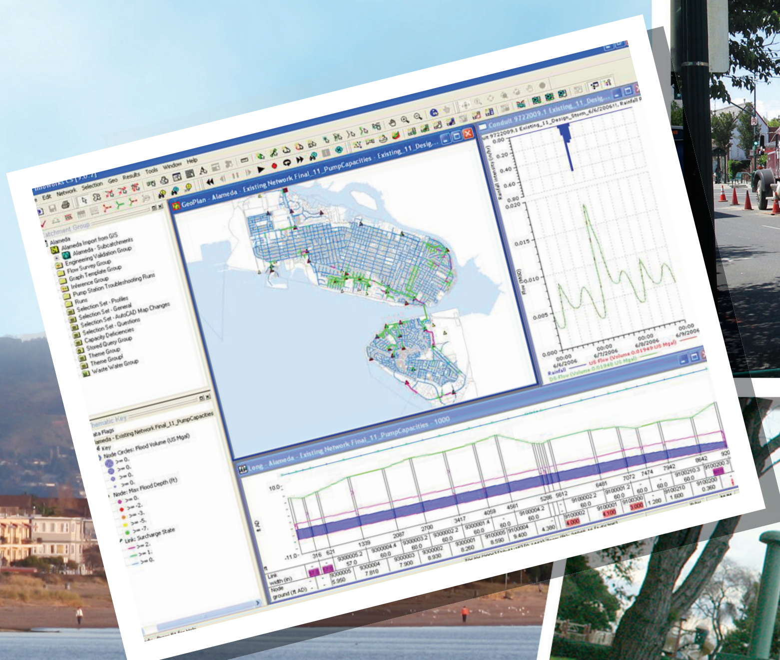
Chapter One
Introduction



Chapter 1 Introduction

This report presents the results and recommendations of the Sewer Master Plan for the City of Alameda (City). The report was prepared by RMC Water and Environment (RMC) under an agreement with the City dated August 26, 2014. This introductory chapter provides background information on the City's sewer system and service area, discusses the objectives and scope of the Master Plan, and describes the contents and organization of the Master Plan report.

1.1 Study Area

The study area for this Master Plan, shown in **Figure 1-1**, consists of the City of Alameda. The City has a population of about 76,000. The main portion of the City comprises the island of Alameda, which is located west of the City of Oakland and is separated from Oakland by the Oakland Inner Harbor (Oakland Estuary). The remaining portion of the City is located on Harbor Bay Isle (formerly known as Bay Farm Island), located immediately to the north of and adjacent to the Oakland International Airport. (Note: Harbor Bay Isle is technically not an island but is connected to the mainland south of the airport.) The northwestern end of the main Alameda island comprises the former Alameda Naval Air Station (NAS), now known as Alameda Point. Alameda is connected to Oakland via two underground tubes at Webster Street and three bridges on the southern end of the main island, and the main island is also connected to Harbor Bay Isle via bridge.

Alameda is largely residential in nature with major commercial areas located along Webster and Park Streets and the Town Center (South Shore) shopping center on Otis Drive. The College of Alameda is located adjacent to the intersection of Webster Street and Ralph Appezzato Memorial Parkway. Older industrial areas, now being planned for redevelopment, are located along the northern and eastern waterfront. Significant recent and ongoing residential and retail development has occurred in the area of the former Fleet Industrial Supply Center, now known as Alameda Landing, and major redevelopment of Alameda Point is in the planning stage.

1.2 Existing Sewer System

The City's sanitary sewer system, shown in **Figure 1-2**, includes approximately 140 miles of City-owned sanitary sewers (including 6 miles of force mains), approximately 3,000 manholes and other sewer structures, and 42 sewage pump stations. Approximately 125 miles of the total system pipeline length and 33 pump stations are located on the main part of the Alameda island and Harbor Bay Isle, and approximately 14 miles of pipeline and 9 pump stations are located in the City-owned portion of Alameda Point. A large portion of Alameda Point was formally transferred to City ownership in 2013, including the collection system and building laterals. The remainder (including an additional 3 miles of sewers) will be transferred at a later date after cleanup operations are completed; however, the City maintains the entire Alameda Point collection system under a contract with the U.S. Navy.

There are over 10 miles of pipelines and seven pump stations located in Alameda that are part of the East Bay Municipal Utility District (EBMUD) wastewater interceptor system, as well as over 14 miles of privately-owned sanitary sewers that are the responsibility of individual Homeowner Associations (HOAs). Most of these private sewers are located on Harbor Bay Isle or in the Bayport development located east of Alameda Point between Willie Stargell Avenue and Ralph Appezzato Memorial Parkway. The U.S. government owns and is responsible for the sanitary sewer system serving the Coast Guard Housing area located north of Bayport.

Wastewater generated in the City's collection system is discharged into EBMUD interceptor pipelines in Alameda and then conveyed through three inverted siphons that connect to EBMUD's South Interceptor in

Oakland. The wastewater is treated at EBMUD's Main Wastewater Treatment Plant (MWWTP) located near the eastern terminus of the San Francisco-Oakland Bay Bridge. EBMUD also receives flows from six other "Satellite" collection system agencies: the cities of Albany, Berkeley, Emeryville, Oakland, and Piedmont, and the Stege Sanitary District.

The City's sewer system is divided into 25 sewer drainage basins, which are grouped into "Interceptor Tributary Areas" (ITAs) defined primarily by their connection points to the EBMUD interceptor. The sewer basins and ITAs are shown in **Figure 1-3.**

Over 75 percent of Alameda's gravity sewer system consists of 8-inch and smaller diameter pipe, and over 90 percent is 12 inches and smaller. **Table 1-1** tabulates the footage of City-owned gravity sewers (not including Alameda Point) by diameter. System force mains range in size from 4 to 16 inches in diameter.

Table 1-1: Gravity Sewer System Inventory

Pipe Size (in.)	Length (feet)	Length (miles)	Percent of Total
Unknown	3,032	0.6	0.5%
<8	212,363	40.2	32.6%
8	288,736	54.7	44.4%
10	57,461	10.9	8.8%
12	28,212	5.3	4.3%
14-16	32,705	6.2	5.0%
18-21	23,353	4.4	3.6%
24-30	4,646	0.9	0.7%
Total*	**650,508**	**123.2**	**100.0%**

* Not including Alameda Point. Total includes about 3 miles of lower laterals that are included in the City's sewer GIS.

The oldest portions of the sewer system date to the early 1900s; however, over 30 percent of the system has been rehabilitated or replaced in the past 30 years. Most older sewers are constructed of clay pipe materials including vitrified clay pipe (VCP), terra cotta, and clay tile, with plastic materials, primarily polyvinyl chloride (PVC) and high-density polyethylene (HDPE) used for newer sewer construction and rehabilitation.

The sewer system also includes approximately 19,000 private sewer laterals. In Alameda, the property owner is responsible for maintenance and repair of the entire service lateral from the building drain to the connection to the City's sewer main. However, the City takes responsibility for replacement of the lower portion of the lateral (within the public right-of-way) when the public sewer main to which it is connected is rehabilitated or replaced, or if the lower lateral fails, whichever occurs first.

Sources: ESRI Basemap

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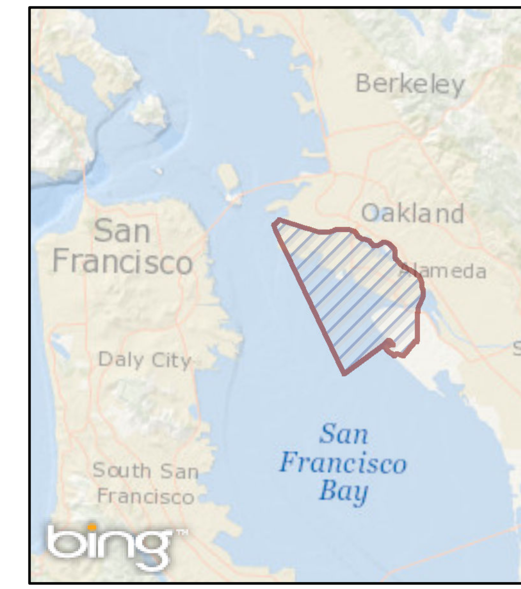
Legend

Alameda City Limit



City of Alameda
Sewer Master Plan

Figure 1-1
Study Area

RMC water and environment

Legend

Gravity Sewers

- ≤ 8"
- 10" - 15"
- > 15"
- Private Sewers
- Force Mains
- EBMUD Interceptor
- Alameda Pump Stations
- EBMUD Pump Stations
- Alameda City Limit

City of Alameda
Sewer Master Plan

Figure 1-2a
Existing Sewer System
(Alameda Island)

RMC water and environment

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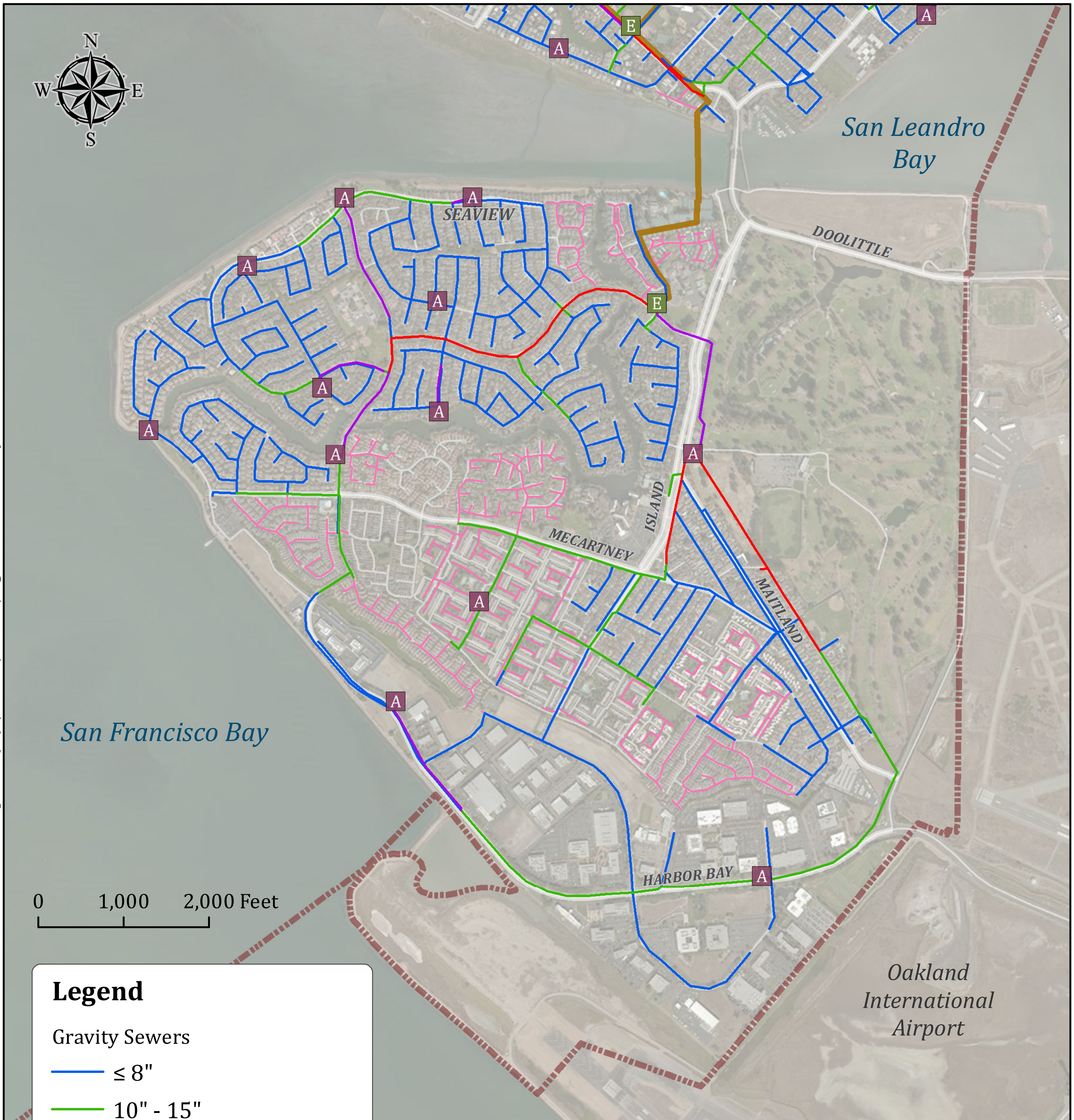
Sources: ESRI Basemap



City of Alameda
Sewer Master Plan

Figure 1-2b
Existing Sewer System
(Harbor Bay Isle)

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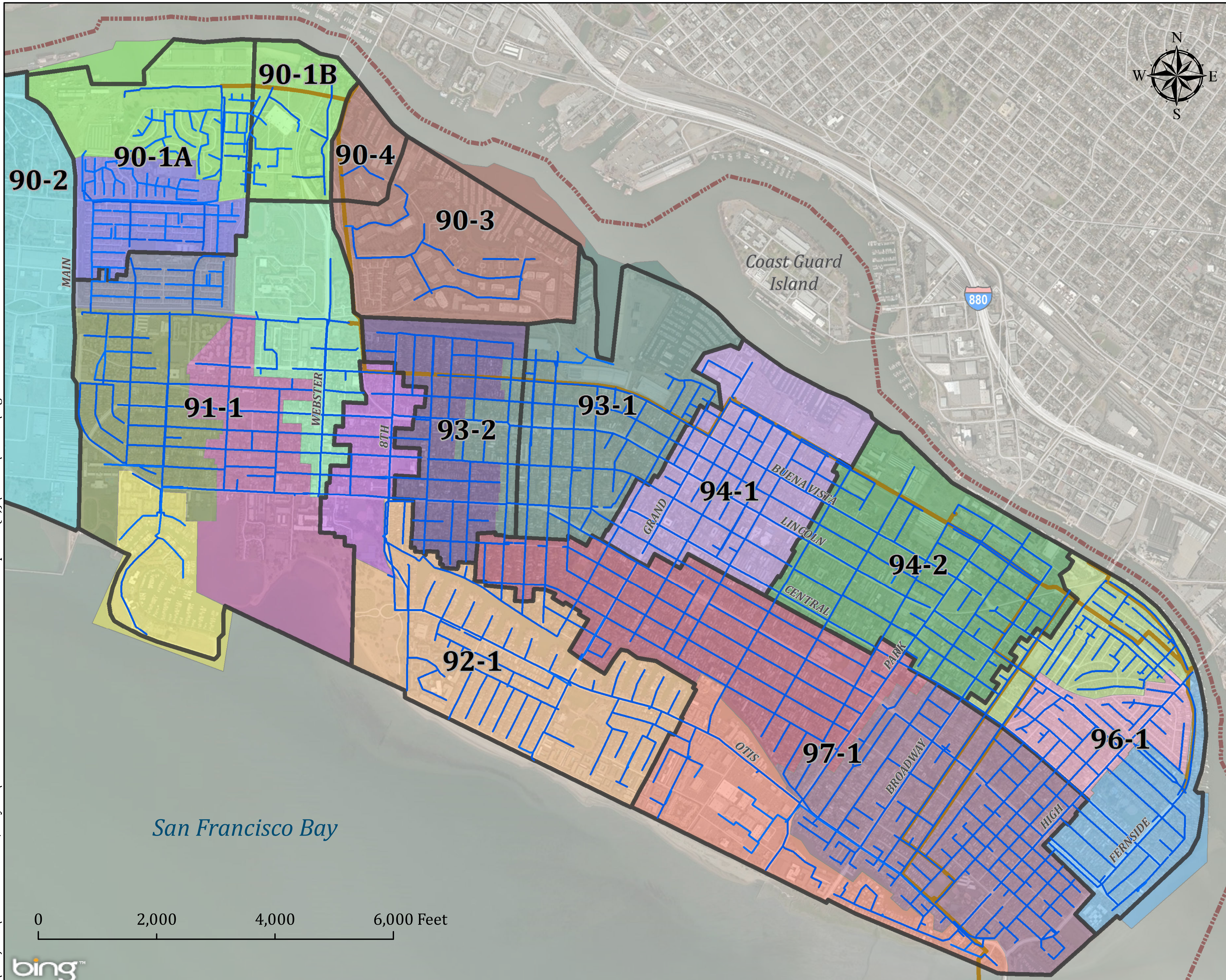
Sources: ESRI Basemap



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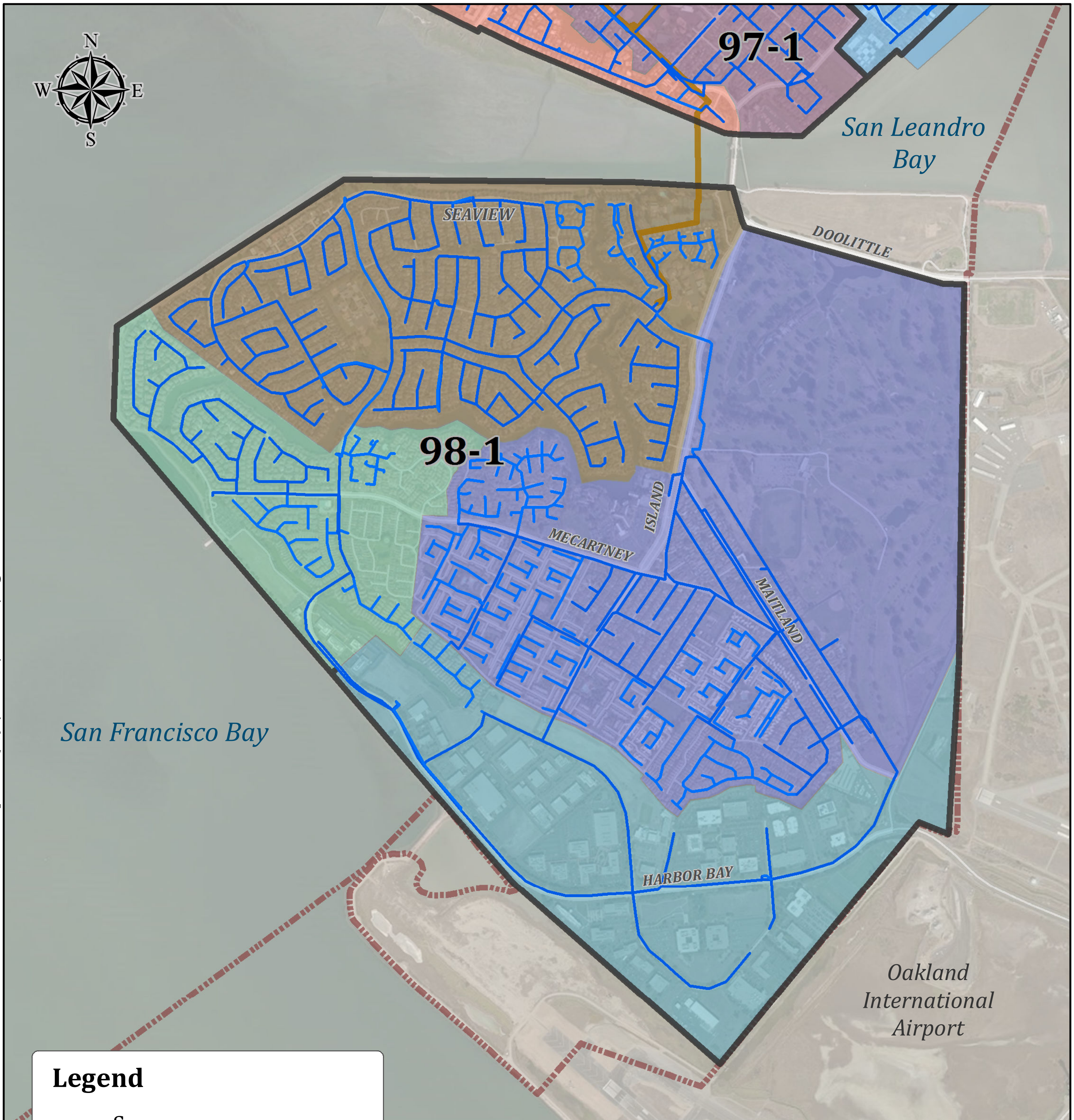
Sources: ESRI Basemap

City of Alameda
Sewer Master Plan

Figure 1-3a
Sewer Basins and Interceptor Tributary Area (Alameda Island)

RMC water and environment



Legend

- Sewers
- EBMUD Interceptor
- Alameda ITAs & ID
- Alameda Basins (typical)
- Alameda City Limit

0 1,000 2,000 Feet

City of Alameda
Sewer Master Plan

Figure 1-3b
Sewer Basins and Interceptor Tributary Areas (Harbor Bay Isle)

Sources: ESRI Basemap

J:\Projects\0232 Alameda, City of\0232-013 Alameda Sewer MP Model Update (SJ)\G. GIS\MXDs\Fig1-3b SewerBasins.mxd

1.3 Background

The last comprehensive evaluation of the City's sanitary sewer system was conducted in the early 1980s as part of the region-wide East Bay Infiltration/Inflow Study, which included all of the seven satellite collection system agencies that are tributary to the EBMUD system. Each agency prepared its own evaluation, called a Sewer System Evaluation Study (SSES). The studies, completed in 1986, resulted in a long-term plan to upgrade the sewer systems and reduce infiltration and inflow (I/I). At the same time, EBMUD completed a Wet Weather Facilities Plan which identified the need for construction of several wet weather facilities (WWFs) to handle flows that could not be conveyed to its MWWTP during wet weather periods. Three WWFs (Oakport and San Antonio Creek in Oakland serving the southern portion of the EBMUD wastewater service area, and Point Isabel in El Cerrito serving the northern portion of the system) were constructed and went into operation in the 1990s. The WWFs provided storage and/or primary-level treatment and disinfection for wastewater discharged during wet weather periods. At the time, the Satellite sewer capacity improvement projects and rehabilitation programs, combined with EBMUD's WWFs and MWWTP improvements, were considered the most cost-effective solution to the region-wide wet weather issues.

In the period since completion of the SSES, Alameda has eliminated known cross-connections between the sanitary and storm drain systems, constructed relief sewer improvements to provide needed system capacity as identified in the SSES, and rehabilitated or replaced over 30 percent of the sewers in the system (including associated lower laterals). In the late 1980s, the City was also the first of the Satellites to adopt a sewer lateral ordinance requiring the inspection and repair or replacement of private (upper) laterals at sale or transfer of property or major remodel, which has resulted in the rehabilitation or replacement of approximately 6,000 laterals city-wide since that time (the City has since joined the EBMUD Regional Private Sewer Lateral program). Improvements in sewer system management tools and practices have also been implemented, including development of a system inventory and mapping system in a geographic information system (GIS) format; implementation of a new computerized maintenance management system (CMMS) to schedule and document maintenance activities; and closed-circuit television (CCTV) inspection program with capture and storage of data in digital format for use in system condition assessment.

Since 2004, the City has also been required to monitor and electronically report occurrences of sanitary sewer overflows (SSOs), initially to the San Francisco Bay Regional Water Quality Control Board (RWQCB or Regional Board), and later (since 2007) to the State Water Resources Control Board (SWRCB) under the Statewide General Waste Discharge Requirements (GWDR) for Sanitary Sewer Systems adopted in 2006. Under these regulations, the City is also required to prepare and adopt a Sewer System Management Plan (SSMP), including plans and programs for addressing the operation and maintenance of the system and assessing and upgrading its condition and capacity; and to audit and update its SSMP regularly.

Since the late 1970s, the City has operated its wastewater collection system under a National Pollutant Discharge Elimination System (NPDES) permit from the Regional Board, which was last renewed in 2014. In 1986, the Regional Board issued a Cease and Desist Order (CDO) to all of the EBMUD Satellites (re-issued in 1993), which required the Satellites to eliminate wet weather overflows from their collection systems by implementing the improvements proposed in the SSES studies (the 1993 CDO extended the period for compliance from the original plan). Based on completion of the required projects, the 1993 CDO was rescinded in 2011 for all of the Satellites except Oakland.

EBMUD also received an NPDES permit for operation of the WWFs constructed based on the 1980s wet weather studies. However, in 2007 the SWRCB remanded the permit based on a ruling by the U.S. Environmental Protection Agency (EPA) that the WWFs, by not providing full secondary treatment prior to discharge, were operating in violation of the Clean Water Act. This decision triggered the issuance of a CDO to EBMUD requiring it to eliminate discharges from its WWFs, and subsequent compliance orders to both EBMUD and the Satellite agencies.

The first of the orders issued to the Satellites was a Findings of Violation and Order for Compliance, or Administrative Order (AO), issued to each of the Satellites in November 2009. The AO required the agencies to develop and implement programs necessary to reduce SSOs and further reduce I/I which causes or contributes to discharges from EBMUD's WWFs. For Alameda, the requirements of the AO included development of an Asset Management Implementation Plan (AMIP); a Private Sewer Lateral (PSL) Inspection and Repair/Replacement Program; Flow Monitoring and I/I Assessment Plan; Inflow Identification and Elimination Plan; Pump Station Improvement Plan; and a Sewer Cleaning and Inspection Program. The requirements of the AO were converted to a Stipulated Order for Preliminary Relief (SO) in September 2011.

Since 2009, Alameda has prepared the plans and reports and implemented the programs required under the AO and SO. In 2010, the City also completed a *Sanitary Sewer System Hydraulic Analysis*[1], including development of a hydraulic model to evaluate system capacity and identify any needed sewer capacity improvements, and a *Sanitary Sewer Pump Station Assessment Report*[2] to identify needed structural and reliability improvements to the City's sewer pump stations. To address the capital demands of its aging sewer system, the City also completed a sewer rate study[3] in 2010 and adopted a 14 percent annual increase to its sewer service charge for a three-year period.

In 2013, EBMUD and the seven Satellite agencies entered into negotiations with the EPA, SWRCB, and RWQCB (Plantiffs) and two non-governmental organizations, San Francisco Baykeeper and Our Children's Earth Foundation (Intervenor Plantiffs), on a Consent Decree (CD) intended to eliminate discharges from the WWFs over an approximate 20-year period through programs designed to reduce I/I in the Satellite collection systems, as initiated under the AO and SO. The Consent Decree incorporates the requirements of the Satellite and EBMUD SOs, as well as a program to accelerate the identification and elimination of inflow and "rapid infiltration" sources, and processes for documenting compliance toward reducing WWF discharges and eliminating them by the required compliance dates. The CD also imposes monetary penalties for non-compliance with any of the requirements. For the Satellites, including Alameda, the CD-required "Work" includes specified annual amounts of sewer rehabilitation, inspection, and cleaning; as well as continued implementation of PSL compliance and inflow elimination programs; and, for Alameda, the pump station renovation plan. The CD became final in September 2014.

In October 2014, the City updated its sewer rate study[4] to reflect the requirements of the CD, and adopted a sewer service charge increase of 3 percent per year for the next five years effective fiscal year 15/16.

Note that whereas the Alameda Point portion of the City's sewer system is not specifically covered by the Work requirements of the CD (other than for repair of "acute" defects and "hot spot" cleaning of areas with a history or at risk for SSOs), the CD does state that the City must require rehabilitation of existing sewer mains and laterals in Alameda Point as a condition of approving building permits for any property that is developed, redeveloped or re-used. Accordingly, the City's Master Infrastructure Plan (MIP) for Alameda Point provides for rehabilitation and replacement of the sewer infrastructure as part of redevelopment of the former base.

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[1] City of Alameda Sanitary Sewer System Hydraulic Analysis, Final Report, RMC Water and Environment, May 2010.

[2] Alameda Sanitary Sewer Pump Station Assessment Report, Schaaf & Wheeler, June 2010.

[3] City of Alameda Sewer Rate Study, Red Oak Consulting, May 2010.

[4] City of Alameda Sewer Rate Study, Bartle Wells Associates, October 2014.

1.4 Study Objectives

The primary objectives of the Sewer Master Plan are to:

- Confirm that the system has adequate capacity to handle peak wet weather flows, as required for the System Evaluation and Capacity Assurance Plan element of the SSMP.
- Satisfy the Rehabilitation and Replacement Plan requirements of the SSMP, AMIP, and CD.
- Establish a firm basis for project priorities and budgets in the City's 20-year Capital Improvement Program.

These objectives, and the basis of planning for the Master Plan, are discussed in more detail in Section 2 of this report.

1.5 Scope of Study

The scope of the Master Plan, as well as a brief discussion of work conducted under each task, is described below.

- **Task 1 – Confirm Basis of Planning, Asset Management Framework, and Coordination with Other Sewer Plans.** This task included a kickoff meeting with City staff to discuss the regulatory and legal requirements that impact the City's sewer system, the City's current and desired levels of service, and how the City is currently managing its assets and setting priorities for system improvements. The purpose of this task was to confirm the basis of planning for the Sewer Master Plan and ensure consistency with other plans, programs, and regulatory mandates.
- **Task 2 – Update Hydraulic Model.** In this task, the hydraulic model of the City's sewer system originally developed in the 2010 study was updated based on the City's latest GIS mapping, pump station information, and existing and projected future land use data. The model calibration for dry and wet weather conditions was confirmed using flow monitoring data collected previously by the City and EBMUD. The model was then used to determine sewer system capacity requirements and identify any potential capacity deficiencies under peak wet weather flow conditions, defined based on a design storm and system performance criteria.
- **Task 3 – Develop and Implement a Risk Model for Prioritizing Sewers for Rehabilitation and Replacement.** This task involved developing a recommended program for sewer rehabilitation and replacement (R/R) through use of a "Pipe Rating Model" that assigns risk scores to pipes based on their likelihood and consequences of failure. The Pipe Rating Model was developed under a separate contract with the City, utilizing the City's GIS and CCTV inspection data.
- **Task 4 – Develop Capital Improvement Program.** Based on the results of Tasks 2 and 3 and the City's Pump Station Renovation Plan, a 20-year CIP was developed for recommended capacity improvements, pump station improvements, and sewer R/R. The estimated cost of the proposed CIP was compared to the City's current and required sewer replacement rate and associated annual budgets.
- **Task 5 – Prepare Sewer Master Plan Report.** This report was prepared to present the results and recommendations of the study.
- **Task 6 – Project Management and Coordination.** Periodic progress meetings and teleconferences were held with City staff to review project status and discuss project issues, and monthly status reports were prepared to document the work completed.

1.6 Report Organization

The contents of each of the chapters and appendices of this Master Plan report are described below.

Executive Summary

The Executive Summary provides a brief, stand-alone summary of the Master Plan report, with emphasis on the major findings and recommendations.

Chapter 1- Introduction

This introductory chapter provides a description of the City's sewer system and service area, background on previous studies and regulatory history and current situation, the objectives and scope of the Master Plan, and the contents and organization of this report.

Chapter 2 – Basis of Planning

This chapter discusses the basis for the Master Plan in the context of regulatory and legal requirements, industry best practices, and the City's desired level of service to its customers. The chapter describes the methodology and criteria utilized for the City's Pipe Rating Model, which was used to help set priorities for sewer rehabilitation and replacement in the Master Plan CIP.

Chapter 3 – Capacity Assessment

This chapter describes the update of the sewer system hydraulic model, basis for estimating model flows, and the calibration of the model for dry and wet weather conditions. This chapter also defines the basis for the capacity assessment of the system, including the design rainfall event and performance criteria; describes the identified capacity deficiencies based on the model results; and presents the needed capacity improvements. A discussion of the planned system improvements in Alameda Point designed to provide adequate conveyance capacity for future flows is also included in this chapter of the report.

Chapter 4 – Condition Assessment

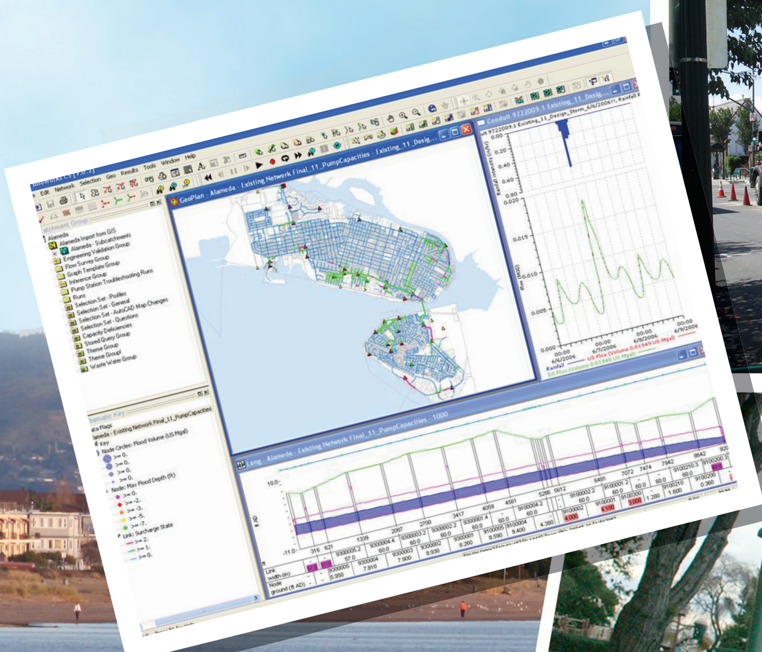
This chapter describes the City's CCTV inspection program and summarizes the condition assessment of the system based on inspection data collected by the City over the past six years.

Chapter 5 – Recommended Capital Improvement Program

This chapter presents the sewer projects that are recommended for inclusion in the City's 20-year CIP based on the results of the capacity and condition assessments and application of the Pipe Rating Model, and the City's pump station renovation plan. The CIP includes a recommended schedule for project implementation and associated capital costs that will form the basis for updates, if needed, to the City's financial plan for the sewer system. Recommendations for project implementation are also provided.

The appendices to the report provide additional detailed information to support the findings and recommendations presented in the report chapters, including selected model hydraulic profiles and detailed tabulation of pipe inventory data and pipe rating model scores.

Chapter Two
Basis of Planning



Chapter 2 Basis of Planning

The overall purpose of this Sewer Master Plan is to establish the basis for the City's Capital Improvement Program (CIP) for its sanitary sewer system for the next twenty years. The Master Plan supports the City's goals for the management and operation of its sanitary sewer system, which include:

- Compliance with applicable State and federal regulations, including the City's NPDES permit and the Statewide GWDR, as well as with the legal requirements of the Consent Decree with the EPA, SWRCB and RWQCB.
- Customer service, such that no capacity-related SSOs occur for storm conditions that do not exceed the City's design event; and such that SSOs and backups caused by sewer blockages are minimized to the greatest extent possible.
- Replacement of sewer assets in a manner that minimizes asset failures and reduces the amount of infiltration and inflow that enters the City's sewer system and the EBMUD interceptor.

The programs implemented by the City to achieve these goals are described in several documents, including the City's Sewer System Management Plan (SSMP) and Asset Management Implementation Plan (AMIP). The programs include on-going maintenance of the sewer system, periodic inspection of sewer assets, investigation of I/I sources, and repair, rehabilitation and replacement of sewer pipes, manholes, and pump stations.

The City's Work section of the Consent Decree specifically requires a minimum amount of sewer rehabilitation (and associated manholes and lower laterals) throughout the duration of the Consent Decree. The required amount of sewer rehabilitation has been established as 13,728 feet (2.6 miles) of mainline sewers annually (on a cumulative basis) through the December 31, 2035.

This Sewer Master Plan utilizes the information that the City has collected through its maintenance, inspection, and monitoring activities to perform an assessment of system condition and capacity; and utilizes the results of those assessments to identify and prioritize sewer system capital improvement needs. This chapter describes the data and tools that support the Sewer Master Plan efforts and the methodology for utilizing that data to develop priorities for sewer rehabilitation and replacement.

2.1 Existing Data and Tools

The City has developed a significant amount of data and tools to support its sewer system management activities. These include:

- ESRI ArcGIS, a geographic information system (GIS) that generates sewer system mapping and contains attribute information on City-owned manholes and pipes in the collection system, including pipe diameters, rim and invert elevations, pipe material, and year of construction or rehabilitation. (Note: Populating this data is an ongoing process, and data are continually updated as new information is obtained from CCTV inspections, maintenance activities, and design surveys.) The GIS is used in conjunction with EMS Webmap Viewer, a web-based tool that allows City staff to view GIS data and maps.
- Granite XP, a closed-circuit television (CCTV) inspection program and database with associated videos and image files for sewer main CCTV inspections conducted since 2009.
- A customized Pipe Rating Model, developed as part of this Sewer Master Plan, which assigns a risk score to each pipe based on likelihood and consequence of failure factors and provides a

means of prioritizing pipes for rehabilitation and replacement. The Pipe Rating Model, described below, was the key tool used for project prioritization for this Sewer Master Plan.

In addition, the City is in the process of implementing Lucity, a computerized maintenance management system (CMMS), which links to the GIS and will contain maintenance and inspection schedules and history (e.g., cleaning results, SSO and blockage records, rehabilitation work, etc.) for all City-owned sewer system assets.

2.2 Pipe Rating Model

The methodology embodied in the Pipe Rating Model is based on guidelines recommended by the National Association of Clean Water Agencies (NACWA).[5] The methodology involves quantifying and assessing the risks posed by the failure or inability of the sewer system to provide the level of service needed to meet the City's sewer system management goals. Using this approach, risk scores can be calculated for each sewer pipe individually. Individual pipe scores can be then be used to prioritize and group pipes into sewer rehabilitation and replacement projects.

The risk of asset failure is calculated by quantifying the likelihood of failure (LOF) and the consequence of failure (COF) of a sewer asset. The likelihood of failure is the possibility of asset failure and is synonymous with the "probability" of failure. The consequence of failure is defined as the impact on level of service resulting from asset failure. The risk equation is defined as follows:

$$\text{Risk} = [(\text{Likelihood}) \times (\text{Consequence})]$$

2.2.1 Likelihood of Failure Categories

Four indicators of likelihood of failure were utilized in the Pipe Rating Model:

- Structural Condition: Structural condition was determined based CCTV inspection results, as stored in the Granite XP database. If CCTV inspection data did not exist for a pipe segment, then the likelihood of failure was estimated based on pipe segment age. Structural condition is a strong indicator of likelihood of failure and was heavily weighted.
- Operations & Maintenance (O&M) Condition: The required frequency of sewer cleaning is an indicator of the likelihood of asset failure due to a maintenance-related issue that could lead to an SSO. In addition, pipes that have roots and grease are also indicators of structural integrity which could lead to eventual failure. Data from the City's CCTV inspection program were used to quantify likelihood of failure due to maintenance condition. This likelihood of failure factor was given a lower weighting than other factors since, unlike structural, capacity and I/I issues, preventive maintenance cleaning can be performed to reduce the risk of SSOs due to recurring maintenance problems.
- Capacity Deficiency: This likelihood of failure factor is calculated from hydraulic modeling results. Sewers with insufficient capacity that are predicted to result in significant surcharge or potential overflows under a design event peak wet weather flow condition were considered to have a high likelihood of failure due to capacity deficiency.
- I/I Contribution: This factor is based on the relative impact of I/I in the City's system on flows in the EBMUD interceptor system that contribute to discharges from EBMUD's Wet Weather Facilities (WWFs). Basins contributing higher amounts of I/I (based on peak I/I flow per foot

[5] National Association of Clean Water Agencies, *Implementing Asset Management: A Practical Guide*, 2007

of pipe) are assigned a higher I/I score and may be targeted for improvements to reduce flows to the EBMUD system.

2.2.2 Consequence of Failure Categories

Consequence of failure is assessed by examining the impact on economic, social and environmental factors. This approach, often referred to as the Triple-Bottom-Line approach, involves identifying and quantifying suitable indicators that represent these core categories. For this study, the following indicators were used to assess the Consequence of Failure:

- **Flow Volume (Economic)**: Larger sewer spills or failure of a sewer asset serving a large tributary area can have a significant impact on the cost of fixing the pipe and restoring damaged property and the surrounding area. The size of the sewer was chosen as an indicator of the potential impact of large spills or failure of a major sewer asset.
- **Community (Social)**: Sewer failures can significantly impact commuters, commercial areas, public facilities, and the community in general. Location in major roads or commercial areas, or proximity to critical facilities such as emergency services, hospitals and schools were used as indicators of potential community impact. In addition, sewers located in easements (i.e., not in a public right-of-way) are considered to have a greater social impact hence, were included as a community impact factor.
- **Environmental**: Sewer overflows that reach surface waters can adversely impact water quality and the environment. Distance to surface water and storm drain inlets was used as an indicator of the potential environmental impact of a sewer spill.

2.2.3 Risk Score Calculations

The Pipe Rating Model utilizes data directly from GIS and Granite XP, and indirectly from the hydraulic model developed and used for this Master Plan, to compute LOF scores. Structural and O&M conditions were derived from data from previous and recent CCTV inspection programs collated and managed through Granite XP. Community and environmental COF scores were derived from GIS mapping. The risk score calculations were processed using ArcGIS ModelBuilder tools, which combine a series of GIS processes to automate the risk analysis calculations. The ModelBuilder tools developed for this study will be able to be re-used by the City to update the risk analysis following future data updates to the GIS and CCTV data. The ModelBuillder tools are organized into two toolkits: 1) pre-processing tools and 2) risk analysis tools. The risk score calculations can be displayed on GIS maps.

Figure 2-1 is a conceptual diagram of the Pipe Rating Model framework, illustrating the calculation of asset risk scores. **Table 2-1** and **Table 2-2** present the scoring criteria and weights for the LOF and COF categories, respectively. More detail on the capacity assessment (basis for capacity deficiency LOF factor) and condition assessment (basis for structural condition LOF factor) are provided in Chapters 3 and 4 of this report. The overall risk score results are presented in Chapter 5 and used in the development of the sewer system CIP.

Figure 2-1: Pipe Rating Model Framework

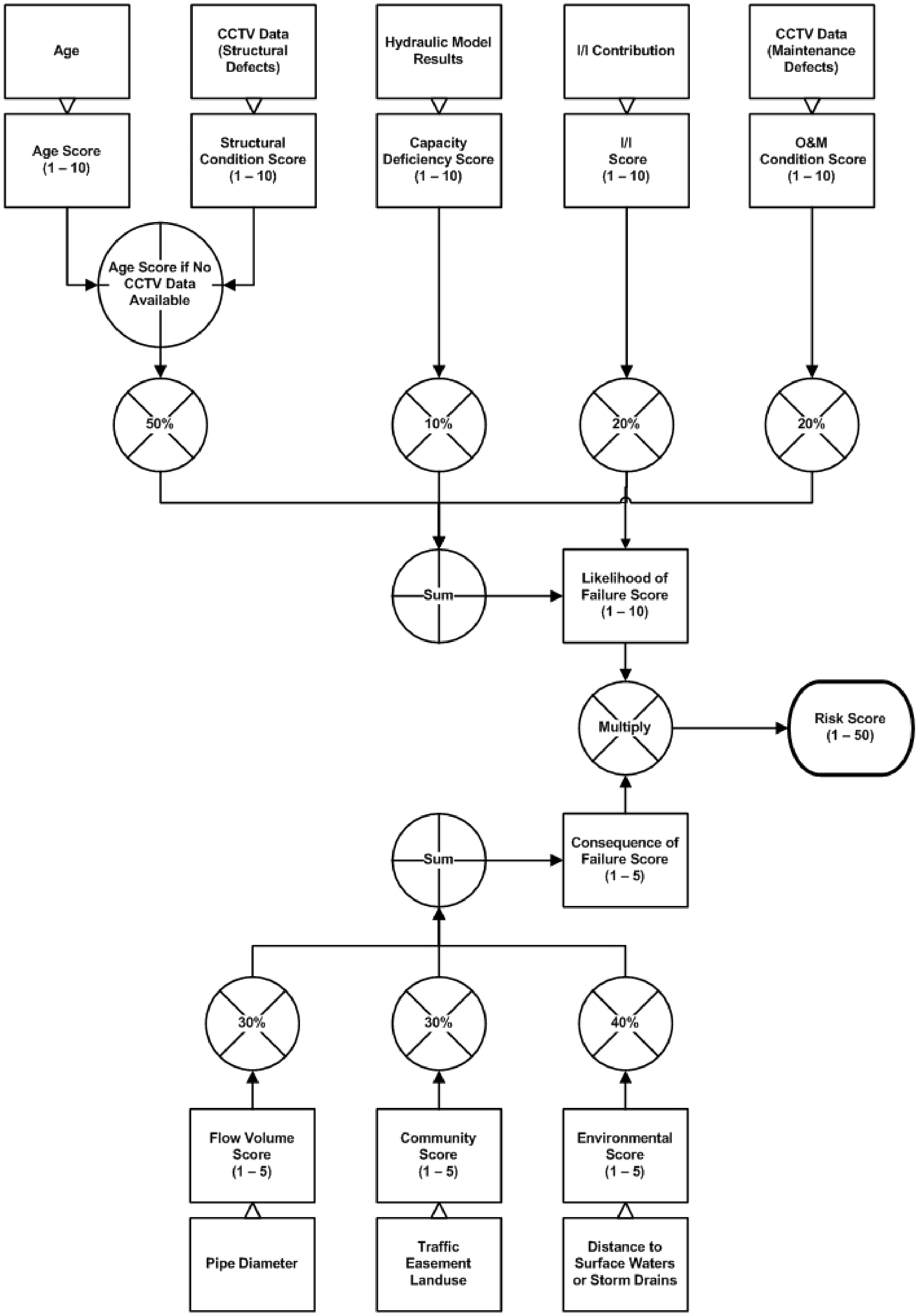


Table 2-1: Likelihood of Failure Scoring

Likelihood Category	Indicator	Weight (%)	Likelihood Score				
			1 (Low)	3	5	8	10 (High)
Structural Condition	Structural Grade Score[a] (from CCTV)	70	<= 2	>2 to 4	>4 to 7	>7 to 9	>9
	Pipe Age[b]		< 20 years	20 to < 40 years	40 to < 60 years	60 to < 80 years	≥ 80 years
O&M Condition	O&M Grade Score[a] (from CCTV)	10	<= 2	>2 to 4	>4 to 7	>7 to 9	> 9
Capacity Deficiency	Model-Predicted Surcharge[c]	10	No surcharge or not in model	Throttled pipe resulting in surcharge under future growth conditions only	Throttled pipe resulting in some surcharge, freeboard ≥ 5 feet	Throttled pipe resulting in significant surcharge, freeboard < 5 feet	Throttled pipe resulting in overflow
Inflow / Infiltration Contribution	Relative Peak I/I Rate[d]	10	Low	N/A	Medium	N/A	High

a. See discussion in Chapter 4.
b. Used only if there is no CCTV inspection data for the pipe.
c. See discussion in Chapter 3.
d. Based on peak I/I rate per foot of pipe determined from flow monitoring and modeling.

Table 2-2: Consequence of Failure Scoring

Consequence Category	Indicator	Weight (%)	Consequence Score				
			1 (Low)	2	3	4	5 (High)
Economic	Diameter (Flow Volume)	30	≤ 8”	10” to 15”	16” to 21”	24” to 27”	> 27”
Community[a] (Social)	Road Type	30	Local	NA	Collector	Arterial	Caltrans
	Land Use		Other	N/A	Commercial District	School	Emergency Operations Facilities[b]
	Easements		N/A	N/A	Yes	N/A	N/A
Environmental[c]	Distance to Surface Waters	40	N/A	N/A	N/A	50 to < 250 ft.	< 50 ft.
	Distance to Storm Inlet		N/A	N/A	N/A	50 to < 250 ft.	< 50 ft.

a. Community score based on the highest of Road Type, Land Use, and Easements scores.
b. Includes police and fire stations, city hall, and emergency operations centers.
c. Environmental score based on the highest of Distance to Surface Waters and Distance to Storm Inlet scores.