Phase 1 Conclusions
CHAPTER 4

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PHASE 1 CONCLUSIONS

The body of this report has focused on the following items:

- The creation and calibration of a hydrologic model (PRO-FLO) and a sediment transport model (PRO-SED)
- The model results for four watershed conditions

The following sections will highlight the key steps, issues, and conclusions of each of these aspects of Phase 1.

Models

The two models developed in this phase are Pajaro River to the Ocean FLOod model (PRO-FLO) and Pajaro River to the Ocean SEDiment generation and transport model (PRO-SED). PRO-FLO is designed to predict annual maximum peak and 3-day average river discharges at four separate points based on a design storm adjustable to a range of event frequencies. PRO-SED analyzes the impact of sediment changes such as sediment load, gradation, and changes in riverbed properties on the lower Pajaro River. It can also be used to investigate different channel maintenance options. As currently calibrated, both models are more than adequate to meet the goals of Phase 1 of the Pajaro River Watershed Study. They can be further refined however if future phases require a greater degree of accuracy.

The hydrologic model PRO-FLO uses river geometry, rainfall patterns, soil groups, and land use data to represent watershed flooding conditions. Rainfall patterns are used to create a design storm that is representative of storms that have caused flooding in the past and can be applied to the model. The soil groups and land use data are analyzed to yield a runoff indicator known as a curve number. Rainfall will either be absorbed by the earth, be retained and create puddles or ponds, or create runoff. The curve number represents the amount of runoff that could be expected with a given amount of rain. River geometry is used to simulate routings to perform dynamic simulations of flood waves that might impact agricultural or urban land. All of these inputs are used in two software packages, HEC-1 and HEC-RAS, which produce both peak and 3-day average discharges based on various storm frequencies. The model is calibrated based on the timing and magnitude of maximum annual peak flows as well as matching exceedance probability graphs of long-standing USGS stream gages. An analysis of five calibration stations yields a standard error of approximately 20% for peak discharge and 3-day average discharge.

The sediment transport model PRO-SED uses the dynamic modeling results from PRO-FLO, river geometry, and sediment data to produce a variety of outputs. These include sedimentation and scour location and evolution of the river shape over time. The software used for this model, MIKE11, was developed by the Danish Hydraulic Institute and is regarded as one of the best sediment modeling programs available. PRO-SED is calibrated to match HEC-RAS outputs developed within PRO-FLO by adjusting hydraulic roughness, composition and thickness of the active bed layer, the flood plain divide, and the number of cross sections used within the model.

Four Watershed Conditions

Four watershed conditions were designed by the Staff Working Group to better understand the impacts that certain factors had as well as to get a feeling for the range of flood discharges that are possible. Those factors include urbanization, agriculture, and existing flood protection structures. The four watershed conditions, along with a brief discussion of the rationale behind each scenario, can be found below.

1. **Back in Time to 1947**: It is important to be able to compare current and future conditions to those of the past. The year 1947 is significant because it is just before the Army Corps of Engineers' levees were built in 1949 and has similar conditions 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 urbanization and land use for each city and county based on the efforts of the individual planning departments. This is the best estimate available for future conditions within the watershed.
3. **Ultimate Buildout in 2050**: This scenario represents a worst-case scenario, in terms of flooding, for urbanization. The model predicts how the watershed responds 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 parallels the urbanization scenario and acts as a worst-case agricultural condition.

FLOODING IMPACTS

Several conclusions can be drawn based on the General Plan Buildout, Ultimate Buildout, and Changes in Agriculture scenario model results. One of the most significant and relevant to this study is the impact of land use on flooding. The type of agriculture might impact local runoff but on a watershed scale there is a minimal effect, probably due to the small percentage of agricultural land. Urbanization plays a larger role but for larger storm events, such as the 50- to 200-year storms, land use does not impact the amount of runoff created as much as one might expect. These large storms will saturate the ground quickly, effectively creating an impermeable surface for any additional rain. Therefore, the amount of runoff created by an urban surface or a natural yet saturated surface is nearly the same. For smaller storms, such as 2- to 25-year storms, land use and urbanization plays a more significant role. The discharges from these storms can have environmental effects if not managed properly. Since the storms and discharges are small however, existing downstream flood protection structures should be sufficient to handle any increases due to urbanization within the next 50 years for the 2- to 10-year floods. Existing control structures should be upgraded to protect against future 25-year floods. Overall, land use, either agricultural or urban, does not greatly affect the probability of flooding in the lower Pajaro River, probably since the total area for these two land use groups within the watershed is much smaller than the rural areas.

The Back in Time condition model results seem to contradict the above conclusions. Since there was less urbanization and less agriculture with far fewer row crops, the above conclusions would lead to the prediction that flooding potential was less significant in 1947 than it is now. However, the model results indicate that flooding potential was worse in 1947. The only other significant change in the watershed since 1947 is the addition of three dams, the Hernandez, Uvas, and Chesbro dams. The addition of these dams significantly reduced the peak flows and somewhat reduced the 3-day average volume. For example, Figure 3-6b shows the peak and Figure 3-6f shows the 3-day average discharge on the lower San Benito River. The historical line represents discharges before the Hernandez Dam while the other three are discharges with the Hernandez Dam in place and functioning. Existing runoff detention is key to downstream flood mitigation.

SEDIMENTATION IMPACTS

Sediment transport within the lower Pajaro River was tested using five simulations based on the results of the HEC-RAS model within PRO-FLO. Changes in peak discharge are unlikely to affect sedimentation patterns based on single storms. Larger storms increase the sediment load deposited at the confluence of the Pajaro and San Benito Rivers but yield little change in bed elevation as most of the additional sediment is transported downstream and out of the river reaches.

Growth of vegetation in the river channel could increase sediment deposition in several ways. As discussed earlier, vegetation increases hydraulic roughness. This slows the current, which allows sediment to settle out of the water column. There is also a mechanical trap on the vegetation itself but this is not accounted for in the model. Over time, the amount of sediment in the river channel will likely be significantly higher than what is modeled by PRO-SED. The sediment build-up could lead to increased opportunity for flooding if not controlled.

Changes in sediment load can be caused by many upstream changes. These include changes in land use, instream gravel mining, incision and erosion of upstream channels, and reservoir construction. Model results indicate, however, that the lower Pajaro River is relatively insensitive to changes in sediment load. The river is able to transport significantly more sediment than it is currently carrying without increasing local deposition.

Based on the above sediment model results, the four conditions modeled with PRO-FLO would have had little, if any, impact on sedimentation in the lower Pajaro River.

Both Upper and Lower Soap Lake play significant roles in limiting runoff peak discharge and sediment input to the lower Pajaro River from the upper reaches.