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Floodplain Analysis Report

San Pablo and Wildcat Creeks

Submitted To:

City of San Pablo

Submitted By:

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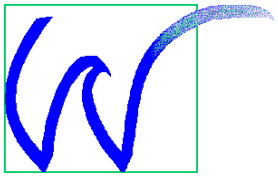

TABLE OF CONTENTS

List of Figures

List of Tables

Appendix

1 INTRODUCTION

The Federal Emergency Management Agency (FEMA) has proposed revisions to the November 17, 1993 Flood Insurance Rate Map (FIRM) for the City of San Pablo (City) based on their recently completed study of hydrology and hydraulics of San Pablo and Wildcat Creeks. This map is in preliminary form dated September 8, 2000. The preliminary map has significant impact to the City, by greatly increasing the amount of area in a Special Flood Hazard Zone for the 100-year flood. It is estimated that approximately 1,200 additional properties will be included in the 100-year flood zone with the Preliminary FIRM boundaries.

The City retained WRECO to perform a review of the FEMA hydraulic study and to verify the location of the 100-year floodplain boundaries for the San Pablo and Wildcat Creeks. An initial study by WRECO included a letter report dated February 16, 2001, and used the City's new topography information as a basis for an appeal of the Preliminary FIRM. The February 16 study determined the probable boundaries included far less flooding area than shown on the September 8, 2000 Preliminary FIRM. It also identified a number of issues that would cause the floodplain boundaries to be reduced from those identified on the September 8, 2000 Preliminary FIRM. These issues include changes in channel and bridge geometry, reductions in channel roughness, and alternative modeling of overland flows. Although the February 16 report included suggestions for additional studies that were necessary to determine the actual extent of flooding, the report did not include revised floodplain maps for FEMA review. FEMA staff has indicated that a floodplain boundary map with supporting hydraulic calculations should be submitted for comparison with their Preliminary FIRM boundaries. The City again retained the services of WRECO to continue with additional hydraulic studies and development of a floodplain boundary map.

This report summarizes the additional hydraulic studies performed following the February 16, 2001 letter report, and describes the development of the revised floodplain boundary map. Report references to map revisions should be interpreted as revisions made to the Preliminary FIRM dated September 8, 2000. The Preliminary FIRM was based on hydraulic analyses and models developed by Questa Engineering Corporation (Questa), the FEMA contractor for this work. Questa submitted the hydraulic models and hydraulic analyses to FEMA on October 1, 1997. These models are denoted as the FEMA models in this report. Report references to revised modeling should be interpreted as revisions made to the FEMA hydraulic models.

2 PROJECT APPROACH

The project approach was based on the additional studies that were recommended in the February 16, 2000 report by WRECO. This approach included the following tasks:

- Perform a field reconnaissance and research to determine channel roughness,
- Revise the FEMA San Pablo and Wildcat Creek HEC-2 computer models to incorporate updated Manning's n roughness, as well as bridge and channel modifications,
- Perform a hydraulic analysis of San Pablo and Wildcat Creek using the revised computer models,
- Perform an analysis of overland flow for floodwaters that leave the creek channels,
- Utilize model results and overland flow results to determine revised flooding water surface elevations,
- Develop a floodplain map from predicted water surface elevations

Each of the tasks provided a component for floodplain map development. After the channel roughness coefficients were identified for each creek, the new Manning's n values were substituted for those in the FEMA model. The FEMA hydraulic models were then revised with new channel floodplain geometry and bridge data, and a 100-year flood simulation was performed. The results from this simulation provided preliminary water surface elevations that were used to compare with channel edge of bank elevations. Where water surfaces were above the edge of bank, flow rates of overland flooding were calculated from topographic information. An iterative process was necessary to determine the combination of reduced flow rates in the creeks and the corresponding overland flow rates that would provide matching water surface elevations. Overland flows were returned to the channel where appropriate. Floodplain maps were developed from the water surface elevations identified in the hydraulic modeling. Rheem Creek, located just north of San Pablo Creek, was not included in this floodplain analysis since it was not included in the FEMA restudy of the Preliminary FIRM area.

This report is a summary of the floodplain analysis and mapping for San Pablo and Wildcat Creeks. The results from each of the tasks in the floodplain mapping are described in the following sections. A separate Hydraulic Analysis Report was developed to include additional detail regarding the hydraulic modeling of the creeks and overland flow areas. The Hydraulic Analysis Report is included as Appendix A in this report.

3 ANALYSIS OF CHANNEL ROUGHNESS (MANNING'S N VALUES)

The FEMA hydraulic analysis generally assumed a constant value for Manning's n along both creeks, with some changes occurring for flow passing through bridge structures. Our preliminary investigation determined that roughness coefficients varied along the channel due to changing vegetation and channel conditions. Site visits to each of the creeks were performed to assess the appropriate Manning's n roughness coefficients to be used for the various creek reaches. The conditions along each creek were photographed, and the stationing of the photo locations identified to catalogue the variations in Manning's n along the channel. Brief memoranda included in the Hydraulic Analysis Report appendices summarize the variation in Manning's n values for each of the creeks.

The Manning's n values developed in this study were generally lower and more varied than those used in the 1997 FEMA model. A comparison of the Manning's n values in the FEMA model and the revised model is shown on Figure 1. The Manning's n values used in the FEMA model appear to be very conservative, and primarily based on the characteristics of the highest Manning's n value found within each creek. For this study, the Manning's n of many of the reaches was reduced based on field inspection of the creeks. The Manning's n values used along Wildcat Creek are more varied, since the creek was dry and easily accessible during inspection visits. The Manning's n values for San Pablo Creek are less varied due to limited access (steep banks and fewer public crossings) along the creek.

A number of references were used to develop the revised Manning's n values for the two creeks and are described in the Hydraulic Analysis Report. However, there are two main factors that substantiate the reductions in Manning's n along the channel compared with the FEMA model. The first is the increased level of maintenance of the creeks being performed by the City since the original FEMA modeling was performed. The Manning's n values used in the FEMA model were originally assessed in the Final Report – Flood Plain Delineation, Wildcat and San Pablo Creeks, California, US Army Corps of Engineers, performed by Water Engineering & Technology, Inc. (WET), January 1989. Since that time, the City of San Pablo has initiated a program for annual cleanup and vegetation removal from the creeks. In 1994, the City performed a major cleanup of Wildcat Creek, and performed a cleanup of San Pablo Creek the following year. The cleanup included removal of trash, accumulated debris, creek blockages, as well as trimming of trees in the creek flow area. Cut trees and stumps were visible during a recent inspection of the creeks to assess Manning's n values. The City does additional trimming every fall to remove brush and maintain the flow areas within the creeks. In addition, after major storms the City inspects the creeks for blockages and has the blockages removed.

Another factor that likely influenced the higher Manning's n values selected for the FEMA model is the season the WET creek inspection was performed. Their inspection occurred in late August, when vegetation densities are among the highest. Photographs taken this year by WRECO during the summer months show considerably more vegetation growth than those taken earlier during the winter peak flow period. As mentioned previously, City maintenance crews routinely remove creek side vegetation in the fall, to prepare for the winter rainy season. This trimming reduces vegetation density, and reduces the overall Manning's n value of the reach.

The lowering of the Manning's n values for many portions of the creeks allowed the creeks to flow at a lower depth. This reduced the amount of flood flows leaving the channel and, in many cases, lowered the flooding levels to below the edge of bank elevations at the channel. Local residents

have observed that incidents of flooding have been less since the City implemented its creek cleanup program.

4 REVISION OF EXISTING MODELS

The HEC-2 hydraulic models used for the September 8, 2000 floodplain map of San Pablo and Wildcat Creeks were significantly revised for this study. The revisions included:

- Conversion of the HEC-2 model to a HEC-RAS model (Version 3.0)
- Development of a new station line for both creeks
- Use of new topography information from recent aerial mapping
    - Revision of the edge of bank elevations for weir and overbank flows
    - Revision of lengths and elevations of floodplain portion of cross sections
- Revision of Manning's n values based on WRECO field studies
- Addition of recent construction as-built information
    - Replacement of Rumrill Boulevard box culvert at Wildcat Creek
    - Revised channel geometry at mitigation site along Wildcat Creek at 23rd Street
    - Corps of Engineers Flood Control Projects for both creeks

These revisions are described in more detail in the following paragraphs.

4.1 Conversion of HEC-2 Model to HEC-RAS Model

The model was converted to HEC-RAS version 3.0, which has capability for split flow analysis. The FEMA models were HEC-2 models that contained a number of split flow locations that could not be converted properly in earlier versions of HEC-RAS software. FEMA encourages the use of HEC-RAS rather than HEC-2 for revisions or restudies of streams.

4.2 Development of a New Station Line for Wildcat and San Pablo Creeks

In review of the stationing developed for the FEMA models, discrepancies were found between the stationing of structures from the FEMA model and the distances measured in the current aerial survey information. These discrepancies and the corrections applied to the stationing are described in detail in the Hydraulics Analysis Report.

For consistency, the Army Corps of Engineers (COE) project stationing was used for all COE project locations, and was extended upstream when it matched the existing stationing. The COE has constructed flood control projects in the downstream reaches of San Pablo and Wildcat Creek to mitigate flooding problems. In the mid 1990's, the COE performed channel modifications along both creeks from just downstream of the Southern Pacific (SP) Railroad to just upstream of the Atchison, Topeka and Sante Fe (AT&SF) Railroad. The stationing for these projects was extended from downstream project stationing.

Three survey equations were necessary along the station line and are shown on Figure 1. On San Pablo Creek, a discrepancy with the lengths near the San Pablo Avenue bridge was corrected by adding 100 feet to the modeled cross section immediately downstream of the bridge. The stationing at the upstream end of the COE project on Wildcat Creek did not match the FEMA model stationing, and an equation was set at the end of the COE project to correct this difference. The second was added just upstream of the Davis Park Culvert, with forty feet reduction in reach length upstream of Station 137+79.

4.3 Use of New Topography Information from Recent Aerial Mapping

The City retained the services of Towill, Inc., in December 2000 to perform an aerial survey of the floodplain area. The new topography was used to revise the edge of bank elevations and the lengths and elevations of overbank areas of the cross sections. The new survey information provided a two feet contour interval, compared with a five feet contour interval used in the FEMA hydraulic analysis.

The new topography information was used only to modify the overbank areas of the creek floodplains. The bottom elevations of the main channel were not altered in this study. Many of the overbank cross sections along the channel that were not adjacent to bridges were revised to include only the area up to the nearest peak overbank elevation. Areas outside of this elevation generally flow away from the creeks and were assumed to be included in the overland flow calculations. The cross sections near the bridges were extended beyond these limits to determine the extent of overbank and weir flow over the roadways that were associated with the peak flow.

4.4 Addition of Recent Construction As-Built Information

The as-built information from four projects was added to the model. These include the replacement of the Rumrill Boulevard box culvert and channel improvements downstream of 23rd Street along Wildcat Creek, and the Corps of Engineers Flood Control Projects along each creek. The Rumrill Boulevard box culvert and channel improvements at 23rd Street increased the flow cross sectional area, which slightly reduced the head loss through these sections compared with the previous model. The COE projects constructed in 1995 will convey the 100-year flow with no flooding through the area between the AT&SF and SP Railroad tracks. These projects have shallow and at times supercritical flow. However, the reduction in water surface is not conveyed a significant distance upstream of the projects due to the critical depth channel control conditions located at the upstream end of each project and the high Manning's n values of the natural creek channels.

5 HYDRAULIC ANALYSES OF SAN PABLO AND WILDCAT CREEKS

The revised hydraulic models were used to determine flood elevations in the main channels and overland flow releases from the channel. The 100-year discharges for San Pablo and Wildcat Creeks were determined in a COE report entitled Wildcat-San Pablo Creeks, Contra Costa County, California, Feasibility Report for Water Resources Development, dated August 1973. The 100-year event peak flow was 5100 cfs at Church Lane for the San Pablo Creek channel, and 2300 cfs at Vale Road for the Wildcat Creek channel. The models of each creek were analyzed separately to determine the maximum water surface elevations at each cross section. For this analysis, all culverts and bridges were assumed to be free of debris throughout their length, and would not be restricted by blockages of the entrances. The water surface profiles described in this section include flow adjustments made for the release and return of overland flow along the channel. A description of the hydraulic analysis of the two creeks, which includes the overland flow analysis, is provided in Appendix A.

A comparison of the FEMA and revised water surface profile for San Pablo Creek is shown on Figure 2. Comparisons of the water surface elevations at each station are listed in Table 1. The negative values in Table 1 represent locations where the revised water surface profile is lower than the FEMA water surface profile. Stations with no water surface information shown for the FEMA model results are those that were added to the revised model.

Along San Pablo Creek, the revised water surface elevations are lower than the FEMA water surface elevations in the area downstream of Giant Road and upstream of the Regello Court area, which is halfway between Rumrill Boulevard and San Pablo Avenue. The lower water surface elevations downstream of Giant Road are due to the use of lower Manning's n values in the revised model for the concrete lined channel constructed by the Corps of Engineers. Likewise, lower Manning's n values for the natural channel in the revised model cause the upstream areas of San Pablo Creek to have a lower water surface elevation. The water surface elevations in the area near Rumrill Boulevard is similar in both models, since the lower Manning's n values in the revised model provide more conveyance in each section, and less upstream overland flow loss than the FEMA model. This causes more water to be conveyed in the channel in this area, increasing the water surface elevations.

The area immediately upstream of Giant Road has higher water surface elevations in the revised model due to the channel transition structure at the upstream end of the COE project. The structure is located immediately upstream of Giant Road. This structure was included in the revised model, but not in the FEMA model. This structure is 2.2 feet higher than the downstream concrete channel bottom elevation, and causes the flow to drop through critical depth at the transition. The FEMA model also did not include the higher bottom elevation cross sections at the transition structure.

The overland flow releases from the San Pablo Creek channel are limited primarily to areas downstream of the Regello Court area and upstream of Giant Road. Flow was released from the right and left banks of the channel in areas upstream of Rumrill Boulevard. Overland flow from Wildcat Creek enters the left bank of the channel in the area downstream of Rumrill Boulevard, increasing the creek flow rate. These flow rates are described in more detail in the overland flow section.

A comparison of the FEMA and revised water surface profile for Wildcat Creek is shown on Figure 3. The water surface elevations at each station along the creek are listed in Table 2, similar to the

comparison for San Pablo Creek. In the Wildcat Creek water surface profile comparison on Figure 3, the revised water surface elevations are generally lower than the FEMA water surface elevations, except near the Church Lane and ~~Van Ness Street bridge crossings~~, and the area just upstream of Rumrill Boulevard. The lower water surface elevations are due to the lower Manning's n values used for some locations in the natural channel of the revised model. The lower water surface elevations in the area near and downstream of the AT&SF Railroad are a result of the use of lower Manning's n values in the revised model for the rip rap and concrete lined channel constructed by the Corps of Engineers.

Overland flow occurs at intermittent locations along the length of the Wildcat Creek channel. Water surfaces are above the top of bank just upstream of Church Lane, and in most reaches downstream of Van Ness Street to the AT&SF Railroad. These are described in more detail in the overland flow section.

6 ANALYSIS OF OVERLAND FLOWS

Flow that leaves the channel and travels along streets and across land outside of the channel is termed an overland flow. The analysis of overland flow is an iterative process, requiring adjustment to overland flow diversions and return flow to the channel depending on water surface elevations observed in the channel and along the overland flow route. Both creeks are perched in relation to the topography, with the ground elevations outside of the channel at times lower than the edge of channel bank. In this case, once overland flow leaves the channel, the flow will be routed away from the channel. The overland flow outside of the main channel was generally analyzed using a separate HEC-RAS model. The boundary conditions were based on topographic surface conditions in the overland flow areas and channel water surfaces from the water surface profile. The Manning's n values were determined from land use.

The flow rates along portions of each creek channel, and approximate flood releases from the channel in a 100-year event are shown on Figure 4. The flow rates were determined by comparing the channel water surface elevation with the channel bank elevation to obtain an approximate depth of flow. In each overland flow area, the slope of the topography away from the channel was used with the Manning equation to determine normal depths at specified flow rates. These normal depths were compared with the calculated depth at the edge of the channel to determine an estimated release rate from the channel. These flows were then routed along the ground surface outside of the channel area. If the overland flow was adjacent to the channel, the flow rates were adjusted to maintain consistency with water surfaces in the channel. Where flow moved away from the channel, the water surfaces were developed from the normal depths of the flow rates across the topography.

The approximate route of the flood releases from the channel was determined by observation from the Towill topographic maps. The results from the HEC-RAS model provided the water surface elevation along the route. Cross sections were typically developed perpendicular to the flow direction, with Manning's n values assigned to various lengths of the cross section depending on land type. Typical Manning's n values were 0.015 for street cross sections and 0.60 for developed (lawn and housing) areas. The high 0.60 Manning's n value is assumed to account for fencing, houses, and other obstructions that are typically present in developed areas.

For areas where flooding was limited to a few inches above the top of curb, a reduced Manning's n of 0.02 was used for front lawn flow resistance. This flooding occurred along Pullman and Dodson Streets, 14th and 15th Streets, and the southern portion of Rumrill Boulevard along Wildcat Creek. A typical street cross section was used with the Towill topography information, since extensive street gutter and roadway elevations were not available. In some areas, the overland flows could be conveyed along streets with limited flooding of buildings. In other areas, higher flow rates and ponding of water created greater flooding and water depths. The low elevations at Trenton Boulevard create a pool where flooding occurs.

Four primary overland flow areas were identified in the revised model results. These areas included:

North of San Pablo Creek and west of 17th Street to Giant Road
Between San Pablo and Wildcat Creeks, Downstream of Davis Park to the AT&SF Railroad
South of Wildcat Creek and west of Davis Park to the AT&SF Railroad
Adjacent to Wildcat Creek, between Davis Park to just upstream of Church Lane.

The flooding in these areas is described in the following paragraphs. A detailed analysis of the flooding, including cross section locations and water surface elevations, is included in the Hydraulic Analysis Report in Appendix A.

North of San Pablo Creek and West of 17th Street to Giant Road. At peak flows, the San Pablo Creek water surface will exceed the top of the right bank near 17th Street. The water surface continues to exceed the top of right bank for the remainder of the downstream reach to the COE creek improvement project. The topography of the area north of the creek is lower than at the creek bank, causing the water to be conveyed northward until it pools in an area north of Trenton Boulevard. The maximum pool water surface elevation of 25 feet is roughly based on the volume of water released from the creek during the short duration of the peak flow period. This will create a flooding depth of about four feet in the pool area. The water surface elevations along the overland flow path to the pool were determined from a HEC-RAS model.

Between San Pablo and Wildcat Creeks, Downstream of Davis Park to the AT&SF Railroad. This area is flooded by overtopping of banks on both creeks. The flooding along San Pablo Creek occurs starting at Brookhaven Court, with flooding from Wildcat Creek due to the overtopping of the Davis Park Culvert. These flows are conveyed westward, primarily along the street areas, and overtop Rumrill Boulevard. The total flow then crosses Brookside Drive and returns to San Pablo Creek. Maximum flooding depths of about six feet occur in the lowest elevations near Randy Lane.

South of Wildcat Creek and west of Davis Park to the AT&SF Railroad. The flooding in this area is due to the overtopping of Davis Park Culvert. The flow that exceeds Davis Park Culvert capacity is routed along the park area, then flows primarily along Folsom Avenue. At 15th Street, the topography allows the flows to move south, away from the channel, as well as west. The amount of flow moving south is quite small, and generally causes flooding only slightly above the top of curb. All flow is assumed to be diverted back to Wildcat Creek in the area between Rumrill Boulevard and the AT&SF Railroad.

Adjacent to Wildcat Creek, between Davis Park to just upstream of Church Lane. Overland flows start just upstream of Church Lane, where a restriction in bridge capacity created high water surface elevations just upstream of the bridge. The left channel bank and Church Lane road surface area south of the Church Lane Bridge has a lower elevation than the water surface, and flow passes over Church Lane at peak flow. The overland flow continues west along Dover Avenue, and is returned to the creek at Dodson, Pullman, and Van Ness Streets. Flow depths are slightly above the top of curb elevations in these areas. Between Van Ness Street and Church Lane, the creek water surface is generally below the edge of bank elevations. However, the bank elevations along Wildcat Creek are slightly higher than the ground surface elevations further away from the creek. The flooding south of Wildcat Creek on Van Ness is due to the storm drain connection into the bridge from this area.

At Van Ness Street, the right bank elevations are lower than the water surface, causing flows to be conveyed along Standard Avenue and University Avenue. Some left bank elevation are also exceeded between Van Ness Street and 23rd Street. Although the culvert at 23rd Street has sufficient capacity to convey the peak flows, the overland flows along Standard Avenue will most likely flow across 23rd Street at the low roadway elevations north of the culvert. The overland flow in the area between 23rd Street and the Davis Park Culvert includes both sides of the channel, due to the limited channel capacity and low edge of bank elevations.

7 DEVELOPMENT OF REVISED FLOODPLAIN MAPS

The floodplain maps were developed from the creek hydraulic modeling and overland flow modeling information. Water surfaces in the creeks and overland flow areas with equal elevations were connected to identify approximate flood surface contours. Direction of flow and topography were also considered in development of water surface contours. The extent of the floodplain from the peak flows in the San Pablo and Wildcat Creeks is shown on Figure 5. The revised floodplain boundary generally includes the limit of the floodplain, inclusive of areas where flooding is less than one foot deep. These areas include approximately 140 acres.

A comparison with the FEMA floodplain boundary is also included on the Figure 5. The limit of the floodplain in the revised model is approximately 200 acres less than the 340 acres calculated with the FEMA model and shown on the Preliminary FIRM. Water surface elevations are also significantly reduced with the revised model. Some examples of the change in water surface elevation at specific locations are listed in Table 3.

Table 3. Comparison of FEMA and Revised Model Floodplain Map Flooding Depths

Location	Flooding Depths	
	FEMA Model	Revised Model
Mac Arthur Ave and Rumrill Blvd	4 feet	none
Douglas Street and Clare St	7 feet	none
Rumrill Blvd and Alvarado St	6 feet	2 feet

8 SUMMARY

As a result of the revised hydraulic modeling of San Pablo and Wildcat Creeks, the area encompassed by the 100-year floodplain boundary has been significantly reduced from that identified in the preliminary September 8, 2000 Flood Insurance Rate Map (FIRM). The reduction in floodplain boundaries in the revised model is due to the reduction in Manning's n values, the modeling of recent channel improvements, and use of a recently developed topographic map with 2-foot contour intervals and spot elevations. The Manning's n values in the FEMA model were conservatively based on heaviest vegetation growth in densest creek reaches. These Manning's n values were lowered in the revised model due to channel maintenance procedures currently practiced by the City of San Pablo and observed channel conditions during winter peak flow periods. The recent channel improvements have increased the channel cross sectional area and reduced velocity and head loss. The revised model also included alterations to modeled bridge sections based on current as-builts obtained from the City of San Pablo. The new topographic information allowed clearer definition of edge of bank elevations and limits of flooding for overland flow. The revised model indicates a 100-year floodplain boundary of 140 acres, compared with the 340 acre floodplain area of the September 8, 2000 map boundary.

Appendix A

Hydraulic Analysis Report