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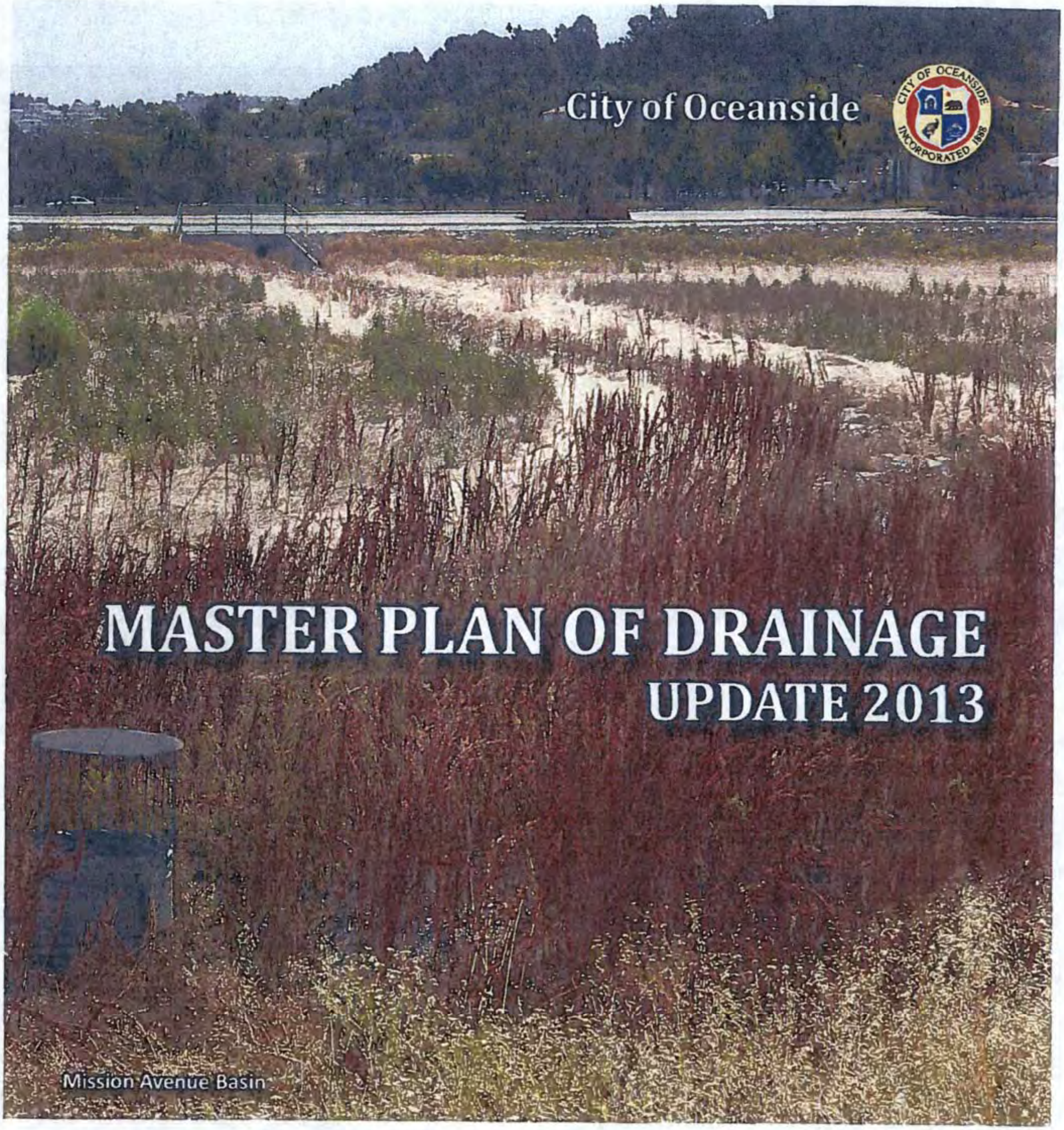

MASTER PLAN OF DRAINAGE
UPDATE 2013

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October 2013

City of Oceanside

MASTER PLAN OF DRAINAGE
UPDATE 2013

Mission Avenue Basin

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October 2013

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STORM DRAIN ATLAS

1. EXECUTIVE SUMMARY

Background

Since the 2005 City of Oceanside (City) Master Plan of Drainage (MPD), various developments have affected storm runoff flow patterns, and new drainage facilities have been added to the City's storm drainage system. These factors and their impacts to the City's overall drainage system were considered in this MPD update.

The City of Oceanside hired Tory R. Walker Engineering, Inc. (TRWE) to update the 2005 MPD. The following tasks were completed:

- Researched background hydrologic information
- Updated database with new information
- Analyzed and selected modeling software
- Reviewed existing and proposed detention basins
- Performed capacity analysis of existing drainage system
- Recommended drainage system upgrades
- Updated estimated construction costs
- Identified potential capital improvement projects
- Addressed potential drainage impact fee revisions
- Analyzed flow in Loma Alta Creek (see Appendix)
- Reviewed City drainage system design criteria (see Appendix)
- Created MPD specific GIS database
- Analyzed Oceanside precipitation data (see Appendix)


Buena Vista Creek

Objectives

The objectives of this study were to model the City's master planned drainage facilities, and then identify deficiencies and recommended upgrades which could be constructed as future development occurs.

TRWE strove to develop reasonable, optimized solutions to drainage system deficiencies. By choosing alternatives that are neither under-designed nor over-designed, the City will be able to address drainage requirements more cost effectively. Under-designed facilities will not provide adequate flood protection, while over-designed facilities will have a lesser probability of ever being constructed (**Figure 1-1**). The results of this study can be used to provide the basis for the City to update drainage development fees and to identity and prioritize drainage capital improvement projects. This Master Plan optimizes risk by focusing on the 25-year storm based on NOAA Atlas 14 tables (**Figure 1-2**). This design criteria applies to MPD facilities only, not to major watercourse facilities, which are typically designed for a 100-year storm.

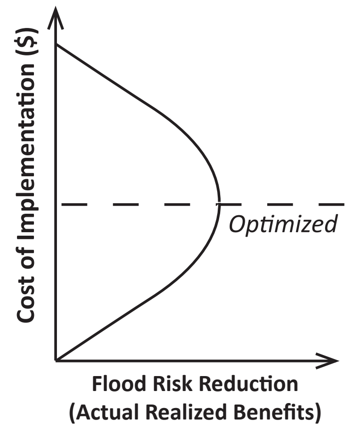


FIGURE 1-1

MPD facilities were defined as drainage facilities having flow capacity equal to or greater than a 36-inch reinforced concrete pipe under similar hydraulic conditions. TRWE also modeled 30-inch pipes - if they should be upsized to 36-inch they became a MPD facility. In addition, this study also considered peak flow attenuation using existing and planned detention basins. Private drainage systems, Caltrans facilities, and creeks and rivers were not considered to be master plan facilities.

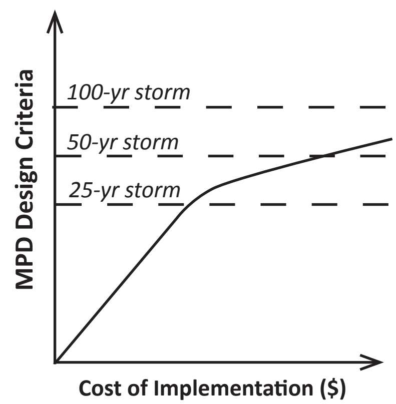


FIGURE 1-2

This master plan update identified:

- Existing MPD facilities that were not adequate in a 10-, 25-, and 100-year storms
- Possible MPD drainage facilities needed in undeveloped areas at build-out
- MPD facilities with maintenance concerns

New and upsized storm drains will typically either be constructed as a capital improvement project, or as part of a new development or redevelopment. Thus, facilities are constructed by a developer, or by City contract using the drainage fees for that particular district, as development occurs. The funds collected within a drainage district must be used for the benefit of that drainage district.

Detailed design of new drainage facilities is not a part of this study. The recommendations in this report serve as a basis for future drainage fees and capital improvement projects. The capacity analysis was conducted at a planning level, and sizing results were only intended to be approximate. This MPD did not perform the detailed hydrologic analyses required for design.

Summary Results

TRWE analyzed 2,790 drainage facilities (30-inches and greater) for 2-, 10-, 25-and 100-year size storms. For this MPD, a facility is defined as a portion of a drainage system separated by cleanouts, manholes, or changes in size, slope, or material. A drainage facility is considered inadequate if it overflows the ground elevation for a particular sized storm. **Table 1-1** summaries those facilities by watershed.

Table 1-1
MPD Facilities Summary by Watershed

Watershed Number	Watershed Name	Total Length Analyzed (ft)	Inadequate Facilities	
			Length (ft)	Percent
1	Pilgrim Creek	34,550	1,470	4.3
2	San Luis Rey River	183,450	10,930	6.0
3	Garrison Creek	44,150	2,140	4.8
4	Loma Alta Creek	112,830	8,600	7.6
5	Buena Vista Creek	61,670	12,530	20.3
6	Aqua Hedionda Head Waters	30,360	590	1.9
7	Pacific Ocean/Beach Area	10,440	4,680	44.8
	Total	**477,450**	**40,940**	**8.6**

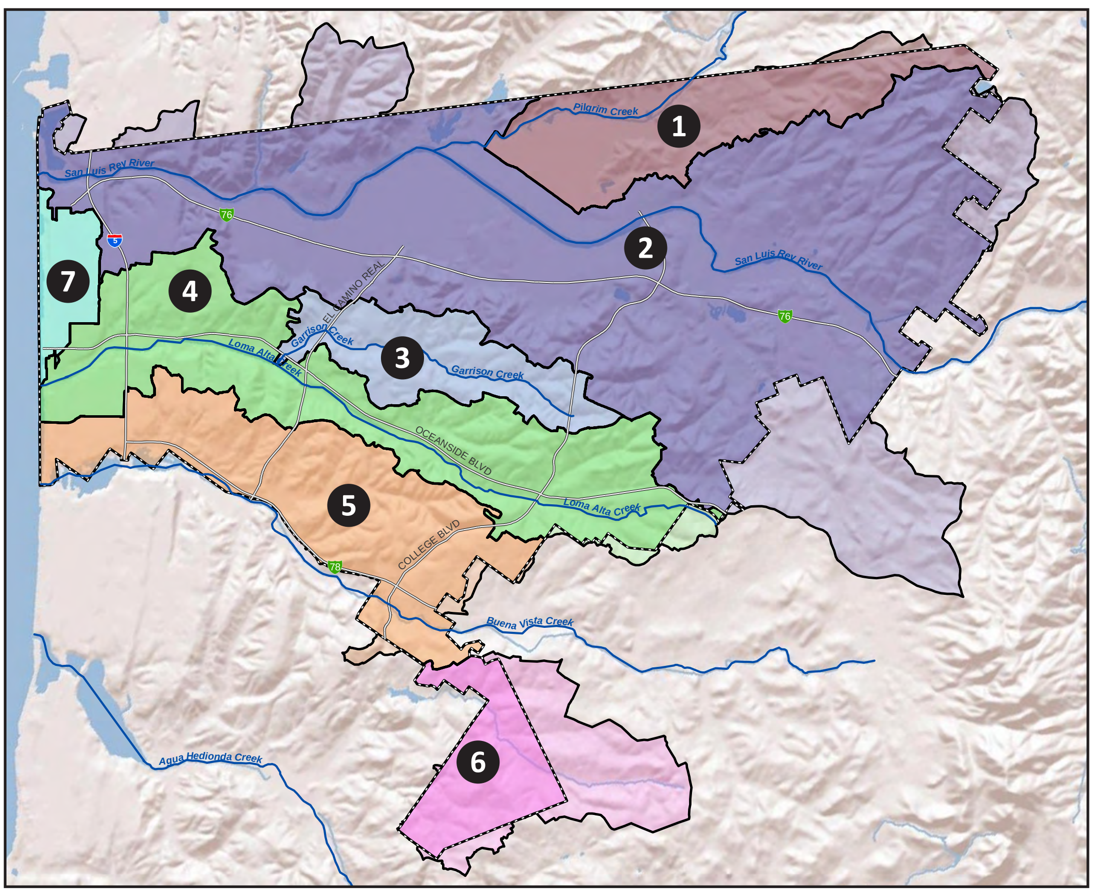


Figure 1-3
Watershed Boundaries

2. OVERVIEW

Study Area

Oceanside has experienced mild growth over the last decade. Between 2000 and 2010, the population grew about 4% to 167,086, and housing units increased 8% to 59,581.

The City is bordered by Marine Corps Base Camp Pendleton to the north, the City of Vista to the east, the Pacific Ocean to the west, and the City of Carlsbad to the south. Unincorporated areas are also east of the City. Interstate Highway 5 runs north-south along the western edge and State Routes 78 and 76 bisect the City running east-west. Oceanside is the third most populous City in San Diego County.

Figure 2-1
Oceanside Census

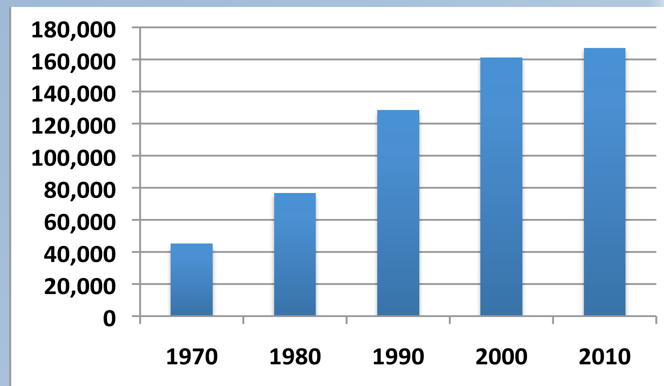
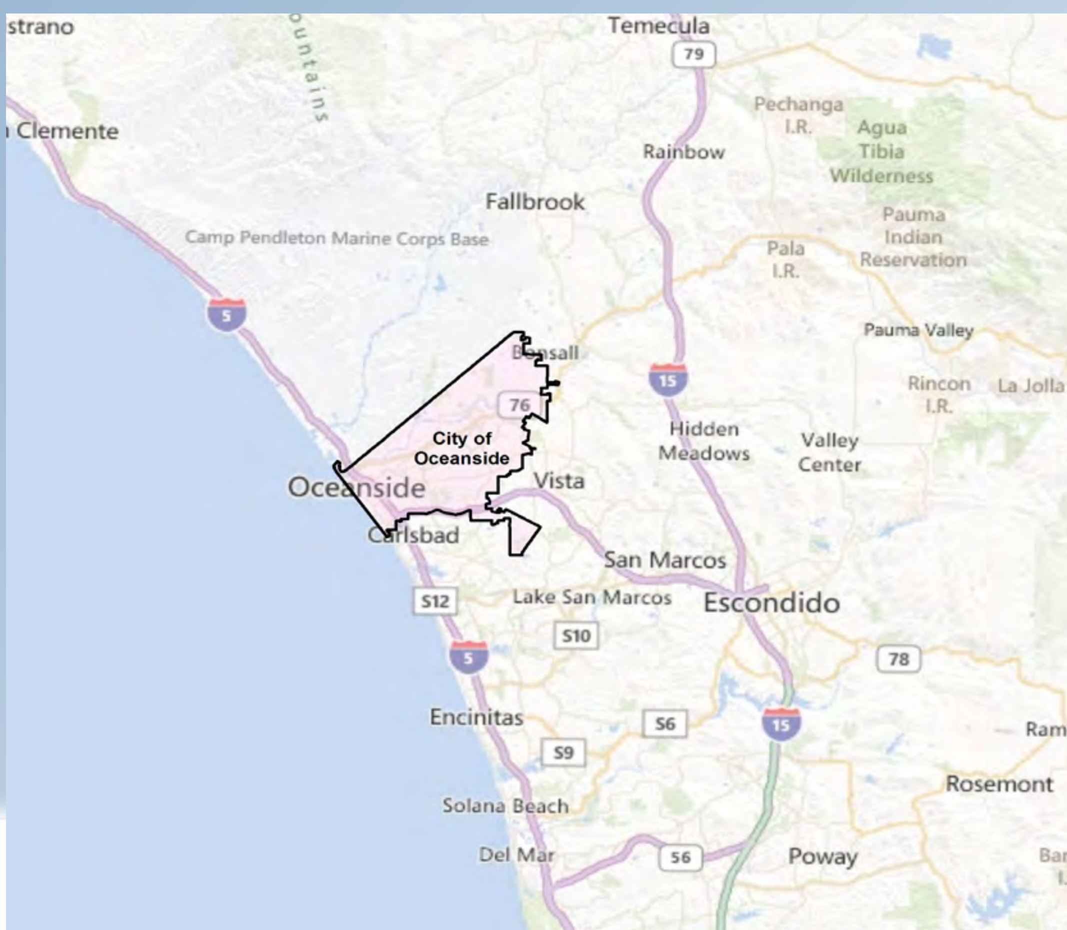
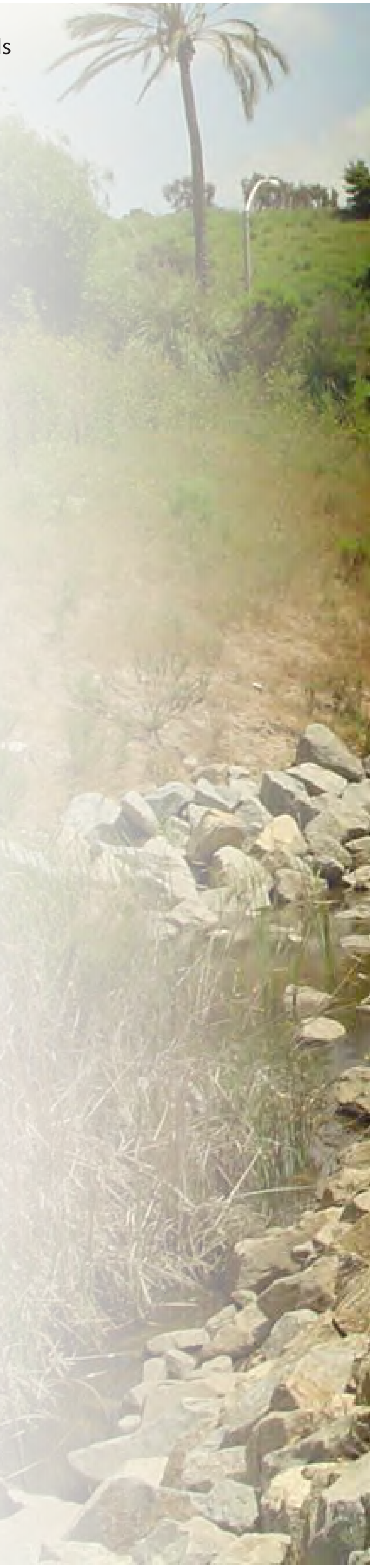


Figure 2-2
Oceanside Location Map





Oceanside is a coastal Southern California charter City governed by an elected council. It has an area of 42 square miles and is divided into seven major watersheds (**Table 2-1**). Most of the basins drain to rivers that flow to the Pacific Ocean. For this study, each watershed was divided into minor basins and sub-basins based on topography and existing drainage systems.

Table 2-1
Oceanside Watersheds

Watershed Number	Watershed Name	Area w/in City (sq. miles)
1	Pilgrim Creek	3.6
2	San Luis Rey River	21.2
3	Garrison Creek	2.4
4	Loma Alta Creek	7.1
5	Buena Vista Creek	5.3
6	Aqua Hedionda Head Waters	1.8
7	Pacific Ocean/Beach Area	0.9
	Total	**42.2 sq. miles**

The rainfall runoff flow rate and volume that reaches the drainage system depends on the following:

- The topography (slope and flow length)
- The type of underlying soil (infiltration capacity)
- The land use (imperviousness)
- The size and duration of the storm (volume and distribution of rainfall)
- The type and extent of vegetative cover (retention)

Steeper slopes do not allow as much time for infiltration as shallower slopes. Clay soils will generate higher runoff volumes than sandy porous soils. Also, rainfall runoff is higher on saturated soils than dry soils. Land use with more paved areas will have higher runoff than natural open spaces. Vegetation also retains more rainfall than bare ground. The model takes all of these factors into account to calculate the percentage of runoff for a particular sub-basin.

Topography

Hydrology studies start with a topographic map showing elevation contour lines and natural features. For this study, 2009 aerial topography (**Figure 2-3**) was obtained from the City. The topography is based on the NAVD-88 datum. Since most of the storm drain facilities in the City were constructed on the NGVD-29 datum, TRWE used Geographic Information System (GIS) software to lower the recent topography by two feet to more closely match the older facility datum. This approximately adjusted topography allowed modeling of underground (e.g., pipe) and aboveground (e.g., street flows) at the same time.

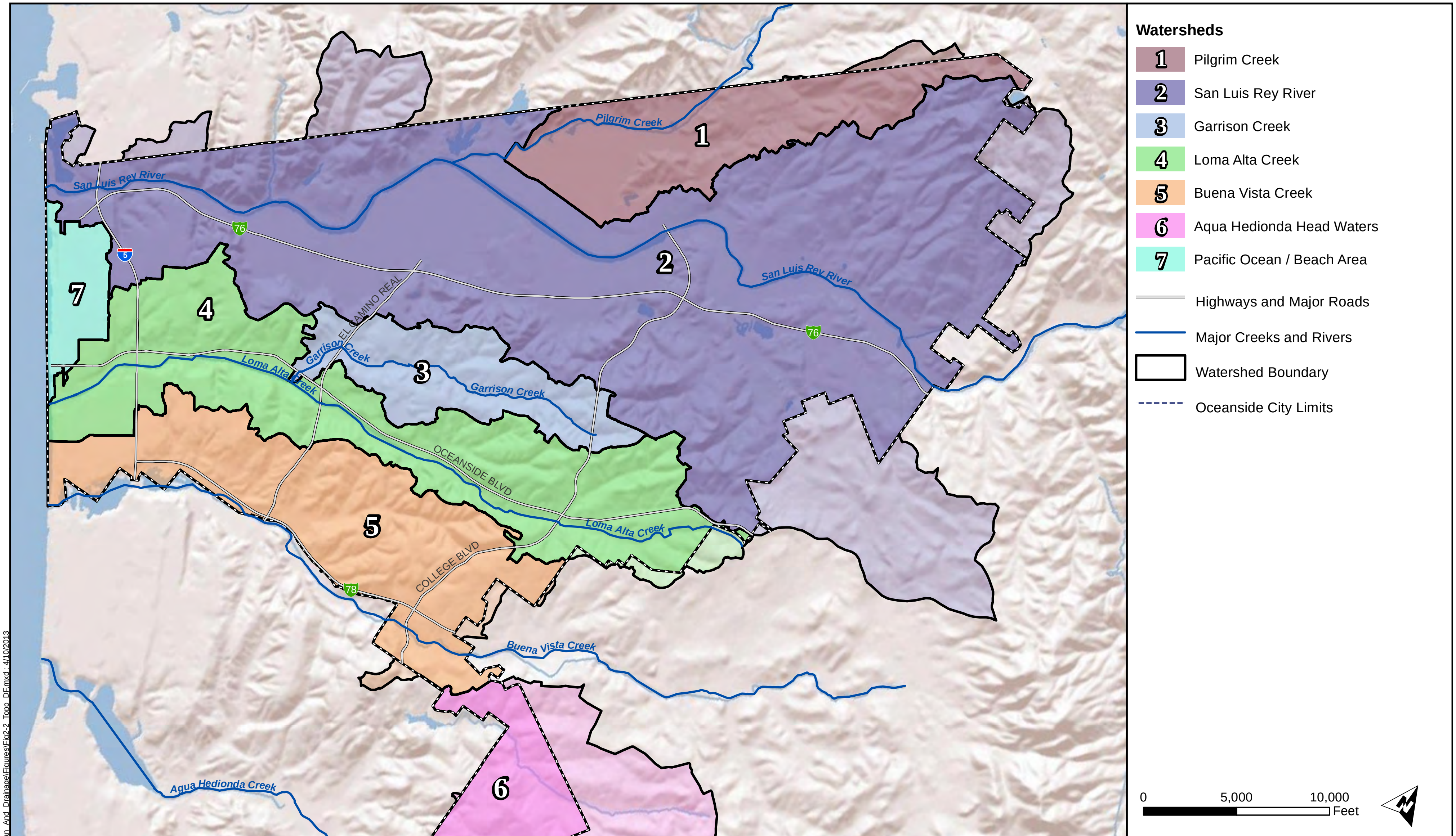


Figure 2-3
Topography

Soils

Soil types directly affect the amount of runoff from a particular site. This infiltration capacity, along with the slope and type of development on the site, directly correlates to the percentage of rainfall that reaches the drainage system.

The Natural Resources Conservation Service (NRCS), formerly Soil Conservation Service (SCS), defines four hydrologic soils groups:

Group A - *Soils have high infiltration rate when thoroughly wetted; chiefly deep, well-drained to excessively drained sand, gravel, or both. Rate of water transmission is high; thus runoff potential is low.*

Group B - *Soils have moderate infiltration rate when thoroughly wetted; chiefly soils that are moderately deep to deep, moderately well drained to well drained, and moderately coarse textured. Rate of water transmission is moderate.*

Group C - *Soils have slow infiltration rate when thoroughly wetted; chiefly soils that have a layer impeding downward movement of water, or moderately fine to fine textured soils that have a slow infiltration rate. Rate of water transmission is slow.*

Group D - *Soils have very slow infiltration rate when thoroughly wetted; chiefly clays that have a high shrink-swell potential, soils that have a high permanent water table, soils that have a clay pan or clay layer at or near the surface, or soils that are shallow over nearly impervious material. Rate of water transmission is very slow.*

San Luis Rey River Basin

Figure 2-4 on the following page shows the soil groups and their percentage within Oceanside's boundaries. As shown, Group D is the predominant soil type within the City. Because of more clay type soils, there will obviously be higher runoff and less infiltration.

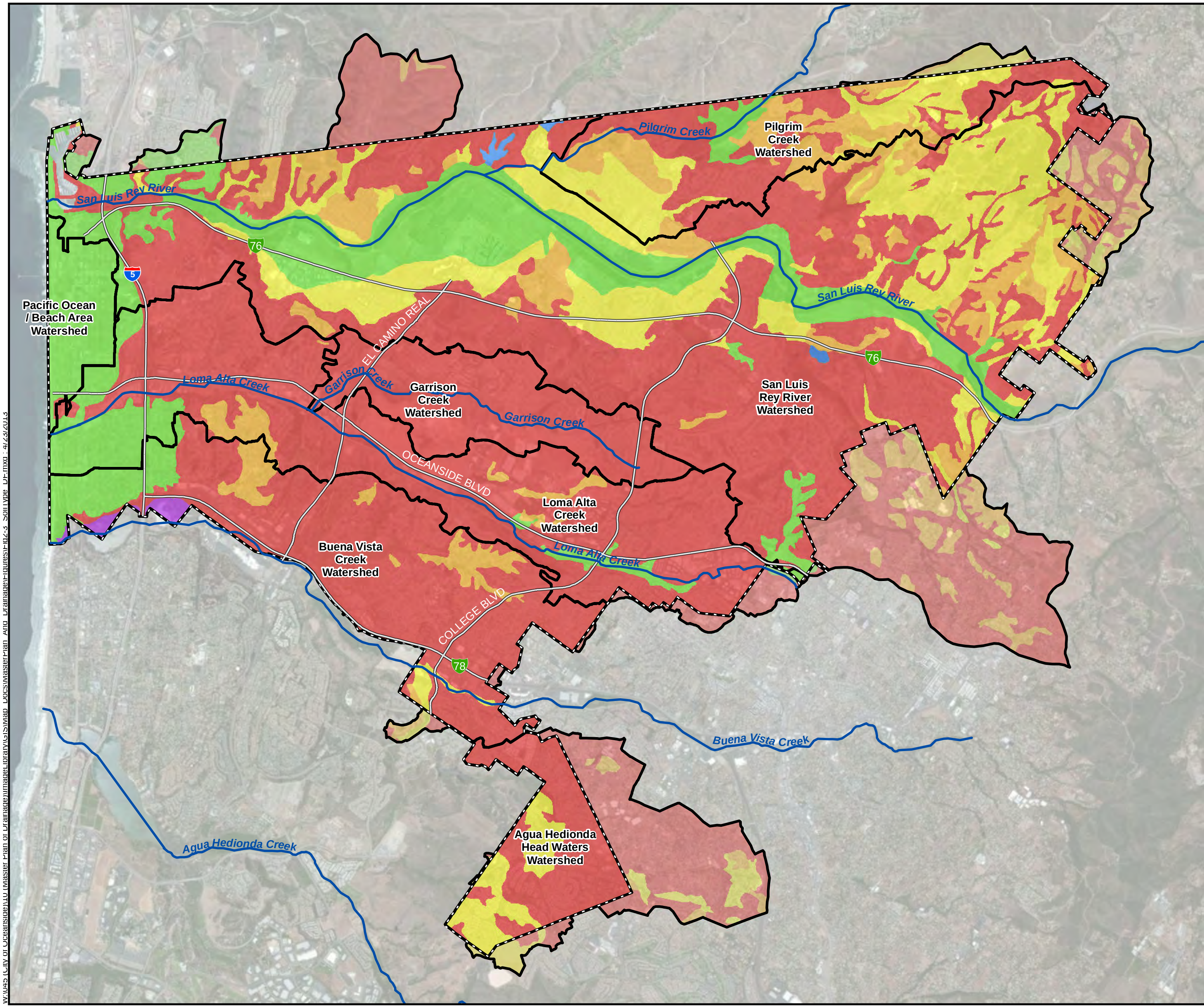


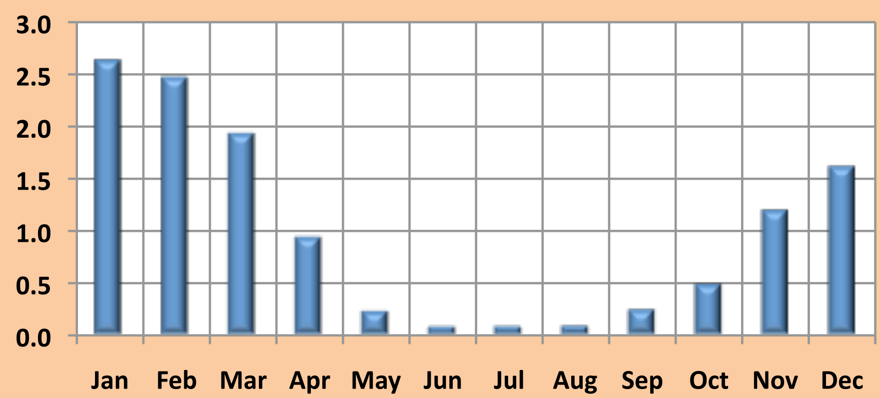
Figure 2-4
Soil Groups

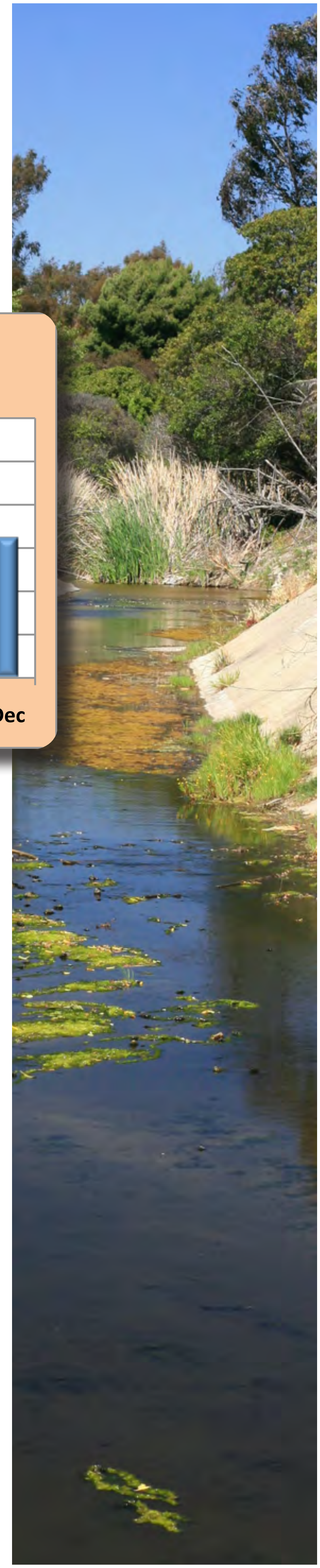
Climate

Rainfall

Oceanside rainfall is highly seasonal, as shown in **Figure 2-5**, with approximately 60% occurring during the wettest months of January, February and March, and only 2% during the driest months of June, July and August. Apart from the seasonal cycle, long-term variations in precipitation associated with El Niño and La Niña phenomena have been observed in Oceanside (and are common to all of Southern California).

Figure 2-5
Seasonal Precipitation In Oceanside (inches)

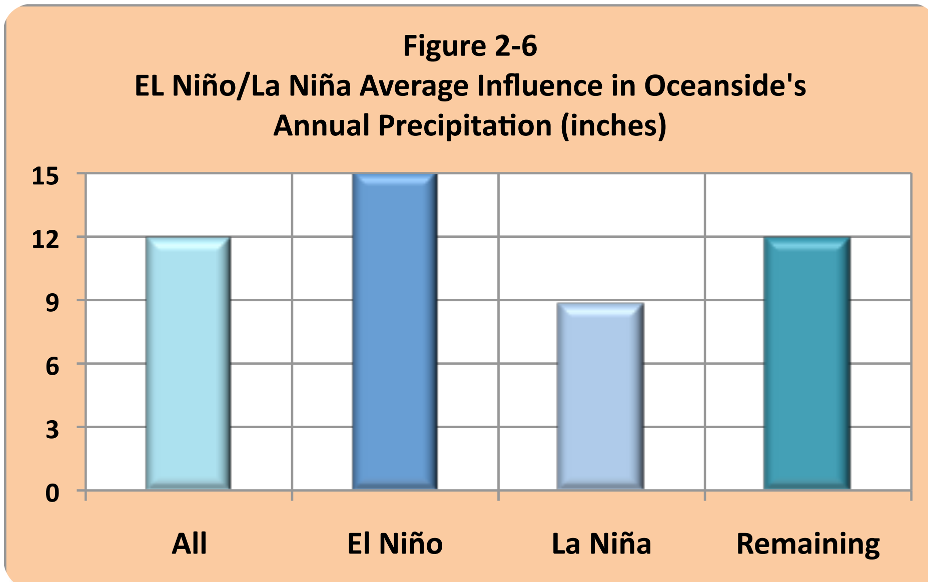




El Niño–Southern Oscillation (ENSO), or El Niño/La Niña–Southern Oscillation, is a quasi-periodic climate pattern that occurs across the tropical Pacific Ocean roughly every five years. The Southern Oscillation refers to variations in the temperature of the surface of the tropical eastern Pacific Ocean (warming and cooling known as El Niño and La Niña respectively) and in surface air pressure in the tropical western Pacific. The two variations are coupled: the warm oceanic phase, El Niño, accompanies high air surface pressure in the western Pacific, while the cold phase, La Niña, accompanies low surface air pressure in the eastern Pacific.

From 1952 to 2011, the eight strongest El Niño events (nine years total) averaged annual rainfall of 15.0-inches, while the seven strongest La Niña events (nine years total) averaged an annual rainfall of 8.7-inches. The remaining 42 years (weak or absent El Niño / La Niña effects) have an average of 11.9-inches, the same value measured when all years were considered (**Figure 2-6**).

ENSO is responsible for precipitation variations in many regions of the world, including Southern California. Here, El Niño years are usually associated with above-normal precipitation (sometimes it may not occur, as during the strong El Niño year from August 1986 to July 1987 with 10.0-inches of rain), while La Niña years are usually associated with below-normal precipitation (the only exception in the last 60 years being the strong La Niña year of May 2010 to April 2011, with 20.3-inches of rain).



Flooding

Flooding events in Oceanside can often be localized and associated with intense storms overwhelming the local drainage system, which may be insufficient in certain areas. Flooding is also more widespread and large-scale, associated with the flooding of the main creeks and rivers in the City, especially the largest, San Luis Rey River. The two highest San Luis Rey River flooding levels since 1937, according to NOAA, occurred January 16, 1993, after more than 10-inches of rain in the City during the previous 20 days, and likely due to higher precipitation levels in the upstream portions of the watershed.

Additionally, flooding occurred in January 11, 2005, after about 8.5-inches of rain the previous 15 days, and persistent rain since December 14, 2004, in the watershed. Although rainfall is the main contributing factor to flooding, other factors, including antecedent soil moisture conditions before the storm, potentially occurring snow melt in the high mountains, and initial level of the upstream reservoirs may increase flooding conditions downstream.

Land Use

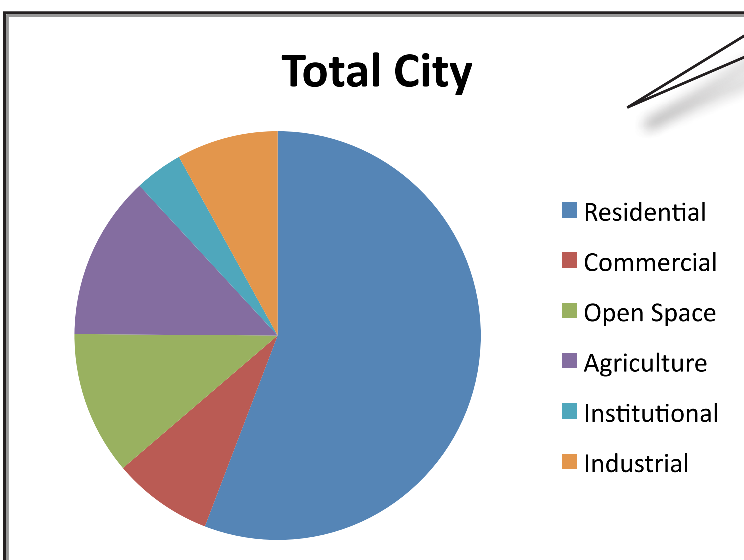
As previously noted, ultimate land use is an important indicator of runoff potential. One of the tasks for this MPD, therefore, was to create a GIS based land use map showing the ultimate build-out condition per the General Plan.

TRWE started with parcel boundaries, then overlaid a CAD land use map, used GIS to create land use shape files, and labeled these areas according to the City's 2007 Generalized Land Use Map designations. The coastal region was defined by the City's Local Coastal Program Map. For drainage areas that extended beyond the city limits, TRWE used the surrounding area's land use designations (SanGIS, Carlsbad, Vista) to generate runoff potential for this study.

The results of the GIS land use data yielded the results shown in **Table 2-2** and **Figure 2-7**.

Table 2-2
Ultimate Land Use by Watershed

Land Use Class	Pilgrim Creek	San Luis Rey River	Garrison Creek	Loma Alta Creek	Buena Vista Creek	Agua Hedionda Head Waters	Pacific Ocean / Beach Area	Total City
Residential	71%	48%	62%	52%	69%	89%	59%	56%
Commercial	0%	6%	2%	9%	19%	5%	32%	8%
Open Space	12%	16%	8%	6%	7%	3%	6%	11%
Agriculture	16%	23%	0%	0%	0%	0%	0%	13%
Institutional	1%	4%	8%	3%	5%	3%	2%	4%
Industrial	0%	3%	20%	30%	0%	0%	1%	8%



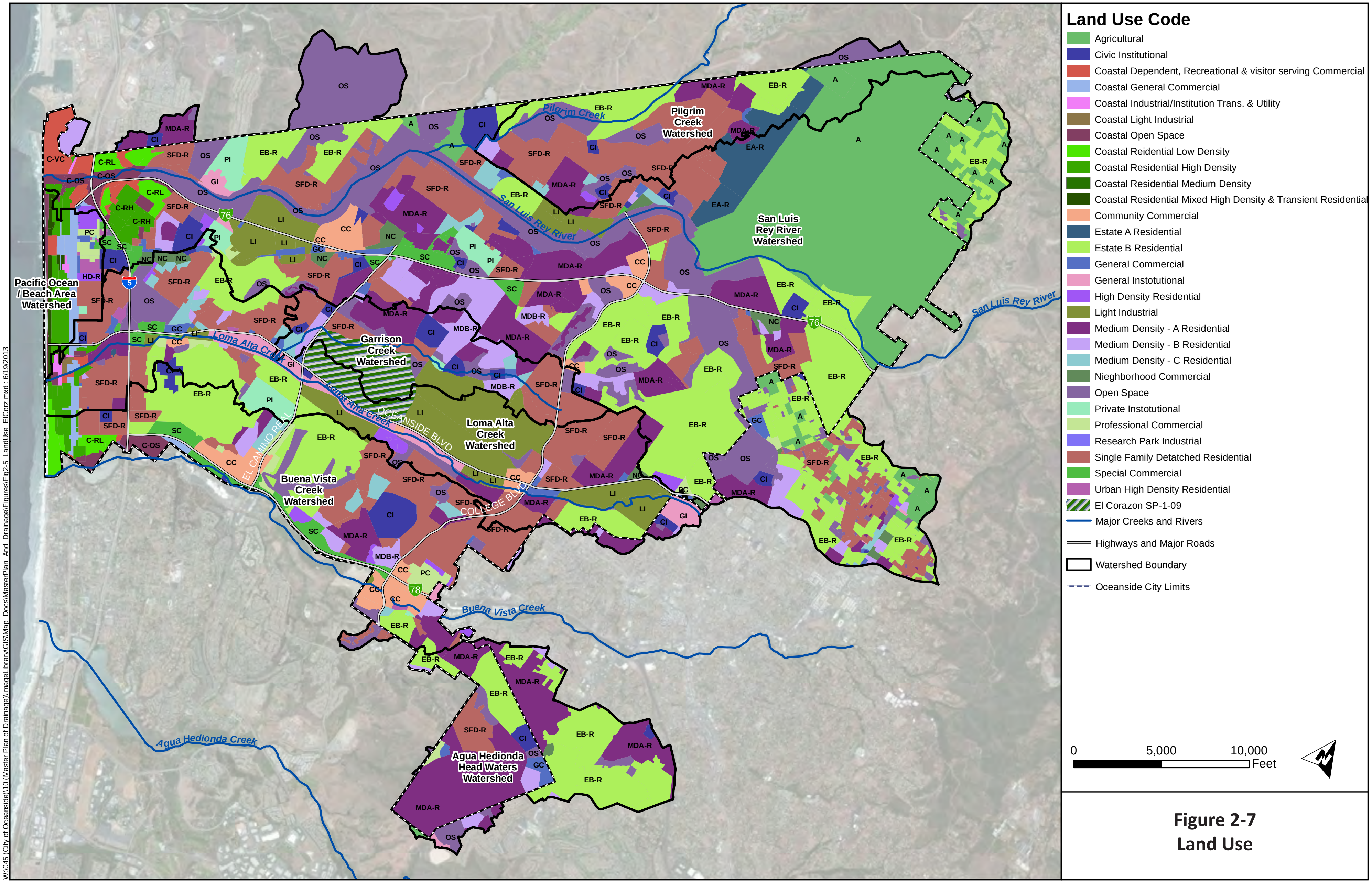


Figure 2-7
Land Use

3. ANALYSIS

Hydrologic and Hydraulic Analysis

A hydrologic and hydraulic model was created in xpstorm© to assess the capacity of the MPD system facilities. The model, using the runoff potential and precipitation for each sub-basin, generated a runoff peak flow and volume. These volumes and peak flows were routed through existing MPD facilities to check for their adequacy.

The hydrology methodology employed for this MPD was the Soil Conservation Service (SCS) Unit Hydrograph (UH) hydrologic method. SCS UH methodology was selected due to its applicability to large scale watersheds and the ability to model peak flows and volumes. The SCS UH method requires the following input:

- Tributary basin area
- Runoff potential [Curve Numbers (CN)]
- Time to peak (T_p)
- Precipitation

Once these inputs have been incorporated within the SCS UH analysis, rainfall precipitation is routed over a tributary basin whose infiltration and surface routing characteristics have been defined by the corresponding CN and T_p calculations. This routing over the basin then results in a hydrograph, providing a detailed analysis of flow experienced over the duration of a storm event.

The generated hydrographs were then routed via a hydraulic network consisting of MPD storm drains, culverts, detention basins and urban open channels. An underground storm drain was deemed hydraulically sufficient if the drain was able to contain the hydraulic grade line (HGL) beneath the rim elevation of the upstream and downstream cleanout structure, effectively ensuring that there was no surface drainage experienced during the storm event.

In the event that the existing storm drain was hydraulically deficient (i.e. the HGL was exceeding rim elevations), the excess flow was modeled via an overland flow route. This was undertaken to ensure that, not only were all flows accounted for, but that locations of potential surface flooding could be easily identified.

For the purpose of this master planning effort, TRWE have made a general assumption that underground storm drain facilities will be considered adequate (in terms of capacity only) when they have the capacity to convey at least a 25-year design storm. It is common policy and practice for many public agencies to adopt a 25-year frequency for design of public and private underground storm drain systems (e.g., Orange County and Los Angeles County). Where such policies exist, there is usually also a limit to the size or type of structure, beyond which a 50-year or 100-year storm is required for design. The reasoning behind this policy is in the recognition that these underground storm drain systems typically are under streets, which are also designed to convey storm flows and often have more capacity than the underground systems. As it is also important to maintain vehicular capacity and safety in streets, and especially for emergency vehicles, it is also common to require designs to ensure at least one dry lane in major storm events.

Analysis Methodology

Using the previous master plan as a guide, the City's major watersheds were first divided into basins, then those basins were further divided into sub-basins. The following procedure, graphically illustrated in **Figure 3-1**, was used to prepare each sub-basin for analysis:

- Utilize the previous MPD sub-basin drainage area delineation as a starting point.
- Adjust sub-basin boundaries where new construction altered drainage patterns. Smaller sub-basins areas from the previous study were combined to allow for more efficient modeling.
- Tabularize average Curve Numbers (CN) with Oceanside's land use designations. **Table 3-1** lists the average CN values for this study.
- Calculate weighted CNs in GIS based on the area of land use overlaying the soils group. **Figures 3-2 and 3-3** are GIS plots of the weighted CN values.
- Compile flow lengths and slopes in GIS for each sub-basin and export the data for hydrologic analysis.
- Generate rainfall volumes and peaks for the 2-, 10-, 25-, and 100-yr storms, using NOAA Atlas 14 precipitation (see **Appendix**).
- Route flow downstream by node. Nodes were defined where the facility began, where the size, material or slope changed, or where additional flows entered the system. Manning's roughness of 0.014 was used for concrete pipes and 0.025 for corrugated metal pipes.
- Flag existing pipe as undersized if the hydraulic grade line (HGL) exceeds the elevation (ground, street, manhole rim) at that point. Although the MPD only considered 36-inch and larger, TRWE also considered smaller facilities at inadequate locations.
- Route excess flow to the street as overland flow, and then re-enter it to the system at the next node.
- Compare the HGL again to the surface elevation, and repeat the process downstream.

Buena Vista Creek

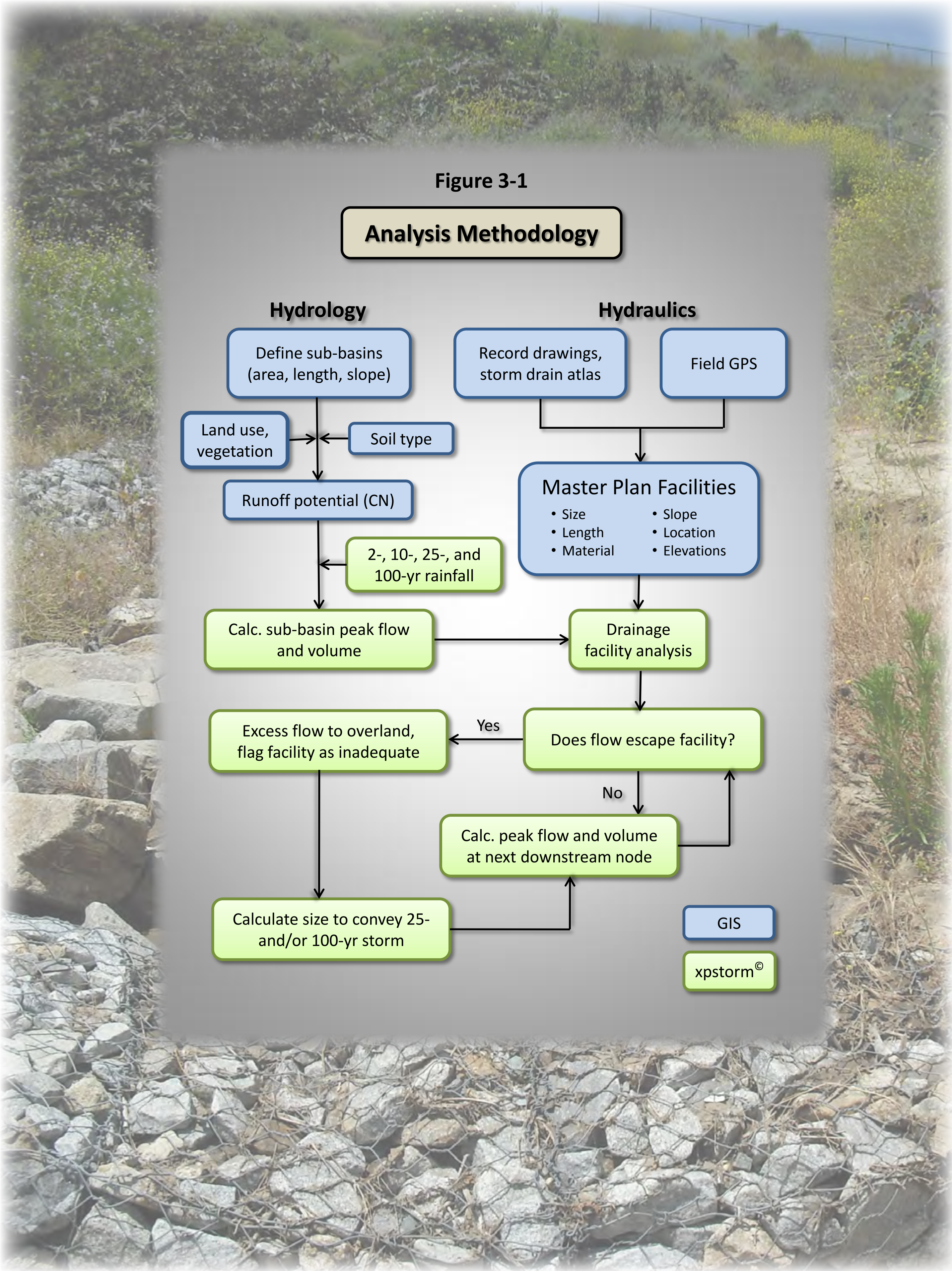


Figure 3-1

Analysis Methodology

Table 3-1, Land Use Loss Rates

City of Oceanside General and Coastal Plan Land Use		San Diego County 2003 Hydrology Manual *(For Reference Only)*		Rational Method "C"				SCS UH Method Curve Number "CN" 50, 100-year storm				SCS UH Method Curve Number "CN" 2, 5, 10, 25-year storm			
Residential			*% Impervious*	*Soil A*	*Soil B*	*Soil C*	*Soil D*	*Soil A*	*Soil B*	*Soil C*	*Soil D*	*Soil A*	*Soil B*	*Soil C*	*Soil D*
EA-R	Estate A Residential (0.5 - 0.9 DU/A)	Residential, 1.0 DU/A or less	10	0.27	0.32	0.36	0.41	44	64	77	82	35	54	68	74
EB-R	Estate B Residential (1.0 - 3.5)	Residential, 2.9 DU/A or less	25	0.38	0.41	0.45	0.49	53	70	80	85	43	60	71	77
SFD-R	Single Family Detached Residential (3.6 - 5.9)	Residential, 4.3 DU/A or less	30	0.41	0.45	0.48	0.52	57	72	81	86	47	62	73	79
MDA-R	Medium Density - A Residential (6.0 - 9.9)	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57	61	75	83	88	51	66	75	81
MDB-R	Medium Density - B Residential (10.0 - 15.0)	Residential, 10.9 DU/A or less	45	0.52	0.54	0.57	0.60	64	77	85	89	54	68	77	83
MDC-R	Medium Density - C Residential (15.1 - 20.9)	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63	67	79	86	90	57	70	79	84
HD-R	High Density Residential (21.0 - 28.9)	Residential, 24.0 DU/A or less	65	0.66	0.67	0.69	0.71	77	85	90	92	68	77	84	87
UHD-R	Ultra High Density Residential (29.0 - 43.0)	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79	86	90	93	94	79	84	88	90
C-RL	Low Density Residential (coastal), R-1	Residential, 7.3 DU/A or less	40	0.48	0.51	0.54	0.57	61	75	83	88	51	66	75	81
C-RM	Medium Density Residential (coastal), R-2	Residential, 14.5 DU/A or less	50	0.55	0.58	0.60	0.63	67	79	86	90	57	70	79	84
C-RH	High Density Residential (coastal), R-3	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79	86	90	93	94	79	84	88	90
C-RMHT	Mixed High Density & Trans. Res. (coastal)	Residential, 43.0 DU/A or less	80	0.76	0.77	0.78	0.79	86	90	93	94	79	84	88	90
Commercial															
CC	Community Commercial	Neighborhood Commercial	80	0.76	0.77	0.78	0.79	86	90	93	94	79	84	88	90
NC	Neighborhood Commercial	Neighborhood Commercial	80	0.76	0.80	0.78	0.79	86	90	93	94	79	84	88	90
GC	General Commercial	General Commercial	85	0.80	0.84	0.81	0.82	89	92	94	95	83	87	90	91
SC	Special Commercial	Office Professional/Commercial	90	0.83	0.84	0.84	0.85	92	94	96	96	87	90	93	93
PC	Professional Commercial	Office Professional/Commercial	90	0.83	0.80	0.84	0.85	92	94	96	96	87	90	93	93
C-GC	General Commercial (coastal)	General Commercial	85	0.83	0.80	0.81	0.82	89	92	94	95	83	87	90	91
C-VC	Commercial Visitor (coastal)	General Commercial	85	0.80	0.80	0.81	0.82	89	92	94	95	83	87	90	91
Open Space															
OS	Open Space	Permanent Open Space	0	0.20	0.25	0.30	0.35	55	72	81	86	45	62	73	79
C-OS	Open Space (coastal)	Permanent Open Space	0	0.20	0.25	0.30	0.35	55	72	81	86	45	62	73	79
Agriculture															
A	Agricultural	Permanent Open Space	0	0.20	0.25	0.30	0.35	55	72	81	86	45	62	73	79
Institutional															
CI	Civic Institutional	Neighborhood Commercial	80	0.76	0.77	0.78	0.79	86	90	93	94	79	84	88	90
PI	Private Institutional	Neighborhood Commercial	80	0.76	0.77	0.78	0.79	86	90	93	94	79	84	88	90
Industrial															
GI	General Industrial	General Industrial	95	0.87	0.87	0.87	0.87	95	96	97	97	91	93	94	94
LI	Light Industrial	Limited Industrial	90	0.83	0.84	0.84	0.85	92	94	96	96	87	90	93	93
RP-I	Research Park Industrial	General Industrial	95	0.87	0.87	0.87	0.87	95	96	97	97	91	93	94	94
C-LI	Light Industrial (coastal)	Limited Industrial	90	0.83	0.84	0.84	0.85	92	94	96	96	87	90	93	93
C-TU	Transportation & Utility (coastal)	General Industrial	95	0.87	0.87	0.87	0.87	95	96	97	97	91	93	94	94

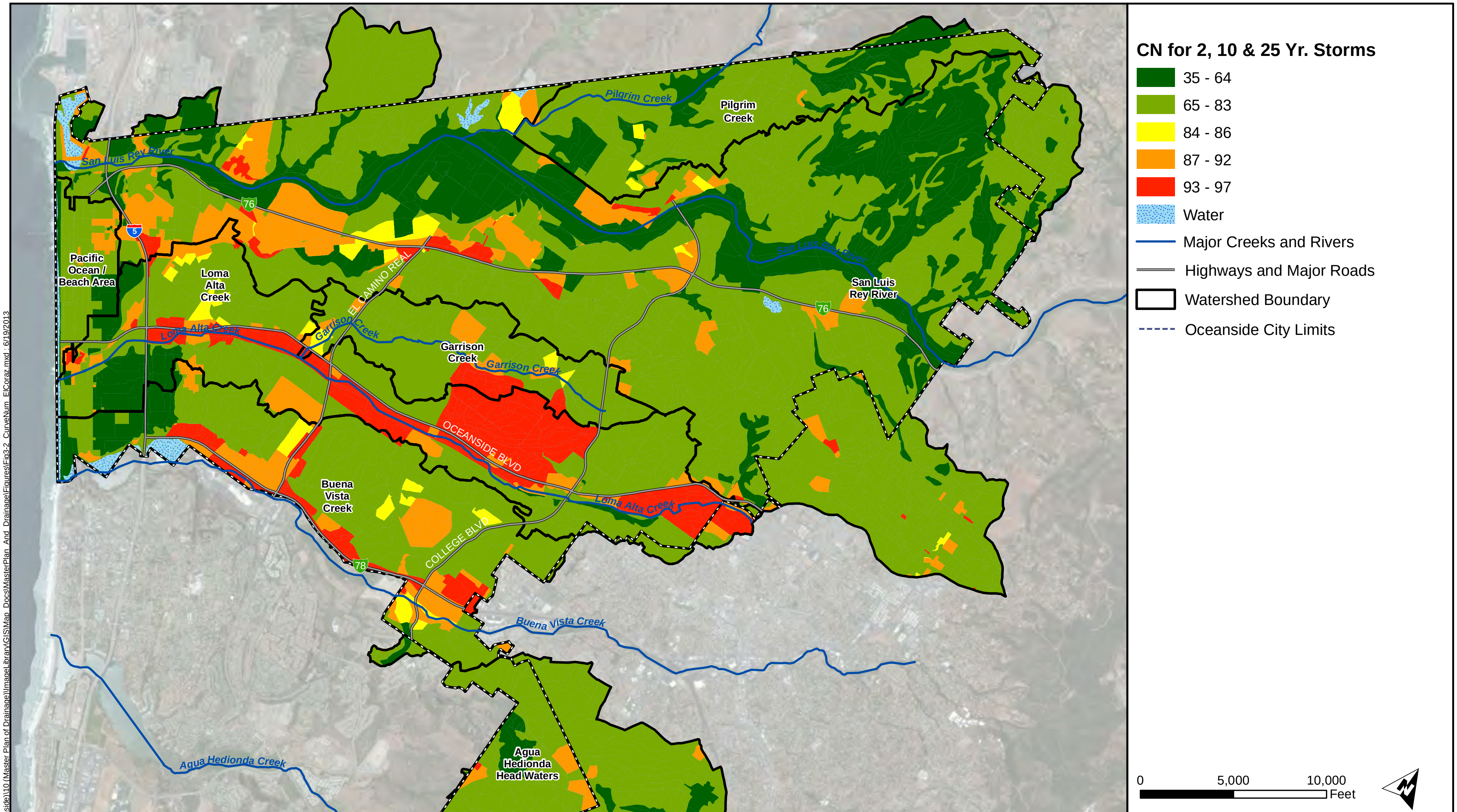


Figure 3-2
Runoff Curve Numbers (CN)

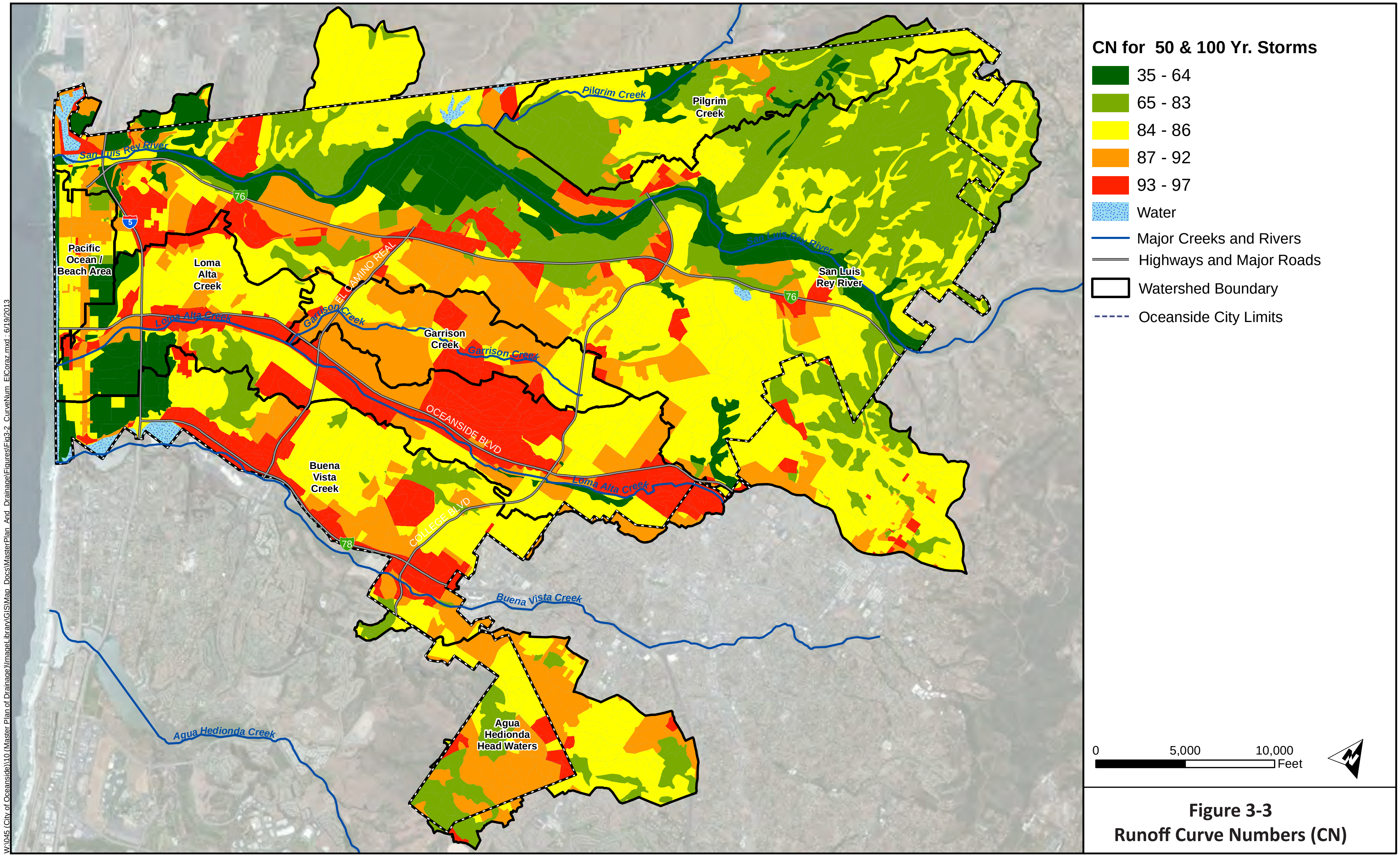


Figure 3-3
Runoff Curve Numbers (CN)

Precipitation

This section summarizes TRWE's examination of alternative precipitation distribution methods by analyzing intensity values which are site-specific to the City of Oceanside. Three methods were analyzed: the SDCHM Method, the TRWE Method (developed specifically for this MPD and explained below), and the NOAA Atlas 14 Method. Although the TRWE Method is site specific and statistically solid, the NOAA Method was selected, as it produces intermediate results and comes from tables provided by a well-established weather source.

Background: SDCHM Method

Since its adoption by the County in 2003, the *San Diego County Hydrology Manual* (SDCHM) has been the guide followed by most engineers and designers to estimate extreme precipitation events in San Diego County. The SDCHM focuses on the 6-hour storm event (P_6) at a given period of return. As long as P_6 is between 45% to 65% of the 24–hour precipitation event, P_{24}, a condition that always occurs within the limits of the City of Oceanside (mathematically $0.45 \cdot P_{24} < P_6 < 0.65 \cdot P_{24}$), there is no need to apply any correction to the 6-hour precipitation value. The maximum intensity is then obtained with the following power-law equation:

$$I_T = 7.44 \cdot P_{6,T} \cdot t^{-0.645} \qquad \textbf{(1)}$$

where, I_T (in inches per hour) is the intensity at a given return period T, with duration of t minutes, as a function of the 6-hour storm event with a return period T.

In order to estimate the precipitation distribution, **equation (1)** is used in 5 or 10 minute intervals. The maximum intensity is calculated with the nested-storm procedure, assuming that the precipitation peak occurs after 2/3 of the storm has passed. In other words, the highest 5 minute intensity in a 6-hour storm beginning at noon, occurs between 4:00 p.m. to 4:05 p.m.; while the highest 5 minute intensity in a 24-hour storm analysis starting at midnight, also occurs between 4:00 p.m. and 4:05 p.m.

For this method, modification of the nested storm procedure has not been attempted. The peak flow will occur at the beginning of the 4th hour in a 6-hour storm analysis, and the remaining intensities would be positioned as explained in the SDCHM. However, there have been significant discrepancies in terms of the adequacy of the intensity equation, as the values of intensity for short durations (which are the ones that generate the peak flows of most analyses) are unrealistically large and not supported by the precipitation data. For this reason, two additional methods were a part of this study: first, an analysis of 57 years of Oceanside hourly precipitation time series data as published by the clean water web page (***http://projectcleanwater.org/html/wg_susmp.html***) and as used for continuous simulation analysis in hydromodification studies (known from this point forward as the TRWE Method); and second, precipitation frequency estimates as assigned by NOAA as a function of the location (known from this point forward as the NOAA Method).

Additional Intensity Calculations: the TRWE Method

It is TRWE's opinion that the analysis performed on original Oceanside precipitation data is the most accurate procedure for the determination of the intensity equation. There are four main reasons for this assertion: first, it is based on 57 of the most extreme independent intensity events, regardless of the occurrence of the event (meaning that the 57 highest independent events are randomly distributed in time, and not assigned as one event per year); second, it is based on fitting the data to the general intensity equation (from which both the power-law SDCHM Method and the NOAA Tables are particular cases); third, the precipitation data fits the statistical distribution selected by satisfying advanced statistical tests (such as the Anderson-Darling test of normality); and fourth, the TRWE Method does not generate unreasonably large intensities that have not been recorded in any 15 minute or 60 minute measurements available for Oceanside.

The following are the set of intensity equations that describe the intensity distribution I (in/hr) for time durations smaller than 6 hours [t is in hours in **equation (3)**], as a function of the return period T (years):

$$B = 0.407+0.027[\log(T-1)]^2-0.0067[\log(T-1)] \quad \textbf{(2)}$$

$$I = (P_6/6)+[(6+B)/(t+B)]^{0.675} \quad \textbf{(3)}$$

The only drawback of the TRWE Method is associated with its innovative approach that has not been peer-reviewed by statisticians and hydrologists, and it is not a method published by a nationally recognized weather organization (such as NOAA) or by a large public agency. Details of the statistical analysis are provided in **Appendix C**.

Pilgrim Creek

Chosen Method: NOAA Atlas 14

The third intensity distribution considered is the analysis of the National Oceanic and Atmospheric Administration (NOAA) data. The NOAA methodology is an improvement over the SDCHM Methodology, and it is based on the NOAA web-page Tables (**Appendix D)**. An analysis of the intensity values suggest that a power-law extrapolation has been performed for intensities smaller than 1 hour, as there are not known long-extended records of precipitation measured in less than 60 minute time intervals (at least not known by the authors of this study).

For this analysis, TRWE divided Oceanside into three precipitation regions from east to west. Precipitation for each region was obtained by selecting a representative point on the NOAA Precipitation Frequency Data Server (PFDS).

Comparison of Results

Figure 3-4 shows the distribution of a 6-hour, 100-year storm event using the nested methodology and the intensity equations (or tables in the case of NOAA) explained here. It is clear that the SDCHM rainfall values are the highest, followed by the NOAA tables, and then by the TRWE Method.

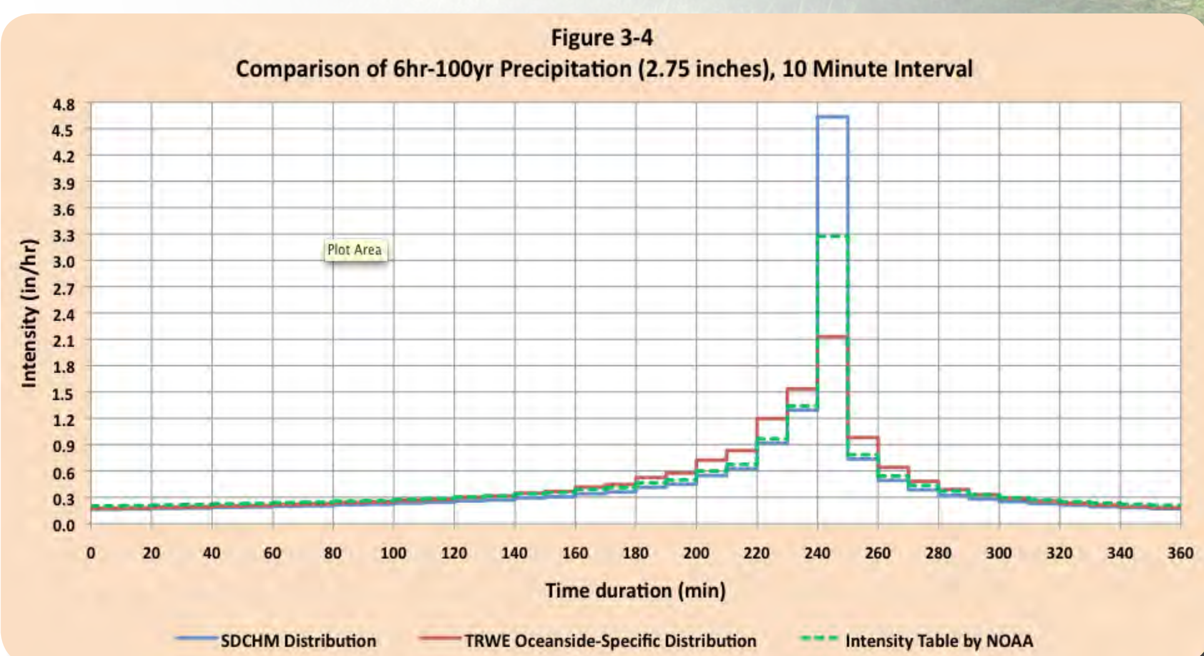
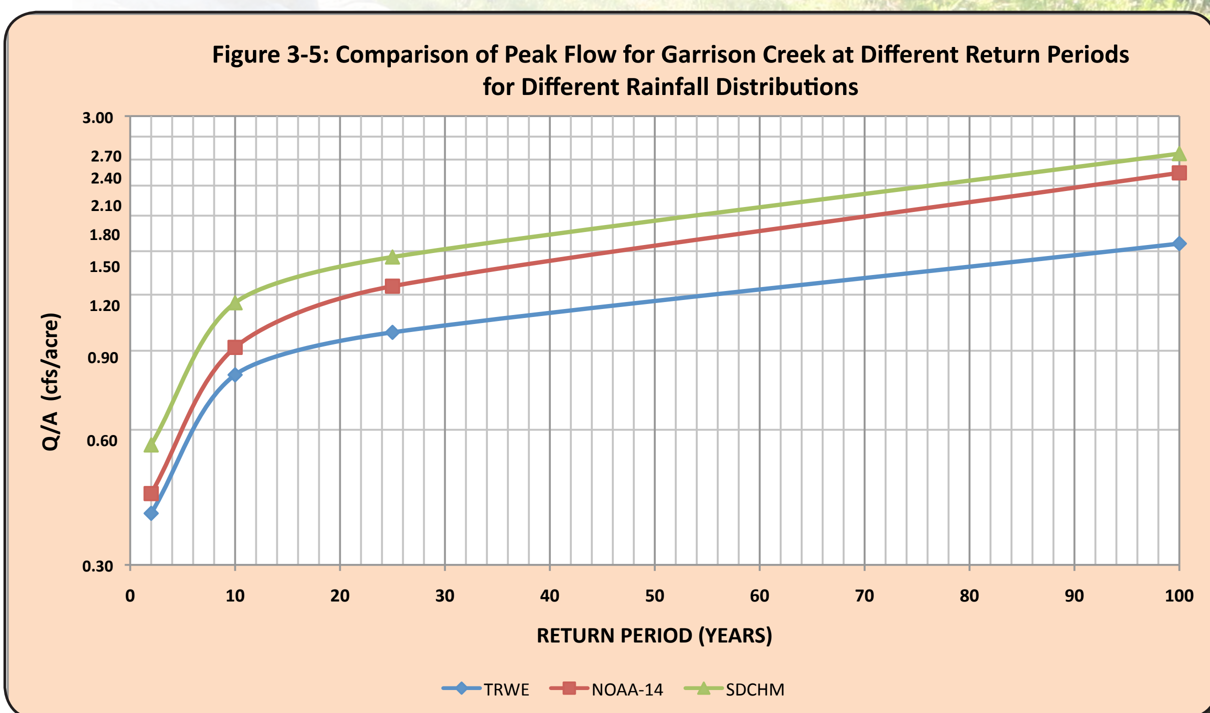


Figure 3-4
Comparison of 6hr-100yr Precipitation (2.75 inches), 10 Minute Interval

Figure 3-5 illustrates variation of the peak flow estimates per unit area in Garrison Creek depending on the intensity equation selected. In all cases the TRWE Method determines the lowest values, followed by NOAA and then the SDCHM equation, which generates the largest results. NOAA values are closer to TRWE values than to SDCHM values for return periods smaller than 25 years and closer to SDCHM values than to TRWE values for return period equal to or larger than 25 years.

For reasons already discussed, the NOAA information is used for the MPD, which generates intermediate results between the two other methods, and is an improvement over the current estimates obtained with the SDCHM. NOAA is also a nationally recognized authority on weather analysis, and their method is being incorporated into other southern California public agencies' methods.

Figure 3-5: Comparison of Peak Flow for Garrison Creek at Different Return Periods for Different Rainfall Distributions



Geographic Information System (GIS)

One of the tasks for this study was to develop a Master Plan specific GIS database of MPD facilities. GIS is a program that stores and visually portrays data. By querying the data with specific requests, the user can visualize data in ways to quickly reveal relationships, patterns, and trends. This more detailed geo-spatially referenced data allows for better hydrologic and hydraulic analysis of the storm drainage system. This data could also be used in the future for water quality studies, more detailed system analysis, and to identify potential utility conflicts.

The storm drain facility data was organized according to a GIS template developed by the City. TRWE populated the fields that pertained to the MPD, including the facility size, material, length, slope, invert elevations, as-built plan and date, and editor comments. ESRI's ArcGIS© program was used for this study.

The following steps were used to build the City's storm drain GIS database:

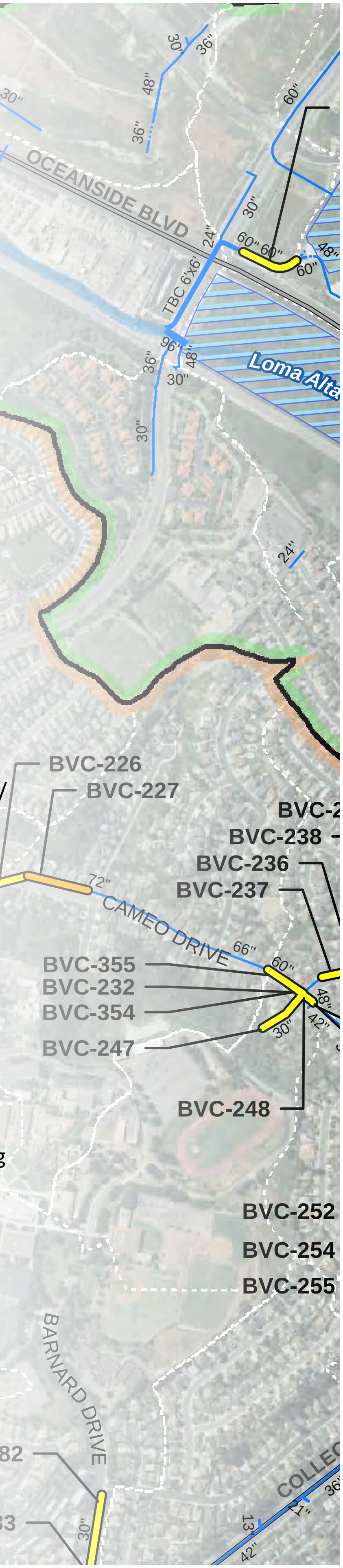
- Utilize the City's GIS template and field GPS data
- Use the City's map atlas to locate as-built plans
- Reference the existing facilities to the aerial mapping
- Locate the facility plans and input the MPD specific data
- Verify data and export to the modeling program

Computer Modeling

At TRWE's recommendation, the City selected xpstorm© (by xp software), a hydrologic/ hydraulic model. It is a dynamic modeling tool for storm water systems based on SWMM that was originally developed by the EPA.

This model identifies system deficiencies, optimizes pond detention, routes parallel flows, and models the timing of hydrographs to give a more accurate representation of flows. Previous master plans used a limited static model that could not accurately model peak flows. Since these older/ traditional models do not adequately represent dual drainage systems (e.g., pipe and street flows together), complex analyses have almost never been attempted, which sometimes results in guesswork and over-designed facilities.

With the surface topography and accurate storm drain data both in GIS, such modeling can be done with greater accuracy. The combined conveyance capacity of the subsurface storm drain and the overland street section can convey design flows, while still maintaining a computed hydraulic grade line or water surface elevation less than a standard gutter section depth. Storm drains that result in flow depths greater than the street section can be categorized as potential problem areas. Detailed elevation information in GIS is essential for modeling these dual drainage systems.



Cost Estimate Basis

Cost estimates for new and upgraded storm drain facilities were based on an opinion of probable construction costs. Costs were estimated on a per linear foot basis for circular storm drain conduits, box culverts and channels (where applicable).

The costs per linear foot of the facility were developed using approximate current construction costs, information from recent construction bid estimates, and from cost information gathered from various agencies and sources. In addition, the current Engineering News Record, Construction Cost Index (ENR CCI) for Los Angeles for January 2013 is noted as 9,437. Future construction cost opinions can be adjusted on the then current ENR CCI value.

Storm Drain Unit Costs

For circular reinforced concrete pipes, the base unit construction costs per linear foot are noted in **Table 3-1** below. The base unit costs for reinforced box culverts are shown in **Table 3-2**.

The total facility costs include the following:

- Removal of existing facility, trenching, bedding, compaction, backfill, trench resurfacing, and potential relocation of existing minor utilities.
- Box culverts include headwall and wing walls.
- Curb inlet and catch basin upgrades, additions, and/or modifications.
- Markups were an additional 50% of base construction cost (see the description of the anticipated markups at the end of this section).

Construction details and quantities are based on the *San Diego Regional Standard Drawings*.

Table 3-1
RCP Storm Drain Facility Unit Cost

Diameter (inches)	Total Facility Costs (per LF)
36	$530
42	$620
48	$720
54	$800
60	$870
66	$920
72	$990
78	$1,040
84	$1,120
90	$1,160
96	$1,220

Table 3-2
RCB Storm Drain Facility Unit Cost

Ht x W (feet)	Total Facility Costs (per LF)
2 x 3	$420
Dbl 3 x 6	$1,390
Dbl 3 x 8	$1,730
Tri 5 x 8	$2,700
5 x 8	$1,080
6 x 8	$1,170

Markups

Markups totaling 50% were applied to the costs for both circular storm drains and box culverts/channels as follows:

Design Services – 25%

- Agency processing and permitting
- Facility design
- Construction drawings and specifications
- As-built plans

Construction Services – 15%

- Contract management
- Utility location services
- Coordination with other utility agencies
- Construction inspection

Contingencies – 10%

- Unforeseen project conditions

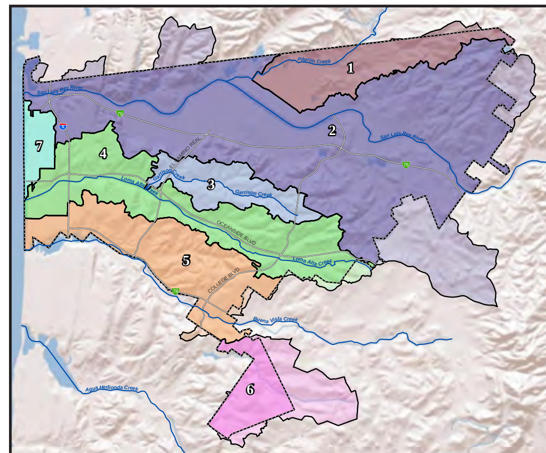
This opinion of probable costs for proposed facility upgrades does not include procurement of easements, right-of-way, environmental costs, and difficult locations. For facilities that were impacted by these potential costs, an additional 20% to 80% cost should be applied on a case-by-case basis.

The opinion of probable costs provided in this MPD update were planning level/ conceptual project estimates, with markups added as noted to account for some of the unknowns. Actual construction costs for new and upgraded facilities may vary due to more detailed site-specific variables typically encountered at final design and construction phase. TRWE does not guarantee the accuracy of the opinion as compared to actual bids or costs to the City.

4. FINDINGS

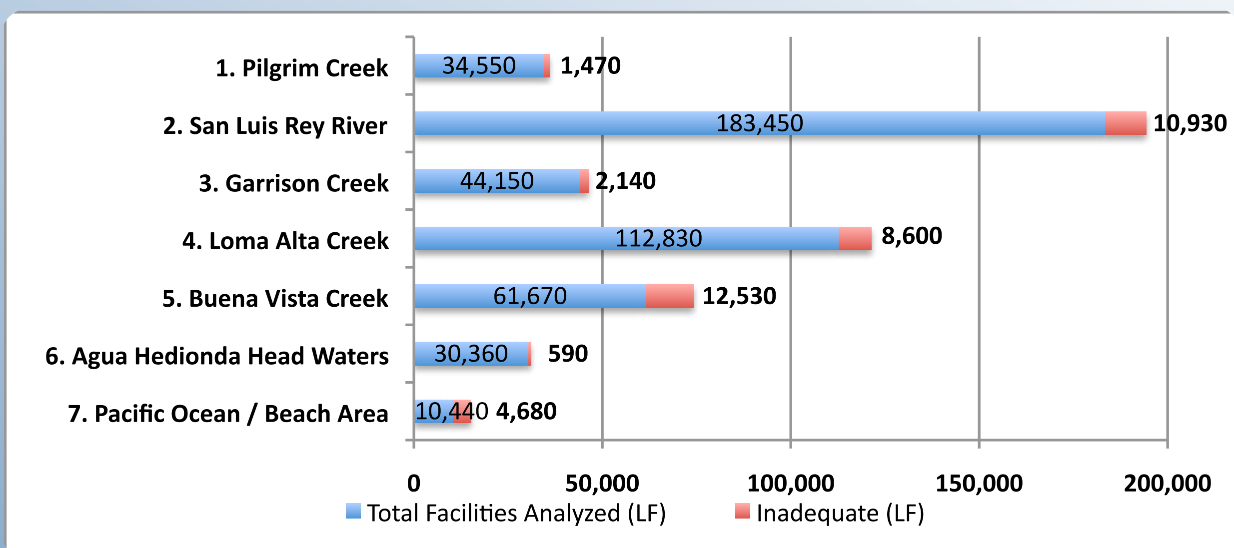
Summary

This section summarizes results of TRWE's analysis for the City's MPD facilities. Existing drainage facilities, 30-inches and larger, were analyzed for the 2-, 10-, 25-, and 100-year storms. Those facilities that overflowed during 2-, 10- and 25-year storms were upsized to carry the 25-year and 100-year storms. Facilities that overflowed during a 100-year storm were upsized to convey the 100-year storm. No facitlities analyzed were inadequate for the 2-year storm. Recommended facility sizes listed are minimum sizes based on hydraulic analysis only; and therefore might be larger in some cases. The following tables, organized by drainage watershed, list the inadequate facilities along with the calculated larger sizes to convey that storm.

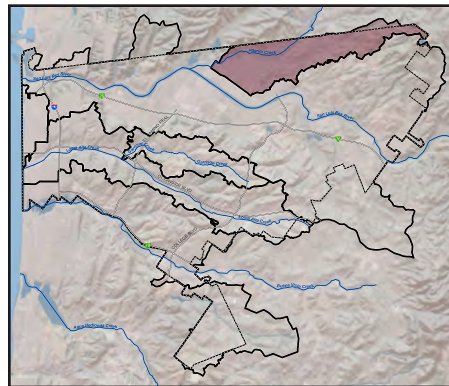


At the end of this report is the **Storm Drain Atlas**. This collection of 11" x 17" maps show only the existing storm drain facilities used in this analysis and if they are adequate to convey the study storms. Existing facilities that were found to be undersized are color-coded for the size of storm that the computer model showed overflowing. The label on the maps corresponds to the facilities on the following tables. Unless otherwise noted, circular facilities include arch and ellipse pipes.

Figure 4-1
Summary of Storm Drain Analysis



Pilgrim Creek Watershed

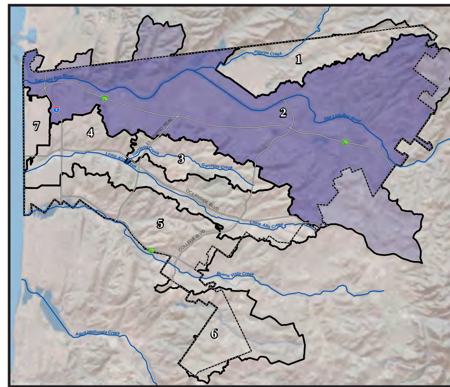


The Pilgrim Creek watershed is in the northern part of the City, and receives some drainage from Marine Corps Base Camp Pendleton. The watershed contains nature preserves along with housing. Flow from Pilgrim Creek joins the San Luis Rey River, west of Douglas Drive. The watershed is 71% residential, 16% agriculture use and 12% open space.

Table 4-1
Pilgrim Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
PC-148	D	CIPP	30	242			●		36
PC-149	D	CIPP	30	498		◆		36	42
PC-179	C	RCP	36	213			●		42
PC-200	D	CIPP	30	517	■			42	60

San Luis Rey River Watershed



The San Luis Rey River watershed is the largest drainage watershed in the city. It drains approximately 560 square miles, with its headwaters at Hot Springs Mountain (elevation 6,400 feet). Upstream flow is controlled by the Lake Henshaw Dam. The US Army Corps of Engineers (Corps) has conducted numerous studies of the river. Corps levees along portions of the river control the higher flows. Within the city, the watershed is 48% residential, 23% agriculture use, and 16% open space.

Table 4-2
San Luis Rey River Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
SLR-7	O	RCP	36	664			●		42
SLR-42	O	Unknown	36	100			●		42
SLR-51	J	Parallel RCPs	42	100			●		48
SLR-52	J		42	100			●		48
SLR-72	I	RCP	33	181			●		42
SLR-90	I	CIPP	72	233			●		78
SLR-92	I	CIPP	72	258			●		78
SLR-120	I	RCP	48	54			●		84
SLR-121	I	RCP	36	37			●		54
SLR-122	I	RCP	30	253			●		36
SLR-123	I	RCP	30	219			●		42
SLR-124	I	RCP	60	522			●		66
SLR-125	I	RCP	60	537			●		66
SLR-127	I	RCP	60	97			●		66
SLR-153	I	Single Box Culvert	6’x8’	68			●		6’x8’
SLR-154	I	Single Box Culvert	6’x8’	20			●		6’x8’

Table 4-2
San Luis Rey River Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
SLR-155	I	RCP	66	428			●		72
SLR-158	I	RCP	60	275			●		66
SLR-188	I	RCP	30	232			●		36
SLR-267	N	CIPP	30	337			●		36
SLR-288	I	RCP	30	296			●		36
SLR-289	I	RCP	30	197			●		36
SLR-300	I	RCP	48	468			●		60
SLR-311	H	RCP	36	346			●		42
SLR-319	H	RCP	30	289			●		36
SLR-320	I	RCP	30	246			●		36
SLR-321	I	RCP	30	257			●		42
SLR-379	H	RCP	60	264			●		66
SLR-424	I	RCP	30	216			●		42
SLR-556	H	RCP	36	148			●		48
SLR-558	H	RCP	36	443			●		48
SLR-559	H	RCP	30	160			●		42
SLR-560	H	RCP	30	104			●		36
SLR-563	H	RCP	30	328			●		48
SLR-603	H	RCP	36	66			●		42
SLR-678	H	RCP	30	98			●		42
SLR-679	H	RCP	30	98			●		42
SLR-680	H	RCP	30	98			●		42
SLR-681	H	Parallel RCPs	24	98			●		48
SLR-685	H		24	98			●		48

Table 4-2
San Luis Rey River Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
SLR-707	C	RCP	30	183			●		42
SLR-725	G	CMP	36	131		◆		42	48
SLR-727	G	CMP	36	28		◆		42	60
SLR-728	G	CMP	36	118		◆		42	60
SLR-732	G	RCP	30	160		◆		48	60
SLR-738	G	RCP	30	37			●		54
SLR-845	H	RCP	36	36			●		42
SLR-861	G	Double Box Culvert	2.5'x5' ea	54			●		Dbl 3' x 6'
SLR-863	G	Single Box Culvert	2'x6'	75			●		Dbl 3' x 6'
SLR-866	A	RCP	33	247			●		48
SLR-885	H	Unknown	30	530			●		36
SLR-909	H	RCP	48	249			●		54

Garrison Creek Watershed

The Garrison Creek watershed is located at the center of the city. It a smaller basin and drains into Loma Alta Creek just west of El Camino Real. The watershed is 62% residential, 20% industrial, 8% institutional and 8% open space.

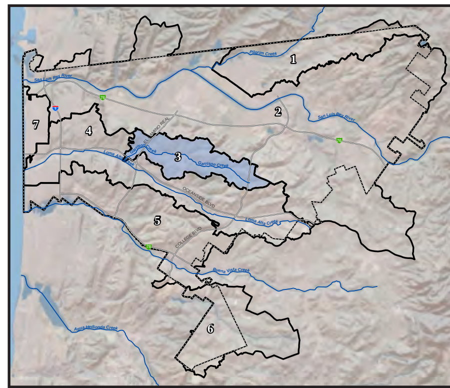
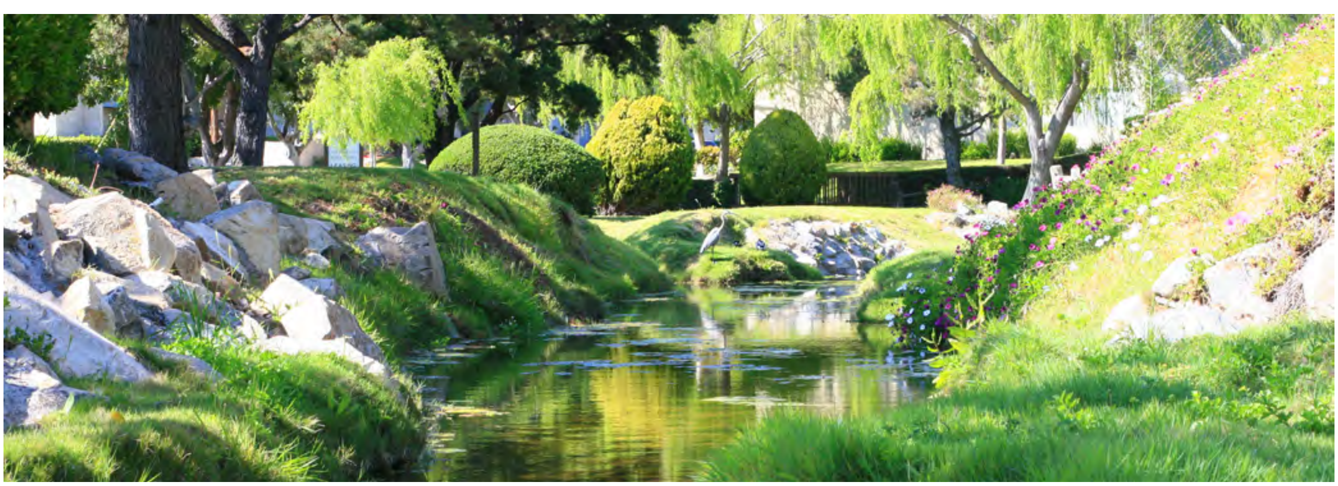


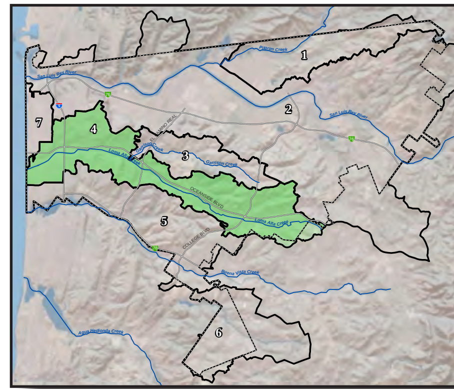
Table 4-3
Garrison Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
GC-97	H	RCP	36	280			●		72
GC-98	H	RCP	36	325			●		60
GC-99	H	RCP	36	50			●		60
GC-170	H	RCP	60	208			●		96
GC-176	G	CIPP (Parallel to 84”)	72	500			●		78
GC-177	G	CIPP (Parallel to 84”)	72	577		◆		78	84
GC-178	H	CIPP	66	171			●		96
GC-191	G	Trapezoidal channel under road	54” deep	31			●		(1)

(1) requires detailed analysis



Loma Alta Creek Watershed



The Loma Alta Creek watershed is over seven square miles in size and is almost all contained within Oceanside. It extends over seven miles inland to an elevation of 640 feet. The watershed is 52% residential, 30% industrial, 9% commercial and 6% open space.

Table 4-4
Loma Alta Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
LAC-43	M	RCP	30	124			●		42
LAC-44	M	RCP	30	45			●		36
LAC-45	M	RCP	30	183			●		36
LAC-46	M	RCP	30	33			●		36
LAC-70	M	CIPP	48	414			●		54
LAC-75	M	CP	48	354			●		54
LAC-76	M	CP	48	233			●		78
LAC-149	M	CIPP	36	78			●		42
LAC-150	M	CIPP	36	194			●		42
LAC-193	L	Rock Lined Channel	60” deep	323			●		(1)
LAC-247	M	Triple Box Culvert	5’ x 6’ ea	53			●		5’ x 8’ ea

(1) requires detailed analysis

Table 4-4
Loma Alta Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
LAC-422	M	RCP	30	147			●		36
LAC-489	G	CMPE	42	446	■			54	66
LAC-490	G	RCP	36	56	■			48	60
LAC-501	F	RCP	30	207		◆		42	48
LAC-502	F	RCP	30	68			●		42
LAC-504	F	RCP	36	40			●		42
LAC-505	F	RCP	36	56			●		48
LAC-507	F	RCP	36	87			●		48
LAC-528	F	RCP	30	41	■			42	54
LAC-529	F	RCP	30	71	■			42	54
LAC-530	F	CMP	24	18	■			30	36
LAC-557	F	RCP	60	152			●		66
LAC-558	F	RCP	60	607			●		78
LAC-559	F	RCP	60	200			●		66
LAC-562	F	RCP	72	325			●		78
LAC-563	F	RCP	72	342			●		78
LAC-565	F	Single Box Culvert	5’ x 6’	43			●		5’ x 8’
LAC-570	F	Single Box Culvert	5’ x 6’	142			●		5’ x 8’
LAC-572	F	RCP	36	30			●		42
LAC-578	F	Parallel RCPs	24	99			●		60
LAC-579	F		24	99			●		60
LAC-587	F	RCP	36	138			●		42
LAC-601	F	RCP	54	237			●		60
LAC-602	F	RCP	54	109			●		60
LAC-603	F	RCP	48	242			●		60

Table 4-4
Loma Alta Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
LAC-604	F	RCP	48	139			●		72
LAC-605	F	RCP	54	306			●		60
LAC-606	F	RCP	54	214			●		72
LAC-617	F	RCP	30	140			●		36
LAC-630	F	Double Box Culvert	3’ x 5 ‘ ea	76			●		3’ x 8’ ea
LAC-634	F	Single Box Culvert	5’ x 6’	187			●		5’ x 8’
LAC-636	F	Parallel CMPEs	42	78			●		48
LAC-637	F	Parallel CMPEs	27	78			●		36
LAC-638	F	Parallel CMPEs	42	78			●		48
LAC-639	F	Parallel CMPEs	27	78			●		36
LAC-689	F	RCP	30	150			●		42
LAC-717	G	CMPE	36	23	■			36	42
LAC-718	G	CMPE	36	307			●		66
LAC-719	G	CMPE	36	41	■			48	60
LAC-730	F	Concrete Open Channel	48 deep	674			●		54

Buena Vista Creek Watershed

The Buena Vista Creek watershed is in the southern portion of the city. This watershed also receives part of its flow from the City of Carlsbad to the south. Buena Vista Creek generally follows State Route 78, which is predominately commercial development. The watershed is 69% residential land, 19% commercial and 7% open space.

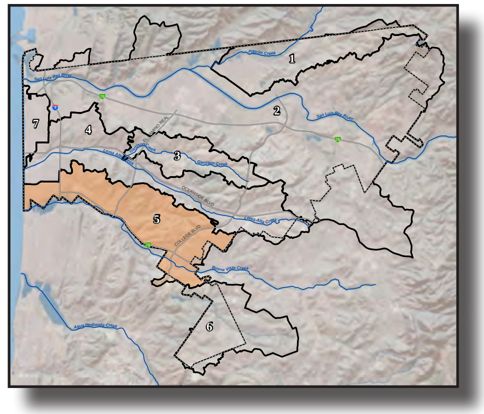


Table 4-5
Buena Vista Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
BVC-2	K	Single Box Culvert	1’x3’	90			●		2’ x 3’
BVC-78	K	RCP	60	356		◆			72
BVC-79	K	RCP	60	142			●		72
BVC-81	L	CIPP	48	100		◆		54	72
BVC-82	L	CIPP	48	106			●		72
BVC-85	L	CIPP	48	325			●		72
BVC-89	K	RCP	36	128			●		48
BVC-102	L	RCP	42	52		◆		54	66
BVC-103	L	RCP	42	20		◆		54	66
BVC-109	L	RCP	30	273			●		48
BVC-126	P	RCP	30	72			●		42
BVC-127	P	RCP	30	118			●		36
BVC-129	P	RCP	30	40			●		48
BVC-134	P	RCP	30	112			●		36
BVC-136	P	RCP	36	355			●		42
BVC-138	L	SRSP	72	496			●		84
BVC-139	L	SRSP	72	311			●		84
BVC-140	L	SRSP	72	193			●		84

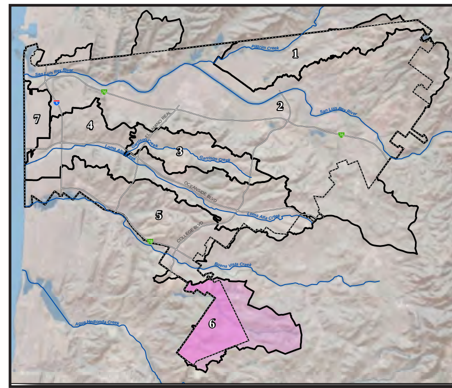
Table 4-5
Buena Vista Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
BVC-141	L	SRSP	72	503			●		84
BVC-179	L	RCP	30	225			●		36
BVC-183	L	RCP	30	260		◆		36	42
BVC-184	L	RCP	30	191		◆		36	42
BVC-185	L	RCP	30	281	■			42	48
BVC-186	L	RCP	30	175	■			42	54
BVC-187	L	RCP	36	168		◆		48	54
BVC-188	L	RCP	36	108		◆		54	60
BVC-189	L	RCP	42	294			●		60
BVC-190	L	RCP	42	108			●		54
BVC-191	L	RCP	42	61			●		54
BVC-198	L	RCP	48	96			●		54
BVC-199	L	RCP	48	17			●		60
BVC-224	L	CIPP	36	248			●		42
BVC-226	L	RCP	72	279			●		84
BVC-227	L	CIPP	72	341		◆		78	84
BVC-231	L	CIPP	48	76			●		72
BVC-232	L	CIPP	60	105			●		72
BVC-236	L	CIPP	30	37			●		36
BVC-237	L	CIPP	30	162			●		36
BVC-238	L	CIPP	30	241			●		36
BVC-239	L	CIPP	30	271			●		36
BVC-243	M	RCP	30	50			●		42
BVC-247	L	RCP	30	143			●		36
BVC-248	L	RCP	30	151			●		36

Table 4-5
Buena Vista Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
BVC-252	L	CIPP	42	361			●		54
BVC-254	L	CIPP	42	90			●		54
BVC-255	L	CIPP	42	87			●		48
BVC-258	M	RCP	36	274			●		54
BVC-259	M	RCP	30	57		◆	●	42	54
BVC-264	P	RCP	42	127			●		48
BVC-282	L	RCP	30	351			●		36
BVC-283	L	RCP	33	380			●		36
BVC-287	P	CMP	72	57			●		78
BVC-289	P	CMP	72	709			●		78
BVC-321	P	RCP	42	25			●		48
BVC-322	P	RCP	36	290		◆		42	54
BVC-323	P	RCP	36	15		◆		42	48
BVC-324	P	RCP	36	202			●		48
BVC-325	P	RCP	30	35		◆		42	54
BVC-326	P	RCP	30	40			●		54
BVC-330	P	RCP	48	210			●		54
BVC-353	L	CIPP	60	68			●		72
BVC-354	L	CIPP	60	105			●		72
BVC-355	L	CIPP	60	116			●		72

Agua Hedionda Head Waters Watershed

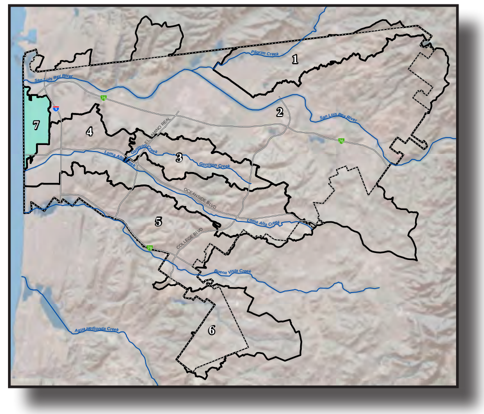


This drainage area tributary to Aqua Hedionda Creek (south of the city) is in the very southern portion of Oceanside. Drainage is into Calavera Creek and Little Encinas Creek, which also run through the City of Carlsbad to Agua Hedionda Creek and then to the Pacific Ocean. This watershed is predominately residential (89%) that has been mostly developed.

Table 4-6
Agua Hedionda Head Waters Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
AH-1	P	RCP	30	29			●		36
AH-2	P	RCP	30	115			●		36
AH-10	P	RCP	60	174			●		66
AH-98	Q	RCP	30	276			●		36

Pacific Ocean/Beach Area Watershed



The Pacific Ocean/Beach Area is located at the western edge of the city, along the Pacific Ocean. This one square mile area is an older section of the city with many smaller homes and apartments. Most of the drainage is carried by street flow in steeper areas and by pipes in the flatter areas. This older area of the city is 59% residential and 32% commercial land use.

Table 4-7
Pacific Ocean/Beach Area Watershed
Computed Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Min. Storm for Inadequate Facility			Recommended Size to Convey	
		Facility Type	Size (inches)	Length (feet)	10-year	25-year	100-year	25-year	100-year
PO-9	F	RCP	42	41			●		48
PO-10	F	RCP	48	111			●		54
PO-11	F	CIPP	48	26			●		66
PO-13	F	CIPP	42	450			●		48
PO-15	F	CIPP	48	85			●		54
PO-16	F	RCP	48	61			●		54
PO-18	A	RCP	36	285			●		42
PO-19	A	RCP	30	584			●		36
PO-22	A	RCP	36	52	■			48	66
PO-23	A	RCP	36	364	■			54	66
PO-24	A	RCP	36	139		◆		48	66
PO-25	A	RCP	36	422		◆		42	60
PO-26	A	RCP	36	234	■			48	66
PO-27	A	RCP	30	52	■			36	48
PO-36	A	RCP	36	338	■			54	60
PO-37	A	RCP	36	756	■			72	72
PO-38	A	RCP	36	384	■			54	66
PO-39	A	RCP	30	301			●		36

Drainage District Fees

Periodically, a city needs to re-examine fees charged for drainage improvements. This updated MPD may be used to adjust or confirm drainage district fees. California Assembly Bill 1600 (Gov. Code, Sec 66000 et. seq.) requires that a public agency determine a reasonable relationship between the fees collected and the cost of public facilities.

The cost for drainage improvements have traditionally divided into two components; major watercourse facilities necessary to provide for the river/creek storm water runoff to the Pacific Ocean, and local facilities which carry runoff from the smaller drainage basins to the major watercourse. A local facility is defined as a MPD facility, having an equivalent conveyance to a 36-inch RCP or larger.

Existing drainage fees by Drainage District have been adopted by Ordinance No. 85-23 and Resolution No. 06-R0335-1. It is recommended, for now, that those fees remain the same, as shown below. This MPD is a stand alone document and does not attempt to update the fee structure.

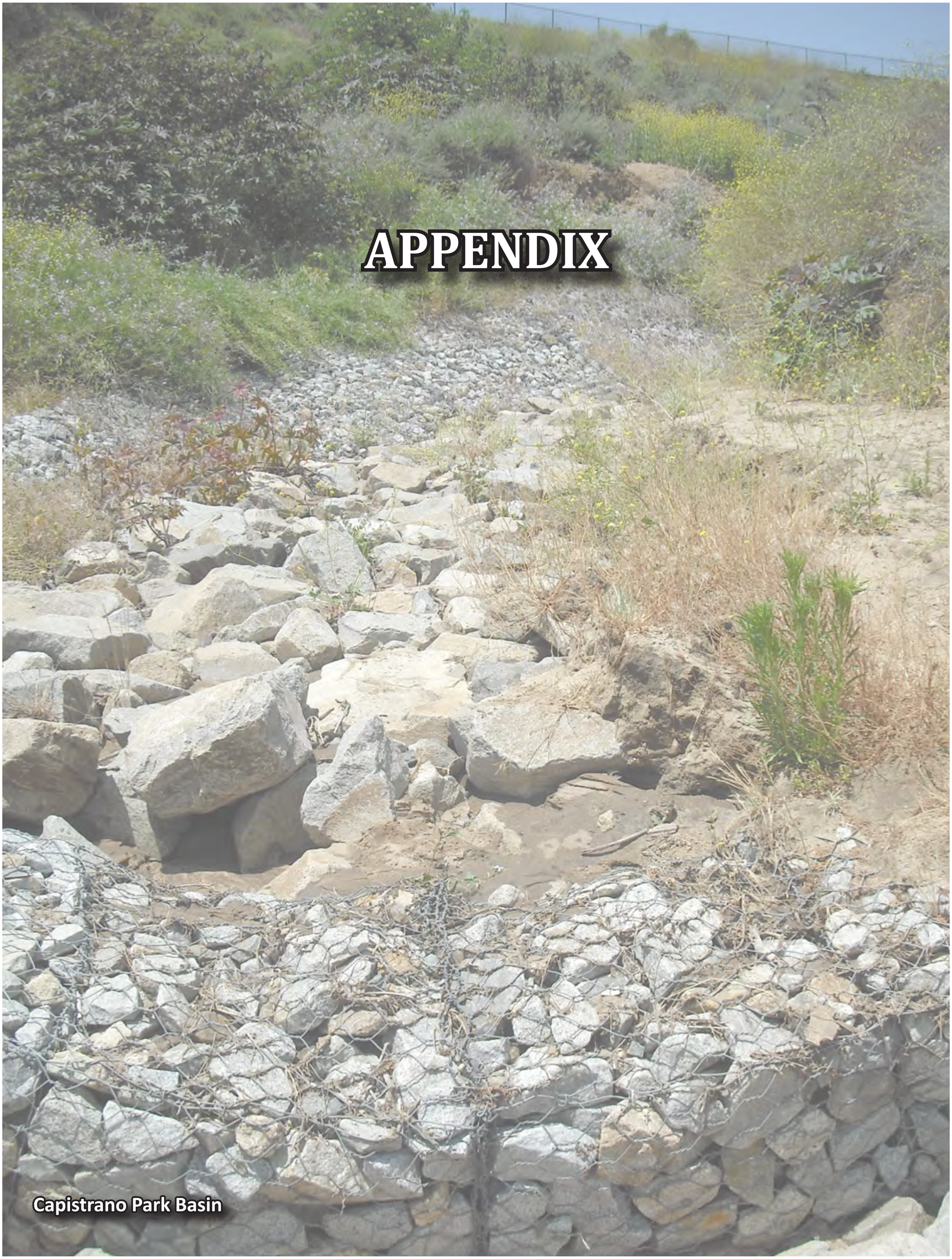
Table 4-9
Drainage District Fees (per acre)

Drainage District	General Watershed Location	Major Watercourse Component	Local Facility Component	Total
I-a	San Luis Rey River	$3,842	$7,500	$11,342
I-b	San Luis Rey River	$3,842	$3,842	$7,684
I-c	San Luis Rey River	$3,842	$0	$3,842
I-d	San Luis Rey River, Pilgrim Creek	$3,842	$4,870	$8,712
II-a	Loma Alta Creek, Garrison Creek	$8,611	$7,353	$15,964
II-b	Loma Alta Creek	$8,611	$4,766	$13,377
III-a	Buena Vista Creek	$1,459	$2,460	$3,919
IV	Agua Hedionda Head Waters	$0	$5,988	$5,988
V	Pacific Ocean / Beach Area	$0	$2,843	$2,843

Drainage facilities required by new development should be financed by new development. As conditions of approval of a final Subdivision Map or building permits, the City may require the developer to construct all Master Plan facilities located on site at the developer's expense, with possible partial reimbursement from fees collected previously from other developers in the watershed.

In addition, the developer should fulfill one of the following alternatives to finance offsite drainage facilities:

1. Pay development impact fees for planned local drainage facilities established by local ordinance under the Subdivision Map Act.
2. Participate in formation of a drainage improvement district. If an improvement district is formed, a portion of the assessments may be credited against impact fees.
3. The developer may construct, as his/her expense, all those facilities required to serve his/her project and connect to any existing adequate facilities. Portions of these expenses may be reimbursed later if an improvement district is formed. The cost of construction of Master Plan facilities may be credited against assessments or fees.


APPENDIX
Capistrano Park Basin

Appendix A

Loma Alta Creek – Optimization Study

Loma Alta Creek has a history of periodically overtopping its banks and flooding adjacent properties. A vast majority of the more flood prone areas are downstream (west) of El Camino Real. These areas include commercial and industrial properties along Industry Street and Oceanside Boulevard, adjacent to the creek. Many properties west of Interstate 5, mostly residential, are also prone to flooding in major storm events.

This problem was identified and studied years ago, and subsequently, three regional detention basins were designed to reduce the flood risks. Two of the detention basins have been designed and constructed (Garrison and El Camino Real); one remains to be constructed (Rancho Del Oro).

The frequency of flooding along Loma Alta Creek has increased with new development within the watershed and with encroachment within the floodplain and floodway. TRWE prepared an initial evaluation of ways to reduce flood risks along Loma Alta Creek, and primarily downstream of El Camino Real. Generally, the two primary means to reduce flood risk within a watershed are to reduce flood peak flows and/or to increase flood conveyance capacity. Therefore, possible solutions could include one or both means in some combination. The goal of this study was to identify an optimal approach to reduce flood risks by studying both means.

Toward that end, TRWE prepared several analyses that would assist in our evaluation. We prepared a precipitation analysis, which is summarized in **Section 3** and **Appendix C** of the MPD. We also prepared a new hydrologic analysis of the watershed, using xpswmm, which will also be useful for any future watershed studies. Lastly, TRWE prepared an optimization analysis, which consisted of two parts: a peak flow reduction optimization and a flow conveyance optimization. The precipitation and hydrologic analyses were used for the peak flow reduction analysis.

The peak flow reduction optimization analysis evaluated a number of modifications (and combinations of those modifications) to the three regional detention basins and to the Collins detention basins. Other potential detention basin locations were also evaluated. Our study found that any significant reductions in peak flows as a result of modifications to detention basins were essentially canceled out by a number of constraints:

1. The designs of the existing and proposed detention basins maximized the storage volumes of floodwater, based on a previous hydrologic methodology and criteria, which although acceptable at the time of design, presented a constraint for expanding the volumes of the basins.
2. Flow-through detention basins constructed in series are generally less efficient than basins constructed in parallel, since flow reductions tend to diminish as water is conveyed downstream.
3. The lower portion of the watershed is mostly built out. Much of the flow conveyed in Loma Alta Creek is generated from these downstream areas of the watershed, which reduces the effectiveness of upstream detention. No feasible locations for new detention in the lower portion of the watershed were identified, due to the built-out condition, including existing encroachment into the floodplain.

Our flow conveyance optimization analysis evaluated a number of alternative channel sections downstream of El Camino Real. Due to the lack of significant peak flow reduction from the other analyses, however, we determined that the opportunities for reducing flood risks through flow conveyance optimization were minimal without loss of property. This analysis also clearly demonstrated that the improvements made by the North County Transit District (NCTD) to the rail have significantly affected capacity and conveyance options. NCTD is the majority property owner of Special Flood Hazard Area (SFHA) designated land, located adjacent to Loma Alta Creek within the Optimization Study area. Therefore, City staff has recommended and encouraged NCTD staff to respond to the SPRINTER project impacts by forming and administering a Loma Alta Creek vegetation management assessment district. Annual financial contributions toward vegetation management within the assessment district should be divided proportionally; taking into consideration the land owner's percentage share land within the total assessment district area, as well as all respective benefits realized.

One additional analysis we performed was a very preliminary analysis that would incorporate the El Corazon pit at the northeast corner of El Camino Real and Oceanside Boulevard. This existing pit could retain a significant volume of storm flow and could feasibly be connected to either (or both) the Garrison Creek or El Camino Real detention basins. This concept is based on setting an overflow elevation in one of (or both) detention basins, such that the pit would receive flow only in very rare and severe storms (e.g., greater than 25-year or 50-year). Our preliminary analysis indicates this concept could greatly reduce downstream flooding impacts of extreme storm events. We recommend this concept be studied in more detail to determine the actual flow reduction that could be achieved.

In summary, the Loma Alta Creek optimization study indicates that a number of constraints combine to make potential flood risk reduction solutions problematic on a systematic basis. Flood protection measures on a property by property basis remain viable in many cases, however. Further study to incorporate the use of the El Corazon pit could yield a significant reduction in flood risk for extreme storm events.

Appendix B

Drainage System Design Criteria Memo

The City of Oceanside's "Drainage System Design Criteria" was last revised in 1992. It is incorporated into the City's "Engineers Design and Processing Manual" as Section 6. TRWE has reviewed this section and recommends its replacement with the more recent San Diego County Drainage Design Manual (DDM). Reasons for this recommendation include the fact that there have been a number of changes in methods and materials since 1992; also, the DDM was a rather thorough county-wide effort, carefully prepared by a team of engineering consultants and a Technical Advisory Committee (TAC).

The initial effort to prepare the DDM was completed in 2005, and the DDM was just recently updated, again with a project consultant and a TAC. Tory Walker was actively involved on the TAC for both efforts. The stated purpose of the DDM is as follows:

1.1 PURPOSE AND SCOPE

This Drainage Design Manual (Manual) establishes design standards and procedures for stormwater drainage and flood management facilities in San Diego County, California. These design standards and procedures provide guidance to local jurisdictions, design engineers, developers, contractors, and others in the selection, design, construction, and maintenance of stormwater drainage and flood management facilities. This Manual covers the following topics:

- Street Drainage and Inlets
- Storm Drains
- Culverts
- Open Channels
- Detention Basins
- Energy Dissipaters
- Debris Basins and Barriers

This manual limits its content to the planning and design infrastructure in the context of stormwater conveyance and flood management. For issues of stormwater quality, readers are directed to other resources, specifically the San Diego County Stormwater Standards Manual.

As noted above, the DDM was prepared with the intention of establishing design standards and procedures that would provide guidance throughout San Diego County. As part of the TAC, first in 2004 and 2005, then again in 2011 and 2012, Tory Walker and other TAC members spent many hours reviewing and making recommendations to incorporate into the DDM design standards, procedures and methods commonly used elsewhere in southern California. Most of these recommendations were accepted and were incorporated into the DDM.

Some of the publications reviewed for the DDM were included in the references (Section 5.3), but in addition to those listed in the references, the TAC reviewed and considered all the other southern California county drainage design manuals.

Because Los Angeles County's "Hydraulic Design Manual" was generally understood to be the standard by which to compare, and most other county manuals borrowed heavily from that manual, the TAC recommended limiting the list of references. Additional publications reviewed and considered included ones from Caltrans, Clark County (NV), Federal Highway Administration, U.S. Army Corps of Engineers, and American Public Works Association.

The extensive review of the various design standards, procedures and methods generated hours of discussion, drafts and revisions to the DDM. It is our opinion that, with the completion of the most recent revision, the DDM meets the goal of establishing drainage design criteria standards and procedures that should be used county-wide. Thus, it is our recommendation that the most recent DDM be adopted by the City and replace the 1992 "Drainage System Design Criteria."

Appendix C

TRWE Precipitation Analysis

The precipitation intensity-duration-frequency (IDF) curve most widely used in San Diego County (contained in the 2003 *San Diego County Hydrology Manual*) has been shown to be not supported by a statistical analysis of hourly rainfall data, and consequently, unrealistic and overly conservative for durations of less than one hour. Therefore, TRWE analyzed the existing Oceanside hourly precipitation data to determine a more realistic IDF curve based upon precipitation gauge measurements taken since 1951.

Data for our analysis came from hourly data used for continuous simulations, obtained from the Project Clean Water (PCW) web site (***http://projectcleanwater.org/html/wg_susmp.html***), as well as average data obtained from the Western Regional Climate Center (WRCC) on its web page *(****http://wrcc.dri.edu/summary/Climsmsca.html***), combined with detailed hourly data purchased from WRCC. We also used a correlation analysis from different data sets in Oceanside and the best data in the County (San Diego Lindbergh Station) to improve the data analysis. These improvements included filling gaps and establishing better values of intensities valid for Oceanside.

The reason for this detailed analysis is clearly seen from the extreme differences found in peak flows obtained from continuous simulations (2-, 5-, 10-, 25-and 50-year peak flows) and the peak flows estimated from synthetic storm analysis in the *San Diego County Hydrology Manual* (SDCHM). In some cases, such differences can be more than one order of magnitude. These differences are due to multiple factors, including:

1. Extremely conservative approach to the determination of intensities for durations of less than one hour. The mathematical power-law equation recommended in the SDCHM ($I = k/t_n$) does not correspond with the best possible adjustment of the data, but also has the inconvenience of infinite intensity when the time of duration "t" reduces to zero. The *Handbook of Hydrology* recommends a better approach to avoid this mathematical obstacle: $I = k/(t + c)^n$. The additional constant "c" will force the intensity "I" to have a finite maximum value, even for a duration t=0 minutes, which is consistent with physical observations. Also, the addition of a constant c makes the power law equation a particular case of the more general intensity equation, and significantly reduces the intensity when the time of concentration is very low (10 minutes or less).
2. Single storm analyses were highly dependent on the time of concentration, which is most often smaller than 15 minutes for sub-areas, while continuous simulation analysis is associated with hourly data and consequently hourly peak flows. In other words, continuous simulation models using hourly precipitation data generate peak flows that were hourly in duration, while single storm event peak flows were instantaneous in duration. As there is a underestimation in continuous simulation associated with a 1-hour time interval, and as there is an overestimation associated with the power law intensity (especially for times of concentration less than 15 minutes), these modeling approaches

generate significant differences in peak flow.

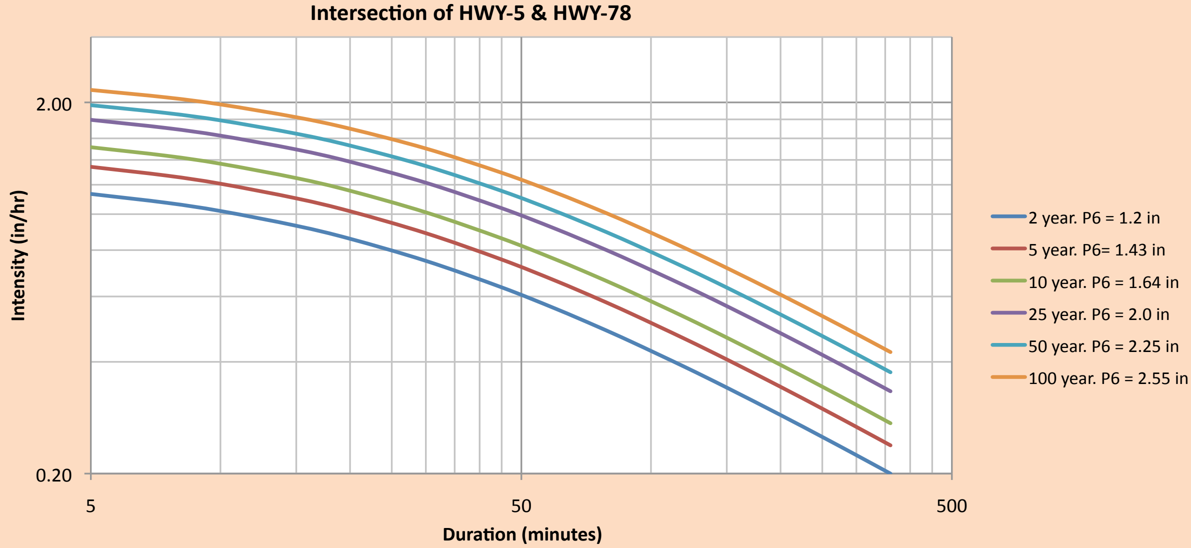
3. Elimination of the artificial disaggregation of the precipitation data in Oceanside. Seven percent of the data used for continuous simulation in Oceanside was improperly disaggregated in the recent HMP county-wide effort; this percentage increases to 11% for intensities larger than 0.5 in/hr. We performed a proper disaggregation of the data that preserves the statistical properties of the original data and does not generate artificial storms with a synthetic distribution that does not actually occur in nature.
4. Elimination of the aggregation of the data at the 0.1 inch level. This process artificially generates hourly intensities that can only occur in 0.1 in/hr increments and distorts the real intensity distribution. We used improved statistical analysis that takes into consideration the intensity-duration curve of the time periods where the data was collected with greater precision.
5. Inexact nature of the runoff (C) coefficient in single storm analysis. The C coefficient according to the SDCHM is independent of the intensity, which differs from all other hydrology manuals in Southern California (Los Angeles, Orange County, Riverside, San Bernardino and Ventura). A better definition of the C coefficient would give a more accurate estimation of the peak flow, especially for smaller storms.

As part of this task, TRWE studied in detail the “n, d” largest extreme events, with “n” being the number of years where data was properly obtained, and “d” the duration value selected (1, 2, 3, 4, 5, 6, 8, 10, 12, 15, 18, 21 and 24 hours). Those events were analyzed at different durations in order to properly extrapolate the intensity at shorter time intervals, and generate an adequate intensity-duration curve.

Figure C-1 shows the complete intensity-duration curves obtained for Oceanside for a specific location with values of P_6 given by the SDCHM Maps.

The

Figure C-1
Intensity-Duration Curves Example
Intersection of HWY-5 & HWY-78



mathematical representation of the intensity vs. duration curves, as a function of the Period of Return T (from 2 to 100 years), the 6-hour precipitation value P_6 obtained from the SDCHM isopluvial Maps (inches), and the duration desired (t in hours) can be summarized by the following equations:

$I = A \cdot P_6 \cdot (t+B)^{-0.675}$; A and B were obtained with equations below:

$A = 0.1667 \cdot (6+B)^{0.675}$; $B = 0.407 + 0.027(\log(T-1))^2 - 0.0067(\log(T-1))$

It is evident from the equations that for t = 6 hours, $I = P_6/6$.

Figure C-2 shows a comparison of the precipitation distribution obtained with the proposed equation vs. the current SDCHM distribution. It is clear that the new distribution significantly reduces the extremely large intensity values that were obtained as a consequence of a power-law model.

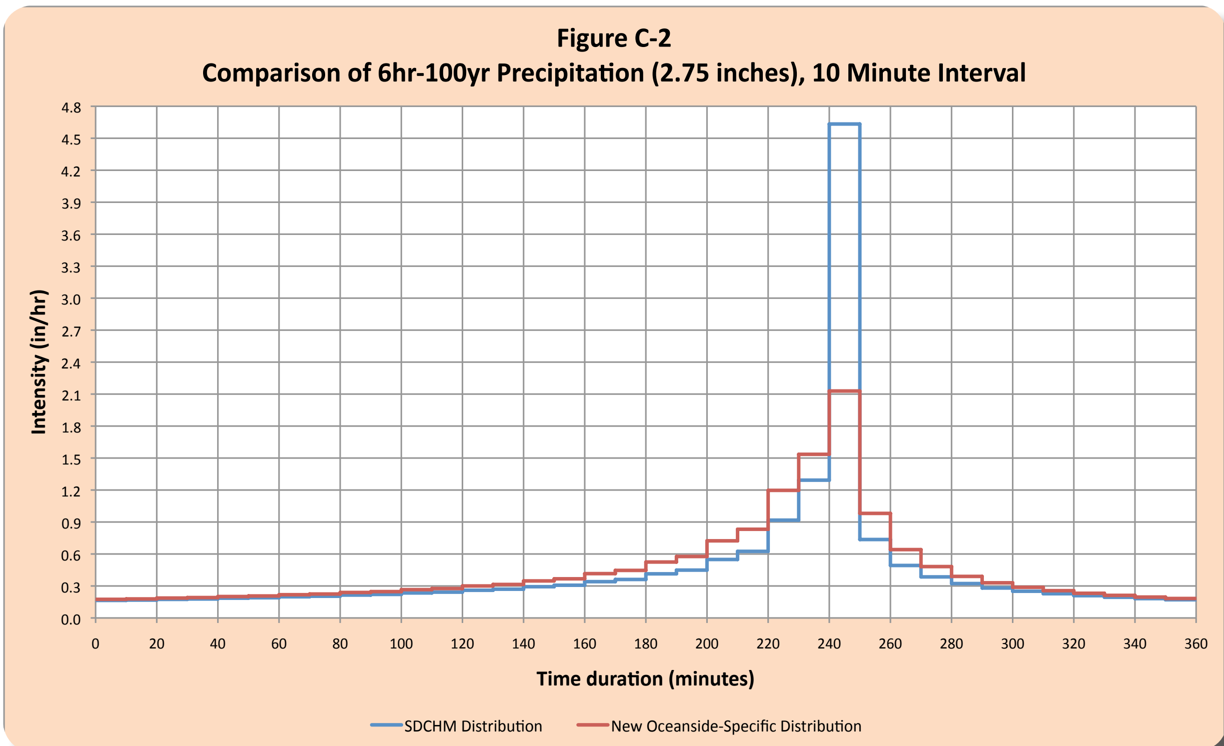
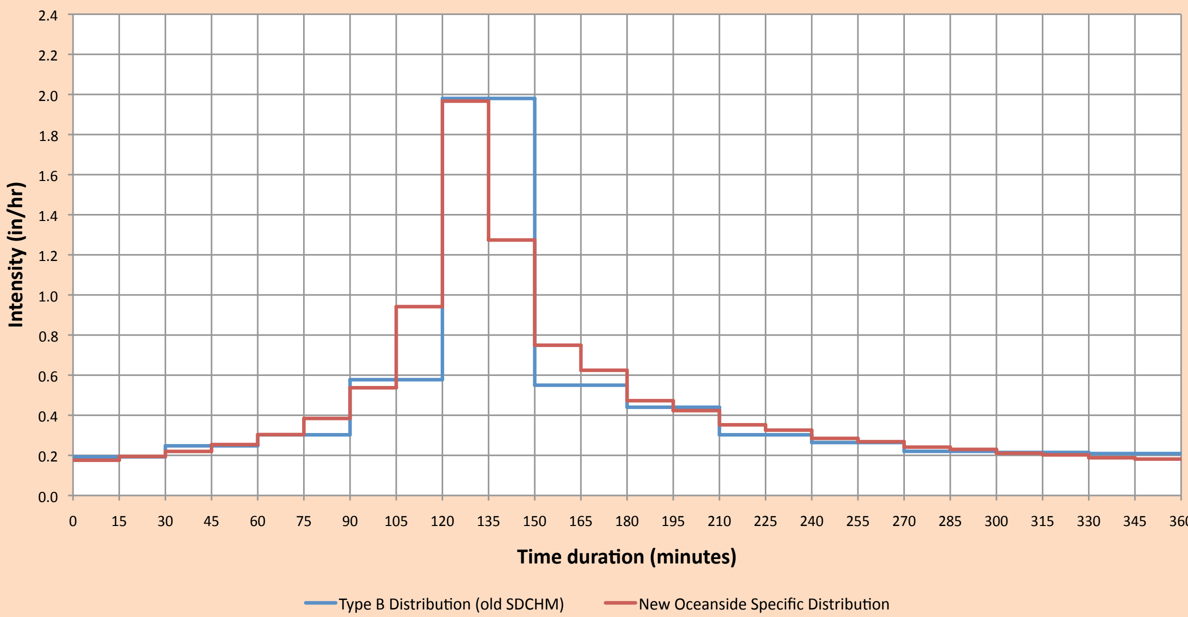


Figure C-3 shows a comparison of the new precipitation distribution vs. the previous Type B distribution from the 1993 SDCHM. It is interesting to note the similarity between the peaks. However, our statistical analysis suggests that the placement of the peak is closer to the 2/3 principle of the current SDCHM (after 4 hours for a 6-hour storm and after 16 hours for a 24-hour storm). Therefore, the use of the intensity equation suggested here for Oceanside, coupled with the Synthetic Precipitation Distribution Methodology of the SDCHM, is the best alternative to simulate precipitation conditions in Oceanside.

Figure C-3
Comparison of 6hr-100yr Precipitation (2.75 inches), 15 Minute Interval



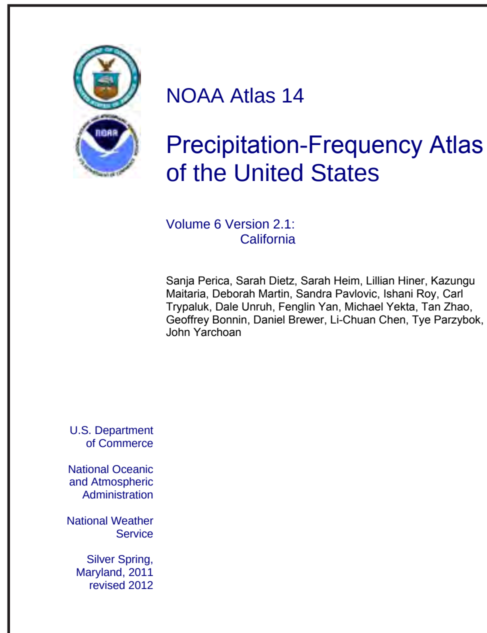
Precipitation Time Series for Continuous Simulation Analysis

As most of the time series analysis of precipitation performed for the previous task can be useful for continuous simulation purposes, TRWE improved the intensity-duration curve at an hourly level plus the extrapolation analysis that allowed building continuous time series with a time interval of 15-minutes and 30-minutes. Those time series were generated in such a way that the statistical properties of the rainfall distribution were preserved, and those series can be used for continuous simulation depending on the time of concentration of the potential project. Establishment of time series with shorter time interval increased the peak flows and generated more realistic values, and significantly reduced differences between continuous analysis and single storm analysis.

Appendix D

NOAA Method Reference Materials

For this MPD update it was decided to use the rainfall analysis method as detailed in ***"NOAA Atlas 14, Precipitation-Frequency Atlas of the United States, Volume 6 Version 2.1: California, revised 2012."*** This document provides information on the underlying data and functioning of the PFDS.



NOAA Atlas 14

Precipitation-Frequency Atlas of the United States

Volume 6 Version 2.1: California

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

U.S. Department of Commerce

National Oceanic and Atmospheric Administration

National Weather Service

Silver Spring, Maryland, 2011 revised 2012

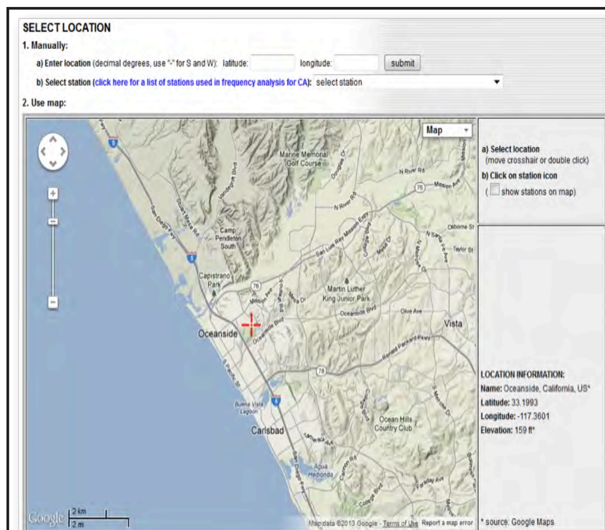
Data is kept on NOAA's Precipitation Frequency Data Server (PFDS), which is described as:

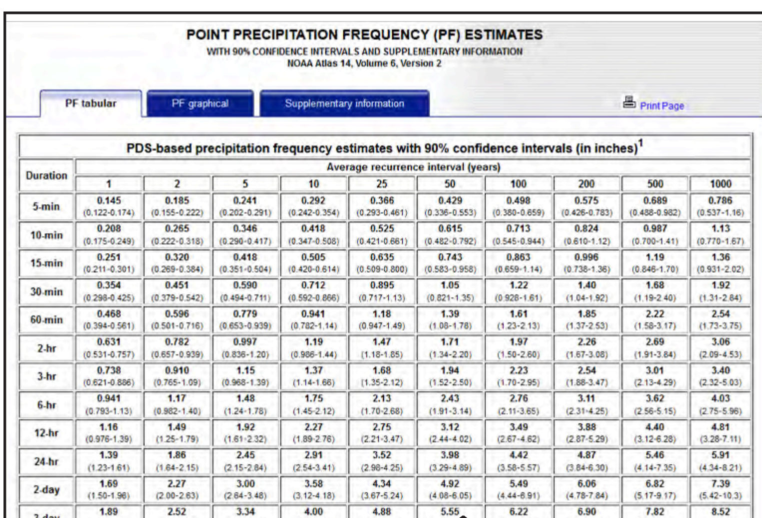
> *"The Precipitation Frequency Data Server (PFDS) is a point-and-click interface developed to deliver NOAA Atlas 14 precipitation frequency estimates and associated information. Upon clicking a state on the map above or selecting a state name from the drop-down menu, an interactive map of that state will be displayed. From there, a user can identify a location for which precipitation frequency estimates are needed.*

> *"Estimates and their confidence intervals can be displayed directly as tables or graphs via separate tabs. Links to supplementary information (such as ASCII grids of estimates, associated temporal distributions of heavy rainfall, time series data at observation sites, cartographic maps, etc.) can also be found."*

The following procedure may be used for obtaining NOAA Atlas 14 rainfall data:

- Go to NOAA's PFDS at, ***http://hdsc.nws.noaa.gov/hdsc/pfds/index.html***
- Select California from the drop down menu, or from the figure.
- Navigate to your desired location by entering latitude and longitude, selecting a rain gage station, or by zooming and double clicking on the map.
- After selecting a point location on the map, Point Precipitation Frequency Estimates will be displayed in a table for the selected point. The data may be printed or exported to a file in csv format.





POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION

NOAA Atlas 14, Volume 6, Version 2

PF tabular | PF graphical | Supplementary information | Print Page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.145 (0.122-0.174)	0.185 (0.155-0.222)	0.241 (0.202-0.291)	0.292 (0.242-0.354)	0.366 (0.293-0.461)	0.429 (0.336-0.553)	0.498 (0.380-0.659)	0.575 (0.426-0.783)	0.689 (0.488-0.982)	0.786 (0.537-1.16)
10-min	0.208 (0.175-0.249)	0.265 (0.222-0.318)	0.346 (0.290-0.417)	0.418 (0.347-0.508)	0.525 (0.421-0.661)	0.615 (0.482-0.792)	0.713 (0.545-0.944)	0.824 (0.610-1.12)	0.987 (0.700-1.41)	1.13 (0.770-1.67)
15-min	0.251 (0.211-0.301)	0.320 (0.269-0.384)	0.418 (0.351-0.504)	0.505 (0.420-0.614)	0.635 (0.509-0.800)	0.743 (0.583-0.958)	0.863 (0.659-1.14)	0.996 (0.738-1.36)	1.19 (0.846-1.70)	1.36 (0.931-2.02)
30-min	0.354 (0.298-0.425)	0.451 (0.379-0.542)	0.590 (0.494-0.711)	0.712 (0.592-0.866)	0.895 (0.717-1.13)	1.05 (0.821-1.35)	1.22 (0.928-1.61)	1.40 (1.04-1.92)	1.68 (1.19-2.40)	1.92 (1.31-2.84)
60-min	0.468 (0.394-0.561)	0.596 (0.501-0.716)	0.779 (0.653-0.939)	0.941 (0.782-1.14)	1.18 (0.947-1.49)	1.39 (1.08-1.78)	1.61 (1.23-2.13)	1.85 (1.37-2.53)	2.22 (1.58-3.17)	2.54 (1.73-3.75)
2-hr	0.631 (0.531-0.757)	0.782 (0.657-0.939)	0.997 (0.836-1.20)	1.19 (0.986-1.44)	1.47 (1.18-1.85)	1.71 (1.34-2.20)	1.97 (1.50-2.60)	2.26 (1.67-3.08)	2.69 (1.91-3.84)	3.06 (2.09-4.53)
3-hr	0.738 (0.621-0.886)	0.910 (0.765-1.09)	1.15 (0.968-1.39)	1.37 (1.14-1.66)	1.68 (1.35-2.12)	1.94 (1.52-2.50)	2.23 (1.70-2.95)	2.54 (1.88-3.47)	3.01 (2.13-4.29)	3.40 (2.32-5.03)
6-hr	0.941 (0.793-1.13)	1.17 (0.982-1.40)	1.48 (1.24-1.78)	1.75 (1.45-2.12)	2.13 (1.70-2.68)	2.43 (1.91-3.14)	2.76 (2.11-3.65)	3.11 (2.31-4.25)	3.62 (2.56-5.15)	4.03 (2.75-5.96)
12-hr	1.16 (0.976-1.39)	1.49 (1.25-1.79)	1.92 (1.61-2.32)	2.27 (1.89-2.76)	2.75 (2.21-3.47)	3.12 (2.44-4.02)	3.49 (2.67-4.62)	3.88 (2.87-5.29)	4.40 (3.12-6.28)	4.81 (3.28-7.11)
24-hr	1.39 (1.23-1.61)	1.86 (1.64-2.15)	2.45 (2.15-2.84)	2.91 (2.54-3.41)	3.52 (2.98-4.25)	3.98 (3.29-4.89)	4.42 (3.58-5.57)	4.87 (3.84-6.30)	5.46 (4.14-7.35)	5.91 (4.34-8.21)
2-day	1.69 (1.50-1.96)	2.27 (2.00-2.63)	3.00 (2.64-3.48)	3.58 (3.12-4.18)	4.34 (3.67-5.24)	4.92 (4.08-6.05)	5.49 (4.44-6.91)	6.06 (4.78-7.84)	6.82 (5.17-9.17)	7.39 (5.42-10.3)
3-day	1.89 (1.67-2.19)	2.52 (2.23-2.92)	3.34 (2.94-3.88)	4.00 (3.49-4.68)	4.88 (4.13-5.89)	5.55 (4.60-6.83)	6.22 (5.04-7.84)	6.90 (5.45-8.93)	7.82 (5.93-10.5)	8.52 (6.25-11.8)

Appendix E

Maintenance Concerns

In 2011, TRWE engineers and Oceanside Maintenance staff visited areas in the City with maintenance concerns. That information from those visits and further conversations with City staff are summarized below in **Table E-1**. These areas of concern were considered during the analysis of Master Plan storm drains. **Figure E-1** shows the approximate location of those maintenance sites. It is probable that current conditions may differ since time has elapsed and City crews continue to address these and other sites.

Table E-1
2011 Maintenance Concerns

ID	Location	Description
1A	Half pipe drains	Downtown area pipe failures
1B	San Luis Rey River@ Pacific Street	Outfall to the ocean/flooded bike path
1C	Bike Path @ Neptune	Slope failure/grated basin
1D	Tremont-Seagaze to Surfrider	RCP undersized
1E	Center Ave @ Ocean High School	Flooding in 2010
2A	Loma Alta Creek @ railroad	Debris on trestle
2B	Loma Alta Creek @ Coast Highway	Channel next to mobile home park
2C	Buccaneer @ Pacific Street	Outfall to ocean
2D	Buena Vista Lagoon @ Weir	Outfall to ocean
2E	Buena Vista Lagoon @ Coast Highway	Flooding on roadway
2F	Cassidy @ Pacific Street	Grates pack with debris
2G	Lucky Street	CMP Failure
2H	2100 block of Nevada	Private drain floods street
3A	Pala @ Los Arbolitos	Flooding in road
3B	Coco Palms	Flooding in road
3C	Airport spillway (middle pond)	Debris in channel at headwall
3D	Rivertree easement	54-inch RCP failure
3E	Capistrano Basin	Silt and erosion
3F	Capistrano Park storm drain outfall @ river	Outlet pipe failure at river
3G	Storm drain @ Camp Pendleton boundary	Pipe separation, street subsidence, outlet not found
3H	Breeze Street Canyon	Pipe separation, street subsidence, outlet not found
4A	Las Vegas	Flooding in road
4B	El Monte	Pipe into slope concrete ditch
4C	Hacienda Drive	Flooding in road
4D	Mesa west of Butler	CMP failure
4E	Parnassus @ Fowles	Pipe undersized
4F	Tonapah	Silt in ditch - street flooding
4G	Garrison @ Oceanside Blvd	Creek floods into road
4H	Garrison between Oceanside and Industrial	Silt
5A	Haymar west of El Camino Real	Road lower than Buena Vista Creek, some historic inundation
5B	Ridgeway south of Grandview	Curb inlet not complete
5C	Loma Alta Creek east of Crouch	Debris on box culverts
5D	Ups Street cul de sac	Pipe clogs with debris

Table E-1 2011 Maintenance Concerns		
ID	**Location**	**Description**
5E	El Camino @ Basil	CMP obstruction
5F	Skylark east of Downs	Slope failure
5G	Magdalena Basin	Debris on outlet
5H	Loma Alta Creek @ Cavalier Mobile Home Park	Historic flooding
6A	San Luis Rey River Bridges	Debris on bridge supports
6B	Valley Heights @ Mission	Debris in roadway
6C	Old Grove @ Frazee Basin	Some historic sediment deposition and overflow
6D	Oleander Bridge and Basin	Some reconstruction needed, stagnant water
7A	Mesa @ El Camino Real	Clear debris from basin inlet
7B	El Corazon	Erosion into road
7C	Garrison Detention Basin Wall	Some scour and periodic repair
8A	Valley @ Skyline	Curb doesn't drain
8B	Rancho Del Oro @ RR crossing	Guillotine gates debris
8C	Oceanside Blvd @ Ready Mix	Dig out pipes
8D	Rancho Del Oro Sprinter Station	Flooding
8F	College @ Marvin Street	Street floods
9A	Wilshire Road Basin	Sediment/ silt
9B	Hollowglen Basin	Debris on Standpipe
9C	North River Road east of Sleeping Indian	Small aging bridge
9D	Via Puerta Del Sol	Small aging bridge/ slope erosion
9E	Sleeping Indian Area	Farmland Erosion into road
9F	Noirth River road - 2 Culverts	CMP with corrosion
10A	Guajome Lake Road	Dirt Road needs grading
10B	Wendela Basin	Debris on standpipe
10C	Mesa @ North Santa Fe	Earthen Channel silt
10D	Masters @ Silverbluff	Drain clogs
10E	North Santa Fe	Dig Out pipes
10F	Melrose @ North Santa Fe	Runoff overflows onto intersection
11A	North Ave Earthen Channel	Slope erosion
12A	Buena Vista Creek @ College	Box Culvert undersized
12B	San Fran-Peak Station	Sediment and dissipater Failure
12C	Tiberon Channel	Debris on box culverts
12D	Lake Channel Erosion	Ongoing channel and drop-structure degradation
12E	East end of Tiberon	Erosion at concrete and rip rap boundary
12F	Miramonte Culvert	Historic failure/repair

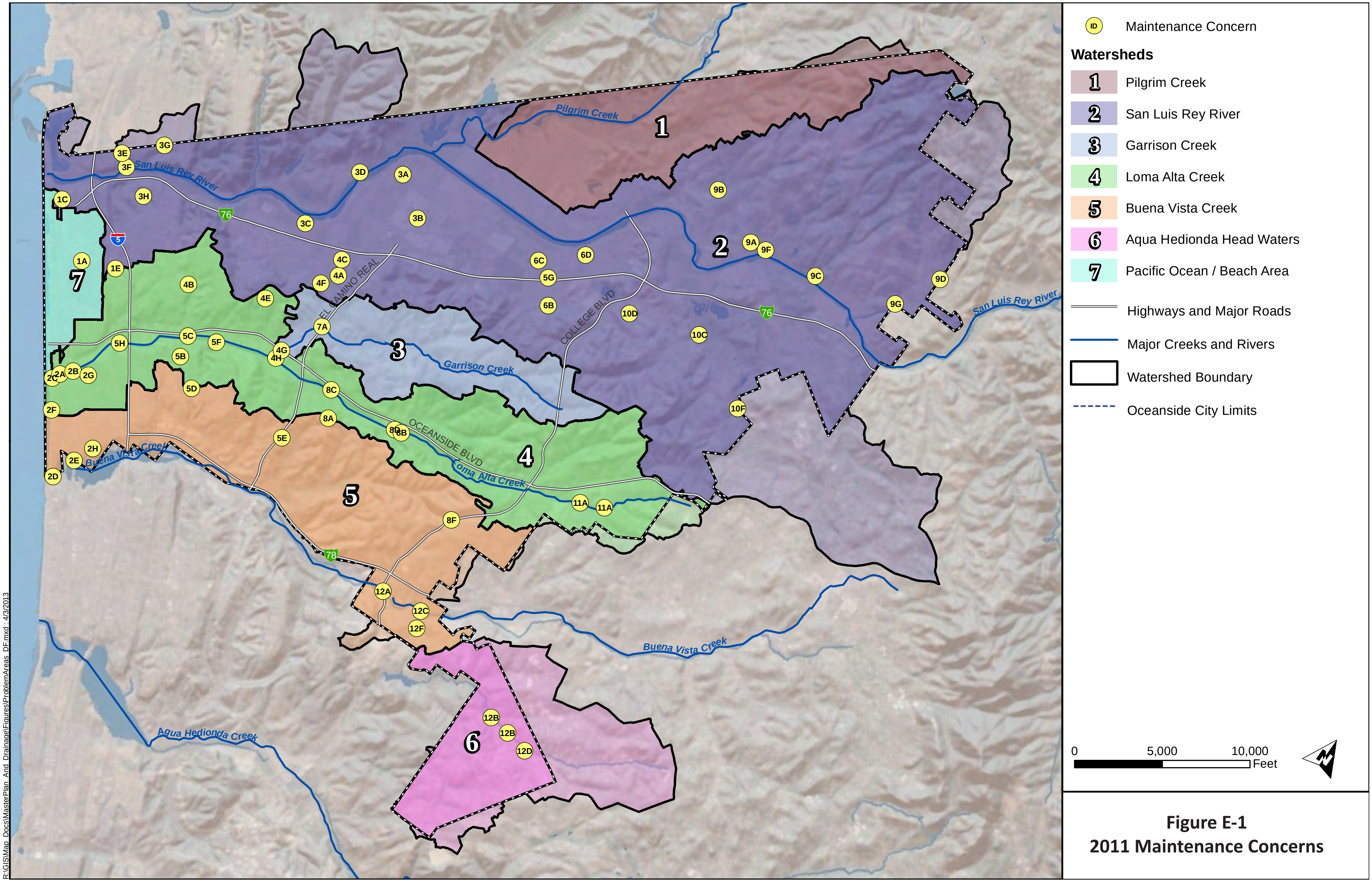


Figure E-1
2011 Maintenance Concerns

Appendix F

Preliminary Upgrade Costs

For this MPD upgrade costs are summarized below. These costs are based on unit costs as listed in Section 3, and facilities as listed in Section 4. As stated earlier, these costs are only for planning purposes. Recommended facility sizes listed are minimum sizes based on hydraulic analysis only; and therefore might be larger in some cases.

Watershed	Estimated Upgrade Costs	
	25-Year	100-Year
Pilgrim Creek Watershed	$ 584,480	$ 1,018,870
San Luis Rey River Watershed	$ 286,940	$ 8,403,090
Garrison Creek Watershed	$ 600,080	$ 2,322,070
Loma Alta Creek Watershed	$ 644,610	$ 7,372,340
Buena Vista Creek Watershed	$ 1,467,490	$ 9,436,013
Agua Hedionda Head Waters Watershed	$ 0	$ 382,680
Pacific Ocean/Beach Area Watershed	$ 2,159,520	$ 3,754,500
Totals	**$ 5,743,120**	**$ 32,689,563**

Table F-1
Pilgrim Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
PC-148	D	CIPP	30	242		36		$ 128,260
PC-149	D	CIPP	30	498	36	42	$ 263,940	$ 308,760
PC-179	C	RCP	36	213		42		$ 132,060
PC-200	D	CIPP	30	517	42	60	$ 320,540	$ 449,790
Subtotal Pilgrim Creek Watershed							**$ 584,480**	**$ 1,018,870**

Table F-2
San Luis Rey River Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
SLR-7	O	RCP	36	664		42		$ 411,680
SLR-7	O	RCP	36	664		42		$ 411,680
SLR-42	O	Unknown	36	100		42		$ 62,000
SLR-51	J	Parallel RCPs	42	100		48		$ 72,000
SLR-52	J		42	100		48		$ 72,000
SLR-72	I	RCP	33	181		42		$ 112,220
SLR-90	I	CIPP	72	233		78		$ 242,320
SLR-92	I	CIPP	72	258		78		$ 268,320
SLR-120	I	RCP	48	54		84		$ 60,480
SLR-121	I	RCP	36	37		54		$ 29,600
SLR-122	I	RCP	30	253		36		$ 134,090
SLR-123	I	RCP	30	219		42		$ 135,780
SLR-124	I	RCP	60	522		66		$ 480,240
SLR-125	I	RCP	60	537		66		$ 494,040
SLR-127	I	RCP	60	97		66		$ 89,240
SLR-153	I	Single Box Culvert	6’x8’	68		6’x8’		$ 79,560
SLR-154	I	Single Box Culvert	6’x8’	20		6’x8’		$ 23,400
SLR-155	I	RCP	66	428		72		$ 423,720
SLR-158	I	RCP	60	275		66		$ 253,000
SLR-188	I	RCP	30	232		36		$ 122,960
SLR-267	N	CIPP	30	337		36		$ 178,610
SLR-288	I	RCP	30	296		36		$ 156,880
SLR-289	I	RCP	30	197		36		$ 104,410
SLR-300	I	RCP	48	468		60		$ 407,160
SLR-311	H	RCP	36	346		42		$ 214,520
SLR-319	H	RCP	30	289		36		$ 153,170
SLR-320	I	RCP	30	246		36		$ 130,380
SLR-321	I	RCP	30	257		42		$ 159,340

Table F-2
San Luis Rey River Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
SLR-379	H	RCP	60	264		66		$ 242,880
SLR-424	I	RCP	30	216		42		$ 133,920
SLR-556	H	RCP	36	148		48		$ 106,560
SLR-558	H	RCP	36	443		48		$ 318,960
SLR-559	H	RCP	30	160		42		$ 99,200
SLR-560	H	RCP	30	104		36		$ 55,120
SLR-563	H	RCP	30	328		48		$ 236,160
SLR-603	H	RCP	36	66		42		$ 40,920
SLR-678	H	RCP	30	98		42		$ 60,760
SLR-679	H	RCP	30	98		42		$ 60,760
SLR-680	H	RCP	30	98		42		$ 60,760
SLR-681	H	Parallel RCPs	24	98		48		$ 70,560
SLR-685	H		24	98		48		$ 70,560
SLR-707	C	RCP	30	183		42		$ 113,460
SLR-725	G	CMP	36	131	42	48	$ 81,220	$ 94,320
SLR-727	G	CMP	36	28	42	60	$ 17,360	$ 24,360
SLR-728	G	CMP	36	118	42	60	$ 73,160	$ 102,660
SLR-732	G	RCP	30	160	48	60	$ 115,200	$ 139,200
SLR-738	G	RCP	30	37		54		$ 29,600
SLR-845	H	RCP	36	36		42		$ 22,320
SLR-861	G	Double Box Culvert	2.5’x5’ ea	54		Dbl 3’ x 6’		$ 75,060
SLR-863	G	Single Box Culvert	2’x6’	75		Dbl 3’ x 6’		$ 104,250
SLR-866	A	RCP	33	247		48		$ 177,840
SLR-885	H	Unknown	30	530		36		$ 280,900
SLR-909	H	RCP	48	249		54		$ 199,200
Subtotal San Luis Rey River Watershed							**$ 286,940**	**$ 8,403,090**

Table F-3
Garrison Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
GC-97	H	RCP	36	280		72		$ 277,200
GC-98	H	RCP	36	325		60		$ 282,750
GC-99	H	RCP	36	50		60		$ 43,500
GC-170	H	RCP	60	208		96		$ 253,760
GC-176	G	CIPP (Parallel to 84”)	72	500		78		$ 520,000
GC-177	G	CIPP (Parallel to 84”)	72	577	78	84	$ 600,080	$ 646,240
GC-178	H	CIPP	66	171		96		$ 208,620
GC-191	G	Trapezoidal channel under road	54” deep	31		Design		$ 90,000
Subtotal Garrison Creek Watershed							**$ 600,080**	**$ 2,322,070**

Table F-4

Loma Alta Creek Watershed

Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
LAC-43	M	RCP	30	124		42		$ 76,880
LAC-44	M	RCP	30	45		36		$ 23,850
LAC-45	M	RCP	30	183		36		$ 96,990
LAC-46	M	RCP	30	33		36		$ 17,490
LAC-70	M	CIPP	48	414		54		$ 331,200
LAC-75	M	CP	48	354		54		$ 283,200
LAC-76	M	CP	48	233		78		$ 242,320
LAC-149	M	CIPP	36	78		42		$ 48,360
LAC-150	M	CIPP	36	194		42		$ 120,280
LAC-193	L	Rock lined Channel	60” deep	323		design		$ 300,000
LAC-247	M	Triple Box Culvert	5’ x 6’ ea	53		5’ x 8’ ea		$ 57,240
LAC-422	M	RCP	30	147		36		$ 77,910
LAC-489	G	CMPE	42	446	54	66	$ 356,800	$ 410,320
LAC-490	G	RCP	36	56	48	60	$ 40,320	$ 48,720
LAC-501	F	RCP	30	207	42	48	$ 128,340	$ 149,040
LAC-502	F	RCP	30	68		42		$ 42,160
LAC-504	F	RCP	36	40		42		$ 24,800
LAC-505	F	RCP	36	56		48		$ 40,320
LAC-507	F	RCP	36	87		48		$ 62,640
LAC-528	F	RCP	30	41	42	54	$ 25,420	$ 32,800
LAC-529	F	RCP	30	71	42	54	$ 44,020	$ 56,800
LAC-530	F	CMP	24	18	30	36	$ 8,000	$ 9,540
LAC-557	F	RCP	60	152		66		$ 139,840
LAC-558	F	RCP	60	607		78		$ 631,280
LAC-559	F	RCP	60	200		66		$ 184,000
LAC-562	F	RCP	72	325		78		$ 338,000
LAC-563	F	RCP	72	342		78		$ 355,680
LAC-565	F	Single Box Culvert	5’ x 6’	43		5’ x 8’		$ 46,440

Table F-4
Loma Alta Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
LAC-570	F	Single Box Culvert	5' x 6'	142		5' x 8'		$ 153,360
LAC-572	F	RCP	36	30		42		$ 18,600
LAC-578	F	Parallel RCPs	24	99		60		$ 86,130
LAC-579	F		24	99		60		$ 86,130
LAC-587	F	RCP	36	138		42		$ 85,560
LAC-601	F	RCP	54	237		60		$ 206,190
LAC-602	F	RCP	54	109		60		$ 94,830
LAC-603	F	RCP	48	242		60		$ 210,540
LAC-604	F	RCP	48	139		72		$ 137,610
LAC-605	F	RCP	54	306		60		$ 266,220
LAC-606	F	RCP	54	214		72		$ 211,860
LAC-617	F	RCP	30	140		36		$ 74,200
LAC-630	F	Double Box Culvert	3' x 5 ' ea	76		3' x 8' ea		$ 131,480
LAC-634	F	Single Box Culvert	5' x 6'	187		5' x 8'		$ 201,960
LAC-636	F	Parallel CMPEs	42	78		48		$ 56,160
LAC-637	F		27	78		36		$ 41,340
LAC-638	F		42	78		48		$ 56,160
LAC-639	F		27	78		36		$ 41,340
LAC-689	F	RCP	30	150		42		$ 93,000
LAC-717	G	CMPE	36	23	36	42	$ 12,190	$ 14,260
LAC-718	G	CMPE	36	307		66		$ 282,440
LAC-719	G	CMPE	36	41	48	60	$ 29,520	$ 35,670
LAC-730	F	Concrete Open Channel	48" deep	674		54		$ 539,200
Subtotal Loma Alta Creek Watershed							**$ 644,610**	**$ 7,372,340**

Table F-5

Buena Vista Creek Watershed

Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
BVC-2	K	Single Box Culvert	1'x3'	90		2' x 3'		$ 37,800
BVC-78	K	RCP	60	356		72		$ 352,440
BVC-79	K	RCP	60	142		72		$ 140,580
BVC-81	L	CIPP	48	100	54	72	$ 80,000	$ 99,000
BVC-82	L	CIPP	48	106		72		$ 104,940
BVC-85	L	CIPP	48	325		72		$ 321,750
BVC-89	K	RCP	36	128		48		$ 92,160
BVC-102	L	RCP	42	52	54	66	$ 41,600	$ 47,840
BVC-103	L	RCP	42	20	54	66	$ 16,000	$ 18,400
BVC-109	L	RCP	30	273		48		$ 196,560
BVC-126	P	RCP	30	72		42		$ 44,640
BVC-127	P	RCP	30	118		36		$ 62,540
BVC-129	P	RCP	30	40		48		$ 28,800
BVC-134	P	RCP	30	112		36		$ 59,360
BVC-136	P	RCP	36	355		42		$ 220,100
BVC-138	L	SRSP	72	496		84		$ 555,520
BVC-139	L	SRSP	72	311		84		$ 348,320
BVC-140	L	SRSP	72	193		84		$ 216,160
BVC-141	L	SRSP	72	503		84		$ 563,360
BVC-179	L	RCP	30	225		36		$ 119,250
BVC-183	L	RCP	30	260	36	42	$ 137,800	$ 161,200
BVC-184	L	RCP	30	191	36	42	$ 101,230	$ 118,420
BVC-185	L	RCP	30	281	42	48	$ 174,220	$ 202,320
BVC-186	L	RCP	30	175	42	54	$ 108,500	$ 140,000
BVC-187	L	RCP	36	168	48	54	$ 120,960	$ 134,400
BVC-188	L	RCP	36	108	54	60	$ 86,400	$ 93,960
BVC-189	L	RCP	42	294		60		$ 255,780
BVC-190	L	RCP	42	108		54		$ 86,400

Table F-5

Buena Vista Creek Watershed

Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
BVC-191	L	RCP	42	61		54		$ 48,800
BVC-198	L	RCP	48	96		54		$ 76,800
BVC-199	L	RCP	48	17		60		$ 14,790
BVC-224	L	CIPP	36	248		42		$ 153,760
BVC-226	L	RCP	72	279		84		$ 312,480
BVC-227	L	CIPP	72	341	78	84	$ 354,640	$ 381,920
BVC-231	L	CIPP	48	76		72		$ 75,240
BVC-232	L	CIPP	60	105		72		$ 103,950
BVC-236	L	CIPP	30	37		36		$ 19,610
BVC-237	L	CIPP	30	162		36		$ 85,860
BVC-238	L	CIPP	30	241		36		$ 127,730
BVC-239	L	CIPP	30	271		36		$ 143,630
BVC-243	M	RCP	30	50		42		$ 31,000
BVC-247	L	RCP	30	143		36		$ 75,790
BVC-248	L	RCP	30	151		36		$ 80,030
BVC-252	L	CIPP	42	361		54		$ 288,800
BVC-254	L	CIPP	42	90		54		$ 72,000
BVC-255	L	CIPP	42	87		48		$ 62,640
BVC-258	M	RCP	36	274		54		$ 219,200
BVC-259	M	RCP	30	57	42	54	$ 35,340	$ 45,600
BVC-264	P	RCP	42	127		48		$ 91,440
BVC-282	L	RCP	30	351		36		$ 186,030
BVC-283	L	RCP	33	380		36		$ 201,400
BVC-287	P	CMP	72	57		78		$ 59,280
BVC-289	P	CMP	72	709		78		$ 737,360
BVC-321	P	RCP	42	25		48		$ 18,000
BVC-322	P	RCP	36	290	42	54	$ 179,800	$ 232,000
BVC-323	P	RCP	36	15	42	48	$ 9,300	$ 10,800

Table F-5
Buena Vista Creek Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
BVC-324	P	RCP	36	202		48		$ 145,440
BVC-325	P	RCP	30	35	42	54	$ 21,700	$ 28,000
BVC-326	P	RCP	30	40		54		$ 32,000
BVC-330	P	RCP	48	210		54		$ 168,000
BVC-353	L	CIPP	60	68		72		$ 67,320
BVC-354	L	CIPP	60	105		72		$ 103,950
BVC-355	L	CIPP	60	116		72		$ 114,840
Subtotal Buena Vista Creek Watershed							**$ 1,467,490**	**$ 9,436,013**

Table F-6
Agua Hedionda Head Waters Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Cost	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
AH-1	P	RCP	30	29		36		$ 15,370
AH-2	P	RCP	30	115		36		$ 60,950
AH-10	P	RCP	60	174		66		$ 160,080
AH-98	Q	RCP	30	276		36		$ 146,280
Subtotal Agua Hedionda Head Waters Watershed							**$ 0**	**$ 382,680**

Table F-7
Pacific Ocean/Beach Area Watershed
Recommended Storm Drain Facility Improvements

Facility ID	Atlas Page	Existing			Recommended Size to Convey		Estimated Upgrade Costs	
		Facility Type	Size (inches)	Length (feet)	25-year	100-year	25-year	100-year
PO-9	F	RCP	42	41		48		$ 29,520
PO-10	F	RCP	48	111		54		$ 88,800
PO-11	F	CIPP	48	26		66		$ 23,920
PO-13	F	CIPP	42	450		48		$ 324,000
PO-15	F	CIPP	48	85		54		$ 68,000
PO-16	F	RCP	48	61		54		$ 48,800
PO-18	A	RCP	36	285		42		$ 176,700
PO-19	A	RCP	30	584		36		$ 309,520
PO-22	A	RCP	36	52	48	66	$ 37,440	$ 47,840
PO-23	A	RCP	36	364	54	66	$ 291,200	$ 334,880
PO-24	A	RCP	36	139	48	66	$ 100,080	$ 127,880
PO-25	A	RCP	36	422	42	60	$ 261,640	$ 367,140
PO-26	A	RCP	36	234	48	66	$ 168,480	$ 215,280
PO-27	A	RCP	30	52	36	48	$ 27,560	$ 37,440
PO-36	A	RCP	36	338	54	60	$ 270,400	$ 294,060
PO-37	A	RCP	36	756	66	72	$ 695,520	$ 748,440
PO-38	A	RCP	36	384	54	66	$ 307,200	$ 353,280
PO-39	A	RCP	30	301		36		$ 159,000
Subtotal Pacific Ocean/Beach Area Watershed							**$ 2,159,520**	**$ 3,754,500**

Appendix G

Table G-1 Abbreviations	
CAD	Computer Aided Drafting
CIPP	Cast-In-Place Pipe
CMP	Corrugated Metal Pipe
CMPA	Corrugated Metal Pipe Arch
CMPE	Corrugated Metal Pipe Elliptical
CN	Curve Number
CP	Concrete Pipe
DBC	Double Box Culvert
ENR CCI	Engineering News Record Construction Cost Index
DDM	Drainage Design Manual
ENSO	El Niño - Southern Oscillation
GIS	Geographic Information System
HGL	Hydraulic Grade Line
GPS	Global Positioning System
HMP	Hydromodification Management Plan
IDF	Intensity-Duration-Frequency
in/hr	inches per hour
MPD	Master Plan of Drainage
NAVD	North American Vertical Datum
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
OBC	Other Box Culvert (greater than 3 barrels)
PCW	Project Clean Water
PFCS	Precipitation Frequency Data Server
RCB	Reinforced Concrete Box
RCP	Reinforced Concrete Pipe
SanGIS	San Diego Geographic Information Source
SBC	Single Box Culvert
SCS	Soil Conservation Service
SDCHM	San Diego County Hydrology Manual
SRSP	Spiral Rib Steel Pipe
TAC	Technical Advisory Committee
TBC	Triple Box Culvert
Tp	Time to peak
TRWE	Tory R. Walker Engineering, Inc.
UH	Unit Hydrograph
X-year	A storm event which has a 1/X chance of being equaled or exceeded in any given year.

Appendix H

Acknowledgements

City of Oceanside
Scott Smith, PE, PLS - *City Engineer*
Ulf Fagerborn, PE - *Engineering*
Mark Sabelis - *Public Works*
Maryam Wagner - *Engineering GIS Project Manager*
Bill Tuck - *Engineering GPS, GIS Facilities*

Tory R. Walker Engineering, Inc.
Tory Walker, PE, CFM, LEED GA - *Project Manager*
Leland Womack, MS, PE - *Assistant PM*
John Duewel, PE - *Civil Engineer*
Luis Parra, PhD, PE, CPSWQ, D.WRE, ToR - *Hydrology*
David Edwards, PE - *Hydraulics*
Edward Drury, EIT - *xpstorm Modeling*
Robin Brush - *GIS*
Victor Castellanos, EIT - *Facilities*
Tyler Schemper, PE
Dane Summers
Monique Bottger
Kelly Lipin

Others
Tobias Wolf, GIS Manager - *HDR*
Dillon Fitch, GIS Specialist - *HDR*
Charles Willess, PLS - *Gold Coast Surveying, Inc.*
Bruce Bonde, PLS - *Gold Coast Surveying, Inc.*
Nicholas Willess - *Gold Coast Surveying, Inc.*

Seacliff Terrace - Scoping Meeting Attendees 9-16-2013

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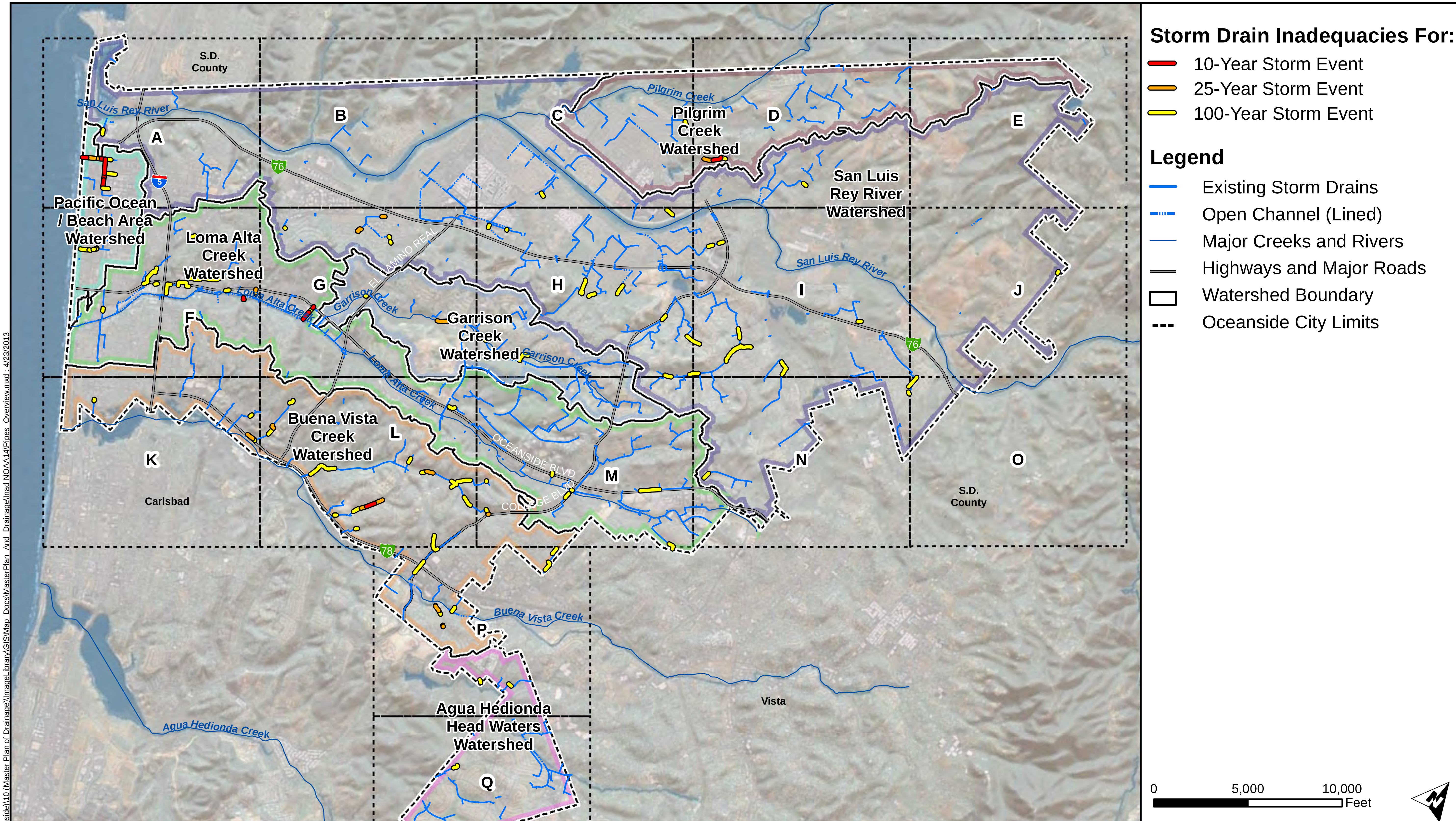
Suzanne Larson	1021 Costa Pacifica #2303		760-468-4959
Gary Larson	1021 Costa Pacifica #2303	gary-larson@sbcglobal.net	760-468-0396
M. Woods	1019 Costa Pacifica #1408		
Tom Woods	1019 Costa Pacifica #1408	woodsey49@hotmail.com	
Peggy Graham	1019 Costa Pacifica #1406	queenpeggy316@cox.net	
Doreen Pottios	1021 Costa Pacifica #2413	dpottios@gmail.com	760-275-6674
Gene Edick	939 N. Coast Highway		



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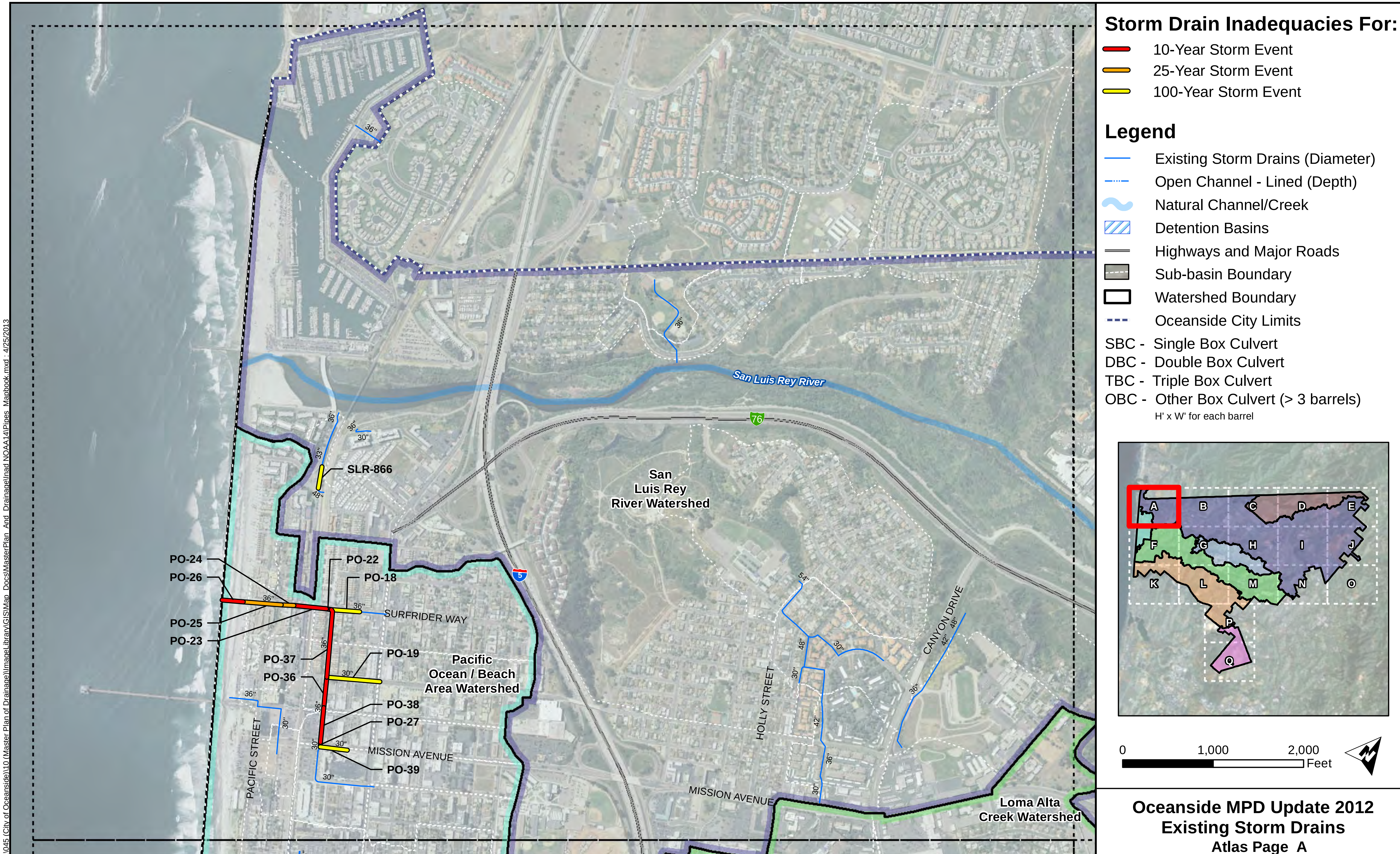

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Existing Storm Drains
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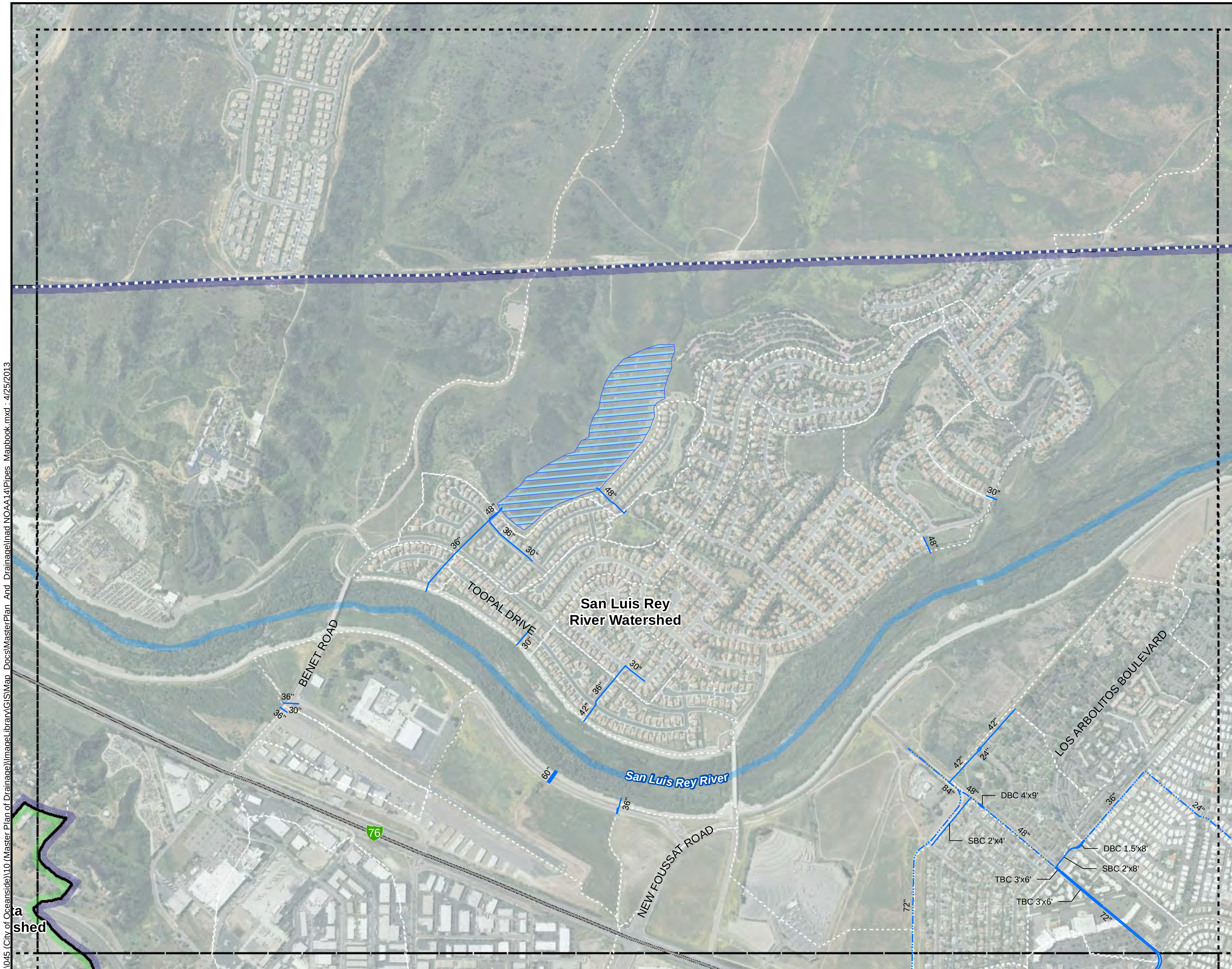

Storm Drain Inadequacies For:

- 10-Year Storm Event
- 25-Year Storm Event
- 100-Year Storm Event

Legend

- Existing Storm Drains (Diameter)
- Open Channel - Lined (Depth)
- Natural Channel/Creek
- Detention Basins
- Highways and Major Roads
- Sub-basin Boundary
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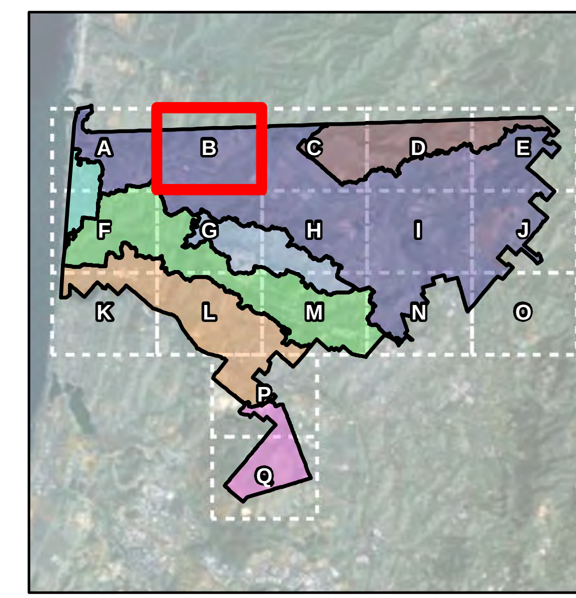
- Oceanside City Limits

SBC - Single Box Culvert
DBC - Double Box Culvert
TBC - Triple Box Culvert
OBC - Other Box Culvert (> 3 barrels)
H' x W' for each barrel



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Oceanside MPD Update 2012
Existing Storm Drains
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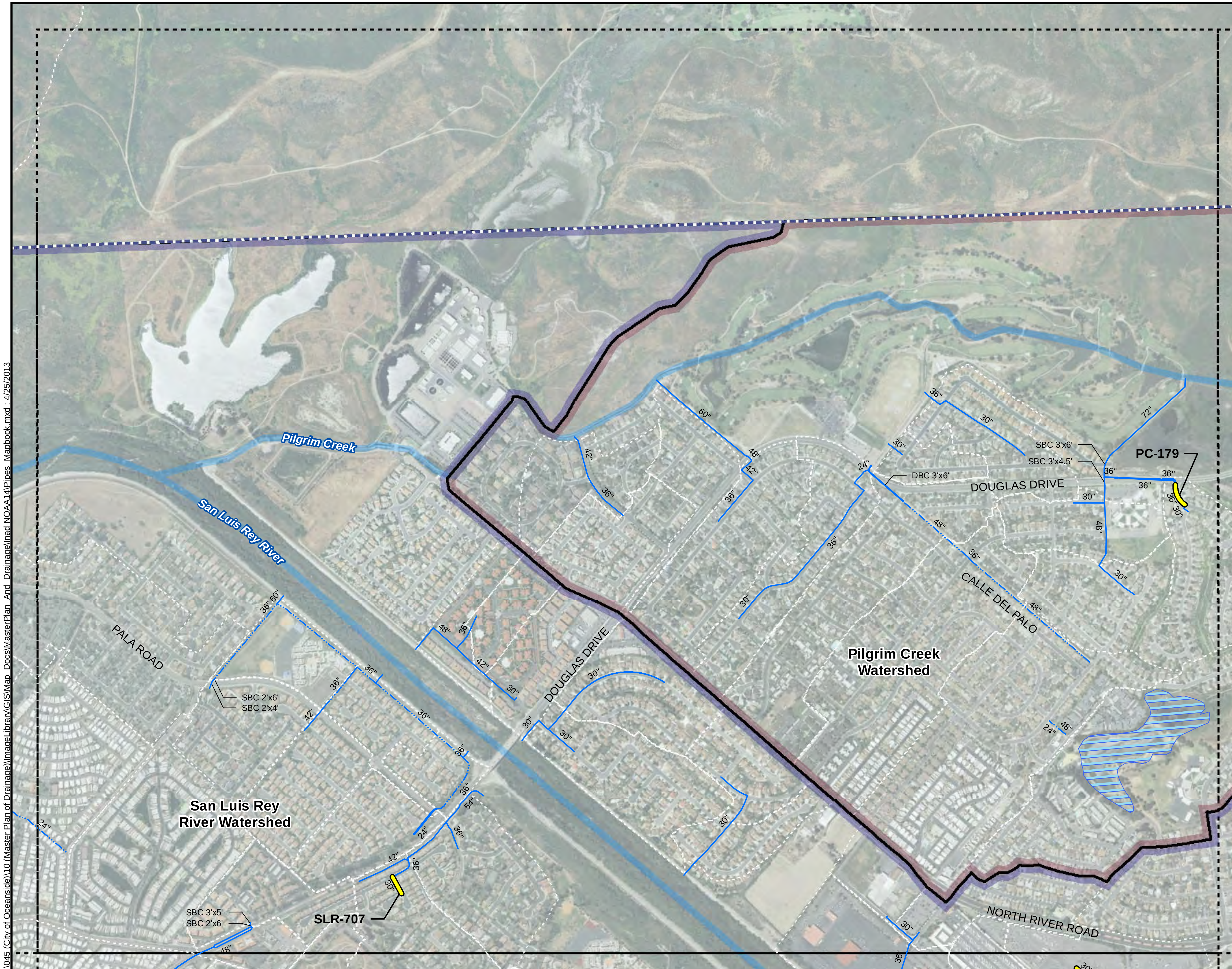

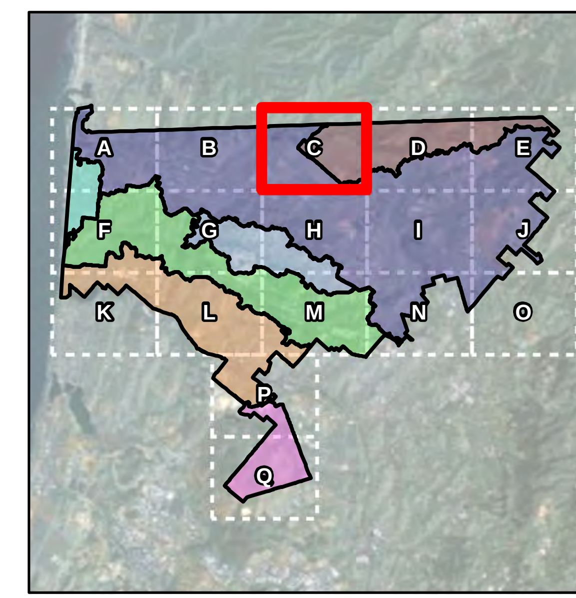

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Existing Storm Drains
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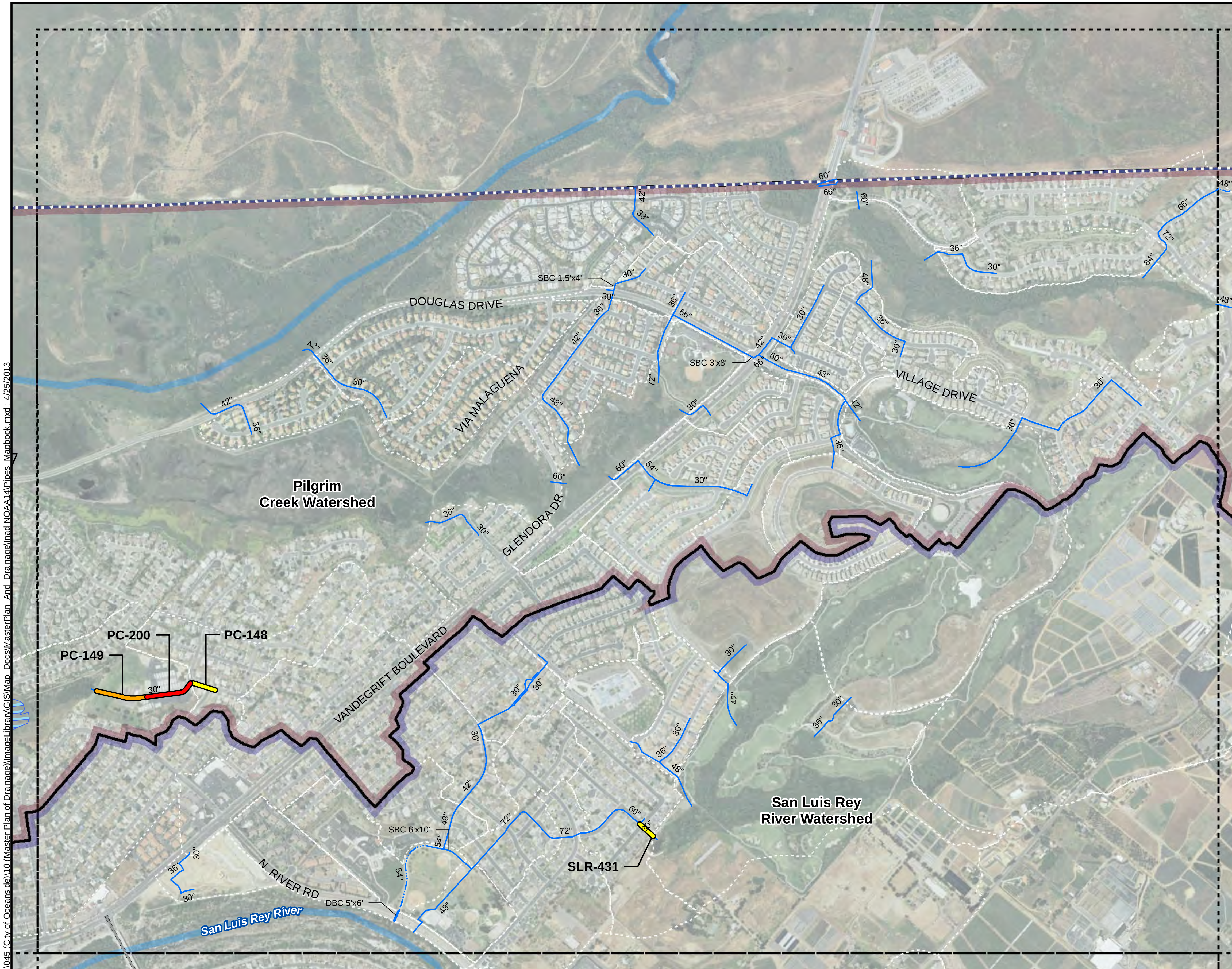

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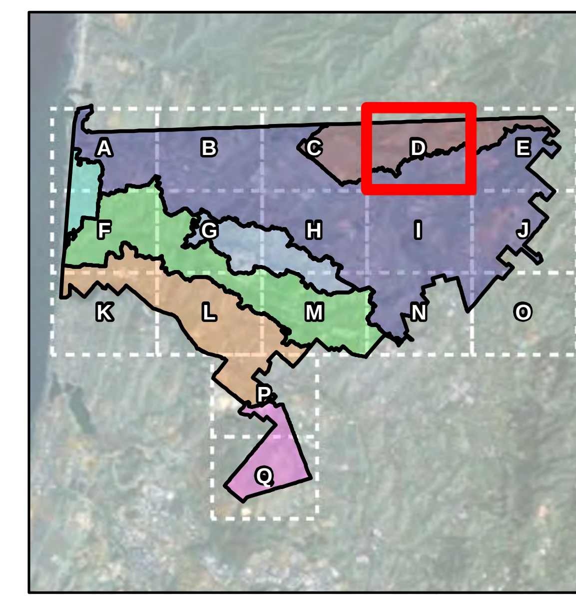

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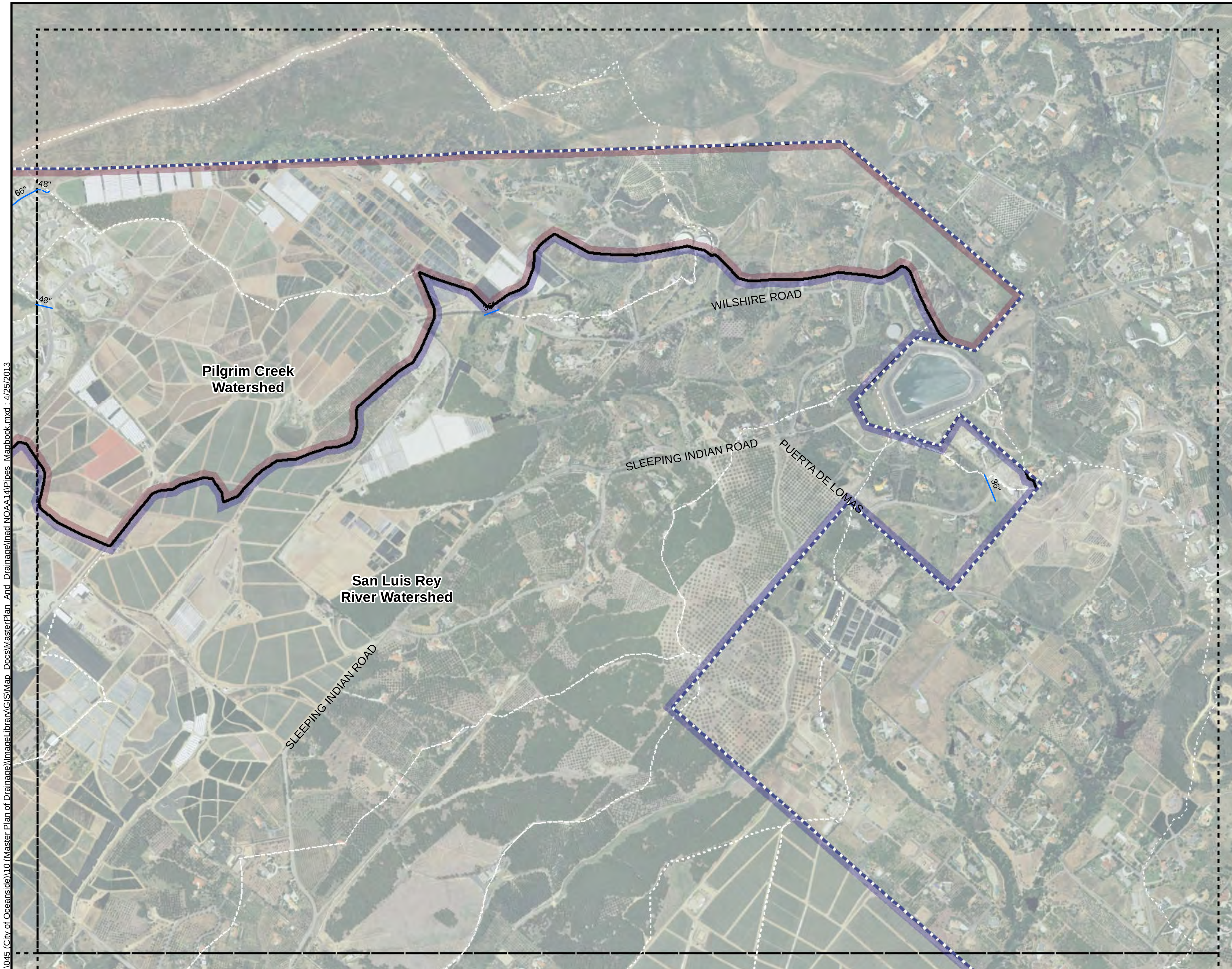

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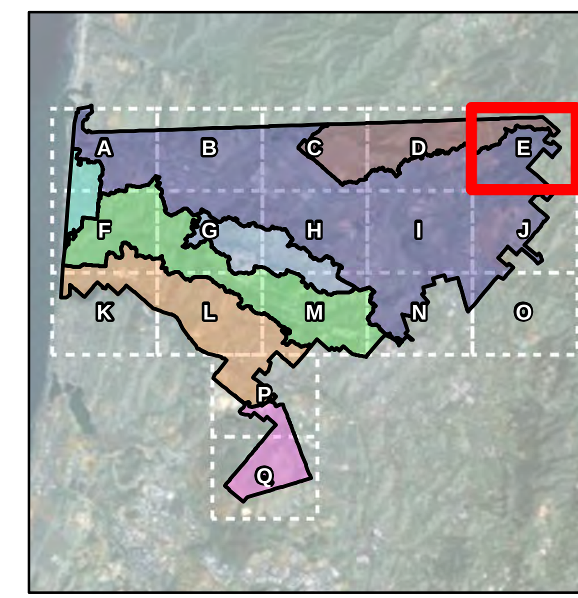

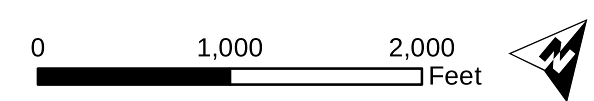

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Existing Storm Drains
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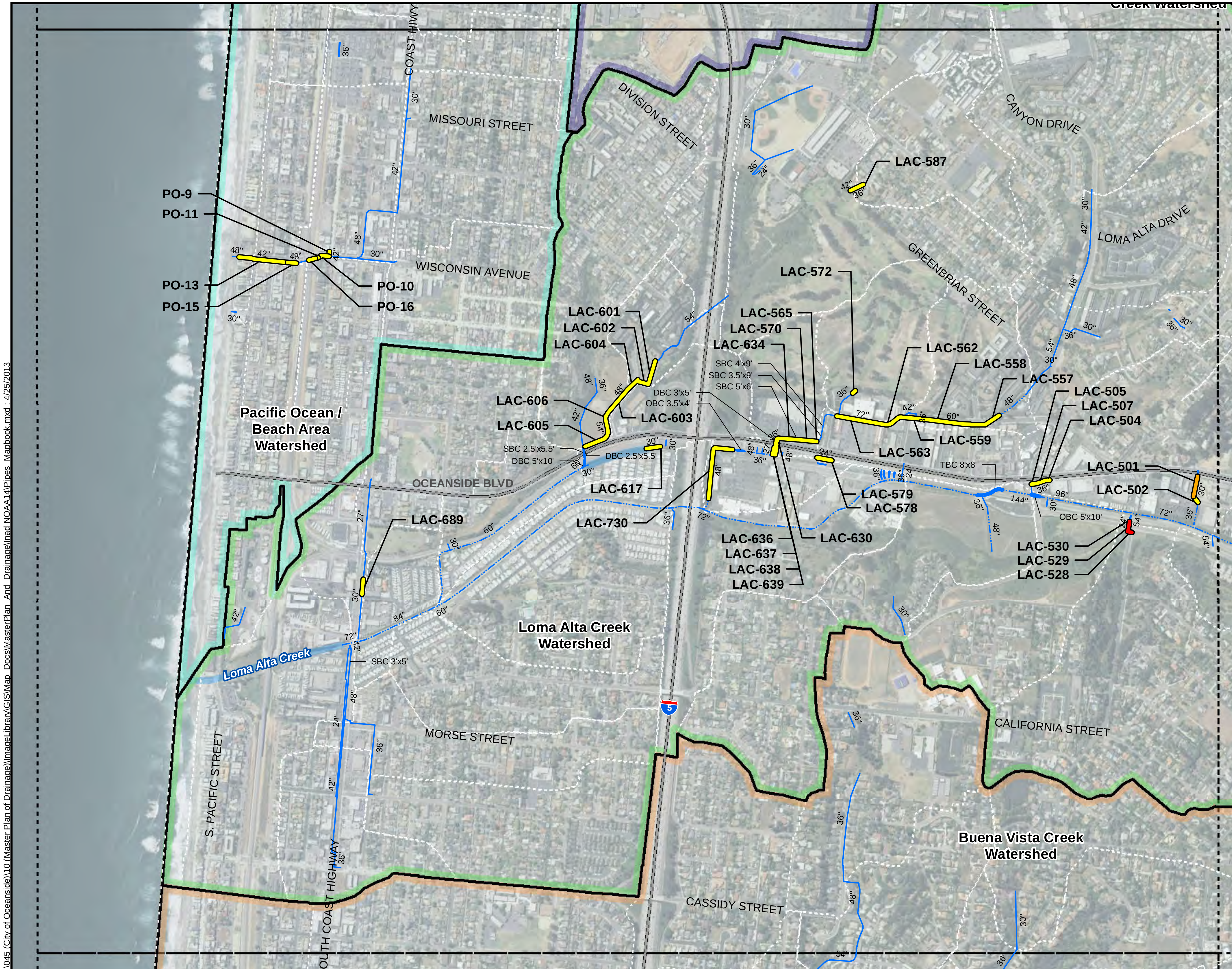

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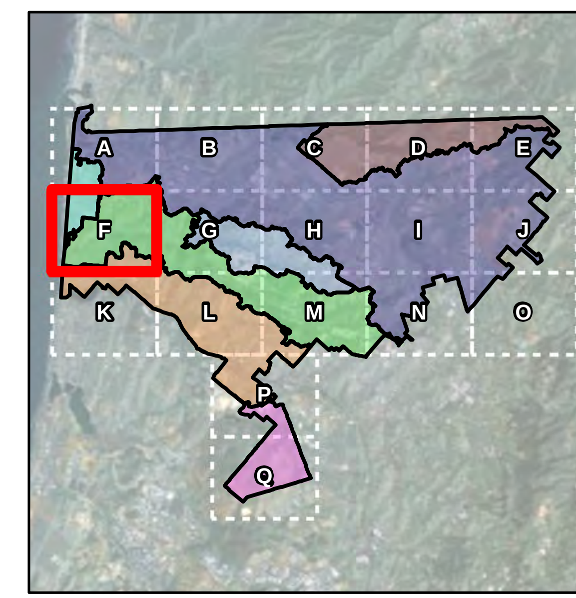

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Existing Storm Drains
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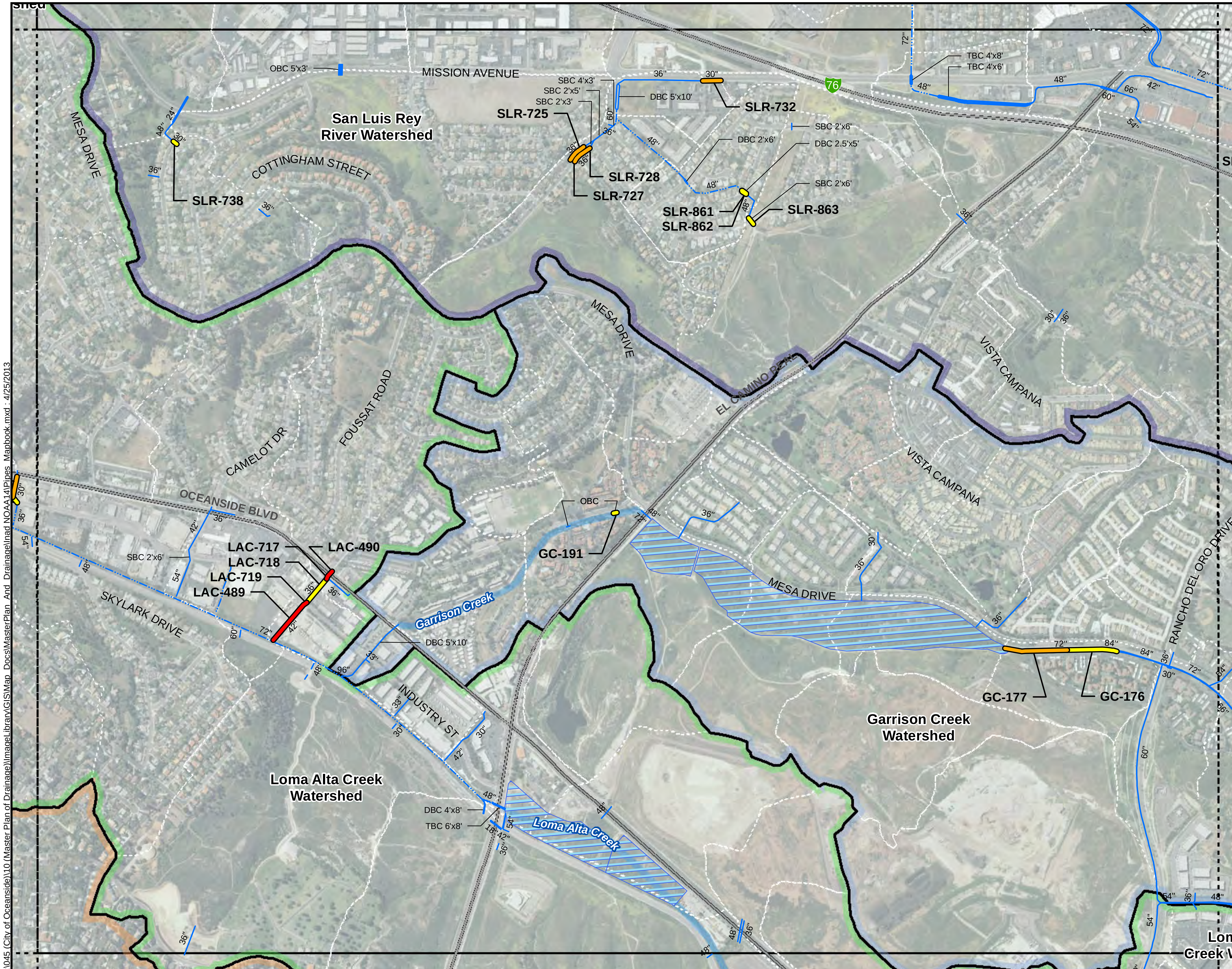

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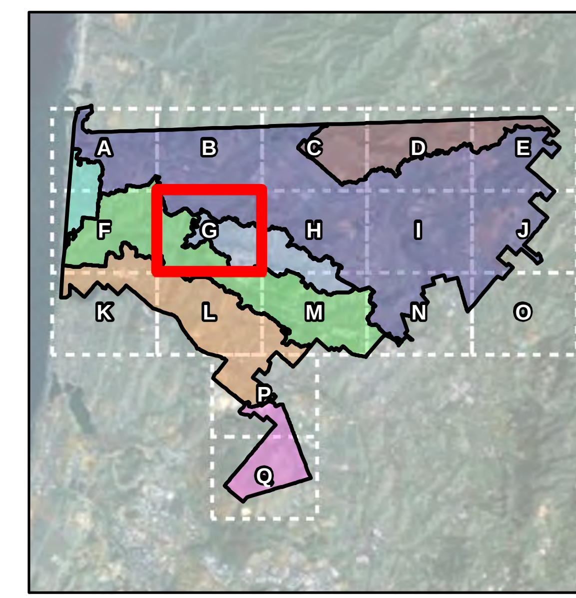

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Existing Storm Drains
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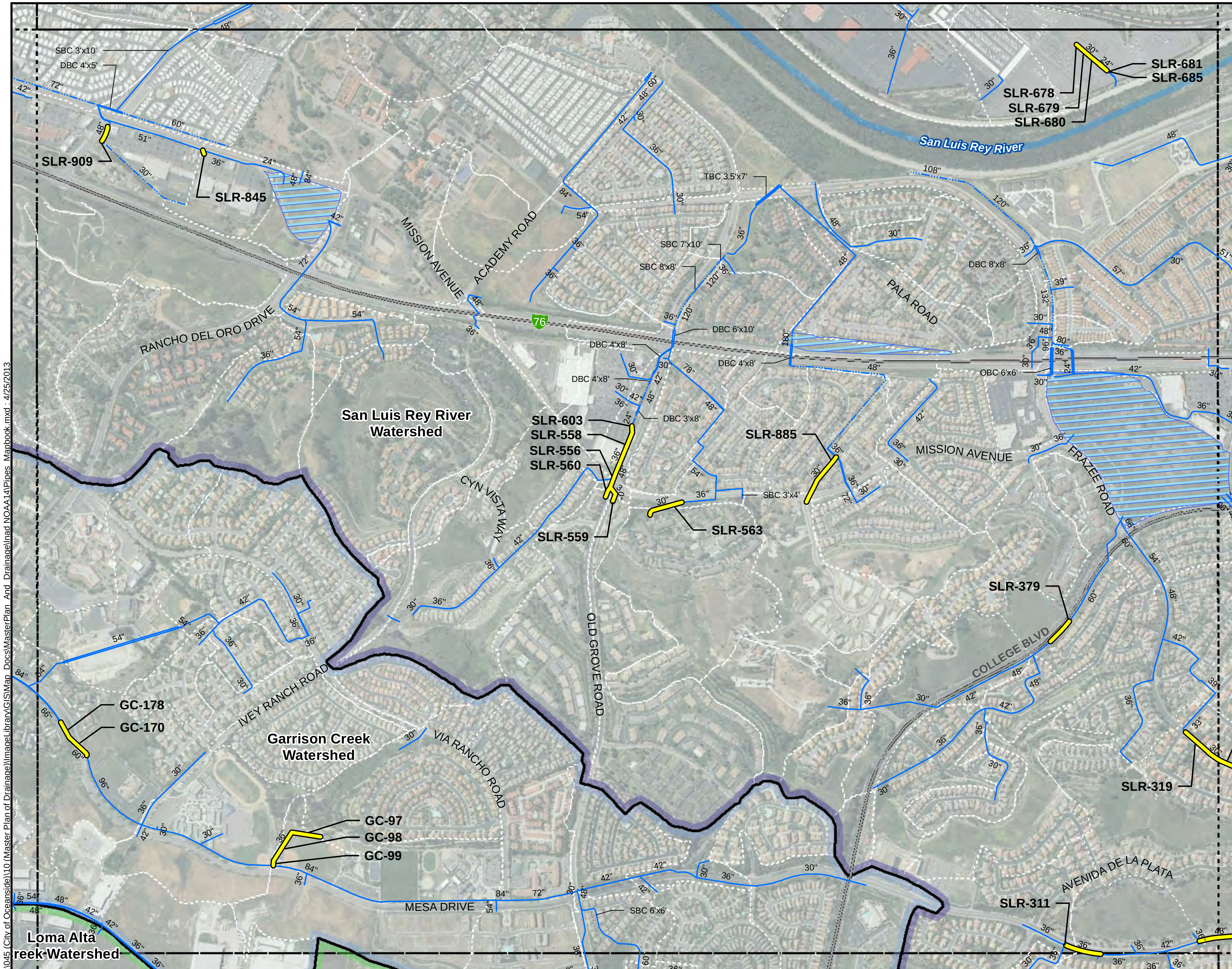

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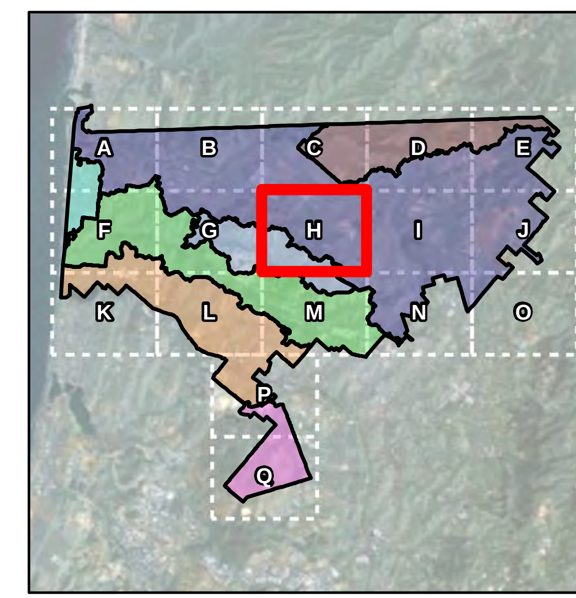

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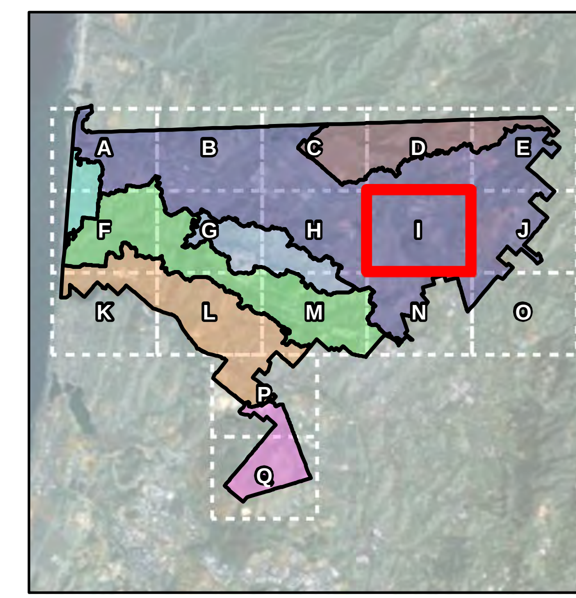

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Existing Storm Drains
Atlas Page I

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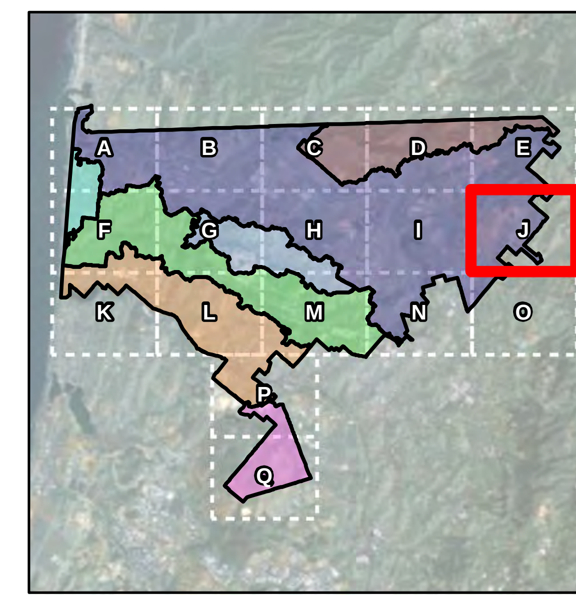

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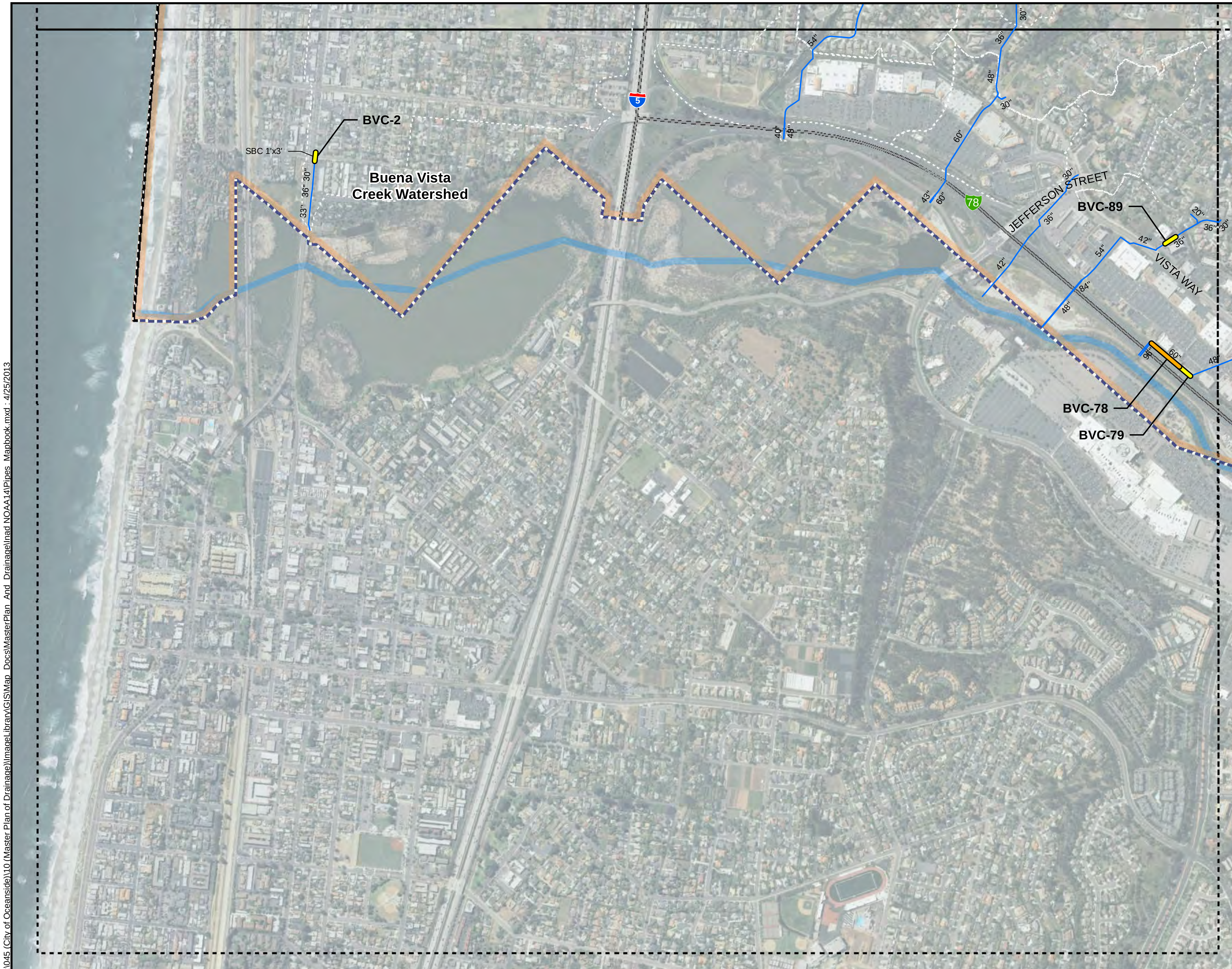

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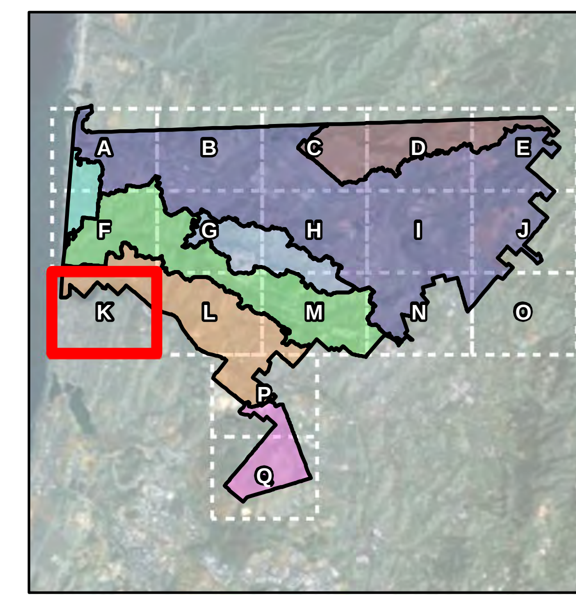

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Existing Storm Drains
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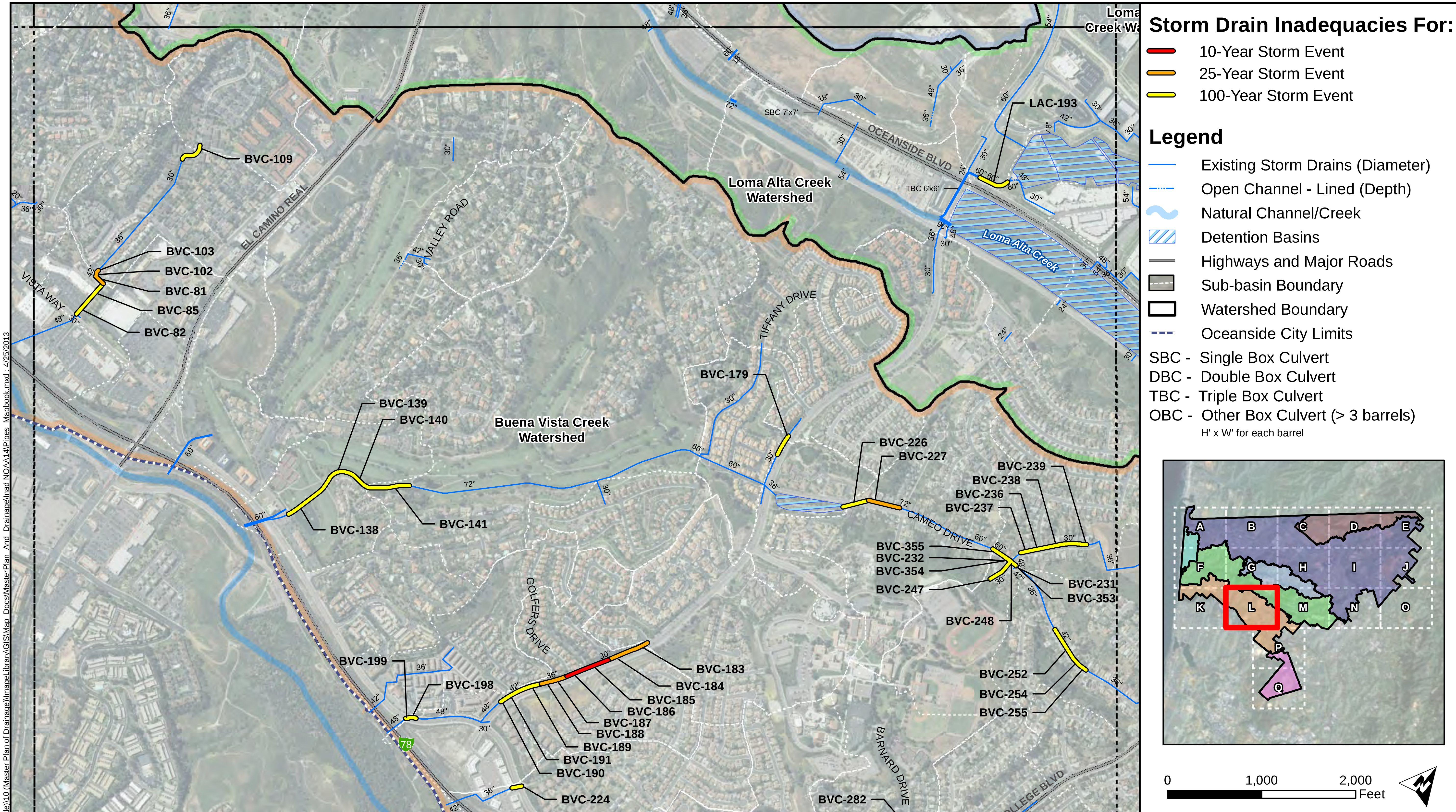

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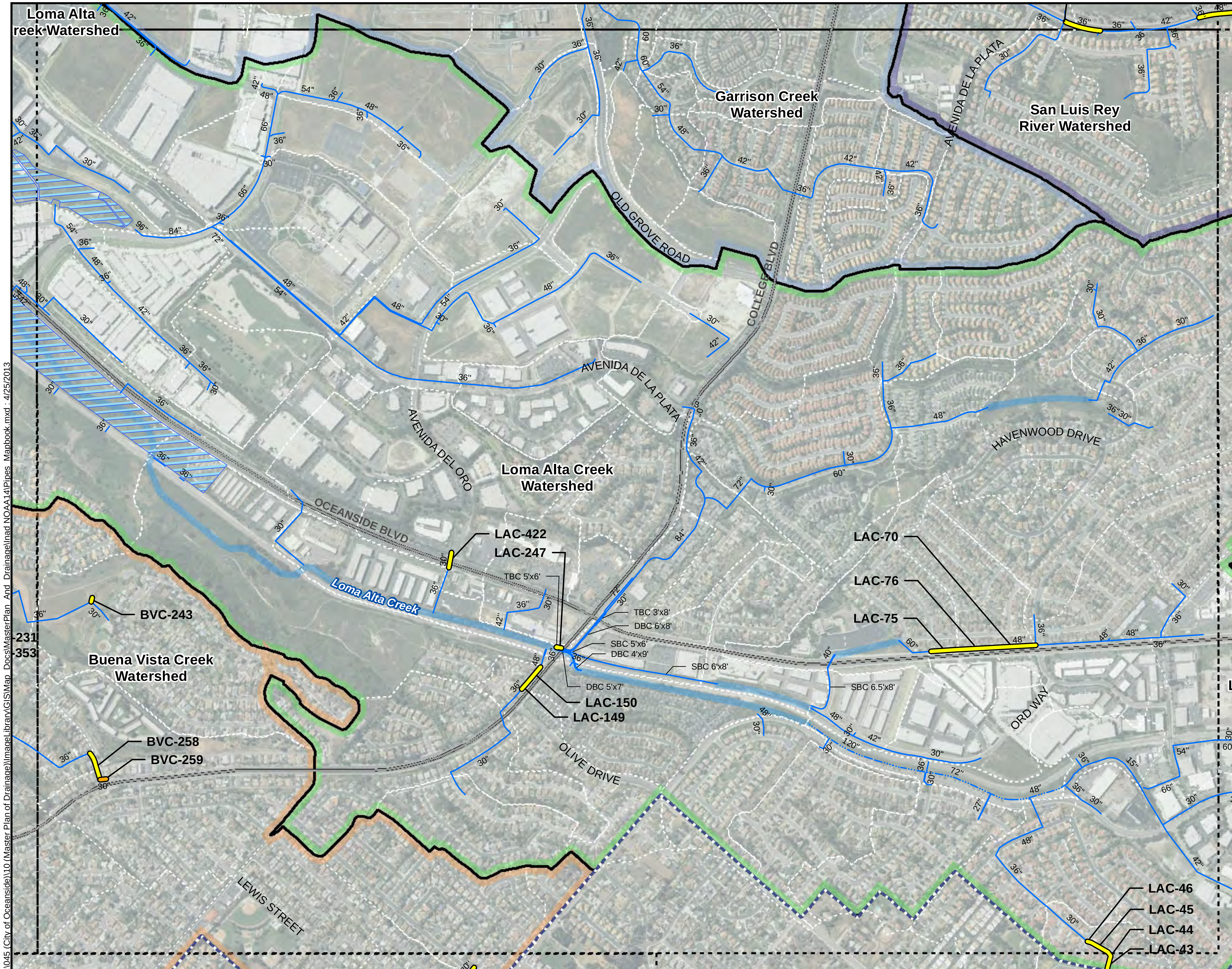
Existing Storm Drains
Atlas Page L



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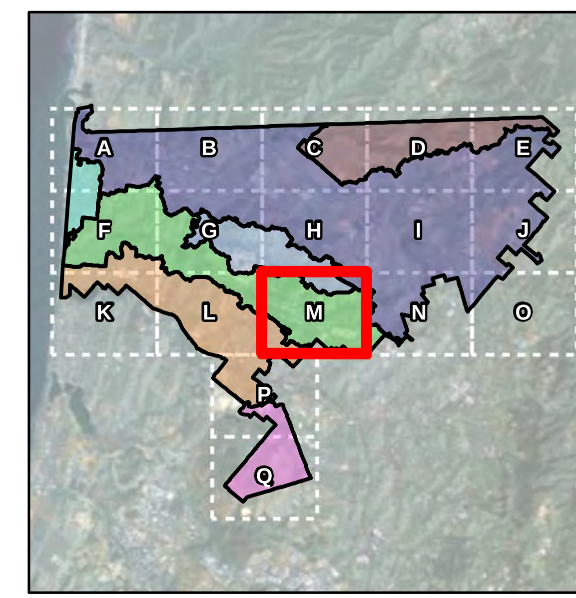

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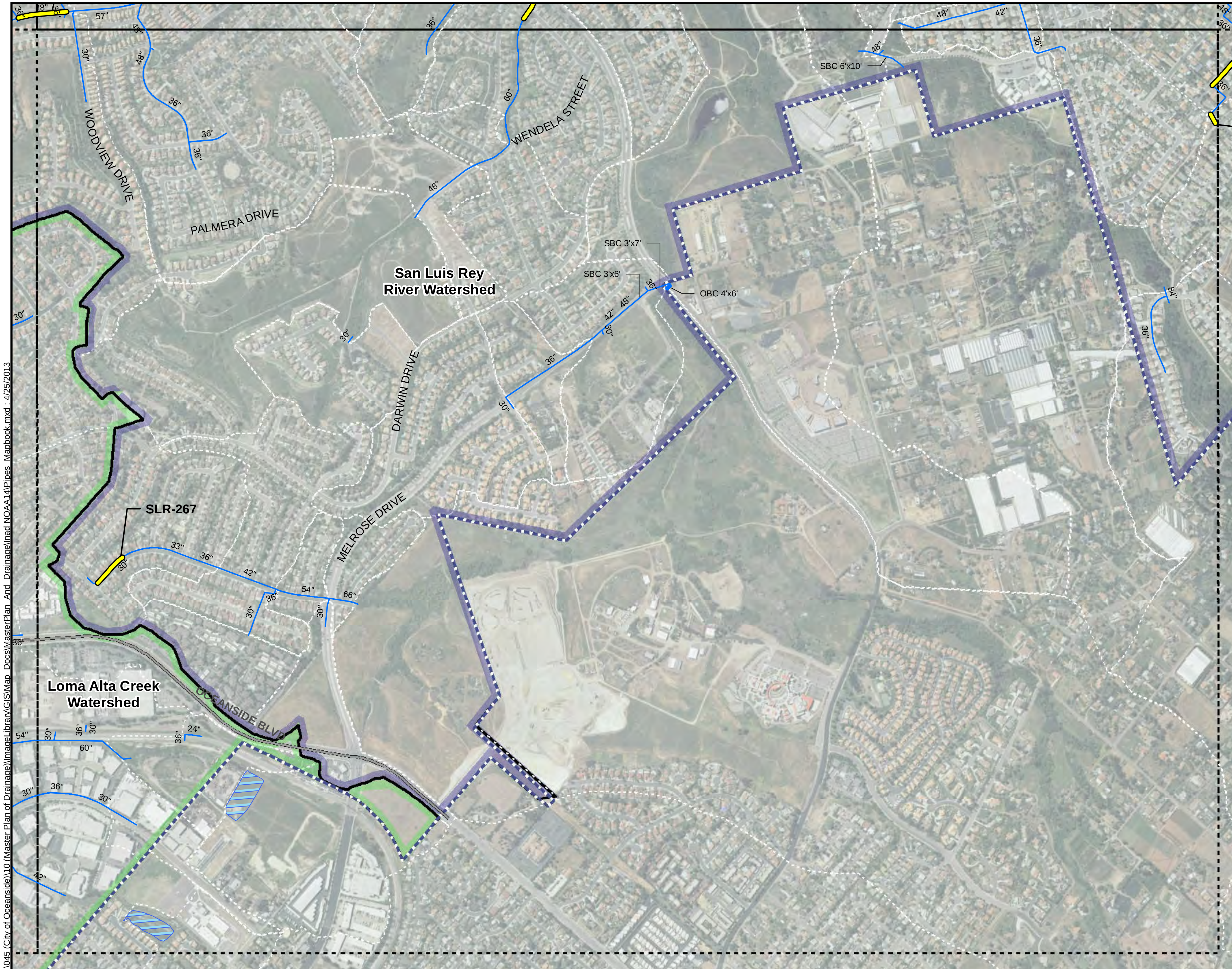
Existing Storm Drains
Atlas Page M



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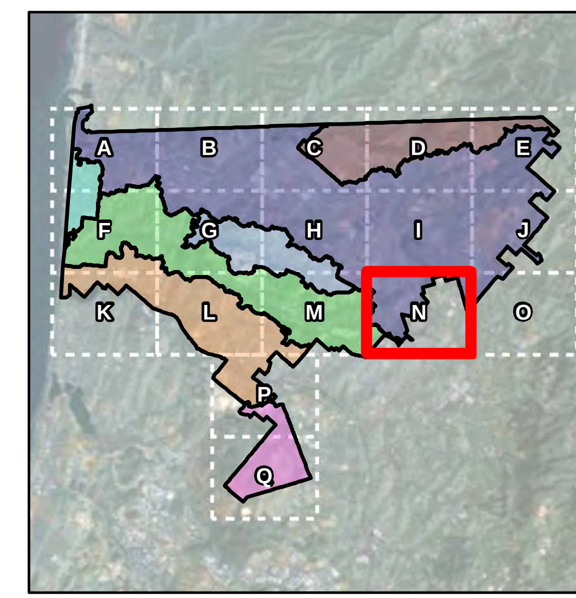
Storm Drain Inadequacies For:

- 10-Year Storm Event
- 25-Year Storm Event
- 100-Year Storm Event

Legend

- Existing Storm Drains (Diameter)
- Open Channel - Lined (Depth)
- Natural Channel/Creek
- Detention Basins
- Highways and Major Roads
- Sub-basin Boundary
- Watershed Boundary
- Oceanside City Limits

SBC - Single Box Culvert
DBC - Double Box Culvert
TBC - Triple Box Culvert
OBC - Other Box Culvert (> 3 barrels)
H' x W' for each barrel



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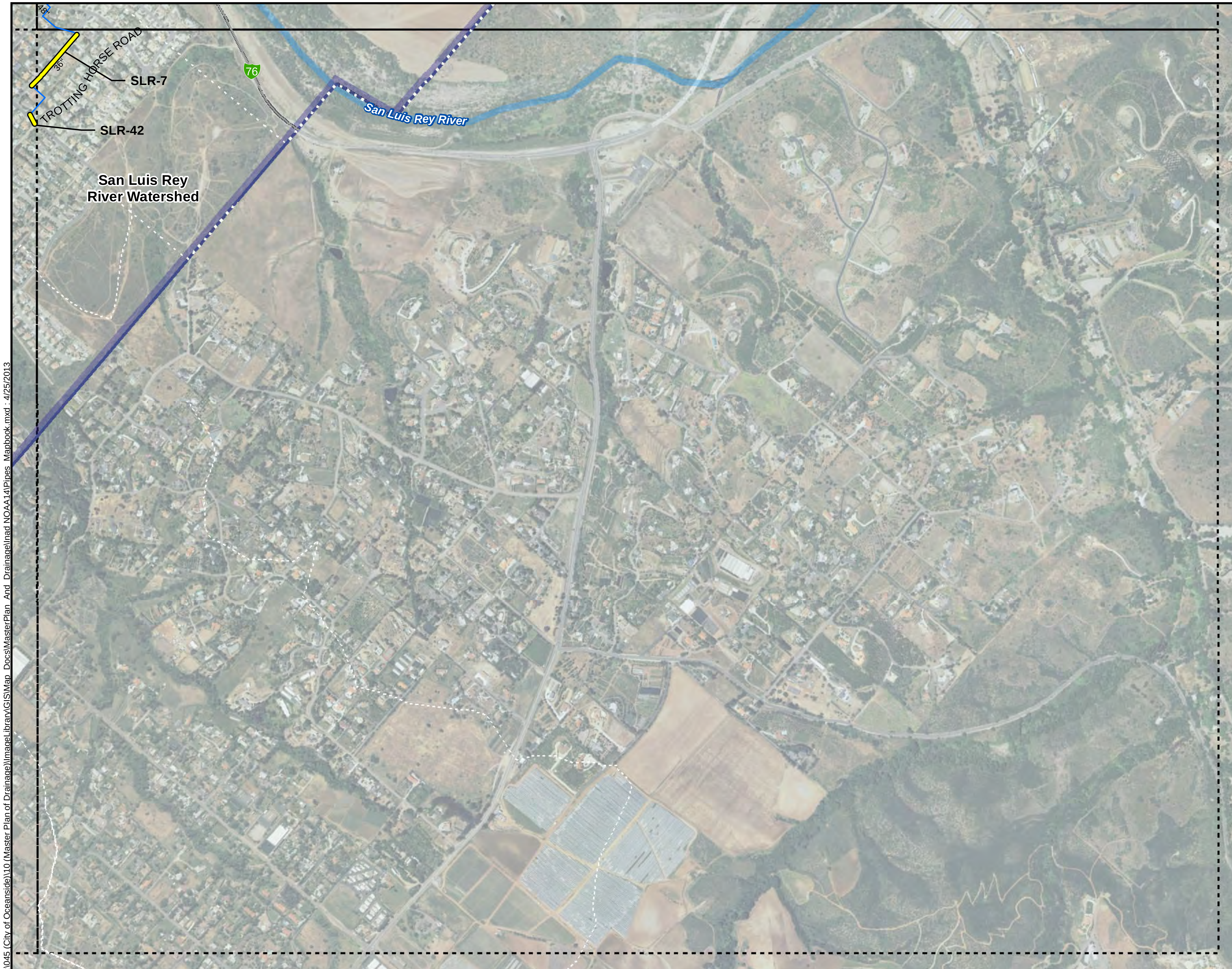
Oceanside MPD Update 2012
Existing Storm Drains
Atlas Page N



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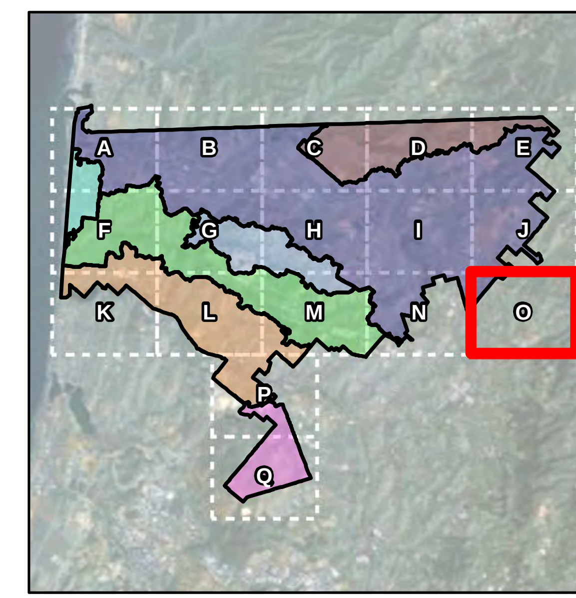

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Oceanside MPD Update 2012
Existing Storm Drains
Atlas Page O

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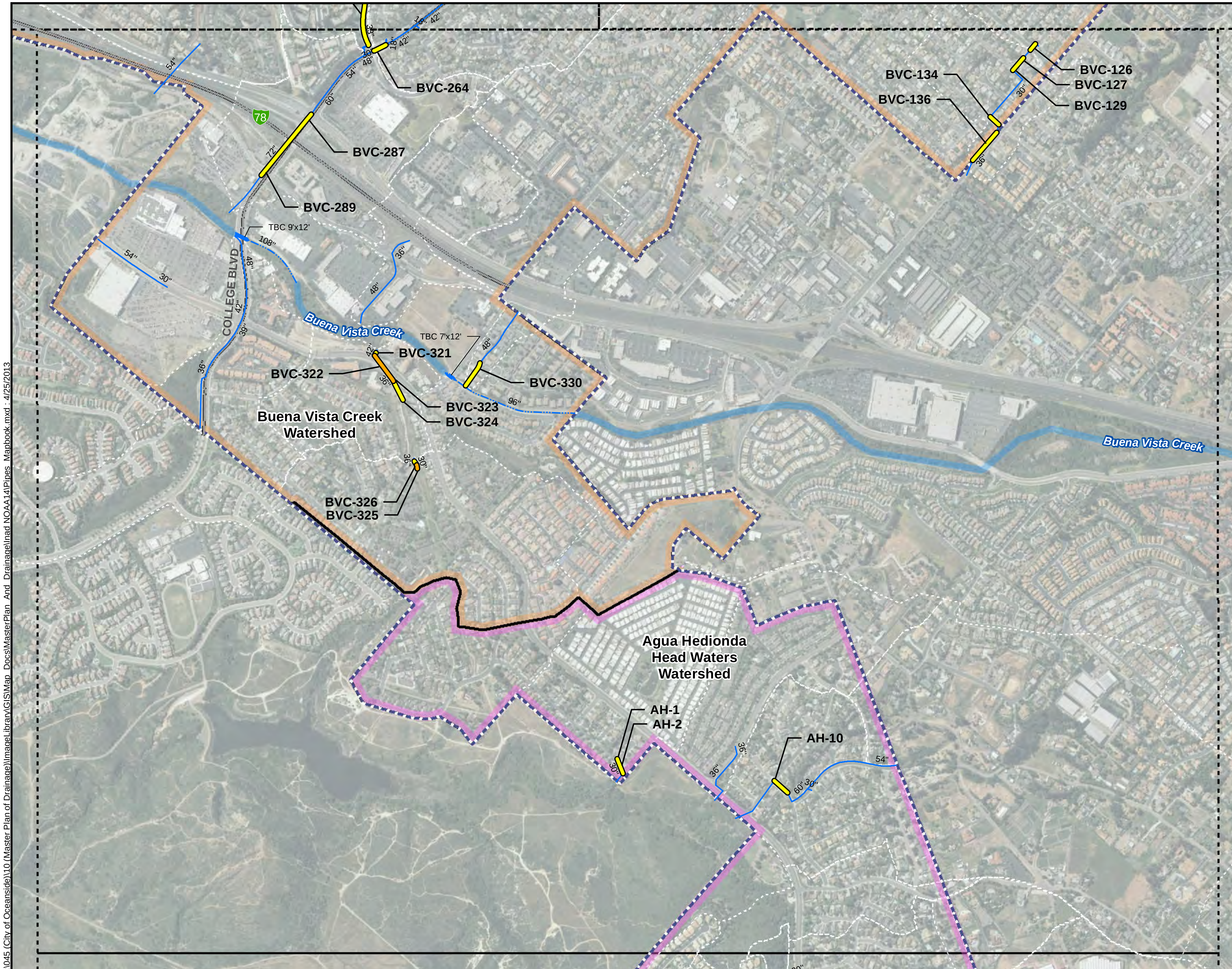

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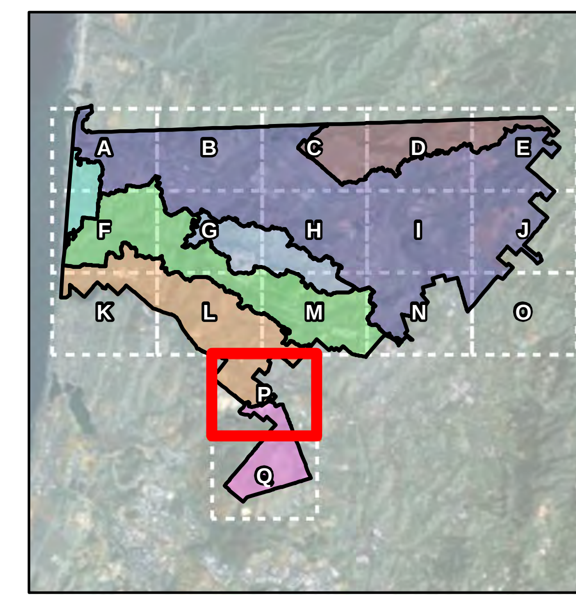

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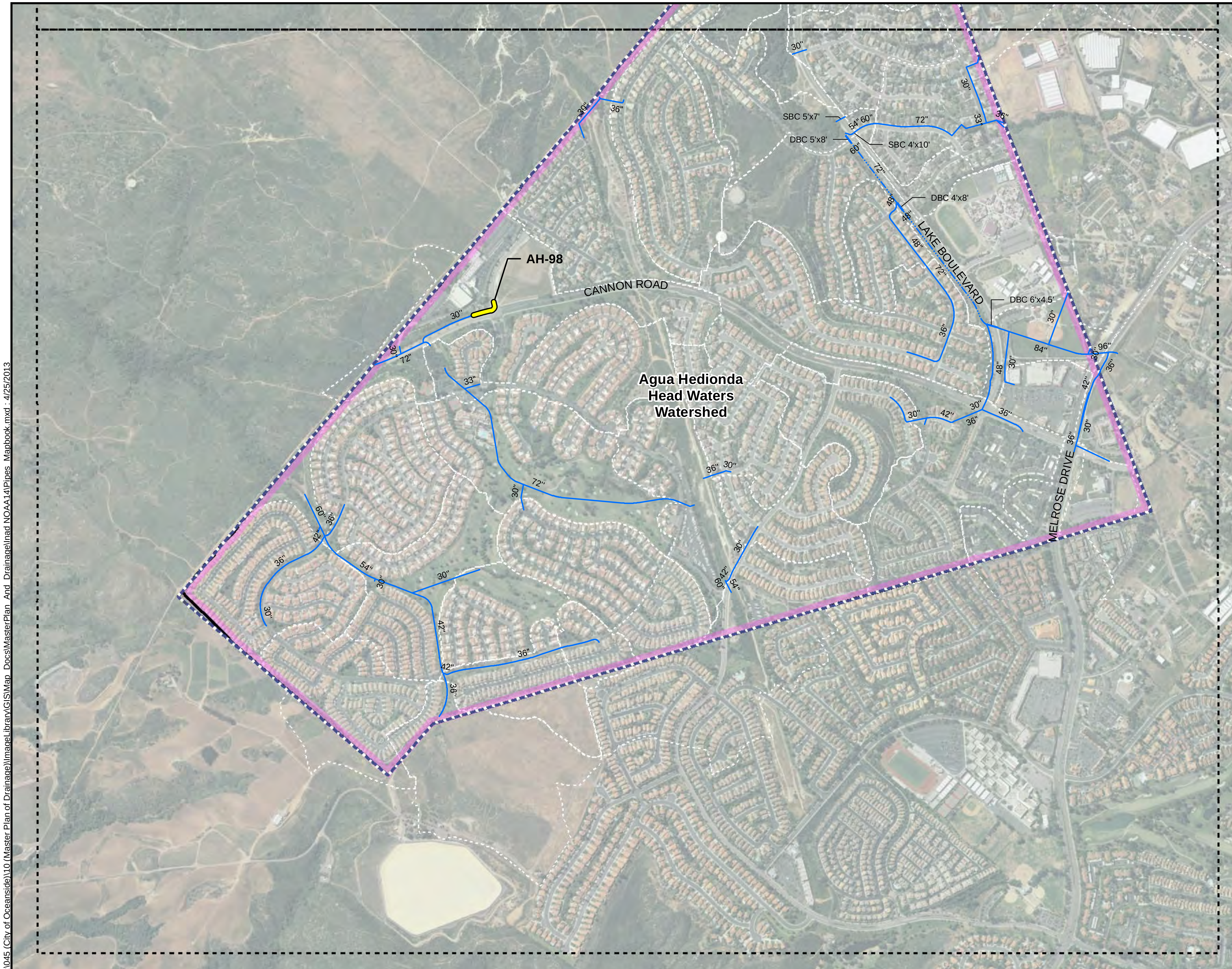
Oceanside MPD Update 2012
Existing Storm Drains
Atlas Page P



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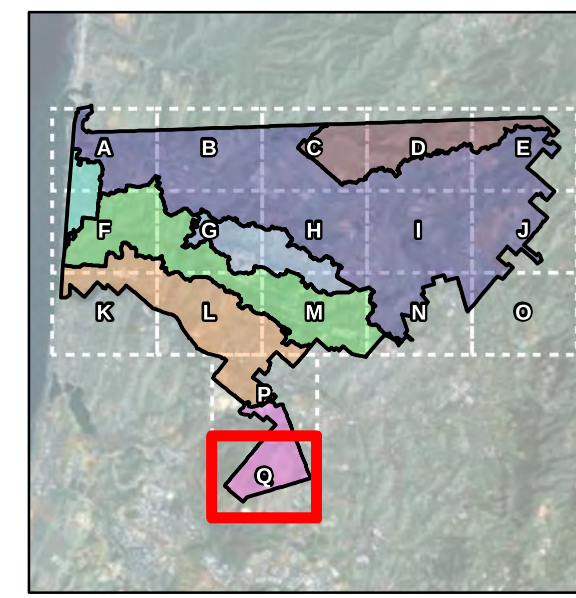

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