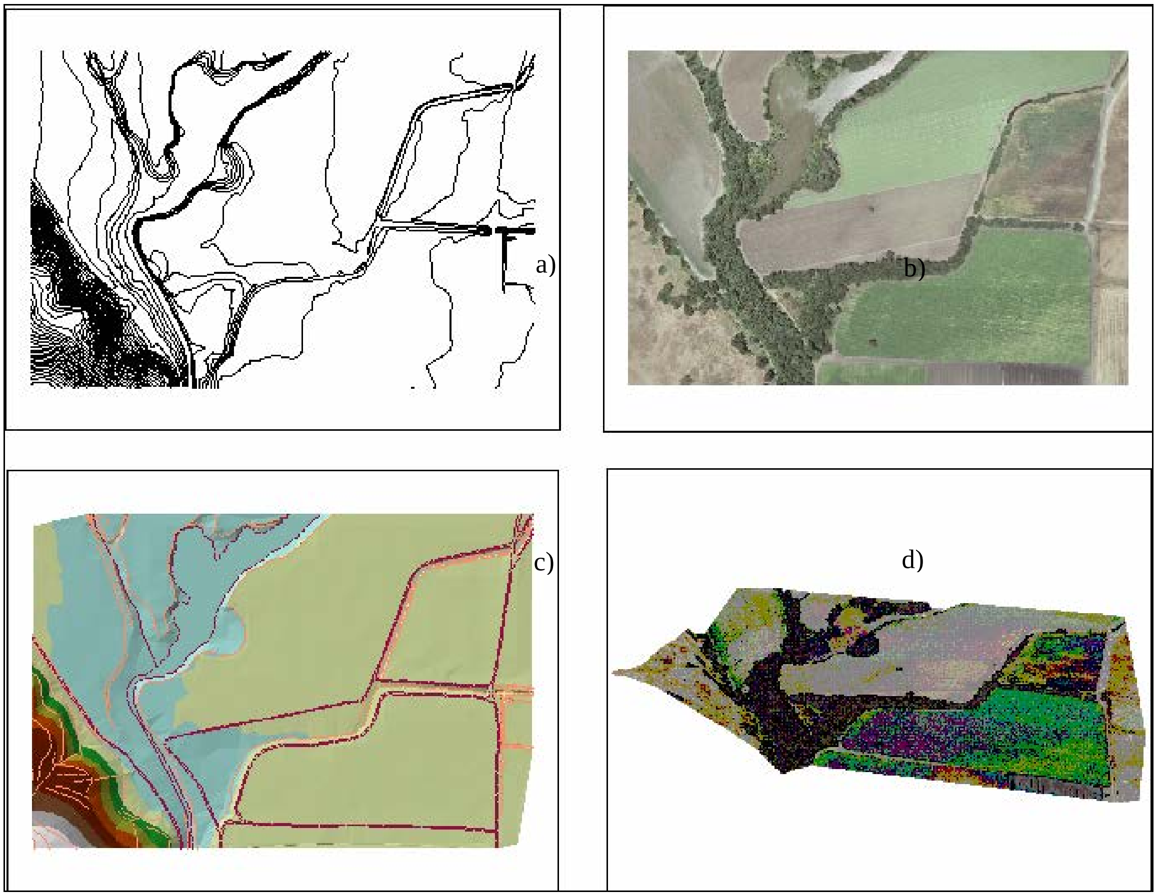
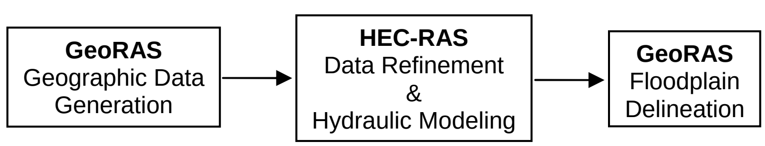


Figure 9: Examples of received data. The represented area is close to the outlet of Soap Lake. The data shown in this figure are: a) Contour lines b) Aerial photography c) Digital terrain model d) Synthesis of a), b), and c) with a vertical exaggeration of 5:1.

GIS Tools

A Beta release of HEC-GeoRAS from ESRI was used in conjunction with ArcGIS 8.3 to transfer the GIS information to a HEC-RAS environment. A 3D Analyst extension is required for HEC-GeoRAS to function.

HEC-GeoRAS (GeoRAS) consists of two modules: one for preprocessing data for import to HEC-RAS and one for processing a HEC-RAS export file containing water surface elevations and profile boundary polygons. In the preprocessing stage, users create model features using GeoRAS and then draw stream centerlines, flow paths, cross sections, and other optional features using standard ArcGIS editing tools. A GeoRAS tool then creates stationing and connectivity for all applicable features and extracts elevations from the TIN representing the study area ground surface. A tool is provided to translate the GIS format to an ASCII text file that is interpretable by HEC-RAS. HEC-RAS reads the import file and creates the geometry file of the model. Once modeling is complete within HEC-RAS, the user exports the profile water surface elevations back into a text file. GeoRAS can then



interpret those results and delineate floodplains for steady-state modeling results. The floodplain delineation process within GeoRAS is explained in TM 3.4: Floodplain Boundaries Mapping. Figure 10 is a process flow diagram for using HEC-GeoRAS from the HEC-GeoRAS Tools Overview Manual (Beta 6 v8.0, ESRI 4/04).

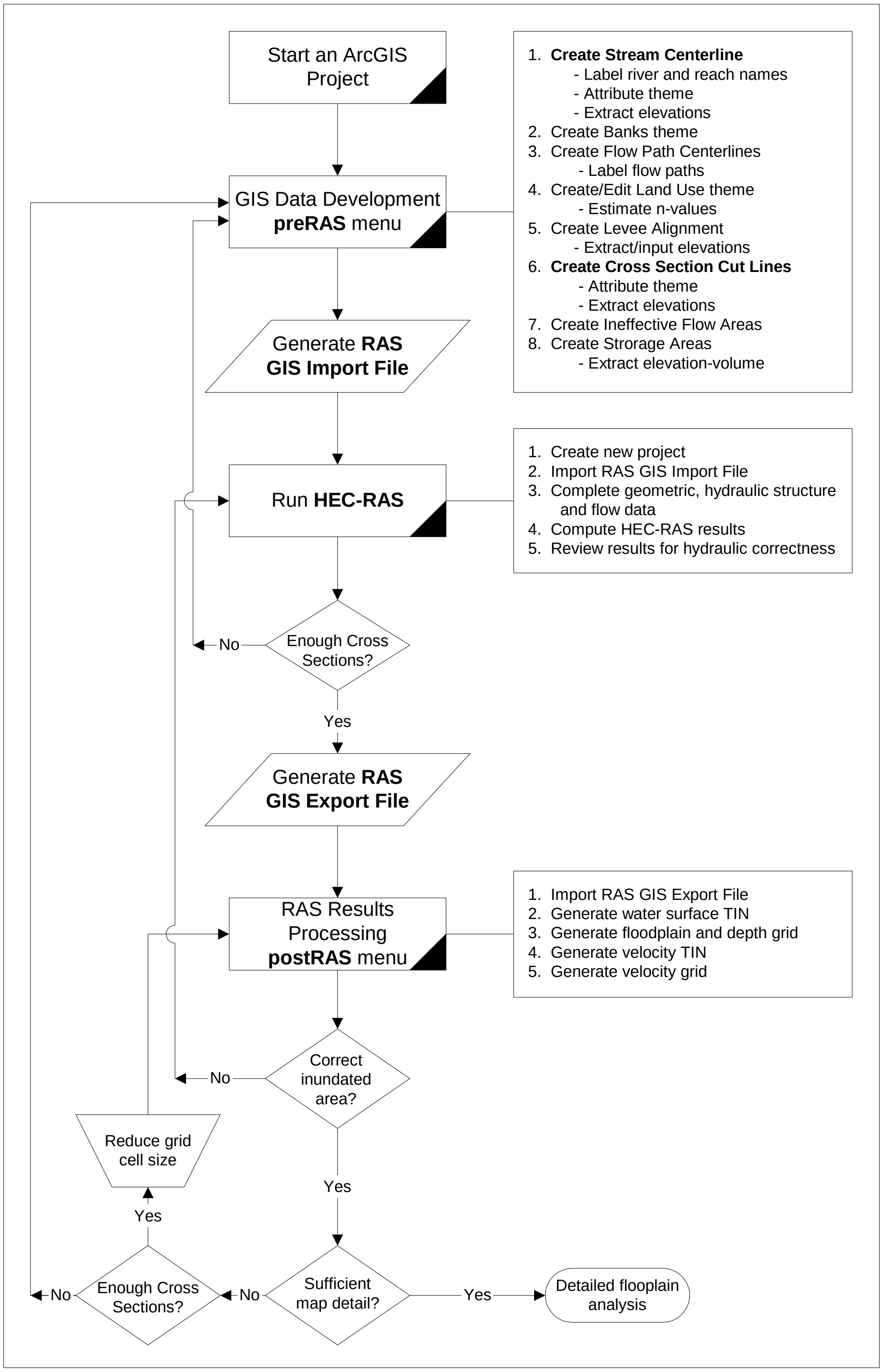


Figure 10: Process flow diagram for using HEC-GeoRAS. (ESRI 4/04)

Feature Creation and Assumptions

This section describes how geographic features were created and modified within HEC-GeoRAS and HEC-RAS. There is also discussion regarding assumptions made regarding feature creation.

- Stream Centerline: Stream centerlines were generated based on the thalweg of the stream. Where the terrain data indicated a flat bed, one of two methods was used. Usually the centerline of the stream could be defined by the channel midpoint based on aerial photography. Where there was an irregular shape or pooling, the centerline was defined as the median between the points where the bank started to rise. Figure 11 below shows example cross sections where the thalweg can and can not be used to define the stream centerline. Available photography was also used to help define centerlines where a thalweg was not apparent.

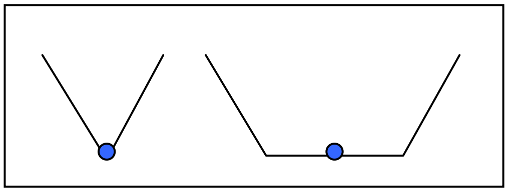


Figure 11: Examples of stream centerline delineation using the thalweg and the midpoint of the channel bottom.

  Stream centerlines were defined only for those waterways which were modeled as part of Phase 1 which include the Pajaro River, Llagas Creek, and Uvas/Carnadero Creek. Millers Canal was also modeled since it is a dominant feature in the study area. Flow for the canal was derived as explained in the flow model section above.

  Centerlines were divided into reaches based on the connectivity of the waterways. A model junction was placed at every confluence of waterways. A section of river between two junctions or between a junction and a river endpoint was defined to be a single reach.

- Cross Sections: Cross sections were placed at 500 foot intervals along each of the major waterways in the study area. Some locations were adjusted to meet local conditions. Others were added at bridge crossings to better define the land elevations and channel constrictions. The length of the individual cross section was defined by the study area topography. Reach subbasins were developed and the cross sections were extended to the edge of the subbasin. Some editing of cross section length was required to avoid overlapping boundary polygons. Overlapping boundary polygons would mean that a single area could convey flow from two separate river reaches which causes problems in the GeoRAS post-processing. An example is shown below in Figure 12.

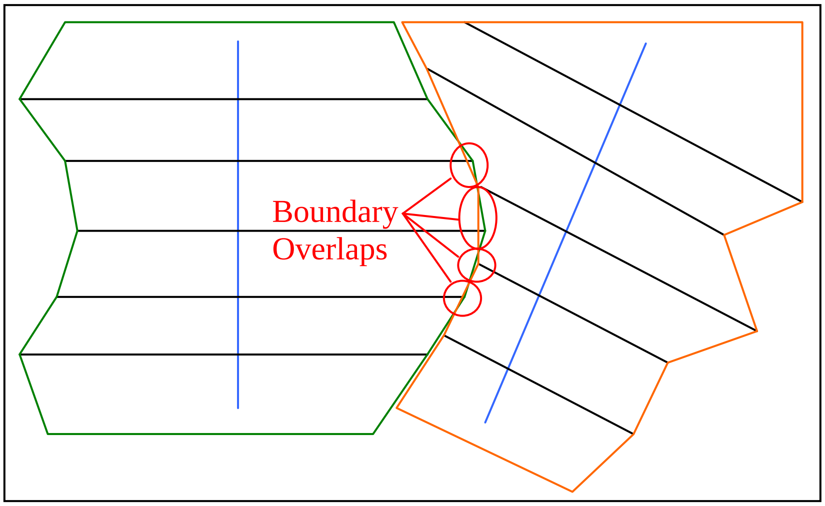


Figure 12: Overbank boundary overlaps caused by extending cross sections too far.

- Bank Locations: Bank location is used to define the left overbank, channel, and right overbank. This designation is used when applying the Mannings n roughness coefficient, which can be different for all three locations. Bank location was designated based on changes in land use cover visible in the aerial photography. Figure 13 below is an example of the bank delineation using land use change and designation of left and right overbanks and the channel.

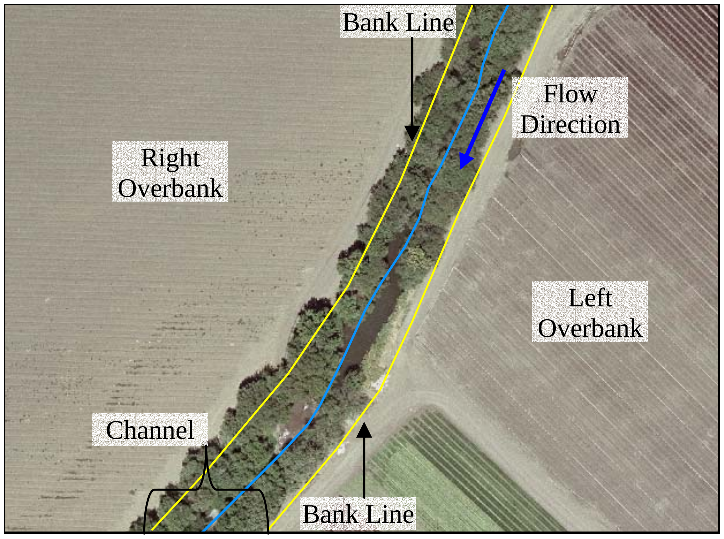


Figure 13: Bank and overbank delineation based on aerial photography.

- Levee Locations: Levees were used in the model to prevent flooding in low sections across the entire width of the cross section. Without the levees, the model would indicate flooding in any area lower than the water surface elevation. With the levees in place, water was contained to between the channel and the levee. Once the water surface elevation increases above the levee elevation, the water is allowed to spread across the cross section as if no levee were present. Schematic cross sections are shown below to demonstrate the effect of levees on containing inundated areas.

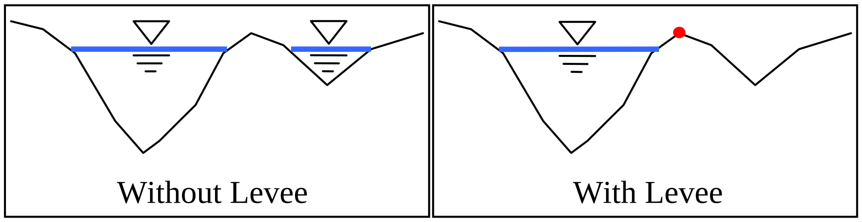


Figure 14: Schematic of water surface without and with a levee. The levee prevents overtopping before the water surface rises above a high point in the ground.

Levee locations were determined by a process involving both aerial photography and the HEC-RAS cross section profiles. High points in relatively similar locations across several cross sections were identified. This trend of high points was matched with a corresponding high linear feature in the aerial photograph, such as a raised road. Linear features are preferable for levees since it is more difficult for the overbank flow to get behind the levee. Local high points not associated with a high linear feature would form islands rather than contain flow to a narrower channel.

- Bridges: Bridges were modeled at five crossings: Millers Canal and Frazier Lake Rd, Pajaro River and Frazier Lake Rd, Pajaro River and the Railroad, Pajaro River and Hwy 25, and Uvas/Carnadero Creek and Hwy 25. A detailed crossing analysis was not made; instead, open span bridges with a bridge deck thickness of 2 ft. were assumed. Surrounding terrain conditions were taken from only the available topographic GIS data. The width of the bridge was taken from the aerial photography using GIS measuring tools. HEC-RAS was used to model flow through and over all of the bridges except for the two Frazier Lake Road bridges. At these bridges the energy equilibrium at the upstream and downstream cross-sections could not be achieved by the model and caused artificially high water surface levels upstream of Frazier Lake Road. To eliminate this error, the water surface elevation of the cross-sections above and immediately upstream of the bridge was set. The water surface elevation was determined based on a methodology outlined by the U.S. Department of Transportation in their hydraulic design series. The methodology was adjusted to account for extensive weir overflow along the road embankment. This was accomplished by subtracting the amount of water flowing under the bridge from the total flow in the reach and dividing the remainder over a sectioned embankment.

- Ineffective Areas: Ineffective areas are locations where water is being stored but not actively conveyed. The velocity of the water in these areas is close to or equal to zero. There was one ineffective area modeled within the Soap Lake study area, shown in Figure 15 below. This area is considered ineffective because of height of Hwy 25 and the railroad. Except in major events, water is unable to flow over these structures. Water flowing under the railroad bridge is assumed to flow directly toward the Highway 25 bridge rather than conveyed in the riverbank area.

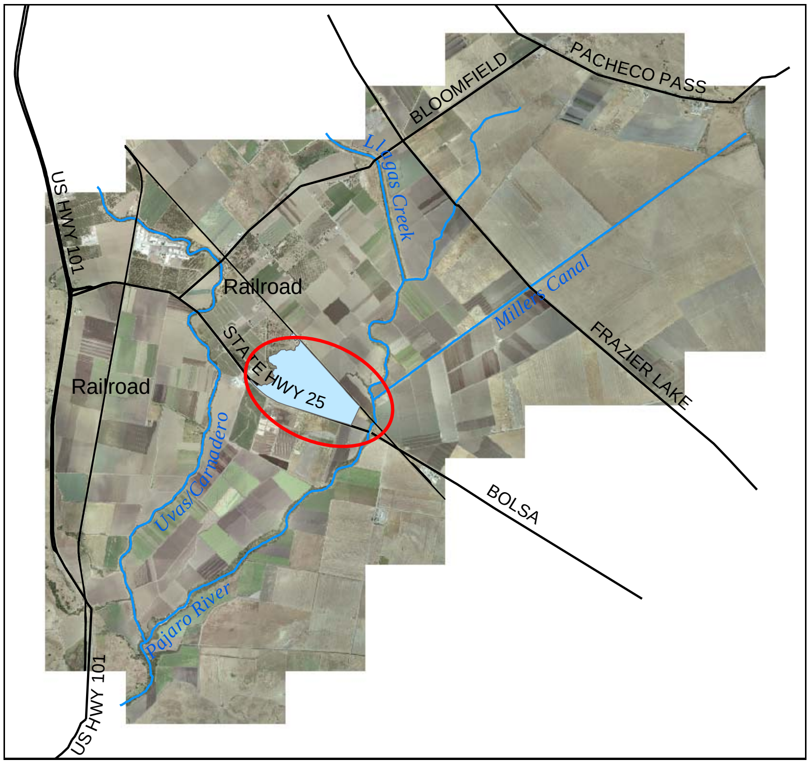


Figure 15: Ineffective flow area in the Soap Lake modeled area. The area is ineffective because of the high railroad and Hwy 25.

Hydraulic Model Results

Based on the above inputs and conditions, the Soap Lake hydraulic model produced water surface elevations for the 2-, 10-, 25-, 50-, and 100-year events at each cross section. Output format is the standard HEC-RAS format.

Limitations and Implications

Applications of this model are limited by the amount and quality of input data available.

As stressed earlier in this TM, the hydraulic model is based on the results and assumptions of the Phase 1 HEC-1 model. The purpose of the HEC-1 model was to predict peak and 3-day average flow at four discrete locations within the watershed and no attempt was made to calibrate individual subwatersheds. Therefore, inputs to the hydraulic model may be higher or lower than might be expected based on other models or field observations. Varying the magnitude of flows from different parts of the study area can impact the floodplain limits. Additional work would be required to refine the input flows and downstream boundary conditions.

Manning's n roughness values greatly impact the results of the model. The values used were based on other available models for the area. While these values are often approximated and variable, a current land use study of the Soap Lake area would help to improve confidence in the Manning's n values.

The Soap Lake hydraulic model does not account for all of the watershed features. There are minor streams that were not modeled, such as Tic and Tar creeks, as well as culverts and small bridges. These were not included due to a lack of information. Bridges that were included assumed no piers and no structures other than those captured in the topography data.

With all of the limitations described above in mind, the hydraulic model does meet its goals. It accounts for the major waterways and features of the study area when calculating water surface elevations and extents of flooding. It is possible to compare relative flooding frequencies for numerous locations when prioritizing which areas are most critical to preserving the Soap Lake effect. The model defines the floodplain shape better than the FEMA approximated floodplain. The model results are not intended to replace the FEMA floodplain delineations though. Additional discussion regarding the floodplains can be found below.

Floodplain Mapping

Floodplain mapping was accomplished using the hydraulic modeling results and the floodplain maps can be found in Appendix B. The primary method for the floodplain mapping was using the post-processing module of the HEC-GeoRAS and GIS processes but other methods included split flow over a broad-crested weir, intersection between the water surface elevation and the ground elevation, and a stage-storage analysis. Each of these methods is described below. Also included in this section is a discussion of the limitation and applications of the final floodplain maps.

Floodplain Creation Methodology

To the extent of the modeled cross sections, the floodplains were created using a variation on the HEC-GeoRAS tool. There are areas outside the limits of the hydraulic model that are still considered within the Soap Lake Study area. These areas were modeled using HEC-RAS results but applying different methodologies such as split weir flow where a new overland flow path was created and extending the water surface where the ground was flat but no channel or cross sections were available. Also, a later time-frame than that accounted for in the hydraulic model was simulated using a stage-storage analysis.

General Floodplain

Most of the Soap Lake study area was modeled using a combination of the HEC-GeoRAS post-processing tools and several GIS processes. Once the hydraulic modeling is complete within HEC-RAS, the user can export the results to an ASCII text format. GeoRAS tools are used to interpret the text file and turn it into a GIS-friendly format. A layer of cross section locations with water surface elevations for each profile are created. At this point in the process, GeoRAS with ArcGIS 8.3 is no longer helpful in the delineation process as it is unable to interpret the ground contours adequately due to bugs in the software. A grid based process is used to finish the delineation.

The delineation process can be summarized as determining whether the modeled water surface is above or below the ground elevation. In order to do this, there are several steps:

1. The terrain surface used to generate the elevations and locations of all of the HEC-RAS features in the pre-processing GeoRAS module is converted to a 20-foot grid, maintaining the spatial location and elevation as an attribute.
2. A water surface TIN is created based on the GeoRAS cross sections.
3. The water surface TIN is turned into a 20-foot grid.
4. The ground surface grid elevations are subtracted from the water surface grid elevations. The calculation extent is limited to the extent of the cross sections.

These steps are repeated for each profile exported from HEC-RAS. This process is also used to extend the floodplain beyond the east and southeast model edge. Line files are extended across the low-resolution surface dataset that maintain the spacing and orientation of the HEC-RAS model cross sections. The water surface elevation attribute of each cross section is also transferred to the new lines, effectively acting as a cross section extension.

The output grid from step 4 has a range of both positive and negative values. Positive values indicate a water surface above a ground surface, or flooding. In order to make display and later processing easier, each difference grid is reclassified to indicate only whether the area was flooded or not flooded.

Split Weir Flow

Topography in the left and right overbanks of Uvas/Carnadero Creek precluded modeling these areas the same way as the rest of the study area. The channel and channel walls for this creek are actually the high points in the region. Since HEC-RAS is a one dimensional model, it would assume that the water surface calculated for the channel would be extended to the limit of the study area or when the ground elevation was the same as the water surface elevation. This inherent assumption in the model would grossly over exaggerate the amount of flooding caused by overtopping. Figure 16 represents the effect of a slight overtopping with a 1D assumption.

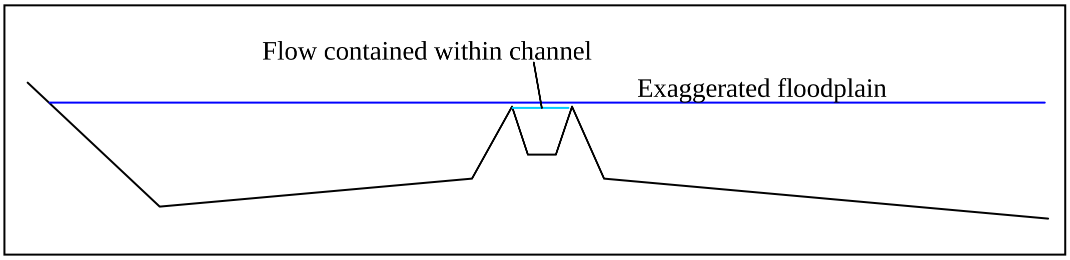


Figure 16: Representation of the effect of a 1-dimensional assumption on model results. A slight increase in flow leads to massive predicted flooding and unreasonable results.

In order to more accurately represent the flooding caused by overtopping of the Uvas/Carnadero levees, the Uvas/Carnadero overbanks were not included in the HEC-RAS model. Instead, weir flow over the levees was assumed and an overland flow path was developed.

Weir Calculations

Water surface elevations were observed to be above the channel capacity at various points for all modeled flow events (100-, 50-, 25-, 10-, and 2-year). Attempts to model the weir flow within HEC-RAS at these points were abandoned after the model failed to converge within the allowed 60 iterations. For this reason, the general broad crested weir flow equation was used. This equation is:

$$Q = CLH^{3/2}$$

Where Q is the weir flow, in cubic feet per second (cfs), C is the weir flow coefficient, L is the length of the weir crest in feet, and H is the difference in head between the water surface and the weir crest. The weir flow coefficient is assumed to be 3.33 (Lindeburg, 2001). The length was assumed to be the overbank length between the most upstream flooded cross section and the next downstream cross section.

The iterative process of determining the weir flow was to run the model, determine the location of the most upstream overbank flow condition, perform the weir calculation, and remove the calculated weir flow from the next downstream cross section as shown in Figure 17. In order to perform the calculation, it was assumed that the water surface head remained constant over the entire length of the weir and the weir crest was assumed to be the higher in elevation of the highest overbank point or the cross section end-point. In the case of both banks being overtopped, it was assumed that the lowest channel bank dictated the direction of the flooding. The model was run again with the adjusted flows and the process was repeated. All of the flow removed through these weir calculations was reintroduced to the model at the cross section just downstream of where Tic Creek (not modeled) would have joined Uvas/Carnadero Creek.

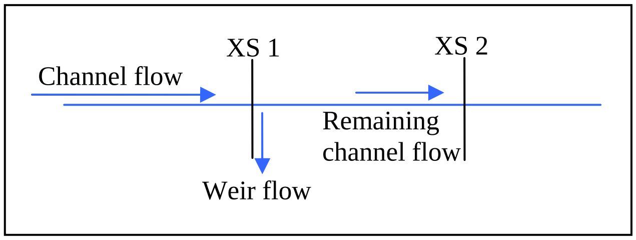


Figure 17: Split flow schematic.

The weir flow iteration process continued downstream until backwater conditions were encountered. Backwater conditions were apparent when the water surface profile and the energy grade line became nearly constant as shown in Figure 18 below. The effect of the backwater is that the weir flow, dependent on the difference in water surface and overbank ground elevation, becomes more than the total flow in the channel. This is because the water surface elevation remained constant but the overbank ground elevation continued to drop.

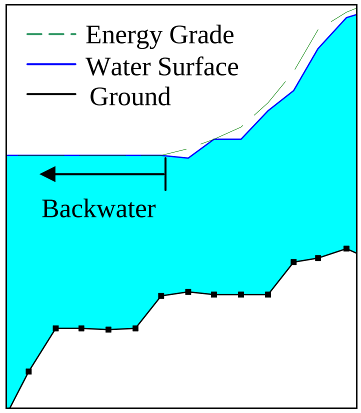


Figure 18: Energy and water surface diagram demonstrating the start of a backwater effect.

Results from the weir flow process are summarized in Table 6. Locations experiencing overflow are identified in Figure 19.

Table 6: Weir flows calculated for Uvas/Carnadero Creek, and their respective River Station and overbank floodplain.

Uvas/ Carnadero Creek Subreach and River Stations	**Weir Flow Loss (cfs)**					**Overbank**
	2-year	10-year	25-year	50-year	100-year	
23,000 - 22,500					1,136	Rightbank
22,500 - 22,000				1,945	3,061	Leftbank
9,500 - 9,000		2,838	5,035	5,883	5,273	Rightbank
Total	0*	2,838	5,035	7,828	9,470	

* It was not necessary to calculate weir flow for the 2-year event since all overflow could be modeled in HEC-RAS. Overflows from the channel occurred in the lowest most reaches of Carnadero Creek where the overbank flow was either contained in the overbank geometry or would merge with Pajaro River rightbank overflow. Therefore, no additional weir flow calculations were needed.

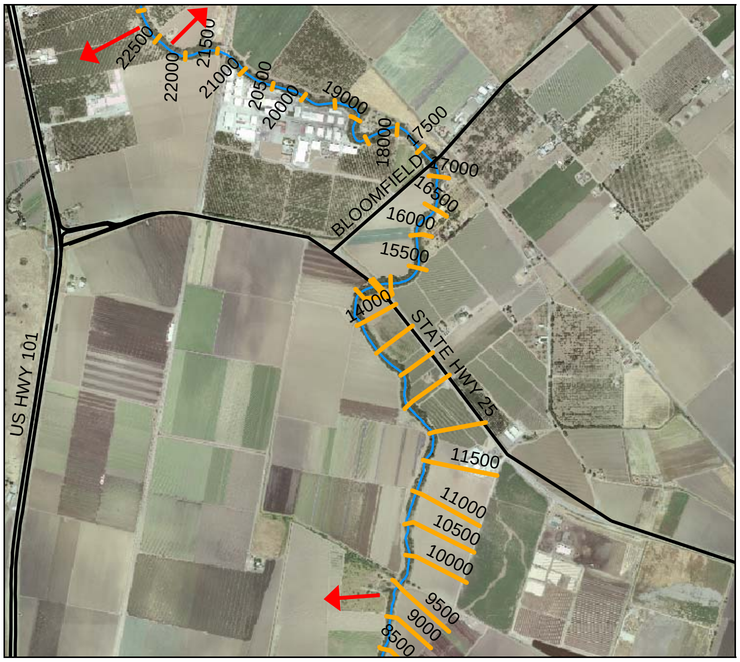


Figure 19: Overflow locations on Uvas/Carnadero Creek. The orange lines are cross section cut lines for Uvas/Carnadero Creek.

Overland Flow

Manning's open channel flow equation was used to develop representative flow paths. Manning's equation is:

$$Q = (1.49/n)AR^{2/3}\sqrt{s}$$

where n is Manning's roughness coefficient, A is the area of flow, R is the hydraulic radius, and s is the slope in the direction of flow. In this case, Q is the calculated weir flow. In a triangular channel,

$$A = d^2 / \tan\theta$$

and

$$R = (d\cos\theta)/2$$

where d is the depth of flow and θ is the average angle of inclination of the channel side. These variables are depicted in the Figure 20 below.

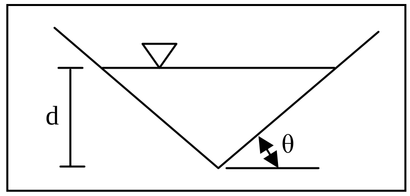


Figure 20: Diagram of depth of flow and angle of inclination in a triangular channel.

Rearranging the above equations,

$$d = \left[(nQ/1.49)(\tan\theta/\sqrt{s})(2/\cos\theta)^{2/3}\right]^{3/8}$$

Using these equations, a generalized cross section and slope, and simple trigonometry, it is possible to determine a width and depth of floodplain.

A representative area was chosen for each overbank and a cross section was developed using GIS elevation extraction techniques. The detailed cross section for each overbank was then generalized to form a triangular channel. Using the dimensions of the triangles, shown in Figure 21, it is possible to determine θ for the above equation. Manning's n is assumed to be 0.04 to be consistent with the other overbank roughness coefficients.

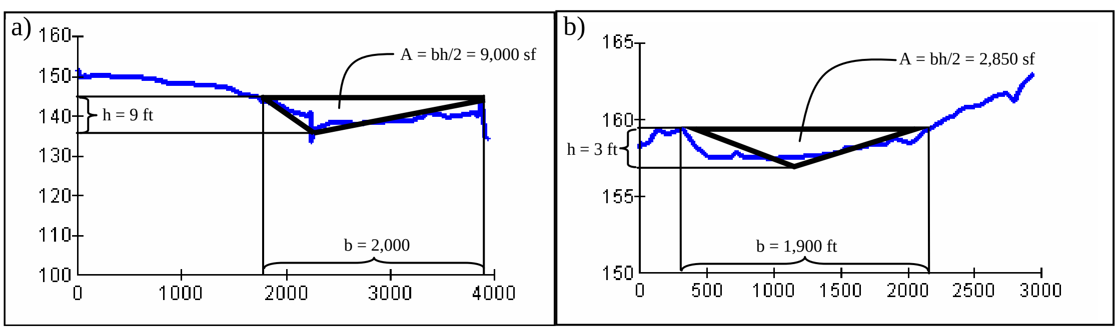


Figure 21: Generalized cross sections for a) right overbank and b) left overbank. Heights, widths, and areas shown are for full overbank conditions.

The remaining variable is the slope s. The slope is developed by creating another triangle through generalizing another cutline. The direction of the cut line in this case though is in the direction of the flow, rather than perpendicular to the flow. Figure 22 shows the overbank slopes.

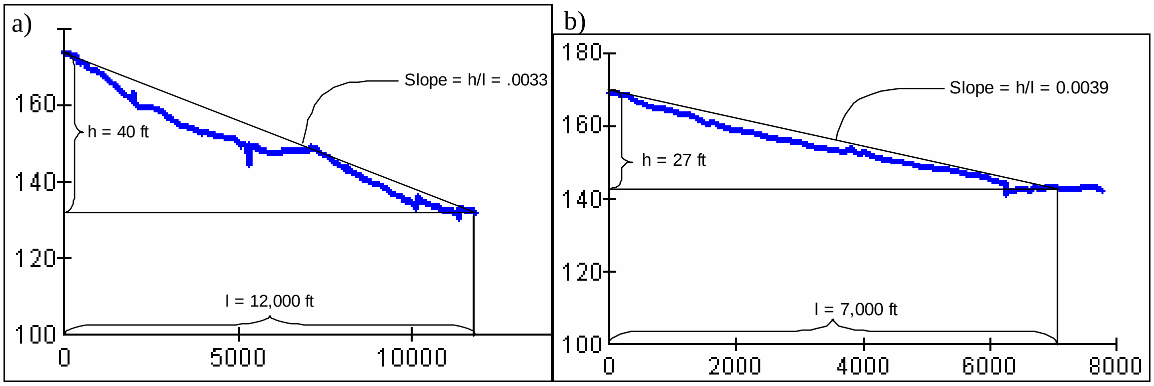


Figure 22: Generalized slopes for a) right overbank and b) left overbank.

Locations of the cross sections and slope lines can be seen in Figure 23. Table 7 summarizes the widths and depths of the overbank flow paths calculated with this method.

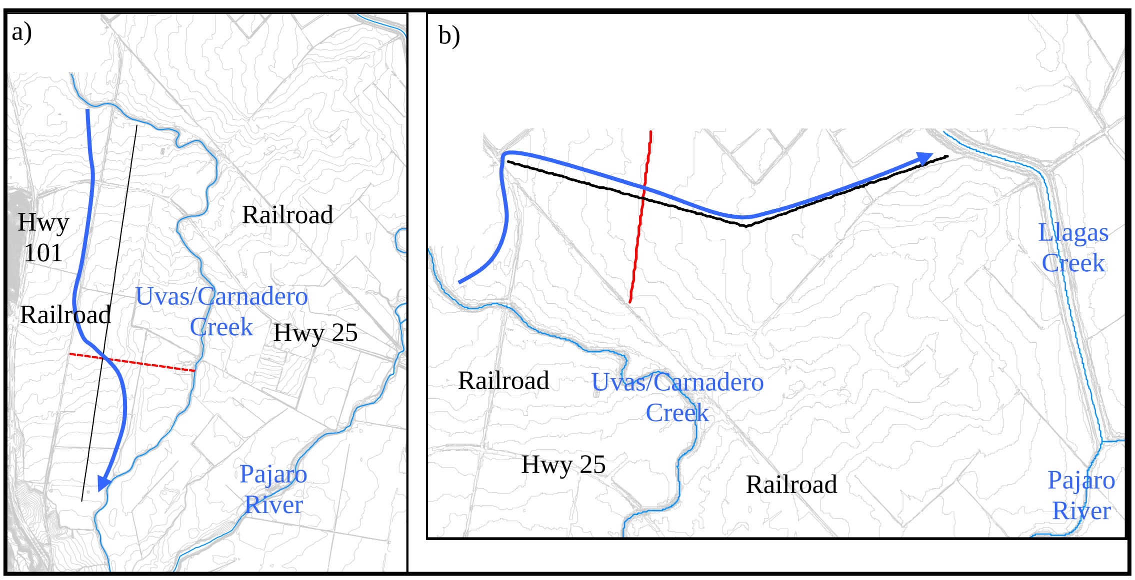


Figure 23: Generalized cross sections (dashed red) and generalized slope lines (black) for the Uvas/Carnadero a) right overbank and b) left overbank. Approximate flow lines are depicted as the blue arrow.

Table 7: Summary of right and left overbank flow paths.

Flow Event	River Station	Weir flow (cfs)	Normal depth (ft)	Top width of flow (ft)	Overbank
100-year	22,500	1,136	2.14	475	Rightbank
100-year	22,000	3,061	2.03	1285	Leftbank
100-year	9,000	5,273	3.80	845	Rightbank
50-year	22,000	1,945	1.71	1084	Leftbank
50-year	9,000	5,883	3.96	880	Rightbank
25-year	9,000	5,035	3.74	830	Rightbank
10-year	9,000	2,838	3.01	670	Rightbank

The overflow areas were analyzed and a most likely flow path was established. Flow paths were created using only the available topography and imagery. No field visits were made to identify culverts or other features that might affect the flow path.

Backwater Impact Area

Portions of the study area near the upstream edges of the study area were not included in the hydraulic model due to model cross section layout. Since they were not included in the model, no flood level was calculated for these areas. However, these areas can become flooded under some conditions.

The area upstream of the Pajaro River source is a large, relatively flat area with no defined, significant drainage path. This area is therefore ideal to extend the backwater effect to areas that were not included in the hydraulic model.

Water surface elevations at the first cross section on the Pajaro River are equivalent to the ground elevation where the flooding stops, as shown in Figure 24. A grid was created with an elevation equal to the upstream water surface elevation for the general area that would be affected by the backwater. The terrain grid was subtracted from the water surface elevation grid and, similar to the above methods, positive results indicated flooded areas and negative results indicated the ground would not be inundated. These 20ft output grid results were also reclassified in the same manner as the general floodplain for easy display and later processing.

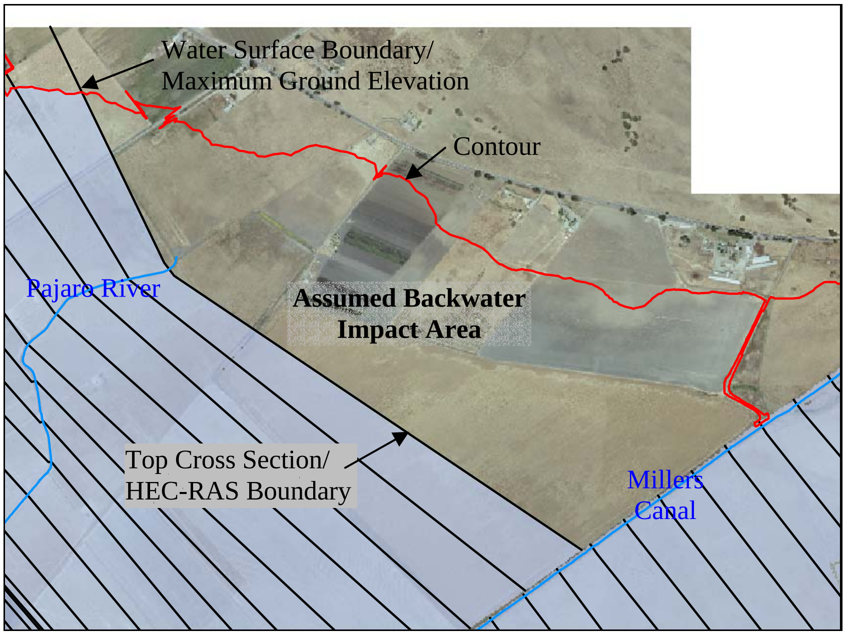


Figure 24: Demonstration of defining the assumed backwater impact area based on limit of flooding at the top cross section.

There is a small section of Millers Canal just downstream of San Felipe Lake that also was not included in the hydraulic model due to the placement of cross sections. The overbank areas of the Millers Canal reach and the Upper Pajaro River are separated by a raised road. Therefore a similar analysis was performed but with a different water surface elevation for the area south of San Felipe Lake.

The same backwater analysis was applied to the extended floodplain area north and northeast of the most upstream extended Millers Canal cross section. This backwater area extends through San Felipe Lake and across the Tequisquita Slough and Pacheco Creek.

Soap Lake Peak Stage Analysis

The hydraulic model and floodplains derived from its output are based on peak flows in each reach. At the time of peak inlet flows, the flow and water level at the outlet of Soap Lake is much lower than outlet peak values that will be reached later in the storm. This difference in the inflow and outflow causes the water surface in the lake to rise. The highest Soap Lake water levels during a storm event should be checked against the water levels created by the maximum flow in the channels.

To account for this effect, peak water surface levels are extracted from the model output and translated into level planes with an elevation equivalent to the highest water surface level. These water levels are shown in Table 8 below. Using GIS tools, the elevation of the water surface plane is compared to the corresponding ground elevation and the water surface plane is partitioned into one of the categories: above, below, or the same elevation as the ground surface. Areas are considered to be flooded if the water surface is above or at the same elevation as the ground. Flooded areas were converted into 20ft grid format and reclassified in the same manner as the general floodplain.

Table 8: Peak water surface elevations (WSE) at Soap Lake outlet.

Event	Outlet WSE
2-Year	126.5 feet
10-Year	136.5 feet
25-Year	140.7 feet
50-Year	143.1 feet
100-Year	144.3 feet

Floodplain Assembly

In order to create a single floodplain map, rather than the four separate floodplains described in the above sections, some final processing and assembly is required. Individual pieces can not be analyzed separately because there is some overlap and augmentation based on the combination of pieces.

The grids from the general floodplain, the upper end of the Pajaro River, and the backwater floodplains were merged to form a single grid. Highest priority in the merge was given to the downstream backwater floodplains and lowest priority in the merge was given to the general floodplain using the HEC-RAS output. The priority order is dictated by the extent of the dataset. Priority while merging impacts the values of individual cells, thereby affecting the final floodplain. Figure 25 below demonstrates the impact of prioritization on data outcome. As can be seen, having the wrong priority order can lead to over- or under-estimating the floodplains predicted for the different areas and conditions.

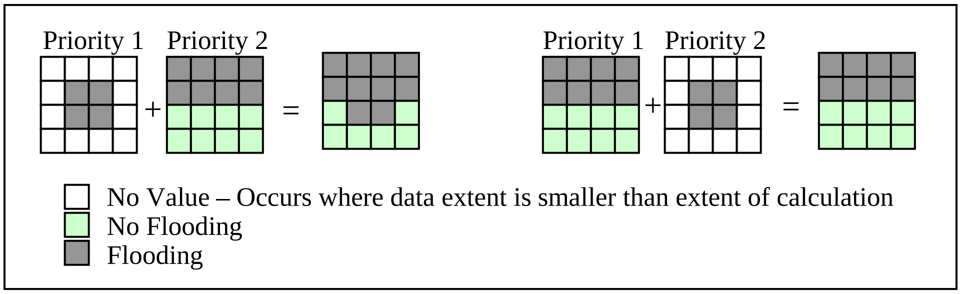


Figure 25: Depiction of the importance of grid priority. With the wrong priority order, cell values may be misclassified. Using the same input grids, the second grid calculation has 1/8 less cells classified as flooded.

The final step in floodplain assembly is to fill in areas not included by the hydraulic and floodplain models and trim floodplain spurs that should not be included in the final floodplain. Minor areas with data gaps were identified within the floodplain area or in areas where flooding would be expected. These were small areas that did not reflect expected flooding due to the positioning of the cross sections. An example is shown below in Figure 26. These areas were filled in based on interpolation of the water surface elevation between the upstream and downstream cross sections. A check was made that the ground elevation was below the water surface and the photography was examined for features that would prevent the water from flooding the area in question. Flooded areas upstream of the water source were checked for consistency with the backwater assumptions described earlier. Unrealistic flooding was trimmed to fit the assumptions. Flooded areas downstream of the water source were not altered.

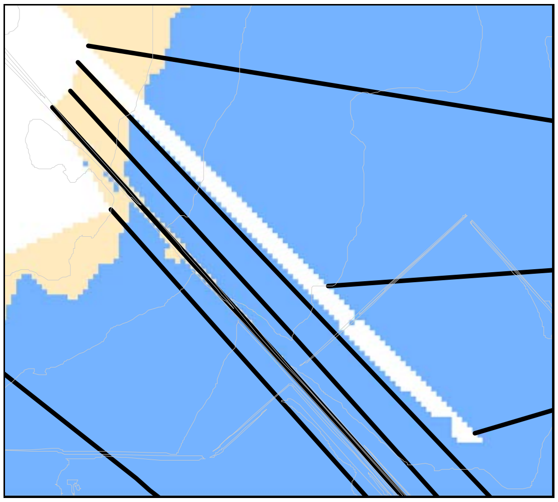


Figure 26: Example of a data gap caused by cross section placement. The blue shading indicates flooding, the yellow shading indicates no flooding, and the white shading indicates no data. The thin grey lines are contour lines and the thick black lines are cross section cut lines. The gap shown here is approximately 100 ft. wide.

As mentioned above, the floodplain maps can be found in Appendix B. These include the modeled 2-, 10-, 25-, 50-, and 100-year floodplain maps as well as a map of the existing approximated FEMA floodplain as a point of comparison.

Applications and Limitations for Floodplain Mapping

Applications of the floodplain maps should be limited to those within the Pajaro River Watershed Study. The maps are based on work performed for the Study and are graphical records of all of the assumptions built into the previous models. These assumptions include those made for the Phase 1 HEC-1 model and the Phase 3 HEC-RAS model. While they can be compared to FEMA flood maps, they are not intended to replace them at this time. Additional work would be required before they can be submitted as an official floodplain record.

It should also be recognized that the floodplain maps are the results of a one dimensional steady-state modeling. The extent of flooding shown can be considered a worse case scenario as it assumes that peak flows are constant and all tributary inputs coincide. Also, since the HEC-RAS modeling is steady-state, outflow hydrographs are not available from the model.

The Uvas/Carnadero weir flows are approximations. Assuming a constant head difference across the entire length between two cross sections most likely overestimates the water lost to weir flow and underestimates the potential for downstream flooding. Reducing the distance between the cross sections or performing detailed bank profile analysis would increase confidence in the results. Current methodology is adequate for the purposes of this model. It should also be noted that discharge locations in the upper reaches of Uvas/Carnadero Creek predicted through this method are similar to those predicted by the FEMA detailed study for the same area.

The Uvas/Carnadero overbank flow paths are approximations as well. As mentioned previously, culverts or other passageways were not modeled specifically. Only those terrain features identifiable through available topography were considered. Also, the use of a generalized cross section is a good approximation for a large area but the overbank storage area varies spatially. Location specific cross sections would improve the accuracy regarding floodplain width. Since these floodplain maps are intended only to serve as indicators of flooding potential, the generalized cross section method is adequate.

Conclusions

Tasks 3.3 and 3.4 have resulted in successful development of several products useful to both to this study and other efforts. A stage storage curve has been developed. It accurately defines the water surface elevation and storage for a defined area. Applicable to the Pajaro River Watershed Study and available as a reference for other studies, a general plan buildout floodplain for the 2-, 10-, 25-, 50-, and 100-year events has been developed based on Phase 1 hydrology.

The groundwork has also been laid for additional studies in this important area. The data gathered and model structure created for these tasks can be applied to future models. With calibrated input hydrology, detailed land use studies, and additional information regarding smaller waterways and passages, users could have additional confidence in and flexibility interpreting the results of the next generation of models.

The current Soap Lake hydraulic model describes the shape and location of Soap Lake during a range of event magnitudes. Model results indicate that the location of Soap Lake is actually further south-east than originally predicted by the FEMA approximated 100-year floodplain. There is also less storage than anticipated in the Uvas/Carnadero overbanks. In the right overbank, the topography creates a shallow channel between Uvas/Carnadero Creek and Hwy 101 but the creek levees, or banks, spill most of the excess water very high in the reach. Water does not overtop the banks throughout the reach and therefore little of the overbank is wetted. In the left overbank there is a ridge that rises well above the water surface that precludes storage in much of the area between Uvas/Carnadero and Llagas Creeks.

There is a shift in water storage over the course of a flood. During the peak inflows, much of the storage is in the upper study area and utilizes the upper reach overbanks as flow paths. The water surface generally tracks with the ground elevation. Once the peak inlet flows have passed, the water storage takes place in the lower reaches of Soap Lake. The extent of flooding is dictated more by the water surface at the outlet of Soap Lake, which creates a level water surface in the floodplain.

It is interesting to note the large jump in floodplain area between the 2- and 10-year events. As can be seen in Figure 27, the increase in floodplain is greater in the 2- to 10-year return period range than in the 10- to 100-year range. Also shown in Figure 27, the rate of floodplain spreading per increase in flow is greater in the 2- to 10-year event range than in the 10- to 25-year event range. This indicates that there is a wide, shallow floodplain next to the rivers and channels. There are significant implications associated with this topography. Small increases in flow to Soap Lake during frequent events result in a substantially bigger floodplain and therefore unusable agricultural land while inundated. An increase in channel roughness would also lead to more frequent, larger floods in Soap Lake.

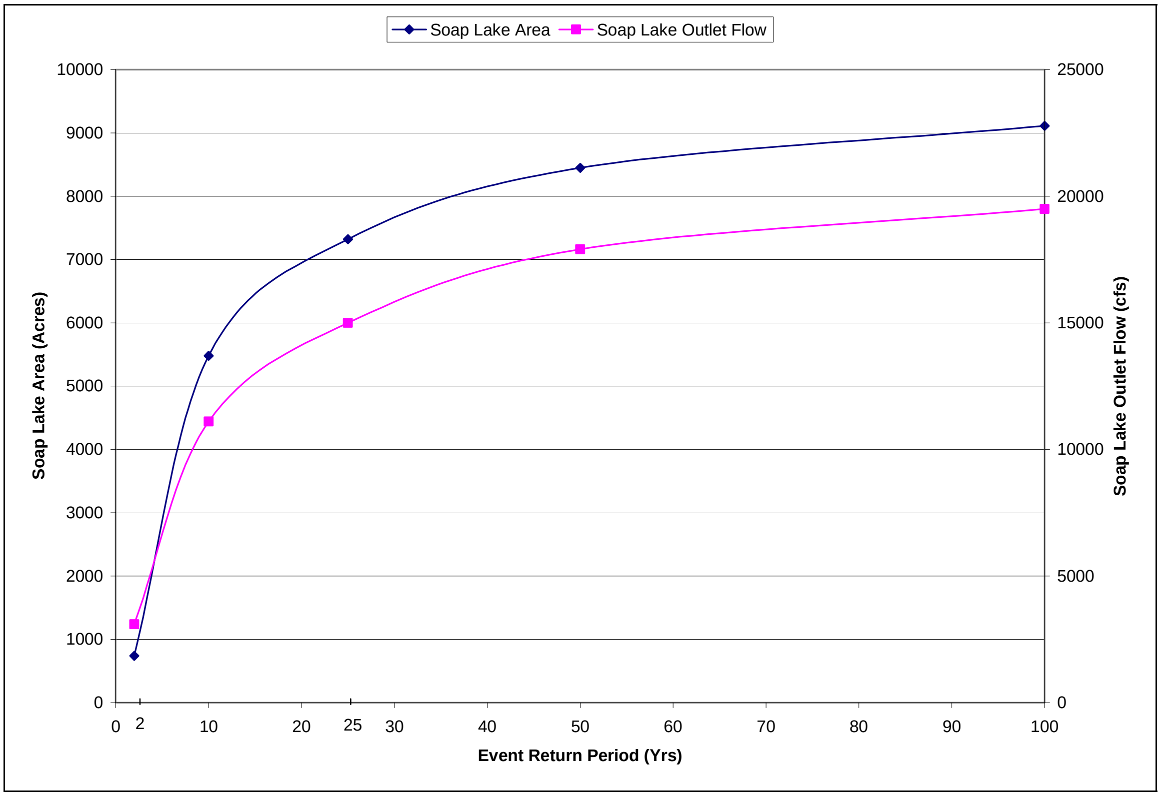


Figure 27: Soap Lake area and outlet flow.

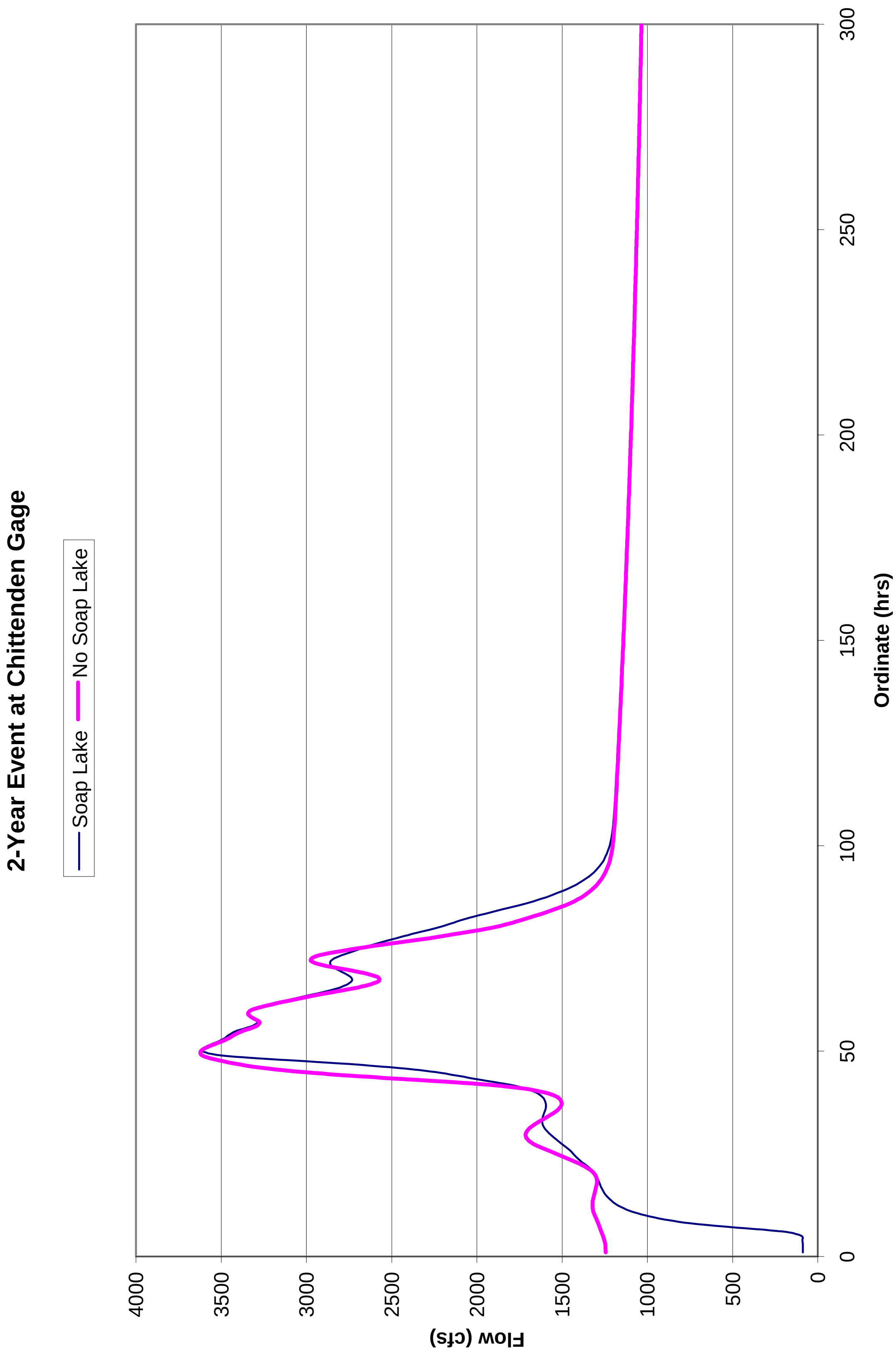
Next Steps

The model results and floodplain maps will assist in the development of the proposed Soap Lake Preservation Project. CEQA documentation will use the floodplain delineations to research all of the area impacted by the Soap Lake Preservation Project. The floodplain maps will be used to help to prioritize particular parcels and areas for order of preservation.

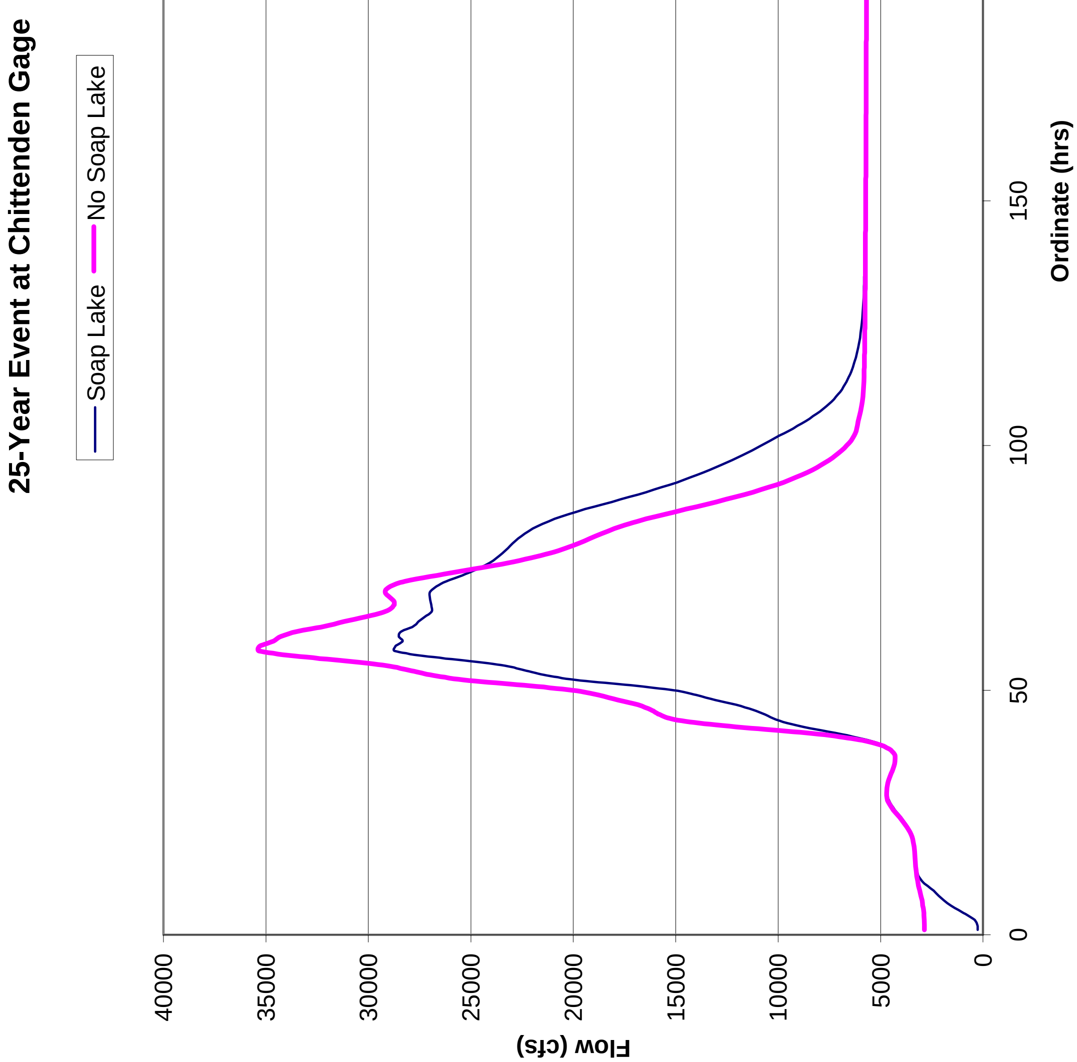
Appendix A

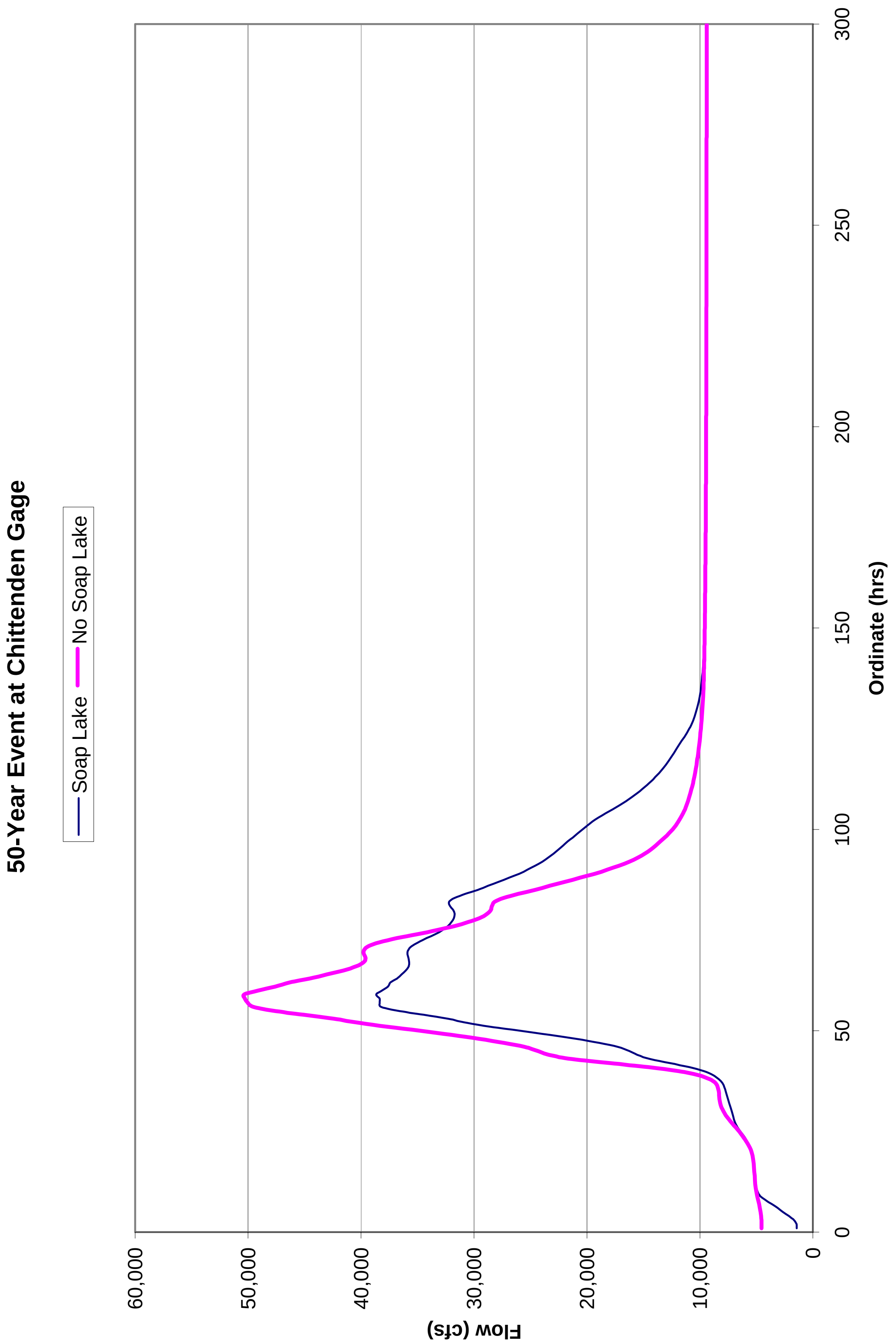
This appendix contains hydrographs representing flow at Chittenden assuming Soap Lake is present and also assuming the Soap Lake storage and attenuation capabilities have been completely lost. The hydrographs were developed using the HEC-1 model created as a part of Phase 1 of the Pajaro River Watershed Study. No changes were made to the model to represent flow with Soap Lake in place. Removing the Soap Lake storage card from the HEC-1 model simulates a loss of storage and, as can be seen in the following graphs, drastically impacts the downstream flow.

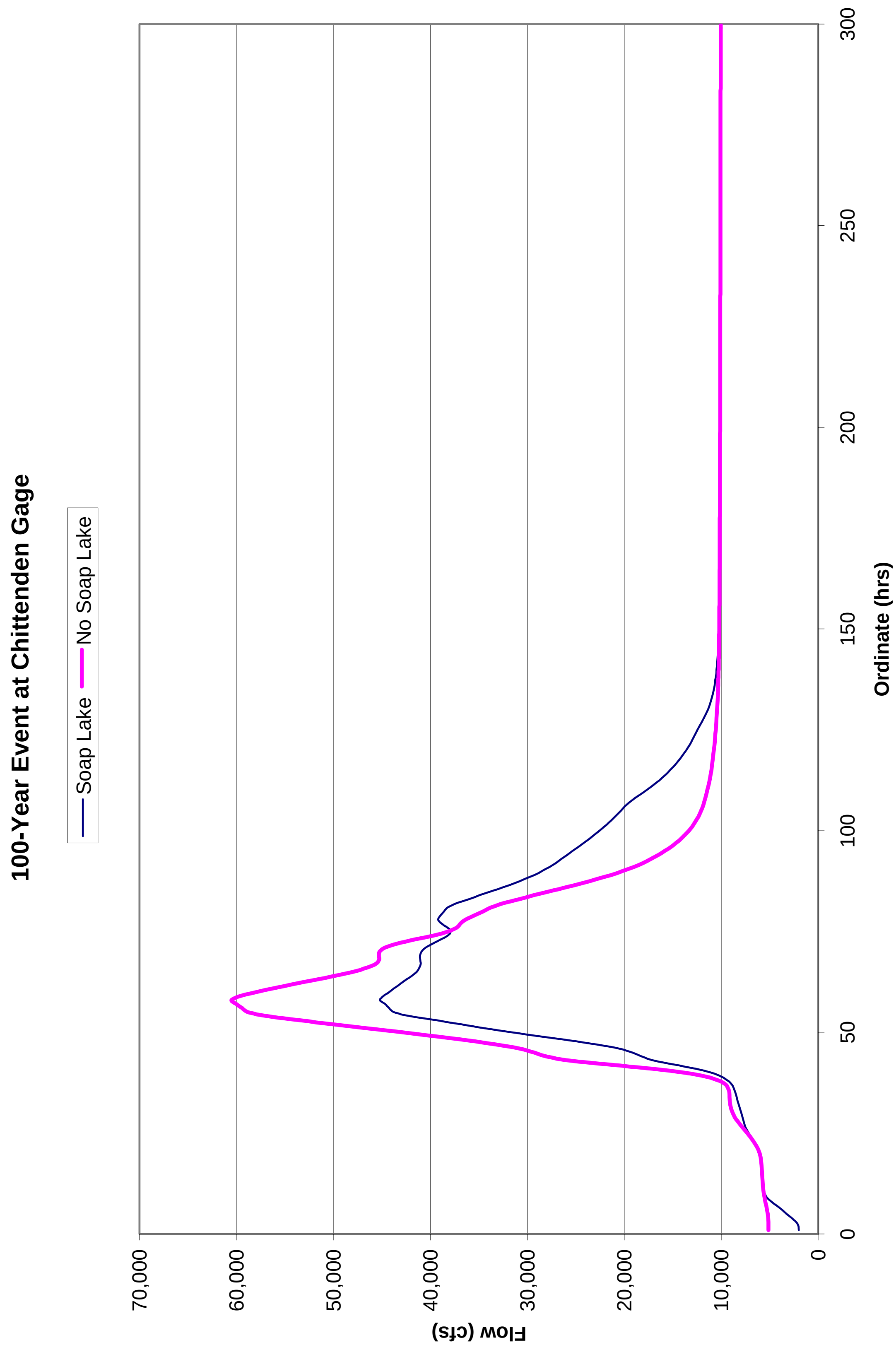
The following pages of hydrographs have been split according to event return periods to facilitate comparison of similar hydrographs.

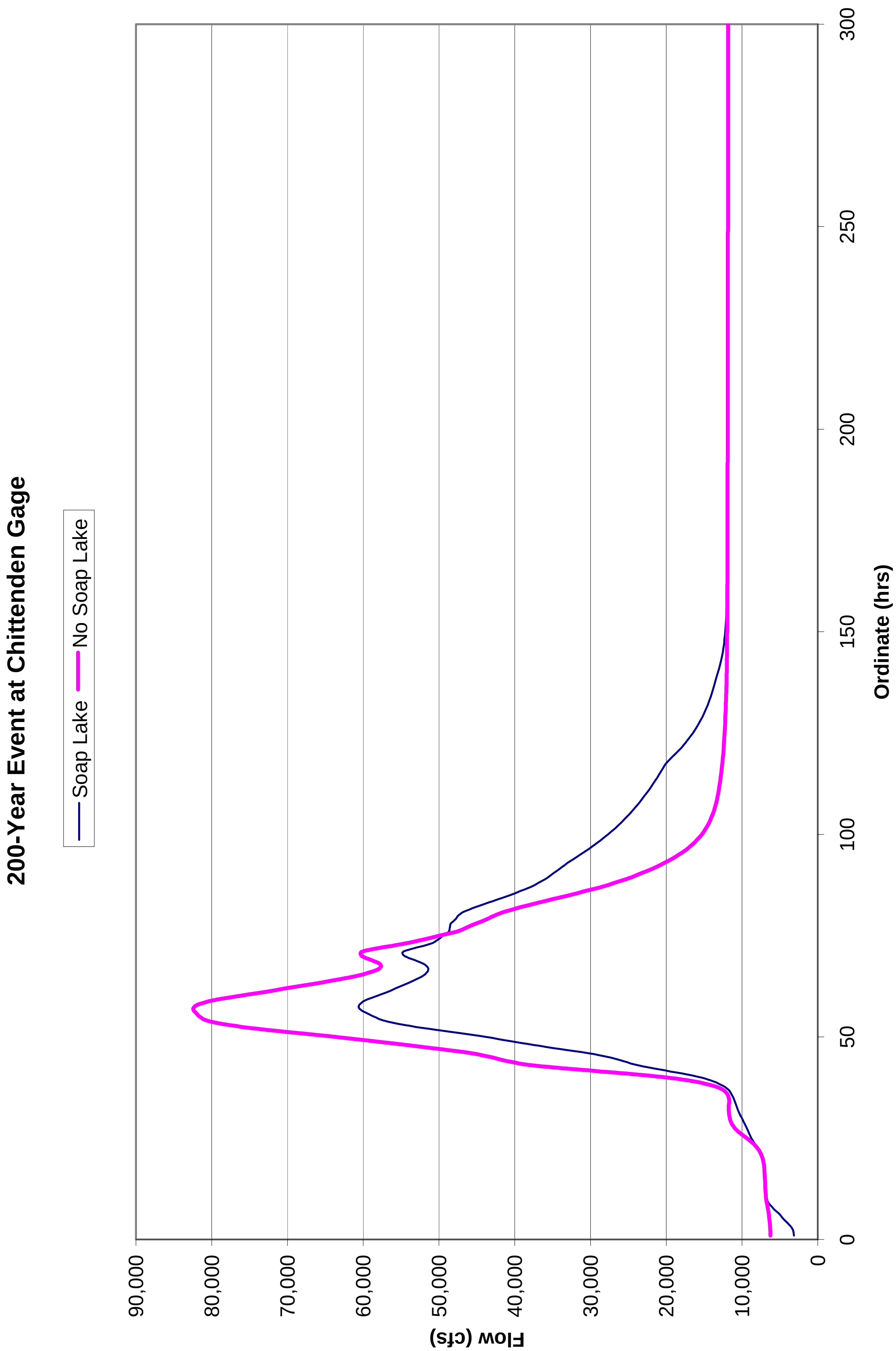

2-Year Event at Chittenden Gage
Soap Lake
No Soap Lake
Flow (cfs)
4000
3500
3000
2500
2000
1500
1000
500
0
Ordinate (hrs)
0
50
100
150
200
250
300


10-Year Event at Chittenden Gage
Soap Lake
No Soap Lake
Flow (cfs)
25000
20000
15000
10000
5000
0
Ordinate (hrs)
0
50
100
150
200
250
300


25-Year Event at Chittenden Gage
Soap Lake
No Soap Lake
Flow (cfs)
Ordinate (hrs)
0
5000
10000
15000
20000
25000
30000
35000
40000
0
50
100
150
200
250
300

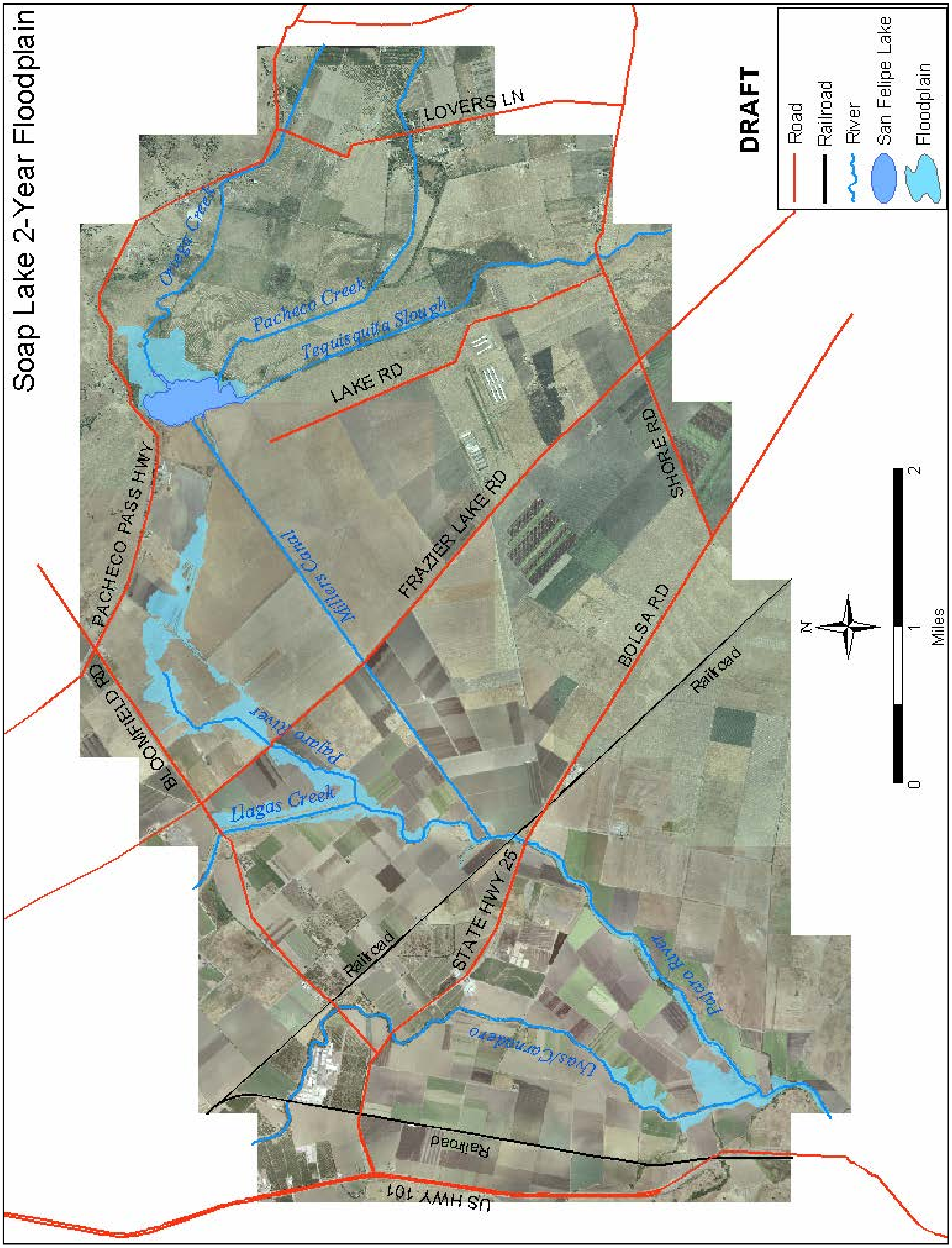

50-Year Event at Chittenden Gage
Soap Lake
No Soap Lake
Flow (cfs)
60,000
50,000
40,000
30,000
20,000
10,000
0
Ordinate (hrs)
0
50
100
150
200
250
300

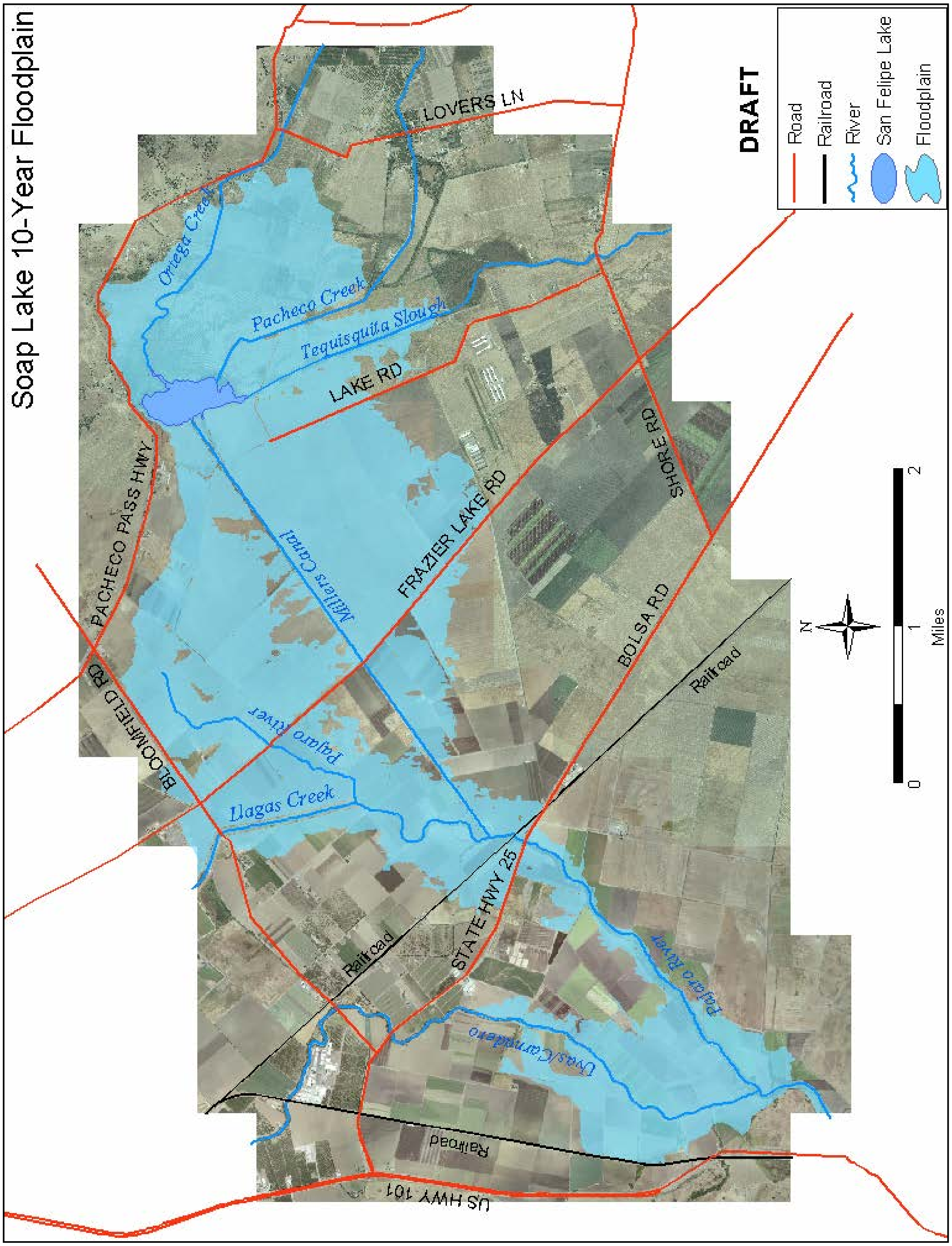

100-Year Event at Chittenden Gage
Soap Lake
No Soap Lake
Flow (cfs)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Ordinate (hrs)
0
50
100
150
200
250
300

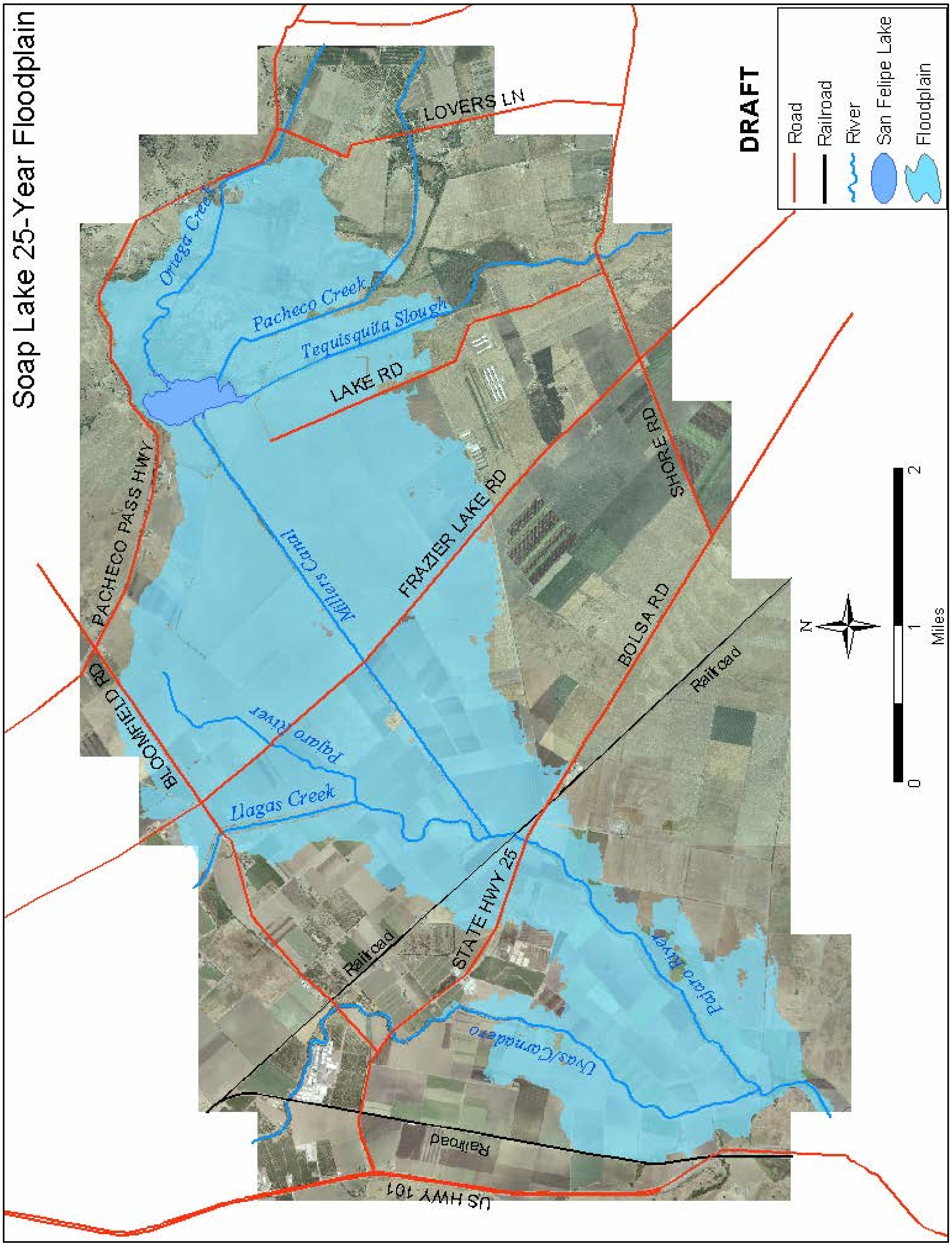

200-Year Event at Chittenden Gage
Soap Lake
No Soap Lake
Flow (cfs)
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Ordinate (hrs)
0
50
100
150
200
250
300

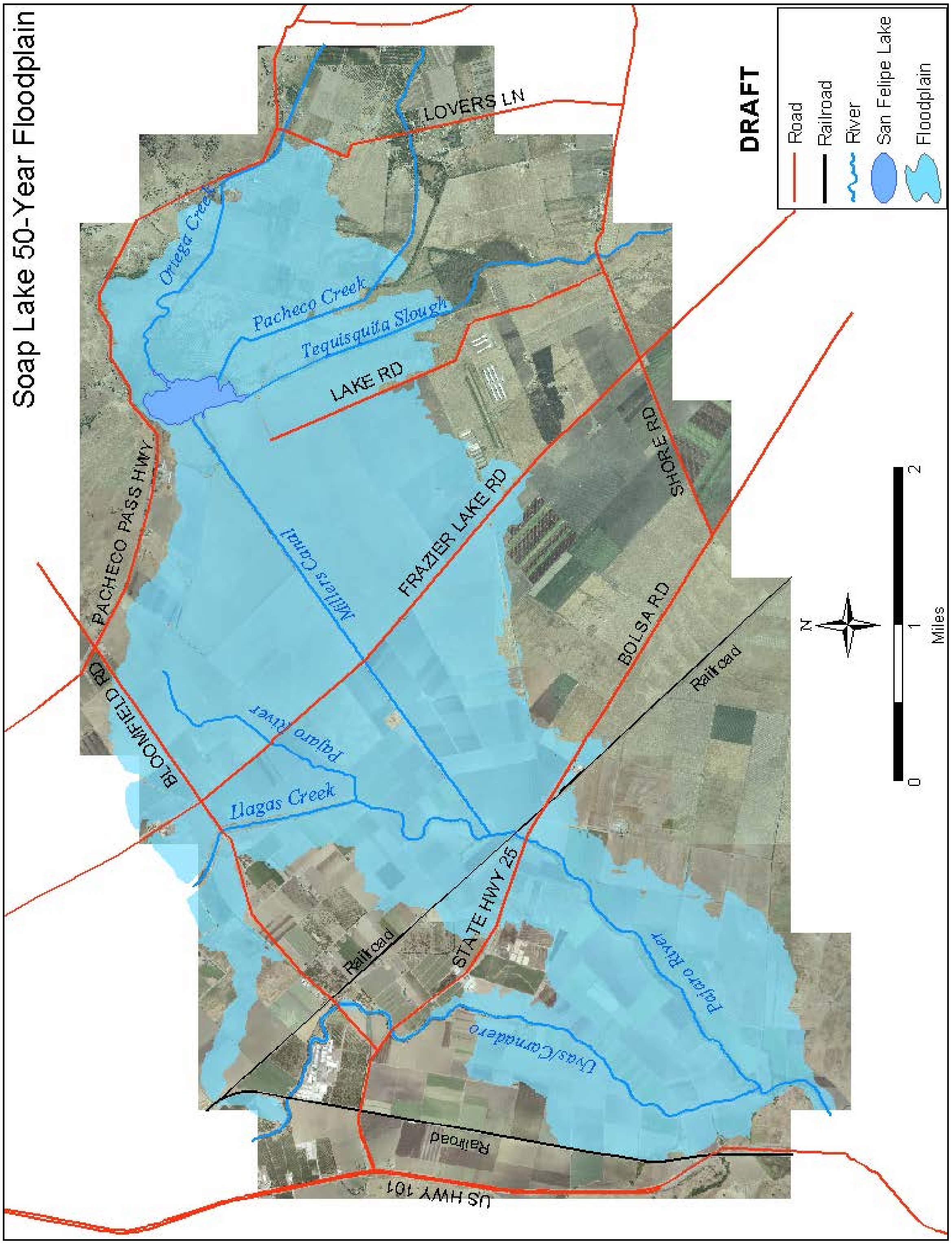
Appendix B

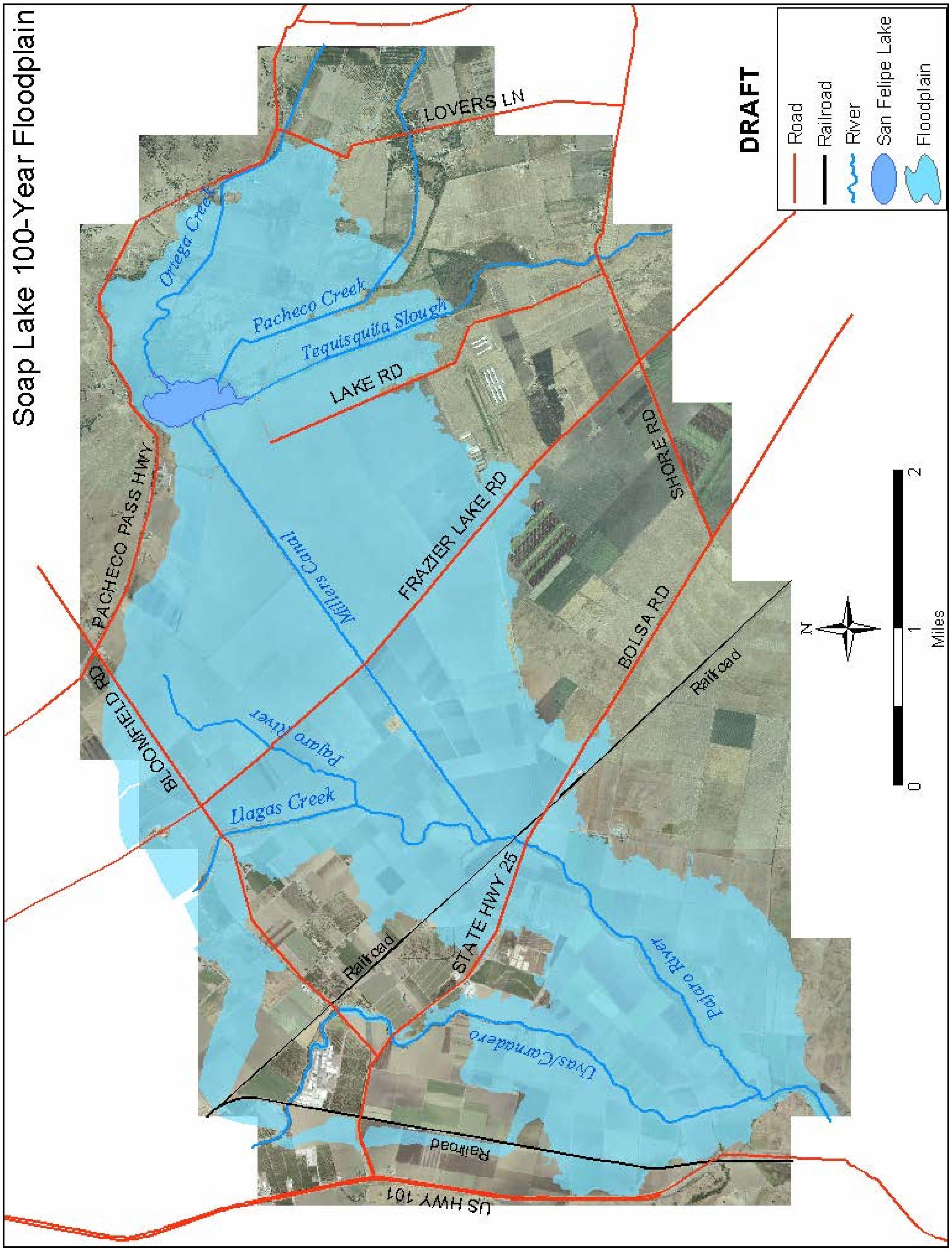
Appendix B contains floodplain maps developed using the HEC-RAS model described in this technical memorandum. The following maps represent model and method results for the 2-, 10-, 25-, 50-, and 100-year flood events. Also included is a map of the existing FEMA floodplain and the Soap Lake floodplain area.

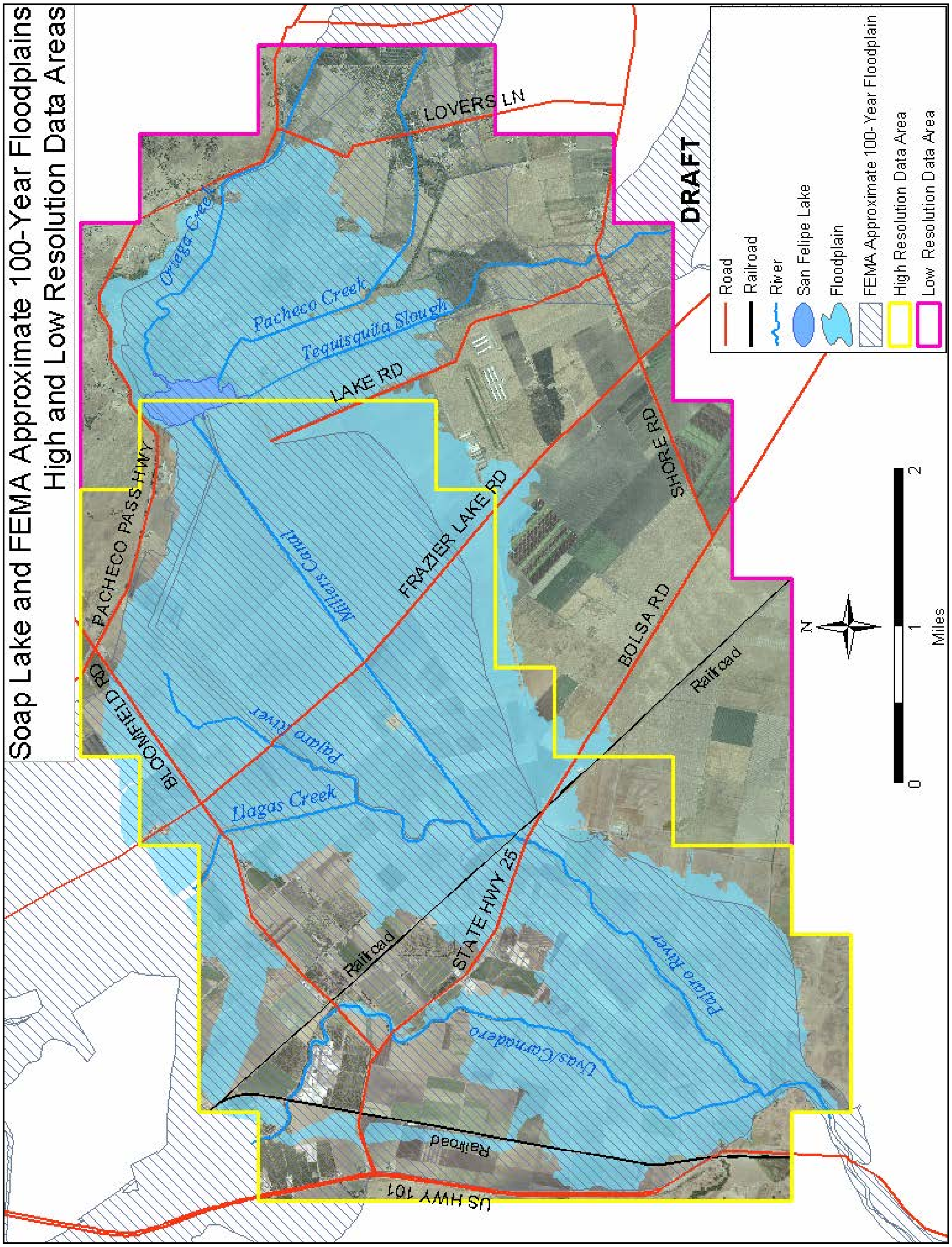

Soap Lake 2-Year Floodplain
DRAFT
Road
Railroad
River
San Felipe Lake
Floodplain
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slough
LAKE RD
PACHECO PASS HWY
Millers Canal
FRAZIER LAKE RD
SHORE RD
BOLSA RD
Railroad
BLOOMFIELD RD
Pajaro River
Llagas Creek
STATE HWY 25
Railroad
Pajaro River
Uvas/Carnadero
Railroad
US HWY 101
N
0
1
2
Miles


Soap Lake 10-Year Floodplain
DRAFT
Road
Railroad
River
San Felipe Lake
Floodplain
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slough
LAKE RD
PACHECO PASS HWY
Millers Canal
FRAZIER LAKE RD
SHORE RD
BOLSA RD
Railroad
BLOOMFIELD RD
Pajaro River
Llagas Creek
STATE HWY 25
Railroad
Pajaro River
Uvas/Carnadero
Railroad
US HWY 101
N
0
1
2
Miles


Soap Lake 25-Year Floodplain
DRAFT
Road
Railroad
River
San Felipe Lake
Floodplain
0
1
2
Miles
N
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slough
LAKE RD
PACHECO PASS HWY
Millers Canal
FRAZIER LAKE RD
SHORE RD
BOLSA RD
Railroad
BLOOMFIELD RD
Pajaro River
Llagas Creek
STATE HWY 25
Railroad
Pajaro River
Uvas/Carnadero
Railroad
US HWY 101


Soap Lake 50-Year Floodplain
DRAFT
Road
Railroad
River
San Felipe Lake
Floodplain
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slough
LAKE RD
PACHECO PASS HWY
Millers Canal
FRAZIER LAKE RD
SHORE RD
BOLSA RD
Railroad
BLOOMFIELD RD
Pajaro River
Llagas Creek
STATE HWY 25
Railroad
Uvas/Carnadero
Pajaro River
Railroad
US HWY 101
N
0
1
2
Miles


Soap Lake 100-Year Floodplain
DRAFT
Road
Railroad
River
San Felipe Lake
Floodplain
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slough
LAKE RD
PACHECO PASS HWY
FRAZIER LAKE RD
SHORE RD
Millers Canal
BOLSA RD
Railroad
N
0
1
2
Miles
BLOOMFIELD RD
Pajaro River
Llagas Creek
STATE HWY 25
Railroad
Pajaro River
Uvas/Carnadero
Railroad
US HWY 101


Soap Lake and FEMA Approximate 100-Year Floodplains
High and Low Resolution Data Areas
DRAFT
Road
Railroad
River
San Felipe Lake
Floodplain
FEMA Approximate 100-Year Floodplain
High Resolution Data Area
Low Resolution Data Area
0
1
2
Miles
N
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slough
LAKE RD
PACHECO PASS HWY
Millers Canal
FRAZIER LAKE RD
SHORE RD
BOLSA RD
Railroad
BLOOMFIELD RD
Pajaro River
Llagas Creek
STATE HWY 25
Uvas/Carnadero
US HWY 101

PAJARO RIVER WATERSHED
FLOOD PREVENTION AUTHORITY
Phase 3: Conceptual Design of Soap Lake Preservation Project
Phase 4a: Design Level Mapping Technical Support

Technical Memorandum No. 3.5

Raines, Melton & Carella, Inc.

Task: **Impacted Facilities Assessment**

To: **PRWFPA Staff Working Group**

Prepared by: **Tim Harrison**

Reviewed by: **Lidia Gutierrez, Karen Frye**

Date: **August 18, 2004**

Reference: **0053-003.5**

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Introduction

This technical memorandum (TM) describes the results of work completed as part of Task 3.5: Impacted Facilities Assessment of the Pajaro River Watershed Study. RMC was tasked with identifying impacted facilities in a range of flood events. The methodology used to determine the impacted facilities is described as are the benefits and limitations of the method.

Phase 3 of the Pajaro River Watershed Study (Study) is a continuation of the Pajaro River Watershed Flood Prevention Authority's (Authority) efforts to provide flood protection to areas below the confluence of the Pajaro and San Benito rivers. Phase 1 of the Study consisted of hydrologic, hydraulic, and sediment modeling of the entire watershed. Model results of the 2-, 10-, 25-, 50-, and 100-year flows at critical locations on the Pajaro River were developed. Phase 2 of the Study consisted of developing flood protection alternatives and project packages to manage the modeled 100-year flows.

One of the most significant conclusions coming out of both Phase 1 and Phase 2 was the importance of the Soap Lake floodplain to the Pajaro Valley flood protection solution. Soap Lake, located along the Pajaro River between San Felipe Lake and upstream of Hwy 101, currently detains storm water flows from the Upper Pajaro River watershed upstream of the Pajaro River confluence with the San Benito River. Loss of this natural detention would increase the magnitude of flooding downstream of the confluence. Figure 1 shows the entire watershed highlighting the Upper Pajaro and San Benito subwatersheds as well as the location of Soap Lake.

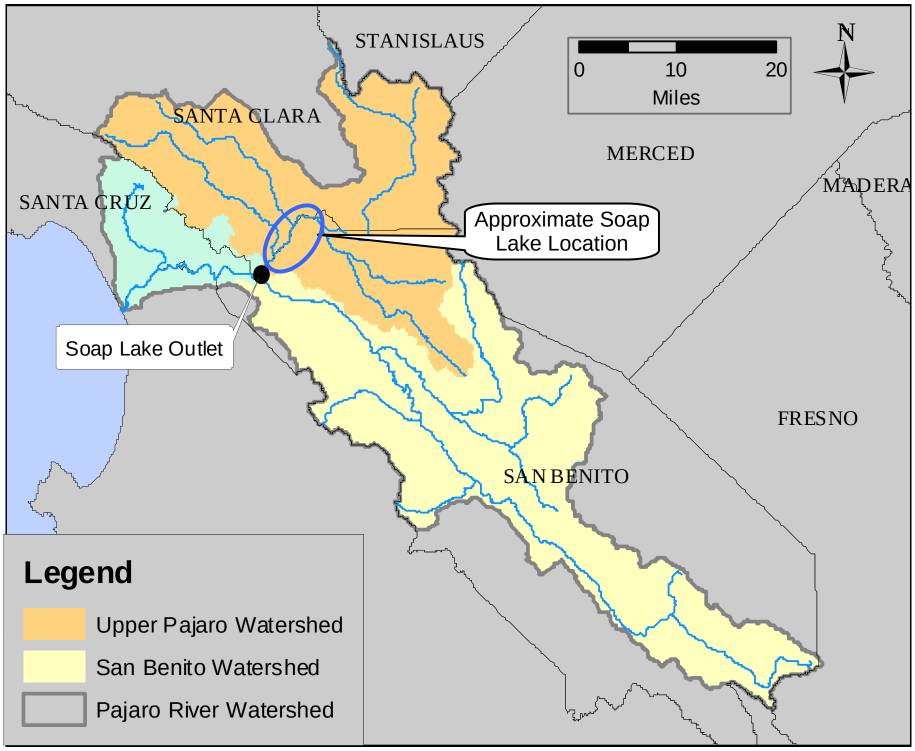


Figure 1: Pajaro River Watershed. The major upper subwatersheds are highlighted.

The Soap Lake floodplain is a natural detention basin, storing water and reducing peak flows that would otherwise increase flooding in the lower Pajaro River. Upper Soap Lake is also known as San Felipe Lake and is a permanent body of water. The Soap Lake floodplain lies along the Pajaro River within San Benito and Santa Clara Counties between San Felipe Lake and the Highway 101 crossing (Figure 2). The main land use is agriculture, including row crops and pasture land. During significant rain events, the low-lying areas of the Soap Lake area become flooded and there is flow backup on the Pajaro River upstream of the San Benito River.

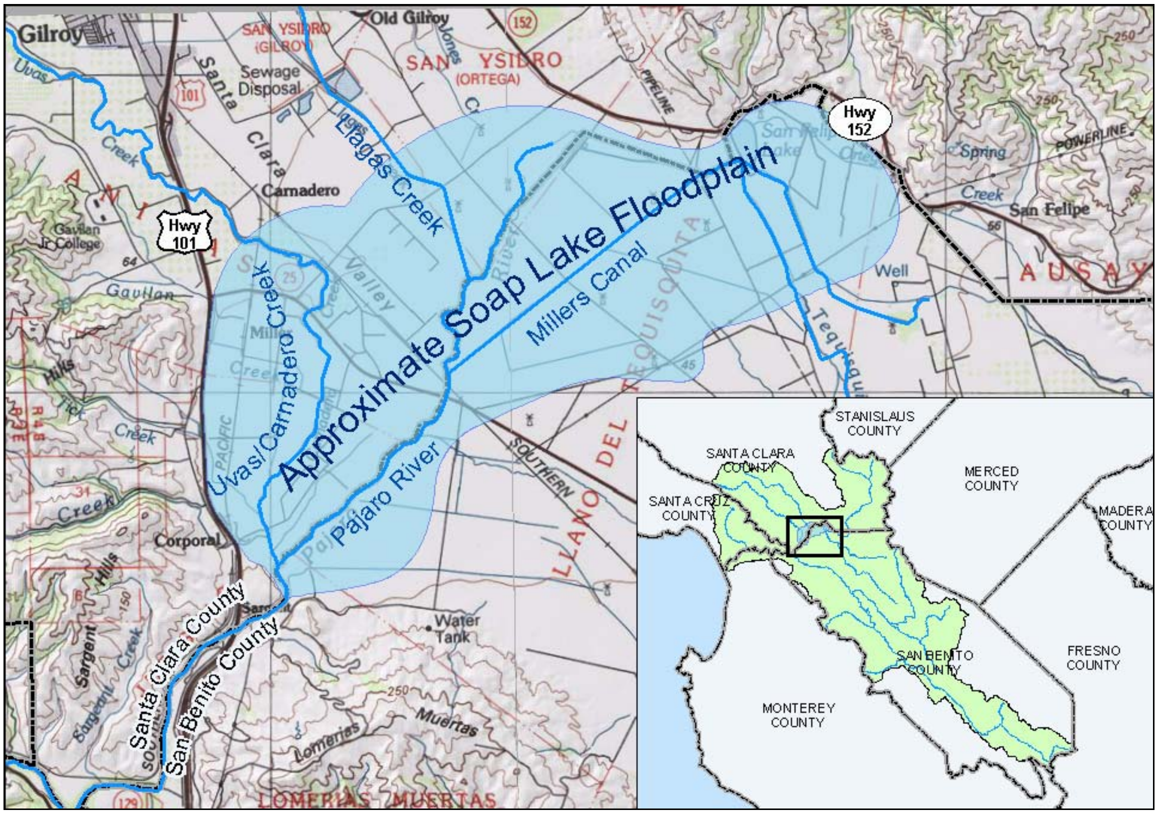


Figure 2: Soap Lake study area.

Work completed earlier in Phase 3, described in TM 3.3-4, models and maps the 2-, 10-, 25-, 50-, and 100-year Soap Lake floodplains. These floodplains are the basis of the impacted facility assessment.

Assessment Methodology

This section describes the methodology used to assess the impact of a range of flood events on study area facilities and features.

Process

GIS tools and data were used to identify facilities in the Soap Lake floodplain. Facilities such as roads, bridges, and railroads were digitized from the aerial photography. Pipelines and seismic faults were obtained from other sources and are described below. Soap Lake floodplains for the 2-, 10-, 25-, 50-, and 100-year flood events have been developed as a part of this study. These are also in GIS grid and shapefile formats. The study area features were clipped based on the extent of the different floodplains. This process yielded small segments of each facility that were within the extent of the floodplains. The length or area of each of these impacted segments was calculated. The sum of these segments' lengths and areas is the total amount of facility impacted for a given flood event.

Process Benefits and Limitations

Utilizing GIS tools provides precision in the calculation of impact length and area but the accuracy of the measurement is dependent on many things. This section describes the benefits and limitations of using GIS in this analysis.

GIS spatial analysis is a very good way to quickly assess the impact of an event like flooding. It is also believed to be much more accurate than field work. The field work would involve estimation of the limits of flooding based on relative location to visual land marks as well as traversing the floodplain area. In a large, rural area like Soap Lake, much of the land is inaccessible without numerous permissions from private land owners. The GIS clipping process is precise to within fractions of an inch. While not necessarily required for this gross analysis, this type of precision does provide some level of confidence that segments or sections of the identified facilities are not being overlooked as they could be if measured by hand.

The GIS analysis is limited by the accuracy of the data that is used in the clipping process. This accuracy is primarily a factor of scale. If the feature data was created at a large scale, it would be appropriate for that scale but its applications are somewhat limited at a smaller scale. At scales smaller than for what the data was intended, the features, such as roads, will appear to be poorly digitized. If a feature is misplaced, too large, or too small, the quantification of impact will be affected. Concerns with the accuracy of individual facilities will be discussed in future sections. In addition to the facility scale and accuracy, it is necessary also to consider the floodplain accuracy. The accuracy of the floodplains is limited by the accuracy of the floodplain model assumptions and the assumptions of the hydraulic model. Also, a grid with 20-foot spacing was used to model the floodplains. When the grid was turned into a shapefile, the edges were generalized. As a result, based on the pythagorian theorem, the edge of the floodplain may be up to 14 feet different from the grid centerpoints. The overall result of the generalization provides a smooth floodplain with very good overall accuracy. It is anticipated that the areas included and not included in the floodplain are approximately equal and would average out over the study area. Figure 3 gives an example of the generalization effect.

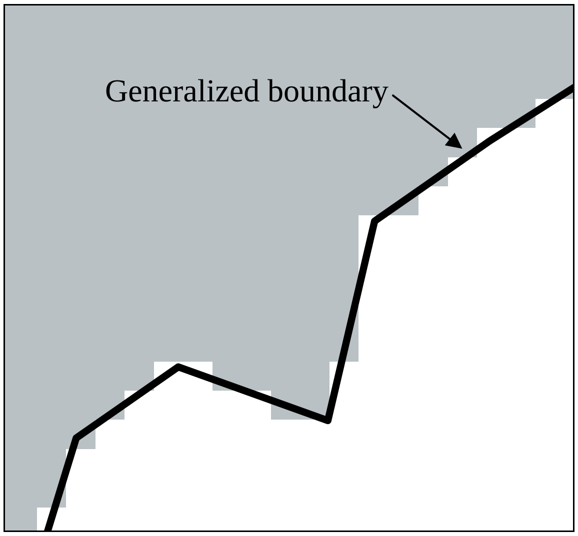


Figure 3: Generalization effect. White space on the gray side of the black line and vice versa are flooded areas not included or non-flooded areas included in the floodplains. The overall floodplain boundary is a good approximation based on the information available.

Facility Description

This section describes the facilities included in the analysis. Any deviations from the method described above are also described.

Roads and Highways

Two files were used to quantify the impact of the flooding on roads and highways. The first, a polygon file, has a very high level of accuracy and was digitized from the aerial photography and topography used to generate the hydraulic model and floodplains. The polygon road layer represents the major roads such as Hwy 101, Hwy 25, Bloomfield Rd, Frazier Lake Rd, Bolsa Rd, Lake Rd, and Lovers Ln, as well as many of the minor roads. The other, a line file, represents the centerlines of the polygon road file described above. The polygon road layer is used to give an estimate of road area impacted and the line road layer is used to estimate the length of road impacted.

Bridges

Bridge impacts were not quantified using the general method described earlier in this TM. Instead, impacted bridges were counted. Bridges were considered to be impacted if they bordered or crossed the boundaries of the floodplain. It is assumed that an extended floodplain at the bridge location would lead to structural or traffic flow impacts. No analysis was performed to determine if water would overtop the bridge, nor was there analysis of velocity or scour potential.

Railroads

The impact of flooding to railroads is quantified similarly to roads. A polygon file was digitized to capture the edge of the railroad right-of-way (ROW). A centerline file was created based on the boundaries of the polygon file. These files have a high level of accuracy. The impacted area and length calculated for this feature includes impacted railroad bridges that are also counted as part of the bridge features.

Utilities

Two utilities, the Santa Clara Conduit and the proposed Pajaro Valley Water Management Agency (PVWMA) Import Pipeline, were the focus of this facility type. No accuracy information was available for the Santa Clara Conduit line file but it is believed to be reasonably accurate. The PVWMA pipeline line file was digitized from design documentation that was current as of the date of this TM. Some small changes in alignment are expected by final design and construction. The length calculated from these two files is considered to be fairly accurate.

Seismic Faults

The locations of seismic faults were obtained from the CA Department of Conservation Division of Mines and Geology through CD 2001-04: GIS files of Official Alquist-Priolo Earthquake Fault Zones. The most significant faults within the Soap Lake are the Sargent Fault and Calaveras Fault. The magnitude of impact is quantified by calculating the length of the fault lines that are within the floodplain.

Special Structures

Special structures were designated based on a visual inspection of aerial photography. Compounds and structures within the floodplains that did not appear to be single homes or small, private structures were included in the facility count.

Impacted Facilities

All of the facilities described above are impacted for floods with return periods between 2 and 100 years with the exception of special facilities, which are impacted for floods with return periods between 50 and 100 years. Table 1 below summarizes the effects and impact of flooding on each of the described facilities.

Table 1: Summary of flooding impacts.

Facility	Impact
Highway/Roadway	Slows or stops traffic and commerce
Bridges	Slows or stops traffic and commerce
Railroad	Slows or stops rail traffic and commerce
Utility	Damage to infrastructure, inability to repair damage leading to no delivery of drinking or irrigation water
Seismic Faults	Inability to repair damage caused by ground shaking during flood
Special Structures	Damage to airplanes and equipment, release of chemicals

In addition to the described facilities, there may be other utilities or proposed projects that were not included in the analysis due to lack of available information. One such project is the California High-Speed Train System. For this project, two route options are being explored that will traverse the Soap Lake project area at grade. Figure 4 shows the Draft EIR/EIS maps available for the high-speed rail project in this area. Another upcoming project that could impact or be impacted by flooding is the widening of Hwy 25 and construction of new bridges. It is important that agencies and organizations responsible for this and similar projects be aware of the critical nature of the Soap Lake floodplain and how their projects might impact flooding locally and downstream.

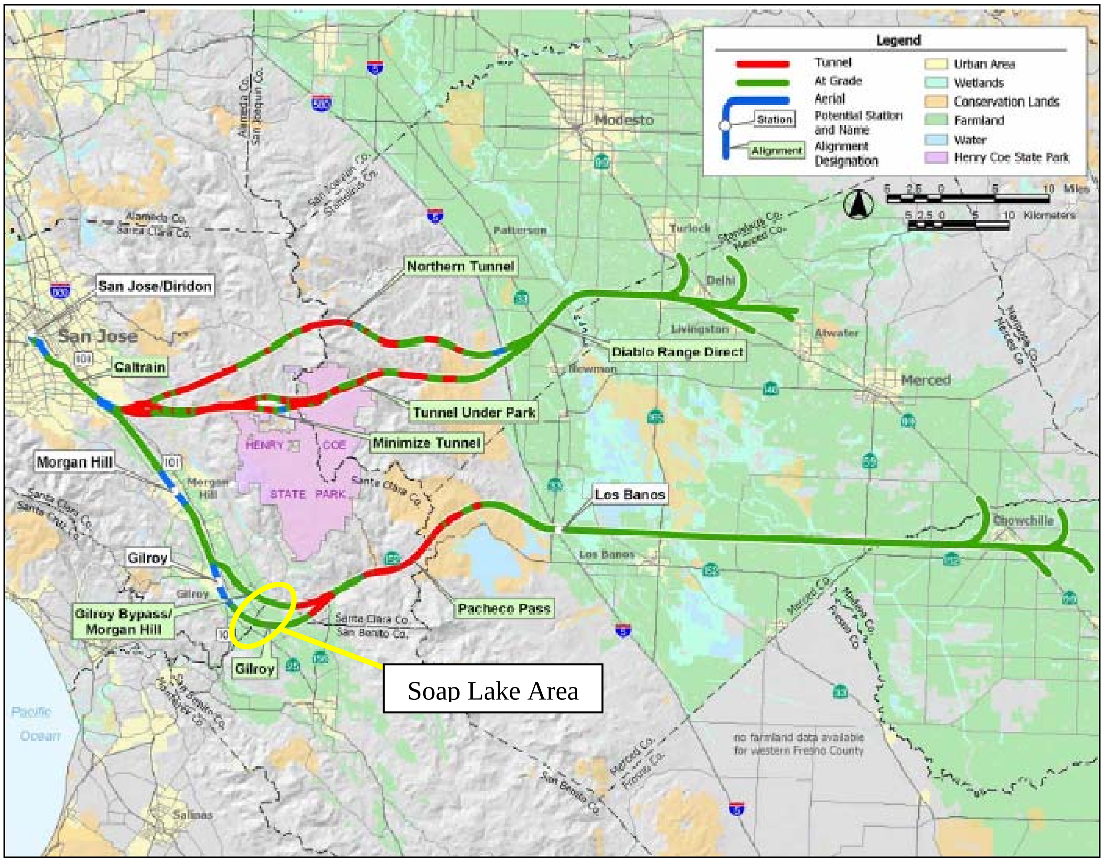
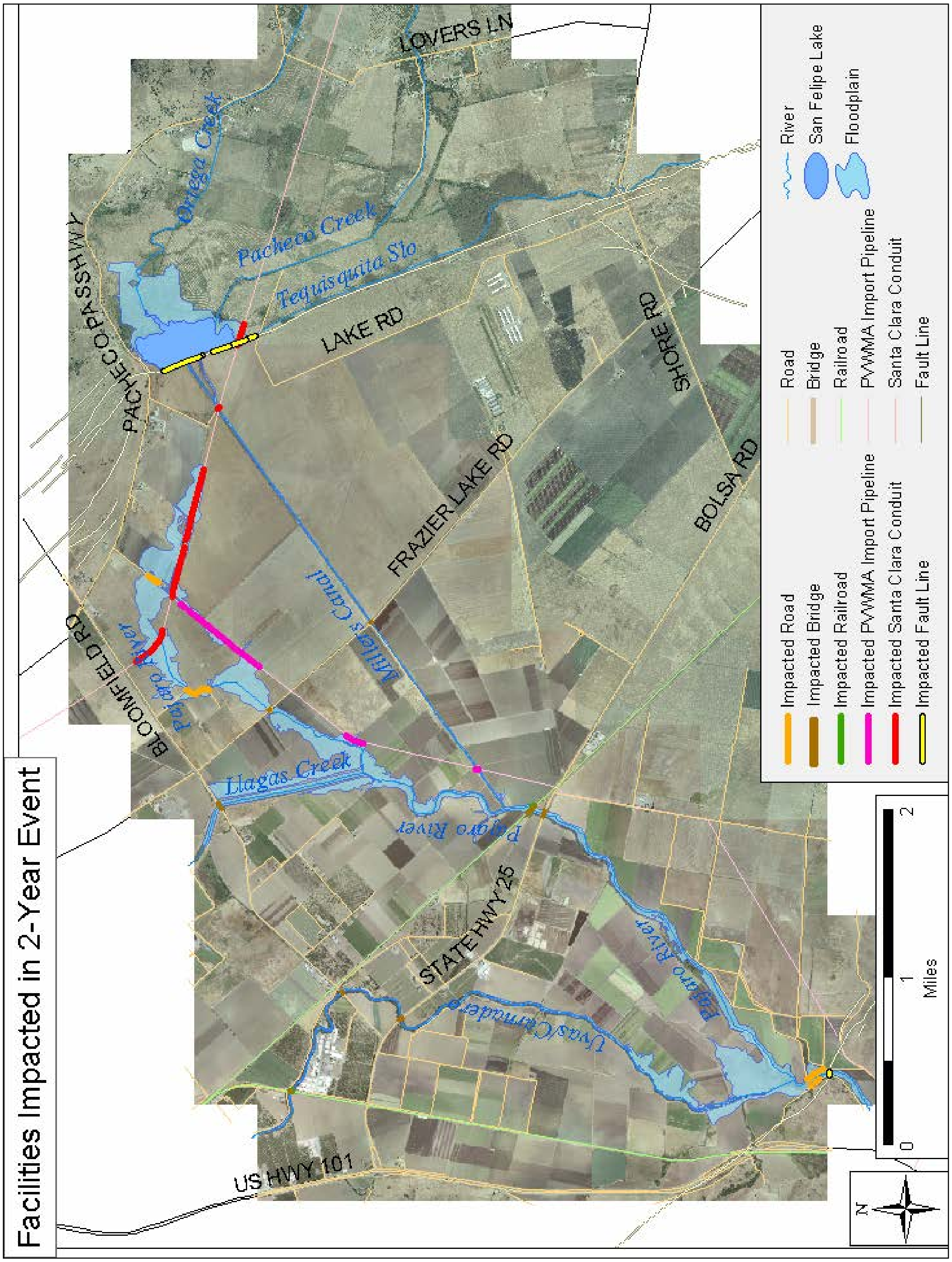


Figure 4: High-speed rail options between San Jose and the central valley. Map from the CA High-Speed Rail Draft EIS/EIR.

The following tables summarize the results of the impacted facilities analyses and calculations. The values represent a general, watershed overview of the impacted facilities. Detailed analysis should be undertaken to evaluate flood impacts at particular areas of concern. The figures show the location of the impacted facilities.

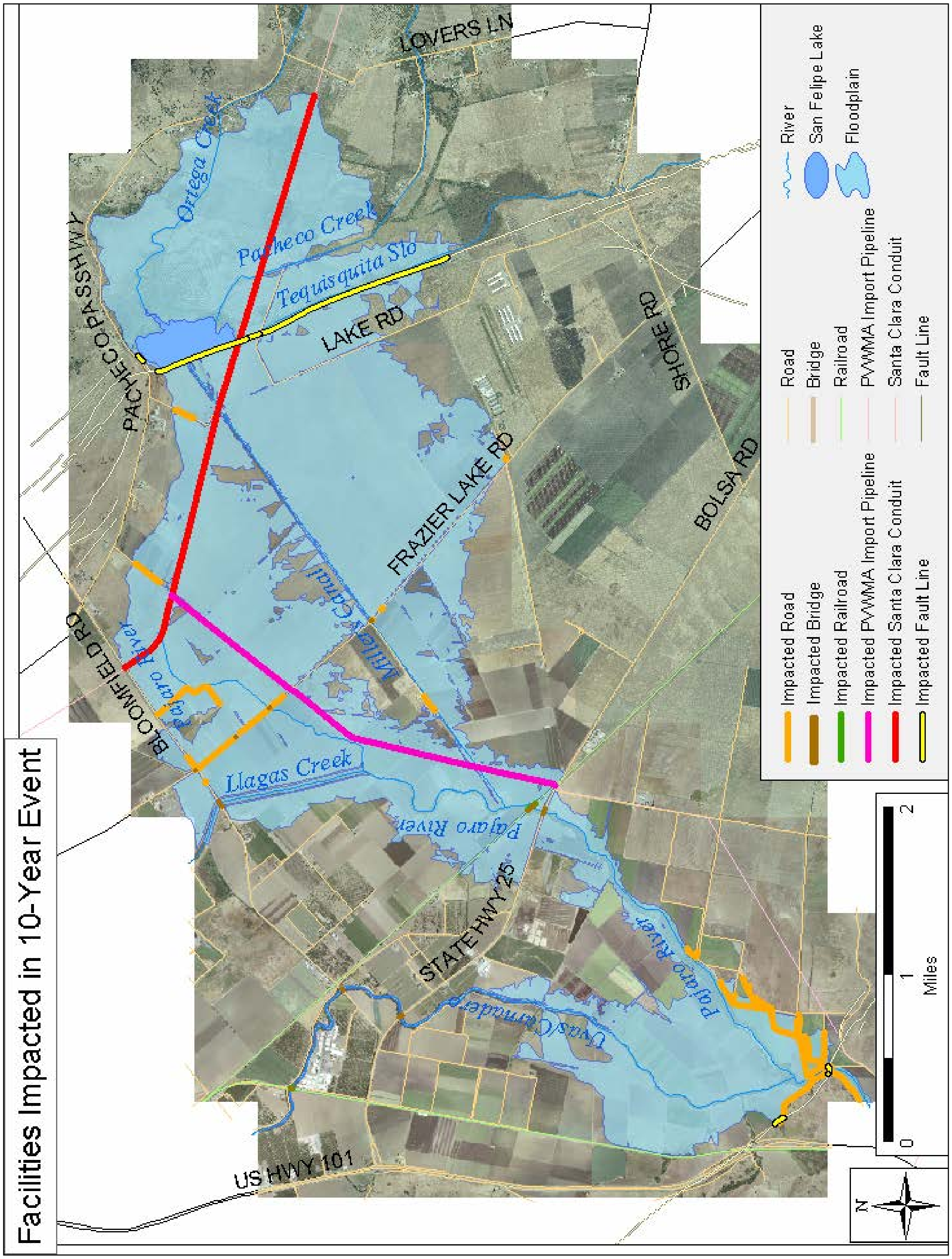
2-Year Flood Impacts

Facility Type	Impact	Length/Area of Impact	Examples
Highway/Roadways	Yes	1,300 ft; 12,800 sf	Hwy 25, Frazier Lake Rd, Bloomfield Rd
Bridges	Yes	8 Bridges	Bloomfield @ Llagas, Railroad @ Pajaro, Hwy 25 @ Pajaro, Bloomfield @ Carnadero, Hwy 25 @ Carnadero, Railroad @ Carnadero
Railroad	Yes	300 ft; 4,500 sf	Railroad bridges at Pajaro and Carnadero
Utility	Yes	9,400 ft	Santa Clara Conduit, PVWMA Import Pipeline
Seismic Fault	Yes	2,600 ft	Sargent
Special Structures	No	-	-


Facilities Impacted in 2-Year Event
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slo
PACHECO PASS HWY
LAKE RD
SHORE RD
FRAZIER LAKE RD
BOLSA RD
BLOOMFIELD RD
Pajaro River
Millers Canal
Llagas Creek
STATE HWY 25
Uvas/Carnadero
US HWY 101
Impacted Road
Impacted Bridge
Impacted Railroad
Impacted PVWMA Import Pipeline
Impacted Santa Clara Conduit
Impacted Fault Line
Road
Bridge
Railroad
PVWMA Import Pipeline
Santa Clara Conduit
Fault Line
River
San Felipe Lake
Floodplain
0
1
2
Miles
N

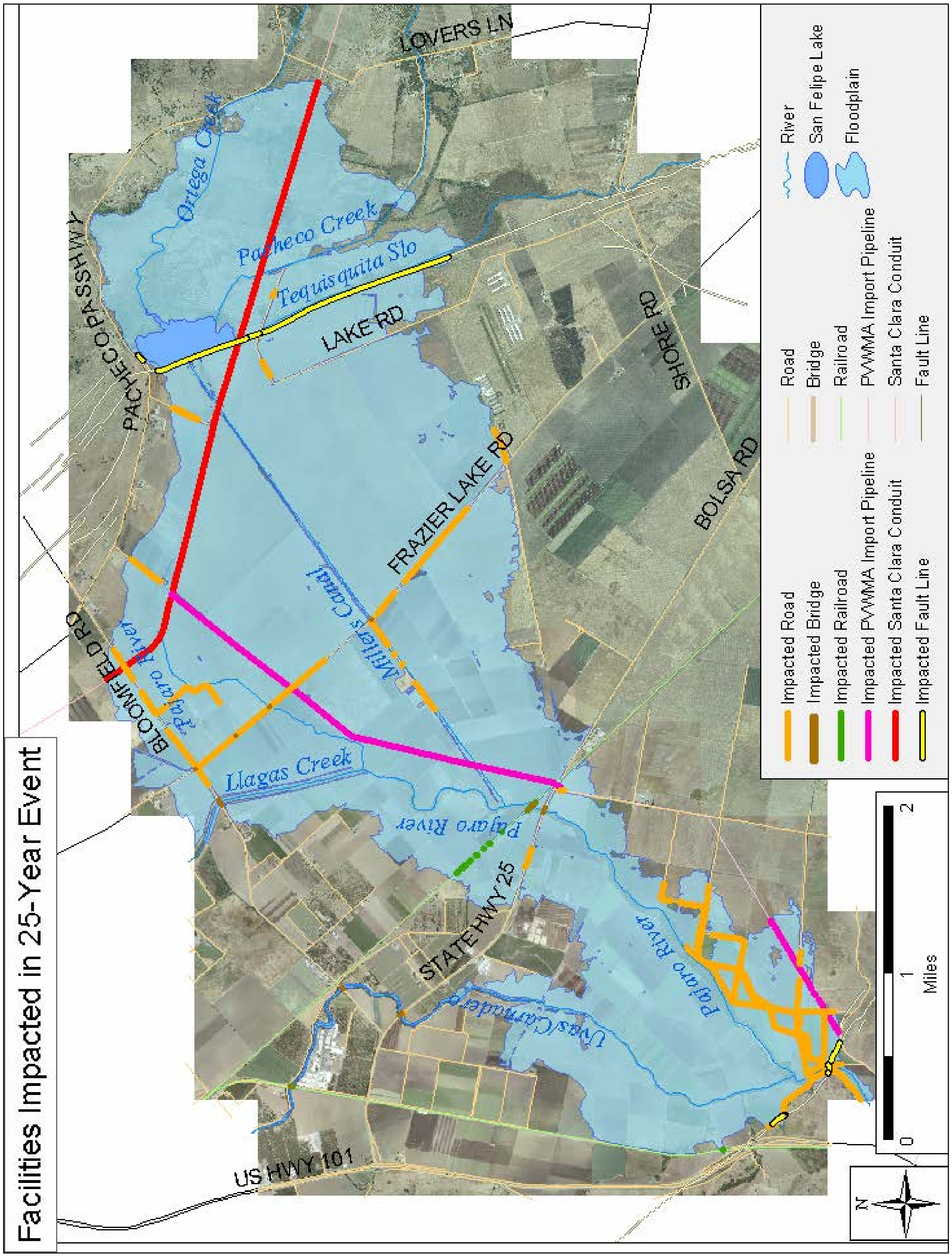
10-Year Flood Impacts

Facility Type	Impact	Length/Area of Impact	Examples
Highway/Roadways	Yes	23,400 ft; 298,000 sf	Hwy 25, Frazier Lake Rd, Bloomfield Rd, Bolsa Rd
Bridges	Yes	10 Bridges	Bloomfield @ Llagas, Railroad @ Pajaro, Hwy 25 @ Pajaro, Bloomfield @ Carnadero, Hwy 25 @ Carnadero, Railroad @ Carnadero, Frazier Lake @ Pajaro, Frazier Lake @ Millers
Railroad	Yes	400 ft; 5,000 sf	Railroad bridges at Pajaro and Carnadero, Railroad at Tic
Utility	Yes	32,800 ft	Santa Clara Conduit, PVWMA Import Pipeline
Seismic Fault	Yes	10,500 ft	Sargent, Calaveras
Special Structures	No	-	-


Facilities Impacted in 10-Year Event
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slo
LAKE RD
PACHECO PASS HWY
SHORE RD
FRAZIER LAKE RD
BOLSA RD
Millers Canal
BLOOMFIELD RD
Pajaro River
Llagas Creek
STATE HWY 25
Uvas/Carnadero
US HWY 101
River
San Felipe Lake
Floodplain
Road
Bridge
Railroad
PVWMA Import Pipeline
Santa Clara Conduit
Fault Line
Impacted Road
Impacted Bridge
Impacted Railroad
Impacted PVWMA Import Pipeline
Impacted Santa Clara Conduit
Impacted Fault Line
0
1
2
Miles
N

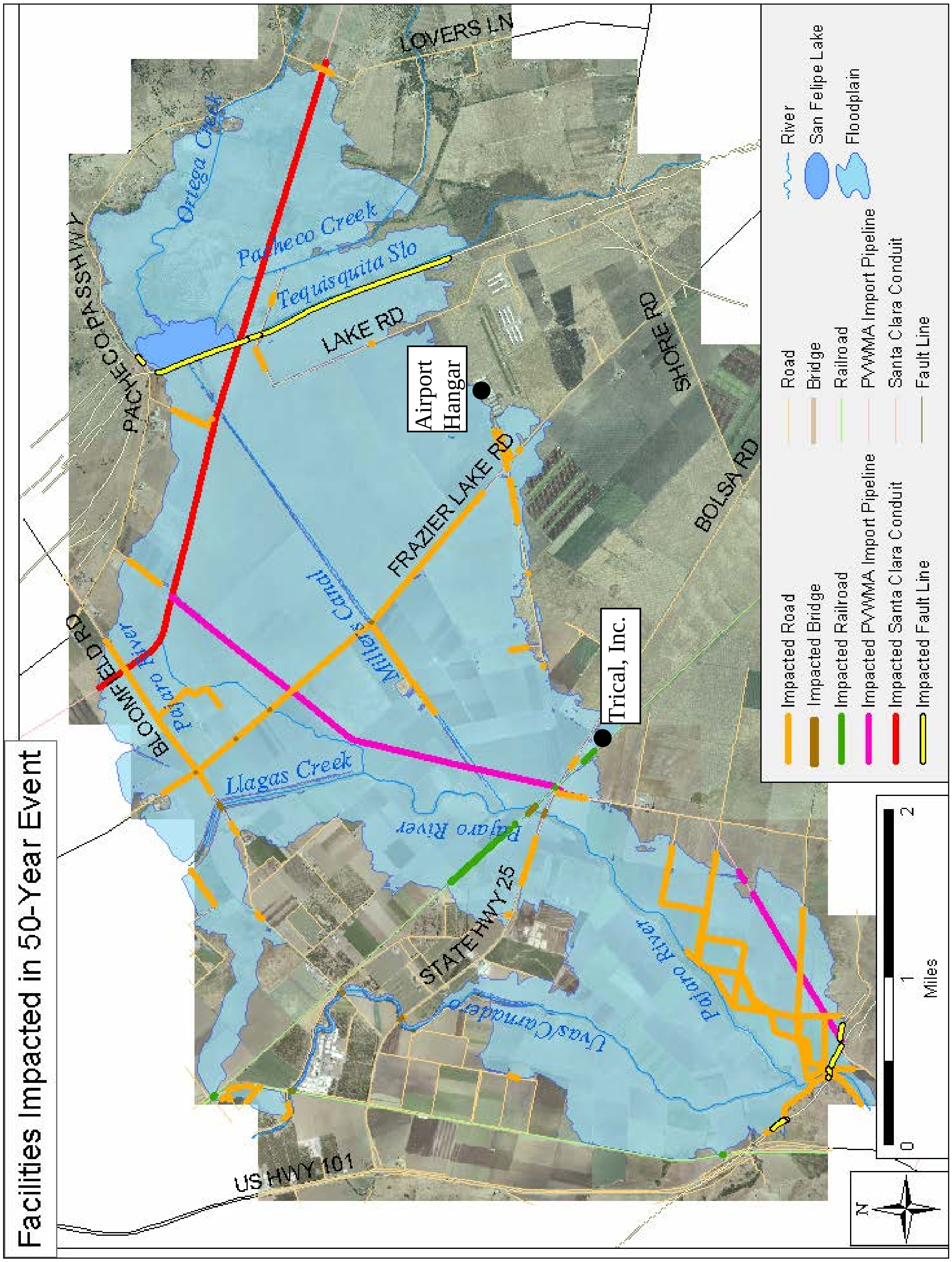
25-Year Flood Impacts

Facility Type	Impact	Length/Area of Impact	Examples
Highway/Roadways	Yes	52,400 ft; 813,000 sf	Hwy 25, Frazier Lake Rd, Bloomfield Rd, Bolsa Rd
Bridges	Yes	10 Bridges	Bloomfield @ Llagas, Railroad @ Pajaro, Hwy 25 @ Pajaro, Bloomfield @ Carnadero, Hwy 25 @ Carnadero, Railroad @ Carnadero, Frazier Lake @ Pajaro, Frazier Lake @ Millers
Railroad	Yes	500 ft; 12,700 sf	Railroad bridges at Pajaro, Railroad at Tic, Railroad NW of Pajaro bridge
Utility	Yes	38,000 ft	Santa Clara Conduit, PVWMA Import Pipeline
Seismic Fault	Yes	11,400 ft	Sargent, Calaveras
Special Structures	No	-	-


Facilities Impacted in 25-Year Event
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slo
LAKE RD
PACHECO PASS HWY
SHORE RD
BOLSA RD
FRAZIER LAKE RD
Millers Canal
BLOOMFIELD RD
Pajaro River
Llagas Creek
Pajaro River
STATE HWY 25
Pajaro River
Uvas/Carnadero
US HWY 101
River
San Felipe Lake
Floodplain
Road
Bridge
Railroad
PVWMA Import Pipeline
Santa Clara Conduit
Fault Line
Impacted Road
Impacted Bridge
Impacted Railroad
Impacted PVWMA Import Pipeline
Impacted Santa Clara Conduit
Impacted Fault Line
0
1
2
Miles
N

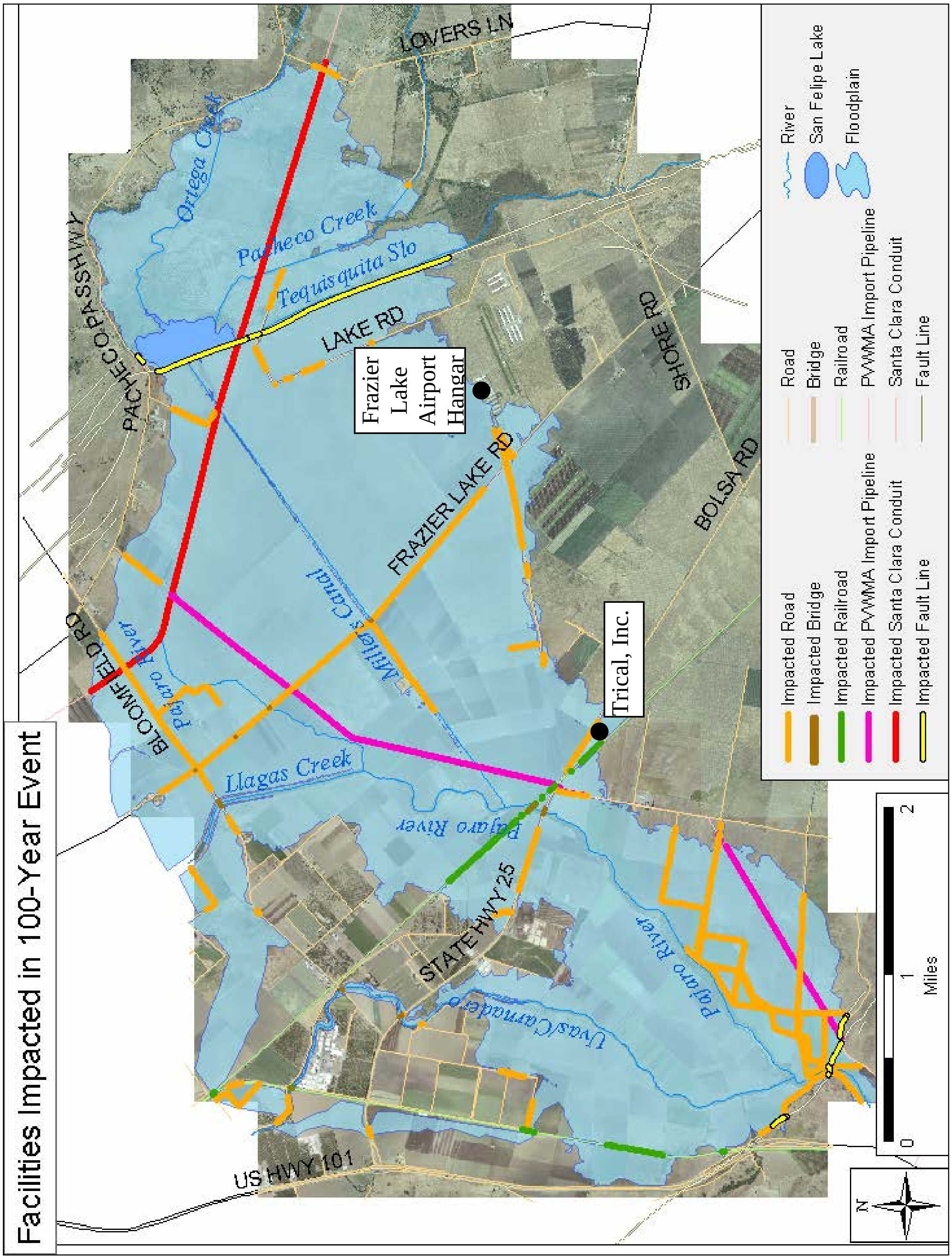
50-Year Flood Impacts

Facility Type	Impact	Length/Area of Impact	Examples
Highway/Roadways	Yes	75,200 ft; 1,270,000 sf	Hwy 25, Frazier Lake Rd, Bloomfield Rd, Bolsa Rd
Bridges	Yes	10 Bridges	Bloomfield @ Llagas, Railroad @ Pajaro, Hwy 25 @ Pajaro, Bloomfield @ Carnadero, Hwy 25 @ Carnadero, Railroad @ Carnadero, Frazier Lake @ Pajaro, Frazier Lake @ Millers
Railroad	Yes	1,700 ft; 59,200 sf	Railroad bridges at Pajaro, Railroad at Tic, Railroad NW & SE of Pajaro bridge, Intersection of railroad lines
Utility	Yes	41,600 ft	Santa Clara Conduit, PVWMA Import Pipeline
Seismic Fault	Yes	12,000 ft	Sargent, Calaveras
Special Structures	Yes	2 sites	TriCal, Inc., Airport Hangars


Facilities Impacted in 50-Year Event
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slo
PACHECO PASS HWY
LAKE RD
Airport Hangar
SHORE RD
FRAZIER LAKE RD
BOLSA RD
Miller's Canal
BLOOMFIELD RD
Pajaro River
Trical, Inc.
Llagas Creek
Pajaro River
STATE HWY 25
Uvas/Carnadero
Pajaro River
US HWY 101
Impacted Road
Impacted Bridge
Impacted Railroad
Impacted PVWMA Import Pipeline
Impacted Santa Clara Conduit
Impacted Fault Line
Road
Bridge
Railroad
PVWMA Import Pipeline
Santa Clara Conduit
Fault Line
River
San Felipe Lake
Floodplain
0
1
2
Miles
N

100-Year Flood Impacts

Facility Type	Impact	Length/Area of Impact	Examples
Highway/Roadways	Yes	89,100 ft; 1,580,000 sf	Hwy 25, Frazier Lake Rd, Bloomfield Rd, Bolsa Rd
Bridges	Yes	10 Bridges	Bloomfield @ Llagas, Railroad @ Pajaro, Hwy 25 @ Pajaro, Bloomfield @ Carnadero, Hwy 25 @ Carnadero, Railroad @ Carnadero, Frazier Lake @ Pajaro, Frazier Lake @ Millers
Railroad	Yes	5,100 ft; 167,000 sf	Railroad bridges at Pajaro, Railroad at Tic, Railroad NW & SE of Pajaro bridge, Intersection of railroad lines
Utility	Yes	43,800 ft	Santa Clara Conduit, PVWMA Import Pipeline
Seismic Fault	Yes	12,200 ft	Sargent, Calaveras
Special Structures	Yes	2 sites	TriCal, Inc., Airport Hangars


Facilities Impacted in 100-Year Event
LOVERS LN
Ortega Creek
Pacheco Creek
Tequisquita Slo
PACHECO PASS HWY
LAKE RD
Frazier Lake Airport Hangar
SHORE RD
FRAZIER LAKE RD
BOLSA RD
Millers Canal
BLOOMFIELD RD
Pajaro River
Trical, Inc.
Llagas Creek
Pajaro River
STATE HWY 25
Uvas/Carnadero
Pajaro River
US HWY 101
River
San Felipe Lake
Floodplain
Road
Bridge
Railroad
PVWMA Import Pipeline
Santa Clara Conduit
Fault Line
Impacted Road
Impacted Bridge
Impacted Railroad
Impacted PVWMA Import Pipeline
Impacted Santa Clara Conduit
Impacted Fault Line
0
1
2
Miles
N

Conclusions

Work completed for Task 5 of Phase 3 of the Study has shown that flooding within the Soap Lake study area can cause significant damage and create significant impacts. These impacts will be important locally within the study area but also regionally and potentially state-wide. Railroads, highways, and pipelines within the study area impact potable and irrigation water supplies, commercial and emergency transportation routes, and potentially significant intercity routes. It should be noted however, that the Soap Lake Preservation Project does not increase the risk of damage above the baseline level.

This study has shown and provided a planning level estimate of the amount of damage caused by a range of flood magnitudes. If necessary, this estimate can be used to approximate the damage costs and mitigation required after a flood occurs.

PAJARO RIVER WATERSHED
FLOOD PREVENTION AUTHORITY
Phase 3: Conceptual Design of Soap Lake Preservation Project
Phase 4a: Design Level Mapping Technical Support

Technical Memorandum No. 3.6

Raines, Melton & Carella, Inc.

Task:	**Land Acquisition Needs Assessment**
To:	**PRWFPA Staff Working Group**
Prepared by:	**Tim Harrison**
Reviewed by:	**Lidia Gutierrez, Karen Frye**
Date:	**August 18, 2004**
Reference:	**0053-003.6**

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Introduction

This technical memorandum (TM) describes the results of work completed as part of Task 3.6: Land Acquisition Needs Assessment of the Pajaro River Watershed Study. RMC was tasked with identifying land acquisition needs for the project and developing a preliminary list of right-of-way needs. This TM prioritizes the order of acquisition of sections of Soap Lake based on flooding frequency. Also included is discussion regarding fee title purchases and easements as well as who should maintain ownership of the land. Guidelines and considerations for parcel purchase are also summarized.

Background

Phase 3 of the Pajaro River Watershed Study (Study) is a continuation of the Pajaro River Watershed Flood Prevention Authority's (Authority) efforts to provide flood protection to areas below the confluence of the Pajaro and San Benito rivers. Phase 1 of the Study consisted of hydrologic, hydraulic, and sediment modeling of the entire watershed. Model results of the 2-, 10-, 25-, 50-, and 100-year flows at four representative locations on the Pajaro River were developed. Phase 2 of the Study consisted of developing flood protection alternatives and project packages to manage the modeled 100-year flows.

Soap Lake Floodplain

One of the most significant conclusions coming out of both Phase 1 and Phase 2 was the importance of the Soap Lake floodplain to the Pajaro Valley flood protection solution. The Soap Lake floodplain currently detains storm water flows from the Upper Pajaro River watershed upstream of the Pajaro River confluence with the San Benito River. Loss of this natural detention would increase the magnitude of flooding downstream of the confluence. Figure 1 shows the entire watershed highlighting the Upper Pajaro and San Benito subwatersheds as well as the location of the Soap Lake floodplain.

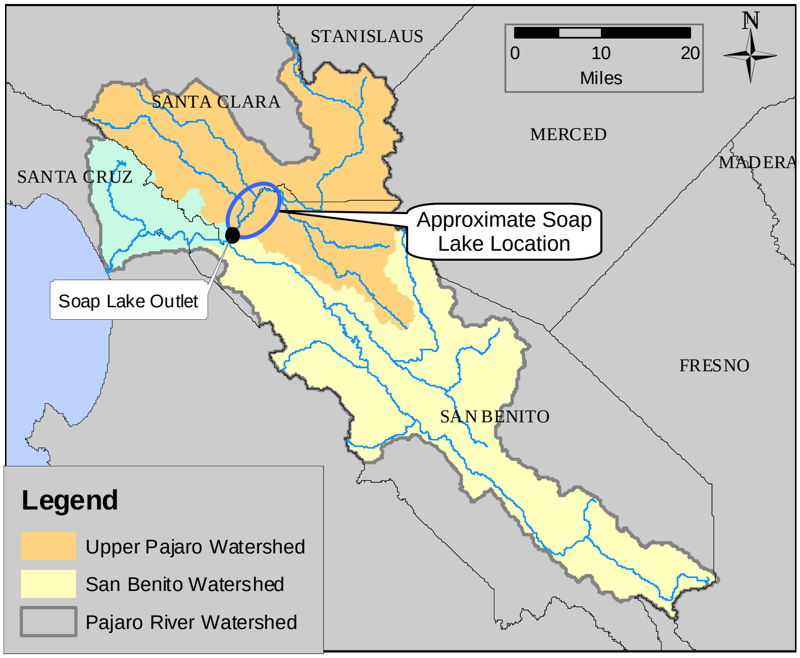


Figure 1: Pajaro River Watershed. The major upper subwatersheds are highlighted.

The Soap Lake floodplain is a natural detention basin, storing water and reducing peak flows that would otherwise increase flooding in the lower Pajaro River. Upper Soap Lake is also known as San Felipe Lake and is a permanent body of water. The Soap Lake floodplain lies along the Pajaro River within San Benito and Santa Clara Counties between upstream of San Felipe Lake and upstream of the Highway 101 crossing (Figure 2). The main land use is agriculture, including row crops and pasture land. During significant rain events, the low-lying areas of the Soap Lake area become flooded and there is flow backup on the Pajaro River upstream of the San Benito River.

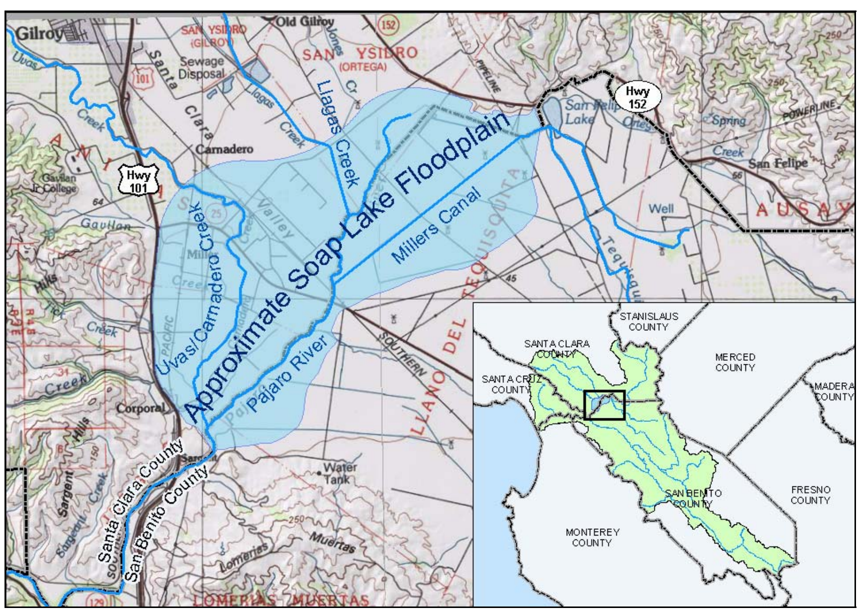


Figure 2: Soap Lake study area.

Work completed earlier in Phase 3, described in TM 3.3-4, models and maps the 2-, 10-, 25-, 50-, and 100-year Soap Lake floodplains. These floodplains are the basis of the land acquisition needs assessment.

Primary Acquisition Options

There are many options available to the Authority to acquire or encourage acquisition of land rights. Two of these options, conservation easements and fee title purchases, are considered to be the most viable options and are the focus of this TM.

Conservation Easement Description

A flood or agricultural conservation easement is a legal agreement between the landowner and another party to restrict the uses of and activities on a piece of property while preserving the landowner's ownership of the property. The original landowner can also sell the property to a new owner and easement to a third party at the same time. The easement purchase would restrict the building of structures that could be damaged during floods or that could result in increased runoff and increased downstream flooding. Examples of such structures include buildings, fill materials, septic tanks, and parking lots and other paved areas.

There are several conservation easements already within the Soap Lake area and can be seen in Figure 3. These include:

- Carnadero Preserve: 478 total acres have been acquired. 198 acres is owned by SCVWD as mitigation and riparian habitat enhancement while the rest is currently held by the Land Trust for Santa Clara County. The Land Trust's land will be returned to agricultural production with an easement precluding future development.
- Helperin Property: The 200-acre easement held by the California Department of Fish and Game is split into two uses: 175 acres for continued agricultural use and the remaining 25 acres for a wetland area along the Pajaro River.
- Silacci Property: 301 acres were acquired by the Santa Clara County Open Space Authority. There will be passive wetland restoration by restricting cattle access to the river. A multi-use trail corridor is planned for along Bloomfield Road.
- Wildlands: Wildlands, Inc., a habitat development and management company, purchased 300 acres in San Benito County to create wetlands and improve grazing land. The project would create approximately 150 acres of wetlands for development mitigation. The site was recently used for sewage disposal resulting in elevated nitrate levels. Wildlands, Inc. will manage the site to reduce the nitrate levels and return grazing to the site. No public access is anticipated for the site, although guided tours may be accommodated.

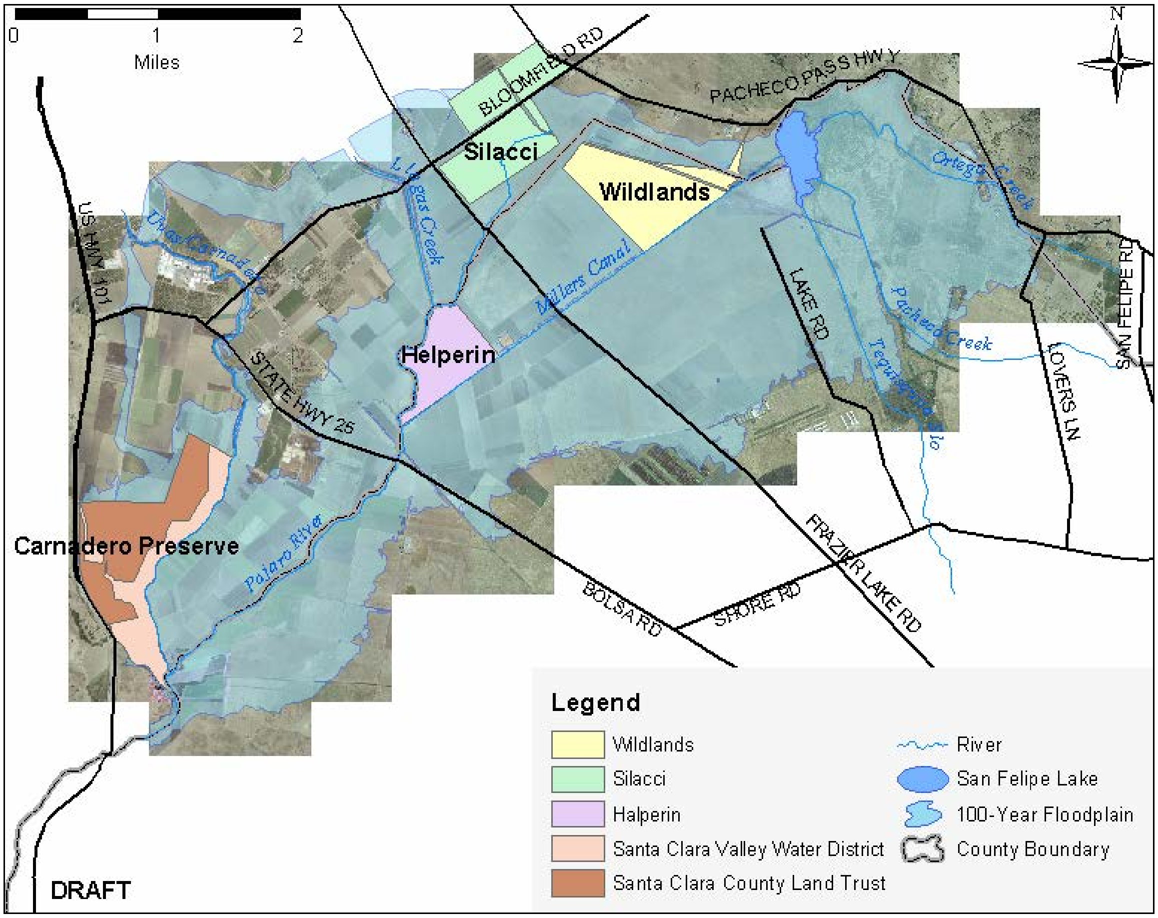


Figure 3: Areas of Soap Lake with conservation easements or habitat enhancement areas.

Fee title purchase and land leaseback

Land would be acquired from a willing seller. The owner sells his property rights to the buying authority, and then the land is leased back to its original or a new owner. The buying authority then has control of the land use but allows a second party to maintain an acceptable land use. By allowing the land to be leased, some of the purchase price for the land can be recouped. Land acquisition is one of the options available to the Pajaro River Watershed Authority to provide flood protection to the lower Pajaro River.

Purchase Priority

In order to maintain current flood flows in the downstream reaches of the Pajaro River, it is necessary to maintain or improve the detention potential within Soap Lake. The recommended method for this is acquisition of land to maintain the current land uses within Soap Lake or allow them to revert to a more natural state. The acquisition can allow benefits beyond downstream flood protection though. These additional benefits should be considered when it is necessary to choose amongst several parcels. Every effort should be made though to purchase any parcel within the floodplain when it becomes available. The following paragraphs summarize some of the additional considerations.

Flooding Frequency

Since the goal of the Soap Lake Preservation Project is to prevent additional downstream flooding, it is important to try to protect those areas most frequently flooded first. It is recognized that frequently flooded parcels are harder to develop and so it may seem that less-frequently flooded parcels should be protected first. These parcels have a much lower flood protection value however. Protecting less frequently flooded areas first could allow development to take place which would increase flow velocity during smaller events and additionally to shortcut or bypass the floodplain storage during large events. There are additional benefits to preserving frequently flooded parcels as well. These include seasonal habitat when fields are flooded, permanent habitat enhancement if land is purchased as in the Carnadero Preserve, and reduced liability for flood damages. It should be noted though that any parcel within the 100-year floodplain should be acquired when available.

Appendix A summarizes the parcels within each flood zone by county. Also included in Appendix A are figures depicting the impacted parcels and their relation to the floodplains of various frequencies.

Connections and Corridors

Parcel purchases that would create connections between existing easements and corridors should also have a high priority. When two or more existing easements become connected, there are many additional benefits beyond those found with islands of easements. Corridors provide opportunity for more developed wildlife and plant communities, allowing species to spread and move more easily. Also, connected parcels allow for better maintenance access.

Efforts should be made to purchase parcels along existing and planned regional trails. Recreation, such as trails, is another linear use that would benefit from contiguous preserved parcels. Contiguous parcels along proposed trail routes would encourage and speed the development of the trails. As connecting parcels are added to the preserved parcels, the viewshed from the trail will be preserved as well which will encourage long-term use of the trails. Development of trails should be restricted to existing and currently planned regional trails to limit unnecessary proliferation of local trails. With the proposed easement system, farmers will continue to farm the land and must maintain as much farmable land as possible. Not allowing unnecessary local trails will also reduce the potential for trespassing and vandalism, including animal harassment.

Purchase and Easement Conditions

There are some conditions that need to be met regardless of the preservation method. These include:

- Access to the river for maintenance
- Access to existing and planned utilities for maintenance, repair, and construction

Additional consideration should be made for trail easements as a condition of the flood, agriculture, or conservation easement or title purchase as outlined in the previous section. There are times though when a trail might not be acceptable, for example if the trail could interfere with agricultural operations or if sensitive habitat exists or will be developed.

Ownership

Ownership is an important consideration once a determination has been made to purchase a parcel. The owner is responsible for the ongoing maintenance and liability for the property and, without partnering, is responsible for the purchase cost. In return for assuming the above responsibilities, the parcel or lease owner is able to define the use characteristics and patterns in addition to all of the benefits mentioned in the previous sections.

The Authority is not the only body that should be considered as potential owners of the Soap Lake parcels. Other agencies such as counties, water districts, and private organizations are all currently easement and title holders of Soap Lake parcels and could all be owners of additional land or holders of easements. There are benefits and disadvantages of each however that need to be evaluated for each purchase. Table 1 summarizes some of the pros and cons for each type of organization.

Table 1: Advantages and disadvantages of different potential owners and easement holders of Soap Lake parcels.

Owner	Advantages of ownership	Disadvantages of ownership
Authority	• Multi-county and agency collaboration • Future land use changes dependent on multi-county and agency consensus	• Uncertainty regarding longevity of Authority • Determining a lead agency • No full time staff available
Individual County	• Able to incorporate purchase into General Plan to include in regional planning • Within boundaries • Mitigation opportunities for other projects • Full time staff available • Have taxing authority for self-sufficiency	• Entity able to shift priorities for parcel away from the Floodplain Preservation Project goals due to political or economic pressure
Individual Water District	• Mitigation opportunities for other projects • Full time staff available • Able to adjust rates for self-sufficiency	• Entity able to shift priorities for parcel away from the Floodplain Preservation Project goals due to political or economic pressure • Water district does not have land use authority
Private Organization (such as The Nature Conservancy, Land Trust of Santa Clara or San Benito County, Open Space Authority, etc.)	• Part of mission to conserve and preserve land use • Authority role would be proponent of purchase • Public is more accepting/trusting of non-government entity • Experience negotiating and monitoring easements • Full time staff available	• Entity able to shift priorities for parcel away from the Floodplain Preservation Project goals due to political or economic pressure • Funding is not constant
State and Federal Agencies (such as CA Department of Fish and Game and Bureau of Land Management)	• Authority role would be proponent of purchase • Mission of agency to own and manage land • Full time staff available • Potential funding source	• Entity able to shift priorities for parcel away from the Floodplain Preservation Project goals due to political or economic pressure

As can be seen in Table 1 above, all of the agencies and organizations have different strengths and weaknesses. These characteristics might make one organization or agency more or less appropriate for a given purchase. There may also be more interest in particular parcels by particular agencies. Therefore it is important to reevaluate the most appropriate easement or title purchasing organization or agency for each purchase on a case-by-case basis.

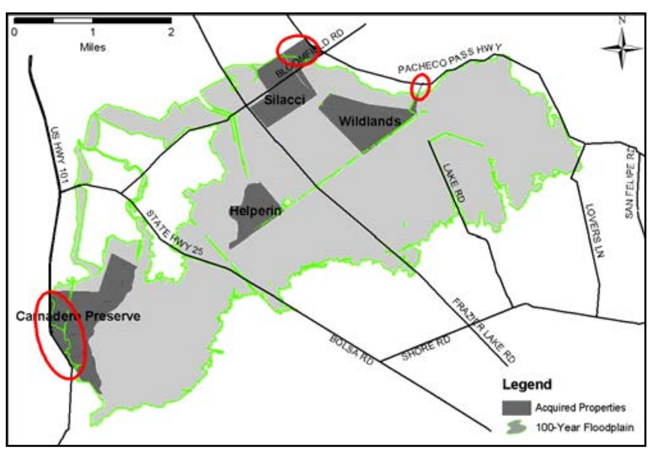
By taking advantage of partnering opportunities, it is possible to take advantage of the strengths of the above entities to offset the weaknesses of a single entity. Partnering would also share costs among several entities and make many funding sources available. Each organization has specialized knowledge and has different established relationships with land owners and the public. It's recommended that partnering take place, either officially or unofficially, whenever possible.

When the Authority is not deemed to be the most suitable owner for a parcel, there are ways in which the Authority can maintain some degree of control over the easement language. For example, the Authority may be able to assist funding the purchase and/or maintenance costs of the parcel. If a grant is being pursued, the Authority could use its multi-agency, cooperative entity status and be a partner on the application or write letters of support for a favorable grant applicant. In return, the Authority could request certain language be included in the easement or purchase contract or request some oversight in the management of the land.

Conclusions and Recommendations

The goal of this technical memorandum is to assess the land acquisition requirements of the Soap Lake Preservation Project. To do this, all parcels wholely or partially within the 100-year floodplain are identified. Additionally, two primary acquisition options are identified and discussed as are some guidelines to help prioritize parcel acquisition order.

The two primary mechanisms for preserving Soap Lake are conservation/agriculture easements and fee title purchases. There are currently conservation easements in place on several pieces of property and several more being considered. The four existing easements are protecting 1,279 acres of the 14,500 acres of whole parcels with at least a small piece within the 100-year floodplain. These four easements conserve 1,200 acres within the 9,100 acre 100-year floodplain, or about 13% of the Soap Lake preservation area as shown to the right. Figure 4 depicts the physical meaning of the values found in the table and helps to explain the discrepancy between the floodplain area and the whole parcel area.



Some of the acquired properties have land outside of the floodplain.

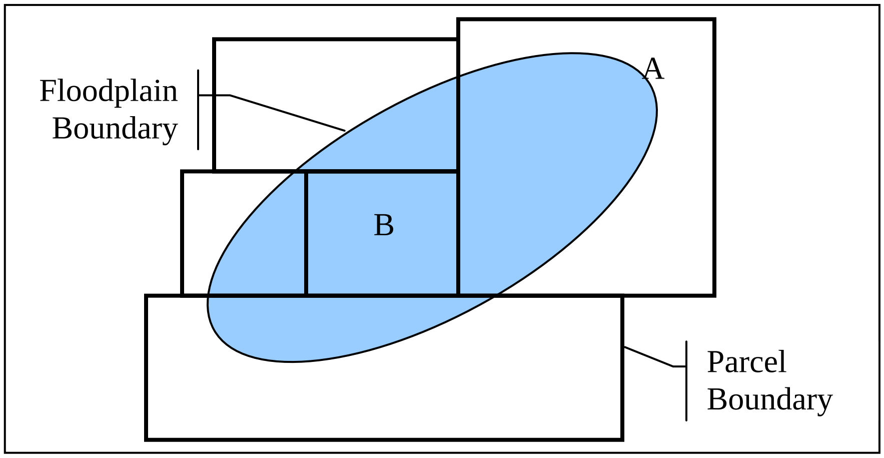


Figure 4: Schematic of why there is a discrepancy between the whole parcel area and floodplain area. In Parcel A, only a portion of the parcel is impacted by the floodplain so the total parcel area is much larger than the floodplain area. In Parcel B, the values are equivalent since all of Parcel B is within the floodplain boundary.

Table 2 below summarizes the total acreage of the floodplain already conserved, the acreage of the floodplain, and the impacted whole parcel acreage by event.

Table 2: Summary of conserved land within Soap Lake and total parcel area. All values are in acres. The difference between the conserved land and floodplain area values is the acreage of land that must still be preserved to maintain current Soap Lake attenuation benefits.

Event	Conserved Land within Floodplain	Floodplain Area	Whole Parcel Area
2-Year	80	740	6,590
10-Year	890	5,480	9,710
25-Year	1,080	7,320	11,800
50-Year	1,120	8,450	13,640
100-Year	1,200	9,110	14,550

As can be seen in Table 2, there is a wide discrepancy in the floodplain area and the total acreage of parcels. Considering only flood protection, it is recommended that, if possible, only impacted portions of the parcels be purchased as a cost-saving measure. If this is not possible or other impacts and benefits are a consideration, it may be worthwhile to purchase entire parcels.

There are a number of considerations regarding priority and purchase order when there is an opportunity to purchase multiple parcels. Flooding frequency and the spatial relationship of the parcel or parcels to existing conserved parcels should be taken into account. More frequently flooded parcels have many flood protection and habitat advantages over less frequently flooded parcels. Contiguous parcels also provide wildlife and recreational corridors.

Ownership of the easement or land title could potentially fall to a number of organizations, including the Authority, individual counties, individual water districts, and other private and public organizations. It is recommended that a partnering approach be used in order to maximize the strengths of individual groups while minimizing the weaknesses. Regardless of the final owner or partnership, the Authority should maintain a presence in the proceedings in order to ensure that the Soap Lake attenuation and storage benefits continue and become a permanent consideration in any attempts at future development.

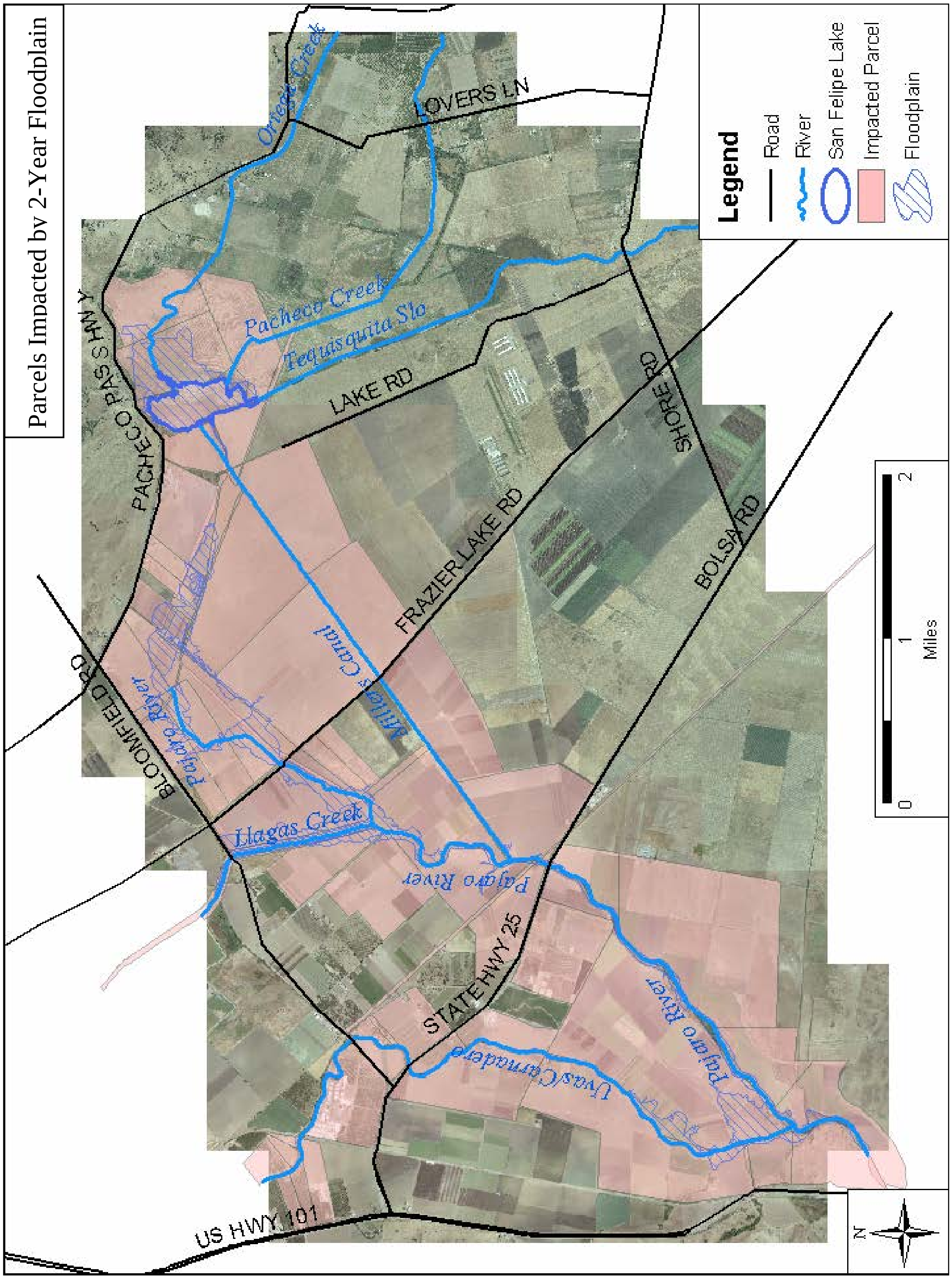
Appendix A

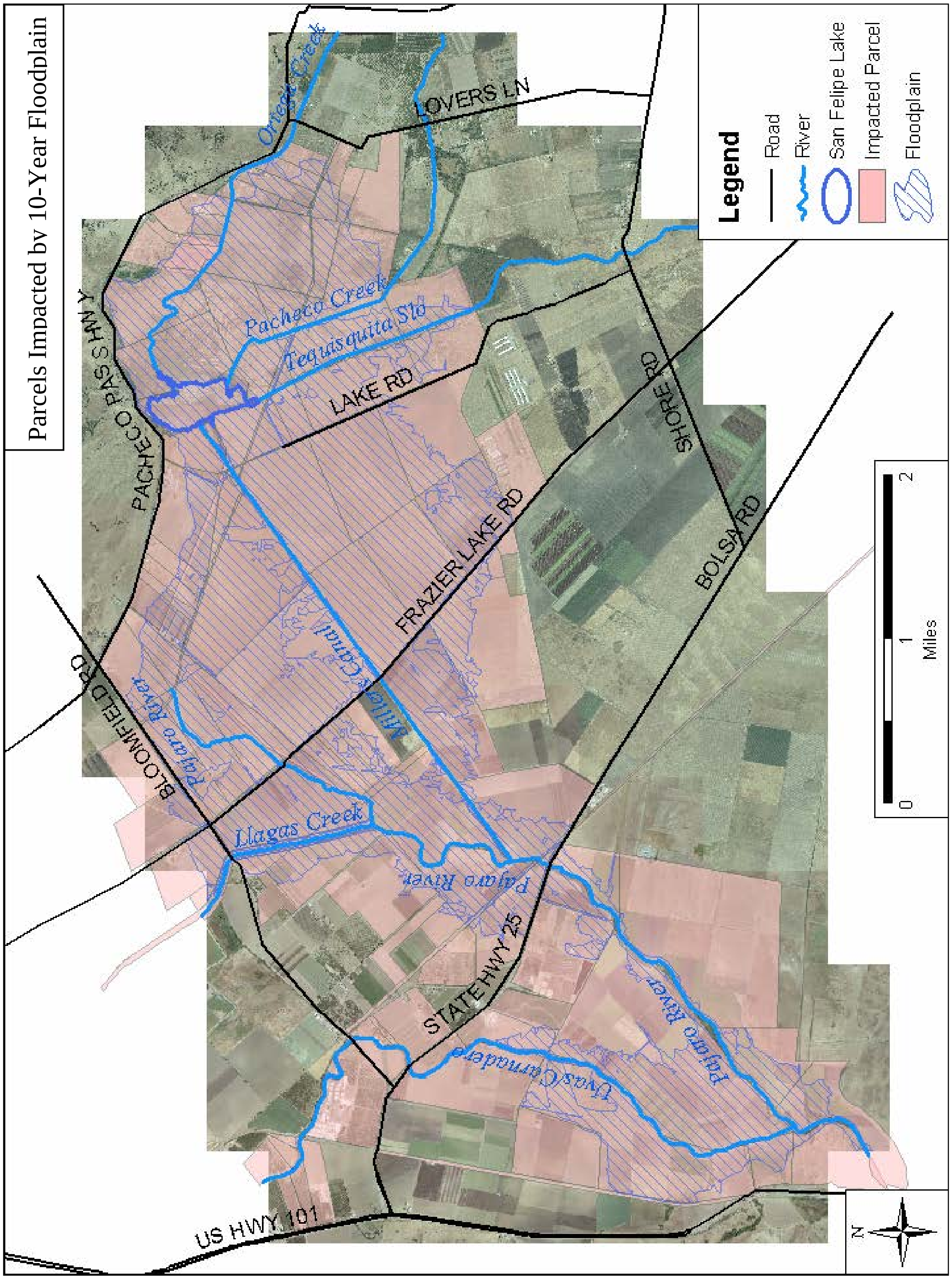
This appendix contains a list of parcels in Table A that are impacted by a flood with a given frequency. Larger events include the parcels listed for smaller events; i.e. the parcel list for the 10-year event includes those parcels listed for a 2-year event as well.

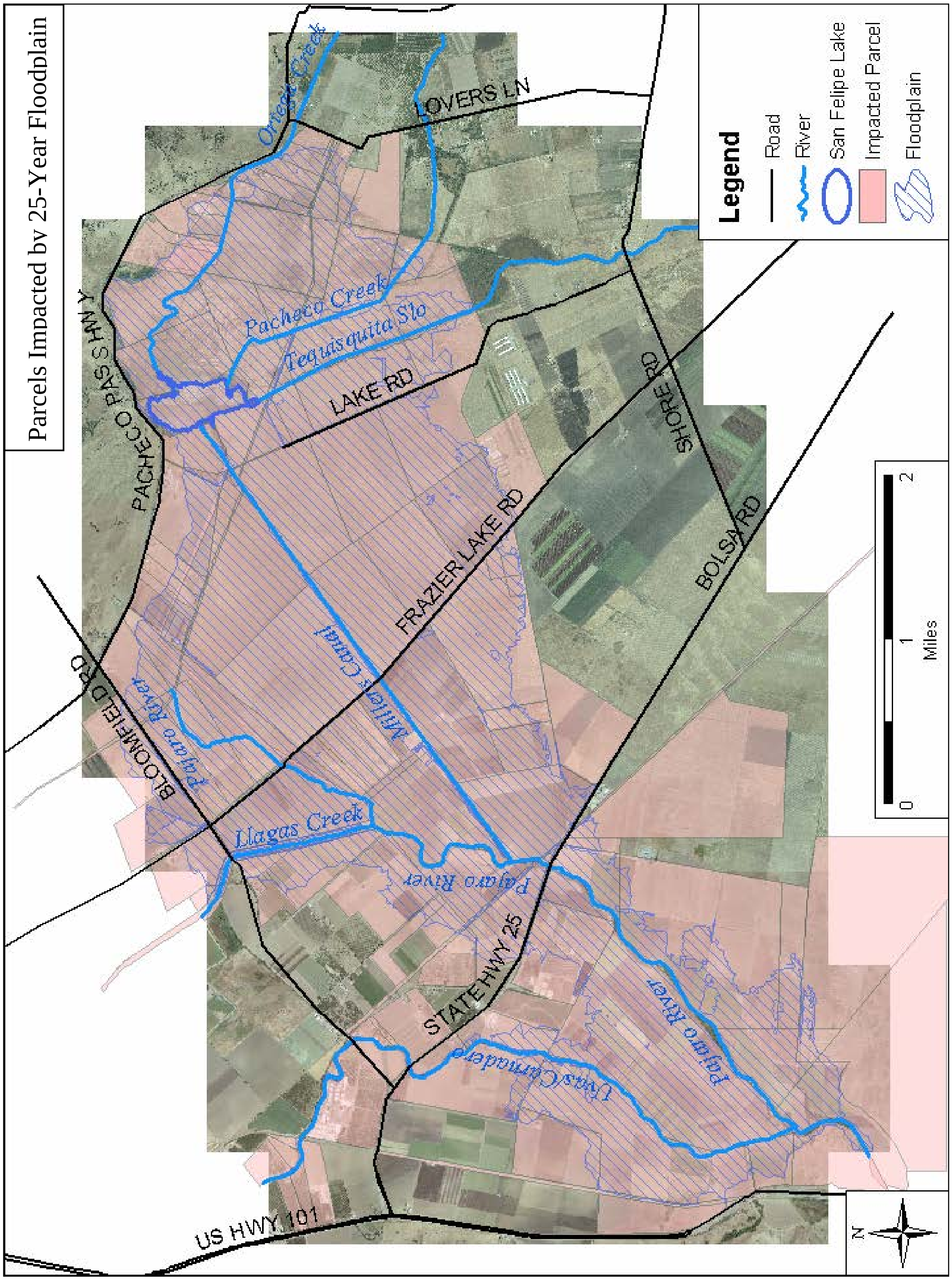
The figures following Table A show the parcels and their relative position and level of impact within the 2-, 10-, 25-, 50-, and 100-year floodplains.

Table A: List of parcels impacted by the 2-, 10-, 25-, 50-, and 100-year floodplain. The number following the event return period is the total number of parcels in that list.

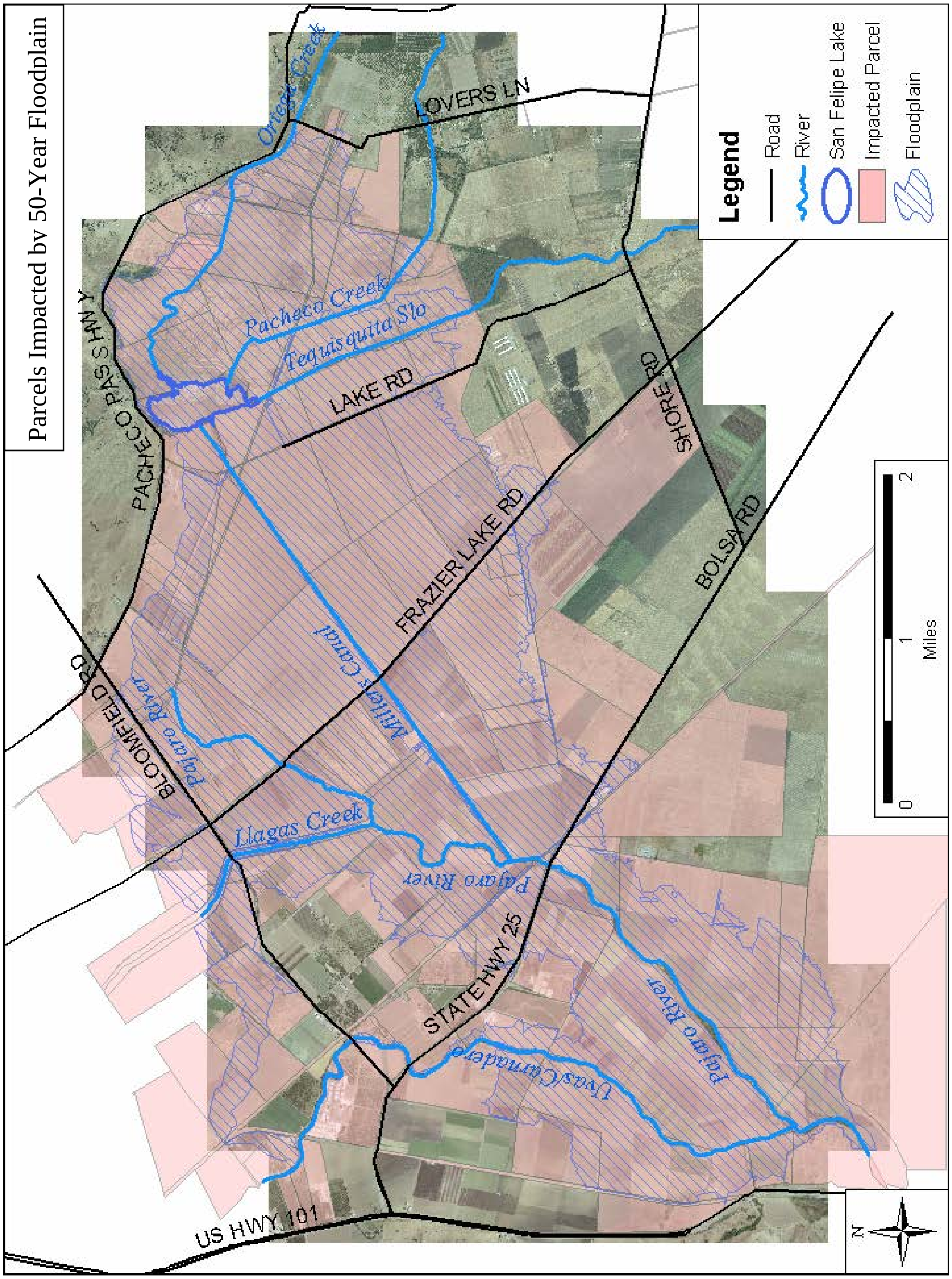
2-Year Event: 83		10-Year Event: 60		25-Year Event: 17		50-Year Event: 30		100-Year Event: 16	
Santa Clara	San Benito	Santa Clara	San Benito	Santa Clara	San Benito	Santa Clara	San Benito	Santa Clara	San Benito
84128019	130010001	84126032	130010036	84126030	130010028	84126012	130040005	84127014	130050001
84129021	130010010	84127001	130010037	84126031	130040033	84126013	130040009	84128007	130050031
84129025	130010012	84128018	130020008	84136008	130050005	84128020	130040025	84130002	130070014
84131005	130010014	84129022	130020008	84139005	130070006	84129023	130050018	84132007	130070016
84131006	130010016	84136001	130020009	89829008	130070009	84129024	130070005	84132008	150020016
84131007	130010017	84136007	130020010		130090008	84129030	130070012	84132009	150030016
84132004	130010019	84137011	130020014		130090010	84129031	130070013	84132011	
84132005	130010021	84137025	130020015		130090019	84130003	150020013	84132013	
84132006	130010023	84138006	130020015		130090020	84130004	150020014	84134002	
84133004	130010025	84138008	130020016		150010010	84130007	150020014	84135005	
84133006	130010026	84139015	130020018		150010020	84130012	150020015	All parcels in 50-year event	
84133007	130010029	84139020	130020021		150010020	84131003			
84135001	130010029	84140004	130020021	All parcels in 10-year event		84131004			
84135002	130010030	89826002	130030007			84131023			
84135003	130010031	89826010	130030007			84131024			
84136009	130010032	89828007	130030007			84133003			
84136009	130010032	89828008	130030007			84137014			
84136009	130010033	89828012	130040022			84138007			
84136010	130010034	89828013	130040022			89825036			
84137009	130010035		130040028			All parcels in 25-year event			
84137010	130020001		130050003						
84137024	130020004		130050004						
84137027	130020005		130050017						
84138009	130020006		150010001						
84138010	130020017		150010008						
84139009	130020017		150010013						
84139010	130020019		150010015						
84139011	130020020		150010015						
84139016	130020022		150010016						
84139017	130040015		150010017						
84140005	130040032		150010018						
84140006	130040032		150010019						
84140008	130070008		150010021						
84140009	130070010		150030009						
84140010	130090007		150030010						
84140011	130090018		150030021						
84140012			150030026						
84140013			150030027						
84151001			150030028						
84151002			150030028						
84151003			150030029						
84151006		All parcels in 2-year event							
89826001									
89826003									
89826005									

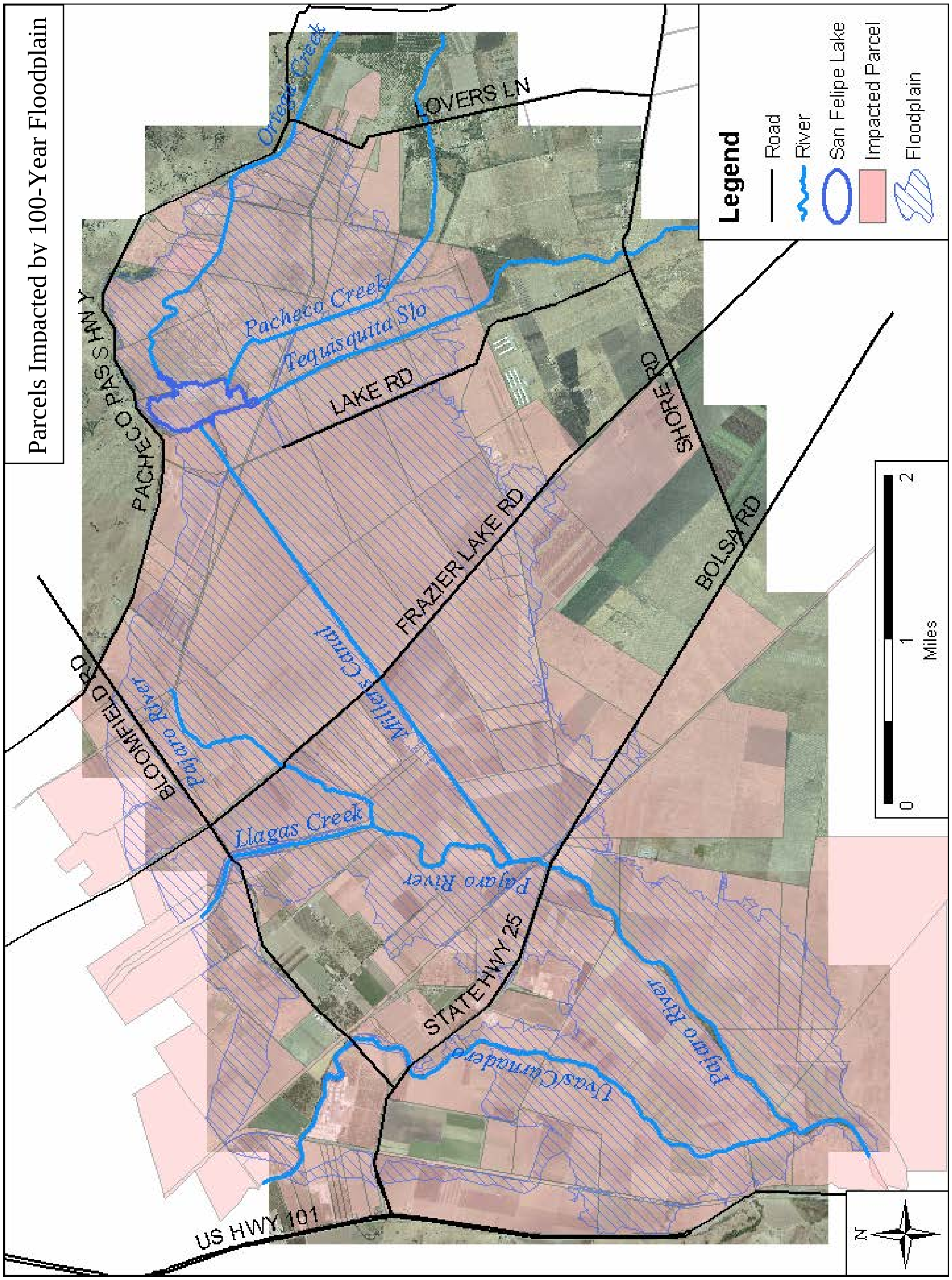

Parcels Impacted by 2-Year Floodplain
Legend
Road
River
San Felipe Lake
Impacted Parcel
Floodplain
0
1
2
Miles
N
Ortega Creek
LOVERS LN
Pacheco Creek
Tequisquita Slo
LAKE RD
PACHECO PASS HWY
SHORE RD
FRAZIER LAKE RD
BOLSA RD
Millers Canal
BLOOMFIELD RD
Pajaro River
Llagas Creek
Pajaro River
STATE HWY 25
Pajaro River
Uvas/Carnadero
US HWY 101


Parcels Impacted by 10-Year Floodplain
Legend
Road
River
San Felipe Lake
Impacted Parcel
Floodplain
0
1
2
Miles
N
Ortega Creek
LOVERS LN
Pacheco Creek
Tequisquita Slo
LAKE RD
PACHECO PASS HWY
SHORE RD
FRAZIER LAKE RD
BOLSA RD
Miller Canal
Pajaro River
BLOOMFIELD RD
Llagas Creek
Pajaro River
STATE HWY 25
Uvas/Carnadero
Pajaro River
US HWY 101



Parcels Impacted by 25-Year Floodplain


Parcels Impacted by 50-Year Floodplain
Legend
Road
River
San Felipe Lake
Impacted Parcel
Floodplain
0
1
2
Miles
N
Ortega Creek
LOVERS LN
Pacheco Creek
Tequisquita Slo
LAKE RD
PACHECO PASS HWY
SHORE RD
BOLSA RD
FRAZIER LAKE RD
Millers Canal
BLOOMFIELD RD
Pajaro River
Llagas Creek
Pajaro River
STATE HWY 25
Uvas/Carnadero
Pajaro River
US HWY 101


Parcels Impacted by 100-Year Floodplain
Ortega Creek
LOVERS LN
Pacheco Creek
Tequisquita Slo
LAKE RD
PACHECO PASS HWY
SHORE RD
FRAZIER LAKE RD
BOLSA RD
Millers Canal
BLOOMFIELD RD
Pajaro River
Llagas Creek
Pajaro River
STATE HWY 25
Uvas/Carnadero
Pajaro River
US HWY 101
Legend
Road
River
San Felipe Lake
Impacted Parcel
Floodplain
0
1
2
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PAJARO RIVER WATERSHED
FLOOD PREVENTION AUTHORITY
Phase 3: Conceptual Design of Soap Lake Preservation Project
Phase 4a: Design Level Mapping Technical Support

Technical Memorandum No. 3.7

Raines, Melton & Carella, Inc.

Task:	**Cost Estimating**
To:	**PRWFPA Staff Working Group**
Prepared by:	**Tim Harrison**
Reviewed by:	**Lidia Gutierrez, Karen Frye**
Date:	**September 15, 2004**
Reference:	**0053-003.7**

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Introduction

This technical memorandum (TM) describes the results of work completed as part of Task 3.7: Cost Estimating for the Soap Lake Floodplain Preservation Project as part of the Pajaro River Watershed Study. RMC was tasked with providing a conceptual level cost estimate for the CEQA project. This TM identifies approximate land costs per acre for both fee title purchase and easement. The cost to purchase the land or a flood and conservation easement within each level of floodplain (2-, 10-, 25-, 50-, and 100-year) is calculated based on the unit costs.

Background

Phase 3 of the Pajaro River Watershed Study (Study) is a continuation of the Pajaro River Watershed Flood Prevention Authority's (Authority) efforts to provide flood protection to areas below the confluence of the Pajaro and San Benito rivers. Phase 1 of the Study consisted of hydrologic, hydraulic, and sediment modeling of the entire watershed. Model results of the 2-, 10-, 25-, 50-, and 100-year flows at four representative locations on the Pajaro River were developed. Phase 2 of the Study consisted of developing flood protection alternatives and project packages to manage the modeled 100-year flows.

Soap Lake Floodplain

One of the most significant conclusions coming out of both Phase 1 and Phase 2 was the importance of the Soap Lake floodplain to the Pajaro Valley flood protection solution. The Soap Lake floodplain currently detains storm water flows from the Upper Pajaro River watershed upstream of the Pajaro River confluence with the San Benito River. Loss of this natural detention would increase the magnitude of flooding downstream of the confluence. Figure 1 shows the entire watershed highlighting the Upper Pajaro and San Benito subwatersheds as well as the location of the Soap Lake floodplain.

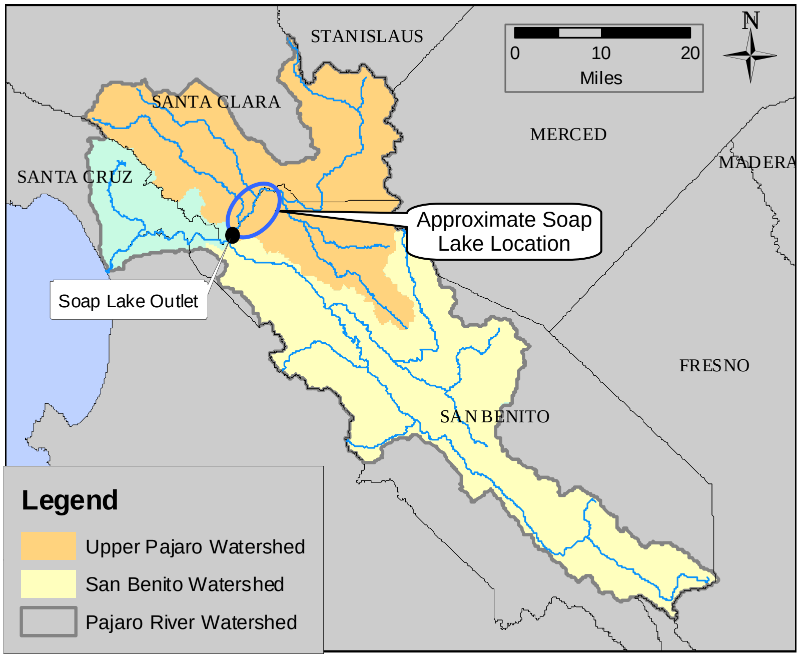

Figure 1: Pajaro River Watershed. The major upper subwatersheds are highlighted.

The Soap Lake floodplain is a natural detention basin, storing water and reducing peak flows that would otherwise increase flooding in the lower Pajaro River. Upper Soap Lake is also known as San Felipe Lake and is a permanent body of water. The Soap Lake floodplain lies along the Pajaro River within San Benito and Santa Clara Counties between upstream of San Felipe Lake and upstream of the Highway 101 crossing (Figure 2). The main land use is agriculture, including row crops and pasture land. During significant rain events, the low-lying areas of the Soap Lake area become flooded and there is flow backup on the Pajaro River upstream of the San Benito River.

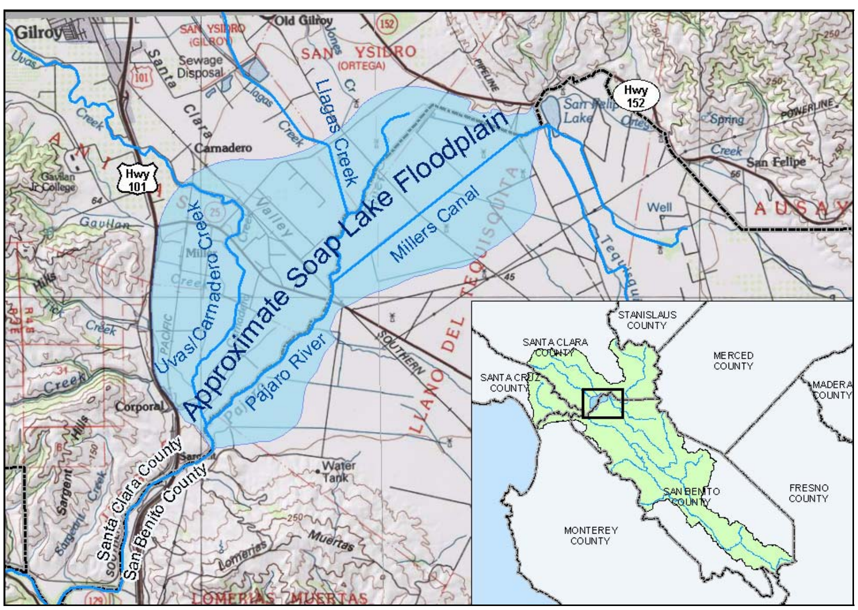

Figure 2: Soap Lake study area.

Work completed earlier in Phase 3, described in TM 3.3-4, models and maps the 2-, 10-, 25-, 50-, and 100-year Soap Lake floodplains. These floodplains are the basis of the cost estimate for the Soap Lake Floodplain Preservation Project.

Unit Costs for Soap Lake Floodplain Acquisition

Unit costs, in this case the cost of an acre of land, are an efficient way to perform conceptual level cost estimates. Since the two primary acquisition methods for the Soap Lake Preservation Project are fee title purchases and flood and conservation easements, unit costs were obtained for each of these.

The following table summarizes the unit costs obtained for the fee titles and easements. It also shows the recommended unit costs for the Soap Lake Preservation Project.

Table 1: Unit costs for fee title purchase and flood and conservation easement purchase.

	Unit Cost/acre	
Source	**Fee title**	**Easement**
The Nature Conservancy *	$12-14k	$4-7k
Santa Clara County Land Trust **	$8-15k	$5k
Recommended Unit Cost +	$12,000	$5,000

* Estimate obtained from Lloyd Wagstaff of TNC based on 2004 land acquisitions.
** Estimate obtained from Nancy Richardson of Santa Clara County Land Trust based on multiple recent land acquisitions.
+ Average of referenced unit costs. Accounts for high value properties (irrigated agriculture) and low value properties (open rangeland).

In general, easements cost from approximately 30% to 60% of fee title purchase. The recommended unit cost of $5,000/acre for easements and $12,000/acre for fee title acquisitions will be applied to the floodplain acreages in the next section to yield total costs.

Fee Title and Easement Costs for Soap Lake Floodplain Acquisition

The total cost of land purchase is the product of the unit cost and the area of interest. The following tables show the fee title purchase and easement purchase costs of the 2-, 10-, 25-, 50-, and 100-year floodplains within Soap Lake.

Table 2: Estimated fee title purchase costs for a range of event frequency floodplains of Soap Lake.

Floodplain	Area (Acres)*	Unit Cost/Acre	Extended Cost (millions)
2-Year	740	$12,000	$8.9
10-Year	5,480	$12,000	$65.8
25-Year	7,320	$12,000	$87.8
50-Year	8,450	$12,000	$101.4
100-Year	9,110	$12,000	$109.3

* Pajaro River Watershed Study TM 3.6.

Table 3: Estimated flood and conservation easement purchase costs for a range of event frequency floodplains of Soap Lake.

Floodplain	Area (Acres)*	Unit Cost/Acre	Extended Cost (millions)
2-Year	740	$5,000	$3.7
10-Year	5,480	$5,000	$27.4
25-Year	7,320	$5,000	$36.6
50-Year	8,450	$5,000	$42.3
100-Year	9,110	$5,000	$45.6

* Pajaro River Watershed Study TM 3.6.

As discussed in TM 3.6, the floodplain boundaries do not exactly correspond to the local parcel boundaries. Therefore there are pieces of parcels within the floodplain while the rest of the parcel is not impacted by the flood waters. It should be noted that the acreages used in Tables 2 and 3 are the floodplain acreages and not the parcel acreages. These costs are applicable assuming the parcels can be split into parts or easements can be purchased for only part of the property. The costs for the entire parcels are summarized in the tables below.

Table 4: Estimated fee title purchase costs for whole parcels within the floodplain levels of Soap Lake.

Floodplain	Area (Acres)*	Unit Cost/Acre	Extended Cost (millions)
2-Year	6,590	$12,000	$79.1
10-Year	9,710	$12,000	$116.5
25-Year	11,800	$12,000	$141.6
50-Year	13,640	$12,000	$163.7
100-Year	14,550	$12,000	$174.6

* Pajaro River Watershed Study TM 3.6.

Table 5: Estimated flood and conservation easement purchase costs for whole parcels within the floodplain levels of Soap Lake.

Floodplain	Area (Acres)*	Unit Cost/Acre	Extended Cost (millions)
2-Year	6,590	$5,000	$33
10-Year	9,710	$5,000	$48.6
25-Year	11,800	$5,000	$59
50-Year	13,640	$5,000	$68.2
100-Year	14,550	$5,000	$72.8

* Pajaro River Watershed Study TM 3.6.

Conclusions and Recommendations

The goal of this technical memorandum is to estimate the costs of the Soap Lake Preservation Project. To do this, unit costs for fee title and easement purchases were determined and applied to the areas of the 2-, 10-, 25-, 50-, and 100-year floodplains. Table 7 summarizes the cost to preserve the floodplain characteristics of the 100-year floodplain.

Table 7: Purchase costs of 100-year floodplain.

100-Year Floodplain	Fee Title Purchase	Easement Purchase
Limited to flooding extent	$109.3 million	$45.6 million
Whole parcel	$174.6 million	$72.8 million

It is anticipated that the actual cost of the floodplain will be between the whole parcel fee title purchase cost ($174.6 million) and the easement purchases limited to the extent of the flooding ($45.6 million). These two values are extremes and both are considered to be unlikely. It is expected that the actual purchase pattern of the floodplain will include both easements and fee title purchases. It is also likely that some of the parcels at the fringe of the floodplain will be purchased in entirety while others will be divided. It should also be noted that there are oftentimes "bulk discounts" when land is purchased in large tracts. These discounts could also lower the total price.

The total costs represented in this TM are sensitive to the unit costs used in the analysis. While effort was made to use a representative unit cost, it is likely that some parcels would actually be underpriced and some would be overpriced based on the unit cost used. This, and any overall shift in the cost of land, could affect the total cost of the Soap Lake Floodplain Preservation Project.

PAJARO RIVER WATERSHED
FLOOD PREVENTION AUTHORITY
Phase 3: Conceptual Design of Soap Lake Preservation Project
Phase 4a: Design Level Mapping Technical Support

Technical Memorandum

Raines, Melton & Carella, Inc.

Task:	**The Value of Soap Lake and the Soap Lake Floodplain Preservation Project**
To:	**PRWFPA Staff Working Group**
Prepared by:	**Tim Harrison**
Reviewed by:	**Lidia Gutierrez**
Date:	**October 7, 2004**
Reference:	**0053-003**

The analysis and conclusions in this technical memorandum (TM) emphasize the importance of Soap Lake and the Soap Lake Floodplain Preservation Project. Soap Lake currently attenuates peak flows from the Upper Pajaro River Watershed, upstream of the confluence with the San Benito River. Estimates of the 100-year flood flow at Chittenden, just upstream of Watsonville, range from 40,000 cfs to 44,000 cfs. The Lower Pajaro Levee Project is being designed to pass up to this amount of water safely to the Monterey Bay. Without Soap Lake, the peak 100-year flow at Chittenden is expected to increase to 60,500 cfs, which is well above the current levee design capacity. The levee height would need to be raised significantly to accommodate the higher peak flows.

The remainder of this TM summarizes the analyses performed to quantify the impact that no attenuation in Soap Lake would have on the Lower Pajaro Levee Project. Data, as provided by the U.S. Army Corps of Engineers, is summarized. The additional volume of levee is calculated as a way to scale the estimated cost of the currently proposed levee design to what the cost of the levees would be without Soap Lake. The additional land required for the project is also calculated as a function of the increased height of the levees. At the end of the memorandum, the analyses are summarized and conclusions are drawn from those analyses.

Data

The U.S. Army Corps of Engineers (Corps) was able to provide the Authority with the height and length of the four main reaches of the main stem of Alternative 2a. Table 1 is a summary of this levee data. The Corps was also able to model an increased flow scenario which represents the lower Pajaro River flow without Soap Lake attenuating the peak flows from the Upper Pajaro River Watershed. Based on work performed for the Pajaro River Watershed Study, this value is anticipated to be about 60,500 cfs. The increased levee height for each reach is also included in Table 1.

Table 1: Levee data based on current design of Lower Pajaro Levee Project and likely required levee height increases beyond the current design without Soap Lake. All data has been provided by Eric Thaut and William Firth of the Corps.

	Left Bank			Right Bank		
	Reach 1	**Reaches 2-3**	**Reach 4**	**Reach 1**	**Reach 2-3**	**Reach 4**
Length (ft)	14,668	12,628	25,162	18,943	12,306	27,616
Proposed Height (ft)	12.6	11.8	11.5	12.2	11.7	12.8
Add'l Height Required w/o Soap Lake (ft)	3	4	3.5	3	4	3.5

The Corps was also able to provide other important information for this analysis, including:

- Crown width - 14 ft
- Levee slope - 2:1 on the land side and 3:1 on the river side
- Cost as currently proposed - $112,000,000
- Additional impacts without Soap Lake
    - Might need new bridge for Hwy 1
    - Would need new bridge for Main Street
    - Railroad bridge would need to be altered or abandoned

All of this information will be utilized to identify the value of Soap Lake and the Soap Lake Floodplain Preservation Project in the following sections.

Analysis

Before any analysis can be performed, there must be a physical understanding of the shape of the levee. Figure 1 below graphically portrays the shape of the levee and identifies all of the necessary levee dimensions that will be used for the analysis.

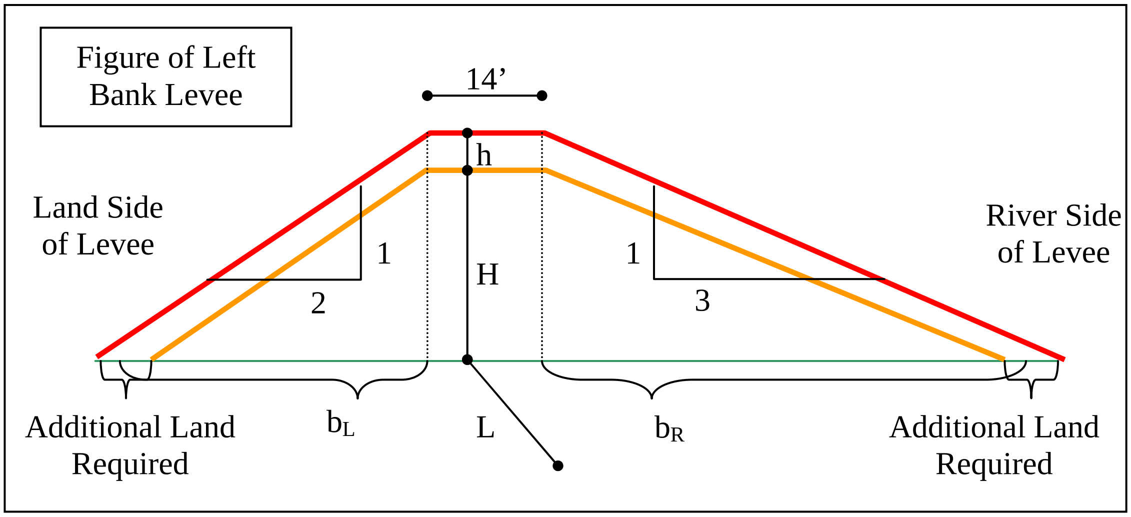

Figure 1: Graphical representation of the left bank levee shape and the analysis parameters. The right bank levee is a mirror image of left bank levee. H is the current design height of the levee, h is the increase in levee height required to contain the Pajaro River flow without Soap Lake, L is the length of the reach, and b_L and b_R are the width of the land-side and river-side levee wings respectively.

The volume of the levee will be calculated based on the levee data provided by the Corps with and without the increased height. The cost can then be scaled to yield an approximation of the cost that would be required to build the larger levee. The amount of extra land needed for the levee footprint will also be calculated.

Levee Volume

The volume of the levee can be calculated by dividing a cross section of the levee into three pieces represented as simple geometric shapes (rectangles and triangles), determining their area, and multiplying those areas by the length of the reach. In equation form:

$$V = L(\tfrac{1}{2} b_L (H+h)) + 14L(H+h) + L(\tfrac{1}{2} b_R (H+h))$$

$$b_L = 2(H+h) \quad b_R = 3(H+h)$$

h is 0 ft for the currently proposed levee design. This calculation needs to be performed for each reach of both banks.

Once the volumes of every reach have been calculated for both the current design and the required design without Soap Lake they can be compared to determine a relative comparison of sizes.

Table 2 is a summary of the above analyses.

Table 2: Volume of the levees with and without Soap Lake.

Levee Volume	Left Bank			Right Bank		
	Reach 1	**Reaches 2-3**	**Reach 4**	**Reach 1**	**Reach 2-3**	**Reach 4**
With Soap Lake	$8.4x10^6$ cf	$6.5x10^6$ cf	$12.4x10^6$ cf	$10.3x10^6$ cf	$6.2x10^6$ cf	$16.3x10^6$ cf
Without Soap Lake	$12.1x10^6$ cf	$10.7x10^6$ cf	$19.4x10^6$ cf	$15.0x10^6$ cf	$10.2x10^6$ cf	$24.6x10^6$ cf
Difference	$3.7x10^6$ cf	$4.2x10^6$ cf	$5.0x10^6$ cf	$4.7x10^6$ cf	$4.0x10^6$ cf	$8.3x10^6$ cf

The total increase in volume is approximately 30 million cubic feet. This represents an increase of 150 % over the current levee design.

Cost

To determine the incremental and total cost of the levee without Soap Lake compared to the current design, the current cost estimate was scaled linearly with the increase in volume.

$$Cost = \frac{V[H+h]}{V[H]} * C_I$$

where C_I is the current proposed cost ($112 million). The result of this calculation yields the total cost and the incremental cost is obtained by subtracting the two costs.

The incremental cost of the levees without Soap Lake is $56 million. The total cost without Soap Lake is $168 million.

Footprint

In order to maintain the slopes of the current levee design, the footprint of the levee must increase proportionally to the increase in height. The figure above shows center aligned expansion but, in order to maintain hydraulic capacity in the Pajaro River, the levee expansion would more likely the river-side toe as a common point. The total burden of additional land for the levee would then fall to the land side.

The incremental amount of land required for the larger levee is the same as the area of overlap shown in the figure above. The sprawl of the levee is determined by subtracting the base length of the smaller levee cross section from the base length of the larger levee cross section. The land area required is determined by multiplying the levee sprawl by the length of the reach as shown below.

$$Area = L(b_L[H+h] - b_L[H]) + L(b_R[H+h] - b_R[H])$$

As with the volume analysis, this calculation needs to be performed for each reach of both banks. Table 3 below summarizes the results of this analysis.

Table 3: Additional land area required to accommodate increased levee footprint required to contain River flows without Soap Lake.

	Left Bank			**Right Bank**		
	Reach 1	**Reach 2-3**	**Reach 4**	**Reach 1**	**Reach 2-3**	**Reach 4**
Additional Land Required	220,000 sf	253,000 sf	440,000 sf	284,000 sf	246,000 sf	483,000 sf

The total additional land required is 1,926,000 sf, equivalent to 44 acres.

Summary

If Soap Lake were not able to attenuate peak flows, the Lower Pajaro Levee Project would be impacted in the following ways:

- **Additional Cost -** $60 million
- **Additional Land -** 44 acres
- **Other Impacts -** Might need new bridge and approach at Hwy 1; Would need new bridge and approach at Main Street; Railroad bridge would need to be modified to accommodate 4+ feet of levee on either side of the railroad line or be abandoned.

Conclusion

The Lower Pajaro Project may not be feasible without the Soap Lake and its attenuation of large peak flows. The levee cost alone would be about 50% higher than the current estimate. The railroad bridge would need to be modified to accommodate levees on either side of the railroad line that are over four feet above grade. An alternative is to abandon or reroute the railroad line and remove the bridge completely. Rebuilding two of the major bridges in the area would add significantly to the cost and cause a huge public disruption as the bridges were rebuilt and the bridge approaches built-up and modified. Farmers and local residents would also need to give up an additional 44 acres of land to accommodate the increased levee height.