Wastewater and Water Systems Climate Adaptation Plan

Adopted by City Council on 4/14/2026

APRIL 2026 | CITY OF SANTA BARBARA

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Prepared by Water Systems Consulting, Inc. and Environmental Science Associates

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ACRONYMS & ABBREVIATIONS

Acronym	Description
AOP	Advanced Oxidation Process
AWPF	Advanced Water Purification Facility
BFE	Base Flood Elevation
CALTRANS	California Department of Transportation
CCC	California Coastal Commission
CCTV	Closed Circuit Television
CFS	Cubic Feet per Second
CIWQS	California Integrated Water Quality System
CMIP6	Coupled Model Intercomparison Project 6
COMB	Cachuma Operation and Maintenance Board
COSMOS	Coastal Storm Modeling System
DFE	Design Flood Elevation
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FT	Feet
GCM	General Circulation Model
HDPE	High-Density Polyethylene
IN	Inch
IPCC	Intergovernmental Panel on Climate Change
I&I	Infiltration and Inflow
LOCA2	Localized Construction Analogue Version 2
MBR	Membrane Bioreactor
MF	Microfiltration
MG	Million Gallons
MGD	Million Gallons per Day
MHHW	Mean Higher High Water
MJHMP	Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan
MLLW	Mean Lower Low Water

MSL	Mean Sea Level
NPDES	National Pollutant Discharge Elimination System
NOAA	National Oceanic and Atmospheric Administration
OPC	Ocean Protection Council
OST	Ocean Science Trust
PRV	Pressure Reducing Valve
PSCA	Pump Station and Chemical Area
PVC	Polyvinyl Chloride
QCM	Quantitative Conceptual Model
RCAMP	Regional Coastal Adaptation Monitoring Program
RCP	Reinforced Concrete Pipe
RCP	Representative Concentration Pathway
RO	Reverse Osmosis
SAFE	Stormwater Adaptive Filtration Equipment
SLIP	Sewer Lateral Inspection Program
SLR	Sea Level Rise
SSO	Sanitary Sewer Overflow
SSP	Shared Socioeconomic Pathways
UPRR	Union Pacific Railroad
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
UV	Ultraviolet
VFD	Variable Frequency Drive
WDR	Waste Discharge Requirement
WUCA	Water Utility Climate Change Alliance

Executive Summary

This Wastewater and Water Systems Climate Adaptation Plan evaluates impacts on the City's critical water and wastewater systems from hazards worsened by climate change. It is part of a broader City Adaptation and Resilience Program, which monitors changing conditions and adapts infrastructure in phases. Funded by the California Coastal Commission, Coastal Conservancy, and the City itself, the Plan satisfies state requirements and supports City Council’s goals to prepare for the effects of climate change.

What's in the Plan:

- Analysis of impacts from flooding, erosion, sea level rise, changing rainfall, groundwater rise, wildfire, drought, and extreme heat on all parts of the wastewater and water systems.
- Focuses on low-lying coastal areas that face the greatest threat from flooding and erosion.
- Prioritization of vulnerabilities: the highest risks are impacts to the wastewater system from flooding during heavy rainfall events and coastal storms (high ocean waves and storm surge).
- Recommended actions to improve resilience in phases, based on defined thresholds.

Key Hazard Risks:

- Next 25 years: As the climate warms, rain becomes more intense, and the 100-year rain event is five times more likely and 10-year storm (e.g., January 2023 storm) is twice as likely. During heavy rainfall and high wave events, floodwater can enter the sewer collection system. This can overwhelm both the collection pipes and capacity at the treatment plant (El Estero Water Resource Center), potentially causing sewer overflows. Flooding from moderate rainfall events can also surround and affect access to the plant. During very large rainfall events, some equipment and treatment processes at the plant could also be at risk from onsite flooding.
- 25-50 years: Sea-level rise accelerates and, without intervention, the Waterfront area and Cabrillo Boulevard, including underlying utilities, faces significant erosion and flooding from coastal storms. El Estero Water Resources Center faces significant flooding risk from large rainfall events combined with sea level rise. Without intervention, low-lying areas north of Cabrillo Blvd and south of Highway 101 could also face flooding from coastal storm surge. This combined with groundwater rise increases the risk of significant amounts of seawater getting into the sewer system, which would

affect operation of the El Estero Water Resources Center as the plant treatment process relies on bacteria that can't survive in saline conditions.

- 50+ years: Without intervention, low-lying areas north of Highway 101 could face flooding from coastal storm surge. Additionally, by 4.9 feet of sea level rise (~2100) flooding from regular high tides would extend into low-lying areas north of Highway 101. Significant seawater flows into the wastewater collection system would render the El Estero Water Resources Center unable to treat wastewater for extended periods following inundation events.

Priority Adaptation Actions for Near-Term (Next 25 Years) Implementation:

- Wastewater Collection System: Build on existing projects that address sewer infiltration and inflow to seal manholes in low-lying areas, rehabilitate flood-prone sewer lines, and increase collection system and treatment plant storage to handle increased flows from flooding and prevent infiltration of saline water. These actions will be defined as part of the proposed *Wastewater System Wet Weather Capacity Study*.

  Make plans to pressurize the sewer system in low-lying areas in phases in the next 25 to 50 years as implementation triggers are met. Customer connections will need to be modified prior to the public sewer mains being pressurized. The City should consider an ordinance in the next five years to require new connections in the low-lying areas to include facilities needed for pressurization and incentives to customers to facilitate conversion of existing sewer connections over the next 25 years. These actions will be defined as part of the proposed *Low Pressure Sewer Conversion Study*.

- El Estero WRC: Develop a formal operations plan for El Estero Water Resource Center during flooding events and implement additional flood protection measures (e.g., floodwalls and elevation of key infrastructure). These actions will be defined as part of the proposed *El Estero WRC Flood Protection Study*.

- Coastal Erosion: Plan to protect or relocate infrastructure affected by shoreline erosion in near and mid-term (potable water line in Chase Palm Park, desalination weir box, and utilities in Cabrillo Boulevard and Shoreline Drive). Plan for long-term inland relocation of the West Beach sewer main.

Implementation:

- Regularly monitor changes in coastal features and groundwater depth and assess infrastructure in flood-prone and coastal areas.
- Update this Plan every 10 years to address changed conditions and new information.
- Plan for funding needs and staff resources. In the next 25 years:
  - $2 to 3 million for studies and design
  - $50 to $130 million in infrastructure modifications
  - Additional staff resources (i.e., engineers, project managers, operators)
- Long-term planning should consider the costs and impacts of protecting El Estero Water Resources Center in place and elevating access roads or relocating the plant by the end of this century. Any potential relocation decision will be informed by future monitoring and extensive coordination with the community and neighboring sanitary agencies to explore opportunities in and outside of the City for potential regional consolidation of treatment facilities. Among properties currently owned by the City that are not anticipated to be impacted by sea level rise, the municipal golf course is one possible location that is large enough to accommodate a new treatment plant.

ES-1 Introduction

This Wastewater and Water Systems Climate Adaptation Plan (Plan) assesses how hazards exacerbated by climate change could impact City of Santa Barbara's (City) wastewater and water infrastructure and outlines a phased approach for adapting these systems over time. Building on the City's 2021 Sea-Level Rise Adaptation Plan (2021 SLR Adaptation Plan) (ESA, 2021) and the 2021 Santa Barbara County Climate Change Vulnerability Assessment (County of Santa Barbara, 2021), it focuses on a range of climate hazards, including sea level rise, increased storm rainfall, coastal flooding and erosion, wave impacts, tidal inundation, and groundwater rise. It includes a detailed analysis of these threats, while providing a higher-level review of drought, extreme heat, and wildfire risks, which are already largely addressed through the City's existing water supply planning and operations.

Asset-specific analysis was conducted for the following critical infrastructure:

- The wastewater collection system, including lift stations.
- The wastewater treatment system, including El Estero Water Resource Center (El Estero WRC) and the treatment plant's outfall system (El Estero outfall).
- The potable water treatment systems, including the Charles E. Meyer Desalination Plant (Desalination Plant) and the associated ocean intake pipeline.
- The potable water distribution system.
- The recycled water system, including the planned potable reuse system.

While the Plan addresses the impacts of climate hazards on the entire wastewater and water systems in the City, special attention is paid to increasing the resilience of the wastewater collection system in the low-lying, prone flood areas of the City that are most at risk in the near-term. Risks and adaptation options are structured into three timeframes: near-term (within the next 25 years), mid-term (25 to 50 years), and long-term (50+ years).

This Plan satisfies permitting and planning requirements of the California Coastal Commission and the City's El Estero WRC National Pollutant Discharge Elimination System (NPDES) permit.

Citywide Adaptation and Resilience Program

This Plan is part of a broader Citywide Adaptation and Resilience Program developed to implement policies in the City's General Plan and Coastal Land Use Plan that address adaptation to hazards worsened by climate change. The program collaborates across all City departments and with regional and state agencies to ensure a unified, proactive approach to climate adaptation. It also supports compliance with state requirements for climate analysis tied to permits, plans, and funding, positioning the City to secure funding and implement resilience projects effectively.

In 2021, City Council adopted the 2021 SLR Adaptation Plan, which outlined priority projects to address current and future coastal hazards. The Plan takes a phased approach, monitoring changing conditions and triggering adaptive actions as needed. Adapting the City's wastewater and water systems was identified as a top priority in the 2021 plan.

The Santa Barbara County Climate Change Vulnerability Assessment (County of Santa Barbara, 2021), also completed in 2021, provides countywide analysis of climate change impacts, including analysis of changes in rainfall patterns and rising heat.

Since 2021, the City's program has advanced implementation efforts and secured funding from the Coastal Conservancy and California Coastal Commission. Current funded projects include:

1) Regional Climate Adaptation Monitoring Program: Development of a regional coastal monitoring program in Santa Barbara and Ventura counties to track how soon actions are needed and the effectiveness of adaptation projects.
2) 30-Year Waterfront Adaptation Plan: A plan to prepare the waterfront for increased storm surges, erosion, and flooding by providing solutions that preserve and enhance recreation, commerce, beach access, habitat, and critical infrastructure for the near-term and future generations.
3) Stormwater Model and Flood Analysis: Preparation of a model of flows of the City's stormwater system, analysis of flooding resulting from a range of intensity of storms including smaller, more frequent storms, and adaptation options for portions of the stormwater system.
4) Airport Climate Vulnerability and Adaptation Plan: Evaluation of climate change vulnerability and potential adaptation options for the City's airport.

Study Area

The study area for this Plan, shown in Figure ES-1, encompasses the City's water and wastewater service areas. It does not include the portion of the City occupied by the Santa Barbara Airport, which is the subject of a climate adaptation plan specific to the Goleta Slough area. Based on the high priority water and wastewater infrastructure risks identified in the 2021 SLR Adaptation Plan, this Plan has more in-depth analysis of a "focused study area," shown in red in Figure ES-2, that generally covers the low-lying waterfront and beach areas and low-lying flood areas between Castillo Street to Milpas Street and inland to the US-101 freeway. This focused study area already experiences flooding during major storm events and is the most at-risk area for increased hazards over time.

Figure ES-1. Citywide Study Area

Figure ES-2. Focused Study Area

Adaptation Approach: Prioritization and Phasing

To create this Plan, the first step was identifying climate change hazards in Santa Barbara and assessing their impact on the City's water and wastewater systems. These vulnerabilities were ranked based on the likelihood and severity of potential events, guiding the development of various adaptation options, from protecting existing infrastructure to relocating it. Some options may require further data and analysis for informed decision-making.

This Plan builds to an adaptation strategy that recommends immediate next steps and thresholds for implementation. Near-term (next 25 years) recommendations are the most prescriptive, while mid-term (25 to 50 years) and long-term (50+ years) recommendations provide higher-level guidance.

Projections for sea level rise and other climate changes are regularly updated and refined as new studies emerge, changing conditions are monitored, and models are refined. As a result, the recommendations in this Plan are structured to accommodate future changes to projections and the performance of adaptation measures. Monitoring of changing conditions is a key component to the City's overall approach to planning for climate hazards. Because of the timing uncertainty and range of projections for sea level rise, this Plan provides a framework of planning based on amounts of sea level rise, rather than exactly when those amounts of sea level rise will occur. Adaptation recommendations are phased, with different actions recommended when certain thresholds or triggers are reached on the ground. Lead time to study, plan for, and implement adaptation actions is built into the triggers so that necessary improvements are made prior to major impacts occurring.

This plan is intended to be a living document and recommended to be reevaluated and updated roughly every decade based on:

- Observed climate change impacts and the latest climate change projections, new adaptation approaches, and legal/policy changes.
- Further refinement of the City's overall adaptation plans. Future updates of this Plan will be coordinated with other City climate change planning and adaptation documents to ensure a comprehensive and consistent strategy is implemented over time.

ES-2 Hazard Assessment and Vulnerability Analysis

The following hazards were analyzed in this Plan: stormwater flooding, coastal storm flooding, coastal storm wave run-up, tidal inundation, shoreline erosion, and groundwater rise. This executive summary predominantly focuses on flooding and erosion, due to their potential for high impacts to the City's systems. These hazards were assessed and applied to water and wastewater assets to determine vulnerabilities. Figures were developed that overlay the City's water and wastewater systems with different hazards. The hazards assessment considered both the impacts from rainfall events during storms (stormwater flooding) or from high ocean levels and waves during normal conditions and storm conditions (coastal hazards). Additional analyses estimated future stormwater flooding due to climate change and projected shoreline erosion with future sea level rise. **Note that these hazards represent projected future conditions without taking action as a hypothetical "do nothing" baseline scenario to inform adaptation options**, such as regional flood protection or beach nourishment.

The hazards assessment was completed using Federal Emergency Management Agency (FEMA) Flood Insurance Study and Flood Insurance Rate Maps for stormwater flooding, United States Geological Survey Coastal Storm Modeling System (CoSMoS) 3.0 for tidal inundation and groundwater rise, a shoreline erosion assessment performed for the City's 30-year Waterfront Adaptation Plan (ESA, 2025b), and hydrodynamic modeling of coastal flooding performed for the City's 30-year Waterfront Adaptation Plan (Stantec, 2025). To estimate changes in precipitation, data from the Coupled Model Intercomparison Project 6 general circulation models was used.

Sea Level Rise Scenarios

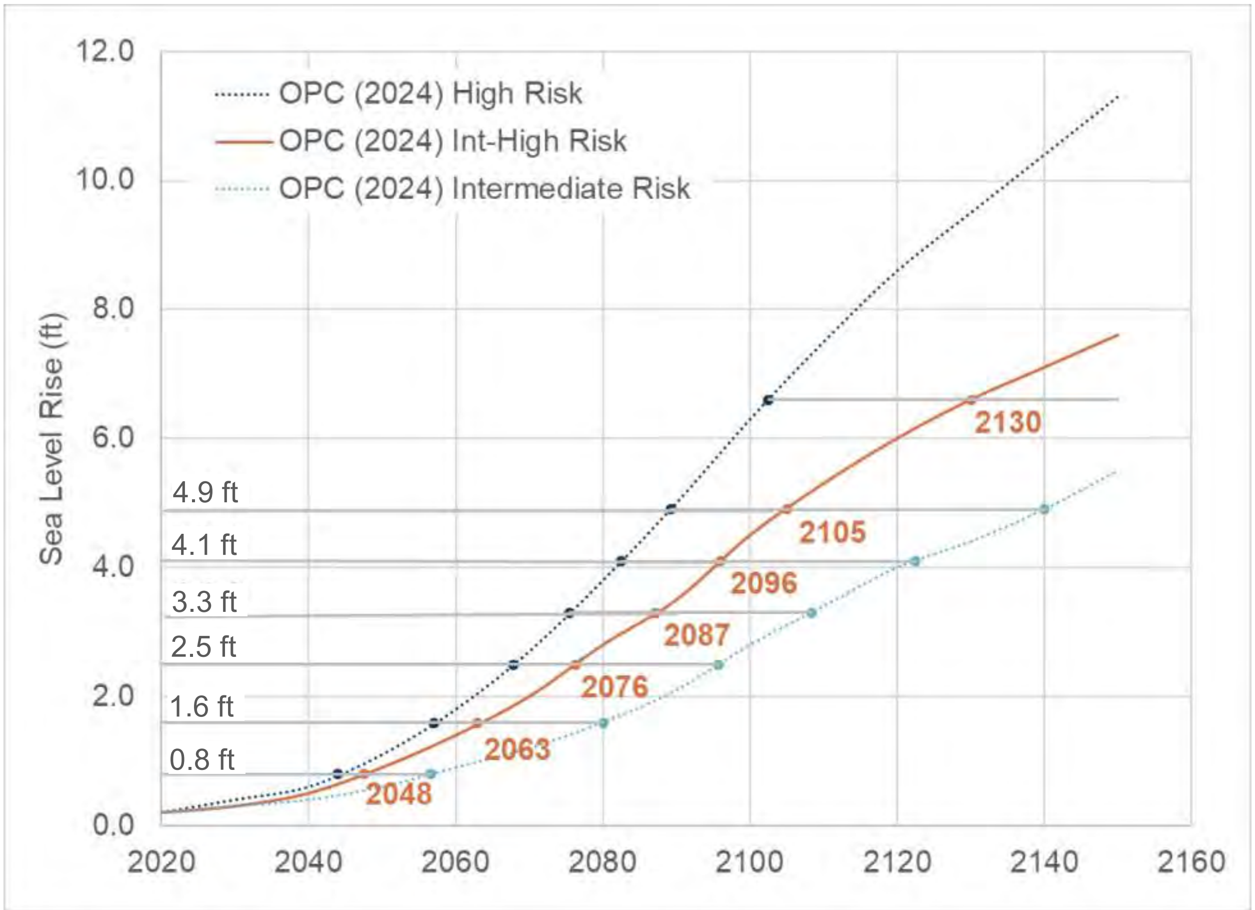
Sea level rise near the City is influenced by factors like ocean thermal expansion, Antarctic ice sheet melting, ocean circulation, and land elevation changes. As research advances, sea level projections are updated based on new knowledge about these processes and greenhouse gas emissions forecasts. Table ES-1 and Figure ES-3 show the latest sea level rise scenarios from the 2024 Ocean Protection Council's (OPC) guidance for Santa Barbara from the baseline year of 2000. These projections vary in likelihood. The analysis in this Plan focuses on the Intermediate-High Scenario, which offers a conservative estimate for sea level rise by 2100 and is appropriate for planning for water and wastewater systems. While cutting global emissions could slow sea level rise, some increase is already inevitable due to past emissions. The key difference between scenarios is the timing of specific sea level milestones, with likelihoods ranging from moderate (Intermediate Scenario) to very low (High Scenario). To address timing uncertainty, this Plan analyzes hazards at the specific sea level rise amounts shown in Table ES-1 because they represent key points relevant to vulnerabilities of the wastewater and water systems. Approximately just under an inch of sea level rise has already occurred relative to the baseline year of 2000.

Table ES-1. Sea Level Rise Scenarios with Timing Based on 2024 OPC Guidance

Sea Level Rise Amount	Sea Level Rise Scenarios (Risk Aversion Application) Projected Dates of Sea Level Rise Amount — Decreasing likelihood of occurrence →		
	Intermediate Scenario (Low Risk Aversion)	Intermediate-High Scenario (Med-High Risk Aversion)	High Scenario (Extreme Risk Aversion)
0.8 ft	2057	2048	2044
1.6 ft	2080	2063	2057
2.5 ft	2096	2076	2068
3.3 ft	2108	2087	2075
4.1 ft	2123	2096	2083
4.9 ft	2140	2105	2089
6.6 ft	After 2150	2130	2103

Note: This Plan is based on the Intermediate-High sea level rise scenario (light blue highlight).

Figure ES-3. Sea Level Rise Scenarios with Timing Based on 2024 OPC Guidance



Stormwater Flooding from High Rainfall Events

Figure ES-4 shows the City's water and wastewater infrastructure and the extent of flooding from intense rainfall, as estimated by FEMA's 100-year flood hazard maps. This flooding overlaps about 41 miles of sewer pipes, 537 manholes, 27 miles of potable water pipes, and 7 miles of recycled water pipes.

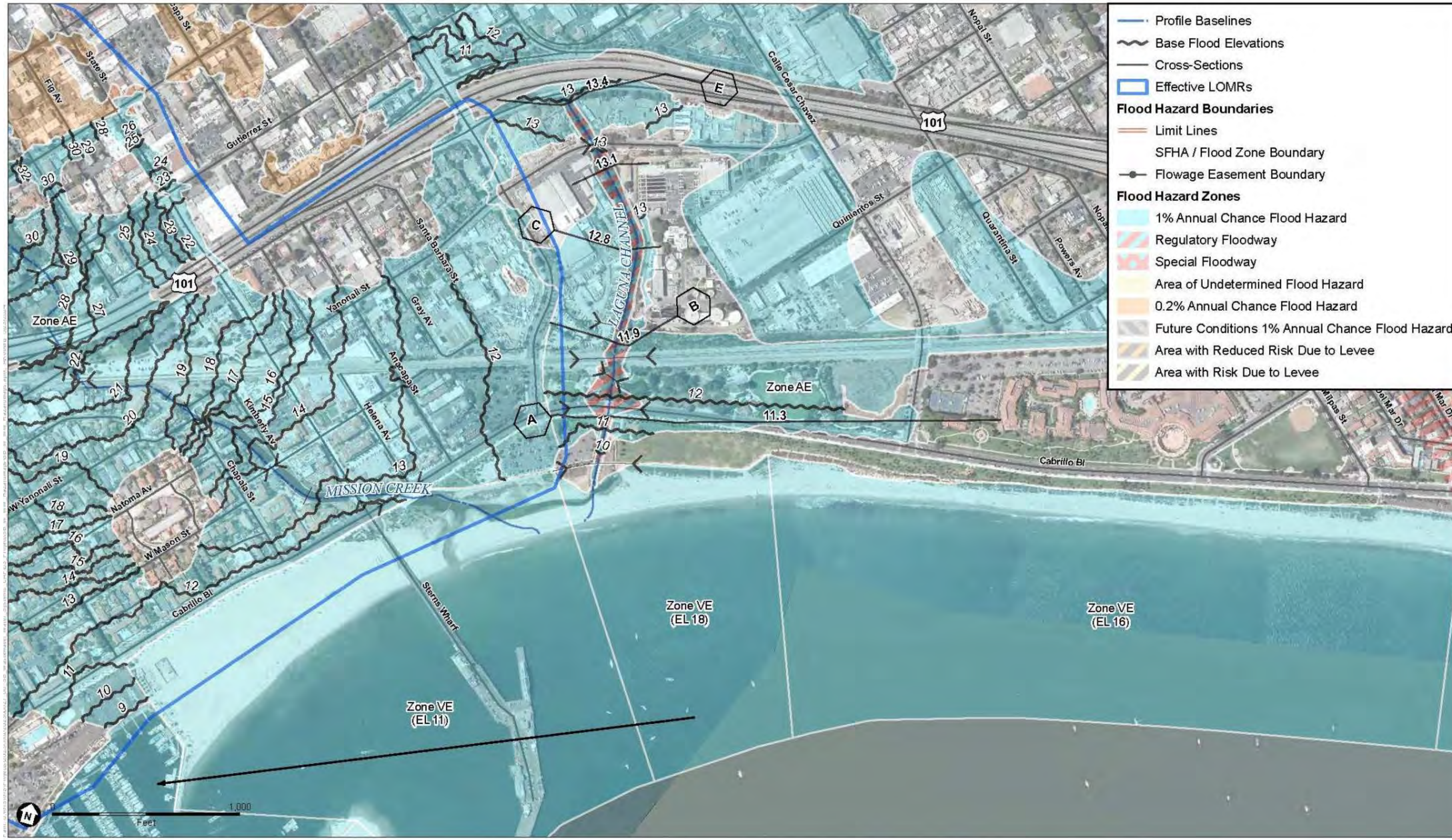
The FEMA 100-year flood hazard zone is an area with a 1% chance of flooding each year, based on past data. However, it doesn't account for climate change impacts. Climate change is expected to increase the frequency and intensity of rainfall. For instance, a storm that once had a 1% chance of occurring (a 100-year event) may soon occur with a 5% to 10% chance annually. These changes are already starting to take place and are expected to increase over time. Recent storms, which were considered 5- to 10-year rainfall events, caused significant flooding and are an example of the more frequent storms expected with climate change.

Table ES-2. Projected 24-hour Rainfall Event Return Interval (and Percent Annual Chance of Occurrence) with Climate Change

Scenario	24-hr Rainfall Event Return Interval (% Annual Chance of Occurrence)				
Past Precipitation	5-year storm (20%)	10-year storm (10%)	50-year storm (2%)	100-year storm (1%)	500-year storm (0.2%)
Future Precipitation with Climate Change (2030 to 2100)	2- to 3-year storm (33%-50%)	5-year storm (20%)	10-year storm (10%)	10- to 20-year storm (5%-10%)	30- to 50-year storm (2%-3%)

FEMA maps do not show flood extents or depths for smaller more frequent storms (e.g., the 5-, 10-, or 50-year storms). In addition, they do not show potential flooding from changes in rainfall patterns from climate change or flooding combining with sea level rise. Preliminary modeling and analysis completed as part of this Plan shows that, with future sea level rise, Mission Creek Lagoon water levels, Laguna Creek backfilling, and Laguna Creek flood frequency and extent are expected to increase due to increasing beach berm height during lagoon closures and increasing high tide levels.

Figure ES-4. FEMA 100-Year Flood Map



SOURCE: FEMA, ESA

D202300027 Santa Barbara Wastewater and Water Systems Climate Adaptation Plan

The highest risk vulnerabilities of the wastewater and water systems from stormwater flooding in the future from climate changes include:

- More frequent and severe floods, along with groundwater rise, are likely to lead to higher flows into the wastewater collection system and at El Estero WRC. Excessive flows during high rainfall events could cause the system to be overwhelmed, resulting in increased possibilities of sanitary sewer overflows.
- Recent storms (approximately 5- and 10-year storms) have prevented access to El Estero WRC because of flooding in local streets surrounding the treatment plant. Larger, more intense storms would prevent access, risk operator safety, impact the timely delivery and export of materials, and reliable plant operations.
- Looking at the combined 100-year rainfall stormwater flooding event with sea level rise, lower areas along the perimeter of El Estero WRC would flood during high rainfall events with 0.8 ft of sea level rise (~2050). By 2.5 ft of sea level rise (~2075), the entire site is projected to flood during the historic 100-year high rainfall event.

The City plans to conduct more detailed modeling through the Stormwater Model and Flood Analysis, focusing on smaller, more frequent storms and evaluating flood impacts and adaptation options, especially for Laguna Creek. Findings from this analysis will inform future updates to this Plan.

Coastal Hazards

Coastal hazards are those caused by high ocean levels and waves during normal and storm conditions. This Plan analyzes five categories of hazards with permanent and temporary impacts as discussed in the following sections.

City water and wastewater infrastructure overlaid with projected coastal storm flooding and tidal inundation for existing conditions through 4.9 ft of sea level rise (~2100) are provided in Figure ES-9 through Figure ES-15 (at the end of this Executive Summary) and compiled in Appendix A. These figures show coastal hazards (but do not include stormwater flooding from high rainfall events or combined events) and are the level of hazard projected without any action taken at a citywide or regional level to reduce flooding and erosion impacts. Shoreline erosion for existing conditions through 4.9 ft of sea level rise (~2100) are provided in Figure ES-16 and Figure ES-17 (at the end of this Executive Summary) and are also compiled in Appendix A.

Coastal Storm Flooding

Coastal storm flooding is characterized by temporary flooding from high ocean water levels caused by coastal storm surge events resulting in significant consequences, such as infiltration of brackish water into unsealed manholes or other open structures designed to provide access into the wastewater systems.

Of the coastal hazards, coastal flooding from ocean storm surge impacts the largest amounts of coastal infrastructure, as summarized in Table ES-3. During the 100-year coastal storm and under existing conditions, the Leadbetter, West, and East beaches and Cabrillo Boulevard from Stearns Wharf to Andree Clark Bird Refuge experience flooding. With 0.8 ft of sea level rise (~2050), flooding of Cabrillo Boulevard is projected with a 1-year coastal storm. Coastal storm flooding extends to the railroad under 1.6 ft of sea level rise (~2065) and extends to US-101 under 2.5 ft of sea level rise (~2075). By 3.3 ft of sea level rise (~2085), the 100-year coastal storm is projected to flood portions of downtown north of Highway 101.

Table ES-3. Coastal Infrastructure Impacted by Flooding During 100-Year Coastal Storm under SLR Scenarios

SLR Scenario	Sewer Pipe (miles)	Sewer Manholes (number)	Sewer Connections (number)	Potable Water Pipe (miles)	Potable Connections (number)	Recycled Water Pipe (miles)
Current (2025)	1.7	16	39	2.6	49	2.7
0.8 ft (~2050)	4.3	44	101	4.0	96	3.4
1.6 ft (~2065)	4.6	64	120	4.9	137	3.6
2.5 ft (~2075)	6.0	81	214	6.8	187	3.8
3.3 ft (~2085)	10.8	148	572	11.6	449	4.7
4.1 ft (~2095)	13.2	177	809	14.0	663	4.9
4.9 ft (~2100)	15.5	223	1015	17.0	906	5.1

Tidal Inundation

Tidal inundation is characterized by areas regularly flooded by typical monthly spring high tides, leading to permanent impacts and significant consequences due to saltwater infiltration into the wastewater system.

Under existing conditions, developed areas are not tidally inundated under regular, non-storm conditions. By 4.1 ft of sea level rise (~2095), regular high tides are projected to flow up Laguna Creek adjacent to El Estero WRC and spring high tides (occurring approximately twice per month) with typical winter wave conditions are projected to inundate the coastal zone south of the UPRR. By 4.9 ft of sea level rise (~2100), low-lying areas adjacent to Laguna Creek north and south of US 101 are at risk of daily tidal inundation.

Shoreline Erosion

Shoreline erosion areas that may be lost due to erosion from wave action, causing permanent impacts and severe consequences as assets are washed away, damaged, undercut, or otherwise compromised structurally. The shoreline erosion analysis is based on long-term erosion each year as well as erosion from a 100-year storm to project shoreline profiles at key pipelines (El Estero outfall, Desalination Plant intake, and the West Beach sewer main). Erosion amounts were projected based on historic erosion rates with additional projected erosion due to sea level rise.

If no action is taken, shoreline erosion along East Beach is projected to reach Cabrillo Boulevard, east of Calle Cesar Chavez, by 1.6 ft of sea level rise (~2065), risking exposure and failure of utilities buried under Cabrillo Blvd. By 2.5 ft of sea level rise (~2075), shoreline erosion risks exposure and failure of utilities buried under Shoreline Drive and erosion into Chase Palm Park will require relocation of the potable water line in the park.

At the current sea level, the El Estero outfall manhole is projected to be exposed with a 100-year storm. The manhole is projected to be exposed 5 ft above the beach surface with 0.8 ft sea level rise (~2050) due to erosion. The El Estero outfall pipeline has the potential to be exposed at 2.5 ft sea level rise (~2075) but is not projected to be undercut by erosion.

The Desalination Plant intake weir box is currently exposed a few feet above the beach and protected by rip rap. During the 100-year storm, the weir box may be fully exposed and the Desalination intake pipeline has the potential to be exposed. With 0.8 ft of sea level rise (~2050), the weir box and pipeline are projected to be exposed.

The West Beach shoreline analysis indicates that West Beach is stable. Future erosion projections show that the West Beach sewer will not be exposed through 4.9 ft of sea level rise (~2100). Monitoring of erosion is recommended to inform adaptation needs at West Beach. The analysis showed that coastal storm flooding and coastal storm wave runup may cause some erosion around the West Beach sewer manholes.

Groundwater Rise

Groundwater rise causes regular high groundwater levels with increased salinity from rising sea levels, causing permanent impacts and significant consequences due to infiltration and corrosion of wastewater and water infrastructure.

Groundwater levels were analyzed to identify the extent of shallow groundwater and potential impacts to City assets. Note that the available groundwater data was limited and future updates are recommended to be supplemented with locally collected data to improve data reliability. Establishment of a monitoring program for depth and salinity of shallow groundwater should be established as soon as possible.

Buried infrastructure either fully or partially submerged by shallow groundwater in the coastal area under sea level rise is summarized in Table ES-4. The depth to groundwater decreases with sea level rise, becoming very shallow in much of downtown with 2.5 ft of sea level rise (~2075) and greater. With 4.1 ft of sea level rise (~2095), larger portions of downtown may experience emergent groundwater.

Table ES-4. Coastal Infrastructure Impacted by Groundwater Rise under SLR Scenarios

SLR Scenario	Sewer Pipe (miles)	Potable Water Pipe (miles)	Recycled Water Pipe (miles)
Current (2025)	18.7	9.8	2.6
0.8 ft (~2050)	19.6	12.2	3.0
1.6 ft (~2065)	20.2	12.8	3.0
2.5 ft (~2075)	21.2	13.6	3.0
3.3 ft (~2085)	22.0	14.0	3.0
4.1 ft (~2095)	22.5	14.0	3.0
4.9 ft (~2100)	22.6	15.6	3.0

Note: Values are for pipes estimated to be fully or partially submerged by shallow groundwater. Note that groundwater depths were estimated using CoSMoS, which may be estimating groundwater levels shallower than current observations. As a result, shallow groundwater monitoring is recommended to update groundwater depth estimates.

Drought, Heat, and Wildfire

Drought, heat, and wildfire can pose significant challenges for water and wastewater infrastructure, such as:

- Droughts can lead to reduced water use, which results in lower wastewater flows with higher solids content, potentially resulting in buildup within pipelines and hydrogen sulfide corrosion. As pollutants build up, wastewater treatment processes may become strained, operate less efficiently, and require adjustments to meet discharge standards.
- Heat and wildfires can strain electrical equipment that may overheat, reduce efficiency, increase maintenance needs, and potentially result in failure and impact service.
- Heat and wildfires may also strain treatment processes by promoting the growth of microorganisms in raw water supplies that may require additional treatment to meet standards.

Because Santa Barbara has been experiencing extreme droughts and intense wildfires in the recent past, the City has largely already addressed these hazards through diversifying the water supply portfolio and employing additional maintenance and treatment methods.

Risk Assessment Results

A risk assessment matrix was employed to prioritize wastewater and water systems' vulnerability to climate change of various coastal water and wastewater system components. A risk matrix is a tool used to assess the level of risk posed by an undesirable event by considering both the likelihood of the event taking place and the severity of the event's consequences.

The highest infrastructure risks in the near-term (now through 0.8 ft of sea level rise (~2050)) are predominantly related to increased frequency and severity of stormwater flooding from high intensity rainfall events and include:

- Exceedance of capacities in the wastewater collection system and El Estero WRC, leading to increased sanitary sewer overflows and potential Clean Water Act violations.
- On-site flooding at El Estero WRC could put wastewater treatment processes and equipment at risk of failures, leading to potential violations of the Clean Water Act.
- Off-site flooding in neighborhoods surrounding El Estero WRC could prevent access to the plant, leading to staff safety and operational challenges.

The highest infrastructure risks in the mid-term (0.8 ft to 2.5 ft of sea level rise (~2050 to ~2075)) are predominantly driven by shoreline erosion and wave action hazards that threaten the following assets:

- Buried utilities located in Cabrillo Blvd
- Potable water pipeline in Chase Palm Park
- Desalination intake system

These near-term and mid-term risks are spatially presented in Figure ES-5. More details on the vulnerability of each asset and potential adaptation options are below.

Figure ES-5. Highest Near-Term (Next 25 Years) and Mid-Term (25 to 50 Years) Infrastructure Risks from Climate Change

ES-4 Adaptation Strategy

The analysis of adaptation options for each piece of infrastructure includes information on the timeframe and conditions for triggering the action. **Recommended actions are divided into four timeframes[1]:**

- **Immediate Next Steps** (0 to 5 Years)
- **Near-Term** (5-25 years): now to 0.8 ft SLR (~2050)
- **Mid-Term** (25-50 years): 0.8 ft to 2.5 ft SLR (~2075)
- **Long-Term** (50+ years): 2.5 ft to 6.6 ft. SLR (~2130)

Mid-term adaptation options will generally be dependent upon the success of near-term water and wastewater system adaptation measures, success of citywide and regional adaptation measures to lessen erosion and flooding impacts, and changes in existing and projected conditions. The target time for implementation, as well as the steps required to implement an adaptation option, such as planning, design, and construction, are considered and included in the implementation plan.

This section outlines potential measures to protect assets if citywide adaptation (e.g., flood or shoreline protection) is insufficient. Future flooding in low-lying areas will be influenced by several sources, including rainfall and coastal flooding due to sea level rise, making full flood protection difficult. Further studies are needed to evaluate citywide flood and erosion control options. While citywide flood control efforts may delay the need for individual infrastructure adaptation projects, infrastructure-specific measures will likely still be necessary at some point due to ongoing flood risks and the critical nature of the wastewater and water systems.

Wastewater Treatment Adaptation Summary

The City's wastewater treatment system consists of El Estero WRC for treatment of wastewater and the El Estero outfall to safely dispose of treated wastewater into the Pacific Ocean. The highest near-term risks identified for El Estero WRC and El Estero outfall are:

- El Estero WRC Onsite Flooding: Portions of El Estero WRC are projected to flood during the 100-year storm at existing sea levels if flood water is allowed to find its way onsite. Vulnerable areas include the primary and secondary clarifiers area which house electrical and controls systems; electrical equipment located throughout the plant in low elevation areas, and the front and back access gates. These areas are likely to flood during the 100-year storm by 0.8 ft of sea level rise (~2050), and most of the site is projected to flood during the 100-year storm by 2.5 ft of sea level rise (~2075).
- El Estero WRC Access from Offsite Flooding: Recent 5- and 10- year storms have temporarily (less than 12 hours) prevented access to the plant due to flooding in local

[1] Years included with sea level rise levels are associated with the Intermediate-High Sea Level Rise Scenario. As described in Section ES-2, sea level rise amounts could occur sooner or later.

streets. Larger storms could prevent access for over 24 hours, which risks staff safety, timely delivery and export of materials, and reliable plant operations.

In addition, near-term onsite and offsite flooding risks to El Estero WRC are projected to worsen in the mid-term with higher intensity rainfall during storms and sea level rise. The highest risk for El Estero outfall is potential exposure and undercutting of the outfall pipeline in the mid-term due to offshore and beach erosion. Adaptation recommendations for these risks are summarized below.

El Estero WRC On-Site Flooding

- **Immediate Next Steps (0-5 Years):** Additional data collection and analysis are recommended to further define vulnerabilities and build confidence on a path toward adaptation, including:
    - **Stormwater Model and Flood Analysis:** Study high frequency, lower-level rainfall events and associated flooding surrounding El Estero WRC to fill data gaps, such as extent and recurrence of flooding with climate change. Analyze options to modify stormwater system to reduce flooding. This effort is already funded. Findings from the stormwater analysis will be incorporated into other studies in this Plan that are recommended as immediate next steps.
    - **El Estero WRC Flood Protection Study:** Evaluate and recommend phasing of flood protection measures considering Stormwater Model and Flood Analysis findings. Compare the merits of protecting or elevating individual treatment processes and/or protecting the whole site with a floodwall system. The study would define a phased approach to provide flood protection through at least 2.5 ft of sea level rise (~2075).
- **Near-Term (Through 0.8 ft SLR (~2050)):** Implement the recommendations from the El Estero WRC Flood Protection Study (e.g., floodwalls and/or elevation of infrastructure). In addition, the City may consider reserving areas in City-owned property as potential sites for long term relocation of wastewater infrastructure due to the limited number of feasible locations.
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** Update the El Estero WRC Flood Protection Study considering: 1) updated hazard and vulnerability assessments, especially timing of sea level rise; 2) proficiency of flood protection measures implemented in and around El Estero WRC; and 3) long-term risks for El Estero WRC. Implement the updated study recommendations.

Off-Site Flooding Limiting Access to El Estero WRC

- **Immediate Next Steps (0-5 Years):** Formalize an El Estero WRC Flood Conditions Operations Plan to document operation practices during flood conditions; shift schedule and plant access protocols; resources and accommodations for staff for prolonged shifts; expanded solids storage capacity; and protocols for solids hauling and chemical delivery schedules that account for extended lack of access to the plant.

- **Near-Term (Through 0.8 ft SLR (~2050)):** Reevaluate flood preparations following completion of the Stormwater Model and Flood Analysis, which will better characterize flood risks, to determine if larger investments in road infrastructure are needed to provide access to El Estero WRC up to 0.8 ft of sea level rise (~2050).
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** Update the previous flood operations analysis considering: 1) updated hazard and vulnerability assessments, especially timing of sea level rise; 2) proficiency of implemented local and regional measures; and 3) long-term plans for El Estero WRC. Further study long-term options for elevating roads or providing alternate access to El Estero WRC in coordination with analysis of options for potential relocation of the plant.

El Estero Outfall

- **Near-Term (Through 0.8 ft SLR (~2050)):** Shoreline erosion along East Beach is projected to expose the outfall's onshore manhole up to about 5 ft by 0.8 ft of sea level rise (~2050). The outfall manhole could be surrounded by ocean water at low tide by 2.5 ft of sea level rise (~2075). Although the City has not used this manhole for routine pipeline inspections in recent history, it may be valuable for future access and is recommended to be protected in the near-term. Depending on changing climate conditions and operational needs further in the future, potential manhole relocation or abandonment may be investigated.
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** The portion of the outfall pipeline under East Beach is projected to be exposed by 2.5 ft of sea level rise (~2075), and it will be fully submerged when the pipeline is eventually exposed. The outfall pipeline is anticipated to be resilient to the impacts of shoreline erosion due to its depth of installation, existing sheet piles on both sides, and significant existing rock armor overlying the pipe. Regular condition assessments, which are required by the NPDES permit, are expected to continue and identify issues as they arise. Such assessments will serve as reoccurring monitoring and data collection points and will inform updated erosion projections to determine future needs for improvements.

El Estero WRC (Long-Term)

El Estero WRC sits at a higher elevation than the areas surrounding it and the more significant issues with the wastewater system in the near- and mid-term are related to flooding events that affect areas surrounding the plant. In the near-term, flood protection investments at the site will be needed and access during flood hazards can be managed with limited modifications to existing practices. In the mid-term, more substantial road and site access improvements may be required.

In the mid-term, the City will also need to further study and consider whether to relocate El Estero WRC in the long-term given the costs required to address safe, reliable access during recurrent flooding, and to protect the site from extreme flooding at high amounts of sea level rise. That decision will be part of future updates to this Plan that will benefit from more years of monitoring and additional information on how climate changes are affecting the region and possible adaptation options. Any relocation study would involve close coordination with regional partners to explore opportunities for shared facilities and to identify potential sites of sufficient size across the region. Among properties currently owned by the City, the municipal golf course on Las Positas Road is large enough to accommodate a new wastewater treatment plant if needed.

Wastewater Collection Adaptation Summary

The City's wastewater collection system includes approximately 254 miles of gravity sewer mains, approximately 5,900 manholes, 7 lift stations, and approximately 2 miles of force main (pressurized sewer main). The City already experiences difficulties managing flows within the existing collection system and capacities at El Estero WRC during high rainfall events due to stormwater inflows and infiltration into pipes and manholes.

The City utilizes a comprehensive Condition Assessment Program to monitor and evaluate the condition of its wastewater collection system. This program is designed to identify structural deficiencies, reduce the risk of sanitary sewer overflows, and support long-term asset management and capital planning. Core condition assessments are conducted using Closed-Circuit Television (CCTV) inspections. The City aims to inspect approximately 20% of the system annually, achieving complete coverage over a five-year cycle. Priority is given to high-risk areas, including those near surface waters, steep slopes, high groundwater elevations, environmentally sensitive zones, and locations listed on the Clean Water Act Section 303(d) List for bacterial impairment.

In addition to CCTV, the City employs complementary inspection tools and techniques such as SmartCover remote flow monitoring, visual inspections, smoke testing, dye testing, and hydraulic modeling. These methods help detect various issues, including cracks, sags, root intrusions, joint separations, inflow and infiltration, and structural failures. The integration of SmartCovers enables real-time monitoring of flow conditions, enhancing the City's ability to prioritize maintenance and capital projects based on actual system performance data.

While the City targets approximately 2.6 miles of sewer main annually for repair or replacement primarily to reduce I&I and address structural defects, capacity-related projects are prioritized separately based on evaluation results.

The City is expected to experience more frequent and severe floods from rain and coastal storms, along with groundwater rise, due to climate change. This is likely to lead to increased infiltration and inflow into the collection system that could lead to exceedance of wastewater treatment capacity and sanitary sewer overflows. In addition, the wastewater treatment system can manage limited volumes of saline water but the combination of increased flooding events with the potential for introduction of saline water - rising groundwater levels, coastal storm events, or tidal inundation - will eventually trigger the need for conversion to a low-pressure collection system in low-lying coastal areas.

The primary risks of climate change are:

- Increased frequency of exceedance of collection system and El Estero WRC capacities during storm events (both high rainfall events and coastal storms causing storm surge).

- In the mid-term, persistent inflow and infiltration of saline water into the collection system south of Highway 101 from rising groundwater levels, seawater intrusion into surficial groundwater, and ocean inundation during coastal storms and regular high tides due to sea level rise, causing corrosion of infrastructure and trouble treating saline water at El Estero WRC.

Recommended adaptation measures for the collection system include:

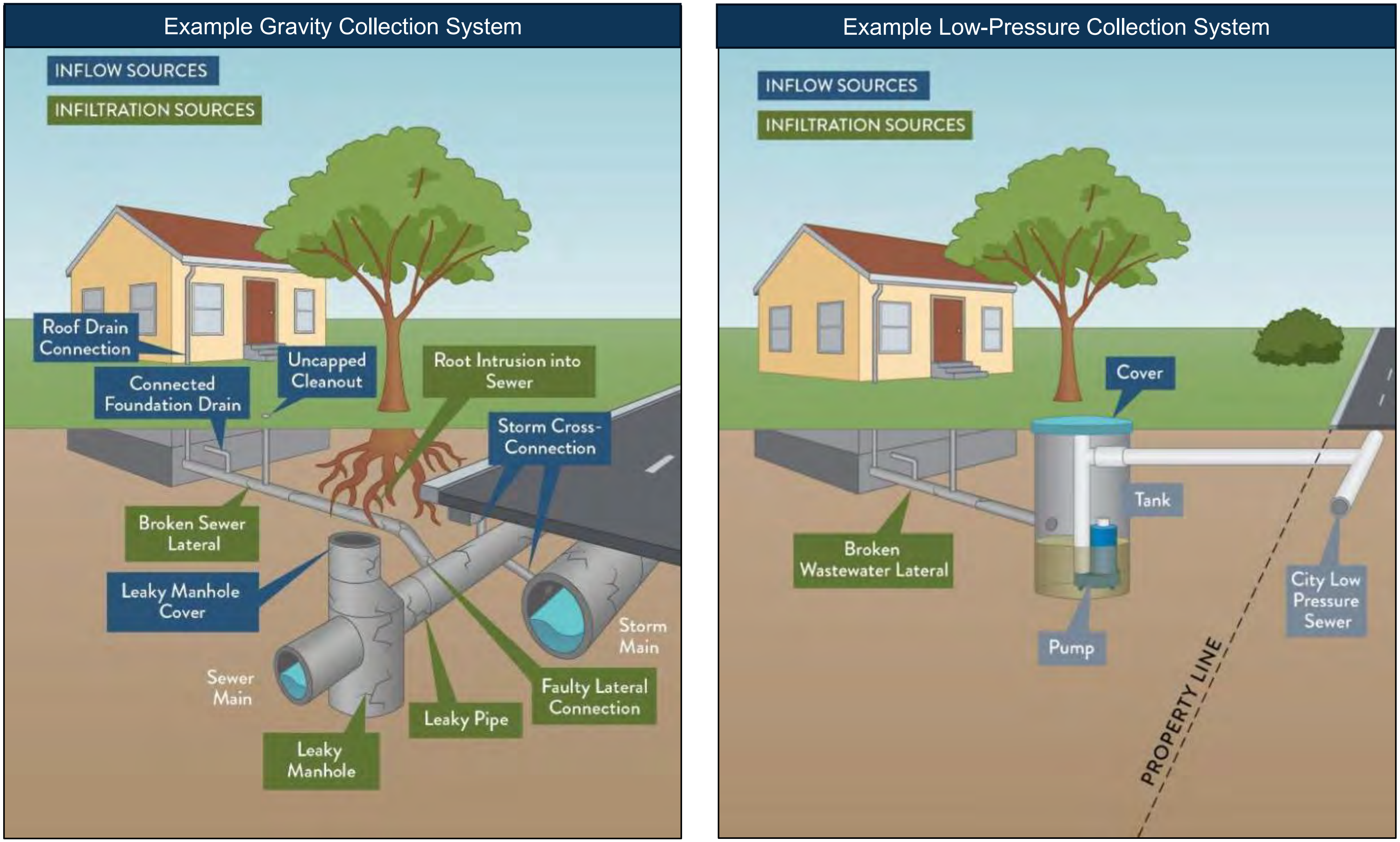
Immediate Next Steps (0-5 Years):

- Seal collection system manholes that could be regularly flooded, including West Beach sewer manholes, to prevent inflow and the possibility of the manhole covers being removed by members of the public during flooding events to act as a drain.
- Complete a Wastewater System Capacity Study to identify the largest sources of existing infiltration and inflow during storms and evaluate options to reduce infiltration and inflow in the collection system and increase storage capacity at El Estero WRC. Potential adaptation options include manhole sealing, sewer and manhole rehabilitation, customer lateral rehabilitation, investigation of illegal connections and removal, and increasing wet weather storage capacity with wastewater storage basins.
- Complete a Low Pressure Sewer Conversion Study to plan for the mid-term conversion of the low-lying coastal portion of the collection system from a gravity fed system to a low-pressure system. This should include changing design and connection requirements in the near-term for new private and public projects in low-lying areas to accommodate a future conversion to a pressurized system. The City should consider an ordinance in the next five years to require new connections in the low-lying areas to include facilities needed for pressurization and incentives to customers to facilitate conversion of existing sewer connections over the next 25 years. The study should also analyze feasible and effective alternatives to pressurization that could achieve the same goals. A comparison of the City's existing gravity collection system with a low-pressure collection is shown in Figure ES-6.

- **Near-Term (Through 0.8 ft SLR (~2050)):** Implement additional recommended adaptation measures to manage capacity in the collection system and at El Estero WRC based on the proposed Wastewater System Capacity Study. Implement low-pressure sewer lateral ordinance and facilitate conversion of existing customer sewer connections to low-pressure connections in low-lying coastal areas.

- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** Update capacity analysis and implement the recommended measures to manage capacity in the collection system and at El Estero WRC. Ensure that Cabrillo Blvd and the utilities located under the street will be protected from shoreline erosion. Install initial phases of low-pressure collection system in areas most impacted by flooding from rain and coastal storms as implementation triggers are met.

Figure ES-6. Infiltration and Inflow Sources for Gravity and Low-Pressure Collection Systems



These graphics show the typical infiltration and inflow (I&I) sources to two types of sewer collection systems. The City's existing gravity system, shown on the left, has many I&I sources. During heavy rainfall and high wave events, floodwater can enter the sewer collection system, which can overwhelm both the collection pipes and capacity at the treatment plant (El Estero Water Resource Center), potentially causing sewer overflows. Low-pressure sewer collection systems, shown on the right, prevent almost all sources of I&I.

In the **long-term**, when flooding from tides is frequent, or elevated groundwater tables persist, the remainder of the existing gravity collection system in the low-lying coastal area should be converted to a low-pressure collection system if large-scale flood prevention measures, such as levees or service levels change, are not capable of fully mitigating flooding hazards from rain and coastal storms.

Converting the existing collection system in the coastal area to a low-pressure collection system is an expensive but highly reliable approach to reduce infiltration and inflow from tides, storms, and groundwater entering the existing gravity system. The City's existing measures to reduce sewer inflow and infiltration are not as effective when facing higher flooding recurrence, higher groundwater levels, and more saline water. The City expects to monitor flooding and groundwater rise in these low-lying areas area to decide in the near-term how to address impacts to the wastewater collection system in the mid- and long-term.

West Beach Sewer Trunk Main Shoreline Erosion

The West Beach sewer trunk main conveys approximately half of the City's dry weather sewer flows to El Estero WRC. It is located beneath West Beach, south of the bike path, crosses Mission Lagoon, and continues along the beach before turning north to follow Laguna Creek to El Estero WRC. Due to its critical role and vulnerable beachfront location, this Plan analyzed adaptation needs for the West Beach sewer main.

West Beach sewer is not projected to be exposed from shoreline erosion through 4.9 feet of sea-level rise. Projected exposure would prompt the need for relocation inland. This would be a major project due to the main's size, importance, and gravity-based flow, and would require new infrastructure to lift flows from low-lying areas. One possible new alignment is from Pershing Park to inland of US 101 to avoid the projected climate vulnerabilities in the coastal area, although studies of impacts to recreational assets would be needed. Ideally, relocation would coincide with any future pressurization of the system and should be planned at least 10 years before projected exposure.

Potable Water System Adaptation Summary

While the vulnerabilities of the whole potable water system were assessed, particular attention was given to those portions of the system in the coastal low-lying areas. Potable water distribution assets in this area include buried distribution piping, valves, and equipment vaults, as well as above-ground components including valves, backflow preventers, and hydrants. The Charles E. Meyer Desalination Plant (Desalination Plant) is also located within this area.

The highest **near-term** risk identified for the potable water system is damage to the desalination intake infrastructure caused by loss of cover of sand from erosion and offshore wave action. The highest **mid-term** risk is damage to potable water pipeline segments under Cabrillo Blvd, Shoreline Drive, and Chase Palm Park from shoreline erosion and wave action. The highest **long-term** risks are loss of Desalination Plant site access and infrastructure damage from future flood events caused by high rainfall events, coastal storms or, eventually, tidal inundation.

Also, sea water flooding and brackish groundwater rise are likely to increase soil salinity and cause corrosion of metal pipes and metal pipe components, which could shorten infrastructure lifespans. Consequently, the City should consider replacement of aging pipes in the coastal area with non-metallic materials, such as HDPE or PVC, and implement corrosion prevention methods where metallic pipe or fittings must be installed.

Seawater intrusion into the City's groundwater wells, located inland of US 101, is an issue that City has historically monitored. The City typically increases groundwater pumping during extended droughts, which can cause the seawater / groundwater interface to move slightly inland. However, under normal periods of little or no pumping, the groundwater flow is toward the ocean, which stops intrusion and pushes the seawater interface seaward. Sea level rise will slightly increase to potential for seawater intrusion, but the predominant cause of seawater intrusion will continue to be heavy pumping of the City's groundwater wells. The City will continue to monitor for seawater intrusion and adjust pumping based on observations.

Desalination Intake System Erosion

The weir box, intake pipeline, and intake structure for the desalination system are projected to be impacted by 0.8 ft of sea level rise (~2050). The City is currently designing an intake structure replacement.

- **Near-Term (Through 0.8 ft SLR (~2050)):** The weir box at East Beach likely needs additional protection by 0.8 ft of sea level rise (~2050). The weir box could be abandoned, relocated, or protected as outlined in the Intake Structure Weir Box Relocation Erosion Protection Study (Carollo, 2019).
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** A portion of the intake pipeline is projected to be exposed and unsupported between 0.8 and 1.6 ft of sea level rise (~2065), which would require protection or replacement of the pipeline, depending on the planned Desalination Plant operations timeline. Inspection and monitoring of the pipeline will be important to inform decisions.

Potable Water Pipeline Segments Erosion

- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** Relocate the potable water pipeline in Chase Palm Park further inland. Ensure protection measures are planned for Cabrillo Blvd and Shoreline Drive so that potable water infrastructure in Cabrillo Blvd is protected. The City should consider replacement of aging pipes in the coastal area with non-metallic materials, such as HDPE or PVC, and implement corrosion prevention methods where metallic pipe or fittings must be installed.

Desalination Plant Site Flooding

- **Near-Term (Through 0.8 ft SLR (~2050)):** Determine if new flood protection measures are needed through 2.5 ft of sea level rise (~2075) based on the planned Stormwater Model and Flood Analysis findings. Consider need for flood protection measures for adjacent Annex Yard as well.
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** If the plant continues to operate in the mid-term, implement flood protection measures through 2.5 ft of sea level rise (~2075) and update the plant flood vulnerability analysis considering: 1) updated hazard and

vulnerability assessments; 2) proficiency of implemented local and regional measures; and 3) long-term plans for the Desalination Plant.

Recycled Water System Adaptation Summary

The City's recycled water system consists of a tertiary treatment system and pump station at El Estero WRC, one recycled water reservoir, and approximately 13.4 miles of recycled water pipeline. In the focused study area, recycled water pipelines in Chase Palm Park may be impacted by shoreline erosion in the near-term (by 0.8 ft of sea level rise (~2050)).

Recycled Water Pipelines

- **Near-Term (Through 0.8 ft SLR (~2050)):** Evaluate and implement regional adaptation efforts such as beach nourishment to reduce erosion concerns in the beach area. Consider and evaluate feasibility of relocation inland.
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** Relocate the recycled water pipeline in Chase Palm Park further inland.

General Citywide Adaptation Summary

Monitoring, Conditions Assessments, and Plan Updates

Implementation of this Plan will occur in phases based on changing conditions over time. As such, monitoring and regular updates of the plan are critical. This Plan is intended to be a living document and expected to be regularly updated every decade based on observed climate changes, observed impacts to the wastewater and water systems, new climate change projections, and further refinement of the City's overall adaptation approach over time.

The City is partnering with the coastal cities and counties within BEACON's jurisdiction spanning Santa Barbara and Ventura Counties to track and report shoreline erosion, bluff erosion, and flooding. The City is also working with the County of Santa Barbara on standardized flood and erosion documentation. This Plan highlights the need for the City to coordinate monitoring of salinity and elevations of surficial groundwater in the low-lying portions of the City, in addition to potable groundwater monitoring program that is already occurring. In addition, site specific shoreline erosion monitoring is a high priority given the location of buried infrastructure within West and East beaches. Modeling and monitoring of stormwater flooding in the low-lying area of the city associated with Laguna Creek are particularly important for future decision making regarding El Estero WRC and wastewater collection system assets. This work will begin with the Stormwater Model and Flood Analysis project already funded.

Given changing environmental conditions, the City will need to pay particular attention to condition assessments of wastewater and water infrastructure in the low-lying areas of the City. For example, the City could conduct condition inspection of buried infrastructure opportunistically when they are exposed for other reasons, such as maintenance or repair. Inspections could include visually assessing pipes, testing valves, measuring pipe corrosion, and performing soil corrosivity assessments and pipe failure analysis.

ES-5 Summary of High Priority Actions

Table ES-5 summarizes the highest priority recommended projects and actions for the wastewater and water systems based on timing and phase of implementation. Prioritization is based on the level of associated risk, which considers impact of infrastructure vulnerability, likelihood of impact, and criticality of infrastructure. The highest priority recommendations are presented spatially in Figure ES-7 and shown within an implementation plan in Figure ES-8.

Rough costs for implementation – roughly $50 million to $130 million in wastewater and water infrastructure improvements over the next 25 years – were developed to support initial budgeting but should be updated once studies are completed that include project alternatives analysis and cost estimating. Project implementation will also require additional City staff resources, such as engineers, project managers, and operators.

Note that in the long-term, beyond 2.5 ft of sea level rise (~2075), coastal flooding from the ocean and regular tidal inundation are expected to occur and the pace of sea level rise is projected to increase. Many of the largest infrastructure investments to support climate change adaptation, such as relocation of El Estero WRC, are not projected to be needed until the long-term. Potential long-term adaptation measures will be evaluated as part of the proposed regular updates to this Plan, which will consider the latest climate change projections, monitoring data, effectiveness of adaptation measures, risk tolerance, and City priorities. Potential adaptation measures will also need to consider the useful life of the facilities they are protecting if relocation of El Estero WRC and the Desalination Plant are planned. Finally, large infrastructure projects can take 10 to 20 years from planning through construction, so planning will likely need for many projects to start during the mid-term. More specific timing is expected to be available in future Plan updates.

Table ES-5. Summary of High Priority Actions

Action	Adaptation Recommendations
Immediate (0-5 Years)	
Interim Adaptation Measures	• Seal manholes in flood-prone areas (e.g., West Beach sewer). • Continue Mission Lagoon berm management to facilitate. stormwater flows reaching the ocean and reduce ponding time.
Improve Understanding of Flood Hazards	• 30-Year Waterfront Adaptation Plan: Develop a near-term strategy for coastal areas. • Stormwater Model and Flood Analysis: Study flooding around El Estero WRC. • Wastewater System Capacity Study: Characterize sources of infiltration and inflow and potential solutions. • Low-Pressure Sewer Conversion Study: Define potential phasing of sewer conversions based on projected hazards. • El Estero WRC Flood Protection Study: Identify flood protection measures with sea level rise.
Flood Access & Protection for El Estero WRC	• Formalize Flood Conditions Operations Plan.
Near-Term (5-25 Years, 0-0.8 ft SLR)	
Wastewater System Capacity Improvements	• Implement improvements from the Wastewater System Capacity Study (e.g., manhole sealing, sewer rehabilitation, wastewater storage at El Estero WRC). • Facilitate low-pressure customer connection conversions for low-lying properties and plan for pressurization of low-lying collection systems.
Flood Access & Protection for El Estero WRC	• Implement floodwall system protection for El Estero WRC. • Plan stormwater improvements for Laguna Creek.
Mid-Term (25-50 Years, 0.8-2.5 ft SLR)	
Wastewater System Capacity Improvements	• Implement remaining recommendations from Wastewater System Capacity Study. • Implement initial phases of low-pressure collection system in low lying areas and plan for full pressurization of impacted collection system.
El Estero WRC Flood Protection Measures	• Implement additional flood protection for El Estero WRC. • Conduct long-term El Estero Flood Protection, Flood Access, and Relocation Study.
Potable & Sewer Pipeline Protection	• Protect utilities from shoreline erosion along Cabrillo Blvd and Shoreline Drive. • Relocate potable water pipeline in Chase Palm Park.
Flood Access & Protection for El Estero WRC	• Improve access to El Estero WRC as flooding increases.

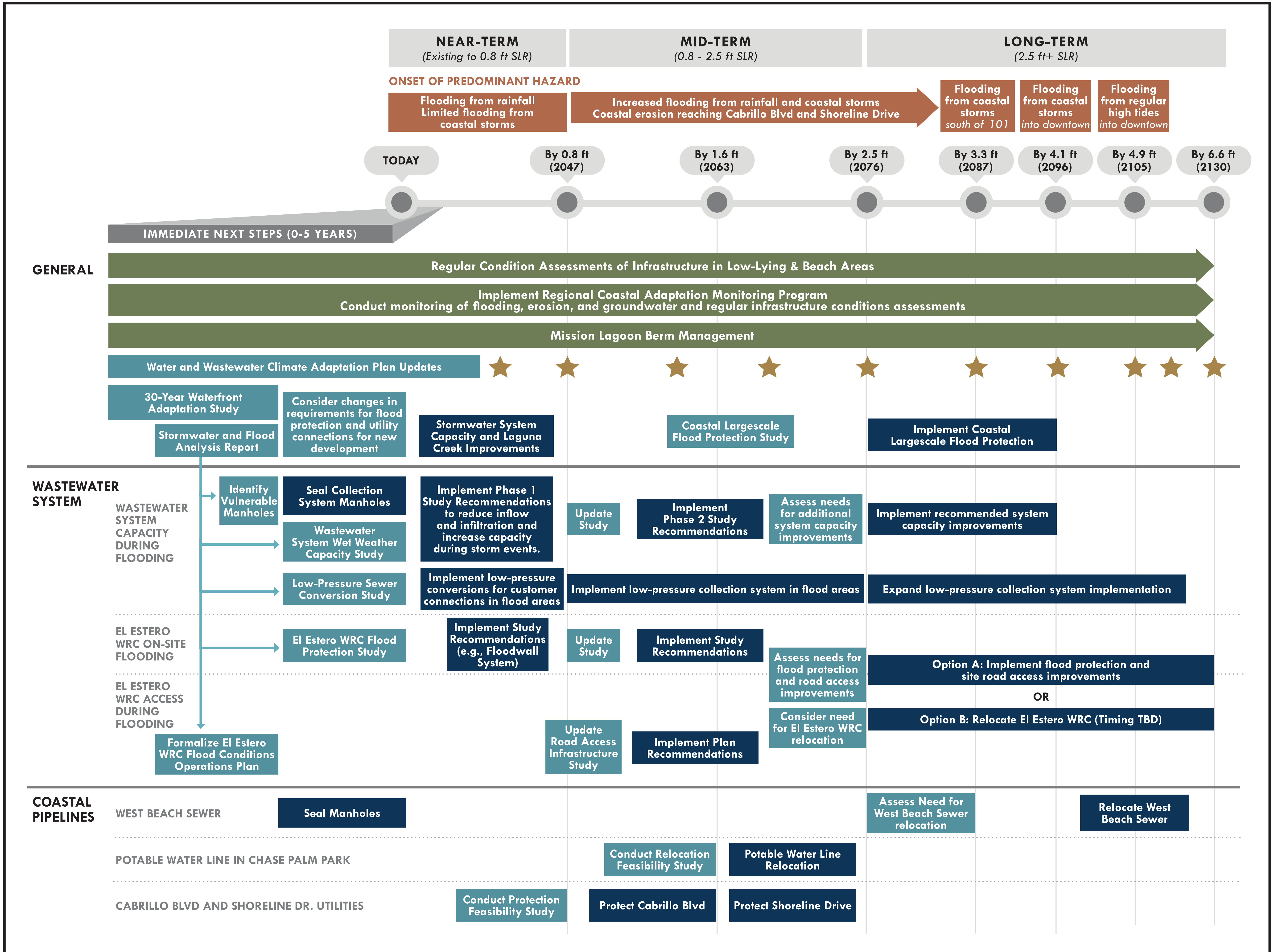
Figure ES-7. Adaptation Measures for Highest Near-Term and Mid-Term Infrastructure Risks from Climate Change

Timeframes:

- Immediate Next Steps (0 to 5 Years)
- Near-Term (now through 0.8 ft SLR [~2050]; 5 to 25 years)
- Mid-Term (0.8 ft to 2.5 ft SLR [~2050 to ~2075]; 25 to 50 years)
- Long-Term (2.5+ ft SLR [~2075+]; 50+ years)

Water & Wastewater Climate Adaptation Project

Figure ES-8
Implementation Plan



Legend

- Hazard
- Monitoring and Maintenance
- Study
- Design and Construct

WSC

Water & Wastewater Climate Adaptation Project

Figure ES-9. Coastal Hazards, Existing

Legend

- El Estero WRC
- Desalination Plant
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure ES-10. Coastal Hazards, 0.8 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure ES-11. Coastal Hazards, 1.6 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure ES-12. Coastal Hazards, 2.5 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure ES-13. Coastal Hazards, 3.3 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)
- Tidal Inundation

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure ES-14. Coastal Hazards, 4.1 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure ES-15. Coastal Hazards, 4.9 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure ES-16. Shoreline Erosion, East Beach and West Beach

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Shoreline Retreat

- 0.8 ft SLR
- 1.6 ft SLR
- 2.5 ft SLR
- 3.3 ft SLR
- 4.1 ft SLR
- 4.9 ft SLR

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.1 0.2 Miles

0 420 840 US Feet

Water & Wastewater Climate Adaptation Project

Figure ES-17. Shoreline Erosion, Leadbetter Beach

Legend

- Sewer Manhole
- Sewer Main
- Water Main
- Desalination Intake
- Recycled Water Main

Shoreline Retreat

- 0.8 ft SLR
- 1.6 ft SLR
- 2.5 ft SLR
- 3.3 ft SLR
- 4.1 ft SLR
- 4.9 ft SLR

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.03 0.07 Miles

0 137.5 275 US Feet

1.0 Introduction

Climate changes, such as sea level rise and changes in rainfall intensities, are already affecting the City of Santa Barbara (City) infrastructure. These impacts are projected to accelerate significantly in upcoming years. The City's 2021 Sea Level Rise Adaptation Plan (2021 SLR Adaptation Plan) identified adapting the City's wastewater and water infrastructure as the highest priority action to initiate in the next few years. This Water and Wastewater Systems Climate Adaptation Plan (Plan) builds on the work of the 2021 SLR Adaptation Plan, assesses vulnerabilities specific to the wastewater and water systems, and presents a phased approach to adapt these systems to the hazards associated with climate change over time. The City continues to proactively plan for and implement projects to increase the resilience of its systems in service to its customers.

The City completed the 2021 SLR Adaptation Plan (ESA, 2021) to identify vulnerabilities to coastal hazards expected from sea level rise and to identify potential actions to prepare for and adapt over time. The 2021 SLR Adaptation Plan focused on the coastal area and evaluated erosion along the beach, bluff erosion, tidal inundation, storm waves, and coastal storm flooding.

The 2021 SLR Adaptation Plan included three high-priority recommendations for "major infrastructure:"

- Monitor utility system and transportation system interruptions, rising sea levels, beach erosion, and flooding events.
- Study options for relocation and/or flood proofing of major wastewater, water, and utility lines and infrastructure south of Cabrillo Boulevard (Highest Priority).
- Initiate a comprehensive study of adaptation options for threatened portions of the wastewater system, including redesign of portions of the system, adaptation options for El Estero Water Resource Center, and possible service point improvements.

The City is addressing the first bullet through development of a Regional Coastal Adaptation Monitoring Program (see Section 1.5.2.2) and the second two bullets with this Plan. By including the water system within this Plan, the City is also addressing a lower priority recommendation from the 2021 SLR Adaptation Plan:

- Study the potential impacts to the water system from sea level rise and possible adaptation options.

1.1 Plan Purpose

The goals of this Plan are to comprehensively evaluate the vulnerabilities of the City's water and wastewater infrastructure to climate changes and to develop options to adapt these systems in a phased manner over time. This Plan builds on the citywide analysis conducted in the 2021 SLR Adaptation Plan (ESA, 2021) and the 2021 Santa Barbara County Climate Change Vulnerability Assessment (County of Santa Barbara, 2021), focusing on the water and wastewater systems and looking beyond sea level rise to other vulnerabilities associated with climate change. The Plan evaluates increased storm water flooding hazards associated with changes in rainfall patterns and coastal hazards exacerbated by sea level rise, including flooding and erosion from coastal storms, wave run-up, tidal inundation, shoreline erosion, and groundwater rise. A higher-level analysis is conducted for other climate change hazards such as increased drought, heat, and wildfire risks.

Hazards, vulnerabilities, and adaptation options for the following critical infrastructure are evaluated:

- The wastewater collection system;
- The wastewater treatment system, including El Estero Water Resources Center (El Estero WRC) and the treatment plant's outfall system (El Estero outfall);
- The potable water treatment systems, including the Charles E. Meyer Desalination Plant (Desalination Plant) and the associated ocean intake pipeline;
- The potable water distribution system; and
- The recycled water system, including the planned potable reuse system.

1.2 Funding Sources

This project is partially funded by grants provided by the California Coastal Commission and State Coastal Conservancy and incorporates the scope included in those grant agreements.

1.3 Study Area

The study area for this Plan encompasses the City's water and wastewater service areas, shown in Figure 1-1. Sea level rise is expected to predominantly impact the City's coastal area, as shown in Figure 1-2. Based on the high priority water and wastewater infrastructure risks identified in the 2021 SLR Adaptation Plan, the Plan has more in-depth analysis of a "focused study area" that covers the low-lying waterfront and beach areas and low-lying flood areas between Castillo Street to Milpas Street and inland to the US-101 freeway (Figure 1-3). Infrastructure evaluated includes El Estero WRC and the El Estero outfall, sewer mains and manholes, the Desalination Plant and ocean intake pipeline, water distribution system, and recycled water system.

Coastal bluff areas west of the Focused Study Area are addressed in the vulnerability assessment. They were found to have lower risks, so discussion is limited. Climate change impacts to inland areas are also discussed but at a higher level than the focused study area. Coastal infrastructure located outside of the focus area, such as potable pump stations and sewer lift stations, was also evaluated at a high-level.

Figure 1-1. Plan Study Area

Note: Study area excludes Santa Barbara Municipal Airport, which is subject to a climate adaptation plan specific to the Goleta Slough area.

Figure 1-2. 2021 Sea Level Rise Hazard Areas

Source: City of Santa Barbara Sea Level Rise Adaptation Plan (ESA, 2021), Figure ES-14

Figure 1-3. Focused Study Area

1.4 Approach

A climate change hazards analysis was completed and used to inform a vulnerability assessment of the City's wastewater and water systems to climate change. Potential adaptation options were identified that included different approaches such as protect or adapt infrastructure in place, regional protection measures, and relocation of infrastructure. The potential adaptation measures are compared with alternatives and recommendations are made where sufficient information is available. Where noted, some recommendations require additional data collection and analysis as the next step to inform future decision making.

This Plan concludes with an adaptation strategy that identifies immediate next steps and thresholds to implement additional planning, design, or construction measures over time. Near-term (next 25 years) recommendations have the most details while mid-term (25 to 50 years) and long-term (50+ years) recommendations are anticipated to be updated over time based on new information and experience. This Plan is recommended to be reevaluated and updated every decade based on 1) observed climate change impacts and the latest climate change projections, new adaptation approaches, and legal/policy changes and 2) further refinement of the City's overall adaptation strategies/plans.

Future updates of this Plan will integrate with other City climate change planning and adaptation documents to ensure a comprehensive and consistent strategy is implemented over time. This Plan is one of the first to be developed for specific City assets and is presented in a manner to facilitate these planned regular updates by clearly stating assumptions, basis for projections, and rationale for recommendations.

This Plan is part of a suite of adaptation actions the City is conducting through an Adaptation and Resilience Program based in the Sustainability and Resilience Department but involving teams of staff in all the departments of the City. Other related projects that are ongoing are the development of: 1) a regional coastal adaptation monitoring program in Santa Barbara and Ventura counties; 2) a specific 30-year adaptation plan for the City's waterfront and harbor; an adaptation plan for the airport; and 3) creation of a stormwater system model and analysis of flooding from high intensity rainfall events and associated improvement options for the stormwater system.

1.4.1 Managing Changing Conditions

This Plan includes the best available information at the time of publication, including the latest sea level rise projections from the National Oceanic and Atmospheric Administration's (NOAA) 2022 Global and Regional Sea Level Rise Scenarios for the United States (Sweet, et al., 2022) and guidance from the Ocean Protection Council's (OPC) State of California Sea Level Rise Guidance: 2024 Science and Policy Update (2024 OPC SLR Guidance) (OPC, 2024).

These documents update previous projections and guidance that were used within the City's 2021 SLR Adaptation Plan, including 2018 CCC Sea Level Rise Policy Guidance (CCC, 2018) and 2018 OPC Sea Level Rise Guidance (OPC, 2018).

As described further in Section 2, projections for sea level rise and other climate changes are regularly updated and refined as new studies emerge, changing conditions are monitored, and models are refined. As a result, the analysis and monitoring recommendations in this Plan are structured to accommodate future changes to projections and performance of adaptation measures. This is explicitly included in the adaptation strategy in Chapter 9. While there is uncertainty in the rate and timing of sea level rise along the coast, the amounts of sea level rise considered in this Plan are expected to occur at some point in the future. **Because of the timing uncertainty, this Plan provides a framework of planning based on amounts of sea level rise, rather than exactly when those amounts of sea level rise will occur.**

1.4.2 Guiding Principles

As part of the process for the 2021 SLR Adaptation Plan, the Sea Level Rise Adaptation Plan Subcommittee established guiding principles to guide the prioritization and selection of adaptation strategies. These Guiding Principles provide a foundation upon which future project decisions can be made and help in evaluating how well adaptation actions help meet established community values and expectations. These principles are documented below and were used to develop this Plan.

1. *Prioritize:*
    a. *Protection of human life, health, and safety.*
    b. *Critical facilities, public transportation systems, and public services for basic City functions.*
2. *Minimize the impacts of sea level rise and related hazards to:*
    a. *Coastal-dependent development.*
    b. *Public access to and along the shoreline, beaches, parks, open spaces, and recreation.*
    c. *Existing and future development.*
    d. *The local economy.*
    e. *Coastal resources.*
3. *Design adaptation strategies that:*
    a. *Use the best-available science and technology.*
    b. *Are flexible and which have processes for updates based on new information.*
4. *Ensure that adaptation strategies:*
    a. *Minimize the risks of coastal hazards.*
    b. *Are legally, technically, and financially feasible.*
    c. *Are consistent with federal and state laws.*
    d. *Avoid, where feasible, or minimize impacts to coastal resources.*
    e. *Do not preclude or prevent the implementation of future adaptation strategies to address longer-term hazards.*
5. *Encourage:*
    a. *Adaptation strategies that broadly protect the community's health, safety, and welfare.*
    b. *Equitable sharing of costs and benefits of sea level rise and related hazards.*

c. *Adaptation strategies that benefit or minimize impacts to vulnerable populations that may have a higher sensitivity and lower adaptive capacity towards hazards.*
d. *Adaptation strategies that have co-benefits, such as greenhouse gas reduction, resiliency to other climate change impacts, habitat protection or creation, protection and creation of recreation opportunities, improvements to coastal resources, or economic enhancement.*
e. *Emergency response and recovery coordination that factor in increased hazards due to sea level rise.*
f. *Greenhouse gas reductions as a key aspect of resiliency planning.*
g. *Voluntary and proactive resilience actions through incentives such as streamlining permitting.*
h. *Adaptation strategies and programs that build coastal resiliency partnerships.*

1.5 Background

1.5.1 Regulatory Drivers

Several plans and regulatory agencies influenced development of this Plan. A summary of such drivers is provided in the following subsections. A more comprehensive list of relevant plans, guidelines, and permits that influence the City's adaptation approach is described in the 2021 SLR Adaptation Plan.

1.5.1.1 City of Santa Barbara General Plan

The City's General Plan, which directs the City to evaluate the impacts of climate change, adapt to flooding and erosion hazards, and ensure the resilience of critical infrastructure and public services.

1.5.1.2 California Coastal Act

In 1976, the California Legislature enacted the Coastal Act, which requires coastal cities and counties to protect coastal resources and maximize public access to the shoreline through the development of their own local, comprehensive, planning and regulatory programs. (i.e., LCPs) (ESA, 2021). A detailed explanation of the California Coastal Act is provided in the City's 2021 SLR Adaptation Plan. This Plan informs potential vulnerabilities and adaptation options for maintaining City assets in the coastal area.

1.5.1.3 City of Santa Barbara Local Coastal Program

The City's Local Coastal Program (LCP) guides development within the coastal area and promotes protection and enhancement of coastal resources, including public access and recreation, and adaptation to coastal hazards. The City's LCP is consistent with the guidance of the California Coastal Act and was last updated and certified in 2019. The City anticipates amendments to the LCP as additional adaptation recommendations are identified and incorporated into the City's overall adaptation strategy. Such amendments will require approval and adoption by City Council and the CCC (ESA, 2021).

1.5.1.4 NPDES Permit Compliance

Components of the Plan meet the requirements of Condition 9 in the El Estero WRC Waste Discharge Requirements (Order No. R3-2019-00046), issued by the Central Coast Regional Water Quality Control Board (Regional Board). The City's 2021 SLR Adaptation Plan satisfies the first half of Condition 9, and the Regional Coastal Monitoring Program (discussed in Section 1.5) satisfies the monitoring requirements contained in Condition 9. The remaining requirement in Condition 9 is a "facility-specific sea level rise analysis."

Based on consultation with the Regional Board, CCC, and State Coastal Conservancy, the City agreed that this Plan would include the following components:

- **Near-Term (Through 0.8 ft SLR (~2050)) and Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)) Scenarios:** Evaluate relocating, flood-proofing, and/or hardening of major sewer mains and water lines impacted by sea level rise.
- **Long-Term (2.5+ ft SLR):** Explore options and thresholds for actions at El Estero WRC and other portions of coastal wastewater and water systems in long-term sea level rise areas but at a lower level of detail than for the near- and mid-term adaptation options.

1.5.2 Existing Planning Efforts

1.5.2.1 2021 Sea Level Rise Adaptation Plan

The 2021 SLR Adaptation Plan (ESA, 2021) evaluated several adaptation strategies for the projected impacts to public and private assets within the City from similar hazards to the ones discussed in this Plan. The recommendations provided in the City's 2021 SLR Adaptation Plan that would affect water and wastewater assets are summarized below. The studies described in the following section would use these potential adaptation measures as a starting point for evaluation.

Shoreline Erosion Protection

Near-term shoreline protection recommendations from the 2021 SLR Adaptation Plan include (ESA, 2021):

- Study expansion of beach nourishment, seasonal sand berms, and optimize current sand bypassing practices.
- Plan for either the relocation, floodproofing, or protection of major wastewater and water pipelines that are located south of Cabrillo Boulevard and possibly other assets, regardless of any beach nourishment that occurs (as discussed in this Report).
- Consider, as public assets in this area are redeveloped, options to avoid hazard areas or adaptation of hazards through elevation of structures or floodwall systems.

Mid- and long-term recommendations from the 2021 SLR Adaptation Plan include (ESA, 2021):

- Installation of large-scale shoreline protection devices or levees along the City's waterfront either by raising Cabrillo Boulevard and Shoreline Drive or by installing a seawall along the waterfront. As described below, to mitigate flooding in the lower downtown area, large-scale shoreline protection devices or levees along the waterfront would need to be continuous from Shoreline Park to the Clark Estate and be combined with a creek floodwall system, groundwater pumping, stormwater pumping, and other measures. The effectiveness of these measures is uncertain.

- Relocation or removal of certain waterfront assets.
- Rerouting portions of Shoreline Drive and Cabrillo Boulevard, if needed.
- Installation of groins or artificial reefs if additional studies show them to be feasible and effective.

Flooding Adaptation

The 2021 SLR Adaptation Plan included the following near-term flooding adaptation (through 0.8 ft of sea level rise (~2050)) recommendations (ESA, 2021):

- Reconstruct and redesign the tide gates and pumps at Laguna Creek.
- Consider altering floodplain and building regulations to require new and substantially redeveloped buildings to be elevated or floodproofed to higher flood elevations, particularly south of Highway 101.
- Consider changes to creek setbacks, particularly if additional studies on the interaction of sea level rise and increased precipitation and creek flooding with climate change are conducted and indicate the need.
- Conduct additional studies to understand:
  - effects of sea level rise on groundwater levels
  - potential for groundwater contamination to spread with changing water levels
  - changes in local rainfall patterns and stormwater conveyance capacities.

In the mid-term (0.8 ft (~2050) to 2.5 ft of sea level rise (~2075)) and long-term (2.5+ ft of sea level rise), the City could consider options such as (ESA, 2021):

- Use of creek floodwall systems up Mission, Laguna, and Sycamore Creeks.
- Groundwater pumping.
- Continuous seawalls or levees along the waterfront.
- Pumping of stormwater.
- Elevation and floodproofing of development.
- Phased removal or relocation of development in tidal inundation areas.

In order to mitigate long-term flooding, several, if not all, of the measures listed above would need to be completed together if relocation of development is not an option. The effectiveness and feasibility of these flood control measures in the long-term is uncertain. Since completion of the 2021 SLR Adaptation Plan, additional flood protection concepts have been developed and are planned to be evaluated in the City's 30-Year Waterfront Adaptation Plan. This is described in Section 1.5.2.3.

Bluff Erosion

Based on the risk assessment in Section 8.4.1.1, water and wastewater infrastructure has relatively low vulnerability to bluff erosion. The 2021 SLR Adaptation Plan recommended the following near-term actions to manage bluff erosion (ESA, 2021):

- Closely monitoring beach and bluff erosion.
- Expansion of existing drainage best management practices to reduce the rate of bluff erosion from runoff and irrigation.
- Continuation of current policies that require bluff setbacks for new development and substantial redevelopment and limitations on the use of revetments except to protect essential public services, major public roads, and public beach access stairways.
- Relocation or removal of non-critical assets (e.g., pathways, benches) in Shoreline Park and Douglas Family Preserve.

In the mid-term, erosion of public and private assets will accelerate, and public use of many of the bluff-backed beaches will likely be lost to erosion. During the mid-term, the City could consider (ESA, 2021):

- Use of revetments and slope stabilization on a larger scale to protect Shoreline Drive, Cliff Drive, public access along the top of the bluffs, and/or a useable portion of Shoreline Park.
- Removal and relocation of infrastructure, roads, and development.

1.5.2.2 Regional Coastal Adaptation Monitoring Program

The City has partnered with the Beach Erosion Authority for Clean Oceans and Nourishment (BEACON), a joint power authority with member agencies from the coastal cities and counties between Point Mugu and Point Conception. Together, the City and BEACON are developing a regional shoreline monitoring program that will provide consistent data and analysis for coastal adaptation efforts in the BEACON region; this is known as the Regional Coastal Adaptation Monitoring Program (RCAMP).

The RCAMP objectives are to provide local management agencies with the information needed to assess if changed conditions warrant new adaptation approaches and if implementation actions result in regional resilience benefits or impacts. The Monitoring Program is being developed in collaboration with BEACON members, a Science Advisory Committee, and stakeholders, and will include recommended monitoring protocols and pilot projects for physical coastal processes, ecological processes, socioeconomics, and Chumash cultural resources. A draft RCAMP Monitoring Plan was published in August 2025 (ESA, 2025). Data that may be collected includes physical attributes such as sea levels, shoreline position, bluff position, flood frequency, and social attributes such as the parcels and socioeconomic status of census tracts affected by flooding events. Data collected from RCAMP can be used to inform City decision-making around the extent and timing of adaptation measures, establish triggers for shoreline erosion adaptation measures, and inform the success of implemented measures in the future. If additional data collection and monitoring are needed, the City may need to initiate its own efforts (for example, monitoring shallow groundwater levels and quality).

1.5.2.3 30-Year Waterfront Adaptation Plan

The City has also initiated a 30-Year Waterfront Adaptation Plan to develop a near-term adaptation strategy for the waterfront area of the City that spans from Leadbetter Point to the Clarke Estate. This work effort will include new site-specific and asset-specific technical analyses of key coastal resources, a series of adaptation options that will build to a recommended strategy, the estimated cost of infrastructure improvements and adaptation strategies, and conceptual drawing drafts for targeted adaptation projects.

The 30-year time horizon was chosen for the near-term analysis because there is a high level of scientific consensus about the anticipated amount of sea level rise during this period. Additionally, 30-years reflects a timeframe during which significant increases in storm damage risks in the waterfront area are likely, but largescale alterations (such as levees, continuous seawalls, or extensive abandonment) are not expected to be required.

The overarching goal of the 30-Year Waterfront Adaptation Plan is to prepare the waterfront area for increased storm surges, erosion, and flooding while continuing to provide critical services, coastal-dependent boating uses, recreation, and beach access in the next 30 years. The 30-Year Waterfront Adaptation Plan is a high-priority implementation item from the City's 2021 SLR Adaptation Plan and is expected to be completed in 2026. Key elements of the 30-Year Waterfront Adaptation Plan will include:

- A refined hazard definition and updated exposure analysis that incorporates wave run-up, geomorphology, dredging and sediment management, and groundwater rise.
- Vulnerability profiles and graphics that support public engagement, including an interactive, bilingual hazards map.
- A Harbor breakwater and groins study that assesses the feasibility and costs of raising and potential modifications to these existing protective structures.
- An analysis of adaptation alternatives for major assets along the waterfront that considers feasibility, effectiveness, costs, the unique characteristics of the waterfront area, the City's vision for access and connectivity, and existing and future regulatory framework. Particular attention will be paid to the Harbor Commercial Area and Harbor West Parking Lot areas that have experienced frequent flooding and storm surge during the last few winters.
- State and regulatory agency coordination and consultation.
- Bilingual, interactive, and engaging community outreach.
- Survey and conceptual design for key recommended adaptation projects.

The 30-Year Waterfront Adaptation Plan will include several components that extend beyond the scope of this Plan, including:

- Updated shoreline erosion analysis that considers geomorphology, dredging, and sediment management.
    - Note that the updated shoreline erosion analysis for West Beach was included in this Plan since it used site specific information to develop the projections
- Storm-driven waves and wave run-up hazards assessment under multiple storm scenarios.
- Regional adaptation measures such as beach nourishment and dune formation.

This forthcoming information will influence future adaptation options for water and wastewater infrastructure along the shoreline. Consequently, some recommendations in this Plan will be dependent on conclusions from the 30-Year Waterfront Adaptation Plan.

1.5.3 Recent Approaches to Adaptation Planning

Adapting to climate change has become a pressing concern for many municipalities in recent years with limited precedent established when it comes to adaptation strategies and their implementation. A 2023 study by the Water Research Foundation, *Holistic Approaches to Flood Mitigation Planning and Modeling under Extreme Events and Climate Impacts*, examined approaches to flood mitigation planning by interviewing 17 utilities from 18 states, four Canadian provinces, and the United Kingdom (The Water Research Foundation, 2023). The efforts of these municipalities to adapt to their new reality and outcomes of these efforts are applicable to the City's climate change adaptation conditions and are summarized below.

- Enhancing understanding of hazards.
- Building partnerships.
- Obtaining funding and financing for adaptation measures.
- Improving design and construction standards.
- Safeguarding existing assets.

1. Enhancing understanding of hazards

In the absence of readily-available alternatives, many utilities have relied on the historical FEMA flood maps that only map historic hazards to determine what geographic areas and infrastructure are at risk or may be at risk of flooding in the future. However, many have echoed the sentiment that the FEMA flood maps are not an adequate tool for risk assessment due to the lack of consideration of several factors, such as:

- Joint probability flood analysis, such as delineation of flood extents that are a result of both coastal and pluvial flooding.
- Soil moisture, which can have significant impact on consequences of floods.
- Post-burn hydrological changes.
- Cloud-burst events.
- Flood conditions during less than 100-year events that are much more frequent.
- Changes in magnitude and frequency of occurrence of floods due to climate change.

As the study concludes: "FEMA maps are for insurance purposes, and updated maps are [required] for decision-making, emergency preparedness and response" (The Water Research Foundation, 2023). As a result, many communities are investing in more accurate flood probability mapping as their frontline climate change adaptation effort.

In addition to developing and refining models, some utilities are working on acquiring data to validate their flood mapping models. This may involve installation of United States Geological Survey (USGS) gauges and flow meters at key flood-prone areas, or more innovative approaches, such as leveraging crowd-sourced data (e.g. social media photos) to identify flood hotspots (The Water Research Foundation, 2023).

Meanwhile, some utilities are focused on understanding the impacts of hazards on their infrastructure and are funding studies that attempt to assess the consequences of design storm exceedances on specific assets.

CITY ACTIONS

As described in Section 1.5.2, the City has several studies planned to better define climate change related risks and potential adaptation measures, including for creek flooding, I&I, and coastal protection. A key recommendation of this Plan is to conduct updated flood modeling of storms of higher frequency (5, 10, 25, 50-year storms) while factoring in climate changes in rainfall patterns and sea level rise. Additional work to model the stormwater system and see if any capacity improvements to alleviate flooding of lower-level storms can assist with flood frequency. Additional analysis of Laguna Creek and Mission Creek improvements is also needed to understand the potential to alleviate flooding from larger storms. This data collection is recommended to be completed prior to making major investments in flood adaptation measures for water and wastewater infrastructure. However, note that the feasibility of citywide flood protection measures substantially alleviating flooding during large events in the lower downtown area are low. With higher amounts of sea level rise over time, flooding levels will increase no matter what flood protection measures are deployed. Therefore, any decision to floodproof wastewater and water infrastructure should consider that improvements are likely to be needed over time, but the exact timing of the need for improvements is not known. As such, the City is already working on monitoring studies regionally and is phasing adaptation implementation based on changed conditions (amounts of sea level rise that occur and flood frequency) instead of exact dates that they might occur. One of the City's top priorities in adaptation planning is to develop appropriate monitoring of changing conditions with which to make decisions on phasing of adaptation.

2. Building partnerships

The development and implementation of large-scale climate change adaptation solutions is challenging at a utility or municipality level due to the costs and scale of problems. Many communities have engaged U.S. Army Corps of Engineers (USACE), FEMA, EPA, and other potential partners to assist in the following (The Water Research Foundation, 2023):

- Define level of service standards.
- Standardize design guidelines.
- Collaborate on development of integrated frameworks for stormwater management that incorporate climate change.
- Develop watershed-level approaches to climate change impact adaptation.

Building a partnership with community residents is essential for garnering public cooperation and successfully implementing public programs. While engaging the public on climate change impacts can be contentious and challenging, it remains an essential pillar of a robust adaptation framework (The Water Research Foundation, 2023).

Following an unprecedented flooding disaster that has resulted in billions of dollars in damage, the City of Calgary executed a broad public engagement initiative. The initiative included working with representatives of communities directly affected by flooding to incorporate social and cultural aspects into flood adaptation planning. The city reported converting even their most apprehensive stakeholders into strong and proactive adaptation plan advocates (The Water Research Foundation, 2023).

The public feedback fed into an important assessment of organized retreat, which included economic, social, and historical dimensions.

CITY'S ACTIVITIES

The City has initiated regional partnerships, such as the Regional Climate Adaptation Monitoring Program for regional data collection, and this Plan leverages CoSMoS, which was led by USGS. The City has also organized the City Interdepartmental Climate Adaptation Team, which includes members of relevant City departments: Community Development, Public Works, Parks & Recreation, Sustainability & Resilience, Airport, Fire, City Administrators Office, Finance, and Waterfront. The group discusses available information and adaptation options while carefully considering ramifications to all City systems, residents, and businesses. From a public engagement perspective, the City conducted extensive outreach during development of the 2021 SLR Adaptation Plan and has extensive outreach planned as part of the ongoing 30-Year Waterfront Adaptation Plan.

3. Obtaining funding & financing for adaptation measures

A number of communities have had success with securing funding for climate change adaptation measures (The Water Research Foundation, 2023). Among the early success stories are:

- New York City Department of Environmental Protection secured funds for cloud burst mitigation projects from the FEMA Hazard Mitigation program.
- The Minnesota Department of Natural Resources secured funds for statewide LiDAR coverage from the State's Clean Water Legacy Fund.
- The City of Atlanta pursued FEMA buyouts to address challenges posed by residential flooding.

Others have implemented local fee structures to fund adaptation (The Water Research Foundation, 2023). The City of Colorado Springs, for example, implemented a drainage basin fee policy where the developer is charged a fee for each acre of new, platted development. If the development is channel adjacent, they must stabilize the channel and can seek reimbursement. The City of Chattanooga incorporated a water quality fee into property tax bills.

CITY'S ACTIVITIES

The City has aggressively pursued grants, including a grant to fund this Plan. Looking forward, the City will need to determine how to best fund climate change adaptation projects considering beneficiaries and equity.

4. Improving design and construction standards

One aspect of adaptation to the new climate reality is building infrastructure that aligns with future climate conditions. Many municipalities have begun revising their design guidelines and standards for new development and retrofits to ensure protection from flood impacts. These early efforts include:

- Implementation of new land development policies, which may include prohibiting expansion beyond existing footprint or prohibiting new construction in certain areas.
- Flood zone land use regulation changes, such as a requirement to adequately demonstrate that flood risk is being mitigated if building in the floodplain or a requirement to provide onsite compensatory floodplain storage.
- Requiring new or substantially retrofitted assets to be designed, constructed, floodproofed, raised, or relocated to locally-established design flood elevations (DFEs). The DFEs are, in almost all cases, higher in elevation than FEMA BFEs, which do not take sea level rise into account.
- Incorporating addition of assets like lakes, parks, and plazas in vulnerable areas that can double as tidewater and floodwater reservoirs when the sea level rises.

Various approaches have been taken to develop local DFEs, including:

- Using 500-year base flood elevation data to develop DFEs for a 100-year planning horizon.
- Examining 25-year storm events in addition to 100-year storm events due to the potential probability of impact to a larger quantity of people.
- Elevating to a minimum of three ft above the 100-year base flood elevation to account for uncertainty.
- Basing DFEs on:
  - Asset criticality.
  - Useful life.
  - Risk tolerance.
  - Uncertainty in hazard projections and future local conditions.

Decisions to change policy and design standards should therefore be based on a comprehensive understanding of both climate change hazards and ramifications — intended and unintended. For example, one community developed a policy requiring all new developments over one acre in size to match the pre-development, historic 100-year flow rates with the intent of managing flood impacts. While this policy successfully curbed runoff rates as intended, it also resulted in altered runoff patterns without any reduction in runoff volume; this ultimately contributed to channel degradation and instability issues.

CITY'S ACTIVITIES

The City plans to complete additional flood studies that include mapping flood extents and depths with sea level rise. Based on this, the City's floodplain ordinance may require floodproofing to a higher base flow elevation where needed and other needed measures.

5. Safeguarding existing assets

Protecting infrastructure from flooding, especially when it cannot be readily relocated or raised, often involves establishing buffer zones for storing floodwater. Flood buffering can be successfully achieved through small-scale projects, which are great for managing smaller, more intense storms with greater recurrence. The following examples of local flood adaptation measures emerged from innovative thinking and tailored approaches that consider the unique needs and conditions of the communities they serve (The Water Research Foundation, 2023):

- Use of green and blue-green infrastructure (natural solutions that support, protect, and enhance natural capital) for small-scale storage and flood buffering:
  - Vegetated bioretention (e.g., lowered, grassy areas) that can safely fill with water to alleviate flooding
  - Tree-planting initiative
  - Bioengineering for streambank restoration
  - Use of existing stream channels to store floodwater
- Provision of capacity relief for stormwater and/or combined sewer systems through:
  - Municipal open-air ponds, parks, and plazas that are able to (or are retrofitted to) double as reservoirs
  - Vaults, pipe systems, and subsurface storage chambers
  - Depressed open air basketball courts that can double as flood storage
  - Private ponds or flood retention systems installed through a municipal program and maintained by the municipality
  - Stormwater infrastructure upgrades, including addition of culverts informed by modeling
- Installation of soft structures to reduce wave action
- Pursuing less-intrusive retrofits to reduce flood risk for existing properties
- Improvements of public flood warning systems
- Optimizing operation of treatment facilities to increase storage available during floods
- Improvements to flood emergency response

CITY'S ACTIVITIES

The City is considering most of the adaptation measures listed above in the Plan or plan to evaluate the measures in upcoming studies, such as the Stormwater Model and Flood Analysis Report and the 30-Year Waterfront Adaptation Plan (described in Section 3.4.3).

2.0 Hazards Approach

This section describes the approach to characterizing hazards associated with climate change that were used to assess infrastructure vulnerabilities. Sea level rise policy guidance and selected scenarios are described. The hazards analyzed in detail include coastal flooding, creek flooding, shoreline erosion, bluff erosion, and groundwater inundation. Increased risks of wildfire, drought, and extreme heat are addressed at a lower level of detail.

2.1 Sea Level Rise Scenarios

This section documents the planning horizons and sea level rise scenarios evaluated for this Plan. This Plan evaluates coastal hazards for existing conditions and six future sea level rise scenarios for the project: 0.8 ft SLR, 1.6 ft SLR, 2.5 ft SLR, 3.3 ft SLR, 4.1 ft SLR, and 4.9 ft SLR. These amounts of sea-level rise are relative to a baseline of sea level in the year 2000, or more specifically, the average sea level from 1991 to 2009. Based on the relative sea level trend calculated by NOAA Tides and Currents (NOAA, 2024), sea levels in Santa Barbara have risen by approximately 28 millimeters (1.1 inches) between 2000 and 2024.

These sea level rise scenarios are consistent with the latest State guidance and available coastal hazard maps for the Santa Barbara area, including United States Geological Survey (USGS) Coastal Storm Modeling System (CoSMoS) 3.0 (O'Neill, et al., 2018) and coastal hazard mapping by ESA for Coastal Resilience Santa Barbara County (ESA, 2015).

2.1.1 California State Sea Level Rise Policy Guidance

The California Ocean Protection Council (OPC) finalized the State of California Sea Level Rise Guidance: 2024 Science and Policy Update (2024 OPC SLR Guidance) (OPC, 2024), which provides projections for sea level rise at various locations along the coast of California through 2150. OPC produced this guidance in partnership with the California Ocean Science Trust (OST) and a scientific Task Force. The guidance is based on the National Oceanic and Atmospheric Administration (NOAA) 2022 Global and Regional Sea Level Rise Scenarios for the United States (Sweet, et al., 2022), which provides updated sea level rise scenarios for the United States based on global projections from the Intergovernmental Panel on Climate Change (IPCC) 6th Assessment Report (IPCC, 2022). The 2024 SLR Guidance presents five sea level rise scenarios and values that incorporate: (1) sea level rise observations, estimated and modeled projections, and uncertainties, and (2) a range of global greenhouse gas emissions scenarios, which rely on shared socioeconomic pathways (SSPs).[2]

Note that future global greenhouse gas emissions and warming scenarios drive the sea level rise projections reported by the OPC. Emissions scenarios are influenced by societal choices and therefore their likelihood of occurrence is inherently uncertain. Sea level rise scenarios are determined by modeling a range of global emissions projections and considering a range of uncertainties in sea level rise processes. Due to the inherent uncertainty of future global greenhouse gas emissions scenarios, the probability of sea levels rising a specific amount by a specific date cannot be determined. Instead, the probability of exceedance of a particular sea

[2] SSP background from OPC 2024 guidance: *Developed more recently, the SSPs are a collection of narrative descriptions of alternative futures of socio-economic development in the absence of climate policy intervention. Five SSPs describe five different pathways that the world could take, drawing on data including population, economic growth, education, urbanization, and the rate of technological development. The SSPs are important inputs into the IPCC sixth assessment and are used to explore how societal choices will affect greenhouse gas emissions.*

level rise scenario provided by the 2024 OPC guidance is contingent or conditional on the assumption of a particular future emissions and warming scenario.

The OPC SLR Guidance (OPC, 2024) **provides the following sea level rise scenarios (and risk aversion applications):**

Intermediate Scenario (Low Risk Aversion): "A range of future emissions pathways; could include contribution from low confidence processes. Based on sea level observations and current estimates of future warming, a reasonable estimate of the upper bound of most likely sea level rise in 2100." The OPC guidance states:

"For short-term adaptation actions (e.g., as part of an adaptation pathways approach) the Intermediate Scenario is recommended, regardless of risk category. This is because multiple lines of evidence identify the Intermediate Scenario as being most likely in the near-term (i.e., 2050) … For low-risk averse projects, it is recommended that the Intermediate Scenario be applied." (OPC, 2024)

Low risk aversion is appropriate for adaptive, lower-consequence projects (e.g., unpaved coastal trails).

Intermediate-High Scenario (Merium-High Risk Aversion): "Intermediate-to-high future emissions and high warming; this scenario is heavily reflective of a world where rapid ice sheet loss processes are contributing to sea level rise." OPC guidance states:

"For medium-high risk averse applications, the Intermediate-High Scenario is recommended. Although there is a 0.1% chance of exceeding the Intermediate-High Scenario in 2100 (assuming 3°C of warming and no low confidence processes) the state recommends a precautionary approach, when possible, to maximize preparedness and resilience. Furthermore, if there is greater than 4°C warming and contribution from low confidence processes, there is a 20% chance of exceeding the Intermediate-High Scenario in 2100 (high levels of warming). Additionally, because medium-risk averse projects have longer lifespans, the Intermediate-High Scenario provides an additional buffer should the project need to persist further into the future than originally planned for." (OPC, 2024)

Medium-high risk aversion is appropriate as a precautionary projection that can be used for less adaptive, more vulnerable projects or populations that will experience medium to high consequences from underestimating sea level rise (e.g., coastal housing development).

High Scenario (Extreme Risk Aversion): "High future emissions and high warming with large potential contributions from rapid ice-sheet loss processes; given the reliance on sea level contributions for processes in which there is currently low confidence in their understanding, a statement on the likelihood of reaching this scenario is not possible." However, assuming high emissions and considering the range of model projections for a high-emissions scenario without contribution from low-confidence processes, the High Scenario's sea level rise estimates have

0.1% or less chance of exceedance by 2100.[3] The OPC states that this scenario "should be used with caution and consideration of the underlying assumptions." The OPC report that:

"For extreme risk averse applications, the High Scenario may be appropriate, however, there are limited situations in which designing and constructing to the High Scenario will be necessary and/or feasible without significant logistical tradeoffs. If significant constraints do not exist, then designing to the High Scenario is recommended, all other factors being equal. However, it is likely that in most situations, factors like the urbanized nature of existing communities, location of existing facilities, requirements to provide service to existing development, and fiscal constraints will make incorporating the High Scenario into initial project design infeasible. The adaptation pathways approach is therefore recommended, in which a smaller amount of sea level rise is incorporated into initial project design while also developing options to address higher sea level rise amounts in the future ... Although the High Scenario has an effectively zero percent chance of being exceeded in 2100 (assuming 3°C of warming and no low confidence processes), extreme risk averse projects have anticipated lifespans beyond 2100 and therefore should be prepared for both worst case values at 2100, as well as higher amounts of sea level rise that are expected beyond 2100." (OPC, 2024)

Extreme risk aversion is appropriate to be considered in planning processes for high consequence projects with little to no adaptive capacity and which could have considerable public health, public safety, or environmental impacts and consideration of the scenario for high consequence projects such as wastewater treatment plants.

The updated guidance recommends evaluation of the Intermediate and Intermediate-High, and consideration of the High Scenario during long term planning of very critical infrastructure. This Plan uses the Intermediate and Intermediate-High Scenarios for time frames of sea level rise thresholds and considers that, under the High Scenario, sea level rise could occur sooner (Section 2.1.2.2).

Several changes were made from the previous State of California Sea Level Rise Guidance (OPC, 2018). The updated 2024 guidance removes the extreme sea level rise scenario (H++) that was included in the previous guidance. The H++ scenario assumed rapid ice sheet loss on Antarctica, which could drive rates of sea level rise 30-40 times faster than the sea level rise experienced over the last century. This scenario is not included in the 2024 update, as the rates and amounts of sea level rise are not supported by best available science. Although the extreme ends of sea level rise estimations continue to fluctuate, there has been increasing consensus about the likely amount of sea level rise. The 2024 guidance provides a greater certainty of sea level rise through 2050 with a California statewide average of 0.8 ft. By 2100,

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[3] As stated in OPC (2024): *"It is important to note that probabilistic projections do not provide actual probabilities of occurrence of sea level rise but provide probabilities that the ensemble of climate models used to estimate contributions of sea-level rise (from processes such as thermal expansion, glacier and ice sheet mass balance, and oceanographic conditions, among others) will predict a certain amount of sea-level rise*." Also, note that the High Scenario has an 8% chance of exceedance when accounting for low confidence processes associated with Antarctica and Greenland ice-sheet loss.

the expected range of sea level rise is between 1.6 and 3.1 ft, although higher amounts cannot be ruled out. Beyond 2100, sea level rise uncertainty increases, with the potential for statewide sea levels to rise from 2.6 to 11.9 ft or greater by 2150.

While the 2024 OPC SLR Guidance provides projections through 2150, it is important to note that sea level rise is expected to continue for centuries because the earth's climate, cryosphere,[4] and ocean systems will require time to respond to the emissions that have already been released to the atmosphere. Although sea level rise is typically presented as a range in the amount of sea level rise that will occur by a certain date (e.g., 0.6 to 1.1 ft of sea level rise by 2050), it can also be presented as a range of time during which a certain amount of sea level rise is projected to occur (e.g., 1.6 ft of sea level rise between 2060 and 2080). Even if emissions are reduced to levels consistent with the low-emissions-based projections, sea level will continue to rise to higher levels, just at a later date.

2.1.1.1 Projections for Santa Barbara

The 2024 OPC SLR Guidance recommends utilizing data from one of twelve NOAA tide gauges that are located along the coast of California. Using the data from the nearest tide gauge to the project site can capture local variations due to tectonic activity or subsidence. The nearest NOAA tide gauge to the City of Santa Barbara is located in Santa Barbara Harbor.

Table 2-1 presents 2024 SLR Guidance projections for the Santa Barbara area in terms of Low, Intermediate-Low, Intermediate, Intermediate-High, and High Scenarios. The recommended scenarios for evaluation (Intermediate, Intermediate-High, and High) are outlined by the dark blue box.

[4] The cryosphere is the portions of the Earth's surface where water is in solid form, like glaciers and ice caps.

Table 2-1. State Guidance. Projected Sea Level Rise for Santa Barbara Area (Ft)

Year	Low	Int-Low	Intermediate	Int-High	High
2020	0.1	0.2	0.2	0.2	0.2
2030	0.2	0.3	0.3	0.3	0.4
2040	0.3	0.4	0.4	0.5	0.6
2050	0.3	0.5	0.6	0.9	1.1
2060	0.4	0.6	0.9	1.4	1.8
2070	0.5	0.7	1.2	2.0	2.7
2080	0.5	0.9	1.6	2.8	3.8
2090	0.5	1.1	2.1	3.5	5
2100	0.6	1.2	2.8	4.5	6.3
2110	0.6	1.4	3.4	5.3	7.5
2120	0.7	1.5	4.0	6.0	8.6
2130	0.7	1.7	4.4	6.6	9.5
2140	0.7	1.9	4.9	7.1	10.4
2150	0.8	2.0	5.5	7.6	11.3

Source: 2024 OPC Guidance (OPC, 2024)

Notes:

1. Median values of Sea Level Scenarios, in ft, for each decade from 2020 to 2150, with a baseline of 2000. All median scenario values incorporate the local estimate of vertical land motion.
2. The Intermediate and Intermediate-High Scenarios outlined by the dark blue box are evaluated and used to estimate time frames of sea level rise referenced in this study. The High Scenario outlined by a dashed line is also considered in sea level rise evaluations. See Section 2.1.2 for further discussion.

2.1.1.2 California Coastal Commission Guidance

In July of 2024, the California Coastal Commission (CCC) released a Public Review Draft 2024 SLR Policy Guidance Update (CCC, 2024). Future phases of adaptation planning will consider the CCC guidance update once the guidance is finalized.

In 2021, the CCC released the Critical Infrastructure Guidance for Sea Level Rise Adaptation Planning (CCC Critical Infrastructure Guidance) with specific guidance for sea level rise adaptation of at-risk critical infrastructure (CCC, 2021). The CCC Critical Infrastructure Guidance is based on the 2018 OPC Sea Level Rise Guidance (OPC, 2018), which is now superseded by the 2024 OPC SLR Guidance. The CCC Critical Infrastructure Guidance is summarized below for reference.

The CCC Critical Infrastructure Guidance document is focused on transportation and water/wastewater infrastructure and builds upon the 2018 science update to the CCC Sea Level Rise Policy Guidance (CCC, 2018). The purpose of the critical infrastructure guidance is to provide policy and planning information to inform sea level rise planning and adaptation decisions that are consistent with the California Coastal Act. The guidance presents key considerations for successful infrastructure adaptation planning with specific recommendations for each infrastructure category. It describes the regulatory framework for infrastructure adaptation planning and provides model policies.

Consistent with direction from 2018 OPC Sea Level Rise Guidance on the potential for extreme sea level rise, CCC recommended evaluating the extreme risk aversion (H++) scenario for critical infrastructure due to the long lifespans and significant consequences associated with extreme sea level rise and related hazard impacts. CCC guidance was to:

> *"Understand and plan for the H++ scenario, not necessarily to site and design for the H++ scenario. In other words, in some cases it may not be appropriate or feasible to site or design a project today such that it will avoid the impacts associated with, for example, ~10 ft of sea level rise (the approximate H++ scenario in 2100 for much of the California coast). However, it is important to analyze this scenario to understand what the associated impacts could be and to begin planning options to adapt to this scenario if and when it occurs, and to ensure that the risks and benefits of economic investments in critical infrastructure are fully understood."* (CCC, 2021)

Given that the 2024 OPC guidance is the best-available science and does not include the H++ scenario, the superseded OPC 2018 guidance's extreme risk aversion (H++) scenario is not considered in this Plan. While the RWQCB permit discussed the extreme risk aversion (H++) scenario, the City confirmed with RWQCB that RWQCB will not require an analysis of the extreme risk aversion scenario for the reasons discussed above.

The City's 2021 SLR Adaptation Plan applied the "medium-high risk scenario" for Santa Barbara contained in the 2018 OPC Sea Level Rise Guidance. **This Plan uses sea level rise from the "Intermediate-High Scenario" in the 2022 NOAA report, which aligns with 2024 OPC SLR Guidance and represents a precautionary projection that is the plausible high-end projection for 2100 should rapid ice sheet loss contribute to sea level rise.** This Plan also considers that, compared to the Intermediate-High Scenario, sea levels could rise faster, as projected in the lower-probability High Scenario, or slower, as in the higher-probability Intermediate Scenario.

2.1.2 Selected Sea Level Rise Scenarios

Sea level rise scenarios were selected for this study by considering the 2024 OPC guidance discussed above (which is based on latest sea level rise science) and the availability of existing sea level rise hazard data.

2.1.2.1 Sea Level Rise Scenarios

The City's 2021 SLR Adaptation Plan (ESA, 2021) analyzed the following sea level rise projections combined with a no storm scenario and a 100-year storm scenario:

- 0.8 ft sea level rise (by 2030)
- 2.5 ft sea level rise (by 2060)
- 6.6 ft sea level rise (by 2100).

Sea level rise amounts are relative to a baseline sea level in the year 2000. Sea levels in Santa Barbara have risen by approximately 28 millimeters (1.1 inches) between 2000 and 2024 (NOAA, 2024). The timing of these sea level rise amounts corresponds to a superseded "medium-high risk scenario" from the OPC 2018 SLR Guidance. The 2024 OPC SLR Guidance, which supersedes the 2018 guidance, provides updated timing for these three scenarios.

This Plan continues to look at the same amounts of sea level rise combined with storm scenarios and added analysis of interim sea level rise scenarios of 3.3 ft SLR, 4.1 ft SLR, and 4.9 ft SLR to assess when certain triggers may occur. In addition, 1.6 ft SLR was included for shoreline erosion cross-sections.

2.1.2.2 Planning Horizons

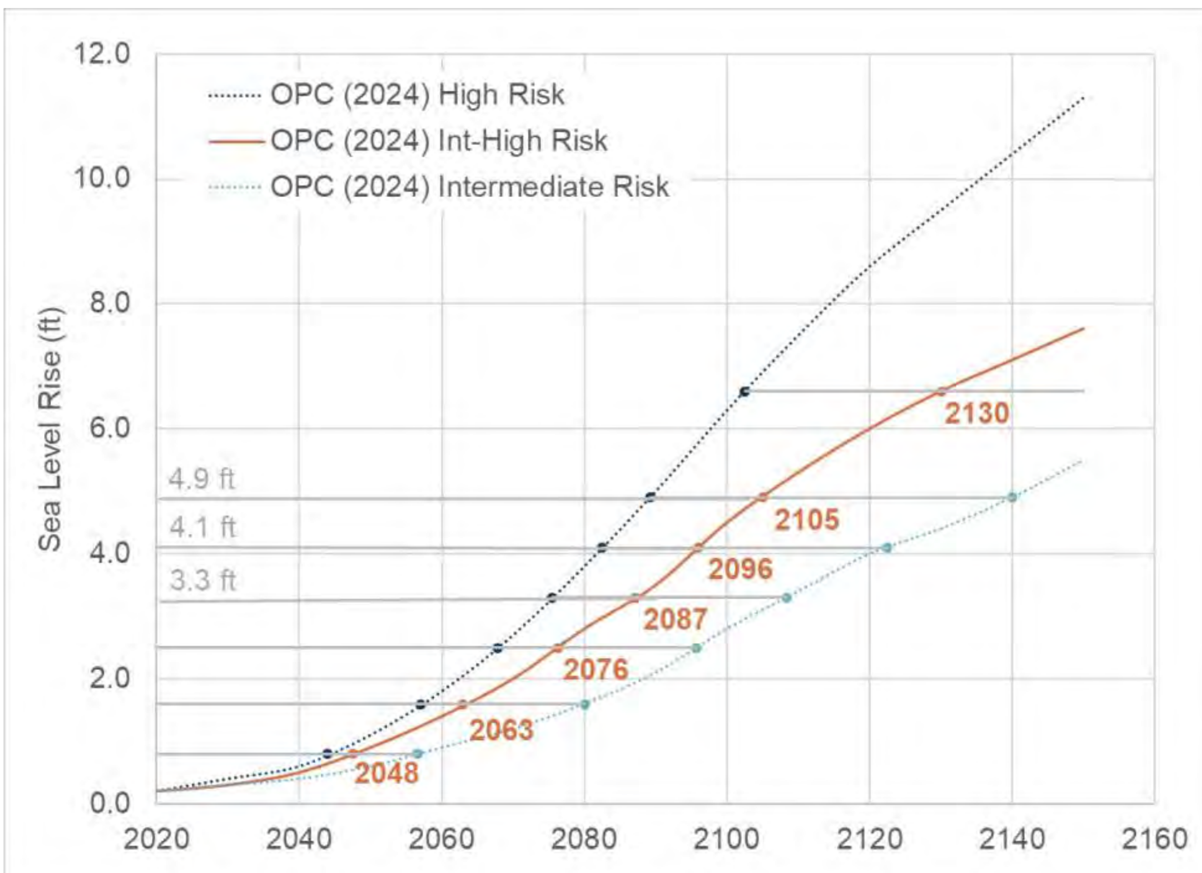
As described in Section 2.1.1, the probability of exceeding the High Scenario in 2100 is less than 0.1% for all warming levels without considering low confidence processes. With very high emissions and warming and contributions from the low confidence processes, this probability increases to 8% (OPC, 2024). The projections included in most of the figures and analysis in this Plan are the Intermediate-High Scenario as a precautionary measure. However, the Plan also considers that there is a possibility, however low probability that might be, that sea level rise amounts could occur as soon as the High Scenario timing and a much higher probability that sea level rise amounts could occur as late as the Intermediate Scenario timing. Table 2-2 and Figure 2-1 summarizes the sea level rise scenarios used for this Plan and anticipated timing based on the OPC 2024 SLR Guidance. Hazard analyses was concentrated on the sea level rise amounts shown in the table as they represent turning points or thresholds where significant changes in conditions relevant to the wastewater and water systems occur.

Table 2-2. Sea Level Rise Scenarios with Timing Based on 2024 OPC Guidance

Sea Level Rise Amount	Sea Level Rise Scenarios (Risk Aversion Application) Projected Dates of Sea Level Rise Amount — Decreasing likelihood of occurrence →		
	Intermediate Scenario (Low Risk Aversion)	Intermediate-High Scenario (Med-High Risk Aversion)	High Scenario (Extreme Risk Aversion)
0.8 ft	2057	2048	2044
2.5 ft	2096	2076	2068
3.3 ft	2108	2087	2075
4.1 ft	2123	2096	2083
4.9 ft	2140	2105	2089
6.6 ft	After 2150	2130	2103

Note: This Plan is based on the Intermediate-High sea level rise scenario (light blue highlight).

Figure 2-1. Sea Level Rise Projections and Plan Scenarios



2.2 Hazards Methodology

This section presents the methods of the sea level rise hazard analysis that uses spatial data for coastal hazard zones, assessment of the Laguna Creek system, and creek flooding and erosion analyses. The analysis projects future creek and Laguna Creek flood levels due to sea level rise and increased precipitation. The erosion analysis projects shoreline erosion for the water and wastewater systems infrastructure. Hazards were characterized under different sea level rise scenarios. **Note that these hazards represent projected future conditions without taking action as a hypothetical "do nothing" baseline scenario to inform adaptation options** such as regional flood protection or beach nourishment.

The hazards assessment for this study was completed using multiple methods. The hazard mapping analysis consists of a spatial assessment of hazard exposure that overlays the water and wastewater assets with hazard maps. Available geospatial hazards data was collected for the pertinent flooding, erosion, and fire hazards as well as water, wastewater, and recycled water systems assets, including El Estero WRC and the Desalination Plant. Additional hazards analyses were completed to estimate future creek flooding with changes in rainfall patterns from climate change and project future shoreline erosion impacts to the beach assets.

This section describes the available hazards data and the specific data sources utilized in this study. Table 2-3 is a summary of the available hazard mapping data organized by hazard type. It also includes a column to explain the supplemental analyses included in this Plan.

Table 2-3. Summary of Available Hazard Mapping Data Organized by Hazard Type

Hazard Type	Mapping Data Source	Supplemental Analyses
Stormwater Flooding	FEMA	See Section 2.2.1
Tidal Inundation	USGS CoSMoS 3.0[a] City's 30-Year Waterfront Adaptation Plan, Coastal Inundation Analysis TM[b]	
Groundwater	USGS CoSMoS 3.0[a]	
Coastal Storm Flooding	City's 30-Year Waterfront Adaptation Plan, Coastal Inundation Analysis TM[b]	
Coastal Storm Waves	Coastal Resilience – Santa Barbara[b]	
Extreme Precipitation		See Section 2.2.2.3
Long-Term Erosion	City's 30-Year Waterfront Adaptation Plan, Coastal Inundation Analysis TM[b]	See Section 2.2.5
Fire	City of Santa Barbara	
Drought	Cal-Adapt	
Extreme Heat	Cal-Adapt	

Notes:

a. Source: (O'Neill, et al., 2018)
b. Source: (Stantec, 2025)
c. Sources: (ESA, 2015) (ESA, 2016)

Coastal hazards, which were mapped using ArcGIS, included the following categories of impacts without action. The categories are distinguished between chronic long-term impacts and temporary event-based impacts.

- **Tidal Inundation.** Areas in the potential future tidal inundation hazard zone would be inundated by typical daily to monthly spring tide conditions (chronic impacts, high consequences). Tidal inundation represents the potential for chronic infiltration of brackish/salt water to occur at high tides.
- **Coastal Storm Flooding.** Areas in the potential future coastal storm flooding hazard zone would be inundated by high ocean water levels caused by storm surge (temporary impacts, significant consequences). Temporary infiltration of brackish water may occur at unsealed manholes or other access structures. Storm scenarios from the Coastal Inundation Analysis TM for the City's 30-Year Waterfront Adaptation Plan (Stantec, 2025) assume that the storm coincides with a spring high tide (high tide levels that occur approximately twice every month). This represents a near-worst case scenario in terms of the coincident astronomical tide.
- **Groundwater Rise.** Areas in the groundwater rise hazard zone would be similarly impacted regularly by inundation (permanent impacts, greatest consequences).
- **Shoreline Erosion.** Areas subject to the potential future shoreline erosion hazard zones may be lost entirely (permanent impacts, greatest consequences). Shoreline erosion consists of landward shoreline movement and scour of assets built on or within the beach.

2.2.1 Stormwater Flooding

Stormwater flooding data from the Federal Emergency Management Agency (FEMA) Flood Insurance Study and Flood Insurance Rate Map (Federal Emergency Management Agency, 2018) include flood profiles for Laguna Creek and Mission Creek and the 100-year storm flooding extents. The FEMA flood hazard zone map for the study area is shown in Figure 2-2. Flood levels with sea level rise were conservatively estimated to increase the FEMA 100-year flood level by the amount of sea level rise (e.g., one foot of sea level rise increases flood elevation by one foot).

Flooding at El Estero WRC and the Desalination Plant is complex. Mission Creek Lagoon and Laguna Creek are remnants of what was once a large, back-barrier coastal wetland complex called Estero de Santa Barbara. The area around El Estero WRC was built following the draining and filling of this wetland complex. As a result, much of the land is low-lying and within the FEMA 100-year creek floodplain. El Estero WRC is at a higher elevation than most surrounding properties and is mostly above the FEMA floodplain.

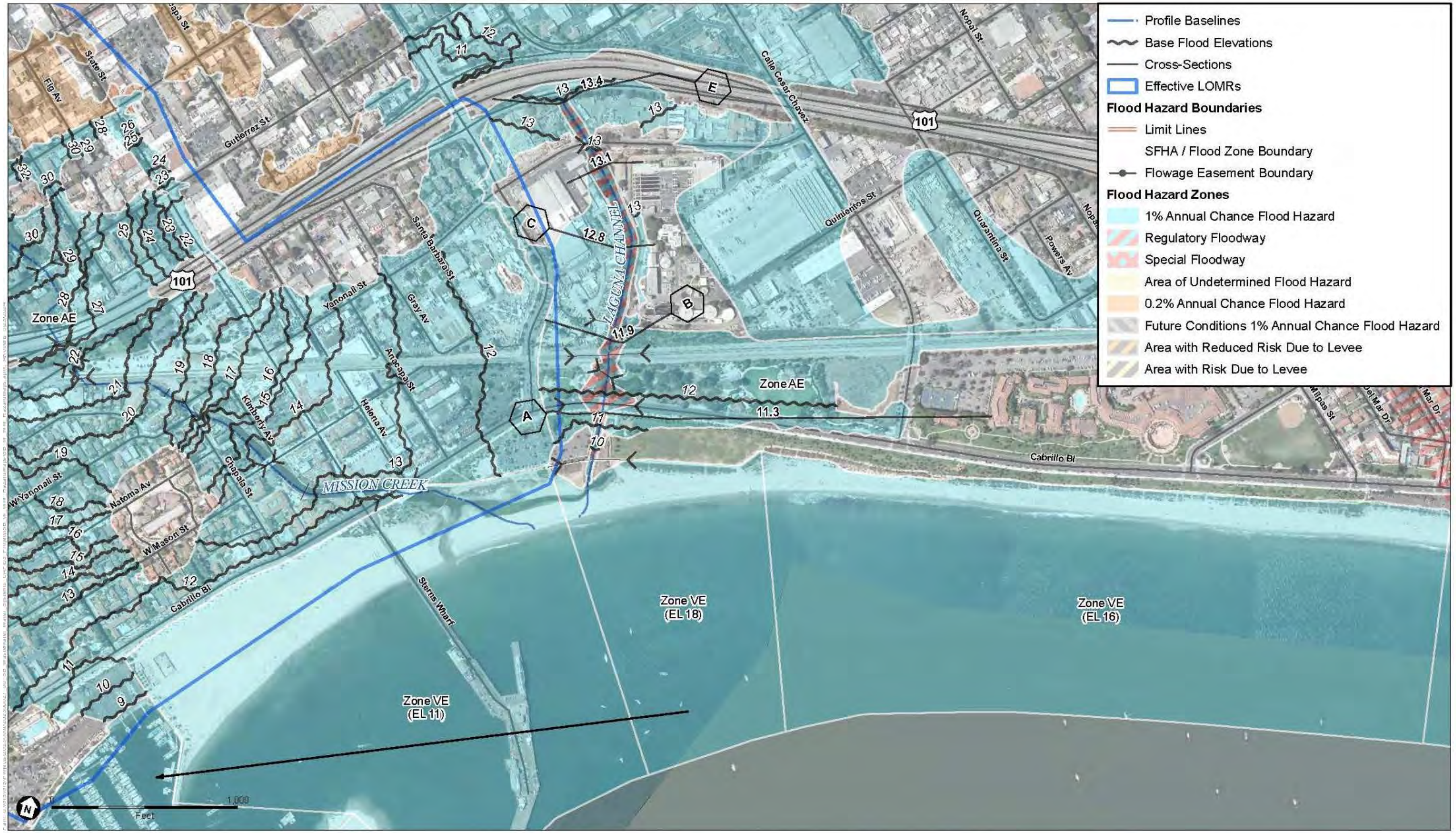
Rainfall runoff from the Laguna Creek watershed (~1 square mile) is collected by a storm drainage system that converges immediately north of US-101. A double 10 ft x 6 ft box culvert carries flow from most of the drainage area under the highway and discharges into an engineering flood control channel, Laguna Creek. Laguna Creek consists of earthen and concrete segments with a hydraulic pump station and tide gate facility at the downstream end.

Local storm drains discharge into the open creek. There is a lack of hydraulic gradient between ground elevations upstream of US-101, Laguna Creek, and the Pacific Ocean. Thus, the conveyances of the US-101 culverts are strongly influenced by the water level in Laguna Creek. The water level in Laguna Creek is, in turn, controlled by the capacity of the pump station, operation of the tide gate facility, beach berm elevation, and water levels at Mission Creek Lagoon and/or the Pacific Ocean.

The Laguna Creek tide gate is typically in the closed position. As creek water levels rise, water is pumped from the creek into the Mission Creek lagoon. The lagoon mouth is intermittently closed, mostly during the dry season, due to the natural formation of the beach sand berm; this is caused by ocean waves depositing sand in the mouth and building up the berm. When it rains enough, the waves are large enough, and/or the berm is mechanically graded and lowered, the berm breaches. When the lagoon is breached, or open, flows from Laguna Creek can discharge through the tide gates with the peak flow occurring at low tide.

Laguna Creek can be susceptible to flooding during storm events. Typically, Mission Creek and Laguna Creek storm flows are necessary to breach the beach berm and allow discharge from the lagoon and creeks. This can result in a several-hour time frame when the tide gate is closed, before the lagoon breaches, during which Laguna Creek cannot drain by gravity. Flat topography and creek capacity south of the US-101 slow drainage through US-101 culverts and contribute to flood risk upstream. The Laguna Creek pump system mechanically pumps and discharges water from Laguna Creek to Mission Creek Lagoon. The pump capacity limits the flow of water from the creek to the lagoon. Flooding in Laguna Creek can occur when creek inflows exceed the pump capacity and/or extreme high tide water levels in Mission Creek Lagoon backflow over the Laguna Creek tide gate structure (see Section 2.2.2.1 for additional discussion).

Figure 2-2. FEMA Flood Hazard Map



SOURCE: FEMA, ESA

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2.2.2 Combined Stormwater Flooding with Climate Change

The FEMA flood map (Figure 2-2) delineates the 100-year flood hazard zone, which signifies areas with a 1% or higher chance of flooding in any year. FEMA does not currently map future flood extents with climate change and sea level rise. ESA estimated future stormwater flooding extents using previous models that ESA developed, projections of future precipitation, and analysis of FEMA model results.

2.2.2.1 Laguna Creek

Laguna Creek is bounded by the US-101 culverts to the north and the tide gate structure on the south. The City relies on the Laguna Creek tide gate (Figure 2-3) and pump system to manage creek and storm drain flooding in the Laguna Creek storm drainage system, see Section 2.2.1 for a description of the drainage system.

Figure 2-3. Laguna Creek Tide Gate

Image Note: Photo shows the existing tide gate with lagoon water level on the downstream end of Laguna Creek

ESA previously developed a water balance model for the City's Mission Lagoon-Laguna Creek Restoration Project (ESA and PWA, 2014) to estimate future flood water levels in Laguna Creek for frequently-occurring (10-year storm event) flooding upstream of US-101. The water balance model included results from the ESA quantitative conceptual model (QCM) of Mission Creek Lagoon opening and closure dynamics and water levels. The Laguna Creek water balance model simulated the flood detention functions of the Laguna Creek tide gate and pump system to evaluate the more frequent flooding that occurs upstream of US-101.

Prior model results show that under past precipitation conditions in a 10-year storm event, Laguna Creek would fill to flood stage (the level in which banks would start to overtop at the tide gate and upstream) in less than half an hour if the pumps and tide gates are not operational. If the pumps are operating but the tide gates do not open, the creek does not fill as quickly. However, the water level will continue to rise with continued inflows from upstream of US-101.

Based on the QCM (which assumes waves naturally build the beach berm until its elevation is approximately eight to nine feet NAVD without grading or following grading), the discharge from pumping from Laguna Creek would fill Mission Creek Lagoon from a typical starting water level (typical closed Mission Creek Lagoon level of about 7.5 ft NAVD) to the beach berm crest elevation and initiate breaching of the beach berm in approximately one hour. The breach allows the water level in the lagoon to fall; this triggers the opening of the tide gates. If the pumps are operating and the tide gates automatically open, Laguna Creek water level begins to fall after approximately an hour, when the tide gate opens as a result of the breach. With the tide gates open, the model indicates that water level in Laguna Creek reaches equilibrium with the lagoon water level.

Based on the prior study, the size of the lagoon may reduce with sea level rise due to landward movement of the beach berm. The height of the beach berm may increase as waves push sand to higher elevations. A smaller lagoon would require less time to fill and would breach sooner. However, the equilibrium water level in the lagoon would be higher due to the sea level rise. The model indicates water levels in Laguna Creek will rise faster and to higher levels with sea level rise than in existing conditions while the lagoon is closed.

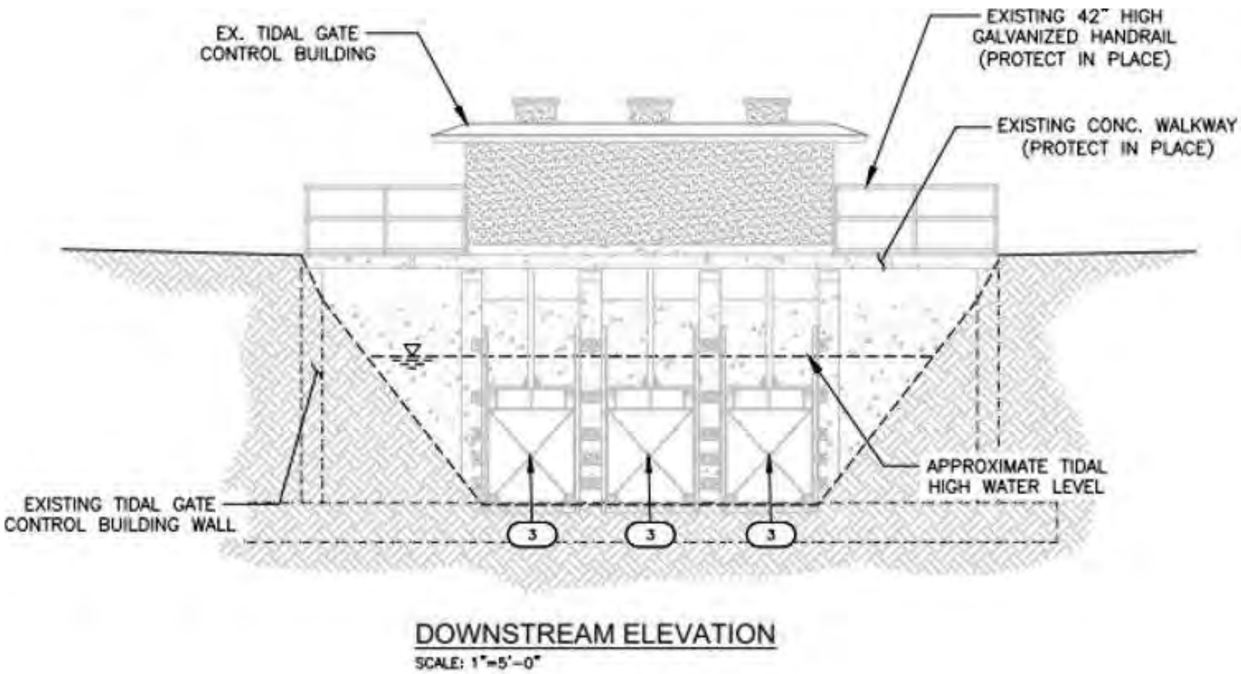
ESA's prior Laguna Creek model was not developed to assess higher levels of flooding that exceed the capacity of the Laguna Creek system and cause out-of-bank flooding south of US-101. To assess higher levels of flooding, ESA performed the assessments below using available model results from the FEMA Flood Insurance Study (Federal Emergency Management Agency, 2018), Global Climate Model (Cal-Adapt, 2018) projections of increased precipitation with climate change, and further assessment of the tide gate and the City's inlet management.

To further assess the function of the Laguna tide gate with sea level rise, ESA used the City's Laguna Pump Station and Creek Modifications (Stantec, 2022) design plans (Figure 2-4) to obtain and assess tide gate structure configuration and elevations relative to sea level rise. The City has designed a Laguna Creek pump system upgrade, the existing Laguna Creek Pump Station and Creek Modifications Project; when implemented, it is expected to provide a combined pumping discharge of approximately 260 to 270 cubic feet per second (cfs) (City staff, personal communication). The design plans show the top of the tide gate structure's existing concrete walkway is at about 11 ft NAVD. There are overflow openings in the tide gate structure below the tide gate control building that allow water to flow through the structure without the gates being open. The bottom elevation of the overflow openings is about seven ft NAVD.

Per the City's Comprehensive Sediment Management Program (City of Santa Barbara, 2021), grading and contouring of the lagoon's beach berm is permitted to have a low point of approximately four to six ft NAVD. At the current sea level, waves may naturally build the beach berm until its elevation is approximately eight to nine ft NAVD without grading or following grading.

If the lagoon is closed and the berm top elevation is nine ft NAVD or greater, the lagoon water (from Mission Creek) can rise above nine ft NAVD, flow through the tide gate structure overflow openings, and backfill into Laguna Creek. According to City staff, backfilling currently occurs in these circumstances. Backfilling makes the pumps less effective until the berm breaches, which allows the lagoon to flow to the ocean and lowers the lagoon water level.

Figure 2-4. Existing Tide Gate Structure Section from City's Design Plans



Future sea level rise is expected to increase lagoon berm height during lagoon closure and high tide levels when the lagoon is open. As a result, sea level rise is expected to increase lagoon water levels, Laguna Creek backfilling, and Laguna Creek flood frequency and extent. Sediment management to maintain the permitted berm elevation may reduce backfilling due to lagoon closure; however, with 3.7 ft of sea level rise, regularly-occurring high tides are expected to cause backfilling (i.e., the average daily high tide level or mean higher-high water (MHHW) level reaches the level of the tide gate openings). Additionally, with about 1.5 ft of sea level rise, backfilling could occur during the highest annual tides (i.e., King Tides) and storm surge and high wave conditions. Note that, at present, MHHW is 5.3 ft NAVD, Highest Astronomical Tide is 7.1 ft NAVD, and highest observed tide is 7.5 ft NAVD. Laguna Creek flood frequency and extent are also expected to increase due to increased precipitation intensity with climate change, which is discussed in Section 2.2.2.3. The risk of the tide gate structure being overtopped and damaged by flood waters is also expected to increase. Laguna Creek flood frequency and extent are also expected to increase due to increased precipitation intensity with climate change, which is discussed in Section 2.2.2.3. The risk of the tide gate structure being overtopped and damaged by flood waters is also expected to increase.

2.2.2.2 FEMA Flood Elevation Projections

ESA projected FEMA base flood elevations (BFEs) with future sea level rise to estimate the future flood elevations and extents. The FEMA Flood Insurance Rate Map (FIRM) appears to use approximate or coarse-scale mapping of the 100-year floodplain extents near the major facilities in the study area, El Estero WRC and the Desalination Plant. To refine the existing flooding extents and project a conservatively-high estimate of future 100-year flood elevations in this area, ESA added the sea level rise amounts to the 100-year flood elevations shown in the FEMA FIRM and the Flood Insurance Study (FIS) flood profiles for Laguna Creek. ESA then mapped flood extents for each sea level rise scenario using existing LiDAR topography and the average flood elevation for each site (El Estero WRC – 12.9 ft North American Vertical Datum of 1988 (NAVD88) and the Desalination Plant – 13.4 ft NAVD88).

2.2.2.3 Increased Extreme Precipitation

ESA leveraged precipitation data from the latest release of the Coupled Model Intercomparison Project 6 (CMIP6) general circulation models (GCM) to estimate projected changes in extreme precipitation frequency for the Laguna Creek watershed. Table 2-4 shows the 24-hour precipitation return interval curves for the Laguna Creek watershed past precipitation conditions (i.e., past climate conditions) and future precipitation. Future projected climate conditions are based on a simulation from 2030 to 2100 and therefore labeled as “Year 2030+.” For example, the past precipitation 50-yr rainfall event is projected to become the future precipitation 10-yr rainfall event. Note that ESA estimated that the January 2023 flood event was approximately a 10-year 24-hour rainfall event for the Laguna Creek watershed based on City rain gage data (Santa Barbara City College 2481) and NOAA Atlas 13. As shown in Table 2-4, the past 10-year event is expected to increase in frequency and become a 5-year event in the future.

Table 2-4. Projected 24-hour Rainfall Event Return Interval (and Percent Annual Chance of Occurrence) with Climate Change

Scenario	24-hr Rainfall Event Return Interval (% Annual Chance of Occurrence)				
Past Precipitation	5-year storm (20%)	10-year storm (10%)	50-year storm (2%)	100-year storm (1%)	500-year storm (0.2%)
Future Precipitation with Climate Change (2030 to 2100)	2- to 3-year storm (33%-50%)	5-year storm (20%)	10-year storm (10%)	10- to 20-year storm (5%-10%)	30- to 50-year storm (2%-3%)

2.2.3 Tidal Inundation

Coastal storm flooding data are from the Coastal Inundation Analysis TM for the City's Waterfront Adaptation Plan (Stantec, 2025), which mapped inundation from the average daily high tide (mean higher high water or MHHW). Monthly spring high tides that are higher than MHHW would cause greater inundation than mapped for the tidal inundation hazard. In addition, extreme high ocean water levels are a common phenomenon along the Santa Barbara waterfront and strongly impacted by storm conditions and the occurrences of El Nino (Griggs & Russell, 2012). Coastal storm flooding hazards that account for extreme water levels are discussed in Section 2.2.4.

Significant flooding has occurred along Mission Creek and the Laguna Creek with elevated sea levels due to high tides and/or storm surge (coastal flooding) create a backwater that prevents drainage of the creek systems as discussed in Section 2.2.2.

Tidal inundation exposure from the average daily high tide would impact assets on the surface by inundation, and buried assets (like sewer lines) could be exposed to saltwater intrusion and corrosion as higher sea levels change groundwater depth and salinity. Changes in sea level are shown in Table 2-5 and include elevations for MHHW, mean sea level (MSL), and mean lower low water (MLLW).

Table 2-5. Projected Mean Sea Level and High Tide Changes with Sea Level Rise

SLR Scenario	MLLW	MSL	MHHW
Current (2025)	0	2.8	5.4
0.8 ft SLR (~2050)	0.8	3.6	6.2
1.6 ft SLR (~2065)	1.6	4.4	7.0
2.5 ft SLR (~2075)	2.5	5.3	7.9
3.3 ft SLR (~2085)	3.3	6.1	8.7
4.1 ft SLR (~2095)	4.1	6.9	9.5
4.9 ft SLR (~2100)	4.9	7.7	10.3

Mean Lower Low Water (MLLW): the average of the lowest daily low tides.
Mean Sea Level (MSL): the average daily sea level.
Mean Higher High Water (MHHW): the average of the highest daily high tides.

2.2.4 Coastal Storm Flooding and Waves

Coastal storm flooding data are from the Coastal Inundation Analysis TM for the City's 30-Year Waterfront Adaptation Plan (Stantec, 2025) and include the extent of coastal storm flooding with sea level rise. Coastal storm flooding indicates direct inundation by ocean water levels during storm events and includes areas subject to coastal wave hazards and damage. Coastal wave hazards include potential high-momentum forces from waves and waves running up and over the beach and landward property, as well as resulting damage to infrastructure. Coastal storm flooding and wave hazards indicates areas that may be damaged or disrupted by flowing water but are likely recoverable and would return to service when floodwaters and waves recede. The coastal storm flooding analysis used a hydrodynamic model to simulate coastal storm flooding due to high ocean water levels and waves. The model used a 100-year storm[5] (1% chance of happening in any year and a 1-year storm (100% annual chance) to represent potential storm event flooding.

2.2.5 Shoreline Erosion

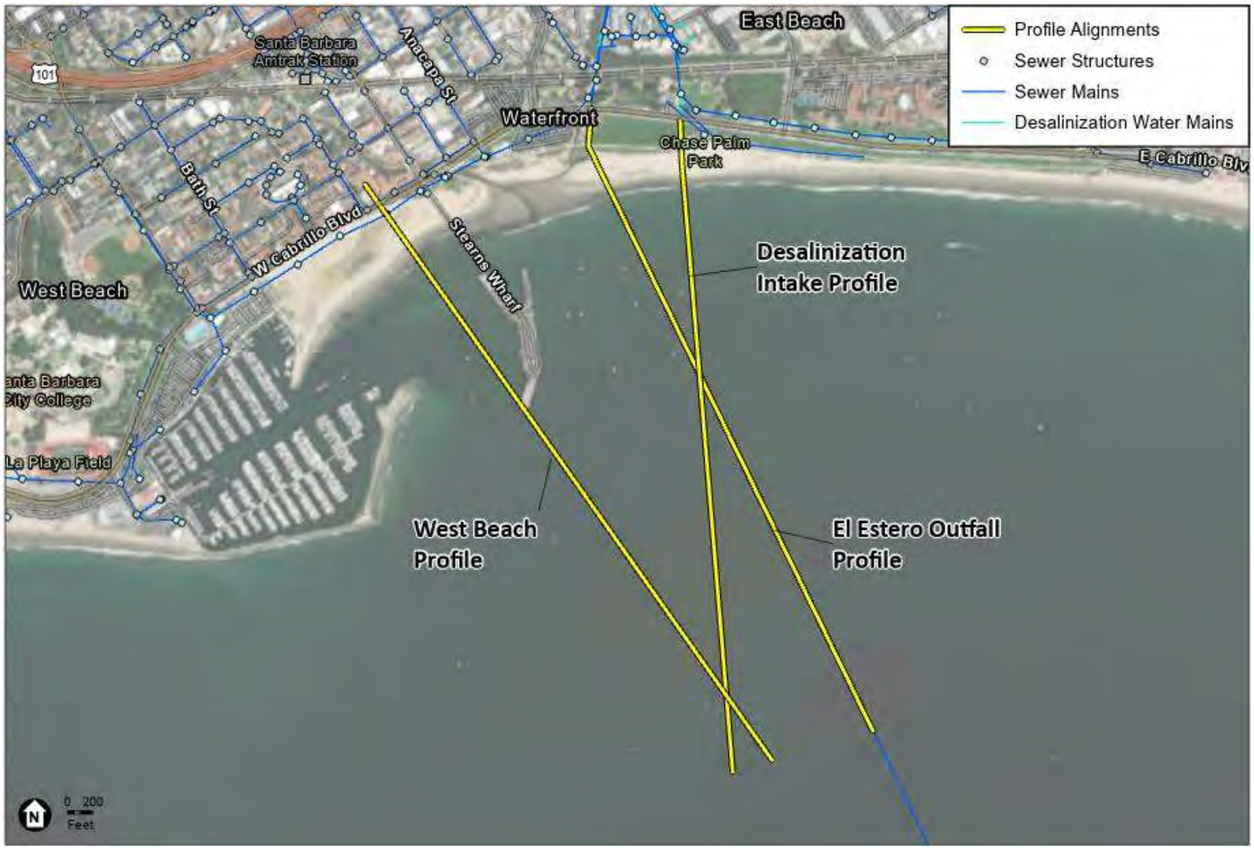
This study uses shoreline erosion hazard data developed for Coastal Inundation Analysis TM for the City's Waterfront Adaptation Plan (Stantec, 2025). In addition, ESA performed a shoreline profile erosion analysis to assess hazards for three pipelines (Figure 2-5):

1. Sewer line beneath West Beach
2. El Estero outfall
3. Desalination Plant intake pipeline

Shore profiles were "cut" from NOAA's 2011 topobathymetric data (NOAA, 2013) at each pipeline. This study applied historic erosion rates using the CoastSat toolbox (Vos, Splinter, Harley, Simmons, & Turner, 2019) and the analysis is documented in the Geomorphic Assessment for the 30-Year Waterfront Adaptation Plan (ESA, 2025b). This study applied the recent shoreline erosion rates along the waterfront from the CoastSat analysis.

[5] The regional 1% annual exceedance probability storm event is reasonable for a large-scale study, but the selected storm may create flooding that is more or less likely (than 1%) at different locations in the City due to local conditions. While this level of detail is sufficient for the vulnerability assessment update, local analysis would be required for engineering decisions.

Figure 2-5. Shoreline Profile Locations for Erosion Analysis



Both long-term erosion and 100-year storm erosion were analyzed to project shore profiles at each profile location. The erosion profiles define two conditions under different sea level rise levels:

- **Long-Term Erosion.** This represents the potential future location and geometry of the beach as an annual average condition, projected from the 2011 shoreline profile. This projection of the long-term erosion rate with sea level rise is the sum of two components: the historic erosion rate and the additional erosion due to sea level rise.

  ESA applied erosion rates from the CoastSat analysis (ESA, 2025b). These erosion rates are based on satellite-derived shoreline data from 2004 to 2024. The recent erosion rate is 3.8 ft/yr along East Beach near the El Estero outfall and the Desalination Plant intake. CoastSat analysis results indicate West Beach has been stable to slightly accretional in response to coastal processes and Harbor dredging practices since 2010 and, therefore, a stable historic shoreline change rate of 0 ft/yr was used for this study. Note that recent dredging practices include dredging the shallow subtidal area between the Harbor channel and the West Beach shoreline, which likely contributes to the stability of the West Beach shoreline since 2010.

  Historic erosion at East Beach is projected into the future by multiplying the historic rate by the time associated with each sea level rise scenario. The additional shoreline retreat due to sea level rise is calculated using the Bruun rule by dividing the sea level rise amount by the profile slope. Profile slopes were based on USGS shoreline profile surveys at East Beach. West Beach erosion is projected due to sea level rise alone because the projections use a stable historic shoreline change rate.

ESA compared calculated shoreline erosion with USGS CoSMoS results. CoSMoS uses a similar approach with additional factors intended to account for longshore transport and other processes (Vitousek, Vos, Splinter, Erikson, & Barnard, 2023). This study projects more erosion compared to the most recent CoSMoS shoreline projections with sea level rise, which is due to the difference in modeling methodology and starting shoreline position.

The potential erosion projections do not consider the effect of coastal armoring or nature-based solutions in reducing erosion.

- **100-Year Storm Erosion.** This type of erosion hazard zone adds the erosion caused by a 100-year storm event to the long-term zone described above. The potential erosion caused by the impact from a large storm event (i.e., 100-year) is based on the CoSMoS 2023 model uncertainty and storm erosion buffers specific to West Beach and East Beach.

Asset exposure was only evaluated in the near-shore zone. Shoreline profiles near each of the assets were extracted from merged topography and bathymetry data circa 2011 (NOAA, 2013). ESA projected eroded profiles by applying a horizontal shift based on the calculated erosion amount (long-term and 100-year storm) and a vertical shift by the sea level rise amount.

2.2.6 Bluff Erosion

Since bluff erosion is projected to occur outside of the focused study area and was identified as a lower likelihood hazard for major water and wastewater infrastructure, the bluff erosion projections from the City's 2021 SLR Adaptation Plan were used in this report.

2.2.7 Groundwater Rise

Groundwater hazard data are from the USGS CoSMoS 3.0 (O'Neill, et al., 2018) and include the extent of these issues with sea level rise. The groundwater data from CoSMoS maps the depth to groundwater, projected rise, and groundwater emergence. The CoSMoS modeling effort is a regional approach and does not include available localized data to inform more site-specific analysis. A hydraulic conductivity of one meter per day was chosen to be appropriate for this analysis based on a review of the USGS model report for groundwater basins in Santa Barbara (Paulinski, Nishikawa, Cromwell, Boyce, & Stanko, 2018).

Note that groundwater levels are estimated based on groundwater modeling from CoSMoS. For example, borehole logs from several borings completed at El Estero WRC during infiltration testing in 2016 indicated groundwater levels ranging between eight and 12 ft below ground surface, while CoSMoS estimates current levels to be between 3.3 to 6.6 ft in the area. This limited comparison indicates that groundwater level rise projections may be overestimated; however, a more substantial groundwater level data analysis is required to make this assertion. Also, shallow groundwater levels can vary between wet and dry seasons, wet and dry years, and with tidal changes. Therefore, shallow groundwater data collection is recommended to increase accuracy of hazard modeling and vulnerabilities assessment. Future monitoring and analysis will inform the potential impacts of climate change, especially groundwater infiltration into the City's sewer system, corrosion of buried infrastructure, and better define adaptation efforts and implementation timing. Establishment of a monitoring program for depth and salinity of shallow groundwater should be established as soon as possible.

2.2.8 Wildfire

Santa Barbara's terrain, vegetation, climate, and wildland-urban interface present suitable conditions for wildfires to occur. Increasing temperatures and dry conditions, extended droughts, and irregular precipitation may contribute to risk. Wildfires are a significant hazard for the built environment, public health, and biodiversity. They also increase air quality concern, as large amounts of carbon dioxide, black carbon, and ozone precursors are released into the atmosphere.

Fire hazard areas from the City were used to map fire hazards within the City limits. In addition, Cal-Adapt provides the Keetch-Byram Drought Index (KBDI) to represent a simplified proxy for the favorability of wildfire occurrence, though it is not a fire predictor. KDBI provides values to estimate dry soils and vegetative detritus as it relates to wildfire favorability, as follows:

- 0–200: Soil and fuel moisture are high, with low wildfire risk.
- 200–400: Soil and fuels start to dry; average wildfire risk.
- 400–600: Onset of drought with moderate to serious wildfire risk.
- 600–800: Severe drought, extreme wildfire risk, and increased occurrence.

In Santa Barbara, the historical average where KDBI was greater than 600 has been nine days per year. This is projected to increase to 25 days per year by mid-century and 59 days per year by end-century indicating increased risk of wildfires.

2.2.9 Drought

Climate models differ on average annual precipitation projections but coincide on other hydrologic metrics relevant to water resources management (Persad, 2020). This includes:

- Snowpack declines.
- Increased fraction of precipitation on extreme rainfall days.
- Shorter, sharper rainy season.
- Increased evapotranspiration.
- Higher frequency of extremely wet and extremely dry years.
- Higher incidence of extreme dry year followed by an extreme wet year or vice versa.

These climate changes affect the availability, volume, and quality of California water supplies.

The Santa Barbara County Multi-Jurisdictional Hazard Mitigation Plan (MJHMP) (County of Santa Barbara, 2023) and U.C. Berkeley's Cal-Adapt tool (Cal-Adapt, 2018) provide projections and visualizations for relevant drought factors. Droughts are a regular occurrence for Southern California, and drought events are expected to continue to occur and increase in terms of intensity and length. Droughts are exacerbated by extreme heat conditions and water shortages due to lower levels of precipitation over a multi-year period.

The intensity of rainfall in Santa Barbara is expected to increase when precipitation events occur. This means increased rainfall and a wet season over a shorter period. Historic annual precipitation in Santa Barbara averaged 20.3 inches (1961-1990). This average is expected to increase to 21.8 in by mid-century and 22.5 in by end-century. At the high end of the range in projections, annual precipitation could increase up to 28.3 in by mid-century and 32 in by end-century (Cal-Adapt, 2018).

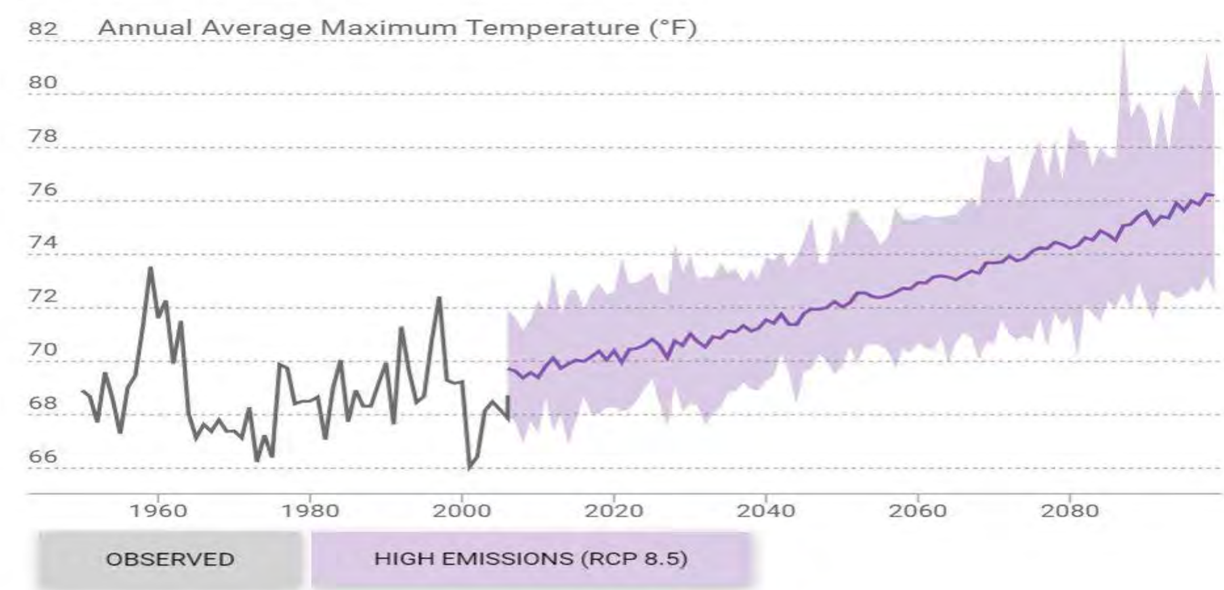
2.2.10 Extreme Heat

The Santa Barbara County MJHMP and U.C. Berkeley's Cal-Adapt tool also provide projections and visualizations for extreme heat conditions. Average temperatures are projected to rise significantly in the 21st century, and cities in Southern California are expected to experience hotter and longer heat waves. On average, coastal communities see lower temperatures compared to inland counterparts and may have less risk of extreme heat. However, they may also be less acclimatized to extreme temperatures when they occur (County of Santa Barbara, 2023).

In the City, the historical (1961-1990) average of daily maximum temperatures is 68.5° Fahrenheit (F). This average is projected to rise to 72.1° F by mid-century and to 74.8° F by end-century, as illustrated in Figure 2-4 (Cal-Adapt, 2018).

Extreme heat is also expected to increase in intensity, frequency, and duration. At the Santa Barbara waterfront, extreme heat days are defined as days in a year when daily high temperatures rise above a threshold temperature of 88.8 °F. Historically, Santa Barbara has experienced an average of three extreme heat days per year. This average is projected to increase to eight days by mid-century and 11 days by end-century (Cal-Adapt, 2018). Sequential extreme heat days can lead to increased daily minimum or nighttime temperatures.

Figure 2-6. Annual Average Maximum Temperatures (Average of Daily Highs)



Note: Cal-Adapt relies on data derived from different plausible future conditions that are projected using representative concentration pathways (RCPs). RCP 8.5 is a no-mitigation scenario where global GHG emissions continue to rise throughout the 21st century (Cal-Adapt, 2018).

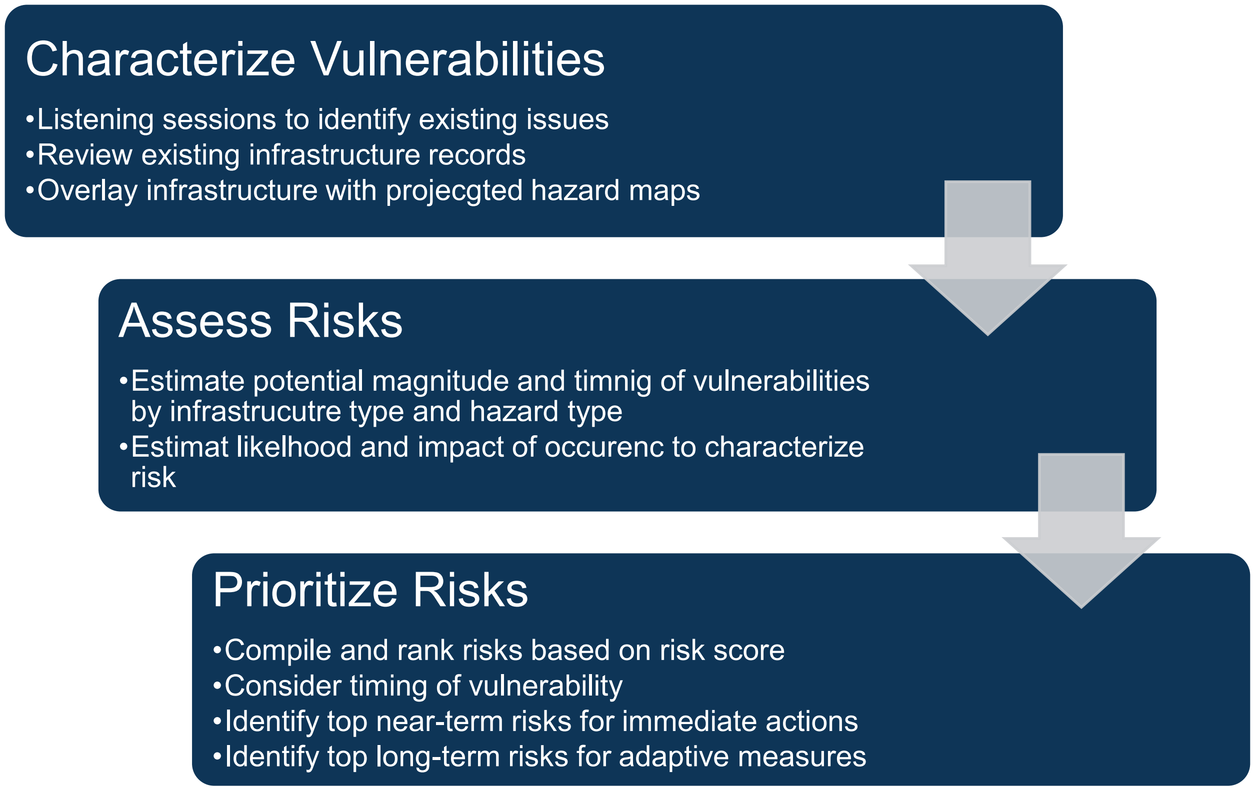
3.0 Systemwide Vulnerabilities and Impacts

The hazards identified in the previous section were applied to the City's wastewater, water, and recycled water systems to conduct a vulnerability assessment. The vulnerability assessment presents the highest risk vulnerabilities to the City's critical infrastructure and informs adaptation options. Vulnerabilities pertaining to several types of assets are discussed in this section while more detailed assessments to specific assets are discussed in Sections 4 through 8.

3.1 Vulnerability & Risk Assessment Overview

Assessing vulnerability and risk are fundamental first steps towards formulating a resilient climate adaptation plan. This assessment offers a structured approach to establishing a consistent understanding of climate change impacts on the City's water and wastewater infrastructure with a primary focus on assets located within the focus area. The primary objective of this assessment is to identify the infrastructure that is most threatened by climate change. The types of vulnerabilities, impacts of the vulnerabilities, and projected timing of the vulnerabilities were used to identify priorities based on the risk assessment. Figure 3-1 illustrates the vulnerability and risk assessment approach adopted as part of this project.

Figure 3-1. Vulnerability and Risk Assessment Approach



WSC analyzed the hazards maps for different sea level rise scenarios overlaid with the City's existing water and wastewater systems in the focused study area to identify system assets impacted by specific hazards. These figures, referred to as vulnerability maps, are included under specific infrastructure discussions in the following chapters and are used as the basis for the vulnerability assessment. In addition, City staff provided information on their concerns regarding specific aspects of water and wastewater systems through various discussions. The magnitude of these concerns, considering likelihood and impact, is addressed in the risk assessment provided within each specific section of Sections 4 through 8.

3.1.1 Risk Assessment Methodology

A risk assessment matrix was employed to prioritize the vulnerability to climate change of various coastal water and wastewater system components. A risk matrix is a tool used to assess the level of risk posed by an undesirable event by considering both the likelihood of the event taking place and the severity of the event's consequences.

The undesirable events examined include:

- Sanitary sewer overflows due to infiltration and inflow of flood waters or rising groundwater into sewer pipes and manholes.
- Exceedance of wastewater treatment and outfall capacity due to wet weather flows, including inflow and infiltration.
- Damage to mechanical and electrical components of water and wastewater infrastructure due to contact with flood waters or rising groundwater.

- Loss of access due to flooding of transportation routes.
- Damage to pipelines and structures near the shore due to loss of cover and bedding support from sea level rise and wave action.
- Events stemming from pipeline damage (sewage spills, pressure loss, potable water contamination) due to changes in saturated soil conditions post-flood or with groundwater level rise.
- Loss of structural stability of buildings and tanks on treatment plant sites due to changes in soil conditions post-flood or with groundwater level rise.
- Reduced useful life of the water distribution system due to corrosion from contact with rising groundwater.
- Loss of service due to power outages caused by floods.

The likelihood and severity of the above listed events were assessed for each individual infrastructure category and hazard considered. For example, pipe fractures due to changes in soil conditions may have a different likelihood of occurring in wastewater collection pipes than in water distribution pipes depending on pipe materials, pipe sizes, and depth of cover. In addition, changes in soil conditions may be more likely to occur after a severe flood than after a gradual rise in groundwater levels.

The criteria used in assessing the likelihood and consequences of undesirable events are shown in Table 3-1.

Table 3-1. Risk Assessment Criteria

		Description
LIKELIHOOD	Almost Certain (5 points)	Undesirable event is expected to occur (~ 95% probability)
	Likely / Probable (4 points)	Undesirable event is likely to occur (~75% probability)
	Possible (3 points)	Undesirable event is not certain to happen, but additional factors may result in an incident (~50% probability)
	Unlikely (2 points)	A rare combination of factors would be required for an incident to result (~25% probability)
	Rare (1 point)	Little or no chance of occurrence (<5% probability)
CONSEQUENCES	Catastrophic (5 points)	• Risk to public health from contact with sewage or from drinking contaminated potable water • Damage to equipment which disrupts service indefinitely • No longer able to ensure staff safety
	Major (4 points)	• Serious damage which disrupts service for longer than one day • Major regulatory non-compliance which does not pose an immediate risk to public health • Need for resources not currently provisioned to implement solution or to keep staff safe
	Moderate (3 points)	• Damage to equipment which disrupts normal operation or causes brief service interruptions but does not result in compliance violations • Need to utilize contingency resources to implement solution or to ensure staff safety
	Minor (2 points)	• Damage to equipment requiring repairs and/or operational overtime to address. No effect on service reliability, regulatory compliance, or staff safety.
	Insignificant (1 point)	• Routine operations can handle the concern. Consequences are not expected.

Note: Likelihood was assessed considering the likelihood of occurrence during the near-term (within 25 years) and long-term (50+ years).

Risk was assessed according to the following formula:

$$Risk = Likelihood\ x\ Consequences$$

Risk outcomes were categorized in the following manner:

- Low risk: 1 to 8 points
- Medium risk: 9 to 15 points
- High risk: 16 to 25 points

3.2 Systemwide Vulnerabilities

This section provides an overview of systemwide vulnerabilities from the hazards presented in Section 2. Vulnerabilities presented include:

- Stormwater Flooding.
- Coastal Flooding (including coastal storm flooding, tidal inundation, and storm waves).
- Groundwater rise.

3.2.1 Stormwater Flooding

The extent of flooding from historical FEMA 100-year storm overlying water and wastewater infrastructure are shown in Figure 3-2. The existing flood extent overlaps roughly 41 miles of sewer pipe, 27 miles of potable water pipe, and seven miles of recycled water pipe as well as 537 sewer manholes, 2,554 sewer laterals (service connections), and 2,699 potable water connections.

In the FEMA flood zone, the majority of the Desalination Plant is flooded. The majority of the El Estero WRC infrastructure is not flooded; however, the entrances are flooded, prohibiting ingress and egress. Future flood extents are discussed below.


Water & Wastewater Climate Adaptation Project
Figure 3-2. FEMA 100-yr Floodplain Map, with City Infrastructure
Legend
El Estero WRC
Desalination Plant
Pump Station & Chemical Area
Sewer Main
West Beach Sewer
Water Main
Recycled Water Main
Desalination Intake
FEMA 100-yr Floodplain
Notes
N
0
0.5
1
Miles
0
2,000
4,000
US Feet
WSC

3.2.2 Coastal Flooding

City water and wastewater infrastructure overlaid with projected coastal storm flooding, tidal inundation, and storm waves for existing conditions through 4.9 ft of sea level rise (~2100) are provided in Figure 3-3 through Figure 3-9. (All the vulnerability figures presented in this chapter are also compiled in Appendix A). Of the coastal hazards, coastal flooding impacts the largest amounts of coastal infrastructure, as summarized in Table 3-2 and Table 3-3 for the 1-year and 100-year coastal storms, respectively.

Table 3-2. Coastal Infrastructure Impacted by 1-Year Coastal Storm Flooding under SLR Scenarios

SLR Scenario	Sewer Pipe (miles)	Sewer Manholes (number)	Sewer Connections (number)	Potable Water Pipe (miles)	Potable Connections (number)	Recycled Water Pipe (miles)
Current (2025)	0.6	7	20	0.6	28	0.6
0.8 ft (~2050)	2.4	20	53	2.9	62	2.8
1.6 ft (~2065)	3.4	44	93	3.9	90	3.3
2.5 ft (~2075)	4.0	55	113	4.7	122	3.5
3.3 ft (~2085)	6.0	79	205	6.9	177	3.8
4.1 ft (~2095)	9.1	127	432	10.0	308	3.9

Table 3-3. Coastal Infrastructure Impacted by 100-Year Coastal Storm Flooding under SLR Scenarios

SLR Scenario	Sewer Pipe (miles)	Sewer Manholes (number)	Sewer Connections (number)	Potable Water Pipe (miles)	Potable Connections (number)	Recycled Water Pipe (miles)
Current (2025)	1.7	16	39	2.6	49	2.7
0.8 ft (~2050)	4.3	44	101	4.0	96	3.4
1.6 ft (~2065)	4.6	64	120	4.9	137	3.6
2.5 ft (~2075)	6.0	81	214	6.8	187	3.8
3.3 ft (~2085)	10.8	148	572	11.6	449	4.7
4.1 ft (~2095)	13.2	177	809	14.0	663	4.9

As shown in the figures, during the 100-year coastal storm and under existing conditions, the Leadbetter, West, and East beaches and Cabrillo Boulevard from Stearns Wharf to Andree Clark Bird Refuge experience flooding. With 0.8 ft of sea level rise (~2050), flooding of Cabrillo Boulevard is projected with a 1-year coastal storm. Coastal storm flooding extends to the railroad under 1.6 ft of sea level rise (~2065) and extends to US-101 under 2.5 ft of sea level rise (~2075). By 3.3 ft of sea level rise (~2085), the 100-year coastal storm is projected to flood portions of downtown north of US 101.

Under existing conditions, City beaches and inundated portions of Cabrillo Blvd are susceptible to coastal storm waves. With 0.8 ft of sea level rise (~2050) and greater, coastal storm wave hazards extend inland into developed areas. Under existing conditions, developed areas are not tidally inundated. Buildings and roadways in the downtown area are at risk of tidal inundation with greater than 3.3 ft of sea level rise (~2085).

3.2.3 Groundwater Rise

City water and wastewater infrastructure overlaid with shallow groundwater projections from existing conditions through 4.9 ft of sea level rise (~2100) are provided in Figure 3-10 through Figure 3-23. All the vulnerability figures presented in this chapter are also compiled in Appendix A.

Buried infrastructure either fully or partially submerged by shallow groundwater in the coastal area is summarized in Table 3-4. According to CoSMoS data, under existing conditions, a large portion of the downtown area has shallow groundwater (3.3 to 6.6 ft below ground). Some areas, including portions of East Cabrillo Boulevard and the area just east of El Estero WRC, have very shallow groundwater (0 to 3.3 ft below ground), and there are some small areas where groundwater may be emergent.

The depth to groundwater decreases with sea level rise, becoming very shallow in much of downtown with 2.5 ft of sea level rise (~2075) and greater. With 4.1 ft of sea level rise (~2095), larger portions of downtown may experience emergent groundwater. As discussed above, portions of the downtown area become increasingly at risk of tidal inundation with more than 3.3 ft of sea level rise (~2085).

Near El Estero WRC and the Desalination Plant, the depth to groundwater remains shallow (3.3 to 6.6 ft below ground) until between 4.1 and 4.9 ft of sea level rise (~2100), when there are portions of El Estero WRC and the Desalination Plant that are very shallow (0 to 3.3 ft below ground). Between 4.9 and 6.6 ft of sea level rise, the depth to groundwater becomes very shallow and there is a portion of El Estero WRC where groundwater may be emergent. Shallow groundwater may contribute to higher amounts of infiltration into City pipelines with defects from age. Additionally, rising groundwater levels may move fine material used in pipeline bedding into the pipeline, causing more rapid degradation.

Table 3-4. Coastal Infrastructure Impacted by Groundwater Rise

SLR Scenario	Sewer Pipe (miles)	Potable Water Pipe (miles)	Recycled Water Pipe (miles)
Current (2025)	18.7	9.8	2.6
0.8 ft (~2050)	19.6	12.2	3.0
1.6 ft (~2065)	20.2	12.8	3.0
2.5 ft (~2075)	21.2	13.6	3.0
3.3 ft (~2085)	22.0	14.0	3.0
4.1 ft (~2095)	22.5	14.0	3.0
4.9 ft (~2100)	22.6	15.6	3.0

Note: Values are for pipes estimated to be fully or partially submerged by shallow groundwater. Note that, as discussed in Section 2.2.7, groundwater depths were estimated using CoSMoS, which may be estimating groundwater levels shallower than current observations. As a result, shallow groundwater monitoring is recommended to update groundwater depth estimates.

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Figure 3-3. Coastal Hazards, Existing

Legend

- El Estero WRC
- Desalination Plant
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

SEAL OF THE CITY OF SANTA BARBARA CALIFORNIA

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Figure 3-4. Coastal Hazards, 0.8 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-5. Coastal Hazards, 1.6 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-6. Coastal Hazards, 2.5 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-7. Coastal Hazards, 3.3 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)
- Tidal Inundation

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

SEAL OF THE CITY OF SANTA BARBARA CALIFORNIA

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-8. Coastal Hazards, 4.1 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-9. Coastal Hazards, 4.9 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

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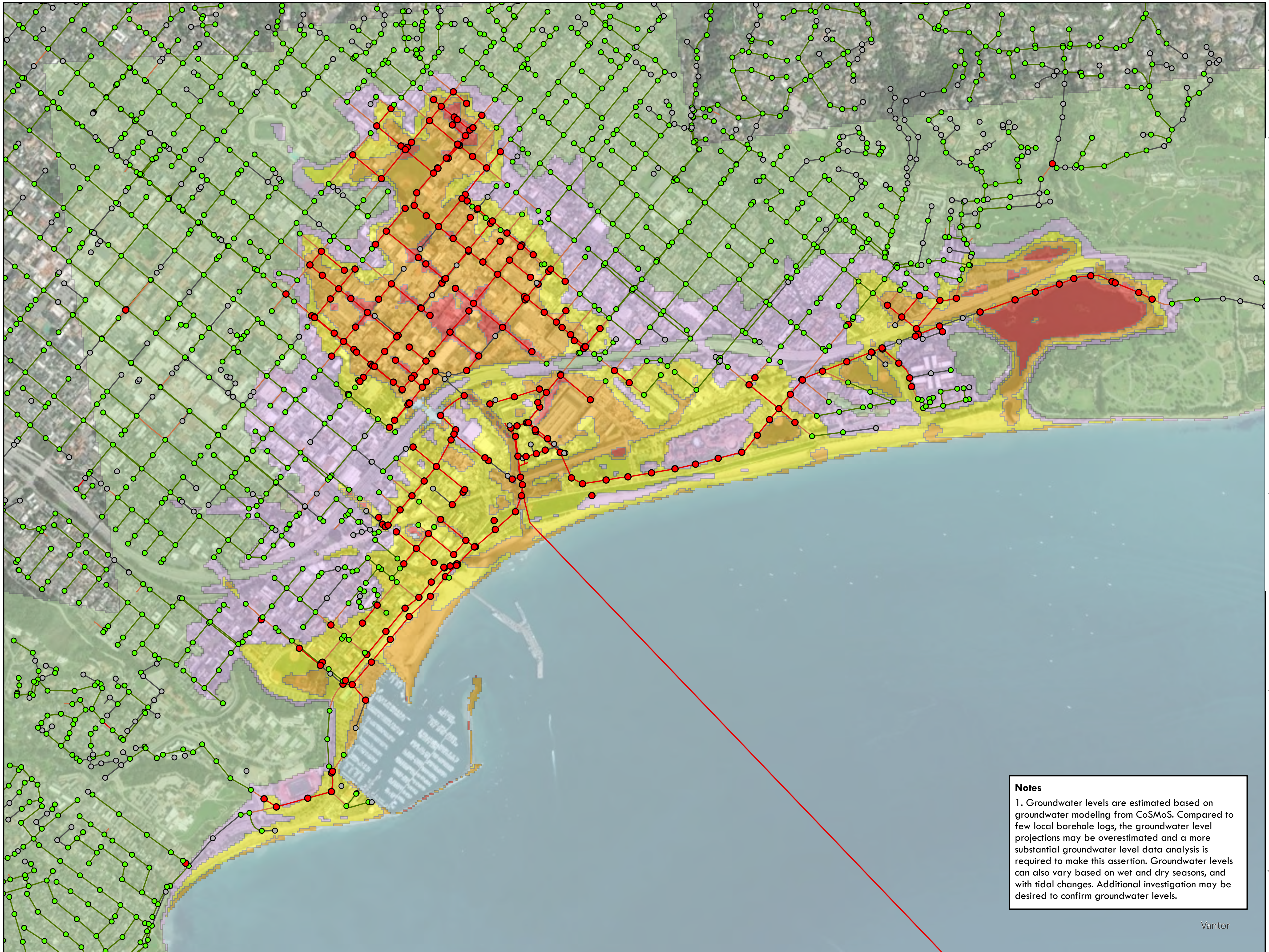
Figure 3-10. Groundwater Levels with Wastewater Infrastructure, Existing



Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

Legend

Manhole Status
- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status
- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface
- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

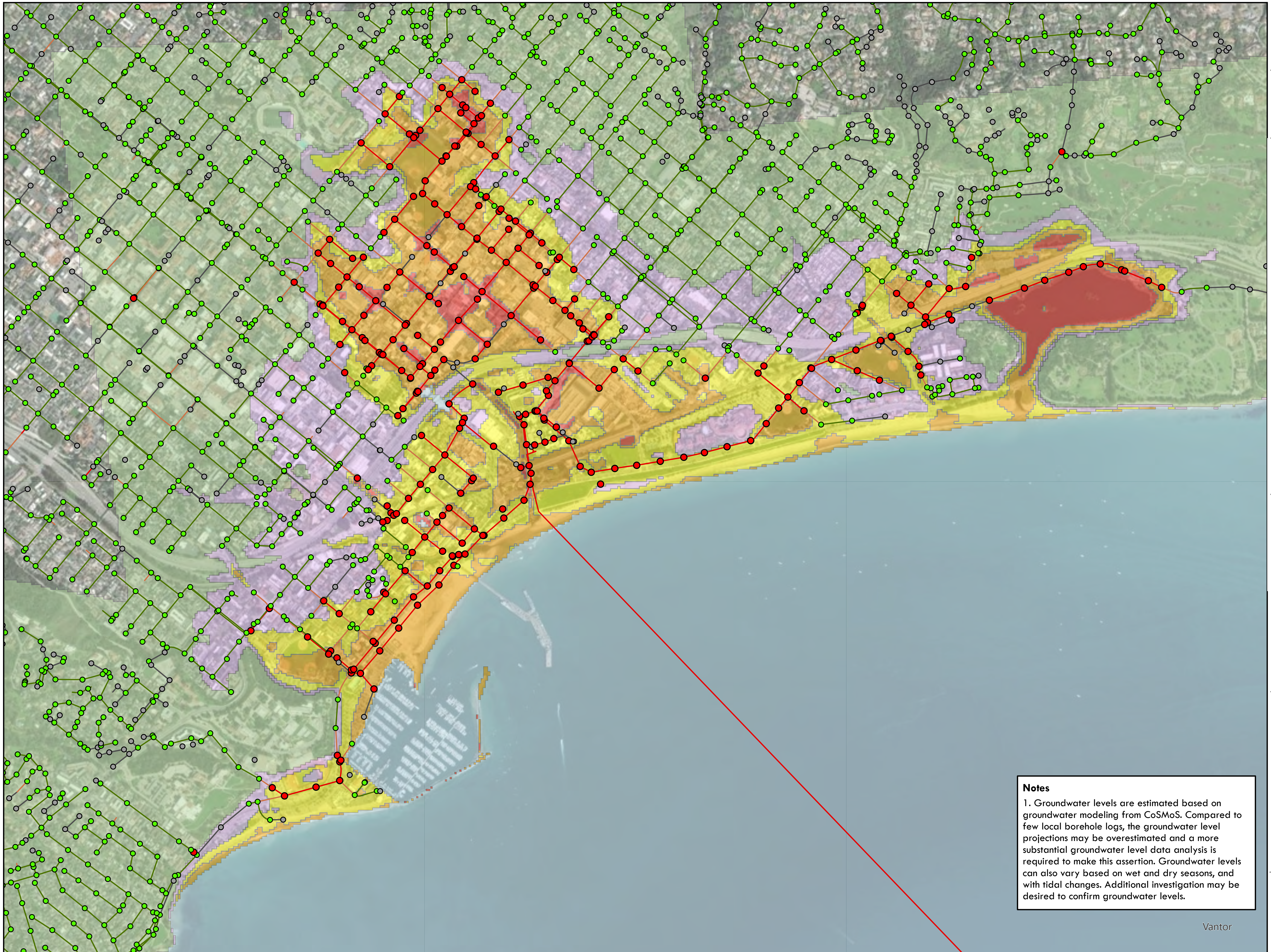
0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-11. Groundwater Levels with Wastewater Infrastructure, 0.8 ft SLR



Legend

Manhole Status

- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status

- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

WSC

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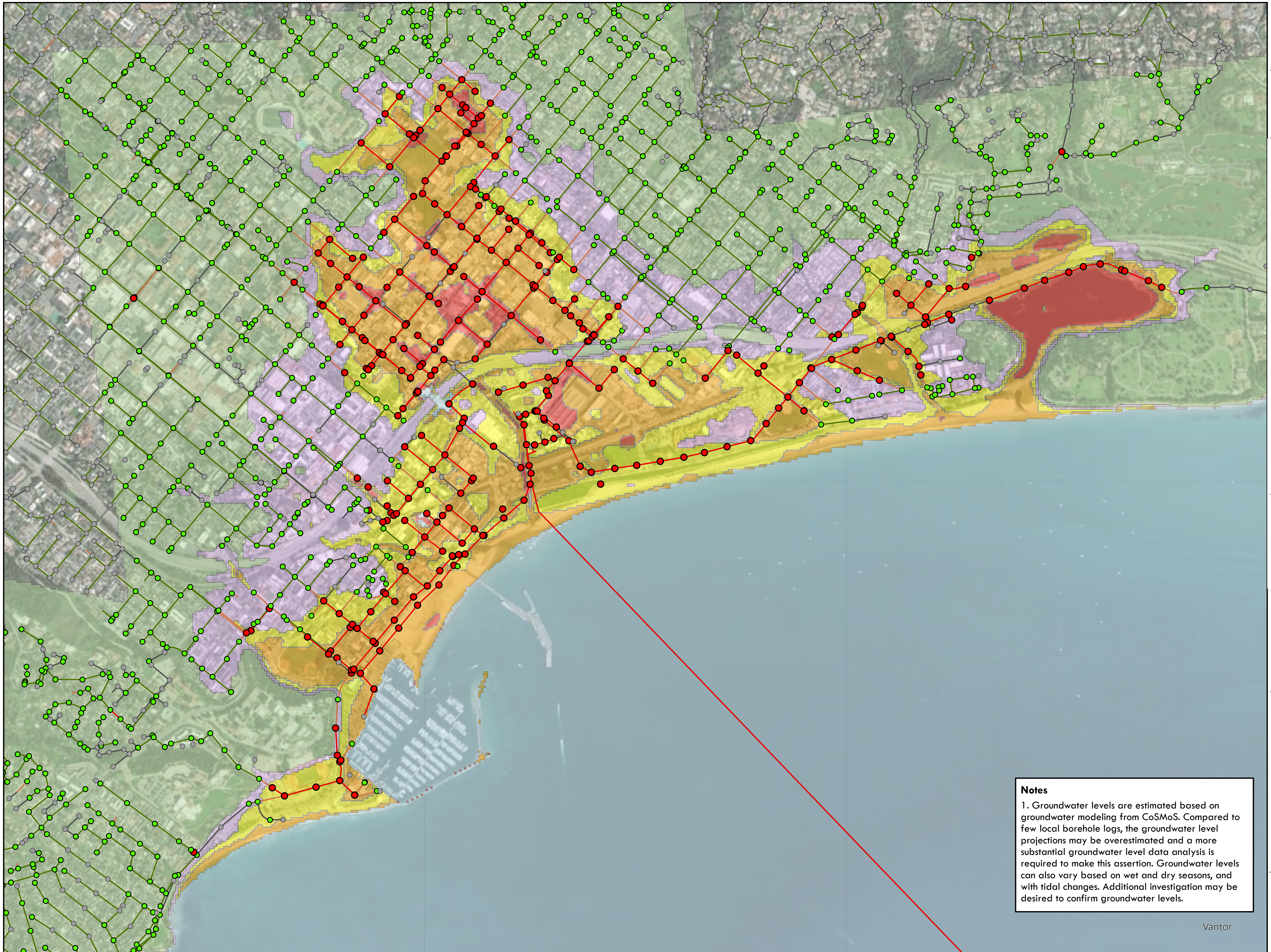
Figure 3-12. Groundwater Levels with Wastewater Infrastructure, 1.6 ft SLR



Legend

Manhole Status

- Submerged
- Not Submerged
- Unknown

Sewer Main Status

- Not Submerged
- Partially Submerged
- Submerged
- Unknown

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

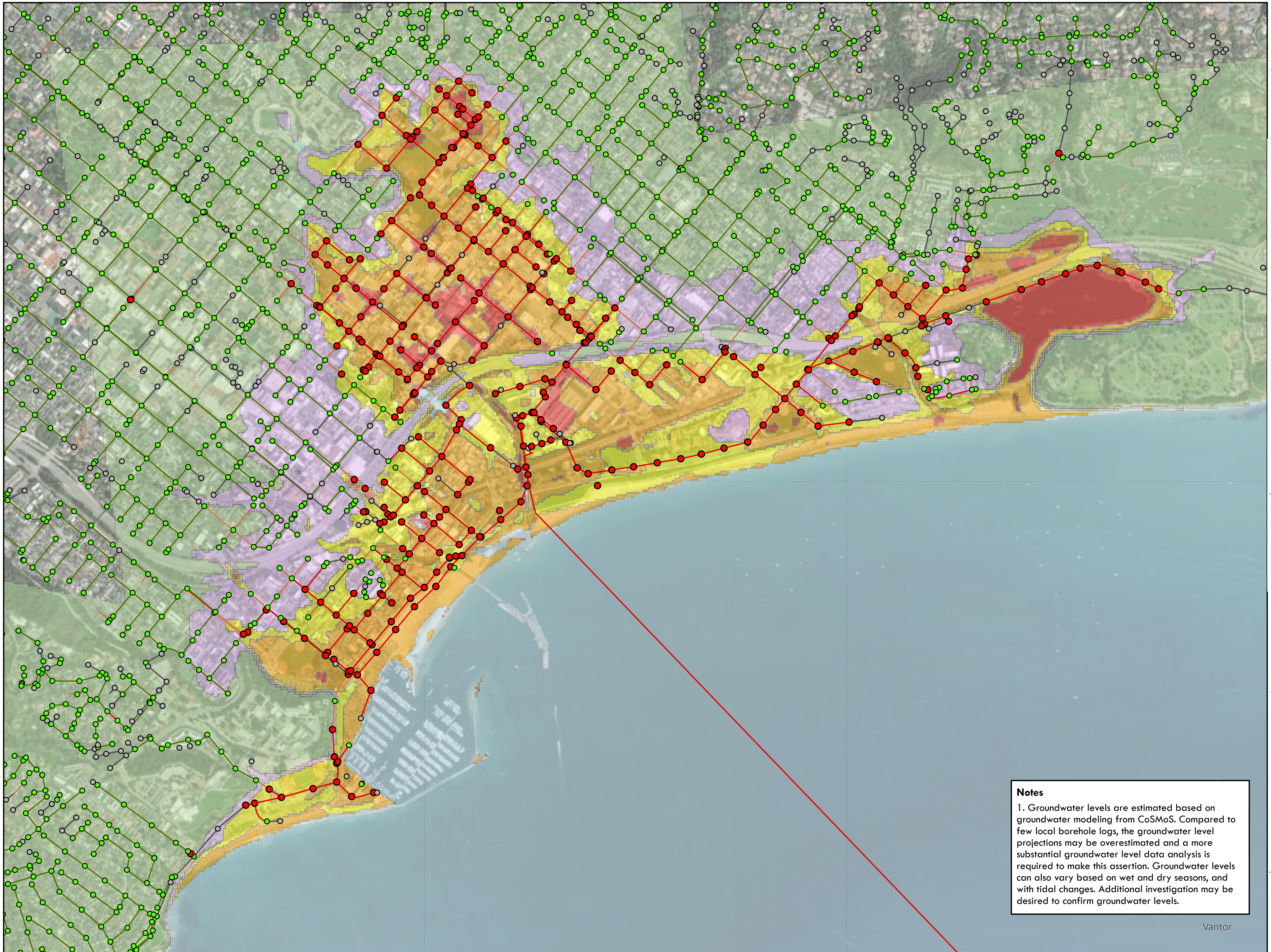
0 0.2 0.4 Miles

0 1,000 2,000 US Feet

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

WSC



Water & Wastewater Climate Adaptation Project

Figure 3-13. Groundwater Levels with Wastewater Infrastructure, 2.5 ft SLR

Legend

Manhole Status
- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status
- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface
- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

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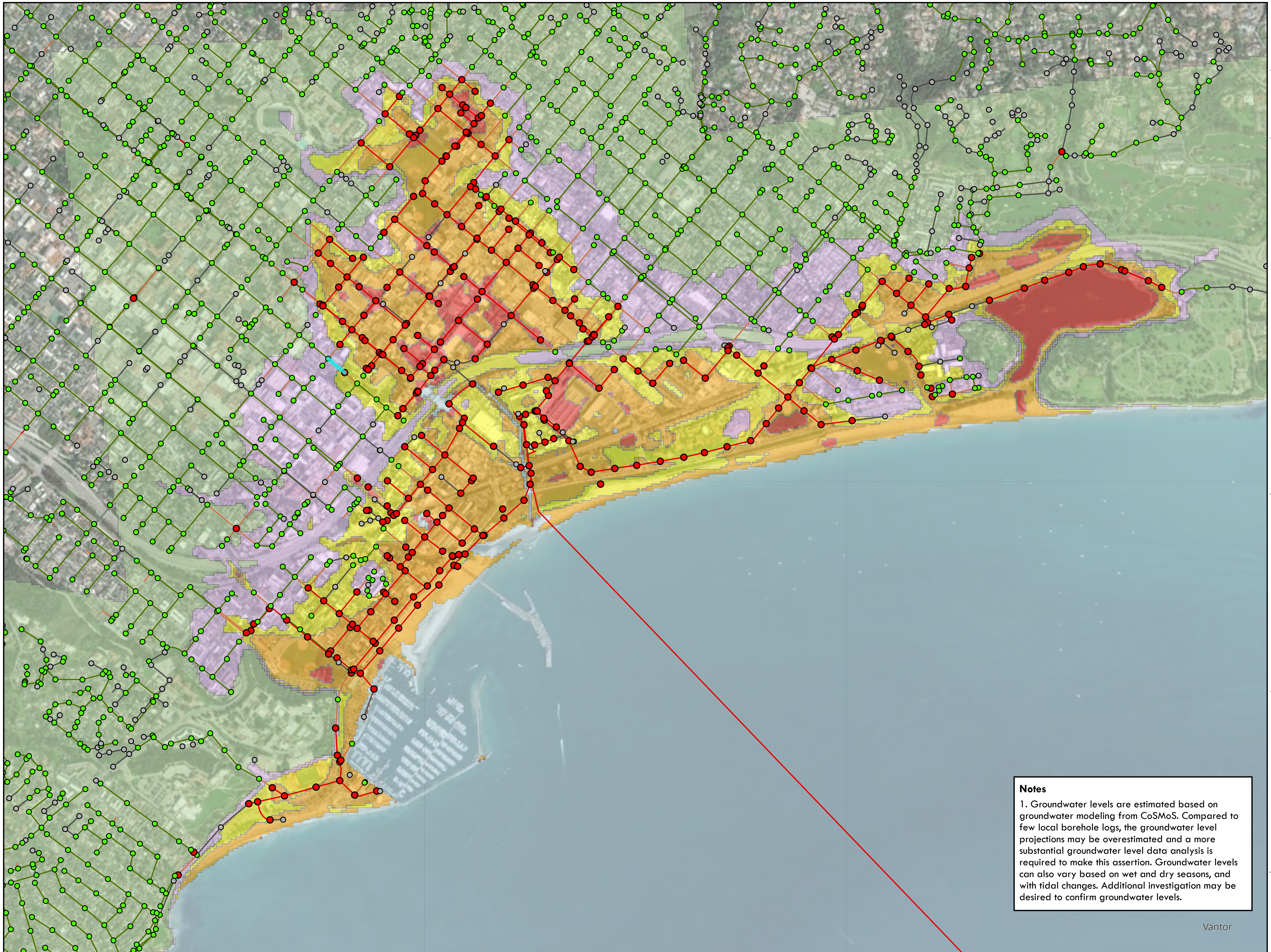
Figure 3-14. Groundwater Levels with Wastewater Infrastructure, 3.3 ft SLR



Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

Legend

Manhole Status

- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status

- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface

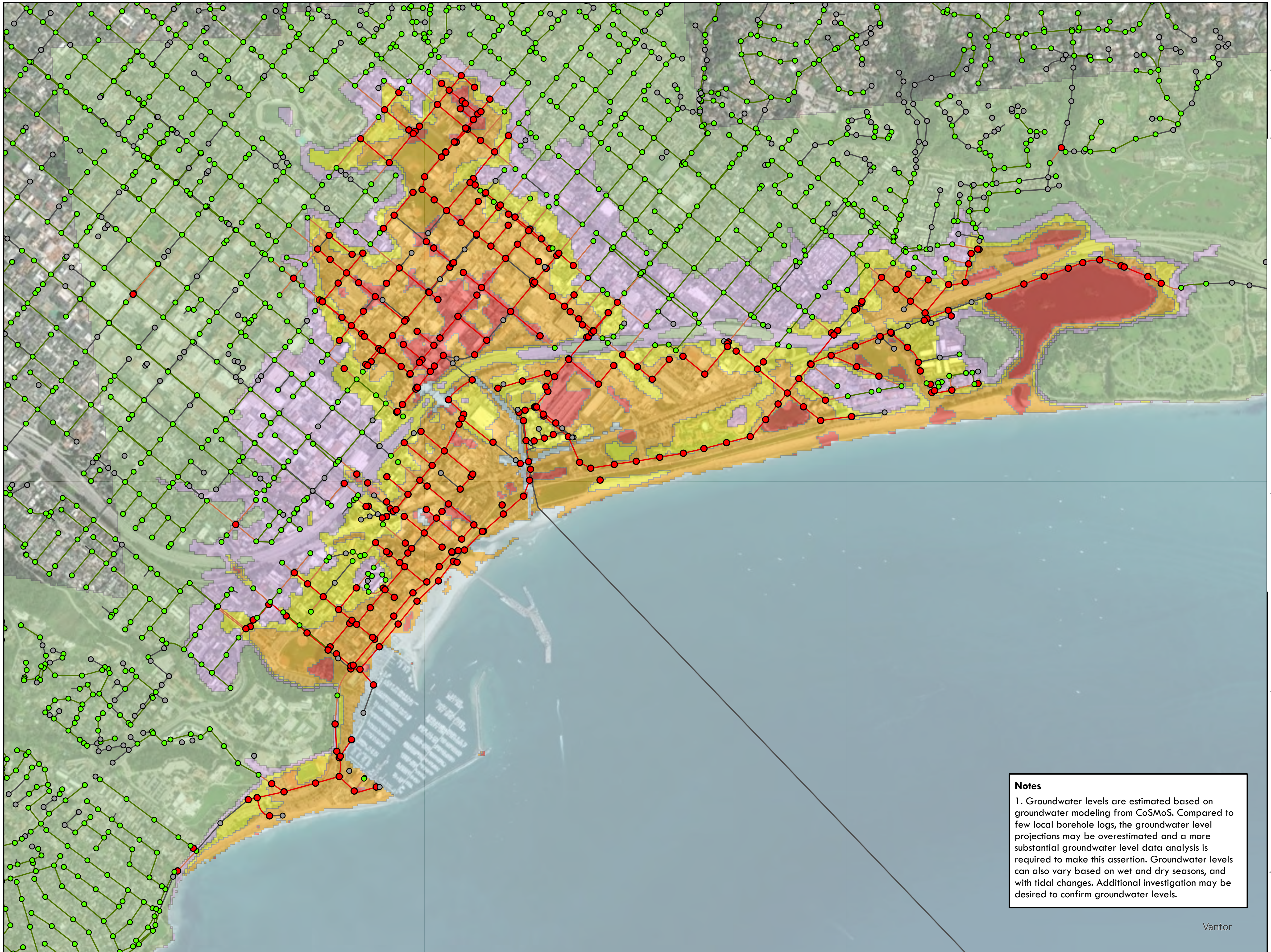
- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC



Water & Wastewater Climate Adaptation Project

Figure 3-15. Groundwater Levels with Wastewater Infrastructure, 4.1 ft SLR

Legend

Manhole Status
- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status
- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface
- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

WSC

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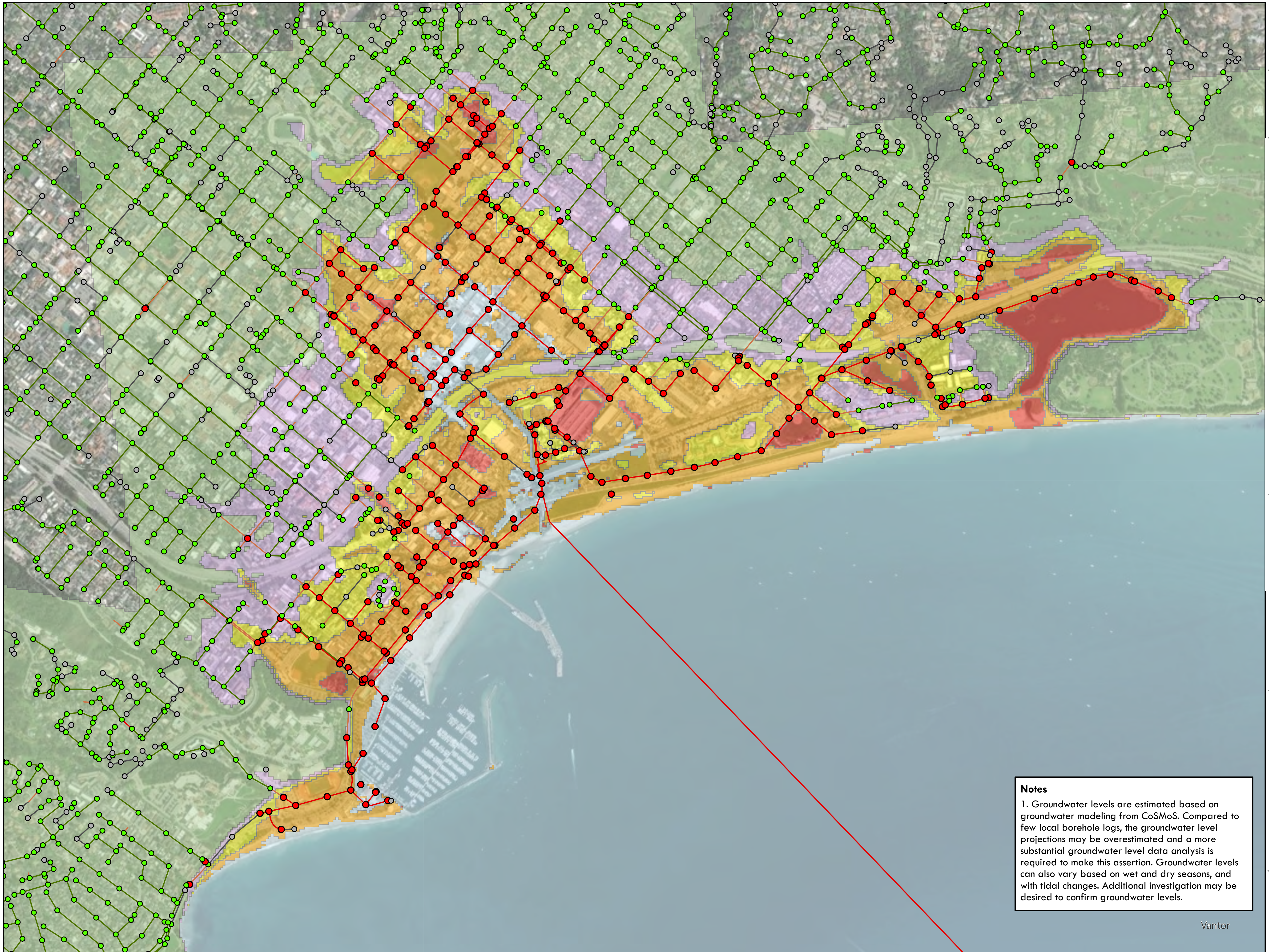
Figure 3-16. Groundwater Levels with Wastewater Infrastructure, 4.9 ft SLR



Legend

Manhole Status

- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status

- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

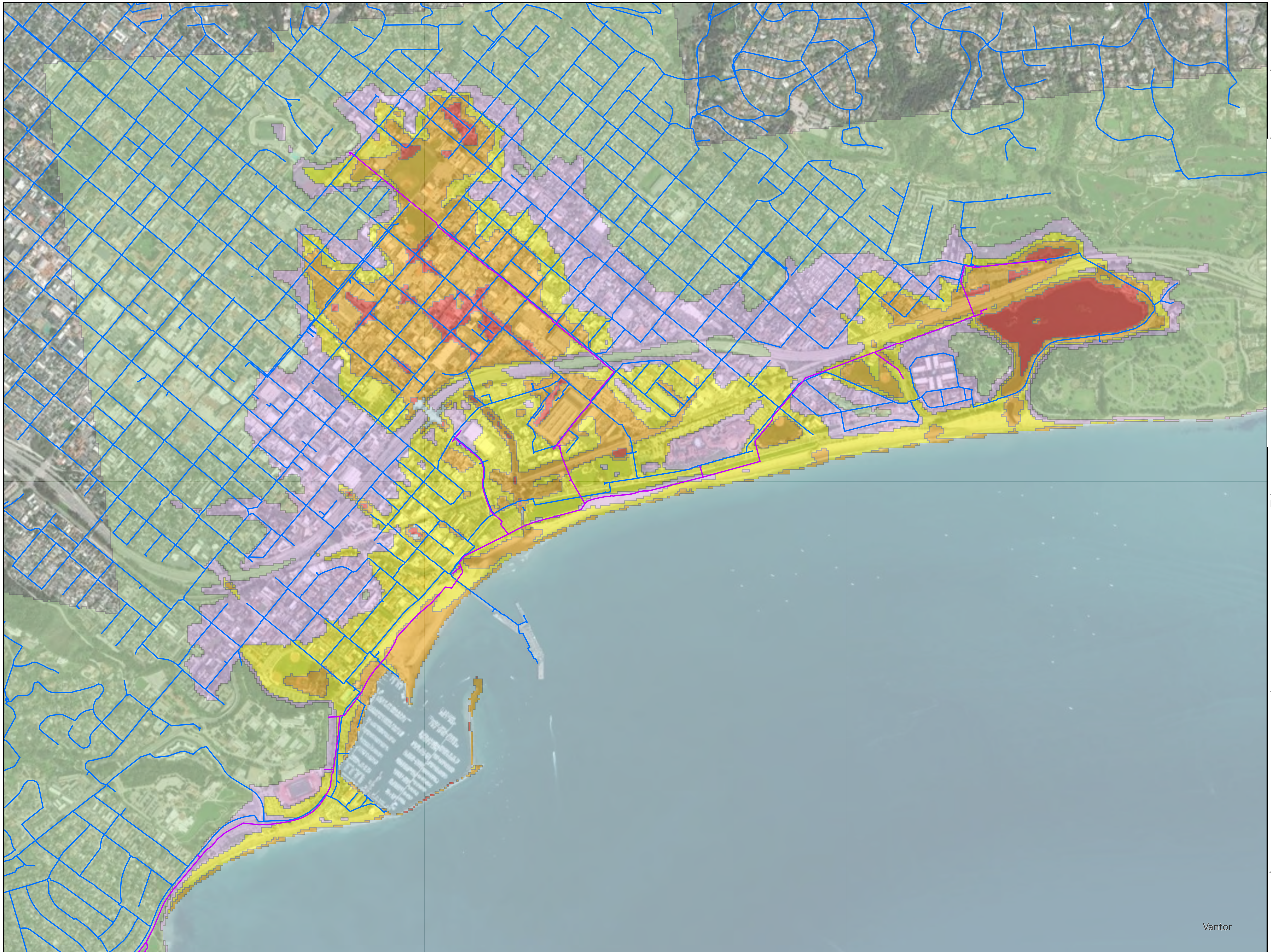
0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-17. Groundwater Levels with Water and Recycled Water Infrastructure, Existing



Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

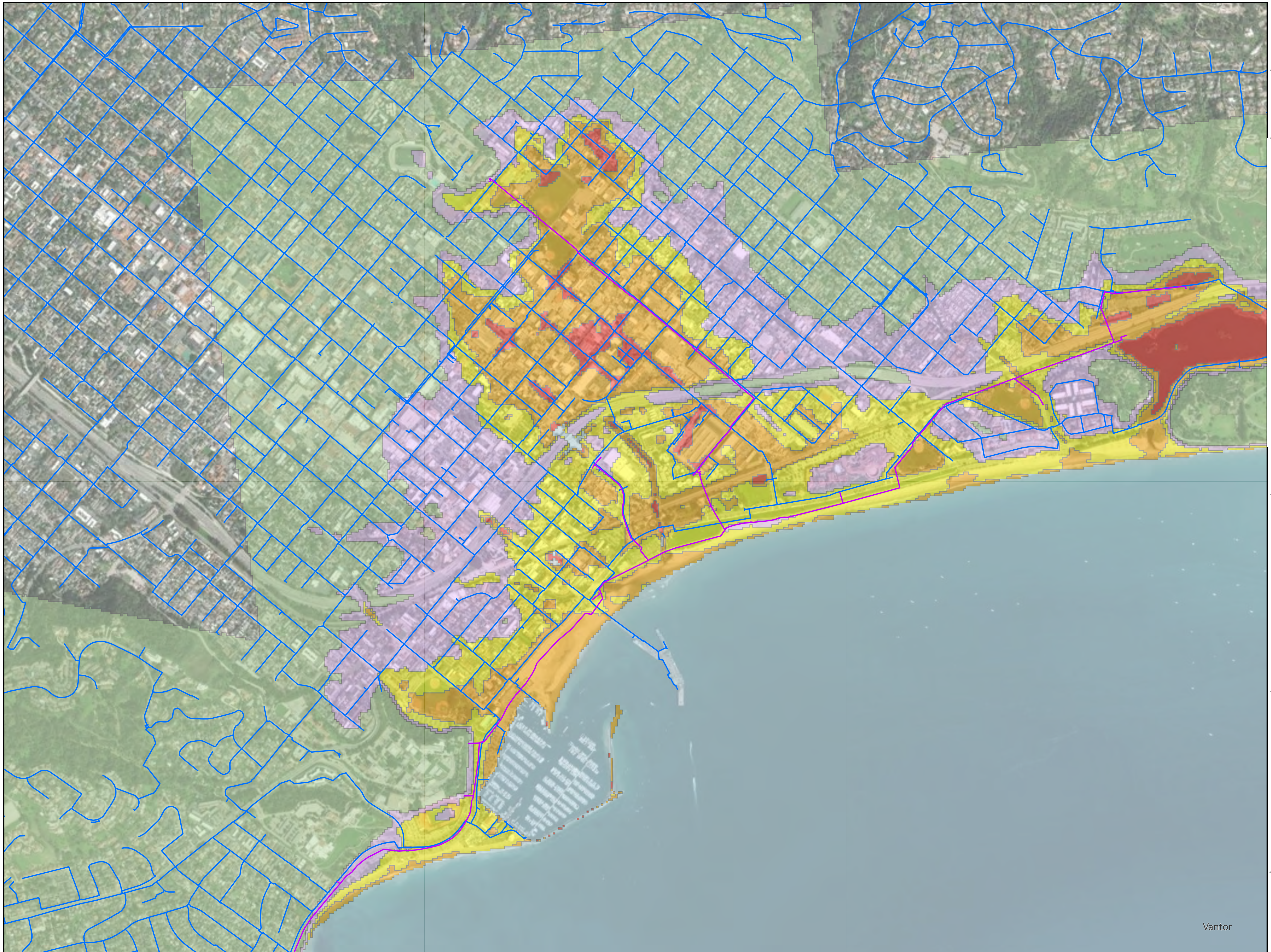
0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-18. Groundwater Levels with Water and Recycled Water Infrastructure, 0.8 ft SLR



Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

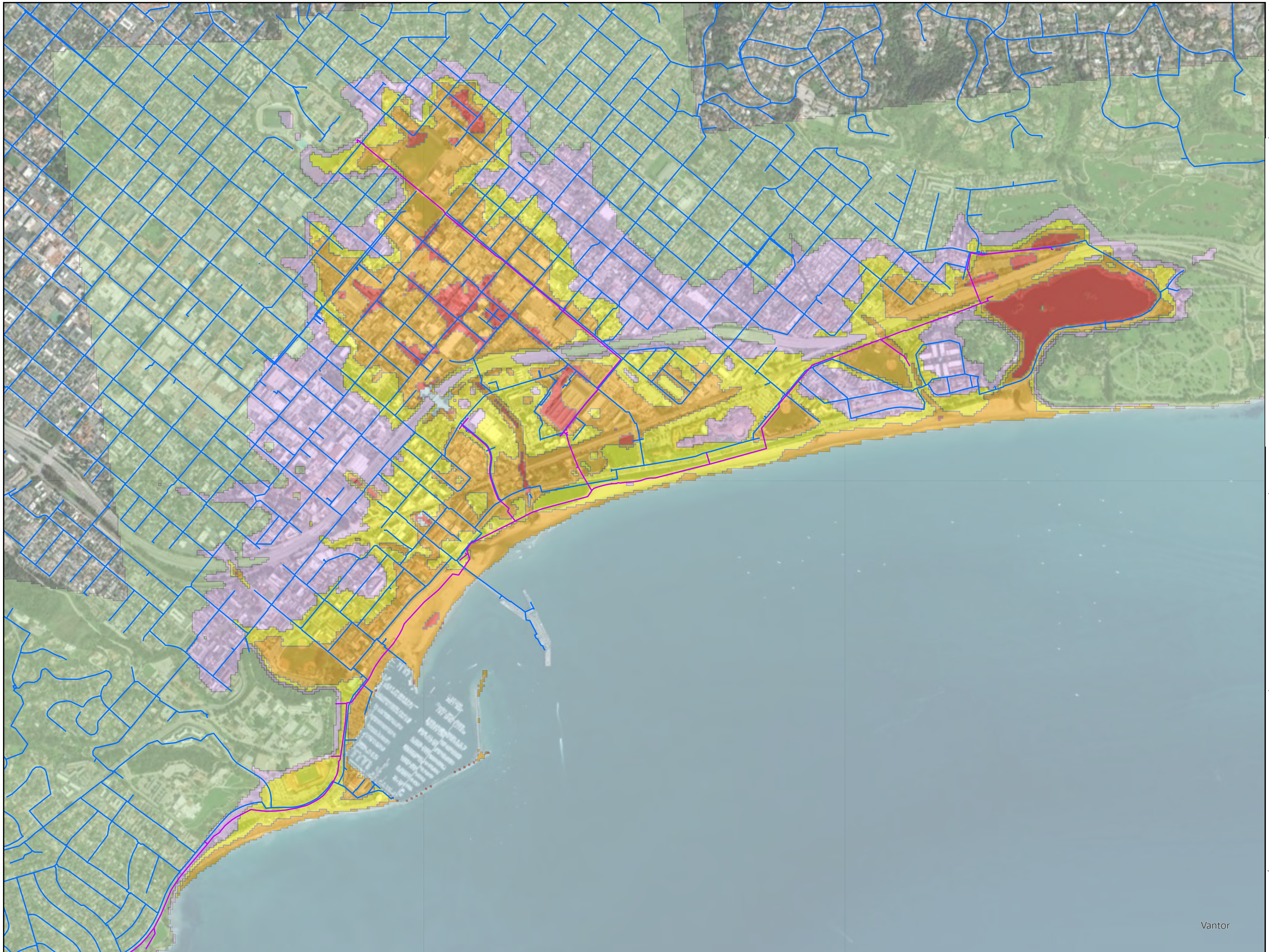


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Figure 3-19. Groundwater Levels with Water and Recycled Water Infrastructure, 1.6 ft SLR

Legend

- Recycled Water Main
- Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

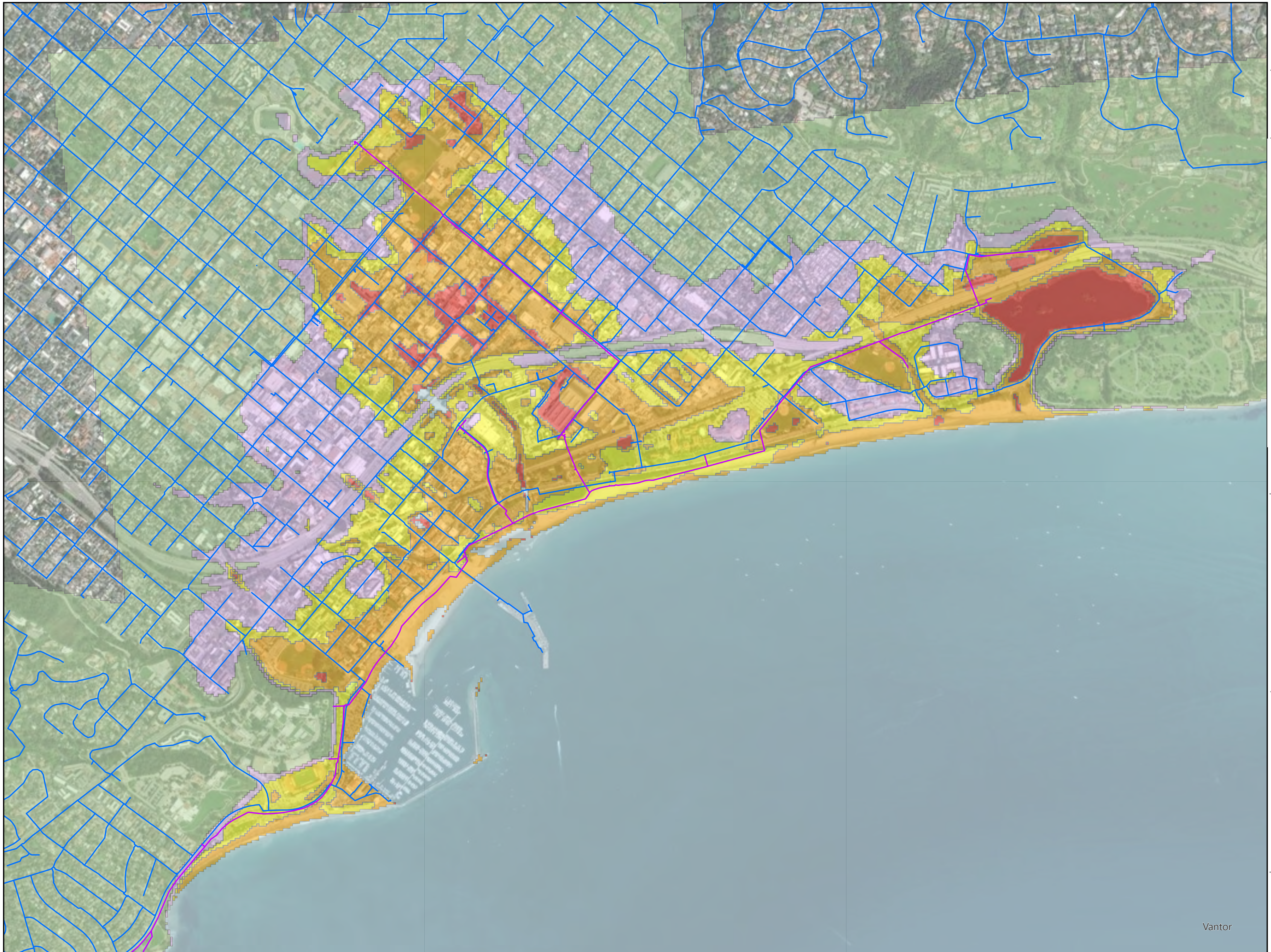
1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC



Water & Wastewater Climate Adaptation Project

Figure 3-20. Groundwater Levels with Water and Recycled Water Infrastructure, 2.5 ft SLR

Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

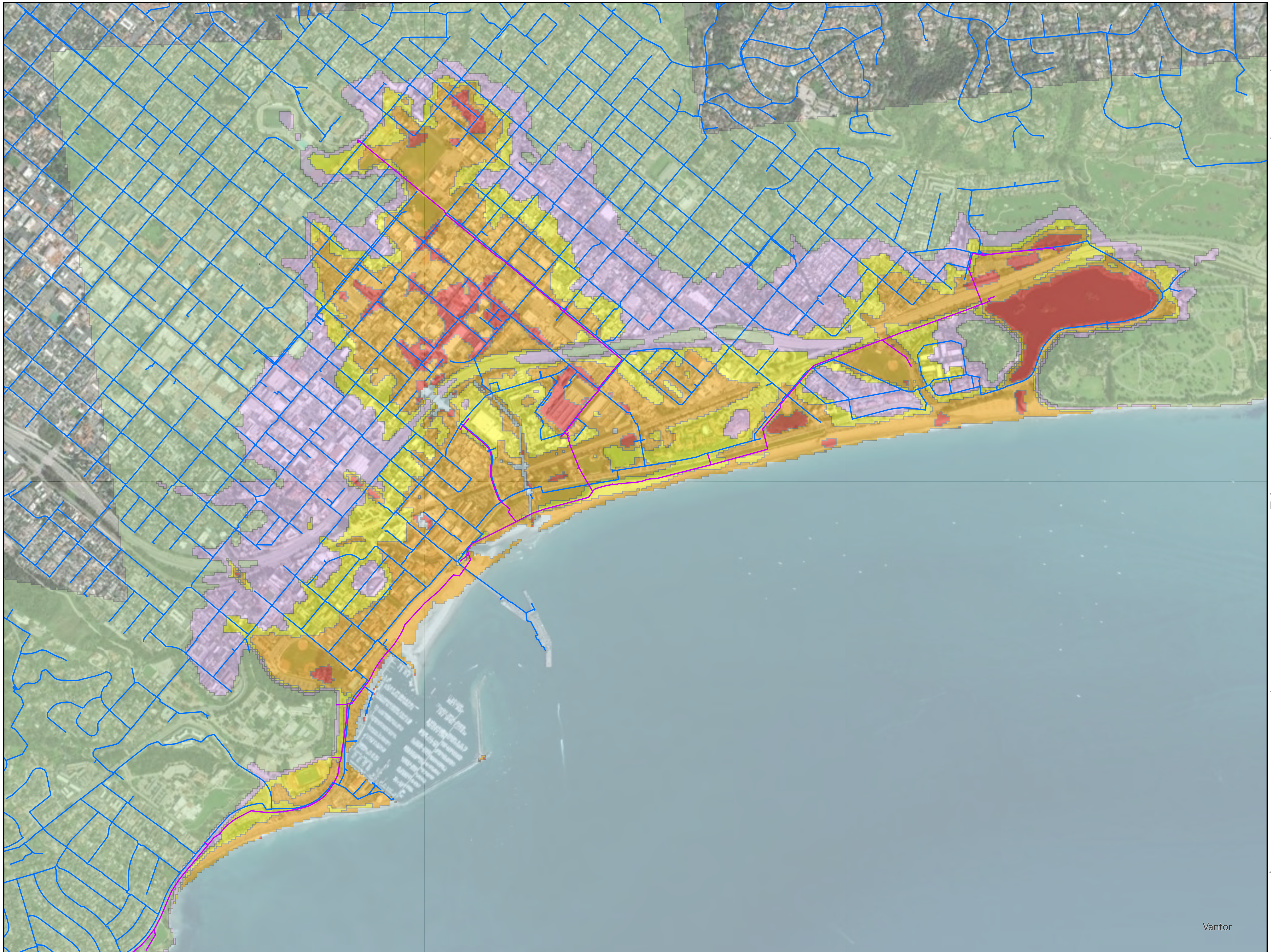
0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-21. Groundwater Levels with Water and Recycled Water Infrastructure, 3.3 ft SLR



Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

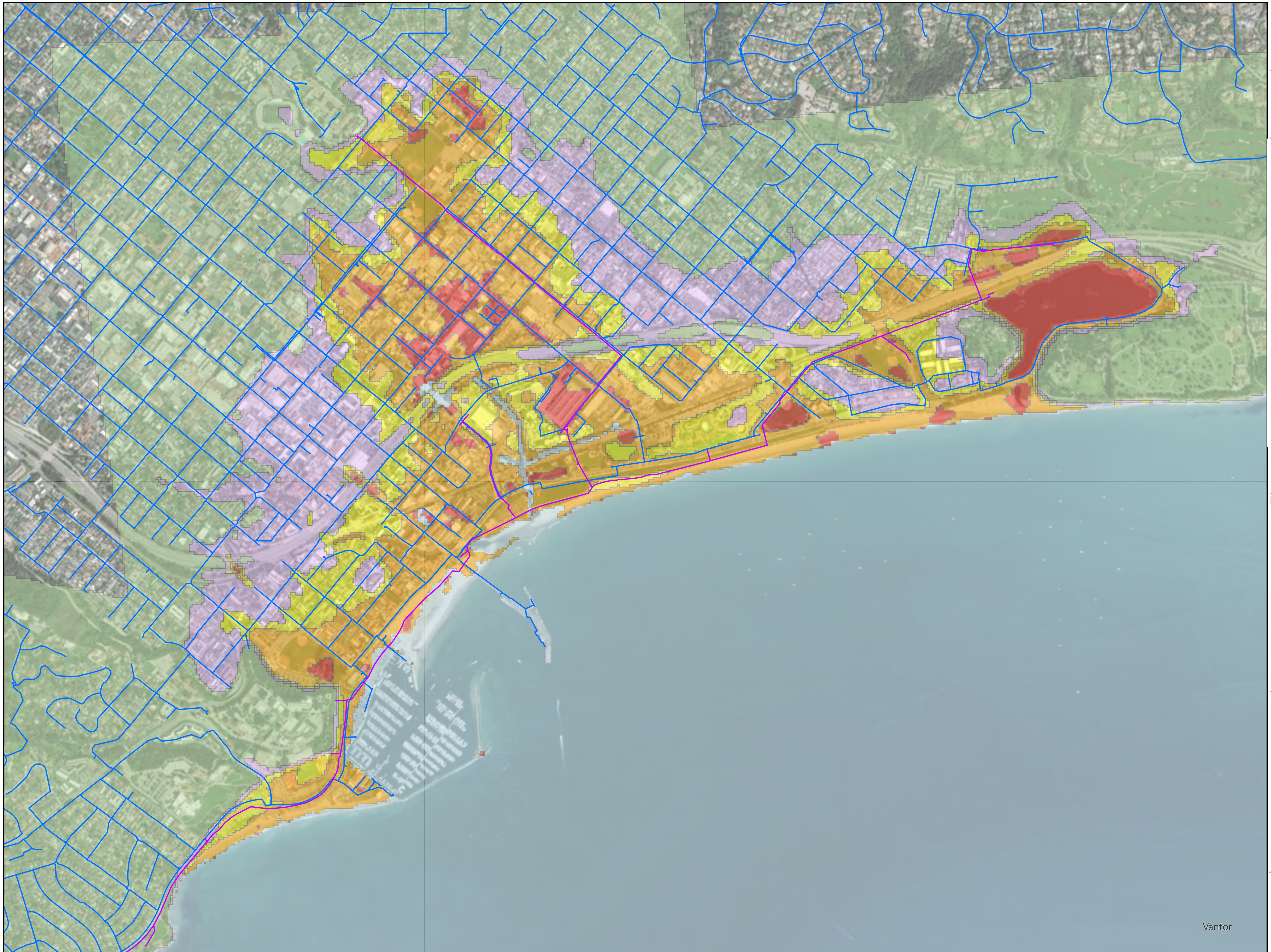
N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

Water & Wastewater Climate Adaptation Project

Figure 3-22. Groundwater Levels with Water and Recycled Water Infrastructure, 4.1 ft SLR



Legend

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

Water & Wastewater Climate Adaptation Project

Figure 3-23. Groundwater Levels with Water and Recycled Water Infrastructure, 4.9 ft SLR

Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

3.3 Common Impacts

This section provides an overview of impacts from the vulnerabilities presented in the previous section that are common to both water and wastewater facilities. These common impacts are presented here to avoid duplicating this information in detail for each component of the water and wastewater systems that are presented in this Plan. Impacts specific to each asset are discussed in Chapters 4 to 8.

Vulnerabilities addressed in this section include:

- Flooding (including stormwater flooding, coastal flooding, tidal inundation, storm waves, and rising groundwater)
- Shoreline Erosion
- Bluff Erosion
- Wildfire
- Drought
- Extreme Heat

3.3.1 Flooding

3.3.1.1 Buried Infrastructure

Both groundwater rise and the effect of advancing and retreating floodwaters can impact soil structure, which may then swell, shrink, or otherwise shift, with a common long-term effect being the development of sinkholes. Both expansion and subsidence of the ground around buried pipelines have the potential to impact the pipe's structural integrity, either through deflection of the pipe or separation of pipe joints. This can lead to pipe cracks, breaks, and subsequent leaks (pressure or gravity pipe) and/or groundwater infiltration (gravity pipe).

Below-ground portions of manholes can be at risk of flotation in saturated soil, which would impact the manhole's structural stability and therefore the stability of upstream and downstream sewer pipelines.

In addition to soil structure impacts, sea water flooding and brackish groundwater rise are likely to increase soil salinity and cause corrosion of metal pipes and metal pipe components, which could shorten infrastructure lifespans.

3.3.1.2 Above Ground Infrastructure

Physical damage to above ground components, such as hydrants, backflow preventers, and pressure reducing valves (PRVs) is common during coastal floods and flood recovery efforts. Some examples of typical damage to above-ground infrastructure includes:

- Sweeping away of unbolted manhole covers, which creates floodwater drainage pathway to sanitary sewer.
- Floodwaters carrying heavy objects, which collide with above-ground infrastructure.
- Supersaturated soils lead to uprooting of trees and destabilizing of power poles, which fall on above-ground water infrastructure.

- Flood recovery crews operating heavy equipment may cause damage to hydrants and manhole covers.

Damage to hydrants and other potable water above ground distribution system components has the potential to cause prolonged periods of service outage, as it can take days to flush and repressurize the system during a flood event and even longer before water is potable again.

3.3.1.3 Creek Crossings

The City has water, wastewater, and recycled water pipelines that cross various creeks throughout the City. Pipelines that cross creeks may be vulnerable to increased flooding and damaged by debris. Some pipelines have been preliminary identified as exposed or located under bridge decks. In previous storm events, the City has experienced pipe breaks from exposed pipelines subject to increased creek flows and debris. The City is investigating all pipelines that cross creeks, including as-built plans, material type, installation year, and access information to inform asset replacement and maintenance needs, including prioritized replacements for increased reliability. A summary of the number of creek crossings by system, cataloged to date is provided in Table 3-5.

Table 3-5. Number of Creek Crossings by System

System	No. of Creek Crossings	Exposed or Vulnerable Creek Crossings
Water	159	15
Wastewater	123	8
Recycled Water	11	0
Desalination	2	0

One significant creek crossing is located at Cabrillo Blvd and Mission Creek. The City's 33-inch (lined) West Beach sewer main crosses at this location and is estimated to be buried 2.5 ft below the creek bed. An abandoned 15-inch sewer main is also in the vicinity of the 33-inch sewer and is buried approximately 1 ft below the creek bed. Both pipelines are encased in concrete. The abandoned 15-inch sewer has since been replaced with a 15-inch sewer located parallel to Mission Creek within Cabrillo Blvd.

Monitoring of Mission Creek bed depth at the West Beach sewer crossing should be conducted annually to identify the potential for pipeline exposure.

3.3.1.4 Facilities

The most common and significant impact of coastal flooding on water and wastewater facilities is loss of utility power. Once power is lost due to a major flood event, it can take many days to restore. Power loss is often exacerbated by severe flooding that limits access to the facility and potentially prevents facility staff from refueling emergency generators or starting up manual and temporary generators. Damage of electrical system components due to contact with flood waters can also render entire facilities inoperable for prolonged periods of time. Facilities with finished floor elevations that are below FEMA's base flood elevations are particularly at risk of this occurrence. In the long term, both flood waters and rising groundwater have the potential to also impact soil stability, which can have catastrophic effects on building foundations and in extreme cases can lead to building collapse.

3.3.2 Shoreline Erosion

Shoreline erosion can lead to loss of protective cover over water and wastewater pipelines buried in the beach area. The amount of cover that can be lost with minimal consequences depends on several factors, such as pipe size, length of exposed pipeline, pipe material, and environment; This can be difficult to predict with confidence. Exposed pipelines are at risk of physical damage and accelerated chemical degradation due to movement, corrosion, abrasion, and damage by equipment and debris. Pipelines that become exposed in the surf zone will be subject to wave action. Wave action will further accelerate the degradation of pipes that are susceptible to corrosion or abrasion, such as metallic, concrete, and vitrified clay pipes. Once half of the buried pipeline diameter is exposed, the pipeline may be at risk of structural failure.

As shoreline erosion progresses, exposed pipelines will undergo a complete loss of bedding support in the beach area. Unsupported pipeline spans can be subject to a high magnitude of lateral loads and uplift forces from wave action, which can catastrophically damage them. The ground supporting beach area manholes and weir boxes may become unstable and eventually completely eroded, leading to unsupported foundations and subsequent failure of both the structure and the pipeline connected to it. In addition, the changing shoreline combined with rising sea levels is likely to lead to a loss of land access to manholes and other structures that are currently accessible.

Shoreline erosion is anticipated to impact all the City's beach area infrastructure to various extents and at various levels of sea level rise. As shown in Figure 3-24 and Figure 3-25, if no action is taken, shoreline erosion along East Beach is projected to reach Cabrillo Boulevard, east of Calle Cesar Chavez, by 1.6 ft of sea level rise (~2065), risking exposure and failure of utilities buried under Cabrillo Blvd. By 2.5 ft of sea level rise (~2075), shoreline erosion risks exposure and failure of utilities buried under Shoreline Drive and Chase Palm Park. For a description of impacts specific to individual beach area assets, refer to the following sections:

- El Estero outfall (Section 4.4.2)
- West Beach sewer (Section 5.3.2)
- Desalination plant intake (Section 6.2.2)
- Potable water distribution pipelines (Section 7.2.3)
- Recycled water distribution pipelines (Section 8.3)

3.3.3 Bluff Erosion

This study focuses on the low-lying waterfront and beach areas along the eastern half of the City. Bluff erosion was identified as a potential hazard in the 2021 SLR Adaptation Plan for Shoreline Drive and Cliff Drive (ESA, 2021). Figure 3-26 and Figure 3-27 illustrate the extent of the projected bluff erosion at 2.5 ft SLR and 6.6 ft SLR, respectively, as well as City's water and wastewater infrastructure that would be impacted.

Water & Wastewater Climate Adaptation Project

Figure 3-24. Shoreline Erosion, East Beach and West Beach

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Shoreline Retreat

- 0.8 ft SLR
- 1.6 ft SLR
- 2.5 ft SLR
- 3.3 ft SLR
- 4.1 ft SLR
- 4.9 ft SLR

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.1 0.2 Miles

0 420 840 US Feet

Water & Wastewater Climate Adaptation Project

Figure 3-25. Shoreline Erosion, Leadbetter Beach

Legend

- Sewer Manhole
- Sewer Main
- Water Main
- Desalination Intake
- Recycled Water Main

Shoreline Retreat

- 0.8 ft SLR
- 1.6 ft SLR
- 2.5 ft SLR
- 3.3 ft SLR
- 4.1 ft SLR
- 4.9 ft SLR

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

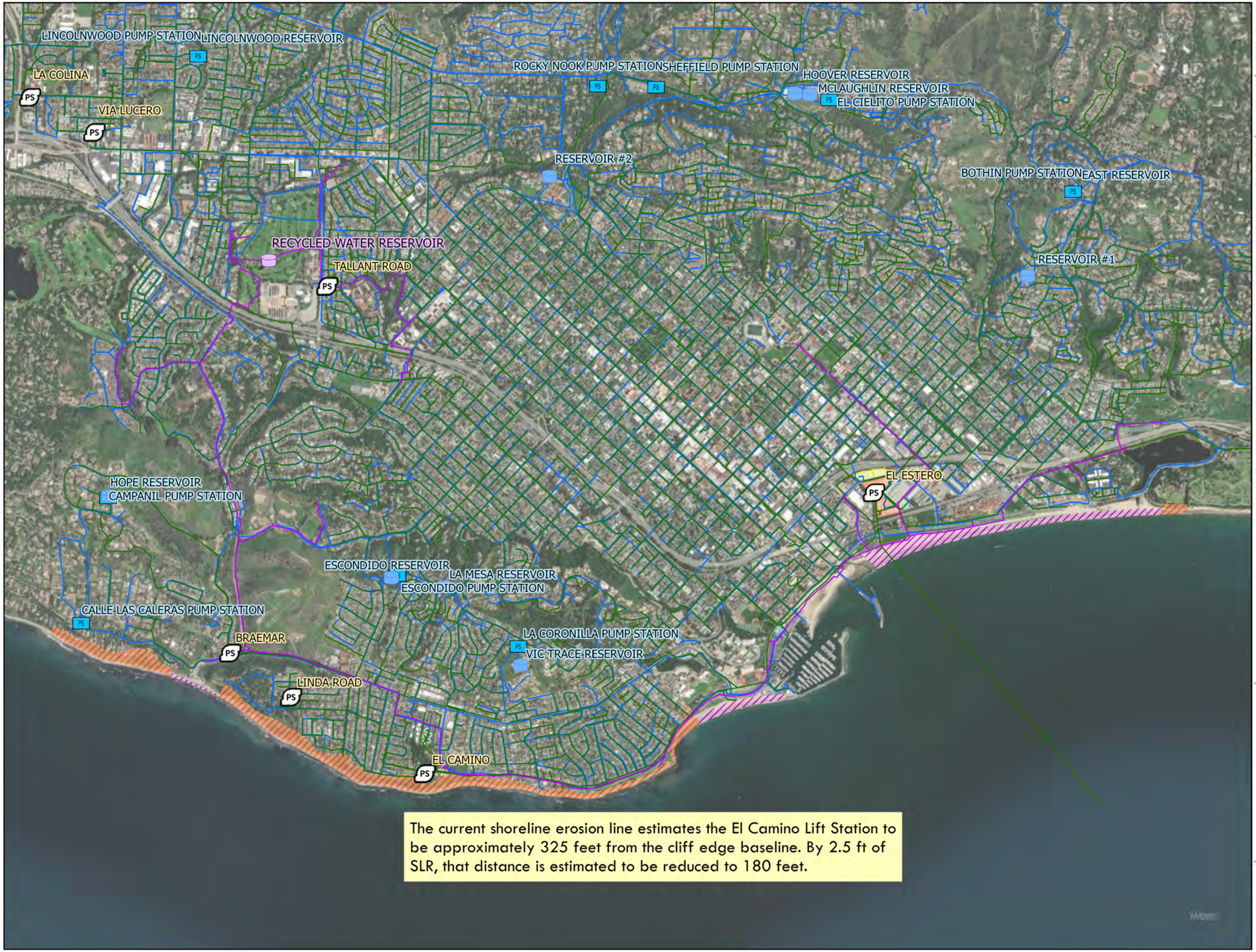
0 0.03 0.07 Miles

0 137.5 275 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-26. 2.5 ft SLR Bluff Erosion



Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Lift Station
- Pump Station
- Reservoir
- Recycled Water Reservoir
- Sewer Main
- Water Main
- Recycled Water Main
- Long Term Bluff Erosion
- Long Term Shoreline Erosion

N

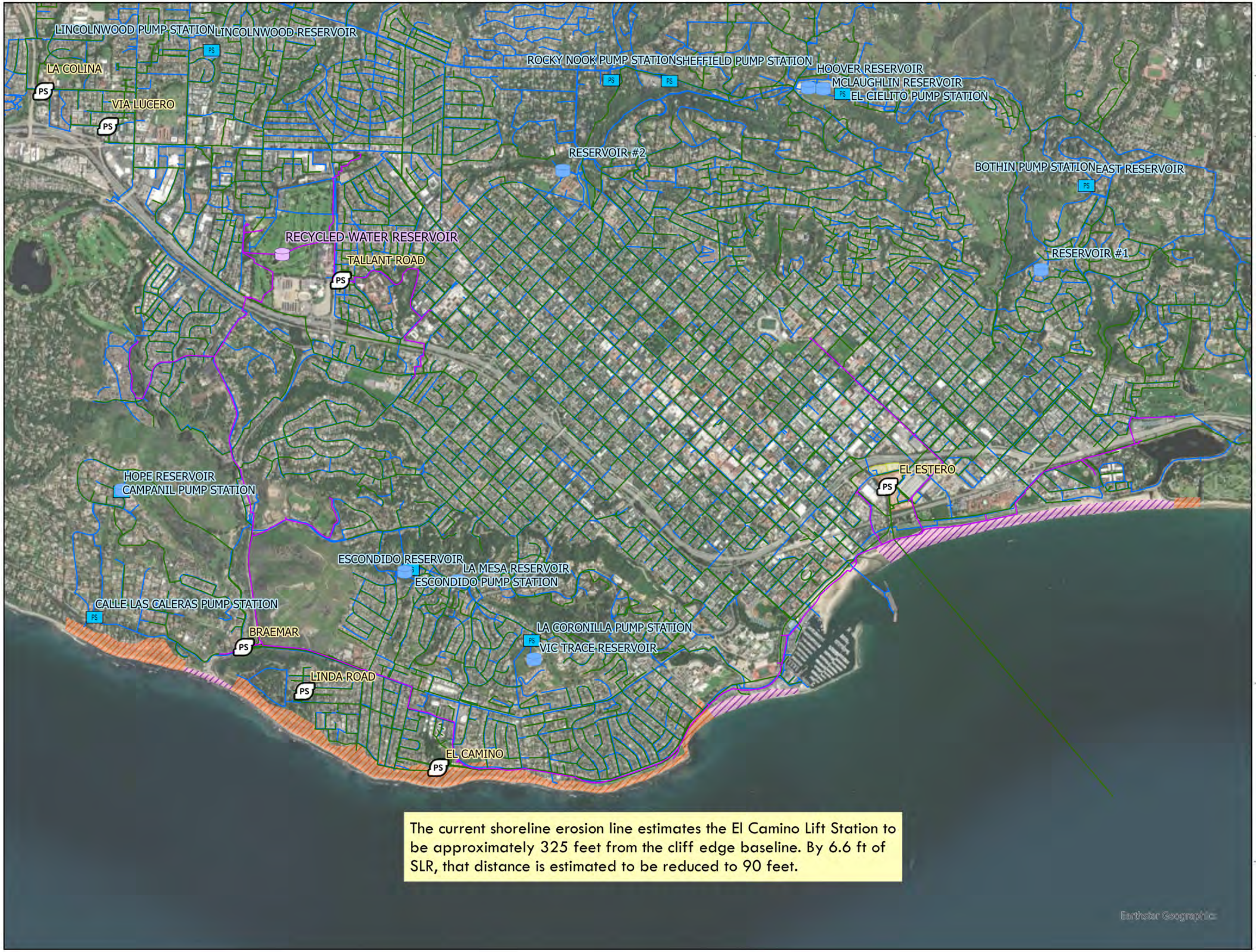
0 0.4 0.8 Miles

0 1,500 3,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-27. 6.6 ft SLR Bluff Erosion



Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Lift Station
- Pump Station
- Reservoir
- Recycled Water Reservoir
- Sewer Main
- Water Main
- Recycled Water Main
- Long Term Bluff Erosion
- Long Term Shoreline Erosion

N

0 0.4 0.8 Miles

0 1,500 3,000 US Feet

WSC

The impacts to infrastructure buried in or built upon bluffs are similar to impacts of shoreline erosion described above but more severe as they would take place much quicker and with a much greater risk of sudden collapse and failure.

Impacts of bluff erosion on water and wastewater infrastructure include:

- **Buried infrastructure and foundations:** Bluff erosion can undermine the stability of the ground supporting water and wastewater pipelines installed along or near the bluff. As the bluff erodes, pipelines may be exposed, making them vulnerable to damage from falling debris, landslides, or collapse of the bluff. This can lead to ruptures, leaks, or breaks in the pipelines, disrupting water or wastewater flow and potentially causing service outages and/or environmental contamination.
- **Facilities:** Bluff erosion can compromise the stability of water and wastewater infrastructure assets located on or near the bluff, such as booster stations, lift stations, and storage reservoirs. As the bluff erodes, the ground supporting these structures may become unstable, leading to structural damage or failure of the asset. This can pose safety risks for personnel, impair the functionality of infrastructure components, and require costly repairs, retrofitting measures, or relocation. Bluff erosion can also result in the loss or degradation of access roads leading to water and wastewater facilities along the bluff. This can impede operation and maintenance activities with potential impacts on service continuity for impacted communities.

3.3.4 Wildfire

This Project's focus area is in a zone of low wildfire risk; however, several City assets in northern and western Santa Barbara are in wildfire risk zones, as shown in Figure 3-28.

These areas contain the following major water and wastewater infrastructure assets:

- Cater Water Treatment Plant.
- Pump stations (8): Cater, El Cielito, Sheffield, Skofield, Calle Las Caleras, Campanil, Escondido, and La Coronilla.
- Lift stations (2): Braemar, Skofield.
- Reservoirs (10): Cater, El Cielito, Hope, Escondido, La Mesa, Sheffield (Hoover and Mclaughlin), Reservoir #1, Reservoir #2, Vic Trace.

These assets are considered vulnerable to wildfires if they are not protected by firebreaks or other means of preventing fire from spreading to the facility. In addition to major infrastructure, any exposed piping, especially of plastic material, in vegetated areas is at risk if it is in a moderate or high wildfire risk zone.

Wildfires pose significant risks to water and wastewater infrastructure and can have far-reaching impacts on potable water supply and quality as well as wastewater treatment and conveyance systems.

Beyond the most apparent impact of fire, which is direct damage to infrastructure, there are additional ramifications to consider:

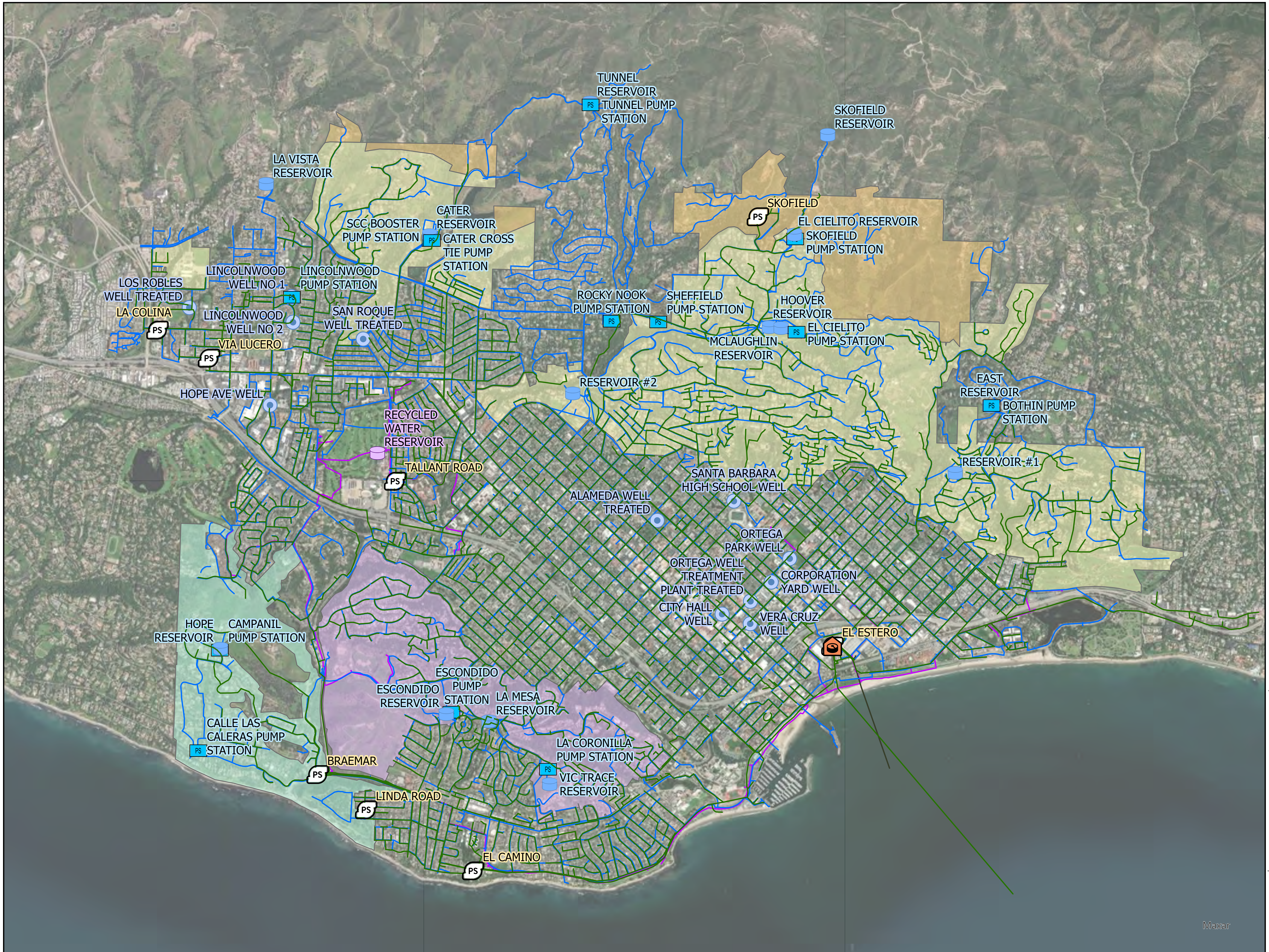
- **Facilities:** Even if infrastructure is not directly damaged by wildfires, it may still be vulnerable to damage from secondary effects such as heat, smoke, and ash deposition. Intense heat from wildfires can cause both above ground and shallow-buried materials (water service lines, meters, and pipelines) to melt, weaken, deform, or fail, leading to leaks, ruptures, contamination, loss of pressure and/or structural damage. In the water distribution system, these effects require mitigation through extensive flushing and sampling and may take several weeks to months before full system restoration. Smoke can damage circuitry in electrical and instrumentation equipment, and ash can clog air intake systems and filters, leading to electrical and mechanical equipment failure.

  Wildfires can also disrupt facility operation by cutting off access, disrupting power supplies, and hindering transportation and logistics. This can lead to interruptions in water and wastewater treatment, pumping, as well as collection and distribution services, impacting service continuity for affected communities. Wildfires can increase the risk of landslides and debris flows, which can also impede access to facilities, exacerbating the challenges of recovery and restoration efforts.

- **Wastewater Collection:** Ash and sediment runoff can enter the wastewater collection system, which can cause clogging and hydraulic overloads in pipes, manholes, and lift stations. This can impact the conveyance capacity of the collection network and impair the performance of downstream treatment processes.
- **Wastewater Treatment Processes:** If runoff enters the sewer, increased wastewater sedimentation and turbidity can impact wastewater treatment processes as well, reducing treatment efficiency and leading to elevated levels of suspended solids, turbidity, and contaminants in treated effluent.
- **Water Treatment Processes:** Wildfires can result in contamination of surface water sources in two ways: 1) Immediate and direct contamination through deposition of ash, debris, and pollutants into any source water or exposed water basins at treatment plant facilities; and 2) Delayed and indirect contamination from increased erosion, sedimentation, and burnt organic materials due to altered hydrological processes.

  Ash and sediment runoff from burned areas can introduce nutrients, organics, metals, and other contaminants into raw water sources, necessitating additional treatment measures to ensure safe drinking water production. Potential wildfire impacts on the City's surface water supplies is a concern but is beyond the scope of this Plan. The Cachuma Operation and Maintenance Board (COMB), which includes the City, prepared a report to evaluate the impacts of wildfire on Lake Cachuma water quality and treated water quality delivered to its downstream users (COMB, 2019).

Overall, wildfires pose significant risks to water and wastewater infrastructure. However, adaptation for wildfire impacts was not the focus of this Plan and is already a key concern for the City's water and wastewater departments. Proactive planning, risk mitigation measures, emergency response protocols, and investments in resilient infrastructure are essential to minimize the impacts of wildfires on water and wastewater infrastructure and protect public health, safety, and the environment in fire-prone areas.



Water & Wastewater Climate Adaptation Project

Figure 3-28. Wildfire Risk to City Facilities

Legend

- El Estero Water Resource Center
- Lift Station
- Sewer Main
- Pump Station
- Reservoir
- Production Well
- Water Main
- Desalination Intake
- Recycled Water Reservoir
- Recycled Water Main

High Fire Hazard Areas

- Coastal
- Coastal Interior
- Extreme Foothill Zone
- Foothill Zone

N

0 0.5 1 Miles

0 2,000 4,000 US Feet

WSC

3.3.5 Drought

Drought can pose significant challenges for water and wastewater infrastructure, requiring proactive management strategies, infrastructure investments, and adaptive measures to mitigate the impacts of water scarcity on water and wastewater treatment, storage, and conveyance systems. **Impacts of droughts may include:**

- **Wastewater Collection**: Reduced water usage by households, businesses, and industries can lead to lower volumes of wastewater entering the collection system. This decrease in sewage flow rates can result in buildup within gravity pipes and conveyance systems, potentially leading to odor issues, increased sedimentation, and the settling of solids. Lower wastewater flows can increase the likelihood of hydrogen sulfide corrosion in sewer pipes, further accelerating infrastructure degradation.
- **Wastewater Treatment Processes**: With lower wastewater flows, pollutants become more concentrated in the remaining wastewater, posing challenges for wastewater treatment plants in maintaining stable treatment performance. High pollutant concentrations can strain treatment processes, reduce operational efficiency, and require adjustments to treatment operations to maintain compliance with discharge permits.
- **Surface Water Diversion**: Both of the City's surface water sources, Lake Cachuma and Gibraltar Reservoir, drain via gravity from intake structures at each of the lakes and are conveyed through tunnels to Lauro Reservoir. During extended drought conditions, as was experienced at the City from 2014 to 2023, temporary pumps must be installed to pump the surface water at Lake Cachuma to the lake's intake structure upstream, where water is then distributed via gravity to the South Coast via the Mission Tunnel. In 2023, the Cachuma Operation and Maintenance Board installed a permanent pipeline at Lake Cachuma that would connect, when needed, to temporary pumps on a floating barge to the intake structure.
- **Potable Water Treatment Processes**: Lower water levels in raw surface water reservoirs and groundwater source wells can concentrate pollutants, making water treatment more challenging and potentially requiring additional treatment steps. Higher water temperatures during droughts can also promote the growth of harmful algae blooms, further complicating water treatment processes.
- **Potable Water Storage and Distribution**: Lower turnover and increased water age in the distribution system can lead to water quality degradation, disinfectant decay, taste and odor issues, corrosion in the distribution system, and reduced hydraulic efficiency.
- **Pumps**: Decreased groundwater levels lead to less efficient operation of groundwater pumps, which increases energy costs and decreases pump life. In extreme cases, groundwater pumps may fail to convey water due to well screens being located above the water level in source groundwater wells. The City monitors groundwater levels to avoid operating pumps below groundwater levels.
- **Buried Infrastructure and Foundations**: Drought conditions can exacerbate the deterioration of buried water infrastructure. Drought conditions can lead to soil shrinkage and settlement, which can cause pipes to shift, crack, or break. Similarly, concrete

infrastructure may suffer from increased cracking due to soil movement and reduced moisture.

3.3.6 Extreme Heat

Apart from increasing the risk of drought and wildfires, excessive heat can have serious direct ramifications on water and wastewater infrastructure. **Impacts of extreme heat can include:**

- **Electrical Equipment:** High temperatures can put stress on mechanical and electrical equipment used in water and wastewater infrastructure, such as pumps, motors, and control systems. Excessive heat can lead to overheating of equipment, reduced efficiency, increased maintenance requirements, and potential equipment failures, disrupt operations and impacting service reliability. Service life of variable frequency drives (VFDs) decreases exponentially with rise in ambient temperatures. Some VFDs are equipped with thermal protection mechanisms that automatically shut down the drive if temperatures exceed certain thresholds to prevent damage to internal components. However, this results in frequent shutdowns and interruptions to operations, which decreases the equipment's service life and time between replacements.
- **Water Treatment Processes:** Higher temperatures can promote the growth of microorganisms in raw water sources and within treatment facilities. Bacteria, algae, and other microbes may proliferate more rapidly in warmer conditions, potentially increasing the microbial load in raw water and requiring additional disinfection and filtration steps to achieve desired water quality standards. In the recent past, the rise in raw water temperatures has contributed to widespread water treatment challenges due to membranes and processes fouling with algae. Elevated temperatures can accelerate the decomposition and degradation of organic matter present in raw water sources. This can lead to increased levels of organic compounds and disinfection byproduct exceedances. Water treatment plants may need to employ additional treatment steps, such as advanced oxidation processes, advanced filtration, or enhanced coagulation, to address the impacts of organic matter degradation on water quality.
- **Wastewater Treatment Processes:** Wastewater treatment is similarly impacted by higher temperatures of influent wastewater. High temperatures impact the performance of biological treatment processes and may increase membrane fouling rates, impacting treatment efficiency, and requiring process adjustments and increased maintenance.
- **Potable Water Distribution and Wastewater Collection, Water Quality:** Elevated temperatures can impact water quality in distribution and wastewater collection systems. In distribution systems, warmer water temperatures can promote bacterial growth and accelerate the decay of disinfectants, potentially leading to microbial contamination and compromised water quality. Increased temperatures can lead to the accumulation of odors and hazardous gases in sewer piping.
- **Potable Water Distribution and Wastewater Collection, Pipelines:** Rapid temperature changes, particularly during hot weather, can cause pipes to expand unevenly, leading to distortion, bending, or joint failure. Thermal expansion can be responsible for cracks, leaks, and structural failure.

3.4 Stormwater Flooding Adaptation Options

There are several opportunities to protect against flooding impacts from climate change and sea level rise that may be achieved at a broader, regional level.

3.4.1 Berm Management

As discussed in Section 2.2.1, Mission Creek Lagoon water above seven ft NAVD can cause flow through the Laguna Creek tide gate structure and backflow into Laguna Creek, which makes the pumps less effective and prevents water from draining out of Laguna Creek. It is recommended that the City continue efforts to grade and contour the lagoon's beach berm to a low point of approximately four to six ft NAVD per the City's Comprehensive Sediment Management Program (City of Santa Barbara, 2021) and permit requirements.

3.4.2 Laguna Creek and Tide Gate

The current Laguna Creek and Tide Gate pump configuration is located at an elevation susceptible to overtopping (Section 2.2.2.1). The City may increase maintenance efforts within Laguna Creek to reclaim storage capacity, reducing flooding when Laguna Creek backfills. In addition, the City may increase berm management activities at the beach, per the City's existing permit, and maintain the berm at a lower elevation than the berm naturally forms. This is so that Mission Lagoon and Laguna Creek can drain to the ocean. This is a temporary solution as increased sea level rise and reduced beach area require additional long-term measures that would be evaluated in the proposed Stormwater Model and Flood Analysis Report (described below).

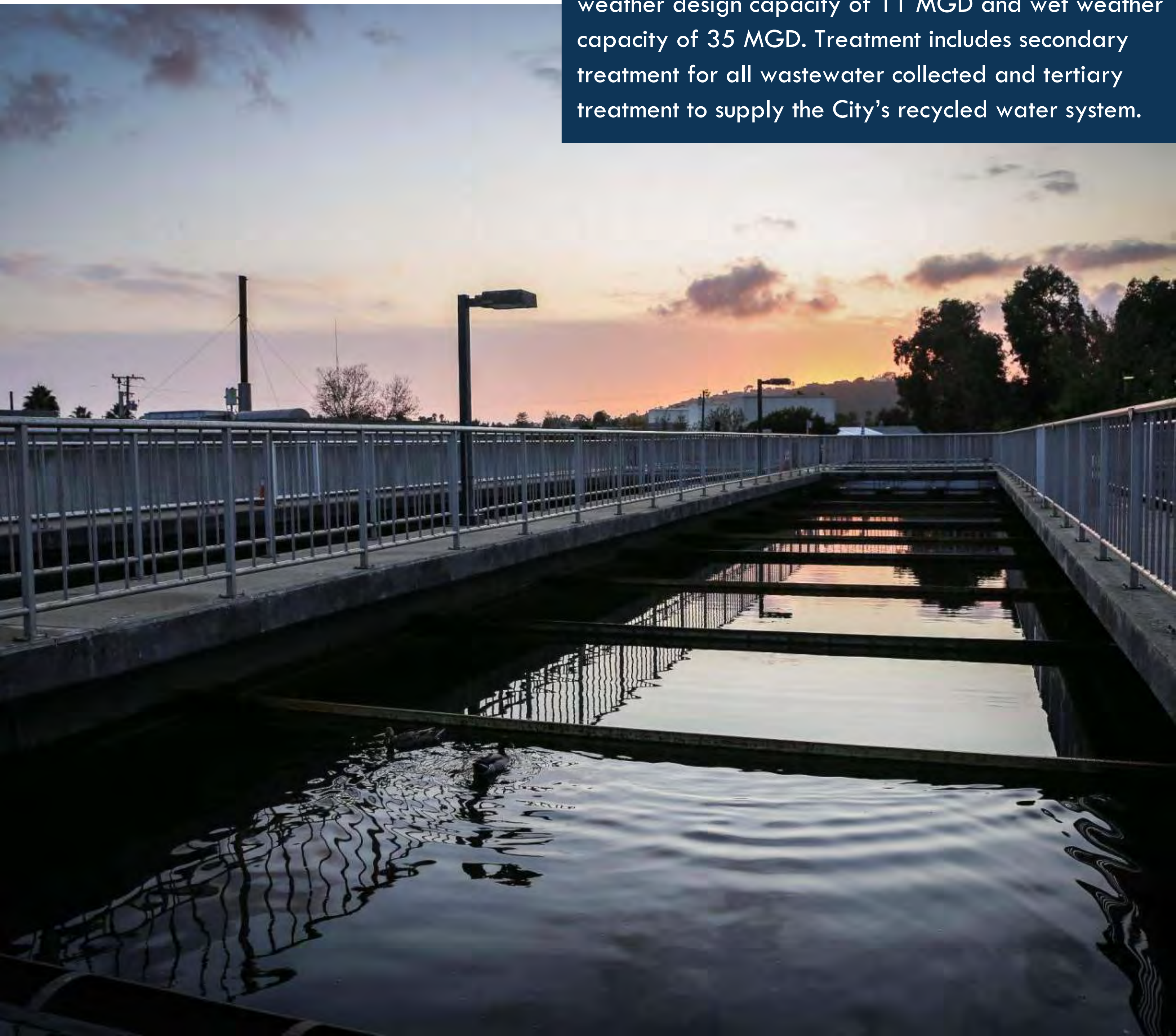
3.4.3 Proposed Stormwater Model and Flood Analysis Report

Additional data collection and analysis pertaining to stormwater and combined flooding, such as flood depths and extent, is needed to better assess vulnerability and potential adaptation strategies. Therefore, WSC recommends that the City complete a Stormwater Model and Flood Analysis Report to further define and evaluate flood impacts and protection options. The scope of the Stormwater Model and Flood Analysis Report is recommended to include:

- The development of a model of the City's storm drain system.
- A model of combined stormwater and coastal storm flooding at various levels (e.g., 2-, 10-, 20-, 50-, and 100-year storms instead of just 100-year storms as is conducted for FEMA maps).
- Focus on the extent of flooding and adaptation options for the more frequent, lower-level storms (e.g., the 5-year rainfall event).
- The identification of adaptation options to increase capacity of the storm drain system.
- The identification of alternatives to adapt Laguna Creek and associated tide gate and pump station.

4.0 Wastewater Treatment

The City's El Estero Water Resources Center has a dry weather design capacity of 11 MGD and wet weather capacity of 35 MGD. Treatment includes secondary treatment for all wastewater collected and tertiary treatment to supply the City's recycled water system.



Vulnerability and Adaptation Summary

The City's wastewater treatment system consists of El Estero WRC for treatment of wastewater and the El Estero outfall to safely dispose of treated wastewater into the Pacific Ocean. The highest near-term risks identified for El Estero WRC and El Estero outfall are:

- El Estero WRC Onsite Flooding: Portions of El Estero WRC are projected to flood during the 100-year storm at existing sea levels if flood water is allowed to find its way onsite. Vulnerable areas include the primary and secondary clarifiers area which house electrical and controls systems; electrical equipment located throughout the plant in low elevation areas, and the front and back access gates. These areas are likely to flood during the 100-year storm by 0.8 ft of sea level rise (~2050), and most of the site is projected to flood during the 100-year storm by 2.5 ft of sea level rise (~2075).
- El Estero WRC Access from Offsite Flooding: Recent 5- and 10- year storms have temporarily (less than 12 hours) prevented access to the plant due to flooding in local streets. Larger storms could prevent access for over 24 hours, which risks staff safety, timely delivery and export of materials, and reliable plant operations.

In addition, near-term onsite and offsite flooding risks to El Estero WRC are projected to worsen in the mid-term with higher intensity rainfall during storms and sea level rise. The highest risk for El Estero outfall is potential exposure and undercutting of the outfall pipeline in the mid-term due to offshore and beach erosion. Adaptation recommendations for these risks are summarized below.

El Estero WRC On-Site Flooding

- **Immediate Next Steps (0-5 Years):** Additional data collection and analysis are recommended to further define vulnerabilities and build confidence on a path toward adaptation, including:
    - **Stormwater Model and Flood Analysis:** Study high frequency, lower-level rainfall events and associated flooding surrounding El Estero WRC to fill data gaps, such as extent and recurrence of flooding with climate change. Analyze options to modify stormwater system to reduce flooding. This effort is already funded. Findings from the stormwater analysis will be incorporated into other studies in this Plan that are recommended as immediate next steps.
    - **El Estero WRC Flood Protection Study:** Evaluate and recommend phasing of flood protection measures considering Stormwater Model and Flood Analysis findings. Compare the merits of protecting or elevating individual treatment processes and/or protecting the whole site with a floodwall system. The study would define a phased approach to provide flood protection through at least 2.5 ft of sea level rise (~2075).
- **Near-Term (Through 0.8 ft SLR (~2050)):** Implement the recommendations from the El Estero WRC Flood Protection Study (e.g., floodwalls and/or elevation of infrastructure). In addition, the City may consider reserving areas in City-owned property as potential

sites for long term relocation of wastewater infrastructure due to the limited number of feasible locations.

- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** Update the El Estero WRC Flood Protection Study considering: 1) updated hazard and vulnerability assessments, especially timing of sea level rise; 2) proficiency of flood protection measures implemented in and around El Estero WRC; and 3) long-term risks for El Estero WRC. Implement the updated study recommendations.

Off-Site Flooding Limiting Access to El Estero WRC

- **Immediate Next Steps (0-5 Years):** Formalize an El Estero WRC Flood Conditions Operations Plan to document operation practices during flood conditions; shift schedule and plant access protocols; resources and accommodations for staff for prolonged shifts; expanded solids storage capacity; and protocols for solids hauling and chemical delivery schedules that account for extended lack of access to the plant.
- **Near-Term (Through 0.8 ft SLR (~2050)):** Reevaluate flood preparations following completion of the Stormwater Model and Flood Analysis, which will better characterize flood risks, to determine if larger investments in road infrastructure are needed to provide access to El Estero WRC up to 0.8 ft of sea level rise (~2050).
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** Update the previous flood operations analysis considering: 1) updated hazard and vulnerability assessments, especially timing of sea level rise; 2) proficiency of implemented local and regional measures; and 3) long-term plans for El Estero WRC. Further study long-term options for elevating roads or providing alternate access to El Estero WRC in coordination with analysis of options for potential relocation of the plant.

El Estero Outfall

- **Near-Term (Through 0.8 ft SLR (~2050)):** Shoreline erosion along East Beach is projected to expose the outfall's onshore manhole up to about 5 ft by 0.8 ft of sea level rise (~2050). The outfall manhole could be surrounded by ocean water at low tide by 2.5 ft of sea level rise (~2075). Although the City has not used this manhole for routine pipeline inspections in recent history, it may be valuable for future access and is recommended to be protected in the near-term. Depending on changing climate conditions and operational needs further in the future, potential manhole relocation or abandonment may be investigated.
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** The portion of the outfall pipeline under East Beach is projected to be exposed by 2.5 ft of sea level rise (~2075), and it will be fully submerged when the pipeline is eventually exposed. The outfall pipeline is anticipated to be resilient to the impacts of shoreline erosion due to its depth of installation, existing sheet piles on both sides, and significant existing rock armor overlying the pipe. Regular condition assessments, which are required by the NPDES permit, are expected to continue and identify issues as they arise. Such assessments

will serve as reoccurring monitoring and data collection points and will inform updated erosion projections to determine future needs for improvements.

El Estero WRC (Long-Term)

El Estero WRC sits at a higher elevation than the areas surrounding it and the more significant issues with the wastewater system in the near- and mid-term are related to flooding events that affect areas surrounding the plant. In the near-term, flood protection investments at the site will be needed and access during flood hazards can be managed with limited modifications to existing practices. In the mid-term, more substantial road and site access improvements may be required.

In the mid-term, the City will also need to further study and consider whether to relocate El Estero WRC in the long-term given the costs required to address safe, reliable access during recurrent flooding, and to protect the site from extreme flooding at high amounts of sea level rise. That decision will be part of future updates to this Plan that will benefit from more years of monitoring and additional information on how climate changes are affecting the region and possible adaptation options. Any relocation study would involve close coordination with regional partners to explore opportunities for shared facilities and to identify potential sites of sufficient size across the region. Among properties currently owned by the City, the municipal golf course on Las Positas Road is large enough to accommodate a new wastewater treatment plant if needed.

4.1 Introduction

The El Estero WRC, presented in Figure 4-1, is bounded by Yanonali Street to the north, Laguna Creek to the west, an environmentally protected area and railroad tracks to the south, and commercial facilities to the east. El Estero WRC treats wastewater from the City's collection system as well as wastewater from a portion of Montecito. The treatment processes include secondary treatment for all wastewater collected and tertiary treatment for the City's recycled water system. The El Estero WRC dry weather design capacity is 11 MGD and wet weather capacity is 35 MGD. Secondary treated wastewater effluent is discharged via the El Estero outfall system into the Pacific Ocean. Tertiary treated wastewater is conveyed to the City's recycled water distribution system for landscape irrigation and other approved recycled water uses.

The primary risks of climate change identified for El Estero WRC and outfall are summarized in Table 4-1 and discussed in the following subsections:

- El Estero WRC Onsite Flooding (Section 4.2)
- El Estero WRC Access during Offsite Flooding (Section 4.3)
- El Estero Outfall Shoreline Erosion (Section 4.4)
- Groundwater Rise (Section 4.5)
- Influent Wastewater Quality (Section 4.6)
- El Estero WRC and Outfall Capacity (Section 5.2)[6]

[6] Capacity risks for the El Estero WRC influent pump station, treatment process, and outfall are discussed along with collection system capacity in Section 5.2.

Figure 4-1. El Estero WRC Site Map

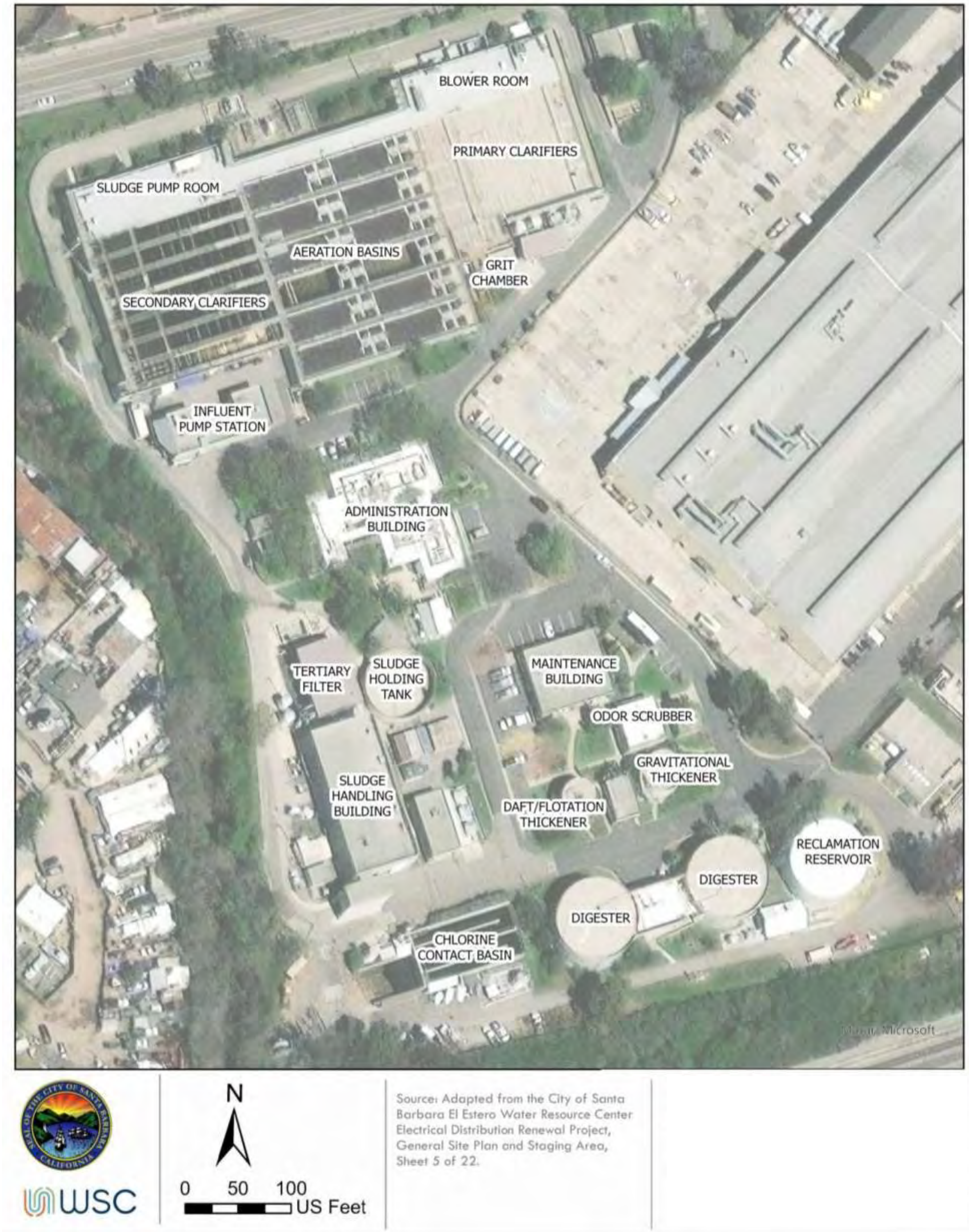


Table 4-1. Risk Assessment for El Estero WRC and Outfall

Hazard	Risk Description	Consequences	Near-Term		Long-Term	
			Likelihood	Risk	Likelihood	Risk
Severe Flooding	Exceedance of treatment train and outfall capacity due to inflow and infiltration	5	5	**25**	5	**25**
Severe Flooding	Damage to mechanical and electronic components of the treatment system	5	4	**20**	5	**25**
Severe Flooding	Loss of access to site	5	4	**20**	5	**25**
Shoreline Erosion and Wave Action	Damage to outfall structures	5	3	**15**	4	**20**
Severe Flooding	Loss of service due to power outage	5	2	**10**	3	**15**
Severe Flooding	Loss of structural stability of buildings and tanks onsite	5	1	**5**	3	**15**
Groundwater Rise	Loss of structural stability of buildings and tanks onsite	5	1	**5**	3	**15**

Refer to Section 3.1 for a description of scoring criteria.
Likelihood: Almost Certain (5 pts); Likely / Probable (4 pts); Possible (3 pts); Unlikely (2 pts); Rare (1 pt).
Consequences: Catastrophic (5 pts); Major (4 pts); Moderate (3 pts); Minor (2 pts); Insignificant (1 pt).
Risk (= Likelihood x Consequences): High (16 to 25 pts); Medium (9 to 15 pts): Low (1 to 8 pts).

4.2 El Estero WRC Onsite Flooding

Stormwater flooding levels with sea level rise were conservatively estimated by increasing the historical FEMA 100-year flood level by the amount of sea level rise (e.g., one foot of sea level rise increases the FEMA base flood elevation by one foot), as shown in Figure 4-2. Results show that the majority of the Desalination Plant and portions of the El Estero WRC are susceptible to flooding from a past 100-year flood event under existing conditions. With 0.8 ft of sea level rise (~2050), more of El Estero WRC and most of the Desalination Plant are flooded. Between 0.8 ft and 2.5 ft of sea level rise (~2075), virtually all of the site is flooded by the past 100-year event. Specific locations of flooding in extreme and typical storm events are also summarized in Table 4-2. Consequently, El Estero WRC stormwater management practices and specific elevations were reviewed to identify potential vulnerabilities to flooding and adaptation opportunities, as discussed below.

Table 4-2. Summary of El Estero WRC Flooding

Flood Hazard	Past Precipitation	0 - 0.8 ft SLR	0.8 - 2.5 ft SLR
Extreme Flood Hazards (Past 50 to 100-year Recurrence Interval)	Entrances flooded, storm drains could backflow	Entrances and some site flooded, increased depth	Virtually all of site flooded, increased depth
Typical Flood Hazards (Past 10-year Recurrence Interval)	Entrances Flooded	Entrances flooded, increased depth, storm drains could backflow	

4.2.1 Site Flood Depths

Estimated flood levels and depth of flooding are provided in Table 4-3 for existing and projected sea level rise conditions. Existing flood depth is based on the historical FEMA 100-year flood elevation.[7] The range and average depth of flooding onsite was determined using the elevation data captured during the site visit (using NAVD 88), compared to the 100-year flood elevation.

Table 4-3. FEMA 100-Year Flood Depth with Sea Level Rise at El Estero WRC

Sea Level Rise Scenario	100-year Flood Elevation (ft NAVD 88)	Range of 100-year Flood Depth (ft NAVD 88)
Existing (FEMA)	12.9	0 – 6.4
0.8 ft (~2050)	13.7	0 – 7.2
1.6 ft (~2065)	14.5	0.1 – 7.9
2.5 ft (~2075)	15.4	1.1 – 8.9
3.3 ft (~2085)	16.2	1.9 – 9.7
4.1 ft (~2095)	17.0	2.7 – 10.5
4.9 ft (~2100)	17.8	3.5 – 11.3

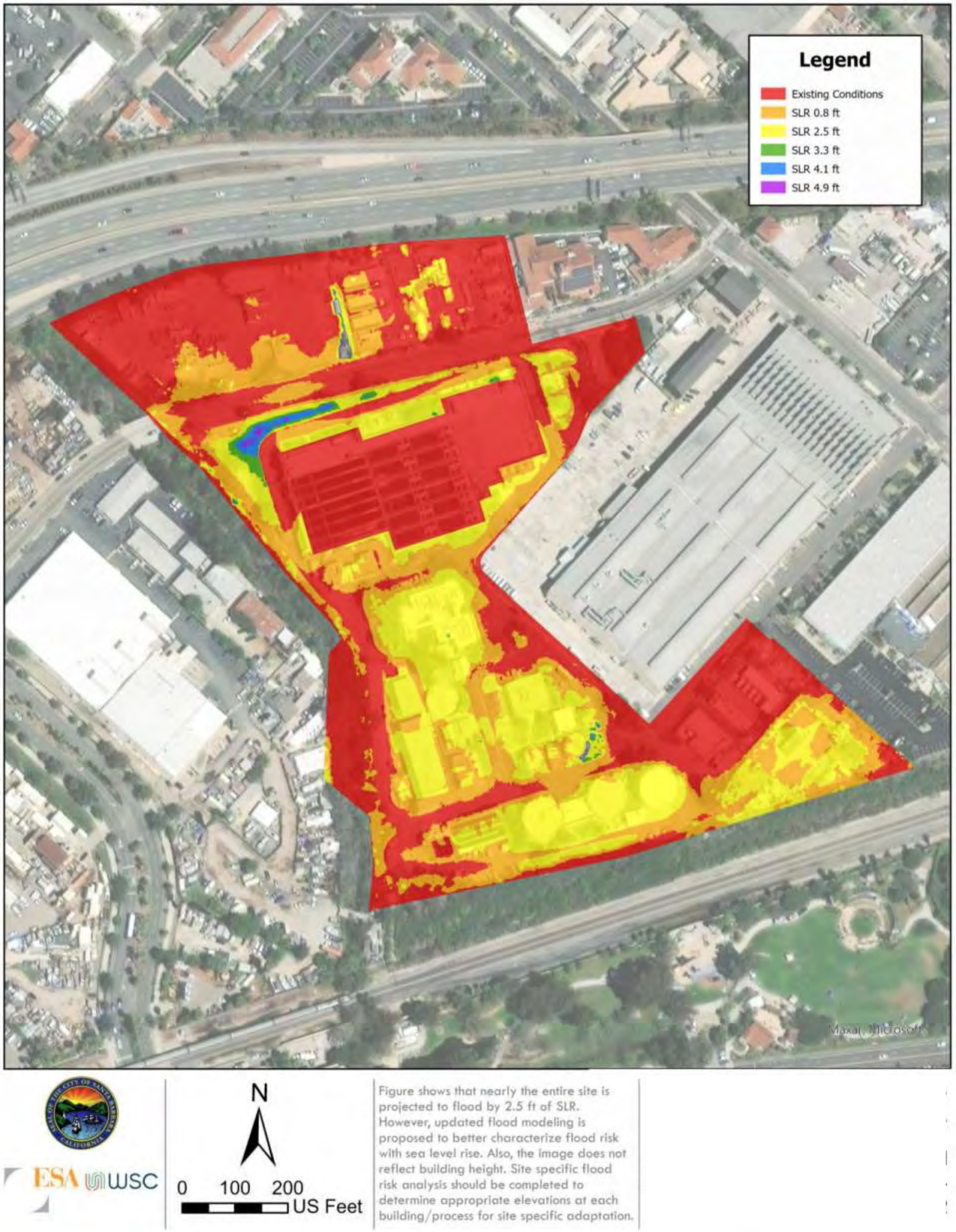
Notes:

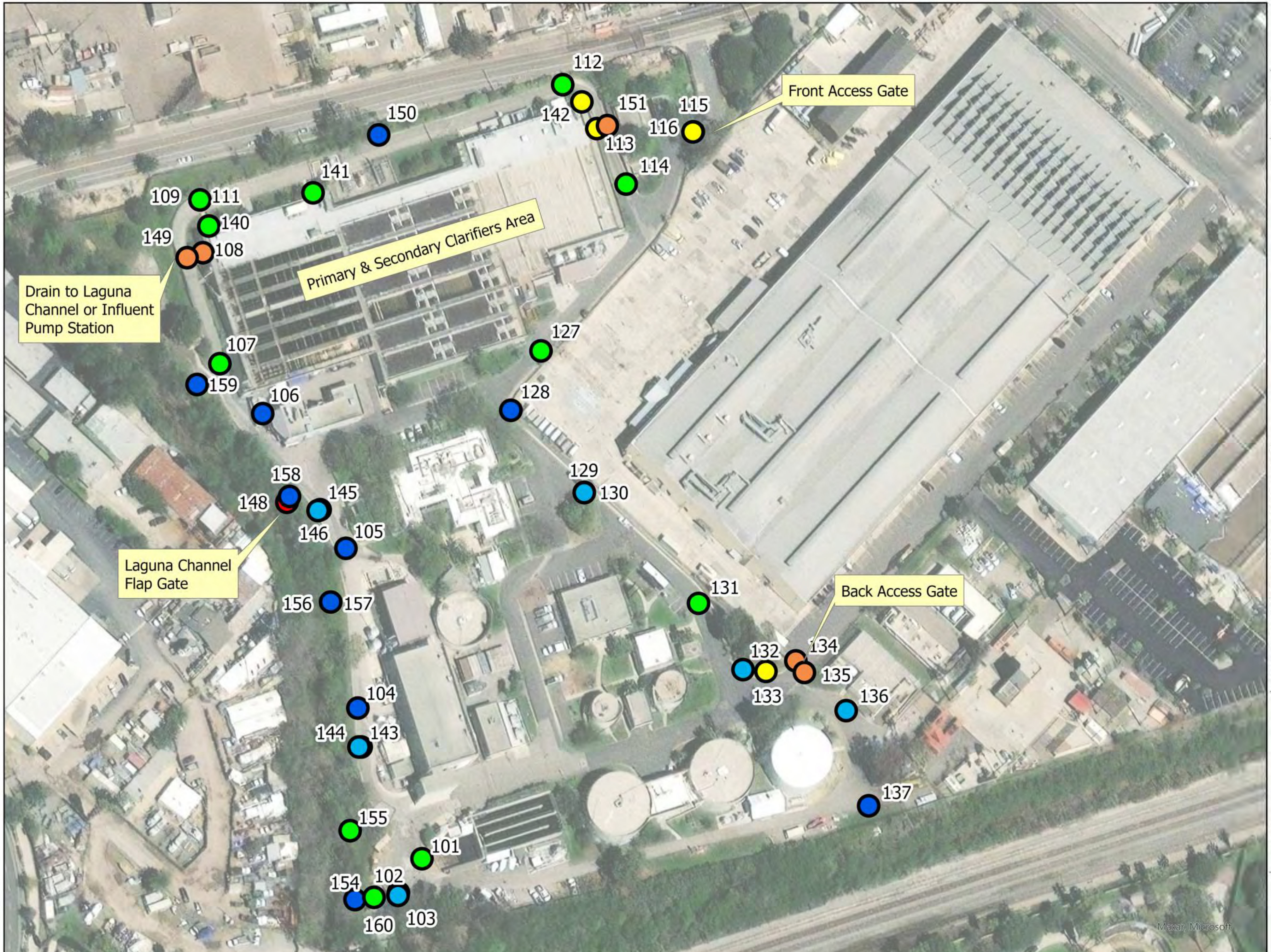
1. Flood elevations are conservatively assumed to rise the same amount as sea level rises. Flood modeling with sea level rise is recommended to more accurately estimate flood elevations with sea level rise.
2. See footnote 7 at the bottom of this page for considerations for "FEMA 100-year storm."

The Project team conducted a site visit with City staff at El Estero WRC in January 2024 to review low-lying areas within the site. This information was used to identify potential vulnerability to onsite flooding. The Project team captured elevations at points along the perimeter of El Estero WRC for comparison with estimated historical FEMA 100-year flood levels, shown in Figure 4-3.

[7] Refer to Section 2.2.2.3 for a discussion of the projected increased frequency and severity of the historical "FEMA 100-year storm." For example, the existing 100-year storm is projected to become a 20-year storm with climate change.

Figure 4-2. El Estero WRC and Desalination Facilities, FEMA 100-yr Flood with Sea Level Rise





Water & Wastewater Climate Adaptation Project

Figure 4-3. Survey Points Measured Compared to Historical FEMA 100-yr Flood Depth

Legend

Depth of Flooding

- >8'
- 5'-8'
- 2'-5'
- 1'-2'
- 0-1'
- Not Flooded

Notes

1. Labels used to reference point location (not an elevation).
2. Survey data measured by ESA on 1/12/2024 during site visit. Elevation data based on NAVD88 to inform elevation and flooding analysis for the Water & Wastewater Climate Adaptation Project. Exact elevations should be confirmed by a licensed surveyor during design of any mitigation efforts.
3. Estimated flood depths based on existing FEMA 100-yr flood mapping and projected sea level rise amounts.

N

0 0.02 0.04 Miles

0 100 200 US Feet

WSC

As shown in Figure 4-3 during a historical FEMA 100-year storm, most of the elevation points are estimated to experience flooding to some extent. However, if flood water is prevented from making its way onsite, the depth of flooding may be reduced or eliminated. For example, Point 149, in the north-west corner of the property, was identified as the lowest point within the site and could experience up to 6.4 ft of flooding under the historic 100-year storm. Unless prevented from entering the building, this would bring water into contact with critical electrical and controls equipment located under the primary and secondary clarifiers and aeration basins.

Overall, the most vulnerable areas within El Estero WRC regarding elevation and low-lying points, discussed in the sections below, are:

- Primary and secondary clarifiers area (flood depths range from 4.6 to 7.6 ft) (Section 4.2.3)
  - Electrical and controls systems near secondary clarifiers (Point 108, existing flood depth of 5.6 ft; Point 113, existing flood depth of 4.6 ft)
  - NW plant drain (Point 149, existing flood depth of 6.4 ft)
  - NE plant drain (Point 151, existing flood depth of 5.2 ft)
- Electrical equipment located in different locations across the plant (Section 4.2.4)
- Back access gate (Point 134, existing flood depth of 5.8 ft), located off Quinientos Street (Section 4.3)
- Front access gate (Point 115, existing flood depth of 3.9 ft) located off Yanonali Street (Section 4.3)

The entire plant is vulnerable to flooding with projected sea level rise, but the analysis conducted for this study focused on the most vulnerable components.

4.2.2 Onsite Stormwater Management System

El Estero WRC is located on an approximately 13.5-acre site that is relatively flat with elevations ranging between approximately five and 18 ft above sea level. El Estero WRC sits on a manmade knoll of fill material, with stormwater draining to the edges of the site on all sides. El Estero WRC is located on the eastern bank of Laguna Creek and is notably higher than the western bank. When Laguna Creek fills, water would overtop the western bank prior to overtopping the eastern bank alongside El Estero WRC.

Stormwater runoff from 51 percent of the site is “uncontained” and is currently discharged off site without treatment. These uncontained areas are associated with either undeveloped areas around the perimeter of El Estero WRC or landscaped areas and planters throughout the site. Stormwater runoff from the remaining 49 percent of the site is either “contained” or “partially contained” and is routed into the headworks of El Estero WRC where it is combined with sewer flows (CDM, 2016). Two partially contained drainage areas along the west side of El Estero WRC discharge stormwater to the headworks under most conditions; they have weirs within the catch basin that allow for overflow to Laguna Creek during extreme events when flooding occurs along the within edges of El Estero WRC. However, on-site stormwater is unlikely to flow too far past the weir to the Laguna Creek since the creek is likely to have high flow levels during these events.

The existing catch basins on the east and west sides of the primary and secondary clarifiers each have two outlets that can discharge either to the plant drain that flows to the headworks or to a storm drain pipeline that flows to Laguna Creek. Each outlet has a gate valve to control the direction of flow. Since Laguna Creek is typically full during storm events, the City keeps this valve closed to reduce risks of Laguna Creek water backing up onsite such that flow is directed to the plant headworks. However, if this valve were to fail, El Estero WRC could potentially experience additional flooding from Laguna Creek water backfilling through this valve. As discussed below, the catch basin on the west side of the clarifiers is at the lowest point in the plant site and is adjacent to critical electrical and controls equipment located underneath the secondary clarifiers.

4.2.3 Primary and Secondary Clarifiers Area

Electrical systems are critical to operations at El Estero WRC. Any interruption to electrical and power systems could cause El Estero WRC to cease operations, which could damage the plant processes, back up raw wastewater within the collections system, increase the risk of sewer overflows, and impact public health. The electrical and controls equipment underneath the clarifiers is vulnerable to flooding from waters entering from the western and eastern entrance to the structure. The equipment is raised three to 18 inches above the floor.

In addition, a roof drain directs flow from the top of the structure to an open drain along the floor of the electrical and controls from the north side of the building to the south side. The volume of flow is small but remains a flood vulnerability from spills or drain backups. There are also several stairs that enter the building with top steps at relatively high elevations.

Points of interest on Figure 4-3 include:

- Point 149 (located at an elevation of 6.5 ft) is a drain located on the western side of the clarifiers structure (Figure 4-4).
- Point 108 (located at an elevation of 7.3 ft) is the western entrance to the area under the clarifiers structure (Figure 4-5).
- Point 113 (located at an elevation of 8.3 ft) is the eastern entrance to the area under the clarifiers structure (Figure 4-6).
- Point 151 (located at an elevation of 7.7 ft) is a drain located on the eastern side of the clarifiers structure.
- Points 140, 141, and 142 (located at elevations of 14.3 ft, 14.2 ft, and 10.7 ft, respectively) are the top step of stairways.

Generally, the entrances underneath the clarifiers are protected by closing and installing portable floodwalls in front of the rolling access doors prior to the beginning of a storm event. However, access is limited to stairways around the clarifier building when these protective measures are in place.

Figure 4-4. Southern View from Point 149

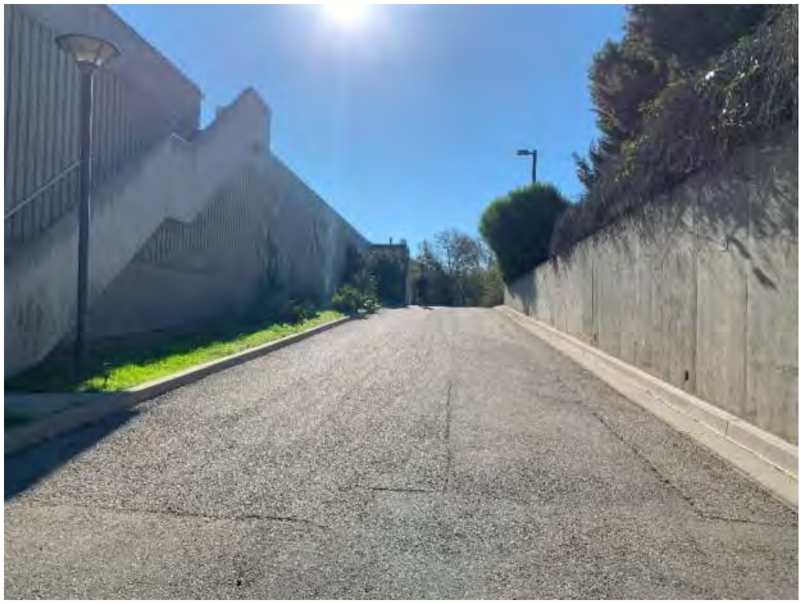


Image Note: Photo taken at Survey Point 149 facing south. Photo shows the slope that leads to this survey point. The concrete wall and vegetation shown on the right-hand side of the photo above act as a barrier to flow captured above; flow above and to the right of this wall is primarily conveyed in the opposite direction towards Laguna Creek. Flow within paved areas of the plant site may flow down this slope to Point 149, a plant drain, and conveyed to plant headworks.

Figure 4-5. Western Entrance to Electrical Systems below Aeration Basins (Point 108)

Image Note: Photo taken at Survey Point 108/149 facing the east. Photo shows the western entrance to area below primary and secondary clarifiers and aeration basins. Access to this area is through a large entrance. During storm events, a rolling door comes down to close access. Portable floodwalls are also placed in front of the rolling to door to further prevent water from entering the area and maintain the integrity of the rolling door.

Figure 4-6. Eastern Entrance to Electrical Systems below Aeration Basins (Point 113)

Image Note: Photo taken at Survey Point 113, facing the west. Photo shows the eastern entrance to area below primary and secondary clarifiers and aeration basins. Access to this area is through a large entrance. During storm events, a rolling door comes down to close access and prevent water from entering the area.

4.2.4 Electrical Systems

El Estero WRC includes four electrical substations onsite that store electrical equipment within a building. The doors leading to these facilities include louvers. When water is high enough, water could potentially enter the electrical substation through the louvers and cause damage, as shown in Figure 4-7. The City has elevated many electrical systems to reduce failure from flooding. However, valve vaults and any electrical conduits and duct banks located close to the ground may still be susceptible to flooding.

There are electrical systems installed outdoors at the brine box awning near the outfall manhole/brine mixing chamber that is susceptible to flooding (shown in Figure 4-8). A junction box is located in this area for sample pumps; however, these sample pumps are redundant and are a lower priority. Additional sample pumps have been installed upstream and downstream of this structure and are primarily used.

Figure 4-7. Electrical Substation C

Image Note: *Electrical substations onsite include access doors with louvers. The lowest opening is approximately 18 inches above the ground surface. Sea level rise between 0.8 ft and 2.5 ft may increase flood levels enough to enter the electrical substation through the louver openings.*

Figure 4-8. Electrical Systems at the Brine Box

Image Note: *Electrical systems installed at the Brine Box may be susceptible to flood depths of an estimated four ft or more. Although electrical systems currently located here are redundant, the City may wish to preserve them in the event that they are needed for use.*

4.2.4.1 Influent Lift Station

The influent pump station at El Estero WRC is critical to El Estero WRC operations and is at risk from subterranean flooding. City staff noted that during storms, incoming wastewater fills the channels within the influent pump station and approaches the metal grate platform in the influent pump station. In such conditions, working inside the influent pump station is a safety risk. Electrical systems within the pump station are rated to NEMA 4, Class 1, Division 1 to withstand temporary saturation.

4.2.5 Adaptation Options

Onsite flooding adaptation options could require substantial investments by the City, so additional flood modeling will better characterize the flood risk beyond the historical 100-year flood and with sea level rise. The analysis proposed in the **Stormwater Model and Flood Analysis Report** (see Section 3.4.3) is expected to provide valuable insight to inform the City's adaptation approach for flooding surrounding El Estero WRC.

Onsite flooding adaptation options can be generally grouped into three categories:

- Protect individual components.
- Prevent flood waters from coming onto El Estero WRC.
- Relocate El Estero WRC inland to an area better protected from coastal and stormwater flooding hazards.

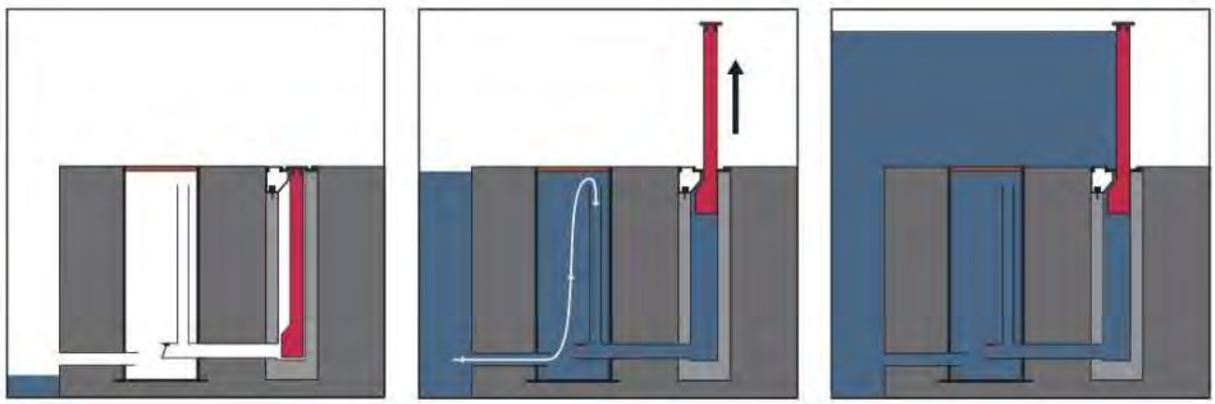
These options are described below along with an initial comparison of options. A more robust alternatives development and analysis that is based on flooding levels and recurrence projections from the Stormwater Model and Flood Analysis Report is recommended and the findings of that report are recommended to inform an El Estero WRC Flood Protection Study. The El Estero WRC Flood Protection Study would include:

- The identification of process-specific vulnerabilities and potential protection measures.
- A preliminary characterization of site protection (e.g., floodwall system).
- A comparison of process-specific protection measures versus sitewide protection measures.

4.2.5.1 Protect Individual Components

The City currently uses portable floodwalls at the rolling doors underneath the primary and secondary/aeration basins to reduce the risk of flood waters from reaching the electrical and controls systems. The City could install more robust and permanent flood barriers that remain below ground during normal operations and can be activated during flood risk events, such as automated self-closing flood barriers (see Figure 4-9). The more permanent barriers cost $300,000 to $1,000,000 with installation, depending on the complexity of retrofitting the barrier into existing buildings. The costs would be better defined as part of the proposed El Estero WRC Flood Protection Study.

Figure 4-9. Self-Closing Flood Barriers Schematic



Source: Self-Closing Flood Barriers Data Sheet (Flood Control International, n.d.)

The City could elevate El Estero WRC processes, as needed, to an elevation above anticipated flood conditions with sea level rise. This would be based on the flooding findings of the Stormwater Model and Flood Analysis Report. The El Estero WRC Flood Protection Study is recommended to include identification of process-specific vulnerabilities and potential protection measures for comparison with sitewide measures.

4.2.5.2 Protect El Estero WRC Site

El Estero WRC is already elevated, but additional protection may be obtained with construction of a floodwall system surrounding the perimeter. A floodwall system would provide a barrier to oncoming water and potentially reduce the need for process-specific protection measures onsite. The City may install a floodwall system along the El Estero perimeter at lower elevations, such as along Laguna Creek and the southern boundary of the site, rather than the entirety of the site. Additionally, the City may install automated flood barriers at entrances that deploy only during storms. Compared with individual process protections, the floodwall system would also prevent off-site storm water from entering plant drains, which discharge to the influent pump station and must be pumped, treated, and discharged to the ocean, creating even more capacity issues.

Ultimately, a floodwall system surrounding the entire site would need to provide a continuous barrier from off-site flooding. Floodwall systems are expensive but reliable measures to protect against flooding. A floodwall system would be needed by 0.8 ft of sea level rise (~2050) to prevent the historical 100-year storm from overtopping the Laguna Creek banks and flowing to the western side of the clarifiers structure. The cost of a floodwall system would range from $10 million to $30 million depending on the length and height needed, and most importantly, subsurface stabilization requirements. The costs would be better defined as part of the proposed El Estero WRC Flood Protection Study.

Even with flood barriers to protect the equipment underneath the clarifiers, the storm flow would be routed via storm drains to the influent pump station and contribute to plant capacity issues (discussed in Section 4.2.2).

4.2.5.3 Relocate El Estero WRC

The City may relocate El Estero WRC inland to avoid coastal and stormwater flooding vulnerabilities. The relocation concept is described in detail in Appendix C and assumes that the Desalination Plant and potable reuse treatment plant would be relocated to the same location. The wastewater component of the relocation concept includes:

- A new water reclamation facility, including treatment processes and supporting facilities, at a location inland from coastal hazards and outside of stormwater flood hazards.
- The conversion of the existing influent pump station into a lift station that could convey peak wet weather flows from the existing El Estero WRC site to the new water reclamation facility.
- A force main to convey sewage from the existing El Estero WRC site to the new water reclamation facility as well as diversions with lift stations from the existing collection system to the new force main.
- An onshore outfall pipeline to convey treated wastewater from the new plant to the existing ocean outfall for discharge to the ocean.

The relocation concept project in Appendix D was developed for the City to better understand the rough cost to implement a new water reclamation facility and to inform near- and mid-term decision making that could support this pathway.[8] **However, with estimated costs of over $870 million and a long implementation time required, investments in and around El Estero WRC to avoid relocation are likely worthwhile.**

4.2.6 Adaptation Recommendations

Immediate Next Steps (0-5 Years)

Additional data collection and analysis is recommended to be completed in the immediate near term to further define vulnerabilities and build confidence on a path toward adaptation. Recommended immediate next steps include

- **Stormwater Model and Flood Analysis Report:** A comprehensive flood study for lower-level storm events surrounding El Estero WRC to fill data gaps, such as the extent and recurrence of flooding with climate change and help refine flood protection alternatives.
- **El Estero WRC Flood Protection Study:** Evaluate and recommend phasing of flood protection measures considering Stormwater Model and Flood Analysis Report findings. Conduct a detailed elevation survey of El Estero WRC components to identify the elevation when protection measures are needed for specific treatment process components. Compare the merits of protecting individual processes or protecting the

[8] There will be opportunities to refine and optimize the relocation project concept, such as a new ocean outfall or alternative force main alignments, prior to detailed planning and design. The City may conduct these efforts as part of regular updates to this Plan and as the likelihood of relocating El Estero WRC becomes a more likely option.

whole site with a floodwall system. The study would define a phased approach to provide flood protection through 2.5 ft of sea level rise (~2075).

The City may also collect groundwater levels in or around El Estero WRC to support future analysis of shallow groundwater impacts on infrastructure. The City may also clarify on-site stormwater management policies and requirements to determine how to best manage flood water that comes onsite. Most stormwater is routed to the headworks, so additional flows from flooding have the potential to overwhelm the influent pump station.

Near-Term (Through 0.8 ft SLR (~2050))

The City may implement the recommendations identified in the El Estero WRC Flood Protection Study to provide near-term flood protection through 0.8 ft of sea level rise (~2050) and design permanent measures for higher levels of protection. Options to be considered include protecting individual components, like elevating specific equipment and/or installing flood gates, or protecting the site with a floodwall system.

As part of long-term planning, the City may consider reserving areas in City-owned property as potential sites for a future new water reclamation facility due to the limited number of feasible new plant locations.

Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075))

Update the flood protection study and implement additional protection measures considering:

1. Updated hazard and vulnerability assessments, especially timing of sea level rise.
2. Proficiency of flood protection measures implemented in and around El Estero WRC.
3. Long-term risks for El Estero WRC.

For example, moving El Estero WRC would reduce benefits associated with certain adaptation measures and make them less cost effective.

Long-Term (2.5+ ft SLR (~2075+))

The need to relocate El Estero WRC will be dependent on the cost and reliability of flood protection options combined with hazards discussed later in this Plan – access issues to the plant during flooding events and capacity issues at the plant and in the collection system during storm events (Section 4.2 and 5.2, respectively).

Stormwater flooding is expected to increase in intensity and recurrence with climate change. The proposed Stormwater Model and Flood Analysis Report would better define the extent and recurrence of flooding around El Estero WRC, which will enable the City to better define the potential timing of El Estero WRC relocation. In addition:

- By 3.3 ft of SLR, stormwater flooding will be compounded by coastal storm flooding.
- By 4.1 ft of SLR, tides will regularly flood some coastal areas.
- By 4.9 ft of SLR, tides will regularly flood areas around El Estero WRC.

The timing of relocation is planned to be reevaluated during the next Plan update to incorporate the latest hazard projections and the effectiveness of initial adaptation measures. The City may expect to initiate planning at least 20 years ahead of when El Estero WRC is projected to be relocated.

4.3 El Estero WRC Access during Offsite Flooding

The areas surrounding El Estero WRC are prone to flooding under existing conditions and lower-level storms compared to the 100-year storm. Estimated flood depths under the historical FEMA 100-year storm for several key access points in the vicinity of El Estero WRC are shown in Figure 4-10. The range of elevations indicates that nearly all the areas surrounding El Estero WRC contain low points lower than the current FEMA base flood elevation.

In the past few years, there have been brief periods (less than 12 hours) when the plant has not been accessible by City staff due to flooding on roads surrounding the plant and the plant entrances. For example, the January 9, 2023, flood event in the City, which was approximately a 10-year event, prevented access to El Estero due to three to four ft of flood depth at the back gate and flooding of streets approaching the front entrance. Lack of safe access inhibits staff, solids hauling, and chemical deliveries from coming and going from the site. Operations staff have extended shifts until access was feasible and safe. However, to date, the brief flooding has not substantially impacted staff.

By 0.8 ft of sea level rise (~2050), flooding depth is estimated to increase to four to five ft and further increase to five to six ft by 2.5 ft of sea level rise (~2075) combined with the historical FEMA 100-year storm. Climate change is anticipated to increase the frequency, duration, and intensity of storms, which could lead to more frequent and longer periods without access to the plant.

El Estero WRC is typically staffed with a minimum of three people per shift. At a minimum, one person is always onsite. Flooding that prevents operations staff access to El Estero WRC could risk proper operation of the treatment plant and put staff's personal safety at risk. Flooding that prevents access to the plant for longer than a typical operations shift will strain on-site resources and could damage processes or equipment onsite.

Solids are hauled away from El Estero WRC Monday through Saturday via US-101. There is minimal space available onsite to store solids. If daily solids hauling does not occur due to flooded access routes, the City has limited ability to properly store solids for more than two days. Flooding that prevents access to the plant for longer than two days would force stockpiling of solids onsite, which is hazardous to humans and the environment. This could also limit access between onsite buildings, making daily operations more difficult.

Chemicals are delivered via US-101 to El Estero WRC. Chemical delivery frequency varies depending on the chemical needed. At a minimum, sodium hypochlorite is delivered every 1.5 weeks, while ferrous chloride is delivered every 3.5 weeks. The City maintains approximately 30-60 days of chemical storage onsite, and there is limited space available to expand chemical storage facilities. During storm events, El Estero WRC treats additional flow, which depletes the chemical reserve faster than during normal operations. If chemical deliveries do not occur due to flooded access routes, City staff would not be able to properly treat and dispose of wastewater. Given the longer duration between chemical deliveries, this is likely a lower-risk vulnerability.

Figure 4-10. El Estero WRC Area 100-yr Flood Depth Estimate Locations

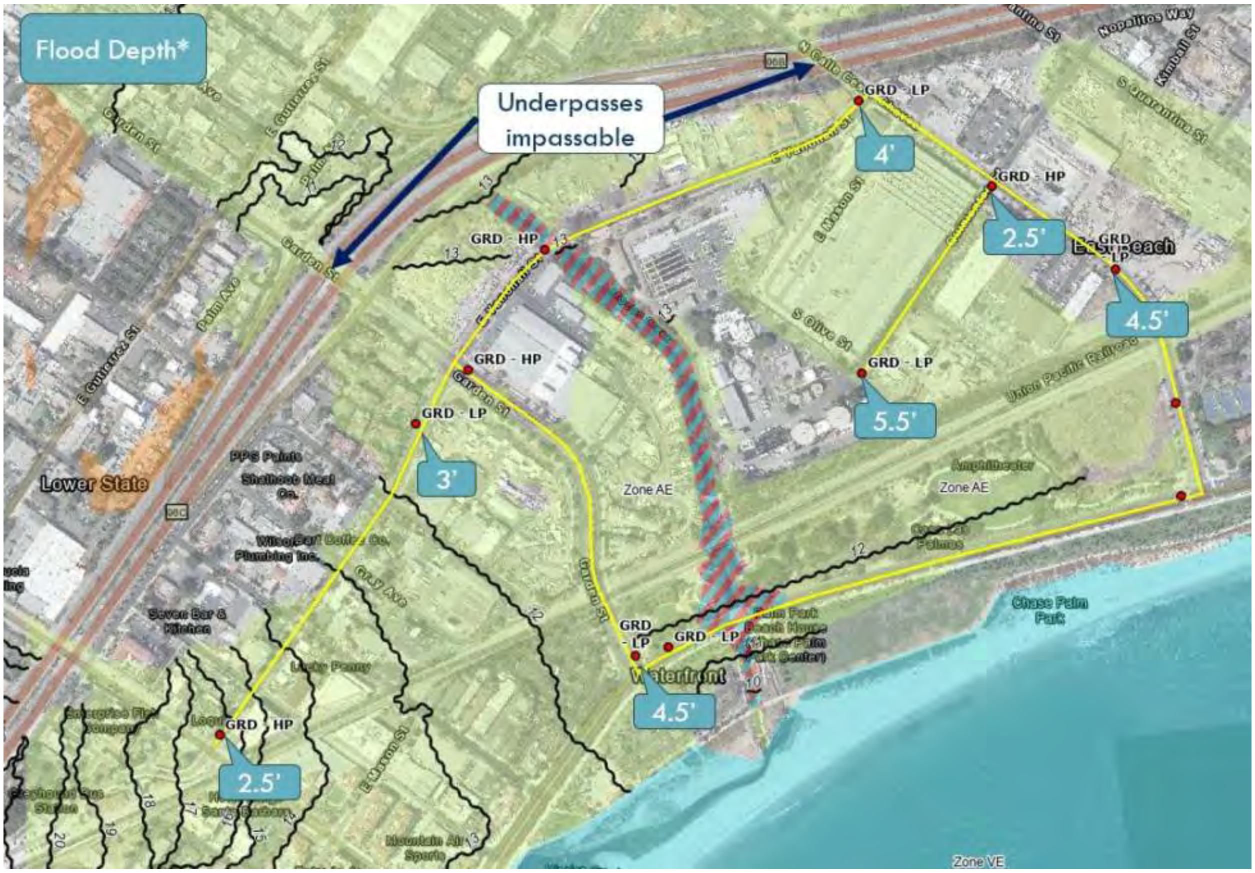


Figure Note: *This figure shows the extent of the historical FEMA 100-year flood (light green shading) and flood depth at selected road access points to the El Estero WRC area.*

Access Gates

Points 115 and 116 on Figure 4-3 were measured at the El Estero WRC front gate, which is located off Yanonali Street. Under historical FEMA 100-year flood conditions, the depth of flooding is estimated to be 3.9 ft. Flooding along Yanonali Street and Calle Cesar Chavez typically occurs during storm events, as shown in Figure 4-11. Flooding at this gate, along with the back gate, can create site access issues.

The back access gate to El Estero WRC, located on Quinientos Street, was the second lowest point measured (Point 134 on Figure 4-3). Under historical FEMA 100-year flood conditions, the depth of flooding is estimated to be 5.9 ft, which would inhibit safe access to and from El Estero WRC through this gate.

Flooding at this gate along with the front gate can create site access issues. Flooding that occurred at the back access gate during the January 9, 2023, storm is shown in Figure 4-12.

Figure 4-11. Example of Yanonali Street and Calle Cesar Chavez – January 9, 2023

Image Note: *Flooding approaching the intersection of Yanonali Street and Calle Cesar Chavez during the January 9, 2023, storm (estimated to be a 10-year, 24-hour event). This area is commonly used to access the El Estero WRC front gate.*

Figure 4-12. Example of Back Access Gate Flooding – January 9, 2023

Image Note: *Photo taken by City staff at the El Estero WRC back access gate on Quinientos Street during the January 9, 2023, storm (estimated to be a 10-year, 24-hour event). The flood waters are roughly four ft deep at the access gate in this image.*

4.3.1 Adaptation Options

The City may consider the following to manage access to El Estero WRC during storms:

- Formalize operation practices during flood conditions in an El Estero WRC Flood Conditions Operations Plan.
- Construct improvements to enable plant operations for 24+ hours without access.
- Plan for and purchase equipment to transport staff to/from the plant during flood conditions.
- Change access road elevations to prevent flooding.

El Estero WRC Flood Conditions Operations Plan

To prepare for storms, the City commonly temporarily houses operators in local hotels to avoid regional access issues that are common, such as flooding of Highway 101 north or south of the City. The City could build on this practice and other existing measures and formalize its flood conditions operations practices in an El Estero WRC Flood Conditions Operations Plan to prepare staff prior to storms and guide staff during flood conditions to ensure their safety and continued service. The El Estero WRC Flood Conditions Operations Plan may include:

- Communication protocols.
- Extended operator shifts.
- Available vehicles.
- Solids management.

In addition to existing practices, the City may evaluate detailed procedures for:

- Extended operator shifts, including support facilities to house staff for extended durations (dormitories, food, water, etc.).
- Contract additional trailers for solids management and storage for 24+ hours without access.
- Proactive chemical deliveries for 5+ days without access.

For staff access, the City may purchase high-clearance, reliable access vehicle(s) combined with an offsite staff parking location for use during flood events. The vehicles would need to reliably and safely traverse flooded roads and staff must be certified to operate the vehicles. When combined with an offsite parking location, vehicle routes are expected to be pre-determined since driving through flood waters in certain areas is not safe in any vehicle.

The El Estero WRC Flood Conditions Operations Plan should be completed as soon as possible to document the current flood response. Once the Stormwater Model and Flood Analysis Report is completed, the El Estero WRC Flood Conditions Operations Plan should also be updated based on a better characterization of future flood depth and recurrence.

Road Access Improvements

Larger-scale access solutions may include partnership opportunities with the California Department of Transportation (Caltrans) to redevelop the existing underpasses at the intersections of US-101 with Garden Street and Calle Cesar Chavez. Alternatively, a new US-

101 offramp directly to the El Estero WRC site could be constructed for use by City staff and emergency personnel only. Access could be secured by constructing a private lane on US-101, with a concrete barrier to limit access to appropriate personnel.

El Estero WRC Relocation

A conceptual adaptation measure to relocate El Estero WRC out of the coastal and stormwater flooding hazards area is described in Section 4.2.5.3 and detailed in Appendix B. Relocating El Estero WRC would avoid access issues during flood conditions at the current site.

4.3.2 Adaptation Recommendations

Immediate Next Steps (0-5 Years)

The City could formalize an El Estero WRC Flood Conditions Operations Plan to document existing flood conditions operations practices and consider topics discussed in Section 4.3.1. This includes communication protocols, extended operator shifts, available vehicles, and solids management. Investment is expected to be limited during the next immediate steps.

Near-Term (Through 0.8 ft SLR (~2050))

The City may reevaluate flood preparation following the completion of the Stormwater Model and Flood Analysis Report, which would better characterize flood risks, to determine if larger investments to provide access up to 0.8 ft of sea level rise (~2050) are warranted. These include options like onsite accommodations for operators, equipment to transport staff to/from the plant, and additional solids management capacity, as discussed in Section 4.3.1.

Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)) & Long-Term (50+ Years)

The City may consider updating the previous flood operations analysis and implementing recommendations considering:

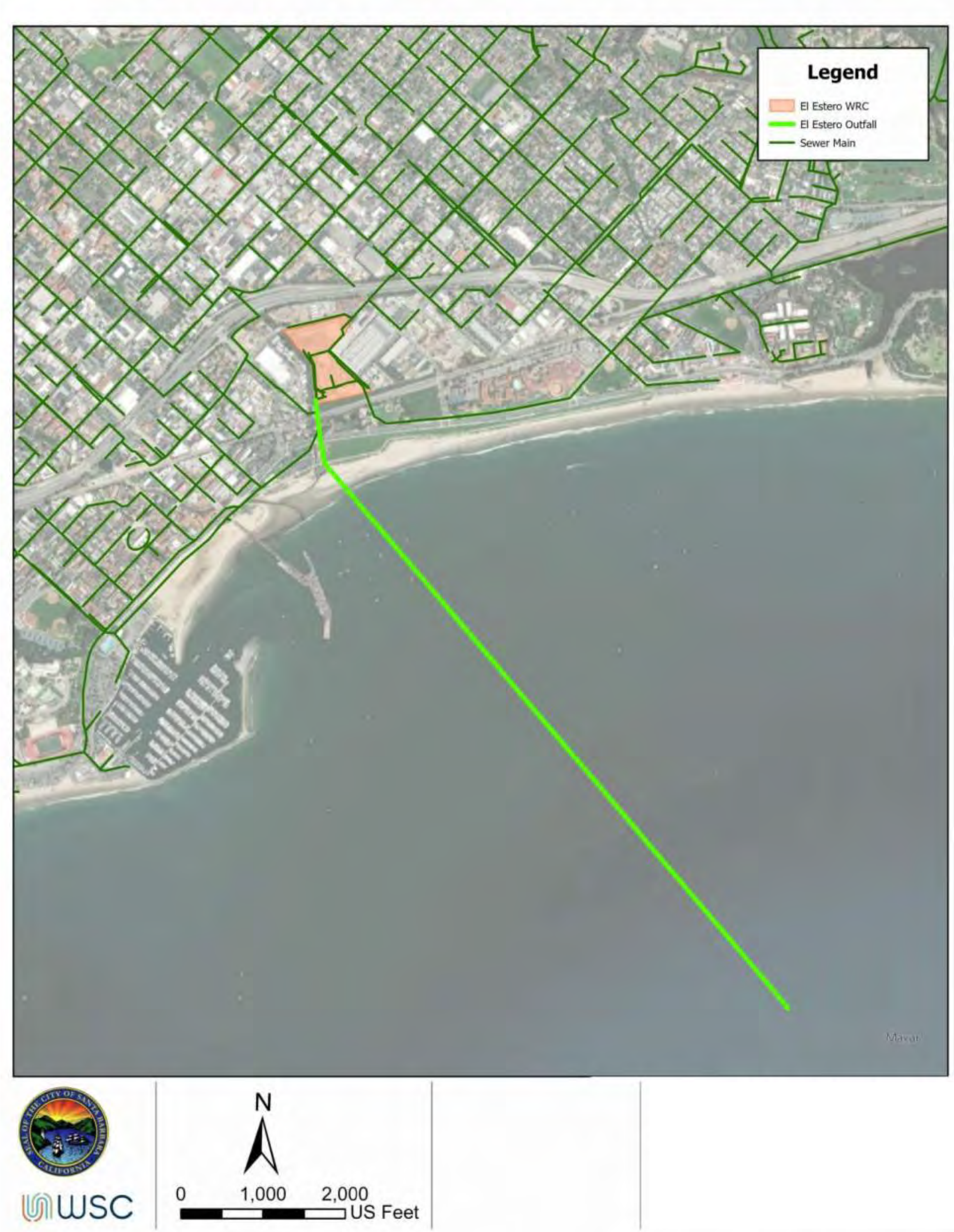
1. Updated hazard and vulnerability assessments, especially timing of sea level rise.
2. Proficiency of implemented local and regional measures.
3. Long-term plans for El Estero WRC.

For example, moving El Estero WRC would reduce benefits associated with certain adaptation measures and make them less cost-effective. If El Estero WRC does not plan to relocate for another 50+ years, major investments in access improvements discussed in Section 4.3.1 may be considered, including major local road improvements or new, private Highway 101 offramp.

4.4 El Estero Outfall

Disinfected and dechlorinated secondary treated wastewater from El Estero WRC, desalination brine, and waste brine are discharged to the Pacific Ocean through the El Estero outfall system constructed in the 1970s. The outfall system, shown in Figure 4-13, begins at the El Estero WRC as an underground pipeline approximately 800 ft in length. This is referred to as the “onshore outfall,” and it transitions to an 8,720-foot long “ocean outfall” pipeline to the Pacific Ocean.

Figure 4-13. El Estero Outfall Location



4.4.1 Onshore Outfall

The onshore outfall begins at the El Estero WRC site, where the 48-inch reinforced concrete pipe (RCP) has ten or more ft of cover per manhole repair record drawings (Carollo, 2017) and spot elevations taken on site as part of the January 2024 site visit (refer to Section 4.2.1).

The 1974 record drawings (Engineering-Science, Inc., 1974) show over ten ft of pipe cover in the beach area as well. There are no available record drawings showing the pipe profile between these two locations, and a consistent 10-foot depth of cover was assumed for the purposes of this vulnerability analysis.

The first 500 ft of the onshore outfall pipe (from manhole 1B at the El Estero WRC to Cabrillo Blvd) may be vulnerable to impacts of increased, more severe flooding in a couple of ways.

First, advancing and retreating floodwaters impact soil structure, which may swell, shrink, or otherwise shift, with a common long-term effect being the development of sinkholes. Both expansion and subsidence of the ground in the pipe vicinity have the potential to impact the pipe's structural integrity, either through deflection of the pipe or separation of pipe joints. This ultimately leads to pipe cracks, breaks, and subsequent leaks and groundwater infiltration.

In this instance, the pipe itself is buried deep enough to be somewhat sheltered from the effects of soil movement, especially if it was installed similarly to the ocean outfall pipe (see Section 4.4.2). In addition, the two shallow borings drilled at the El Estero WRC site in 2016 that are closest to manhole 1B indicate a groundwater level of eight to 12 ft below ground surface (Pacific Materials Laboratory of Santa Barbara, Inc., 2016). This means the pipe likely already rests in saturated soil and would not be measurably impacted by groundwater level rise or floods from a structural point of view.

Another significant impact of floods is stormwater inflow into pipes and manholes. The impact of any additional infiltration may be minimal considering the degree to which the pipe is already subject to saturated soil.

One potential source of inflow and infiltration into the outfall is manhole 1B located at the El Estero WRC site. This manhole was repaired in 2017 and outfitted with a raised bolted manhole cover, epoxy coating on all interior surfaces, and new electrical components (shown in Figure 4-14). While these repairs may adequately address present-day inflow and infiltration concerns, the manhole does not appear to have an extended base or any means of resisting potential flotation in saturated soil, which may impact the manhole's structural stability in the future.

The remaining 200 to 300 ft of the onshore outfall pipe that terminates in the beach manhole are expected to be vulnerable to impacts of beach erosion and wave action described in the next section.

Figure 4-14. Manhole 1B at the El Estero WRC

Image Note: *Photo of Manhole 1B taken during the January 12, 2024, site visit. The manhole may be susceptible to structural issues with rising groundwater and consistent flooding. The electrical junction box shown holds electrical cables for the outfall sample pumps that may be susceptible to flooding.*

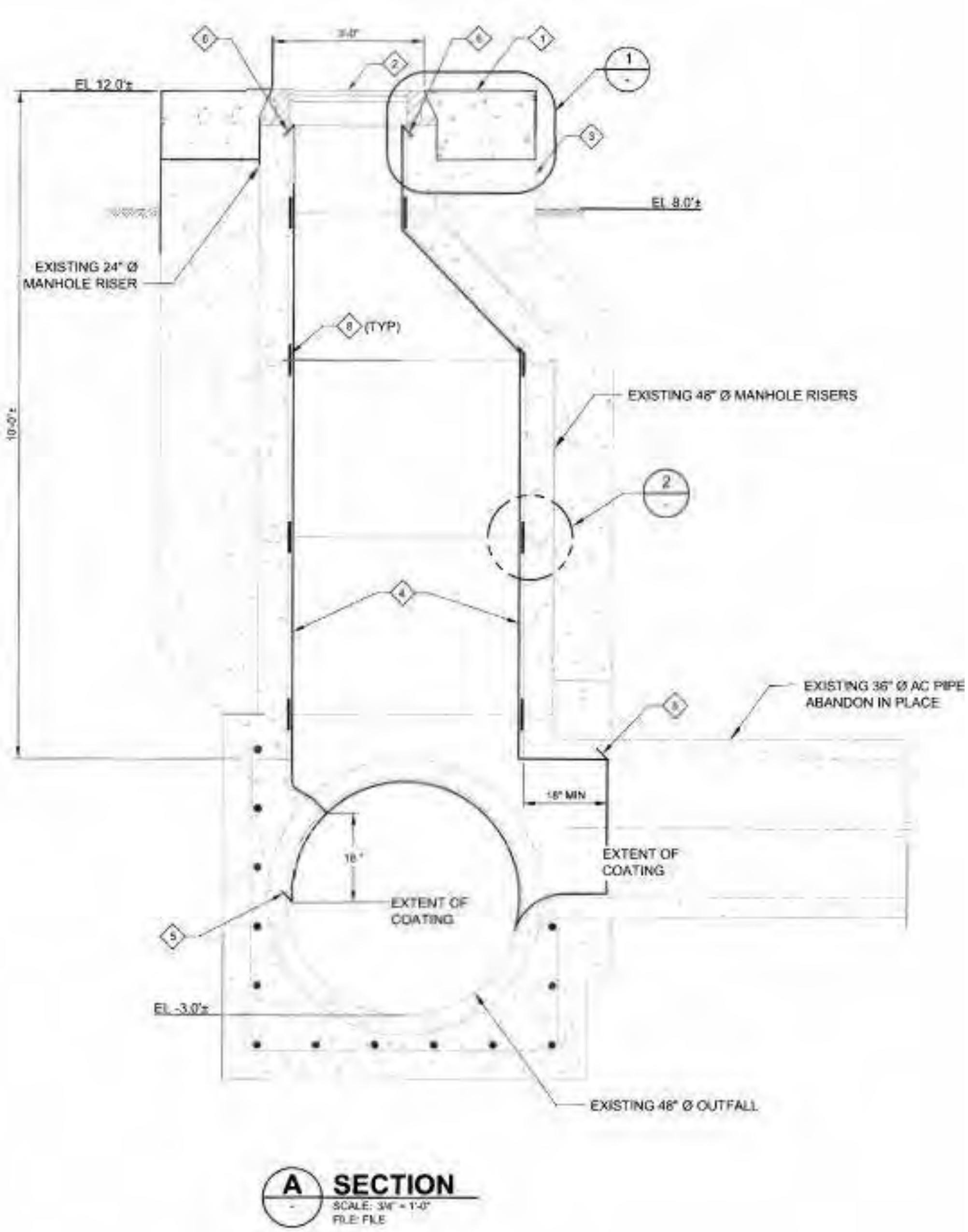
4.4.2 Ocean Outfall

The ocean outfall consists of 8,720 ft of 48-inch RCP pipe with a corrugated steel diffuser section located along the terminal 720 ft of the outfall. The first approximately 400 ft of the ocean outfall are buried in the beach. The next 3,400 ft are buried under the ocean floor, and the remaining approximately 5,000 ft rest on the ocean floor.

The beach segment of the outfall pipe was installed on two or more ft of gravel bedding set in undisturbed soil with two or more ft of rock cover placed on top of the pipe before approximately 10 ft of compacted sand backfill (Engineering-Science, Inc., 1974). The pipe bedding and cover are held in place with deep sheet piles located two feet to each side of the pipeline.

The ocean outfall pipe originates from the beach manhole of which there are no available record drawings. This manhole is currently used for closed circuit television inspection (CCTV) of the outfall pipe. A typical section view of a manhole is provided in Figure 4-15 for informational purposes.

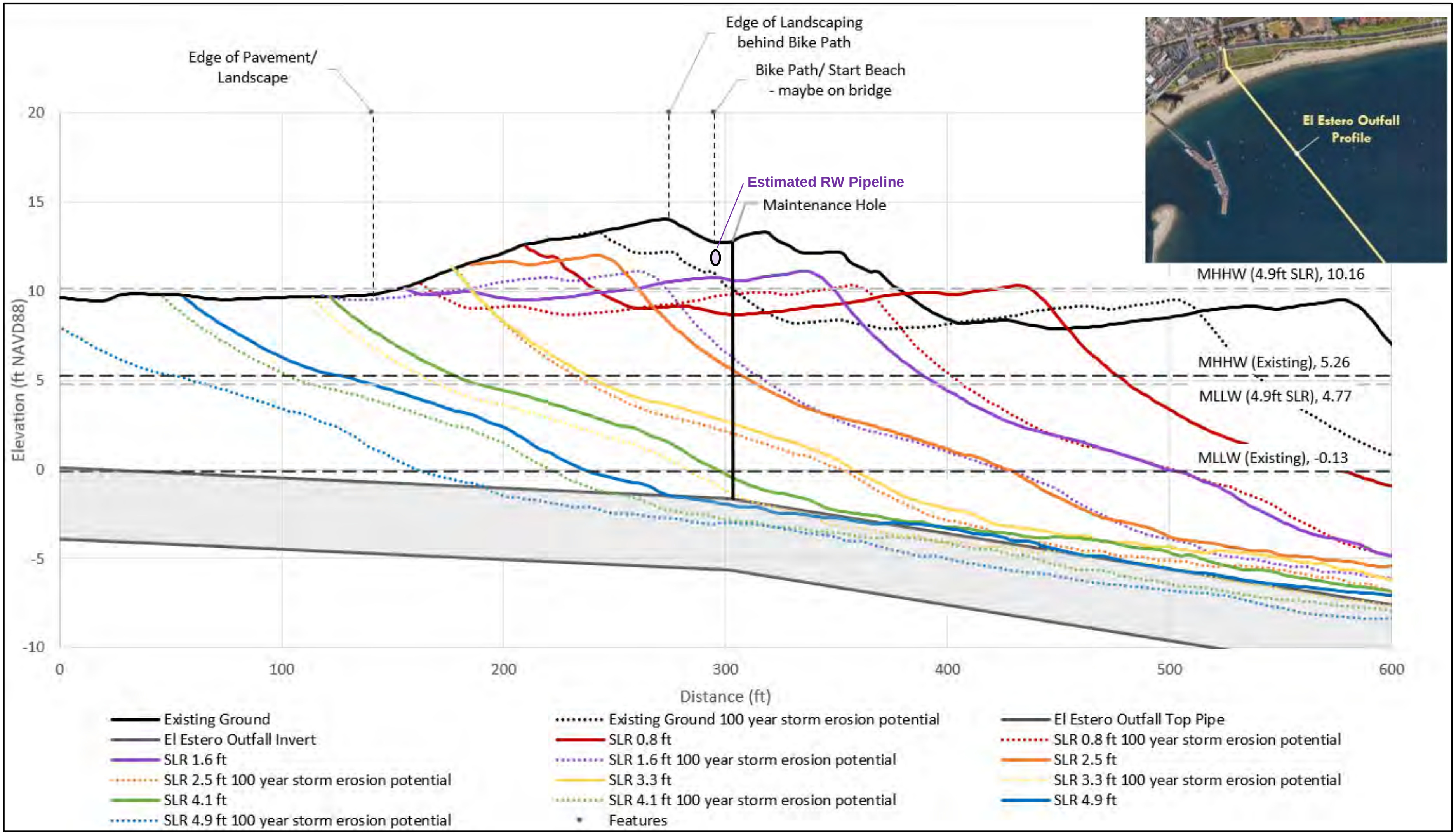
Figure 4-15. Typical Manhole Section



As shown in Figure 4-16, the beach area where the outfall pipe is buried and the outfall manhole is located is expected to be subject to significant erosion and access limitations from sea level rise and storm events. The outfall manhole impacts include:

- **Existing:** The top of the manhole is currently at the beach surface level and may be exposed with a 100-year storm.
- **0.8 ft SLR (~2050)**: The manhole structure is exposed roughly five ft above beach surface.
- **2.5 ft SLR (~2075)**: The manhole structure is exposed roughly seven ft above the beach surface.

Figure 4-16. Erosion Potential with Sea Level Rise, El Estero Outfall



The El Estero outfall ***manhole*** *is projected to be exposed with a 100-year storm and exposed five ft above the beach surface at 0.8 ft of sea level rise (~2050) due to erosion. The El Estero outfall* ***pipeline*** *has the potential to be exposed at 2.5 ft of sea level rise (~2075) due to erosion but is not projected to be undercut by erosion. This analysis excludes any beach nourishment or protection measures that are being considered by the City.*

The outfall pipeline is not projected to be impacted until 2.5 ft of sea level rise (~2075), when loss of beach (sand) cover would expose the rock armor on top of the outfall pipe to wave action. During storms, there may be locations where the top rock armor is washed away completely, exposing the outfall pipe. Loss of cover combined with wave action could lead to loss of structural integrity of the outfall pipe. How much cover can be lost with minimal consequences typically depends on the pipe diameter, length of pipe exposed, pipe material, and environment; it can be difficult to predict with confidence. Once half of the pipe diameter is exposed, the onshore portion of the ocean outfall pipe will be at moderate risk of structural failure. None of the sea level rise scenarios examined predict half of the ocean outfall pipe diameter exposed, and there appears to be limited risk of an unsupported free span of the outfall or undercutting of the manhole foundation. However, transition towards surf zone conditions and associated exposure to increased wave action was not factored into this assessment, and anticipated outfall erosion could be more severe than predicted.

In addition, the exposed parts of the manhole and outfall pipe would be underwater at 2.5 ft of sea level rise (~2075), which may lead to loss of concrete pipe material and corrosion of the reinforcing bars, compounding risk of reduced durability and life expectancy of the structure. It's worth noting, however, that more than half of the ocean outfall pipe sits directly on the ocean floor, only partially covered with ballast rock, with the top of the pipe exposed to sea water. No corrosion-related structural concerns have been reported to date for this stretch of the pipe, although it is important to note that:

- It is possible that problem areas have been missed during underwater inspections due to rock cover.
- This stretch of pipe is not subject to impacts of wave action in the way the onshore portion of the pipe would be. Wave action can significantly speed up degradation of concrete and corrosion of the reinforcing bars.

4.4.3 Adaptation Recommendations

The outfall's onshore manhole is projected to be exposed from erosion by 0.8 ft of sea level rise (~2050) while the outfall pipeline is anticipated to be exposed after 2.5 ft of sea level rise (~2075).

4.4.3.1 Manhole

By 0.8 ft of sea level rise (~2050), shoreline and coastal storm erosion is projected to expose up to about 5 ft of the outfall's onshore manhole. The manhole could be surrounded by ocean water at low tide by 2.5 ft of sea level rise (~2075). The manhole is not currently used by the City and can be abandoned.

4.4.3.2 Pipeline

The outfall pipeline is anticipated to be resilient to the impact of shoreline erosion due to its depth of installation, protection by sheet piles on both sides, and significant quantity of rock armor overlying the pipe.

The pipeline is not projected to be exposed until after 2.5 ft of sea level rise (~2075). When the pipeline is eventually exposed, it will be fully submerged. Other segments of this pipeline have been submerged under water for decades and have performed well. After 2.5 ft of sea level rise (~2075), the outfall will require more frequent monitoring for potential impacts from shoreline erosion. Condition assessment is a critical component of adaptation, and regular assessments of the outfall could be conducted as described for all shoreline infrastructure in Section 9.3.1.3.2.

Note that the condition of this pipeline is already monitored during the regularly scheduled inspections required by the NPDES permit to ensure the proper operation and structural integrity of the system.

4.5 Groundwater Rise

As shown in Figure 3-10 through Figure 3-16, groundwater levels below El Estero WRC are estimated to be between 3.3 to 6.6 ft based on groundwater modeling from CoSMoS. However, borings completed onsite during infiltration testing in 2016 measured groundwater closer to 8 to 12 ft below the surface. The year 2016 was the end of a multi-year drought period, which may have been the cause of the lower groundwater levels identified in the borings. Also, shallow groundwater levels can vary between wet and dry seasons, wet and dry years, and tidal changes.

Shallow groundwater data could be collected to properly interpret modeling data from CoSMoS to estimate risk from shallow groundwater. Groundwater data from the USGS monitoring well at the El Estero WRC site was not used in this vulnerability analysis as it is a deep well that does not reflect shallow groundwater conditions on site.

Shallow groundwater levels indicate that the soil is already saturated and the effects of groundwater on infrastructure may already be occurring. Saturated soil may impact the structural stability of facilities onsite, although no major impacts (such as cracking walls) have been observed. Vulnerabilities from shallow groundwater are discussed further in Section 0.

4.6 Influent Wastewater Quality

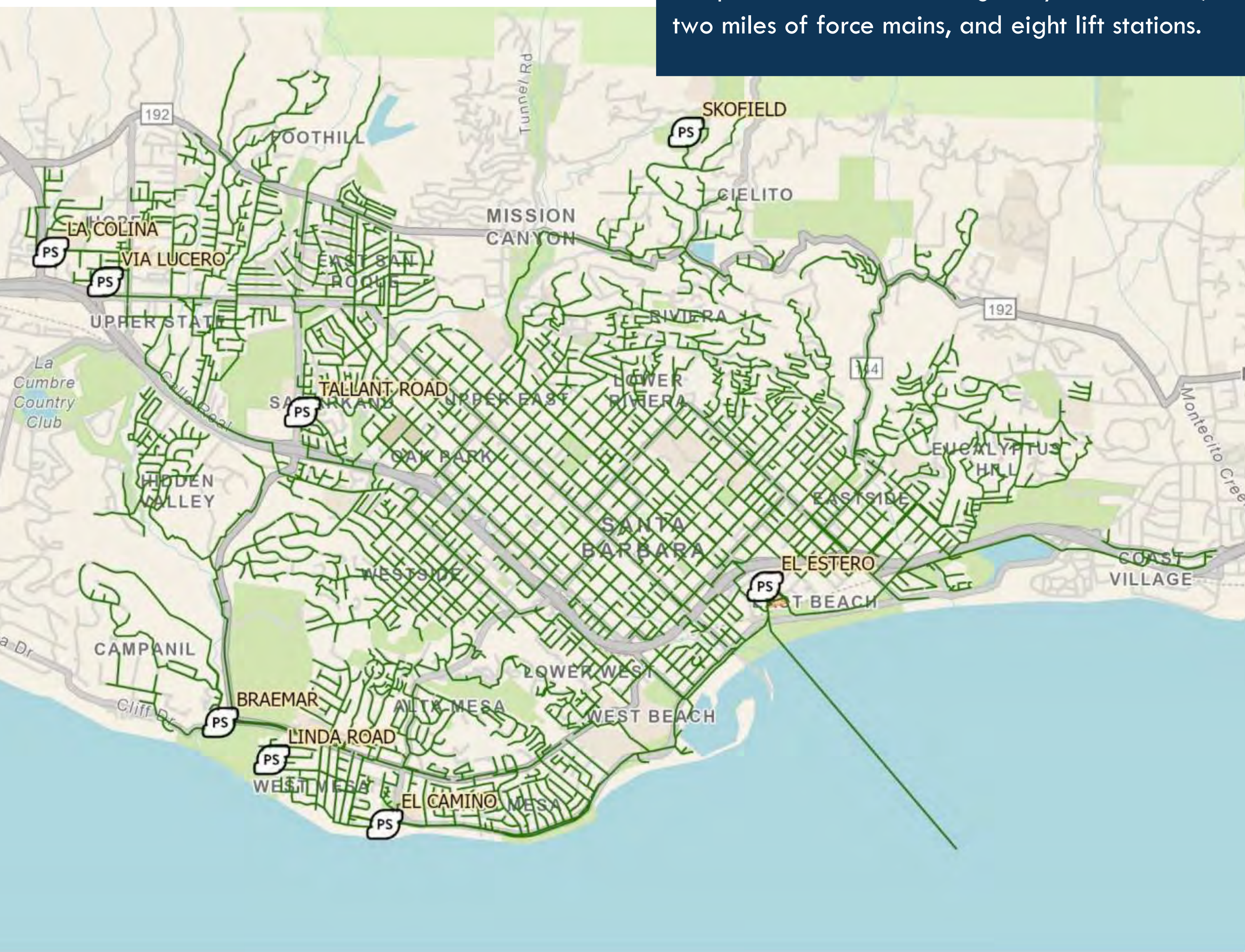
Climate change is impacting influent wastewater quality by water conservation efforts prompted by prolonged and intensifying droughts. These conditions, exacerbated by climate change, lead to reduced wastewater flows. The quality of influent wastewater may face further challenges from the infiltration of saline groundwater, which could be driven by rising sea levels.

The City continues to serve an increasing population with efficient water use habits, and forthcoming State regulations may further require reduced water use. Efficient potable water use reduces the amount of water within the wastewater stream, increasing the strength of constituents, increasing corrosion among pipelines and equipment, creating operational difficulties, reducing plant biological capacity, and increasing costs for collections and treatment. More concentrated wastewater is expected to increase treatment costs (Pitzer, 2019). Additionally, high strength wastewater creates odor issues and limits the ability to store raw wastewater or primary effluent in equalization basins.

Infiltration of saline groundwater within the collection system is expected to occur with sea level rise as groundwater levels rise and seawater intrusion occurs. This would increase the salt content of incoming wastewater to El Estero WRC, which could cause corrosion within pipelines and treatment equipment, impact the efficiency of treatment processes, and require additional maintenance. Additional treatment modifications may be required to remove high concentration of salts, which may also impact the quality of recycled water produced.

5.0 Wastewater Collection

The City's wastewater collection system is composed of 254 miles of gravity sewer mains, two miles of force mains, and eight lift stations.



Vulnerability and Adaptation Summary

The City's wastewater collection system includes approximately 254 miles of gravity sewer mains, approximately 5,900 manholes, 7 lift stations, and approximately 2 miles of force main (pressurized sewer main). The City already experiences difficulties managing flows within the existing collection system and capacities at El Estero WRC during high rainfall events due to stormwater inflows and infiltration into pipes and manholes.

The City is expected to experience more frequent and severe floods from rain and coastal storms, along with groundwater rise, due to climate change. This is likely to lead to increased infiltration and inflow into the collection system that could lead to exceedance of wastewater treatment capacity and sanitary sewer overflows. In addition, the wastewater treatment system can manage limited volumes of saline water but the combination of events with the potential for introduction of saline water - rising groundwater levels, coastal storm events, or tidal inundation - will eventually trigger the need for conversion to a low-pressure collection system.

The primary risks of climate change are:

- Increased frequency of exceedance of collection system and El Estero WRC capacities during storm events (both high rainfall events and coastal storms causing storm surge).
- In the mid-term, persistent inflow and infiltration of saline water into the collection system south of Highway 101 from rising groundwater levels, seawater intrusion into surficial groundwater, and ocean inundation during coastal storms and regular high tides due sea level rise, causing corrosion of infrastructure and trouble treating saline water at El Estero WRC.

Recommended adaptation measures for the collection system include:

- **Immediate Next Steps (0-5 Years):**
  - Seal collection system manholes that flood regularly, including West Beach sewer manholes, to prevent inflow and the possibility of the manhole covers being removed by members of the public during flooding events to act as a drain.
  - Complete a Wastewater System Capacity Study to identify the largest sources of existing infiltration and inflow during storms and evaluate options to reduce infiltration and inflow in the collection system and increase storage capacity at El Estero WRC. Potential adaptation options include manhole sealing, sewer and manhole rehabilitation, customer lateral rehabilitation, investigation of illegal connections and removal, and increasing wet weather storage capacity with wastewater storage basins.
  - Complete a Low Pressure Sewer Conversion Study to plan for the mid-term conversion of the low-lying coastal portion of the collection system from a gravity fed system to a low-pressure system. This should include changing design and connection requirements in the near-term for new private and public projects in low-lying areas to accommodate a future conversion to a pressurized system. The City should consider an ordinance in the next five years to require new connections in the low-lying areas to include facilities needed for pressurization

and incentives to customers to facilitate conversion of existing sewer connections over the next 25 years. The study should also analyze feasible and effective alternatives to pressurization that could achieve the same goals.

- **Near-Term (Through 0.8 ft SLR (~2050)):** Implement additional recommended adaptation measures to manage capacity in the collection system and at El Estero WRC based on the proposed Wastewater System Capacity Study. Implement low-pressure sewer lateral ordinance and facilitate conversion of existing customer sewer connections to low pressure connections in coastal flood prone areas.
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** Update capacity analysis and implement the recommended measures to manage capacity in the collection system and at El Estero WRC. Ensure that Cabrillo Blvd and the utilities located under the street will be protected from shoreline erosion. Install initial phases of low-pressure collection system in areas most impacted by flooding from rain and coastal storms as implementation triggers are met.

In the **long-term**, when flooding from tides is frequent, or elevated groundwater tables persist, the remainder of the existing gravity collection system in the low-lying coastal area should be converted to a low-pressure collection system if large-scale flood prevention measures, such as levees or service levels change, are not capable of fully mitigating flooding hazards from rain and coastal storms.

Converting the existing collection system in the coastal area to a low-pressure collection system is an expensive but highly reliable approach to reduce infiltration and inflow from tides, storms, and groundwater entering the existing gravity system. The City's existing measures to reduce sewer inflow and infiltration are not as effective when facing higher flooding recurrence, higher groundwater levels, and more saline water. The City expects to monitor flooding and groundwater rise in these low-lying areas to decide in the near-term how to address impacts to the wastewater collection system in the mid- and long-term.

West Beach Sewer Trunk Main Shoreline Erosion

The West Beach sewer trunk main conveys approximately half of the City's dry weather sewer flows to El Estero WRC. It is located beneath West Beach, south of the bike path, crosses Mission Lagoon, and continues along the beach before turning north to follow Laguna Creek to El Estero WRC. Due to its critical role and vulnerable beachfront location, this Plan analyzed adaptation needs for the West Beach sewer main.

West Beach sewer is not projected to be exposed from shoreline erosion through 4.9 ft of sea-level rise (~2100). Projected exposure would prompt the need for relocation inland. This would be a major project due to the main's size, importance, and gravity-based flow, and would require new infrastructure to lift flows from low-lying areas. One possible new alignment is from Pershing Park to inland of US 101 to avoid the projected climate vulnerabilities in the coastal area, although studies of impacts to recreational assets would be needed. Ideally, relocation would coincide with any future pressurization of the system and should be planned at least 10 years before projected exposure.

5.1 Introduction

The City's wastewater collection system includes approximately 254 miles of gravity sewer mains that range in size from four inches to 48 inches in diameter, approximately 5,900 manholes, eight lift stations (including the influent pump station at El Estero WRC), and approximately two miles of force main (pressurized sewer main). The City's collection system conveys wastewater to El Estero WRC. Any impacts to El Estero WRC and sewer assets located in the coastal area have the potential to impact sewer service across the entire City. Conversely, infiltration and inflow (I&I)[9] into sewers across the City can cause high flows that creates potential hazards in the coastal area collection system and El Estero WRC.

The coastal wastewater collection system includes a network of collection pipes, some of which are located near shore (West Beach sewer), as well as the Braemar lift station; this is the City's largest and most critical lift station with a pumping capacity of 1,000 gallons per minute. Of the system's totals, approximately 17 miles of gravity sewer mains, 285 manholes, and one lift station (El Estero influent pump station) are located within the Plan focus area near the coast.

The City's wastewater enters El Estero WRC through four influent lines (Figure 5-1):

- Influent line 1A carries wastewater from the western and southern areas of the City following the shoreline along Cabrillo Blvd and contributes approximately 37% of the City's wastewater flow (Larry Walker Associates, 2017).
- Influent line 1B carries wastewater primarily from the downtown and central areas and contributes approximately 42% of City's wastewater flow (Larry Walker Associates, 2017).
- Influent line 2 brings 4% of City's wastewater from the northeast of the City.
- Influent line 3 brings 17% of City's wastewater from the eastern coastal part of the City.

The primary risks of climate change identified for the City's wastewater collection system are summarized in Table 5-1 and discussed in the following subsections:

- Collection system and El Estero WRC capacity limitations (Section 5.2).
- West Beach Sewer flooding and erosion risks (Section 5.3)
- Cabrillo Blvd utilities erosion risks (Section 5.4)
- Flooding at Lift Stations (Section 5.5)

[9] From (USEPA, 2014):There are three major components of wastewater flow in a sanitary sewer system. They are as follows: base sanitary (or wastewater) flow, groundwater infiltration and rainfall derived inflow, and infiltration, more commonly referred to as inflow. Virtually every sewer system has some infiltration and/or inflow. Historically, small amounts of I&I are expected and tolerated. However, infiltration and inflow may be considered excessive when it is the cause of overflows or bypasses, or the cost to transport and treat exceeds the cost to eliminate it. In cases where the I&I may not be considered "excessive" from a cost-to-eliminate perspective but causes health or environmental risks, corrective actions are required.

Figure 5-1. Near-Shore Collection System Facilities

Table 5-1. Risk Assessment for the Wastewater Collection System

Hazard	Risk Description	Consequences	Near-Term		Long-Term	
			Likelihood	Risk	Likelihood	Risk
Severe Flooding	Sanitary sewer overflows due to infiltration and inflow of flood waters into sewer pipes and manholes	5	5	**25**	5	**25**
Shoreline Erosion and Wave Action	Damage to pipes near shore (West Beach sewer)	5	3	**15**	5	**25**
Severe Flooding	Loss of structural stability of Braemar lift station building	5	2	**10**	3	**15**
Severe Flooding	Sewage spills due to structural pipeline damage caused by changes in soil structure	4	2	**8**	3	**12**
Groundwater Rise	Corrosion-related damage to RCP, steel, and vitrified clay pipes from contact with brackish groundwater	4	2	**8**	3	**12**
Groundwater Rise	Sanitary sewer overflows due to infiltration of groundwater into sewer pipes and manholes	3	2	**6**	4	**12**
Groundwater Rise	Sewage spills due to structural pipeline damage caused by changes in soil structure	5	1	**5**	1	**5**

Refer to Section 3.1 for a description of scoring criteria.
Likelihood: Almost Certain (5 pts); Likely / Probable (4 pts); Possible (3 pts); Unlikely (2 pts); Rare (1 pt).
Consequences: Catastrophic (5 pts); Major (4 pts); Moderate (3 pts); Minor (2 pts); Insignificant (1 pt).
Risk (= Likelihood x Consequences): High (16 to 25 pts); Medium (9 to 15 pts): Low (1 to 8 pts).

5.2 Collection System Capacity Limitations

The City already experiences issues managing flows within the existing collection system and El Estero WRC capacities during storm events. The City is expected to experience more frequent and severe floods, along with groundwater rise, due to climate change; this is likely to lead to increased I&I into the collection system. Increased I&I could lead to exceedance of wastewater treatment capacity and SSOs.

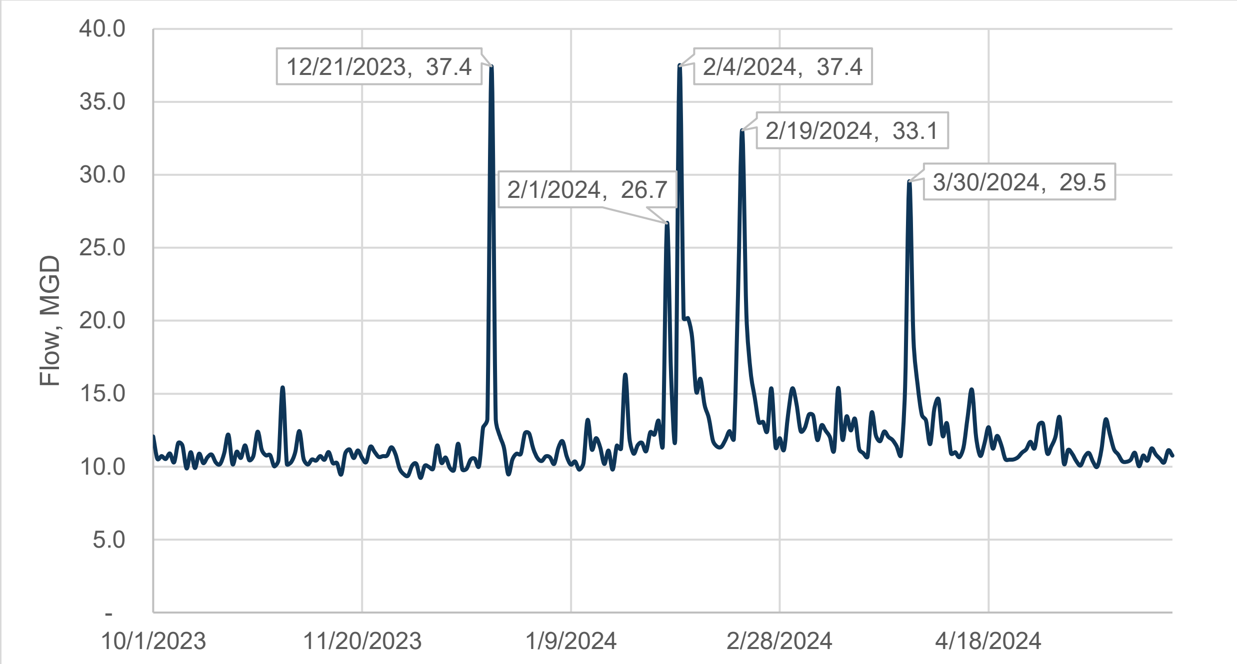
Shoreline erosion from sea level rise is likely to cause loss of cover and support of the collection system piping located in the vicinity of the shore, such as the West Beach sewer. The West Beach sewer refers to a 3,300-foot section of 33-inch sewer main installed under West Beach south of Cabrillo Blvd and is a critical trunk main that conveys approximately 50% of the City's entire dry weather sewer flow. Due to its proximity to the coast, wave action is anticipated to exacerbate impacts to West Beach sewer and other piping in the coastal area by shoreline erosion.

The vulnerabilities associated with I&I and shoreline erosion are described in greater detail in the following subsections. In addition, climate change is anticipated to impact the collection system with more frequent and severe coastal floods. Groundwater rise may impact soil structure around pipes, leading to loss of pipes' structural integrity and pipe breaks. Brackish groundwater exposure around and infiltration into coastal pipes and manholes is likely to increase corrosion of the sewer mains and structures, which will shorten infrastructure lifespans and increase frequency of repairs and replacement. This is described in Section 0.

5.2.1 Wet Weather Flows

The City has experienced high volumes of wastewater flows at El Estero WRC during storm events compared to dry weather flow conditions, indicating the presence of substantial I&I flows. The City's average daily dry weather flow, based on April to September 2022 flows, is approximately 7.2 MGD. In 2023, the City experienced three major storm events on January 9, March 14, and December 21 with estimated peak flows near 35 MGD, 28 MGD, and 37 MGD, respectively. The January 2023 flood event was approximately a 10-year event.

Figure 5-2. El Estero WRC, Maximum Daily Flow (Oct. 2023 to Jun. 2024)



Source: City, October 2023 to June 2024 influent flow data (10-minute intervals)

El Estero WRC can treat up to 35 MGD at peak flows and is consistently operating at capacity for several hours at a time during storm events. To avoid overwhelming the treatment processes, City staff partially close a valve upstream of the influent pump station to reduce flows entering El Estero WRC. Some raw wastewater is then temporarily stored within the City's collection system until it can enter the influent pump station. During all three of the 2023 storm events, the City likely experienced greater influent flows than the reported values because the City restricted flow into El Estero WRC to prevent overwhelming the treatment processes.

With climate change and sea level rise, storms are expected to occur with increased frequency and magnitude, which can increase I&I and lead to higher sewage flows. In addition, tidal inundation is expected to regularly impact the collection system by 4.1 ft of sea level rise (~2095).

5.2.1.1 Infiltration and Inflow

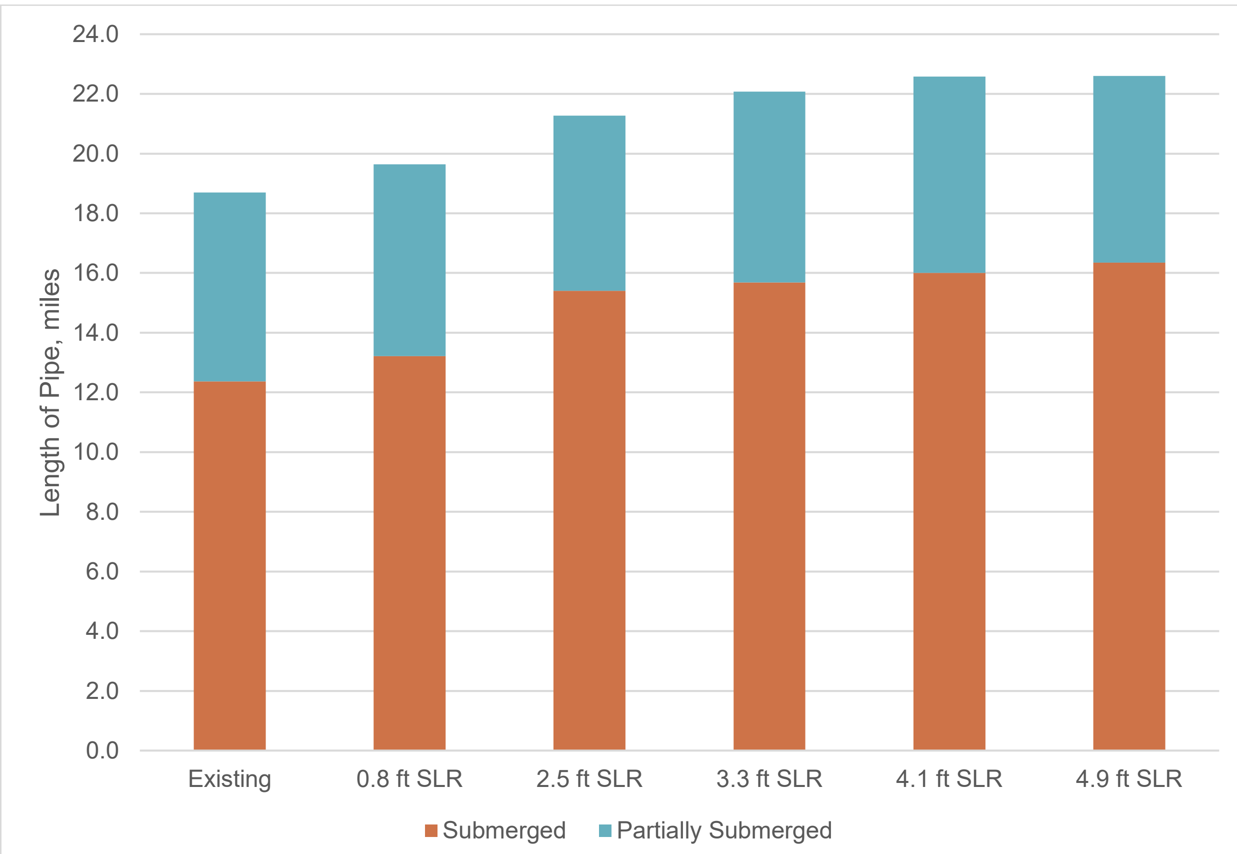
Based on the substantial flows observed in recent history, it is recommended that the City conduct a more comprehensive I&I study. The City has initiated an Infiltration and Inflow Study in May 2024 to evaluate recent storms, identify areas of investigation, and evaluate near-term flow re-routing alternatives. One planned outcome of the Infiltration and Inflow Study is to identify areas to conduct smoke testing, CCTV inspection, or other I&I inspection methods.

Climate change is expected to increase the frequency and severity of storm events. For example, rainfall volume is expected to increase by approximately 30% in a future 10-year, 24-hour storm. Sewer modeling estimated that this future storm may increase wet flows by roughly 20%.

In addition, I&I may increase with rising shallow groundwater levels as well as increased frequency and extent of tidal inundation with sea level rise. To quantify groundwater level impacts, manhole depth to invert and associated pipelines were identified as submerged or partially submerged when compared to groundwater depth. Groundwater depths were estimated using CoSMoS. The CoSMoS shallow groundwater levels may be shallower than current observations, and this Plan recommends shallow groundwater monitoring to update groundwater depth estimates.

Based on the CoSMoS estimates, roughly 7% (18.7 miles) of the collections system is currently partially or fully submerged by groundwater within the focus area and is projected to increase to 9% (22.6 miles) by 4.1 ft of sea level rise (~2095), as shown in Figure 5-3.

Figure 5-3. Estimated Length of Sewer Pipelines Submerged by Groundwater with SLR



Finally, anticipated impacts to soil structure and structural integrity of pipes from floods, groundwater rise, and tidal inundation (Section 3.3.1) are likely to exacerbate I&I by providing new pathways for I&I to enter the collections system.

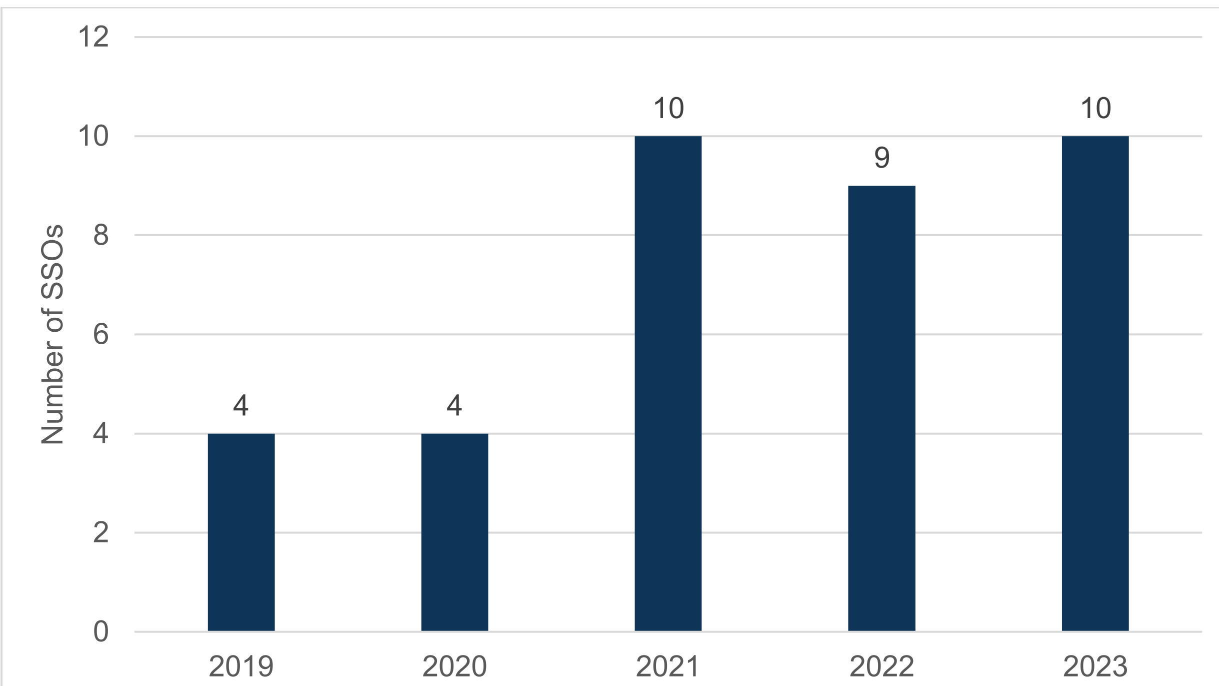
5.2.1.2 Sanitary Sewer Overflows

High wastewater flows can overwhelm collection systems during storm events and lead to sanitary sewer overflows (SSO) as well as El Estero WRC capacity exceedances. An SSO is the unintentional release of wastewater into the environment. SSOs may be caused by pipeline blockages, main breaks, sewer defects that allow stormwater and groundwater to overload the system, improper sewer design, and vandalism. SSOs can contaminate streams, cause water quality issues, damage property, and pose a public health risk. The City strives to minimize the frequency and mitigate the impacts associated with SSOs.

In addition, when El Estero WRC is at capacity, wastewater may be stored within sewer mains prior to entering El Estero WRC, increasing the likelihood of wastewater backing up and overflowing at manholes upstream. On January 9, 2023, two SSOs occurred upstream of El Estero WRC backed up within the collections system due to the amount of sewage.

The City complies with the SWRCB adopted Statewide General Waste Discharge Requirements (WDRs) for Sanitary Sewer Systems, Water Quality Order No. 2006-0003, and reports any SSO event to the California Integrated Water Quality System (CIWQS) online database. The City has experienced multiple SSOs over the last five years, as shown in Figure 5-4. Several of these events have been a result of storm events that exceed El Estero WRC capacity and cause the collections system to be used as temporary storage of wastewater.

Figure 5-4. Number of SSOs within the City's System between 2019 and 2023



The City operates several programs to maintain their collection system and help prevent SSOs. The City's Cleaning and Inspection Program aims to conduct CCTV and clean City mains (greater than 12-inch diameter gravity pipelines) on a five-year basis. Problematic mains are put on a more frequent cleaning and inspection cycle. The City is in the process of conducting CCTV of all small-diameter pipes within the system (12 inches and under) to get updated condition records. In addition to routine maintenance, the City implements an annual sewer rehabilitation program that rehabilitates sewer mains and manholes in poor structural condition. The City also operates the Sewer Lateral Inspection Program (SLIP) to address private sewer lateral deficiencies impacting the collection system. All these programs help maintain the overall condition of the collection system, and the improvements made as part of these programs help reduce I&I entering the collection system.

5.2.2 Adaptation Options

Two general approaches to adaptation for collection system and El Estero WRC capacity exceedances are addressed here:

- Reducing wet weather flows through Citywide flood management or I&I reduction.
- Managing wet weather flows with storage at El Estero WRC or capacity expansion of El Estero WRC.

Beyond Citywide flood protection measures to manage flood frequency and elevations (Section 1.5), the City could implement the following actions to manage wet weather sewage flows:

- I&I Program
- Wet Weather Storage
- Low Pressure System Conversion
- El Estero WRC Capacity Increase

5.2.2.1 I&I Program

The City utilizes a comprehensive Condition Assessment Program to monitor and evaluate the condition of its wastewater collection system. This program is designed to identify structural deficiencies, reduce the risk of sanitary sewer overflows, and support long-term asset management and capital planning. Core condition assessments are conducted using Closed-Circuit Television (CCTV) inspections. The City aims to inspect approximately 20% of the system annually, achieving complete coverage over a five-year cycle. Priority is given to high-risk areas, including those near surface waters, steep slopes, high groundwater elevations, environmentally sensitive zones, and locations listed on the Clean Water Act Section 303(d) List for bacterial impairment.

In addition to CCTV, the City employs complementary inspection tools and techniques such as SmartCover remote flow monitoring, visual inspections, smoke testing, dye testing, and hydraulic modeling. These methods help detect various issues, including cracks, sags, root intrusions, joint separations, inflow and infiltration, and structural failures. The integration of SmartCovers enables real-time monitoring of flow conditions, enhancing the City's ability to prioritize maintenance and capital projects based on actual system performance data.

While the City targets approximately 2.6 miles of sewer main annually for repair or replacement primarily to reduce I&I and address structural defects, capacity-related projects are prioritized separately based on evaluation results.

The City recognizes the need to better characterize the magnitude and potential sources of I&I to optimize investments in the collection system to reduce I&I. A formal and more comprehensive I&I reduction program is recommended to address I&I within the collection system and help alleviate capacity constraints in the collection system and at El Estero WRC. As described below, a detailed I&I reduction program consists of data collection, collection system rehabilitation, customer lateral rehabilitation or replacement, and removal of illegal connections.

5.2.2.1.1 Data Collection

I&I Flow Metering

An I&I flow metering program will allow the City to gather data to inform I&I adaptation investments. The program targets problematic areas and quantifiably measures I&I levels before and after rehabilitation to document the effectiveness of rehabilitation methods. The following parameters are recommended for use in an I&I flow metering study to optimize reduction in I&I and document the effectiveness of the program:

- **Multiple Rain Gauges:** When measuring I&I, having sufficient rain gauges is important to adequately evaluate the rainfall input along with sewage flows. Rainfall intensity can vary within the City's collection system boundary, so it is important to scatter rain gauges throughout the City to obtain accurate data. In hilly areas, a rain gauge is recommended for every one to two square miles of area while the rest of the collection system can be served by one rain gauge for every two to four square miles. For the City, this would equate to a total of roughly 30 rain gauges for the entire collection system. Realistically, a smaller number of rain gauges could be implemented in areas with higher I&I concern.
- **Area/Velocity Meters:** The City currently collects real-time data using SmartCover level sensors throughout the collection system. When performing an I&I study, the use of area/velocity (A/V) meters are preferred to level-only meters because the A/V meters estimate flow by measuring both velocity and level within a pipe. In contrast, level-only meters only have a depth sensor and estimate flow by using the Manning Equation to estimate velocity, which is proportional to the Manning coefficient, hydraulic radius of the pipe, and the slope of the pipe. There is a high risk of error as these parameters can have great variability and are difficult to estimate correctly. Additionally, level measurements can be subject to downstream conditions that mistakenly identify I&I. For example, downstream sediment buildup could cause levels to back up in the monitored manhole but be interpreted as levels rising due to I&I.
- **Sufficient Monitoring Time:** To understand how much I&I the City has, a baseline dry weather flow must be established for each basin. When doing a flow metering study for I&I reduction, keep meters in place for at least 90 days so that adequate dry and wet weather data is available. Failure to monitor for sufficient time runs the risk of underreporting the effectiveness of any I&I reduction efforts. For example, if initial monitoring is done during a dry year and then post-rehabilitation monitoring is done in a wet year, the effectiveness of the reduction efforts will be skewed.
- **Avoid Subtraction:** When planning where to monitor, it is tempting to place flow meters along trunk mains at important areas of interest or to reduce the overall number of meters and thus the cost of the monitoring. However, this can lead to the need for subtracting metering data to estimate the flow in the systems' branches. Minimize this method since it can introduce errors and skew I&I calculations.

- **I&I Calculation Methods:** There are over a dozen metrics for calculating I&I within a collection system with various levels of difficulty and accuracy. When performing an I&I analysis, it is best to utilize a method that normalizes the results based on the size of the monitoring area and rainfall amount. Examples include GPD/capita-inch rain, GPD/LF-inch rain, GPD/acre/inch rain, percent rain as rainfall derived infiltration and inflow, and GPD/acre/inch of indexed rain. This will avoid skewing results towards the smaller basins and provide a more representative idea of where I&I is the most problematic in the collection system.
- **Control Basin:** When monitoring to measure I&I reduction, it can be useful to utilize a control basin. A control basin is a section of the collection system of similar size and topography as the targeted basin for reducing I&I, "rehabilitated basin." The control basin is monitored during both the pre-rehabilitation and post-rehabilitation monitoring but is not itself rehabilitated. By not performing any rehabilitation within the basin, it can serve as a control to help interpret the true baseflow. For example, if pre-rehabilitation monitoring occurs during a dry year and post-rehabilitation monitoring occurs during a wet year, the I&I reduction may be underreported. However, a comparison of control basin flows will indicate the base flow during the post-rehabilitation is higher than that during the dry year, indicating wetter conditions and allowing for better interpretation of the I&I reduction.

Smoke Testing

Smoke testing is an industry standard to help find and address inflow from cross-connections with stormwater infrastructure. The process utilizes blowers to push a smoke source through the collection system. During the test, different runs of pipes are blocked, so smoke is forced to travel through a designated portion of the system. The smoke will travel the path of least resistance and show up at the surface in areas where inflow could be entering, such as illegal storm connections or uncapped lines. These locations are documented so action can be taken to eliminate the cross-connection. Throughout the process, it is key to maintain communication with the public and local fire department to avoid generating worry regarding the smoke. Smoke testing is typically done in areas estimated to have high levels of I&I and suspected of illegal cross-connections.

Dye testing and low voltage conductivity probes (Electro Scan) are additional I&I detection tools that can be considered, depending on the infrastructure and its surrounding conditions.

Groundwater Monitoring

As discussed in Section 9.3.1.4.1, the City could install shallow groundwater monitoring wells to more confidently assess groundwater levels and monitor changes with sea level rise to better understand how shallow groundwater may be contributing to infiltration.

5.2.2.1.2 Sewer and Manhole Rehabilitation

The City currently operates an annual sewer pipeline rehabilitation program to improve the structural integrity of its collection system and reduce I&I. The following modifications can be considered for reducing I&I:

- **Basin Approach:** Historically, the City focused on their worst-condition pipes for rehabilitation regardless of location. In recent years, the City has begun to package pipelines for rehabilitation, partially by geography, to make them more centrally-located for more efficient construction. To focus on I&I, the City could move to a basin-by-basin approach. Basins with high existing I&I or increased flooding projections could be prioritized and all structurally deficient pipes (those with PACP Grade 4 or Grade 5 defects) within the basin could be rehabilitated to address both structural and I&I concerns.
- **Manhole Seals:** Bolted lids could utilize a rubber gasket seal to prevent floodwaters from entering the manholes.
- **Manhole Rehabilitation Program:** A detailed manhole inspection and rehabilitation program could be adopted on a basin level in tandem with a pipeline rehabilitation program. The City currently rehabilitates any manholes in poor condition that are attached to mains being rehabilitated as part of their annual wastewater main rehabilitation program. A manhole rehabilitation program would expand upon this current practice to include a formal condition evaluation of manholes and rehabilitation of manholes meeting a specific condition threshold within a basin (regardless of whether they are connected to a main in poor condition).
- **Polymer Concrete Manholes:** Chlorides in seawater can promote corrosion of exposed steel reinforcement. Additionally, magnesium sulfate in seawater can attack the hardened cement paste in manhole structures. Depending on the condition, this combination could degrade the structural integrity of the existing manhole structures. Polymer concrete manholes use fiberglass reinforcement, instead of steel, allowing it to hold up better in these environments. The material is also corrosion-proof, eliminating the need epoxy or polyurethane lining. Polymer concrete may be considered in areas impacted by seawater and in highly-corrosive environments.
- **Hydrophilic End Seals:** When lining a pipe, the connection point of the main to the manhole, and any reinstated laterals, is not a watertight connection. The City currently uses an epoxy-based seal on the liner; however, this seal is prone to shrinking, which creates an annular space that allows water filtration. The City could transition to using hydrophilic seals at the pipe ends as well as at the lateral connection seals. These gaskets absorb water, sealing the annular space against infiltration.

5.2.2.1.3 Customer Laterals

Customer laterals are a common source of I&I but are not included in the City's annual sewer pipeline rehabilitation program because the laterals are privately owned. The City's existing Sewer Lateral Inspection Program[10] can require customers to rehabilitate their lateral.

The following modifications could be made by the City to reduce I&I from customer laterals:

- **Lateral Connection Seals:** Historically, the City has utilized brim-style lateral connection seals in cases where reinstating laterals leads to an overcut that exposes the

[10] santabarbaraca.gov/government/departments/public-works/water-resources/sewer-lateral-inspection-program

connection opening beyond 100%. To provide a full seal, the City could standardize lateral connection seals at all reinstated laterals. Additionally, the City could transition from the brim-style lateral connection seal to a full wrap, which provides a more robust structural solution and allows for longer lengths when rehabilitating sections of the lateral.

- **Lateral Rehabilitation:** Studies have shown that the most effective I&I reduction programs target laterals. For example, a study on I&I reduction in Sweet Home, Oregon identified that lining laterals alone produced 11% to 16% reduction in I&I in the rehabilitated basins; rehabilitating the laterals alone resulted in 7% to 11% reduction in the rehabilitated basins; and lining both the mains and laterals reduced I&I by up to 65% in the rehabilitated basins (Lee, 2013). When rehabilitating only the mains and using hydrophilic end seals, groundwater can be effectively prevented from entering the mains. This helps avoid situations where groundwater might infiltrate the sewer at a higher elevation through defects in the laterals. While the City does not own the laterals, they could choose to invest in and/or incentivize lateral rehabilitation or they could leverage the existing Sewer Lateral Inspection Program to have laterals rehabilitated for I&I reduction.

5.2.2.1.4 Illegal Connections

The City experienced a quick uptick of influent flow at El Estero WRC during the December 21, 2023, storm, which may be an indicator of illegal sewer connections throughout the collection system. Illegal sewer connections that contribute to wet weather flows in the sewer are commonly private storm drains that direct storm water to the sewer rather than City storm drains or creeks. The sudden increase in flow could suggest that saturated soils are efficiently channeling precipitation into leaky sewers or that City residents are opening manhole covers to drain flooded streets. The City's I&I Study will aim to identify areas where large amounts of I&I (and potentially illegal connections) may be located to be more closely inspected in the field and addressed.

The City may evaluate and consider updating development and property sales policies with respect to sewer laterals. The City may update such policies to require sewer lateral inspection prior to the closing of a property sale or redevelopment of an existing property. Updated policies that require sewer lateral inspection can help the City investigate lateral condition and the presence of illegal connections that may convey I&I into the collection system. If undesirable or illegal connections are found, then the updated policies are recommended to require repair of defects prior to the close of the property sale or granting of redevelopment permits to assist the City in I&I reduction.

5.2.2.2 Wet Weather Storage

Another approach to managing flows that exceed plant capacity is wet weather storage that receives diverted wet weather flows. The stored wastewater can be held after screening and until high flows subside; afterwards, it can be reintroduced into the treatment system. Wet weather storage would help to alleviate wet weather capacity constraints at El Estero WRC, reduce the amount of sewer backing up within the collection system due to throttling at the headworks, and reduce the risk for SSOs upstream. Onsite storage can also serve as dry weather flow equalization to provide consistent flow for wastewater treatment, especially during low flow periods, and avoid secondary effluent recycling that is currently practiced at El Estero WRC. Storage can potentially facilitate electrical load shifting by storing wastewater during peak energy price periods. This may improve treatment efficiency and save costs.

Based on historical and projected wet weather flows, roughly 2.1 and 3.7 MG of storage is needed to temporarily store peak wet weather flows, respectively. (Refer to Appendix C for additional information). However, since staff have historically needed to throttled flow into the plant headworks to protect treatment systems, inflow data may not fully capture actual peak wet weather flows such that peak wet weather flows are not well defined.

Properly sizing the storage must consider a tradeoff of cost and available space. Wet weather storage could be located within the existing El Estero WRC footprint or adjacent to the site. The El Estero WRC site is constrained, so on-site options are limited and would require relocation of existing facilities. For example, the Administration Building, which includes the laboratory used to test samples collected onsite, could be relocated across Yananoli St at the Annex Yard or the tertiary filters area could be replaced if the potable reuse treatment system is constructed in the Annex Yard. Adjacent siting opportunities include commercial properties neighboring the plant, which are typically at lower elevations than the plant.

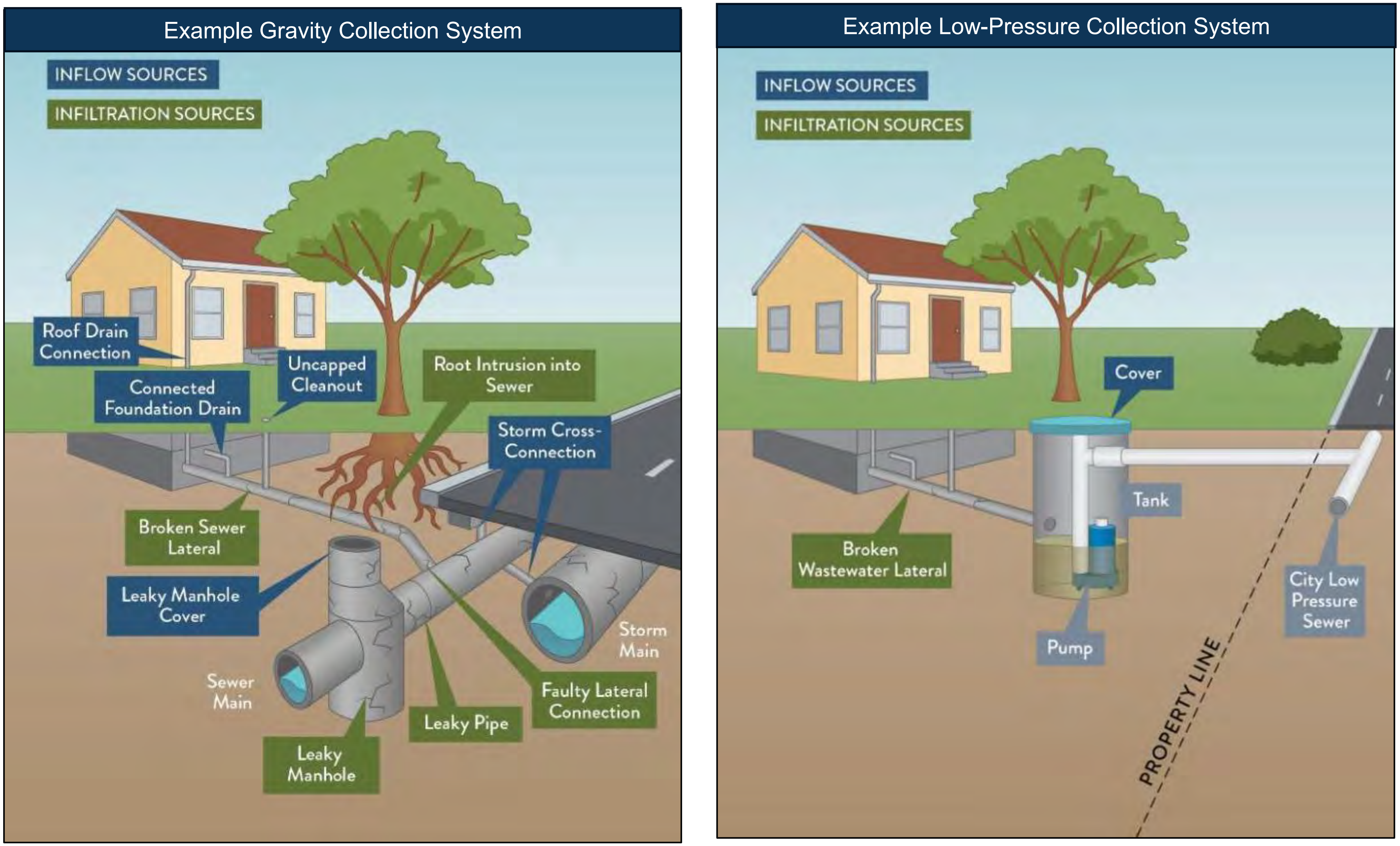
The cost of a new storage basin on-site or adjacent to El Estero WRC would require constructing the basin along with piping to and from the headworks and relocating existing aboveground uses. For example, the Administration Building covers an area similar to one required for wet weather storage and would need to be relocated; maybe across the street to the Annex Yard. The cost of new storage basin would be $10 million to $20 million, depending on the basin size and subsurface conditions (contamination and groundwater levels). The cost to move aboveground facilities would be $5 million to $10 million depending on what facilities are moved and flood protection needs for the new location. The costs would be refined as part of the proposed Wastewater System Capacity Study (see Section 5.2.3).

5.2.2.3 Conversion to Low Pressured Sewer System

In the mid-term, persistent inflow and infiltration of saline water into the collection system south of Highway 101 is projected from rising groundwater levels, seawater intrusion into surficial groundwater, and ocean inundation during coastal storms and regular high tides due sea level rise, causing corrosion of infrastructure and trouble treating saline water at El Estero WRC. In the long-term, flooding from tidal inundation is projected to occur daily by 4.1 ft of sea level rise (~2095). As a result, I&I is expected to be a constant presence in the collection system.

An effective measure to prevent I&I under these conditions is to pressurize the collection system from the customer connection using a low-pressure sewer system, as shown in Figure 5-5.

Figure 5-5. Infiltration and Inflow Sources for Gravity and Low-Pressure Collection Systems



These graphics show the typical infiltration and inflow (I&I) sources to two types of sewer collection systems. The City's existing gravity system, shown on the left, has many I&I sources. During heavy rainfall and high wave events, floodwater can enter the sewer collection system, which can overwhelm both the collection pipes and capacity at the treatment plant (El Estero Water Resource Center), potentially causing sewer overflows. Low-pressure sewer collection systems, shown on the right, prevent almost all sources of I&I.

These systems consist of individual grinder pumps that collect the customer's wastewater and pump it through a new, pressurized lateral into a common pressurized force main. By pressurizing the laterals and main piping, the pressure inside the pipe is greater than that outside the pipe; groundwater and storm water cannot overcome the pipe pressure and enter the collection system. Constructing a new collection system would also remove illegal connections from the existing system in the converted area. Due to the pressurized nature, these systems can be installed with smaller diameter piping and can be installed shallower than gravity sewers.

I&I could continue to be addressed in this low-lying coastal area but the measures are not as effective when faced with increased flooding, increased groundwater levels, and increased salinity and are less certain to be effective. In particular, increased salinity could eventually reach concentrations that compromises the biological treatment processes at El Estero. A typical approach to reduce salinity is reverse osmosis (RO), like the City's desalination plant, but RO requires pre-treatment and would be downstream of El Estero WRC's biological treatment processes. Alternatives treatment processes with higher salinity tolerance and ability to manage influent salinity fluctuations could eventually replace existing treatment processes at El Estero WRC but would require an expensive investment and would not address the capacity issues associated with inflow into the collection system.

Challenges associated with converting to a low-pressure sewer system include determining ownership and maintenance responsibility of the pressurized assets between the City and landowners. Under current City regulations, the landowner owns the lateral upstream of the connection to the City's sewer main and is responsible for maintenance. However, the City may consider being responsible for pump stations maintenance and/or pressurized laterals. Proper operation and maintenance would be essential to achieve the new system's I&I benefits. City maintenance of the systems would require new equipment and expertise. In addition, low-pressure grinder pumps can clog easily from items such as flushed wipes, so outreach to customers is essential for proper usage.

In summary, converting a portion of the existing gravity collection system south of Highway 101 and east of Castillo Street is expected to provide the highest certainty to address increased flooding, increased groundwater levels, and increased salinity at similar costs to feasible alternatives. The cost of converting all sewer connections in this area – roughly 800 connections – would total approximately $50 million consisting of roughly $15 million for private lateral conversions and $35 million for new pressurized pipelines from the laterals to El Estero WRC. The costs would be refined as part of the proposed Wastewater System Capacity Study (see Section 5.2.3).

5.2.2.4 El Estero WRC and Outfall Capacity

El Estero WRC could potentially treat higher flows from the collection system if the plant had additional capacity in the following:

1. Influent pump station
2. Treatment processes
3. Outfall system

Plant inflow data may not represent true peak wet weather flows due to the throttling of flow into the plant headworks; therefore, a design flow for this concept has yet to be developed. Expansion of each potential capacity constraint is discussed conceptually here.

- The existing **influent pump station** capacity is roughly 35 MGD and could be expanded by adding pumps or increasing pump capacity.
- The **treatment process** capacity is roughly 35 MGD. Expansion would require construction of additional treatment processes. The secondary treatment footprint could be reduced by converting to membrane bioreactors, but this cost is likely not justified considering that the City has invested in secondary treatment upgrades in the last decade. The City may create more treatment capacity if the Regional Board would allow bypass of secondary treatment during wet weather. The City of Morro Bay recently received Regional Board approval for bypass of secondary treatment during wet weather events with several restrictions (see the description below).
- The **ocean outfall** capacity is roughly 27 MGD based on existing gravity flow operations. Capacity with gravity flow is expected to decrease slightly over time with sea level rise because of higher ocean levels exerting higher pressure at the outfall outlets. The outfall system capacity may be increased by installing a pump station to pump the effluent through the outfall. This pump station would need to be sized to convey peak wet weather flows, and the ultimate size would be dependent on other measures taken to reduce peak flows through the plant. The pump station would only need to operate during wet weather events with flows greater than 27 MGD.

Morro Bay Wet Weather Bypass

The City of Morro Bay recently constructed a new water reclamation facility that is based around a membrane bioreactor (MBR). The plant was permitted in 2022 by Central Coast Regional Water Quality Control Board Order (No. R3-2022-0029). The plant includes a Stormwater Adaptive Filtration Equipment (SAFE) system consisting of rapidly filtered primary effluent for discharge to the ocean during wet weather that receives flow when MBR capacity is exceeded. During wet weather, ocean discharges consist of MBR effluent and SAFE effluent.

This approach for El Estero WRC could avoid some treatment process constraints but would still require capacity expansion of the influent pump station and outfall. The applicability of this bypass approach for El Estero WRC requires engagement with the Regional Board, evaluation of the existing treatment system, and new infrastructure to convey treated flows.

5.2.3 Adaptation Recommendations

Immediate Next Steps (0-5 Years)

Existing wet weather events result in collection system flows. El Estero WRC inflows exceeding capacity and wastewater flows are expected to increase due to projected increases in precipitation from climate change. However, significant data gaps remain, such as I&I sources and locations and extent and recurrence of flooding to enable the City to make informed decisions on potentially large investments. The flood modeling and options data gaps are proposed to be addressed through a Stormwater Model and Flood Analysis Report (Section

3.4.3), and the I&I data gaps are proposed to be addressed with a Wastewater System Capacity Study (described below). In the interim, the City can implement measures with limited investment and defined benefits. The City could seal manholes in areas that frequently flood to avoid inflow and prevent residents from removing the manhole covers to drain a flood area. An initial list can be prepared based on recent flood events and updated based on flood modeling. Sealing manholes is roughly $10,000 per manhole.

Wastewater System Capacity Study

The City recognizes the need to better characterize I&I for the collection system to optimize investments to reduce or manage I&I. Characterization includes understanding the magnitude and potential sources of I&I. Estimate the contributions from typical I&I sources (i.e., manhole inflow, infiltration from City mains and manholes, customer laterals infiltration, or inflow from illegal connections) to wastewater flows to better direct investment to reduce or manage I&I. Therefore, prepare a Wastewater System Capacity Study comprised of two primary components:

- A definition of I&I sources based on data collection and analysis (see Section 5.2.2.1.1).
- A comparison of adaptation measures identified in Section 5.2.2.

To comprehensively define I&I, additional effort is likely required and includes:

- Extensive sewer flow monitoring during multiple wet years and at least one extended dry period with basins targeted and a limited amount of pipe upstream of each meter.
- Review basins and I&I with the age of the collection system, pipe material, and land use to identify patterns and correlations.
- Use the existing model to identify hydraulic constraints and relief ideas.
- Model possible I&I reduction benefits to quantify potential outcomes.
- Target areas for I&I reduction based on the amount of flow reduced per dollar spent.

After completing the I&I analysis, compare adaptation measures investments with investments at El Estero WRC, such as storage or capacity expansion.

Low-Pressure Sewer Conversion Study

Existing flooding is already causing wet weather capacity issues for the wastewater system – includes both collection system and El Estero WRC – that can be addressed through infiltration and inflow reduction measures and/or storage at El Estero WRC. In addition, the wastewater treatment system can manage limited volumes of saline water. The combination of increased flooding events with the potential for introduction of saline water - rising groundwater levels, coastal storm events, or tidal inundation - will eventually trigger the need for conversion to a low-pressure collection system in low-lying coastal areas.

In the mid-term, initial phases of a low-pressure sewer conversion from gravity fed system will be needed. In the next five years, the City should prepare a Low-Pressure Sewer Conversion Study to define potential phasing of sewer conversions based on projected rain and coastal flooding, groundwater, and tidal hazards. The study should include changing design and connection requirements for new private and public projects in low-lying areas to accommodate a future conversion to a pressurized system. The study should also analyze feasible and effective alternatives to pressurization that could achieve the same goals.

In addition, the City should consider an ordinance in the next five years to require new connections in the low-lying areas to include facilities needed for pressurization and incentives to customers to facilitate conversion of existing sewer connections over the next 25 years.

Near-Term (Through 0.8 ft SLR (~2050))

During the near-term, additional wet weather adaptation measures are suggested to manage, at a minimum, existing wet weather flows. Additional adaptation measures will be needed in the near term since larger flooding is projected from climate change. Potential adaptation measures include manhole sealing, sewer and manhole rehabilitation, customer lateral rehabilitation, illegal connections removal, wet weather storage, and El Estero WRC capacity expansion. The cost and benefits of each of these options is proposed to be addressed in the Wastewater System Capacity Study. Wet weather storage could cost up to $30 million and the study will identify preferred options considering costs and benefits.

In addition, the City could implement a low-pressure lateral ordinance and facilitate conversion of existing customer sewer connections to low-pressure connections in low-lying coastal areas.

Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075))

Stormwater flooding from rain and coastal storms are expected to increase in intensity and recurrence while groundwater rise will increase I&I as more sewers are inundated. The City should initiate installation of initial phases of low-pressure collection system in areas most impacted by flooding from rain and coastal storms as implementation triggers are met. In addition, updated priority list of adaptation measures could be developed considering:

1. Updated hazard and vulnerability assessments, especially timing of sea level rise
2. Performance of implemented local and regional measures
3. Long-term plans for the collection system and El Estero WRC (discussed under Long-Term).

Long-Term (2.5+ ft SLR; 50+ Years)

Stormwater flooding will be compounded by coastal storm flooding by 2.5 ft of sea level rise (~2075), and tides will regularly flood coastal areas by 4.1 ft of sea level rise (~2095). These conditions would drive expansion of conversion to low-pressure systems in regularly flooded areas if they had not already been converted.

The relocation of El Estero WRC inland would be required when Citywide and site flooding protection measures are not sufficient to maintain safe plant operations. If the plant is moved inland, the existing El Estero WRC site could become a large lift station that conveys sewage to a new plant site. Alternatively, the collection system feeding El Estero WRC could be diverted to lift stations prior to reaching the plant and pump the sewage to the new plant location.

5.3 West Beach Sewer

A portion of Influent Line 1A (Figure 5-1) includes a roughly 3,300-foot section of 33-inch vitrified clay pipe installed under West Beach and south of W Cabrillo Blvd; this is known as the West Beach sewer (Figure 5-6). The sewer is a critical trunk main that conveys approximately 50% of the City's entire dry-weather sewer flow. The sewer is at risk of flooding and shoreline erosion. The risks, potential adaptation options, and recommendations are included below.

Figure 5-6. West Beach Sewer Location and Shoreline Profile Alignment

5.3.1 Flooding

West Beach includes storm drains that discharge stormwater onto West Beach, where it commonly pools. The flooded area includes four West Beach sewer manholes that likely contribute to I&I issues and capacity limitations within the system and at El Estero WRC. Coastal storm flooding and coastal storm wave runup are projected to flood manholes with future sea level rise.

5.3.2 Shoreline Erosion

The shoreline erosion analysis indicates that West Beach has remained stable in recent years, with erosion projected only due to future sea level rise. As shown in Figure 5-7, the erosion analysis indicates that the West Beach sewer would not be exposed to shoreline erosion through 4.9 ft of sea level rise (~2100). Note that coastal storm flooding and coastal storm wave runup are projected to flood manholes with future sea level rise, which may cause erosion around the manholes.

5.3.3 Mission Creek Erosion

The West Beach sewer also crosses Mission Creek by Cabrillo Blvd. and is estimated to be buried 2.5 ft below the creek bed. An abandoned 14-inch sewer main is also in the vicinity of the 33-inch sewer and is buried approximately 1 ft below the creek bed. Both pipelines are encased in concrete.

Monitoring of Mission Creek bed depth at the West Beach sewer crossing should be conducted annually to identify the potential for pipeline exposure.

5.3.4 Adaptation Options

Based on the analysis above, the West Beach sewer manholes have existing flooding risks and projected storm erosion risks with future sea level rise. The West Beach sewer pipeline is not projected to be exposed to erosion until after 4.9 ft of sea level rise (~2100). Note that rising sea levels and wave runup may flood manholes and cause storm erosion around the manholes.

5.3.4.1 Manholes

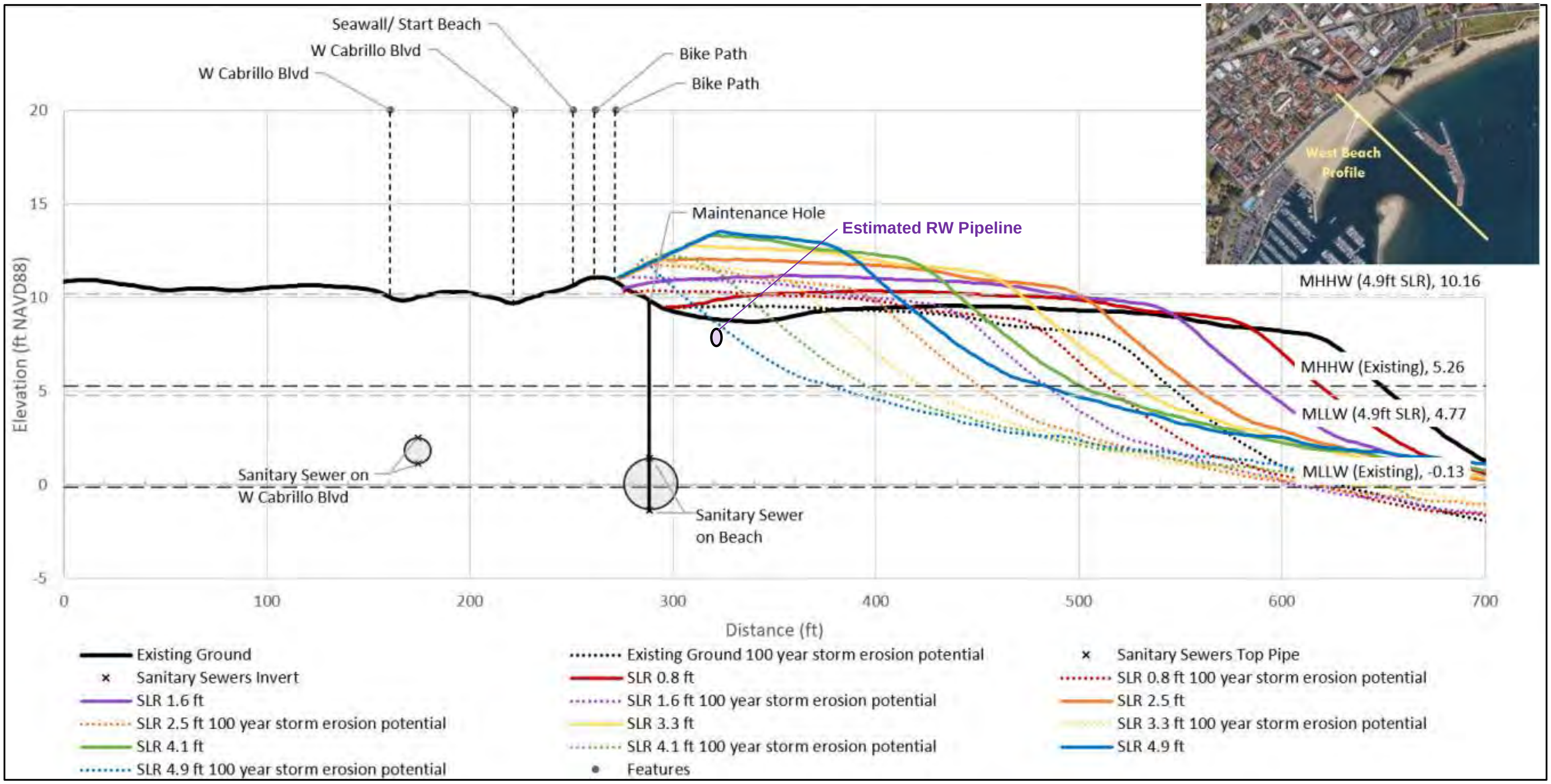
Inflow Adaptation

The existing flooding vulnerability of the manholes could be reduced by:

1. Re-grading the beach and/or relocating stormwater outlets to minimize ponding of stormwater along the bike path.
2. Bolting and sealing manholes.
3. Raising manholes above flood elevations.

Raising the manholes is not preferred due to aesthetics for an important City beach. Regrading the beach is also not preferred as it may require regular regrading. Bolting and sealing the manholes is the preferred method to prevent inflow at the West Beach manholes. However, sealing the manholes may impact the hydraulics of the West Beach sewer main.

Figure 5-7. Erosion Potential with Sea Level Rise, West Beach Sewer



The above results assume that West Beach is stable. Future erosion projections are due to sea level rise alone and show that the West Beach sewer may not be exposed through 4.9 ft of sea level rise (~2100). Note that coastal storm flooding and coastal storm waves are projected to flood manholes with future sea level rise, which may cause storm erosion around the manholes.

This needs further evaluation prior to sealing. For example, the City may seal a few manholes in strategic locations, rather than all the West Beach manholes, to maintain confidence in the hydraulic operation of West Beach sewer.

Exposure Adaptation

The West Beach sewer manholes may be exposed from coastal storms with rising sea levels. Manhole exposure adaptation would only be needed until the pipeline is moved. The primary options to maintain structural integrity are installing rip rap around the manholes or lowering the overall manhole height (e.g., cutting down the manhole).

Rip rap around manholes protects the exterior of the manhole by providing structural support and protection from wave forces. Lowering manhole height, as the sand around the manhole erodes, avoids potential structural failure of unsupported manholes. Lowering also makes the manholes more vulnerable to flooding, so sealing and bolting the manholes is required. Also, manholes are not recommended to be lowered below levels where tides regularly reach the manhole unless corrosion protection is added or below levels where surcharging or sewer backups may cause spills. These levels may be determined as a next step.

Considering the constraints outlined above and that rip rap on the beach is undesirable if it can be avoided, the manholes may be lowered. In addition, beach nourishment and dune restoration, to be considered as part of the City's 30-Year Waterfront Adaptation Plan (in progress), could delay the need for the above-mentioned measures.

5.3.4.2 Pipeline

The erosion analysis conducted for West Beach anticipate no exposure through 4.9 feet of sea level rise. The Mission Creek crossing risk of exposure from exposure across Mission Creek will be evaluated as a next step as well as monitoring of creek bed cover over the pipeline.

The sewer conveys approximately 50% of the City's entire dry-weather sewer flow from Pershing Park through West Beach. After exiting West Beach, the sewer receives additional flow from Stearns Wharf and interties east of Stearn's Wharf and east of Mission Creek near Garden St. To intercept sewer flow prior to entering the hazards area, a proposed sewer main could be constructed to divert flows from the West Beach area near Pershing Park and convey via a new alignment to El Estero WRC. Any existing interties in the West Beach area that tie into the current West Beach sewer may be rerouted to the existing sewer in Cabrillo Blvd or modified to convey via the proposed sewer main. Potential locations for a new sewer main are the following (Figure 5-8):

1. Within Cabrillo Blvd.
2. Between Cabrillo Blvd and US-101 (Mason St is used in this analysis).
3. North of US-101.

The options discussed below include welded HDPE pipe for new sewer mains, including gravity sewers and force mains, to minimize infiltration. Some include new lift stations to force mains.


Water & Wastewater
Climate Adaptation Project
Figure 5-8. West Beach Sewer Relocation Alternatives
Legend
West Beach Sewer
Sewer Main
Relocation Alternatives
North of US-101
Cabrillo Blvd
Mason St
Notes
N
0 0.05 0.1 Miles
0 300 600 US Feet
WSC

The following describes potential options for relocation of the West Beach sewer main:

- **Cabrillo Blvd Alignment, Gravity Sewer:** Abandon the existing 15-inch sewer in Cabrillo Blvd and install a new 36-inch sewer in Cabrillo Blvd from Castillo St to the existing gravity system near Garden St. The new gravity sewer would include tie-ins to the existing 15-inch sewer's local connections.
- **Cabrillo Blvd Alignment, Force Main:** Keep the existing 15-inch sewer in Cabrillo Blvd and potentially install a new lift station at Pershing Park, 24-inch HDPE force main in Cabrillo Blvd from Castillo St to State St, and 36-inch HDPE gravity sewer from State St to the existing gravity system near Garden St. Note that the location of new facilities is expected to be evaluated and refined as alternatives are further defined.
- **Mason St Alignment:** Build a new lift station at Pershing Park and a new 24-inch HDPE force main along Castillo St to Mason St and along Mason St to Anacapa St that discharges to new 36-inch HDPE gravity sewer near Garden St. The proposed 36-inch sewer also could collect flow from the existing 15-inch sewer in Cabrillo Blvd.
- **North of US-101 Alignment:** Build a new lift station at Pershing Park and a new 24-inch HDPE force main along Castillo St that crosses the railroad and US-101 before heading east down Guttierez St to Garden St, where it could tie back into the existing gravity system. To accommodate the flow, the existing 33-inch gravity main along Garden St needs to be upsized to a 48-inch gravity main. Castillo St was chosen for the potential force main alignment because the railroad tracks are on a bridge that crosses Castillo St, and US-101 crosses over Castillo St along a small bridge. This eases pipeline installation and reduces railroad and highway impacts.

The preferred location for a new sewer depends on the likely hazards during the life of the sewer and the potential timing of relocating or partially relocating El Estero WRC. Assuming the West Beach sewer main is relocated after 4.9 ft of sea level rise (~2100). By this time, the area south of US-101 will experience stormwater flooding and daily tidal flooding. Therefore, the preferred alignment north of US-101. The rough cost of a new lift station and force mains from Pershing Park to El Estero routed north of Highway 101 is roughly $60 million.

A detailed alignment study should be performed to select the preferred alignment and provide a detailed opinion of probable cost.

5.3.5 Adaptation Recommendations

Immediate Next Steps (0-5 Years)

To address infiltration vulnerability of the West Beach sewer manholes from flooding and storm waves, seal the manholes. Data collected from recommended shoreline erosion monitoring will be used to monitor triggers for future actions.

Long-Term (50+ Years)

Erosion projections at West Beach estimate that the beach above the sewer will not erode through at least 4.9 ft SLR (~2100). Close monitoring of erosion at West Beach will be conducted in the next several years to better predict erosion rates at the site. Should increased erosion occur, relocating the West Beach sewer may be considered. Potential relocation of the

West Beach sewer main could cost roughly $60 million. The City should consider initiating planning and design of the West Beach sewer relocation at least 10 years prior to anticipated threats. The preferred alignment is north of US-101 to avoid projected flooding hazards south of US-101. The new lift station at Pershing Park and force main along Castillo St should consider its potential use to convey sewage inland for El Estero WRC relocation. The timing and extent of projected sewer relocation should be revisited at each update to this Plan.

5.4 Cabrillo Blvd and Shoreline Drive Infrastructure

As shown in Figure 3-24, the shoreline is projected to erode to Cabrillo Blvd by 1.6 ft of sea level rise (~2065) and to Shoreline Drive by 2.5 ft of sea level rise (~2075) without shoreline adaptation measures. Wastewater and water pipelines along with other utilities located under Cabrillo Blvd and Shoreline Drive would be at risk of exposure and failure if the roads are not protected. If protection measures are not implemented, all sewer lines under the Cabrillo Blvd must be relocated prior to 1.6 ft of sea level rise (~2065) to avoid failure from exposure.

Cabrillo Blvd and utilities buried underneath are assumed to be protected from shoreline erosion by 1.6 ft of sea level rise (~2065) based on the recommendations in the City's 2021 Sea Level Rise Adaptation Plan (ESA, 2021).

5.5 Lift Stations

Of the City's eight sewer lift stations, three are in the coastal hazard area: 1) Braemar; 2) Linda Road; and 3) El Camino de la Luz. The Linda Road and El Camino de la Luz lift stations are located near the coastal bluff area at an elevation of over 100 ft above MSL. Due to their elevation and distance from the bluffs, these lift stations are not expected to be vulnerable to impacts of sea level rise.

5.5.1 Braemar Lift Station

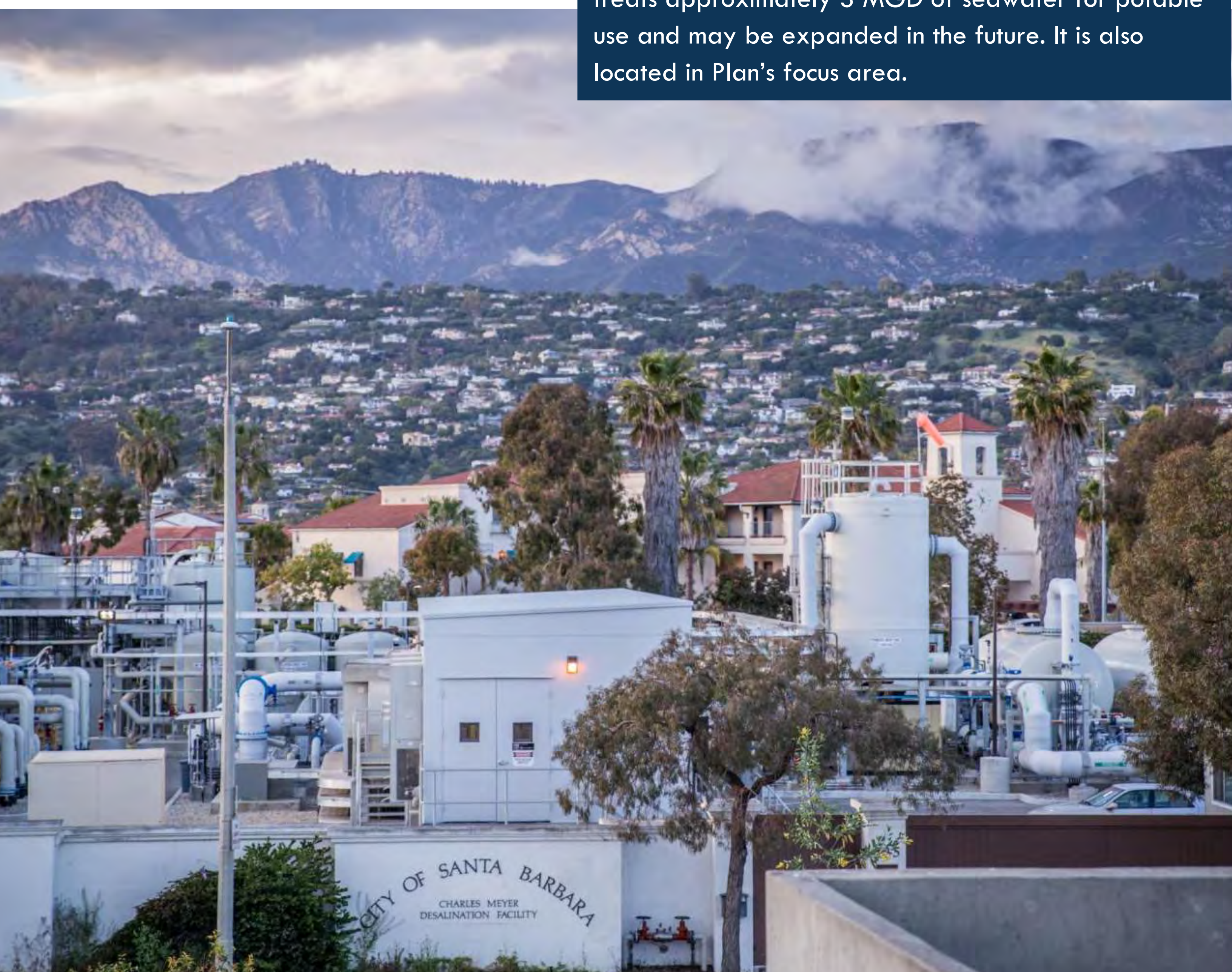
The Braemar lift station is situated in a low-lying area on Cliff Drive, with an approximate elevation of 22 ft above MSL. The Braemar lift station is in the FEMA 100-year flood way, according to the FEMA national flood hazard map, with a base flood elevation of 25.7 ft above MSL near the lift station (Figure 5-9). This area may experience more frequent and intense flooding and bluff erosion (ESA, 2021).

The Braemar lift station was originally constructed in 1962 and is the City's largest and most critical lift station with a pumping capacity of 1,000 gallons per minute (1.4 MGD) (City of Santa Barbara, 2024). This lift station is undergoing extensive rehabilitation with construction completion tentatively scheduled for 2024-2025. The rehabilitation work includes upgrades to mechanical and electrical lift station components that have reached the end of their useful life as well as protection against large flood events (City of Santa Barbara, 2024). Planned flood protection measures include construction of the station to a design flood elevation of 28 ft (FEMA base flood elevation plus two ft of freeboard) through the addition of flood protection panels, increased drywall height in the vicinity of key components, the addition of a sump and pump in the electrical room, and concrete waterproofing.

Figure 5-9. Braemar Lift Station and the FEMA National Flood Hazard Extent

6.0 Potable Water Treatment

The City's Charles E. Meyer Desalination Plant currently treats approximately 3 MGD of seawater for potable use and may be expanded in the future. It is also located in Plan's focus area.



Vulnerability and Adaptation Summary

While the vulnerabilities of the whole potable water system were assessed, particular attention was given to those portions of the system in the Focused Study Area (shown in red in Figure 1-3). The Charles E. Meyer Desalination Plant (Desalination Plant) is also located within this area.

The highest **near-term** risk identified for the potable water system is damage to the desalination intake infrastructure caused by loss of cover of sand from erosion and offshore wave action. The highest **long-term** risks are loss of Desalination Plant site access and infrastructure damage from future flood events caused by high rainfall events, coastal storms or, eventually, tidal inundation.

Seawater intrusion into the City's groundwater wells, located inland of US 101, is an issue that City has historically monitored. The City typically increases groundwater pumping during extended droughts, which can cause the seawater / groundwater interface to move slightly inland. However, under normal periods of little or no pumping, the groundwater flow is toward the ocean, which stops intrusion and pushes the seawater interface seaward. Sea level rise will slightly increase to potential for seawater intrusion, but the predominant cause of seawater intrusion will continue to be heavy pumping of the City's groundwater wells. The City will continue to monitor for seawater intrusion and adjust pumping based on observations.

Desalination Intake System Erosion

The weir box, intake pipeline, and intake structure for the desalination system are projected to be impacted by 0.8 ft of sea level rise (~2050). The City is currently designing an intake structure replacement.

- **Near-Term (Through 0.8 ft SLR (~2050)):** The weir box at East Beach likely needs additional protection by 0.8 ft of sea level rise (~2050). The weir box could be abandoned, relocated, or protected as outlined in the Intake Structure Weir Box Relocation Erosion Protection Study (Carollo, 2019).
- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** A portion of the intake pipeline is projected to be exposed and unsupported between 0.8 (~2050) and 1.6 ft of sea level rise (~2065), which would require protection or replacement of the pipeline, depending on the planned Desalination Plant operations timeline. Inspection and monitoring of the pipeline will be important to inform decisions.

Desalination Plant Site Flooding

- **Near-Term (Through 0.8 ft SLR (~2050)):** Determine if new flood protection measures are needed through 2.5 ft of sea level rise (~2075) based on the planned Stormwater Model and Flood Analysis findings. Consider need for flood protection measures for adjacent Annex Yard as well.

- **Mid-Term (0.8 to 2.5 ft SLR (~2050 to ~2075)):** If the plant continues to operate in the mid-term, implement flood protection measures through 2.5 ft sea level rise and update the plant flood vulnerability analysis considering: 1) updated hazard and vulnerability assessments; 2) proficiency of implemented local and regional measures; and 3) long-term plans for the Desalination Plant.

6.1 Introduction

The City utilizes three water treatment plants:

1. The Charles E. Meyer Desalination Plant (Desalination Plant)
2. The Cater Water Treatment Plant (Cater WTP)
3. The Ortega Groundwater Treatment Plant (Ortega GWTP)

The desalination system and Ortega GWTP are near the hazards identified in this Plan. Flooding and sea level rise vulnerabilities for the desalination system and Ortega GWTP are discussed in Section 6.2 and 6.3, respectively. Risks for the desalination system and Ortega GWTP are discussed in the following subsections. The risks identified are summarized in Table 6-1.

Table 6-1. Potable Water Treatment Risk Assessment

Hazard	Risk Description	Consequences	Near-Term		Long-Term	
			Likelihood	Risk	Likelihood	Risk
DESALINATION PLANT						
Severe Flooding	Loss of access to site	2	4	**8**	4	**8**
Severe Flooding	Loss of service due to power outage	2	4	**8**	4	**8**
Severe Flooding	Loss of structural stability in onsite buildings and tanks	5	1	**5**	2	**10**
Groundwater Rise	Loss of structural stability in onsite buildings and tanks	5	1	**5**	2	**10**
DESALINATION INTAKE						
Shoreline Erosion and Wave Action	Damage to the desalination intake pipeline caused by loss of cover and wave action	4	3	**12**	5	**20**
Groundwater Rise	Corrosion-related damage to buried desalination intake structures caused by contact with brackish groundwater	3	2	**6**	3	**9**
Severe Flooding	Damage to mechanical and electronic components of the pre-treatment system	3	2	**6**	3	**9**

DESALINATION TRANSMISSION						
Severe Flooding	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure	3	1	**3**	3	**9**
Severe Flooding	Potable water contamination due to structural pipeline damage caused by changes in soil structure	4	1	**4**	2	**8**
Groundwater Rise	Corrosion related damage to the RCP transmission pipe from contact with brackish groundwater	3	1	**3**	2	**6**
Severe Flooding	Loss of access to the planned PRV site	1	3	**3**	4	**4**
Severe Flooding	Loss of power at the planned PRV site	1	2	**2**	3	**3**
ORTEGA GWTP						
Severe Flooding	Damage to mechanical and electronic components of the treatment system	3	2	**6**	3	**9**
Severe Flooding	Loss of structural stability in onsite buildings and tanks	5	1	**5**	2	**10**
Severe Flooding	Loss of service due to power outage	2	2	**4**	3	**6**
Severe Flooding	Loss of access to site	2	2	**4**	3	**6**

Refer to Section 3.1 for a description of scoring criteria.
Likelihood: Almost Certain (5 pts); Likely / Probable (4 pts); Possible (3 pts); Unlikely (2 pts); Rare (1 pt).
Consequences: Catastrophic (5 pts); Major (4 pts); Moderate (3 pts); Minor (2 pts); Insignificant (1 pt).
Risk (= Likelihood x Consequences): High (16 to 25 pts); Medium (9 to 15 pts): Low (1 to 8 pts).

6.2 Desalination System

The City's Desalination Plant treats approximately 3.0 MGD of drinking water and is an important component of the City's and other local water agencies' water supply portfolios. The Desalination Plant was designed for a 20-year lifespan with the ability to expand to 10 MGD. The City has a 50-year agreement with Montecito for desalinated water supply, and therefore, the City is most likely to expand the Desalination Plant capacity to approximately 5.0 MGD to meet increased water demand. The desalination system has four main elements located within the coastal hazard area (Figure 6-1):

- Desalination Plant Area (Section 6.2.1)
- Desalination Intake System (Section 6.2.2)
- Desalination Transmission Pipeline (Section 6.2.3)

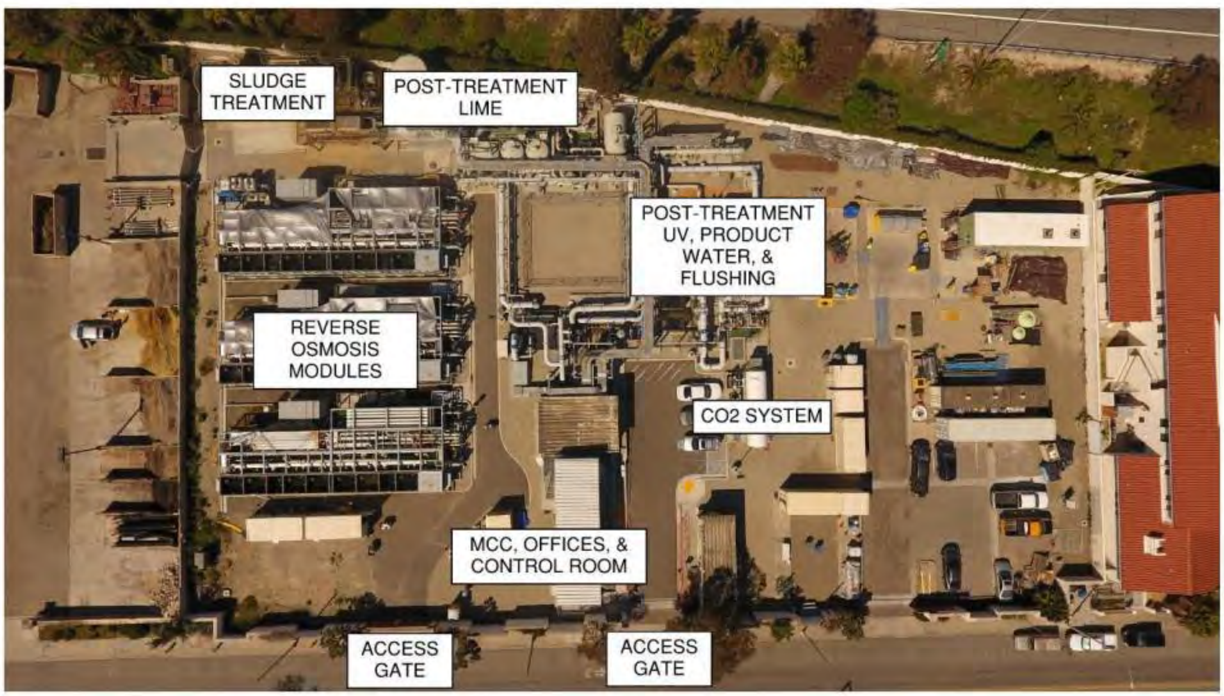
Figure 6-1. Desalination System Components

6.2.1 Desalination Plant Site

The Desalination Plant site is located across the street from El Estero WRC and adjacent to the City's annex yard. US-101 forms the northern boundary of the Desalination Plant. An overall view of the Desalination Plant is provided in Figure 6-2. Due to shared ocean outfall discharge capacity limitations, the Desalination Plant does not operate during storm events to preserve outfall capacity for treated wastewater from El Estero WRC.

The Pump Station and Chemical Area (PSCA) is located near the El Estero WRC back gate on Quinientos Street. Power for the seawater intake pumps, chemical feed pumps, sample water return pump, and a large sump pump are also located at the PSCA site. The PSCA is strategically positioned to meet minimum contact time for chemical reactions to occur before additional treatment at the Desalination Plant. If the PSCA were to be relocated, a new chemical application approach that meets contact time requirements would be needed.

Figure 6-2. Desalination Plant Site



6.2.1.1 Flooding

The Desalination Plant was upgraded in 2016, during which the electrical equipment was elevated to the FEMA base flood elevation plus an additional foot (approximately 14.4 ft). No onsite flooding was observed during the storms that occurred in 2022 and 2023; however, the site is projected to flood under the FEMA 100-year flood. In the future, the flood depths are likely to increase from more intense storms and sea level rise.

WSC and ESA conducted a site visit with City staff at the Desalination Plant to identify low-lying areas and locations vulnerable to flooding within the plant site. The Project team captured elevations at points within the Desalination Plant site and compared them with estimated FEMA

100-year flood levels (Figure 6-3). The data captured and compared is provided in Table 6-2. The range and average depth of onsite flooding were determined by comparing the elevation data collected during the site visit with the FEMA 100-year flood elevation. Elevation data was measured using NAVD88.

Table 6-2. FEMA 100-Year Flood Depth with Sea Level Rise at the Desalination Plant

Sea Level Rise Scenario	100-year Flood Elevation (ft NAVD 88)	Range of 100-year Flood Depth (ft NAVD 88)
Existing (FEMA)	13.4	0 – 3.0
0.8 ft (~2050)	14.2	0.1 – 3.8
1.6 ft (~2065)	15.0	0.9 – 4.7
2.5 ft (~2075)	15.9	1.7 – 5.5
3.3 ft (~2085)	16.7	2.5 – 6.3
4.1 ft (~2095)	17.5	3.3 – 7.1
4.9 ft (~2100)	18.3	4.1 – 7.9

Notes:

1. Flood elevations are conservatively assumed to rise the same amount as sea level rises. Storm modeling with sea level rise is required to more accurately estimate flood elevations with sea level rise.
2. See footnote 7 for considerations for “FEMA 100-year storm.”

Key Takeaways

The five lowest points captured during the site visit are located along the back wall of the Desalination Plant. In this area, there is a storm drain pipeline believed to be owned by the California Department of Transportation (Caltrans). The Desalination Plant electrical systems (Figure 6-4) and the reverse osmosis modules (Figure 6-5) have been elevated above ground to an elevation of 14.2 ft. The electrical equipment is estimated to be high enough to avoid flooding until after a sea level rise of 0.8 ft. Product water pumps are currently being constructed to convey the desalinated water into the City’s distribution system and to Cater WTP. The pumps have a design elevation of 15 ft (FEMA base flood elevation plus approximately 1.6 ft of freeboard). A one-foot sea level rise would reduce freeboard to 0.6 ft, requiring an increase in pump elevation.

Water & Wastewater Climate Adaptation Project

Figure 6-3. Desal Plant Survey Points Measured Compared to Historical FEMA 100-yr Flood Depth

Legend

Depth of Flooding

- >8'
- 5'-8'
- 2'-5'
- 1'-2'
- 0-1'
- Not Flooded

Notes

1. Labels used to reference point location (not an elevation).
2. Survey data measured by ESA on 1/12/2024 during site visit. Elevation data based on NAVD88 to inform elevation and flooding analysis for the Water & Wastewater Climate Adaptation Project. Exact elevations should be confirmed by a licensed surveyor during design of any adaptation efforts.
3. Estimated flood depths based on existing FEMA 100-yr flood mapping and projected sea level rise amounts.

N

0 25 50 US Feet

WSC

Figure 6-4. Elevated Electrical Equipment at Desalination Plant (Survey Point 118)

Image Note: *Photo of Desalination Plant electrical equipment is 14.2 ft, which is approximately the FEMA base flood elevation plus 1-foot.*

Figure 6-5. Elevated Reverse Osmosis Modules

Image Note: Photo of *Desalination Plant reverse osmosis modules are 14.2, which is approximately the FEMA base flood elevation plus 1-foot.*

6.2.1.1.1 PSCA Flooding

Plans for the PSCA (City of Santa Barbara, 2016) include construction elevations in relation to flood data. The PSCA site was constructed to the FEMA base flood elevation in this area of 13.3 ft. According to City staff, the PSCA has not experienced flooding onsite during recent storms, including the January 9, 2023, flood event that was approximately a 10-year event.

The elevation certificate for the site indicated that the lowest adjacent finished grade next to a building is 11.4 ft while the lowest elevation measured was for the electrical feed to pump motors that were installed at 13.7 ft (or 0.4 ft above the FEMA base flood elevation). Sea level rise is projected to raise the base flood elevation, which would increase the risk of flooding the electrical equipment. Electrical equipment is stored outdoors in vented boxes, which may allow future flood waters to infiltration and damage equipment.

In addition to storm flooding, daily tidal inundation is projected to reach the PSCA by 4.9 ft of sea level rise (~2100).

6.2.1.1.2 Adaptation Options

Flood Protection

The Desalination Plant and PSCA are protected from flooding in the near-term due to their relatively recent construction. However, components may need to be elevated again to remain above flood levels once the area is approaching 0.8 ft of sea level rise (~2050) and 0.4 ft of sea level rise (in roughly 10 years) for the plant and PSCA, respectively.

Base new elevation for improvements on anticipated flood levels under future sea level rise conditions that consider the latest plans for Desalination Plant operational life, timing of potential Desalination Plant relocation, and regional flooding adaptation measures and decisions.

Review onsite equipment exposed to the elements to ensure it is rated to withstand water and remain operational once a storm has passed, or consider relocating it to a new, elevated, water-proof enclosure. At a minimum, the City can utilize sandbags or other flood deflection measures until more permanent measures are taken.

Ultimately, the extent and likelihood of flooding the Desalination Plant and PSCA will be better defined in the planned Stormwater Model and Flood Analysis Report. The findings from this study combined with confirmation of component vulnerability will inform preferred flood protection measures.

Relocation

Conceptual adaptation measures were developed to relocate El Estero WRC out of the coastal and stormwater flooding hazards area, described in Section 4.2.5.3 and detailed in Appendix C. If El Estero WRC is relocated, the Desalination Plant should also be relocated if the City plans to continue operations after relocation.

Relocation of the Desalination Plant would entail a new pump station and pipeline to convey ocean water to the new site. The location and size of the new pump station would need to be determined pending identification of the proposed relocation site. The PSCA could potentially remain in place with additional protection measures regarding flooding. Alternatively, the PSCA could be installed at a new location out of the coastal and stormwater flooding hazards area. Since it is located separately from the Desalination Plant, relocation of the PSCA would likely require additional property acquisition to meet chemical contact time prior to entering the Desalination Plant. If the PSCA were located at the new Desalination Plant site, an additional tank to provide sufficient chemical contact time may be required prior to conveying seawater into the Desalination treatment processes.

The Desalination Plant could use the new onshore outfall for El Estero WRC to convey discharges to the ocean outfall so that the Desalination Plant brine can be discharged to the ocean.

El Estero WRC relocation would drive decisions around the timing of the Desalination Plant relocation. Consider El Estero WRC relocation plans when the City decides to invest in Desalination Plant improvements or expansion.

6.2.1.2 Access during Offsite Flooding

Like El Estero WRC, the Desalination Plant and PSCA also experiences access issues from Yanonali Street and Quinientos Street, respectively, during some storm events, including during the January 9, 2023, flood event that approximately a 10-year event. At the current 3.0 MGD production rate, the plant has a total of 16 employees and is typically staffed with 10 people during daytime working hours and one operator during the night shift. The Desalination Plant is not typically operational during storm events to preserve outfall capacity for wastewater treatment. If outfall capacity were to allow for simultaneous operation of the El Estero WRC and the Desalination Plant in the future, storm event flooding could prevent staff access, which would risk the Desalination Plant's operations and put personal safety for staff at risk.

In addition, the Desalination Plant receives chemical deliveries weekly. Flooding that extends for longer than one week could impact plant operations. However, chemical delivery frequency would likely increase if the plant's capacity was expanded in the future.

6.2.1.2.1 Adaptation Options

Similar to El Estero WRC, the Desalination Plant and the PSCA experience limited access during some existing storms. However, Desalination Plant operations are typically paused during storms to avoid desalination brine discharges to the El Estero outfall and preserve outfall capacity to discharge high wet weather flows. Therefore, impacts from access have lower impacts than for El Estero WRC. Access solutions for El Estero WRC could also consider benefits for access to the Desalination Plant and PSCA.

6.2.1.3 Groundwater Rise

Groundwater elevations below the Desalination Plant are estimated to be less than 6.6 ft from the ground surface with levels less than 3.3 ft on the eastern portion of the site (refer to Figure 3-10). With sea level rise, CoSMoS estimates that all groundwater at the Desalination Plant is projected to be less than 3.3 ft below the surface by 4.9 ft of sea level rise (~2100).

Groundwater elevations below the PSCA are estimated to be less than 6.6 ft from the ground surface. Based on CoSMoS data, groundwater may start emerging at the ground surface near the

PSCA entrance by 2.5 ft of sea level rise (~2075), and nearly half of the PSCA site may experience emergent groundwater by 4.9 ft of sea level rise (~2100).

Groundwater depths were estimated using CoSMoS. As discussed in Section 2.2.7, the estimates from CoSMoS were not compared with local groundwater data due to the limited availability of observation data. Therefore, shallow groundwater data collection is recommended to properly interpret modeling data from CoSMoS to estimate risk from shallow groundwater.

The shallow groundwater levels indicate that the soil is already saturated and the effects of groundwater on buried infrastructure (Section 3.3) may already be occurring. Saturated soil may impact the structural stability of facilities onsite, although no major impacts (e.g., cracking walls) have been observed.

6.2.1.3.1 Adaptation Options

Both the Desalination Plant and PSCA are estimated to currently experience shallow (0 – 6.6 ft below ground surface) groundwater. The City could monitor shallow groundwater in the area to determine the risk of emergent groundwater and the need for dewatering at the site as sea level rise increases and further raises groundwater levels.

6.2.1.4 Adaptation Recommendations

Near-Term (Through 0.8 ft SLR (~2050))

The Desalination Plant site is better protected from existing flood risks than El Estero WRC due to more recent construction that placed equipment at least one foot above the historical FEMA 100-year flood elevation. Future flooding risks for the Desalination Plant will be refined with the Stormwater Model and Flood Analysis Report (Section 3.4.3). Based on the planned Stormwater Model and Flood Analysis Report findings, the City could develop a Desalination Plant Flood Protection Study. Within the study, consider the latest planned Desalination Plant useful life and projected flood risks during that period. The City can identify additional adaptation measures for increased flooding by updating the desalination plant flood vulnerability analysis considering: 1) updated hazard and vulnerability assessments; 2) proficiency of implemented local and regional measures; and 3) long-term plans for the Desalination Plant.

6.2.2 Desalination Intake System

The desalination seawater intake system was constructed in the 1990s by retrofitting the abandoned El Estero WRC ocean outfall. The old 42-inch RCP pipeline was sleeved with a 36-inch HDPE liner, offshore intake pumps were installed at the underwater intake structure, and the 36-inch line was connected to the pump header and electrical equipment at the PSCA. An onshore weir box provides access to the pump's power and control cables as well as sodium hypochlorite (disinfectant) tubing that runs from PSCA to the intake pumps in dedicated conduits (Ionics Inc., 1996).

6.2.2.1 Intake Pipeline

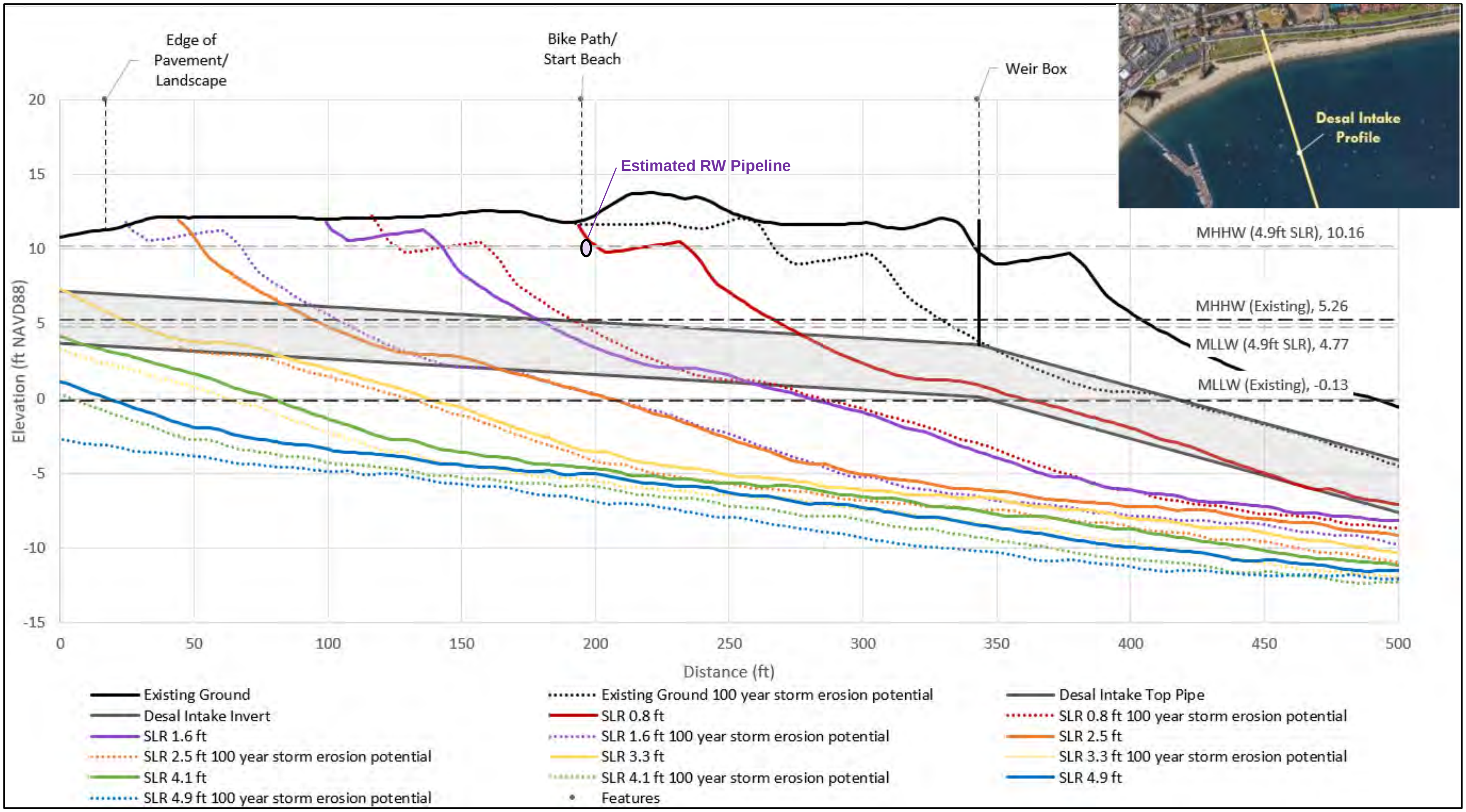
As shown in Figure 6-6, the RCP pipe conveying raw ocean water from the ocean to PSCA may already lack sufficient depth of cover in some areas. By 0.8 ft of sea level rise (~2050), the pipe is projected to have more than 50% of its diameter uncovered for a span of approximately 250 ft in the beach area with the possibility of pipe bedding loss during storms. Most of the uncovered pipe span is anticipated to be submerged with ocean water at high tide by 0.8 ft of sea level rise (~2050). This span of the intake pipeline would be subject to significant wave action. The onshore portion of the RCP pipeline will therefore be vulnerable to damage from wave action, such as material degradation and sea water intrusion. However, with the outer RCP pipe bearing the brunt of the sea level rise impacts, the sheltered HDPE liner inside the RCP pipe is unlikely to suffer damage. With 0.8 ft of sea level rise (~2050), a 100-year storm has the potential to cause erosion of the pipe bedding and leave a span of the intake pipeline unsupported.

The pump power and control conduits and sodium hypochlorite tubing are protected inside the 36-inch HDPE liner pipe between the onshore weir box and the offshore intake pumps. The City reported installation of new HDPE transition fittings during the Desalination Plant reactivation project in 2016 to transition the wires to the inside of the HDPE liner. Before the project was complete, three of the four transition fittings were observed to be leaking. Concrete was cast around the leaking area as a temporary fix.

However, between the beach weir box and the inland PSCA, the electrical and controls conduits and chemical tubing are located outside of the HDPE liner, which may leave them vulnerable to flooding infiltration.

By 1.6 ft of sea level rise (~2065), the intake pipeline is expected to have a significantly unsupported span onshore – approximately 250 ft. Most of this span will be partially submerged in water during low tide and fully submerged during high tide. In addition to material degradation and intrusion concerns mentioned above, this span of pipeline is expected to be subject to lateral loads and uplift forces from wave action. The latter could catastrophically damage both the RCP pipe and the HDPE liner, placing the intake pipeline out of commission until the onshore section is rebuilt and/or fortified.

Figure 6-6. Shoreline Erosion with Sea Level Rise, Desal Intake Infrastructure



The desalination intake weir box is currently exposed with surrounding beach rip rap under existing conditions and may be fully exposed before 0.8 ft of sea level rise (~2050). The desalination intake pipeline has the potential to be exposed at 0.8 ft of sea level rise (~2050). This analysis excludes any beach nourishment or protection measures that are being considered by the City.

6.2.2.2 Onshore Weir Box

The weir box is in the beach area and consists of a concrete structure that is approximately 17 ft by 10 ft and 14 ft tall, according to 2015 as-builts (Kiewit and IDE Technologies). The top of the weir box is approximately eight ft above the top of the intake pipeline, and the weir box foundation is approximately two ft below the bottom of the pipe (Kiewit and IDE Technologies).

In 2019, Carollo Engineers undertook planning to relocate the existing beach weir box to a new location, approximately 60 ft northwest (and inland) of the existing one. The planning effort examined various sea level rise scenarios and their impact on the proposed new weir structure. Undercutting of the intake pipeline on the seaward of the weir box was the primary hazard identified (Carollo, 2019). Other hazards include:

- Limited access to the weir box from land.
- Inundation of the pipe connections within the weir box.
- Potential impacts due to sand cover and/or sand ingress.
- Potential undercutting of the weir box foundation.

The memorandum concluded that adaptation due to sea level rise would not be needed until 2.2 to 2.9 ft of sea level rise. This timeframe corresponded with the following projections:

- The beach profile would recess 120-165 ft inland.
- The loss of sand cover due to beach erosion at the weir box area would be between one to seven ft.

In contrast to the previous projections, shoreline erosion projections prepared for this Plan (Figure 6-6) estimate that by 0.8 ft of sea level rise (~2050):

- The beach profile is expected to recess approximately 100 ft inland, and over 50 ft of water would horizontally separate the weir box from land during high tide events (MHHW) with access possible only during low tide on calm days.
- The loss of sand cover in the weir box area is expected to be approximately 10 ft with potential undercutting of the intake pipeline and weir box foundation during storm events.

These more recent projections underscore the importance of having adaptation measures in place for the onshore portions of the intake pipeline and weir box (as well as other shoreline infrastructure) well in advance of predicted impacts.

6.2.2.3 Offshore Intake

Two intake pumps are located 2,500 ft offshore in approximately 30 ft of sea water where each is housed in an 18 ft by 18 ft, 15 ft tall concrete structure on top of four 50 ft deep 24-inch piles.

During a recent inspection, the City found significant scour under one of the intake pump structures, with an 18-inch gap between the sea floor and bottom of the structure, which was supported entirely by its piles. Pea gravel was installed under the structure as a temporary fix. New scour was also discovered on the other intake structure with measurements indicating nearly 30% of the subgrade scoured.

While there are no available projections of the increase in offshore ocean floor scouring with climate change and sea level rise at a point 2,500 ft away from shore, it is reasonable to assume that an increase in frequency and magnitude of storms will result in bathymetric changes. These changes may further impact the intake pump structure subgrade, potentially at an increased rate.

The pile support system of the pump intake structures appear to be robust and should provide a reliable means of supporting the structures vertically, even in the event of significant ocean floor erosion. The City has plans to harden the intake structure to prevent future subgrade scour and expects to implement improvements by 2026.

6.2.2.4 Adaptation Recommendations

The desalination intake system is among the first of the City's assets anticipated to be impacted by shoreline erosion. The weir box, the surf zone pipeline, and the intake structure are projected to be impacted by 0.8 ft of sea level rise (~2050). Consequently, feasibility investigations and preliminary design efforts are recommended to begin now to enable a timely response to impacts of shoreline erosion on the desalination intake. Investment into the desalination intake protection should consider the useful life of new infrastructure and City's long-term plans for the Desalination Plant. Recommended adaptation actions for each component of the intake system are discussed below.

Intake Pipeline

A portion of the intake pipeline is projected to be exposed and unsupported with between 0.8 ft (~2050) and 1.6 ft of sea level rise (~2065). This condition likely requires the replacement of the intake pipeline if the Desalination Plant continues to operate beyond 25 years from now. The intake pipeline could be protected with additional rock armor as the pipeline becomes more exposed. Environmentally-friendly and nature-based protection options should also be considered. Once protection is no longer effective, an alternative intake pipeline would most likely need to be constructed at a greater depth. Actions would be delayed if City beach nourishments are successfully implemented. Inspection and monitoring of the pipeline will be important to inform the timing of replacement.

Onshore Weir Box

The desalination intake weir box likely needs additional protection by 0.8 ft of sea level rise (~2050). The weir box could be abandoned, relocated, or protected as outlined in the Charles E. Meyer Desalination Plant Intake Structure Weir Box Relocation Erosion Protection Study (Carollo, 2019). Potential adaptation measures for the weir box include:

- Investigation of opportunities to abandon the weir box and move onshore controls and chemical feed to PSCA.
- Relocation of the weir box to higher ground. Floodproofing of the new weir box to ensure a dry box or pump-out condition, and installation of a scour apron at the time of construction.

Offshore Intake Structure

The intake structure has already been impacted by subgrade erosion and requires long-term protection from further scouring. The City has plans to harden the intake structure and prevent future subgrade scour and expects to implement improvements by 2026.

The City should evaluate the merits of moving the offshore pumps onshore to facilitate maintenance and increased infrastructure lifecycle.

6.2.3 Desalination Transmission

In 2023, the City completed the Desal Link project with the purpose of conveying treated ocean water from the Desalination Plant to the Cater WTP Reservoir and, subsequently, all parts of the City’s service area and neighboring jurisdiction, the Montecito Water District. The Desal Link project included installation of approximately 11,800 ft of 24-inch polyvinyl chloride (PVC) main from the Desalination Plant to the existing water main at Mission Street and Garden Street as well as installation of a new pressure reducing valve (PRV) station at the Desalination Plant site.

It is not known whether flood protection has been incorporated into the design of these infrastructure components. According to feedback from the City’s Operations team, the newly constructed PRV did not flood in the last storm but was surrounded by flood water. Like the rest of the infrastructure at the Desalination Plant site, both the transmission main and the PRV are assumed to be vulnerable to impacts of coastal flooding.

6.3 Ortega Groundwater Treatment Plant

The Ortega GWTP currently treats groundwater from four wells within the downtown Santa Barbara area on a seasonal basis with a combined capacity of 2.5 MGD, which represents 6% of the City’s potable water production capacity. Those wells are:

1. Corporation Yard.
2. Vera Cruz.
3. City Hall.
4. High School.

The City’s Ortega Park well is located downtown but is not active, and a connection from the Alameda well to Ortega GWTP is currently being developed. This connection will increase the total well production capacity upstream of the plant to 3 MGD, or 7% of City’s overall treatment capacity.

The Ortega GWTP relies on deliveries of sodium chloride for sodium hypochlorite generation, and the Public Works Corporation Yard stores personal protective equipment, first aid, tools, and fleet equipment (Brown and Caldwell, 2020) (Brown and Caldwell, 2021). With sea level rise, access to these areas may become limited during storms, and provisions may have to be made to ensure continued operation. In the event of power loss in the area, the Ortega GWTP can be supplied by a portable generator provided the site is accessible for delivery to the plant (Brown and Caldwell, 2021).

The Ortega GWTP is located close to FEMA flood zone AH (Figure 6-7), which corresponds to an area of 100-year shallow flooding with a constant water surface elevation (area of ponding) between 14 to 15 ft above mean sea level and flood depths of one to three ft. The Ortega GWTP is located at an elevation of 17 ft (Carollo, 2020). The City's Water System Risk and Resilience Assessment concluded that a flood could cause five days of water service outage at the Ortega GWTP site (Brown and Caldwell, 2020).

The Ortega GWTP is typically operated during the summer months due to higher water demands or during emergency situations if other supplies are not available. Flood-related outages would typically occur during the winter months when the impacts of an outage are limited.

The Corporation Yard well, one of the wells that supply the Ortega GWTP, is located within FEMA flood zone AH (Figure 6-7). FEMA base flood elevation in the vicinity of the Corporation Yard well is 15 ft, while the Corporation Yard ground elevation is 16 ft (Carollo, 2020), which places the Corporation Yard wellhead one foot above the FEMA base flood elevation. This well was replaced in 2014, and its above-ground components are housed on a concrete pad in a parking lot. There are no obvious direct pathways for flood waters to enter the well to impact water quality.

6.4 Groundwater Quality / Seawater Intrusion

Seawater intrusion into the City's groundwater wells, located inland of US 101, is an issue that City has historically monitored. The City typically increases groundwater pumping during extended droughts, which can cause the seawater / groundwater interface to move slightly inland. However, under normal periods of little or no pumping, the groundwater flow is toward the ocean, which stops intrusion and pushes the seawater interface seaward.

As seawater intrusion into the Storage Unit No. 1 aquifer from has been an issue in the past (City of Santa Barbara, 2011), the City undertook an investigation into how much water can safely be pumped from Storage Unit No. 1 to minimize seawater intrusion and to keep the groundwater flowing towards the ocean (Nishikawa, T., 2018). This issue is expected to become more prominent with sea level rise because higher ocean levels create more pressure, driving ocean water inland towards groundwater aquifers.

Sea level rise will slightly increase to potential for seawater intrusion, but the predominant cause of seawater intrusion will continue to be heavy pumping of the City's groundwater wells. The City will continue to monitor for seawater intrusion and adjust pumping based on observations.

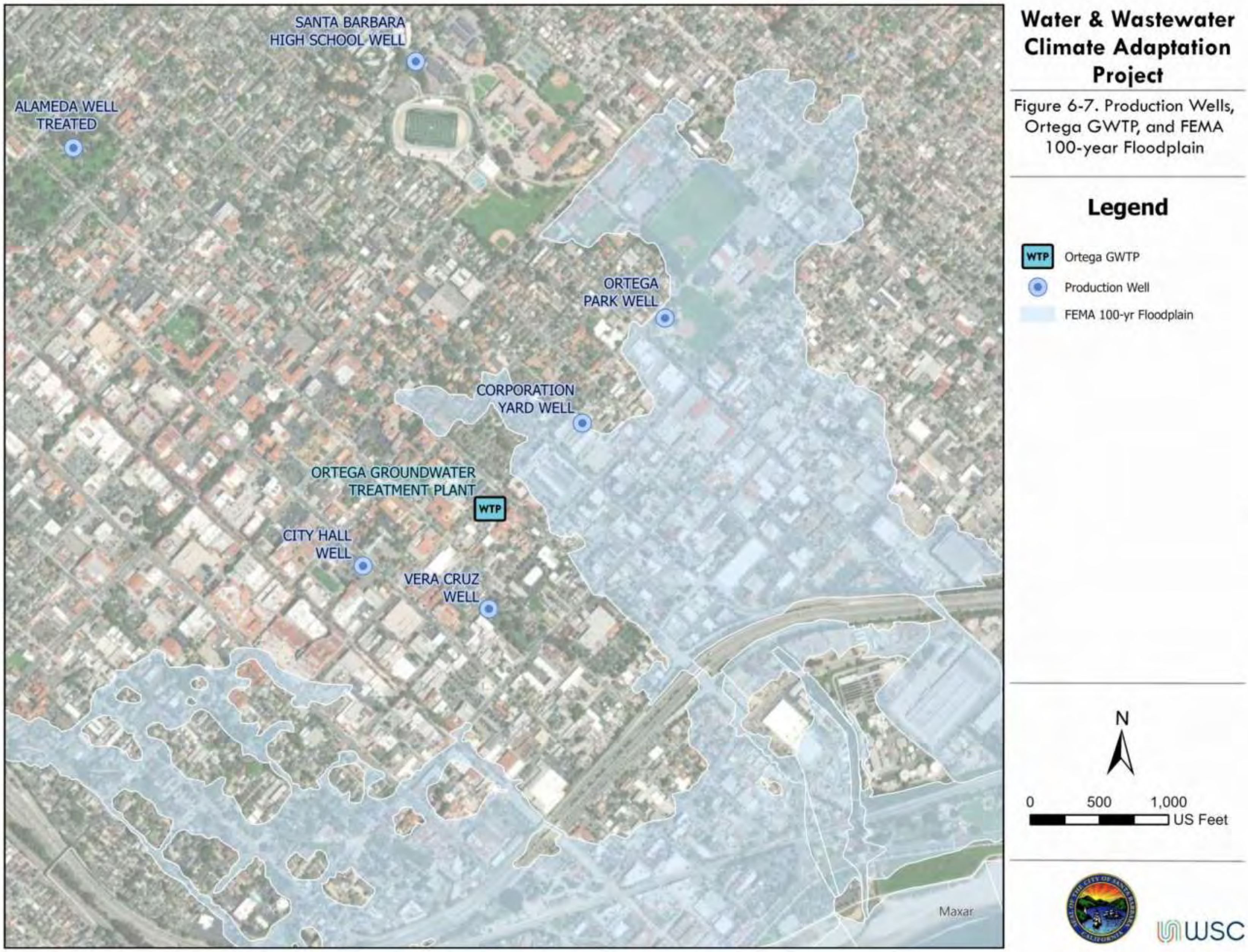
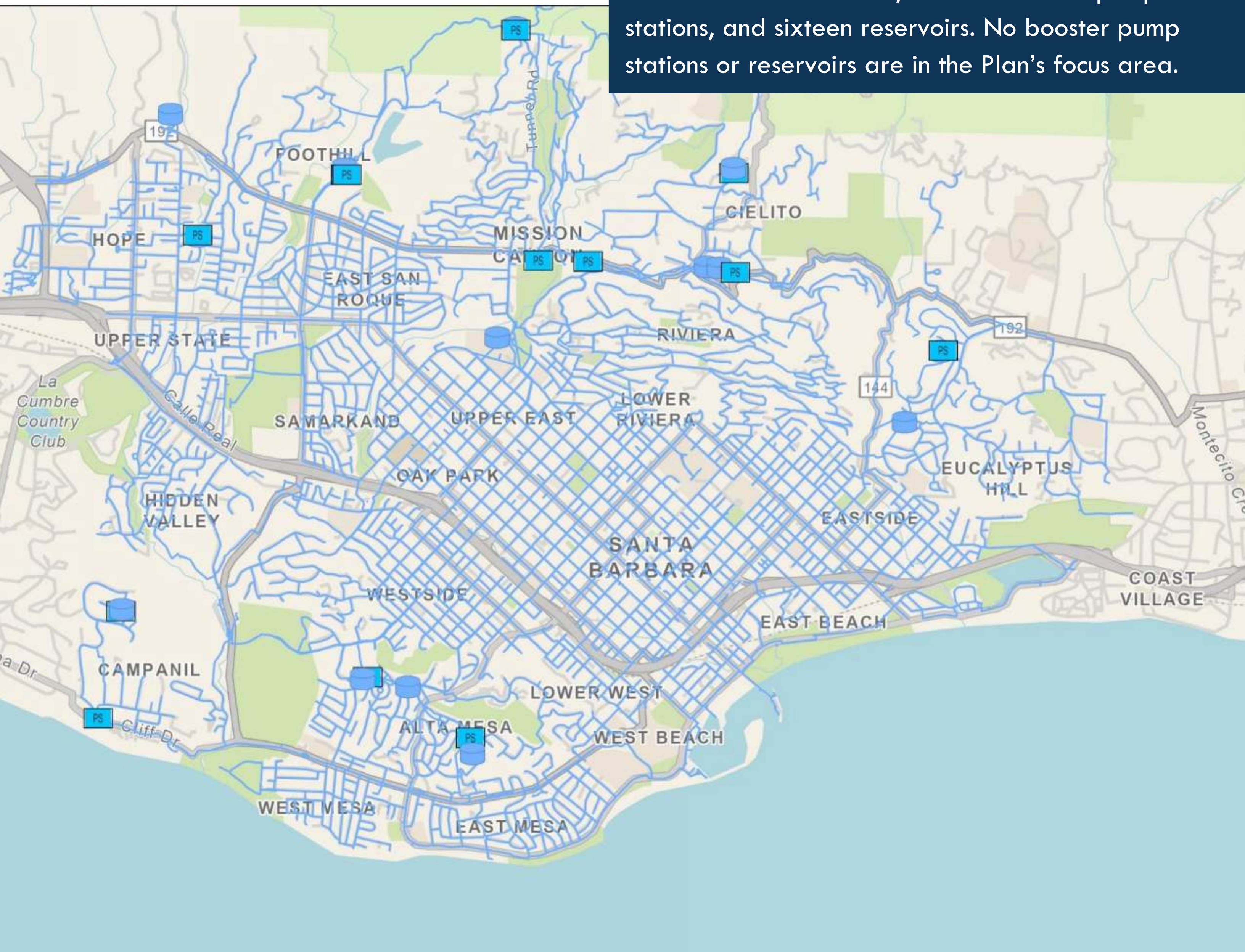


Figure 6-7. Production Wells, Ortega GWTP, and FEMA 100-year Floodplain

7.0 Potable Water Distribution

The City's potable distribution system is composed of 27 miles of water mains, thirteen booster pump stations, and sixteen reservoirs. No booster pump stations or reservoirs are in the Plan's focus area.



Vulnerability and Adaptation Summary

The study area has approximately 27 miles of potable water distribution piping, with diameters ranging from 2 inches to 17 inches. The water distribution piping has similar vulnerabilities as other buried piping regarding climate change impacts, including flooding, groundwater rise, and shoreline erosion. The largest risk for the distribution system is damage to near-shore potable water pipelines from shoreline erosion and wave action, specifically in the **mid-term** for potable water pipeline segments under Cabrillo Blvd, Shoreline Drive, and Chase Palm Park.

While the vulnerabilities of the whole potable water system were assessed, particular attention was given to those portions of the system in the coastal low-lying areas. Potable water distribution assets in this area include buried distribution piping, valves, and equipment vaults, as well as above-ground components including valves, backflow preventers, and hydrants.

Adaptation recommendations for near-shore potable water pipelines risk include:

- **Immediate Next Steps (0-5 Years):** Improve preparedness and emergency response planning (refer to Section 9.3.1.3).
- **Near-Term (Through 0.8 ft SLR (~2050)):**
  - Relocate the potable water pipeline in Chase Palm Park further inland.
  - Ensure protection measures are planned for Cabrillo Blvd and Shoreline Drive to safeguard potable water infrastructure in the area.
  - Consider replacement of aging pipes in the coastal area with non-metallic materials, such as HDPE or PVC, and implement corrosion prevention methods where metallic pipe or fittings must be installed.

Also, sea water flooding and brackish groundwater rise are likely to increase soil salinity and cause corrosion of metal pipes and metal pipe components, which could shorten infrastructure lifespans. Consequently, the City should consider replacement of aging pipes in the coastal area with non-metallic materials, such as HDPE or PVC, and implement corrosion prevention methods where metallic pipe or fittings must be installed.

Seawater intrusion into the City's groundwater wells, located inland of US 101, is an issue that City has historically monitored. The City typically increases groundwater pumping during extended droughts, which can cause the seawater / groundwater interface to move slightly inland. However, under normal periods of little or no pumping, the groundwater flow is toward the ocean, which stops intrusion and pushes the seawater interface seaward. Sea level rise will slightly increase to potential for seawater intrusion, but the predominant cause of seawater intrusion will continue to be heavy pumping of the City's groundwater wells. The City will continue to monitor for seawater intrusion and adjust pumping based on observations.

7.1 Introduction

The potable water distribution system in the study area consists of buried distribution piping, valves, and equipment vaults, as well as above-ground components including valves, backflow preventers, and hydrants. There are no reservoirs or booster pump stations located in the coastal area, except for the distribution pumps contained within the Ortega GWTP and the Desalination Plant (see Section 6.0). Risks for potable water distribution are summarized in Table 7-1 and are discussed in the following subsections.

Table 7-1. Risk Assessment for the Potable Water Distribution System

Hazard	Risk Description	Consequences	Near-Term		Long-Term	
			Likelihood	Risk	Likelihood	Risk
Shoreline Erosion and Wave Action	Damage to pipes near shore	4	3	**12**	5	**20**
Severe Flooding	Potable water contamination due to structural pipeline damage caused by changes in soil structure	5	2	**10**	2	**10**
Severe Flooding	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure	3	2	**6**	3	**9**
Severe Flooding	Loss of water and depressurization due to damage to above ground infrastructure (hydrants, valves)	3	2	**6**	3	**9**
Groundwater Rise	Corrosion-related damage to steel, iron, and copper pipes from contact with brackish groundwater	3	2	**6**	3	**9**
Groundwater Rise	Potable water contamination due to structural pipeline damage caused by changes in soil structure	5	1	**5**	2	**10**
Severe Flooding	Potable water contamination due to damage to above ground infrastructure (hydrants, valves)	5	1	**5**	2	**10**
Groundwater Rise	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure	3	1	**3**	3	**9**

Refer to Section 3.1 for a description of scoring criteria.
Likelihood: Almost Certain (5 pts); Likely / Probable (4 pts); Possible (3 pts); Unlikely (2 pts); Rare (1 pt).
Consequences: Catastrophic (5 pts); Major (4 pts); Moderate (3 pts); Minor (2 pts); Insignificant (1 pt).
Risk (= Likelihood x Consequences): High (16 to 25 pts); Medium (9 to 15 pts): Low (1 to 8 pts).

7.2 Distribution Pipeline

There are approximately 27 miles of potable water distribution piping, ranging in diameter from 2 inches to 17 inches, in the Focused Study Area (defined in Figure 1-3). Pipelines in the study area are mainly made of cast iron that were installed in the first half of the 20th century; additionally, there are some PVC and ductile iron piping that was installed within the last 50 years. These pipelines are typically buried at least 30 inches below ground. In 2018, the national average age of failing water mains was reported as 50 years old (Barfuss, 2023). A large portion of the water distribution piping in the study area is over 50 years old and may be nearing the end of its useful life.

Water distribution piping has similar vulnerabilities as other buried piping regarding climate change impacts, including flooding, groundwater rise, and shoreline erosion. These are discussed in the following sections.

7.2.1 Flooding

As shown in Figure 7-1, roughly 27 miles (8 percent) of the City's distribution pipelines are currently within the FEMA 100-year flood area. Advancing and retreating floodwaters associated with more frequent and intense storms may impact soil structure around the pipes, potentially leading to cracks and breaks in the pipes over the long term (refer to Section 3.2.1). Pipe breaks can lead to contamination of potable water due to loss of pressure and disinfection. Temporary losses of system pressure and the need for pipe repairs could become more frequent in the coastal area due to the potential increase in sea level rise hazards.

Additionally, flooding of below ground vaults may compromise the vault's structural integrity, damage flow meters and electronic pressure gauges, and potentially increase the rates of pipeline corrosion. Pressure monitoring systems should be designed to withstand intense storm flooding, as they play an integral part in detecting pipe leaks and breaks.

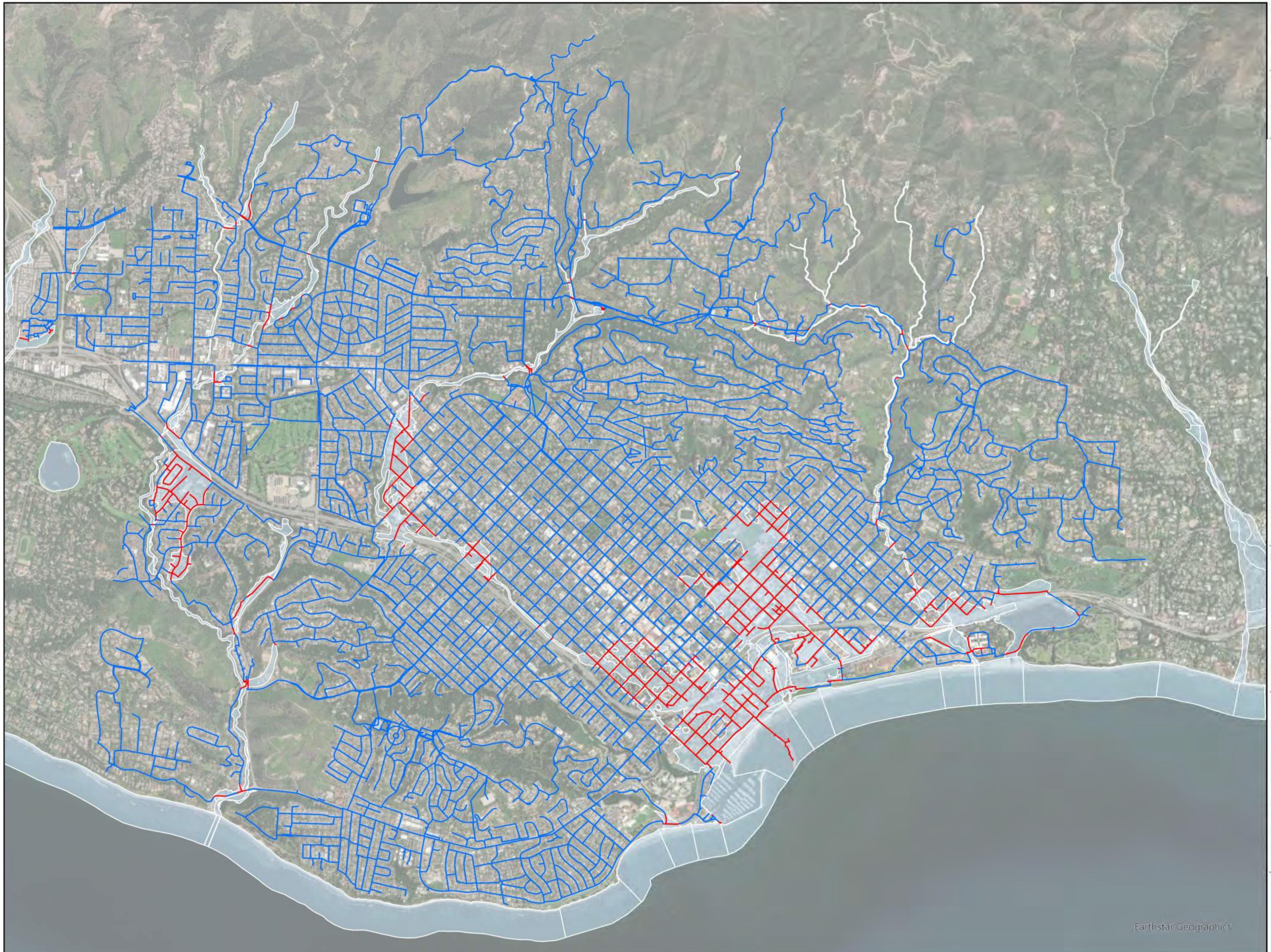
7.2.2 Groundwater Rise

As shown in Figure 7-2, roughly 52,000 ft or 9.9 miles of distribution pipelines located within the focus area are currently estimated to be exposed to groundwater. Analysis of the exposure is based on the typical water main depth of 2.5 ft. Based on CoSMoS groundwater depth estimates, any potable pipeline that falls within emergent or very shallow groundwater depth areas are estimated to be submerged. Note that groundwater depths were estimated using CoSMoS, which may be estimating levels shallower than current observations. As a result, shallow groundwater monitoring is recommended to update groundwater depth estimates.

Rising groundwater levels could reach the depths of shallow buried pipe or higher, impacting the structural integrity of the pipes due to saline water exposure. This can lead to increased rates of corrosion and corrosion-related pipe failures.

Water & Wastewater Climate Adaptation Project

Figure 7-1. Potable Distribution System Pipelines in FEMA 100-yr Floodplain



Legend

- Water Main within FEMA Floodplain
- Water Main
- FEMA 100-yr Floodplain

Notes

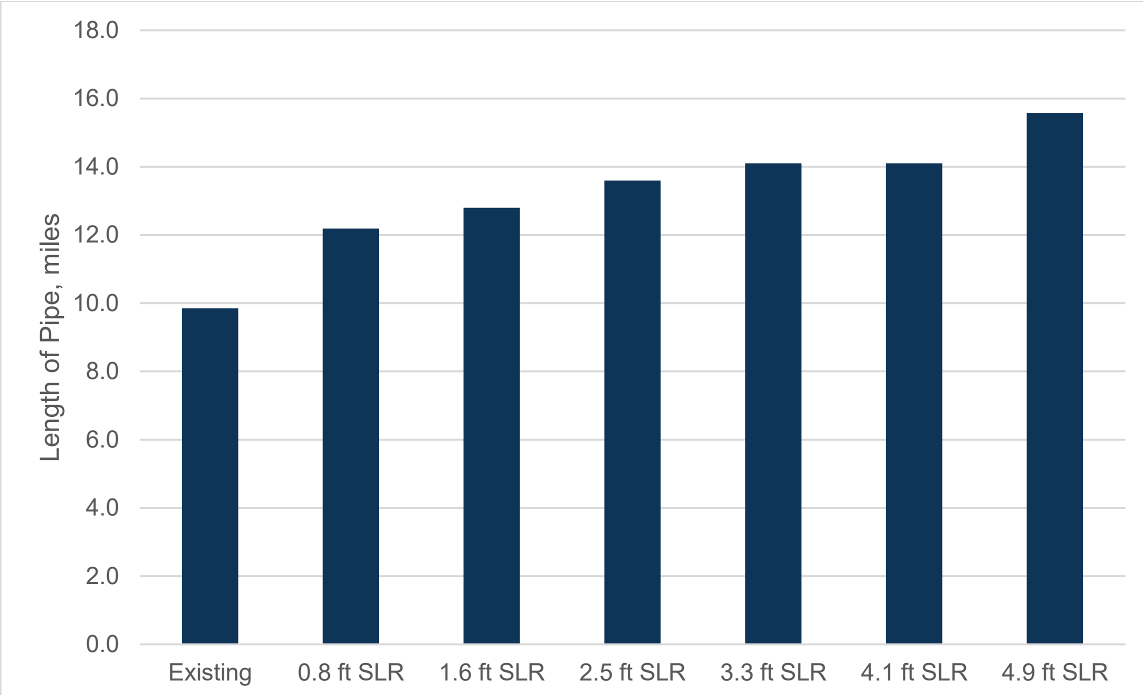
N

0 0.5 1 Miles

0 2,000 4,000 US Feet

WSC

Figure 7-2. Distribution System Pipelines Submerged by Groundwater by SLR Scenario



7.2.3 Shoreline Erosion

As shown in Figure 7-3, the potable water system segments found to be most vulnerable to impacts of shoreline erosion are:

- Pipelines within Cabrillo Blvd and Shoreline Drive
- 12-inch cast iron pipe in Chase Palm Park

Cabrillo Blvd

By a 1.6 ft of sea level rise (~2065), shoreline erosion is anticipated to impact Cabrillo Blvd and piping buried within it. If Citywide protection measures are not implemented, the entire length of the potable water distribution pipeline within Cabrillo Blvd may be considered for relocation. By 2.5 ft of sea level rise (~2075), shoreline erosion is anticipated to have similar impacts on Shoreline Drive and piping buried within it.

Chase Palm Park Pipeline

The potable water pipeline segment in Chase Palm Park is at risk of exposure by 2.5 ft of sea level rise (~2075). This pipeline was not the initial focus of the study, so a shoreline erosion profile was not created. As a result, monitoring of this pipeline segment will be important to determine relocation timing. A new pipeline could be constructed in Cabrillo Blvd in the near term, with the specific timing based on planned updated shoreline erosion analysis.

Figure 7-3. Near-Shore Potable Water Distribution Pipelines

7.3 Adaptation Options

The largest risk identified for the potable water distribution line is structural pipeline damage at discrete locations near the oceanfront, resulting from shoreline erosion and wave action.

Additional risks are:

- Structural pipeline damage caused by changes in surrounding soil structure from floods and/or rising groundwater levels.
- Corrosion-related damage due to pipe contact with sea water or brackish groundwater.

These risks are compounded by the following existing factors:

- Age of the potable water infrastructure in the study area (some of the piping dates to the 1920s, with the majority of the piping at least 50 years old).
- Lack of remote pressure monitoring and control in the study area.

The lack of pressure monitoring combined with potentially high operating pressures in the study area could lead to significant water losses through leaks that go undetected for long periods of time. One of the preventative actions the City could take is the installation of remote pressure monitoring data loggers. Pressure monitoring improves system-wide pressure distribution management and enables the detection of pressure spikes that could contribute to rapid deterioration of pipes over time. Pressure monitoring could be prioritized in areas with both lower and higher operating pressures than normal, ideally on pipe segments that are likely to be most vulnerable. Most vulnerable piping includes lines 3-8 inches in sizes, iron, and older (Barfuss, 2023).

The City can also consider installing leak detection systems on segments of piping most vulnerable to impacts of shoreline erosion, like acoustic detection systems that detect the sound of water escaping through pipe walls. The structural and corrosion risk to buried infrastructure from flood-induced soil movement and groundwater rise are not anticipated in the immediate future but is recommended to be better monitored.

7.4 Adaptation Recommendations

Immediate Next Steps (0-5 Years)

- Improve preparedness and emergency response planning (refer to Section 9.3.1.3).
- Consider installation of remote pressure and leak detection sensors to monitor for leaks in the most vulnerable segments of the potable water distribution pipeline.

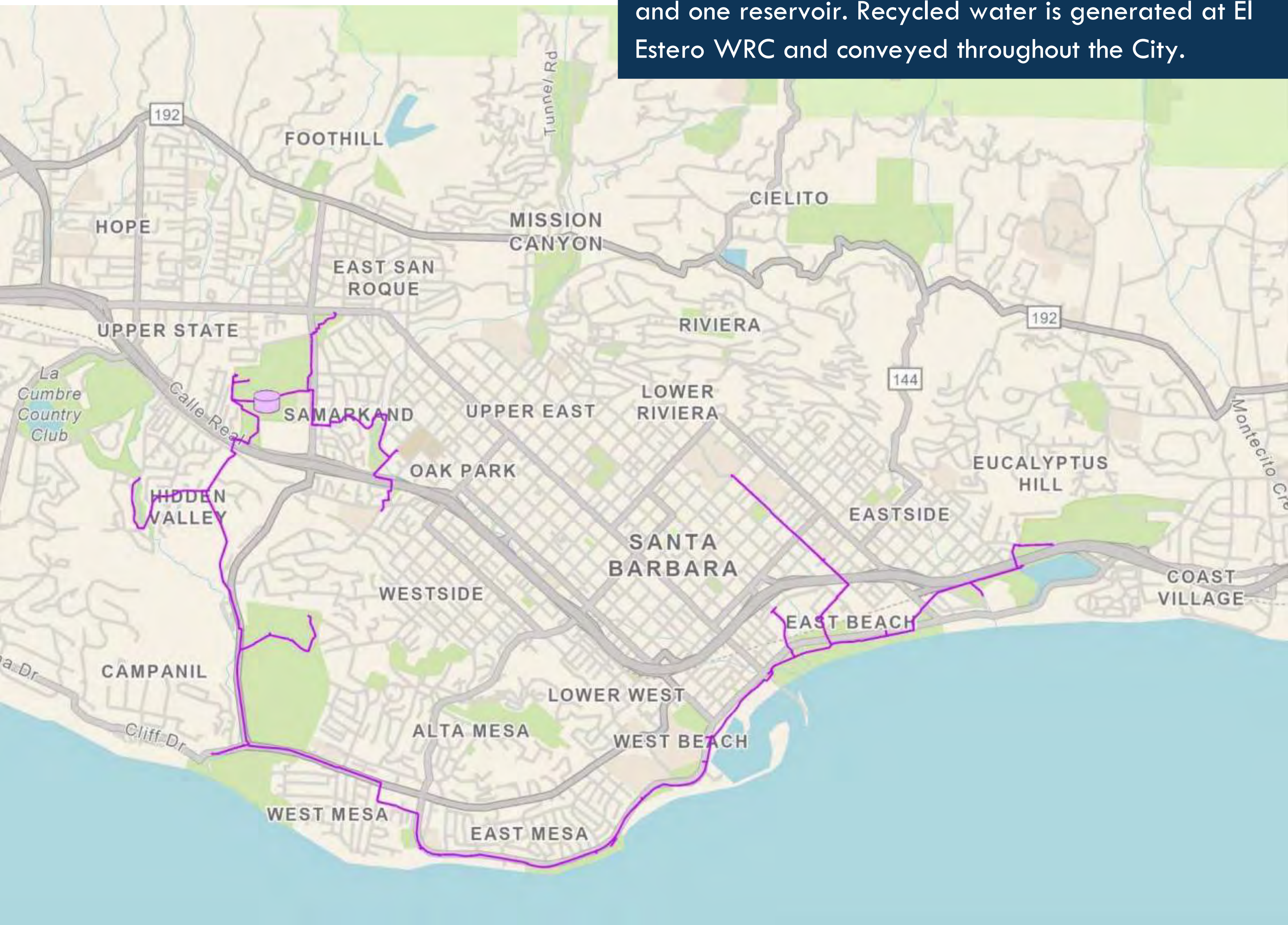
Near-Term (Through 0.8 ft SLR (~2050))

- Relocate the potable water pipeline in Chase Palm Park further inland.
- Ensure protection measures are planned for Cabrillo Blvd so that potable water infrastructure in Cabrillo Blvd is protected.

Consider replacement of aging pipes in the coastal area with non-metallic materials, such as HDPE or PVC, and implement corrosion prevention methods where metallic pipe or fittings must be installed.

8.0 Recycled Water System

The City's recycled water system consists of 13.4 miles of recycled water mains, one booster pump station, and one reservoir. Recycled water is generated at El Estero WRC and conveyed throughout the City.



Vulnerability and Adaptation Summary

The City recycled water system consists of tertiary treatment plant, reservoir, and pumping station located within or adjacent to El Estero WRC. The distribution system consists of 13.4 miles of recycled water mains, booster pumping station, and reservoir. Approximately 2.9 miles of recycled water distribution main is in the Plan’s study area.

The largest risk is damage to recycled water pipelines in Chase Palm Park from shoreline erosion between 0.8 ft and 2.5 ft of sea level rise (~2075). Beyond beach nourishment to mitigate the erosion concerns at East Beach, the City should plan to move the pipelines inland before 0.8 ft of sea level rise (~2050). Investigation of relocation options for this pipeline could begin now. There may be an opportunity to relocate the recycled water lines to Cabrillo Blvd when the potable water line in Chase Palm Park is relocated.

The largest long-term risk is treatment and pumping failures from flooding by 2.5 ft of sea level rise (~2075). However, flooding adaptation measures will be driven by El Estero WRC adaptation since wastewater treatment failures have a much larger consequence than recycled water system failure.

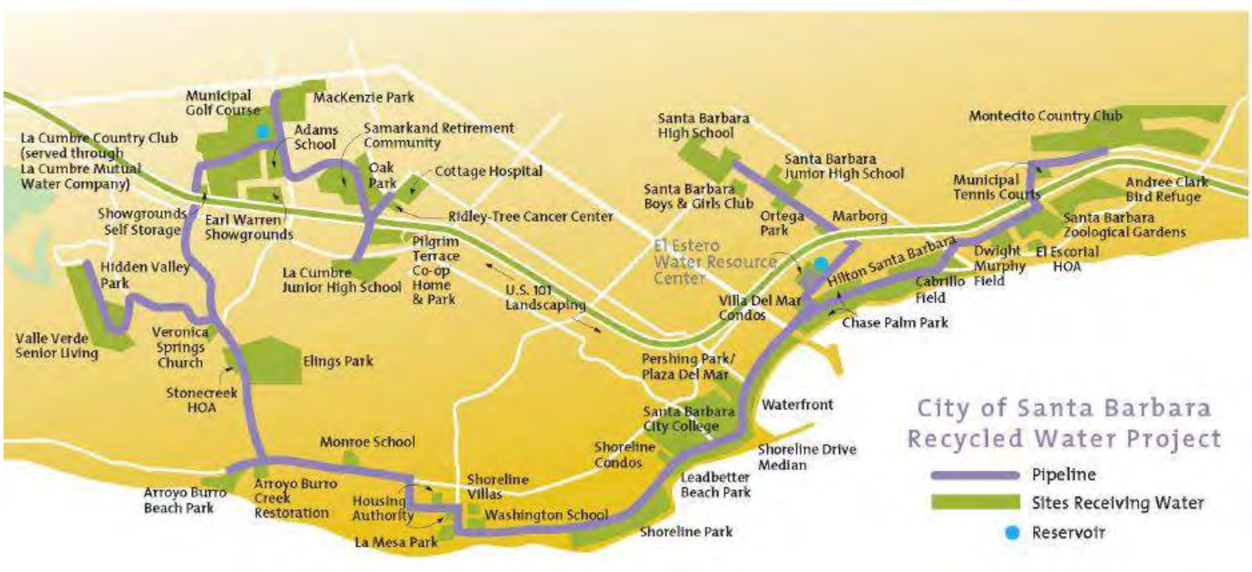
In addition, the City has plans for a future potable reuse project that would treat effluent from El Estero WRC for delivery to Cater Water Treatment Plant and distribution to the customers. The project relies on treated wastewater from El Estero and the existing recycled water distribution system. If El Estero WRC is relocated, the potable reuse project facilities would also be relocated.

8.1 Introduction

The City initiated planning for a recycled water project in the early 1980s and Phase I of the City's recycled water system was completed at El Estero WRC in 1989. It included a tertiary treatment plant with carbon filtration and disinfection, a 600,000-gallon distribution reservoir and pumping station, and 5.1 miles of recycled water distribution main. Phase II was completed in 1992, which added an additional pumping station, a 1.5- million-gallon reservoir at the Santa Barbara Golf Club, and 8.3 miles of distribution main. In 2015, the City completed upgrades to its tertiary treatment plant to include an ultrafiltration treatment process. Approximately 2.9 miles of recycled water distribution main is in the Plan's focus area.

Under normal conditions, the existing recycled water customer demand is approximately 700 AFY plus approximately 300 AFY of process water for use at El Estero WRC. The system provides recycled water to 97 accounts that serve parks, schools, golf courses, and other large landscapes, shown in Figure 8-1.

Figure 8-1. Recycled Water Distribution System



Source: (City of Santa Barbara, 2024)

Overall, the recycled water system is an important component of the City's water supply system but is not a critical system for public health and safety. Loss of the system would require meeting demand with potable water that had been previously met with recycled water. Besides use at El Estero WRC, 99% of the City's recycled water demands are for landscape irrigation, which peaks in the summer.

The recycled water system consists of two main components – treatment and distribution, which are discussed in Section 8.2 and Section 8.3, respectively. Risks for recycled water treatment and distribution are summarized in Table 8-1 and are discussed in the following subsections.

Table 8-1. Risk Assessment for the Recycled Water System

Hazard	Risk Description	Consequences	Near-Term Likelihood	Near-Term Risk	Long-Term Likelihood	Long-Term Risk
RECYCLED WATER TREATMENT						
Severe Flooding	Damage to mechanical and electronic components of the treatment system	3	3	**9**	5	**15**
Severe Flooding	Loss of access to site	2	4	**8**	5	**10**
Severe Flooding	Loss of service due to power outage	2	3	**6**	3	**6**
Severe Flooding	Loss of structural stability of buildings and tanks on site	5	1	**5**	2	**10**
Groundwater Rise	Loss of structural stability of buildings and tanks on site	5	1	**5**	2	**10**
RECYCLED WATER DISTRIBUTION						
Shoreline Erosion and Wave Action	Damage to pipes near shore	3	4	**12**	5	**15**
Severe Flooding	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure	3	2	**6**	3	**9**
Groundwater Rise	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure	3	1	**3**	3	**9**

Refer to Section 3.1 for a description of scoring criteria.
Likelihood: Almost Certain (5 pts); Likely / Probable (4 pts); Possible (3 pts); Unlikely (2 pts); Rare (1 pt).
Consequences: Catastrophic (5 pts); Major (4 pts); Moderate (3 pts); Minor (2 pts); Insignificant (1 pt).
Risk (= Likelihood x Consequences): High (16 to 25 pts); Medium (9 to 15 pts): Low (1 to 8 pts).

8.2 Recycled Water Treatment System

The recycled water treatment system, shown in Figure 8-2, consists of ultrafiltration followed by chlorine disinfection. The Recycled Water Distribution Pump Station pumps recycled water from the El Estero WRC site to the distribution system at higher elevations throughout the City. The ultrafiltration system and recycled water storage tank is located within the El Estero WRC while the disinfection system and pump station are located adjacent to El Estero WRC, near the back gate on Quinientos Street and next to the Desalination Plant PSCA.

Figure 8-2. Recycled Water Treatment Components [Located at El Estero WRC]

The recycled water structures within El Estero WRC have similar vulnerabilities to flooding as the El Estero WRC site, as described in Section 4.2, but with lower consequences of failure.

Plans for the disinfection system and pump station were not available to estimate construction elevations; but, according to City staff, the equipment has not experienced onsite flooding since the site is located at a higher elevation than the roadway.

Access to the disinfection system and the pump station has been impeded by flooding on Quinientos Street during large storm events (as discussed for El Estero WRC in Section 4.3). In addition to storm flooding, daily tidal inundation is projected to reach the area by 4.9 ft of sea level rise (~2100) (Figure 3-9).

8.2.1 Adaptation Options

Recycled water treatment adaptation for flooding will be driven by El Estero WRC adaptation, which could be a floodwall system protecting the plant site. The recycled water distribution pump station and chlorine contact basin are located adjacent to the desalination system PSCA and subject to flooding and access concerns discussed in Section 6.2. Similar to the El Estero WRC and Desalination PSCA flood protection options, the City could implement flood protection measures, protect the individual components from flooding (raise processes or seal vulnerable points), install flood protection around each site, and/or relocate the facilities in conjunction with El Estero WRC.

When evaluating flood adaptation measures for El Estero WRC and the PSCA, consider protection measures for the recycled water treatment.

8.3 Recycled Water Distribution System

As shown on Figure 8-3, the coastal segment of the recycled water distribution pipeline is located between Cabrillo Blvd and Shoreline Drive and the ocean. Specifically, the section vulnerable to sea level rise is east of Mission Creek located under the bike path. The recycled water pipeline in the study area includes 10- to 18-inch C-900 PVC, with over a dozen 4- to 8-inch service lines branching off along the route. The depth of cover over the entire pipeline is unknown and assumed to be 2.5 ft, which is the City’s standard minimum depth of cover over pipelines.

As the pipe cover progressively erodes with sea level rise, the recycled water PVC pipe will become exposed to sun and wave action. Ultraviolet light exposure may cause degradation of the PVC pipe; and, combined with wave action, the pipe will likely be vulnerable to breaking. The PVC pipe would also be subject to corrosion but is better positioned to withstand contact with sea water than metallic or concrete pipe. Proper bedding is also particularly important for PVC pipe to limit any pipe deflection. Once the PVC pipeline is undercut by shoreline erosion, ensuring its structural integrity will be a challenge.

Figure 8-3. Recycled Water Distribution System in Coastal Area

As shown in Figure 4-16 and Figure 6-6, the recycled water pipeline under the bike path in the vicinity of the El Estero outfall may be exposed during a current 100-year storm event. The shoreline erosion impacts become more significant with 0.8 ft of sea level rise (~2050), at which point a large segment of the recycled water pipeline is expected to be undercut.

As shown in Figure 5-7, limited existing cover is estimated to be present over the recycled water pipeline buried in West Beach. The erosion analysis indicates that the pipeline would not be exposed to shoreline erosion through 4.9 ft of sea level rise (~2100) but coastal storm flooding and coastal storm wave runup with future sea level rise could cause erosion.

8.3.1 Adaptation Options

Beyond beach nourishment and protection measures to mitigate the erosion concerns at East Beach (by Chase Palm Park) under future sea level rise scenarios, the following adaptation options apply to the recycled water pipeline specifically:

- Once partially exposed, the PVC pipe could be painted with light-colored, water-based paint to prevent damage from ultraviolet light rays.
- If loss of bedding support is encountered before the affected pipe segment can be reinstalled at a greater depth or moved inland, temporary measures could be undertaken promptly to support the undercut span of pipeline in place. Flexible pipe is not likely to withstand the loss of bedding support and stiffer metallic pipe.
- If proactive measures are desired, the pipeline could be reinstalled at a greater depth or moved inland before 0.8 ft of sea level rise (~2050). Investigation of relocation options for this pipeline could begin now. There may be an opportunity to relocate the recycled water lines to Cabrillo Blvd if the potable water line in Chase Palm Park is moved inland.

Continued operation of the recycled water distribution system beyond 0.8 ft of sea level rise (~2050) (assuming no protection measures are implemented) will likely require a minimum relocation of the pipeline inland to Cabrillo Blvd. It should be noted that the existing recycled water pipeline does not have enough capacity to be repurposed for the planned potable reuse flows, and portions of the pipeline will require upsizing. Before this Plan's development, the City considered adding a parallel pipeline next to the existing pipeline to accommodate potable reuse flows. An alternative to this solution could be to abandon the existing recycled water pipeline once it is damaged beyond repair due to shoreline erosion and install one large pipeline further inland to accommodate planned potable reuse system flows.

The recycled water pipeline along East Beach, east from Chase Palm Park, is also at risk from shoreline erosion and could be relocated; however, this segment is less critical since it serves only a handful of recycled water customers.

8.4 Planned Potable Reuse System

Potable reuse refers to advanced treatment (purification) of recycled water for drinking water purposes. If potable reuse were initiated, the City would take secondary treated wastewater from El Estero WRC and further treat the water to meet or exceed potable reuse requirements. The City completed a Potable Reuse Feasibility Study in 2017 (Carollo, 2017) that evaluated three types of potable reuse — groundwater augmentation, raw water augmentation, and treated drinking water augmentation. For the 2020 Enhanced Urban Water Management Plan (2020 EUWMP) (WSC, 2021), raw water augmentation was selected for future incorporation into water portfolios. The raw water augmentation alternative included several assumptions used to define the necessary facilities:

- Treatment train consisted of microfiltration (MF), ultraviolet (UV) light disinfection, reverse osmosis (RO), and a UV / advanced oxidation process (AOP) system.[11]
- Treatment facilities would be located at the City's Annex Yard (Figure 8-4 and Figure 8-5).
- Pipelines (Figure 8-6).
    - Use of existing recycled water (non-potable) distribution system from El Estero WRC to the underground storage reservoir at the Santa Barbara Golf Course. Recycled water service to customers along this portion of the recycled water distribution system would be replaced with supplies from the potable water system.
    - New pipeline from the Corporation Yard to the existing recycled water distribution system.
    - Parallel pipeline for a portion of the existing recycled water distribution system.
    - Repurpose existing Golf Course Recycled Water Pump Station.
    - New pipeline from the Golf Course Recycled Water Pump Station to Lauro Reservoir (at Cater WTP).

The primary vulnerabilities of a future potable reuse project are its dependence on existing systems (flows from El Estero WRC and the use of the existing recycled water distribution system), and potential onsite flooding at the proposed treatment site (Annex Yard). Vulnerabilities to El Estero WRC production are discussed in Section 4.0, and vulnerabilities to the recycled water distribution system are discussed in Section 8.3.

The planned future potable reuse site is located immediately west of the existing Desalination Plant site and is anticipated to be as vulnerable to flooding as the Desalination Plant site. The Desalination Plant site vulnerabilities are described in Section 6.2.1.

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[11] California adopted direct potable reuse regulations in January of 2024 that likely alter some assumptions applied in the 2017 feasibility study, such as adding ozone/BAC and reducing storage, but, for the purposes of this analysis, the general footprint is expected to be similar.

Figure 8-4. Potable Reuse AWTF Location

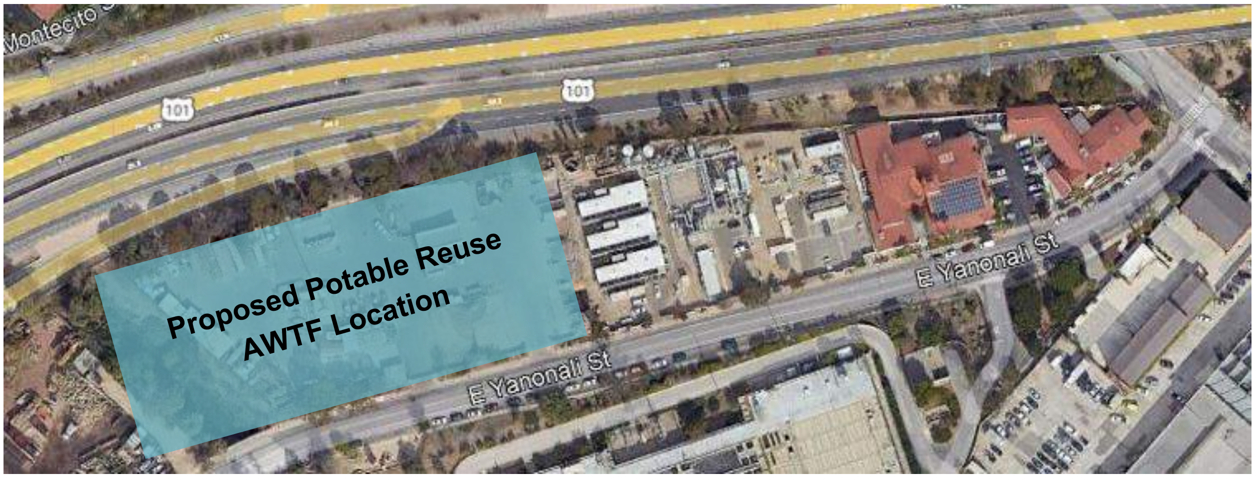
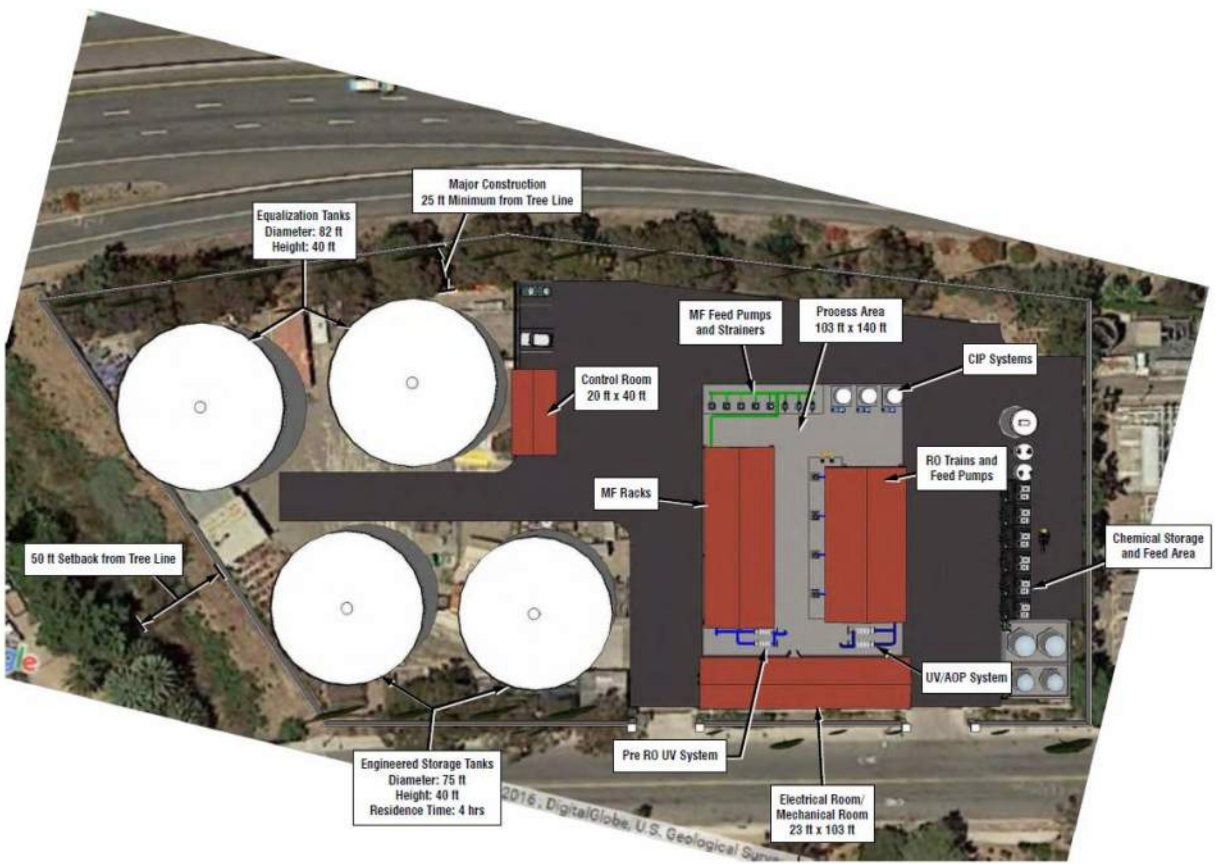
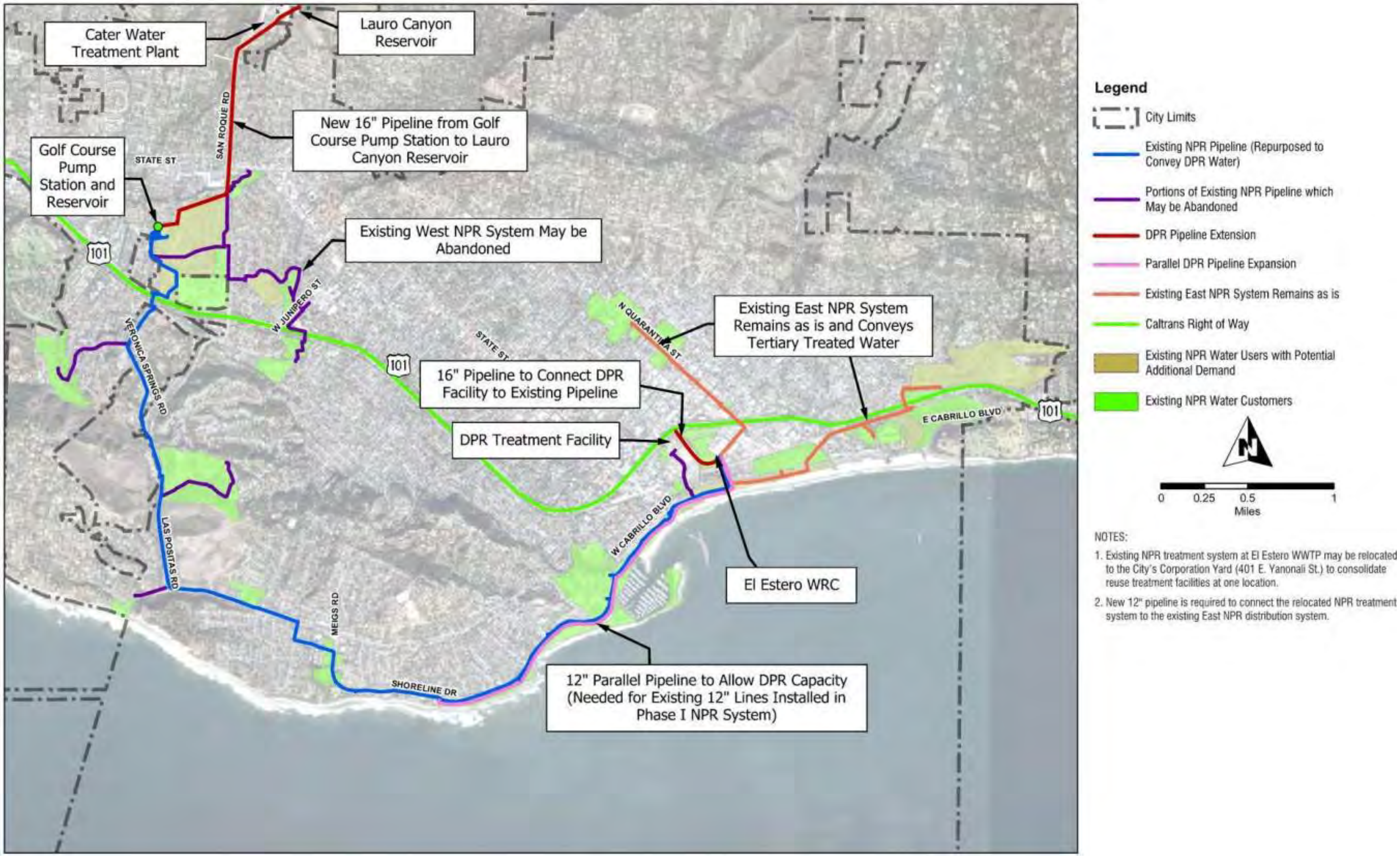


Figure 8-5. Potable Reuse AWTF Site Plan



Source: *Potable Reuse Feasibility Study* (Carollo, 2017), Figure 3-31

Figure 8-6. Proposed Potable Reuse Conveyance System



Source: *Potable Reuse Feasibility Study* (Carollo, 2017), Figure 3-26;
NPR: Non-potable reuse; DPR: Direct potable reuse

8.4.1.1 Adaptation Options

The primary vulnerabilities and risks for a future potable reuse system are:

1. Failure of the near-shore sections of the recycled water distribution system that are planned to be repurposed for potable reuse conveyance.
2. El Estero WRC operations failure.
3. Flooding risk at the proposed potable reuse treatment plant site (Annex Yard).

The timing and need to mitigate for these risks will be dependent on erosion protection measures and the success of flood protection and I&I reduction measures. Importantly, implementation of the potable reuse project will require confidence in the viability of its infrastructure for the project lifecycle. The potable reuse project is anticipated to be added as a water supply source as early as 2035 (WSC, 2021) and would operate for at least 30 years, which correlates to sea level rise projections of 0.8 ft to 2.5 ft. In addition, the City could consider the potential for relocation of El Estero WRC before they begin investing in the potable reuse project since the potable reuse treatment system is assumed to be co-located with El Estero WRC.

Recycled Water Pipelines

Without beach nourishment and protection measures, the near-shore recycled water pipeline is vulnerable to shoreline erosion between 0.8 ft and 2.5 ft of sea level rise (~2075); therefore, new recycled water pipelines would likely be needed for the potable reuse project. Pipelines dedicated to the potable reuse project could take a more direct route to the golf course than following the existing recycled water system.

El Estero WRC Effluent

The potable reuse project is dependent on effluent from El Estero WRC. If El Estero WRC vulnerabilities reach a point where the plant cannot reliably produce treated effluent, El Estero WRC is presumed to require relocation out of the coastal area, as discussed in Section 4.2.5.3 and detailed in Appendix C. In this scenario, the potable reuse treatment system would be co-located with the new El Estero WRC location. New recycled water pipelines would be required to convey purified water from the new treatment site to Cater WTP. The potable reuse project would still be dependent on an ocean outfall associated with the new El Estero WRC so that potable reuse treatment waste streams can be discharged to the ocean.

Annex Yard Flooding

Much of the Annex Yard, which is the proposed location of the potable reuse treatment plant, is located within the FEMA 100-year flood plain, and the entire site could be flooded with the past 100-year storm and 0.8 ft of sea level rise (~2050). City staff noted that no flooding was observed during recent storms, including during the January 9, 2023, flood event that approximately a 10-year event. Ultimately, the extent and likelihood of flooding the Desalination Plant and PSCA will be better defined in the planned Stormwater Model and Flood Analysis Report. The findings from this study combined with confirmation of component vulnerability will inform preferred flood protection measures.

8.4.2 Adaptation Recommendations

Immediate Next Steps (0-5 Years)

- Begin planning for Chase Palm Park recycled water pipeline exposure.
- Improve preparedness and emergency response planning (refer to Section 9.3.1.3).

Near-Term (Through 0.8 ft SLR (~2050))

- Implement a floodwall system at El Estero WRC, which would include protecting the tertiary treatment system.
- Determine flood protection needs at the Annex Yard and Recycled Water Pump Station (near the desalination PSCA) considering flood elevations from Stormwater Model and Flood Analysis Report.

9.0 Adaptation Strategy

This Adaptive Strategy provides a guide for the City to adapt the wastewater and water systems in phases in response to climate changes. Recommended projects and actions are laid out in series relative to sea level rise milestones and observed changes in conditions (e.g., beach width and flood frequency). The recommendations are prioritized based on risk and system criticality. They include triggers for action to initiate planning and design of projects so that solutions can be implemented prior to impacts occurring.

9.1 Adaptation Strategy Approach

The analysis of adaptation options for each piece of infrastructure includes information on the timeframe and conditions for triggering the action. The timeframe for actions is divided into four categories:[12]

- Immediate Next Steps (0 – 5 Years).
- Near-Term (through 0.8 ft SLR [~2050]; 5 to 25 years).
- Mid-Term (0.8 ft to 2.5 ft SLR [~2050 to ~2075]; 25 to 50 years).
- Long-Term (2.5+ ft SLR [~2075+]; 50+ years).

Mid-term adaptation options will generally be dependent on success of near-term water and wastewater system adaptation measures, success of citywide and regional adaptation measures, and changes in existing and projected conditions. The target time for implementation, as well as steps required to implement an adaptation option, such as planning, design, and construction, are considered and included in the implementation plan.

The infrastructure-specific measures in this section aim to protect assets in a hypothetical scenario where citywide adaptation, such as flood or shoreline protection, are not implemented. The success of citywide adaptation may reduce or delay mid- and long-term adaptation measures identified for individual infrastructure. Additional studies are needed to define the citywide flood and erosion control options at a similar level of detail as the adaptation options presented in this Plan. An overview of the proposed studies to address risk characterization data gaps and to evaluate regional adaptation measures is presented in Section 9.3.1. However, at best, citywide measures are likely to, at best, alleviate smaller, high frequency flooding events and for larger events, maintain existing risks for some time and delay the need for some adaptation measures considering that existing flood risks will be exacerbated as coastal flooding and tidal inundation add to the recurrence and magnitude of flooding.

9.2 Risk Assessment Results

Risk assessments for each different wastewater and water system infrastructure group is presented at the beginning of each section. A complete list of the risks associated with climate change is included in Appendix B. The "high" infrastructure risks in the near-term (now through 0.8 ft of sea level rise (~2050)) are predominantly caused by stormwater flooding during high rainfall events that are projected to increase in frequency and severity with climate change and include:

- Collection system and El Estero WRC capacity exceedances.
- On-site flooding at El Estero WRC that could cause component failure.
- Off-site flooding that could prevent access to El Estero WRC.

[12] Years included with sea level rise levels are associated with intermediate-high risk. See Section 2.1.2 for discussion of projected sea level rise timing.

"High" infrastructure risks in the mid-term are driven by shoreline erosion and wave action hazards and include potential:

- Damage to the buried utilities located in Cabrillo Blvd and Shoreline Drive.
- Damage to the potable water pipeline in Chase Palm Park.
- Damage to the desalination intake system.
- Damage to the El Estero WRC outfall pipeline.

Potential adaptation measures for the high, medium, and low risks associated with impacts of climate change on the City's water and wastewater infrastructure were addressed in Chapters 4 to 8 and are compiled in this section.

9.3 Recommended Projects & Actions

The recommended adaptation measures to address top risks were identified by infrastructure type in chapters 4 to 8. The recommended projects and actions are presented in this section based on timing and priority. The priority of recommendations is based on the level of associated risk, which considers the impact of infrastructure vulnerability, likelihood of impact, and criticality of infrastructure. The list of recommended projects is included in Appendix D. This Plan is anticipated to be updated comprehensively every 10 years based on climate change projections, monitoring data, effectiveness of adaptation measures, risk tolerance, and City priorities. The Plan updates are anticipated to modify recommended adaptation measures, data gaps, policies, design guidelines, and response plans. Minor updates to priorities and projects will occur at a higher frequency. Figure 9-1 highlights the recommended adaptation measures for the highest infrastructure risks from climate change and Figure 9-2 provide a more detailed flow chart of the recommendations from immediate next steps through long-term. The recommended projects and actions are described in detail in the remainder of this section.

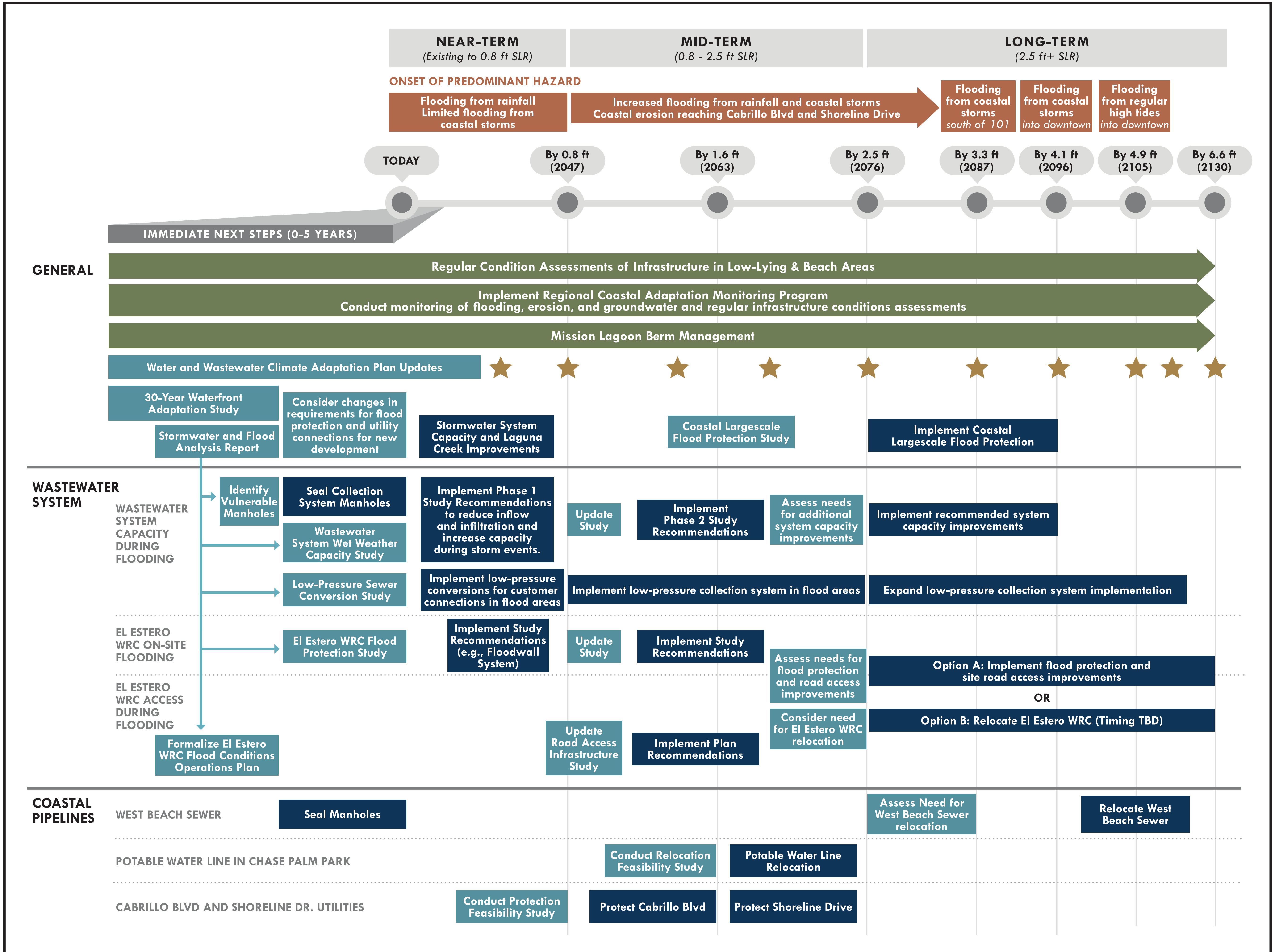
Figure 9-1. Adaptation Measures for the Highest Near-Term and Mid-Term Infrastructure Risks from Climate Change

Timeframes:

- Immediate Next Steps (0 to 5 Years)
- Near-Term (now through 0.8 ft SLR [~2050]; 5 to 25 years)
- Mid-Term (0.8 ft to 2.5 ft SLR [~2050 to ~2075]; 25 to 50 years)
- Long-Term (2.5+ ft SLR [~2075+]; 50+ years)

Water & Wastewater Climate Adaptation Project

Figure 9-2
Implementation Plan



Legend

- Hazard
- Monitoring and Maintenance
- Study
- Design and Construct

WSC

9.3.1 Immediate Next Steps (0-5 Years)

To address top risks, complete the following actions in the next five years:

1. Evaluate and implement interim adaptation measures addressing I&I and shoreline infrastructure at risk, regardless of regional flood or shoreline erosion adaptation plans.
2. Improve understanding of flood hazards, I&I sources, and regional adaptation options through planned and proposed studies. Then, update potential adaptation measure evaluations and recommendations based on this information.
3. Update preparedness and response plans for projected impacts from climate change hazards.
4. Establish a baseline and initiate regular monitoring of coastal assets for condition, shoreline erosion, and shallow groundwater levels.
5. Establish interim policy mechanisms and design guidelines.
6. Engage in partnership with other coastal communities, state, and federal agencies.
7. Expand public outreach to inform the public and gain input on public priorities.

Each of these items is discussed in the subsections below.

9.3.1.1 Interim Adaptation Measures

The following measures are identified as high-priority recommendations for implementation in the next five years to address existing flooding hazards:

- **Collection System Manhole Sealing:** Seal collection system manholes that are regularly flooded, including West Beach sewer manholes, to prevent inflow and the possibility of the manhole covers being removed to act as a drain. The cost is roughly $10,000 per manhole and an initial list can be prepared based on recent flood events and may be updated based on planned flood modeling combined with manhole rim elevations.
- **Mission Lagoon Berm Management:** Conduct maintenance to reduce the height of the Mission Lagoon Berm to encourage the estuary mouth to open naturally, as is currently allowed, to reduce the risk of storm water backing up into Laguna Creek over the tide gate.

In addition, El Estero outfall's onshore manhole is anticipated to be exposed by up to 5 ft (vertically) by 0.8 ft of sea level rise (~2050). Planning for replacement is recommended to begin now to enable a timely response to impacts of shoreline erosion.

9.3.1.2 Update Evaluations and Recommendations

Many potential climate change adaptation measures discussed in this report require a substantial investment from the City. To ensure the City allocates funds for mid-term and long-term climate change adaptation effectively, the City may first address the data gaps identified in this report to build confidence in the chosen adaptation approach. The following evaluations are recommended:

- **Stormwater Model and Flood Analysis Report** (described in Section 3.4.3). This study is proposed to better define the existing and future flood hazards for the City and to evaluate potential flood adaptation measures. Updated flood characterization will allow risks from this Plan to be updated and the potential adaptation measures for individual infrastructure to be compared with flood measures recommended throughout the City. The proposed flood analysis includes:
  - Developing a model of the City's storm drain system.
  - Modeling combined stormwater and coastal storm flooding at various levels (e.g., 2-, 10-, 20-, 50-, and 100-year storms instead of just 100-year storms as is conducted for FEMA maps).
  - Identifying adaptation options to increase the capacity of the storm drain system.
  - Identify alternatives to adapt Laguna Creek and the associated tide gate and pump station.

  Findings from the stormwater analysis will be incorporated into other studies in this Plan that are recommended as immediate next steps.

- **Wastewater System Capacity Study** (described in Section 5.2.3). This evaluation is recommended to identify the largest sources (type and location) of existing I&I. The flood risk will be updated based on Stormwater Model and Flood Analysis Report findings on future flooding events. Following, wastewater system capacity adaptation options (described in Section 5.2.2) will be evaluated to identify near-term recommendations. The focus will be on locations identified where future flood hazards are projected to increase.
- **Low-Pressure Sewer Conversion Study** (described in Section 5.2.3). The study should define potential phasing of sewer conversions from a gravity system to a low-pressure system based on projected rain and coastal flooding, groundwater, and tidal hazards. The study should include changing design and connection requirements for new private and public projects in low-lying areas to accommodate a future conversion to a pressurized system. The study should also analyze feasible and effective alternatives to pressurization that could achieve the same goals.

  In addition, the City should consider an ordinance in the next five years to require new connections in the low-lying areas to include facilities needed for pressurization and incentives to customers to facilitate conversion of existing sewer connections over the next 25 years.

- **El Estero WRC Flood Protection Study** (described in Section 4.2.5). This assessment includes a comprehensive flood vulnerability survey of components at El Estero WRC and updated flood risk assessment based on the Stormwater Model and Flood Analysis Report findings on future flooding events. Based on this information, potential flood protection options (described in Section 4.2.5) can be re-evaluated to identify near-term recommendations.

9.3.1.3 Preparedness and Response Planning

To ensure effective and cost-efficient asset protection in the immediate future, the City could review and update protocols listed in Flood and Emergency Response Plans for facilities in the coastal area. These documents may consider including:

- Clear instructions on when and what assets are to be inspected, including inspection forms and instructions on where reported information is to be stored.
- First response measures for a comprehensive list of potential emergency events (ex. flooding of the El Estero WRC site or access roads, plant capacity exceedance, etc.).
- Standard procedures for addressing issues of concern noted during regular asset inspections (e.g., exposure of buried assets).
- List of preferred or pre-selected materials for interim asset protection in the coastal area, including acceptable substitutions (e.g., pre-procured rock armor and flood barriers, mat revetments, gabions, or other slope stabilization materials of choice). The City may consider having some of these materials in store in locations that can be easily accessed during extreme coastal flood events.
    - The current material storage location is the Annex Yard, which is adjacent to the Desalination Plant and El Estero WRC. It is at risk of on-site flooding during a historical FEMA 100-year storm and access restrictions from local flooding on roads during storms smaller than the historical FEMA 100-year storm. The City may consider options for another site in the future.
- List of vendors that can provide additional necessary materials on short notice.
- List of local contractors that can assist the City with emergency response and/or pipeline repairs on short notice along with clear guidance on when to contact third parties for assistance.

The goal of this exercise is to ensure continued operation and save valuable time and resources during event response by making decisions, or creating a decision framework, in advance of an emergency. Once these documents are updated, consider providing training sessions to all applicable staff on any procedural updates. This additional step will ensure that staff have a clear understanding of who to contact and how to address issues in an efficient and prompt manner.

The City could investigate the extent to which regulatory approvals are required for any of the recommended measures, such as use of rock armor to stabilize exposed piping. In the event regulatory approvals are required for interim asset protection, the City may initiate these applications in the near-term.

9.3.1.3.1 El Estero WRC Area Flooding Preparation

One example of recommended hazard response planning is planning for sustained El Estero WRC operations at El Estero WRC during major flooding around the site. One recommendation is formalizing the El Estero WRC Flood Conditions Operations Plan (discussed in Section 4.3.1). Potential operational modifications for El Estero WRC are discussed in Section 4.2.5.

9.3.1.3.2 Shoreline Erosion Response

Before pipeline segments become exposed due to erosion or other hazards, the City will plan to protect the pipe and/or relocate the pipe. The City will first consider using nature-based approaches to pipe protection, such as beach nourishment, dune restoration, and cobble placement. Relocating the pipe may involve lowering the pipe to a deeper elevation that would not be subject to erosion or moving the pipe inland.

If nature-based protection measures and/or relocating the pipe are not feasible in the near-term, interim protection measures using traditional armoring or hybrid traditional/nature-based approaches may be needed. In this case, protection may include placing a layer of rock armor over or around buried pipelines. Rock armor typically includes large rock able to withstand anticipated wave forces placed over smaller filter rock or fabric, which enables proper drainage while preventing erosion. The thickness, size, and other characteristics of rock armor must be carefully selected for each individual application by following established engineering design practices, such as the ones outlined in “Design of Coastal Revetments, Seawalls, and Bulkheads” manual by U.S. Army Corps of Engineers (USACE 1995).

To prepare to respond to pipeline exposure, the City may consider completing the following:

- Pre-select and pre-source cost-effective options for temporary asset protection and slope stabilization in the event of daylighting of buried assets (e.g., sand, cobble, and/or rock armor and filter fabric) to ensure availability of materials on short notice.
- Research the extent of regulatory approvals required for the above.

If pipe breaks occur and segments of piping are replaced, the following practices are recommended:

- Replacement of damaged pipe segments with flexible pipe systems where possible. Restrained joints and flexible pipe such as high-density polyethylene (HDPE) can withstand the forces exerted by soil movement better than rigid materials and have a much lower incidence of pipe breaks. Flexible pipes and restrained joints can flex and bend without breaking, reducing the risk of damage from loss of bedding support, soil movement, and wave action. Plastic pipe is also a good option for mitigation of corrosion concerns.
- Where metallic pipe or fittings must be installed, corrosion prevention methods may be included, such as installation of polywrap, cathodic protection, and dielectric coatings (Barfuss, 2023). Replacement of cast iron piping is also recommended due to a higher rate of reported pipe breaks (Barfuss, 2023).
- Where possible, the depth of pipe cover may be increased by burying the pipes deeper and/or using sufficient armor to keep pipelines in place.
- Use of pipe collars and anchor systems to stabilize pipe. Pipe collars can help secure pipes in place and prevent them from floating or shifting in changing soil conditions. Collars are typically installed at regular intervals along the length of the pipe to provide stability and resistance to buoyancy forces.

9.3.1.4 Asset Condition and Hazard Baseline

Establishing a baseline for asset condition near shore is a fundamental first step in executing an effective asset monitoring program. A baseline will provide a point of reference against future change, which can be used to track the rate of change, new risks, and the effectiveness of any implemented measures. An established baseline combined with ongoing monitoring of asset condition, shoreline erosion progression, groundwater levels, and flood impacts will comprise key data feeding into adaptation planning and decision-making.

The City could collect the information listed below to establish a coastal asset condition and hazard baseline. Coordination with other members of RCAMP is suggested to determine whether the collection of the data listed below will be part of (or can be added to) the scope of RCAMP (discussed in Section 1.5.2.2). Obtain the following information to establish a condition baseline during the next five years for assets near shore:

- Spot check and document cover over buried pipelines that have been identified in this study to be at risk in the near term from impacts of shoreline erosion. Permanently mark or clearly document these locations for future monitoring.
- Check the entire length of buried pipes for any exposed components, and document their location, condition, and proximity to water at high tide (MHHW).
- Document the condition of underwater infrastructure, including pipeline and intake platform scour, and the amount of rock cover on segments of pipeline that rest on the ocean floor.
- Document erosion progression at East and West Beach against other permanent benchmarks during the timeframe when water/wastewater assets are still fully covered and are not practical to use as reference points.
- Document erosion progression near bases of bluffs along with any slope stability observations that can be made visually or cost-effectively (e.g., installation of piezometers in optimal monitoring locations).

Ongoing condition and hazard monitoring is key to the success of an iterative adaptation plan and will inform decisions at every subsequent re-evaluation. Regularly scheduled assessments can be carried out against the established condition and sea level rise baseline and would document any changes noted since the previous inspection, such as:

- Further condition deterioration or greater erosion over infrastructure previously found to be exposed.
- Locations where buried infrastructure is newly exposed, extent of exposure (both vertically and horizontally), and the condition of exposed materials.
- Changes in distance from MHHW of critical components that must remain accessible by Operations.
- Changes in the observed condition of underwater infrastructure.

Currently, the City relies on a comprehensive pipe replacement model to identify proactive replacements and does not perform regular pipe inspections. One of the preventative actions the City could take is installation of remote pressure monitoring and leak detection sensors on pressurized pipelines.

The City can also consider implementing a passive pipe inspection program for pipes that are suspected to be buried below groundwater level to aid with timely identification of early signs of failure due to corrosion. While proactive condition assessments of pipes can be expensive and disruptive to the community, opportunistic condition inspection is a cost-effective option as it can be carried out when a pipe is exposed for other reasons, such as maintenance, repair, or proactive replacement. Opportunistic condition assessments can be used to visually assess pipes, test valves, measure pipe corrosion (e.g., Energy Dispersive Spectroscopy testing), and perform soil corrosivity assessments and pipe failure analysis.

Valves are sometimes overlooked during condition assessments due to perceived low risk, as valves usually fail in the open position and are less likely to affect service levels until they are needed, potentially many years later. However, the cost of failure can be impacted substantially by the time it takes to find and shut off isolation valves. The City could prioritize valves for exercising, condition assessment, and replacement similar to how pipes are prioritized. Valve condition assessment may also include acoustic leak detection.

9.3.1.4.1 Shallow Groundwater Monitoring

The City should implement a shallow (less than 20-ft deep) groundwater monitoring program to better characterize existing risks from shallow groundwater and to track changes in levels or quality that will impact coastal infrastructure.

As previously discussed, shallow groundwater elevations presented in this Plan are based on data from CoSMoS, which does not account for variations between wet and dry seasons, wet and dry years, and tidal changes. The estimates from CoSMoS could not be comprehensively compared with local shallow groundwater data due to limited available data (Section 3.4.1).

Since estimates from CoSMoS indicate that much of the coastal collection system could be submerged in shallow groundwater, groundwater level monitoring is essential to validate or adjust projections included in this study. Shallow groundwater can be a significant contributor to baseline I&I in the collection system. Understanding whether the existing system is mostly submerged or is likely to be submerged is important for the recommended Wastewater System Capacity Study (see Section 5.2.3).

In addition, shallow groundwater near the ocean has the potential to expose infrastructure to saline water, causing increased rates of corrosion and potentially introducing saline water to the wastewater collection system. This could affect treatment at El Estero WRC. Groundwater salinity can be tracked to help project potential seasonal and/or annual changes in groundwater salinity. It is recommended to collect shallow groundwater data (level and salinity) to properly interpret modeling data from CoSMoS and estimate risk from shallow groundwater.

The City could also increase influent wastewater salinity monitoring frequency to identify potential changes in wastewater quality and align sampling times at the plant with groundwater sampling.

9.3.1.4.2 Flood Monitoring

Consider recording the following information during or after significant wet weather events to better characterize events and the observed impacts:

- Date, type, and duration of wet weather event.
- Total precipitation.
- Flood extents and depths.
- Flow (and, if practical, depth) in the Laguna Creek.
- Flood depths on and in the vicinity of El Estero WRC.
- Details of impacts to operations (e.g., where access was no longer available).
- Details of asset protections measures employed and their effectiveness.
- Financial impacts of the event, if available.

9.3.1.5 Policy Mechanisms and Design Guidelines

9.3.1.5.1 Policies

Policy changes, such as re-zoning in the coastal area, may occur after the City has a better understanding of hazards, regional and citywide adaptation measures, and their implementation timeline. However, some consideration of policy mechanisms for protection of people and infrastructure in the coastal area may be warranted now. The City could build on its previous climate change public engagement efforts by updating a comprehensive list of stakeholder groups that could be directly or indirectly affected by City policies regarding coastal area development. Inviting stakeholders to the decision table early is an opportunity to hold difficult conversations before policy decisions are made, ultimately contributing to the success of new policies.

Once hazard understanding is improved and flood zone extents are defined, the City can consider the following changes to design standards in the flood zone:

- Limiting new construction.
- Limiting the level of service commitments.
- Prohibiting expansion beyond existing footprint.
- Requiring or incentivizing property owners to complete water and wastewater infrastructure upgrades.
- Assuming ownership of private water and wastewater infrastructure components.
- Requiring developers to provide onsite compensatory floodplain storage.
- Requiring replacement of damaged distribution piping with corrosion-resistant materials in corrosion-prone areas.
- Requiring all new construction to be built to a new design flood elevation.
- Establishing freeboard requirements for infrastructure (e.g., bridges, plants, ponds).

9.3.1.5.2 Design Considerations

As pipe breaks occur and segments of piping are replaced, the following pipeline design and installation practices are recommended:

- Replace damaged pipe segments with restrained joint pipe systems that have flexible pipe connections.
- Incorporate corrosion prevention methods.
- Increase depth of pipe cover and/or using armoring.
- Use of pipe collars and anchor systems to stabilize pipe.
- Optimize valve placement during the design and construction of new development and pipe replacement to improve system resiliency.

Evaluate options to protect critical above-ground infrastructure from impact with debris carried by floodwaters on an individual basis. In many instances in the past, objects as large and heavy as vehicles have been found floating down flooded roads. Where possible, move critical infrastructure from high-traffic locations or protect them with concrete barriers.

When designing new or retrofitted aboveground facilities, consider including design flood elevation that account for the projected flooding levels associated with sea level rise during the facility's lifetime.

As base flood elevations are updated (likely as a result of the Stormwater Model and Flood Analysis Report), the City could update standard design practices to incorporate on-site flood risk into new designs. The new design flood elevation would consider regional flood protection measures, site protection measures, and future flood elevations with sea level rise.

9.3.1.6 Partnerships and Collaboration

The City has initiated collaborative climate change response efforts such as participation in BEACON and organization of the City Interdepartmental Climate Adaptation Staff Team. In addition to this work, the City could consider the following:

- Joining Water Utility Climate Change Alliance (WUCA). The WUCA alliance leverages utility experiences from municipalities and utility operators across the country to develop actionable practices in climate change adaptation. Other WUCA members on the west coast are the San Diego County Water Authority and the San Francisco Public Utilities Commission. The City could reach out to these organizations to discuss the value of WUCA membership as well as other ways to share lessons learned, climate models, and decision-making tools.
- Reaching out to coastal communities that are not part of BEACON but are currently undertaking their own adaptation measures. One example is the City of San Clemente, which has recently completed a major beach nourishment project and likely has valuable insights to offer when it comes to partnership with USACE; obtaining federal funding for shoreline protection, adaptation timeline, costs, and construction challenges, and early successes.

- Initiating a working relationship with USACE and FEMA to address sea level rise impacts. The City could begin this work by sharing their adaptation planning progress with these and any other appropriate agencies and requesting feedback. Welcome these agencies to participate in and provide feedback on developing amendments to design standards, analysis of large-scale adaptation measures, and other aspects of adaptation planning. Regulatory agencies have a wealth of information to share when it comes to early successes (both with adaptation and obtaining funding) and are important stakeholders to bring to the table early on.
- Expanding the City Interdepartmental Climate Staff Team or supplementing it with another group that strategically welcomes non-governmental stakeholders from the City. One example of such a stakeholder is UPRR. UPRR played an important role in beach protection planning decisions in San Clemente, where the need for railroad protection was an important economic factor in the decision to proceed with beach nourishment. It would be sensible for the City to consider any large-scale or regional adaptation measures in partnership with UPRR.
- Coordinate with electrical and natural gas utility providers to further assess potential impacts and adaptation options for the energy transmission and distribution systems.

9.3.2 Near-Term (Through 0.8 ft SLR (~2050); 5-25 years)

Near-term recommended adaptation measures will continue to be evaluated as part of the following recommended studies over the next five years (described in Section 9.3.1.2):

- 30-Year Waterfront Adaptation Plan
- Stormwater Model and Flood Analysis Report
- Wastewater System Capacity Study
- Low-Pressure Sewer Conversion Study
- El Estero WRC Flood Protection Study

The proposed studies, along with recommended monitoring, will address data gaps and incorporate other flood and shoreline erosion adaptation measures to improve confidence in the City's near-term recommendations.

This section describes recommended projects in the near-term to mitigate projected vulnerabilities. The recommendations are organized by priority.

9.3.2.1 High Priority Recommendations

The following projects are high-priority recommendations for the protection of wastewater and water systems in the near-term:

- **Wastewater System Capacity Improvements (Near-Term):** Implement the recommended additional adaptation measures to manage capacity in the wastewater system and at El Estero WRC based on the proposed Wastewater System Capacity Study. Potential measures were described in Section 5.2.3 and include:

  - I&I reduction from sewer and manhole lining, customer lateral rehabilitation and/or replacement, and removal of illegal connections.
  - Storage of wet weather flows at El Estero WRC.
  - Expansion of El Estero WRC capacity from the influent pump station to the outfall.

  As an example, wet weather storage could cost up to $30 million and the study will identify preferred options considering costs and benefits.
- **El Estero WRC Area Flood Conditions Operations Plan (Near-Term):** Based on the Stormwater Model and Flood Analysis Report, update flood access preparation plans for El Estero WRC and surrounding facilities. Potential access improvements were discussed in Section 4.3.1.
- **El Estero WRC Flood Protection Measures (0.8 ft SLR):** Essential processes at El Estero WRC are projected to be flooded during a historic FEMA 100-year storm event at 0.8 ft of sea level rise (~2050). Constructing a floodwall system surrounding the site is recommended. The cost of a floodwall system would range from $10 million to $30 million and would be better defined as part of the proposed El Estero WRC Flood Protection Study. In the interim, measures to protect critical equipment, such as temporary barriers, should continue to be used.
- **Desalination Intake System Improvements – Weir Box:** Depending on regional shoreline erosion adaptation measures, abandon, relocate, or protect the weir box as outlined in the Charles E. Meyer Desalination Plant Intake Structure Weir Box Relocation Erosion Protection Study (Carollo, 2019).
- **Laguna Creek, Tide Gate, and Pump Station and Stormwater Improvements:** Implement the recommended improvements based on the recommendations from the 30-Year Waterfront Adaptation Plan and proposed Stormwater Model and Flood Analysis Report. Potential improvements were described in Section 3.4.2.

The following planning efforts are recommended to be conducted to prepare for mid-term adaptation measures:

- **Potable Pipeline Relocation Planning (Chase Palm Park):** Initiate planning and design to relocate the potable water pipeline in Chase Palm Park inland to Cabrillo Blvd to prevent future damage from erosion.

Collection System Low Pressure Conversion

In the mid-term, initial phases of a low-pressure sewer conversion from gravity fed system will be needed. In the near-term, the City could implement a low-pressure lateral ordinance and facilitate conversion of existing customer sewer connections to low-pressure connections in low-lying coastal areas as implementation triggers are met.

9.3.2.2 Medium Priority Recommendations

The following projects are medium-priority recommendations for the protection of wastewater and water systems in the near-term:

- **Desalination Plant, PSCA, Annex Yard, and Recycled Water Pump Station Flood Protection Measures (0.8 ft SLR):** This item combines flood protection recommendations for the desalination and recycled water systems due to their proximity and similar risk. The Desalination Plant, PSCA, Annex Yard, and Recycled Water Pump Station may need to enhance flood protection measures to maintain safe and effective operations through 0.8 ft of sea level rise (~2050), depending on findings from the Stormwater Model and Flood Analysis Report. Recommendations are dependent on the extent of projected flooding. In addition, measures for each system have slightly different considerations:
  - **Desalination Plant & PSCA:** Implementation depends on plans to operate the system beyond 2035 and is based on future decisions with potable reuse.
  - **Annex Yard:** Implementation depends on completion of the proposed potable reuse project, currently planned for 2035.
  - **Recycled Water Pump Station:** Implementation depends on latest projected operational life of the non-potable recycled water system and the potential incorporation of the existing system for the potable reuse system.

9.3.2.3 Lower Priority Recommendations

The following project is a lower-priority recommendations for the protection of wastewater and water systems in the near-term:

- **Recycled Water Pipeline Exposure Response Preparation:** The recycled water pipeline in Chase Palm Park is expected to be exposed by shoreline erosion without regional shoreline erosion adaptation measures. The City should prepare to respond to pipeline exposure, as outlined in Section 7.2.3.

9.3.3 Mid-Term (0.8 to 2.5 ft SLR; 20-50 years)

Adaptation measures implemented in the mid-term will be evaluated as part of the proposed regular updates to this Plan. The updates will consider the latest climate change projections, monitoring data, effectiveness of adaptation measures, risk tolerance, and City priorities.

Stormwater flooding is projected to worsen, coastal flooding is projected to worsen, and shoreline erosion starts to impact more infrastructure without greater City flooding and shoreline erosion adaptation measures. Potential adaptation measures will need to consider the useful life of the facilities they are protecting if relocation of El Estero WRC and the Desalination Plant is being planned in the long-term.

This section describes recommended mid-term adaptation measures for projected vulnerabilities in the absence of greater City flood and shoreline erosion adaptation measures. The recommendations are organized by priority.

9.3.3.1 High Priority Recommendations

The following projects are high priority for protection of wastewater and water systems in the mid-term. However, they are dependent on the extent and performance of greater City flood and shoreline erosion adaptation measures:

- **Wastewater System Capacity Improvements (Mid-Term):** Initiate installation of initial phases of low-pressure collection system in areas most impacted by flooding from rain and coastal storms as implementation triggers are met. In addition, implement the updated recommended adaptation measures to manage capacity at wastewater system and at El Estero WRC. Potential measures were described in Section 5.2.2 and are the same as the near-term options below:
  - I&I reduction from sewer and manhole lining, customer lateral rehabilitation and/or replacement, and removal of illegal connections.
  - Storage of wet weather flows at El Estero WRC.
  - Expansion of El Estero WRC capacity from influent pump station to the outfall.
- **El Estero WRC Flood Protection Measures (2.5 ft SLR):** The entire El Estero WRC site is projected flood during a historic 100-year storm event by 2.5 ft of sea level rise (~2075). El Estero WRC would need to enhance its own flood protection measures to maintain safe and effective operations through at least 2.5 ft of sea level rise (~2075) if greater City flood protection measures are not effective enough. The most likely measure is raising the recommended floodwall system.
- **El Estero WRC Area Access Improvements (Mid-Term):** Implement recommended access improvements, which were discussed in Section 4.3.1 and will be updated based on near-term studies listed in Section 9.3.1.2.
- **Potable Pipeline Relocation (Chase Palm Park):** Construct a new potable water pipeline within Cabrillo Blvd to replace the existing segment in Chase Palm Park.
- **Cabrillo Boulevard and Shoreline Drive Utilities Protection:** Ensure that Cabrillo Blvd and Shoreline Drive and the utilities located under the streets will be protected from shoreline erosion. Without shoreline erosion adaptation measures, utilities within Cabrillo Blvd and Shoreline Drive are projected to be exposed through shoreline erosion by 1.6 and 2.5 ft of sea level rise (~2075), respectively. The relocation of these utilities was not evaluated in this Plan based on the assumption that the streets would be protected by shoreline erosion adaptation measures through at least 2.5 ft of sea level rise (~2075).

9.3.3.2 Medium Priority Recommendations

The following projects are medium-priority recommendations for protection of wastewater and water systems in the mid-term depending on the extent and performance of flood and shoreline erosion adaptation measures:

- **Desalination Intake Pipeline Replacement:** If the Desalination Plant continues to operate beyond 0.8 ft of sea level rise (~2050), the existing intake pipeline may need to be replaced due to shoreline erosion.

- **Desalination Plant, PSCA, Annex Yard, and Recycled Water Pump Station Flood Protection Measures (2.5 ft SLR):** This item combines flood protection recommendations for the desalination and recycled water systems due to their proximity and similar risk. The Desalination Plant, PSCA, Annex Yard, and Recycled Water Pump Station may need to enhance onsite flood protection measures to maintain safe and effective operations for several feet of additional sea level rise. Recommendations are dependent on the extent of projected flooding. Implementing measures for each system requires considering unique factors specific to each one:
  - **Desalination Plant & PSCA:** Implementation depends on the latest projected operational life of the facility and the latest projections of future El Estero WRC relocation, which could include the Desalination Plant.
  - **Annex Yard:** Implementation depends on completion of the proposed potable reuse project and the latest projections for future El Estero WRC relocation, which would include potable reuse facilities.
  - **Recycled Water Pump Station:** Implementation depends on the latest projected operational life of the non-potable recycled water system, the potential incorporation of the existing system for the potable reuse system, and the latest projections for future El Estero WRC relocation, which would include potable reuse facilities.

9.3.4 Long-Term (2.5+ ft SLR; 50+ Years)

Beyond 2.5 ft of sea level rise (~2075), coastal flooding from the ocean and regular tidal inundation are expected to occur and the pace of sea level rise is projected to increase. Many of the largest infrastructure investments to support climate change adaptation, such as West Beach sewer relocation and El Estero WRC relocation are not projected to be needed until the long-term. Potential long-term adaptation measures will be evaluated as part of the proposed regular updates to this Plan, which will consider the latest climate change projections, monitoring data, effectiveness of adaptation measures, risk tolerance, and City priorities. Potential adaptation measures will also need to consider the useful life of the facilities they are protecting if relocation of El Estero WRC and the Desalination Plant are planned. Finally, large infrastructure projects can take 10 to 20 years from planning through construction, so planning will likely need for many projects to start during the mid-term. More specific timing is expected to be available in future Plan updates.

West Beach Sewer Relocation

The West Beach sewer pipeline is not projected to be exposed to erosion until after 4.9 ft of sea level rise (~2100). Initiate relocation planning and design at least 10 years prior to the latest projections for sewer exposure from shoreline erosion. Relocation considerations were discussed in Section 5.3.4.2.

El Estero WRC Relocation

El Estero WRC sits on a higher elevation than the areas surrounding it and so in the near and mid-term the bigger issues with the wastewater system are related to flooding events that affect areas surrounding the plant. These storms can cause temporary loss of access to the plant and capacity issues in the wastewater collection system and plant processes. Access and flood hazards at El Estero WRC can be managed in the near-term (through 0.8 ft SLR (~2050); next 25 years) with limited modifications to existing practices while mid-term (0.8 to 2.5 ft SLR; 25 to 50 years) will require flood protection investments at the site and may require road and site access improvements. Additionally, the City will be launching a wastewater system capacity study to identify improvements that can be made to address inflows into the collection system during storms and associated capacity issues.

In the mid-term, the City will need to consider whether to relocate El Estero WRC in the long-term given the costs required to address safe, reliable access during recurrent flooding and protect the site from extreme flooding at high amounts of sea level rise. That decision will be part of future updates to the Wastewater Adaptation Plan that will benefit from many more years of monitoring and additional information on how climate changes are affecting the region and possible adaptation options. Any relocation study would involve close coordination with regional partners to explore opportunities for shared facilities and to identify potential sites of sufficient size across the region. Among properties currently owned by the City, the municipal golf course on Las Positas Road is large enough to accommodate a new wastewater treatment plant if needed.

9.4 Capital Improvement Plan

The recommended projects are listed by risk priority in Appendix D for:

- Immediate next steps (next 5 years)
- Near-term – through 0.8 ft of sea level rise (~2050) (5 to 25 years)
- Mid-term – 0.8 ft to 2.5 ft of sea level rise (~2050 to ~2075) (25 to 50 years)

In Table 9-1, a range of rough costs for high priority projects through the mid-term are listed. Note that the purpose of the cost compilation is to provide a rough, order-of-magnitude cost for preliminary City budget planning. Beyond immediate next steps, specific projects have not been identified within each recommended project because they will be identified during subsequent studies with alternatives analysis and cost estimating. Therefore, rough, order-of-magnitude cost estimates for projects that could be part of high priority recommendations were included here to support long-term budget planning. The cost projections should be updated once the studies with alternatives analysis are completed. The cost range is wide, and the final cost may significantly deviate depending on project selection, design evolution, site conditions, and permitting.

Table 9-1. Rough Costs for High Priority Projects through Mid-Term

Project		Very Rough Cost
Immediate Next Steps (0 – 5 Years)		
Mission Lagoon Berm Management		Continued City operations
Studies	El Estero WRC Flood Protection Study Low-Pressure Sewer Conversion Study Stormwater and Flood Analysis Report Wastewater System Capacity Study	$1M to $2M
Collection System (incl. West Beach) - Seal Manholes		$10,000 per manhole $0.5M to $1M
Immediate Next Steps Total		**$1.5M to $3M**
Near-Term (through 0.8 ft of Sea Level Rise [~2050]; 5 to 25 Years)		
Desalination Intake Weir Box Adaptation		$0.5M to $5M
El Estero WRC Flood Protection Measures (0.8 ft SLR)		$20M to $50M
El Estero WRC Flood Access Preparation Improvements (0.8 ft SLR)		$0.5M to $5M
Laguna Tide Gate Improvements		$5M to $20M
Low-Pressure Service Conversions for Low-Lying Properties		$0.1M
Wastewater System Capacity Improvements (Near-Term)		$20M to $50M
Near-Term Total		**$50M to $130M**
Mid-Term (0.8 ft to 2.5 ft of Sea Level Rise [~2050 to ~2075]; 25 to 50 Years)		
Cabrillo Boulevard & Shoreline Drive Utilities Protection		$50 to $150M
El Estero WRC Flood Protection Measures (2.5 ft SLR)		$10M to $50M
El Estero WRC Flood Access Preparation Improvements (2.5 ft SLR)		$5M to $25M
Low-Pressure Conversions for Low-Lying Sewers		$10M to $50M
Potable Pipeline Relocation (Chase Palm Park)		$2M to $10M
Wastewater System Capacity Improvements (Mid-Term)		$10M to $50M
Mid-Term Total		**$85M to $335M**

Note: The purpose of this table is to provide a rough, order-of-magnitude cost for preliminary City budget planning. Beyond immediate next steps, specific projects have not been identified within each recommended project because they will be identified during subsequent studies with alternatives analysis and cost estimating. Therefore, rough, order-of-magnitude cost estimates for projects that could be part of high priority recommendations were included here to support long-term budget planning. The cost projections should be updated once the studies with alternatives analysis are completed. The cost range is wide, and the final cost may significantly deviate depending on project selection, design evolution, site conditions, and permitting.

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Appendix A Vulnerability Maps

A

Water & Wastewater Climate Adaptation Project

Figure 3-3. Coastal Hazards, Existing

Legend

- El Estero WRC
- Desalination Plant
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-4. Coastal Hazards, 0.8 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-5. Coastal Hazards, 1.6 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-6. Coastal Hazards, 2.5 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-7. Coastal Hazards, 3.3 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)
- Tidal Inundation

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-8. Coastal Hazards, 4.1 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.15 0.3 Miles

0 500 1,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-9. Coastal Hazards, 4.9 ft SLR

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Hazards

- Tidal Inundation
- Shoreline Retreat
- Coastal Storm Flooding (100-yr)
- Coastal Storm Flooding (1-yr)

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

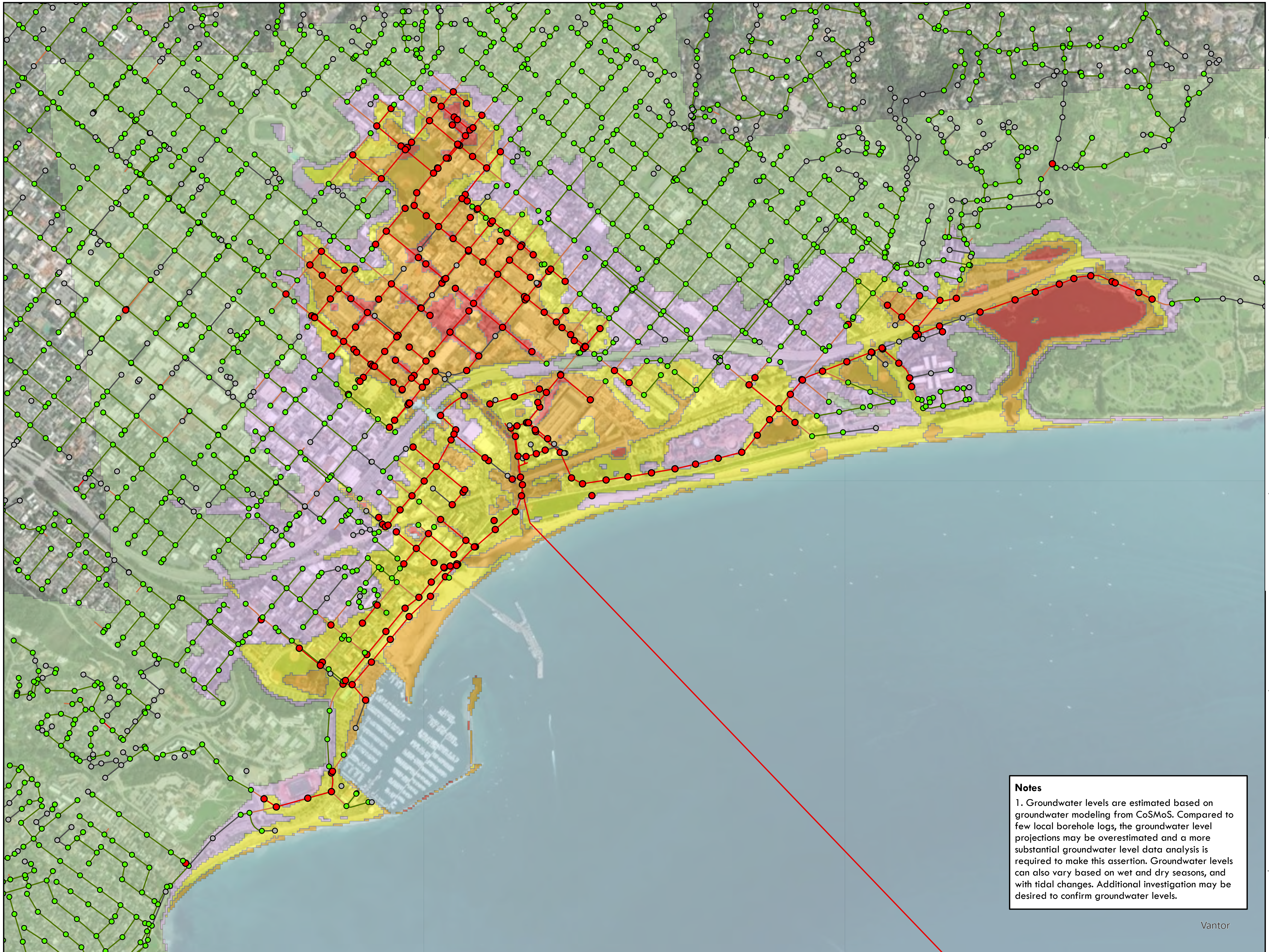
N

0 0.15 0.3 Miles

0 500 1,000 US Feet

Water & Wastewater Climate Adaptation Project

Figure 3-10. Groundwater Levels with Wastewater Infrastructure, Existing



Legend

Manhole Status

- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status

- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface

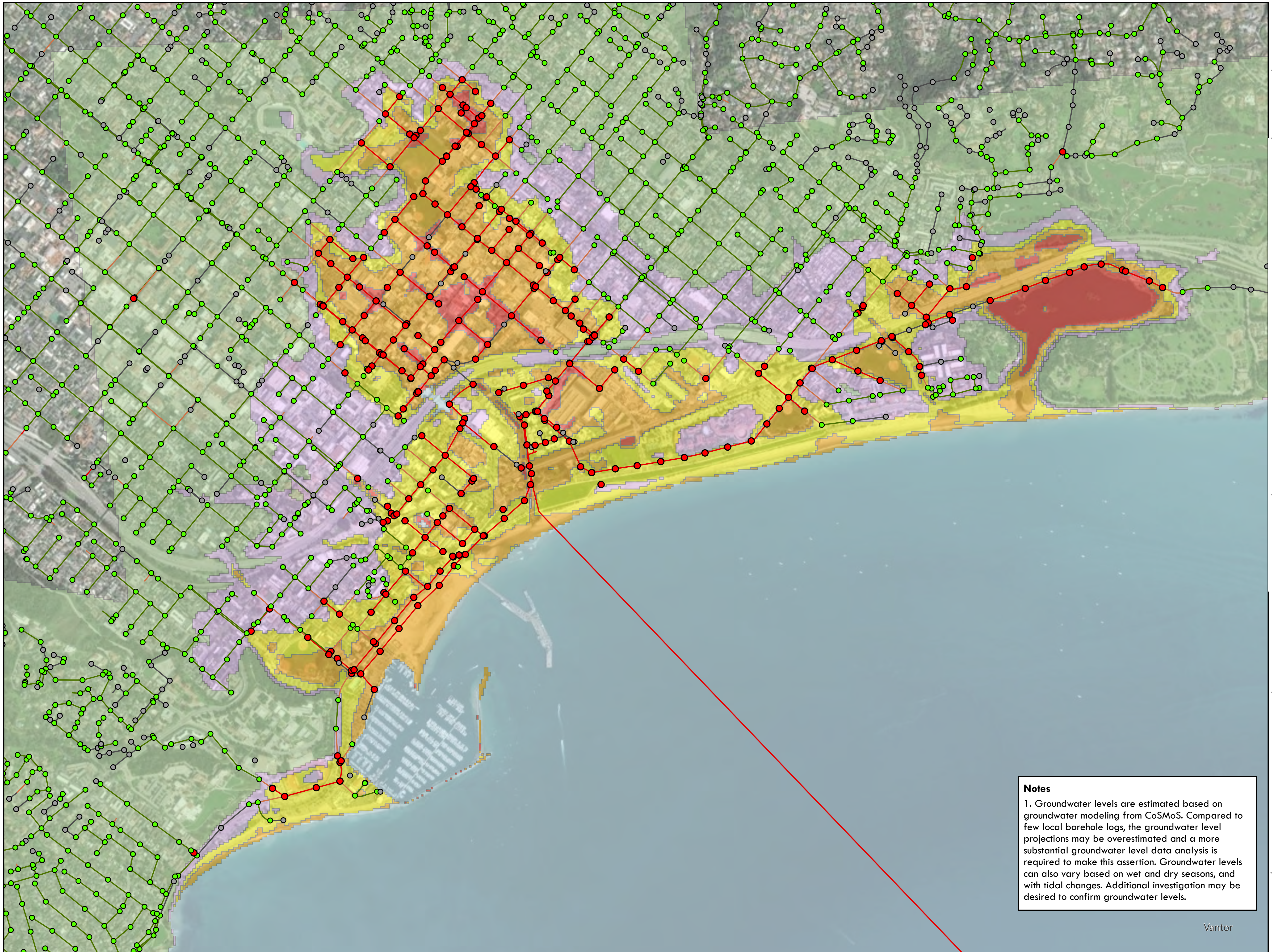
- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC



Water & Wastewater Climate Adaptation Project

Figure 3-11. Groundwater Levels with Wastewater Infrastructure, 0.8 ft SLR

Legend

Manhole Status
- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status
- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface
- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

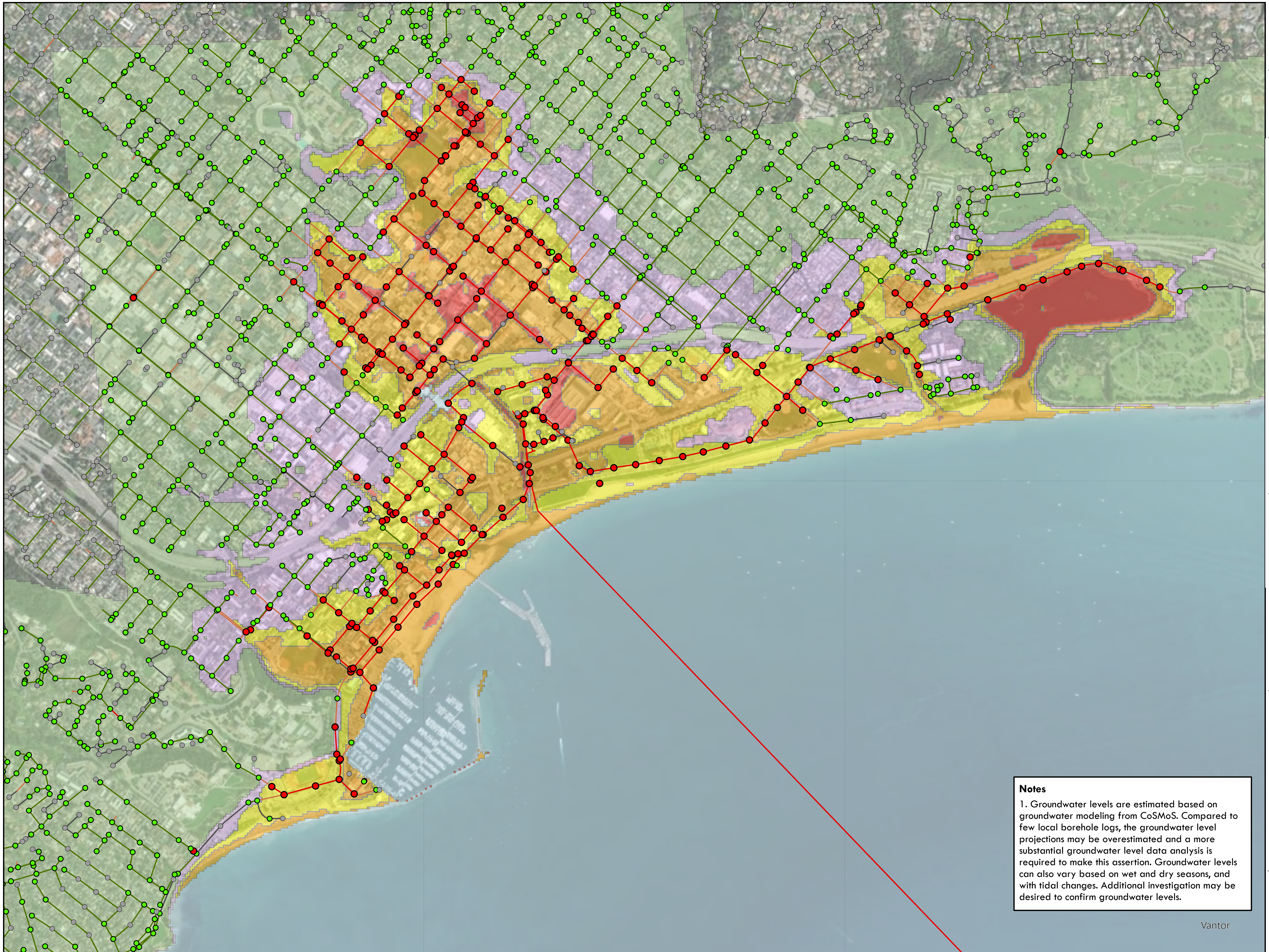
Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-12. Groundwater Levels with Wastewater Infrastructure, 1.6 ft SLR



Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

Legend

Manhole Status

- Submerged
- Not Submerged
- Unknown

Sewer Main Status

- Not Submerged
- Partially Submerged
- Submerged
- Unknown

Groundwater Depth Below Surface

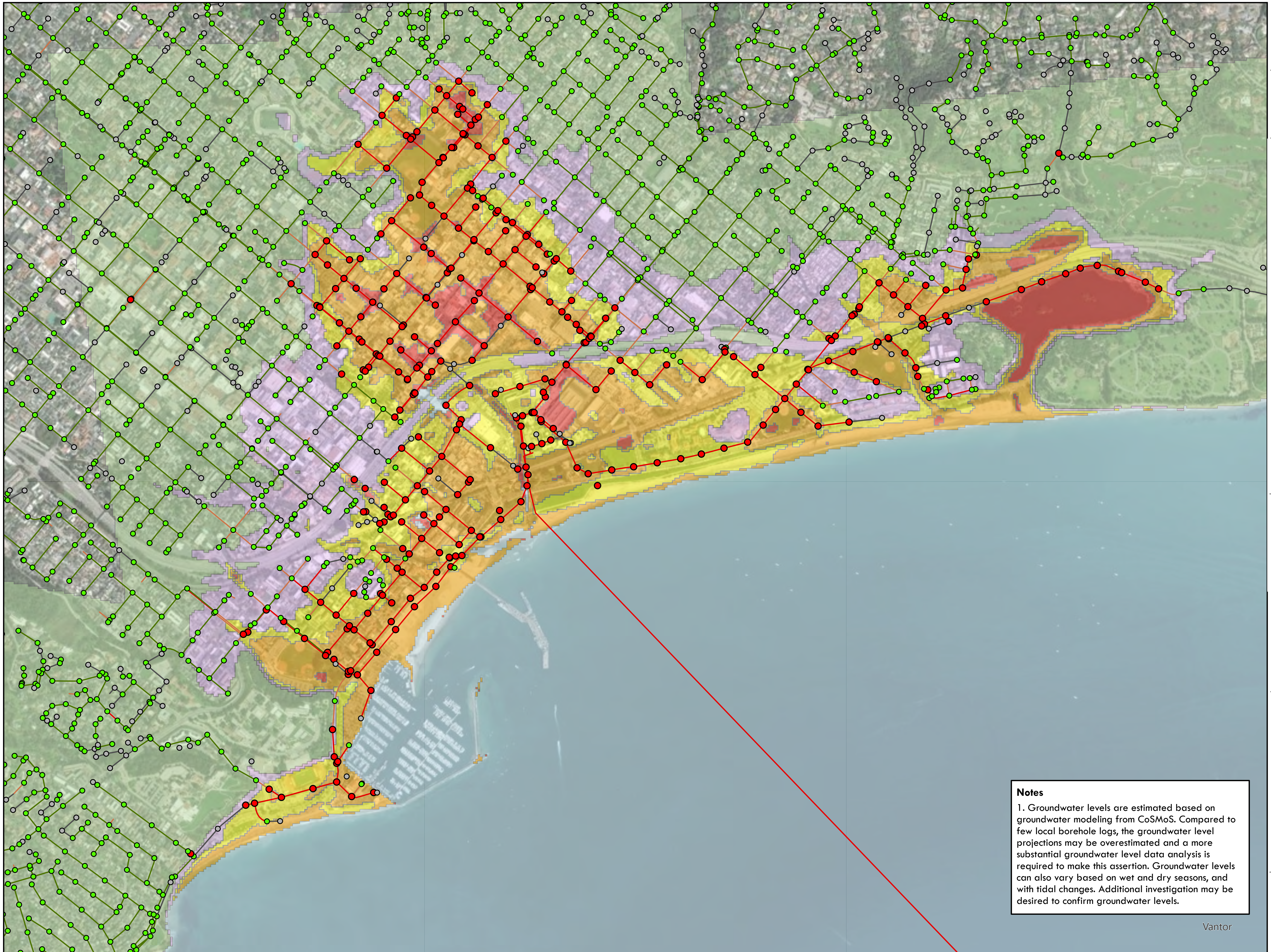
- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC



Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

Water & Wastewater Climate Adaptation Project

Figure 3-13. Groundwater Levels with Wastewater Infrastructure, 2.5 ft SLR

Legend

Manhole Status

- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status

- Submerged
- Partially Submerged
- Not Submerged
- Unknown

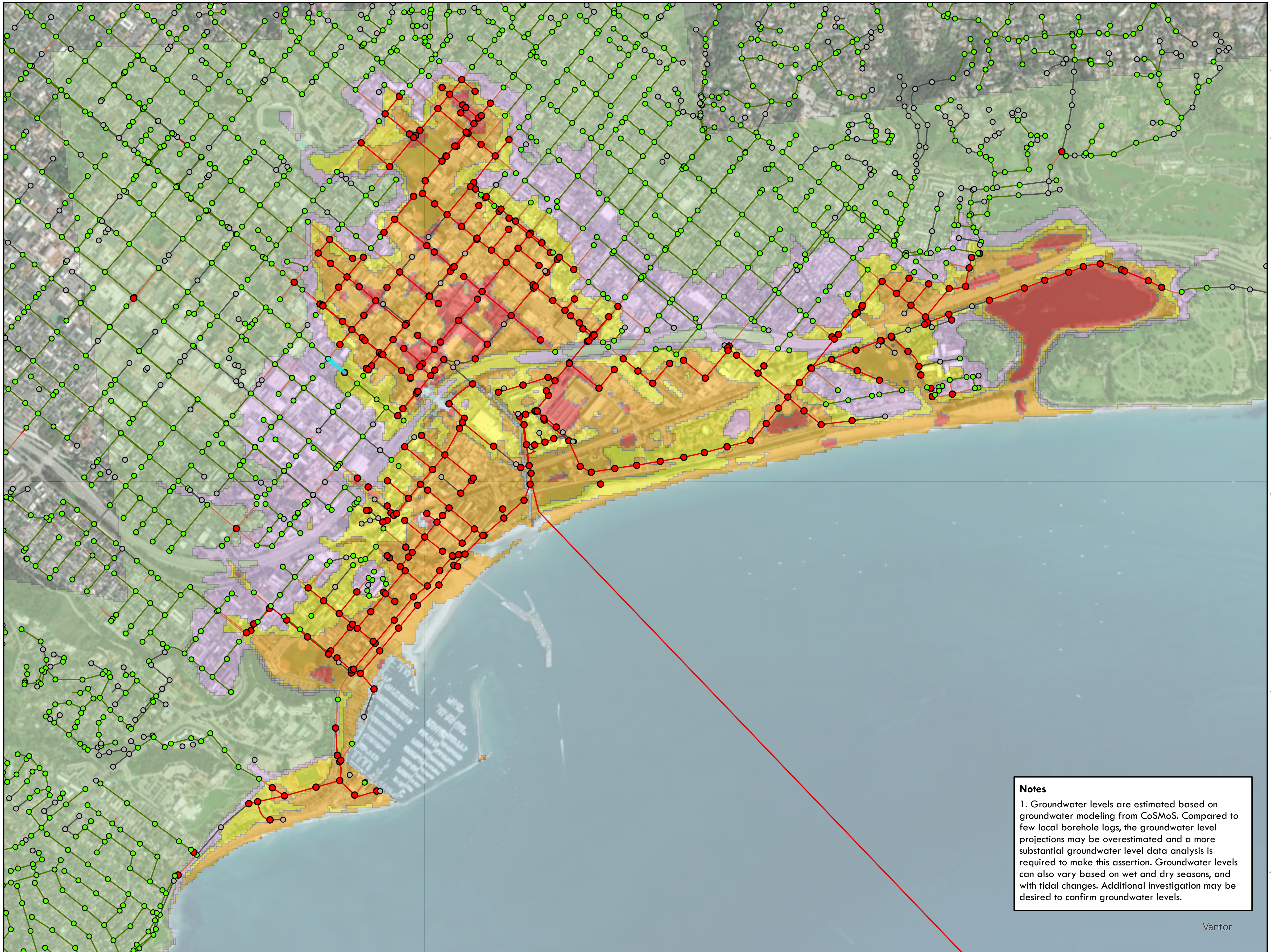
Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet



Water & Wastewater Climate Adaptation Project

Figure 3-14. Groundwater Levels with Wastewater Infrastructure, 3.3 ft SLR

Legend

Manhole Status
- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status
- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface
- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

0 0.2 0.4 Miles

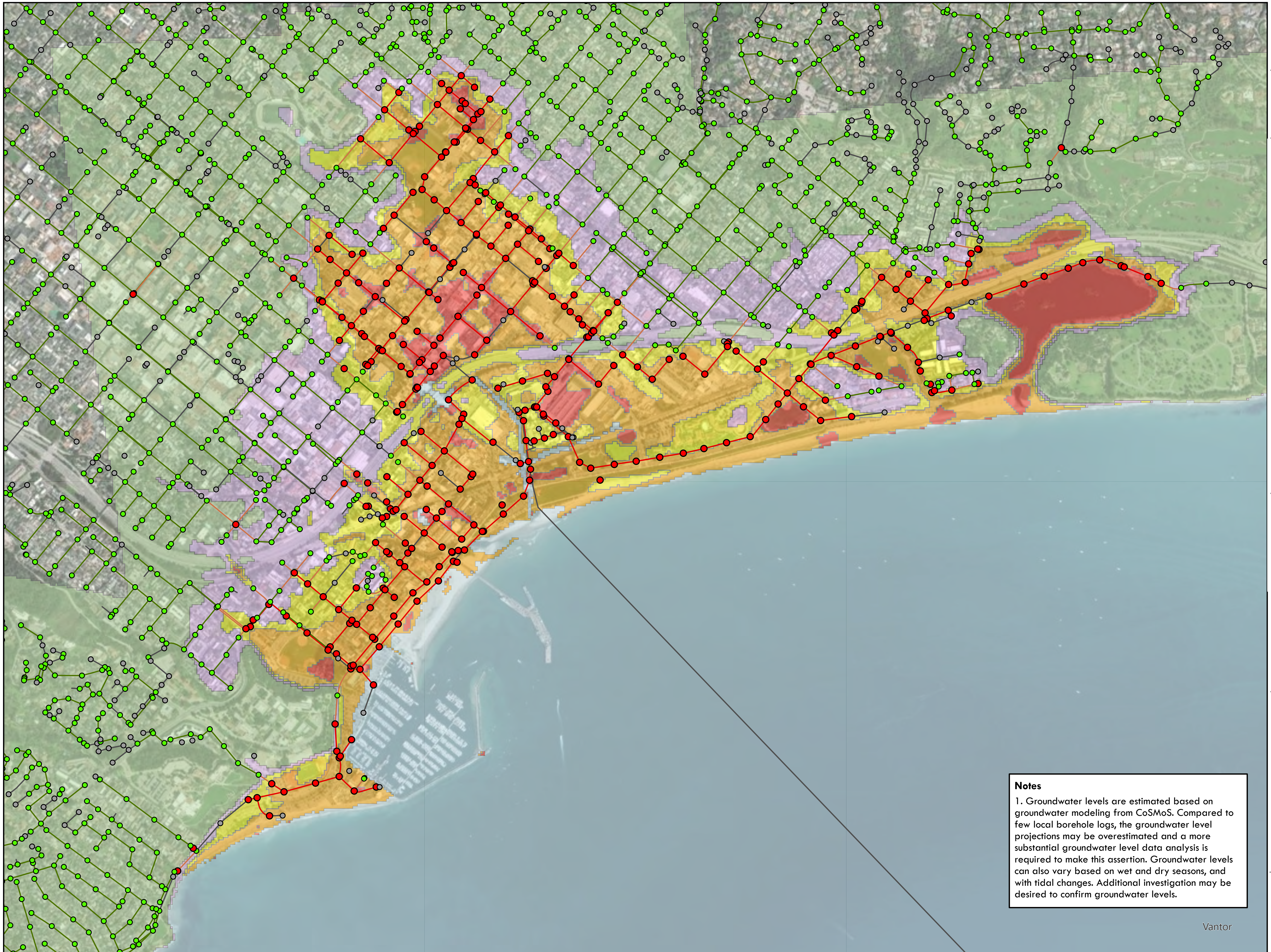
0 1,000 2,000 US Feet

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

Water & Wastewater Climate Adaptation Project

Figure 3-15. Groundwater Levels with Wastewater Infrastructure, 4.1 ft SLR



Legend

Manhole Status

- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status

- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

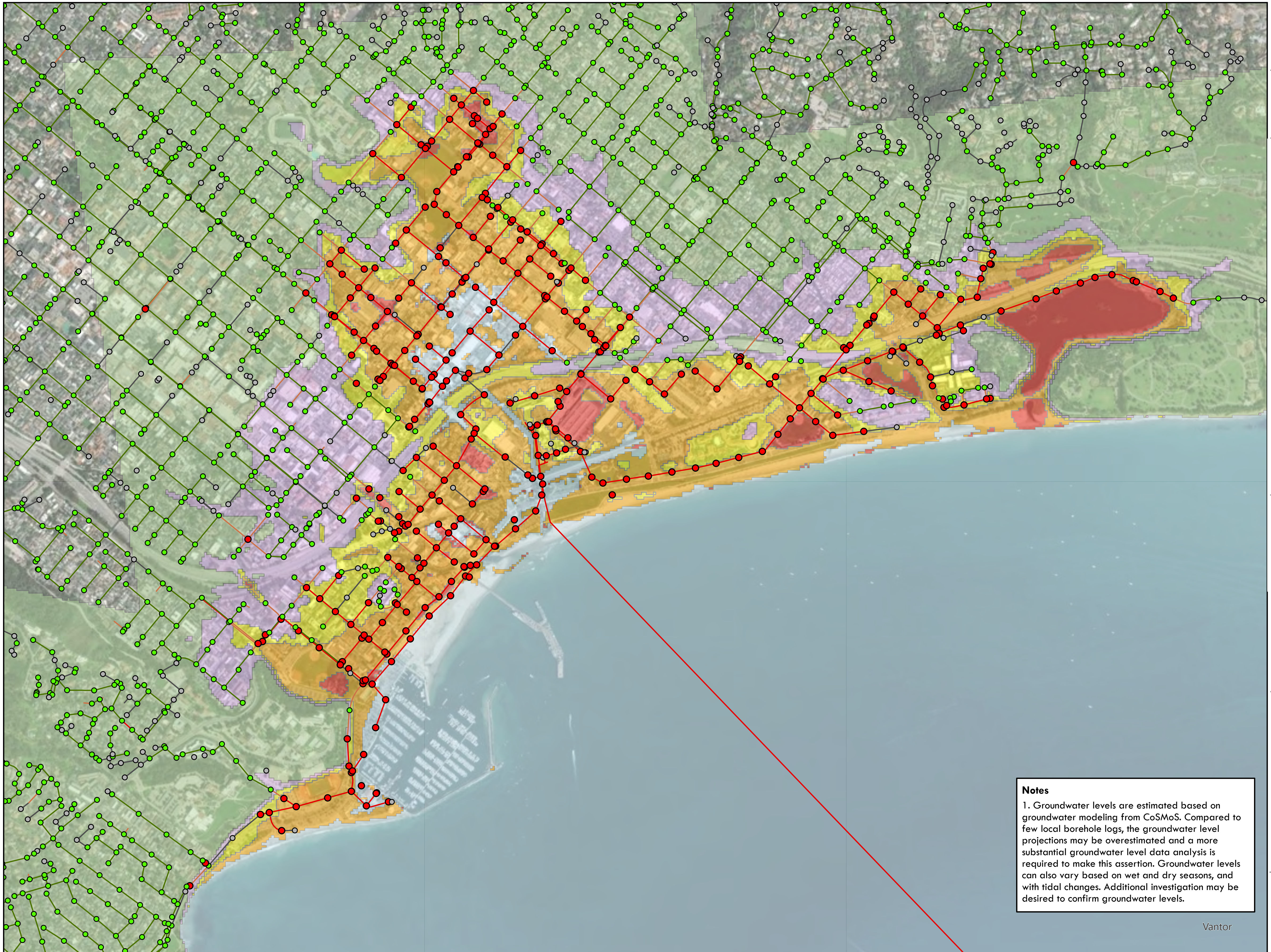
0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-16. Groundwater Levels with Wastewater Infrastructure, 4.9 ft SLR



Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.

Legend

Manhole Status

- Submerged
- Not Submerged
- Depth Unknown

Sewer Main Status

- Submerged
- Partially Submerged
- Not Submerged
- Unknown

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

N

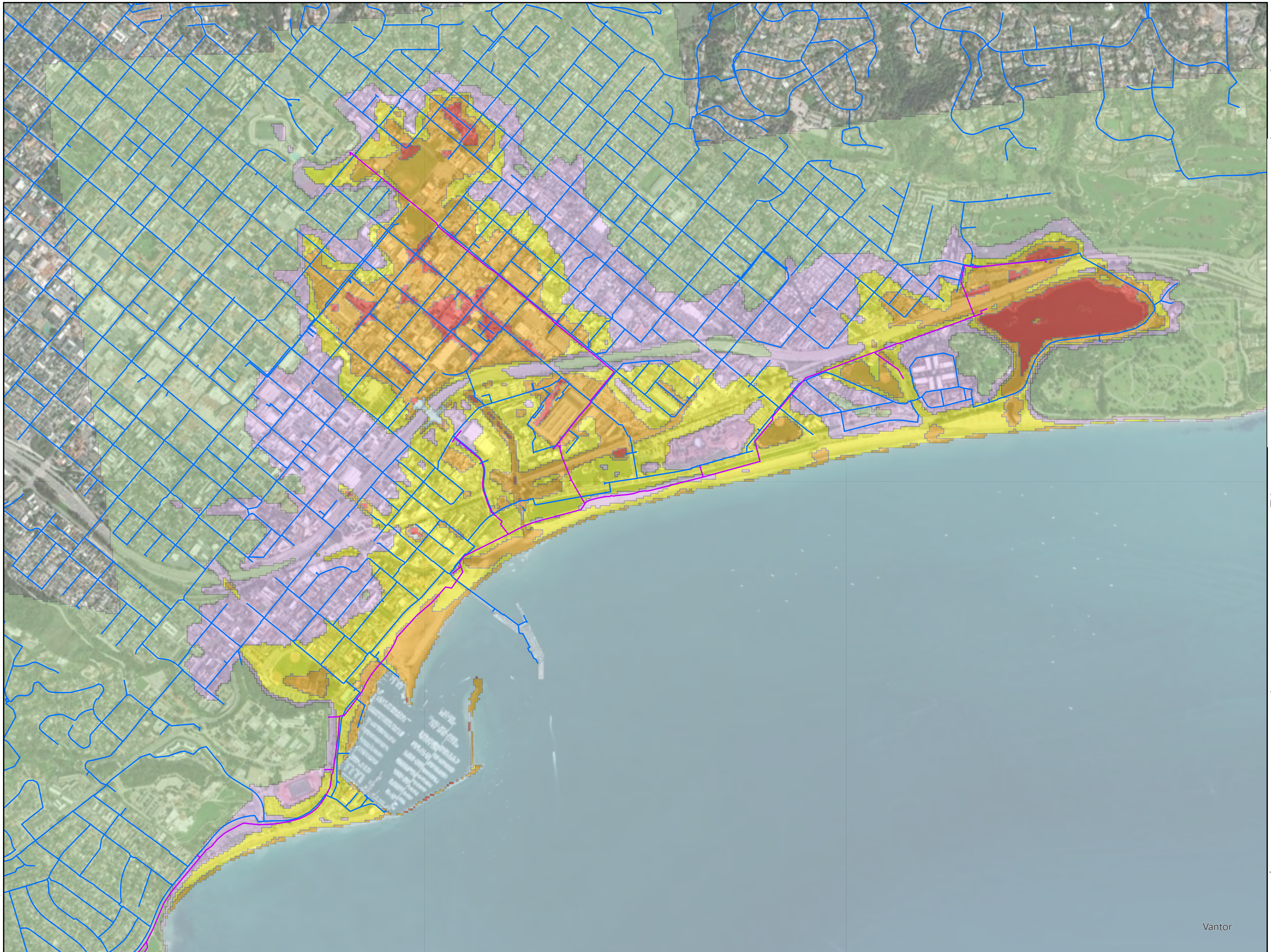
0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-17. Groundwater Levels with Water and Recycled Water Infrastructure, Existing



Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

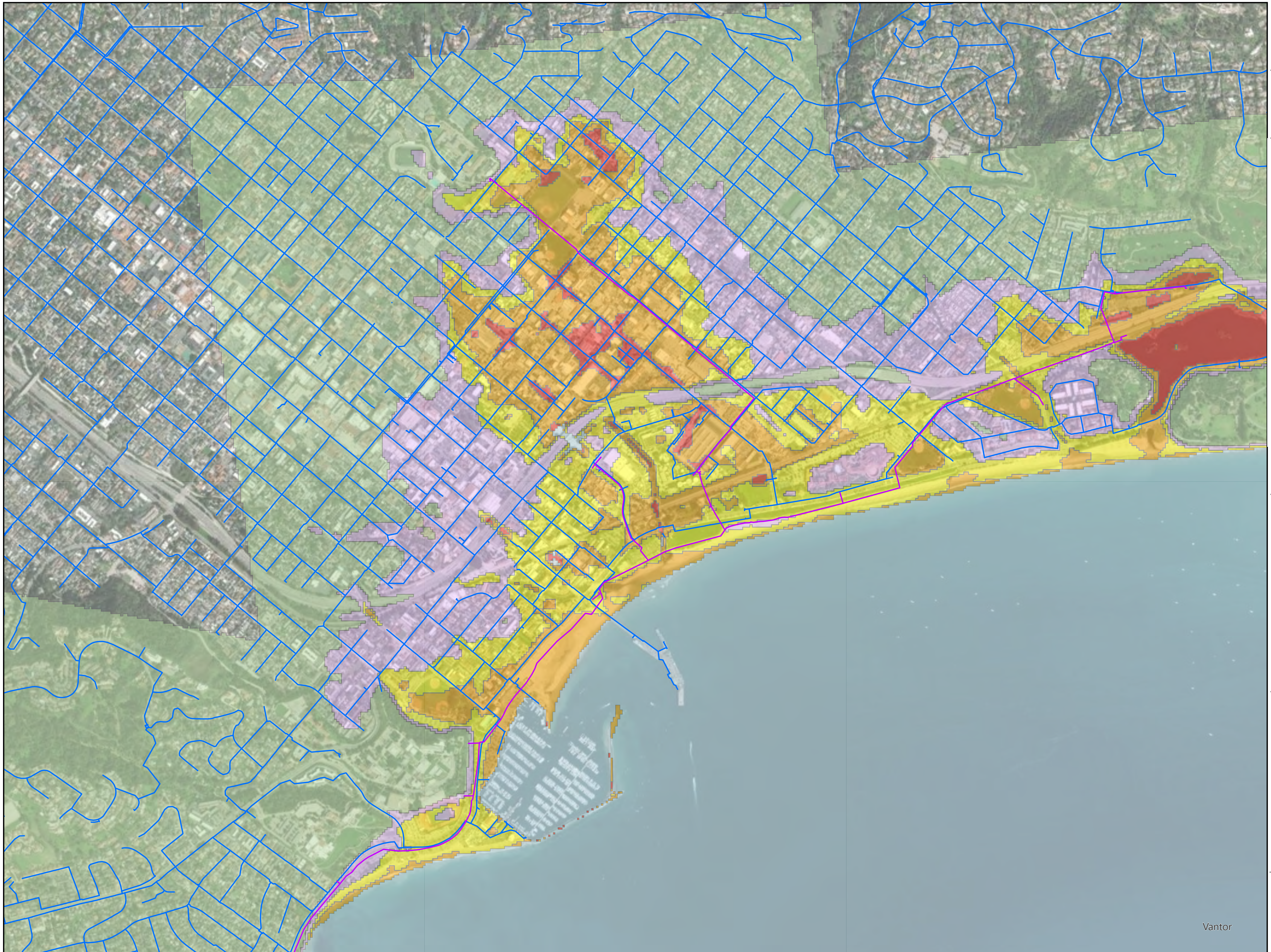
0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-18. Groundwater Levels with Water and Recycled Water Infrastructure, 0.8 ft SLR



Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

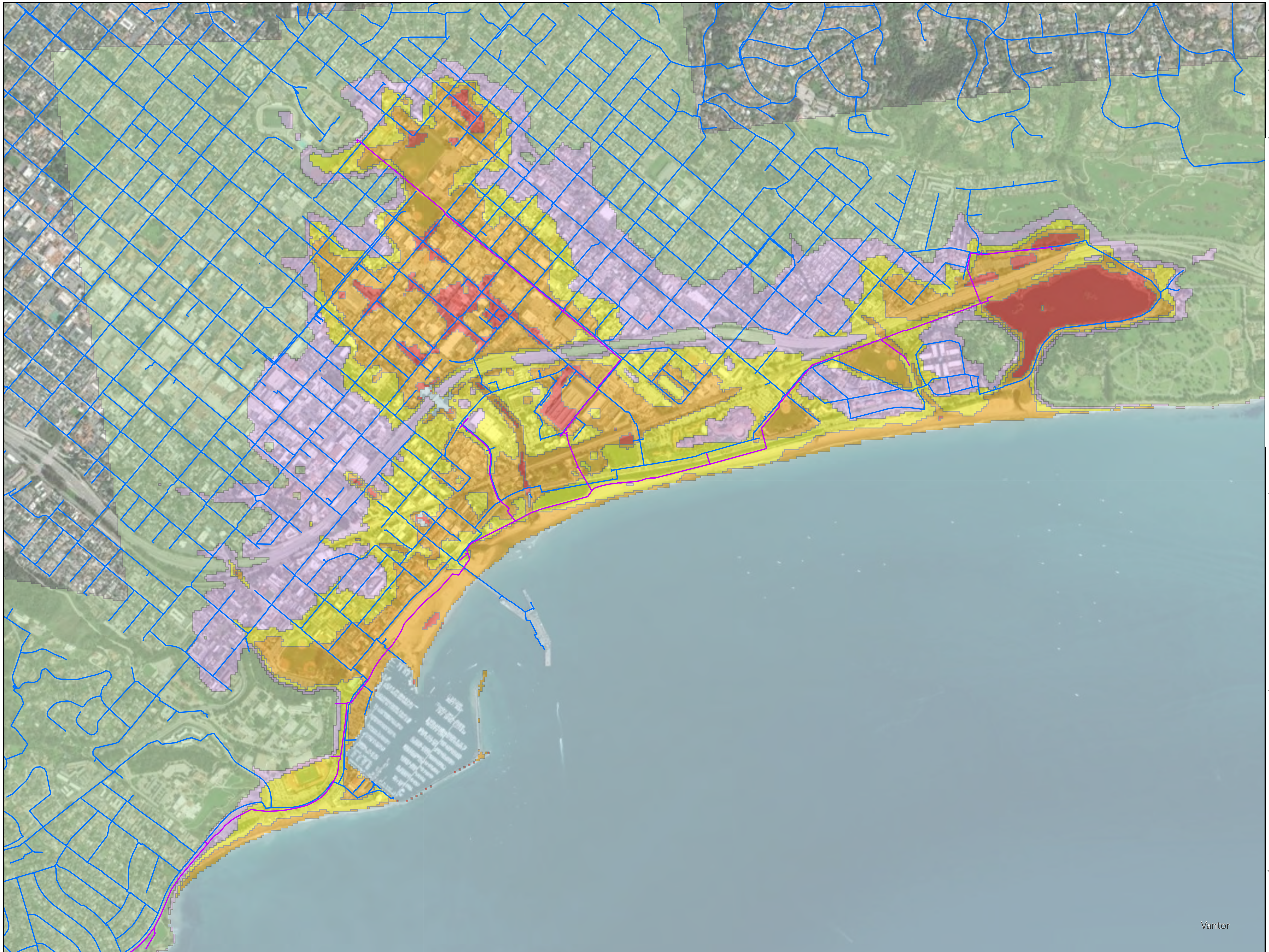
Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet



Water & Wastewater Climate Adaptation Project

Figure 3-19. Groundwater Levels with Water and Recycled Water Infrastructure, 1.6 ft SLR

Legend

- Recycled Water Main
- Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

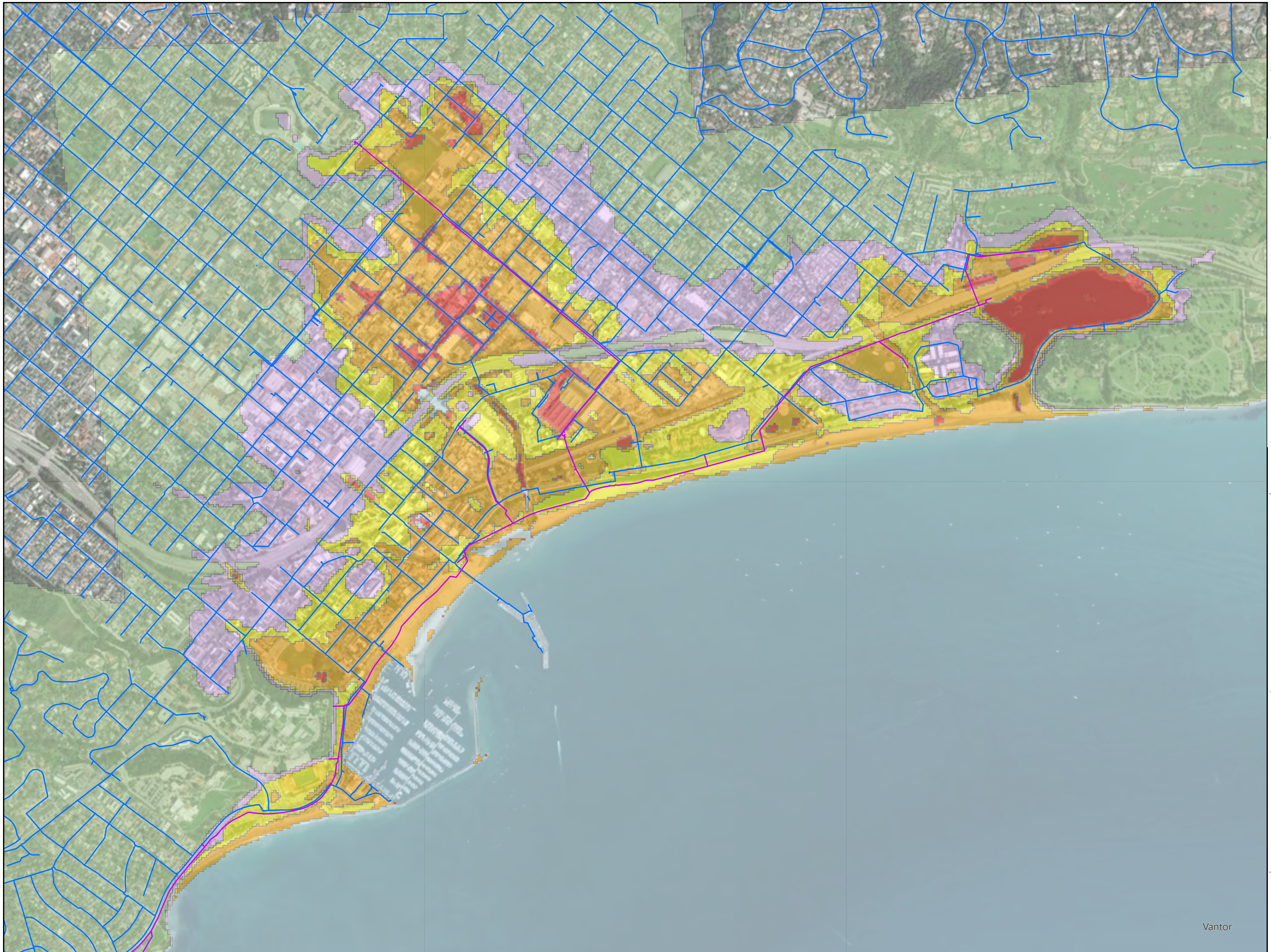
1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC



Water & Wastewater Climate Adaptation Project

Figure 3-20. Groundwater Levels with Water and Recycled Water Infrastructure, 2.5 ft SLR

Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

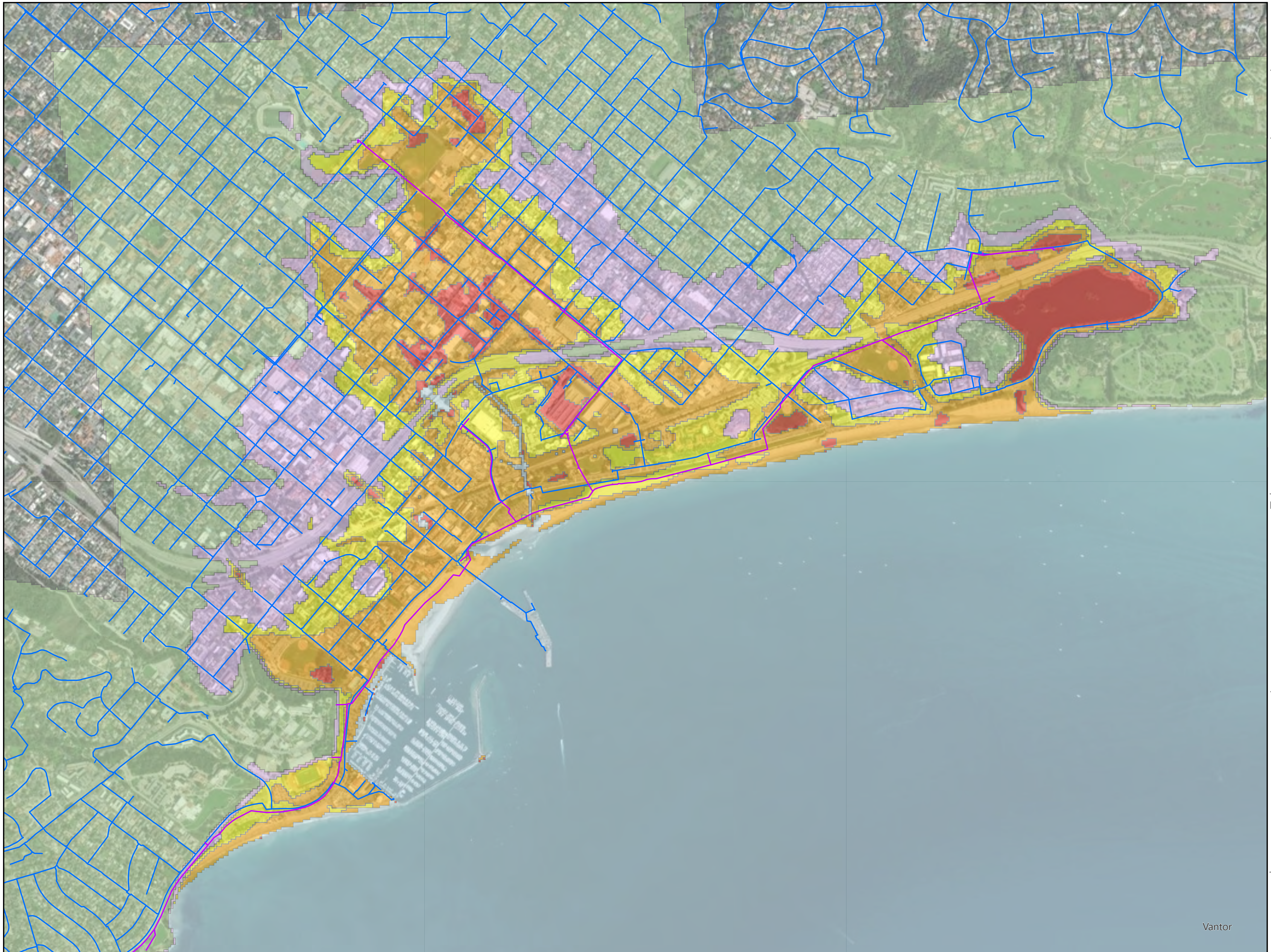
N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

SEAL OF THE CITY OF SANTA BARBARA CALIFORNIA

WSC



Water & Wastewater Climate Adaptation Project

Figure 3-21. Groundwater Levels with Water and Recycled Water Infrastructure, 3.3 ft SLR

Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

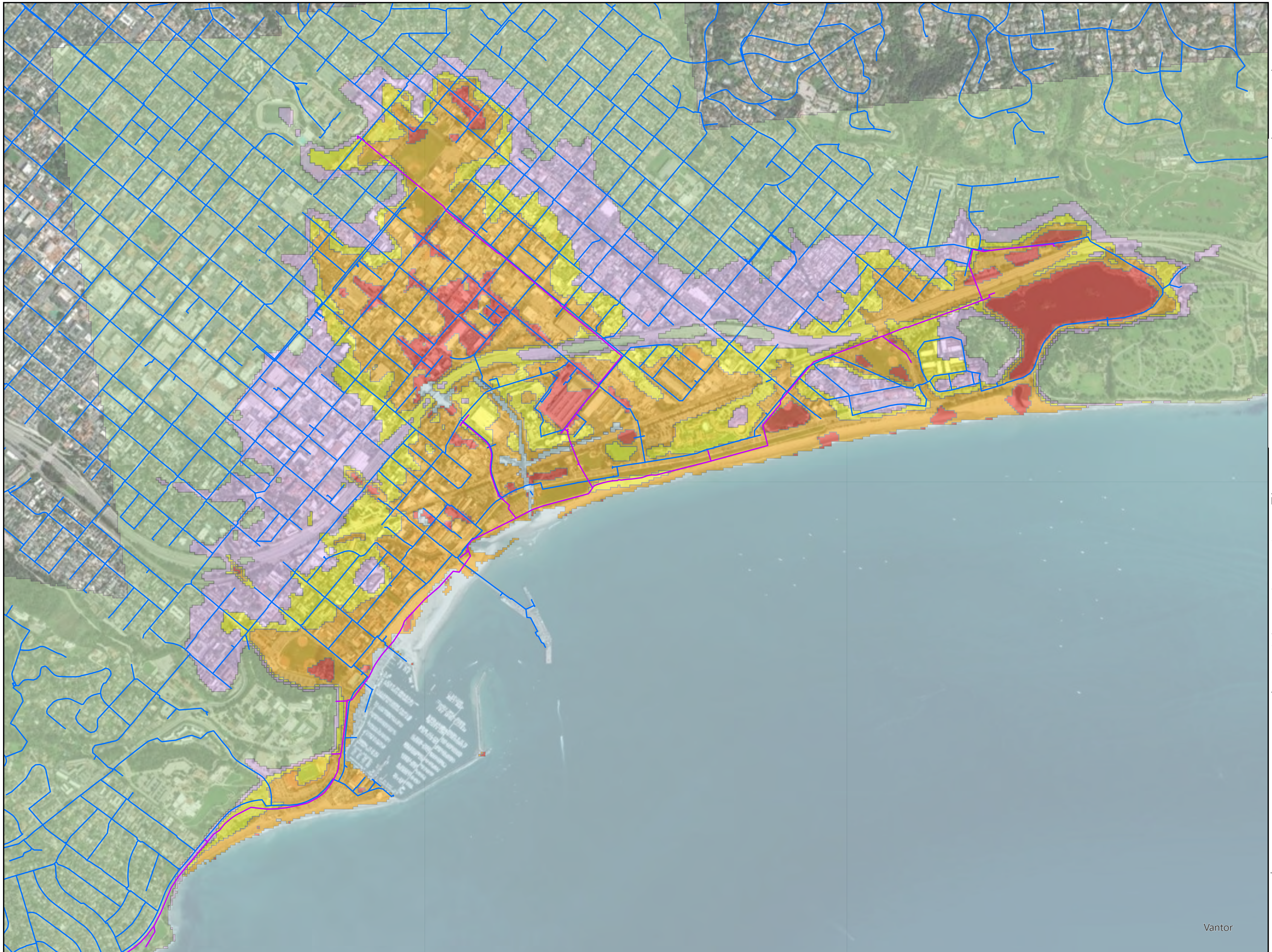
N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

SEAL OF THE CITY OF SANTA BARBARA CALIFORNIA

WSC



Water & Wastewater Climate Adaptation Project

Figure 3-22. Groundwater Levels with Water and Recycled Water Infrastructure, 4.1 ft SLR

Legend

- Water Main
- Recycled Water Main

Groundwater Depth Below Surface

- 0 ft; emergent
- 0-3.3 ft; very shallow
- 3.3-6.6 ft; shallow
- 6.6-16.4 ft; moderate
- >16.4 ft; deep
- marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-23. Groundwater Levels with Water and Recycled Water Infrastructure, 4.9 ft SLR

Legend

Water Main

Recycled Water Main

Groundwater Depth Below Surface

0 ft; emergent

0-3.3 ft; very shallow

3.3-6.6 ft; shallow

6.6-16.4 ft; moderate

>16.4 ft; deep

marine/tidal

Notes

1. Groundwater levels are estimated based on groundwater modeling from CoSMoS. Compared to few local borehole logs, the groundwater level projections may be overestimated and a more substantial groundwater level data analysis is required to make this assertion. Groundwater levels can also vary based on wet and dry seasons, and with tidal changes. Additional investigation may be desired to confirm groundwater levels.
2. Water and Recycled Water mains are estimated to be installed with a minimum depth of cover of 2.5 feet.
3. Pipelines that are within the emergent or very shallow groundwater depth areas are estimated to be submerged.

N

0 0.2 0.4 Miles

0 1,000 2,000 US Feet

Water & Wastewater Climate Adaptation Project

Figure 3-24. Shoreline Erosion, East Beach and West Beach

Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Sewer Manhole
- Sewer Main
- West Beach Sewer
- Water Main
- Desalination Intake
- Recycled Water Main

Shoreline Retreat

- 0.8 ft SLR
- 1.6 ft SLR
- 2.5 ft SLR
- 3.3 ft SLR
- 4.1 ft SLR
- 4.9 ft SLR

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

0 0.1 0.2 Miles

0 420 840 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-25. Shoreline Erosion, Leadbetter Beach

Legend

- Sewer Manhole
- Sewer Main
- Water Main
- Desalination Intake
- Recycled Water Main

Shoreline Retreat

- 0.8 ft SLR
- 1.6 ft SLR
- 2.5 ft SLR
- 3.3 ft SLR
- 4.1 ft SLR
- 4.9 ft SLR

Notes

1. Erosion at West Beach is analyzed separately and discussed further in the Wastewater and Water Systems Climate Adaptation Plan.

N

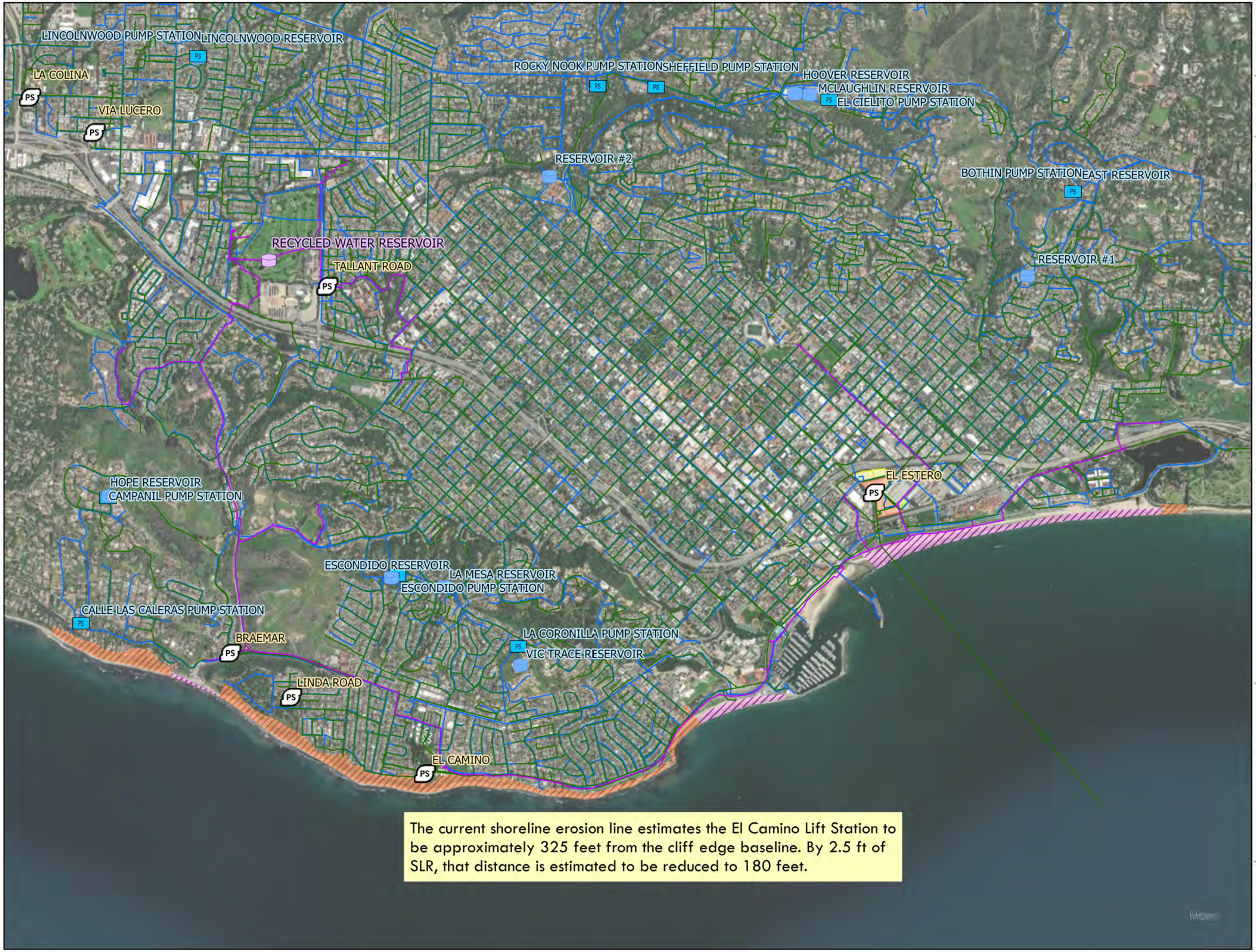
0 0.03 0.07 Miles

0 137.5 275 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-26. 2.5 ft SLR Bluff Erosion



Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Lift Station
- Pump Station
- Reservoir
- Recycled Water Reservoir
- Sewer Main
- Water Main
- Recycled Water Main
- Long Term Bluff Erosion
- Long Term Shoreline Erosion

N

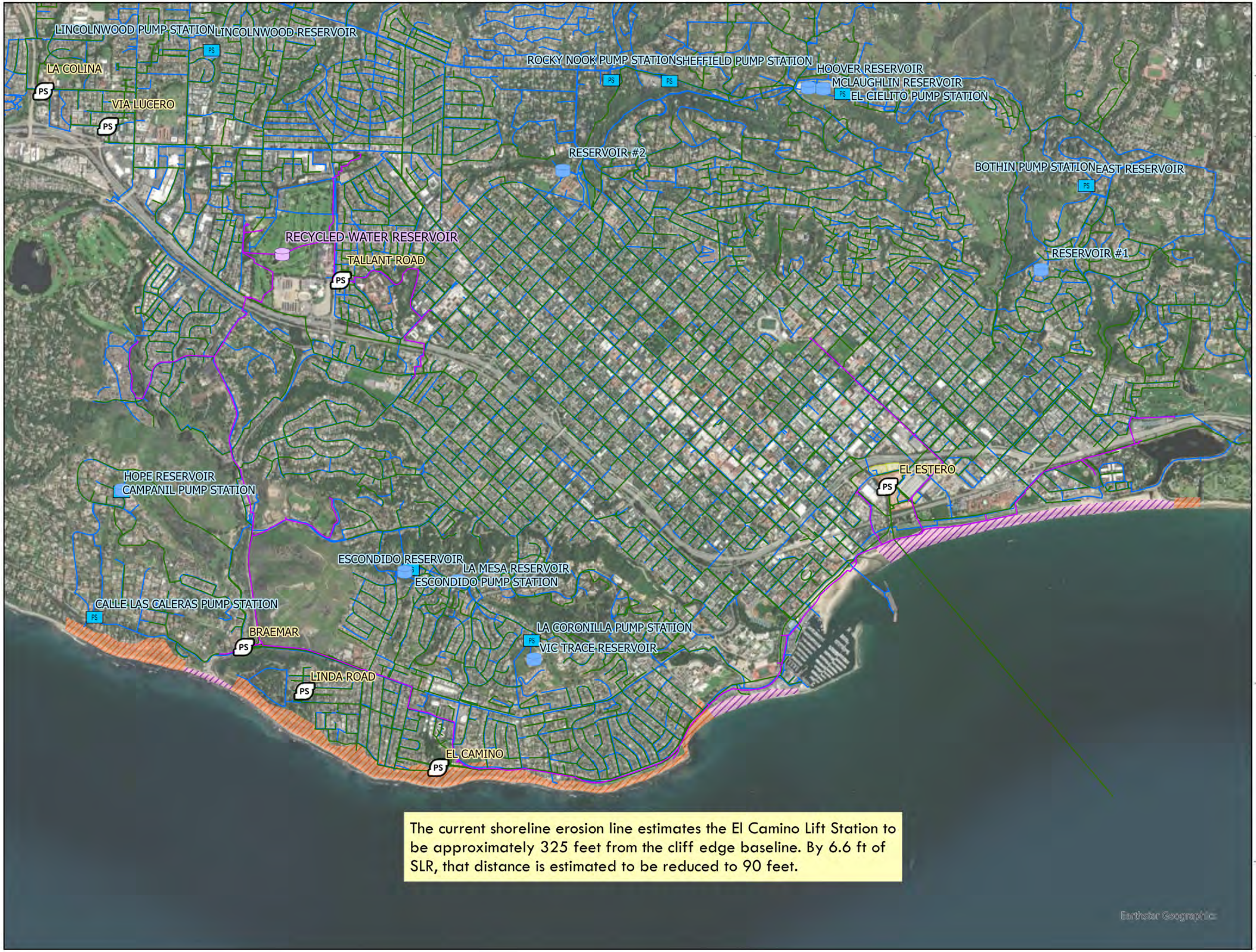
0 0.4 0.8 Miles

0 1,500 3,000 US Feet

WSC

Water & Wastewater Climate Adaptation Project

Figure 3-27. 6.6 ft SLR Bluff Erosion



Legend

- El Estero WRC
- Desal Plant & Annex Yard
- Pump Station & Chemical Area
- Lift Station
- Pump Station
- Reservoir
- Recycled Water Reservoir
- Sewer Main
- Water Main
- Recycled Water Main
- Long Term Bluff Erosion
- Long Term Shoreline Erosion

N

0 0.4 0.8 Miles

0 1,500 3,000 US Feet

WSC

Appendix B Risk Assessment Table

B

HAZARD	RISK DESCRIPTION	CONSEQUENCES	NEAR-TERM LIKELIHOOD	NEAR-TERM RISK	LONG-TERM LIKELIHOOD	LONG-TERM RISK	RATIONALE FOR CONSEQUENCE SCORE
Wastewater Treatment							
Severe flooding	Exceedance of treatment train and outfall capacity due to inflow and infiltration	Catastrophic (5)	Almost Certain (5)	High (25)	Almost Certain (5)	High (25)	Exceedances have been managed in the past by using upstream piping as equalization storage without risk to public health or disruption of service. However, this is not a reliable long term operational solution, and the problem requires need for resources not currently provisioned for.
Severe flooding	Loss of access to site	Catastrophic (5)	Likely / Probable (4)	High (20)	Almost Certain (5)	High (25)	Given this is the sole WWTP in the City, short term outage or reduction in capacity may result in a major regulatory non-compliance.
Severe flooding	Damage to mechanical and electronic components of the treatment system	Catastrophic (5)	Likely / Probable (4)	High (20)	Almost Certain (5)	High (25)	Given this is the sole WWTP in the City, short term outage or reduction in capacity may result in a major regulatory non-compliance. Costly repairs may be required which may prolong the service outage.
Shoreline erosion & wave action	Damage to outfall structures	Catastrophic (5)	Possible (3)	Medium (15)	Likely / Probable (4)	High (20)	Damage to onshore portion of the outfall structure may result in a large raw sewage discharge in the beach area. Potential for risk to public health and major regulatory non-compliance.
Severe flooding	Loss of service due to power outage	Catastrophic (5)	Unlikely (2)	Medium (10)	Possible (3)	Medium (15)	Given this is the sole WWTP in the City, short term outage or reduction in capacity may result in a major regulatory non-compliance. Backup generators are on-site.
Severe flooding	Loss of structural stability of buildings and tanks on site	Catastrophic (5)	Rare (1)	Low (5)	Possible (3)	Medium (15)	Staff safety would be at risk due to potential of sudden large structure collapse
Groundwater rise	Loss of structural stability of buildings and tanks on site	Catastrophic (5)	Rare (1)	Low (5)	Possible (3)	Medium (15)	Staff safety would be at risk due to potential of sudden large structure collapse
Wastewater Collection System							
Severe flooding	Sanitary sewer overflows due to infiltration and inflow of flood waters into sewer pipes and manholes.	Catastrophic (5)	Almost Certain (5)	High (25)	Almost Certain (5)	High (25)	Raw sewage releases over significant area of City.
Shoreline erosion & wave action	Damage to pipes near shore (West Beach sewer)	Catastrophic (5)	Unlikely (2)	Medium (10)	Possible (3)	Medium (15)	Risk to public health from contact with raw sewage, regulatory non-compliance from spill of sewage into the beach area
Severe flooding	Loss of structural stability of Braemar lift station building	Catastrophic (5)	Unlikely (2)	Medium (10)	Possible (3)	Medium (15)	Staff safety would be at risk due to potential of sudden large structure collapse
Severe flooding	Sewage spills due to structural pipeline damage caused by changes in soil structure.	Major (4)	Unlikely (2)	Low (8)	Possible (3)	Medium (12)	Risk to public health from contact with raw sewage
Groundwater rise	Corrosion-related damage to RCP, steel, and vitrified clay pipes from contact with brackish groundwater	Major (4)	Unlikely (2)	Low (8)	Possible (3)	Medium (12)	Damage to WW collection pipes in the coastal area would disrupt service for a period of time longer than one day, cause major regulatory non-compliance, and require resources not currently provisioned for. Risk to public health and staff safety can most likely be averted given the nature and the timeline of expected damage.
Groundwater rise	Sanitary sewer overflows due to infiltration of groundwater into sewer pipes and manholes.	Moderate (3)	Unlikely (2)	Low (6)	Likely / Probable (4)	Medium (12)	Higher groundwater would contributed to increased dry weateher flows in the collection system to El Estero WRC. A higher baseline would increase peak flows during wet weather flows. Although, the consequence is dependnet on the exent of additional flows caused by groundwater rise.
Groundwater rise	Sewage spills due to structural pipeline damage caused by changes in soil structure.	Catastrophic (5)	Rare (1)	Low (5)	Rare (1)	Low (5)	Risk to public health from contact with raw sewage

HAZARD	RISK DESCRIPTION	CONSEQUENCES	NEAR-TERM LIKELIHOOD	NEAR-TERM RISK	LONG-TERM LIKELIHOOD	LONG-TERM RISK	RATIONALE FOR CONSEQUENCE SCORE
Desalination Transmission							
Severe flooding	Potable water contamination due to structural pipeline damage caused by changes in soil structure.	Major (4)	Rare (1)	Low (4)	Unlikely (2)	Low (8)	Risk to public health from drinking contaminated potable water; but could be diverted prior to entering the potable water system downgraded from "Catastrophic" to "Major"
Severe flooding	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure.	Moderate (3)	Rare (1)	Low (3)	Possible (3)	Medium (9)	Given production capacity (7% of the City's potable water production capacity), temporary transmission loss will fall in the "Minor" consequence category. Pipeline repair will be costly, requiring resources that are not currently provisioned for, which amounts to "Major" category of consequence. Given that repairs will not be urgent, overall consequence score of "Moderate" was assigned.
Groundwater rise	Corrosion related damage to the RCP transmission pipe from contact with brackish groundwater	Moderate (3)	Rare (1)	Low (3)	Unlikely (2)	Low (6)	GW may reach depth of RCP transmission pipe and cause material degradation. Given desal production capacity, the consequence to City service will be minor. However, need for costly repairs increases the consequence rating to "Moderate".
Severe flooding	Loss of access to the planned PRV site	Insignificant (1)	Possible (3)	Low (3)	Likely / Probable (4)	Low (4)	It is not known whether flood protection has been incorporated into the design of the Santa Barbara Desal Link project. According to feedback from the City's Operations team, the newly constructed PRV did not flood in the last storm but was surrounded by water.
Severe flooding	Loss of power at the planned PRV site	Insignificant (1)	Unlikely (2)	Low (2)	Possible (3)	Low (3)	It is not known whether flood protection has been incorporated into the design of the Santa Barbara Desal Link project. According to feedback from the City's Operations team, the newly constructed PRV did not flood in the last storm but was surrounded by water.
Desalination Intake							
Shoreline erosion & wave action	Damage to the desalination intake structures caused by loss of cover and wave action	Major (4)	Possible (3)	Medium (12)	Almost Certain (5)	High (20)	Given potential extended outage from intake failure and intake repair will be costly, requiring resources that are not currently provisioned for, which amounts to "Major" category of consequence.
Groundwater rise	Corrosion-related damage to buried desalination intake structures caused by contact with brackish groundwater	Moderate (3)	Unlikely (2)	Low (6)	Possible (3)	Medium (9)	GW may reach depth of inland portion of RCP pipe and cause material degradation. Given desal production capacity, the consequence to City service will be minor. However, need for costly repairs increases the consequence rating to "Moderate".
Severe flooding	Damage to mechanical and electronic components of the pre-treatment system	Moderate (3)	Unlikely (2)	Low (6)	Possible (3)	Medium (9)	Given production capacity (7% of the City's potable water production capacity), production loss will fall in the "Minor" category. However, need for potentially costly equipment repair increases the consequence rating to "Moderate".
Desalination Plant							
Severe flooding	Loss of structural stability in onsite buildings and tanks	Catastrophic (5)	Rare (1)	Low (5)	Unlikely (2)	Medium (10)	Staff safety would be at risk due to potential of sudden large structure collapse
Severe flooding	Loss of access to site	Minor (2)	Likely / Probable (4)	Low (8)	Likely / Probable (4)	Low (8)	Given that desalination plant operations are typically shut off during major storms to maintain ocean outfall capacity, temporary access loss will fall in the "Minor" consequence category.
Severe flooding	Loss of service due to power outage	Minor (2)	Likely / Probable (4)	Low (8)	Likely / Probable (4)	Low (8)	Given that desalination plant operations are typically shut off during major storms to maintain ocean outfall capacity, temporary power loss will fall in the "Minor" consequence category.
Groundwater rise	Loss of structural stability of buildings and tanks on site	Catastrophic (5)	Rare (1)	Low (5)	Unlikely (2)	Medium (10)	Staff safety would be at risk due to potential of sudden large structure collapse

HAZARD	RISK DESCRIPTION	CONSEQUENCES	NEAR-TERM LIKELIHOOD	NEAR-TERM RISK	LONG-TERM LIKELIHOOD	LONG-TERM RISK	RATIONALE FOR CONSEQUENCE SCORE
Potable Water Distribution							
Shoreline erosion & wave action	Damage to pipes near shore	Major (4)	Possible (3)	Medium (12)	Almost Certain (5)	High (20)	"Likely/Probable" rating is for pipeline segment within Chase Palm Park. "Major" rating reflects a potential potable water outage for an unknown number of waterfront customers (end of distribution line), and assumes that pipeline will be placed out of service before any catastrophic consequences, like potable water contamination.
Severe flooding	Potable water contamination due to structural pipeline damage caused by changes in soil structure.	Catastrophic (5)	Unlikely (2)	Medium (10)	Unlikely (2)	Medium (10)	Risk to public health from drinking contaminated potable water
Severe flooding	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure.	Moderate (3)	Unlikely (2)	Low (6)	Possible (3)	Medium (9)	Damage to water distribution piping in the coastal area would affect a small percentage of City's service area. Costly repairs may be required.
Severe flooding	Loss of water and depressurization due to damage to above ground infrastructure (hydrants, valves)	Moderate (3)	Unlikely (2)	Low (6)	Possible (3)	Medium (9)	Damage to water distribution piping in the coastal area would affect a small percentage of City's service area. Costly repairs may be required.
Groundwater rise	Corrosion-related damage to steel, iron, and copper pipes from contact with brackish groundwater.	Moderate (3)	Unlikely (2)	Low (6)	Possible (3)	Medium (9)	Damage to water distribution piping in the coastal area would affect a small percentage of City's service area. Slow action of corrosion is not likely to cause damage that will result in potable water contamination. Costly repairs may be required.
Groundwater rise	Potable water contamination due to structural pipeline damage caused by changes in soil structure.	Catastrophic (5)	Rare (1)	Low (5)	Unlikely (2)	Medium (10)	Risk to public health from drinking contaminated potable water
Severe flooding	Potable water contamination due to damage to above ground infrastructure (hydrants, valves)	Catastrophic (5)	Rare (1)	Low (5)	Unlikely (2)	Medium (10)	Risk to public health from drinking contaminated potable water
Groundwater rise	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure.	Moderate (3)	Rare (1)	Low (3)	Possible (3)	Medium (9)	Damage to water distribution piping in the coastal area would affect a small percentage of City's service area. Costly repairs may be required.
Ortega GWTP							
Severe flooding	Damage to mechanical and electronic components of the treatment system	Moderate (3)	Unlikely (2)	Low (6)	Possible (3)	Medium (9)	Given production capacity (6% of the City's potable water production capacity) and plant use only in summer, production loss is "Minor". However, need for potentially costly equipment repair increases the consequence rating to "Moderate".
Severe flooding	Loss of structural stability of buildings and tanks on site	Catastrophic (5)	Rare (1)	Low (5)	Unlikely (2)	Medium (10)	Staff safety would be at risk due to potential of sudden large structure collapse
Severe flooding	Loss of service due to power outage	Minor (2)	Unlikely (2)	Low (4)	Possible (3)	Low (6)	Given production capacity (6% of the City's potable water production capacity) and plant use only in summer, production loss is "Minor". However, need for potentially costly equipment repair increases the consequence rating to "Moderate".
Severe flooding	Loss of access to site	Minor (2)	Unlikely (2)	Low (4)	Possible (3)	Low (6)	Given production capacity (6% of the City's potable water production capacity) and plant use only in summer, production loss is "Minor". However, need for potentially costly equipment repair increases the consequence rating to "Moderate".

HAZARD	RISK DESCRIPTION	CONSEQUENCES	NEAR-TERM LIKELIHOOD	NEAR-TERM RISK	LONG-TERM LIKELIHOOD	LONG-TERM RISK	RATIONALE FOR CONSEQUENCE SCORE
Recycled Water Treatment							
Severe flooding	Loss of structural stability of buildings and tanks on site	Catastrophic (5)	Rare (1)	Low (5)	Unlikely (2)	Medium (10)	Staff safety would be at risk due to potential of sudden large structure collapse
Severe flooding	Damage to mechanical and electronic components of the treatment system	Moderate (3)	Possible (3)	Medium (9)	Almost Certain (5)	Medium (15)	Given production rates (<1 MGD) and primarily summer use, temporary loss of access and associated potential brief service interruption is "Minor". However, need for potentially costly equipment repair increases to "Moderate".
Severe flooding	Loss of access to site	Minor (2)	Likely / Probable (4)	Low (8)	Almost Certain (5)	Medium (10)	Given production rates (<1 MGD) and primarily summer use, temporary loss of access and associated potential brief service interruption is "Minor".
Severe flooding	Loss of service due to power outage	Minor (2)	Possible (3)	Low (6)	Possible (3)	Low (6)	Given production rates (<1 MGD) and primarily summer use, temporary loss of access and associated potential brief service interruption is "Minor".
Groundwater rise	Loss of structural stability of buildings and tanks on site	Catastrophic (5)	Rare (1)	Low (5)	Unlikely (2)	Medium (10)	Staff safety would be at risk due to potential of sudden large structure collapse
Recycled Water Distribution							
Shoreline erosion & wave action	Damage to pipes near shore	Moderate (3)	Likely / Probable (4)	Medium (12)	Almost Certain (5)	Medium (15)	Given production rates (<1 MGD) and primarily summer use, temporary loss of access and associated potential brief service interruption is "Minor". However, need for potentially costly pipeline repair increases to "Moderate".
Severe flooding	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure.	Moderate (3)	Unlikely (2)	Low (6)	Possible (3)	Medium (9)	Given production rates (<1 MGD) and primarily summer use, temporary loss of access and associated potential brief service interruption is "Minor". However, need for potentially costly pipeline repair increases to "Moderate".
Groundwater rise	Loss of water and depressurization due to structural pipeline damage caused by changes in soil structure.	Moderate (3)	Rare (1)	Low (3)	Possible (3)	Medium (9)	Given production rates (<1 MGD) and primarily summer use, temporary loss of access and associated potential brief service interruption is "Minor". However, need for potentially costly pipeline repair increases to "Moderate".
Groundwater rise	Corrosion-related damage to PVC pipes from contact with brackish groundwater	Insignificant (1)	Unlikely (2)	Low (2)	Possible (3)	Low (3)	PVC pipes are not likely to be damaged by brackish GW

WSC

Appendix C El Estero WRC Facilities Relocation Concept TM

C

Technical Memorandum

Date:	10/31/2025
Owner:	City of Santa Barbara
Project:	Water & Wastewater Systems Climate Adaptation Plan
Subject:	**El Estero WRC Relocation Concept**

1.0 Introduction

1.1 Background

The City of Santa Barbara (City) owns and operates the El Estero Water Resource Center (El Estero WRC) that provides secondary treatment and disposal of municipal and industrial wastewater. The El Estero WRC treatment process includes screening and grinding, aerated grit removal, primary clarification, activated sludge process for biochemical oxygen demand (BOD) removal, secondary clarification, disinfection (with sodium hypochlorite), dechlorination (with sodium bisulfite), and biosolids processing.

The facility's 2019 National Pollutant Discharge Elimination System (NPDES) permit requires the City to submit a sea level rise adaptation plan to the Central Coast Regional Water Quality Board. The sea level rise adaptation plan must address impacts of flooding and other coastal hazards on the City's wastewater facilities and consider a range of adaptation alternatives, including facility relocation. The City retained WSC to complete the Wastewater and Water Systems Climate Adaptation Plan. This technical memorandum (TM) is an appendix to the Wastewater and Water Systems Climate Adaptation Plan.

1.2 Purpose

The purpose of this TM is to conceptually define a project to construct a new water reclamation facility (WRF) at an inland location and discuss alternatives for re-routing the collection system to protect wastewater facilities from potential coastal hazards. The findings of this TM will inform long-term planning decisions for investments to protect El Estero WRC from future hazards, such as fluvial flooding, coastal flooding, and tidal inundation.

1.3 Planning Considerations

The need to relocate El Estero WRC will be dependent on the cost and reliability of flood protection options combined with hazards discussed later in this Plan – access issues to the plant during flooding events and capacity issues at the plant and in the collection system during storm events. Creek flooding is expected to increase in intensity and recurrence with climate change. The proposed Stormwater and Flood Analysis Report would better define the extent and recurrence of flooding around El Estero WRC, which will enable the City to better define the potential timing of El Estero WRC relocation. In addition:

- By 3.3 ft of SLR, creek flooding will be compounded by coastal storm flooding
- By 4.1 ft of SLR, tides will regularly flood some coastal areas.
- By 4.9 ft of SLR, tides will regularly flood areas around El Estero WRC.

Based on our current understanding of the creek, coastal and tidal flooding projections, the timing of relocation could be as early as 2.5 ft of SLR if on-site flooding, plant access, and plant capacity issues cannot be addressed properly or as late as 4.9 ft of SLR if measures address risks properly. Therefore, the timing of relocation should be evaluated during the next Plan update – once the latest hazard projections are available and effectiveness of initial mitigation measures are understood. The City should initiate planning at least 20 years ahead of when El Estero WRC is projected to be relocated and should ensure that existing space is reserved for future plant relocation.

1.4 Approach

The new WRF analysis included the following steps:

1. Perform historical flows and loads analysis using influent wastewater data from California Integrated Water Quality System (CIWQS) and the City.
2. Apply buildout assumptions provided by the City to develop projected flows and loads to be used for preliminary design basis.
3. Select representative treatment process assuming membrane bioreactor (MBR) process due to its relatively compact size and potential integration with future potable reuse treatment train.
4. Define preliminary design criteria for process sizing using projected flows and loads and select redundancy criteria based on engineering judgment.
5. Use CapdetWorks[1] to generate preliminary design and cost estimation results for the representative treatment process.
6. Quantify total footprint required for new WRF and potable reuse facility at new site.
7. Identify infrastructure needs and costs for the new wastewater collection system and land outfall to serve new WRF.

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[1] CapdetWorks is a cost-estimating tool based on the CAPDET model that was originally developed by the U.S. Army Corps of Engineers for the U.S. EPA in 1973 and updated regularly. https://www.hydromantis.com/CapdetWorks.html

8. Estimate total project costs for El Estero WRC relocation.

1.4.1 Cost Estimates

Cost estimates in this TM were developed based on limited information and should be considered an AACE Class 5 estimate (-50%, +100%) for concept screening based on 0% to 2% level of project definition. The cost estimate includes a construction contingency and unaccounted-for costs of 40% of raw construction costs and implementation costs (e.g, planning, design, legal, etc.) of 40% of construction costs. These percentages are appropriate for the level of project definition and the scope of constructing a new WRF and large force mains within a built-out city. The cost of land purchase is not included in the capital cost estimate. Costs are in 2024 dollars.

1.5 Constraints

The wastewater characterization analysis described in this TM was performed at a planning level to size unit processes for a new facility, which would be required in the event of El Estero WRC relocation. This update to projected flows and loads is conservative in nature and should not be utilized for future preliminary design or detailed design efforts. Consideration of future regulatory requirements, a more detailed wastewater characterization, and additional influent wastewater sampling are recommended to improve accuracy of the City's projected flows and loads.

2.0 WRF Design Criteria

The purpose of this section is to document the process of design criteria development for a new, inland WRF. The design criteria include influent wastewater flow and loading characteristics. These criteria are used to size process unites and establish the footprint and cost of the new facility in the CapdetWorks model. The estimated footprint of the new facility will provide the basis for screening potential City parcels to site the relocated facility.

2.1 Approach

Influent wastewater flows and loads were characterized over several averaging periods to inform design sizing of treatment system unit processes. WSC selected averaging periods for flows and loads that are relevant to the City's NPDES permit limits and conceptual design.

Influent wastewater flows were characterized over the following averaging periods:

- Average Annual, Average Dry Weather (ADWF), and Maximum Month to provide a basis for process sizing.
- Maximum Week, Maximum Day, and Peak Hour to evaluate equalization needs and determine flow management strategy.

The following constituents were analyzed for influent wastewater loading:

- Carbonaceous biochemical oxygen demand (cBOD) to align with current permit requirements for effluent water quality criteria (see Section 2.2.4).
- Chemical oxygen demand (COD), ammonia, and total Kjeldahl nitrogen (TKN) to provide a basis for process sizing.

To further inform process sizing, loadings for the following constituents were also developed using assumed industry standard constituent ratios:

- 5-day biochemical oxygen demand (BOD) and total suspended solids (TSS)

Annual flows and loads from 2021 through 2023 were evaluated for this analysis. It is recommended the City consider a longer historical analytical period for subsequent and more detailed analyses to capture any year-to-year variations in wastewater strength and flows.

2.2 Data Sources

This section summarizes the data collected for this analysis and the respective data sources.

2.2.1 Flows and Loads Data

WSC obtained two sets of influent flow and water quality data for this analysis:

- Confluent composite data set provided by the City via email on November 9, 2023.
- Data obtained from the CIWQS database.

The two data sources were evaluated for consistency and applicability to the El Estero WRC relocation planning. Table 1 captures the sources, timeframe, and content of the flows and loads data sources.

Table 1: Influent Wastewater Flows and Loads Data Sources

Data Source	CIWQS	City[2]
Monitoring Location / Sample Source	INF-001[1]	Confluent Composite[2]
Data Timeframe	2021-2023	2021-2023
Frequency of Available Results	Loads: Average monthly Flow: Daily and instantaneous maximum	Monthly average Monthly minimum Monthly maximum
Parameters Reported	Flow cBOD TSS	Flow cBOD COD TKN Ammonia

Notes:

1. The monitoring location INF-001 is defined in the NPDES permit as “influent wastewater prior to treatment and following all significant inputs to the collection system or the headworks of untreated wastewater, upstream of any in-plant return flows, where representative samples of wastewater influent can be obtained”.
2. Data provided by the City via email on November 9, 2023. The source of this data was a confluent composite sample, which includes solids handling process return flows but does not include the secondary effluent return. Solids handling process return flows include the gravity thickener and dissolved air floatation overflows and the belt filter press filtrate.

2.2.2 Precipitation Data

Precipitation data for the years 2021 through 2023 was obtained from the National Ocean Atmospheric Administration Climate Data Center (NOAA CDC) Station USC00047902 (latitude/longitude: 34.4167°, -119.6844°). Precipitation data was used to determine the driest and the dryest three consecutive months of the year for the purpose of establishing the facility’s average dry weather flow period.

2.2.3 Buildout Growth Projections

The City’s wastewater flows were projected to increase by 27% from 2020 to buildout (projected to occur in 2050), based on the recent Update to Wastewater Collection System Hydraulic Model (WSC 2024). To account for projected 27% growth, a multiplier of 1.27 times historical flows and loads was used in this analysis to estimate buildout flows and loads. The buildout flows and loads where then applied to the new WRF design criteria.

The 2020 Enhanced Urban Water Management Plan lists the buildout (2050) population as 110,205 for the water service area (WSC 2020). The sewer service area excludes Mission Creek (buildout population of 2,944), therefore a buildout population of 107,261 was used in this analysis for the buildout sewer service area. Population data was used to develop per capita flow and load values which helps characterize the influent wastewater stream in comparison to expected values for primarily domestic wastewater systems.

2.2.4 Effluent Requirements

The El Estero WRC 2019 NPDES permit capacity for dry weather average monthly discharge is 11 million gallons per day (MGD). The effluent limitations for major constituents are shown in Table 2.

Table 2: NPDES Permit Effluent Limitations for Major Constituents

Parameter	Units	Average Monthly	Average Weekly	Maximum Daily	Instantaneous Minimum	Instantaneous Maximum
Carbonaceous Biochemical Oxygen Demand 5-day @ 20°C	mg/L	25	40	90	---	---
	lbs/day[1]	2,290	3,670	8,260	---	---
Total Suspended Solids	mg/L	30	45	90	---	---
	lbs/day[1]	2,750	4,130	8,260	---	---
pH	standard units	-	---	---	6.0	9.0

Note:

1. Mass-based effluent limitations were calculated using the following formula:
   lbs/day = pollutant concentration (mg/L) * permitted flow (11 MGD) * conversion faction (8.34)

2.3 Data Analysis and Results

This section summarizes the historical and projected flows and loads, and wet weather equalization considerations for the WRF's hydraulic design criteria.

2.3.1 Historical and Projected Flows

Historical flows were consistent in both data sets obtained. Projected average annual flow is estimated to increase from 6.1 MGD to 7.8 MGD based on the 27% increase to buildout conditions. As shown in Table 3, projected average dry weather, maximum month, and maximum week flows were estimated based on applying respective historical peaking factors (compared to average annual flow) to the projected average annual flow.

Table 3: Historical and Projected Flows and Peaking Factors

Averaging Period	Historical Flows (2021-2023) (MGD)	Historical Peaking Factor to Average Annual	Projected Buildout Flows (MGD)
Average Annual	6.1	--	7.8
Average Dry Weather (ADWF)	5.9	0.97	7.5
Maximum Monthly	8.9	1.5	11.3
Maximum Week	12.8	2.1	16.2

Historical maximum day and peak hour flows are based on outputs from the City's sewer model for a design 10-year, 24-hour storm, which was loaded based on recent storm data. Buildout wet weather flows were modeled using the design 10-year, 24-hour storm with projected increased ADWF of 1.7 MGD included in base wastewater flows. To account for anticipated impacts of climate change on storm intensity, wet weather flows were modeled using the design 10-year, 24-hour storm incorporated a projected 30% increase in future precipitation intensity.

The historical and buildout design 10-year, 24-hour storms are presented in Figure 1. Historical and buildout wet weather flows are summarized in Table 4.

Figure 1. Daily Hydrograph for WRF Design Wet Weather Flows

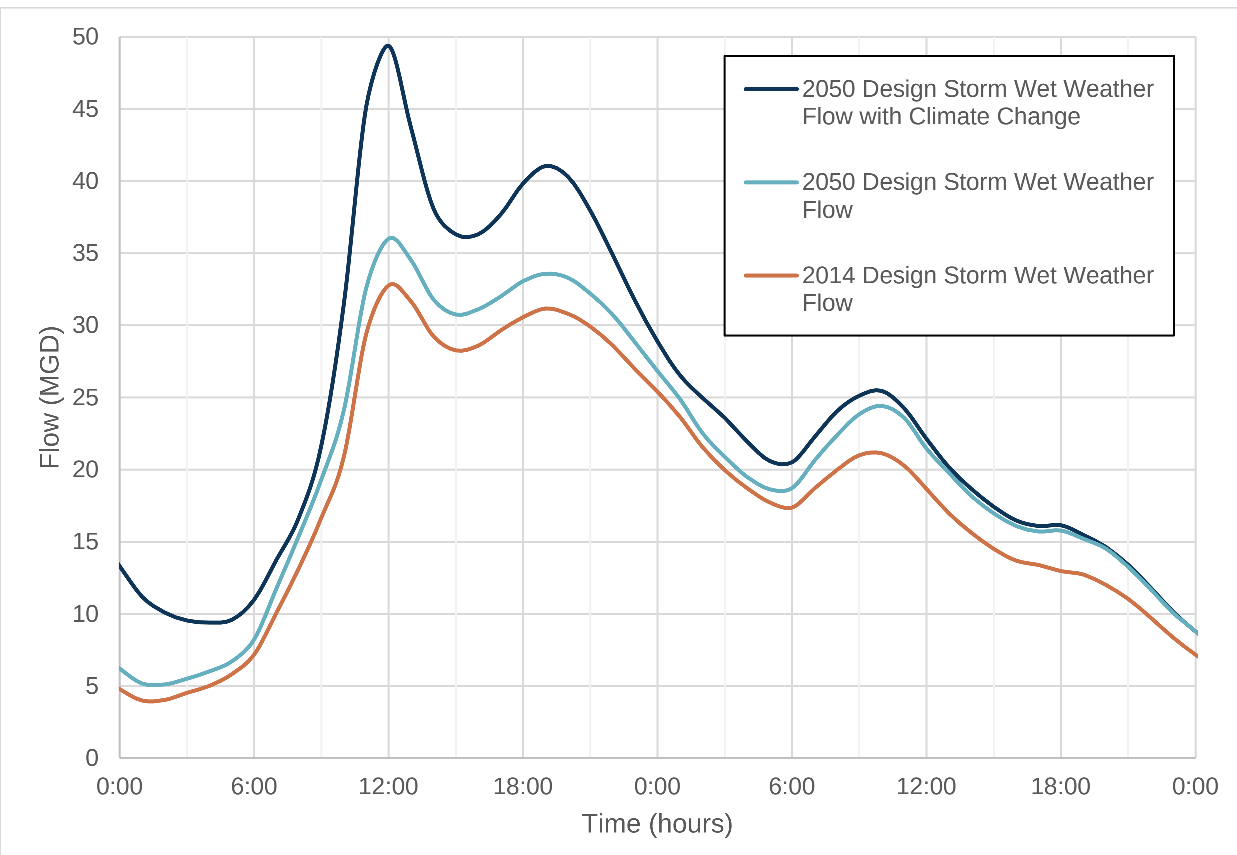


Table 4: Historical and Buildout Wet Weather Flows

Period	Maximum Day (MGD)	Peak Hour (MGD)
Historical Wet Weather Flows		
Historical-yr 24-hr Storm[1]	25.5	32.8
January 9, 2023 Storm[2]	26.8	34.5
Buildout Wet Weather Flows		
Buildout 10-yr 24-hr Storm[1]	27.7	36.0
Buildout 10-yr 24-hr Storm with Climate Change[3]	32.6	49.4

Notes:

1. Influent flows from 2013 Preliminary Design Report design storm; used in the collection system hydraulic model.
2. Actual value is likely higher than reported value due to influent flow throttling upstream of INF-001 metering location during wet weather events.
3. Modeled flows from modeled infiltration and inflow due to higher intensity storms from climate change.

2.3.2 Historical and Projected Loads

While the flow data between flow and load data sources was the same, water quality data in the CIWQS data set differed from the data obtained from the City for the confluent sampling point. The confluent sampling point is located downstream of where solids process return flows are introduced. Based on a mass balance check between the two data sets, the cBOD values of the confluent sample data set are artificially low.

Table 5: Historical cBOD Results

Month-Year	Confluent Composite cBOD (mg/L)			CIWQS INF-001 cBOD (mg/L)
	Average	Min	Max	
Jan-22	235	186	286	407
Feb-22	256	208	288	486
Mar-22	235	194	281	394
Apr-22	244	206	291	428
May-22	205	138	260	642
Jun-22	234	191	304	507
Jul-22	261	201	312	481
Aug-22	284	195	340	415
Sep-22	264	198	329	365
Oct-22	303	136	440	393
Nov-22	289	241	358	309
Dec-22	264	181	488	372

CIWQS data, which excludes solids process return flows, should be more representative of influent water quality. However, when applying a typical cBOD:BOD ratio of 0.65 and BOD:COD ratio of 2.0, BOD and COD values calculated from CIWQS cBOD values would be considered very high strength for a primarily domestic wastewater system (COD of ~1,380 mg/L).

WSC could not identify which data set was accurate, therefore, per capita COD loading values from the Final Preliminary Design Report prepared for the El Estero WWTP Secondary Treatment System Improvements (Brown and Caldwell, 2013) were used to set design criteria for the new WRF. The design values in pounds of COD per day were converted to COD per capita per day based on the 2013 design population of 101,672 (Brown and Caldwell, 2013). The per capita COD loadings were then multiplied by the buildout (2050) sewer service area population of 107,261, and conservatively increased by an additional 20% to account for uncertainty in accuracy of cBOD values that were used to derive COD loading projections.

BOD and TSS values were derived from COD values according to standard conversion factors:

- 2:1 COD:BOD Ratio
- 1:1 TSS:BOD Ratio

TKN and ammonia loading values from the City's confluent composite data set were deemed representative of typical nitrogen loading ranges of domestic wastewater and applied to the analysis. Clarification from the City on potential issues or inaccuracy of the confluent composite data may modify the approach for selecting representative nitrogen loading.

All projected 2050 loadings were obtained from historical loadings using a factor of 1.27 (per Section 2.2.3). Table 6 summarizes projected buildout loadings and concentrations.

Table 6: Projected Buildout Loadings and Concentrations

	Average Annual		Maximum Month	
Parameter	**Projected Loads (lb/d)**	**Projected Concentrations[1] (mg/L)**	**Projected Loads (lb/d)**	**Projected Concentrations[1] (mg/L)**
COD	37,800	582	42,100	446
BOD	18,900	291	21,100	224
TSS	18,900	291	21,100	224
Ammonia (as N)	2,530	40	3,250	35
TKN (as N)	3,160	49	5,050	54

Note:

1. Concentration (mg/L) = Loading (lbs/day) / (Flow * 8.345)

2.3.3 Storage Requirements

The purpose of flow equalization (EQ) is to mitigate transient low and high flows to the treatment process. Storage can equalize the daytime peaks from daily diurnal flow and peak wet weather flows to improve treatment performance and allow for downsizing of treatment processes, respectively. Storage plays an especially important role in climate change adaptation, as increased infiltration and inflow from storm events are anticipated to increase peak influent flows to the WRF.

The El Estero WRC does not have an EQ basin, which has led the City to re-circulate secondary effluent during low flow periods of the day, and to use collection system pipe capacity to store peak wet weather flows. The new WRF would be relocated at a higher elevation and would be fed by pressurized force mains, which cannot be used for temporary storage; therefore, on-site EQ is required for the new WRF.

Selection of EQ volume is a balance between the cost of EQ versus downstream processes, available footprint, and O&M requirements of the EQ basin and the downstream unit processes. Based on historical flows, 1.2 MG of storage would equalize diurnal ADWF to provide a flow equal to or less than ADWF throughout a 24-hour period. ADWF diurnal EQ would need to increase to 1.5 MG to accommodate projected buildout flows.

Storage capacity for wet weather flow storage can be substantially higher depending on the design storm and the WRF capacity. The 10-year, 24-hour design storm, previously developed and included in the City's current collection system model, was used to analyze potential future flows with climate change to identify EQ storage needs. The 10-year, 24-hour hydrograph simulates the amount of rainfall that enters the collection system and becomes wet weather flow that is ultimately treated at El Estero WRC. By using the hydrograph, the expected peak flow at El Estero WRC was identified and used to inform EQ sizing. Based on buildout conditions, the design 10-year, 24-hour storm with climate change (see Table 4 and Figure 1) and the existing El Estero WRC capacity of 36.0 mgd, 2.1 MG of storage is needed to store wet weather flows. In comparison, a new WRF sized for projected maximum day flows of 32.6 mgd would require 3.7 MG of storage.

For this TM, a WRF design flow of 32.6 mgd is assumed along with 3.7 MG of storage. A future analysis should adjust the WRF design flow and storage to optimize lifecycle costs.

2.3.3.1 Wet Weather Bypass

At other California wastewater facilities, Regional Boards have allowed for bypass of a portion of wet weather flows to mitigate the cost burden of increasing capacity of downstream processes. For example, the City of Morro Bay's new membrane bioreactor (MBR) wastewater facility was permitted in 2022 by the Central Coast Regional Water Quality Control Board Order (No. R3-2022-0029). The facility includes a Stormwater Adaptive Filtration Equipment "SAFE" system consisting of rapidly filtered primary effluent for discharge to the ocean during wet weather conditions when MBR capacity is exceeded. During wet weather, ocean discharges consist of mixed MBR effluent and SAFE effluent. This approach is an example of keeping MBR capacity at a reasonable size while partially treating wet weather flows prior to ocean discharge while still meeting permit limits. As the City considers implementation of wastewater system upgrades or improvements as part of their climate adaptation planning, it is recommended the City explore this strategy with the Regional Board. For the purposes of this analysis, bypassing partially untreated wastewater was not considered to provide a conservative basis for process sizing.

3.0 New WRF Facilities

This section defines new facilities including the WRF, collection system infrastructure, land outfall pipeline, and the potable reuse facility.

3.1 Location

For the purposes of this analysis, the new WRF is assumed to be located at the Santa Barbara Golf Course. The site was used to simplify the analysis and was selected based on the Potable Reuse Feasibility Study in 2017 (Carollo, 2017), which assumed potable reuse water would be conveyed to the golf course and then pumped to Lauro Reservoir. **A robust site selection process will be required as part of planning efforts to relocate El Estero WRC.** This was not conducted as part of this study since relocation is expected to be at least 50 to 100 years (2.5 ft of sea level rise to 6.6 ft sea level rise) in the future. The golf course site was selected to facilitate defining a new system concept and enable cost estimating for future planning and decision making.

3.2 Water Reclamation Facility

Preliminary wastewater treatment process selections were made according to treatment objectives, to minimize WRF footprint, and based on current understanding of influent wastewater quality and flows. Design flows are presented in Table 7.

Table 7. New WRF, Design Flows

Item	Values
Average Annual Flow, Buildout	7.8 MGD
Maximum Day Flow, Buildout	32.6 MGD
Peak Hour Flow, Buildout	49.4 MGD
MBR Capacity	32.6 MGD

The selected processes include:

- Liquid Stream
  - Headworks and influent pump station
  - Preliminary treatment
  - Equalization
  - Membrane bioreactor
  - Chlorination and dechlorination
- Solids Stream
  - Gravity thickener
  - Anaerobic digestion
  - Filter press

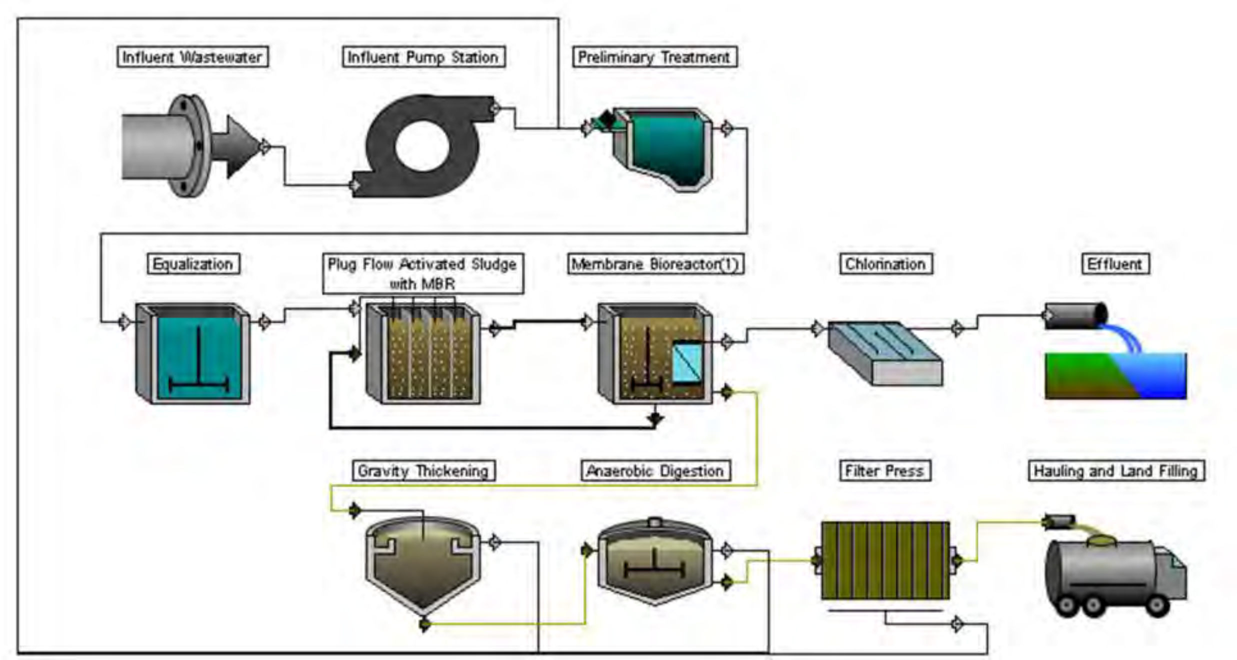
These processes formed the treatment train, shown in Figure 2, were selected in the CapdetWorks software to estimate costs. The inputs into the CapdetWorks model included:

- Influent characteristics, such as flow rates and constituent concentrations
- Unit process selections
- Unit costs and cost indices

The outputs included:

- Design calculations for each unit process using built-in design criteria and algorithms
- Estimated unit process and facility costs

Figure 2: New Facility Treatment Process Train



Note: Redundant processes are not shown.

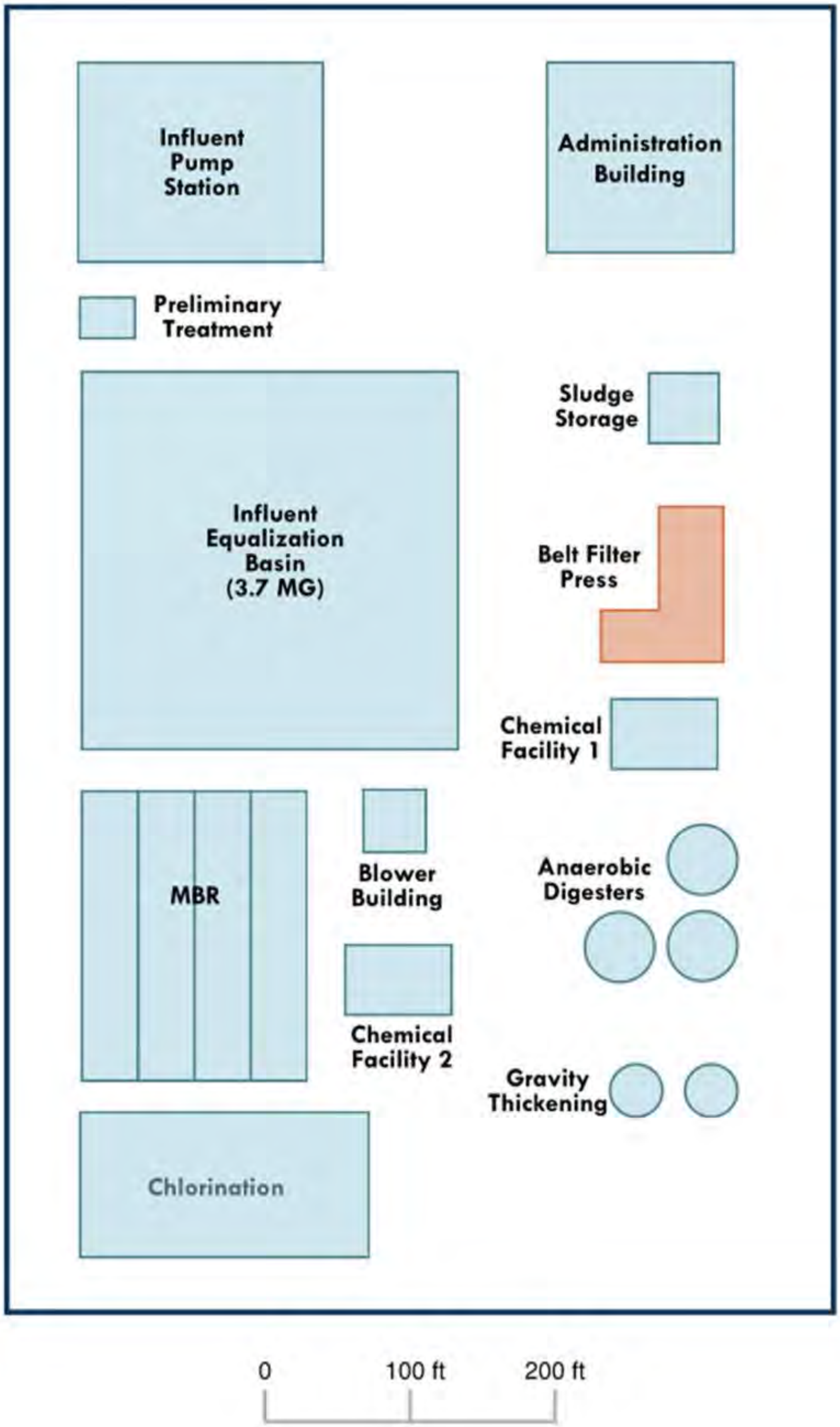
The preliminary capital cost estimate is $557 M (Table 8) with an estimated footprint of 12 acres (Figure 3).

Table 8. New WRF, Cost Estimate

Item	Values
Sitework	$10,000,000
Yard Piping and Fire Service	$12,500,000
Influent Pump Station	$20,000,000
Plug Flow Activated Sludge with MBR	$16,900,000
Gravity Thickening	$2,600,000
Preliminary Treatment	$4,700,000
Membrane Bioreactor	$48,900,000
Anaerobic Digestion	$13,300,000
Chlorination	$16,600,000
Filter Press	$6,700,000
Odor Control	$20,000,000
Equalization Storage (3.7 MG)	$15,600,000
Administration Building	$15,000,000
Collection System Building	$7,500,000
Process Area Subtotal	**$210,000,000**
General Conditions (18%)	$38,000,000
Electrical, Instrumentation & Controls (20%)	$42,000,000
Unaccounted for Costs (20%)	$42,000,000
Raw Construction Subtotal	**$332,000,000**
Construction Contingency (20%)	$66,000,000
Construction Total	**$398,000,000**
Land Acquisition	$--
Implementation / Soft Costs (40%)	$159,000,000
Total Capital Cost	**$557,000,000**

Note: Costs are in 2024 dollars. Cost estimates were developed based on limited information and should be considered an AACE Class 5 estimate (-50%, +100%) for concept screening based on 0% to 2% level of project definition. Land purchase costs are not included.

Figure 3: New WRF Conceptual Site Layout



3.3 Distributed Infrastructure

The new WRF location will require raw wastewater that is currently routed to El Estero WRC to be conveyed to the new WRF location. In addition, the treated effluent must be conveyed back to the ocean outfall via a new land outfall.

3.3.1 Collection System

The existing collection system would continue to flow to El Estero WRC and would be pumped from El Estero WRC to the new WRF location. Gravity flows proximate to the new WRF location or proposed lift stations flows would diverted to the new WRF or lift stations, respectively, prior to El Estero WRC where possible. For the purposes of this TM, the regional lift station is assumed to be located near Castillo St and north of US-101 and the force main is assumed to be located along Castillo Street (Figure 4). Note that the purpose of this TM is to develop order-of-magnitude cost estimates for a new WRF and identify potential future planning considerations that may influence near-term decisions by the City. Therefore, an alignment alternatives analysis was not conducted for this TM.

The lift station and force main would be sized to convey future peak hour flow with climate change, which is roughly 50 mgd, based on **Error! Reference source not found.**. Assuming roughly 5 mgd can be diverted via gravity to the new WRF site (based on the collection system model), the lift station and force main would need to convey roughly 45 mgd. The force main would be roughly 2.8 miles of 54-in diameter pipe. Note that open cut trench construction methods are assumed; although, trenchless methods should be considered during future planning phases to minimize impacts and risks in the generally congested area.

Two lift stations and force mains, shown in Figure 4, would feed the regional lift station: 1) Roughly 25 mgd lift station at El Estero WRC; and 2) Roughly 20 mgd lift station at Pershing Park to capture the flows from the west side that would be conveyed through the West Beach sewer, which would be abandoned by the time a new WRF is needed.

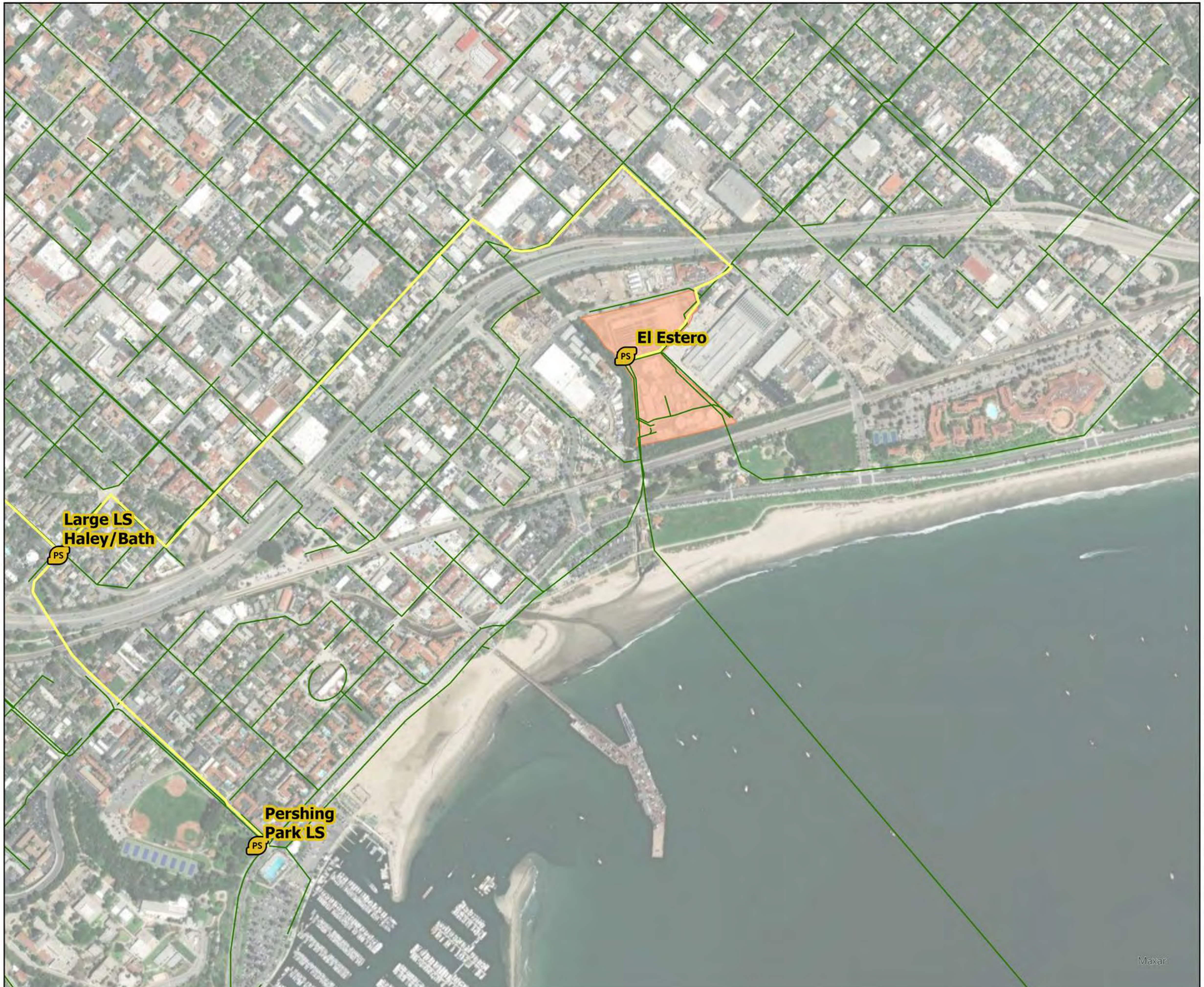
Note that the purpose of this TM is to develop order-of-magnitude cost estimates for a new WRF and identify potential future planning considerations that may influence near-term decisions by the City. Therefore, the lift station and force main systems were not optimized for this TM.

3.3.2 Land Outfall

A new land outfall is needed to convey treated wastewater and concentrate from the potable reuse facility to the existing outfall starting at El Estero WRC. The new land outfall alignment is assumed to parallel the new primary force main to the new WRF along Castillo St (Figure 4). Note that the purpose of this TM is to develop order-of-magnitude cost estimates for a new WRF and identify potential future planning considerations that may influence near-term decisions by the City. Therefore, an alignment alternatives analysis was not conducted for this TM.

Water & Wastewater Climate Adaptation Project

Figure 4. Proposed Lift Stations and Force Mains for El Estero WRC Relocation



Legend

- El Estero WRC
- PS Proposed Lift Station
- Proposed Force Main
- Sewer Main

N

0 0.1 0.2 Miles

0 500 1,000 US Feet

WSC

For the purposes of this TM, the existing outfall is assumed to continue to be used for the new WRF; however, a new ocean outfall may be needed by the time the new WRF is constructed (at least 50- to 100-years in the future) and a new location may be considered in that case.

The land outfall would need to convey up to 32.6 MGD, based on future peak hour flow with climate change of 49.4 MGD with equalization enabling effluent flows to reduce to 32.6 MGD. Peak hour flows are assumed to be equalized through storage and treatment. The land outfall is assumed be 3.8 miles of 54-in diameter pipe based on gravity flow. A 60-in diameter HDPE pipe is assumed to achieve 54-in inner diameter. Similar to the force mains conveying raw wastewater to the new WRF, open cut trench construction methods are assumed for the land outfall; although, trenchless methods should be considered during future planning phases to minimize impacts and risks for developed and congested areas. And similar to the other aspects of this TM, pipeline size was not optimized.

3.3.3 Collection System Cost Estimate

Table 9 presents a high-level cost for the collection system.

Table 9. Collection System to the New WRF, Cost Estimate

Item	Values
EEWRC Equalization Basin	$20,000,000
Lift Stations	$30,000,000
Force Mains	$30,200,000
Land Outfall	$24,000,000
Collection System Construction Subtotal	**$104,000,000**
General Conditions (18%)	$19,000,000
Unaccounted for Costs (20%)	$21,000,000
Raw Construction Subtotal	**$144,000,000**
Construction Contingency (20%)	$58,000,000
Construction Total	**$223,000,000**
Land Acquisition	$--
Implementation / Soft Costs (40%)	$90,000,000
Total Capital Cost	**$313,000,000**

Note: Costs are in 2024 dollars. Cost estimates were developed based on limited information and should be considered an AACE Class 5 estimate (-50%, +100%) for concept screening based on 0% to 2% level of project definition. Land purchase costs are not included.

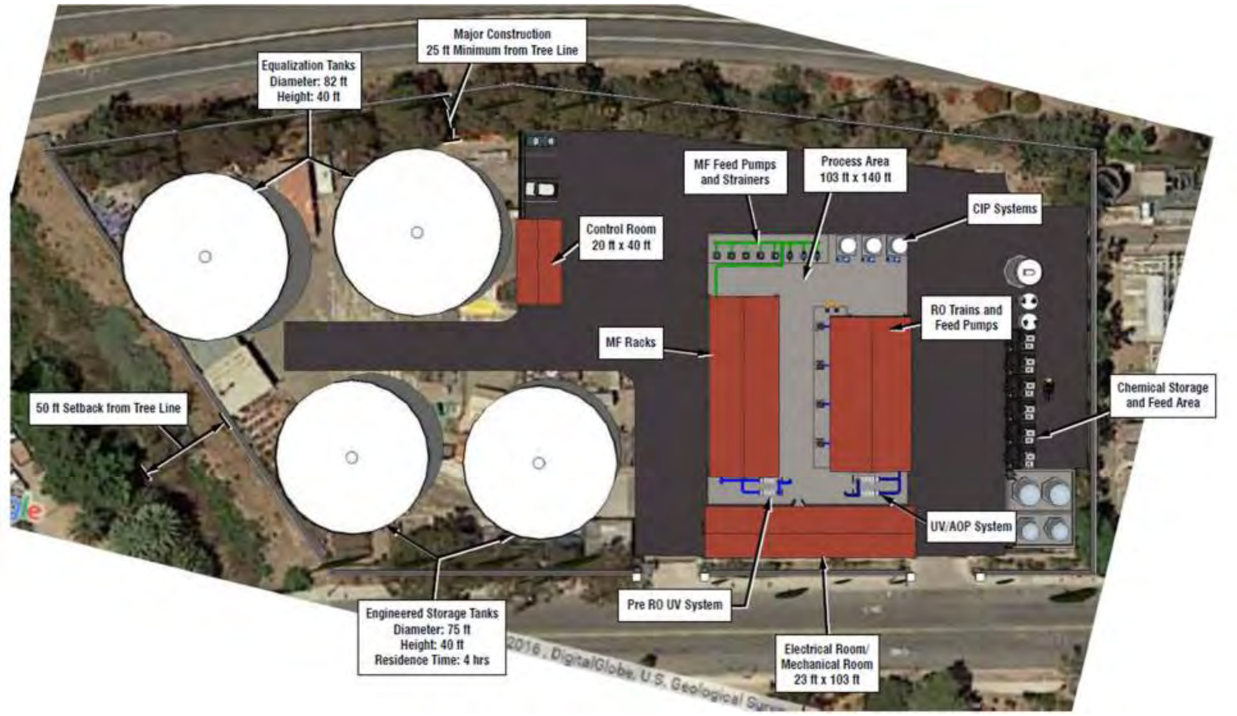
3.4 Potable Reuse Facility

The City completed a Potable Reuse Feasibility Study in 2017 (Carollo, 2017) that evaluated three types of potable reuse: groundwater augmentation, raw water augmentation, and treated drinking water augmentation. For the 2020 Enhanced Urban Water Management Plan (Water Systems Consulting, Inc., 2021), raw water augmentation was selected for incorporation into water portfolios. If El Estero WRC is relocated to an inland location, the Potable Reuse Facility would be consistent with the 2017 study concept with exceptions noted:

- Treatment train consisting of ozone with biological activated carbon (BAC), reverse osmosis, ultraviolet light disinfection, and advanced oxidation process systems. Compared with the 2017 study concept:
  - Ozone/BAC was added based on recent California direct potable reuse regulations.[2]
  - Microfiltration was excluded from the advanced treatment train because it is included in the new WRF membrane bioreactor.
- The footprint is roughly 3 acres based on the original site plan, shown in Figure 5, at the City's Annex Yard.
- Treatment facilities are assumed to be located adjacent to the new WRF. For the purposes of this analysis, the Santa Barbara Golf Course is the assumed location (see Section 3.1 for additional discussion).
- New pump station at the advanced treatment location to convey water to Lauro Reservoir. Compared with the 2017 study concept, the pump station is assumed to be new rather than repurposing the existing recycled water pump station.
- New pipeline from a new pump station to Lauro Reservoir, shown in Figure 6. Compared with the 2017 study concept, pipelines from El Estero WRC to the golf course are not needed.

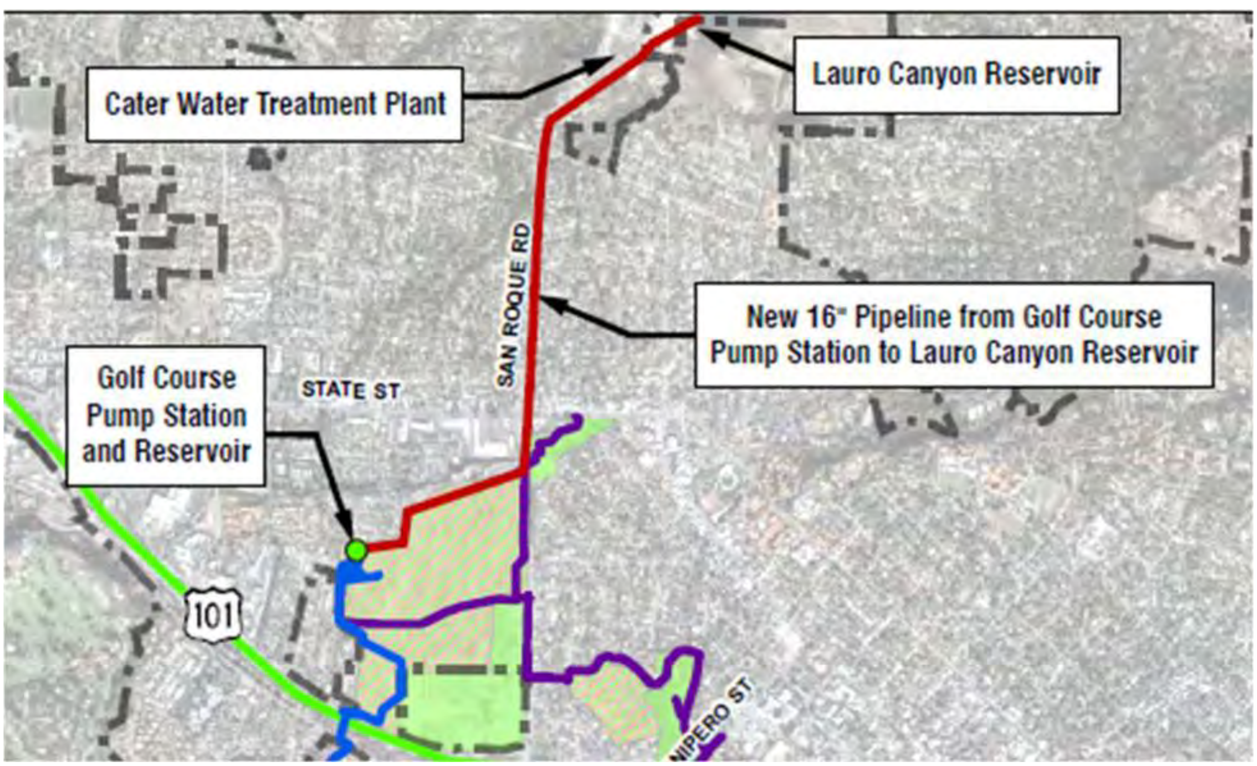
[2] California adopted direct potable reuse regulations in January 2024 that likely alter some assumptions applied in the 2017 feasibility study, such as adding ozone/BAC and reducing storage, but, for the purposes of this analysis, the general footprint is expected to be similar.

Figure 5. Potable Reuse AWTF Site Plan



Source: *Potable Reuse Feasibility Study* (Carollo 2017), Figure 3-31

Figure 6. Proposed Potable Reuse Conveyance System



Source: *Potable Reuse Feasibility Study* (Carollo 2017), Figure 3-26
Note: Red pipeline is proposed for this concept. Blue pipeline (from El Estero WRC) is not needed, and purple pipeline (existing recycled water pipeline) will likely be abandoned.

4.0 Summary

This TM presents a high-level concept for relocation of the existing El Estero WRC inland and out of coastal and fluvial hazard areas, assuming that the vulnerabilities from the hazards could not be managed in a 50- to 100-year period. The concept was developed to support alternatives analysis and long-term planning for the City's wastewater collection and treatment planning. The concept also includes moving the proposed potable reuse project location from the City's Annex Yard to the new WRF location.

As summarized in the tables below, the new WRF and potable reuse project would require roughly 15 acres of land and a new WRC, collection system, and land outfall would cost over $870 million. Note that the cost estimates were developed based on limited information and should be considered an AACE Class 5 estimate (-50%, +100%) for concept screening based on 0% to 2% level of project definition.

Table 10. New WRF and Potable Reuse Project, Footprint

Item	Values
New WRF	~12 Acres
Potable Reuse Facility	~3 Acres
Total	**~15 Acres**

Note: Values are rough estimates and require facility planning to increase the level of accuracy.

Table 11. New WRF and Potable Reuse Project, Capital Cost Estimate

Item	Values
New WRF	$557 M
Collection System & Land Outfall	$313 M
Total Capital Cost	**$870 M**

Note: Costs are in 2024 dollars. Cost estimates were developed based on limited information and should be considered an AACE Class 5 estimate (-50%, +100%) for concept screening based on 0% to 2% level of project definition. Land purchase costs are not included.

4.1 Planning Considerations

Access and flood hazards at El Estero WRC can be managed in the near-term with limited modifications to existing practices while mid-term will require flood protection investments at the site and may require road and site access improvements. Additionally, the City will be launching a wet weather capacity study to identify improvements that can be made to address inflows into the collection system during storms and associated capacity issues.

In the mid-term, the City will need to consider whether to relocate El Estero WRC in the long-term given the costs required to address safe, reliable access during recurrent flooding and protect the site from extreme flooding at high amounts of sea level rise. That decision will be part of future updates to the Wastewater Adaptation Plan that will benefit from many more years of monitoring and additional information on how climate changes are affecting the region and possible adaptation options. Any relocation study would involve close coordination with regional partners to explore opportunities for shared facilities and to identify potential sites of sufficient size across the region. Among properties currently owned by the City, the municipal golf course on Las Positas is large enough to accommodate a new wastewater treatment plant if needed.

Appendix D List of Recommended Projects and Actions

D

#	Project Timing	Project Priority	Project Name	Impacted Infrastructure	Hazard Mitigated
1	0 - Immediate	High	Collection System (incl. West Beach) - Seal Manholes	Collection System	Flood
2	0 - Immediate	High	El Estero WRC Flood Protection Study	El Estero WRC	Flood
3	0 - Immediate	High	Mission Lagoon Berm Management	All - Flooding from Rain Storm	Flood
4	0 - Immediate	High	Low-Pressure Sewer Conversion Study	Collection System	Flood
5	0 - Immediate	High	Stormwater and Flood Analysis Report	Collection System / El Estero WRC	Flood
6	0 - Immediate	High	Wastewater System Capacity Study	Collection System / El Estero WRC	Flood
7	1 - Near-term	High	Desalination Intake Weir Box Adaptation	Desalination Intake	Flood
8	1 - Near-term	High	El Estero WRC Flood Access Preparation Improvements (Near-Term)	El Estero WRC	Flood
9	1 - Near-term	High	El Estero WRC Flood Protection Measures (0.8 ft SLR)	El Estero WRC	Flood
10	1 - Near-term	High	Laguna Tide Gate Improvements	All - Rain Event Flooding	Flood
11	1 - Near-term	High	Low-Pressure Service Conversions for Low-Lying Properties	Collection System	Flood
12	1 - Near-term	High	Wastewater System Capacity Improvements (Near-Term)	Collection System / El Estero WRC	Flood
13	1 - Near-term	Med	Annex Yard Flood Protection (0.8 ft SLR)	Recycled Water	Flood
14	1 - Near-term	Med	Desalination Plant Flood Protection Measures (0.8 ft SLR)	Desalination Plant/PSCA	Flood
15	1 - Near-term	Med	Desalination PSCA Flood Protection Measures (0.8 ft SLR)	Desalination Plant/PSCA	Flood
16	1 - Near-term	Low-Med	Recycled Water Pump Station Flood Protection Measures (0.8 ft SLR)	Recycled Water	Flood
17	1 - Near-term	Low	El Estero Outfall Manhole Relocation	El Estero Outfall	Erosion
18	2 - Mid-term	High	Cabrillo Blvd Utilities Protection	All Utilites	Erosion
19	2 - Mid-term	High	El Estero WRC Flood Access Improvements (Mid-Term)	El Estero WRC	Flood
20	2 - Mid-term	High	El Estero WRC Flood Protection Measures (2.5 ft SLR)	El Estero WRC	Flood
21	2 - Mid-term	High	Low-Pressure Conversions for Low-Lying Sewers	Collection System	Flood
22	2 - Mid-term	High	Potable Pipeline Relocation (Chase Palm Park)	Water Distribution	Erosion
23	2 - Mid-term	High	Wastewater System Capacity Improvements (Mid-Term)	Collection System / El Estero WRC	Flood
24	2 - Mid-term	Med	Annex Yard Flood Protection (2.5 ft SLR)	Recycled Water	Flood
25	2 - Mid-term	Med	Desalination Plant Flood Protection Measures (2.5 ft SLR)	Desalination Plant/PSCA	Flood
26	2 - Mid-term	Med	Desalination PSCA Flood Protection Measures (2.5 ft SLR)	Desalination Plant/PSCA	Flood
27	2 - Mid-term	Med	Desalination System Intake Pipeline Replacement	Desalination Intake	Erosion
28	2 - Mid-term	Low-Med	Recycled Water Pump Station Flood Protection Measures (2.5 ft SLR)	Recycled Water	Flood
29	2 - Mid-term	Low	Recycled Water Pipeline Relocation (Chase Palm Park)	Recycled Water	Flood