Sanjon Barranca
Pre-Design Study / Final Report
City of Ventura
Ventura County, California

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Prepared for:

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EXECUTIVE SUMMARY

The purpose of this report is to summarize the work completed on the Pre-Design Study for the Sanjon Barranca storm drain system, in the City of Ventura, in western Ventura County, California. Recent investigations by the Ventura County Watershed Protection District (District) and evidence of historical flooding indicate that the existing system does not have the capacity for the 100-year flood. As such, the District identified the system as a candidate for a Capital Improvement Project. The scope of this study was to evaluate existing and proposed improvements and make recommendations for future consideration.

The District provided hard copy results from a hydrologic model (Modified Rational Method) of the Sanjon Barranca watershed. The results were provided for 100-year frequency only. The District's hydrologic multipliers were used to develop 50-, 25-, 10-, 5-, and 2-year flows. HDR developed an existing condition hydraulic model using WSPGW for the storm drain structures and HEC-RAS for the floodplain. Inundation limits were mapped for 10-, 25-, 50-, and 100-year storm events using HECRAS, GeoRAS, and GIS tools and corresponding damages were estimated using the US Army Corps of Engineers "Expected Annual Flood Damage Computation (EAD)" method.

The analysis of the Sanjon Barranca storm drain system indicated that the existing capacity is less than a 10-year storm. The corresponding expected annual damages due to residual flooding were estimated to be $435,000, with a corresponding present worth value of $6,000,000. The condition of the existing facilities is fair with an estimated life expectancy of 20 years with no treatment.

The following three alternative system improvements were studied to alleviate all or a portion of the 100-year flood damages:

- Alternative 1 – Replace the existing system to provide 100-year level of protection. Options were included for both replacement and parallel facilities (1A) and for replacement only (1B).
- Alternative 2 – Provide a detention basin(s) to reduce peak flow rates in the system and replace existing choke points in the system to provide 100-year level of protection. Options were included for a single basin (2A) and for two basins (2B).
- Alternative 3 – Improve existing choke points in the system (Segment 3A) to provide a minimum 10-year level of protection from the headworks to Thompson Boulevard; construct approximately 350 feet of open channel upstream of Highway 101 (Segment 3B) to convey the 10-year flows contained within the existing system; and construct a parallel facility in San Jon Road (Segment 3C) from Thompson Boulevard to the open channel just upstream of Highway 101, to convey the 100-year flows in excess of the 10-year channel capacity. Costs for each of the three segments were separated for possible phasing considerations.

The preliminary cost opinion for each of these alternatives is summarized in the table below.

Summary of Costs

Alternative	Cost	Level of Protection
1A	$16,450,656	100 yr
1B	$19,192,232	100 yr
2A	$31,225,131	100 yr
2B	$26,524,344	100 yr
3	$12,476,275	10 yr

The primary benefit of these alternatives is the reduction in flood damages. Alternatives 1A, 1B, 2A, and 2B would result in the elimination of the $6,000,000 in flood damages (present worth value); however, Alternative 3 would only reduce the damages to $2,290,000 (approximate 10-year level of protection), for a net benefit of $3,710,000. Comparing the costs of these alternatives to the potential benefits (see table below), indicates that none of the alternatives provides a benefit-to-cost ratio (B/C Ratio) above 1.0.

Benefit to Cost Comparison

Alternative	Benefit	Cost	Level of Protection	B/C Ratio
1A	$6,000,000	$16,450,656	100 yr	0.36
1B	$6,000,000	$19,192,232	100 yr	0.31
2A	$6,000,000	$31,225,131	100 yr	0.19
2B	$6,000,000	$26,524,344	100 yr	0.23
3	$3,710,000	$12,476,275	10 yr	0.30

Although the project could not be recommended based on flood damage reduction benefits alone, Alternative 3 could be considered for ecosystem restoration and water quality benefits.

The initial scope of the Pre-Design Study was not completed due to the interim results indicating the benefit-to-cost ratio would not support the project when only considering flood damage reduction benefits. The project was put on hold on April 11, 2007 and an Interim Report was prepared to document the work completed to date (see Sanjon Barranca Pre-Design Study Interim Report, HDR, May 2007). A meeting of the Sanjon Barranca Stakeholders on June 19, 2007 resulted in the subsequent decision to consider one additional alternative to evaluate ecosystem restoration as a possible project benefit. This alternative was added as Alternative 3. This report summarizes and documents all of the work completed through the evaluation of Alternative 3. Components of the scope not completed include: Preliminary Environmental Assessment (Task 9); Develop Comparison Matrix (Task 12); Meeting to Select Preferred Alternative (Task 13); Utility Identification and Base Sheets (Task 14); and Pre-Design Construction Drawings (Task 15).

1.0 INTRODUCTION AND PROJECT BACKGROUND

The purpose of this report is to summarize the work completed on the Pre-Design Study for the Sanjon Barranca storm drain system, in the City of Ventura, in western Ventura County, California as shown in Figure 1. Recent investigations by the Ventura County Watershed Protection District (District) and evidence of historical flooding indicate that the existing system does not have the capacity for the 100-year flood. As such, the District identified the system as a candidate for a Capital Improvement Project. The scope of this study was to evaluate existing and proposed improvements and make recommendations for future consideration.

This project involves the Sanjon Barranca watershed from the ocean outlet downstream of Harbor Blvd. to the headwaters in the foothills, in the City of Ventura. For the purposes of this study, the headwaters are defined as a point approximately halfway between the upstream most inlet of the existing facilities (66-inch RCP near Buena Vista Street) and the City limits.

The study identified several deficiencies in the storm drain system that contributes to flooding in the Sanjon Barranca watershed. The study team evaluated the economic impact of the flooding and a number of preliminary alternatives to reduce the frequency of flooding and provide a higher level of protection to downstream properties than now exist.

As is discussed in Section 6.0 – Conclusions and Recommendations, the initial scope of the Pre-Design Study was not completed due to the interim results indicating the benefit-to-cost ratio would not support the project when only considering flood damage reduction benefits. The project was put on hold on April 11, 2007 and an Interim Report was prepared to document the work completed to date (see Sanjon Barranca Pre-Design Study Interim Report, HDR, May 2007). A meeting of the Sanjon Barranca Stakeholders on June 19, 2007 resulted in the subsequent decision to consider one additional alternative to evaluate ecosystem restoration as a possible project benefit. This alternative was added as Alternative 3.

1.1 SANJON BARRANCA WATERSHED CHARACTERISTICS

The upper watershed of the Sanjon Barranca is largely rugged uplands and steeply-sloped smaller tributary watersheds covered with native vegetation. The creek then enters a storm drain system and flows through the City of Ventura developed with moderately-sized residential dwellings in a suburban setting. Future development in the watershed is expected to be minimal, as much of the remaining upper watershed area is too steep for the siting of residences or commercial structures.

The Sanjon Barranca storm drain system is known to have moderate flooding in recent years. Particular problem areas have been the open channel areas near Poli Street.

1.2 CLOSED CIRCUIT TELEVISION DATA REVIEW

Closed Circuit Television (CCTV) Inspection Tapes and Reports for underground facilities of Sanjon Barranca were obtained from Ventura County Watershed Protection District (VCWPD). These inspections were performed by Performance Pipeline Technologies during the period of December 21, 2006 and December 29, 2006. CCTV inspections began at the upstream end of 66” pipe near Buena Vista Street and continued downstream through underground structures to the downstream end of 8’x9’ Arch pipe at SPRR.

Inspection tapes were reviewed to identify maintenance and/or structural problems that could affect long-term serviceability of the existing facilities. All the problems identified in the CCTV inspection are classified in following types.

Debris/Silt

When the channel/pipe invert is partially filled by sediment blocking the flow, it is identified as Debris/Silt Problem. Sediment may include debris, rocks, silts, etc. This problem will need some maintenance efforts to clean the facilities to get full efficiency. This problem is assumed to have low impact on long-term serviceability of the facilities.

Defective Service Connection

If the lateral to the main facility is damaged or abandoned or if there is any break-in-connection, it is identified as Defective Service Connection. This problem is assumed to have low impact on long-term serviceability of the facilities and may need minor repairs or maintenance efforts to fix.

Invert Damage

When there is damage to the flow invert of the element either due to upstream drop or any other reason, it is defined as Invert Damage. This problem is assumed to have low impact on long-term serviceability of the facilities and may need minor repairs or maintenance efforts to fix.

Spalling

When layer or fragment of concrete is broken off from the surface of structural element, it is defined as Spalling. This occurs due to high shear stress and temperature. This problem is assumed to have low to moderate impact on long-term serviceability of the facilities depending upon the location and extent of spalling. Some minor local repairs might be required to fix the problem.

Rebar Exposed

When the pieces from the surface of the structure is broken exposing rebar or other inner structural elements, it is defined as Rebar Exposed. This is moderate-impact problem and can grow or cause other problems (e.g. instability of structure, water seepage) if not addressed. Some minor local repairs might be required to fix the problem.

Infiltration Seeping at Joint

When there is water seeping at the joints or through the cracks on the element surface, it is defined as Infiltration Seeping at Joints. This could have moderate to high impact on long-term serviceability of the facilities depending upon the extent of damage. This may need local patch-repair work or replacement of structure after thorough review at each location to correct the problem.

Table 1 lists the storm drain segment type and length while Table 2 gives the number of occurrences of each damage type for the segment.

Figure 2 shows the existing storm drain structures that comprise the Sanjon Barranca system. The existing facilities were based on data from As-Built drawings and verified and/or modified by the CCTV data review.

Inspection tapes were reviewed to assess the condition of the existing storm drain system and estimate the remaining service life performance. The tapes show existing structural problems that include exposed rebar, spalling, invert erosion damage, defective service connections and seepage through the walls of the reinforced concrete box (RCB) culvert.

One problem affecting the RCB culvert's efficiency is the amount of debris that enters the storm drain facility. The debris can cause damage to the channel's invert, exposing rebar and erosion of the storm drain facility. Damaged storm drain inverts and walls should be resurfaced. Once the RCB culvert has been resurfaced, it is recommended to provide debris basin, racks or guard post near the entrance of the RCB culvert. This will prevent debris from entering the storm drain.

Another evident problem is seepage. This may occur from the water accumulating outside the RCB culvert walls and seeping thru the walls. The seepage causes cracks along the RCB culvert walls. A repair plan would include removing any unsound concrete in cracked areas and crack cleaning followed by an epoxy grout application. A solution to keep infiltration seepage from reoccurring is to core drill sub-drains with filter fabric at 50 foot intervals along the storm drain box culvert's alignment. This will provide a point of concentration for water outside of the storm drain to enter the facility through the sub-drains as oppose to seeping through the walls.

It was also observed that poor construction is a contributing factor to several deficiencies in the RCB culvert and thus resulting in defective service connections at several locations along the channel. A solution to correct this problem would be to repair the connection by covering up or removing exposed rebar where the rebar serves no structural component.

If the existing storm drain facility goes untreated, it is estimated that the remaining service life is approximately 20 years. With appropriate repairs and improvements, the serviceability life span can be extended to about 40 years. The initial required repairs are estimated to cost $648,000 (see Table 3 below). Additional repairs will likely be needed in the future. It is assumed that 20% of the initial repair cost will be needed every five years. This results in an annualized maintenance cost of $71,038.

Figure 1. Vicinity Map

Figure 2. Existing Facilities

Table 1. CCTV Data Summary

Video/Segment No.	Approx. Stations	Segment Type	Length
21	5530-4551	5.5' RCP	979
21.1	4551-4513	5' RCP	38
21.1	4513-4506	5' CMP	7
21.2	4506-4190	5'X4' CMPA	316
20	4190-4178	4'X6' RCB	12
	-	Drop of 27 feet	
20.1	4178-4063	6X6 RCB	115
	4063-3818	Open Channel	245
20.2	3818-3619	6' RCP	199
20.3	3619-3614	7'X7' RCB	5
	-	Drop of 3 feet	
20.3	3614-3543	7'X7' RCB	71
	3543-3497	Open Channel	46
20.4	3497-3344	6' RCP	153
20.5	3344-2787	6'X6' RCB	557
20.6	2787-2682	7' CMP	105
20.7	2682-2065	7'X7' RCB	617
	2065-2055	Transition	10
20.8	2055-1931	5' RCP	124
	-	Drop of 3.5 feet	
20.9	1931-1866	6'X6' RCB	65
20.10	1866-1439	6' RCP	427
20.11	1439-1277	8'X9' Arch	162
	1277-1248	Transition	29
Total Length Measured			**4282**
Current Alignment Length (Sta 5530-1255) = 4275			

Table 2. CCTV Data Damage Summary

Segment Type	Number of Occurrences for Each Damage Type					
	Debris/ Silt	Defective Service Connection	Invert Damage	Spalling	Rebar Exposed	Infiltration Seeping at Joint
5.5' RCP		1				
5' RCP						
5' CMP						
5'X4' CMPA						
4'X6' RCB			1		2	
Drop of 27 feet						
6X6 RCB	1	1			1	
Open Channel						
6' RCP			1			
7'X7' RCB	1	1				
Drop of 3 feet						
7'X7' RCB						
Open Channel						
6' RCP						
6'X6' RCB				2	2	2
7' CMP						
7'X7' RCB	1	6	1	1		for ~ 200 ft
Transition					1	
5' RCP		2	2			for ~ 60 ft
Drop of 3.5 feet						
6'X6' RCB			1		1	3
6' RCP			1			for ~ 150 ft
8'X9' Arch			1			for ~ 120 ft
Transition						

Table 3. Maintenance Cost Opinion

ITEM NO.	ITEM DESCRIPTION	EST. QTY.	UNIT	UNIT COST	TOTAL
1	Mobilization/Demobilization	1	LS	$20,000.00	$20,000.00
2	Removal of unsound concrete	2500	SF	$110.00	$275,000.00
3	Sandblast walls and soffit	7000	SF	$2.50	$17,500.00
4	Patch with epoxy cement	7000	SF	$20.00	$140,000.00
5	Miscellenous steel removal/repair	1	LS	$10,000.00	$10,000.00
6	Invert repaving	6300	SF	$30.00	$189,000.00
7	Weep holes	84	EA	$60.00	$5,000.00
10	Storm water control	1	LS	$20,000.00	$20,000.00
				SUBTOTAL:	**$676,500.00**
				15% CONTINGENCY:	**$101,500.00**
				***GRAND TOTAL:**	**$778,000.00**

Assumptions:

RCB area of repair was estimated to be about 10% of wall area

RCB invert repair was estimated to be about 25% of the invert area

Note:

* Grand total to be the initial cost estimate of repair and approximately 20% of that cost every 5 years there after for the remaining 40 year life span.

2.0 HYDROLOGY

2.1 RATIONAL METHOD HYDROLOGY FROM VCWPD

The District provided hard copy results from a hydrologic model (Modified Rational Method) of the Sanjon Barranca watershed. The results were provided for 100-year frequency only. The District's hydrologic multipliers were used to develop 50-, 25-, 10-, 5-, and 2-year flows. Basins 1A, 2B, 3A, 4C, and 5A were considered as "Undeveloped Watersheds", while remaining basins were considered as "Developed Watersheds". See Table 4 below for the hydrologic multipliers. The VCRAT 100-year results from the District and other frequency flows obtained with the multipliers are summarized in Table 5. HDR reviewed the VCRAT model and confirmed that it met the needs of the Pre-Design Study.

Figure 3 shows a summary of the flow data HDR received and additional hydrologic data used to develop storm hydrographs for use in analyzing the effectiveness of proposed detention basins.

Table 4. Ventura County Hydrologic Multipliers

Frequency of Occurrence (years)	Q100	Q50	Q25	Q10	Q5	Q2
Peak Flows from Undeveloped Watersheds	1.38	1.00	0.70	0.50	0.23	0.08
Peak Flows from Developed Watersheds	1.20	1.00	0.83	0.68	0.45	0.16

Table 5. Summary of Peak Discharges

Concentration Points	Frequency of Occurrence (years)					
	Q100	Q50	Q25	Q10	Q5	Q2
98 B	288	209	146	105	48	17
101 B	863	625	438	313	144	50
102 B	980	710	497	355	163	57
104 B	1080	793	566	412	201	70
107 D	322	227	159	113	52	18
108 BD	1393	1020	725	525	253	88
115 B	1582	1178	856	632	324	113
116 AB	4474	3588	2856	2271	1408	499

2.2 STORM HYDROGRAPH METHOD (UPPER BASIN ONLY)

A HEC-HMS model was developed for the upper watershed area shown in Figure 3 to generate a storm hydrograph for use in the design of the detention basin alternative. For the purpose of this study, the upper watershed is defined as the area upstream of the inlet to the existing 66-inch RCP near Buena Vista Street.

When compared to the Modified Rational Method model results from the District, the HEC-HMS peak flows are reduced by approximately 20 percent. For example, at concentration point 102 B, Q100 is 980 cfs for the VCRAT analysis while the HMS model gives 750 cfs. Due to conservative assumptions built into the rational method and more detailed data input for the flood hydrograph method, we would expect the HMS results to be less than the rational method results. See preliminary alternatives analysis Alternative 2 for the results of adding detention basins to the model.

Figure 3. Hydrology Workmap

2.3 HEC-HMS METHODOLOGY

The HEC-HMS model consists of three components to simulate the rainfall-runoff process. The Basin model deals with the shape and size of the watershed, the meteorological model includes the development of a hypothetical design storm, and the control sets up the timing parameters needed in order to properly model a storm. The steps involved in developing the complete model are outlined below.

2.4 BASIN MODEL

The Basin model is the first component of HEC-HMS where the parameters are entered to model loss rates, overland flow and channel routing. There are different methods available in HEC-HMS to accomplish this, giving the user several options to control and properly model the watershed. These parameters include drainage areas of sub-basins, stream lengths, slopes, longest flow paths, distance to centroids of those sub-basins and lag-time. ArcGIS was used to generate a shapefile by digitizing the watershed boundaries which were then compared with the paper maps provided by Ventura County. The ArcGIS program was also used to calculate the area and flow paths of the sub-basins within the watershed.

Loss Parameters

There are several methods for estimating the rainfall losses due to infiltration. HEC-HMS has the ability of selecting between many of these options such as the Green and Ampt, gridded SCS Curve Number, initial and constant loss method, SCS Curve Number method, as well as others. SCS Curve Number method is used for modeling the Sanjon Barranca watershed because it is consistent with the VCRAT software and the District's Hydrology Manual. With soil data and land use information available, we selected SCS curve numbers from the tables in the District's Hydrology manual. The SCS method classifies hydrologic soil groups as A, B, C, and D, while the District numbers them from 1 through 7 according to infiltration rates, 1 being a very slow infiltration rate (equivalent to SCS hydrologic soil group D) and 7 with the highest infiltration rate (6 and 7 are equivalent to SCS hydrologic soil group A). See VCWPD Hydrology Manual page 2-3 in Appendix 3.

For undeveloped areas at the upstream of the Sanjon Barranca watershed the land use type is considered to be good condition open brush and further downstream of the watershed is considered to be good condition brush. This is judged based on the best available aerial photography. Exhibit 14A and Exhibit 14B in Appendix A from the Ventura County Hydrology Manual, December 2006 gives the Curve Numbers based on Hydrologic soil group and the developed (Exhibit 14A) and undeveloped (Exhibit 14B) land uses.

Two additional parameters needed for SCS Curve Number loss method are the percent impervious and the initial abstraction; however, the curve number tables (Exhibits 14A & 14B) incorporate the percent impervious values for urban areas. These percent impervious values are used to calculate the weighted percent impervious by dividing the area impervious with the total area of the sub-basin. Initial abstraction is a function of the curve numbers and is calculated by using the U.S Natural Resources Conservation Service (NRCS) method. This method assumes that initial abstraction (depression storage, evaporation, and interception losses) is equal to 20% of the storage capacity.

$$I_a = 0.2 \times Sc$$

Where $$Sc = \frac{1000 - 10 \times CN}{CN}$$

The variable Sc described as storage capacity of the soil and CN is the Curve number.

Runoff Transformation

HEC-HMS has several options to transform the excess precipitation to direct run-off. These options include Kinematic Wave method, Clark Unit hydrograph, SCS Unit hydrograph, Snyder Unit hydrograph and others. The SCS Unit hydrograph approach was used for this model because of its widespread use, applicability, and to be consistent with the loss method and the meteorological model (all SCS methods). There is only one parameter needed in HEC-HMS, which is the lag time in minutes. Basin lag time is estimated using the US Army Corps of Engineers Los Angeles District (USACE 1989) lag equation.

$$Lag = 24 \times n \left(\frac{L \times L_{ca}}{S^{1/2}} \right)^{0.38}$$

Where: L = length of the longest watercourse, in mi

Lca = length along longest watercourse, in mi, measured from the outlet to a point perpendicular to the centroid of the basin

S = overall slope (ft/mi) of longest watercourse between headwater and collection point

n = basin roughness factor

A value of n= 0.030 is used for undeveloped areas (natural ground) and n= 0.015 is used for developed areas (residential/commercial).

The length along the longest watercourses and overall slope for the watershed can be calculated using the GIS tools in ArcGIS. This is done by obtaining the elevations at the upstream and downstream ends of the sub-basin and dividing the difference in elevations by the length of the flow path.

Channel Routing

The final option in the basin model used for the Sanjon Barranca model was the channel routing. There are several options for routing water through the stream channel. HEC-HMS has the ability to select between different hydrologic routing options such as Kinematic Wave, Modified Puls, Muskingum-Cunge, Lag method and many others. Muskingum-Cunge method was used for this model because it was developed based on the physical characteristics of natural rivers and the upper watershed area of the Sanjon Barranca is all natural channels. The input parameters needed for this method include channel cross-section shape, bottom width of the channel, side slopes, reach lengths, and Manning's n factor. For the channel shape the options available in Muskingum-Cunge method are circle, eight point, rectangular, trapezoid and triangular. The channel shape for the Sanjon Barranca watershed is set to be trapezoidal with a bottom width of 5 ft and side slope of 1H: 1V for all reaches. Slopes are estimated by dividing the difference of elevations at the upstream and downstream ends of the reaches by the total length of the reach.

2.5 METEOROLOGICAL MODEL

The second component of HEC-HMS, the meteorological model, includes precipitation and evapotranspiration data. There are several different methods for modeling the precipitation with HEC-HMS. The frequency-storm method, SCS storm, gage weights method, and gridded precipitation are a few. The SCS storm method was selected for this model because it was developed specifically for use in coastal California (see Appendix 3). Due to the watershed size and time of concentration, a 24-hour storm is adequate for use in runoff volume analysis (to study detention basins).

A Meteorological model for the 100-yr 24-hr precipitation was created using the SCS storm method. This method was based on the synthetic storm hyetographs developed by United States Department of Agriculture Soil Conservation Service (1973, 1986) for the 6-hr and 24-hr storms in the United States. Based on Figure 7.2.17, in Larry W. Mays "Water Resources Engineering," first edition, the geographical location of the Sanjon Barranca watershed falls under Type I Rainfall distribution zone as shown in Figure 4 below.

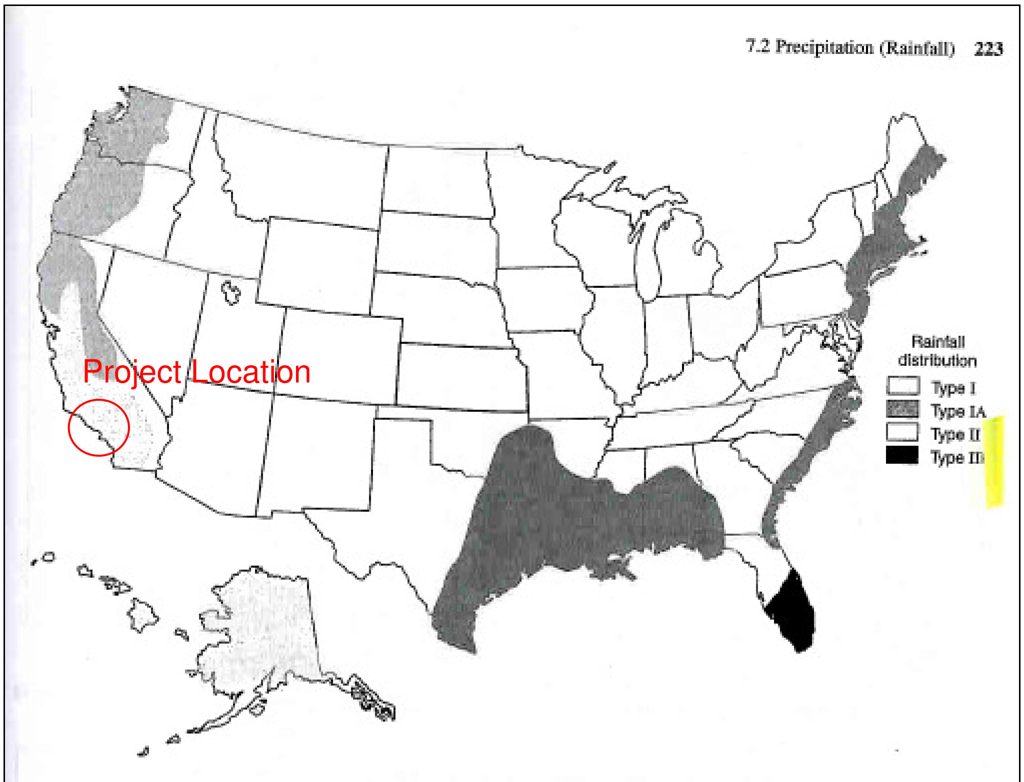

Figure 7.2.17 Location within the United States for application of the SCS 24-hour rainfall hyetographs (from U.S. Department of Agriculture Soil Conservation Service (1986)).

Figure 4. SCS 24-Hour Rainfall Hyetographs

2.6 CONTROL SPECIFICATION

This is the component in which the date and timing of the runs will be entered. It also contains entry for time interval in which the user can specify how often each of the model calculations is performed. The control was set to run for a 24-hour duration at one minute time steps.

3.0 EXISTING CONDITION HYDRAULIC MODEL AND MAPPING

HDR developed an existing condition hydraulic model using WSPG for the storm drain structures and HEC-RAS for the floodplain. The WSPG model was developed from records obtained from the District and from the City of Ventura. Figure 4 shows a plan view of the existing condition WSPG model, capacities at critical points, and the 100-year peak flows from the VCRAT results.

3.1 WSPG MODEL RESULTS

Figure 4 shows the section of open channel where flooding occurs in red. Figure 5 shows a profile of the WSPG model for the 10-year event. The plotted hydraulic grade line (HGL) clearly shows that the storm drain will be under pressure flow conditions in many areas. Water will exit the system at the reach of open channel below Poli St. and at the open channel under the retail building just downstream of Main St.

The hydraulic capacity of each system reach was estimated based on the WSPG Model and Manning's Equation. The capacities were then compared to the 10-year event peak discharges to determine the flow remaining in the system and the overflow in each reach. Where lateral flow is contained within a closed system, the system was assumed to have the capacity to convey the flow under a surcharged condition (i.e. no flow can exit the system). Flow is only allowed to leave the system within the open channel reaches.

Table 6 summarizes how that flow will be distributed as it makes its way through the system. The storm drain capacity results from the WSPG model are incorporated to show how much of the flow will result in flooding. The highlighted numbers represent points where the capacity is restricted (commonly referred to as a "choke point"). The results in Table 6 show that the Sanjon Barranca storm drain has the capacity to pass a five-year flood.

3.2 HEC-RAS MODEL RESULTS

The overflow quantities were used to approximate the inundation area for each storm event. A HEC-RAS model was developed to evaluate the flood limits and depths. Cross-sections were taken at critical locations using 1-foot topographic mapping. HEC-GeoRAS was used to both cut the cross-sections and to map the flood limits and depths.

Figure 6 shows the results of the HEC-RAS model analysis of the 100-year overflow. See Section 4 for the Economic Damage analysis that results from the flooding.

Figure 5. Existing Condition WSPG Storm Drain Model

Figure 6. Storm Drain Profile for 10-Year Event

Table 6. Existing Condition Storm Drain System Flows

Location	Q100 (cfs)					Q50 (cfs)				
	Total	Lateral	U/S In-Pipe	D/S Pipe Capacity	Overflow	Total	Lateral	U/S In-Pipe	D/S Pipe Capacity	Overflow
Headwater (from undeveloped sub-basins 1A, 2B, 3A, 4C, and 5A)	980	980	980	710	270	710	710	710	710	0
Lateral at 47+00 (from developed sub-basin 6A)	1080	100	710	810	270	793	83	710	793	0
Lateral at 38+20 (from undeveloped sub-basin 8D and 7A)	1393	313	810	244	1149	1020	227	793	244	776
Station 35+16	1393	0	244	244	1149	1020	0	244	244	776
Lateral at 20+64 (from developed sub-basin 10E and 9A)	1582	189	244	433	1149	1178	158	244	402	776
Prince Barranca at 8+40 (developed)	4474	2892	433	3325	1149	3588	2410	402	2812	776

Location	Q25 (cfs)					Q10 (cfs)				
	Total	Lateral	U/S In-Pipe	D/S Pipe Capacity	Overflow	Total	Lateral	U/S In-Pipe	D/S Pipe Capacity	Overflow
Headwater (from undeveloped sub-basins 1A, 2B, 3A, 4C, and 5A)	497	497	497	497	0	355	355	355	355	0
Lateral at 47+00 (from developed sub-basin 6A)	566	69	497	566	0	412	57	355	412	0
Lateral at 38+20 (from undeveloped sub-basin 8D and 7A)	725	159	566	244	481	525	113	412	244	281
Station 35+16	725	0	244	244	481	525	0	244	244	281
Lateral at 20+64 (from developed sub-basin 10E and 9A)	856	131	244	375	481	632	107	244	351	281
Prince Barranca at 8+40 (developed)	2856	2000	375	2375	481	2271	1639	351	1990	281

Location	Q5 (cfs)					Q2 (cfs)				
	Total	Lateral	U/S In-Pipe	D/S Pipe Capacity	Overflow	Total	Lateral	U/S In-Pipe	D/S Pipe Capacity	Overflow
Headwater (from undeveloped sub-basins 1A, 2B, 3A, 4C, and 5A)	163	163	163	163	0	57	57	57	57	0
Lateral at 47+00 (from developed sub-basin 6A)	201	38	163	201	0	70	13	57	70	0
Lateral at 38+20 (from undeveloped sub-basin 8D and 7A)	253	52	201	244	9	88	18	70	88	0
Station 35+16	253	0	244	244	9	88	0	88	88	0
Lateral at 20+64 (from developed sub-basin 10E and 9A)	324	71	244	315	9	113	25	88	113	0
Prince Barranca at 8+40 (developed)	1408	1085	315	1399	9	499	386	113	499	0

Notes: 1. Q100 obtained from VCWPD provided hydrologic model.
2. Q50, Q25, Q10, Q5, and Q2 calculated using Ventura County multipliers.
3. Subareas upstream of station 47+00 assumed as undeveloped.
4. Subareas downstream of station 47+00 assumed as developed.
5. Capacity is limited by choke points.

4.0 FLOOD DAMAGE ANALYSIS

4.1 INTRODUCTION AND PURPOSE

The purpose of this section is to present the methodology used to calculate potential damages associated with various storm events and to estimate expected annual damage. The potential damages are based on aerial photos and 1-foot topography obtained from Ventura County Watershed Protection District (District). No detailed ground surveys of channel cross sections or elevations were conducted. The inundation maps generated by HEC-GeoRAS model along with aerial photos were used to develop structure counts, square footage of commercial structures and other potential inundated areas for a range of storm events from 10- to 100-year.

Current market values for residential structures, property values for commercial structures, school, church etc. were provided by the District. Damages based on flooding depth were calculated using generic Depth-Damage Curves developed by US Army Corps of Engineers.

4.2 APPROACH

Inundation limits were mapped for 10-, 25-, 50-, and 100-year storm events using HECRAS, GeoRAS, and GIS tools (See Figures 7a, 7b, 7c, and 7d for inundation mapping) and corresponding damages were estimated using the following approach:

- Identify inundated structures for all storm events listed above
- Calculate depth of flooding for each structure for each storm event
- Calculate damage for each structure for each storm event based on flooding depth using "Generic Depth-Damage Curves" prepared by US Army Corps of Engineers Institute of Water Resources (IWR)
- Calculate total flood damages for each storm event
- Plot percent exceedance frequency of storm events against total damages
- Calculate Expected Annual Damage cost as described in US Army Corps of Engineers "Expected Annual Flood Damage Computation (EAD)" software User's manual

Total flood damage cost includes structure damage cost, contents damage cost, clean-up cost, temporary rental assistance cost (TRA), and public assistance cost (PA).

Figure 7A. 10-Year Inundation Area

Figure 7B. 25-Year Inundation Area

Figure 7C. 50-Year Inundation Area

Figure 7D. 100-Year Inundation Area

4.3 ASSESSMENT OF DAMAGES FOR EXISTING CONDITIONS

Residential Structures (Homes)

The District provided total market values for homes including land and structure values which are listed in Table 7 below. The structure value is assumed to be 40% of the total value (per the District). Total structure value is usually equal to mean depreciated replacement value of the structure. It is assumed that mean depreciated structure value is 64% of its current market value. Structure and contents damages were calculated based on the depreciated structure value and depth of flooding.

Table 7. Parcel Market Values

Address	Parcel Market Value[1]
1279 Meta Street	$457,000
1658 Buena Vista Street	$1,377,000
227 Barnard Way	$1,864,000
215 Barnard Way	$1,446,000
216 Barnard Way	$1,450,000
213 Barnard Street	$1,768,000
157 S Crimea Street	$394,000
1279 Meta Street	$456,000
1293 Meta Street	$564,000
171 S Crimea Street	$465,000

Note: [1] Parcel Market Value includes land value and values for all the structures on the parcel in year 2008

A recent Corps of Engineers Report for economic assessment of Calleguas Creek Watershed, which included data from Marshall and Swift (a real estate evaluation firm), documents the potential costs for clean-up, temporary rental assistance (TRA), and public assistance (PA). These costs can be expressed as a percent of the structure value as follows:

- Clean-up costs = 11% of structure damage
- TRA costs = 3% of structure damage
- PA costs = 10% of structure damage

Details of total residential (homes) damages including structures, contents, clean-up, TRA, and PA are provided in Appendix 2.

Residential Structures (Apartments)

The District provided the total value of $4M for each apartment complex. Only a fraction of this value was used as a structure value based on the percent of apartment structure inundated. Total apartment damages including structures, contents, clean-up, TRA and PA were calculated as described in Residential Structures (Homes) damages above and details are provided in Appendix 2.

Commercial Structures

The District provided a value of $25 / SqFt for commercial structures. Inundation area mapped using HEC-GeoRAS was used to calculate total inundated commercial structures area. Structures and contents damages were calculated based on structure value and depth of flooding. Details of total damages are provided in Appendix 2.

School / Church Properties

For school and church properties, the District provided structure value of $25 / SqFt and an open area market value of $500,000 / acre. Cleanup and repair costs for inundated open areas are assumed as 10% of this total market value. Open areas damages were calculated using HEC-GeoRAS mapped inundation area. Structure and contents damages were calculated using structure values and depth of flooding. Details of total damages are provided in Appendix 2.

Total Damages

From the hydraulic analysis of Sanjon Barranca using WSPG model, the existing storm drain system was determined to have capacity for approximately a 5-year storm event. For higher storm events, water starts spilling from open channel reaches causing flooding. The damages described above were calculated for each of 10-, 25-, 50-, and 100-year storm events (i.e. exceedence probabilities of 10, 4, 2, and 1-percent, respectively).

Total damages for each development type are given for each storm event in Table 8 below:

Table 8. Total Damages for Existing Condition

Type	10-yr Event	25-yr Event	50-yr Event	100-yr Event
Residential Damages (Homes)	$123,720	$123,720	$123,720	$731,003
Residential Damages (Apartments)	$1,514,926	$1,592,895	$1,592,895	$1,665,622
Commercial Damages	$532,750	$591,250	$701,250	$752,250
School & Church Damages	$544,000	$569,500	$594,500	$964,500
Total Damages	**$2,715,396**	**$2,877,365**	**$3,012,365**	**$4,113,375**

4.4 EXPECTED ANNUAL DAMAGE (EAD) FOR EXISTING CONDITIONS

Expected Annual Damage is calculated based on instructions given in US Army Corps of Engineers "Expected Annual Flood Damage Computation (EAD)" software User's manual. When exceedance frequency is plotted against its associated damages, the area under curve gives the value for EAD. Figure 8A below shows the Exceedance Frequency-Damages plot.

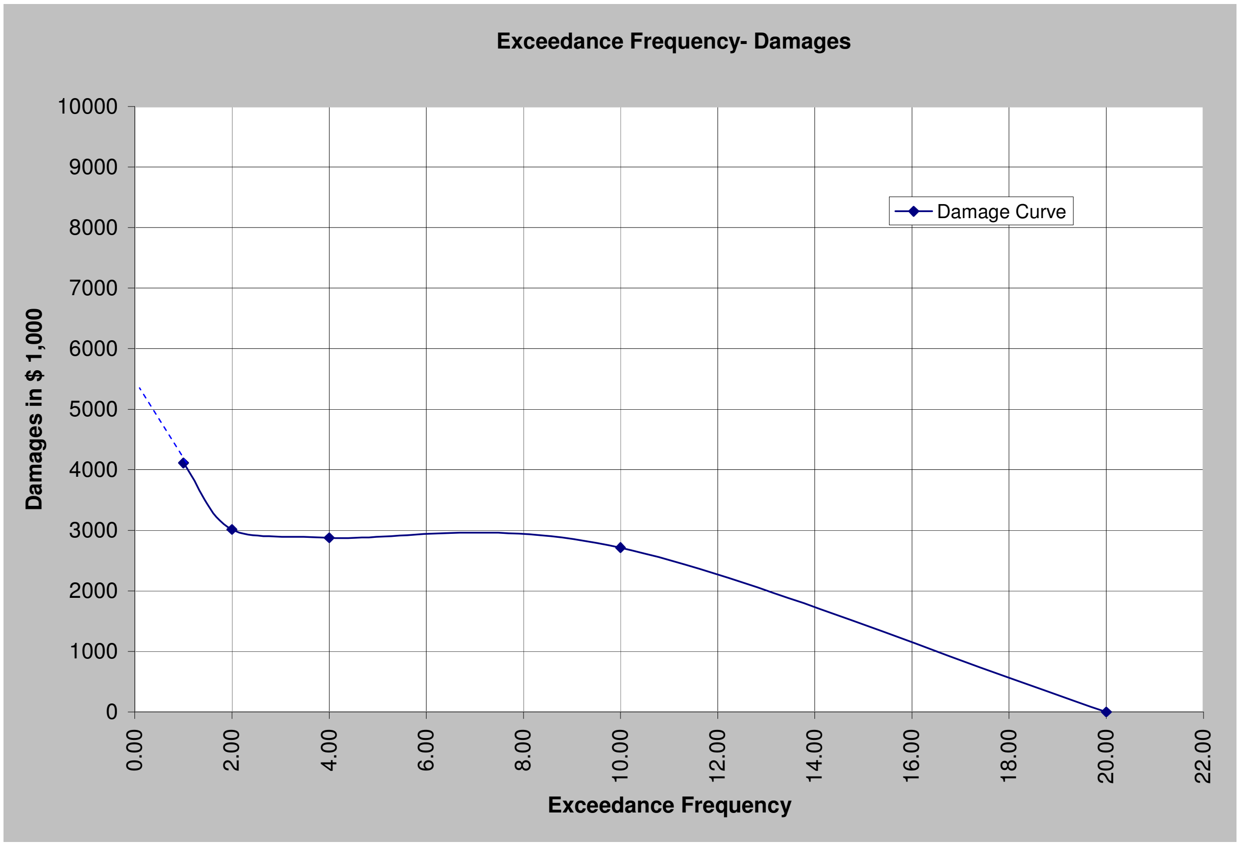

Figure 8A. Exceedance Frequency-Damages Curve for Existing Condition

The area under the curve is estimated as $435,000 which is equal to EAD. This EAD computed is for current conditions and for year 2008.

For the project period of 50 years, the damage, stage, flow, and frequency data might change over time. Instead of calculating EAD for each year, it is common practice to select several future years (usually project period) and interpolate/extrapolate based on current EAD. This method is illustrated in US Army Corps of Engineers "Expected Annual Flood Damage Computation (EAD)" software User's manual. For the scope of this project, it is assumed that the damages associated with flooding remain the same for the project period of 50 years. By using a discount rate of 7%, the total present value of expected annual damages for a 50-year period can be calculated using the following formula:

Single Payment Present Worth = P/F = 1/ (1 + i) N

Using this formula, the total estimated Present Value of the EAD = $6,000,000

4.5 ASSESSMENT OF DAMAGES FOR ALTERNATIVE 3

The proposed improvements for Alternative 3 are described in Section 5.9 below. These improvements reduce flooding up to 10-year frequency. There would be flood damages for frequencies higher than 10-year. By following similar methodology as above and using inundation limits for Alternative 3, total damages for each development type are given in Table 9 below.

Table 9. Total Damages for Alternative 3

Type	10-yr Event	50-yr Event	100-yr Event
Residential Damages (Homes)	$0	$95,500	$702,783
Residential Damages (Apartments)	$0	$1,514,926	$1,665,622
Commercial Damages	$0	$493,750	$726,750
School & Church Damages	$0	$568,500	$964,500
Total Damages	**$0**	**$2,672,676**	**$4,059,655**

4.6 EXPECTED ANNUAL DAMAGE (EAD) FOR ALTERNATIVE 3

Exceedance frequency was plotted against its associated damages as shown in Figure 8B below. The area under curve gives the value for EAD, which is estimated as $166,000. This EAD is calculated for Alternative 3 and for year 2008. For the project period of 50 years with discount rate of 7%, the total present value of expected annual damages are $2,290,000. The annual damages were calculated using similar methodology as above for that of existing conditions.

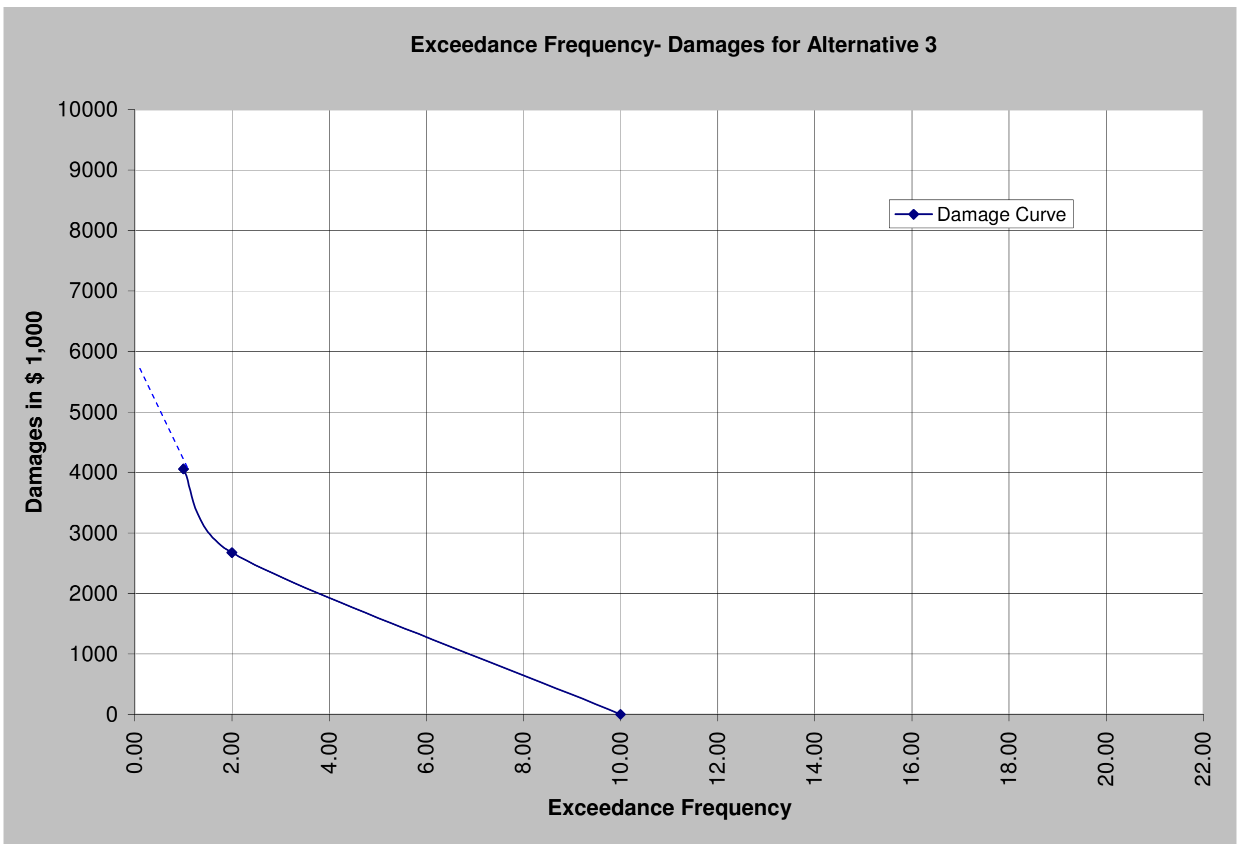

Figure 8B. Exceedance Frequency-Damages Curve for Alternative 3

5.0 PRELIMINARY ALTERNATIVES ANALYSIS

In order to ensure that all potential issues identified at Sanjon Barranca were identified, a site investigation and data search were conducted. Development of a summary of identified problems led to the formulation of opportunities and constraints within which the problem set would be confined.

Following the identification of problems, opportunities, and constraints, the study team developed a preliminary list of applicable solutions to the problems. These alternative plans were examined at the preliminary level for their technical feasibility and cost-effectiveness.

5.1 PROBLEMS, OPPORTUNITIES, AND CONSTRAINTS

On-site field examination and technical evaluation of the Sanjon Barranca storm drain indicated the following problems:

- Maintenance issues with existing facilities
- Insufficient flow capacity available to contain the 10-, 25-, 50-, and 100-year flood hydrographs
- Limited Right-of-Way
- Constraints at ocean outlet

5.2 ALTERNATIVES ANALYSIS AND DESIGN APPROACH

A minimum of 100-year flood protection is desired. The 100-year peak flows are to be safely conveyed to the outlet by means of both surface (i.e., streets) and underground (i.e., storm drains) facilities. Potential measures to achieve the goal of reducing flooding along the Sanjon Barranca include:

- Increase the capacity of the storm drain by opening up restriction points.
- Replace the entire storm drain with a larger one.
- Construct a new parallel storm drain to carry the excess flows.
- Reduce the peak flood by adding a detention basin(s).
- Combinations of two or more of the previous measures.

Preliminary analysis showed that a combination of the measures listed above would be required to eliminate flooding. The two most likely combinations of the potential measures are to increase the capacity along the entire length of the system by replacing segments and installing parallel structures or to install a detention basin near the entrance to the storm drain and increase the storm drain capacity at points that currently restrict flow.

5.3 ENVIRONMENTAL ASSESSMENT

The initial project scope included a preliminary environmental assessment to consist of a constraints-level analysis of the preferred alternative. Since the project was put on hold without the selection of a preferred alternative, the environmental assessment was not completed. It was concluded that additional costs associated with potential mitigation would only make the proposed alternatives less feasible (from a benefit-to-cost perspective), so the environmental assessment would not impact the project conclusions.

A simplified approach was used to account for potential mitigation costs for the proposed alternatives. Based on input from the District environmental staff, an average mitigation cost of $100,000 to $125,000 per acre was used for cost estimating purposes.

5.4 PRELIMINARY ESTIMATE OF PROBABLE COST

As part of the alternative evaluation, the preliminary estimate of probable costs for each alternative were evaluated. These estimates are very preliminary and based on the best available unit cost information given below, but actual costs may vary significantly from those listed here. These costs are intended to be used as an order of magnitude cost comparison of alternatives.

Unit costs and assumptions used for this study are:

- Mobilization and demobilization = 5%
- Insurance and bonds = 3%
- Clearing and Grubbing = $2,000/Ac
- Excavation = $15/CY
- Demolition = $100/CY
- Shoring = $312/LF
- Backfill and compaction = $15/CY
- Haul export material = $15/CY
- Reinforcement-Concrete-Pipe = $290/LF
- Cast-in-place RCB = $700/CY
- Foundation-over-excavation = $15/CY
- Asphalt concrete resurfacing = $15/SF
- Initial repair cost for existing SD system = $778,000
- Maintenance cost for existing SD system = 20% of initial repair cost every five years
- Maintenance (inspection, trash removal) cost for proposed SD system/detention basins = $6,000/year
- Maintenance (invert repaving) cost for proposed SD system (approx 5,200' long) = $80,000 every 25-years
- Maintenance (debris/sediment removal) cost for Detention basins = $20,000 every 5-years
- Environmental mitigation = $75,000/Ac to $125,000/Ac
- Traffic control for a major street = $100,000/MO
- Utilities relocation = 15%
- Permits Cost = 5%
- Construction contingencies = 30%
- Final design = 5%

The cost opinion excludes the following items:

- Right-of-way acquisition
- Environmental permitting and documentation
- Geotechnical analysis and soil stabilization

5.5 ALTERNATIVE 0 – NO-ACTION ALTERNATIVE

This alternative assumes that nothing is done to address the problems identified at Sanjon Barranca. The storm drain would remain as it is today. Figure 2 illustrates the current configuration of the storm drain and its characteristics. For reference, Figure 6 illustrates the 100-year inundation area applicable to current and future without-project conditions.

Under the No-Action alternative, the storm drain system would not contain the 1% exceedance (100-year) design flood event. Damages associated with this flood event would be substantial.

The No-Action Alternative does not meet the goals and objectives of reducing flood inundation damages to downstream properties. It does not reduce threats to life and safety of downstream residents. It does not reduce emergency costs, vehicular damage, or flood insurance costs to residents of the floodplain.

5.6 ALTERNATIVE 1A – INCREASE CAPACITY (REPLACEMENT AND PARALLEL OPTION)

Alternative 1 would increase the capacity along the entire length of the system by replacing some segments and installing parallel structures at other places. Table 10 shows the additional capacity required to mitigate 100-year flooding in Sanjon Barranca without changing the runoff patterns with a detention basin.

This alternative would construct parallel facilities from the headworks to Poli Street and from Thompson Boulevard to the ocean outlet, and replace the existing underground facilities from Poli Street to Thompson Boulevard. See Figure 9A for a plan view of the proposed improvements and Figure 10 for the proposed profile.

There are two locations where the existing storm drain conflicts with existing structures: namely, just downstream of Main Street (alignment under an existing retail store) and between Santa Clara and Thompson Boulevard (alignment under or just adjacent to an existing school building). The replacement of these facilities would require the alignment to be adjusted to avoid these structures.

Table 10. Additional Storm Drain Capacity Required to Increase Flood Protection

Flood Frequency (years)	Q100	Q50	Q25	Q10
Additional Capacity Required from Station 38+20 Downstream to Prevent Flooding (cfs)	1149	1071	949	776

Table 11 shows the hydraulic effect of increasing the system capacity. Note that there is no overflow.

Table 11. System Flows After Replacing and Adding Parallel Storm Drains

Location	Q100 (cfs)					Q50 (cfs)				
	Total	Lateral	U/S In-Pipe	Overflow	D/S In-Pipe	Total	Lateral	U/S In-Pipe	Overflow	D/S In-Pipe
Headwater (from undeveloped sub-basins 1A, 2B, 3A, 4C, and 5A)	980	980	0	0	980	710	710	0	0	710
Lateral at 47+00 (from developed sub-basin 6A)	1080	100	980	0	1080	793	83	710	0	793
Lateral at 38+20 (from undeveloped sub-basin 8D and 7A)	1393	313	1080	0	1393	1020	227	793	0	1020
Station 35+16	1393	0	1393	0	1393	1020	0	1020	0	1020
Lateral at 20+64 (from developed sub-basin 10E and 9A)	1582	189	1393	0	1582	1178	158	1020	0	1178
Prince Barranca at 8+40 (developed)	4474	2892	1582	0	4474	3588	2410	1178	0	3588
Location	**Q25 (cfs)**					**Q10 (cfs)**				
	Total	**Lateral**	**U/S In-Pipe**	**Overflow**	**D/S In-Pipe**	**Total**	**Lateral**	**U/S In-Pipe**	**Overflow**	**D/S In-Pipe**
Headwater (from undeveloped sub-basins 1A, 2B, 3A, 4C, and 5A)	497	497	0	0	497	355	355	0	0	355
Lateral at 47+00 (from developed sub-basin 6A)	566	69	497	0	566	412	57	355	0	412
Lateral at 38+20 (from undeveloped sub-basin 8D and 7A)	725	159	566	0	725	525	113	412	0	525
Station 35+16	725	0	725	0	725	525	0	525	0	525
Lateral at 20+64 (from developed sub-basin 10E and 9A)	856	131	725	0	856	632	107	525	0	632
Prince Barranca at 8+40 (developed)	2856	2000	856	0	2856	2271	1639	632	0	2271

Notes: 1. Q100 obtained from VCWPD provided hydrologic model.
2. Q50, Q25, Q10, Q5, and Q2 calculated using Ventura County multipliers.
3. Subareas upstream of station 47+00 assumed as undeveloped.
4. Subareas downstream of station 47+00 assumed as developed.

5.7 ALTERNATIVE 1B – INCREASE CAPACITY (REPLACEMENT ONLY OPTION)

Alternative 1B would increase the capacity along the entire length of the system by replacing the existing storm drains with 100-year capacity structures. This alternative would replace the sections of open channel creating a closed (box/pipe) structure for the entire alignment. See Figure 9B for a plan view of the proposed improvements.

Figure 9A. Alternative 1A – Increase Storm Drain Capacity Along Entire Alignment

Figure 9B. Alternative 1B – Increase Storm Drain Capacity Along Entire Alignment

Figure 10. Alternative 1A – Profile

Table 12 and 13 shows the preliminary cost opinion for the improvements shown in Figures 9A and 9B. These values are very preliminary and are only intended to be used as an order of magnitude cost comparison of alternatives. Further analysis is required.

Table 12. Alternative 1A Cost Opinion

	QUANTITY	UNITS	UNIT PRICE	TOTAL COST
MOBILIZATION				
Mobilization and Demobilization (5%)				$425,778
Insurance and Bonds (3%)				$255,467
SUBTOTAL				**$681,245**
STRUCTURES				
Parallel Storm Drain Station 55+50 to 41+00 (+/-1,450 ft)				
60" Dia. Reinforced Concrete Pipe	1,450	LF	$290.00	$420,500
Storm Drain Excavation	6,444	CY	$15.00	$96,660
Shoring	2,900	LF	$312.00	$904,800
Storm Drain Backfill and Compaction	4,926	CY	$15.00	$73,890
Haul Export Material	1,518	CY	$15.00	$22,770
Replace Storm Drain Station 41+00 to 20+00 (+/-2,100 ft)				
Demolish	2,621	CY	$100.00	$262,100
8' x 6' Cast-in-Place Reinforced Concrete Box	1,866	CY	$700.00	$1,306,200
Storm Drain Excavation	18,044	CY	$15.00	$270,660
Shoring	4,200	LF	$312.00	$1,310,400
Storm Drain Backfill and Compaction	13,144	CY	$15.00	$197,160
Haul Export Material	4,900	CY	$15.00	$73,500
Environmental Mitigation for Storm Drains	0.10	AC	$75,000.00	$7,231
Parallel Storm Drain Station 20+00 to 10+00 (+/-1,000 ft)				
8' x 6' Cast-in-Place Reinforced Concrete Box	888	CY	$700.00	$621,600
Storm Drain Excavation	8,592	CY	$15.00	$128,880
Shoring	2,000	LF	$312.00	$624,000
Storm Drain Backfill and Compaction	6,259	CY	$15.00	$93,885
Haul Export Material	2,333	CY	$15.00	$34,995
Asphalt Concrete Re-Surfacing	8,000	SF	$15.00	$120,000
Parallel Storm Drain Station 10+00 to 3+50 (+/-650 ft)				
2 x 12' x 9' Cast-in-Place Reinforced Concrete Box	1,517	CY	$700.00	$1,061,900
Storm Drain Excavation	7,511	CY	$15.00	$112,665
Shoring	1,300	LF	$312.00	$405,600
Storm Drain Backfill and Compaction	1,252	CY	$15.00	$18,780
Haul Export Material	6,259	CY	$15.00	$93,885
Asphalt Concrete Re-Surfacing	16,900	SF	$15.00	$253,500
Maintenance Cost (Assume 50 years)	1	LS	$816,520.00	$816,520
Traffic Control	6	LS	$100,000.00	$600,000
Project Subtotal				**$10,613,326**
Utilities Relocation (15%)				**$1,591,999**
Permits Cost (5%)				**$530,666**
Construction Contingencies (30%)				**$3,183,998**
Final Design (5%)				**$530,666**
Estimate of Probable Construction				**$16,450,656**
TOTAL ESTIMATED PROJECT COST				**$16,450,656**

Table 13. Alternative 1B Cost Opinion

	QUANTITY	UNITS	UNIT PRICE	TOTAL COST
MOBILIZATION				
Mobilization and Demobilization (5%)				$541,507
Insurance and Bonds (3%)				$324,904
SUBTOTAL				**$866,412**
STRUCTURES				
Replace Storm Drain Station 55+35 to 21+50 (+/-3,400 ft)				
Demolish	3,657	CY	$100.00	$365,700
8' x 6' Cast-in-Place Reinforced Concrete Box	3,035	CY	$700.00	$2,124,370
Storm Drain Excavation	31,859	CY	$15.00	$477,889
Shoring	6,800	LF	$312.00	$2,121,600
Storm Drain Backfill and Compaction	22,793	CY	$15.00	$341,889
Haul Export Material	9,067	CY	$15.00	$136,000
Environmental Mitigation for Storm Drains	0.10	AC	$75,000.00	$7,231
Replace Storm Drain Station 21+50 to 8+60 (+/-1,300 ft)				
Demolish	1,741	CY	$100.00	$174,100
2 x 8' x 6' Cast-in-Place Reinforced Concrete Box	2,191	CY	$700.00	$1,533,519
Storm Drain Excavation	28,889	CY	$15.00	$433,333
Shoring	2,600	LF	$312.00	$811,200
Storm Drain Backfill and Compaction	21,956	CY	$15.00	$329,333
Haul Export Material	6,933	CY	$15.00	$104,000
Replace Storm Drain Station 8+60 to 3+50 (+/-510 ft)				
Demolish	2,418	CY	$100.00	$241,800
2 x 14' x 10' Cast-in-Place Reinforced Concrete Box	1,511	CY	$700.00	$1,057,778
Storm Drain Excavation	8,406	CY	$15.00	$126,083
Shoring	1,020	LF	$312.00	$318,240
Storm Drain Backfill and Compaction	3,872	CY	$15.00	$58,083
Haul Export Material	4,533	CY	$15.00	$68,000
Maintenance Cost (assume 50 years)	1	LS	$85,524.00	$85,524
Traffic Control	6	LS	$100,000.00	$600,000
Project Subtotal				**$12,382,085**
Utilities Relocation (15%)				**$1,857,313**
Permits Cost (5%)				**$619,104**
Construction Contingencies (30%)				**$3,714,626**
Final Design (5%)				**$619,104**
Estimate of Probable Construction				**$19,192,232**
TOTAL ESTIMATED PROJECT COST				**$19,192,232**

5.8 ALTERNATIVE 2A – DETENTION BASIN AND IMPROVE CHOKE POINTS (SINGLE BASIN OPTION)

Alternative 2A involves installing a detention basin upstream of the entrance to the existing storm drain and increasing the storm drain capacity at points that currently restrict flow. See Figure 11 for a plan view of the proposed improvements.

Figure 12 shows a possible detention basin configuration downstream of the confluence of two tributaries near the entrance to the storm drain system. Table 14 lists various frequency flows through the storm drain system after constructing detention basin and improving choke points.

The detention basin alternative does not include dead storage volume for debris storage. Further analysis is required to determine the debris yield for the watershed and design the detention capacity accordingly. Further analysis should follow the District's Detention Basin Criteria which is included in Appendix 4.

Figures 13, 14, and 15 show the results of routing the 100-year flow through Basin 1 using the HEC-HMS model.

Table 15 shows the preliminary cost opinion for the improvements shown in Figures 11 and 12. Several existing homes line the ridges along both sides of the canyon where the detention basin would be located. Although these homes may not be directly impacted, the basin could present a negative aesthetic feature for the adjacent properties. For the purpose of this study, it was assumed that the impacted properties (total of 13) would be purchased at of cost of $1 Million each. These values are very preliminary and are only intended to be used as an order of magnitude cost comparison of alternatives. Further analysis is required.

Figure 11. Alternative 2A – Construct Detention Basin and Improve Choke Points in Existing System

Figure 12. Alternative 2A – Single Detention Basin Downstream of Confluence

HEC-HMS Storm Hydrograph Routing Through Basin

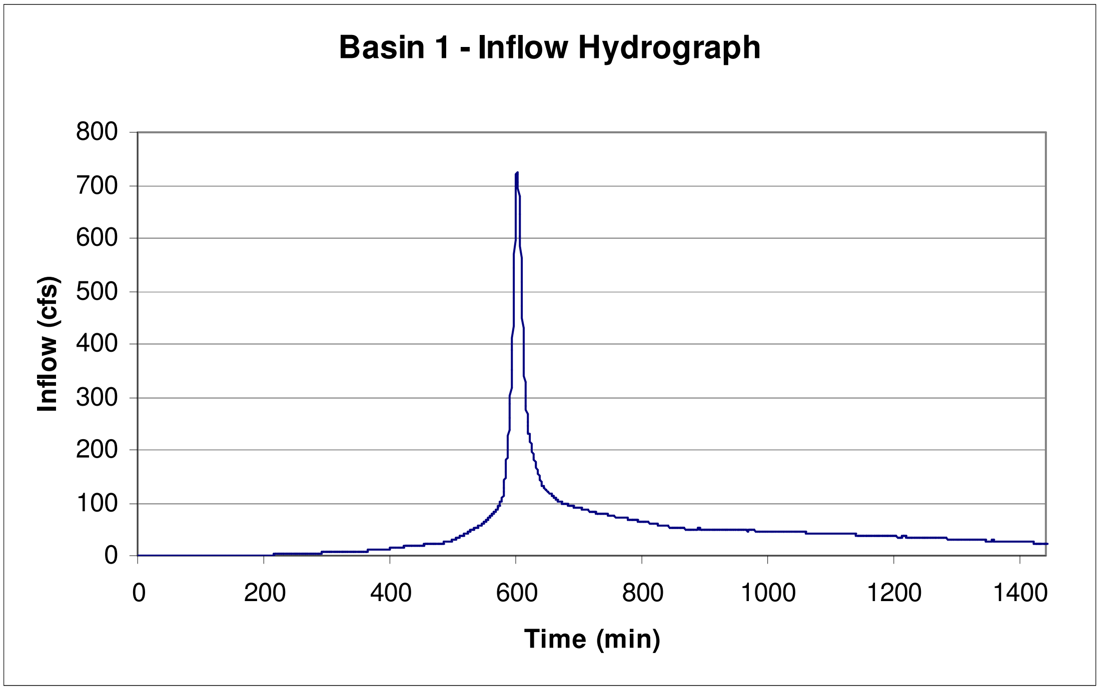

Figure 13. Basin 1 – Inflow Hydrograph

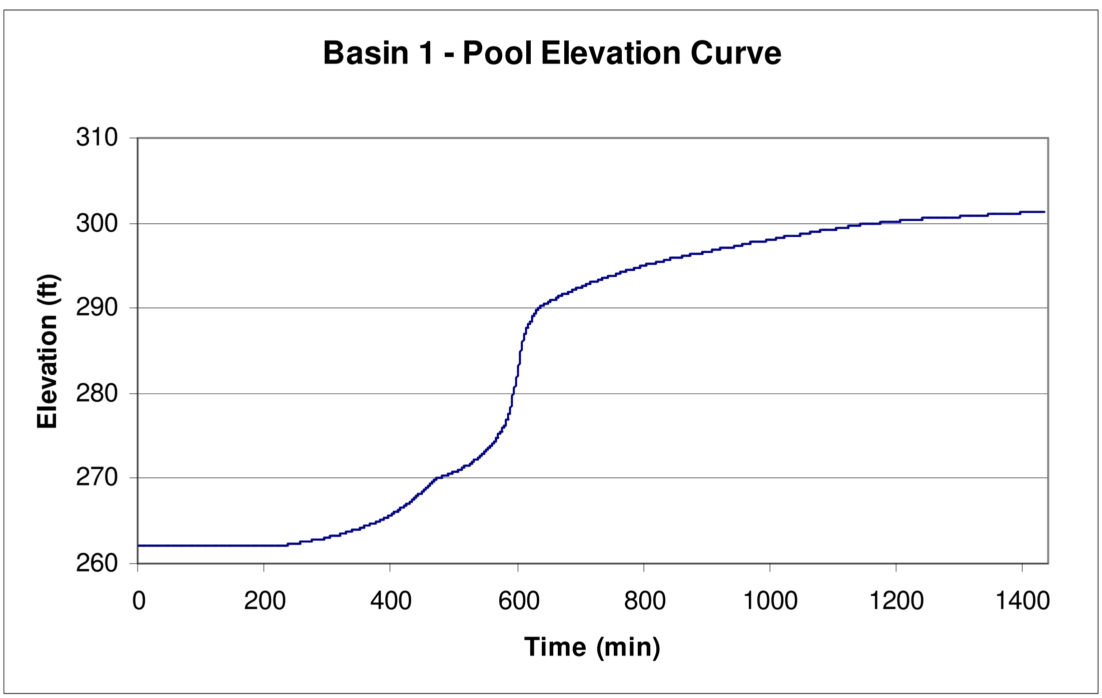

Figure 14. Basin 1 – Pool Elevation Curve

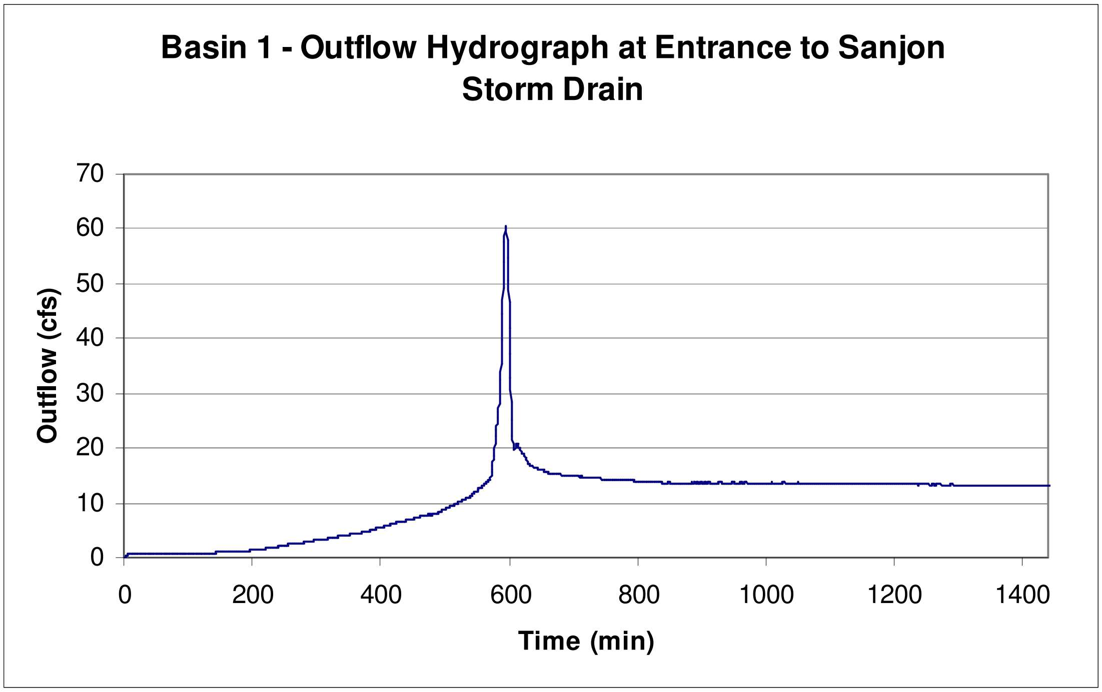

Figure 15. Basin 1 – Outflow Hydrograph at Entrance to Sanjon Storm Drain

Table 14. System Flows After Constructing Detention Basin 1 and Improving Choke Points

Location	Q100 (cfs)					Q50 (cfs)				
	Total	Lateral	U/S In-Pipe	Overflow	D/S In-Pipe	Total	Lateral	U/S In-Pipe	Overflow	D/S In-Pipe
Headwater Exiting New Detention Basin	60	60	60	0	60	43	43	43	0	43
Lateral at 47+00 (from developed sub-basin 6A)	160	100	60	0	160	127	83	43	0	127
Lateral at 38+20 (from undeveloped sub-basin 8D and 7A)	473	313	160	0	473	354	227	127	0	354
Station 35+16	473	0	473	0	473	354	0	354	0	354
Lateral at 20+64 (from developed sub-basin 10E and 9A)	662	189	473	0	662	511	158	354	0	511
Prince Barranca at 8+40 (developed)	3554	2892	662	0	3554	2921	2410	511	0	2921
Location	**Q25 (cfs)**					**Q10 (cfs)**				
	Total	**Lateral**	**U/S In-Pipe**	**Overflow**	**D/S In-Pipe**	**Total**	**Lateral**	**U/S In-Pipe**	**Overflow**	**D/S In-Pipe**
Headwater (from undeveloped sub-basins 1A, 2B, 3A, 4C, and 5A)	30	30	30	0	30	22	22	22	0	22
Lateral at 47+00 (from developed sub-basin 6A)	100	69	30	0	100	78	57	22	0	78
Lateral at 38+20 (from undeveloped sub-basin 8D and 7A)	258	159	100	0	258	192	113	78	0	192
Station 35+16	258	0	258	0	258	192	0	192	0	192
Lateral at 20+64 (from developed sub-basin 10E and 9A)	389	131	258	0	389	299	107	192	0	299
Prince Barranca at 8+40 (developed)	2389	2000	389	0	2389	1938	1639	299	0	1938

Notes:
1. Q100 obtained from VCWPD provided hydrologic model.
2. Q50, Q25, Q10, Q5, and Q2 calculated using Ventura County multipliers.
3. Subareas upstream of station 47+00 assumed as undeveloped.
4. Subareas downstream of station 47+00 assumed as developed.
6. Peak flows are reduced by new basin and capacity is increased.

Table 15. Alternative 2A Cost Opinion

	QUANTITY	UNITS	UNIT PRICE	TOTAL COST
MOBILIZATION				
Mobilization and Demobilization (5%)				$864,030
Insurance and Bonds (3%)				$518,418
SUBTOTAL				**$1,382,448**
STRUCTURES				
Purchase of Residential Structures	13	EA	$1,000,000.00	$13,000,000
Detention Basin				
Clearing and Grubbing	3	Acre	$2,000.00	$6,000
Foundation Over-Excavation	23,075	CY	$15.00	$346,125
Structural Fill and Compaction (3:1 Embankments)	49,600	CY	$15.00	$744,000
Haul Import Material	26,525	CY	$15.00	$397,875
Outlet Structure & Spillway	1	LS	$1,000,000.00	$1,000,000
Environmental Mitigation	7	Acre	$125,000.00	$882,500
Replace Storm Drain Station 38+50 to 34+00 (+/-450 ft)				
Demolish	448	CY	$100.00	$44,800
7' x 7' Cast-in-Place Reinforced Concrete Box	400	CY	$700.00	$280,000
Storm Drain Excavation	2,670	CY	$15.00	$40,050
Shoring	900	LF	$312.00	$280,800
Storm Drain Backfill and Compaction	1,600	CY	$15.00	$24,000
Haul Export Material	1,070	CY	$15.00	$16,050
Environmental Mitigation for Storm Drains	0.03	AC	$75,000.00	$2,066
Replace Storm Drain Station 21+00 to 19+40 (+/-160 ft)				
Demolish	160	CY	$100.00	$16,000
6' x 6' Cast-in-Place Reinforced Concrete Box	108	CY	$700.00	$75,600
Storm Drain Excavation	830	CY	$15.00	$12,450
Shoring	320	LF	$312.00	$99,840
Storm Drain Backfill and Compaction	540	CY	$15.00	$8,100
Haul Export Material	290	CY	$15.00	$4,350
Maintenance Cost (Assume 50 years)	1	LS	$1,282,191.00	$1,282,191
Traffic Control	2	LS	$100,000.00	$200,000
Project Subtotal				**$20,145,246**
Utilities Relocation (15%)				**$3,021,787**
Permits Cost (5%)				**$1,007,262**
Construction Contingencies (30%)				**$6,043,574**
Final Design (5%)				**$1,007,262**
Estimate of Probable Construction				**$31,225,131**
TOTAL ESTIMATED PROJECT COST				**$31,225,131**

5.9 ALTERNATIVE 2B – DETENTION BASIN AND IMPROVE CHOKE POINTS (TWO BASIN OPTION)

Alternative 2B involves installing two detention basins in lieu of the single basin in Alternative 2A. Figure 16 shows a possible detention basin configuration that uses two earth fill dams further upstream from the entrance to the storm drain. The purpose of moving the basins upstream is to avoid visual and geotechnical impacts to the existing homes along the ridges of the canyon.

Figures 17, 18, 19, 20, and 21 show the results of routing the 100-year flow through Basins 2 and 3 using the HEC-HMS model.

This alternative does not include dead volume for debris storage. Further analysis is required to determine the debris yield for the watershed and design the detention capacity accordingly. Further analysis should follow the District's Detention Basin Criteria which is included in Appendix 4.

Table 16 shows the preliminary cost opinion for the improvements shown in Figure 16. Several existing homes line the ridges along both sides of the canyon where the detention basin would be located. Although these homes may not be directly impacted, the basin could present a negative aesthetic feature for the adjacent properties. For the purpose of this study, it was assumed that the impacted properties (total of 8) would be purchased at of cost of $1 Million each. These values are very preliminary and are only intended to be used as an order of magnitude cost comparison of alternatives. Further analysis is required.

Table 16. Alternative 2B Cost Opinion

	QUANTITY	UNITS	UNIT PRICE	TOTAL COST
MOBILIZATION				
Mobilization and Demobilization (5%)				$723,625
Insurance and Bonds (3%)				$434,175
SUBTOTAL				**$1,157,799**
STRUCTURES				
Purchase of Residential Structures	8	EA	$1,000,000.00	$8,000,000
Detention Basin 2				
Clearing and Grubbing	2.8	Acre	$2,000.00	$5,602
Foundation Over-Excavation	9,230	CY	$15.00	$138,450
Structural Fill and Compaction (3:1 Embankments)	19,720	CY	$15.00	$295,800
Haul Import Material	10,490	CY	$15.00	$157,350
Outlet Structure & Spillway	1	LS	$1,000,000.00	$1,000,000
Environmental Mitigation	2.80	Acre	$125,000.00	$350,000
Detention Basin 3				
Clearing and Grubbing	4.3	Acre	$2,000.00	$8,682
Foundation Over-Excavation	13,845	CY	$15.00	$207,675
Structural Fill and Compaction (3:1 Embankments)	69,000	CY	$15.00	$1,035,000
Haul Import Material	55,155	CY	$15.00	$827,325
Outlet Structure & Spillway	1	LS	$1,000,000.00	$1,000,000
Environmental Mitigation	4.34	Acre	$125,000.00	$542,500
Replace Storm Drain Station 38+50 to 34+00 (+/-450 ft)				
Demolish	448	CY	$100.00	$44,800
7' x 7' Cast-in-Place Reinforced Concrete Box	400	CY	$700.00	$280,000
Storm Drain Excavation	2,670	CY	$15.00	$40,050
Shoring	900	LF	$312.00	$280,800
Storm Drain Backfill and Compaction	1,600	CY	$15.00	$24,000
Haul Export Material	1,070	CY	$15.00	$16,050
Environmental Mitigation for Storm Drains	0.03	AC	$75,000.00	$2,066
Replace Storm Drain Station 21+00 to 19+40 (+/-160 ft)				
Demolish	160	CY	$100.00	$16,000
6' x 6' Cast-in-Place Reinforced Concrete Box	108	CY	$700.00	$75,600
Storm Drain Excavation	830	CY	$15.00	$12,450
Shoring	320	LF	$312.00	$99,840
Storm Drain Backfill and Compaction	540	CY	$15.00	$8,100
Haul Export Material	290	CY	$15.00	$4,350
Maintenance Cost (Assume 50 years)	1	LS	$1,282,191.00	$1,282,191
Traffic Control	2	LS	$100,000.00	$200,000
Project Subtotal				**$17,112,480**
Utilities Relocation (15%)				**$2,566,872**
Permits Cost (5%)				**$855,624**
Construction Contingencies (30%)				**$5,133,744**
Final Design (5%)				**$855,624**
Estimate of Probable Construction				**$26,524,344**
TOTAL ESTIMATED PROJECT COST				**$26,524,344**

Figure 16. Alternative 2B – Two Detention Basins Upstream of Confluence

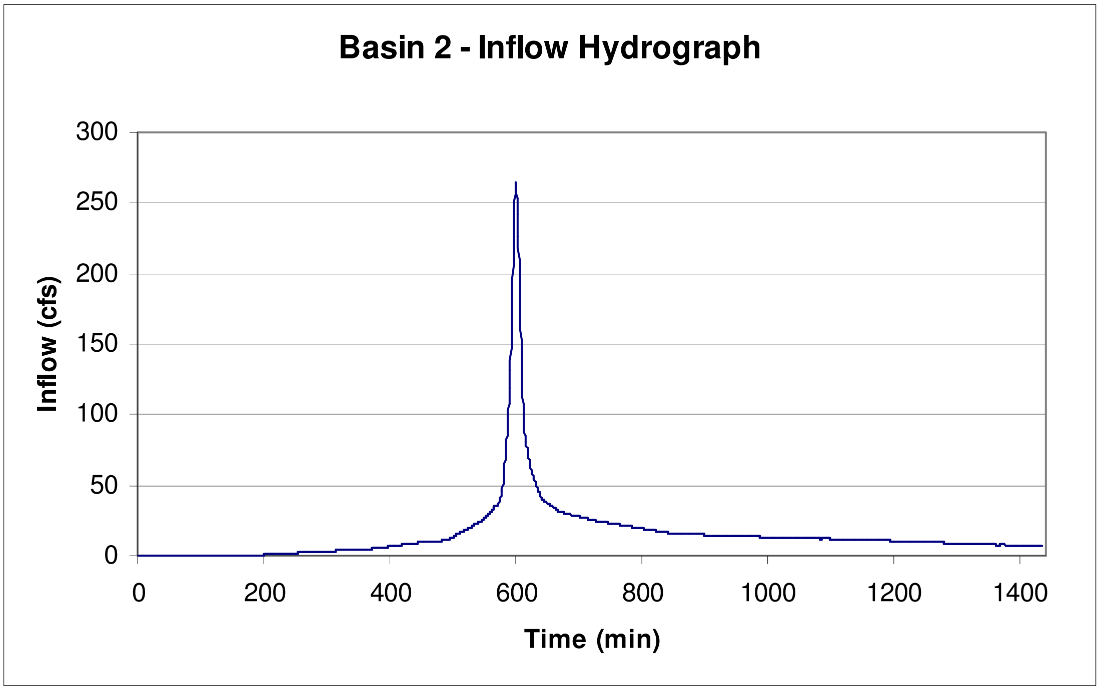

Figure 17. Basin 2 – Inflow Hydrograph

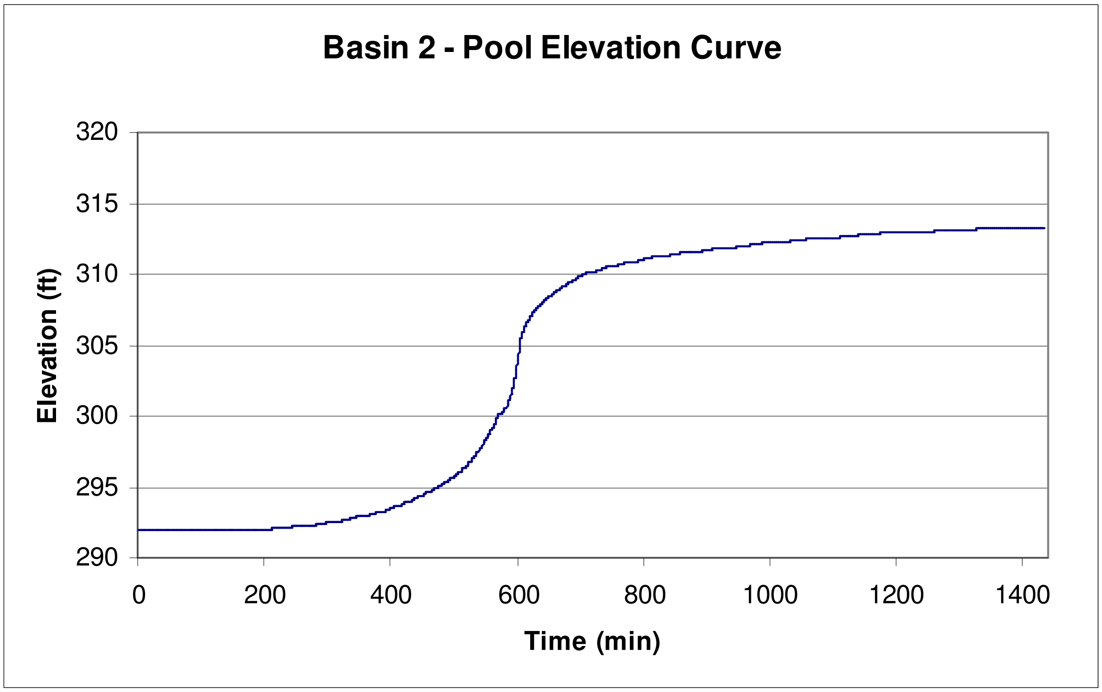

Figure 18. Basin 2 – Pool Elevation Curve

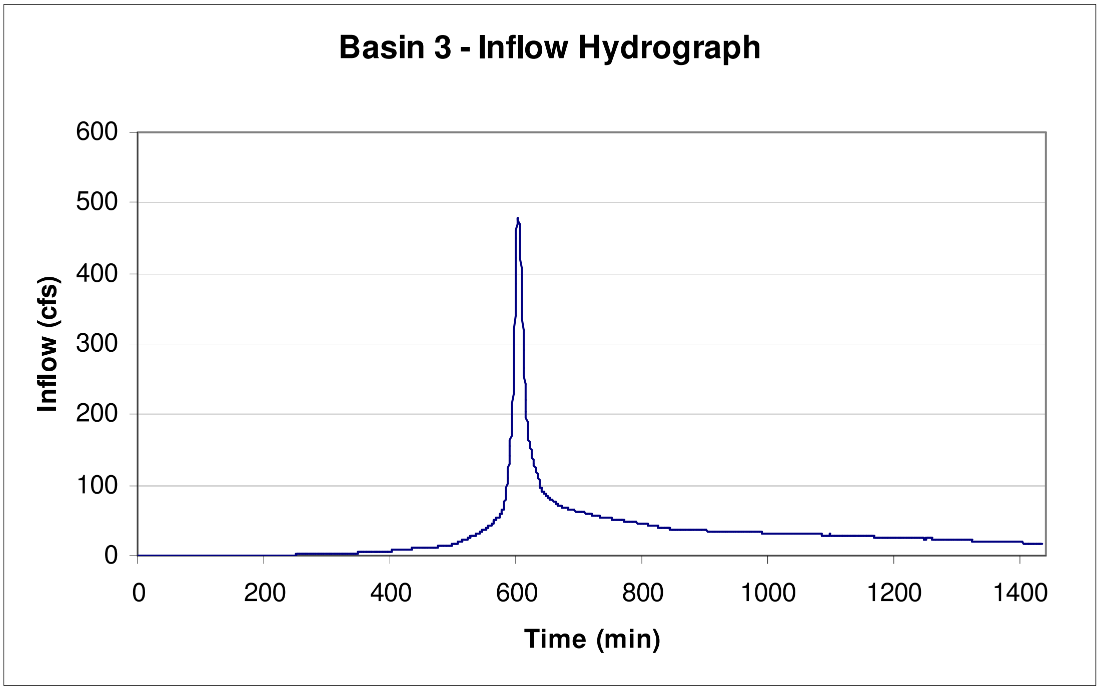

Figure 19. Basin 3 – Inflow Hydrograph

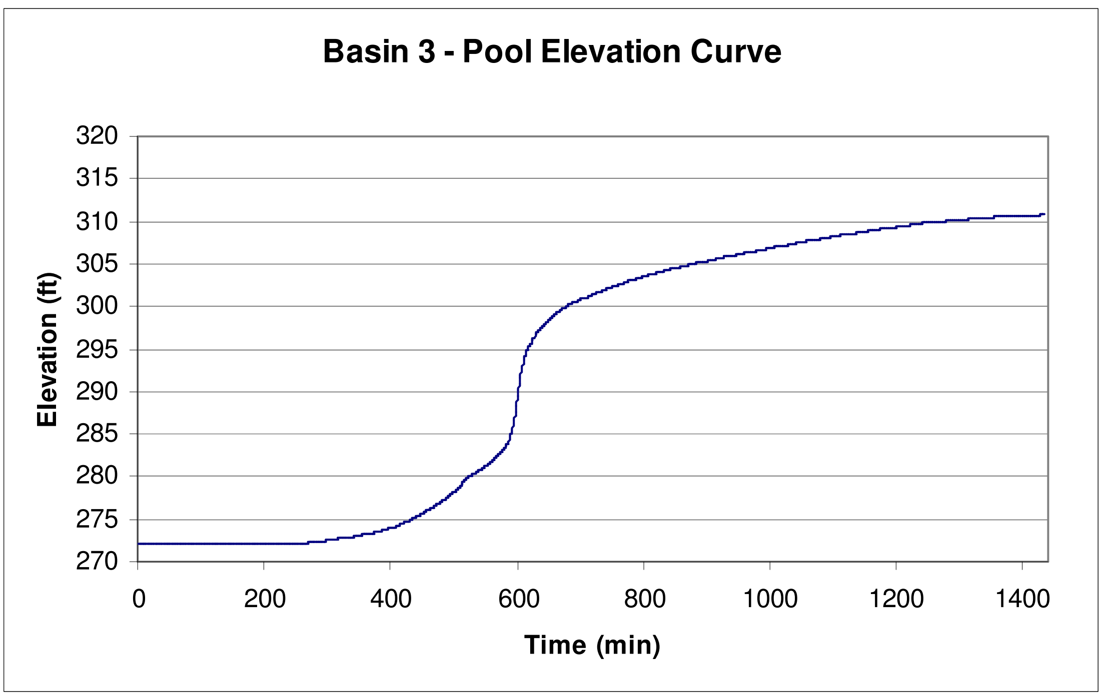

Figure 20. Basin 3 – Pool Elevation Curve

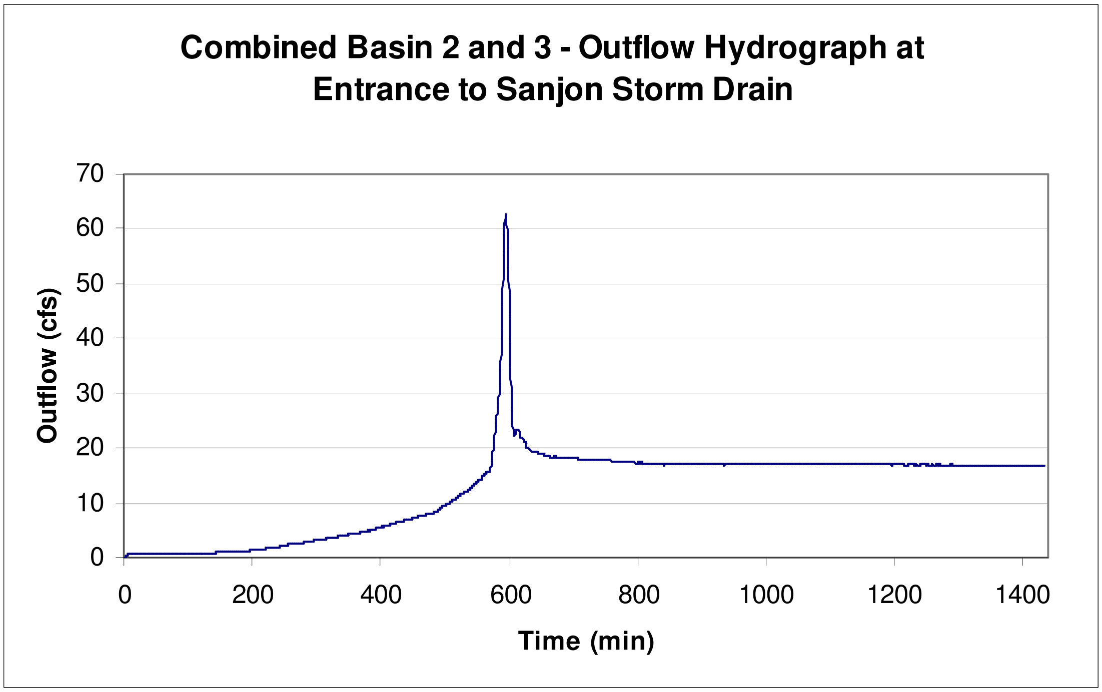

Figure 21. Combined Basin 2 and 3 Outflow Hydrograph at Entrance to Sanjon Storm Drain

5.10 ALTERNATIVE 3 – IMPROVE CHOKE POINTS AND INCREASE DOWNSTREAM CAPACITY

Alternative 3 proposes removing the choke points from the existing system to carry a minimum of the 10-year discharge without any overflows or flooding and pick up the entire overflow from higher frequency flows in a new parallel system downstream of Thompson Boulevard. Alternative 3 only includes 10-year protection in the upper watershed due to the limited benefits of increasing the flood protection to 100-year (see Section 6.0 – Conclusions and Recommendations). This alternative was added at the request of the Sanjon Barranca Stakeholders (June 9, 2007 Stakeholders Meeting) to determine if partial flood protection could be justified, along with the potential for ecosystem and wetland restoration downstream of Thompson Boulevard.

For the purpose of separating costs, Alternative 3 was divided into three segments as follows (shown in Figure 22):

- Segment 3A: Remove chokes from existing storm-drain system
    - Replace 6’ RCP with 7’X7’ RCB at station 38+29
    - Replace 6’ RCP with 7’X7’ RCB at station 35+16
    - Replace 5’ RCP with 6’X6’ RCB at station 20+64
- Segment 3B: Replace 6.25’ RCP and 7.24’X8.81’ Arch with a new trapezoidal open channel with “soft bottom” between Union Pacific Railroad (station 12+50) and Highway 101 (station 6+00) to carry lower frequency flows
- Segment 3C: Design new parallel system from just upstream of Thompson Boulevard to Highway 101 to carry overflow, which cannot get into existing system, and flow from Prince Barranca. This includes 8’X8’ RCB from just upstream of Thomson Boulevard (approximate station 20+64) to confluence with Prince Barranca (station 8+40) and four 8’X8’ RCBs (or two 16’X8’ RCBs) from Station 8+40 to confluence to existing system near Highway 101 (approximate station 5+90). Option to replace existing 16’X8’ RCB under Highway 101 by four 10’X8’ RCBs or two 20’X8’ RCBs

The WSPG model was used to evaluate the proposed changes to the existing system. One model was created for the existing system with the new open channel (between UPRR and Highway 101) and chokes removed as noted above. This model was run with 10-year discharges. A second model was created for the new parallel system with 100-year discharges that exceeded the existing system capacity. See Figure 23 for the 100-year inundation area and Figures 24 and 25 for WSPG model outputs for the proposed systems. Maximum of “Mean Higher High Water” (MHHW) from three locations near the project area was used as a starting water condition for the models. Flow distribution for the models is summarized in Table 17.

Table 17. Flow Distribution for Alternative 3

Location	Total	Existing System	Overflow	Parallel System
Headwater	980	355	652	N/A
Station 35+16	1393	525	868	N/A
Thompson Blvd (station 20+64)	1582	525	0	1057
Confluence with Prince Barranca (station 8+40)	4474	525	0	3949

With the chokes removed, the existing system will carry the 10-year discharge with a free water surface (i.e. non-pressure flow). The proposed open channel downstream of the UPRR will be designed to carry the 10-year discharge. The 100-year discharge exceeding the capacity of existing system will flow overland to Thompson Boulevard from where it will be picked up by series of inlets (to be designed) into the new parallel system. Near Highway 101, the new system will join the proposed open channel and then connect to the existing concrete channel under the highway.

The existing channel under the highway is undersized and results in significant flooding of Harbor Boulevard and San Jon Road. It is proposed to use the existing channel to avoid constructing a new or secondary outlet to the ocean. This will result in the continued flooding and subsequent closing of the roadways in the future. As an option, four new 10'X8' RCBs could be constructed to replace the concrete open channel. These RCBs could be under pressure because of tidal effect and backwater. There could still be 1-2 ft of flooding near outlet, but the duration and frequency of flooding would be reduced due to the improved outlet. The revisions to the existing outlet would likely have to be permitted through the California Coastal Commission.

A significant benefit of this alternative is the potential to restore the reach of open channel upstream of Highway 101. Information provided by Paul Jenkin, Environmental Director of Surfrider Foundation (Ventura County Chapter Coordinator, Matilija Coalition) indicates that there was a small coastal wetland area adjacent to San Jon Road prior to the construction of Highway 101 (see Appendix 5). The ability to restore at least a portion of this habitat could be considered as part of, or independent of, the flood control improvements. Based on a preliminary evaluation, the proposed open channel upstream of the highway could be designed to provide native vegetation and habitat for local wildlife, as well as water quality benefits for the urban runoff generated from the upstream watershed. The ability to provide a balance between hydraulic capacity, channel stability, maintenance, and habitat is critical to a successful restoration project. Potential design constraints are summarized below:

- Open channel needs to be deep (17' below existing ground) in order to meet upstream storm drain invert.
- Slope of the existing storm drain at the location of proposed open channel is approximately 2%. In order to reduce velocities in the open channel, the slope needs to be reduced to less than 0.5%. To obtain this slope, the open channel would need the equivalent of 12 feet in vertical drop structures. This could consist of 4 drop structures of 2-3 feet drop for each or a fewer number of higher drops.
- The channel bottom should be protected near drops by means of riprap or other suitable technique to protect against scour.
- Existing ground near upper portion of the proposed open channel is very high compared to channel invert. In order to reduce impact area for open channel construction, retaining walls of 8-10 feet high would be needed for approximately 150 feet in length.
- To eliminate the retention wall, the open channel could be constructed starting just downstream of station 9+00 (near the access road crossing).

These elements would have to be investigated further to verify concept feasibility.

In addition, the City's existing pump station located within the San Jon Road median, could be reoperated to divert low flows from Sanjon Barranca to the existing wetlands south of San Jon Road. The pump is currently operated to pump flows from the wetlands to the channel, but could be reversed to provide water to the wetland during dry periods when there is still urban runoff generated from the upstream watershed. The additional water source would benefit the wetlands and the wetlands would, in turn, provide water quality benefits for the stormwater runoff.

Another option would be to extend the restoration reach further upstream by shifting the alignment into the existing San Jon Road right-of-way. The existing slope on the north side of the channel alignment prevents the channel from being extended past the existing access road (i.e. limited width between the roadway and the hillside). If the channel alignment was shifted to the south, into the west-bound lanes of San Jon Road, the channel could be extended all the way to the railroad. This would result in an additional 350 lineal feet of channel and 0.4 acres of habitat. The existing east-bound lands would have to be converted to two-way traffic (one lane each direction). This option would have to be coordinated with the City. When approached with this option, The City provided the following comments (per Vicki Musgrove, City of Ventura):

"One of the City's primary coastal watersheds is the Sanjon-Prince Barranca, which drains at the San Buenaventura State Beach at Sanjon Road. This system faces significant water quality challenges caused by urban development. Preliminary assessment indicate the stormdrain system's capacity for this watershed is inadequate, increasing the potential for serious flooding. In addition, the concrete drainage channel extends onto the beach, causing the low flows to stagnant even during extended dry periods. Even small rainfalls deliver large quantities of urban runoff to the beach, which causes localized flooding. Bacterial sampling of the ocean water indicates degraded water quality, resulting in this site being listed as an impaired water body.

The proposed project at this highly visible site would restore the historic creeks, coastal wetlands and natural habitat, which have been gradually altered by urban development. While a restoration plan will require careful planning to analyze the hydrology and physical constraints of the existing infrastructure, possible project components may include:

- *Reduce Sanjon Road to two lanes*
- *Shift street functions away from flooded area and relocate beach parking in the drier upland location to provide space for wetlands*
- *Replace concrete channel with open creek and greenbelt may extend up Thompson Blvd, creating a linear park connection Midtown and the beach*
- *Bike/walking path would connect with coastal bike trail*

Funding: At this time, no funding has been identified. Project estimates range from $5-20 million."

Tables 18, 19, and 20 show the preliminary cost opinion for the three segments shown in Figure 22. These values are preliminary and are only intended to be used as an order of magnitude cost comparison of alternatives. Further analysis is required.

Figure 22. Alternative 3 – Remove Chokes, New Parallel Storm Drains for Lower System

Figure 23. Alternative 3 – 100 Year Inundation Area

Figure 24. Alternative 3 – Main Storm Drain Profile

Figure 25. Alternative 3 – New Parallel Storm Drain Profile

Figure 26. Details: Alternative 3 – Trapezoidal Channel

Table 18. Alternative 3 - Segment 3A Cost Opinion for Removing Chokes

	QUANTITY	UNITS	UNIT PRICE	TOTAL COST
MOBILIZATION				
Mobilization and Demobilization (5%)				$34,017
Insurance and Bonds (3%)				$20,410
SUBTOTAL				**$54,428**
STRUCTURES				
Replace Storm Drain Station 38+29 to 36+32 (+/- 197 ft)				
Demolish	206	CY	$100.00	$20,600
7' x 7' Cast-in-Place Reinforced Concrete Box	151	CY	$700.00	$105,723
Storm Drain Excavation	919	CY	$15.00	$13,790
Shoring	394	LF	$312.00	$122,928
Storm Drain Backfill and Compaction	409	CY	$15.00	$6,129
Haul Export Material	511	CY	$15.00	$7,661
Environmental Mitigation for Storm Drains	0.02	AC	$75,000.00	$1,632
Replace Storm Drain Station 35+16 to 33+71 (+/- 145 ft)				
Demolish	132	CY	$100.00	$13,200
7' x 7' Cast-in-Place Reinforced Concrete Box	111	CY	$700.00	$77,817
Storm Drain Excavation	1,004	CY	$15.00	$15,064
Shoring	290	LF	$312.00	$90,480
Storm Drain Backfill and Compaction	628	CY	$15.00	$9,425
Haul Export Material	376	CY	$15.00	$5,639
Replace Storm Drain Station 20+64 to 19+40 (+/-124 ft)				
Demolish	90	CY	$100.00	$9,000
6' x 6' Cast-in-Place Reinforced Concrete Box	84	CY	$700.00	$58,831
Storm Drain Excavation	1,502	CY	$15.00	$22,527
Shoring	248	LF	$312.00	$77,376
Storm Drain Backfill and Compaction	914	CY	$15.00	$13,709
Haul Export Material	588	CY	$15.00	$8,818
Maintenance Cost (Assume 50 years)	1	LS	$722,964.00	$722,964
Traffic Control	1	LS	$100,000.00	$100,000
Project Subtotal				**$1,557,740**
Utilities Relocation (15%)				**$233,661**
Permits Cost (5%)				**$77,887**
Construction Contingencies (30%)				**$467,322**
Final Design (5%)				**$77,887**
Estimate of Probable Construction				**$2,414,498**
TOTAL ESTIMATED PROJECT COST				**$2,414,498**

Table 19. Alternative 3 - Segment 3B Cost Opinion for New Open Channel

	QUANTITY	UNITS	UNIT PRICE	TOTAL COST
MOBILIZATION				
Mobilization and Demobilization (5%)				$36,509
Insurance and Bonds (3%)				$21,905
SUBTOTAL				**$58,414**
STRUCTURES				
New Open Channel				
Excavation	8,500	CY	$15.00	$127,500
Channel - Concrete surfacing	31,678	SF	$15.00	$475,170
Haul Export Material	8,500	CY	$15.00	$127,500
Traffic Control	1	LS	$100,000.00	$100,000
Project Subtotal				**$888,584**
Utilities Relocation (15%)				**$133,288**
Permits (5%)				**$44,429**
Construction Contingencies (30%)				**$266,575**
Final Design (5%)				**$44,429**
Estimate of Probable Construction				**$1,377,305**
TOTAL ESTIMATED PROJECT COST				**$1,377,305**

Table 20. Alternative 3 - Segment 3C Cost Opinion for New Parallel System

	QUANTITY	UNITS	UNIT PRICE	TOTAL COST
MOBILIZATION				
Mobilization and Demobilization (5%)				$244,347
Insurance and Bonds (3%)				$146,608
SUBTOTAL				**$390,954**
STRUCTURES				
New Parallel System (+/- 1,320 ft)				
8' x 8' Cast-in-Place Reinforced Concrete Box	1,472	CY	$700.00	$1,030,089
Storm Drain Excavation	13,982	CY	$15.00	$209,733
Shoring	1,320	LF	$312.00	$411,840
Storm Drain Backfill and Compaction	9,387	CY	$15.00	$140,800
Haul Export Material	4,596	CY	$15.00	$68,933
Asphalt Concrete Re-Surfacing	128,040	SF	$15.00	$1,920,600
New Parallel System (+/- 250 ft)				
2 x 16' x 8' Cast-in-Place Reinforced Concrete Box	741	CY	$700.00	$518,519
Storm Drain Excavation	3,972	CY	$15.00	$59,583
Shoring	500	LF	$312.00	$156,000
Storm Drain Backfill and Compaction	731	CY	$15.00	$10,972
Haul Export Material	3,241	CY	$15.00	$48,611
Asphalt Concrete Re-Surfacing	20,750	SF	$15.00	$311,250
Maintenance Cost (Assume 50 years)	1	LS	$25,000.00	$25,000
Traffic Control	3	LS	$100,000.00	$300,000
Project Subtotal				**$5,602,885**
Utilities Relocation (15%)				**$840,433**
Permits Cost (5%)				**$280,144**
Construction Contingencies (30%)				**$1,680,866**
Final Design (5%)				**$280,144**
Estimate of Probable Construction				**$8,684,472**
TOTAL ESTIMATED PROJECT COST				**$8,684,472**

6.0 CONCLUSIONS AND RECOMMENDATIONS

The analysis of the existing Sanjon Barranca storm drain system indicated that the existing capacity is less than a 10-year storm. The corresponding expected annual damages due to residual flooding was estimated to be $435,000, with a 50-year present worth value of $6,000,000. The condition of the existing facilities is fair with an estimated life expectancy of 20 years and annualized maintenance costs of $85,414.

The following three alternative system improvements were studied to alleviate all or a portion of the 100-year flood damages:

- Alternative 1A/1B – Replace the existing system partially (Alternative 1A) or completely (Alternative 1B) with new or parallel facilities to provide 100-year level of protection.
- Alternative 2A/2B – Provide a detention basin (two basins for Alternative 2B) to reduce peak flow rates in the system and replace existing choke points in the system to provide 100-year level of protection.
- Alternative 3 – Improve existing choke points in the system to provide a minimum 10-year level of protection from the headworks to Thompson Boulevard (Segment 3A); construct an open channel from the railroad to the ocean outlet to convey the 10-year flows contained within the existing system (Segment 3B); and construct a parallel facility in San Jon Road from Thompson Boulevard to the open channel just upstream of Highway 101 (Segment 3C), to convey the 100-year flows in excess of the 10-year channel capacity.

The preliminary cost opinion for each of these alternatives is summarized in Table 21.

Table 21. Summary of Costs

Alternative	Cost	Level of Protection
1A	$16,450,656	100 yr
1B	$19,192,232	100 yr
2A	$31,225,131	100 yr
2B	$26,524,344	100 yr
3	$12,476,275	10 yr

The primary benefit of these alternatives is the reduction in flood damages. Alternatives 1A, 1B, 2A and 2B would result in the elimination of the $6,000,000 in flood damages (present worth value); however, Alternative 3 would only reduce the damages to $2,290,000, for a net benefit of $3,710,000. Comparing the costs of these alternatives to the potential benefits (see Table 22), indicates that none of the three alternatives provides a benefit-to-cost ratio (B/C Ratio) above 1.0. There were no other viable alternatives identified, so the project was terminated without further study.

Table 22. Benefit to Cost Comparison

Alternative	Benefit	Cost	Level of Protection	B/C Ratio
1A	$6,000,000	$16,450,656	100 yr	0.36
1B	$6,000,000	$19,192,232	100 yr	0.31
2A	$6,000,000	$31,225,131	100 yr	0.19
2B	$6,000,000	$26,524,344	100 yr	0.23
3	$3,710,000	$12,476,275	10 yr	0.30

Although the project could not be recommended based on flood damage reduction benefits alone, Alternative 3 could be considered for ecosystem restoration and water quality benefits. Alternative 3 would result in the creation of 0.4 acres of wetland and riparian habitat. The 350 feet of open channel would also serve as a bio-filter for the urban runoff discharging to San Buenaventura State Beach and the coastal waters of Pierpoint Bay. In addition, the City's existing pump station within the San Jon Road median could be re-operated to provide an additional source of water to the existing wetlands south of San Jon Road, as well as providing additional water quality benefits. Passive recreational features, such as a bike/walking path, could be incorporated as well.

In addition, it may be possible to combine a portion of the Sanjon Barranca improvements with the proposed Prince Barranca improvement project. The Prince Barranca channel joins the Sanjon Barranca channel downstream of the railroad. The preferred alternative for the Prince Barranca Drainage Improvement Study (prepared by CDM, January 2008) recommends an upstream detention basin to reduce the peak discharge to the existing flow capacity of the existing downstream facilities. The Prince Barranca study, however, does not take into account the limited capacity below its confluence with Sanjon Barranca. With a benefit-to-cost ratio in excess of 1.0, it may be possible to include at least a portion of the proposed improvements to the lower reach of Sanjon Barranca within the Prince Barranca project.

7.0 REFERENCES

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APPENDIX 1

Water Surface Pressure Gradient (WSPG) Model Results

APPENDIX 2
Economic Flood Damage Tables

APPENDIX 3
Hydrology References

APPENDIX 4
Ventura County Flood Control District
Detention Basin Criteria

APPENDIX 5
Wetland Restoration Concept
(Paul Jenkin)

APPENDIX 6
CD of Electronic Data Including:
Water Surface Pressure Gradient (WSPG) Storm Drain Model
HEC-HMS Model
HEC-RAS Model
Economic Analysis Spreadsheets
Cost Spreadsheets
Interim Report

APPENDIX 7
VCWPD Review Comments
and
HDR Responses