



Four Watershed Conditions

CHAPTER 3

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FOUR WATERSHED CONDITIONS

One of the major goals of Phase 1 of the PRWS is to see how land use affects flooding frequency and flooding intensity. Modeling the watershed in different conditions gives insight into future flooding problems and allows the impacts of development trends to be identified. As a starting point, four watershed conditions have been modeled with both PRO-FLO and PRO-SED. The conditions were chosen based on particular questions that needed to be answered and the four conditions comprehensively span the extent of reasonable land use changes. Other conditions can be modeled as needed at a later point.

The following paragraphs are split into three sections. The first describes the individual hydrologic watershed conditions and their possible impacts on future planning within the Pajaro River watershed. The second discusses the four sediment transport conditions modeled. The third summarizes lessons learned from the modeling exercise and provides some additional discussion regarding their impacts.

Hydrologic Model Scenarios and Results

Each of the four conditions was chosen based on both individual characteristics and patterns that can be established between all of them. The model was calibrated using existing conditions. The following four conditions allow the model to explore watershed response to changes that might affect downstream flooding.

1. **Back in Time to 1947:** It is important to be able to compare current and future conditions to those of the past. The historical perspective provides a glimpse of how flooding has changed due to known shifts in land use. The year 1947 is significant because it was just before the Corps' levees were built in 1949 and had conditions similar to when the 1955 flood occurred. In addition, three of the four existing reservoirs and some additional levees were not yet in place in 1947.
2. **General Plan Buildout:** This scenario allows the model to predict the watershed flood potential using the urban and agricultural land uses for each city and county designated by the individual planning departments. This is the best estimate available for future conditions within the watershed. While the horizons of the individual general plans vary greatly, this scenario is intended to approximately represent the years between 2015 and 2020.
3. **Ultimate Buildout in 2050:** This scenario represents a worst-case scenario, in terms of flooding, for urbanization. The model predicts how the watershed would respond to unchecked growth in the cities beyond what the general plans allow. The year 2050 is the approximate end of the economic life of a project started at the time of this report.
4. **Changes in Agriculture:** Agriculture can play a large role in the amount of runoff and therefore flooding in an area. This scenario does not represent any particular time period but parallels the Ultimate Buildout scenario in that it represents a worst-case agricultural condition.

The next sections go into greater detail for each scenario, including how the data was developed for the condition and the results of each HEC-1 and HEC-RAS model run. HEC-RAS peak discharges on the lower reaches are slightly lower than those calculated by HEC-1 due to HEC-RAS's ability to model attenuation within the river system. The discharge and relative change for each condition and frequency between the two model structures is similar. Either model could be considered representative of the actual discharges and both support conclusions based on this study. Figure 2-1 shows the locations of the comparison points highlighted in the tables displaying model results.

BACK IN TIME TO 1947

Watershed Condition and Data

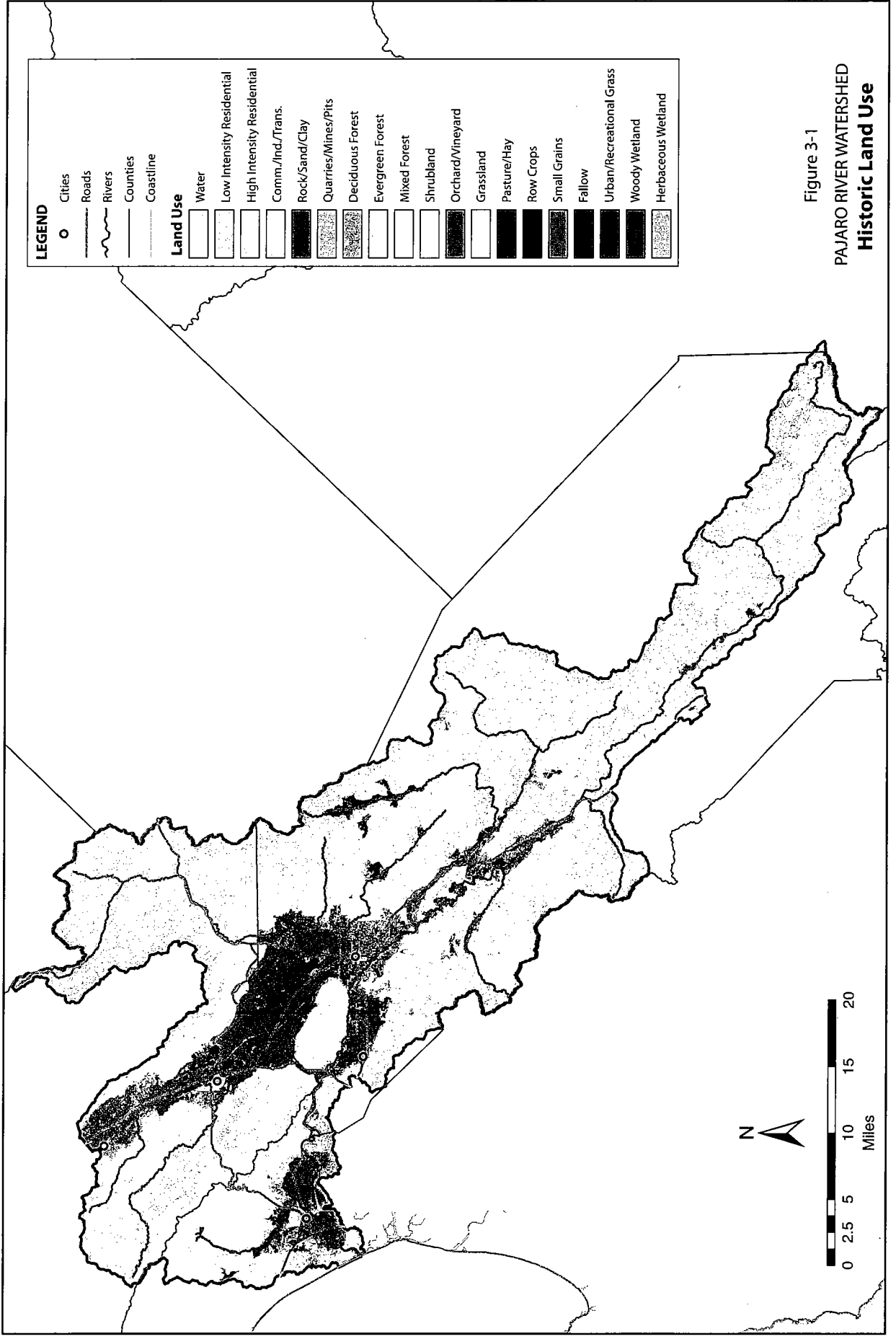
This simulation represents flooding conditions that the Corps was using to design the levees on the lower Pajaro River. Data used to represent the historic watershed condition are the same except for the land use and some routing changes.

The routing changes were necessary because of post-1947 upstream flood control and water supply projects. Uvas Dam, Chesbro Dam, and Hernandez Dam have all been built since 1947. The only major dam in the watershed before 1947 was the Pacheco Dam. Since the dams did not exist prior to 1947 and the Corps did not have any way to predict their existence, storage and attenuation effects were removed from the model, allowing the water to flow through the reaches uninhibited. Also, in 1947, Llagas Creek did not have the existing leveed channel in its lower reaches. To account for this pre-channel condition, the routing in this reach was changed to include the additional attenuation that would be expected with a smaller channel and a larger flood plain.

Historic land use was obtained from several different sources. The extent of the cities is determined from an interpolation of USGS topographic maps. Every few years, the USGS remaps any given quad at the 7.5 minute and 15 minute scale. All USGS maps for each 15-minute quad impacting the Pajaro River watershed around 1947 were obtained. Maps developed before and after 1947 were used as guides for the actual area of urbanization within the watershed in 1947. The new urban areas were mapped on the land use Geographic Information System (GIS) database.

Agricultural information for this time period is not available in a graphical format. Instead, the historic agriculture land use is derived from a combination of resources. Agricultural data was obtained by combining information from historic aerial photos from the early 1940s, county crop reports from that era, and conversations with local farm bureau and historic society representatives.

Figure 3-1 shows the distribution of the land uses used by PRO-FLO that were found in the Pajaro River watershed in 1947. Comparison with Figure 2-5 shows the type and size of the changes made to arrive at the historic land use.



LEGEND

- Cities
- Roads
- Rivers
- Counties
- Coastline

Land Use

- Water
- Low Intensity Residential
- High Intensity Residential
- Comm./Ind./Trans.
- Rock/Sand/Clay
- Quarries/Mines/Pits
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrubland
- Orchard/Vineyard
- Grassland
- Pasture/Hay
- Row Crops
- Small Grains
- Fallow
- Urban/Recreational Grass
- Woody Wetland
- Herbaceous Wetland

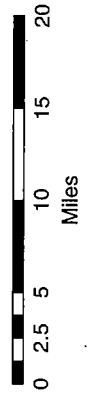


Figure 3-1
PAJARO RIVER WATERSHED
Historic Land Use

Model Results

With the routing changes in place and the impermeability and curve numbers adjusted to match the land use, PRO-FLO produced the following results. For each comparison point and return period, Table 3-1 contains the peak and 3-day average modeled flows and Table 3-2 contains the relative change from existing conditions. Discussion of the results follows.

Table 3-1: Model output for historical watershed condition. It is important to note that runoff has decreased since 1947. The sub-watershed areas are square miles and the discharge units are cfs.

a) HEC-1

Location	Area	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr
San Benito R.	664						
Peak Q		1,880	13,300	21,500	30,500	37,300	52,200
3-Day Avg. Q		602	4,540	8,010	12,800	15,700	21,900
Lake Outlet	505						
Peak Q		4,470	15,200	20,300	24,800	26,400	30,000
3-Day Avg. Q		2,340	10,200	15,600	20,100	22,100	25,900
Chittenden	1,186						
Peak Q		3,720	19,500	31,300	42,000	50,200	68,800
3-Day Avg. Q		2,150	11,300	19,000	27,800	32,100	41,300
D/S Salsipuedes	1,274						
Peak Q		4,310	21,500	33,800	45,100	53,500	73,500
3-Day Avg. Q		2,710	13,300	21,400	30,500	35,200	45,300

b) HEC-RAS

Location	Area	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr
San Benito R.	664						
Peak Q		1,880	13,300	21,500	30,500	37,300	52,200
3-Day Avg. Q		602	4,540	8,010	12,800	15,700	21,900
Lake Outlet	505						
Peak Q		4,470	15,400	21,500	27,000	30,300	35,300
3-Day Avg. Q		2,340	10,200	15,600	20,600	22,800	27,600
Chittenden	1,186						
Peak Q		3,720	19,200	31,600	41,500	48,500	63,100
3-Day Avg. Q		2,150	11,300	19,100	28,000	32,500	42,200
D/S Salsipuedes	1,274						
Peak Q		4,310	21,600	35,000	45,100	52,400	69,400
3-Day Avg. Q		2,710	13,300	21,500	30,700	35,500	46,200

Table 3-2: Relative change in model output for historical watershed condition. It is important to note that runoff has decreased since 1947. The sub-watershed areas are square miles and the percentages represent change from the current model flow at that return period.

a) HEC-1

Location	Area	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr
San Benito R.	664						
Peak Q		48.1%	24.4%	14.7%	16.9%	18.4%	17.2%
3-Day Avg. Q		32.6%	23.2%	15.0%	7.5%	5.9%	4.4%
Lake Outlet	505						
Peak Q		32.0%	4.9%	2.7%	1.0%	1.1%	1.1%
3-Day Avg. Q		12.7%	5.1%	2.5%	1.4%	1.2%	0.9%
Chittenden	1,186						
Peak Q		21.3%	19.2%	12.0%	10.2%	12.5%	14.8%
3-Day Avg. Q		2.6%	8.3%	7.4%	4.5%	3.9%	3.0%
D/S Salsipuedes	1,274						
Peak Q		13.9%	12.6%	9.6%	6.4%	8.4%	11.0%
3-Day Avg. Q		1.4%	6.9%	7.0%	4.5%	3.9%	3.1%

b) HEC-RAS

Location	Area	2-yr	10-yr	25-yr	50-yr	100-yr	200-yr
San Benito R.	664						
Peak Q		48.1%	24.4%	14.7%	16.9%	18.4%	17.2%
3-Day Avg. Q		32.6%	23.2%	15.0%	7.5%	5.9%	4.4%
Lake Outlet	505						
Peak Q		32.0%	4.0%	1.3%	0.4%	-0.2%	0.4%
3-Day Avg. Q		12.7%	5.2%	2.5%	1.4%	1.2%	0.9%
Chittenden	1,186						
Peak Q		21.3%	13.6%	10.5%	9.5%	11.0%	9.6%
3-Day Avg. Q		2.6%	8.4%	7.5%	4.5%	3.9%	3.0%
D/S Salsipuedes	1,274						
Peak Q		13.9%	9.8%	10.2%	7.0%	8.0%	8.4%
3-Day Avg. Q		1.4%	7.0%	6.9%	4.4%	3.9%	3.1%

As can be seen in Table 3-2 by the positive percentage change or by comparing Tables 3-1 and 2-7, both peak and average discharges were higher in 1947 than they are today. For the San Benito River, it was discovered that Hernandez Reservoir detains and significantly attenuates the runoff hydrograph from the 85 square mile watershed for the reservoir. Not having the reservoir not only increases the discharges, but equally important for downstream effects, it moves the peak discharge up about eight hours. With this shift the San Benito River flood wave adds almost directly to the peaks of other sub-watershed hydrographs. The effects can be seen in the increases at the Chittenden and downstream of the Pajaro River confluence with Salsipuedes Creek.

Removing the Uvas and Chesbro Reservoirs had similar effects on peak discharges that can be seen at the Lake Outlet location. The model hydrographs indicate that the peaks were increased significantly on both creeks. When the Llagas peak met the Pajaro River peak though, the established Pajaro peak dominated. The Llagas peak was slightly smaller and arrived sooner than the Pajaro peak, which was delayed due to the attenuation effects of Pacheco Reservoir and Upper Soap Lake. At the confluence with the Uvas Creek however, the combination of the Uvas and Llagas peaks overwhelmed the Pajaro peak and became dominant. This complex

interaction results in a slight increase at the larger return period and much greater increases at higher frequencies.

The 3-day average discharges were greater than existing because the water supply dams were not there to trap part of the flood flows and keep them in the reservoirs for later release.

GENERAL PLAN BUILDOUT AND ULTIMATE BUILDOUT IN 2050

These two watershed scenarios have been grouped together due to similarities in both their goals and results. Both conditions were chosen to see the effects of urbanization on runoff but at different times in the future. Consequently, results show similar trends.

Watershed Condition and Data

Land uses for the General Plan Buildout were obtained from the general plans of the four counties (Monterey, San Benito, Santa Clara, and Santa Cruz) and five cities in the watershed (Gilroy, Hollister, Morgan Hill, San Juan Bautista, and Watsonville). The land uses defined by the general plans were overlaid on the current land uses. The effect is that only those areas with land uses other than what is currently defined were changed. The goal of this modeling scenario was to identify future downstream flooding based on planned development, both in terms of urbanization and agricultural expansion. For this reason, no additional sources of data were necessary.

Figure 3-2 shows the distribution of the land uses used by PRO-FLO that could be found at the outer limit of the communities' general plans.

An extrapolation of urban area land use percentage was used to predict city growth through the year 2050. City sprawl for this scenario is based on the percentage of urbanized areas from the historical, current, and general plan watershed conditions representing, respectively, the years 1947, 1992, and about 2015. As mentioned earlier, 1992 land use can be assumed to represent current conditions. The Ultimate Buildout scenario was applied to the General Plan Buildout land use since it would be the most similar and would reduce any error assumed in this method. The increase in percentage urbanized was applied equally to the three types of urban land use, those being low intensity residential, high intensity residential and commercial/industrial/transportation, within sub-watersheds that would be affected by the cities' growth. The remaining area of sub-watershed unaffected by urbanization was redistributed among the other land use categories, including agriculture, based on the original ratio of land uses. Sub-watersheds not affected by urban growth were left the same as those in the General Plan Buildout scenario.

