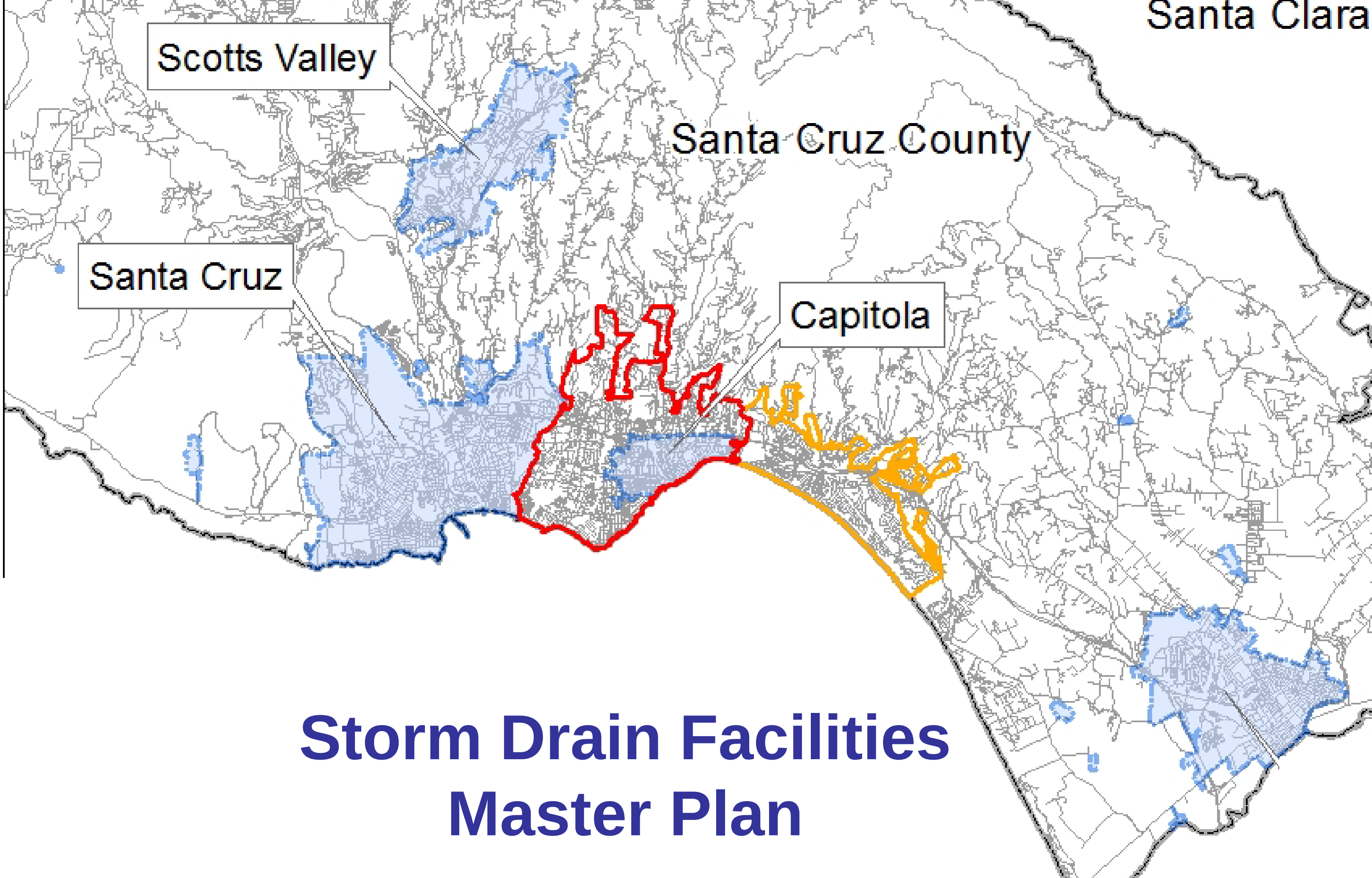


Storm Drain Facilities Master Plan





Santa Cruz County

Schaaf & Wheeler
Consulting Civil Engineers

Funding for this project has been provided in part through an agreement with the State Water Resources Control Board. The contents of this document do not necessarily reflect the views and policies of the State Water Resources Control Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. (Gov. Code, § 7550; 40 CFR 31.20)”

CHAPTER 1
MASTER PLAN OVERVIEW

A significant planning effort has been undertaken to help guide the Santa Cruz County Flood Control and Water Conservation District to establish a prioritized Master Plans Improvement Program to mitigate the impacts of stormwater runoff in Zones 5 and 6. Other master plan goals are to evaluate existing storm drainage conveyance and present the condition assessment of storm drainage facilities. This document identifies recommended improvements needed to provide a 10-year level of runoff conveyance, which is consistent with many communities in California. Master plans were created for each zone at the time of original zone formation and were in effect for many years. A second Master Plan has been completed for Zone 5 (KVL, 1998). This effort represents the 3rd master plan for Zone 5 and 2nd master plan for Zone 6.

STUDY OBJECTIVES

The basic objective of this master plan document is to provide an examination of the possibility of system restrictions within the storm drain networks of Zones 5 and 6 of Santa Cruz County, and list the recommended projects within County right of way or on County property that are necessary to convey the 10-year storm event. Specifically, this study identifies projects needed to provide a level of protection consistent with the priorities chosen by the County through this master planning process. Several objectives have been accomplished:

1. Geographical information system (GIS) based storm drain system models for Zone 5 and Zone 6 of the County have been built allowing County staff, other engineers, and developers to easily locate relevant data;
2. The design storm event and level of conveyance criteria were selected;
3. The ability of existing storm drain facilities throughout Zones 5 and 6 of the County to meet these criteria has been evaluated. System deficiencies are categorized in terms of the likelihood of public safety and/or potential property damage;
4. The physical condition of specific segments of the drainage systems have been assessed;
5. A prioritized Master Plans Improvement Program is outlined;
6. Projected improvement costs are summarized.

BACKGROUND

Detailed study background including hydrologic and environmental settings and runoff conveyance facilities within the County are described in Chapter 2 of this report. A brief synopsis of the history of system capacity analysis conducted prior to this master plan is provided below.

Zone 5 Master Drainage Plan, 1998

Conducted by Santa Cruz County Flood Control and Water Conservation District- Zone 5, this study included a capacity analysis of the drainage network within Zone 5. Various improvement alternatives were proposed, with few improvements that were constructed when sufficient funding was acquired.

SOURCES OF SURFACE PONDING

Runoff generated within the boundary of Zones 5 and 6 is conveyed through storm drain systems that outfall to creeks and ultimately Monterey Bay. Conveyance and capacity deficiencies within the storm drainage network can contribute to surface ponding within the Zones. For the purposes of this report surface ponding is defined as the surcharge of water above ground surface at a drainage inlet or manhole. The primary objective of the Storm Drain Master Plan is to address the likelihood of the occurrence of surface ponding. Because the County of Santa Cruz is located in a coastal setting, the capacity of these drainage systems may be linked to the tides and influence of the surrounding waters. Surface ponding caused by creek spills, tsunamis, sea level rise, or other such events have not been addressed in this report

WORK PRODUCTS

This master plan is intended to function at several levels. County planners and engineers responsible for capital improvements should find that this document contains sufficient background information and data to serve as a basis for future improvement implementation and/or modification. For those County staff and other parties interested in a more in-depth examination of storm drain facilities within Zones 5 and 6, the companion GIS-based InfoSWMM hydraulic model is available. InfoSWMM uses SWMM, a program designed by the US Environmental Protection Agency, to model hydrology, hydraulics, and water quality of urban drainage and sewer systems. As discussed in supporting reports and documents, the following information is available via the GIS:

1. ***Inventory of Drainage Facilities.*** Drainage pipes 12-inches in diameter and larger in the study area have been imported into the storm drain model. Known facilities were included, regardless of ownership status. Information pertaining to each system component may be accessed graphically or through database spreadsheets which have been provided electronically.

2. ***Tributary Drainage Areas.*** Land areas used to generate local runoff are also available graphically in the storm drain model, which catalogs tributary area, factors related to land use and soil conditions and other basin morphology.

3. ***Storm Drain Capacities Evaluation.*** Storm drain capacities are documented in the model. For each drainage system component, peak discharge and maximum hydraulic grade line are computed. Based on hydraulic grade calculations, the degree of surcharge and depth (based on theoretical HGL) of water above ground are also determined. This determination is then used to assign priorities for system remediation.

4. ***Drainage System Profiles.*** Those interested in viewing drainage system profiles may do so graphically using software features specifically designed for this purpose. Real-time animations of water surface profiles and corresponding surface ponding depths for design storm events are also available.

A stormwater facilities condition assessment report is included in Appendix D of this report.

STUDY FINDINGS

Several conclusions have been reached regarding the drainage network and culverts within Zones 5 and 6. From these conclusions, improvements are suggested to improve the system's performance so as to reduce the potential for surface ponding. Actual implementation of the proposed improvements will be dependent on finding funding sources which is uncertain at this time. While there are many areas with adequate storm drain conveyance, there are also known areas within each drainage region where surface ponding is likely to occur. Based on both modeling results and the conversations with County staff, areas in Zones 5 and 6 that have a high likelihood of notable ponding or have experienced ponding in the past include: Rio Del Mar Flats and Soquel Village. The condition assessment exposed a damaged pipe section, numbered as Z5-pipe-5709 located north of Pinewood Street (defined as the Pinewood project in Chapter 5), that is recommended as a high priority repair project. The improvements in this Master Plan should be considered a guide to drainage issues and recommended improvements within the study area, superceding any previous improvement recommendations.

The drainage network and culvert improvements recommended in this report do not include work on private property. The storm drain capacities evaluation may be used to determine if improvements on private property are necessary for providing a 10-year level of service.

MASTER PLAN COSTS AND BENEFITS

Drainage network improvements are recommended to reduce the likelihood of surface ponding and related economic impacts during large storm events. All residents receive a benefit from a functional storm drain system regardless of whether their property is directly affected by improvements and maintenance.

Table 1-1 summarizes the recommended master plan improvement cost estimates per drainage region. Projects to meet 10-year level of service includes pipe and pump station improvements. Please refer to Chapter 5 and Chapter 6 for figures detailing the storm drain deficiencies and recommended improvements.

Table 1-1: Summary of Master Plan Improvement Costs

Master Plan Improvements	Within Zone 5	Within Zone 6	Total
Projects to Meet 10-Year Level of Service	$9,010,000	$4,220,000	$13,230,000
Condition Related Improvements	$300,000	$830,000	$1,130,000
Culvert Improvements	$230,000	-	$230,000
Total	**$9,540,000**	**$5,050,000**	**$14,590,000**

The condition assessment report recommends that stormwater facilities be reassessed on a periodic basis, and also recommends that an in-depth assessment of all network facilities located within Zones 5 and 6 take place in the near future. A cost for this in-depth assessment is summarized in

Table 1-2. An annual condition assessment cost for Zones 5 and 6 is summarized in Table 1-3.

Table 1-2: Summary of Condition Assessment Estimate

Project	Assessment Cost	Total Cost
Cost per Zone	$ 350,000	$ 420,000

Table 1-3: Summary of Annual Condition Assessment Costs

Project	Annual Cost
Cost per Zone	$ 30,000

CONCLUSION

Reducing existing drainage limitations by improving those portions of the drainage system that are the County's responsibility is a worthy goal subject to funding constraints. This Master Plan provides a tool for Santa Cruz County citizens and officials to use in their efforts to reduce both nuisance surface ponding, and the likelihood of more serious local surface ponding related hazards to private and/or public property, and to maintain the drainage network in good working condition.

CHAPTER 2
BACKGROUND

This chapter provides a general background of characteristics existing within the Santa Cruz County Flood Control and Water Conservation District, Zone 5 and Zone 6. Master Plan objectives, hydrologic settings, condition assessment, and runoff conveyance facilities are described and discussed within.

MASTER PLAN OBJECTIVES

The basic objectives of this master plan are to evaluate existing storm drainage conveyance and present the condition assessment of storm drainage facilities. This document identifies recommended improvements needed to provide a 10-year level of runoff conveyance in the public portions of the storm drain system, which is consistent with many communities in California. Over the life of a 30-year mortgage, there is a 96 percent chance of experiencing a 10-year storm event. This is shown in Table 2-1, which provides an interesting perspective on flood risk. This study provides a numeric model of the storm drain system in Zones 5 and 6, and ties them into the major runoff conveyance facilities. The results of that analysis are included in Chapter 5.

Table 2-1: Relative Risk of Various Storm Events

	10-year	100-year
Annual risk of event	10%	1%
Risk of at least one event in 10 years	65%	10%
Risk of at least one event in 30 years	96%	26%
Risk of at least one event in 100 years	99.997%	63%

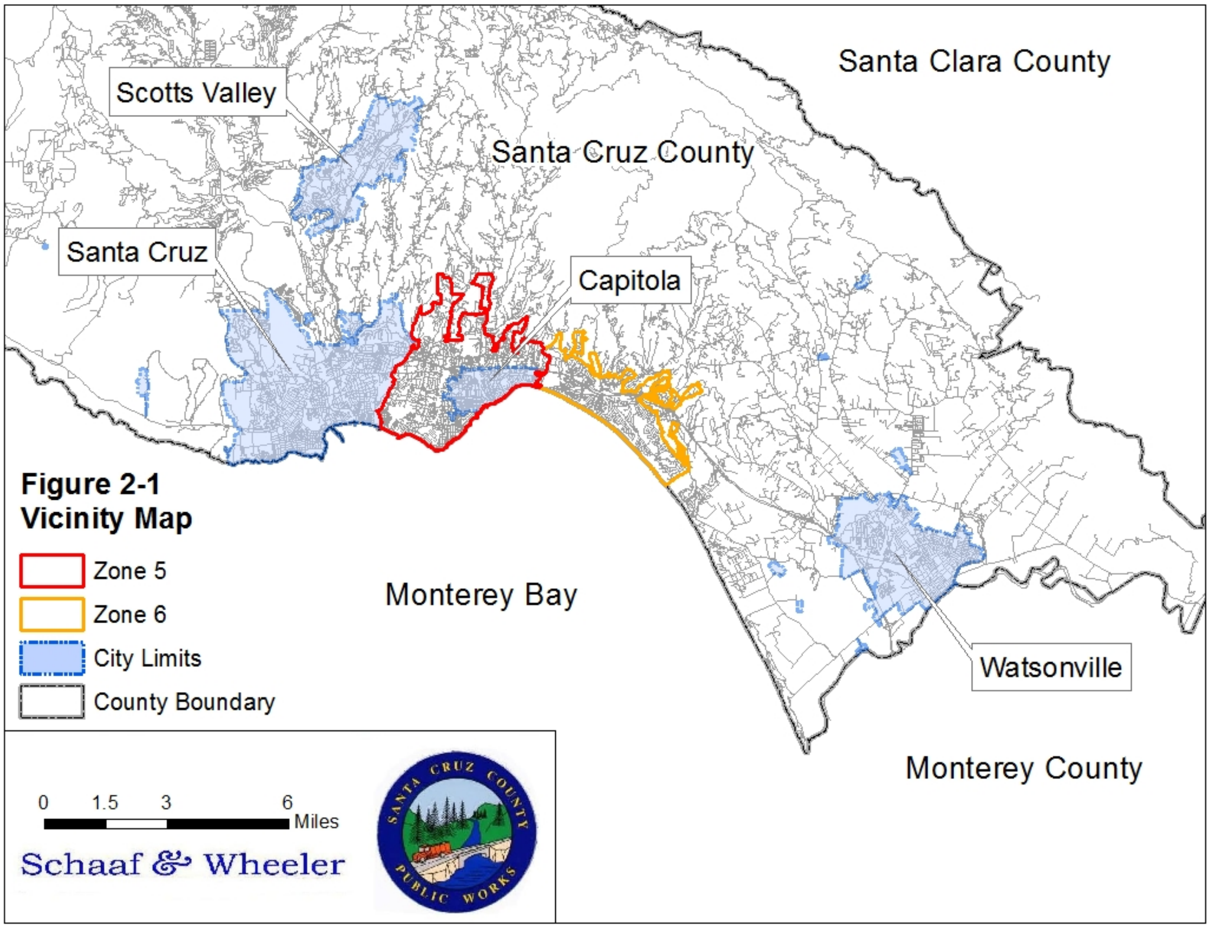
The Master Plan seeks to:

- Assess the performance of the existing storm drainage network during a 10-year storm event;
- Identify recommended improvements to meet a 10-year level of runoff conveyance in the public portions of the storm drainage network;
- Prioritize said recommended improvements based on risk reduction; and
- Assess the condition of a limited number of storm drainage facilities.

HYDROLOGIC AND ENVIRONMENTAL SETTINGS

The County of Santa Cruz is on the northern end of the Monterey Bay. It is bordered by Santa Clara County, Monterey County, San Mateo County, and Monterey Bay. Figure 2-1 places Zones 5 and 6 in Santa Cruz County in their regional context. Although the City of Capitola is located within Zone

5, they declined to participate in this master planning effort, so most facilities in the City were not analyzed as part of this study.



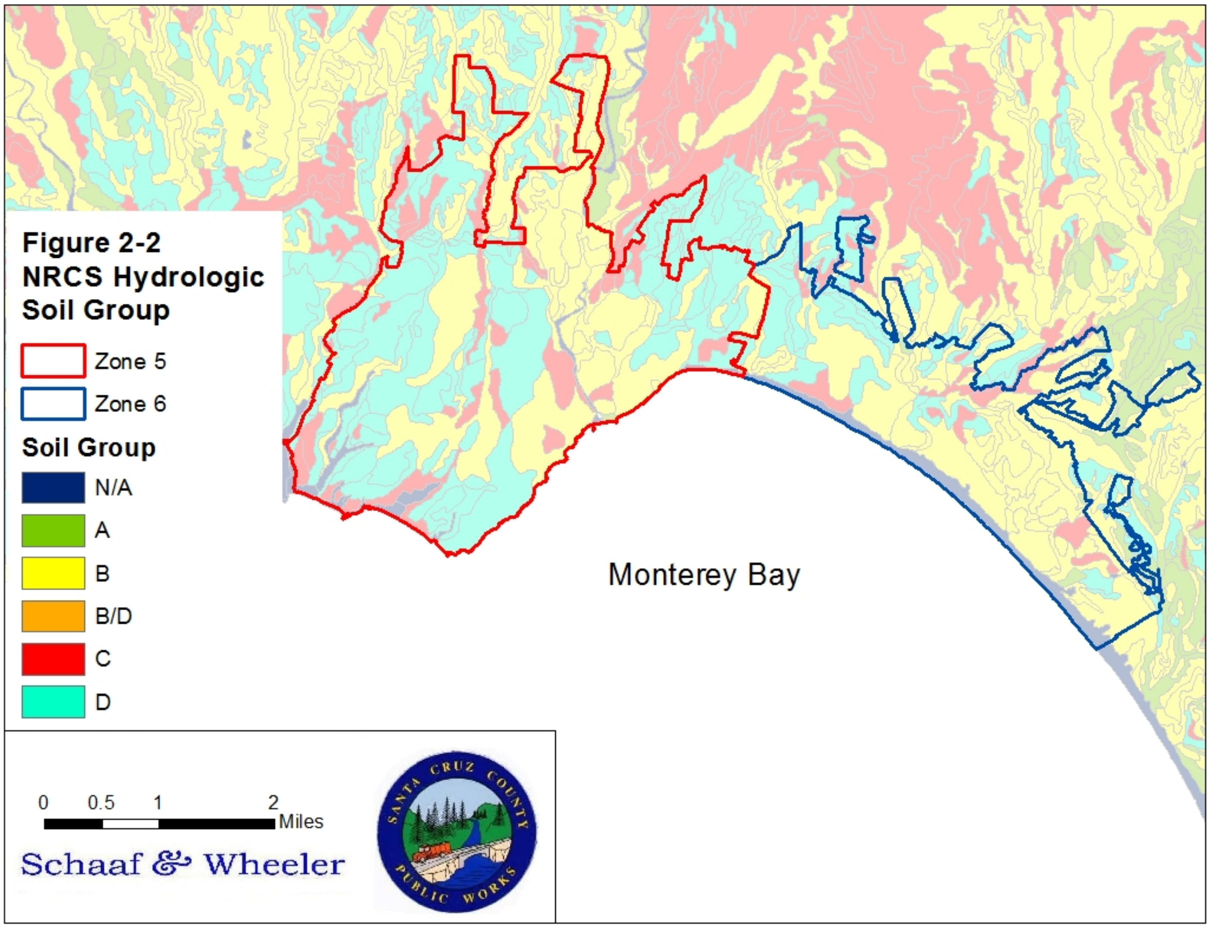
Zones 5 and 6 are minimally to steeply sloped, with elevations ranging from 0 feet National Geodetic Vertical Datum (NGVD), to about 660 feet NGVD.

Climate

Santa Cruz's climate is marine-influenced with an average summertime high temperature of 76°F and an average low of 54°F, dropping to an average winter nighttime low temperature of 41°F and an average high of 62°F. Mean annual precipitation ranges from 22 to 35 inches, with the majority of that precipitation falling from November through March. Precipitation occurs entirely as rainfall. Snowmelt is not a hydrologic process that significantly affects runoff in this portion of the County**.**

Soils

The Natural Resources Conservation Service (NRCS) has classified soils into four hydrologic soil groups (A,B,C, and D) according to their infiltration rates, which correlates to a soil's ability to absorb and transmit water; this aids in the determination of direct runoff from rainfall. NRCS has classified nearly all soils within Zones 5 and 6 as groups B, C, and D, which have moderate to very slow infiltration rates and will affect the amount of runoff and the magnitude of flood risk experienced throughout the zones. Figure 2-2 shows the soil types in the zones.



Land Use

Although open space is scattered throughout the County, the vast majority of the lower portions of Zones 5 and 6 have been urbanized. The County's land use information reflecting the County's General Plan was made available to Schaaf & Wheeler in graphical and GIS formats, and is shown in Figure 4-1. The County's GIS parcel data, which includes land use attributes, was used to determine runoff characteristics. Each land use type is assigned an NRCS Curve Number that varies with land use and soil type, as set forth in the United States Department of Agriculture (USDA) NRCS Technical Release 55 (TR-55) *Urban Hydrology for Small Watersheds* and explained in more detail in Chapter 4.

RUNOFF CONVEYANCE FACILITIES

Precipitation that falls within the County of Santa Cruz generates stormwater runoff that is conveyed in a number of mostly man-made runoff conveyance systems discharging to the creeks and Monterey

Bay. Most of these systems do not interact with one another, and potential improvements to one system should not impact the performance of other systems, either positively or negatively. Zones 5 and 6 and their contributing drainage areas are entirely contained within the County itself. Only the urbanized portion of the watershed was studied, with a total study area of 10.8 square miles (6,912 acres). Though the City of Capitola, located in Zone 5, was not included in this study, runoff generated within the City flowing to a facility within the County was accounted for.

Zones 5 and 6 generally drain to the south to Monterey Bay. Rainfall runoff flows overland via streets to storm drain inlets. In some locations runoff travels long distances before reaching an inlet; moreover, portions of this runoff ponds along roadways and infiltrates or evaporates over time. The storm drain inlet types range from older inlets to more modern gutter grates. The County's standard plans currently include one type of catch basin inlet.

Storm Drain Network

Figure 2-3 presents the Zones 5 and 6 studied drainage regions based on topography and the existing drainage network, all of which are tributary to creeks or Monterey Bay. The study area is defined as the existing pipe networks and each network's tributary area. Labeled subcatchment maps are provided in Appendix A.

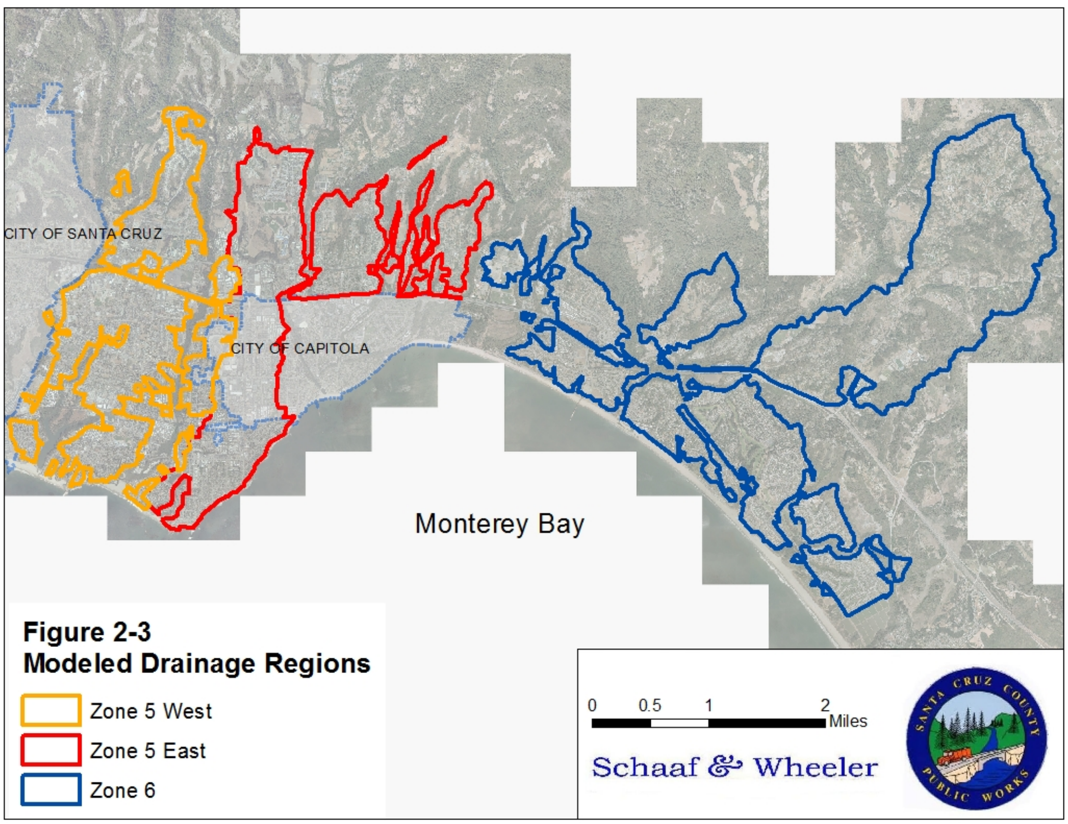


Figure 2-3
Modeled Drainage Regions

Once flow enters a storm drain, it travels through storm drain pipes and channels until discharging to a creek or Monterey Bay. The tributary areas for each modeled drainage region serviced by the modeled Zones 5 and 6 drainage network and the total length of storm drain pipes (12 inches and larger) within each area are presented in Table 2-2.

Table 2-2: Watershed Areas and Length of Storm Drain Pipe

Drainage Area	Area (square miles)	Pipe (miles)
Zone 5 West	2.5	26.7
Zone 5 East	2.7	22.5
Zone 6	5.6	23.4
TOTAL	10.8	72.6

Stormwater Facilities Condition Assessment

V&A was retained by Schaaf & Wheeler to assess the condition of various stormwater facilities. A list of piping and culverts ranked as medium to high priority for assessment was provided by the County. Primarily high priority piping and culverts south of Highway 1 were evaluated; however, some lower priority facilities in close proximity to higher priority facilities were evaluated as well. Piping and culverts were assessed through the use of a pole mounted camera and by performing a confined space entry on the pipe runs and culverts where applicable.

Various evaluation methods were used during the assessment: VANDA Concrete and Metallic Condition Index ratings (an index created by V&A to provide consistent reporting of corrosion damage based on qualitative, objective criteria); locations of visually identified defective areas were noted; pipe deflections, visible concrete cracks, concrete spalls, offset or displaced pipe joints, and other associated defects within the stormwater pipe were documented; and photographs and handheld video of pipelines and culverts were obtained.

CHAPTER 3
METHODOLOGIES

The methodology used to evaluate storm drain system performance must be technically sound, yet simple to understand and apply. The hydrologic methodology used to analyze rainfall runoff and system performance is based on the County of Santa Cruz Design Criteria – Part 3 (CDC), and expanded upon to produce a more in depth analysis. Ideally, the same hydrologic methodology used in this study will continue to be used for studies of a similar scope. The hydraulic methodology used to analyze network flow is a modification of the CDC to allow pressure flow and a hydraulic grade line of 6-inches above ground level. This modification allows the County to make feasible improvements to an existing, aging system in a manner that limits the risk of property damage. The purpose of this chapter is to outline the methodology applied to evaluate the storm drain system performance for the Zones 5 and 6 storm drain master planning effort. The actual data applied (network, land use, etc.) in this methodology is discussed in Chapter 4, Data.

GIS BASED MODELING

Schaaf & Wheeler and County staff reviewed several options to determine the preferred storm drain modeling software for the master planning effort. InfoSWMM was selected and is a software program distributed by MWH Soft for the analysis, design and management of urban drainage systems, including storm water sewers and sanitary sewers. The InfoSWMM model works within ArcGIS and can simulate runoff, open channel flow, pipe flow, and water quality. The program has been chosen to model a number of the urbanized storm drain systems within the County of Santa Cruz because of its capabilities with overland flow, weirs, pumps, pipe networks, and storage areas; the incorporation of the Natural Resources Conservation Service (NRCS) Curve Number hydrology method; SWMM compatibility; and the overall stability of the model. Though the models were developed using the proprietary InfoSWMM, the final models offer direct ArcGIS integration, enabling engineers and GIS professionals to work simultaneously on the same integrated platform.

The storm drain systems are modeled as three independent urban drainage regions based on the number of outlet points and the major drainage network for each area. Zone 5 is split in two sub-regions: Zone 5 West and Zone 5 East. Zone 6 is modeled as one drainage region. Each drainage region model is composed of a pipe network (pipes, manholes, catch basins, etc.), and the urban catchments drained by the pipe network.

Operation

Two separate calculations are performed by InfoSWMM for the analysis: a stormwater runoff calculation that determines the amount of water entering the storm drain system from a specific rainfall event; and a pipe flow calculation that replicates how the storm drain system, including pumps, will convey those flows to outlets. Flows resulting from the runoff calculation are used as inflows for the subsequent pipe flow calculation.

InfoSWMM has three infiltration methods: Horton, Green-Ampt, and Natural Resources Conservation Service (NRCS) Curve Number. The storm drain models use the NRCS Curve Number method to calculate surface runoff. This method is detailed in the USDA Technical Release 55 (TR-55), *Urban Hydrology for Small Watersheds*. The runoff simulation duration is set equal to the design storm duration or some lesser duration depending on the period of interest; a 24-hour storm is used for this analysis. The model can be started at any point during the chosen design storm to assess surface runoff for any period of the design storm, with computations made based on a user-specified constant time step.

The InfoSWMM pipe flow model offers a choice of three flow description approximations: Steady State, Kinematic Wave, and Dynamic Wave. Each is distinguished based on the set of forces that each takes into account. The County storm drain model uses the most comprehensive flow description, Dynamic Wave, which incorporates the effects of gravitational, friction, pressure gradient and inertial forces. Because it accounts for all forces affecting flow conditions, this method allows the model to accurately simulate fast transients and backwater profiles. Water above node rims can be simulated by using an artificial basin above the ground level, referred to in InfoSWMM as ponding. The pipe flow simulation can be executed using either a constant or variable time step, and can be run for any portion of the time interval specified by the input rainfall time series and corresponding calculated runoff hydrograph. A time step of 2 seconds is used for the models within the County with an adjustment factor of 0.75. These values are based on model stability and computation time.

Input and Output

InfoSWMM surface runoff calculations require two types of input data: boundary data and urban catchment data. Boundary data for the run-off computation consists of an input rainfall time series representing the design storm event for the model. Urban catchment data includes the boundaries of each drainage catchment, along with relevant physical and hydrologic parameters including surface area and parameters used to calculate basin lag time. Drainage catchments for the study area are shown in Appendix A, and input data corresponding to the catchments are provided in Appendix G. The runoff calculation output is a runoff hydrograph that corresponds to the input rainfall time series.

InfoSWMM pipe flow calculations require network data, operational data, and boundary data as input. Network data consists of the pipe network elements including nodes (manholes, outlets and storage nodes) and links (pipes, culverts, and open channels). Parameters required to describe nodes include the x and y coordinates of the node, a unique name, node type (junction or outfall), node depth and invert levels, and water levels at outfalls (unless indentified as a free outfall).

Parameters required to describe links include a unique name, name of upstream and downstream nodes, shape and dimensions, material or roughness, upstream and downstream inverts, and head loss coefficients. Structural system elements including gates, weirs, pumps and orifices are all modeled as functional relationships connecting two nodes in the system, or associated with one node in the case of free flow out of the system.

Output from the pipe flow computation includes the calculated water level at each node, pump discharges, weir discharges, water level in network branches, discharge in network branches, water velocity in network branches, water volume in the system, and time step data. Output is viewed using GIS or the InfoSWMM program. Within InfoSWMM, results may be displayed in plan view or as a profile for a selected network section, and may be viewed as a temporal animation or at maximum values. Results can be exported in table format and viewed in ArcGIS as shapefiles.

Additional outputs which can be derived from InfoSWMM network results include water depth, surface ponding, pressure in closed conduits, the flow (Q) calculated from Manning's equation for each link, and model instability.

SURFACE RUNOFF CALCULATIONS

As described above, the first step of the InfoSWMM model is to complete a stormwater runoff calculation that determines the amount of water entering the storm drain system from a specific rainfall event. Boundary and catchment data must be input to the model to complete this calculation.

Boundary Data

Boundary data for the run-off computation consists of an input rainfall time series representing the design storm event for the model. Since it is impossible to anticipate the impact of every conceivable storm, precipitation frequency analyses are often used to design facilities that control storm runoff. A common practice is to construct a design storm, which is a rainfall pattern used in hydrologic models to estimate surface runoff.

A design storm is used in lieu of a single historic storm event to ensure that local rainfall statistics (i.e. depth, duration and frequency) are preserved. When combined with regional specific data for land use and loss rates, the model should produce runoff estimates that are consistent with frequency analyses of gauged stream-flow in the Santa Cruz County area. In other words, the ten-year design storm pattern used for InfoSWMM modeling creates results consistent with a ten-year storm runoff event.

Precipitation frequency analyses are based on concepts of probability and statistics. Engineers generally assume that the frequency (probability) of a rainfall event is coincident with the frequency of direct storm water runoff, although runoff is determined by a number of factors (particularly land use conditions in the basin) in addition to the precipitation event. This master plan effort included modeling the hydrology for the 2-year, 5-year, 10-year, 25-year, 50-year and 100-year frequency storm/precipitation events. As discussed in Chapter 2, Background, the 10-year storm event was used as the design event for the stormwater drainage system.

The synthetic unit hydrograph is a numerical representation of the time response of catchment runoff caused by one inch of excess rainfall applied uniformly over a unit of time. Many different techniques are available to estimate unit hydrographs. The EPA SWMM model uses a modification of the NRCS method to transform hypothetical rainfall distribution and design rainfall depth into a runoff hydrograph. Basin lag is calculated using basin slope, basin area, and basin width. This width is not well defined in the EPA manuals; however, an estimation of the basin area divided by the flow path can be used. Using Figure SWM-2 from the CDC, a value for P60 was selected for each zone. Figure SWM-3 "Rainfall Intensity-Duration Curves 10-Year Return Period" in the CDC was used to determine the intensity for a 10-year storm event, for 15, 30, 60, 120, 240, and 1,440 minute durations. Factors for converting intensities to return periods other than 10 years are provided in Fig. SWM-3 of the CDC and were used to calculate the intensity for a 2, 5, 10, 25, 50, and 100-year storm event.

In order to create storm patterns for input to the InfoSWMM model, a general rainfall pattern was manipulated to match local rainfall statistics. The general rainfall distribution pattern utilized for this analysis is the (NRCS) Type I synthetic 24-hour rainfall pattern. The Type I pattern is representative of pacific maritime climate with wet winters and dry summers (TR-55, Appendix B). The NRCS Type I rainfall pattern is distributed in 30-minute time increments with a fraction of the total rainfall apportioned to each 30-minute increment. This rainfall pattern with 30-minute time steps was then balanced such that the total rainfall resulting from the pattern matched the total rainfall depths for the 15-minute, 30-minute, 1-, 2-, 4-, and 24-hour storm durations obtained using the IDF curves in the CDC.

The HEC-1 output, which represents a fractional rainfall pattern, is manipulated to convert the storm to a 15-minute time step by assuming that the fraction of rainfall for each 15-minute period is equal to one-half of the 30-minute fraction. Finally, the storm pattern was further balanced to match the 15-minute, 30-minute, 1-, 2-, 4-, and 24-hour rainfall intensities. Total rainfall depth for each storm event is calculated by multiplying the storm duration, in hours, by the intensity for each storm event assuming a 24-hour storm. Each fractional rainfall in the storm pattern is then multiplied by the total rainfall depth to create a rainfall pattern for each storm event. The resulting balanced pattern provides total rainfall depths equal to the calculated values using the IDF curves for all of the storm durations. Storm pattern information is input into the InfoSWMM model as rainfall volume. The 10-year balanced storm for Zone 5 is shown in Figure 3-1 with the associated 10-year design rainfall shown in tabular values in Table 3-1. This information for the various other storms analyzed (2-, 5-, 10-, 25-, 50-, and 100-year storm events) for both zones is included in Appendix J.

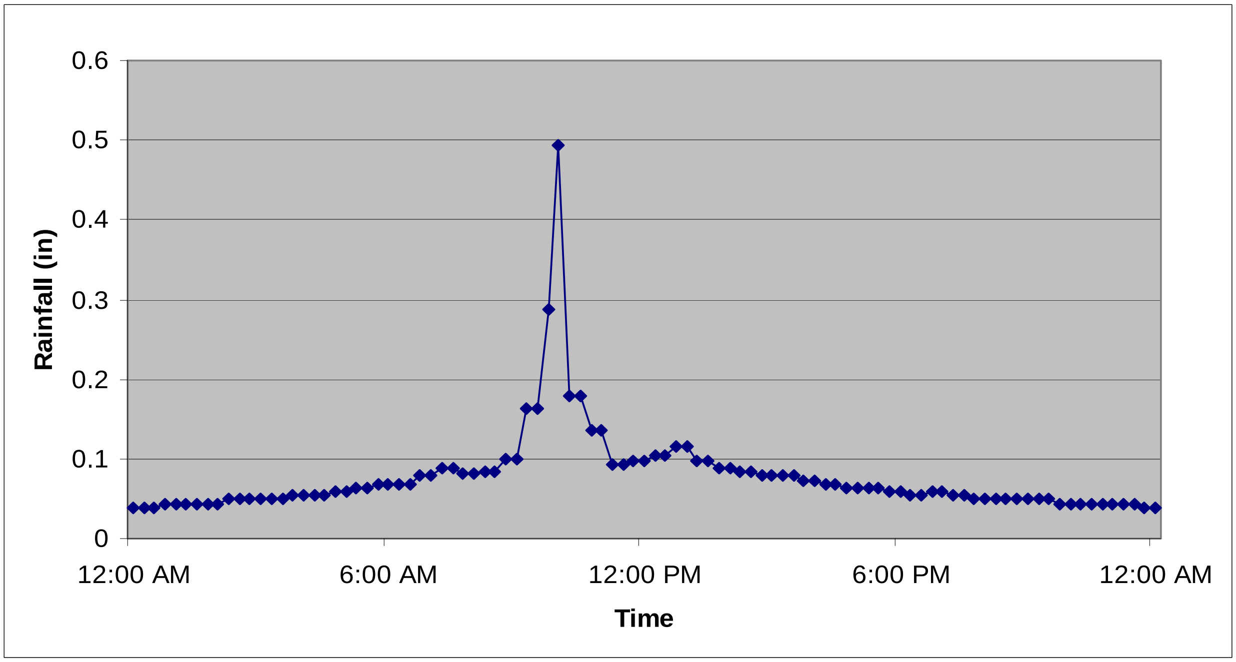


Figure 3-1: Zone 5 Balanced 10Year Storm

Table 3-1: Zone 5, 10 year 24-hour Design Storm Values

Time	Unitless Rainfall (%/15 min)	15-Minute Intensity (in/hr)	Actual Rainfall (in/15 min)	Time	Unitless Rainfall (%/15 min)	15-Minute Intensity (in/hr)	Actual Rainfall (in/15 min)	Time	Unitless Rainfall (%/15 min)	15-Minute Intensity (in/hr)	Actual Rainfall (in/15 min)
0:15	0.0053	0.1562	0.0391	8:15	0.0114	0.3288	0.0822	16:15	0.0092	0.2931	0.0733
0:30	0.0053	0.1562	0.0391	8:30	0.0114	0.3378	0.0844	16:30	0.0092	0.2723	0.0681
0:45	0.0059	0.1562	0.0391	8:45	0.0133	0.3378	0.0844	16:45	0.0085	0.2723	0.0681
1:00	0.0059	0.1756	0.0439	9:00	0.0133	0.3943	0.0986	17:00	0.0085	0.2530	0.0632
1:15	0.0059	0.1756	0.0439	9:15	0.0220	0.3943	0.0986	17:15	0.0085	0.2530	0.0632
1:30	0.0059	0.1756	0.0439	9:30	0.0220	0.6532	0.1633	17:30	0.0085	0.2530	0.0632
1:45	0.0059	0.1756	0.0439	9:45	0.0386	0.6532	0.1633	17:45	0.0079	0.2530	0.0632
2:00	0.0059	0.1756	0.0439	10:00	0.0662	1.1500	0.2875	18:00	0.0079	0.2336	0.0584
2:15	0.0066	0.1756	0.0439	10:15	0.0242	1.9700	0.4925	18:15	0.0072	0.2336	0.0584
2:30	0.0066	0.1949	0.0487	10:30	0.0242	0.7200	0.1800	18:30	0.0072	0.2143	0.0536
2:45	0.0066	0.1949	0.0487	10:45	0.0184	0.7200	0.1800	18:45	0.0079	0.2143	0.0536
3:00	0.0066	0.1949	0.0487	11:00	0.0184	0.5476	0.1369	19:00	0.0079	0.2336	0.0584
3:15	0.0066	0.1949	0.0487	11:15	0.0126	0.5476	0.1369	19:15	0.0072	0.2336	0.0584
3:30	0.0066	0.1949	0.0487	11:30	0.0126	0.3750	0.0937	19:30	0.0072	0.2143	0.0536
3:45	0.0072	0.1949	0.0487	11:45	0.0130	0.3750	0.0937	19:45	0.0066	0.2143	0.0536
4:00	0.0072	0.2143	0.0536	12:00	0.0130	0.3869	0.0967	20:00	0.0066	0.1949	0.0487
4:15	0.0072	0.2143	0.0536	12:15	0.0141	0.3869	0.0967	20:15	0.0066	0.1949	0.0487
4:30	0.0072	0.2143	0.0536	12:30	0.0141	0.4181	0.1045	20:30	0.0066	0.1949	0.0487
4:45	0.0079	0.2143	0.0536	12:45	0.0155	0.4181	0.1045	20:45	0.0066	0.1949	0.0487
5:00	0.0079	0.2336	0.0584	13:00	0.0155	0.4598	0.1149	21:00	0.0066	0.1949	0.0487
5:15	0.0085	0.2336	0.0584	13:15	0.0131	0.4598	0.1149	21:15	0.0066	0.1949	0.0487
5:30	0.0085	0.2530	0.0632	13:30	0.0131	0.3899	0.0975	21:30	0.0066	0.1949	0.0487
5:45	0.0092	0.2530	0.0632	13:45	0.0118	0.3899	0.0975	21:45	0.0059	0.1949	0.0487
6:00	0.0092	0.2723	0.0681	14:00	0.0118	0.3512	0.0878	22:00	0.0059	0.1756	0.0439
6:15	0.0092	0.2723	0.0681	14:15	0.0112	0.3512	0.0878	22:15	0.0059	0.1756	0.0439
6:30	0.0092	0.2723	0.0681	14:30	0.0112	0.3318	0.0830	22:30	0.0059	0.1756	0.0439
6:45	0.0105	0.2723	0.0681	14:45	0.0105	0.3318	0.0830	22:45	0.0059	0.1756	0.0439
7:00	0.0105	0.3125	0.0781	15:00	0.0105	0.3125	0.0781	23:00	0.0059	0.1756	0.0439
7:15	0.0118	0.3125	0.0781	15:15	0.0105	0.3125	0.0781	23:15	0.0059	0.1756	0.0439
7:30	0.0118	0.3512	0.0878	15:30	0.0105	0.3125	0.0781	23:30	0.0059	0.1756	0.0439
7:45	0.0111	0.3512	0.0878	15:45	0.0099	0.3125	0.0781	23:45	0.0053	0.1756	0.0439
8:00	0.0111	0.3288	0.0822	16:00	0.0099	0.2931	0.0733	24:00	0.0053	0.1562	0.0391
								TOTAL:	**1.00**		**7.44**

Urban Catchment Data

Urban catchment data includes the boundaries of each drainage catchment, along with relevant physical and hydrologic parameters including surface area, land use characteristics, and parameters used to calculate basin lag time. Zones 5 and 6 are divided up into drainage areas, called subcatchments, based on the topography of the area. A GIS file containing information on watersheds was provided by the County of Santa Cruz. An ArcGIS tool was first utilized to automatically divide the large watersheds into smaller basins based on the topography. Secondly, these pre-defined basins were manually divided into more precise subcatchments based on topography and when necessary, an aerial image.

As mentioned previously, the InfoSWMM program utilizes the NRCS Curve Number (CN) methodology to determine basin runoff. This methodology relies on the use of curve numbers to characterize basin infiltration and runoff potential. Curve numbers are based on a combination of land use, soil characteristics, and antecedent moisture condition. Land use information provided by the County of Santa Cruz is used to define the land use within Zones 5 and 6. In areas of the study that are not included in the land use GIS data, an aerial image provided by the County was used to identify the land use type. Schaaf & Wheeler obtained soil data from the *U.S. Department of Agriculture, Natural Resources Conservation Service (USDA-NRCS),* which provides information regarding the Hydrologic Soil Group (HSG) of the soil in the County and is consistent with the NRCS methodology. The Antecedent Moisture Condition (AMC) describes the relative wetness or dryness of the watershed preceding a given storm event. Schaaf & Wheeler established the AMC for different storm events by calibrating a hydrologic model (HEC-1) to Soquel Creek flow statistics. This process is described in detail below.

Soquel Creek Antecedent Moisture Condition Calibration

Stream gage data for Soquel Creek (Hydrologic Unit ID: 18060001) was obtained by Schaaf & Wheeler from the United States Geological Survey (USGS). A Flood Frequency Analysis (FFA) was performed using the program FFA created by the U.S. Army Corps of Engineers (USACE) to estimate the peak flow in Soquel Creek for a return period of 2, 5, 10, 50, and 100 years. Using computer program Origin 6.1 (OriginLab Corporation, 1991-2000), computed discharge is plotted against exceedance probability with the y-axis set as “Log-10” and the x-axis set as type “Probability”, as shown in Figure 3-2. From this graph, the peak flow at the gauge location for each of the storm events is determined.

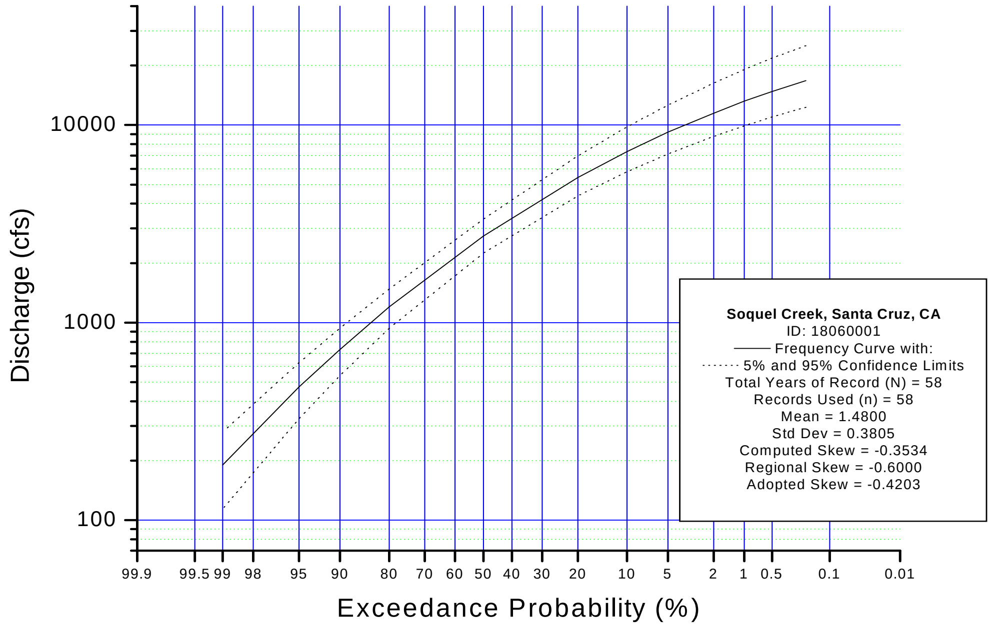


Figure 3-2: Soquel Creek Exceedance Probability

As mentioned previously, the CN is estimated as a function of hydrologic soil group, land use, and antecedent moisture condition (AMC), with AMC defined as the moisture content of a soil prior to any precipitation event. The AMC generally varies depending on the severity or recurrence interval of a given storm. AMC is characterized by the NRCS as:

AMC I	soils are dry
AMC II	average conditions
AMC III	heavy rainfall, or light rainfall with low temperatures; saturated soil

The watershed draining to the Soquel Creek gage is delineated, and curve numbers for various AMCs are assigned to each land use/soil type. An area-weighted curve number for a variety of possible AMCs was calculated for the drainage basin using Spatial Analyst tools in ArcGIS. A simplified hydrologic model (HEC-1) was created for the watershed draining to the Soquel Creek gage using the storm pattern methodology previously described. Basin lag for the model was determined using the following equation:

$$Lag = K \cdot N \left[\frac{L \cdot Lc}{\sqrt{S}} \right]^{0.38}$$

where *Lag* is lag time in hours, *L* is the length of the basin's longest watercourse in miles, *K* is 24 and unitless, *Lc* is the length along the basin's longest water course measured from the outlet to a point opposite the watershed area's centroid in miles, *S* is the average stream slope (ft/mile), and *N* is a basin roughness factor. It should be noted that the basin roughness factor is not the same as Manning's roughness coefficient (*n*). For urban watersheds, the relationship between Manning's *n*-value and the basin *N*-factor is:

$$N = 0.3318\, n^{0.6328}$$

The flow predicted by the model for various AMCs at the gage is then compared to the actual peak flow calculated by the flood frequency analysis, and the AMC corresponding to the closest match in runoff assigned for each storm event. Table 3-2 summarizes the results of this analysis.

Table 3-2: Results of AMC Calibration

Recurrence Interval	FFA Peak Flow (cfs)	HEC-1 Predicted Flow (cfs)		Assigned AMC
		AMC I.5	AMC II	
100-Year	13,200	12,276	14,798	I
50-Year	11,500	10,402	12,797	I.25
25-Year	10,000	8,594	10,839	I.25
10-Year	7,350	6,274	8,267	I.25
5-Year	5,430	4,643	6,396	I.25
2-Year	2,740	2,654	3,943	I

Curve numbers vary from 0 to 100, with 0 equating to no runoff from a basin and 100 indicating that all precipitation will run off. USDA-NRCS Technical Release 55 (TR-55) *Urban Hydrology for Small Watersheds* was used to determine curve numbers for various land uses depending on soil type and AMC. Table 3-3 summarizes the NRCS Curve Numbers for an AMC of II.

Table 3-3: NRCS Curve Numbers

Land Use	Symbol	AMC II Soil Group			
		A	B	C	D
Agriculture	A	66	77	85	89
Coastal Dependent	CD	98	98	98	98
Commercial Agriculture	CA	58	72	81	85
Commercial Services	C-4	89	92	94	95
Community Commercial	C-2	89	92	94	95
Industrial	M-1	81	88	91	93
Mineral Extraction Industrial	M-3	81	88	91	93
Mobile Home Exclusive	MHE	77	85	90	92
Multi-Family Residential	RM	77	85	90	92
Natural Areas	NA	43	65	76	82
Neighborhood Commercial	C-1	89	92	94	95
Parks, Recreation and Open Space	PR	49	69	79	84
Professional-Administrative Office	PA	89	92	94	95
Public and Community Facilities	PF	68	79	86	89
Residential Agricultural	RA	59	74	82	86
Rural Residential	RR	57	72	81	86
Single-Family Residential	R-1	61	75	83	87
Special Use	SU	49	69	79	84
Tourist Commercial	CT	89	92	94	95
Timber Production	TP	43	65	76	82
Visitor Accommodations	VA	89	92	94	95
Water	W	100	100	100	100

PIPE FLOW CALCULATIONS

Detailed analyses of peak stormwater discharge are performed with the InfoSWMM program, which also determines the flow condition in each drainage system element. The InfoSWMM technical manual should be referenced for a more detailed description.

Data

The methodology for pipe flow calculations is detailed below. The calculations rely on information on the storm drain network such as pipe diameter, length, material, and elevation data. Extensive field work, review of as-built plans, interpolations, and engineering judgment and assumptions were utilized to supplement the initial storm drain network GIS data provided by the County. It should be noted that the goal of updating the GIS database was to create a database sufficient for storm drain master planning efforts. Less effort was spent completing those elements of the database that are less relevant to the modeling and master planning of storm drains (such as pipe invert elevations, which are irrelevant when pipes are surcharged). The accuracy of the resulting GIS database is sufficient for master planning efforts. The process of updating the database, including assumptions and shortcomings, are detailed in Chapter 4, Data.

Schaaf & Wheeler obtained topography data from the County of Santa Cruz, which provides topographic information at 2-foot intervals based on an NAVD88 vertical datum (topographic data is available from the Central Coast Joint Data Committee). In rural areas where 2-foot contours were not available, Schaaf & Wheeler utilized 10 foot contours based on an NAVD88 datum, also provided by the County of Santa Cruz. The data is provided in the State Plane (California Zone III) coordinate system, and covers the entire study area.

Closed conduits

Pipes are modeled as one-dimensional closed conduit links which connect two nodes in the model. The conduit link is described by a constant cross-section along its length, constant bottom slope, and straight alignment. The unsteady flow in closed conduits is calculated using continuity and conservation of momentum equations, distinguishing between pipes flowing partially full (free surface flow), and those flowing full (pressurized flow). The Darcy-Wiesbach equation for pressure flow conditions was selected for this study. This Darcy-Wiesbach equation is:

$$h_f = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g}$$

where h_f is the head loss due to friction in feet, f is a Darcy-Weisbach friction factor, L is the length of pipe in feet, D is the hydraulic diameter of the pipe in feet, and V is the average flow velocity in the pipe (ft/sec).

The majority of pipes within the model are reinforced concrete pipe (RCP) with a Manning's '*n*' of 0.015. There are a few corrugated metal pipes (CMP) with '*n*' of 0.015, polyvinyl chloride pipes (PVC) and high-density polyethylene pipes (HDPE) with '*n*' of 0.01, and open channels with '*n*' of 0.025. If the pipe material is unknown, RCP was assumed. These '*n*' values differ slightly from values presented in the CDC to account for the increase in roughness that occurs as a pipe network ages, but are consistent with values published in the various engineering publications listed in Section B – Design References of the CDC.

Open Channels

Sections of open channel were only included in the model if a storm drain network flows into an open channel and back into another storm drain system. InfoSWMM uses Manning's equation to calculate channel conveyance and normal flow depths. Creeks are not included in the storm drain models, except when connecting storm drain systems. The InfoSWMM hydraulic model is designed to approximate the level of service of the existing storm drainage network, and creek performance is, for the most part, irrelevant to storm drain system performance as explained in more detail in the outlet boundary conditions section below. Other modeling software (HEC-RAS) and significantly more topographic data would be required to determine channel water surface profiles for the various exceedance intervals and creeks in the study area.

Storage Facilities

There are many private storage facilities throughout Zones 5 and 6, however, only County storage facilities were included in this analysis. The storm drain collection system at Brommer Street near 38th Avenue in Zone 5 East overflows a weir into a storage basin facility, or detention pond. Two 30 horsepower pumps are located in the detention pond. Located at the southwest corner of the pond is an overflow outlet where water is able to drain back into the system during the storm event should the water level in the storage basin rise up high enough. InfoSWMM models storage areas according to the volume of the basin. The model requires a basin bottom elevation, a maximum depth, and an initial water depth. In addition to these constraints, multiple basin surface areas and corresponding elevations are input to the model. This data is based on the 2-foot topography previously described. These data are entered into a node representing the basin which is connected to the piping network with at least one upstream link and downstream link. Other existing parks were not studied as storage facilities; however, these open areas may provide potential storm water storage benefits.

Pumping Facilities

Pumps are modeled in InfoSWMM as a function of the difference in water levels between two nodes. Pumps are characterized by starting and stopping water levels and a capacity curve of differential head vs. flow data for the pump. The pumps at the detention pond facility described above are the only pumps studied for this master plan. The input data for the Brommer Street pump station is detailed in Chapter 4, Data.

Outlet Boundary Conditions

Pipe network outlets can be modeled with either a free outfall or a water surface elevation (set or variable with time) which captures backwater effects due to receiving water levels. The majority of creek outfalls in the Zone 5 and 6 models are modeled as free outfalls. This approach is utilized because it creates results that are reasonably accurate without being overly conservative. In general, Creek watersheds in Zones 5 and 6 are large enough that coincident peaks (peak flows in the Creek and pipe network occur at the same time) are unlikely. If coincident peaks were assumed, the results would be very conservative, and could lead to inflated and unreasonable recommended improvements. Conversely, if a free outfall is allowed, any resulting surface ponding is due entirely to pipe capacity restraints, not backwater conditions. If backwater conditions did exist, these same pipes would experience only greater surcharging. Thus, allowing free outfalls provides a first step in prioritizing improvements by limiting the recommended improvements to those pipes which are undersized for their drainage area, regardless of backwater conditions.

Some outfalls, however, discharge directly to a lagoon or creek location that is regularly surcharged. These locations are mostly in the lower watershed, and as such the storm drain lines tend to be flatter. These lower sloped pipes are more likely to be significantly impacted by backwater. The FEMA 10-year water surface elevation for the creek channels is used as the boundary condition at these locations.

Culverts

Several culverts within Zones 5 and 6 were not included in the InfoSWMM network models. These culverts are typically located on channels that do not have direct impacts on the storm drain pipe networks. Schaaf & Wheeler analyzed the culverts by comparing the hydraulic capacity against peak runoff rates for various storm frequencies. Peak runoff rates were estimated using HEC-1, hydrology analysis software developed by the US Army Corps of Engineers. Culvert drainage areas were delineated and assigned hydrologic parameters using the methods described in the Surface Runoff Calculations section of this chapter. The storm pattern and rainfall totals described in the Boundary Data section of this chapter were used for the analysis.

Culvert capacity was analyzed using HY-8, culvert hydraulics analysis software developed by the Federal Highway Administration. A total of twenty eight (28) culverts, thirteen (13) in Zone 5 and fifteen (15) in Zone 6, were analyzed. The culvert hydraulics calculations rely on information such as culvert dimension, length, material, headwall condition, and downstream channel topography. Review of as-built plans, interpolation, County provided topographic information, aerial photographs, and engineering judgment and assumptions were utilized to supplement the initial culvert GIS data provided by the County.

CHAPTER 4
DATA

OVERVIEW

Schaaf & Wheeler reviewed and utilized readily available land use, topographic, geographical and storm drain system data within the County of Santa Cruz (County). Available data was often missing or incorrect, and efforts were made to improve and add to the collective data. Where necessary, assumptions and engineering judgment were used to complete remaining data gaps. This chapter summarizes the findings and data acquired as part of the Zone 5 and Zone 6 Storm Drain Master Plan (SDMP). Data limitations, assumptions and impacts to the SDMP are also summarized.

DATA SOURCES

Topography and Aerial Imagery

All project data and results are in NAVD88 (feet). Some of the data provided by the County is on the NGVD29 vertical datum, which was converted to NAVD88 using the following equation:

$$\text{NGVD29} + 2.73 \text{ feet} = \text{NAVD88}$$

2007 Santa Cruz County 2-foot contour topography data (NAVD88) with one foot accuracy (plus or minus 1.0 foot) is also utilized for ground surface information. All data is in the State Plane (California Zone III) coordinate system. The County's 2007 high resolution digital aerial imagery was also utilized.

Pump Stations

There is one storm water pump station in the study area. The 38th Avenue detention basin pump station is located along Brommer Street between 38th Avenue and Windward Lane. This station is designed to pump stormwater from the detention basin to the 48-inch RCP pipe along the perimeter of the basin. The existing station consists of two 30 HP pumps. Both pumps are operational and have a float system that can be set to operate automatically or manually. There is an engine generator hookup that allows the pump station to be powered during an electrical outage. The pump station communicates with the Sanitation Division's SCADA system which alerts staff when pump failure occurs. The County does not have an operation curve for this pump station. In order to include the pump station in the modeling efforts, however, it is assumed to have the same performance curve as a Flygt CP3201.180 LT pump which is also 30 HP and operates in a similar total dynamic head range. The pump on and off levels were assumed to be set at water depths of three feet and one foot, respectively, based on conversations with Zone 5 maintenance staff.

AutoCAD and GIS

The County provided AutoCAD and GIS files to the Schaaf & Wheeler team for use on this project. The County GIS data utilized for this project includes: storm drain pipes, storm drain manholes and inlets, existing land use, zone limits and parcel data. The County's raw storm drain GIS data is missing a quantity of information critical to accurately modeling the storm drain system. The data which is included in the GIS files is often of unknown accuracy or source (for example, elevation data based on an unknown vertical datum). The steps taken to complete the data set to a master planning level of accuracy are detailed in the Data Quality and Data Assumptions sections of this chapter.

Historical Data and As-Builts

A hard copy of the 1998 Zone 5 SDMP was reviewed for relevant data. As-built information from Caltrans and Santa Cruz County for Highway 1 was reviewed for storm drainage data. The County's as-built and improvement plans were used to verify the County provided GIS data and to fill in data gaps.

Field Measurements

Schaaf & Wheeler spent approximately six weeks in the field verifying key locations within the system and measuring missing pipe diameters and invert depths. Collecting accurate pipe diameters was the highest priority of the field measurements. Once pipes become surcharged, their invert elevation and slope become irrelevant to pipe flow calculations since the surcharged hydraulic grade line controls pipe capacities. Therefore, the pipe diameter and rim elevation are the most important values when developing an accurate model of the system.

Approximately a dozen areas in Zone 6 and two dozen areas in Zone 5 were identified as high priority due to missing all or most of the pipe diameters and invert elevations. Four weeks were dedicated to collecting and verifying data in Zone 5, beginning with the areas classified as high priority. Two weeks were spent in Zone 6, using the same method. Invert elevations were measured as a depth from the rim elevation, and pipe diameters were measured and recorded.

FEMA and CCJDC Data

The Central Coast Joint Data Committee (CCJDC) GIS, which includes creek centerlines, watershed delineations and 1-foot contour topography, was referenced for this study. FEMA reports were referenced for creek water surface levels, which were used to assign an existing water surface elevation to fixed outfalls. Creeks and open channels were generally not modeled for this SDMP except in specific cases where a storm drain system discharges into a creek or open channel, which subsequently enters back into the storm drain system before ultimately discharging. In general, the data available from CCJDC was provided to Schaaf & Wheeler via the County.

Land Use Data and Runoff Characteristics

As mentioned previously, land use GIS data was provided by the County of Santa Cruz, reflecting the County's General Plan. Zones 5 and 6 are primarily residential areas, with interspersed commercial areas and open space, often in the form of creeks and their surrounding riparian corridors. The various land use codes and descriptions found in the GIS database are summarized in Table 4-1. Based on the County of Santa Cruz's General Plan GIS data, the land use in Zones 5 and 6 is roughly 61% residential, 9% commercial, 20% parks and open space and 10% public facilities. Figure 4-1 illustrates the land uses. Street pavement limits are not separated out in the County's GIS. The portions of Zone 5 within the City of Capitola limits draining into the County are roughly 45% residential, 45% commercial, 2% parks and open space, 2% public facilities and 7% "unknown". Portions of the drainage area that are missing land use or defined as "unknown" were assigned land uses based on available aerial photography.

Table 4-1. Land Use GIS Codes

Land Use Code	Description
A	Agriculture
C-1	Neighborhood Commercial
C-2	Community Commercial
C-4	Commercial Services
CA	Commercial Agriculture
CD	Coastal Dependent
CT	Tourist Commercial
M-1	Industrial
M-3	Mineral Extraction Industrial
MHE	Mobile Home Exclusive
NA	Natural Areas
PA	Professional-Administrative Office
PF	Public and Community Facilities
PR	Parks, Recreation and Open Space
R-1	Single-Family Residential
RA	Residential Agricultural
RM	Multi-Family Residential
RR	Rural Residential
SU	Special Use
TP	Timber Production
VA	Visitor Accommodations
W	Water

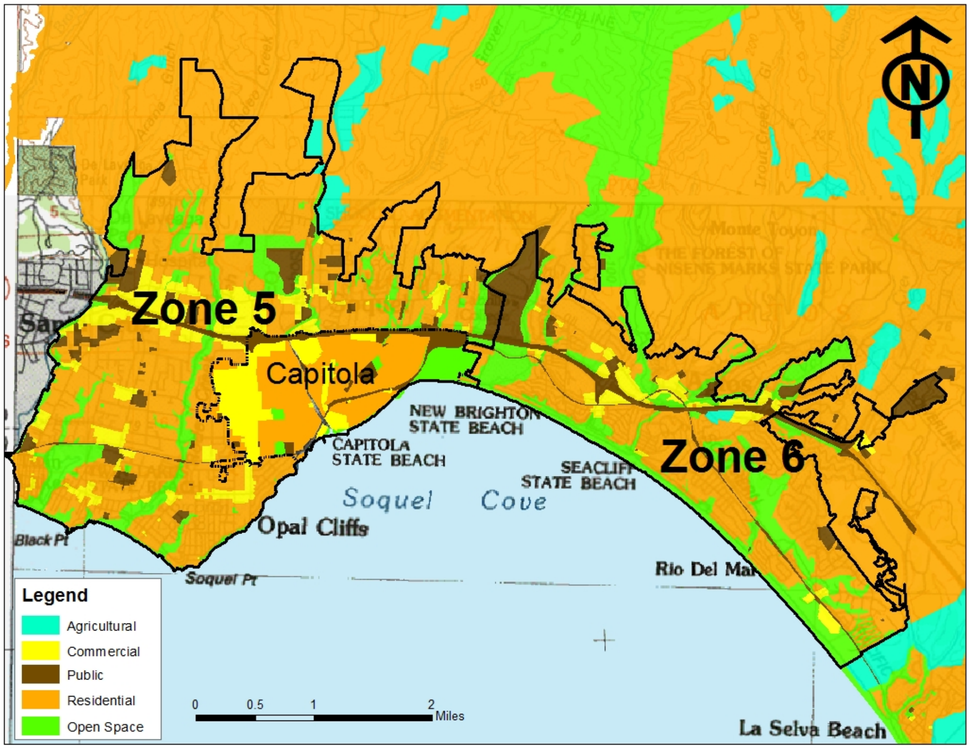


Figure 4-1. Existing Land Use

Soils classification is based on hydraulic soil group (A, B, C or D); this data is produced by the Natural Resources Conservation Service (NRCS), and its use in this analysis is described more fully in Chapter 3, Methodology. Both Zone 5 and Zone 6 in the County of Santa Cruz are composed mainly of soil groups B and D. As described in Chapter 3, Methodology, the Curve Number methodology is used for surface runoff calculations.

Because the study area is mostly built out, there is little potential for large development within the Zone 5 and Zone 6 limits; however there is potential for redevelopment and other land use changes that could affect runoff. GIS data with potential land use changes is not available; therefore, Schaaf & Wheeler has not analyzed the changes in CN from potential land use changes. It is recommended that potential impacts to the storm drain system be accounted for when future land use changes are considered.

DATA QUALITY

The quality and accuracy of the data collected for the Zones 5 and 6 SDMP varies greatly. The County's GIS is generally spatially accurate but attributed data is often missing and/or not sourced. Although some of the data in the GIS attributes may be traced to as-built plans, often those plans do not include all of the necessary information such as vertical datum. As such, even that information which is included in the GIS attribute files is of unknown accuracy.

MODELED DATA ASSUMPTIONS

For this study Schaaf & Wheeler compared the original GIS data with record drawings and improvement plans provided by the County. Data corrections or additions were manually entered into GIS. The next step included extensive field research to collect and verify pipe sizes and material; the condition of manholes, inlets and pipes; system layouts; and to measure invert depths. Wherever possible, field measurements were used to provide missing pipe diameter information. When field measurements were not feasible (due to either pipe location or depth), record drawings provided by the County were referenced. Any remaining unknown pipe diameters were assigned based on the diameter of surrounding pipes. All data corrections, additions, and assumptions are documented in the GIS database.

As described previously, one issue with the existing GIS database was that the elevation data, both for rims and inverts, was on unknown and inconsistent datums. The first step to complete the database for modeling purposes was to assign rim elevations to every node using the previously described 2-foot topographic data. Where the rim elevation provided by the topographic data closely matched the rim elevation in the original database, the invert elevation in the original database (if available) was used. The remaining missing invert elevations are then assigned based on either applying the field measured depth, or a depth calculated as the difference between the rim and invert provided in the original dataset. Finally, any remaining missing invert elevations are interpolated between up and downstream nodes. The method of assigning elevation data is preserved in the "Description" field of the final GIS database utilized by the model.

After all of the information, including new systems not included in the original data from the County, was entered into the GIS database, each pipe and node was given a unique identification number. The first part of the ID indicates what zone the element is within. The second part identifies the type, i.e. pipe, manhole, inlet, etc. The third part is the unique ID number given to each feature. For example, a node with the ID number Z5_MH_2100 is manhole number 2100 in Zone 5. Table 4-4 gives a description of each feature type.

Table 4-4. GIS Feature Descriptions

MH	Manhole
IL	Inlet
CB	Catch Basin
SGMH	Silt & Grease Manhole
SGIL	Silt & Grease Inlet
PIPE	Pipe or culvert
CHANNEL	Open channel

InfoSWMM requires a 'basin width' be input to the model for each catchment area. As discussed in Chapter 3, Methodology, this 'basin width' is assumed to be the basin area divided by the flow length. The Manning's roughness coefficients "N" assigned for basins are 0.15 for pervious surfaces and 0.012 for impervious surfaces. Depression storage is assumed to be 0.15 inch for pervious surfaces and 0.07 inch for impervious surfaces. These values are based on available InfoSWMM documentation. The minimum basin slope is assumed to be 0.2 percent. In some locations pipe networks are connected with roadside ditches. Trapezoidal approximations of ditches, or open channels, are used for this project. It is assumed that these open channels are 5 feet deep, have a 2 foot bottom width, and 2:1 side slopes.

As stated previously, the major creek channels within Santa Cruz were not modeled for this project, except in rare scenarios where a storm drain system discharges to an open channel and re-enters the storm drain network.

Schaaf & Wheeler made inquiries with the County to determine the ownership trends of storm drain facilities throughout Zones 5 and 6. It was determined that the facilities located within the County right-of-way are generally under the jurisdiction of the County, or the District. Most other facilities outside of the right-of-way are typically privately owned, except where past projects have been formally implemented by the County, or the District. Improvements will only be recommended within County controlled right-of-way, and on other sites where County or District responsibility is confirmed.

It is Schaaf & Wheeler's opinion that the data used in this analysis is at an appropriate accuracy for master planning. The uncertainty in the analysis, due to the data gaps and assumptions made, is acceptable at a planning level. As projects move into the design phase, field data specific to those locations should be gathered and added to the model for a more in depth analysis.

STORM DRAIN TIE-INS

There are connections between the drainage network in Zone 5 and the drainage network in the City of Capitola. The drainage network crosses into, or out of, the City of Capitola at eight locations (green stars in Figure 4-5). These limited locations within Capitola City limits were necessarily included in the assessment for reasons of hydrology and hydraulic continuity. Otherwise, systems within the City of Capitola were not evaluated and are not shown.

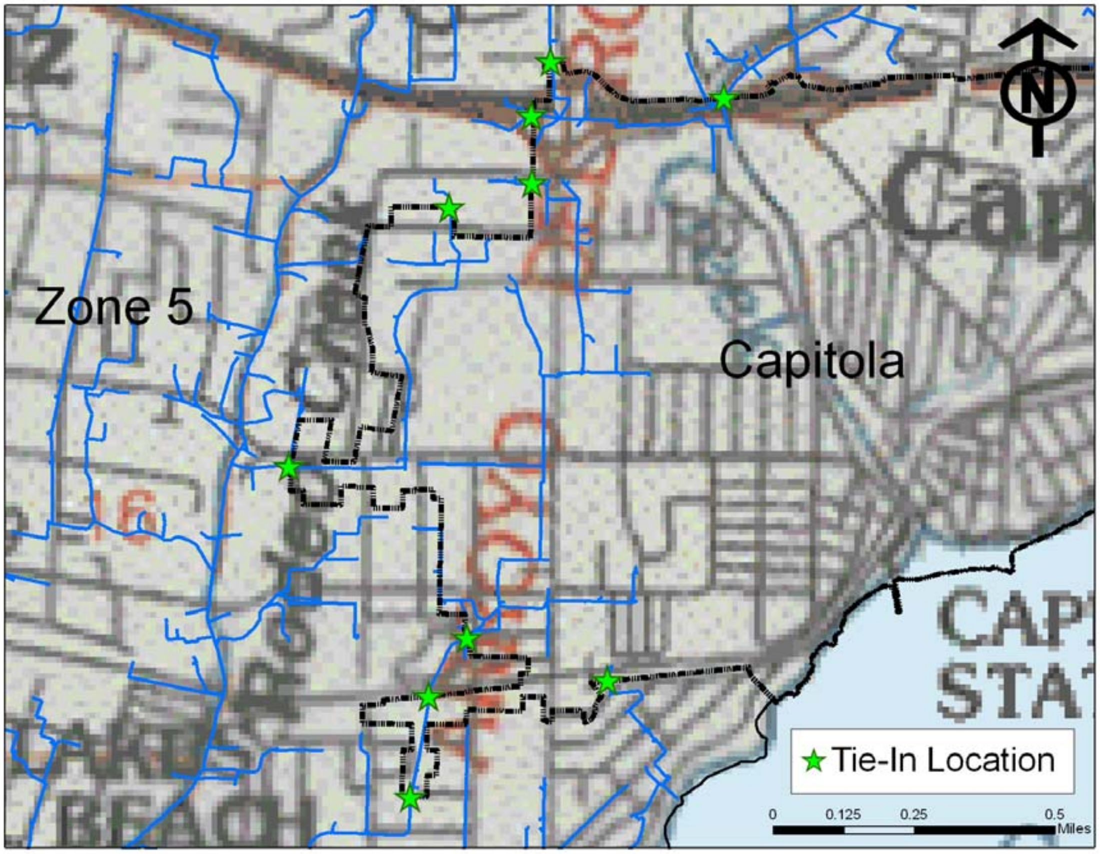


Figure 4-5. System Tie-Ins

CHAPTER 5

STORM DRAIN COLLECTION SYSTEMS

The performance analysis of the storm drain collection system (public and private) located within Zones 5 and 6 forms the essential core of this master plan. This chapter describes major storm drain facilities, historic problem areas, pumping or storage facilities (if applicable), and other known flood hazards for each drainage region. Within each drainage region, areas with recommended system improvements are identified and prioritized. For the purposes of conciseness and readability, this chapter presents only the 10-year InfoSWMM predicted surface ponding depths and those projects recommended to alleviate or minimize surface ponding based on the 10-year standard previously described in Chapter 3, Methodology.

EVALUATION OF STORM DRAIN CAPACITY

Criteria

Each collection system has been analyzed for existing land use based on the County GIS Zoning to determine its runoff condition during the design 10-year storm. As described previously, future land use changes within the County are not expected to significantly worsen surface ponding conditions; most land uses which are slated for development or redevelopment currently have existing impervious surfaces. Areas of significant ponding are recognized herein and recommended improvements to restore system performance in accordance with criteria outlined in Chapter 3 are prescribed.

Additional flow capacity requirements are determined by upsizing existing pipes in the InfoSWMM model until surface ponding is reduced to acceptable levels. It is impossible to entirely remove predicted ponding throughout the zones, either due to local topography (for example, at low 'bathtub' areas) or infeasibility of improvements, but the majority of model-predicted ponding within the County right-of-way can be mitigated to the previously described criteria with the recommended improvements proposed herein. Improvements were not prescribed for portions of deficient drainage system that are located on private lands (outside the County right-of-way), although improvements on private lands might be feasible as well. New alignments were only recommended to alleviate existing drainage issues within the County right-of-way.

Prioritizing Deficiencies and Needed Improvements

The storm drain system in Zones 5 and 6 is broken into three drainage regions as shown in Figure 2-3. Each area contains some combination of pipes, pumps, culverts, outlets, and lagoons. These facilities all eventually discharge into Monterey Bay. The basins are organized around natural topographic boundaries and drainage facility boundaries or watersheds. It should be noted that private drainage systems that connect to public systems have been analyzed; however, private cross culverts (i.e. Caltrans culverts, culverts outside County right-of-way, pipes smaller than 12" diameter, etc.) are not included in this analysis. Recently installed storm drain systems may have been designed to site-specific drainage characteristics. These systems are not analyzed in detail, but are generally categorized to low priority. Future refinement of the model could more precisely account for these site-specific drainage characteristics and more accurately represent the local drainage conditions.

Recommended master plan improvements, derived from model results, are shown in Figures 5-1 through 5-6. In some locations, the HGL predicted by the model at individual nodes may be greater than actual water surface elevation during a storm event. This is due to limitations and assumptions inherent in the modeling software. In order to 'ground truth' predictive model results, Schaaf & Wheeler discussed model results with County staff and compared results to previously completed drainage studies where available. Schaaf & Wheeler also took into account the topography to determine whether the water surface elevation predicted by the model could occur at the inlet locations. For instance, if the inlet in question is located on a sloped street, water will surface flow downhill instead of ponding at that location; however, if a number of inlets in one area are surcharged it is an indication of a network capacity restriction. Locations for recommended system improvements are based on the results of this complete process, not solely on model results. As such, some locations predicted to have surface ponding surcharge based on model results alone are not recommended for improvements. The recommended improvements were prioritized based on the results of the above process, combined with consideration of the anticipated severity of ponding at each location and the benefit/cost relationship of proposed improvements. The following color code is used to highlight project prioritization within each drainage area:

Pipe Color	Improvement Priority
Red	High Priority
Yellow	Moderate Priority
Green	Low Priority

This section outlines the ultimate improvements needed to achieve a 10-year level of service by alleviating or minimizing predicted surface ponding within each of the three drainage regions. Each improvement was grouped with nearby improvements that could be undertaken simultaneously and named using a major street, generally the most downstream, within the group of improvements. This naming convention is used to identify the improvements in maps and tables. A complete list of recommended improvements with figures depicting storm drain network improvement pipes including pipe location, size requirements and costs for each improvement is available in Chapter 6.

SANTA CRUZ ZONE 5 WEST SYSTEMS

Overview

The Zone 5 West modeled drainage area is approximately 2.5 square miles, and is bounded by the Monterey Bay on the south, the City of Santa Cruz to the west, Capitola and Zone 5 East to the east, and by the Santa Cruz Mountains to the north. The trunk lines of the Zone 5 West collection system model consist of 1,397 nodes, 158 outlets and no pump stations. The Zone 5 West area has a total (including lateral lines) of 141,171 linear feet (26.7 miles) of modeled storm drain pipes equal or greater than one foot in diameter. In general, the Zone 5 West area drains southward, with most of the runoff being conveyed to Monterey Bay by Rodeo Gulch, Leona Creek and Arana Gulch.

Identified Areas of Concerns

InfoSWMM analysis of the Zone 5 West systems for the 10-year 24-hour storm event showed surface ponding (theoretical HGL above the rim elevation of the node) occurring at 97 of the 1397 trunk line nodes. Of these, InfoSWMM predicts a ponding depth of less than 0.5 foot at 44 nodes. Depths of between 0.5 and 1.0 feet above the ground occurred at 15 nodes, with the remaining 38 nodes experiencing ponding depths greater than one foot. A map of the 10-year ponding depths predicted by InfoSWMM with no improvements is presented in Figure 5-1.

Improvements

The improvements within Santa Cruz Zone 5 West recommended to alleviate or minimize surface ponding in the public right-of-way during a 10-year storm event are shown in Figure 5-2.

Moderate priority improvements are required to provide a 10-year level of service at four locations. These projects range from upsizing small sections of pipe to large projects requiring significant pipe improvements along with new outfalls. The County may need to re-prioritize these projects based on funding, other utility improvements, redevelopment, and land use changes.

There are six identified low priority projects within Zone 5 West. These projects would eliminate nuisance ponding and may only get built if there are significant changes to land use, roadway, or redevelopment projects in the area.

SANTA CRUZ ZONE 5 EAST SYSTEMS

Overview

The Zone 5 East modeled drainage area is approximately 2.7 square miles, and is bounded by water and Zone 6 on the east, by Zone 5 West along the west, the Santa Cruz Mountains to the north, and the Monterey Bay to the south. The trunk lines of the Zone 5 East collection system consist of 1,182 modeled nodes, 163 outlets and one pump station. The Zone 5 East area has a total (including lateral lines) of 123,785 linear feet (23.4 miles) of modeled storm drain pipes equal or greater than one foot in diameter. In general, the Zone 5 East area drains southward, with most of the runoff being conveyed to Monterey Bay by Soquel Creek, Noble Gulch and Stream 472 (Moran Creek).

Identified Areas of Concern

InfoSWMM analysis of the Zone 5 East systems for the 10-year storm event showed surface ponding (theoretical HGL above the rim elevation of the node) occurring at 160 of the 1,182 trunk line nodes. Of these, InfoSWMM predicts a ponding depth of less than 0.5 foot at 64 nodes. Depths of between 0.5 and 1.0 feet above the street occurred at 39 nodes, with the remaining 57 nodes experiencing ponding depths greater than one foot. A map of the 10-year ponding depths predicted by InfoSWMM with no improvements is presented in Figure 5-3.

Improvements

The improvements within Santa Cruz Zone 5 East recommended to alleviate or minimize surface ponding in the public right-of-way during a 10-year storm event are shown in Figure 5-4.

The Soquel Village project is a high priority project that would alleviate the conveyance issues at Soquel Drive and Porter Street by constructing a new pipe along Porter Street to an existing outfall to Soquel Creek near Soquel Wharf Road. Adding backup power at the pump station at the 38th Avenue detention basin is also recommended as a high priority improvement. This improvement includes the installation of an engine generator, an automatic transfer switch, and electrical panel modifications.

Moderate priority improvements are recommended to provide a 10-year level of service at three locations. These projects range from upsizing small sections of pipe to large projects requiring significant pipe improvements along with new outfalls. The County may need to re-prioritize these projects based on funding, other utility improvements, redevelopment, and land use changes.

There are five identified low priority projects within Zone 5 East. These projects would most likely eliminate nuisance surface ponding and may only get built if there are significant changes to land use, redevelopment, or roadway projects in the area.

SANTA CRUZ ZONE 6 SYSTEMS

Overview

The Zone 6 modeled drainage area is approximately 5.6 square miles, and is bounded by Watsonville on the east, by Zone 5 East to the west, the Santa Cruz Mountains to the north and the Monterey Bay to the south. The trunk lines of the Zone 6 collection system consist of 1,102 modeled nodes, 162 modeled outlets and no pump stations. The Zone 6 area has a total (including lateral lines) of 123,785 linear feet (23.4 miles) of modeled storm drain pipes equal or greater than one foot in diameter. In general, the Zone 6 area drains southward to Monterey Bay. The two major conveyance systems are Aptos and Borregas Creeks.

Identified Areas of Concern

InfoSWMM analysis of the Zone 6 systems for the 10-year storm event showed surface ponding (theoretical HGL above the rim elevation of the node) occurring at 37 of the 1102 trunk line nodes. Of these, InfoSWMM predicts a ponding depth of less than 0.5 foot at 13 nodes. Depths of between 0.5 and 1.0 feet above the street occurred at 1 node, with the remaining 21 nodes experiencing ponding depths greater than one foot. A map of the 10-year ponding depths predicted by InfoSWMM with no improvements is presented in Figure 5-5.

Improvements

The improvements within Santa Cruz County Flood Control and Water Conservation District-Zone 6 recommended to alleviate or minimize surface ponding in the public right-of-way during a ten-year storm event are shown in Figure 5-6.

The Rio Del Mar project is a high priority project that would alleviate known surface ponding issues stemming from surrounding localized runoff into this low lying area that includes Esplanade, Rio Del Mar Boulevard and Aptos Beach Drive. Pipe improvements along these streets will not increase capacity when the outfall to Aptos Creek is closed. The mouth of Aptos Creek is often closed off to the ocean. This causes elevated water levels in the creek that restrict discharges from the storm drain system. A new pump station and separate outfall to the ocean would be required to provide protection to this low lying area. A possible location for this pump station is at the corner of Rio Del Mar Boulevard and Aptos Beach Drive. Extensive planning, design and permitting will be required for this new facility.

Moderate priority improvements are required to provide a 10-year level of service at one location. This project requires upsizing small sections of pipe. The County may need to re-prioritize this project based on funding, other utility improvements, redevelopment, and land use changes.

CONDITION ASSESSMENT

A condition assessment of several key hydraulic structures within Zones 5 and 6 was performed by V&A Engineering. Each location was rated based on corrosion, condition and access. Due to budget limitations, only a fraction of the system was analyzed; however, this initial study provides a good indication of the condition of the overall system. Pipes requiring repair or replacement in the near future are included in the list of recommended master plan improvements in Chapter 6. The cost of annual inspection of additional structures is included in this list.

The overall condition of the observed structures is good with some exceptions. Figure 5-7 and Figure 5-8 show the storm water facility rating assigned to each assessed structure. Access was an issue at several locations due to vegetation, stuck manholes and private property. It is recommended that structures assigned an “Excellent” rating be reassessed within 15 years, structures assigned a “Good” rating be reassessed within 10 years, structures assigned a “Fair” rating be reassessed within 5 years with repairs considered at that point in time. Structures assigned a “Poor” rating should be prioritized for rehabilitation within the next 5 years and should be considered high priority projects. These reassessment and prioritization timeframes are subject to funding being made available. The complete V&A report is included in Appendix D.

Recommendations

The Pinewood project is a high priority project located within Zone 5 to prevent pipe collapse by replacing a two damaged pipes. V&A recommends performing this repair within the next 5 years. The Valencia project, located within Zone 6, is a high priority project to replace a culvert in poor condition. V&A recommends completing a more thorough assessment of storm drainage facilities located within Zones 5 and 6. This is a high priority recommendation.

The Brommer/30th project, located within Zone 5, is a moderate priority project to replace a manhole in poor condition. The Dolphin project, located within Zone 6, is a moderate priority project to replace a culvert in fair condition.

CULVERT ANALYSIS

Schaaf & Wheeler analyzed a total of 28 culverts, 13 within Zone 5 and 15 within Zone 6. Culverts were analyzed using the InfoSWMM model results and the use of the HY-8 software to determine whether they have 10-year and 100-year capacity. The results are presented in Figure 5-9 and Figure 5-10. The complete culvert capacity analysis can be found in Appendix K.

Based on this analysis, 1 project in Zone 5 is included in the list of Recommended Master Plan Improvements. This is a high priority due to existing culverts not having sufficient 10-year capacity. There are no recommended culvert improvements in Zone 6.

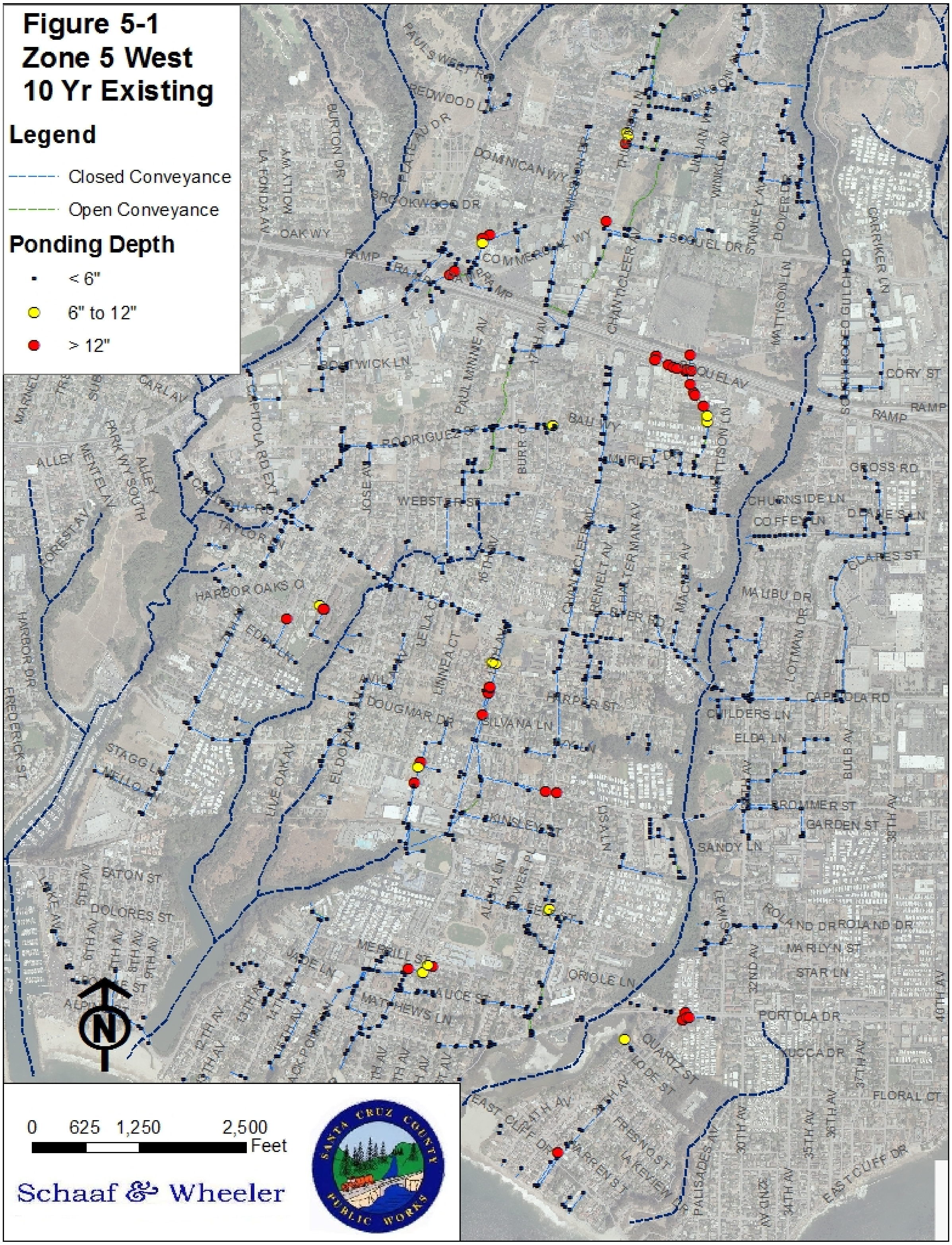


Figure 5-1: Zone 5 West 10-Year Ponding Depths Predicted by InfoSWMM

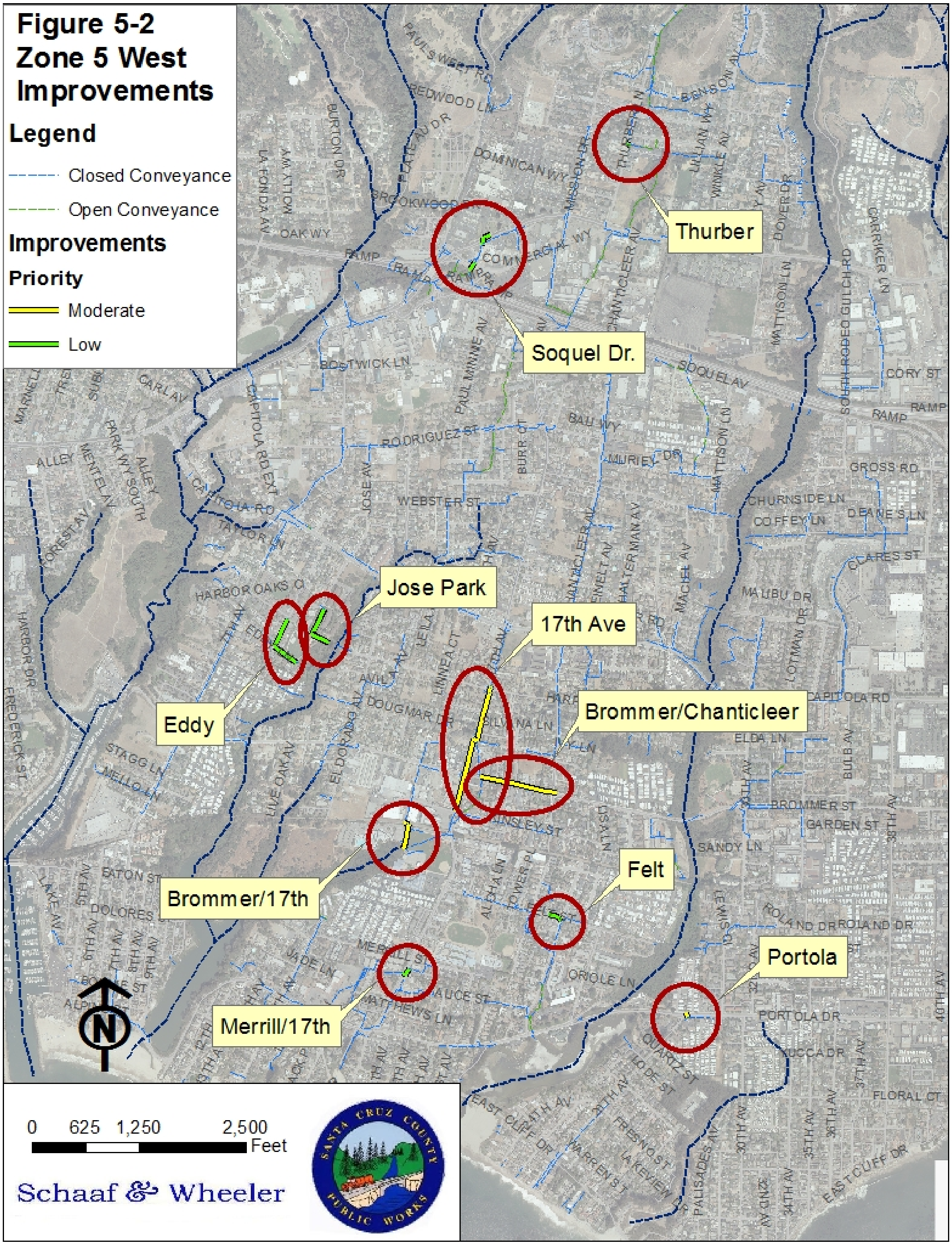


Figure 5-2: Zone 5 West Storm Drainage Piping Capacity Improvements

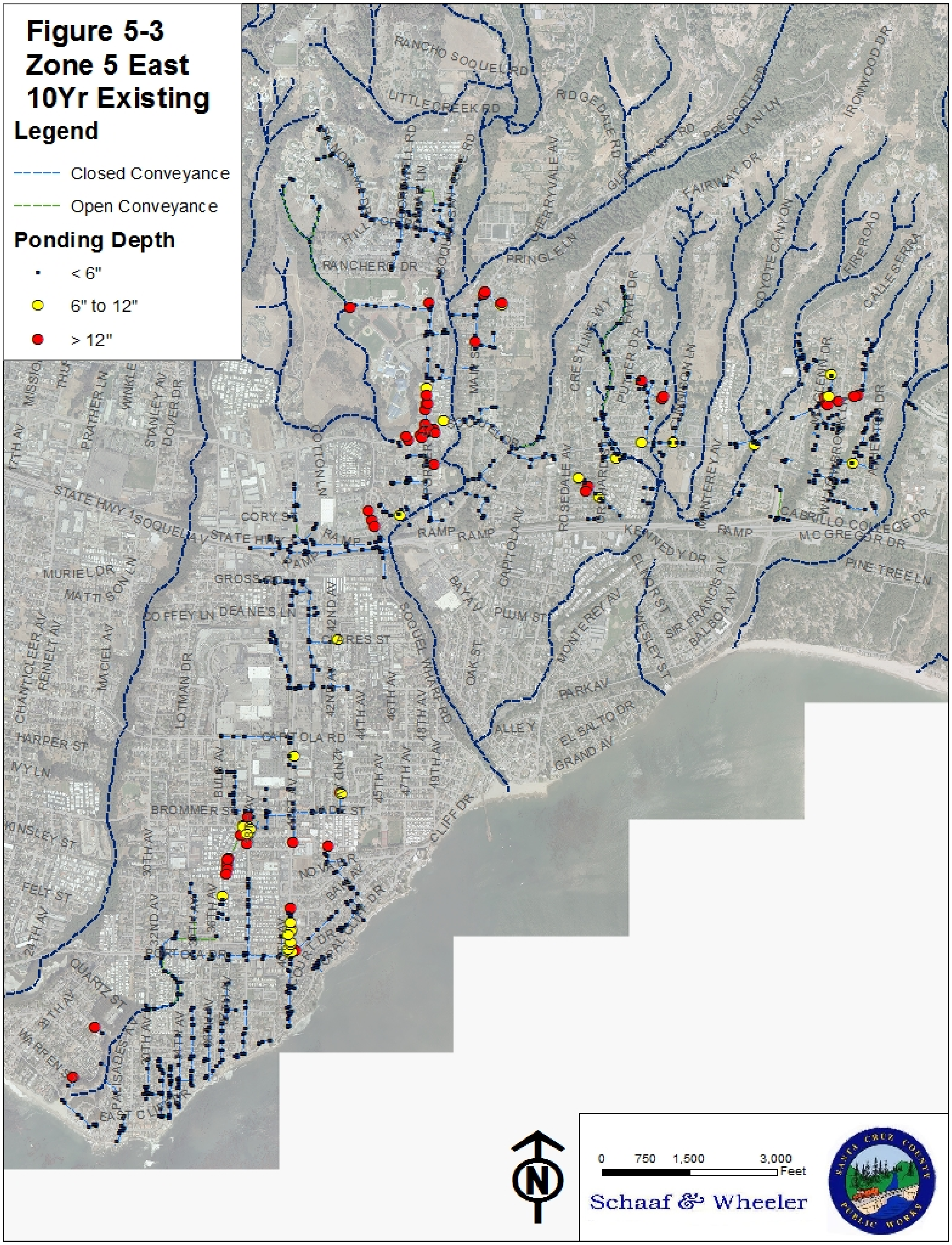


Figure 5-3: Zone 5 East 10-Year Ponding Depths Predicted by InfoSWMM with No Improvements

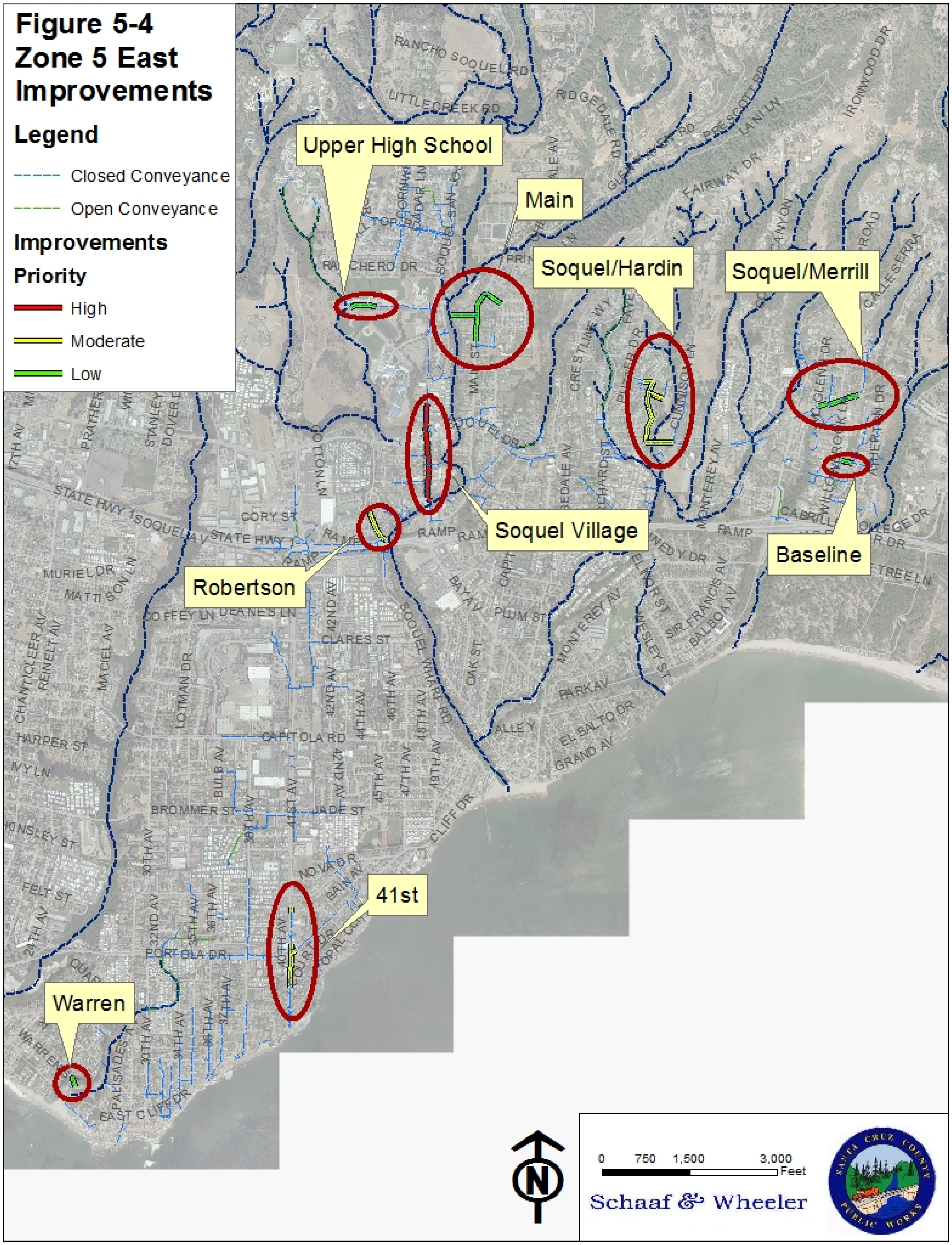


Figure 5-4: Zone 5 East Storm Drainage Piping Capacity Improvements

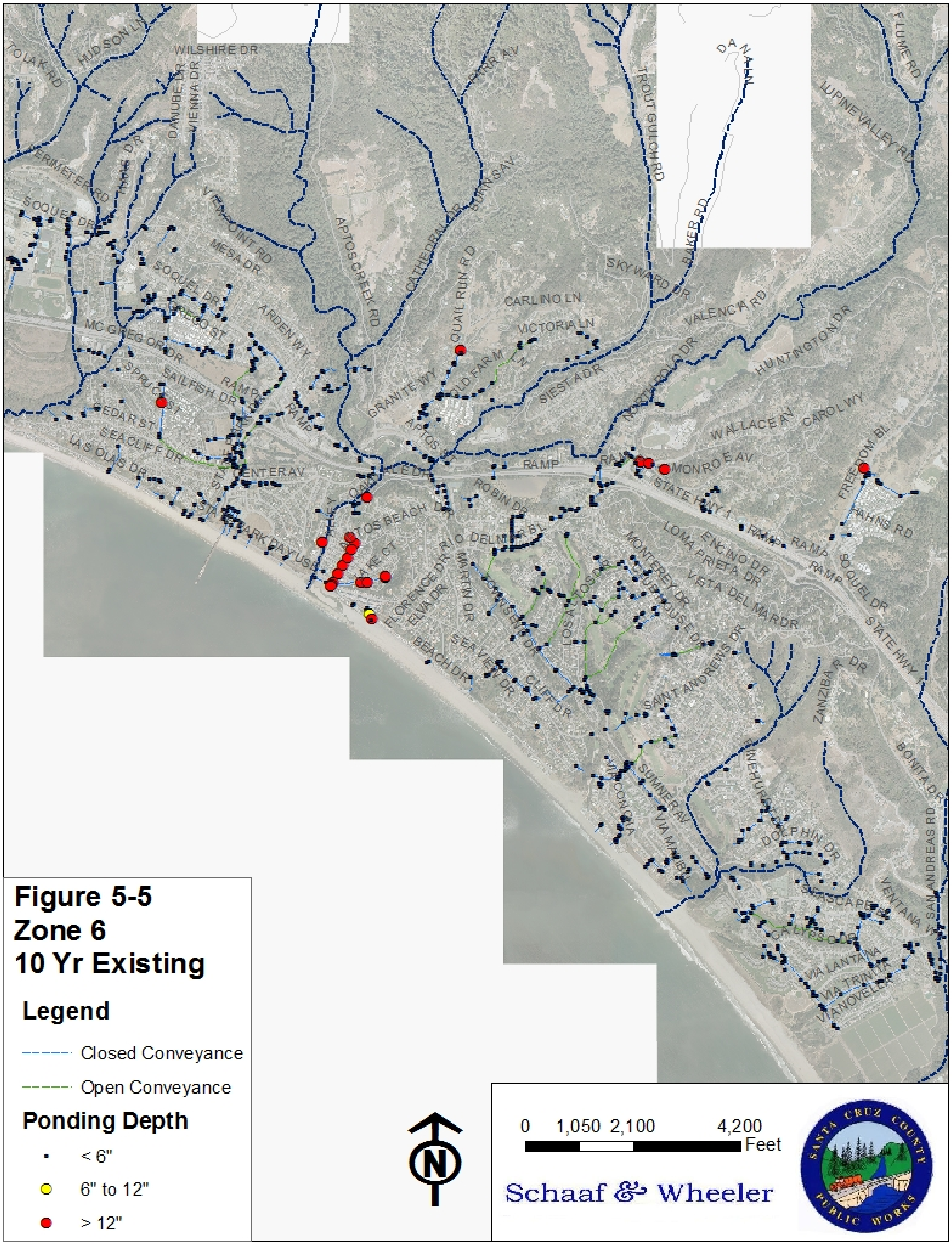


Figure 5-5: Zone 6 10-Year Ponding Depths Predicted by InfoSWMM with No Improvements

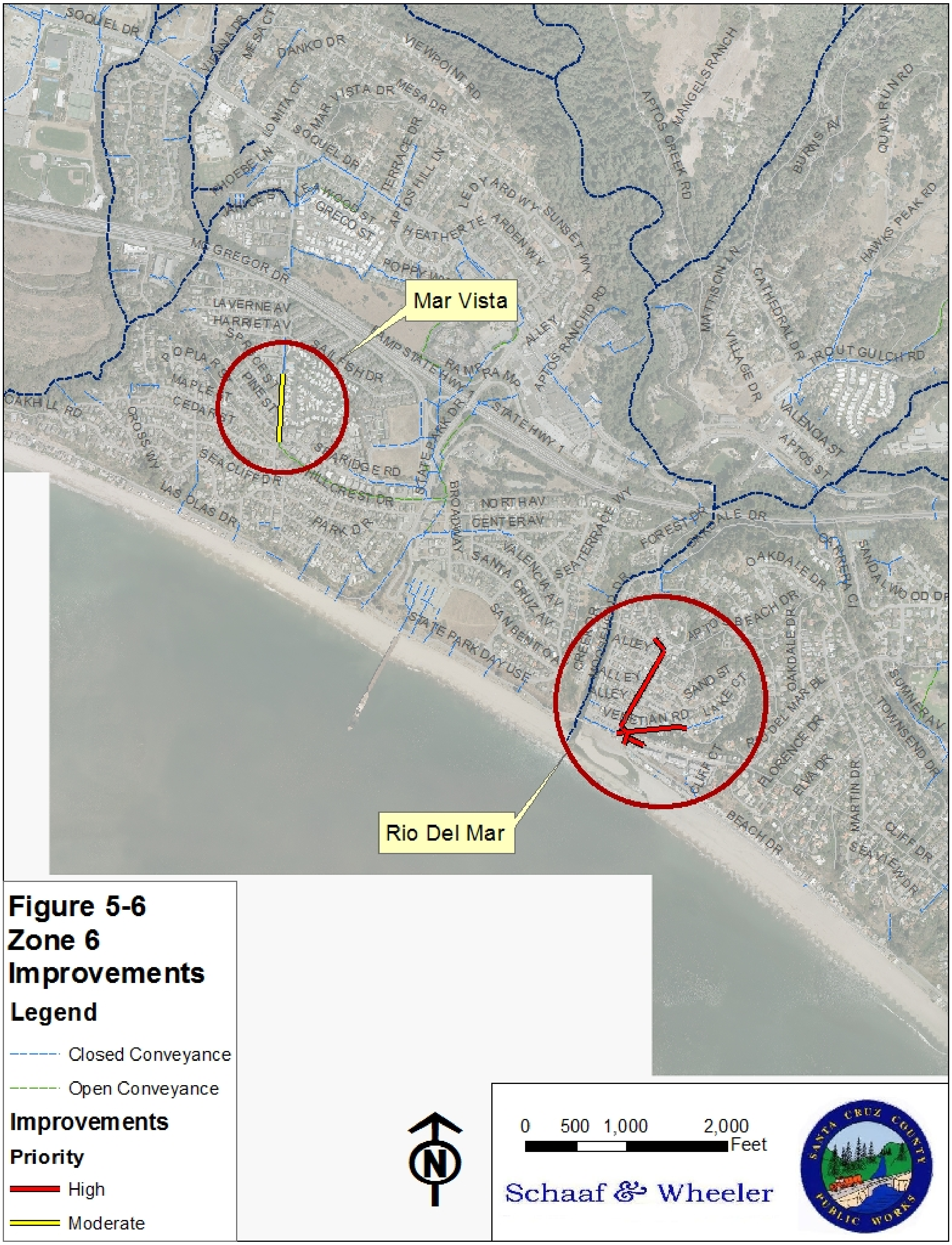


Figure 5-6: Zone 6 Storm Drainage Piping Capacity Improvements

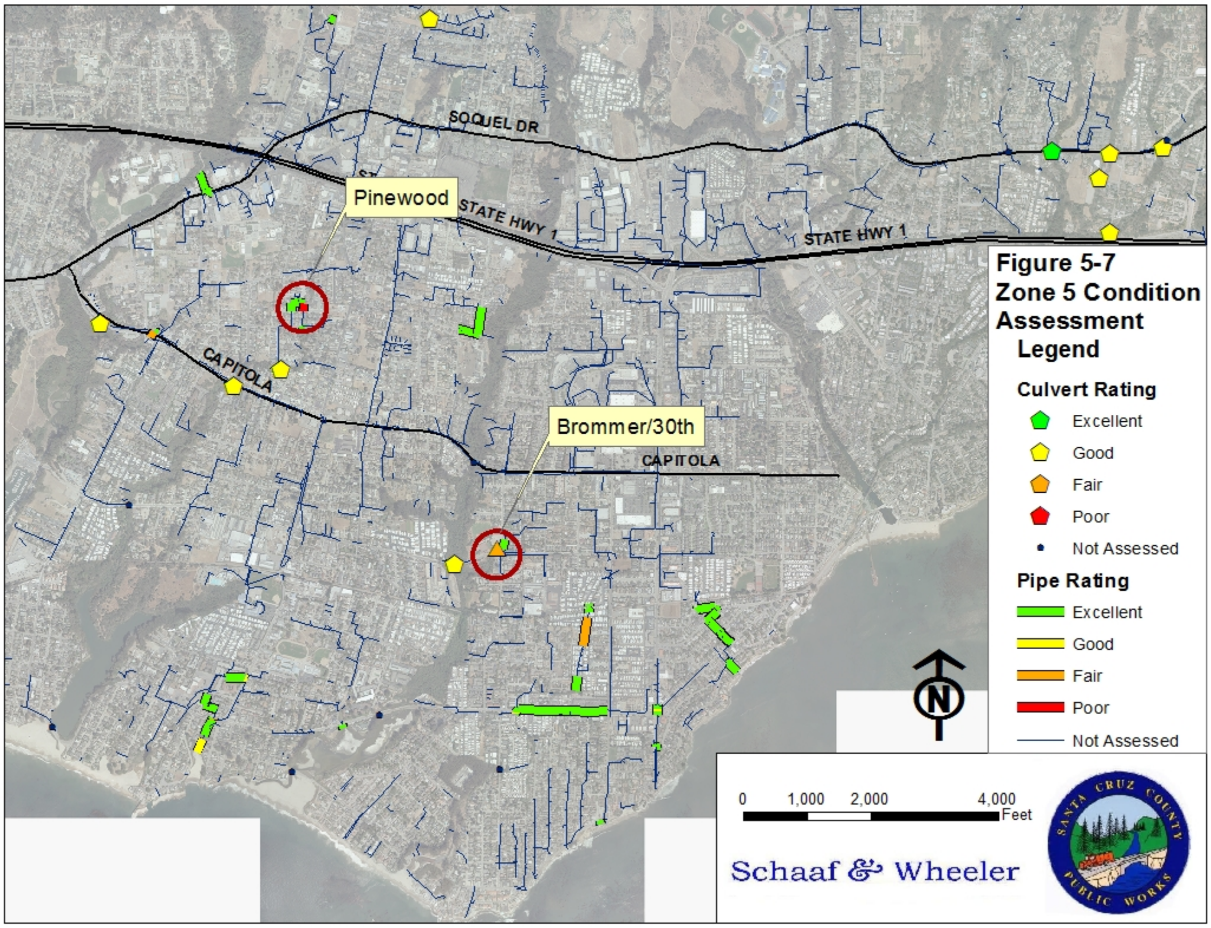


Figure 5-7: Zone 5 Condition Assessment

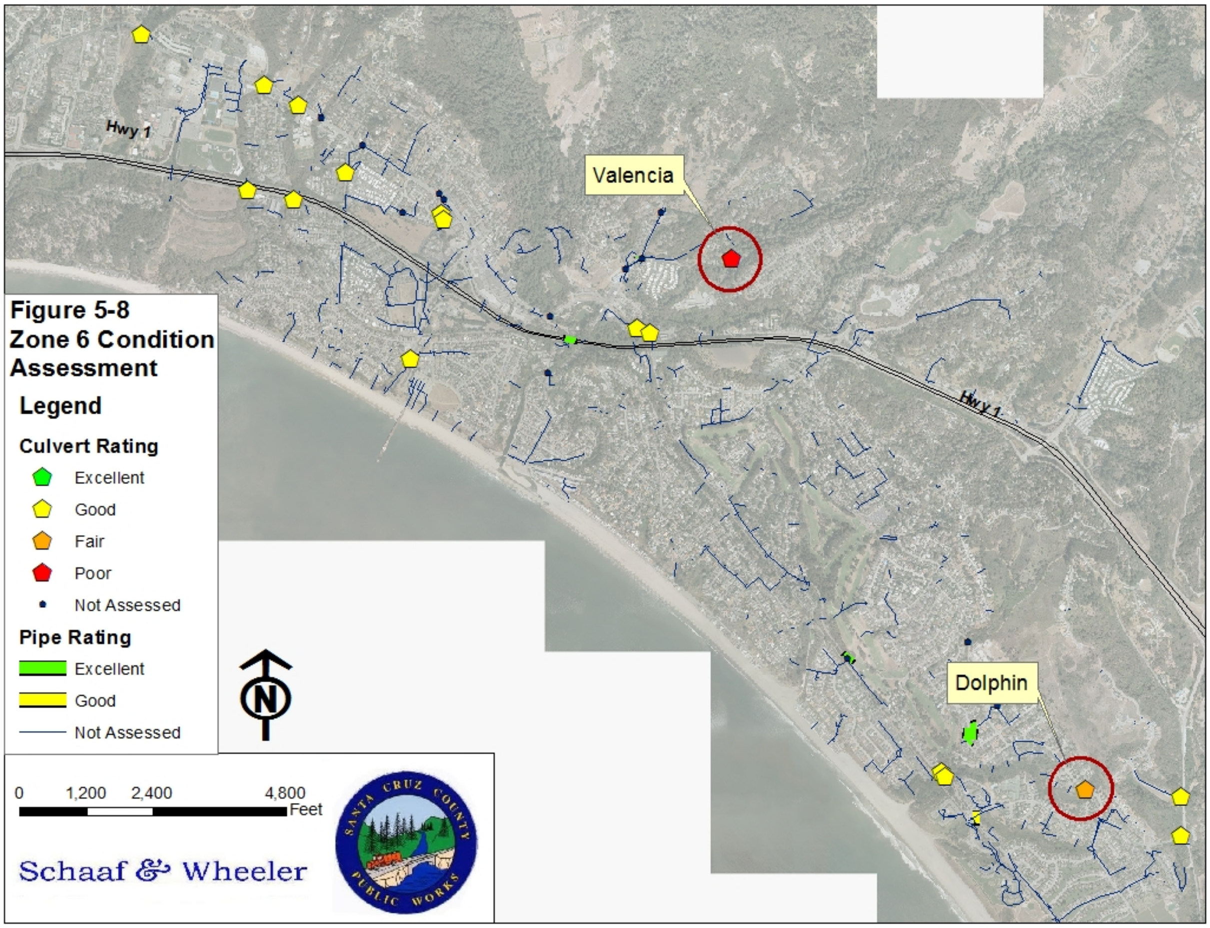


Figure 5-8: Zone 6 Condition Assessment

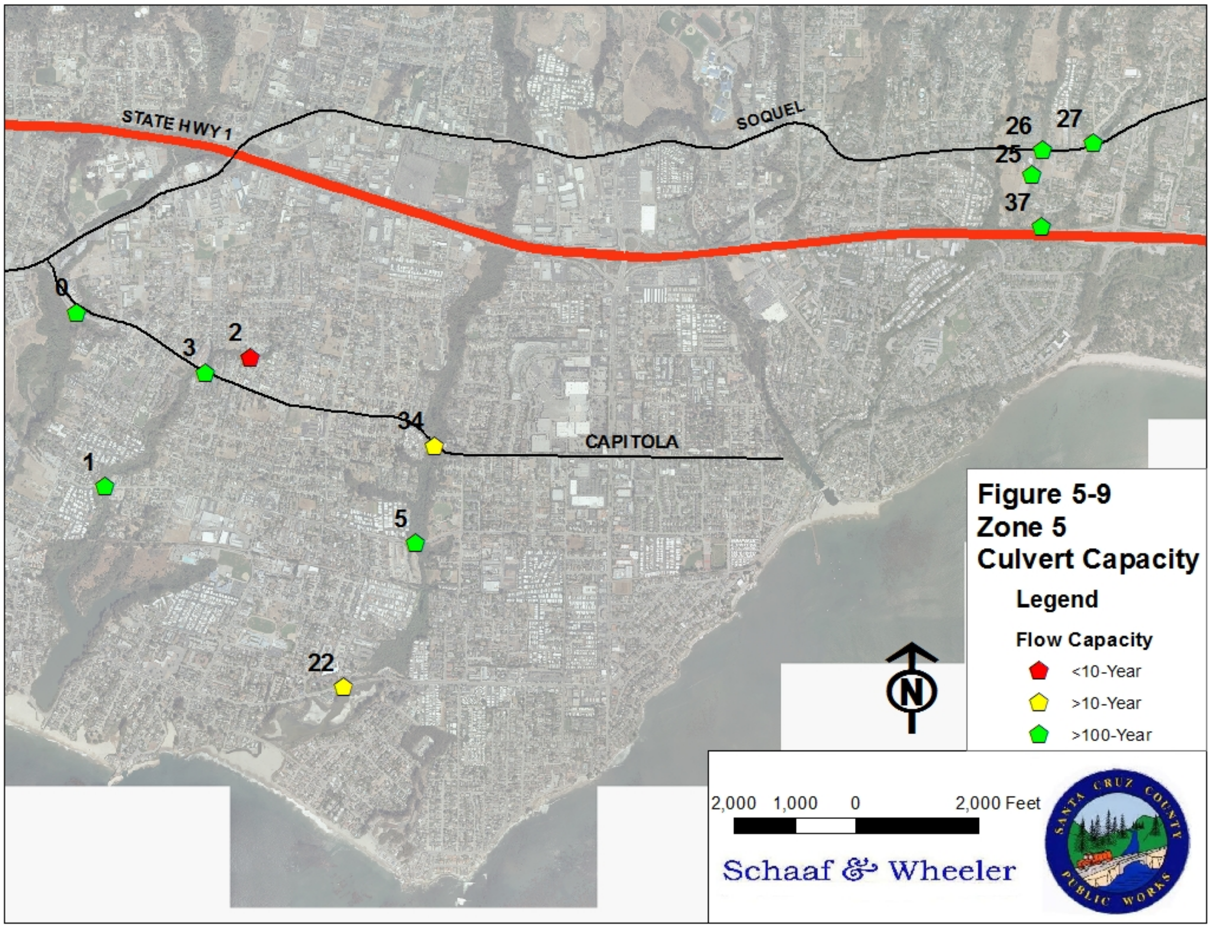


Figure 5-9: Zone 5 Culvert Capacity

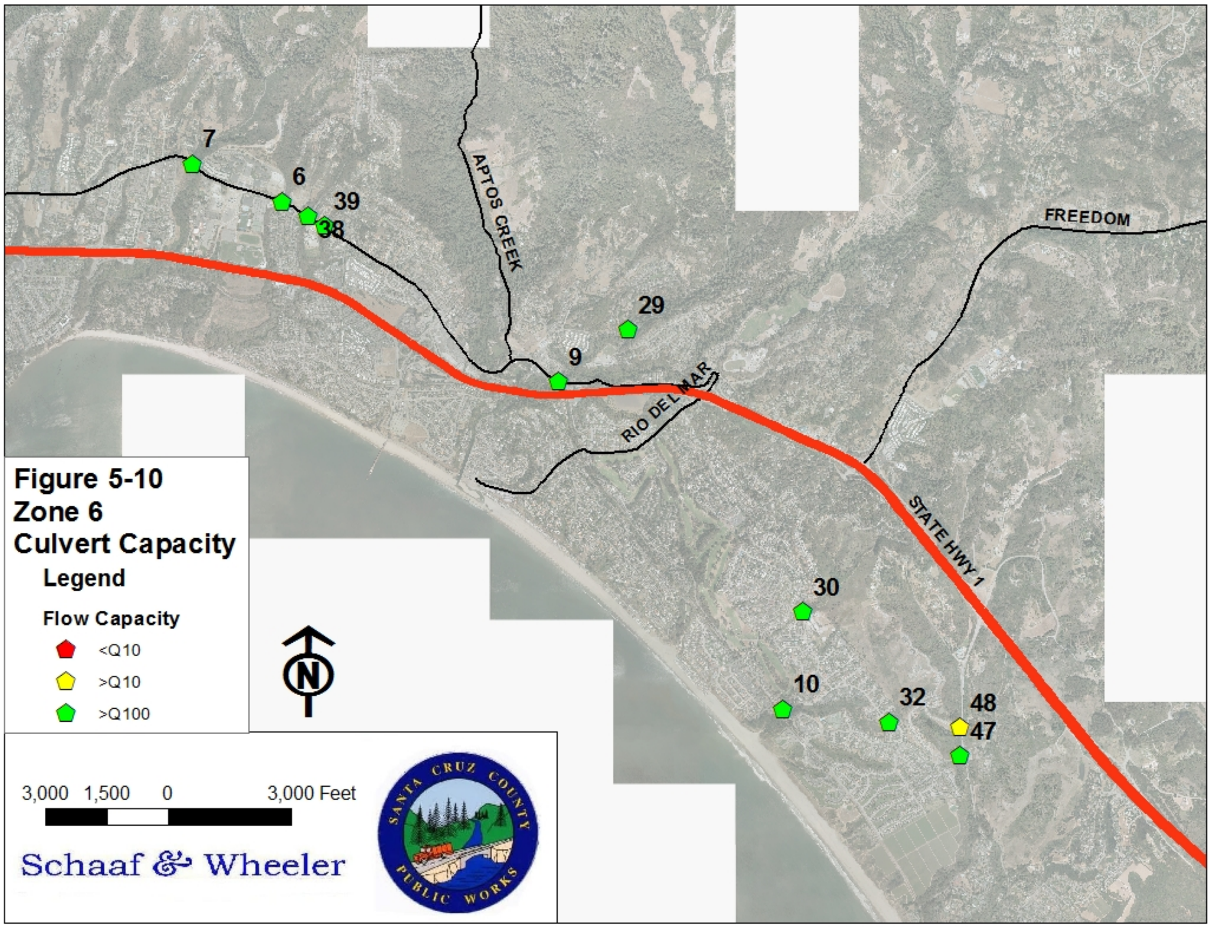


Figure 5-10: Zone 6 Culvert Capacity

CHAPTER 6
RECOMMENDED MASTER PLAN IMPROVEMENTS

Chapter 5, Collection Systems, discusses the storm drain collection systems in Zones 5 and 6 and recommends improvements. This chapter provides prioritized recommended master plan improvements. The recommended improvements cost estimates provide an overall guideline for the County to use in preparing annual budgets. Exigent circumstances and future in-field experiences may necessitate deviations from these recommended master plan improvements.

The recommended improvements do not include the cost of new facilities related to new development (e.g., pipeline extensions to serve areas that are currently undeveloped and not served by an existing County pipeline). It does not include replacement of facilities on private land (not in County right-of-way). These new facilities would be constructed as part of the new developments or private land improvements.

IMPROVEMENT PRIORITIES

The proposed recommended storm drain facility improvements for Zones 5 and 6 in Santa Cruz County is broken into three priority levels for funding and implementation. The total capacity improvement project costs required for each priority level are shown in Table 6-1. Each drainage region includes the recommended projects, including pipe, pump station, condition related improvements, and culvert improvements. Also included in the table are recommended pump station upgrades such as the addition of on-site backup power. The costs for additional condition assessment are not included in this table.

Table 6-1 Summary of 10-Year Storm Protection Improvement Costs

Public Right of Way					
	Length	High Priority	Moderate Priority	Low Priority	Total
Zone 5	15,700	$2,230,000	$3,840,000	$3,470,000	$9,540,000
Zone 6	2,800	$4,670,000	$380,000	-	$5,050,000
Total	**18,500**	**$6,900,000**	**$4,220,000**	**$3,470,000**	**$14,590,000**

The costs presented in Table 6-1 include an adjustment in estimated construction cost to cover design, administration, and contingency costs. The cost increase is discussed in the pertinent sections of this chapter.

ALTERNATIVE IMPROVEMENT PROJECTS

Two essential types of projects are traditionally utilized to increase storm drain system capacity: install a new relief storm drain parallel to the system lacking capacity; or replace the overloaded pipe with larger diameter pipe in the same alignment. The two alternatives can be made equivalent to one another using the following formula, assuming that pipe material and length are equal:

$D_R = (D_e^{2.63} + D_p^{2.63})^{0.38}$

where D_R = diameter of replacement pipe;

D_e = diameter of overloaded pipe; and

D_p = diameter of parallel relief drain.

Assuming the existing pipe is adequate in terms of condition, the installation of a new parallel pipe is typically more cost effective than pipe replacement since the required pipe size is smaller and the existing pipe does not need to be removed. This does not take into account the long term maintenance associated with a parallel system. The selection of a capacity improvement strategy will vary from project to project; and be governed by field constraints such as conflicting utilities, rights-of-way, environmental concerns, permit requirements and traffic control.

Traditional cut and cover methods of construction will be employed for most storm drain construction. However, the utilization of trenchless methods such as bore and jack, directional drilling, cured-in-place pipe (CIPP), slip-lining, and others, may increasingly find application in special circumstances where existing development encroaches upon the pipe alignment, or disruption of other services and land uses is too costly.

CHANNEL DAY-LIGHTING ALTERNATIVE PROJECTS

An alternative to the replacement of existing undersized pipe systems is day-lighting. This would involve replacing buried pipe networks with vegetated earthen channels, with cross culverts or bridges at roadway crossings, particularly where natural drainage channels and streams have been previously piped. This alternative may reduce liability exposure by discouraging unwise development encroachment, improve access and safety, enhance water quality, reduce sediment, and increase aesthetics compared to traditional pipe replacement projects. Open channel alternatives may not always be a viable alternative for every improvement project due to right-of-way issues, hydraulics, safety, or economic limitations. Appendix F further illustrates the components and benefits of day-lighting. Applying day-lighting principals to system extensions is another approach the County may consider. Adding grassy swales to streets without storm systems can reduce drainage issues and provide water quality benefits. The County should conduct public outreach on the merits of these alternatives and assist land owners to determine the impacts if these projects occur on private lands. Many of the existing drainage easements are not documented in detail and could pose limitations to day-lighting.

COST OF IMPROVEMENTS

Costs have been estimated using information from other drainage projects in the area, cost estimating guides (*2012 Current Construction Costs,* Saylor Publications, Inc.), and engineering judgment. The cost per linear foot of improvement used for the cost estimates are given in Table 6-2 (note that these costs do not include the 40% increase for design, administration, and contingency included in all other tables). Connection (i.e. manhole) replacement cost estimates ranged from

$11,000 to $34,000 depending on diameters. All estimates are based on the Engineering News Record (ENR) May 2013 index of 9515. Costs include open trenching in roadway, up to ten feet in depth. Costs do not include permitting or any environmental documentation. Most of these projects are expected to qualify for negative declarations from permitting agencies for California Environmental Quality Act (CEQA) purposes.

Table 6-2: Storm Drain Cost Per Linear Foot

Diameter (inches)	Dollar per Linear foot of Pipe	Dollar per Connection
15	$132	$11,850
18	$150	$11,930
24	$194	$13,123
27	$258	$14,435
30	$323	$15,879
36	$354	$17,467
42	$384	$19,213
45	$464	$21,135
48	$545	$23,248
54	$814	$25,573
60	$936	$28,130
66	$1,080	$30,943
72	$1,268	$34,038

In addition to increased pipe capacity, some increased pump station capacity recommendations were also made. The pump station capacity improvement costs are for construction of new pump stations and are estimated to be $25,000 per station cfs (not including contingencies and permitting). New outfall costs were estimated to be $25,000 per new outfall (not including contingencies and permitting). It should be noted that wide variations in actual outfall costs are expected.

RECOMMENDED IMPROVEMENT PROGRAM

A proposed Master Plan Improvement Program which summarizes the recommended pipe improvement cost allowances by project name and drainage region is presented in Tables 6-3 thru 6-5. All cost estimates include an additional 40% for design, administration, and contingency costs. Maps of the improved pipe diameters are shown in Figures 6-1 through 6-5. In summary:

Table 6-3: Santa Cruz, Zone 5 West 10-Year Storm Capacity Recommended Piping Improvements (listed in order of priority)

Project	Pipe Length	Connections	Outfalls	Construction Cost	Total Cost
17th	1,540	9		$600,000	$840,000
Brommer/ 17th	1,056	9	1	$400,000	$560,000
Brommer/ Chanticleer	912	4		$180,000	$250,000
Portola	768	8	1	$270,000	$380,000
Jose Park	613	5	1	$210,000	$290,000
Merrill/17th	396	5		$120,000	$170,000
Soquel Drive	1,073	10		$630,000	$880,000
Thurber	37	2		$30,000	$40,000
Felt	236	4		$80,000	$110,000
Eddy	678	3	1	$160,000	$220,000
TOTAL	**7,311**	**59**	**4**	**$2,680,000**	**$3,740,000**

Table 6-4: Santa Cruz, Zone 5 East 10-Year Storm Capacity Recommended Piping Improvements (listed in order of priority)

Project	Pipe Length	Connections	Outfalls	Construction Cost	Total Cost
Soquel Village	1,709	8		$1,230,000	$1,720,000
Robertson	600	5	1	$200,000	$280,000
41st	921	11		$340,000	$480,000
Soquel/Hardin	2,009	14	1	$590,000	$830,000
Soquel/Merrill	695	6		$240,000	$340,000
Main	1,659	13	1	$730,000	$1,020,000
Upper High School	448	3		$160,000	$220,000
Baseline	196	2		$50,000	$70,000
Warren	194	2	1	$80,000	$110,000
TOTAL	**8,433**	**64**	**4**	**$3,620,000**	**$5,070,000**

Table 6-5: Santa Cruz, Zone 6 10-Year Storm Capacity Recommended Piping Improvements (listed in order of priority)

Project	Pipe Length	Connections	Outfalls	Construction Cost	Total Cost
Rio Del Mar	2,131	15	1	$700,000	$980,000
Mar Vista	685	3		$170,000	$240,000
TOTAL	**2,816**	**18**	**1**	**$870,000**	**$1,220,000**

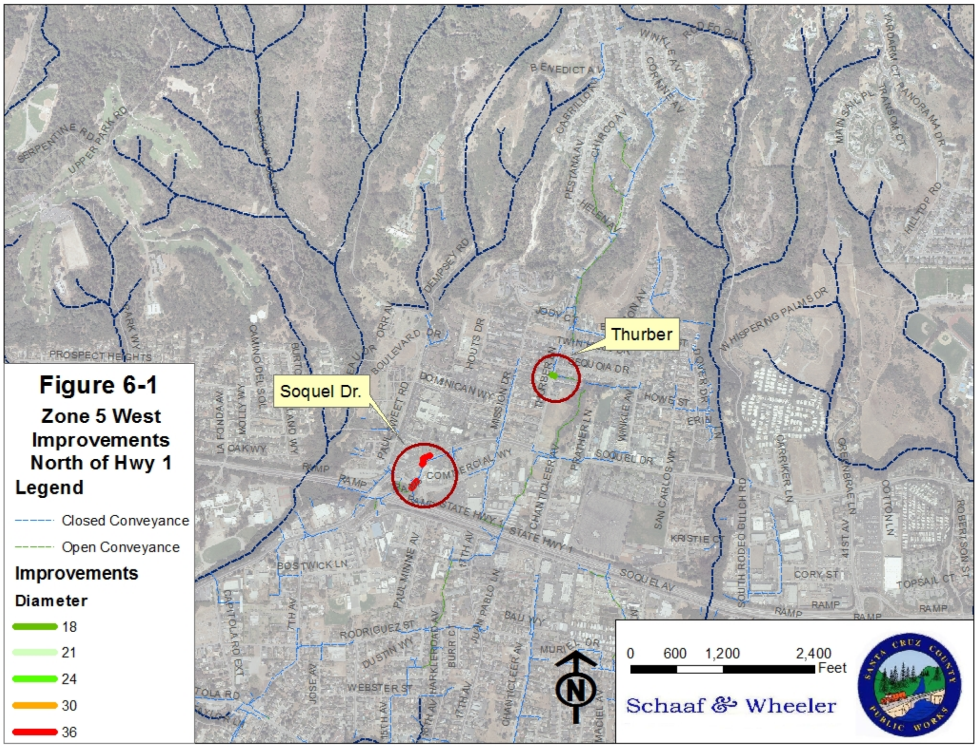


Figure 6-1 Zone 5 West Improvements North of Hwy 1

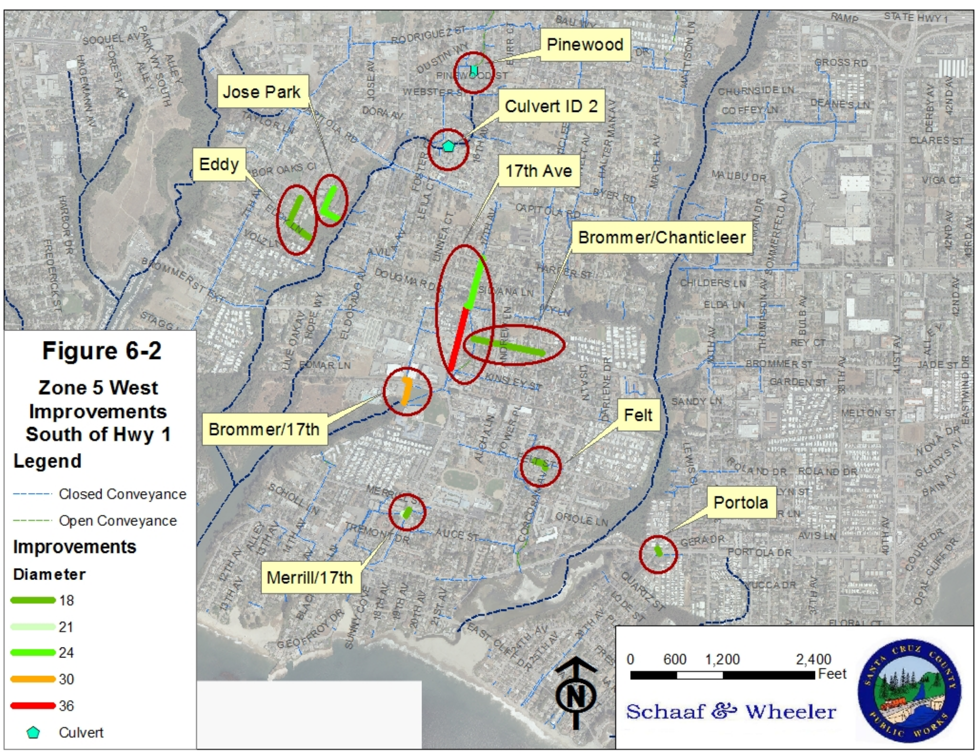


Figure 6-2 Zone 5 West Improvements South of Hwy 1

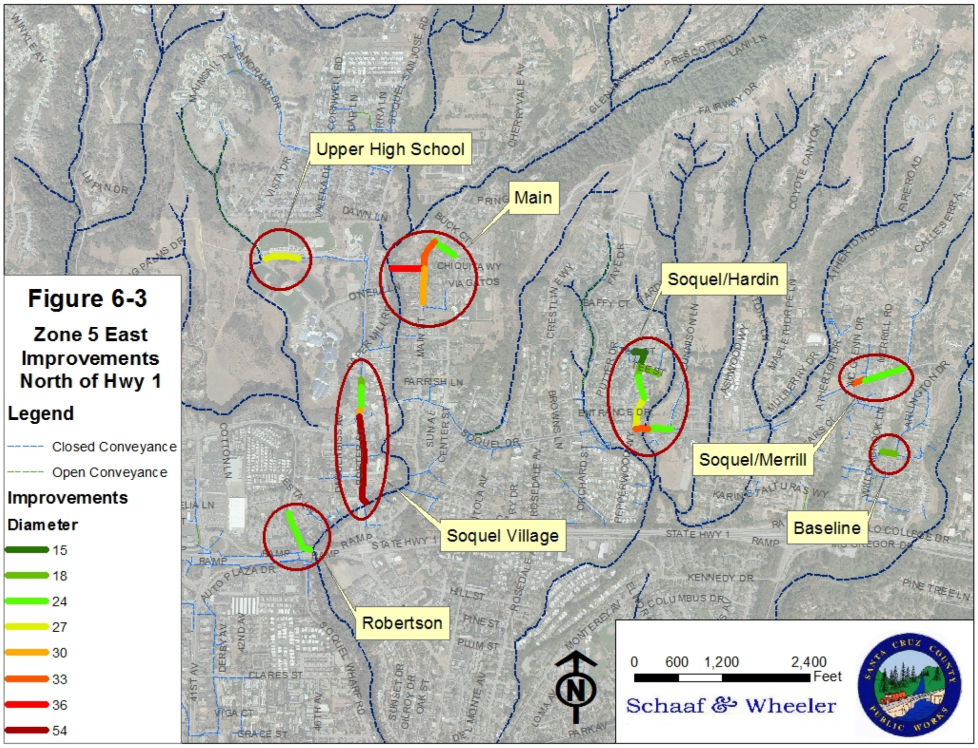


Figure 6-3 Zone 5 East Improvements North of Hwy 1

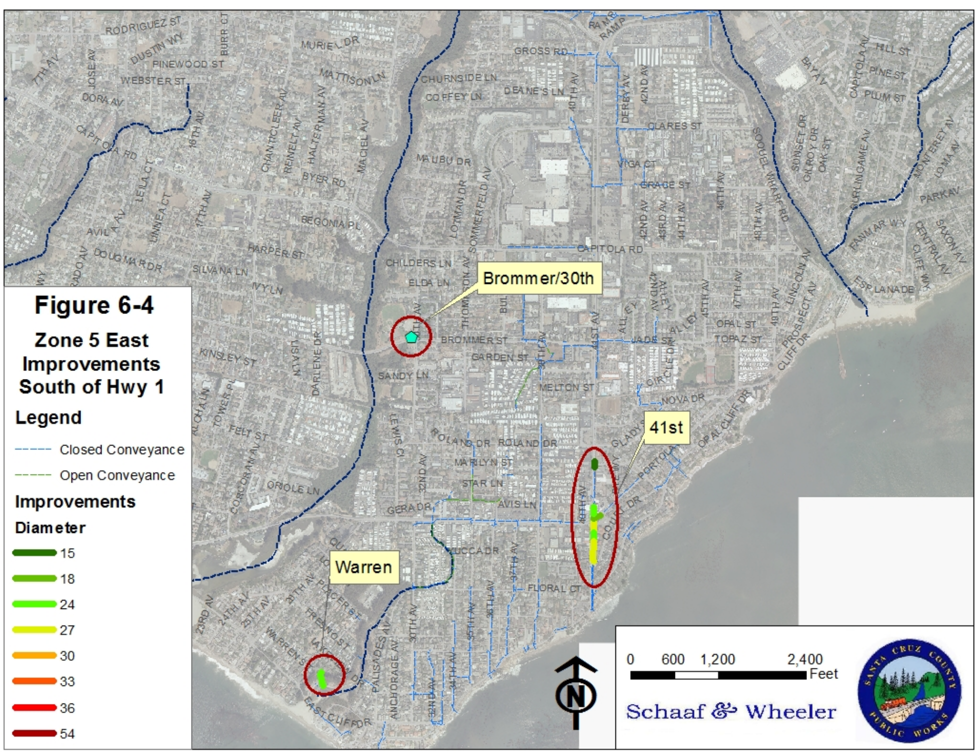


Figure 6-4 Zone 5 East Improvements South of Hwy 1

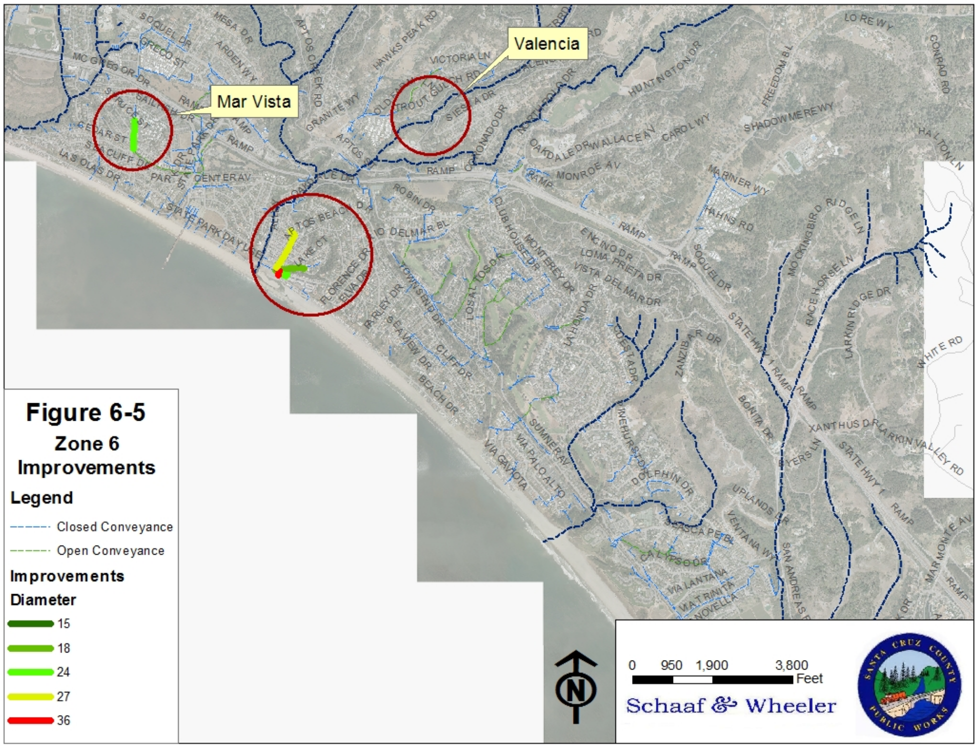


Figure 6-5 Zone 6 Improvements

The pipe improvements recommended in the above tables and figures are all capacity related improvements – projects that will decrease surface ponding on the streets of Zone 5 and 6. In addition to these pipe capacity improvements, there are recommended pump station improvements to increase capacity, reliability, and redundancy. These projects include installation of on-site backup power at the 38th Avenue detention basin pump station and installation of the Rio Del Mar pump station.

Based on past projects and engineering judgment, the estimated cost for adding backup power at the 38th Avenue detention basin pump station is $200,000. This cost includes the evaluation and installation of an engine generator, an automatic transfer switch, and electrical panel modifications to accommodate the backup power. Although capacity upgrades are not recommended at this time, the existing pump station is in poor condition and replacement of the facility should be considered.

The Rio Del Mar pump station is a critical and high priority improvement. The County has identified preliminary pumps with a total pump station design flow of 85cfs. The performance curves for these pumps were analyzed in the hydraulic model with good results. This improvement would include a new outfall to the ocean and will require significant permitting which is not included in this plan.

Table 6-6 presents the total allowance recommendations for these pump station improvements. Costs include a 40% increase of the construction cost to cover design, administrative, and contingency costs. The Rio Del Mar pump station is a considered a high priority improvement. The 38th Avenue detention pond pump station improvements are considered moderate priority.

Table 6-6: Pump Station Improvement Recommendations

Pump Station	Zone	Backup Power	Capacity Improvements
38th Avenue Detention	5	$200,000	-
Rio Del Mar	6	*	$3,000,000

* Backup power cost included in capacity improvements cost.

Culverts in the County right-of-way were analyzed to determine the existing and required capacity. Table 6-7 provides a summary of the replacement size and project cost allowances. It was assumed that the replacement culvert will be reinforced concrete pipe. This is a high priority improvement.

Table 6-7: Culvert Upgrade Recommendations*

Culvert ID	Zone	Length	Current Size	Type	Size Needed (RCP)	Construction Cost	Total Cost
2	**5**	**100**	**66”**	**RCP**	**72”**	**$ 161,000**	**$ 230,000**

* Total Cost rounded up to next $10,000

V&A assessed the condition of stormwater facilities and assigned stormwater facility rankings. There are two condition related improvements within Zone 5. The Pinewood area facilities were ranked as poor with immediate repair recommended, and is considered a high priority improvement. The Brommer/30th project, a manhole replacement project, is a moderate priority improvement. There are two condition related culvert replacement improvements recommend within Zone 6. Valencia is a high priority project, and Dolphin is a moderate priority project. Table 6-8 provides a summary of repair costs with an additional 40% for design, administration, and contingency costs. V&A also recommends performing an in-depth assessment of all stormwater facilities located in Zone 5 and 6, which is also considered a high priority project. A cost estimate for this assessment is presented in Table 6-9 with a 20% contingency for administrative costs. V&A also provides recommendations for reassessment periods for the remaining assessed stormwater facilities. Table 6-10 provides an annual cost for this assessment, with a 20% contingency to cover administrative costs.

Table 6-8: Condition Repair Estimate*

Project	Zone	Pipe Length	Construction Cost	Total Cost
Pinewood	5	145	$ 200,000	$ 280,000
Brommer/30th	5	-	$ 14,000	$ 20,000
Valencia	6	160	$ 490,000	$ 690,000
Dolphin	6	130	$ 100,000	$ 140,000

* Total Cost rounded up to next $10,000

Table 6-9: Condition Assessment Estimate

Project	Cost	Cost w/Contigency
Cost per Zone	$ 350,000	$ 420,000

Table 6-10: Annual Condition Assessment

Project	Annual Cost
Cost per Zone	$ 30,000