Ross Valley Sanitary District

Sewer System Replacement Master Plan

Draft Final Report

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RMC Water and Environment

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List of Abbreviations

ACP	asbestos cement pipe
BWF	base wastewater flow
CATS	casing test station
CSE	copper/copper sulfate reference electrode
CCTV	closed circuit television (inspection)
CIP	Capital Improvement Plan
CIPP	cured in place pipe
CMSA	Central Marin Sanitation Agency
DI	ductile iron
District	Ross Valley Sanitary District
ENR CCI	Engineering News Record Construction Cost Index
EOP	Emergency Operations Plan
ETS	electrolysis test station
FM	force main
ft	feet
GPM	gallons per minute
GWI	groundwater infiltration
HDPE	high density polyethylene
HIMCAD	History Inventory Maintenance and Condition Assessment Database
I&C	instrumentation and controls
IFTS	insulating flange test station
I/I	infiltration and inflow
in	inch
LF	Linear feet
MCC	Motor control center
MGD	million gallons per day
NFPA	National Fire Protection Act
OERP	Overflow Emergency Response Plan
O&M	operations and maintenance
PS	pump station
PVC	polyvinyl chloride
RCCP	reinforced concrete cylinder pipe
RDI/I	rainfall-dependent infiltration and inflow
RVSD	Ross Valley Sanitary District
RWQCB	Regional Water Quality Control Board
SCADA	Supervisory control and data acquisition

SHECAP	System Hydraulic Evaluation and Capacity Assurance Plan
SSACIP	Sewer System Assessment and Capital Improvement Planning
SSMP	Sewer System Management Plan
SSO	sanitary sewer overflow
TM	Technical Memorandum
UT	Ultrasonic thickness
VCP	vitrified clay pipe
VFD	Variable frequency drive
WS L/C	cement mortar lined and coated welded steel
WWTP	wastewater treatment plant

Executive Summary

ES-1 Introduction

This Sewer System Replacement Master Plan (Master Plan) describes existing gravity sewer, pump station, and force main systems operated by Ross Valley Sanitary District (RVSD or District), identifies issues related to capacity and condition, recommends projects to improve or remedy these issues, and presents associated project costs.

The Master Plan was completed under Task 2 of the agreement between the District and RMC Water and Environment dated October 2005. The purpose of the Master Plan is to provide the District with a baseline system-wide assessment and replacement plan, as well as tools to help the District perform continued assessments and plan updates in the future.

The Master Plan is organized by type of facility as follows:

Chapter 1 Gravity Sewer Master Plan

Chapter 2 Force Main Master Plan

Chapter 3 Pump Station Master Plan

ES-2 System Overview

The District provides wastewater collection service to the towns of Fairfax, San Anselmo, and Ross; the City of Larkspur (including Bon Air); and the unincorporated areas of Sleepy Hollow, Kentfield, Kent Woodlands, Oak Manor, and Greenbrae. Under contract to Marin County, the District also operates and maintains the wastewater collection system in Murray Park. In addition, the District conveys flows from Sanitary District No. 2 of Marin County (Corte Madera) and San Quentin Prison and Village to Central Marin Sanitation Agency (CMSA). **Figure ES-3-1** shows the District's service area boundary and location.

The District has 194 miles of gravity pipelines serving a population of approximately 45,000 in a 27 square mile area. The District operates 20 pumping stations and associated force mains. **Table ES-2-1** summarizes the components that comprise the District's sewer system. District sewer flows are conveyed to the CMSA wastewater treatment plant (WWTP) in San Rafael for treatment and disposal. **Figure ES-4-1** in Section ES-4.1 shows the District's gravity sewer system and **Figure ES-5-1** in Section ES-5.1 shows the District's pump stations and force mains.

Table ES-2-1 Summary of RVSD System Components

System Component	Quantity	Units
Gravity Lines	194	Miles
Manholes	5161	Number
Force Mains	7.4	Miles
Pump Stations	20	Number

ES-3 Development of Facility Master Plans

This Master Plan combines the efforts of three specialized teams that used a consistent approach toward development of their individual plans. The three teams: gravity sewer team, force main team, and pump station team worked independently to assess their respective systems using the following general process:

- Review existing information

- Inspect existing facilities to the extent allowable
- Discuss operational and maintenance issues with District staff
- Conduct specialized assessments as required
- Identify needed improvements related to capacity and condition needs
- Assess criticality of proposed improvements
- Estimate improvement costs

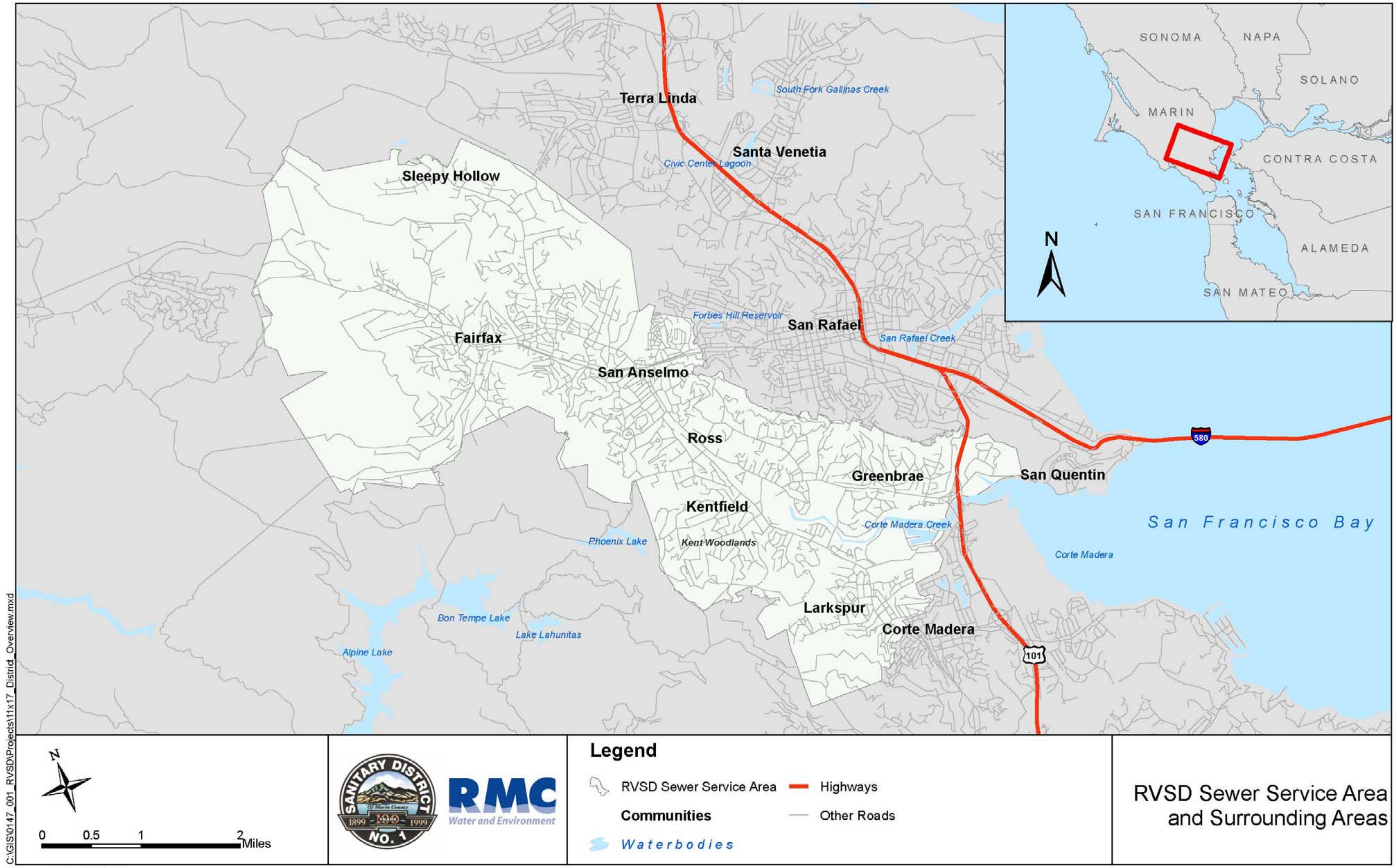
Proposed improvements and information related to project criticality and cost will be combined and evaluated with respect to system-wide needs and priorities in a separate strategic long-term capital improvement plan (TM CIP-4).

Table ES-3-1 summarizes the recommended projects from this master plan. Summaries of each facility master plans are presented below.

Table ES-3-1 Summary of Recommended Projects for Entire System

Recommended Project	# of Projects	Cost
Gravity Sewer Rehabilitation	5	$16,578,000
SHECAP Projects	21	$22,324,000
Gravity Sewer CCTV Inspection of Entire System	5	$2,000,000
Force Main Replacement/Rehabilitation	4	$9,421,000
Force Main Test Station Repairs	5	$448,400
Force Main Investigation	1	$47,500
Pump Station Replacement/Rehabilitation	18	$2,808,000
Total	**59**	**$53,626,900**

Figure ES-3-1 District Service Overview



Source: RVSD GIS Database

ES-4 Gravity Sewer Master Plan

ES-4.1 Gravity Sewer System Description

The District's gravity sewer collection system, shown in **Figure ES-4-1**, includes approximately 194 miles of pipelines. Almost 90 percent of the gravity system is comprised of 8-inch and smaller diameter sewers, primarily constructed of vitrified clay pipe (VCP). Although the exact age of most of the District's collection system is unknown, the majority of the pipes were installed before 1950, and some portions of the system are over 100 years old.

ES-4.2 Gravity Sewer System Master Plan Approach and Findings

The Gravity Sewer Master Plan was developed based on the assessment of system hydraulic capacity from the District's recently completed Sanitary Sewer Hydraulic Evaluation and Capacity Assurance Plan (SHECAP) project, and evaluation of previously identified sewer rehabilitation needs developed by District operation and maintenance field staff. In addition to identifying rehabilitation projects, the plan recommends an ongoing program for rehabilitation of pipelines as determined by a continuous system-wide condition assessment program. A detailed methodology for condition assessment is presented in a Technical Memorandum (TM) entitled Guidelines for Sewer Condition Assessment and Rehabilitation Decision Methodology, included in Appendix C.

ES-4.2.1 System Hydraulic Analysis and Capacity Assurance Plan

The SHECAP project, completed in August 2006, addressed the hydraulic capacity of the trunk sewer system. The hydraulic analysis included 23 miles of larger diameter gravity sewer pipelines and eight of the District's larger pump stations and associated force mains.

SHECAP included estimates for each of three components of sewer system flows: base wastewater flow (BWF), groundwater infiltration (GWI), and rainfall-dependent infiltration and inflow (RDI/I). The capacity analysis was conducted with respect to a 5-year recurrence frequency design storm. This design event was selected to be consistent with design assumptions used by CMSA and other agencies in the San Francisco Bay region.

The evaluation identified a number of capacity issues during design storm peak wet weather scenarios. Evaluation results were reviewed with District staff, confirming the general accuracy of wet weather surcharges or overflows that were predicted by the model.

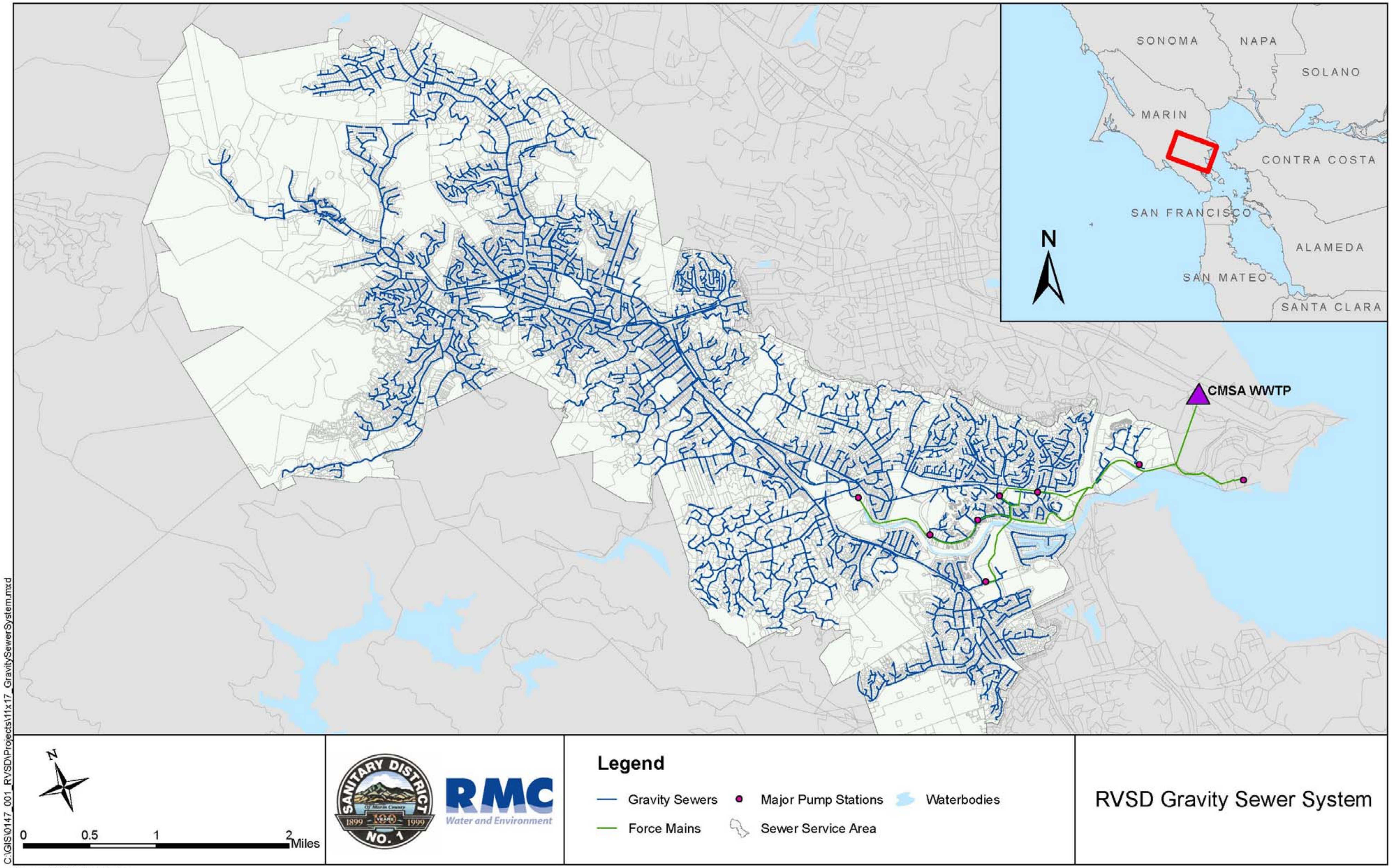
Based on results from the hydraulic analysis, SHECAP identified the need for 21 sewer improvement projects. These projects are described later in this section.

ES-4.2.2 Known Maintenance Problems and Rehabilitation Needs

The District's sewer system experiences many of the issues that are common to systems of similar age located in similar terrain. Common problems include root intrusion and grease and debris buildup in the sewers, which can cause blockages if not addressed on a regular basis. District staff cleans pipeline segments with high maintenance needs on a 6-month maintenance frequency. Rehabilitation of these sewers could potentially reduce the frequency of required maintenance and risk of blockages and overflows.

Over the years, the District has compiled and updated a list of sewer rehabilitation needs that extends beyond the 6-month maintenance areas. Pipe segments are added to the list and reprioritized based on staff field experience. The list includes areas with a wide variety of physical issues and repair needs. This rehabilitation needs list provides a basis for moving forward with the future rehabilitation plan.

Figure ES-4-1 Gravity Sewer System



Source: RVSD GIS Database

ES-4.2.3 Sewer Condition Assessment Methodology

The Gravity Sewer Master Plan included the development of a sewer condition assessment methodology to assist the District with a plan to systematically identify and prioritize future sewer improvement projects. The methodology includes a discussion of inspection methods, data formats, and a recommended method of data analysis.

The plan recommends that the District establish a baseline condition assessment through system inspection, with pipelines grouped by area, over a five-year period. A suggested inspection priority map, based on known problem areas and magnitude of RDI/I as determined by SHECAP, is shown in **Figure ES-4-2.**

The assessment would use closed-circuit television (CCTV) and visual inspection, with smoke or dye testing as needed to help identify sources of RDI/I. Inspection results area translated through a systematic process into pipeline defect scores and a pipeline condition grade as described in the proposed methodology. The condition grade combined with potential impact of failure would help priority replacement needs.

ES-4.3 Recommended Gravity Sewers Improvement Projects and Estimated Costs

Recommended improvements for the gravity sewer system include the capacity relief projects identified through SHECAP; rehabilitation projects previously identified by District staff; and future rehabilitation and replacement projects that will be developed based on a system-wide sewer inspection and condition assessment program.

ES-4.3.1 Priority Projects Recommended for Fiscal Year 2006-07

Based on the District's rehabilitation needs list, five high priority gravity sewer rehabilitation/replacement projects were combined with critical SHECAP projects to comprise an interim Fiscal Year 2006-07 Capital Improvement Plan. This section presents these priority projects; all costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index).

Bon Air Tunnel Inversion Liner Project

This project involved lining approximately 3,000 feet of the original 30-inch trunk sewer between Bon Air shopping center and Bon Air Road in Larkspur. The construction contract was awarded in June 2006 for a bid amount of $1,304,000 plus a 15% contingency. Construction was completed in December 2006.

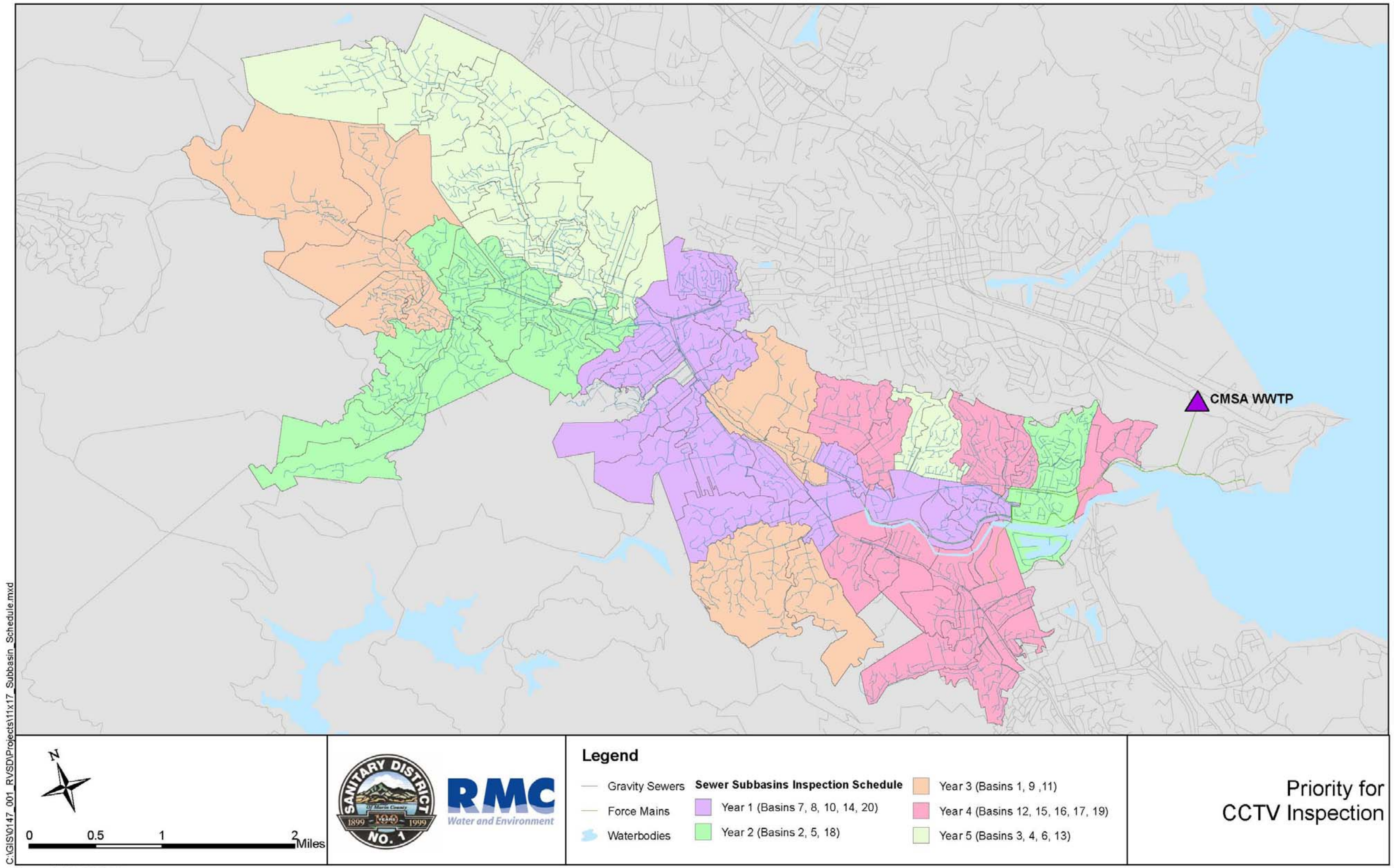
Cascade Sewer

This project includes a combination of sewer rehabilitation and SHECAP projects. The sewer component will replace 3,620 feet of pipe, including a 10-inch pipe adjacent to Cascade Creek in Fairfax and other smaller diameter sewers in the vicinity, including Wood Lane. The project is currently in the design phase, with construction planned for July 1 through October 15, 2007. Construction during this time period is contingent upon obtaining permits required to work adjacent to and within Cascade Creek. .

SHECAP Project No. 4 – Creek/Bolinas would upsize 4,079 feet of existing 10-inch sewer on Bolinas Road and adjacent roadways.

Estimated capital costs for the Cascade Creek Sewer project and SHECAP Creek/Bolinas Project are $1,358,000 and $1,679,000, respectively.

Figure ES-4-2 Sewer Subbasin Inspection Schedule



Source: RVSD GIS Database

Winship Park/Sir Francis Drake/Shady Lane

This project would replace sewer pipelines along Sir Francis Drake Boulevard in San Anselmo and in the Winship Park area of Ross. The project is recommended to be combined with SHECAP Project No. 10 – Sir Francis Drake/Winship and Project No. 12 – Upper Shady Lane Trunk Sewer. The combined projects would replace approximately 19,400 feet of sewer pipelines. Estimated capital costs are $4,156,000 for sewer rehabilitation, and $1,892,000 for SHECAP projects.

Sequoia Park/Olive Avenue/Tozzi Creek Crossing

This project would replace approximately 22,000 feet of sewer pipeline near Sequoia Road in San Anselmo, and Olive Avenue and Park Drive in Ross. Estimated capital cost: $6,374,000.

Olive-Walnut/North-Hill/Holcomb-Monte Vista/San Anselmo Ave./Hickory/Cypress

This project would replace sewers with maintenance issues in nine streets at various locations in the District's service area. The project would include approximately 11,000 feet of sewer replacement. Estimated capital cost: $3,387,000.

ES-4.3.2 Capacity Improvement Projects

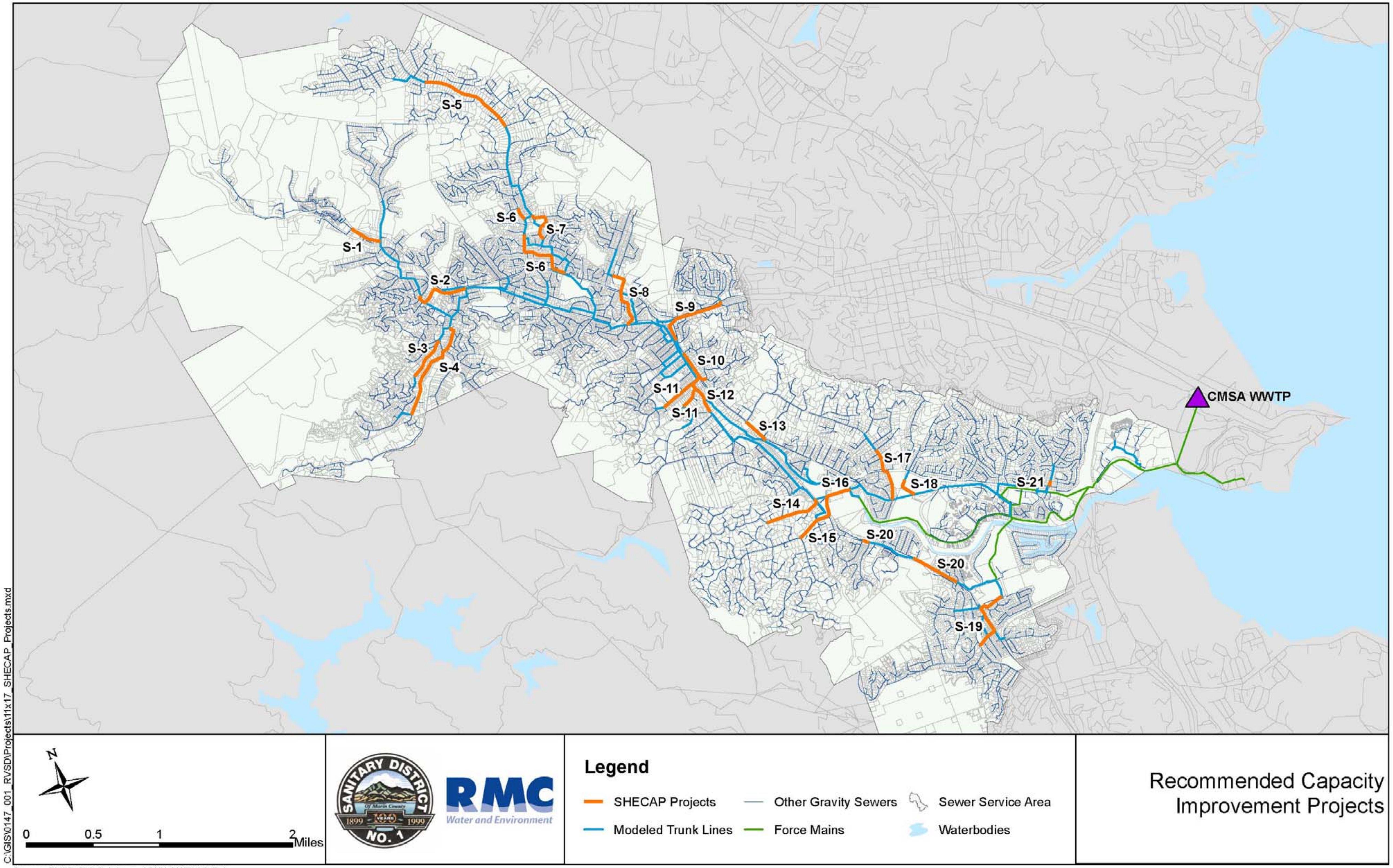
SHECAP identified 21 capacity relief projects throughout the District's gravity trunk sewer system, as shown in **Figure ES-4-3**. The SHECAP projects and their estimated costs are listed in **Table ES-4-1.** The recommended priority order for construction, based on location in the system and relative severity of capacity deficiencies, is also shown in the table. All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index). SHECAP Project No. 4, No. 10, and No. 12 have been recommended for acceleration as components of the Fiscal Year 2006-07 interim CIP, as discussed in ES-4.3.1.

Table ES-4-1 SHECAP Projects and Costs

Project No.	Description[a]	Estimated Capital Cost[b]	Priority
1	Westbrae / Hawthorne	$ 425,000	19
2	Spruce / Park / Merwin / Broadway	$ 1,754,000	8
3	Cascade	$ 573,000	11
4	Creek / Bolinas	$ 1,679,000	9
5	Upper Butterfield	$ 1,586,000	10
6	Lower Butterfield / Meadowcroft / Broadmoor / SFDB	$ 1,985,000	13
7	The Alameda / Brookmead	$ 766,000	16
8	Sonoma / Nokomis	$ 1,789,000	14
9	Miracle Mile	$ 1,747,000	4
10	Sir Francis Drake / Winship	$ 977,000	3
11	Bolinas / Fernhill	$ 1,077,000	17
12	Upper Shady Lane Trunk Sewer	$ 915,000	2
13	Sir Francis Drake / Berry	$ 472,000	20
14	Goodhill	$ 769,000	5
15	Woodland / College	$ 1,309,000	6
16	Kentfield Relief Sewer	$ 1,001,000	1
17	Laurel Grove / McAllister	$ 951,000	12
18	Manor Easement	$ 339,000	21
19	William / Holcomb / Meadowood	$ 1,306,000	7
20	Magnolia	$ 838,000	15
21	Eliseo	$ 66,000	18

a. See SHECAP report for project details.
b. Costs are indexed to August 2006 San Francisco ENR CCI of 8464

Figure ES-4-3 Recommended Capacity Improvement Projects



Source: RVSD GIS Database, MWH SHECAP Data

ES-4.3.3 Long Term Sewer Rehabilitation Budgeting

The recommended long-term sewer rehabilitation plan includes projects and placeholders for unidentified projects comprised of the following:

- Projects identified by the SHECAP study that were not included in the District's FY2006-07 CIP, but recommended for the District's long-range capital improvement program (TM CIP-4)
- Projects listed on the ongoing rehabilitation needs list that are highlighted by District staff as requiring immediate implementation. This needs list is expected to change from year to year
- Projects identified as a result of the District's ongoing CCTV inspection program.

In general, replacement of one percent of the system per year is considered a reasonable basis for sewer rehabilitation budgeting. However, the age and condition of the District's system warrants a more aggressive rate of replacement. For the purposes of long-range master plan development, a $3 to 6 million annual budget for replacement projects is recommended beyond the projects identified in this report. This budget would allow the District to rehabilitate up to two percent (four miles) of the gravity sewer system each year. As gravity sewer maintenance issues subside with continued replacement, as confirmed by reduced SSOs and CCTV inspections, the District may elect to reduce the rate of sewer replacement to one percent per year.

In addition, approximately $400,000 per year over the next 5 years is recommended for the baseline CCTV inspection of the entire system.

ES-5 Force Main Master Plan

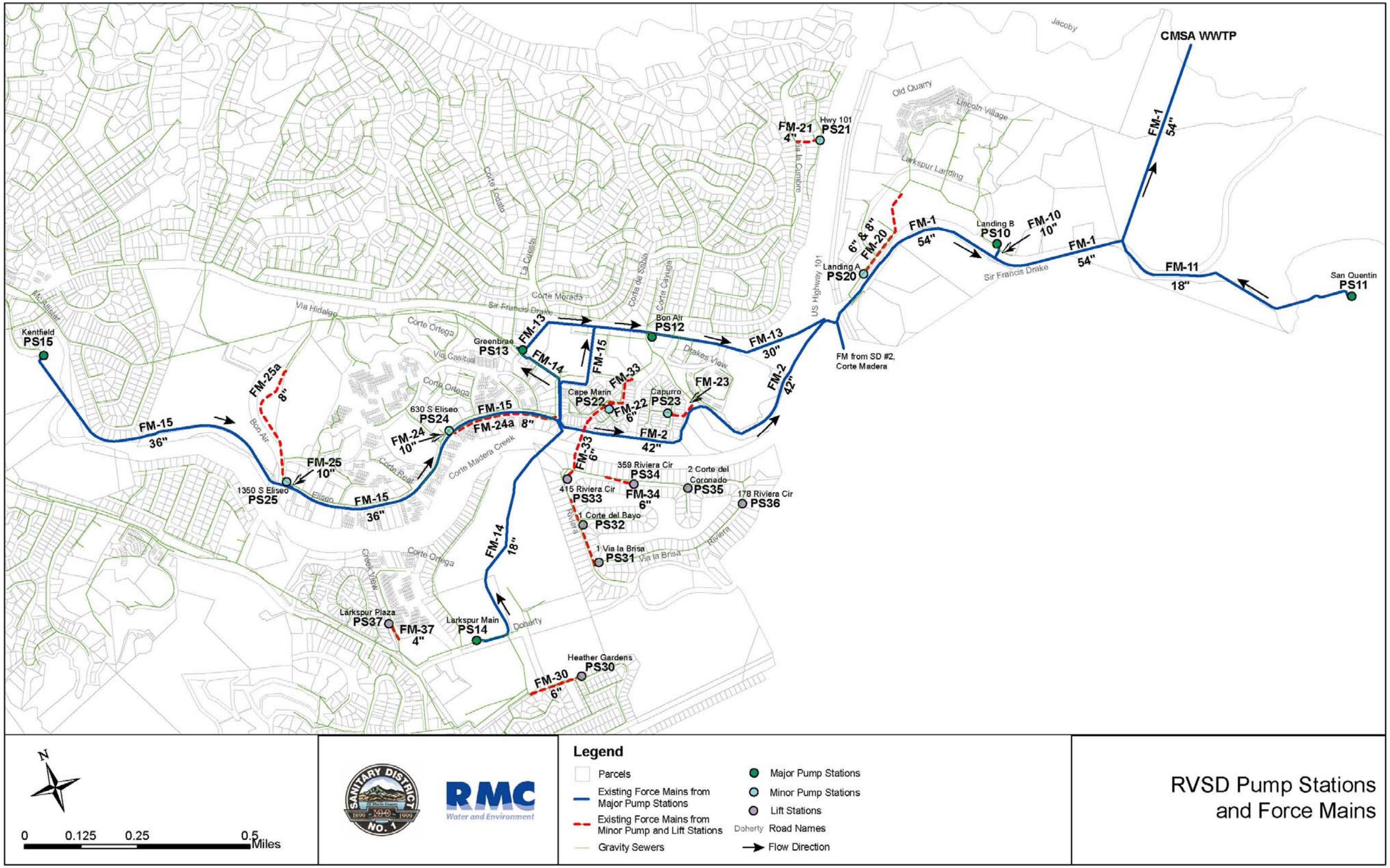
ES-5.1 Force Main System Description

The District has 24 force mains from 20 pump stations ranging in size from 4 to 54 inches in diameter. The District's force mains were installed between 1959 and 1989; a map of the District's force mains and pump stations is presented in **Figure ES-5-1.** The objective of the Force Main Master Plan is to assess existing pipe condition, capacity, and remaining useful life, and develop a prioritized program of rehabilitation and replacement for the District.

ES-5.2 Approach to Force Main Master Plan Development

Force Main Master Plan development followed the general process described in Section ES-3. Specific to this effort, the team reviewed previous studies, including findings from the District's SHECAP project completed in August 2006; conducted an external corrosion assessment; and held discussions with District staff related to validate findings from the above efforts and understand any ongoing maintenance concerns.

Figure ES-5-1 RVSD Pump Stations and Force Mains



ES-5.3 Force Main Master Plan Key Findings

ES-5.3.1 Sanitary Sewer Hydraulic Evaluation and Capacity Assurance Plan, MWH, 2006

The SHECAP evaluation is described in greater detail in Section ES-4.2. Regarding force main capacity, SHECAP results indicate that Kentfield Force Main (FM-15) must be upsized in order to adequately convey design flows from the Kentfield Pump Station. The hydraulic capacity of the District's remaining force mains is sufficient.

ES-5.3.2 External Corrosion Assessment

A review of available documentation identified 27 cathodic test stations located on seven of the District's force mains. Field measurements and inspections at 19 of these test stations were conducted by Corrpro Companies in November 2006; the remaining stations could not be located. Results from these investigations are presented in Appendix E. Inspections performed included: 1) a pipe-to-soil potential survey, 2) electrical continuity survey, and 3) soil resistivity survey. These surveys determined the relative corrosivity of the environment in the area surrounding each pipeline, assessed electrical continuity of adjacent pipeline segments, and identified pipelines that require additional monitoring, rehabilitation, or replacement.

ES-5.3.3 Immediate Operations and Maintenance Concerns

Discussions with operations and maintenance staff highlighted two locations in the force main system with potential issues related to known and potential SSOs. Rehabilitation projects for both of these force mains, Highway 101 and Riviera Circle force mains were identified and are discussed further in Section ES-5.4.

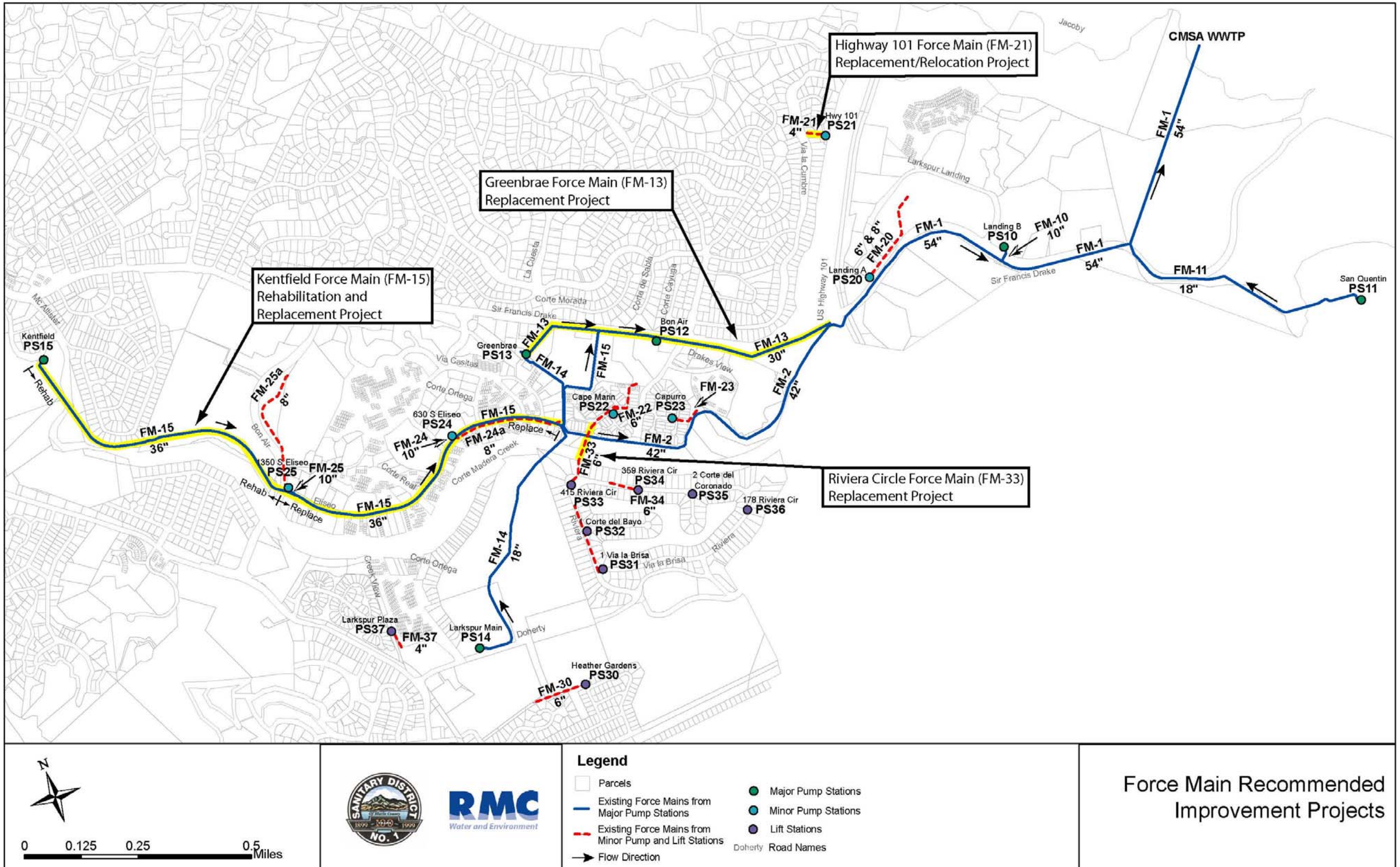
ES-5.4 Recommended Force Main Replacement Projects

Based on the review of existing information, findings from the external corrosion assessment, and discussions with staff, four force main replacement projects were identified for the long-term CIP (TM CIP-4). These projects are listed in **Table ES-5-1**, shown in **Figure ES-5-2** and described below.

Table ES-5-1 Proposed Force Main Replacement Projects

Project	Action	Pipe Diameter (in)	Pipe Length (ft)
Greenbrae (FM-13)	Replacement	30	2,900
Kentfield (FM-15)	Rehabilitation	35	3,800
	Replacement	42	3,700
Highway 101 (FM-21)	Replacement	4	700
Riviera Circle (FM-33)	Replacement	6	350

Figure ES-5-2 Recommended Force Main Improvement Projects



ES-5.4.1 Greenbrae Force Main (FM-13) Replacement Project

The Greenbrae Force Main (FM) was installed in 1959, and is nearing the end of its design life. Field surveys indicate that there is greater than 90 percent probability that corrosion is occurring on the pipeline. The field investigation also indicated that installing or increasing pipeline cathodic protection to extend the useful life of the pipeline would be minimally effective.

It is recommended that the District take immediate action to monitor continued corrosion, and to replace the force main as part of the long-term CIP (TM CIP-4). Near-term action items include excavating and inspecting the existing pipeline at three locations, and performing ultrasonic thickness testing if required. If the visual examination and testing conclude that immediate replacement of the pipeline is not required, the District should install electrolysis test stations to more closely monitor ongoing corrosion.

Further, it is recommended that the long-term CIP include a full replacement project for the force main. Pipeline replacement length would be approximately 2,900 feet.

ES-5.4.2 Kentfield Force Main (FM-15) Replacement Project

The Kentfield FM is a 36-inch diameter fiberglass "Techite" pipeline that was installed in 1972. In the late 1970s, Techite was found to be vulnerable to catastrophic failure. This force main conveys 60 percent of the District's flow during wet weather, without redundancy. Due to the critical nature of this pipeline, and the elevated risk of failure, replacement of this force main is a priority for the District. In addition, the SHECAP study determined that the force main requires additional capacity to handle peak design wet weather flows.

An alternatives evaluation for replacement of the Kentfield FM was conducted to identify a potential project for the District's Fiscal Year 2006-2007 CIP. This evaluation is described in Technical Memorandum FM-1, which is included in Appendix F. The project that is recommended based on this evaluation would rehabilitate approximately 3,800 feet of pipe from the Kentfield Pump Station (PS) to a location west of Bon Air Road, and replace approximately 3,700 feet of pipe downstream of this location. This alternative would require a dry weather construction period, during which flow to the Kentfield PS would be diverted to the Greenbrae PS.

ES-5.4.3 Highway 101 Force Main (FM-21) Inspection and Replacement Projects

The Highway 101 FM is a 4-inch ductile iron pipe that has leaked in the past, causing sanitary sewer overflows (SSOs). Elimination of future SSOs is considered a priority due to the proximity of this pipeline to private residences. The recommended project replaces the force main with a 4-inch HDPE pipe.

ES-5.4.4 Riviera Circle Force Main (FM-33) Replacement Project

The Riviera Circle FM crosses Corte Madera Creek by means of two 50-foot sections of 6-inch rubber sewerage hose on either side of a 200 foot long section of 6-inch cement mortar lined and coated welded steel pipe. The welded steel pipe crossing the brackish creek is not cathodically protected, and underground piping is at or below sea level. It is recommended to replace the crossing with 6-inch PVC or HDPE pipe using directional drilling construction methods. In conjunction with this work, existing welded steel pipe on the north side of the creek would also be replaced with PVC or HDPE pipe.

ES-5.5 Additional Force Main System Recommendations

In addition to the force main rehabilitation or replacement projects described above, other additional system enhancements are recommended for implementation in 2007 and in future years. Recommended projects involve visual inspection, test station installation, and anode repairs.

Table ES-5-2 Recommended Projects with regard to Additional System Enhancements

Force Main Name	FM Number	Connect Existing Anodes to Pipeline	Install Electrolysis Test Station(s)	Close Internal Survey & Exterior Pipeline Inspection	UT Testing
Ross Valley	1		✓		
Greenbrae Kentfield Relief	2		✓		
Landing B	10	✓	✓		
Greenbrae	13	✓		✓	✓
Larkspur	14		✓	✓	
Heather Gardens	30		✓	✓	

ES-5.6 Estimated Force Main Projects Costs

Conceptual cost estimates for the projects proposed in Section ES-5.4 are presented in **Table ES-5-3**. Estimates include construction contingencies, and an allowance for engineering, legal, and administrative fees. Base costs for the recommended cathodic protection projects were developed through discussion with Corrpro Companies, Inc. staff. All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index).

Table ES-5-3 Force Main Inspection, Anode Repair, and Test Station Replacement Costs

Project Name	Project Description	Estimated Construction Cost [a]
Greenbrae Force Main Replacement Project	Replace existing pipe with HDPE	$1,982,000
Kentfield Force Main Replacement Project	Rehabilitation and replace existing pipe with structural liner and HDPE.	$7,194,000
Highway 101 Force Main Replacement Project	Replace existing pipe with PVC or HDPE	$182,000
Riviera Circle Force Main Replacement Project	Replacement existing pipe with HDPE	$63,000
Landing B Force Main Test Station / Anode Repair Project	Repair anode connection to pipe. Replace missing electrolysis test station.	$47,400
Greenbrae Kentfield Relief Force Main Test Station Project	Repair / Install One Test Station	$23,700
Greenbrae Inspection and Test Station / Anode Repair Project	Conduct close internal survey. Conduct external inspection & UT testing @ 3 locations. Install three new test stations. Repair one anode connection.	$148,400
Larkspur Force Main Test Station / Anode Repair Project	Conduct close interval survey. Conduct external inspection. Install three test stations and complete anode repair.	$110,900
Heather Gardens Force Main Inspection Project	Conduct close interval survey. Conduct external inspection & UT testing if required.	$47,500
Ross Valley Interceptor Test Station Project	Repair / Install Five Electrolysis Test Stations	$118,000
Totals		**$9,916,900**

Footnotes:

a. Costs are indexed to August 2006 San Francisco ENR CCI of 8464.

ES-6 Pump Station Master Plan

ES-6.1 Pump Station System Description

The District owns and operates 20 pump stations with design capacities ranging from 0.09 MGD (PS-37 - Larkspur Plaza) to 36.9 MGD (PS15 - Kentfield). A map of the District's pump stations and force mains is shown in **Figure ES-5-1.**

The 20 pump stations are listed in **Table ES-6-1** and classified as major, minor, or lift pump stations. Major pump stations pump directly to the CMSA WWTP through a common 54-inch force main. Minor pump stations generally pump into a gravity sewer or into a smaller force main. Lift stations lift or pump sewage into the nearby, local gravity system.

Table ES-6-1 Summary of RVSD Pump Stations

PS #	Name	Type
PS-10	Landing B	Major
PS-11	San Quentin	Major
PS-12	Bon Air	Major
PS-13	Greenbrae	Major
PS-14	Larkspur Main	Major
PS-15	Kentfield	Major
PS-20	Landing A	Minor
PS-21	Highway 101	Minor
PS-22	Cape Marin	Minor
PS 23	Capurro	Minor
PS-24	Eliseo	Minor
PS-25	South Eliseo	Minor
PS-30	Heather Garden	Lift Station
PS-31	Via la Brisa	Lift Station
PS-32	Corte del Bayo	Lift Station
PS-33	415 Riviera Circle	Lift Station
PS-34	359 Riviera Circle	Lift Station
PS-35	2 Corte del Coronado	Lift Station
PS-36	178 Riviera Circle	Lift Station
PS-37	Larkspur Plaza	Lift Station

ES-6.2 Approach to Pump Station Master Plan Development

Pump Station Master Plan development followed the general process described in Section ES-3. Specific to this effort, the team reviewed existing pump station maintenance records, reports and studies, and conducted individual pump station inspections and assessments.

ES-6.3 Pump Station Master Plan Key Findings

ES-6.3.1 Existing Pump Station Maintenance Records

The District maintains daily logs documenting pump running times. Hard copies of the logs for 2005 were reviewed as a key component of the pump station capacity assessment; reviews focused on running times for December 2005, in order to capture data from the relatively severe storms leading to and on December 31. Evaluation of pump running times helped determine whether spare or standby pump capacity was available during the wet weather period. This evaluation confirmed SHECAP results regarding capacity needs for Bon Air (PS-12), Larkspur Main (PS-14), Kentfield (PS-15), and also identified Heather Garden (PS-30) as requiring additional pumping capacity in the future, after upstream sewer surcharging is addressed.

ES-6.3.2 Review of Previous Reports

Information from the following documents was used to confirm or augment recommendations developed as a result of the pump station field reconnaissance effort that is described below. This section presents a brief summary of each document reviewed:

Force Main Improvement Program (Nute Engineering, May 1998) provides an inventory of the District's force mains, estimates the remaining useful life of these facilities, and sets forth a long range plan for their eventual replacement or rehabilitation.

Central Marin Sanitation Agency (CMSA) Interceptor Network Hydraulic Model Final Report (Nolte, September 2, 2004) contains a brief description of a pump station and force main modeling effort performed by Nolte in 2004. The modeling effort consisted of steady state modeling and did not include any of the gravity portions of the District's collection system.

Kentfield Pump Station Review (Nute Engineering, January 1998) contains an inventory of the Kentfield Pump Station (PS) existing equipment, an analysis of the structural integrity of the pump station, an analysis of pumping reliability, a corrosion investigation, and an evaluation of the electrical system and other pump station equipment. It also presents a program of staged improvements to the Kentfield PS to improve overall operational flexibility

Sanitary Sewer Hydraulic Evaluation and Capacity Assurance Plan (SHECAP, MWH, August 2006) modeled all six major pump stations and two minor pump stations, Eliseo (PS-24) and South Eliseo (PS-25). These pump stations discharge directly into the force main system that conveys all of the District's wastewater flow to the CMSA WWTP. The SHECAP study analyzed pump station capacities under normal operating conditions (no standby pumps running) and firm capacity conditions (largest pump out of service).

SHECAP identified capacity deficiencies at the Bon Air Pump Station (PS-13), Larkspur Main Pump Station (PS-14), and Kentfield Pump Station (PS-15). SHECAP recognized that PS-15 capacity issues could be resolved by increasing the size of the downstream force main.

Draft Wastewater Pumping Station Reliability Recommendations (San Francisco Bay Regional Water Quality Control Board, October 1996) include proposed facility guidelines in three categories: 1) Design Requirements; 2) Emergency Procedures Requirements; and 3) Maintenance, Inspection and Testing Requirements. These categories are further delineated as shown in **Table ES-6-2**.

Table ES-6-2 RWQCB Reliability Subcategories

Category	Subcategory
Design Requirements	Capacity Protection from flooding Mechanical – ventilation Isolation valves and bypass pumping Standby power Automatic controls Instrumentation – metering of discharge
Emergency Procedures	Protective measures Emergency response plan Spills procedures
Maintenance, Inspection & Testing	Preventive maintenance program Inspection and testing Record keeping

ES-6.3.3 Pump Station Field Reconnaissance and Condition Assessment

A visual condition assessment performed for all of the District's pump stations except the San Quentin Pump Station served as a basis for development of project recommendations in the Pump Station Master

Plan. This condition assessment, which identified apparent structural and mechanical deficiencies, was followed by discussions with District staff regarding findings. Recommended improvement categories for each pump station are summarized in **Table ES-6-3**.

Table ES-6-3 Summary of Recommended Improvements by Category

PS#	Name	Piping & Valving	Electrical	I&C	Structural	Health & Safety	Neighborhood Issues	Capacity Needs	Influent Sewer/ FM	Maintenance/Reliability	Overflow Potential
10	Landing B	Renovation in progress by District									
11	San Quentin	RVSD operates "dry" side only. Not inspected.									
12	Bon Air	✓	✓	✓	✓	✓	✓	✓			
13	Greenbrae	✓	✓	✓	✓	✓					
14	Larkspur Main			✓		✓		✓			
15	Kentfield		✓	✓		✓		✓			
20	Landing A		✓	✓		✓				✓	
21	Highway 101	✓		✓					✓		
22	Cape Marin	✓		✓							
23	Capurro	✓		✓							
24	Eliseo	✓	✓	✓							
25	South Eliseo	✓	✓	✓						✓	
30	Heather Garden	✓		✓	✓	✓				✓	
31	Via la Brisa	✓		✓	✓	✓				✓	
32	Corte del Bayo	✓		✓	✓	✓				✓	
33	415 Riviera Circle	✓		✓							
34	359 Riviera Circle	✓		✓	✓			✓		✓	
35	Corte del Coronado	✓		✓	✓			✓		✓	
36	178 Riviera Circle	✓		✓	✓			✓		✓	
37	Larkspur Plaza	✓	✓	✓							

ES-6.4 Recommended Pump Station Replacement Projects

Recommended projects for each pump station are summarized in **Table ES-6-4.** Completion of these projects within the next ten years, with an emphasis on resolving safety and capacity issues early, is recommended. Conceptual cost estimates for these projects are presented in Section ES-6.5.

In addition to the pump station rehabilitation projects described above, the Pump Station Master Plan recommends that a detailed study of pump station operations be considered to determine whether groupings of small pump stations in residential neighborhoods should be combined into single, larger stations. It is also recommended that the District develop an asset management list for each pump station.

Table ES-6-4 Summary of Recommended Projects by Pump Station

PS#	Name	Recommended Projects
10	Landing B	• Renovation completed by District in 2006
11	San Quentin	• RVSD operates “wet” side only. Not inspected.
12	Bon Air	• Replace specific components and perform general maintenance • Install new ventilation system and odor control • Increase pumping capacity
13	Greenbrae	• Replace or install specific components and upgrade electrical • Improve ventilation system
14	Larkspur Main	• Install specific components and improve ventilation system • Increase pumping capacity
15	Kentfield	• Install additional flowmeters and associated controls
20	Landing A	• Install specific components and new ventilation system • Consider backup generator • Upgrade station to meet fire code
21 & 22	Highway 101 & Cape Marin	• Install flow meter and vault, connect to SCADA
23	Capurro	• Install flow meter and vault, connect to SCADA • Investigate potential for combining with PS22
24 & 25	Eliseo & South Eliseo	• Install flow meter and vault, connect to SCADA • Install generator sound enclosure
30	Heather Garden	• Install flow meter and vault, connect to SCADA • Perform general structural modifications • Replace pumps to address wet weather surcharge issues
31 & 32	Via la Brisa & Corte del Bayo	• Install flow meter and vault, connect to SCADA • Modify valve pit and wet well, install new submersible pumps • Install ventilation system
33	415 Riviera Circle	• Install flow meter and vault, connect to SCADA
34, 35 & 36	359 Riviera Circle ; Corte del Coronado ; 178 Riviera Circle	• Install flow meter and vault, connect to SCADA • Modify wet well and install two new pumps • Improve station access
37	Larkspur Plaza	• Replace valves, add flowmeter and connect to SCADA • Recommend separate power feed

ES-6.5 Estimated Pump Station Project Costs

Conceptual cost estimates for the projects proposed in Section ES-6.4 are presented in **Table ES-6-5**. A more detailed capital cost breakdown can be found in Appendix H. Construction costs are based on recently completed projects of a similar nature, supplemented with information from RSMeans as appropriate. Estimates include contractor construction contingencies, as well as engineering, legal and administrative fees. All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index).

Table ES-6-5 Pump Station Project Estimated Costs

PS #	Name	Estimated Costs ($)
10	Landing B	$0 (PS replaced in 2006)
11	San Quentin	$0
12	Bon Air	$364,000
13	Greenbrae	$265,000
14	Larkspur Main	$111,000
15	Kentfield	$154,000
20	Landing A	$258,000
21	101	$60,000
22	Cape Marin	$43,000
23	Capurro	$43,000
24	630 Eliseo	$68,000
25	1350 S. Eliseo	$94,000
30	Heather Garden	$92,000
31	1 Via la Brisa	$213,000
32	1 Corte del Bayo	$213,000
33	415 Riviera Circle	$43,000
34	359 Riviera Circle	$248,000
35	2 Corte del Coronado	$248,000
36	178 Riviera Circle	$248,00
37	Larkspur Plaza	$43,000
Total		**$2,808,000**

Chapter 1 Gravity Sewer Master Plan

This chapter presents the master plan for the gravity sewer system. The master plan addresses the improvement needs of the gravity sewer system with respect to hydraulic capacity, structural condition, and maintenance issues. The Gravity Sewer Master Plan was developed based on the assessment of system hydraulic capacity completed under the District's recently completed Sanitary Sewer Hydraulic Evaluation and Capacity Assurance Plan (SHECAP) project; previously identified sewer rehabilitation needs developed by District operation and maintenance field staff; and recommendations for a future system-wide condition assessment. The proposed methodology for the system-wide condition assessment is presented in a Technical Memorandum (TM) titled Guidelines for Sewer Condition Assessment and Rehabilitation Decision Methodology prepared as part of this master planning effort.

The Gravity Sewer Master Plan identifies areas with sewer rehabilitation and capacity enhancement needs, presents associated projects and cost estimates, and recommends a priority schedule for sewer inspection. The SHECAP report and the Guidelines for Sewer Condition Assessment TM are included as Appendices B and C, respectively.

1.1 Background and Purpose of Gravity Sewer System

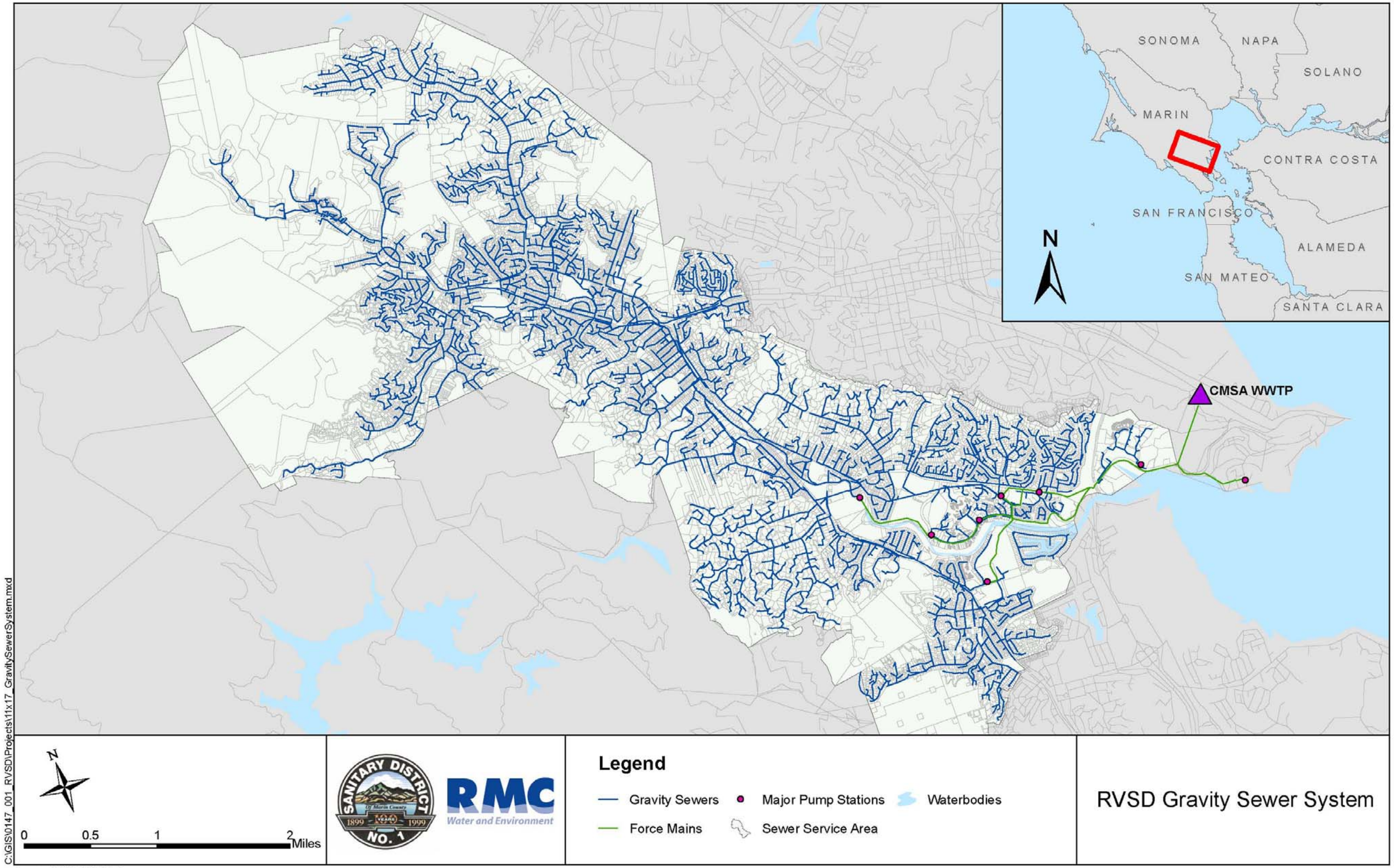
The purpose of the Gravity Sewer Master Plan is to identify the hydraulic capacity requirements of the gravity sewer system and develop recommendations and priorities for rehabilitation and replacement projects to improve system condition and performance. In 2006, the District completed SHECAP, a comprehensive study of the hydraulic capacity of its trunk sewer system, to identify needed sewer capacity improvements. In addition, the District has rehabilitated or replaced almost 40,000 feet (approximately 7-1/2 miles) of sewers over the past 12 years, and has identified a number of additional sewer rehabilitation needs based on maintenance problems and areas of known construction or condition issues. However, only limited inspection and formal condition assessment has been conducted. As the District continues to expand its sewer rehabilitation program, it is seeking a more systematic process for assessing sewer condition and prioritizing sewer rehabilitation and replacement needs.

1.2 Gravity Sewer System Description

The District's collection system includes approximately 194 miles of sewer pipelines. The gravity sewer system is shown in Figure 1-1.

A large portion of the District's collection system was installed before 1950, and the exact age for most of the gravity system is unknown. Some pipes in the system are over 100 years old. The majority of the District's gravity sewers are vitrified clay pipe (VCP) with a diameter of 6 inches. Other pipe materials include asbestos cement, cast iron and ductile iron, reinforced concrete, and plastic (polyvinyl chloride (PVC) and polyethylene). In addition to the Techite Force Main discussed in Chapter 2, there is 522 feet of 24-inch Techite gravity sewers in the system (Saunders Avenue in San Anselmo). **Table 1-1** summarizes pipe length by diameter as tabulated in the District's current sewer inventory database.

Figure 1-1 Gravity Sewer System



Source: RVSD GIS Database

Table 1-1 Summary of Sewer Pipe Length by Diameter

Diameter (in)	Length (ft)	Percent of Total
<6	43,010	4.2
6	732,503	71.5
8	126,875	12.4
10	39,484	3.9
12	19,269	1.9
14	5,296	0.5
15	4,601	0.4
16	778	0.1
18	12,322	1.2
21	6,684	0.7
24	5,241	0.5
27	1,228	0.1
30	11,639	1.1
33	382	0.0
36	9,567	0.9
39	4,716	0.5
42	522	0.1
Total	**1,024,118**	**100**

1.3 Sewer Hydraulic Evaluation and Capacity Assurance Plan

Recommendations for capacity improvements to the sewer system were developed based on results from the SHECAP effort completed by MWH in August 2006. This section summarizes SHECAP development and results.

1.3.1 Computer Model Development

A computer model of the trunk sewer network was developed using InfoWorks™, a fully dynamic hydraulic model. The modeled network included 526 manholes, 23 miles of gravity sewers ranging in size from 6 to 42 inches in diameter, eight of the District's 20 pump stations, and six miles of force mains ranging in size from 8 to 54 inches. Approximately 500 manholes in the trunk sewer system were surveyed and inspected to determine horizontal coordinates, rim elevations, and depth to pipe inverts as part of a field survey conducted for the SHECAP project. Tributary flows for the modeled network where developed by delineating 100 sewer subbasins based on general flow directions and connection points of local sewers to trunk lines.

1.3.2 Basis of Flow Estimates

Wastewater flows were estimated based on U.S. Census population information, customer and water use data from sewer billing records, and a temporary flow monitoring program conducted between December 2004 and March 2005. Model flows were based on three basic components of wastewater flow: base wastewater flow, groundwater infiltration, and rainfall-dependent infiltration and inflow.

Base wastewater flow (BWF) represents flow discharged from residential, commercial, industrial, and institutional users of the sewer system. Residential base wastewater flow was based on a unit flow rate of 60 gallons per capita per day. Non-residential base wastewater flow was calculated from average winter municipal water billing data assuming very little irrigation or lawn sprinkling takes place in winter months.

Groundwater infiltration (GWI) was quantified by comparing flow monitoring data for non-rainfall periods with the modeled dry weather base wastewater flows described above. The difference between the non-rainfall flow monitoring data and the modeled dry weather base flow was assumed to be due to groundwater infiltration. Each subbasin was assigned a groundwater infiltration rate based on the magnitude of GWI for its associated flow monitor.

Rainfall-dependent infiltration and inflow (RDI/I) was quantified by analyzing flow monitoring data during storm events. RDI/I parameters were established for each subbasin based on the percentage of rainfall entered the system as RDI/I and the general shape (flow response) of the RDI/I hydrograph at the associated flow monitor.

1.3.3 Hydraulic Evaluation

Capacity of the system was evaluated with respect to a 5-year frequency design storm event. The hydraulic model was used to evaluate and identify system performance based on an acceptable level of surcharge (defined as the height of flow above the crown of the sewer pipes). For purposes of the capacity evaluation, **an acceptable level of surcharge was defined as a water level in the manhole no higher than 10 feet below the ground surface**. The trunk sewer system was evaluated under both peak dry weather and design storm peak wet weather scenarios. **The hydraulic evaluation identified no capacity deficiencies for dry weather conditions**. However, a number of gravity sewer pipelines located throughout the system were found to have inadequate capacity for wet weather flows. Some pipes experience surcharging due to insufficient pipe capacity, while other pipes experience surcharging due to backwater from downstream capacity deficiencies.

The hydraulic evaluation of sewer system was based on a 5-year frequency wet weather event, called the “design storm.” This design storm was selected to be consistent with design assumptions used by CMSA for expansion of its wastewater treatment plant. A 5-year frequency design event has also been accepted by the Regional Water Quality Control Board (RWQCB) as a reasonable design flow criteria for other agencies in the San Francisco Bay Region.

Modeling results indicate numerous surcharge locations within the gravity sewer system under this design event. Because the hydraulic model did not include the small diameter collection system piping, which provides some storage capacity upstream of the trunk sewers, these results were compared to field experience of historical surcharge and overflow locations. District staff reviewed the modeling results and confirmed the general accuracy of wet weather surcharges or overflows that were predicted by the model.

Chapter 2 and Chapter 3, respectively, of this report include summaries of the force main and pump station capacity issues identified in the SHECAP hydraulic evaluation.

1.3.4 Capacity Assurance Plan

Potential solutions to the predicted wet weather capacity problems can include 1) providing additional hydraulic capacity in the system (“relief solutions”) or 2) repairing sewers to reduce infiltration and inflow (I/I) flows (“rehabilitation solutions”). While sewer rehabilitation corrects the actual cause of wet weather problems, rehabilitation solutions can be very expensive, and their effectiveness may be difficult to predict unless the private portion of the sewer system, the house laterals, are also addressed. Therefore, relief solutions generally provide the most cost effective and expedient way to address the critical capacity problems in the system within a reasonable length of time. Note that sewer rehabilitation is still needed to address structural and maintenance problems, and to prevent further increases in RDI/I.

As part of the SHECAP study, 21 capacity relief projects were developed to address the identified capacity deficiencies in the trunk sewer system. The 21 relief projects are shown in **Figure 1-2**.

MWH conducted visual field assessments for each proposed project to identify feasible construction methods, viable pipeline alignments, and constructability issues. Potential construction methods were identified for each project and include pipe bursting, open cut construction of new or replacement sewers, and microtunneling. The total cost of implementing all 21 relief projects is estimated to be $22.3 million (August 2006$).

1.4 Sewer Rehabilitation Needs List

Over the years, the District has compiled and updated a list of sewer rehabilitation needs that serves as the basis for its yearly rehabilitation activities. Pipe segments are added to the list and reprioritized based on staff field experience. The list includes areas with various types of problems, including sewers with poor grade, shallow pipes, broken pipes, 5-inch and smaller pipes, very old sewers (e.g., greater than 100 years old), pipes with faulty joints, sewers located under buildings, above ground creek crossings, sewers with heavy infiltration, and pipes that have experienced blockages and other maintenance problems. This rehabilitation needs list, in conjunction with the list of capacity improvements identified through SHECAP, provides a basis for the long-term capital improvement program. **Figure 1-3** shows the location of the previously identified sewer rehabilitation needs.

District staff also maintains information regarding gravity sewers that require cleaning and inspection on a six-month maintenance schedule, shown in **Figure 1-4**. Frequent maintenance may indicate the need for rehabilitation or replacement.

1.5 Sewer Condition Assessment Methodology

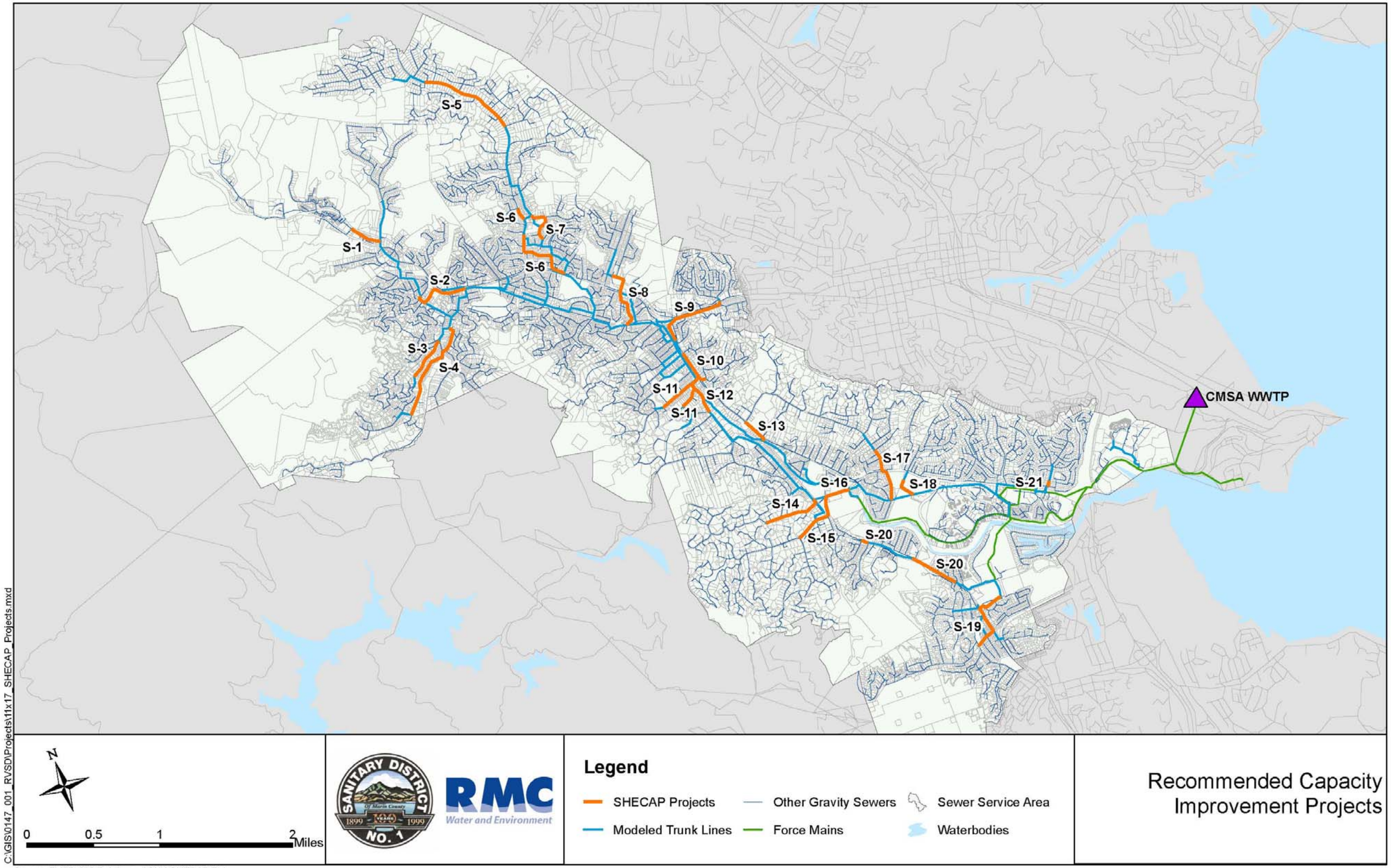
In addition to the trunk system capacity improvement projects identified through SHECAP and specific rehabilitation projects on the District's rehabilitation needs list, the gravity sewer system requires ongoing improvements to address issues that can potentially lead to sanitary sewer overflows (SSOs). In order for the District to effectively make decisions regarding future rehabilitation needs and priorities, a systematic condition assessment methodology should be implemented to standardize and document condition inspections.

This section summarizes the recommended condition assessment methodology. The purpose of this methodology is to characterize the physical condition of the gravity system facilities (pipes and manholes) in order to identify and prioritize required sewer rehabilitation. Appendix C contains the full TM on Guidelines for Sewer Condition Assessment and Rehabilitation Decision Methodology.

1.5.1 Sewer Inspection Methods

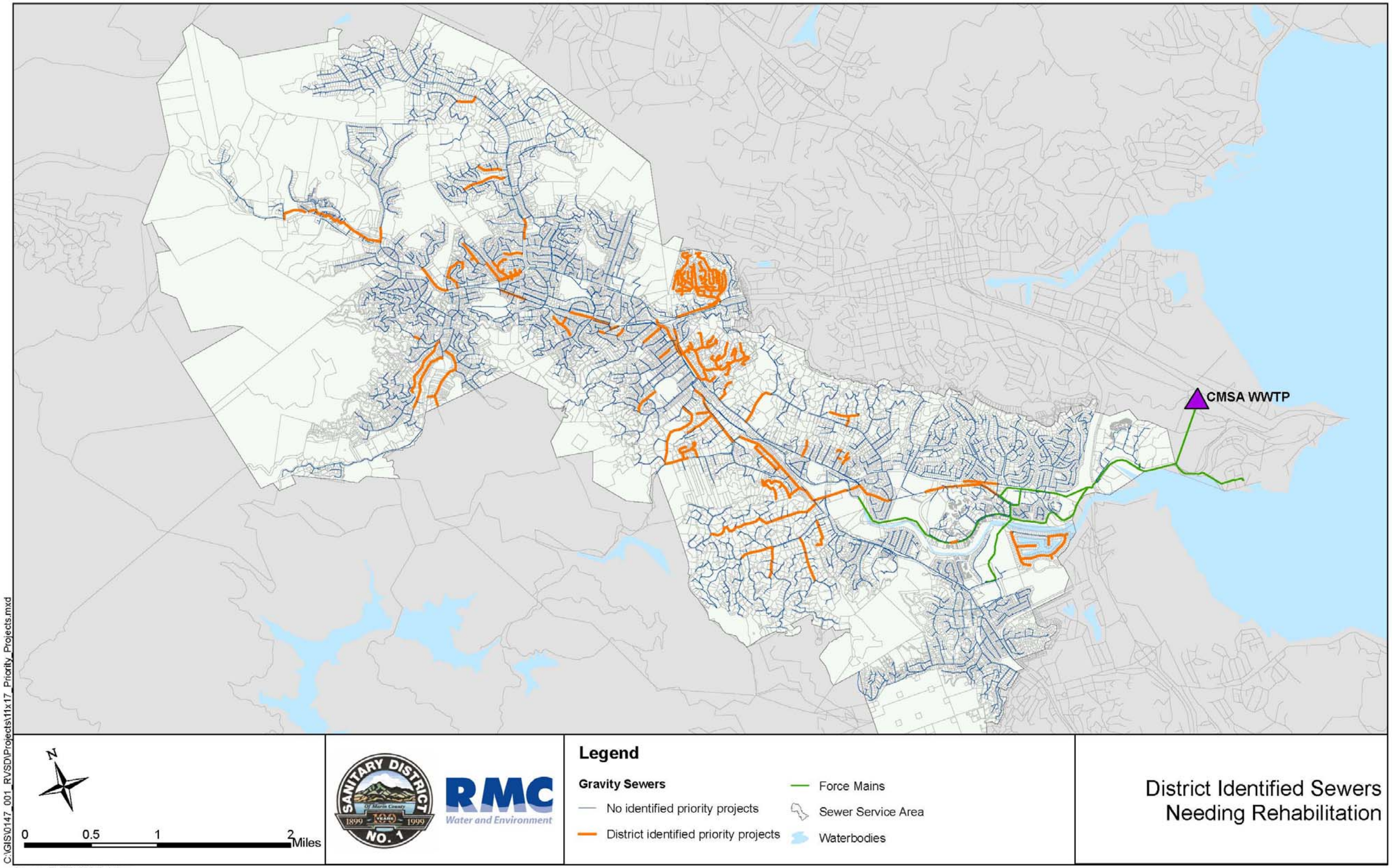
Several sewer inspection methods can be used to determine the condition of the sewer system. Typically, closed-circuit television (CCTV) inspection is used to determine the internal condition of gravity sewer pipelines, and physical (visual) inspection is used to assess the condition of sewer manholes. In addition, other methods such as smoke and dye testing are applicable specifically for identifying sources of I/I in the collection system.

Figure 1-2 Recommended Capacity Improvement Projects



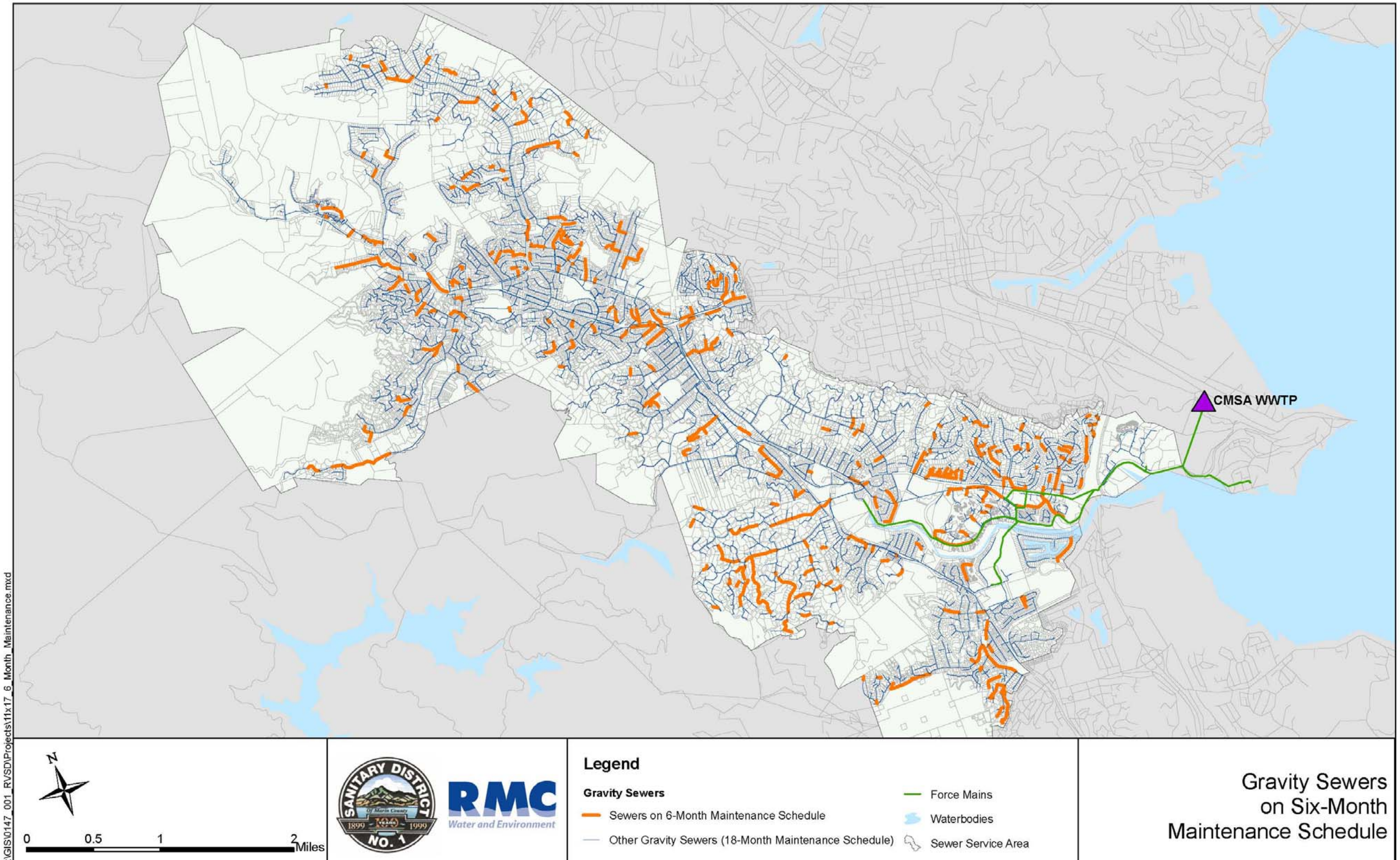
Source: RVSD GIS Database, MWH SHECAP Data

Figure 1-3 District Identified Sewer Rehabilitation Projects



Source: RVSD GIS Database

Figure 1-4 Gravity Sewers on Six-Month Maintenance Schedule



Source: RVSD GIS Database, RVSD Staff Input

Closed Circuit Television Inspection

CCTV inspection is performed by pulling a camera through a sewer line. As the camera progresses through the sewer, the CCTV operator views the interior of the pipe on a video monitor and observes its condition. Defects (e.g., cracks, offset joints, sags, grease, debris, root intrusion) and construction features (e.g., lateral connections) noted during CCTV inspection are recorded by the CCTV operator, and the entire video inspection is saved in digital format or on videotape. In order for CCTV results to be useful, however, the recording of observations and defects needs to be standardized and the information entered into a database. RMC, in conjunction with District staff and technical consultants, has developed detailed guidelines for CCTV inspections and coding of CCTV observations. A full description of the recommended procedures and standards for CCTV inspection is included in the TM on Guidelines for Sewer Condition Assessment and Rehabilitation Decision Methodology included as Appendix C.

Manhole Inspection

Manhole inspection involves a visual inspection of the condition of the exterior and interior of sewer manholes. The inspection may be conducted from the ground surface ("topside" inspection) or by a person entering the manhole. The inspector notes the condition of the manhole cover, frame, walls, benching, and steps, as well as the inlet and outlet sewers (during a topside inspection, the inlet and outlet sewers can be inspected by lowering a camera on a pole to the bottom of the manhole). Manhole inspections can be done in conjunction with CCTV inspection, during sewer cleaning operations, or as a separate activity. The recommended format for manhole inspection data is also provided in the Guidelines for Sewer Condition Assessment and Rehabilitation Decision Methodology TM in Appendix C.

Smoke Testing and Dye Testing

Smoke and dye testing are used to locate RDI/I sources. Smoke testing involves blowing a non-toxic, non-staining low-pressure smoke into a manhole. The smoke travels through the adjacent pipes and into the connecting laterals. The surrounding area up to about 600 feet from the manhole is then visually inspected for smoke emissions. Smoke observed coming from manholes or from the ground indicates the presence of defects in the manholes, sewer lines, or sewer laterals. Smoke coming from roof leaders, driveway or area drains, building foundations, cleanouts, and catch basins indicate possible direct surface drainage connections to the sanitary sewer. Studies have shown that smoke testing is more effective during summer and fall months when the soil is dry and groundwater levels are lower.

Dye testing is generally used as a follow-up to smoke testing to verify possible sources of inflow. This method involves pouring a non-toxic dye into a suspect source of inflow and observing if dye can be seen flowing in nearby manholes.

1.5.2 Sewer Inspection Documentation

The District is implementing a sewer inventory, mapping, and maintenance database, named History Inventory Maintenance and Condition Assessment Database (HIMCAD), that will store, process, and report the results of sewer inspections. Using HIMCAD, logged sewer inspection history of any segment of pipe will be able to be retrieved electronically and the data used to develop condition ratings, discussed in greater detail below, that will aid in prioritizing future sewer rehabilitation projects and maintenance activities.

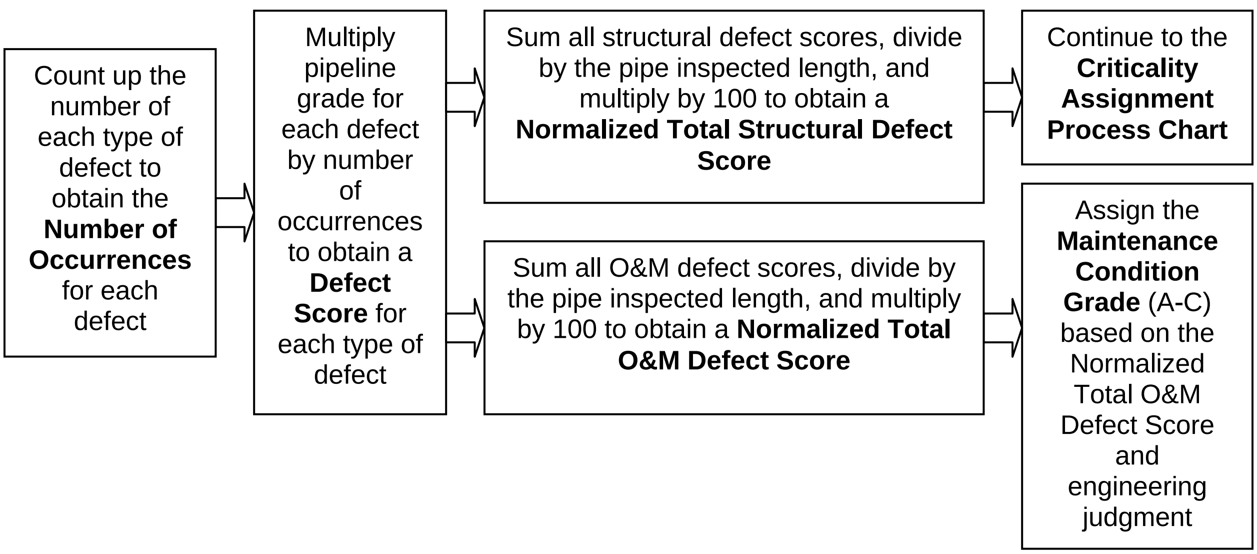
1.5.3 Condition Rating and Prioritization

Data obtained through sewer inspections is used to develop condition ratings of the pipes and to prioritize subsequent rehabilitation and/or maintenance activities. The methodology for developing condition ratings consists of quantifying the observed defects and calculating defect "scores" based on weights or grades assigned to different types of defects. A list of the defect types and recommended defect grades is available in the Guidelines for Sewer Condition Assessment and Rehabilitation Decision Methodology TM in Appendix C. The methodology for developing pipe condition ratings is described below.

Development of Normalized Defect Scores. Documentation from CCTV inspection includes the type, severity, and location (footage from the starting manhole of the inspection) of each defect or construction feature observed during the inspection. Formulas and weighting factors are used to convert the descriptive data developed as part of the pipeline coding system into general categories of pipe condition. Based on the recorded CCTV data, pipeline condition ratings can be generated automatically (i.e., programmed into HIMCAD) for each pipeline reach. Each of the pipeline defect codes (cracks, offset joints, root intrusion, protruding laterals, etc.) are assigned a condition grade from 1 to 5, with a grade of 1 meaning minor (not critical) and a grade of 5 meaning severe (requiring immediate attention). Grades are assigned based on potential for further deterioration or pipe failure. Pipe failure is defined as when the pipe can no longer convey its design capacity.

For each pipeline reach, the number of occurrences of each type of defect is multiplied by its grade to generate a score for each type of defect. The defect scores for all structural defects are summed and divided by the length of pipe inspected to generate a Normalized Total Structural Defect Score (this value is multiplied by 100 to minimize decimal numbers). This process is repeated with the operations and maintenance (O&M) defects to generate a Normalized Total O&M Defect Score. **Figure 1-5** summarizes the step-by-step process for assigning structural and O&M condition grades to pipe segments. In addition to the Normalized Total Structural and O&M Defect Scores, Peak and Mean Defect Scores are also calculated as indicators of the most severe defect occurrence and the typical condition of the pipe.

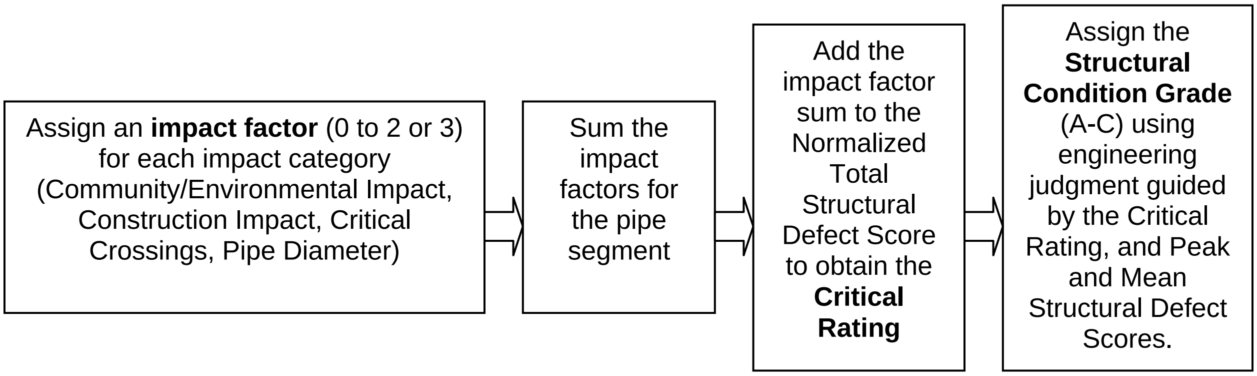
Figure 1-5 Process for Assigning Pipe Segment Structural and Maintenance Condition Grades



Structural Condition Ratings. The Normalized Total Structural Defect Score is augmented to account for the criticality of a pipe segment. Criticality defines the "risk" of failure, which reflects both the probability (based on its condition) and consequences (based on its location and importance) of failure for each segment of pipe. The impact categories used to assign criticality are community/environmental impact, construction impact, critical crossings, and pipe diameter, which reflect size of tributary area and number of customers potentially affected by a pipeline failure. Additional information on the impact categories can be found in the full TM included in Appendix C. Based on these parameters, a Total Impact Factor is calculated for each pipe segment.

The Total Impact Factor is multiplied by the Normalized Total Structural Defect Score to obtain the Critical Rating for the pipe segment. An overall Structural Condition Grade can then be assigned based on the Critical Rating, the Peak and Mean Structural Defect Scores, and engineering judgment. **Figure 1-6** summarizes the step-by-step process for assigning criticality to each pipe segment.

Figure 1-6 Process for Assigning Criticality to each Pipe Segment and Assigning Overall Structural Condition Grade



Structural Condition Grades are defined as Category A (no action required), Category B (rehabilitation or replacement should occur in the near-term, and Category C (pipe requires immediate attention). The Structural Condition Grades helps the decision makers to determine priority for rehabilitation and replacement projects.

Maintenance Condition Ratings. The Normalized Total O&M Defect Score, along with engineering and operations judgment, is used to assign each pipe segment a Maintenance Condition Grade. There are three overall Maintenance and Structural Condition Grades. Maintenance Condition Grades are defined as Category A (no change to current maintenance indicated), Category B (current maintenance practices may not be adequate and should be reviewed), and Category C (immediate or more frequent maintenance or possible rehabilitation or repair is needed). The Maintenance Condition Grades help the decision makers determine priority for changes to maintenance practices.

Manholes. A separate condition evaluation procedure is used for manholes based on results of manhole inspections. A manhole condition rating of Good, Fair or Poor is assigned to each manhole. The manhole inspection form and the full description of manhole condition ratings are provided in the full TM in Appendix C.

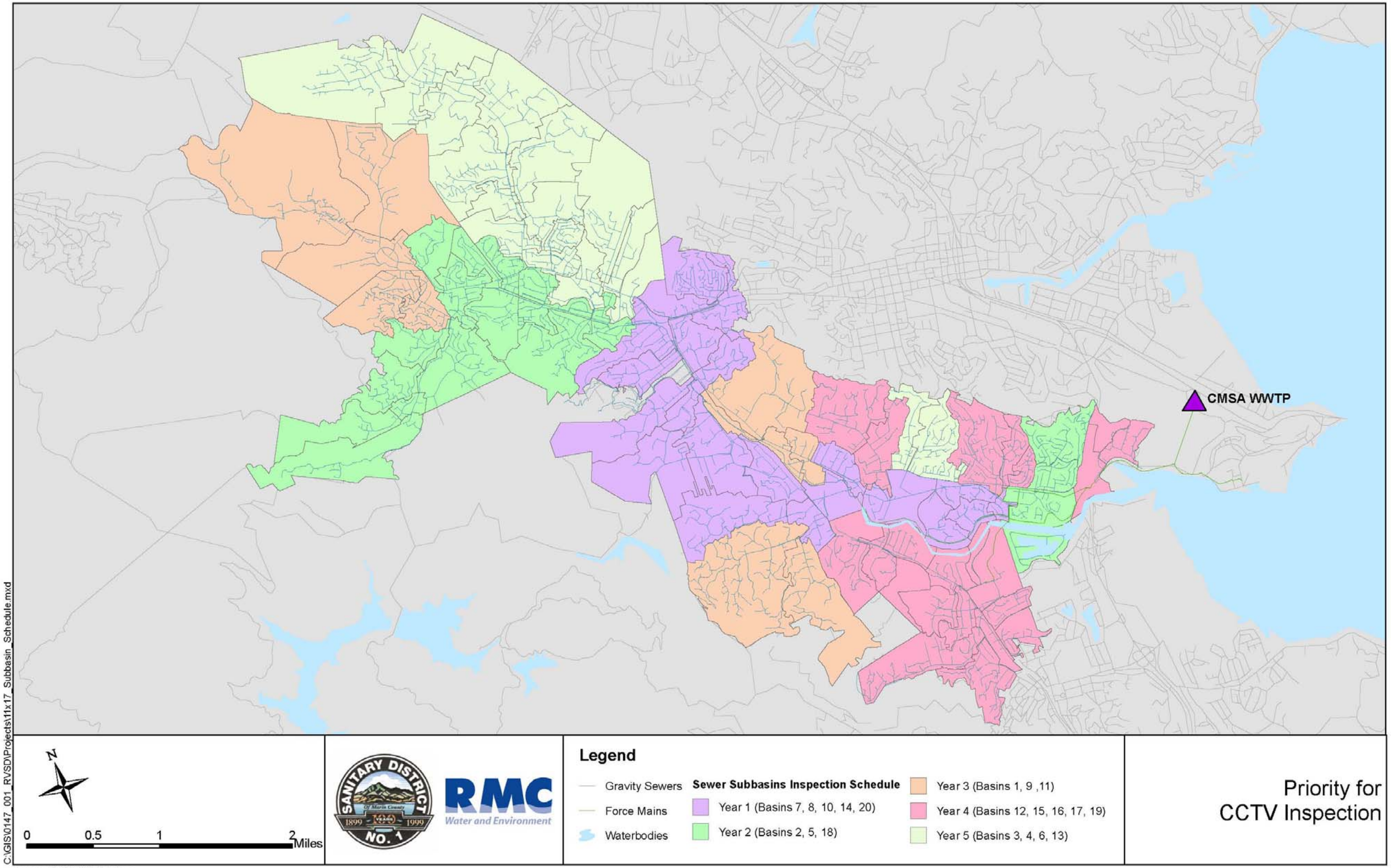
1.6 Sewer Inspection and Rehabilitation Plan

This section presents a plan for sewer system inspection and rehabilitation that is based on information gathered through SHECAP, the rehabilitation needs list, and discussions with staff, and that incorporates standardized system-wide condition assessment.

1.6.1 Prioritization of Areas for Sewer Inspection

The relative priority of projects on the District's rehabilitation needs list with respect to replacement needs for the overall system cannot be determined without a complete system assessment. Therefore, it is recommended that the District complete a full CCTV inspection of the entire system over the next 5 to 10 years. Inspection records of the entire system will provide a baseline for the District to prioritize and move forward with future rehabilitation activities. It is recommended that the pipelines for CCTV inspection be divided based on the sewer basins and subbasins identified in the SHECAP modeling efforts. **Figure 1-7** shows the delineation of the District's service area into five areas based on CCTV inspection priority.

Figure 1-7 Subbasins by CCTV Inspection Priority



Source: RVSD GIS Database

Area priority was determined roughly based on the location of sewers on the District's rehabilitation needs list, the location of known problem areas, and the magnitude of RDI/I per subbasin as determined in the SHECAP study. **Table 1-2** lists the approximate footage of pipe proposed for inspection each year, based on a 5-year inspection period.

Table 1-2 Proposed Schedule for CCTV Inspection

	Basins	Length of Pipe to be Inspected (miles)
Year 1	7, 8, 10, 14, 20	44
Year 2	2, 5, 18	39
Year 3	1, 9, 11	34
Year 4	12, 15, 16, 17, 19	38
Year 5	3, 4, 6, 13	39

1.6.2 Sewer Rehabilitation Plan

In lieu of identifying specific projects to be completed each year, the sewer replacement master plan is structured as a changing document that continually assesses and reprioritizes sewer rehabilitation and replacement projects based on system knowledge and CCTV inspection results. Implementation of such a plan would require allocation of an annual sewer rehabilitation fund that is adequate to allow rehabilitation of priority projects to meet or exceed District goals for system replacement of 2 miles per year. Rehabilitation projects would include a combination of projects identified by staff based on operational and maintenance concerns, as well as projects identified through the CCTV inspection program. This approach provides for a systematic assessment of rehabilitation priorities, yet allows for flexibility and integration of new and unforeseen projects that are critical for optimum operation of the sewer system.

1.7 Sewer Replacement Projects

The projects that have been identified for the long-term capital improvement plan (CIP) for the gravity sewer system include a combination of projects from the SHECAP study, projects from the District's existing priority replacement list, and projects that will be identified in the future based on CCTV results and condition ratings. These projects are described in the following paragraphs.

1.7.1 Priority Projects Recommended for Fiscal Year 2006-07

Based on the District's rehabilitation needs list, five high priority gravity sewer rehabilitation/replacement projects were combined with critical SHECAP projects to comprise an interim Fiscal Year 2006-07 Capital Improvement Plan. This section presents these priority projects; all costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index).

Bon Air Tunnel Inversion Liner Project

This project involved lining approximately 3,000 feet of the original 30-inch trunk sewer between Bon Air shopping center and Bon Air Road in Larkspur. The construction contract was awarded in June 2006 for a bid amount of $1,304,000 plus a 15% contingency. Construction was completed in December 2006.

Cascade Sewer

This project includes a combination of sewer rehabilitation and SHECAP projects. The sewer component will replace 3,620 feet of pipe, including a 10-inch pipe adjacent to Cascade Creek in Fairfax and other smaller diameter sewers in the vicinity, including Wood Lane. The project is currently in the design phase, with construction planned for July 1 through October 15, 2007. Construction during this time period is contingent upon obtaining permits required to work adjacent to and within Cascade Creek.

SHECAP Project No. 4 – Creek/Bolinas would upsize 4,079 feet of existing 10-inch sewer on Bolinas Road, Porteous Avenue, and Creek Road, and within a ravine parallel to and northwest of Bolinas Road. The pipe diameter would be increased to 12- or 15-inches as required to provide adequate capacity. A section of existing sewer mounted on the underside of the Creek Road Bridge would also be replaced.

Winship Park/Sir Francis Drake/Shady Lane

This project would replace substandard sewer pipelines along Sir Francis Drake Boulevard in San Anselmo and in the Winship Park area of Ross. The project is recommended to be combined with SHECAP Project No. 10 – Sir Francis Drake/Winship and Project No. 12 – Upper Shady Lane Trunk Sewer, which would increase the capacity of existing sewers in adjacent sections of Sir Francis Drake Boulevard, Bolinas Avenue, and Shady Lane. The combined projects would replace approximately 19,400 feet of sewer pipelines.

Sequoia Park/Olive Avenue/Tozzi Creek Crossing

This project would replace approximately 22,000 feet of sewer pipeline near Sequoia Road in San Anselmo, and Olive Avenue and Park Drive in Ross.

Olive-Walnut/North-Hill/Holcomb-Monte Vista/San Anselmo Ave./Hickory/Cypress

This project would replace sewers with maintenance issues in nine streets at various locations in the District's service area. The project would include approximately 11,000 feet of sewer replacement.

The estimated capital costs for these recommended sewer rehabilitation projects are presented in Table 1-3**.** All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index).

Table 1-3 FY2006-07 Sewer & SHECAP Rehabilitation Projects

Description[a]	Estimated Capital Cost
Bon Air Tunnel (construction cost only)	$ 1,304,000
Cascade Creek /Wood Lane combined with SHECAP No. 4 – Creek/Bolinas	$ 1,358,000[a] $ 1,679,000[b]
Winship Park Sewer combined with SHECAP No. 10 – Sir Francis Drake/Winship and SHECAP No. 12 – Upper Shady Lane	$ 4,156,000[a] $ 1,892,000[b]
Sequoia Park and Sequoia Collection System/Olive Avenue/Tozzi Creek Crossing	$ 6,374,000
Olive-Walnut/North-Hill/Holcomb-Monte Vista/San Anselmo Ave./Hickory/Cypress	$ 3,387,000

a. Rehabilitation project cost
b. SHECAP project cost

1.7.2 Capacity Improvement Projects and Estimated Costs

The SHECAP capacity improvement projects are listed in **Table 1-4** with their estimated capital costs and suggested time frame for implementation as identified in the SHECAP study. It is expected that these capacity projects would comprise a portion of each year's capital improvement program, with the remainder of the program comprised of rehabilitation projects described in Section 1.7.1 and new projects identified by the system CCTV inspection. SHECAP Project No. 4, No. 10, and No. 12 are recommended for acceleration as part of the Fiscal Year 2006-07 CIP, as discussed in Section 1.7.1. All projects, including pump station and force main improvements, will be further prioritized based on criteria developed for the District's long-term strategic CIP (TM CIP-4). All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index).

Table 1-4 SHECAP Projects and Costs

Project No.	Description[a]	Estimated Capital Cost[b]	Priority[c]
1	Westbrae / Hawthorne	$ 425,000	19
2	Spruce / Park / Merwin / Broadway	$ 1,754,000	8
3	Cascade	$ 573,000	11
4	Creek / Bolinas	$ 1,679,000	9
5	Upper Butterfield	$ 1,586,000	10
6	Lower Butterfield / Meadowcroft / Broadmoor / SFDB	$ 1,985,000	13
7	The Alameda / Brookmead	$ 766,000	16
8	Sonoma / Nokomis	$ 1,789,000	14
9	Miracle Mile	$ 1,747,000	4
10	Sir Francis Drake / Winship	$ 977,000	3
11	Bolinas / Fernhill	$ 1,077,000	17
12	Upper Shady Lane Trunk Sewer	$ 915,000	2
13	Sir Francis Drake / Berry	$ 472,000	20
14	Goodhill	$ 769,000	5
15	Woodland / College	$ 1,309,000	6
16	Kentfield Relief Sewer	$ 1,001,000	1
17	Laurel Grove / McAllister	$ 951,000	12
18	Manor Easement	$ 339,000	21
19	William / Holcomb / Meadowood	$ 1,306,000	7
20	Magnolia	$ 838,000	15
21	Eliseo	$ 66,000	18
	TOTAL	**$22,324,000**	

a. See SHECAP report for project details.
b. Costs are indexed to August 2006 San Francisco ENR CCI of 8464.
c. Priorities 1 through 9 are recommended for implementation in 5-year time frame; remaining projects in 10-year time frame.

1.7.3 Long-term Sewer Rehabilitation Projects and Estimated Costs

District staff maintains on ongoing list of sewer rehabilitation needs, and identified critical projects from this list and system knowledge that were included in the Fiscal Year 2006-07 CIP, as discussed in Section 1.7.1. In addition to the Fiscal Year 2006-07 projects, staff has identified two specific rehabilitation projects that should be included as components of the 10-year CIP: Redhill Sewer Improvements and Hillside Sewer Improvements. These projects rehabilitate 1,677 and 3,489 lineal feet, respectively, of sewer pipelines with known maintenance issues. Estimated capital cost for the Redhill Sewer Improvements project is $545,000, and for the Hillside Sewer Improvements project is $1,134,000.

In addition to the initial projects identified for the interim and long-term capital improvement plans, the District should identify additional rehabilitation and replacement projects based on the results of CCTV inspection and previously identified problem areas, and budget for replacement of a reasonable percentage of its system each year. If it is assumed that the typical useful life of a sewer pipeline is approximately 100 years, then replacement of one percent of the system per year would be a reasonable basis for sewer rehabilitation budgeting. However, the District's system is substantially older and, as a result has greater rehabilitation needs than most systems. Therefore, a more aggressive rate of replacement, two percent per year, is recommended to address the backlog of required projects. In future years, as gravity sewer maintenance issues decrease as confirmed by reduced SSOs and CCTV inspections, this rate could be reduced to one percent.

Based on the above recommendations, it is suggested that an annual budget of $3 to $6 million be allotted for sewer rehabilitation. This budget would provide for replacement of up to two percent (4 miles) of the gravity sewer system per year. In addition, approximately $400,000 per year over the next 5 years should be budgeted for the baseline CCTV inspection of the entire system.

Chapter 2 Force Main Master Plan

This chapter presents the master plan for the force main system. The master plan addresses the improvement needs of the force main system with respect to existing pipe condition, hydraulic capacity, and remaining useful life. The Force Main Master Plan was developed based on review of previous studies and plans, an external corrosion assessment, and discussion with District staff regarding force main trouble areas.

The Force Main Master Plan identifies immediate system improvement needs, presents associated projects and cost estimates, and identifies critical project issues that may drive the schedule for implementation.

2.1 Background and Purpose of Force Main Master Plan

The objective of the Force Main Master Plan is to assess existing pipe condition, capacity, and remaining useful life, and develop a prioritized program of rehabilitation and replacement for the District.

2.2 Force Main System Description

The District's wastewater collection system includes 24 force mains from 20 pump stations that convey wastewater under pressure to the CMSA WWTP. The force main system, installed between 1959 and 1989, is a critical component of the District's wastewater infrastructure. Continuous operation and reliability of the force mains are required to convey sewage flow from the District's gravity collection system. A failure of one or more force mains may result in the need to halt pumping upstream of the failed pipe, thereby increasing the potential for release of sewage through sanitary sewer overflows (SSOs) in the gravity system, or in uncontrolled releases of wastewater from the failed pipeline.

2.2.1 Force Mains

The District's force mains are comprised of various pipeline materials including asbestos cement (AC), ductile iron (DI), high density polyethylene (HDPE), Techite, reinforced concrete cylinder (RCCP), and cement mortar lined and coated welded steel (WS L/C). Three of the WS L/C force mains, FM-10, FM-13, and FM-14, have sections that are cathodically protected by buried magnesium anodes. A map of the District's force mains and pump stations is presented in **Figure 2-1**. **Figure 2-2** provides a detail of the force main junctions in the area near South Eliseo Drive. **Table 2-1** presents and compares force main characteristics, and lists whether as-built information is available for the pipeline. A general description of each force main follows **Table 2-1;** force mains are categorized in the same manner as their associated upstream pump stations: major, minor, and from lift stations. Major force mains are connected to major pump stations and convey wastewater through a common force main to the CMSA WWTP. Minor force mains transport wastewater from smaller pump stations, which pump into gravity sewers or into another force main.

Figure 2-1 RVSD Pump Stations and Force Mains

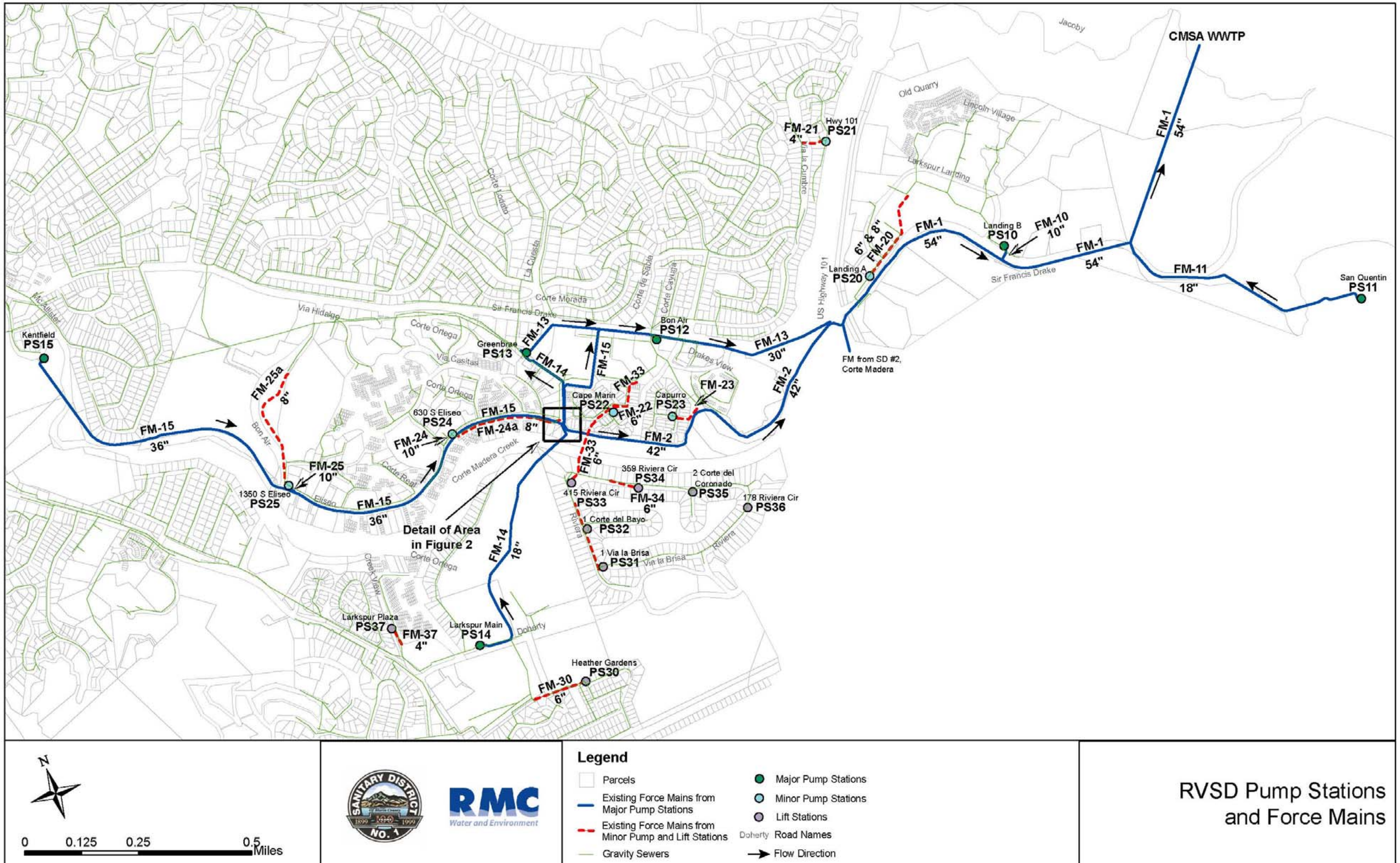


Figure 2-2 Detail of Area near South Eliseo Drive

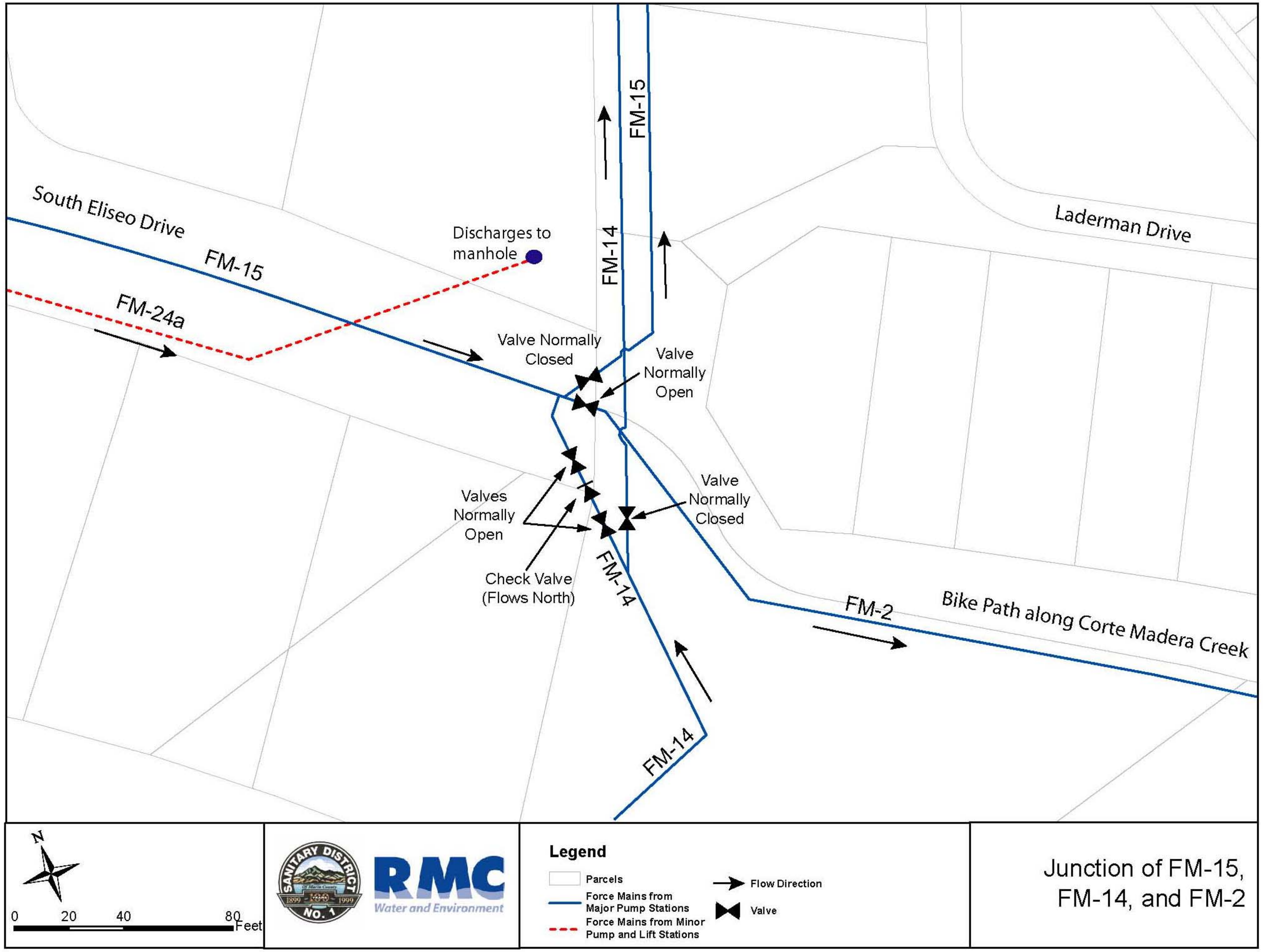


Table 2-1 Ross Valley Sanitary District Force Main Information

FM No.	Force Main Name	PS or FM Discharging into FM	Dia. (in) [a]	Length (feet)	Pipe Material [b]	Location	Installation Date	As-Builts
Force Mains from Major Pump Stations								
FM-1	Ross Valley Interceptor	FM-2, FM-13, FM-10, FM-11, FM from SD#2 (Corte Madera)	54"	2,550	RCCP	From FM-2 to FM-10	1983	Yes
			54"	1,550	RCCP	From FM-10 to San Quentin FM	1983	Yes
			54"	2,550	RCCP	From San Quentin FM to CMSA WWTP	1983	Yes
FM-2	Greenbrae Kentfield Relief FM	FM-14, FM-15	42"	4,267	RCCP	Along Corte Madera Creek Path to FM-1	1987	Yes
FM-10	Landing B FM	PS-10	10"	210	WS L/C	Crossing E Sir Francis Drake Blvd. to FM-10	1983	Yes
FM-11	San Quentin FM	PS-11	18" OD	3,088	HDPE	From San Quentin Prison to FM-1	1984	Yes
FM-12	Bon Air FM	PS-12	8"	25	WS L/C	Crossing Sir Francis Drake Blvd. to FM-13	1984	Yes
FM-13	Greenbrae FM	PS-13	24"	49	WS L/C	Greenbrae PS to connection with FM-13	1983	Yes
			30"	954	RCCP	From easement at Bon Air Shopping Center to connection with FM-15	1959	Yes
			30"	668	WS L/C	From FM-15 along Sir Francis Drake to Bon Air Pump Station	1959	Yes
			30"	1,600	WS L/C	Sir Francis Drake Blvd. from Bon Air PS to Hwy 101 crossing	1959	Yes
			30"	528	WS L/C	Hwy 101 crossing to connection with FM-2	1959	Yes
FM-14	Larkspur FM	PS-14	18"	50	DI	At Larkspur Pump Station	Unknown	No
			20" OD	1,000	HDPE	From Doherty Dr. and Piper Park to Pipe Bend	1988	Yes
			20" OD	2,210	HDPE	From bend to fork near South Eliseo Drive	1989	Yes
			20" OD	72	HDPE	Unknown	1989	Yes
			18"	1,146	WS L/C	From junction of FM-15 to PS-13	1989	No
FM-15	Kentfield FM	PS-15	36"	3,845	Techite	From PS15 to PS25 on Corte Madera Creek Path	1972	Yes
			36"	2,355	Techite	From PS25 to PS24 on S Eliseo Dr.	1972	Yes
			36"	20	WS L/C	Just upstream of FM-24	1989	Yes
			36"	1,314	Techite	From PS24 to Junction of FM-2 on S Eliseo Dr.	1972	Yes
			36"	1,452	Techite	From South Eliseo Drive to Bon Air Shopping Center through Easement	1972	Yes
			Total Major	31,503				
Force Mains from Minor Pump and Lift Stations								
FM-20	Landing A FM	PS-20	6"	300	PVC	East of Sir Francis Drake Blvd.	1978	No
			8"	788	PVC	Along Larkspur Landing Shopping Center	1978	No
FM-21	Hwy 101 FM	PS-21	4"	279	DI	Along Easement	1957	No
FM-22	Cape Marin FM	PS-22	6"	56	PVC	Laderman Lane junction to FM-33	1987	Yes
FM-23	Capurro FM	PS-23	6"	386	PVC	Laderman Lane	1989	No
FM-24	630 S Eliseo FM	PS-24	10"	48	WS L/C	From PS24 to FM-15	1989	Yes
FM-24a	Alternative Force Main	PS-24	10"	28	WS L/C	Junction of new FM to Kentfield	1961	No
			8"	35	WS L/C	Connection to 6" ACP line	Unknown	No
			8"	710	ACP	Along South Eliseo Drive to gravity sewer	1961	No
FM-25	1350 S Eliseo FM	PS-25	10"	177	DI	From PS25 to FM-15	1991	Yes

FM No.	Force Main Name	PS or FM Discharging into FM	Dia. (in) [a]	Length (feet)	Pipe Material [b]	Location	Installation Date	As-Builts
FM-25a	Alternative Force Main	PS-25	8”	50	DI	North of PS25 on Bon Air Road	1991	Yes
			8”	257	ACP	Along Bon Air Road	1964	Yes
			8”	18	DI	Along Bon Air Road	1985	Yes
			8”	850	HDPE	Along Bon Air Road	1985	Yes
			8”	18	DI	Along Bon Air Road	1985	Yes
			8”	162	ACP	Along Bon Air Road	1964	Yes
FM-30	Heather Gardens FM	PS-30	6”	643	Unknown	From PS30 to gravity sewer along easements	Unknown	No
FM-31	1 Via La Brisa FM	PS-31	6”	464	ACP	Rivera Circle	1968	No
FM-32	1 Corte Del Bayo FM	PS-32	6”	319	ACP	Rivera Circle	1968	No
FM-33	415 Rivera Circle FM	PS-33	6”	245	HDPE	From PS on Rivera Circle to creek along property boundary (replaced 1966 WS L/C pipe in 1999)	1985	Yes
			6”	50	Rubber Hose	South side of creek crossing	1966	Yes
			6”	200	WS L/C	Creek crossing	1966	Yes
			6”	50	Rubber Hose	North side of creek crossing	1966	Yes
			6”	55	WS L/C	Connection to PVC line	1966	Yes
			6”	496	PVC	To Junction with PS22 along Laderman Lane	1987	No
			6”	535	PVC	Laderman Lane, Gregory Place	1987	No
FM-34	359 Riviera Circle FM	PS-34	6”	389	PVC	Rivera Circle (replacement in 2001)	1966	Yes
FM-35	2 Corte del Coronado FM [c]	PS-35	Small [d]	Very Short	Unknown	Rivera Circle	1966	No
FM-36	178 Riviera Circle FM [c]	PS-36	Small [d]	Very Short	Unknown	Rivera Circle	1966	No
FM-37	Larkspur Plaza FM [c]	PS-37	4”	Very Short	Unknown	Larkspur Plaza	1966	No
			Total Minor	7,548				

Footnotes:

a. All diameters are inner diameter unless noted as outer diameter (OD).
b. Material Abbreviations: ACP – Asbestos Cement Pipe, DI – Ductile Iron, HDPE – High Density Polyethylene, PVC – Polyvinyl Chloride, RCCP – Reinforced Concrete Cylinder Pipe, WS L/C – Cement mortar lined and coated welded steel.
c. Not a “typical” force main. Pump stations 35 to 37 are small “neighborhood” pump stations. The length of buried pressure pipe is approximately 3 to 5 feet. Information on pipe material is not available.
d. Information on diameter is not available. Diameter is probably 3-inch to 4-inch.

2.2.2 Force Mains from Major Pump Stations

Major force mains convey flow under pressure from major pump stations, which discharge directly to the large-diameter pipeline system leading to the CMSA WWTP. These force mains are labeled FM-1 through FM-15.

- **Ross Valley Interceptor (FM-1)** – This 6,700 foot long, 54-inch diameter RCCP pipeline receives wastewater from the Greenbrae Kentfield Relief FM (FM-2) and Greenbrae FM (FM-13) at the Highway 101 crossing and continues along Sir Francis Drake Blvd to San Quentin Ridge. FM-1 then crosses through San Quentin Ridge to the CMSA WWTP via a 54-inch diameter tunnel. FM-1 also receives wastewater from Sanitation District #2 (Corte Madera), which is sent to the CMSA WWTP.
- **Greenbrae Kentfield Relief (FM-2)** – This 4,200 foot long 42-inch diameter RCCP pipeline receives flow from the Kentfield FM (FM-15) and Larkspur Main FM (FM-14). Valving at the upstream end of FM-2, as shown in **Figure 2-2**, allows flow to be detoured to the Greenbrae FM (FM-13).
- **Landing B (FM-10)** – This 200 foot long 10-inch diameter WS L/C pipeline crosses under Sir Francis Drake Boulevard to connect Landing B Pump Station (PS-10) to FM-1.
- **San Quentin (FM-11)** – This 3,100 foot long, 18-inch outer diameter HDPE pipeline conveys wastewater from the San Quentin Prison and San Quentin Village to FM-1. FM-11 connects to FM-1 at a junction box located immediately south of the tunnel through San Quentin Ridge.
- **Bon Air (FM-12)** – This 25 foot long, 8-inch diameter WS L/C pipeline connects the Bon Air Pump Station (PS-12) to the Greenbrae FM (FM-13).
- **Greenbrae (FM-13)** – A 2,800 foot long, 30-inch diameter WS L/C pipeline that includes a 1,000 foot section of 30-inch diameter RCCP pipe and a 50 foot section of 24-inch diameter WS L/C pipe. Constructed in 1959, FM-13 is the first force main that was installed by the District.
- **Larkspur (FM-14)** – A 3,200 foot long, 20-inch outer diameter HDPE pipeline combined with a 50 foot section of DI pipe and approximately 1,100 feet of WS L/C pipe. FM-14 crosses beneath Corte Madera Creek and is normally valved to discharge to the Greenbrae Kentfield Relief FM (FM-2). However, FM-14 can also be valved to the downstream portion of the Kentfield FM (FM-15), which flows into the Greenbrae FM (FM-13), or to continue via the downstream portion of FM-14 to the Greenbrae Pump Station (PS-13). Valving options are shown in **Figure 2-2.**
- **Kentfield (FM-15)** – This 9,000 foot long, 36-inch Techite pipeline was installed in 1972. In addition to the Techite section, FM-15 includes a 20-foot length of WS L/C pipe that was installed in 1989. During normal operations, wastewater flows from FM-15 directly to FM-2. FM-15 can also valved to divert flow to the Greenbrae FM (FM-13), as shown in **Figure 2-2**.

2.2.3 Force Mains from Minor Pump and Lift Stations

Minor force mains transport wastewater from smaller pump stations, which discharge back into gravity sewers or into other force mains. FM-20 through FM-25a are designated as minor force mains.

- **Landing A (FM-20) –** This force main, comprised of a 300 foot section of 6-inch diameter PVC pipe and 800 feet of 8-inch diameter of PVC pipe, conveys wastewater from Landing A Pump Station (PS-20) and discharges to a gravity sewer which flows to Landing B Pump Station (PS-10).
- **Highway 101 (FM-21) –** This 279 foot long, 4-inch diameter DI pipeline is over 50 years old and discharges to a gravity sewer in Via la Cumbre Street.
- **Cape Marin (FM-22) –** This 56 foot long, 6-inch diameter PVC pipeline installed in 1987 discharges to FM-33, and serves portions of the Drakes Landing development south of the Bon Air shopping center.

- **Capurro (FM-23)** – This 386 foot long, 6-inch diameter PVC pipeline discharges to a gravity sewer that ultimately leads to the Bon Air PS (PS-12).
- **630 South Eliseo (FM-24)** – This 48 foot long, 10-inch diameter WS L/C pipeline conveys wastewater from PS-24 to the Kentfield FM (FM-15). FM-24 is located on the corner of South Eliseo Drive and Bon Air Road.
- **630 S. Eliseo Alternative (FM-24a)** – A 700 foot long, 8-inch diameter AC pipe with a 35 foot section of 8-inch diameter WS L/C pipe and a 28 foot section of 10-inch diameter WS L/C pipe. FM-24a is connected to PS-24, but is not used during normal operations. FM-24a discharges into a gravity sewer that leads to the trunk sewer upstream of the Greenbrae PS, and can be used to reduce the amount of wastewater being discharged to the Kentfield FM.
- **1350 S. Eliseo (FM-25)** – This 120 foot long. 10-inch diameter DI pipeline delivers wastewater from the South Eliseo Pump Station (PS-25) to the Kentfield FM.
- **1350 S. Eliseo Alternative (FM-25a)** – A 1,355 foot long 8-inch diameter pipeline comprised of various materials: DI, HDPE, and AC. FM-25a is only used during emergency events, and diverts wastewater north along Bon Air Road to gravity sewers that ultimately flow to the Greenbrae PS (PS-13).
- **Heather Gardens (FM-30)** – This 600 foot long, 6-inch diameter pipe of unknown material discharges from the Heather Gardens PS (PS-30) to gravity sewers that flow to the Larkspur Main PS (PS-14).
- **1 Via La Brisa (FM-31)** – This 500 foot long, 6-inch diameter AC pipe conveys flow between the Via la Brisa (PS-31) and Corte del Bayo (PS-32) pump stations.
- **1 Corte del Bayo (FM-32)** – This 300 foot long, 6-inch diameter AC pipe conveys flow between PS-32 and the 415 Riviera Circle PS (PS-33).
- **415 Riviera Circle (FM-33)** – This 1,600 foot long, 6-inch diameter force main conveys flow under Corte Madera Creek to a gravity sewer and leads to Bon Air PS. The section of HDPE pipe from 415 Riviera Circle PS (PS-33) north to Corte Madera Creek was installed in 1999. The creek crossing consists of 20 feet of rubber hose on each side of 200 feet of WS L/C pipe. 1,000 feet of PVC pipe completes the alignment north of the creek crossing.
- **359 Riviera Circle (FM-34)** – This 389 foot long, 6-inch diameter PVC pipeline was replaced in 2001. This force main serves the Greenbrae Marina area and discharges into a gravity sewer that leads to PS-33.
- **2 Corte del Coronado (FM-35**) – A 3 to 5 foot long pipe of unknown material that discharges into a nearby gravity sewer.
- **178 Riviera Circle (FM-36) –** A 3 to 5 foot long pipe of unknown material that serves the Greenbrae Marina area.
- **Larkspur Plaza (FM-37)** – This 4-inch diameter force main of unknown length discharges wastewater to a gravity sewer in the Larkspur Plaza development, which eventually discharges to the Larkspur Main PS (PS-14).

2.3 Approach to Force Main Replacement Master Plan Development

Development of the Force Main Replacement Master Plan included the following tasks:

- Review of previous studies and plans to understand the history, past performance, and capacity limitations of existing force mains
- External corrosion assessment to assess the potential for external corrosion in order to identify force main segments that could be structurally compromised due to inadequate cathodic protection. This assessment included:

- Pipe-to-Soil Potential Survey
- Electrical Continuity Survey
- Soil Resistivity Survey

- Discussions with RVSD staff regarding force main trouble areas
- Identification of required projects
- Development of preliminary cost estimates
- Evaluation of relative project priority

2.3.1 Review of Previous Studies and Plans

Two reports were reviewed as a part of the force main system evaluation. This section summarizes the conclusions and recommendations presented in each report.

Force Main Improvement Program, Nute Engineering, May 1998

This report incorporated findings from three investigations completed in 1990 and 1993:

- Ross Valley Sanitary District 42" Greenbrae Kentfield Relief Force Main, 30" Greenbrae Force Main, 12" Pump Station B Force Main, & Ross Valley Interceptor, Phase II – Corrosion Analysis, Corrosion Engineering and Research Company, 1993;
- Ross Valley Sanitary District Collection System Corrosion Evaluation, Corrosion Engineering and Research Company, 1990; and
- Techite Force Main Evaluation Report, B. Jay Schrock, P.E., JSC International Engineering, April 11, 1990.

The evaluation by Nute represents the most recent force main condition assessment completed for the District. All of the force mains in the District were examined, and the study identified the Kentfield FM (FM-15) as high priority for replacement due to its material, age, and proximity to sensitive environmental habitat. FM-15 is constructed of a fiberglass pipe commonly known as "Techite," which is known to fail catastrophically. The report recommended that this line be carefully monitored, particularly with respect to any changes in operation. In addition to addressing FM-15, the study recommended improvements for two additional force main pipelines. The Greenbrae FM (FM-13) is a WS L/C pipe that is nearly 50 years old and experiencing corrosion. In light of its age and condition, FM-13 is recommended for rehabilitation using inversion lining. Also, the 415 Riviera Circle Force Main (FM-33), comprised of a combination of rubber sewerage hose and WS L/C pipe, crosses below Corte Madera Creek. This pipeline is particularly vulnerable to damage from corrosion and also from dredging. The Nute evaluation recommended replacement of the pipe crossing with a non-corrosive pipe material. Other force main conclusions and recommendations are described in the report, which can be found in Appendix D.

Sanitary Sewer Hydraulic Evaluation and Capacity Assurance Plan, MWH, August 2006

This recently-completed hydraulic evaluation modeled the District's larger trunk sewers, major pump stations and force mains, and identified potential locations that required additional capacity. SHECAP evaluated system capacity under a 5-year storm event. **Table 2-2** summarizes the major force mains that were examined by SHECAP. SHECAP results indicate that the hydraulic capacity of the majority of the District's force mains is sufficient. However, the size of the 36-inch Kentfield Force Main limits the ability of the Kentfield Pump Station to pump to its design capacity, which is adequate to handle the projected design storm peak wet weather flow. Therefore, the study recommends that the Kentfield FM (FM-15) be upsized in order to adequately convey design flows. SHECAP study included 5-year Design Storm Peak Flows for seven pump stations. For this report, the Peak Flows for the seven pump stations were converted to velocities for the adjoining force mains based on the force main diameters. The velocity values are also included in **Table 2-2**.

Table 2-2 SHECAP Hydraulic Analysis Results

Force Main	Diameter (in.)	Peak Flow (mgd) [a, b]	Velocity (fps) [c]	Comment [c]
FM-10	10	1.1	3.1	Adequate
FM-11	18	1.7	1.5	Adequate
FM-12	8	1.9	8.5	FM is short (25 feet) therefore it does not require increasing pipe size
FM-13	24	5.5	2.7	Adequate
FM-14	18	8.6	7.6	Adequate
FM-15	36	39.0	8.5	Undersized, increase pipe size to 39" diameter or equivalent
FM-24	10	0.4	1.1	Adequate
FM-25	10	0.7	2.0	Adequate

Footnotes:

a. For this analysis, peak flow equals peak unimpeded flow, which is the flow in the force main assuming the pump station is large enough to pump the peak 5-year storm design flow generated by the collection system without backing up into the collection system.

b. Completed as part of the SHECAP study.

c. Completed as part of this Master Plan study.

2.3.2 External Corrosion Assessment

A review of existing plans and previous studies identified 27 electrolysis test stations, casing test stations, and/or insulating flange test stations on seven of the District's force mains (FM-1, FM-2, FM-10, FM-13, FM-14, FM-15, and FM-24). Test station locations are shown on **Figure 2-3**

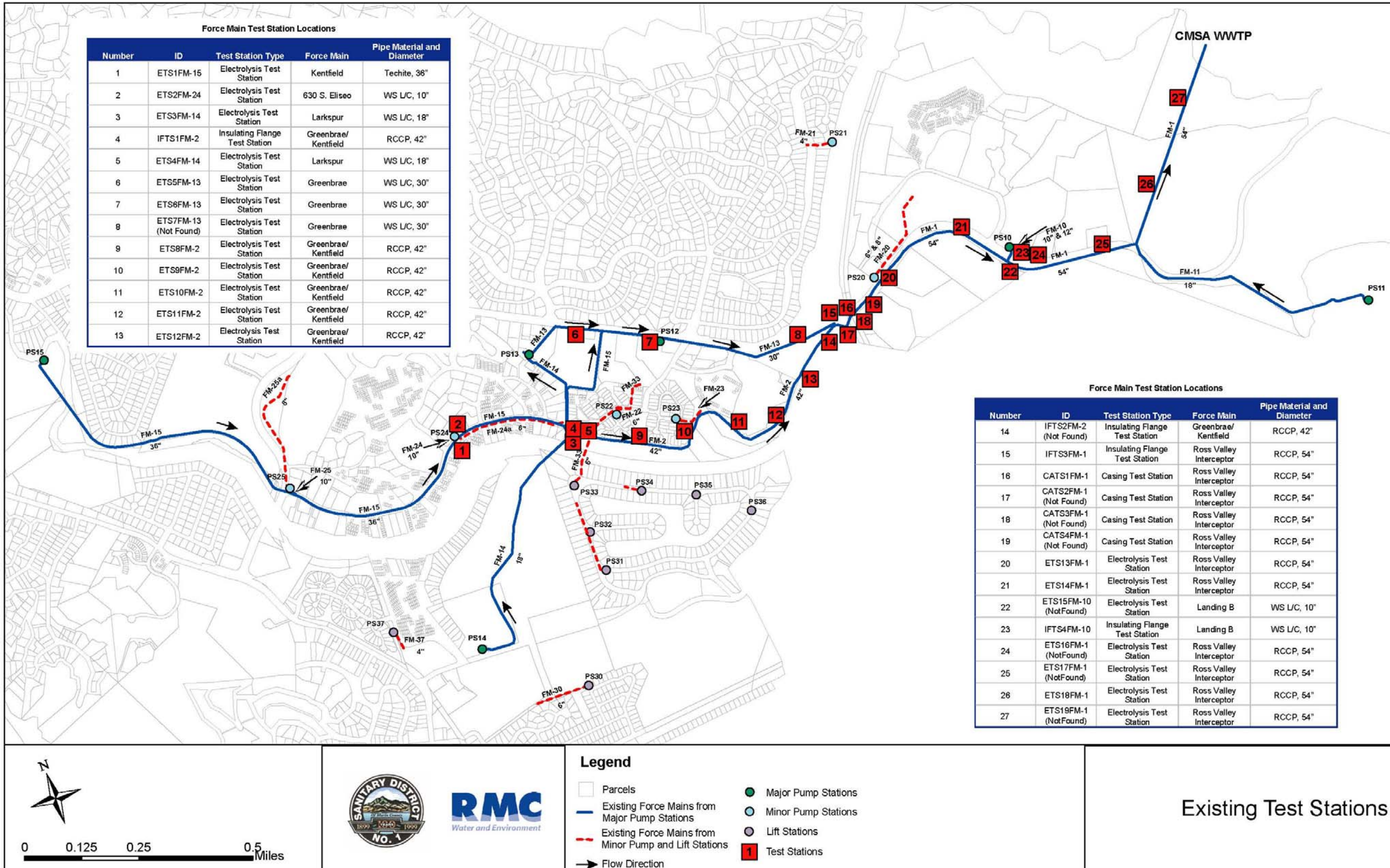
Field measurements and inspections at each of these test stations were conducted and documented in External Corrosion Condition Assessment, Corrpro Companies, November 2006. Results and recommendations from these assessments are provided in this section.

Corrosion Assessment Approach

During April and May 2006, Corrpro Companies, Inc. (Corrpro) conducted an external corrosion assessment of the force mains containing existing test stations. These pipelines consisted of WS L/C and RCCP. This purpose of the investigation was to determine the relative corrosivity of the environment in the area surrounding each pipeline, to assess electrical continuity of adjacent pipeline segments, and provide a report on the findings. Field testing activities included the following tasks:

- Task 1: Pipe-to-Soil Potential Survey
- Task 2: Electrical Continuity Survey
- Task 3: Soil Resistivity Survey

Figure 2-3 Ross Valley Sanitary District Test Station Locations



Force Main Test Station Locations

Number	ID	Test Station Type	Force Main	Pipe Material and Diameter
1	ETS1FM-15	Electrolysis Test Station	Kentfield	Techite, 36"
2	ETS2FM-24	Electrolysis Test Station	630 S. Eliseo	WS L/C, 10"
3	ETS3FM-14	Electrolysis Test Station	Larkspur	WS L/C, 18"
4	IFTS1FM-2	Insulating Flange Test Station	Greenbrae/ Kentfield	RCCP, 42"
5	ETS4FM-14	Electrolysis Test Station	Larkspur	WS L/C, 18"
6	ETS5FM-13	Electrolysis Test Station	Greenbrae	WS L/C, 30"
7	ETS6FM-13	Electrolysis Test Station	Greenbrae	WS L/C, 30"
8	ETS7FM-13 (Not Found)	Electrolysis Test Station	Greenbrae	WS L/C, 30"
9	ETS8FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"
10	ETS9FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"
11	ETS10FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"
12	ETS11FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"
13	ETS12FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"

Force Main Test Station Locations

Number	ID	Test Station Type	Force Main	Pipe Material and Diameter
14	IFTS2FM-2 (Not Found)	Insulating Flange Test Station	Greenbrae/ Kentfield	RCCP, 42"
15	IFTS3FM-1	Insulating Flange Test Station	Ross Valley Interceptor	RCCP, 54"
16	CATS1FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"
17	CATS2FM-1 (Not Found)	Casing Test Station	Ross Valley Interceptor	RCCP, 54"
18	CATS3FM-1 (Not Found)	Casing Test Station	Ross Valley Interceptor	RCCP, 54"
19	CATS4FM-1 (Not Found)	Casing Test Station	Ross Valley Interceptor	RCCP, 54"
20	ETS13FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
21	ETS14FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
22	ETS15FM-10 (NotFound)	Electrolysis Test Station	Landing B	WS L/C, 10"
23	IFTS4FM-10	Insulating Flange Test Station	Landing B	WS L/C, 10"
24	ETS16FM-1 (NotFound)	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
25	ETS17FM-1 (NotFound)	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
26	ETS18FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
27	ETS19FM-1 (NotFound)	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"

Task 1 Pipe-to-Soil Potential Survey

Corrpro located and performed pipe-to-soil potential surveys at 19 of the 27 documented test stations. The objective of the pipe-to-soil potential survey was to determine the relative corrosivity of soil surrounding each pipeline, and identify areas of concern where pipeline corrosion may have occurred. Corrpro compared measured data with archive data collected in 1990 and 1992. Results from the recent survey, combined with observations drawn from 1990 and 1992 data, are summarized in **Table 2-3** and presented in detail in the Corrpro report contained in Appendix E.

The rate of corrosion can vary widely with soil characteristics and other factors, such as moisture content, temperature, etc. However, the progression of corrosion can be monitored by documenting potential survey data and may be classified into stages using ASTM C-876, Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete. The results from this standard test method can be used to describe the relationship between the pipe-to-soil potential and the corrosion activity of embedded steel from electrolysis test stations and from pipes not connected to an anode. The pipe-to-soil potential survey measures the DC voltage between each test station lead wire and a portable copper/copper-sulfate reference electrode (CSE) contacting moist soil within or adjacent to the electrolysis test station (ETS) traffic box. Corrosion activity of steel in concrete (or mortar) using ETS measurements has been defined in ASTM C-876 as follows:

- If the pipe-to-soil potentials over an area are more positive than -200 mV from the CSE, there is greater than 90% probability that no steel corrosion is occurring in that area at the time of the measurement
- If the pipe-to-soil potentials over an area are in the range of -200 to -350 mV from the CSE, corrosion activity of the steel in that area is uncertain
- If the pipe-to-soil potentials over an area are more negative than -350 mV from the CSE, there is greater than 90% probability that steel corrosion is occurring in that area at the time of the measurement

Where an insulating flange test station (IFTS) was installed and could be found, the pipe-to-soil potential was taken on each side of the insulating flange to determine electrical isolation. The two sides of the flange are electrically isolated when the two pipe-to-soil potentials are different. A larger difference in potential indicates better isolation.

Where the casing test stations (CATS) were installed and could be located, the electrical isolation between the pipe and the casing was also confirmed by dissimilar pipe-to-soil potentials. **Table 2-3** lists the two pipe-to-soil potentials for CATS and IFTS, therefore indicating if there is electrical isolation.

In general, pipe-to-soil potentials increased from 1990 to 2006. This is most clearly shown with the Greenbrae Kentfield Relief Force Main (FM-2). As the pipe-to-soil potentials increase (become more negative), it is more likely that corrosion is occurring.

Table 2-3 Summary of Results from Pipe-to-Soil Potential Survey

Figure 2-3 Loc.	Test Station Type [a]	Force Main	Pipe Diameter & Material	Pipe-to-Soil Potential (-mV)			Comments from 2006 Survey
				1990 Survey	1992 Survey	2006 Survey	
1	ETS	Kentfield (FM-15)	36" WS L/C [b]	N/A	N/A	549	>90% probability corrosion is occurring in area
2	ETS	630 S. Eliseo (FM-24)	10" WS L/C	N/A	N/A	617	>90% probability corrosion is occurring in area
3	ETS	Larkspur (FM-14)	18" WS L/C	N/A	N/A	570	>90% probability corrosion is occurring in area
4	IFTS	Greenbrae Kentfield Relief (FM-2)	42" RCCP	470	553, 617	568, 641	Electrical isolation confirmed, but there is >90% probability corrosion is occurring upstream and downstream of the flange
5	ETS	Larkspur (FM-14)	18" WS L/C	N/A	N/A	309	Corrosion activity is uncertain
6	ETS	Greenbrae (FM-13)	30" WS L/C	N/A	578	562	>90% probability corrosion is occurring in area
7	ETS	Greenbrae (FM-13)	30" WS L/C	N/A	586	593	>90% probability corrosion is occurring
8	ETS	Greenbrae (FM-13)	30" WS L/C	N/A	530	N/A	Could Not Locate
9	ETS	Greenbrae Kentfield Relief (FM-2)	42" RCCP	534	583	609	>90% probability corrosion is occurring in area
10	ETS	Greenbrae Kentfield Relief (FM-2)	42" RCCP	553	563	599	>90% probability corrosion is occurring in area
11	ETS	Greenbrae Kentfield Relief (FM-2)	42" RCCP	507	559	595	>90% probability corrosion is occurring in area
12	ETS	Greenbrae Kentfield Relief (FM-2)	42" RCCP	510	559	601	>90% probability corrosion is occurring in area
13	ETS	Greenbrae Kentfield Relief (FM-2)	42" RCCP	524	568	602	>90% probability corrosion is occurring in area
14	IFTS	Greenbrae Kentfield Relief (FM-2)	42" RCCP	524	576, 650	N/A	Could Not Locate
15	IFTS	Ross Valley Interceptor (FM-1)	54" RCCP	603	576, 650	588, 590	Electrical isolation confirmed through electrical continuity survey, but there is >90% probability corrosion is occurring upstream and downstream of the flange
16	CATS	Ross Valley Interceptor (FM-1)	78" Casing & 54" RCCP	600	582, 684	664, 733	Electrical isolation confirmed, but there is >90% probability corrosion is occurring on both the casing and the force main
17	CATS	Ross Valley Interceptor (FM-1)	78" Casing & 54" RCCP	N/A	620, 720	N/A	Could Not Locate
18	CATS	Ross Valley Interceptor (FM-1)	78" Casing & 54" RCCP	N/A	Could Not Locate	N/A	Could Not Locate
19	CATS	Ross Valley Interceptor (FM-1)	78" Casing & 54" RCCP	644	663, 784	N/A	Could Not Locate
20	ETS	Ross Valley Interceptor (FM-1)	54" RCCP	624	670	545	>90% probability corrosion is occurring in area
21	ETS	Ross Valley Interceptor (FM-1)	54" RCCP	N/A	697	632	>90% probability corrosion is occurring in area
22 [c]	ETS	Landing B (FM-10)	10" WS L/C	N/A	493	N/A	Could Not Locate
23 [c]	IFTS	Landing B (FM-10)	10" WS L/C	N/A	624, 635	659, 659	Not isolated, and there is >90% probability corrosion is occurring upstream and downstream of the flange
24	ETS	Ross Valley Interceptor (FM-1)	54" RCCP	693	Could not Locate	675	>90% probability corrosion is occurring in area
25	ETS	Ross Valley Interceptor (FM-1)	54" RCCP	689	743	N/A	Could Not Locate
26	ETS	Ross Valley Interceptor (FM-1)	54" RCCP	280	297	555	>90% probability corrosion is occurring in area
27	ETS	Ross Valley Interceptor (FM-1)	54" RCCP	N/A	N/A	N/A	Could Not Locate

Footnotes:

a. ETS – Electrolysis Test Station, IFTS – Insulating Flange Test Station, CATS – Casing Test Station

b. An electrolysis test station is located on a 20 foot section of cement mortar lined and coated welded steel pipe. This section of pipe is located near FM-24. The majority of the Kentfield Force Main is Techite.

c. Field observations and existing installation sketched conflict. Additional field work is necessary to resolve conflict.

Task 2 - Electrical Continuity Survey

The objective of the electrical continuity survey was to evaluate the longitudinal electrical continuity of the pipelines. Buried anode beds are often installed adjacent to steel pipelines; the anodes are comprised of a material that corrodes preferentially to steel. In this way, the anodes protect the steel until they are exhausted and replaced. Pipeline electrical continuity is essential in order to enable cathodic protection over a long length of pipe from a single anode bed. Welded steel pipe is electrically continuous across the weld material. However, concrete cylinder pipes use bell and spigot joints that must be bonded with an insulated copper cable to ensure electrical continuity across joints.

The electrical continuity survey determined that that the Ross Valley Interceptor (FM-1) and the Greenbrae Kentfield Relief Force Main (FM-2) are electrically continuous. The results also indicate that the Greenbrae Force Main (FM-13) is not electrically continuous between test station location #6 (ETS5FM-13) and test station location #7 (ETS6FM-13), and also between test station location #7 and test station #15 (IFTS3FM-1). As-built records for these test station connections are not available. However, due to the age of the pipeline, which was constructed in 1959, it is reasonable to assume that bonding cables were not installed across pipeline joints. Field data on the electrical continuity survey can be found in the Corrpro Report in Appendix E.

It should also be noted that buried magnesium anodes have been installed in five locations as shown in **Figure 2-3**: locations #1, #2, #5, #7, and #23. However, at location #5, #7, and #23, the anodes are not connected or "terminated" to the pipe. Therefore, these anodes are not providing cathodic protection to the pipeline. It is likely that connection wires between the anodes and the pipe have been severed.

Task 3 - Soil Resistivity Survey

An in-situ soil resistivity survey was conducted to assess and prioritize the requirements for corrosion control measures based on corrosivity of local soils within the pipeline alignments. Soil electrical resistivity was measured at nine locations coinciding with the existing test stations within the alignments of FM-1, FM-2, FM-13, and FM-14 using the Wenner 4-pin method (ASTM G57). These representative test locations were selected based on the convenient access to bare soil for a minimum of 45 linear feet, as necessary for the placement of the driven steel pins. **Table 2-4** describes the level of corrosivity associated with soil resistivity survey results from the field.

Table 2-4 Relation of Soil Resistivity to Degree of Corrosivity

Soil Resistivity (ohm-cm)	Degree of Corrosivity
0 – 500	Very Corrosive
501 – 2,000	Corrosive
2,001 – 10,000	Moderately Corrosive
10,001 – 30,000	Mildly Corrosive
Above 30,000	Negligible

The soil resistivity value indicates the relative capability of the soil to carry electrical current. Areas of low soil resistivity are generally more corrosive than areas of higher resistivity. Soil resistivity will vary substantially with moisture content. Soils exhibiting a high dry resistivity may exhibit a much lower resistivity when wet or saturated depending on such factors as pH and chemical content. Where soil resistivity varies seasonally or otherwise, the degree of corrosivity is usually governed by the lowest measured resistivity. The in-situ soil resistivity survey data collected and corresponding corrosion rating at each location are tabulated in **Table 2-5.** The majority of the sample locations had soils with resistivity between 2,001 and 10,000 ohms, and received a corrosion rating of "moderately corrosive." The soils surveyed were generally wet due to rainfall before the test date; wet soils create optimum field conditions for a soil resistivity survey.

Table 2-5 Soil Resistivity Survey Data

Figure 2-3 Location	Layer Depth (feet)	Resistance (Ω)	Resistivity (Ω-cm)	Corrosion Rating
5	5	4.64	4,443	Moderately Corrosive
	10	2.95	7,564	Moderately Corrosive
	15	2.87	8,544	Moderately Corrosive
6	5	4.32	4,136	Moderately Corrosive
	10	3.36	6,434	Moderately Corrosive
	15	2.4	6,894	Moderately Corrosive
7	5	5.16	5,372	Moderately Corrosive
	10	4.13	7,909	Moderately Corrosive
	15	3.8	10,916	Mildly Corrosive
9	5	2.02	1,934	Corrosive
	10	1.69	3,236	Moderately Corrosive
	15	0.81	2,327	Moderately Corrosive
12	5	3.75	3,591	Moderately Corrosive
	10	3.1	5,937	Moderately Corrosive
	15	1.95	4,501	Moderately Corrosive
15	5	3.95	3,782	Moderately Corrosive
	10	3.26	6,243	Moderately Corrosive
	15	2.54	7,296	Moderately Corrosive
21	5	6.05	5,793	Moderately Corrosive
	10	4.25	8,139	Moderately Corrosive
	15	2.95	8,474	Moderately Corrosive
24	5	4.25	4,069	Moderately Corrosive
	10	3.67	7,028	Moderately Corrosive
	15	2.74	7,871	Moderately Corrosive
26	5	4.57	4,376	Moderately Corrosive
	10	3.8	7,277	Moderately Corrosive
	15	2.36	6,779	Moderately Corrosive

2.3.3 Discussion with RVSD Staff

On January 11 and May 31, 2006, RMC staff met with District staff to discuss force main concerns and obtain further information on the force mains. Significant concerns presented by staff are described below.

- The Kentfield Force Main (FM-15) is top priority for replacement because it consists of Techite, which is known to have severe failure characteristics. Three new pumps have been installed at the Kentfield PS and there is concern as to how this force main will react to the higher pressures that will occur during wet weather events. The winter of 2005 included several large wet weather events; FM-15 conveyed these flows without any issues. However, the underlying apprehension related to potential failure of the Techite pipe is still present. Also, a valve located on FM-15 near the junction with FM-13 does not close and was scheduled to be replaced in September 2006 along with a valve on FM-13 downstream of the junction with FM-15. This effort was aborted on the scheduled day because of the large volume of water passing through FM-13. As of January 2007, the valves have been replaced.

- Installed in 1959, the Greenbrae Force Main (FM-13) was identified as next in priority for force main replacement. As the original force main in Ross Valley, FM-13 had two electrolysis test stations installed in 1992, but has had no other known upgrades or replacements. This force main is at risk due to its age, pipe material, and known corrosion.
- 415 Riviera Circle Force Main (FM-33) is a minor force main that discharges to a gravity sewer and delivers wastewater to the Bon Air PS (PS-12). In 1985, a section of welded steel 6-inch pipe was replaced with 6-inch HDPE pipe from PS-33 to the Corte Madera Creek. The creek crossing consists of two 50 foot sections of sewerage (rubber) hose on either side of 200 feet of WS L/C pipe. The groundwater level varies with the tide, and portions of the pipe may alternate between being above and below the groundwater table.
- Highway 101 Force Main (FM-21) is a minor force main located between homes on Via la Cumbre. This force main is very difficult to access for maintenance. FM-21, installed in 1957, is constructed of DI, and has previously failed. Based on its age and leak history, replacement or abandonment should be planned.

2.4 Force Main Condition Summary and Recommended Improvements

Based on the review of existing reports and plans, supplemented with the recent corrosion investigation, four projects were identified for the long-term Capital Improvement Plan to replace or rehabilitate at-risk force mains. The recommended force main projects are listed in **Table 2-6** and shown in **Figure 2-4**. Detailed descriptions of these projects and their purpose are included below.

Table 2-6 Details of Rehabilitation and Replacement Projects

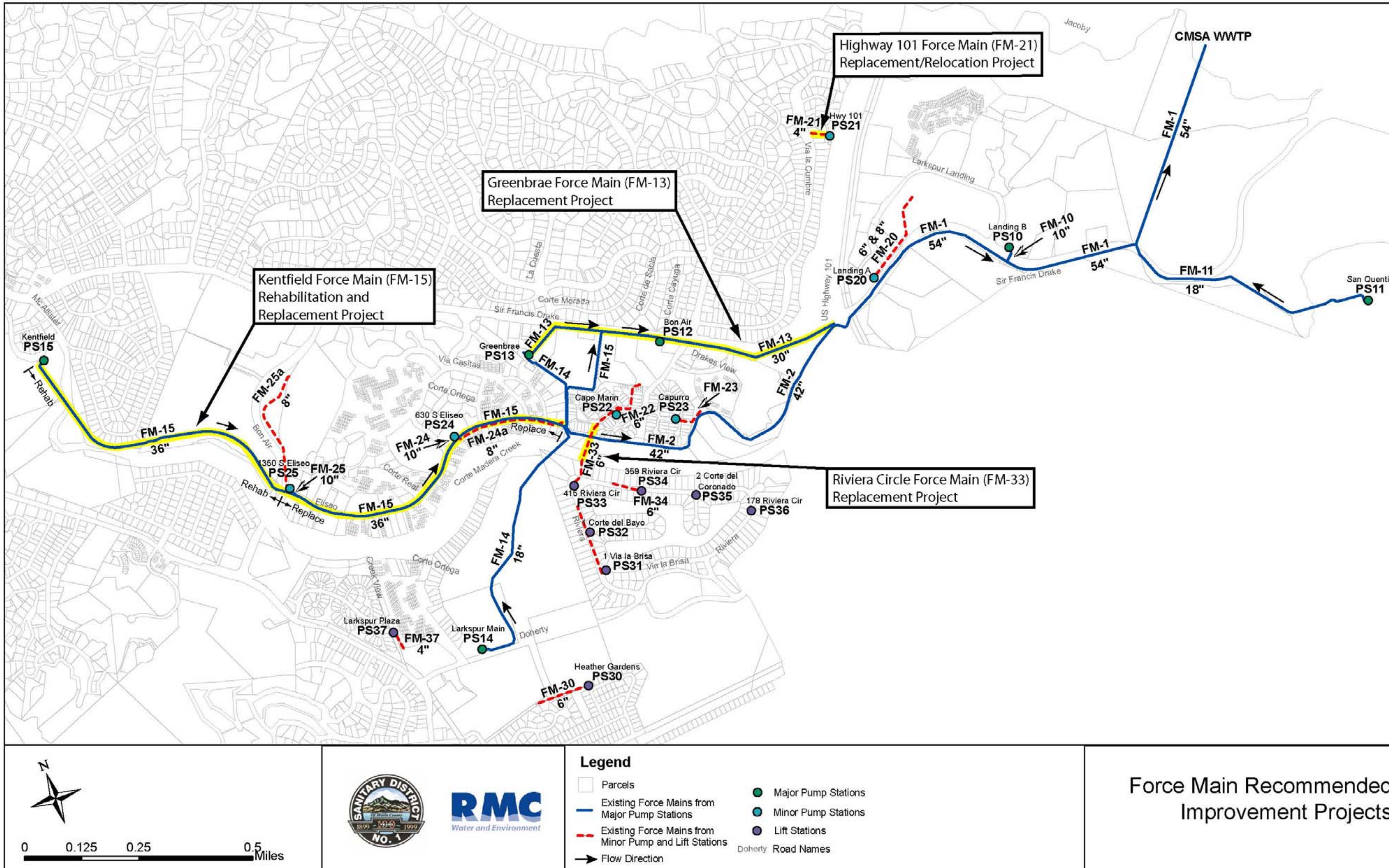
Project	Action	Pipe Diameter (in)	Pipe Length (ft)
Greenbrae (FM-13)	Open Cut New Pipe	30	2,900
Kentfield (FM-15)	Rehabilitation	35	3,800
	Open Cut New Pipe	42	3,700
Highway 101 (FM-21)	Open Cut New Pipe	4	700
415 Riviera Circle (FM-33)	Open Cut New Pipe	6	150
	Directional Drill	6	200

2.4.1 Summary of Pipeline Condition and Recommended Rehabilitation Projects

Greenbrae Force Main (FM-13)

The corrosion investigation conducted on the 30-inch Greenbrae FM indicates that there is greater than 90 percent probability that corrosion is occurring on the pipeline at the ETS locations. This assessment is based on data from two test station locations on a pipeline that is 3,900 feet in length. The survey also determined that FM-13 has gaps in electrical continuity along most of its length. Therefore, information found at the test stations is only relevant to the pipe segment to which the test station is attached; pipeline condition at other locations is not known. Often, an impressed current cathodic protection system is installed on steel pipes to slow external corrosion. However, such a system may not benefit the Greenbrae FM due to its electrical discontinuity.

Figure 2-4 Recommended Force Main Improvement Projects



Due to the age of the force main, which was installed in 1959, a comprehensive long-term solution is recommended. This series of projects would initially establish corrosion activity on the entire pipe length and then replace portions or all of the Greenbrae FM over time. It is recommended to excavate and expose FM-13 at three locations to visually examine the pipeline. In order to identify the three visual inspection locations, a close interval survey and an external coating damage assessment should be performed. The survey consists of measuring pipe-to-soil potentials between established test stations on air release valves or other locations where pipe features reach the ground surface. The survey would identify locations with the largest negative potential which relate to a higher probability of corrosion. This survey, supplemented with an external coating damage assessment of the exposed portion of pipe, would identify pipe locations with the highest potential for ongoing corrosion.

Detailed visual inspection along with ultrasonic thickness (UT) testing would then be conducted at three locations identified as having the highest potential for corrosion. This procedure would involve excavating completely around the pipeline and testing wall thickness at locations around the pipe circumference. Non-uniform pipe wall thickness usually indicates that corrosion is occurring. The majority of the Greenbrae FM is located on the south side of Sir Francis Drake Blvd, in a landscaped area. Therefore, locations for excavation should be available.

The results from these inspections would define any pipeline replacement projects that are required in the future, as well as their urgency. For the purposes of budgeting, a full replacement project is recommended in years five to 10 of the District's CIP (TM CIP-4). The proposed project would replace approximately 2,900 feet of WS L/C pipe from the pump station to the connection with the Ross Valley Interceptor (FM-1) with 30-inch HDPE pipe. The proposed pipe material is adequate to withstand the expected total dynamic head from PS-13 during a design storm event.

In conjunction with the long-term plan, installation of three electrolysis test stations on the existing force main is recommended to more closely monitor ongoing corrosion of the pipeline in the early years of the CIP, before pipeline replacement.

Kentfield Force Main (FM-15)

The Kentfield FM is a fiberglass, "Techite" pipeline that was installed in 1972. In the late 1970s, Techite was found to have a greater probability of failure than other pipe materials, and to exhibit severe failure characteristics, particularly when under external or internal stresses. This force main conveys 60 percent of the District's flow during wet weather, without redundancy. Due to the critical nature of this pipeline, and the elevated risk of failure, replacement of this force main is a priority for the District. In addition, SHECAP determined that the force main requires additional capacity. A preliminary alternatives evaluation for replacement of the Kentfield FM was conducted by RMC to identify a conceptual plan, schedule, and estimated cost for the District's Fiscal Year 2006-2007 CIP. The evaluation is presented in the "Kentfield Force Main Replacement Alternatives Development and Analysis Technical Memorandum (TM)" found in Appendix F.

While additional analysis is necessary before a final alternative can be selected, one project identified in the TM includes a combination of rehabilitation and replacement of the Kentfield FM. The force main would be dewatered in the summer by shutting down the Kentfield PS (PS-15) and diverting flow through a network of sewers to the Greenbrae PS (PS-13). In addition, Pump Stations 24 and 25 would discharge into their respective alternative force mains (FM-24a and FM-25a) and on to the Greenbrae PS. With the Kentfield FM isolated, rehabilitation with cured-in-place pipe (CIPP) liner from the Kentfield PS (PS-15) to the intersection with Bon Air Road and South Eliseo Drive may be feasible. The effective diameter of the lined pipe would be approximately 35 inches. Downstream of PS-25, a new 42-inch pipe would be installed to the connection with the Greenbrae Kentfield Relief Force Main (FM-2) using open cut construction methods. Recommended pipe sizes were selected to meet capacity requirements defined by the SHECAP project. The Kentfield FM Replacement/Rehabilitation Project would also include installing a cathodic protection system on the 630 South Eliseo FM (FM-24) and the 1350 South Eliseo

FM (FM-25), or, alternatively, replacing these steel/ductile iron force mains with a pipe material impervious to corrosion.

Highway 101 Force Main (FM-21)

The Highway 101 Force Main is a 4-inch DI pipe that has leaked in the past, causing sanitary sewer overflows. Until this force main is repaired, additional leaks are expected to occur in the future. This force main does not include any electrolysis test stations, and was not included in the corrosion assessment. Therefore, other than the known leakage, the condition of this pipeline is unknown. FM-21 is located within easements between single family residences; access for repair is expected to be challenging. To eliminate future SSO issues, it is recommended to either replace the force main or possibly abandon PS-21. If force main replacement is selected, installation of 4-inch HDPE or PVC pipe using pipe bursting construction methods or by open trench construction is recommended. If PS-21 were abandoned, flow would need to be diverted to a new gravity sewer that would cross underneath Highway 101. For the purposes of this master plan, replacement of the existing force main pipeline by open trench construction methods is included as the recommended replacement option.

415 Riviera Circle Force Main (FM-33)

The 415 Riviera Circle Force Main crosses Corte Madera Creek by means of two 50-foot sections of 6-inch rubber sewerage hose on either side of a 200 foot long section of 6-inch WS L/C pipe. This force main does not have any existing electrolysis test stations, and was not included in the corrosion assessment. However, underground piping in this area is at or below sea level, and the presence of brackish groundwater is a likely accelerator of corrosion activity. To eliminate the corrosion and failure risk presented by this pipeline, it is recommended to replace the crossing with 6-inch PVC or HDPE pipe using directional drilling underneath the creek. In conjunction with this work, the welded steel pipe on the north side of the creek, also not cathodically protected, would also be replaced.

2.4.2 Criteria for Prioritization

Multiple criteria were used to establish a recommended relative priority for each of the proposed force main projects. These criteria are grouped into two categories: Consequences of Failure and Probability of Failure. Consequences of Failure considers impacts in four sub-categories: environmental impact, community impact, critical crossings, and pipe diameter. Probability of Failure evaluates existing and historical problems associated with each force main, as well as force main age. These criteria are relevant to proposed force main projects only. Actual project priorities relative to system-wide rehabilitation needs are discussed further in the District's Strategic Capital Improvement Plan (TM CIP-4).

Consequences of Failure

This criterion was used to assess the potential consequence of a force main failure. Greater consequence may indicate increased project necessity. Impact factors were assigned to pipes according to four categories:

- **Environmental Impact.** This category reflects the "sensitivity" of the area in which the pipe is located with respect to environmental impacts. Projects ranking higher in the environmental impact category included those adjacent to drainage channels, streams, or wetlands.
- **Community Impact.** This category reflects the impact to the community. Projects ranking higher in the community impact category included those located in side yards, backyards, along streets or within intersections with high traffic volume, or near schools or hospitals. Force mains that rank higher in the community impact category are expected to be more difficult to repair.
- **Critical Crossings.** This category is assigned to projects that cross major or critical utilities. The impact of these crossings is associated with the potential impact related to loss or interruption of service.

- **Pipe Diameter.** The diameter of the pipe is generally related to the size of the tributary area that is served by the force main. Larger diameter pipes rank higher in this category because of the larger area and number of people that would be affected should the pipe fail or be rendered temporarily out of service.

The Kentfield FM runs parallel to Corte Madera Creek for half its length. Consequently, if the pipe were to fail, there could be a large environmental impact to the creek from the SSO. The Greenbrae FM also has a high community impact because the majority of its alignment is located alongside Sir Francis Drake Blvd, a highly traveled thoroughfare. A force main break could shut down this major corridor and also could impact other utilities (water gravity sewers, gas) that are located within the roadway. The Greenbrae and Kentfield force mains are considered large diameter (larger than 12 inches); therefore a large number of people would be affected by a failure.

A break or failure of the 415 Rivera Circle FM would also result in significant impact to the environment, due to its location beneath Corte Madera Creek. The surrounding community would also be affected as many homes are located along the creek banks, and a popular walking path is located south of South Eliseo Drive.

Failure of the Highway 101 Force Main would impact the homes immediately surrounding the pipeline, which is located in side yards off of Via la Cumbre.

All of these force mains have little or no redundancy. Therefore, a break would impact not only the immediate failure area, but sewers upstream.

Probability of Failure

This criterion was used to evaluate the likelihood of a force main failure occurring. This criterion takes into account the number of issues (e.g., breaks) the force main has had in the past and/or exists currently. This criterion also considers useful remaining life based on existing pipe material and whether the pipeline is cathodically protected. A higher score indicates that the force main has had a greater number of issues, or is otherwise more likely to fail.

Highway 101 FM is considered likely to fail due to its history of leaks and its age. The Kentfield FM has a high probability of failure due to issues specific to Techite pipe. The Greenbrae and 415 Riviera Circle force mains also have a high probability of failure due to their age and pipe material.

2.5 Additional Force Main System Recommendations

In addition to the force main rehabilitation or replacement projects described above, a number of additional system enhancements are recommended for implementation in 2007, and in future years as discussed below.

2.5.1 Unavailable Test Stations

As listed in **Table 2-3**, above, the 2006 pipe-to-soil potential survey identified eight test stations shown on District maps that could not be located in the field. As a result, the ability to assess corrosion activity on the District's force mains was diminished. To assess the entire length of a pipeline and eliminate any information gaps along the pipeline, it is important to utilize all test stations. A summary of the stations that could not be located during the 2006 survey year, as well as the status of each station related to previous surveys, are presented in **Table 2-7**.

Table 2-7 Unavailable Test Stations

Figure 2-3 Location	Designation	1990 Survey	1992 Survey	2006 Survey
8	ETS7FM-13	Not Found	Found	Not Found
14	IFTS2FM-2	Found	Found	Not Found
17	CATS2FM-1	Found	Found	Not Found [a]
18	CATS3FM-1	Not Found	Not Found	Not Found
19	CATS4FM-1	Found	Found	Not Found
22	ETS15FM-10	Not Found	Found	Not Found
25	ETS17FM-1	Found	Found	Not Found
27	ETS19FM-1	Not Found	Not Found	Not Found

Footnotes:

a. Test station traffic box without wires.

It is recommended that the District expose or replace each test station listed in the table above. Existing test stations No. 8, 22 and 25 in **Figure 2-3** may be considered as higher priority for replacement, based on location and type. ETS are the primary test stations used to assess pipe-to-soil potential. Missing ETS leave gaps in corrosion activity information along a pipeline. Because Station No. 8, 22 and 25 are ETS and were found in the previous survey, it is believed that they are buried or otherwise inaccessible but can be located.

In addition to locating missing ETS, two welded steel pipelines, FM-13 and FM-10, require new ETS. Two additional ETS are recommended to be placed on FM-13 in addition to Station No. 8. The locations for the two new test stations should be determined based on a close interval survey and external coating damage assessment. This work is recommended for completion in Fiscal Year 2007-08.

It is also recommended that the District being regular corrosion testing, either annually or every two years. The cost of regular corrosion testing should be incorporated into the District's annual operations and maintenance budget which is outside of the scope of the CIP.

2.5.2 Additional Individual Force Main Projects

Recommended projects involving visual inspection, test station installation, and anode repairs are shown in **Figure 2-5**.

Ross Valley Interceptor (FM-1) Test Station Project

During the pipe-to-soil potential survey, five test stations were deemed missing on the Ross Valley Interceptor. If the missing stations cannot be found, new test stations should be installed at the approximate locations of the missing stations. It is assumed for planning purposes that all four test stations will be replaced.

Greenbrae Kentfield Relief Force Main (FM-2) Test Station Project

During the pipe-to-soil potential survey, one test station was not located. This project involves installing a new test station at the location of the existing station.

Landing B Force Main (FM-10) Anode Repair Project

Four magnesium anodes are located near the insulating flange test station on the Landing B Force Main. The pipe-to-soil potential survey indicated that the anodes are not connected to the pipeline and are not providing cathodic protection to the welded steel pipe. It is recommended to excavate to the pipe and reconnect the leads from the anode to the pipeline. Also, one electrolysis test station was deemed missing from the pipe-to-soil potential survey and should be located or replaced.

Greenbrae Force Main (FM-13) Anode Repair Project

Magnesium anodes are located at the test station near Bon Air PS (PS-12). The pipe-to-soil potential survey determined that the leads from the anode to the pipe were not connected. It is recommended the leads be reconnected; this work would require excavation to the desired point of reconnection.

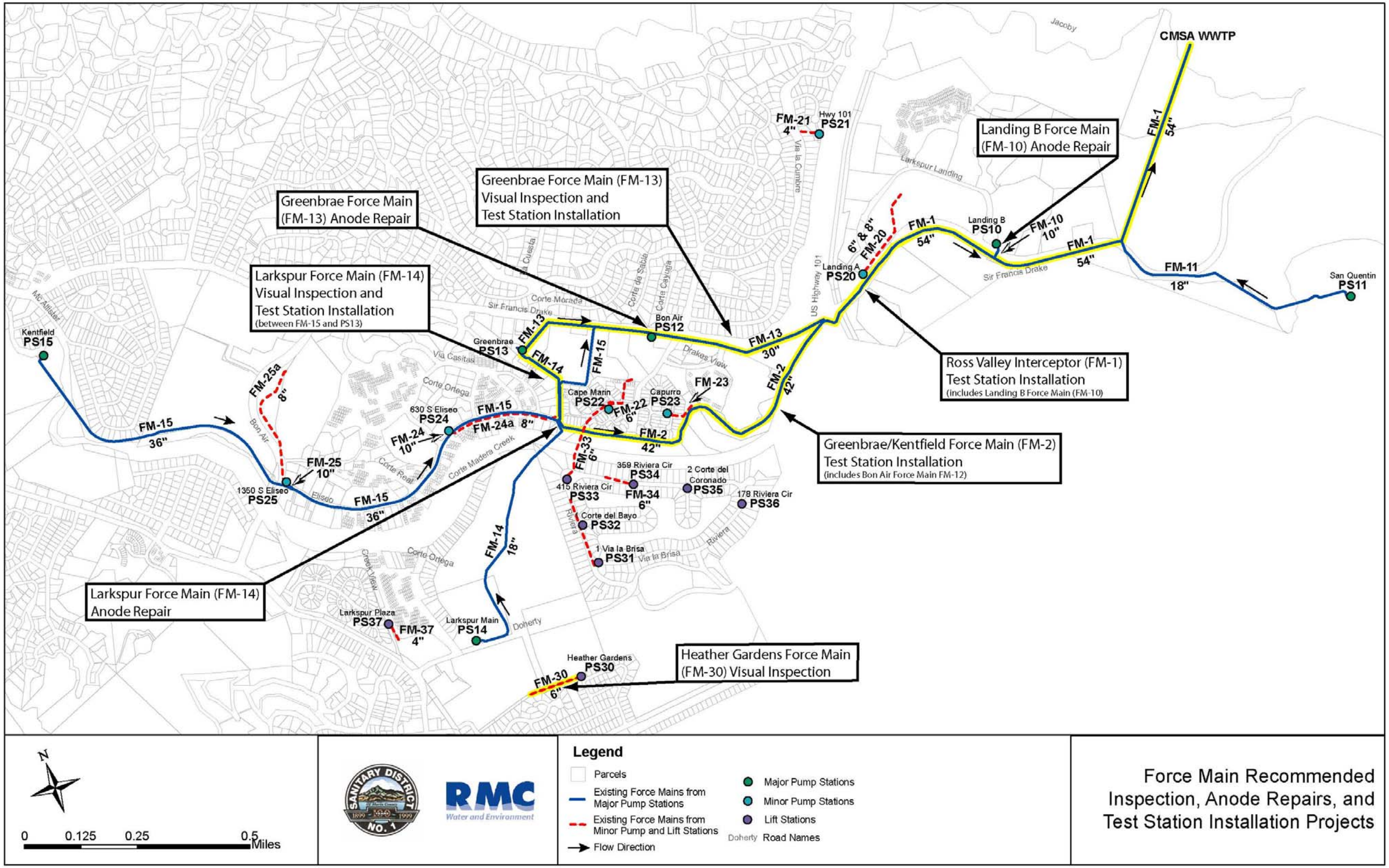
Larkspur Force Main (FM-14) Test Station Project

The section of pipeline from South Eliseo Drive to the Greenbrae PS (PS-13) is comprised of WS L/C pipe. The pipeline is cathodically protected with a magnesium anode at South Eliseo Drive. However, the pipeline is not cathodically protected in any other location, and it is unknown if the pipe is electrically continuous. FM-14 is used during wet weather events; it is important to know if corrosion is occurring, and the extent. It is recommended to install three new ETS along the pipeline to monitor corrosion activity. To determine the optimum locations for the ETS, a close interval survey and an external coating damage assessment should be performed. Installation of three test stations will require excavation to the pipeline, and installing leads and a ground level test box. After the test stations are installed, annual pipe-to-soil potential surveys are recommended to monitor the corrosion activity on the pipeline.

Heather Gardens Force Main (FM-37) Inspection Project

The Heather Gardens FM is located in an easement southeast of the Larkspur PS. The pipe material is unknown. A close interval survey and external coating damage assessment is recommended to determine the pipe material, and if metallic, whether corrosion is occurring. If the pipeline is metallic, one test station should be installed to monitor future corrosion activity.

Figure 2-5 Force Main Recommended Inspection, Anode Repairs, and Test Station Installation Projects



2.6 Estimated Project Costs

2.6.1 Recommended Rehabilitation or Replacement

Capital costs for the project alternatives identified above were developed based on past projects of a similar nature. Unit costs used in the development of cost estimates are listed in **Table 2-8**.

Table 2-8 Economic Assumptions and Unit Costs

Item	Cost
Open Trench Installation	
Residential Streets (i.e. S. Eliseo Drive)	$12/LF-inch dia
Highly Traveled Roads (i.e. Sir Francis Drake Blvd.)	$14/LF-inch dia
Rehabilitation	
Rehab Existing 36-inch Pipe Using CIPP	$250/LF
Directional Drill	
New 6-inch Pipe Installation	$140/LF
Other Cost Estimate Factors	
Construction Cost Contingency	30% of pipeline installation costs
Engineering and Administration	25% of estimated construction costs

The cost for each project is based on the unit costs in **Table 2-8**, and the length of pipe that would be rehabilitated or replaced as presented in **Table 2-9** and included below. All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index). The Kentfield FM replacement project cost is the midpoint value of the five alternatives presented in TM FM-1. The cost was developed in this manner because further engineering analyses are required to confirm whether it is feasible and cost effective for portions of the Kentfield FM to be rehabilitated in lieu of replacement. A unit cost of $40/LF-inch diameter was used for the Highway 101 Force Main replacement project. This cost is higher than shown in **Table 2-8** and reflects accessibility issues and the relatively short length of replacement required.

Table 2-9 Force Main Replacement Costs

Force Main	Project Description	Pipe Length (ft)	Project Costs
Kentfield (FM-15)	Rehabilitation and/or Replacement	7,500	$7,194,000
Greenbrae (FM-13)	Replacement	2,900	$1,982,000
Highway 101 (FM-21)	Replacement	700	$182,000
Riviera Circle (FM-33)	Replacement	350	$63,000
Totals [a,b]		**11,450**	**$9,421,000**

Footnotes:

a. Costs include construction cost contingency and an engineering and administration factor.
b. Costs are indexed to August 2006 San Francisco ENR CCI of 8464.

2.6.2 Additional Force Main System Improvements

Additional force main system improvement costs are listed in **Table 2-10**. These projects may extend the life of the force mains and will allow District staff to monitor corrosion activity on the pipelines. The costs were developed by correspondence with Corrpro staff. All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index).

Table 2-10 Force Main Inspection, Anode Repair, and Test Station Replacement Costs

Force Main	Project Description	Project Costs[b]
Ross Valley Interceptor (FM-1)	Excavation for Test Station Nos. 17, 18, 19, 25, 27	$81,400
	Fix/Install Test Station Nos. 17, 18, 19, 25, 27	$36,600
Greenbrae Kentfield Relief Force Main (FM-2)	Excavation for Test Station No. 14	$16,300
	Fix/Install Test Station No. 14	$7,400
Landing B Force Main (FM-10)	Excavation for Anode Repair	$16,300
	Anode Repair	$7,400
	Excavation for Test Station No. 22	$16,300
	Fix/Install Test Station No. 22	$7,400
Greenbrae Force Main (FM-13)	Close Interval Survey	$8,200
	Pipe Excavation	$48,800
	Visual Inspection and Ultrasonic Thickness Test of FM at 3 locations	$22,000
	Install Three New Test Stations	$22,000
	Excavation for Test Station No. 8	$16,300
	Fix/Install Test Station No. 8	$7,400
	Excavation for Anode Repair	$16,300
	Anode Repair	$7,400
Larkspur Force Main (FM-14)	Close Interval Survey	$8,200
	Pipe Excavation	$48,800
	External Coating Damage Assessment	$8,200
	Install Three New Test Stations	$22,000
	Excavation for Anode Repair	$16,300
	Anode Repair	$7,400
Heather Gardens Force Main (FM-30)	Close Interval Survey	$8,200
	Pipe Excavation	$16,300
	External Coating Damage Assessment	$8,200
	Visual Inspection and Ultrasonic Thickness Test, if pipeline is metallic	$7,400
	Install Test Station, if pipeline is metallic	$7,400
Totals [a]		**$495,900**

Footnotes:

a. Costs include construction cost contingency (30% of project cost) and an engineering and administration (25% of project cost).

b. Costs are indexed to August 2006 San Francisco ENR CCI of 8464.

Chapter 3 Pump Station Master Plan

This chapter presents the master plan for the pump stations (PS). The Pump Station Master Plan addresses the improvement needs of the pump stations with respect to identified deficiencies and operational issues. The Pump Station Master Plan identifies a list of recommended improvements, associated cost estimates, and presents a preliminary priority ranking of the proposed improvements.

3.1 Background and Purpose of Pump Station Master Plan

The purpose of the Pump Station Master Plan is to provide a review of the condition and operation of the District's pump stations based on existing District reports and records and a field reconnaissance evaluation, and to identify needed improvements to provide adequate capacity and address deficiencies in condition, design, access, and reliability.

3.2 Pump Station System Description

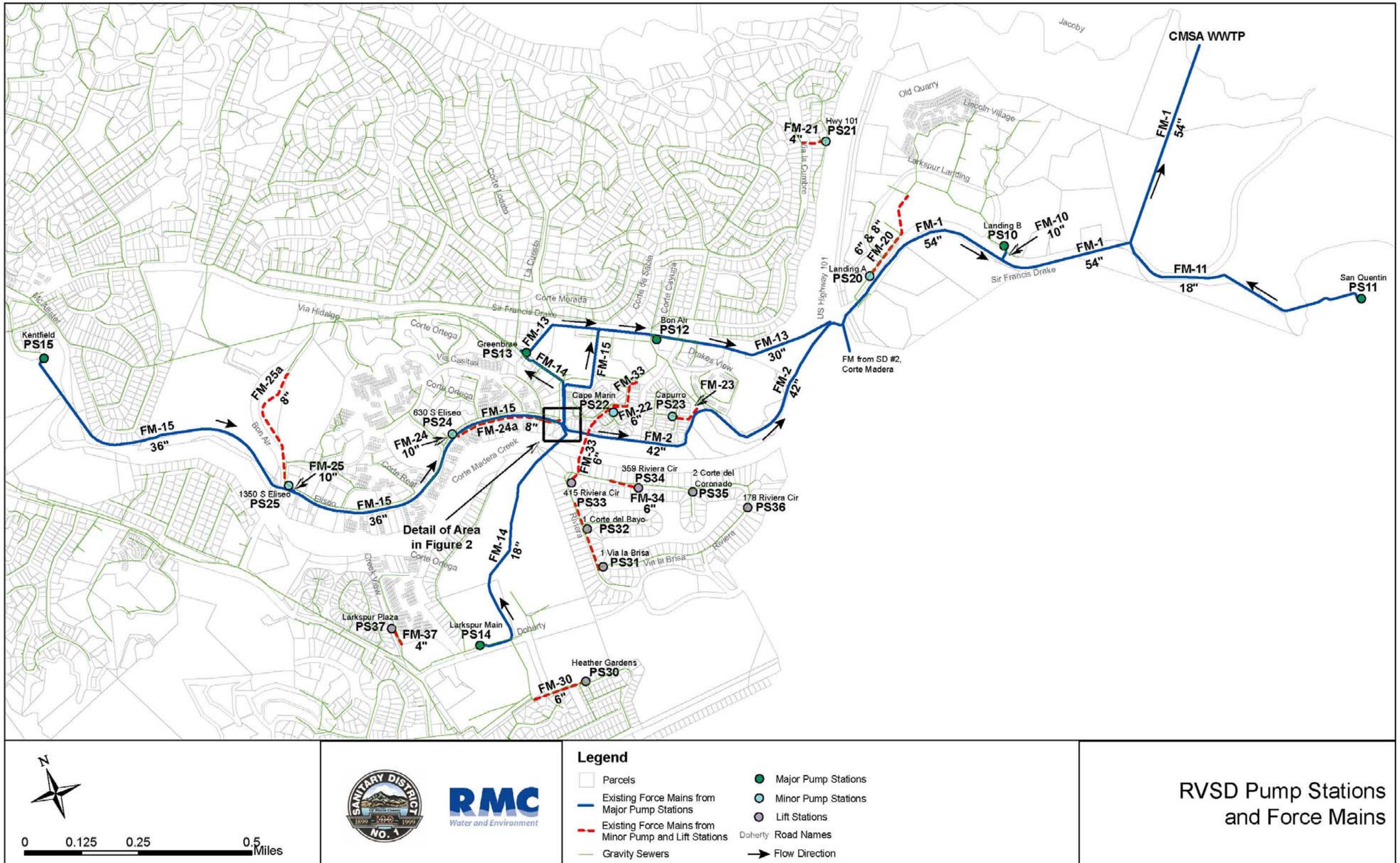
The District's system includes 194 miles of gravity sewers, 20 pump stations, and over 7 miles of force mains. Gravity sewers convey flow to the District's pump stations and then into force mains ranging in diameter from 4-inch to 54-inch. Pump station design capacity ranges from 0.09 million gallon per day (MGD) at PS-37 - Larkspur Plaza to 36.9 MGD at PS-15 - Kentfield.

The 20 pump stations operated by the District are classified as major, minor, or lift pump stations. Major pump stations (PS-10 through 15) are generally the larger pump stations that pump directly to the CMSA WWTP through a common force main. Minor pump stations (PS-20 through 25) are smaller pump stations that generally pump into a gravity sewer or into another force main. Lift stations (PS-30 through 37) are local pump stations that lift sewage into a nearby gravity sewer or pump the sewage through short force mains connected to a gravity sewer. A schematic of the District's pump stations is provided in **Figure 3-1**. A short description of each pump station is provided below.

PS-10 – Landing B PS, originally constructed in 1978, was completely rehabilitated in 2006 at a cost of $1,222,000. Start-up is planned for February 2007. The rehabilitation included the installation of three submersible, multiple-speed drive pumps. PS-10, located at the downstream end of the RVSD collection system, pumps sewage from Landing Circle into a 10-inch force main discharging into the 54-inch force main to the CMSA WWTP.

PS-11 – San Quentin PS, constructed in 1985, pumps sewage generated from San Quentin prison and San Quentin Village into an 18-inch force main discharging into the 54-inch force main leading to the CMSA WWTP. PS-11 consists of three electric pumps that constitute the last point of discharge into the 54-inch force main upstream of the CMSA WWTP. Although this pump station is within the District's jurisdiction, the District is only responsible for the dry side (i.e. pump room) of the station. Although this pump station was not evaluated in this master plan, in 2004, Winzler & Kelly completed a document titled, "California State Prison San Quentin Site Engineering Condemned Inmate Complex Predesign Engineering Report," which concluded that theoretical pumping capacity was adequate for planned flows. This report recommended that the prison conduct a pump test to confirm pump performance.

Figure 3-1 District Pump Stations and Force Mains



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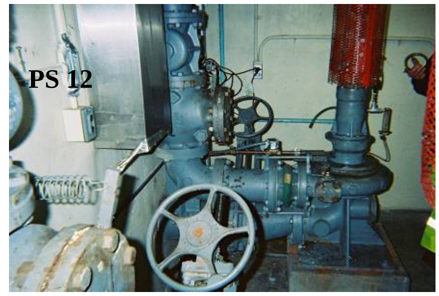


PS-12 – Bon Air PS was constructed in 1984. This station includes two pumps and receives flow from pump stations at Highway 101 (PS-21), Cape Marin (PS-22), Capurro (PS-23) and 415 Riviera Circle (PS-33) and adjacent areas. PS-12 discharges into an 8-inch force main which connects to the 30-inch Greenbrae FM that eventually leads to the 54-inch force main to the CMSA WWTP. This pump station has been identified as having insufficient capacity by District staff; the need for additional capacity has been confirmed by hydraulic modeling conducted through the SHECAP project and the review of District records discussed in greater detail in Section 3.4. General maintenance and upgrades should be considered for this pump station.

PS-13 – Greenbrae PS was rehabilitated in the 1980s. This station consists of three electric pumps that collect sewage from a 30-inch gravity line that serves areas of Kentfield and Greenbrae, and also can receive flow that is bypassed from the Kentfield PS (PS-15) during pump station outages or extreme wet weather events. PS-13 may also collect sewage through the 18-inch force main discharging from Larkspur Main PS (PS-14) under certain conditions. This force main interconnection is not normally used and must be manually brought into service when required. The Greenbrae PS effluent is pumped through a 30-inch force main discharging into the 54-inch force main to the CMSA WWTP. This pump station is in good condition; however, general maintenance and upgrades are recommended due to its age. Specifically, upgrades to potential safety issues are recommended in this master plan as discussed in Section 3.6.

PS-14 –Larkspur Main PS, originally constructed in 1989, was rehabilitated in 2005. Rehabilitation included replacement of electrical panels, motors and rails. This pump station collects sewage from two gravity trunk lines and discharges into an 18-inch force main. The 18-inch force main conveys flows to the 42-inch Greenbrae Kentfield Relief FM. In emergency conditions, flows from the Larkspur FM can be bypassed to an 18-inch force main that feeds Greenbrae PS (PS-13), or alternatively, to a 36-inch pipeline that bypasses Greenbrae PS and discharges into the 30-inch Greenbrae FM downstream of the pump station. Although Larkspur Main PS was upgraded recently, the SHECAP effort identified this pump station as requiring additional firm capacity, as discussed further in Section 3.4.3.

PS-15 – Kentfield PS is the District's largest pump station in term of capacity. This station is located along Corte Madera Creek, at the upstream and northwestern end of the pumping system. Kentfield PS was originally built in the 1970s, but underwent complete rehabilitation prior to 2004. The pump station includes five electric pumps: two pumps operate primarily during dry-weather and three pumps add capacity during wet weather. The pump station discharges to a 36-inch force main that parallels Corte Madera Creek. This pump station experienced an outage during the storm that occurred on December 31, 2005, due to what appears to be inadequate configuration of the newly-installed variable frequency drives (VFDs). During this outage, the hard-wired telephone system failed to convey alarm signals between the Kentfield PS and CMSA WWTP. District staff corrected this issue by reprogramming the VFDs. Also, the pump station is now equipped for backup cell phone communications for emergency situations. Although the Kentfield PS components are new, the SHECAP study identified a potential capacity problem during the design wet weather event. However, this issue is related to an undersized downstream force main and should be addressed through increasing the size of this pipe as described further in the Force Main Master Plan.

PS-20 – Landing A PS was originally constructed in the mid-1960s. This pump station collects sewage from an 8-inch sewer and pumps flow to Landing B PS (PS-10). Based on the condition assessment, this pump station needs general maintenance and equipment upgrades due to its age. Also, specific upgrades are required for the station to meet current fire-code standards.

PS-21 – Highway 101 PS is located along Highway 101 in Larkspur. The station lifts local sewage over 150 feet from a 4-inch pipeline through a 4-inch force main. The sewage then flows by gravity to the Bon Air PS (PS-12). Originally constructed in the 1940s, PS-21 was been rehabilitated recently and is in good condition. However, the original 4-inch ductile iron force main installed in 1957 has been known to have leaked in the past. A project to replace the Highway 101 FM is described further in the Force Main Master Plan.

PS-22 – Cape Marin PS was originally constructed in the late 1990s; the station has not been upgraded since this time but is in good condition. The pump station uses one pump to pump local sewage from a 6-inch gravity line into a 6-inch force main that converts to a 10-inch gravity line feeding Bon Air PS (PS-12).

PS-23 – Capurro pump station was constructed in the late 1990s and is in good condition. This station collects sewage from an 8-inch gravity line and uses one pump to pump flow into a 6-inch force main that converts to a 10-inch gravity line discharging into Bon Air PS (PS-12). Cape Marin and Capurro pump stations are very similar in age, size, and configuration, and are located in the same general area.

PS-24 – Eliseo pump station collects sewage from several gravity lines using one pump and discharges into a 10-inch force main that connects to the 36-inch Kentfield FM. Alternately, this station can discharge into an 8-inch bypass force main that discharges into the 30-inch force main to Greenbrae PS (PS-13). This pump station is adjacent to residential housing and has been identified as having a sound nuisance issue at the onsite generator.

PS-25 – South Eliseo PS collects sewage from local gravity lines and discharges flow to a 10-inch force main that in turn discharges into the 36-inch Kentfield FM. Similar to PS-24, above, an 8-inch bypass force main can alternately be used that discharges into the 30-inch force main to Greenbrae PS (PS-13). Also similar to PS-24, sound nuisance has been identified as an issue at this pump station.

PS-30 – Heather Garden PS includes two submersible pumps. The station collects local sewage that is then pumped into a small section of 6-inch force main that discharges into an 18-inch gravity pipeline to Larkspur PS (PS-14). The pumps are installed in a building shared with the City of Larkspur. No specific issues have been identified at this pump station. However, local sewers have been known to experience surcharging during storms.

PS-31 – Via la Brisa PS is one of six pump stations installed in the Greenbrae Marina residential neighborhood located south of Corte Madera Creek. The other pump stations in this area include PS-32 through 36. These six pump stations drain a relatively flat area constructed on bay fill. The pumps and pipelines were installed in the 1960s and are subject to significant inflow/infiltration (I/I) via the gravity sewer pipelines. Via la Brisa PS includes two electric dry-pit pump pumps that collect sewage from a 6-inch gravity pipeline and discharge into a 6-inch force main, which discharges into an 8-inch gravity pipeline that ultimately flows into 415 Riviera Circle PS (PS-33). Pump replacement and general maintenance and upgrades are recommended as part of the master plan.

PS-32 – Corte del Bayo PS, similar to Via la Brisa PS, includes two electric dry-pit pumps. This station collects sewage from an 8-inch pipeline into a 5-inch pipeline that discharges into a 6-inch force main and an 8-inch gravity line prior to being pumped by 415 Riviera Circle PS (PS-33). Of the six pump stations located in this neighborhood, PS-31 and 32 are the only stations that use non-submersible, self-priming pumps. Pump replacement and general maintenance and upgrades are recommended as part of the master plan.**PS-33 –** This pump station located on **415 Riviera Circle** includes two submersible pumps. This station collects sewage pumped by five pump stations (PS-31 through PS-36) into two 8-inch gravity pipelines. The sewage is then pumped by Bon Air PS (PS-12) into a 30-inch pipeline. No issues related to capacity, reliability, or safety has been identified at this pump station.

PS-34 – The pump station located on **359 Riviera Circle** includes two submersible pumps. This station collects sewage from PS-35 into a 6-inch force main discharging into 415 Riviera Circle PS (PS-33). This pump station is located in the middle of the roadway. As a result, access to the pump station is restricted in its current configuration. A parallel force main was installed in the past to address noise associated with water hammer due to surge in the original force main. Recommendations to improve access to the pump station are proposed later in this Pump Station Master Plan.

PS-35 – The pump station located at **2 Corte del Coronado** includes two submersible pumps. This station collects sewage from the pump station located at 178 Riviera Circle (PS-36) and discharges to an 8-inch gravity pipeline discharging into PS-34. Recommendations to improve access to the pump station are proposed later in this Pump Station Master Plan.

PS-36 – The pump station located at **178 Riviera Circle** includes two submersible pumps. This station collects sewage from an 8-inch gravity pipeline that is pumped through an 8-inch sewer into the pump station located at 2 Corte del Coronado (PS-35). PS-34 though 36 are characterized by difficult access conditions for routine maintenance. Recommendations to improve access to the pump station are proposed later in this Pump Station Master Plan.

PS-37 – The **Larkspur Plaza** PS, located across from Larkspur Plaza Drive, consists of two submersible pumps. This station pumps local sewage into a 4-inch force main discharging into an 8-inch pipeline, which in turn discharges into an 18-inch sewer pipeline prior to being pumped by Larkspur Main PS (PS-14). The pump station shares its electric supply with a storm water pump station operated by the City of Larkspur. It is recommended to provide an independent power supply to the station, otherwise in good condition.

3.3 Approach to Pump Station Master Plan Development

The Pump Station Master Plan incorporates findings from the following activities, described in more detail in the sections that follow:

- Review of District’s previous reports and studies related to the pump station and force main system;
- Review of District’s existing pump station maintenance records;
- Review of Draft Wastewater Pumping Station Reliability Recommendations, San Francisco Bay Region California Regional Water Quality Control Board (RWQCB), Draft October 1996; and,
- Pump station field reconnaissance and condition assessment conducted for this study.

3.4 Capacity Findings and Conclusions

Information reviewed in the District’s existing reports and maintenance records is summarized in this section.

3.4.1 Summary of District's Existing Reports

Previous reports related to the District's pump station and force main systems were consulted as part of this evaluation, including:

- Force Main Improvement Program (Nute Engineering, May 1998) – This document provides an inventory of the District's sewage force mains, estimates the remaining useful life of these facilities, and sets forth a long range plan for their eventual replacement or rehabilitation.
- Central Marin Sanitation Agency (CMSA) Interceptor Network Hydraulic Model Final Report (Nolte, September 2, 2004) - This report contains a brief description of the pump station and force main modeling effort performed by Nolte in 2004. The modeling effort consisted of steady state modeling and did not include any of the gravity portions of the District's collection system.
- Kentfield Pump Station Review (Nute Engineering, January 1998) – This document contains an inventory of the Kentfield Pump Station existing equipment, an analysis of the structural integrity of the pump station, an analysis of the pumping reliability, a corrosion investigation, and an evaluation of the electrical and other pump station equipment. The report also presents a program of staged improvements to the Kentfield PS to improve the overall operational flexibility.
- Sanitary Sewer Hydraulic Evaluation and Capacity Assurance Plan (SHECAP) - The hydraulic model developed in the SHECAP study includes eight pump stations, including all the District's six major pump stations and two minor pump stations. The two minor pump stations included in the SHECAP study are 630 Eliseo Pump Station (PS-24) and 1350 South Eliseo Pump Station (PS-25). These eight modeled pump stations are those that discharge directly into the force main system that conveys all of the District's wastewater flow to the CMSA WWTP. Information on the modeled pump stations (pump discharge rates, pump on/off levels, and wet well dimensions) and associated valves, gates, and force mains were obtained by MWH from information provided by District staff and from available as-built drawings.

3.4.2 Summary of District's Existing Pump Station Records

The District maintains daily logs for each pump station that contain information about individual pump running times. Hard copies of the pump station logs for 2005 were provided by the District and reviewed as a key component of the pump station capacity assessment. Most logs were available in hard copy only; a large amount of the data was not computerized. Therefore, reviews focused on pump station running times for December 2005. This month was selected as representative of pump station operations under high flow conditions due to the relatively severe storms that occurred during the month, including the large December 31, 2005 storm event. Evaluation of pump running times helped determine whether spare or standby pump capacity was available during the wet weather period.

Average and peak running times for December 2005 for each of the District's 20 pump stations are presented in **Table 3-1**. In addition to average and peak running times, **Table 3-1** provides general information on District pump stations, and on pump types, operating modes and capacities.

Table 3-1 Pump Station Characteristics

PS #	PS Name	Type	Service Area	Date Built/ Rehab.	Number of Pumps	Duty Pumps	Standby Pumps	5-year Design Flow (MGD)	Design Capacity (MGD)	Firm Capacity (MGD)	Average Running Time 12/2005 (Hrs/day)					Running Time 12/31/2005 (Hrs/day) [d]				
											Pump 1	Pump 2	Pump 3	Pump 4	Pump 5	Pump 1	Pump 2	Pump 3	Pump 4	Pump 5
10	Landing B	Major	Larkspur Landing	Dec 2006	3	2	1	1.12	1.71	1.71	NA	NA				NA	NA			
11	San Quentin	Major	San Quentin Prison and Village	1985	3	2	1	1.67	2.88	2.88	2.9	4.6	3.6			5.4	19.5	7.6		
12	Bon Air	Major	Bon Air Shopping Center Region	1984	2	2	0	1.86	0.43	0.43	8.9	10.1				21.4	24.0			
13	Greenbrae	Major	Greenbrae	1984	5	2	3	5.51	9.96	9.96	16.0	13.4	0.7	3.9		18.7	8.7	1.2	9.1	1.0
14	Larkspur Main	Major	Larkspur	1989/2005	3	1	2	8.56	8.41	5.88	8.9	3.8	15.2			22.2	13.2	22.5		
15	Kentfield	Major	Kentfield/Upper Ross Valley	1971/2005	5	1[b] Up to 2[c]	1[b] 1[c]	39.0	41.9	36.9	8.0	5.0	9.3	7.9	0.6[e]	14.5	7.4	18.7	20.5	0.0
20	Landing A	Minor	Larkspur Landing	Mid-1970s	2	1	1	Unknown	0.36[a]	0.36[a]	0.9	0.7				4.1	2.5			
21	Highway 101	Minor	Bon Air (portion)	Mid-1940s/2000	2	1	1	Unknown	0.22[a]	0.22[a]	1.0	1.5				6.3	8.5			
22	Cape Marin	Minor	Drake's Landing	Late 1990s	2	1	1	Unknown	0.22[a]	0.22[a]	0.6	0.6				1.6	2.6			
23	Capurro	Minor	Drake's Landing	Late 1990s	2	1	1	Unknown	0.22[a]	0.22[a]	0.3	0.3				0.7	0.7			
24	630 Eliseo	Minor	S.Eliseo Dr./Greenbrae	1984	2	1	1	0.45	1.52	1.52	1.5	0.8				10.9	0.8			
25	1350 S. Eliseo	Minor	S.Eliseo Dr./Greenbrae	1988	3	1	2	0.70	1.41	1.41	0.6	0.6				2.1	1.9			
30	Heather Garden	Lift	Heather Gardens, Larkspur	Unknown	2	1	1	Unknown	0.22[a]	0.22[a]	2.6	4.0				12.7	17.8			
31	1 Via la Brisa	Lift	Greenbrae Marina	Mid-1960s	2	1	1	Unknown	Unknown	Unknown	2.3	2.9				6.6	7.3			
32	1 Corte del Bayo	Lift	Greenbrae Marina	Mid-1960s	2	1	1	Unknown	Unknown	Unknown	0.4	0.5				0.9	1.1			
33	415 Riviera Circle	Lift	Greenbrae Marina	Early 2000	2	1	1	Unknown	0.22[a]	0.22[a]	4.5	4.6				0.9	1.1			
34	359 Riviera Circle	Lift	Greenbrae Marina	Mid-1960s	2	1	1	Unknown	0.22[a]	0.22[a]	1.4	1.2				3.2	3.6			
35	2 Corte del Coronado	Lift	Greenbrae Marina	Mid-1960s	2	1	1	Unknown	0.22[a]	0.22[a]	1.0	1.0				4.4	3.4			
36	178 Riviera Circle	Lift	Greenbrae Marina	Mid-1960s	2	1	1	Unknown	0.22[a]	0.22[a]	2.5	2.0				2.1	4.6			
37	Larkspur Plaza	Lift	Larkspur Plaza	Unknown	2	1	1	Unknown	0.09[a]	0.09[a]	2.2	2.1				14.6	18.4			

Footnotes:

a. Pump station not modeled with SHECAP. Pump station consists of 2 identical pumps, one duty pump and one stand-by pump. Design and firm capacity are assumed to be identical. Design and firm capacity are based on the District's Emergency Response Plan prepared in April 1999. Maximum capacity is unknown but is assumed to twice as much as the firm and design capacity for the purpose of the PS Master Plan. 5-year design flow is unknown.
b. Pump used during dry weather conditions.
c. Pump used during wet weather conditions.
d. December 31, 2005 is taken as reference for high flow conditions.
e. Running time for Pump 5 represents operation only during those periods before wet weather pumps are initiated.

3.4.3 Conclusions from the SHECAP study

The SHECAP study analyzed capacities of the pump stations for a 5-year design storm under the following scenarios: 1) Normal operating or design capacity scenario (defined as the pump station capacity with no standby pumps running); and 2) Firm capacity scenario (defined as the pump station capacity with the largest pump out of service). The modeled pump stations and associated characteristics, as well as results of SHECAP modeling for the two scenarios, are provided in **Table 3-2**.

Table 3-2 Modeled Pump Stations

Pump Station	Pump Operation (Pump # and Function)	Design Discharge by Pump (MGD)	Normal Operating Capacity [a] (MGD)	Firm Capacity [b] (MGD)	5-Year Storm Peak Flow (MGD) [c]
PS-10 (Landing B)	1 (Duty), 2 (Duty), 3 (Standby)	0.85	1.71	1.71	1.12
PS-11 (San Quentin)	1 (Duty), 2 (Assist), 3 (Standby)	2.02	2.88	2.88	1.67
PS-12 (Bon Air)	1 (Duty)	0.43	0.43	0.43	1.86
	2 (Assist)	0.72			
PS-13 (Greenbrae)	1 (Duty), 2 (Standby)	2.02	9.96	9.96	5.51
	3 (Assist), 4 (Standby)	5.76			
	5 (Standby)	6.48			
PS-14 (Larkspur Main)	1 (Duty), 2 (Assist)	1.73	8.41	5.88	8.56
	3 (Assist)	1.73			
PS15 (Kentfield)	1 (Dry Duty), 5 (Dry Assist)	5.76	41.9	36.9	39.0
	2 (Wet Duty), 3 (Wet Assist), 4 (Wet Assist)	23.04			
PS-24	1 (Duty), 2 (Standby)	0.72	1.52	1.52	0.45
PS-25	1 (Duty), 2 (Assist), 3 (Standby)	0.72	1.41	1.41	0.70

Footnotes:

a. Pump station capacity using normal operational settings (standby pumps are off). This capacity equals the firm capacity if the standby pump is the same size as the largest pump.
b. Pump station capacity when largest pump is out of service.
c. 5-year storm peak flows reflect the addition of relief sewers upstream of the pump stations (as proposed in the SHECAP Report) needed to convey the peak flows to the pump stations.

Based on findings from the SHECAP study, all of the pump stations have sufficient capacity to handle predicted 5-year design storm peak wet weather flows under normal pump station operation except for Bon Air and Larkspur pump stations. However, three of the pump stations (Bon Air, Larkspur Main, and Kentfield) may not have sufficient firm capacity to handle the design storm peak flow. The deficiency at the Kentfield PS is likely to be addressed by increasing the size of the 36-inch Kentfield FM and is not expected to require pump station improvements, as discussed further in the SHECAP Report. Therefore, only Bon Air and Larkspur Main pump stations have design and firm capacity issues that should be addressed.

Based on existing records from the District, Bon Air pumps #1 and #2 ran an average of 8.9 hours and 10.1 hours per 24-hour period in December, respectively. Running times for these pumps on December

31 were 22.0 hours and 24.0 hours, respectively. Similarly, Larkspur pumps #1, #2, and #3 operated on average 8.9 hours, 3.8 hours and 15.2 hours per 24-hour period, respectively. The running times for these pumps on December 31, 2005 were 22.2 hours, 13.2 hours and 22.5 hours, respectively. Analysis of running times for Bon Air and Larkspur Pump Stations support the SHECAP findings that these pump stations have inadequate firm capacity for large wet weather events, as they were operating at full capacity on December 31.

Average running times for Kentfield PS were 8.0 hours, 5.0 hours, 9.3 hours, 7.9 hours and 0.6 hours for pumps 1, 2, 3, 4 and 5, respectively. Peak running times on December 31, 2005 were 14.5 hours, 7.4 hours, 18.7 hours, 20.5, and 0.0 hours. In addition, it is important to note that the pump station was shut down for approximately 4 hours during the peak of the storm. Therefore, the extended running times for three of the five available pumps indicate that at least two and possible three pumps operated simultaneously on December 31, as illustrated in **Table 3-1**. If three pumps operated simultaneously, and one of these pumps was a wet duty pump, then the Kentfield PS also has insufficient firm capacity. However, insufficient firm capacity at Kentfield is likely to be addressed by increasing the size of the existing 36-inch force main, as described further in the Force Main Master Plan.

3.5 Reliability Findings and Conclusions

The San Francisco Bay RWQCB has developed a draft pump station guidance document titled, "Wastewater Pumping Station Reliability Recommendations, Draft, October 1996" (Reliability Recommendations). This document was not adopted by the RWQCB and is therefore not considered a standard. This document does not include specific requirements or mandates, but is a good guideline and is intended to provide a consistent overall basis for pump station rehabilitation. The complete document is provided in Appendix G.

3.5.1 Summary of RWQCB Wastewater Pumping Station Reliability Recommendations

The Reliability Recommendations include three categories: 1) Design Requirements; 2) Emergency Procedures Requirements; and 3) Maintenance, Inspection and Testing Requirements. Requirements that were identified as requiring attention at one or more of the District's pump stations are summarized below.

Design Requirements

Pump Station Capacity - Pump station firm capacity (i.e. with the largest pumping unit out of service) should equal or exceed the maximum design flow anticipated. Although design flow is not defined in the Reliability Recommendations, it is assumed that the 5-year storm event is an appropriate wet weather design flow criterion.

Equalization storage basins or increased wet well capacity can be used to reduce the maximum design capacity. However, in most cases, providing standby pumping capacity is preferable to additional storage. In addition, pumping station design should accommodate additional pumping units for potential expansion if flows are anticipated to increase in the future.

Flooding - Pumping stations should be protected from flooding from sewage resulting from power failure or flows exceeding pump station capacity, or flooding due to surface runoff (e.g., overflow of an adjacent creek or drainage facility) caused by a storm event.

Mechanical – National Fire Protection Act (NFPA) 820 guidelines should be applied for ventilation of the pump station. Proper and separate ventilation systems should be provided in both the dry well and the wet well to provide safe working conditions for the operators, and prevent explosive conditions.

Valves and Piping - Suitable isolation valves, a bypass line, or a replacement spool should be provided around the discharge flow meter to allow removal of the meter for cleaning or repairs.

Standby Power for Major Equipment - A standby source of power is recommended. Standby power equipment should be in-place equipment. However, on smaller pumping stations, the installation of a quick-connect receptacle for portable generators is an acceptable alternative to an onsite emergency generator.

Control - Pumps should be automatically controlled based on wet well level. In case of a power failure to the communications system, a battery back-up should provide continuous power to maintain interrupted communications.

Instrumentation - Metering of pump station discharge should be required for large pump stations and is preferred in all stations. Elapse time clocks should be provided on pumps, especially at smaller pumping stations, to estimate discharge rate and total discharge volume. In addition, a level indication system should be provided in all wet wells to allow control of the pumps and to alarm high wet well level.

Emergency Procedures Requirements

The following emergency procedures are required to respond to extreme events such as floods, earthquakes, fires, operational or mechanical failures, civil emergencies, or unsafe environments.

Protective Measures - Protective measures include developing adequate rescue procedures; having appropriate safety equipment and service available, such as portable generators; and being aware of units that are intended to provide redundant operation in case of equipment failure.

Emergency Response Plan - An Emergency Operations Plan (EOP) should be prepared for all of the pump stations, and incorporated within or appended to the District's Overflow Emergency Response Plan (OERP).

Spills Procedure - Reporting of spills and water quality sampling and testing must be conducted in accordance with regulatory requirements, as documented in the District's OERP and Sewer System Management Plan (SSMP).

Maintenance, Inspection and Testing Requirements

An effective maintenance, inspection and testing program is necessary to ensure that the pump stations remain in good operating condition. Examples of typical program components include:

Maintenance - A preventive maintenance program should be implemented based on the manufacturers' recommendations and Operations and Maintenance (O&M) manuals. Checklists and a maintenance accountability system should be established. Spare parts should be kept on hand for pumps, Motor Control Centers (MCCs), engines, and screens.

Inspection and Testing - Inspection and testing of equipment should occur on a periodic basis, and control equipment should be calibrated regularly, in accordance with the manufacturer or the utility's recommendations.

Record Keeping - Complete operating, maintenance, and inspection records should be compiled and retained for each pumping station. Records should include daily flow, wet well level, and pump operation. Maintenance records should include date, type of service, items reviewed, remaining replacement parts, and next scheduled inspection. A program of annual, quarterly, and monthly inspections should be established.

3.5.2 Reliability Conclusions

In addition to the specific improvements discussed in Section 3.6.1, it is recommended that the District implement the following system-wide improvements in order to remain in compliance with the RWQCB reliability requirements.

- **Record Keeping -** The District keeps thorough records of its maintenance activities. However, it is recommended that these maintenance logs be maintained in an electronic database for easier data manipulation, analysis and access. The District is planning to make this transition through further development of its new computerized mapping, system inventory, maintenance history, and condition assessment database, known as HIMCAD.

- **Consolidation of Multiple Small Pump Stations** – The District maintains many small pump stations, sometimes located in close proximity. It is recommended that a detailed study of these portions of the system beyond this investigation be conducted to determine if any of these small pump stations could be eliminated. This study would possibly identify cost-effective solutions to improve overall system operations and efficiency. The cost of completing a further study is not included as a capital project in the CIP.

3.6 Pump Station Condition Assessment Findings and Conclusions

A visual condition assessment was performed for all of the District's pump stations except the San Quentin Pump Station and Heather Garden Pump Station. These assessments were completed during two field visits on December 1, 2005, and April 19, 2006. The purpose of the condition assessment was to identify visible structural and mechanical deficiencies associated with the pump stations, and obtain staff input on operational issues. Templates were developed and completed to document necessary information for each station. These individual pump station summaries are presented in Appendix H and discussed further in this section.

3.6.1 Pump Station Assessment Findings

This Section presents the findings of the pump station condition assessment effort. Identified improvements fall into one of the following categories:

- Piping & Valving – Includes improvements related to piping and valving replacement or repair, and installation of flow meter vaults.
- Electrical – Includes improvements related to general electrical supply, power feed, electrical and VFD panels, and standby power.
- Instrumentation & Control (I&C) – Addresses Supervisory Control and Data Acquisition (SCADA), pump control and flow meter improvements.
- Structural- Addresses wet well, structural condition, leaks, spalling and cracks, and other general structural improvements.
- Health and Safety – Includes improvements to address regulatory compliance, ventilation and potential explosion risks.
- Neighborhood Nuisance – Addresses potential neighborhood disturbances, such as odor, noise, visual nuisance and site security.
- Pump Improvement – Addresses capacity issues, with emphasis on provision of firm and design capacity, as well as replacement of existing pumps that are near the end of their service life.
- Influent Sewer/Force Main – Addresses potential issues associated with influent and effluent pump station pipelines.
- Maintenance/Reliability – Addresses issues such as pump station access, conversion of dry-pit pump stations to submersible pump stations, and change of pump configuration for improved maintenance.
- Overflow Potential – Addresses pump capacity limitations that could lead to SSOs caused by flows generated during a design wet weather flow event.

Table 3-3 provides recommended pump station improvements following the categories identified above. In addition, Appendix H includes the following information for each pump station:

- Pump station characteristics.

- Sketch and pictures.
- Detailed cost estimate of improvements.

A discussion of general and specific improvements recommended as a result of the condition assessment is provided in the sections that follow.

3.6.2 General Pump Station Improvements

In general, it is recommended that flow meters be installed at all pump stations. Based on the size of pumps at a given pump station, it may be necessary to install flow meters at each pump. However, in most cases, one flow meter per station will be appropriate. It is important to note that this recommendation has been incorporated into the proposed improvements and associated cost estimates for all of the District's pump stations, and is also a component of the retrofit of Landing B PS. Installation of flow meters should occur concomitantly with other recommended improvements identified at a given pump station; ultimately, implementation will depend on priorities outlined in the District's Capital Improvement Plan.

It is recommended that pump station data be computerized via SCADA. Computerization of pump station data will improve record keeping. It is also recommended that the District develops an asset management list for each pump station.

3.6.3 Specific Improvements Associated with Pump Stations 31 through 36

Table 3-3 includes issues and recommended improvements for a unique grouping of pump stations: PS-31, PS-32, PS-34, PS-35, and PS-36. These pump stations, as well as PS-33, are located in the Greenbrae Marina area south of Corte Madera Creek and were constructed on bay fill in the 1960s. Their location and nearly identical configuration present similar characteristics and issues that are discussed in further detail in this section.

Pump Stations 31 and 32

It is recommended to replace existing dry-pit pumps in PS–31 and 32 with submersible pumps that would be accessible via access hatches and rails. The existing valve pit would remain, and would require only minor modifications to construct the access hatch. Existing and proposed configurations for PS-31 and 32 are provided in **Figure 3-2.**

Pump Stations 34 through 36

It is recommended to replace existing submersible pumps in PS-34, 35, and 36 with new submersible pumps and change the configuration of the pumps for enhanced access and maintenance. The new pump stations would include a new concrete top slab with access hatch and rails. Each station would also include a new valve box with check valves, butterfly valves and air release valves, access hatch, and a drain to the wet well. Existing and proposed configurations for Pump Stations 34, 35 and 36 are provided in **Figure 3-3**.

Table 3-3 Pump Station Identified Issues and Recommended Improvements

PS #	Name	Recommended Improvements										Summary of Issues and Recommended Improvements
		Piping & Valving	Electrical	I&C	Structural	Health & Safety	Neighborhood Nuisance	Capacity Needs	Influent Sewer / Force Main	Maintenance / Reliability	Overflow Potential	
10	Landing B											▪ Pump Station is being replaced ▪ Pump enclosure is not well ventilated ▪ Water system has no backflow prevention device
11	San Quentin											▪ Not inspected
12	Bon Air	X										▪ Air release valve does not work well. Replace.
		X										▪ Suction head problems probably resulting from vacuum on suction line. Install larger suction line.
				X								▪ Comminutor is not brought back on-line after power outage. Repair pump control, link to SCADA.
						X						▪ Vent into station pumps air from the wet well. Grate opening is only exit mechanism. Install ventilation system.
							X					▪ Station may create odor nuisance due to residential setting. Install odor control.
								X				▪ During high flow conditions, both pumps are needed to convey peak flows; there is no standby capacity. Install larger pumps.
			X		X							▪ Station is in need of general maintenance and upgrades
				X								▪ Install new meter.
13	Greenbrae	X										▪ PS26.3 has a hole in check valve. Replace valve downstream of flow meter.
			X									▪ Station is in need of general electrical upgrades.
				X								▪ Install flow meter on the discharge line of each pump. Install bubbler and connect to SCADA.
						X						▪ Exhaust fan (forced air, dual ventilation supply/exhaust) is pushing more air in than pulling out. ▪ Improve ventilation to put building under negative pressure. ▪ Odor control is carbon activated. Odor control fan to be checked for explosion-proofness. Replace odor fan, as needed. Remaining odor control room functions properly.
					X							▪ Station is in need of general maintenance and upgrades.
14	Larkspur Main			X								▪ Install flow meter in existing flow meter vault and connect to SCADA. ▪ Install new control for new pump, as needed.
						X						▪ An odor control room was installed at the station to address odor problems due to its proximity to a school. ▪ The station only has one vent for ventilation. Install an additional vent to increase air circulation.
								X				▪ Pump station lacks firm capacity (see SHECAP results). ▪ Investigate whether the horsepower of motors of VFDs can increase the pump speed to reach design and firm capacity requirements. ▪ If firm capacity increase cannot be accommodated by existing motors or VFDs, install 2 new pumps to address lack of firm capacity.

PS #	Name	Recommended Improvements										Summary of Issues and Recommended Improvements
		Pumping & Valving	Electrical	I&C	Structural	Health & Safety	Neighborhood Nuisance	Capacity Needs	Influent Sewer / Force Main	Maintenance / Reliability	Overflow Potential	
15	Kentfield		X									▪ Make required electrical upgrades if VFDs need to be replaced.
				X								▪ The station only has one flow meter for five pumps. Install flow meters at discharge end of each pump. ▪ Install new control for new pump, as needed. ▪ Connect new pumps to SCADA.
						X						▪ Air comes in only on one side of the station. ▪ Improve ventilation system.
								X				▪ According to SHECAP analysis, the station lacks firm capacity. ▪ Address firm capacity deficit by rehabilitating and increasing the size of the existing 36-inch force main to a 42-inch (see Force Main Master Plan). ▪ If firm capacity deficit persists after force main increase, increase the size of the two dry-weather pumps possibly by increasing the pump speed, provided motors or VFDs have adequate capacity. If they lack capacity, replace VFDs.
20	Landing A		X									▪ Install backup generator on site. Note that the adjacent busy street can be impacted by closure if the backup generator is required.
				X								▪ Install flow meter.
						X						▪ Pump station is not currently compliant with fire code standards. ▪ Upgrade the station to current fire code standards and to be explosion proof. ▪ Install ventilation system within vault.
										X		▪ Existing pumps are self priming. ▪ Replace existing pumps with submersible pumps.
21	101	X										▪ Construct flow meter vault.
				X								▪ Install flow meter. ▪ Install bubbler sensor. ▪ Connect flow meter to SCADA.
									X			▪ Evaluate possibility of raising the manhole to increase the wet well volume thereby delaying overflows. ▪ Replace original ductile iron force main (see Force Main Master Plan).
												▪ Redundancy: evaluate the possibility of eliminating the pump station by boring and jacking below Highway 101 and connecting to the gravity sewer discharging to PS-20.
22	Cape Marin	X										▪ Construct flow meter vault.
				X								▪ Install flow meter and connect to SCADA.
												▪ Redundancy: evaluate the possibility of eliminating the pump station or Capurro pump station (PS 23) since both stations are in the same vicinity.
23	Capurro	X										▪ Construct flow meter vault.
				X								▪ Install flow meter and connect to SCADA.
												▪ Redundancy: evaluate the possibility of eliminating the pump station or Cape Marin pump station (PS 22) since both stations are in the same vicinity.

PS #	Name	Recommended Improvements										Summary of Issues and Recommended Improvements
		Pumping & Valving	Electrical	I&C	Structural	Health & Safety	Neighborhood Nuisance	Capacity Needs	Influent Sewer / Force Main	Maintenance / Reliability	Overflow Potential	
24	630 Eliseo	X										▪ Construct flow meter vault.
			X									▪ Sound issue due to proximity to residential housing. Install generator sound enclosure.
				X								▪ Install flow meter and connect to SCADA.
25	1350 S. Eliseo	X										▪ Construct flow meter vault.
			X									▪ Sound issue due to proximity to commercial development. Install generator sound enclosure.
				X								▪ Install flow meter. ▪ Install bubbler sensor. ▪ Connect flow meter to SCADA.
										X		▪ Traffic impacted due to location of the pump at turning lane. ▪ Improve station access.
30	Heather Garden	X										▪ Construct flow meter vault. ▪ Replace piping and valving as needed.
				X								▪ Install flow meter. ▪ Install controls for new pumps, as needed. ▪ Connect to SCADA.
					X							▪ Pump station in need of general structural modifications.
								X				▪ Mains surcharge during wet-weather flows. ▪ Replace pumps to alleviate surcharging problems.
31	1 Via la Brisa	X										▪ Construct flow meter vault. ▪ Replace piping and valving as needed.
				X								▪ Install flow meter. ▪ Install controls for new pumps. ▪ Connect to SCADA.
					X							▪ Modify valve pit and wet well.
						X						▪ Install ventilation system.
										X		▪ Existing pumps have to be primed. ▪ Replace existing pumps with submersible pumps.

PS #	Name	Recommended Improvements										Summary of Issues and Recommended Improvements
		Pumping & Valving	Electrical	I&C	Structural	Health & Safety	Neighborhood Nuisance	Capacity Needs	Influent Sewer / Force Main	Maintenance / Reliability	Overflow Potential	
32	1 Corte del Bayo	X										▪ Construct flow meter vault. ▪ Replace piping and valving as needed.
				X								▪ Install flow meter. ▪ Install controls for new pumps. ▪ Connect to SCADA.
					X							▪ Modify valve pit and wet well.
						X						▪ Install ventilation system.
										X		▪ Existing pumps have to be primed. ▪ Replace existing pumps with submersible pumps.
33	415 Riviera Circle	X										▪ Construct flow meter vault.
				X								▪ Install flow meter and connect to SCADA.
34	359 Riviera Circle	X										▪ Install new piping and valving.
				X								▪ Install flow meter. ▪ Install controls for new pumps. ▪ Connect to SCADA.
					X							▪ Modify wet well. ▪ Construct concrete pad.
								X				▪ Install two new pumps.
										X		▪ Maintenance of station is difficult due to difficult access through necked-down manhole. ▪ Rebuild new pump station including street vaults with wet well, rails and aluminum top.
35	2 Corte del Coronado	X										▪ Install new piping and valving.
				X								▪ Install flow meter. ▪ Install controls for new pumps. ▪ Connect to SCADA.
					X							▪ Modify wet well. ▪ Construct concrete pad.
								X				▪ Install two new pumps.
										X		▪ Maintenance of station is difficult due to difficult access through necked-down manhole. ▪ Rebuild new pump station including street vaults with wet well, rails and aluminum top.

PS #	Name	Recommended Improvements										Summary of Issues and Recommended Improvements
		Pumping & Valving	Electrical	I&C	Structural	Health & Safety	Neighborhood Nuisance	Capacity Needs	Influent Sewer / Force Main	Maintenance / Reliability	Overflow Potential	
36	178 Riviera Circle	X										▪ Install new piping and valving.
				X								▪ Install flow meter. ▪ Install controls for new pumps. ▪ Connect to SCADA.
					X							▪ Modify wet well. ▪ Construct concrete pad.
								X				▪ Install two new pumps.
										X		▪ Maintenance of station is difficult due to difficult access through necked-down manhole. ▪ Rebuild new pump station including street vaults with wet well, rails and aluminum top.
37	Larkspur Plaza	X										▪ Pump station has a defective valving system. ▪ Replace valves.
			X									▪ The District and the City of Larkspur currently share 3-line power. It is recommended that the City of Larkspur and the District have separate power lines. ▪ Construct spare power line for District pump station.
				X								▪ Install flow meter and connect to SCADA.
												▪ Area enclosing the pump station is subject to frequent flooding.

Figure 3-2 Existing and Proposed Configurations for Pump Stations 31 & 32

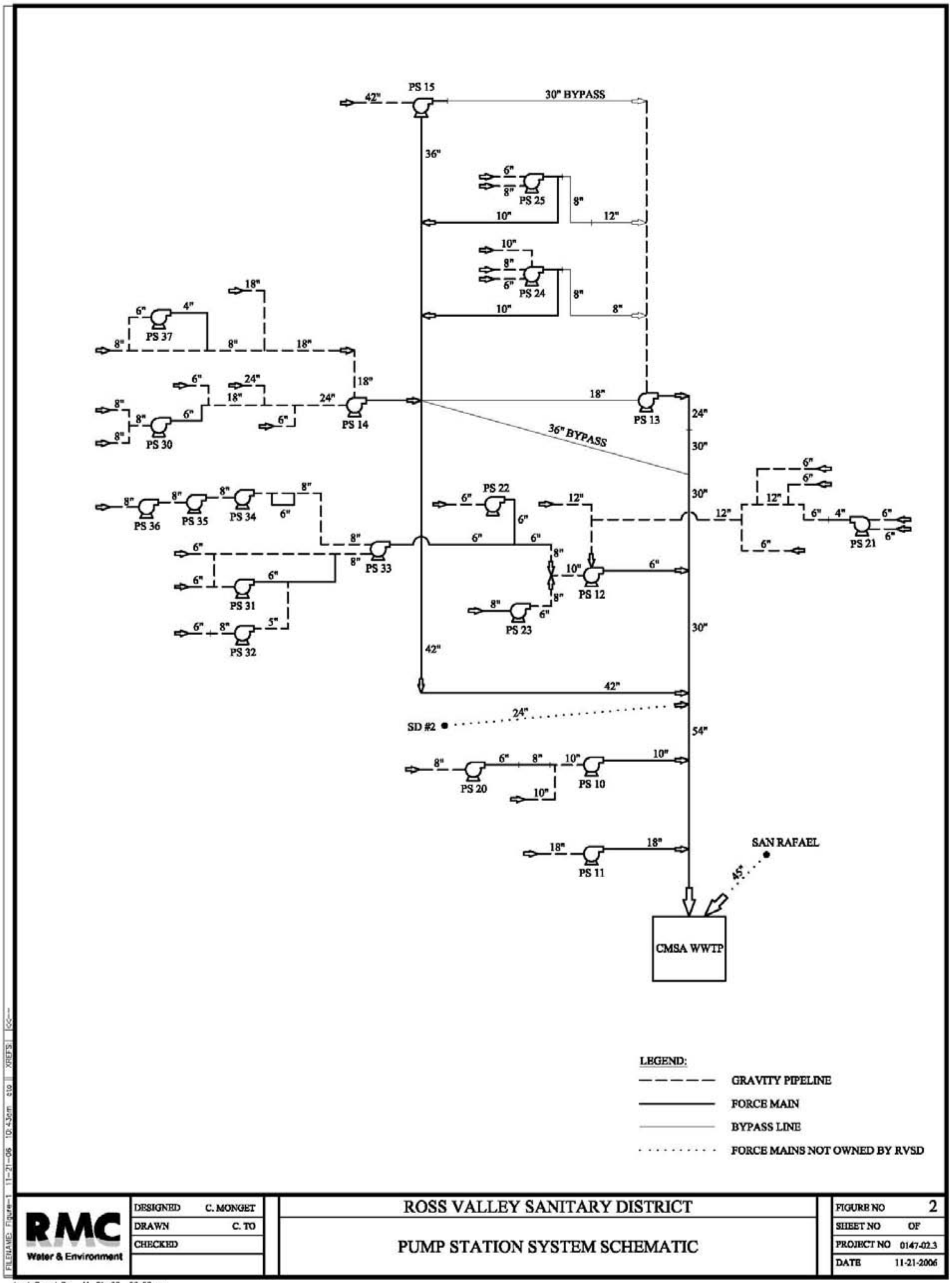
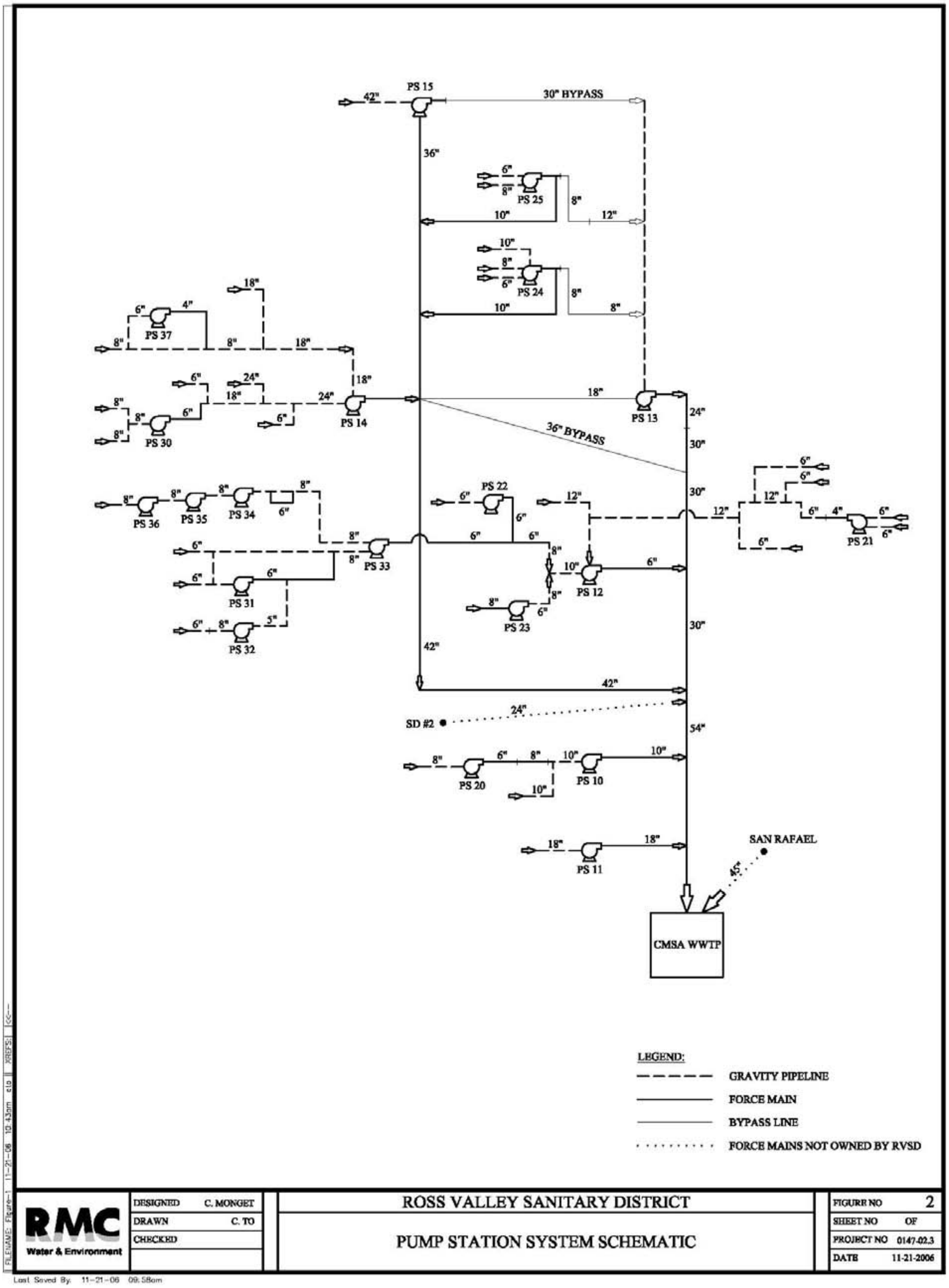


Figure 3-3 Existing and Proposed Configurations for Pump Stations 34, 35 & 36



3.7 Pump Station Improvements Cost and Preliminary Ranking

This section provides a summary of the capital costs associated with the recommended pump station improvements. A more detailed capital cost breakdown can be found in Appendix H. Capital costs include estimated construction costs and engineering, legal, and administrative fees. Construction costs are based on recent, similar projects completed by RMC, as well as RSMeans estimates as appropriate, and include contractor mobilization (5 percent of base construction cost) and construction contingencies (30 percent of base construction cost). Capital costs include engineering, legal, and administrative fees estimated at 25 percent of construction cost with contingencies and mobilization.

As shown in **Table 3-4**, the total estimated cost for the recommended improvements is $2.81 million. All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index).

Table 3-4 Pump Station Improvements Capital Cost

PS #	PS Name	Capital Costs ($)
10	Landing B	$0 (PS is being replaced)
11	San Quentin	$0
12	Bon Air	$364,000
13	Greenbrae	$265,000
14	Larkspur Main	$111,000
15	Kentfield	$154,000
20	Landing A	$258,000
21	101	$60,000
22	Cape Marin	$43,000
23	Capurro	$43,000
24	630 Eliseo	$68,000
25	1350 S. Eliseo	$94,000
30	Heather Garden	$92,000
31	1 Via la Brisa	$213,000
32	1 Corte del Bayo	$213,000
33	415 Riviera Circle	$43,000
34	359 Riviera Circle	$248,000
35	2 Corte del Coronado	$248,000
36	178 Riviera Circle	$248,000
37	Larkspur Plaza	$43,000
Total		**$2,808,000**

In addition, this section presents a preliminary ranking of the recommended pump station improvements. None of the identified improvements were classified as requiring immediate implementation in Fiscal Year 2007. Therefore, these projects supplement the near-term CIP developed by RMC in 2006. The proposed pump station improvements address existing deficiencies, improve reliability, and respond to District staff concerns. The near-term improvements list, as recommended by staff, addresses deficiencies at eight pump stations with a total estimated cost of $1.91 million. This initial ranking list, along with priority and implementation timeframe, is presented in **Table 3-5**, below. All costs are referenced to an August 2006 ENR index of 8464 (San Francisco City Construction Index). The most critical improvements address maintenance issues associated with PS-34 through 36, 31, and 32. Other high priority improvements address capacity issues at PS-12 and 14, and safety issues at PS-13, respectively. This ranking is further refined in development of the District's Capital Improvement Plan.

Table 3-5 Preliminary Ranking of Near-Term Pump Station Improvements

Pump Station #	Pump Station Name	Cost of Improvement ($)	Ranking	Implementation Timeframe
34 35 36	359 Riviera Circle 2 Corte del Coronado 178 Riviera Circle	$248,000 $248,000 $248,000 $744,000	1	2 years
31 32	Via la Brisa 1 Corte del Bayo	$213,000 $213,000 $426,000	2	2 years
12	Bon Air	$364,000	3	3 to 5 years
14	Larkspur	$111,000	4	3 to 5 years
13	Greenbrae	$265,000	5	3 to 5 years
	TOTAL	**$1,910,000**		
Other Pump Station Improvements [a]		$898,000	6	5 to 10 years

Footnotes:

a. As summarized in Table 3-4.

References

MWH Incorporated (August 2006). Sanitary Sewer Hydraulic Evaluation and Capacity Assurance Plan.

Nolte Engineering (September 2004). Central Marin Sanitation Agency Interceptor Network Hydraulic Model Final Report.

Nute Engineering (May 1998). Force Main Improvement Program.

Nute Engineering (January 1998). Kentfield Pump Station Review.

San Francisco Bay Regional Water Quality Control Board (October 1996). Wastewater Pumping Station Reliability Recommendations (draft).

Appendix A - CIP-1 and CIP-2 Technical Memoranda

Appendix B - SHECAP Report

Appendix C - Condition Assessment TM

Appendix D - FM Implementation Program

Appendix E - Corrpro Investigations

Appendix F - Kentfield Alternatives TM

Appendix G - Pump Station Reliability Document

Appendix H - Individual Pump Station Evaluations and Cost Breakdown

Technical Memorandum CIP-1

RVSD Sewer System Assessment and Capital Improvement Planning

Subject: **Prioritization Process**

Prepared For: Barry Hogue, District Manager, RVSD

Prepared by: Rachael Wark and Vivian Housen

Reviewed by: Gisa Ju

Date: July 12, 2006

Reference: 0147-001

This memorandum presents the preliminary goals, criteria and project prioritization process for consideration as part of the development of the Ross Valley Capital Improvement Strategic Plan. This TM is organized as follows:

- Background
- Prioritization Criteria
- Weighting of Criteria
- Project Performance Metrics

1 Background

Facing a number of challenges relating to the condition, capacity and operation of its collection system facilities, Ross Valley Sanitary District (District) has embarked upon several planning efforts to identify effective solutions to address these challenges:

- Sewer Hydraulic Evaluation and Capacity Assurance Plan (SHECAP). This work evaluates trunk sewer facilities and flows, and recommends upgrades to larger-diameter trunk sewers that will minimize the potential for capacity-related sanitary sewer overflows. SHECAP also identifies potential capacity constraints in some smaller-diameter sewers that could be addressed in conjunction with trunk sewer rehabilitation and replacement. SHECAP work was completed in June 2006. A draft report summarizing results is under review by District staff.
- Sewer System Management Plan (SSMP) Gap Analysis. This work, which was completed in late 2005, assessed District operations and documentation with regard to SSMP guidelines. The Gap Analysis identified potential areas that require attention during development of the District's SSMP.
- History Inventory Maintenance Condition Assessment Database (HIMCAD). This effort mapped existing facilities and maintenance information in a GIS database, for future use by the District. Initial HIMCAD mapping was completed in late 2005; the database is a working document and recommendations for improvements will be made based on

findings from ongoing facility assessments.

- Sewer System Assessment and Capital Improvement Planning (SSACIP). This effort includes detailed assessments of the District's facilities, and will culminate in the development of three Master Plans: Sewer Master Plan, Force Main Master Plan, and Pump Station Master Plan, including recommended rehabilitation and replacement projects for each of these groups of facilities. This work, in conjunction with SHECAP and using information from HIMCAD, uses a decision analysis model to develop a long-term projection of system improvement projects for implementation by the District, based on established goals and priorities. SSACIP also recommends near-term projects to be implemented in a one- to three-year timeframe. SSACIP will be completed by the end of 2006; near-term projects will be finalized in July 2006.

As part of the SSACP effort discussed above, the District is developing a long-term Capital Improvement Strategic Plan that will result in a comprehensive, prioritized Capital Improvement Program (CIP). Following identification of solutions by the planning efforts noted above, the next steps in development of a Strategic Plan involve:

1. **Identifying Prioritization Criteria**. These criteria represent the driving forces behind the recommended improvement projects and reflect the goals of the District.
2. **Assigning Relative Weights to the Criteria.** This task involves defining the relative importance of the identified criteria.
3. **Establishing Project Metrics and Evaluating Proposed Projects.** With the criteria and weighting defined, the next step is to determine metrics that will be used to evaluate each of the improvement projects with respect to these parameters, and to conduct this evaluation.
4. **Developing Project Rankings**. A decision model will be used to develop a prioritized list of improvement projects based the above evaluation.
5. **Identifying Overriding Factors**. In general, highest scoring projects should receive the highest priority for implementation. However, there are some cases where project-specific constraints may override the project ranking.
6. **Developing Prioritized Cash Flow & Schedule**. The final step in the process is to work with District staff to develop a cash flow and schedule that balances improvement needs with projected funding.

This memorandum describes potential Prioritization Criteria and Weighting (Steps 1 and 2) for consideration by the District in development of the Strategic Plan, and presents potential project performance metrics by which each improvement project may be evaluated (Step 3).

2 Prioritization Criteria

The District's Mission is "*to provide the highest quality and most cost-effective wastewater collection possible for its constituents by meeting the following goals*:

- *Be available and responsive to the needs of the public*

- *Perform preventive maintenance on all collection system components*
- *Proactively identify and correct public sewer system defects*
- *Work cooperatively with local, state and federal agencies*
- *Uphold the District's standards and specifications on newly constructed public and private sewers"*

The prioritization criteria shown in **Table 1** were developed to support the District's goals, and are presented for consideration by District staff:

Table 1 - Prioritization Criteria

Criteria	Definition
Traffic Impacts / Temporary Shutdowns	Project would minimize potential traffic impacts and/or temporary shutdowns that could result in a system failure or operational issue.
Legal Compliance	Project contributes to requirement for rehabilitation of 2 miles of pipe per year or equivalent.
Regulatory Compliance including SSO Reduction	Project is needed to comply with existing regulations (e.g. reduces risk for Sanitary Sewer Overflows and meet other SSMP requirements).
Large-Scale Impact Involving Trunk Sewers	Project is needed to address capacity deficiencies or reliability issues in an existing trunk sewer that could result in SSOs
Operational Efficiency/Aging Infrastructure	Project is needed to maintain or improve the management, operational efficiency, and reliability of the system, and/or to extend the useful life of the facilities

3 Weighting of Criteria

Table 2 presents proposed weights for the criteria identified for consideration as part of the Strategic Plan, with 5 being most critical to the District, and 1 being less critical but still highly important for the District to achieve its goals.

Table 2 - Criteria Weighting

Criteria	Relative Weighting	
	Score (1-5)	% of Total
Traffic Impacts/Temporary Shutdowns	1	5.3%
Legal Compliance	5	26.3%
Regulatory Compliance (SSOs, SSMP)	5	26.3%
Large-Scale Impact (Trunk Sewer)	5	26.3%
Operational Efficiency/Aging Infrastructure	3	15.8%
Total	**19**	**100%**

4 Project Performance Metrics

Project metrics are benchmarks that will be used to determine to which degree each project meets the prioritization criteria described above. **Table 3** presents a summary of the performance metrics identified for consideration as part of the Strategic Plan.

Table 3 - Project Performance Metrics

Criteria	Performance Metric	
	Project Score	Description
Traffic Impacts/Temporary Shutdowns	**10**	Reduces risk of **high** traffic or shutdown-related impacts in the next 5 years: - Reduces risk of temporary interruption of service to *large number* of customers; and/or - Reduces risk of *significant* traffic impacts from failed infrastructure
	7	Reduces risk of **moderate** traffic or shutdown-related impacts in the next 5 years: - Reduces risk of temporary interruption of service to *some* customers; and/or - Reduces risk of *moderate* traffic impacts from failed infrastructure
	3	Reduces risk of **low** traffic or shutdown-related impacts in the next 5 years: - Reduces risk of temporary interruption of service to *limited number of* customers; and/or - Reduces risk of *low* traffic impacts from failed infrastructure
	0	Does not address traffic or shutdown-related impacts.
Legal Compliance	**10**	Rehabilitates 3000' of pipe or greater.
	9	Rehabilitates 2000' to 3000' of pipe.
	7	Rehabilitates 1000' to 2000' of pipe.
	5	Rehabilitates up to 1000' of pipe.
Regulatory Compliance (SSOs, SSMP) Note: Score increased one level if SSO will impact sensitive environment	**10**	Predicted overflow in 5-year design storm >400,000 gal OR resolves a historical or documented overflow
	9	Predicted overflow in 5-year design storm >100,000 gal
	8	Predicted overflow in 5-year design storm >10,000 gal
	7	Predicted overflow in 5-year design storm >1,000 gal OR resolves a known issue (such as a structural or grease problem) with the potential to cause future SSOs
	5	Predicted surcharge in 5-year design storm within 3 feet of ground surface
	3	Predicted surcharge in 5-year design storm >3 feet below surface
	0	No predicted surcharge
Large-Scale Impact (Trunk Sewer)	**8**	Trunk line modeled in SHECAP and 18" diameter or greater.
	5	Trunk line modeled in SHECAP and less than 18" diameter
	3	Not modeled in SHECAP.
Operational Efficiency/Aging Infrastructure	**10**	Provides critical redundancy or improvement to O&M
	5	Provides level of redundancy or O&M consistent with good operating practices;
	0	Does not address an identified operational efficiency/aging infrastructure

Technical Memorandum CIP-2

RVSD Sewer System Assessment and Capital Improvement Planning

Subject: **Fiscal Year 2007 Prioritized Projects**

Prepared For: Barry Hogue, District Manager, RVSD

Prepared by: Vivian Housen

Reviewed by: Gisa Ju

Date: July 6, 2006

Reference: 0147-001

1 Introduction

RMC is completing a comprehensive Sewer System Assessment and Capital Improvement Planning (SSACIP) effort for Ross Valley Sanitary District (District). The overall goal of this project is to evaluate existing pump stations, force mains, and gravity sewers, and establish requirements and develop a plan for continued rehabilitation or replacement of these facilities. These rehabilitation plans will be summarized in individual master plans developed for each group of facilities. The SSACIP effort incorporates information from other work recently completed by the District, including the Sanitary Sewer Hydraulic Evaluation and Capacity Assurance Plan (SHECAP) and development of the District's inventory, maintenance, and condition assessment database (called HIMCAD), as well as on-going sewer rehabilitation projects, and is scheduled to be completed by the end of 2006.[1]

An intermediate goal of this project is to develop recommendations for priority projects that should be implemented in FY2007. A preliminary list of priority projects was developed after completion of all initial assessments, and using a weighted decision analysis model developed specifically for the District. This model is described in greater detail in Technical Memorandum CIP-1, attached. The preliminary list of projects was reviewed by RMC, District staff and Nute Engineering, and further refined to more accurately reflect District priorities and needs.

The purpose of this Technical Memorandum is to present the finalized list of FY07 prioritized projects, including estimated project costs and projected schedules. This TM is organized as follows:

- Introduction
- FY2007 prioritized projects, including estimated costs and project schedules
- Summary of project drivers
- Next steps

[1] A separate component of the SSACIP that is not discussed in this memorandum is development of a Sewer System Management Plan (SSMP) in accordance with guidelines published by the San Francisco Bay Regional Water Quality Control Board.

2 FY2007 Prioritized Projects

2.1 Project List

Table 1 presents seven projects that are proposed to begin in FY2007. These projects include one force main project and six sewer rehabilitation/replacement projects. Although no pump station projects were identified for completion in FY2007, the pump station assessment did identify areas for future improvement and rehabilitation, and will address these long-term needs in the pump station master plan.

Table 1 – FY2007 Priority Projects

Project Short Name	Description	Approximate Length (ft)
Techite Force Main	Rehabilitates, replaces, and/or increases capacity of the existing techite force main parallel to Corte Madera Creek in Kentfield and along Eliseo Drive in Larkspur. This project require predesign and design in FY2007. Construction is planned for FY2008.	8,000
Bon Air Tunnel	Rehabilitates the original trunk sewer between Bon Air shopping center and Bon Air Road in Larkspur. This project is currently under construction, and will be completed by December 2006.	3,000
Creek/Bolinas/Cascade	Replaces and increases capacity of existing pipelines on Creek Road, Bolinas Road, and in the easement parallel to Cascade Creek in Fairfax, and replaces collection system piping upstream of these sewers and on Wood Lane. A portion of this project is currently under design by Nute Engineering. Due to permitting issues, this project will not be ready for construction until FY2008.	7,652
SFD/Shady Lane	Increases capacity of existing pipelines on Sir Francis Drake Boulevard (San Anselmo) and Bolinas Avenue and Shady Lane (Ross), adds relief sewers, and replaces collection system piping adjacent to these sewers and in Winship Park. CCTV inspection and design are planned for FY2007. Construction will be completed in FY2008.	19,371
Woodland/Goodhill	Increases capacity of existing pipelines on Woodland Road, Goodhill Road, College Avenue, and Stadium Way (Kent Woodlands and Kentfield), and adds two relief sewers. Design is planned for FY2007 with construction in FY2008.	5,850
Sequoia Park/Olive	Replaces collection system piping near Sequoia Road (San Anselmo), and Olive Ave and Park Drive (Ross). CCTV inspection and design are planned for FY2007. Construction will be completed in FY2008.	21,951
Olive/North/Cypress	Replaces collection system piping on nine streets throughout the District's service area. These pipes are experiencing maintenance issues and located in areas where construction during FY2007 is feasible.	11,010

2.2 Project Costs

Estimated costs for the identified FY2007 priority projects are presented in **Table 2**. The projected cost for FY2007 is $6.5 million. This estimate includes CCTV inspection, predesign, and design efforts for most projects, and construction of the Bon Air Tunnel and Olive/North/Cypress project. Costs were developed based on conceptual requirements for pipeline installation, replacement, and rehabilitation. Cost estimates use information from similar projects currently under construction by the District, and in the Bay Area. The estimate provides a +50% to -30% level of accuracy, as defined by AACE International. Costs are benchmarked to ENR Construction Cost Index, San Francisco, April 2006.

In addition to FY2007 priority projects, Table 2 presents other related projects that are recommended as part of the near-term CIP. These additional efforts include implementing a system-wide condition assessment program using CCTV inspection beginning in FY2008[2] and completing ongoing SSACIP and capital projects.

2.3 Project Schedules

Proposed schedules for the FY2007 priority projects are presented in **Table 3**. FY2008 and FY2009 activities include only include projects that are initiated in FY2007. A long-term CIP will be developed by the end of 2006 that identifies projects that will begin design in FY2008 and later. This schedule will be updated and augmented at that time to reflect the final strategic capital improvement plan.

3 Summary of Project Drivers

3.1 Decision Model

RMC created and implemented a decision analysis model to develop an initial list of FY2007 priority projects. Technical Memorandum CIP-1, attached, describes model components, including the process, criteria, and metrics used. Although the decision model captures the most significant project drivers, there is a component of CIP development that cannot be mechanized. This component relies on the facility knowledge of operations and technical staff, and the relationships between various projects (e.g., in general, downstream capacity improvements should be completed before upstream improvements). Therefore, the initial list was reviewed by the project team and discussed with District operations staff and Nute Engineering to make sure that overriding criteria driving project development were accurately addressed.

3.2 Additional Project Drivers

Additional project drivers that were considered in the final list of priority projects include:

1. **Proximity of priority and non-priority projects**. Projects located in the same general proximity were combined to minimize construction impacts and optimize costs. As a result,

[2] FY2007 priority projects involving collection system rehabilitation incorporate CCTV inspection; therefore, the system-wide approach is not recommended to begin until FY2008.

some projects that were not initially flagged as priority projects moved onto the priority list. These projects include portions of the Creek/Bolinas/Cascade, SFD/Shady Lane and Woodland/Goodhill projects.

2. **Interface with other agencies or property owners**. Several projects are located adjacent to other utilities (e.g., water pipelines) with planned construction in FY2007, or in areas with known property or permitting issues. Although project design is planned for FY2007, construction has been deferred to FY2008. These projects include portions of SFD/Shady Lane and Sequoia Park/Olive projects.
3. **Need for accelerated sewer rehabilitation**. The District is committed to rehabilitating at least two miles of sewer pipe every fiscal year. In order to meet this requirement, individual sewer projects in areas where construction during FY2007 appears achievable were included on the priority project list. These individual sewer rehab projects are collectively named Olive/North/Cypress, and include pipelines with known maintenance issues located on nine streets within the District's service area.

3.3 Next Steps

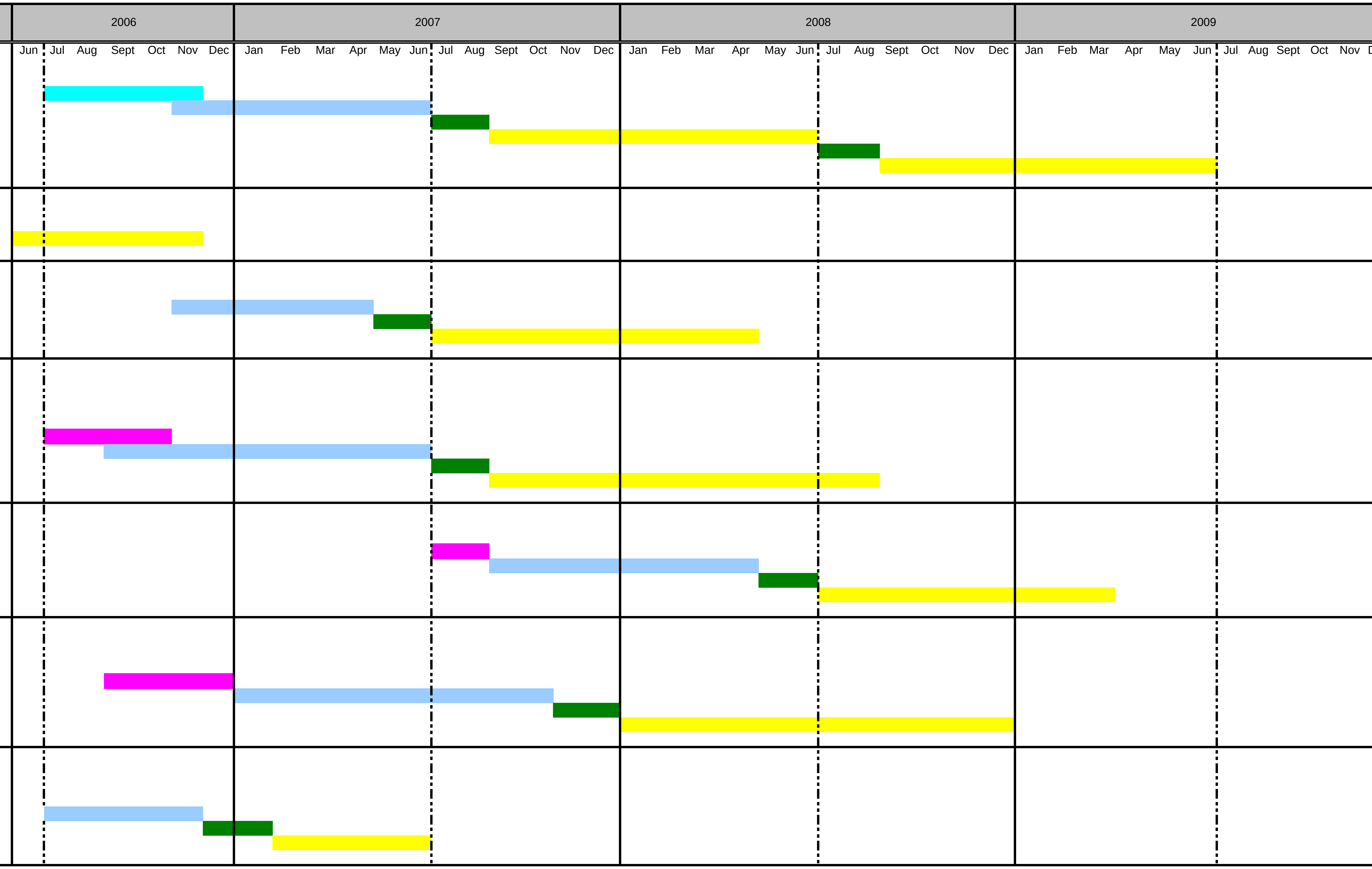
In order to maintain the proposed project schedule, and in particular, to maximize the length of sewer pipe that is rehabilitated in FY2007, it is important that the District initiate CCTV, predesign, and design phases of the priority projects in summer 2006. Depending on project location and potential impact, these early project tasks may include a public outreach or environmental component.

Table 1
RVSD Sewer System Assessment and Capital Improvement Planning
Project Cash Flow for FY07 Priority Projects

Task Name/Subtask (Project ID)	Total Capital Cost	Total Footage	FY2007 ($000)	FY2008 ($000)	FY2009 ($000)	Notes
1. Techite Force Main (F-1)	**$6 to $12.5 M (use $9M average)**	**8,000 ft.**				All Design in FY07. Construction phased across FY08 and FY09.
a Preliminary Design			216	0	0	
b. Final Design			864	0	0	
c. Bid Period - Phase 1			0	0	0	
d. Construction - Phase 1			0	3,960	0	
e. Bid Period - Phase 2			0	0	0	
f. Construction - Phase 2			0	0	3,960	
TOTAL FORCE MAIN PROJECTS			1,080	3,960	3,960	FY08 and FY09 Design & Construction Costs will be updated in late 2006 to include long-term CIP projects.
2. Bon Air Tunnel (R-3)	**$1,303 M**	**3,000 ft.**				
a. Bid Period			0	0	0	
b. Construction			1,303	0	0	
3. Creek/Bolinas (S-4) combined with Cascade Sewer (R-4) & Wood Lane (R-67)	**$3.033 M**	**7,652 ft.**				
a. Design			364	0	0	
b. Bid Period			0	0	0	
c. Construction			0	2,669	0	
4. Sir Francis Drake/Winship (S-10) Combined with Winship Park (R-9), Sir Francis Drake (R-7), Bolinas/Fernhill (S-11), Upper Shady Lane Trunk Sewer (S-12), and Winship Collection System (R-68)	**$7.118 M +$74k condition assessment**	**19,371 ft.**				
a. Condition Assessment			74	0	0	
b. Design			854	0	0	
c. Bid Period			0	0	0	
d. Construction			0	5,220	1,044	
5. Woodland/College (S-15) combined with Goodhill (S-14) and Kentfield Relief Sewer (S-16)	**$3.072 M + $37k condition assessment**	**5,850 ft.**				Design will be accelerated to FY07 if possible after review of final project costs for other priority projects.
a. Condition Assessment			0	37	0	
b. Design			0	369	0	
c. Bid Period			0	0	0	
d. Construction			0	0	2,703	
6. Sequoia Park (R-8, 10, 11) and Sequoia Collection System (R-69) combined with Olive Avenue (2007) and Tozzi Creek Crossing (R-5)	**$6.374 M + $74k condition assessment**	**21,951 ft.**				
a. Condition Assessment			74	0	0	
b. Design			459	306	0	
c. Bid Period			0	0	0	
d. Construction			0	2,805	2,805	
7. Olive-Walnut; North-Hill; Holcomb-Monte Vista; San Anselmo (Ave.); Hickory; Cypress (R-70)	**$3.387 M**	**11,010 ft.**				2 miles of collection system piping rehab to be completed in FY07
a. Condition Assessment			0	0	0	
b. Design			406	0	0	
c. Bid Period			0	0	0	
d. Construction			2,980	0	0	
TOTAL GRAVITY SEWER PROJECTS			**$6,514**	**$11,405**	**$6,552**	**FY08 and FY09 Design & Construction Costs will be updated in late 2006 to include long-term CIP projects.**
Condition Assessment			147	37	0	
Design			2,083	675	0	
Construction			4,283	10,693	6,552	
Additional system-wide condition assessment			0	283	320	FY2007 CCTV for planned projects only. In future years, cost includes 200k feet of CCTV inspection annually, or CCTV of all system pipes within approximately 5 years.
Projects in progress not listed above			150			
SSACIP through end of 2006			500			
OTHER CAPITAL EXPENDITURES			**$650**	**$283**	**$320**	
TOTAL CAPITAL BUDGET			**$7,164**	**$11,688**	**$6,872**	

Table 3
RVSD Sewer System Assessment and Capital Improvement Planning
Estimated Schedules for FY07 Priority Projects

Task Name/Subtask (Project ID)	Total Capital Cost	Total Footage
1. Techite Force Main (F-1) a Preliminary Design b. Final Design c. Bid Period - Phase 1 d. Construction - Phase 1 e. Bid Period - Phase 2 f. Construction - Phase 2	**$6 to $12.5 M (use $9M average)**	**8,000 ft.**
2. Bon Air Tunnel (R-3) a. Bid Period b. Construction	**$1.720 M**	**3,000 ft.**
3. Creek/Bolinas (S-4) combined with Cascade Sewer (R-4) and Wood Lane (R-67) a. Design b. Bid Period c. Construction	**$3.675 M**	**9,732 ft.**
4. Sir Francis Drake/Winship (S-10) Combined with Winship Park (R-9), Sir Francis Drake (R-7), Bolinas/Fernhill (S-11), Upper Shady Lane Trunk Sewer (S-12), and Winship Collection System (R-68) a. Condition Assessment b. Design c. Bid Period d. Construction	**$7.118 M +$72k condition assessment**	**19,371 ft.**
5. Woodland/College (S-15) combined with Goodhill (S-14) and Kentfield Relief Sewer (S-16) a. Condition Assessment b. Design c. Bid Period d. Construction	**$3.072 M + $36k condition assessment**	**5,850 ft.**
6. Sequoia Park (R-8, 10, 11) and Sequoia Collection System (R-69) combined with Olive Avenue (2007) and Tozzi Creek Crossing (R-5) a. Condition Assessment b. Design c. Bid Period d. Construction	**$6.374 M + $72k condition assessment**	**21,951 ft.**
7. Olive-Walnut; North-Hill; Holcomb-Monte Vista; San Anselmo (Ave.); Hickory; Cypress (R-70) a. Condition Assessment b. Design c. Bid Period d. Construction	**$3.386 M**	**11,010 ft.**



See separate SHECAP Report on File at the District Office

Technical Memorandum

Ross Valley Sanitary District
Sewer System Replacement Master Plan

Subject:	**Guidelines for Sewer Condition Assessment and Rehabilitation Decision Methodology**
Prepared For:	Ross Valley Sanitary District
Prepared by:	Jennifer Glynn and Gisa Ju, RMC
Reviewed by:	Glenn Hermanson, RMC; Ed Nute, Nute Engineering
Date:	December 28, 2006
Reference:	0147-2.1.2

The objective of this Technical Memorandum (TM) is to develop sewer condition assessment and rehabilitation decision methodology to be used to identify specific sewer rehabilitation/replacement projects and estimate long-term sewer rehabilitation and replacement needs for the District. The condition assessment approach as described in this TM will also be incorporated into the Measures and Activities element of the District's Sewer System Management Plan. This TM is organized into the following sections:

1. Introduction
2. Sewer and Manhole Inspection Procedures and Data Collection
3. Standard Inspection Codes and Rating Criteria
4. Condition Evaluation Procedures for Pipelines
5. Condition Evaluation Procedures for Manholes
6. Sewer Rehabilitation Decision Methodology

Attachment A – Sample Specifications for Sewer Cleaning & Television Inspection

Attachment B – Descriptions and Photographic Examples of CCTV Inspection Codes

1 Introduction

Formed in 1899, Ross Valley Sanitary District (RVSD) is one of the oldest wastewater agencies in the state. Currently, it serves eight communities in the Ross Valley extending from Larkspur to Fairfax and Sleepy Hollow. The District operates 186 miles of gravity sanitary sewers, 7 miles of pressure force mains, and 20 pump stations. All flow from the District is pumped to the Central Marin Sanitation Agency Wastewater Treatment Plant located near the western end of the Richmond-San Rafael Bridge.

The District is facing a number of challenges regarding its operations including identifying, managing, and implementing the numerous studies and projects required to resolve regulatory, capacity, and condition issues within its system. District staff is concerned about the issues that could arise if the numerous components that are required to assess system integrity, capacity, and reliability are completed without programmatic-level management, direction, and monitoring.

The guidelines presented in this TM will help the District gather information on sewer characteristics, condition, and existing maintenance history and problem areas and provide the District with a decision methodology for sewer improvements. This programmatic approach will help eliminate the potential for overlap of effort and establish a basis for assessment, cost, and project development. RMC will use these tools to develop a plan for near-term and long-term sewer rehabilitation and replacement. This information will be incorporated into the District's Sewer System Replacement Master Plan.

2 Sewer and Manhole Inspection Procedures and Data Collection

This section describes the general inspection and data collection processes for sewer and manhole condition assessment. It includes basic information on pre-inspection activities including mobilization and site assessment, and describes closed-circuit television (CCTV) inspection performance standards, including general information and definitions, quality standards, record keeping requirements, digital data formatting, appropriate screen text information and narration, and special CCTV procedures. This technical memorandum is a guide for performing sewer system inspections by either District field crews or contractors. It is expected that, at least for the immediate future, the majority of these inspections will be completed under contract. Attachment A contains example detailed specifications for Sewer Cleaning and Inspection. These sample specifications can be tailored to the District's requirements and incorporated into a contract negotiated with a CCTV contractor for CCTV inspection of the District's system.

2.1 Mobilization and Site Assessment

Pre-inspection activities include all activities required to mobilize for the field and set up equipment before actually performing CCTV inspection, as well as assessing the requirements for working at the project site. **Table 2-1** is a checklist of the activities to be performed by the contractor before going out in the field. **Table 2-2** is a checklist for site assessment activities to be performed by the contractor or District crews before beginning the actual CCTV data collection.

2.1.1 Access to Private Property

Property owners must be notified if access to property is required. CCTV contractors must follow any required District easement access procedures for the project being performed.

2.1.2 Traffic Control

Traffic control is normally required to perform CCTV inspection. The traffic control standards of the jurisdiction in which the work is located must be followed at all times. In compliance with or in addition to the jurisdiction's requirements, flashing lights must be used for all night work.

2.2 CCTV Performance

CCTV performance includes the following:

- Consistent use of standard forms and codes
- Uniform compliance with setup and inspection procedures
- Quality picture and audible records
- Suitable camera speed, lighting, and panning
- Accuracy when recording file names and electronic data

Table 2-1

Mobilization Checklist

ACTIVITY	CHECK WHEN COMPLETED
Check that all crew members have proper identification	❑
Obtain work orders, maps, and special instructions	❑
Coordinate with crews assisting in work (cleaning, traffic control, etc)	❑
Obtain supply of CDs or DVDs	❑
Assemble equipment needed for work assignment	❑
Check equipment operation	
▪ TV cameras	❑
▪ Computer	❑
▪ Gas detectors	❑
▪ Hand-held radios	❑
Load equipment in field vehicle	
▪ Maps, work orders, other paper work	❑
▪ TV cameras	❑
▪ CDs or DVDs with labels	❑
▪ Gas detectors	❑
▪ Hand-held radios	❑
Check other field supplies	
▪ Safety gear	❑
▪ Traffic cones	❑
▪ Traffic control signs	❑
▪ Camera accessories	❑
▪ Plugs	❑
▪ Hand tools; spare parts	❑
▪ Other field supplies	❑

Table 2-2

Site Assessment Checklist

ACTIVITY	CHECK WHEN COMPLETED
Locate manholes	❑
Obtain access to manholes in easements	❑
Determine traffic control needs	❑
Set up traffic control and signs	❑
Perform atmospheric testing[1] before opening manhole	❑
Clear manhole gasses if necessary until safe atmosphere is obtained	❑
View manhole and flow channel to determine if cleaning and/or flow control are needed	❑
Clean pipe if needed (by CCTV field crew or cleaning crew)	❑
Plug or bypass flow if needed (any interruption in normal flows must be monitored continuously to prevent flooding or overflows) [2]	❑
Select appropriate TV camera and accessories for work to be performed and site conditions	❑
Perform initial manhole inspection prior to CCTV inspection as outline in Section 5 of this TM	❑

[1] Atmospheric testing must be performed even if no personnel entry into the manhole is planned. This prevents personnel leaning over the manhole from being overcome by noxious gasses and allows emergency confined space entry if necessary. If unsafe levels are detected, the crew should attempt to ventilate the manhole. If unsafe levels still remain, a District supervisor should be contacted.

[2] Plugging or bypassing of flow is not to be performed by CCTV contractors without prior approval and on-site supervision by the District.

NOTE: If the safety of field personnel or the public, or safe use of field equipment, is threatened at any time during the CCTV process, the field activities should be stopped and the site secured. If District field personnel are performing the CCTV, the supervisor should be notified immediately. If a CCTV contractor is performing the CCTV, the prime contractor or District's project manager should be notified immediately.

The actual step-by-step procedures for performing CCTV inspection will vary depending on the camera equipment and accessories being used, and the computerized data collection system being used. However, there are some basic procedures that need to be followed in order to obtain acceptable CCTV data.

The following sections summarize these procedures and the standards that should be incorporated by the District. The information provided in this manual is intended to provide guidance for District staff and others involved in the inspection work and is not intended to replace any contractual requirements that bind a contractor performing this work for the District.

2.3 General Information and Definitions

Node. A "node" is a manhole, cleanout, rodding inlet, stub, blind tee, drop inlet, channel, or other sanitary sewer mainline structure, which is typically assigned a structure identification number on system maps.

Pipe Segment. A pipe segment is the section of mainline between two nodes.

Sewer Service Line or Lateral. A sewer service line or lateral is a section of pipe typically serving a single parcel, extending from the house or building to the mainline.

CCTV of Multiple Segments. It may be necessary to perform CCTV inspection on several consecutive pipe segments with one set-up. If this is the case, each segment should be considered a separate data report.

Direction of CCTV. The direction of camera travel should be in the direction of flow in the pipe unless there are access problems that require a reverse set-up, or the camera cannot pass through the pipe from end-to-end in the direction of flow.

Reverse Set-up. CCTV inspection performed against the flow due to upstream manhole access problem, restricted mainline access, or because an obstruction prevents the camera passing. Reverse set-ups for convenience are not acceptable. All CCTV observation locations are to be recorded based on the direction of camera travel.

"Zero" Point of Inspection. The "zero" point of the CCTV inspection is the centerline of the manhole where the camera is inserted. The footage counter should be set accordingly by adding the footage from the centerline of the manhole to the edge of the manhole plus the camera length (or the camera length plus the camera focal length). If a CCTV setup passes through a manhole, the start of the new pipe segment should be recorded at the centerline of the manhole, unless the manhole is not shown on the sewer maps, in which case a manhole observation code should be recorded at the footage location of the new manhole, but a new CCTV record should *not* be started.

End Point of Inspection. The end point of the segment is the centerline of the manhole (or other structure) at the opposite end of the pipe segment from the starting manhole.

Interruption of Progress. If the camera becomes stuck in a pipe or otherwise cannot progress, the cause of the interruption should be evaluated, reported, and, if possible, corrected. If the camera cannot pass, a reverse set-up should be used to complete CCTV inspection of the pipe segment. If cleaning the pipe is required before the inspection can be resumed, recording of CCTV observations should continue at the position where the CCTV inspection was interrupted. A comment regarding the cleaning procedures should be included in the data record. The CCTV contractor should notify the District immediately if a blockage cannot be cleaned using normal hydro-flushing or rodding methods.

Defect Panning. When a defect or other feature is encountered in a pipe, it should be recorded at the footage indicated on the footage counter. Progress of the camera should be slowed and stopped for a minimum of 15 seconds or as needed so that the observation can be panned with the camera, the data recorded, narration made, and a still picture captured if required. If directed by the District, this procedure should also be followed to document typical pipe conditions every 100 feet in concrete pipe, cast iron or ductile iron pipe, or any lined or coated pipe.

Photo Capture. If directed by the District, still picture images should be collected for all severe defects, broken or collapsed pipe, medium and severe corrosion or ovality problems, for any defects coded as 'Other', and for typical pipe conditions.

2.4 CCTV Quality Standards

It is important for all CCTV inspections to be completed to a uniform standard of performance. The use of uniform codes to describe conditions and defects allows the reviewer to gain a good understanding of the condition of the pipe merely by looking at the CCTV inspection report for the pipe. The District should train its staff on proper CCTV inspection procedures and coding protocol. In addition, they should hire contractors who have received proper training on coding and inspection procedures. This will ensure consistent coding and assessment grading of pipeline defects.

A thorough and consistent quality assurance/quality control (QA/QC) program during CCTV inspection work on a regular and on-going basis is also a valuable method to ensure contractor performance, consistent coding methodology, and video quality on an on-going basis. The following are items that should be considered to ensure adequate QA/QC standards during CCTV inspection.

2.4.1 Counter Calibration

The footage counter for the camera must be calibrated weekly during CCTV operations. The footage counter must be accurate to 0.5 feet per 100 feet (0.5 percent). The calibration is performed by checking the cable counter against a measured length of 400 feet. The date of last calibration should be recorded for every CCTV report.

2.4.2 Lighting

Lighting in the pipe should be such that the pipe is illuminated and there is a minimum amount of glare. Lighting should be adjusted as needed according to the size of the pipe to provide a clear picture of the entire periphery of the pipe for all conditions encountered. Illumination sensitivity should be 3 lux or less.

2.4.3 Flow Level

The flow level requirements for CCTV inspection vary depending on the type of inspection being performed. Generally, the more pipe visible, the more data are obtained. The following guidelines apply to various types of CCTV inspection. Lower amounts of visible pipe wall may be allowed, depending on site conditions, with approval of the District.

The following guidelines for maximum flow depth should be followed to the extent possible:

6- to 10-inch pipe:	20% of pipe diameter
12- to 24-inch pipe:	25% of pipe diameter
27-inch and larger pipe:	30% of pipe diameter

Certain types of condition assessment projects may require a greater amount of visibility. Project-specific flow level requirements may be defined by the District or District's engineer.

2.4.4 Camera Travel Speed

The camera travel speed should be a uniform rate of no more than 30 feet per minute. The camera speed should be slower when recording features and defects.

2.4.5 Clarity

All video and still picture images must be clear and sharp. The camera operator should adjust focus, iris, zoom, and lighting as needed to obtain a satisfactory image. The recorded image from the CCTV inspection camera must be free of fog or haze in the pipe. If the camera lens becomes obscured with condensation, grease, scum, or debris, the camera should be removed from the pipe, cleaned, and reinserted to continue inspecting the pipe.

2.5 Record Keeping

CD/DVD Labels. All CD/DVDs must be properly identified with

- CD/DVD number
- Agency name
- Project name and contract number (if applicable)
- Contractor’s name, address, and phone number (if applicable)
- Date of inspection(s)
- Pipe segments listed by upstream to downstream node number (followed by “R” if reverse set-up). Alternately, pipe segment, date, and direction of inspection can be shown together in the video file name format (see next section of Digital Data Format).

2.6 Digital Data Format

2.6.1 CCTV Video

The full CCTV video must be captured in an acceptable format as specified by the District. A typical format is MPEG-2 at 352 X 240 resolution, 30 frames per second, and 1.5 Mbits per second data rate. Other resolution, frame and data rates are acceptable as long as similar or better image quality and acceptable file size are obtained. Each individual pipe segment must be included in a single file, except if a reverse set up is required due to an obstruction, in which case the reverse CCTV should be contained in a separate file.

The files should be named in accordance with the following convention:

Upstream Node ID-Downstream Node ID-mmddyy-Dwn/Rev.mpg

where:

- Upstream/Downstream Node ID is the node (manhole) identification number
- mmddyy is the date of the inspection
- Dwn or Rev indicates whether the CCTV direction is upstream-to-downstream (Down) or downstream-to-upstream (Reverse)

For example, a typical file name for an inspection conducted on August 13, 2006, starting at upstream manhole 1989 and extending to downstream manhole 5243 would be:

1989-5243-081306-Dwn.mpg

Digital video files are to be copied onto CD or DVD and grouped in a logical manner (e.g., by date and/or area of inspection). Forward and reverse inspections of the same segment should be placed on the same CD or DVD if possible.

2.6.2 Still Picture Captures

If required, still images should be captured for all observed defects with a "severe" rating and/or as indicated in the defect descriptions in Section 3. Furthermore, additional still images may be required to be captured every 100 feet to illustrate the typical condition of the pipe for certain types of inspections, e.g., to assess corrosion in RCP sewers. Still images should be in jpeg format at 640 x 480 resolution and should utilize the same file naming convention as described above for the digital video files with the addition of the footage location of the image. Therefore, the file naming convention is:

Upstream Node ID-Downstream Node ID-mmddyy-Dwn/Rev-xxx.jpg

where:

- xxx is the footage location of the defect or observation (to the nearest foot)

For example, a typical file name for a still image at footage 123.4 for the example inspection described above would be:

1989-5243-081306-Dwn-123.jpg

If two or more images are captured at the same footage, add "a", "b", etc. after the footage, e.g.,

1989-5243-081306-Dwn-123a.jpg

1989-5243-081306-Dwn-123b.jpg

Still image files are to be copied onto the same CD or DVD as the corresponding video file for the pipe segment.

2.6.3 Site and CCTV Observations Data

All inspection (header) information and pipe features and defects observed during CCTV inspections should be recorded and captured in a digital database format using the coding system described in Section 3 of this technical memorandum. Various software may be used to capture the data depending on how each CCTV vehicle and/or contractor is equipped. If CCTV software other than that utilized by the District is used, CCTV contractors must provide the data in a format as specified by the District that will permit uploading to the District's computerized data management system.

2.7 Screen Text

2.7.1 Start-up Screen Text

Immediately before the insertion of the camera into the manhole, the following information must be provided as text on the video recording. The text should be clearly displayed on a contrasting background (e.g., white text on dark background or black text on white background). This text should be displayed for approximately 15 seconds or for the duration of the Start-up Narration, whichever is longer. If an inspection is being performed on consecutive pipe segments with the same setup, this information must be provided at the start of each pipe segment.

- Upstream and downstream node numbers
- Direction of camera travel
- Purpose of CCTV
- Location
- Date and time of day
- Job number and/or project name
- CCTV company or District staff
- Operator's name

Note: If the CCTV software being used can only display the "from" and "to" manhole numbers rather than upstream and downstream numbers (as in the case of a reverse inspection), then the upstream and downstream manhole numbers should be clearly stated in the startup video narration.

2.7.2 Running Screen Text

During CCTV, the running screen must include the following information. The display of this information must in no way obscure the central focus of the pipe being inspected.

- Running footage (distance traveled)
- Upstream and downstream (or "from" and "to") node numbers of inspected pipe segment

2.7.3 End Screen Text

The end point of the inspected pipe segment should be indicated with screen text for approximately 15 seconds. The ending screen text should indicate:

- Ending footage
- Date and time of day
- Upstream and downstream node numbers of inspected pipe segment

2.8 Narration

2.8.1 Language and Background Noise

The CCTV video recordings are part of the District's permanent records and should not contain inappropriate language, idle chatter, background noise, and discussions between the operator and other crew members. All video narration must be live by the CCTV operator. Digital voice narration is only allowed if specifically approved by the District.

2.8.2 Start-up Narration

A voice narration must be included in the video recording. This narration must include the following information at the beginning of each pipe segment:

- Upstream and downstream node numbers
- Direction of camera travel
- Type (sewer mainline, service sewer line, storm drain) and purpose of inspection
- Location
- Date
- Job number (if applicable) and/or project name
- Pipe size
- Pipe material
- CCTV company or District staff
- Operator's name

2.8.3 Running Narration

All observations along the length of the pipe must also be narrated, with a description of the observation and clock position, if applicable. For example:

- "Tap at 10 o'clock at 56 feet; factory wye"
- "Severe roots at 23 feet, all around crown of pipe"
- "Medium grease and scum at flow line starting at 45 feet"… "End grease at 85 feet"

2.8.4 End Narration

At the conclusion of the inspection of a pipe segment, the operator should state the final CCTV footage and indicate that the CCTV inspection of the pipe segment is complete. For example:

- "TV inspection of sewer mainline from manhole 1989 to manhole 5243 is complete at 222 feet"

If the inspection had to be abandoned before reaching the ending manhole, then a statement to this effect should be made as part of the ending narration with a reason given as to why the inspection could not be completed.

2.9 Special CCTV Procedures

2.9.1 Buried Manholes

If the CCTV crew encounters a buried manhole, they should determine if it is possible to CCTV through the manhole or conduct the inspection in the reverse direction. If this is possible, it should be done. The crew should then notify the District that the manhole needs to be exposed for future access. If it is not possible to CCTV through the manhole, the crew should notify District that the manhole needs to be exposed in order to complete the assigned CCTV inspection.

2.9.2 Service Line CCTV Inspection

Performing CCTV inspection on sewer service lines requires the use of special, smaller cameras. In the past, service line cameras have been pushed in the direction of flow through the sewer service from the cleanout to the mainline. Newer, state-of-the-art service line cameras are "launched" from the mainline camera and proceed against the direction of flow from the mainline toward the cleanout. This technical memorandum does not include specific procedures for inspecting service lines; however, many of the observation codes listed in Section 3 are applicable to service line CCTV inspection.

2.9.3 Flow Control

As noted above, flow plugging and/or bypass pumping may only be performed if approved and supervised by District.

2.9.4 Pre-Rehabilitation CCTV

Pre-rehabilitation CCTV inspection may be performed immediately before construction of a repair or rehabilitation project. The purpose of this CCTV inspection is to locate lateral connections or identify gross defects that are to be corrected or might interfere with the rehabilitation project. This inspection is for the use of the construction contractor and does not require the same level of defect identification as maintenance or condition assessment CCTV inspection. For specific pre-rehabilitation CCTV inspection requirements, refer to project specific contract specifications.

2.9.5 Large Diameter Pipes

Large diameter pipes (approximately 36 inches and larger) often require special procedures for flow control, lighting, and camera travel. Often self-propelled camera rigs are not suitable for large diameter pipes. In these cases the camera may be floated down the pipe on a raft or "boogie board". Only CCTV crews with the appropriate equipment and training to perform large diameter pipe inspection should be allowed to inspect large diameter pipes.

3 Standard Inspection Codes and Rating Criteria

This section describes the codes to be used for recording observations of pipe and manhole features and defects identified during CCTV inspection. Included are general information and guidelines for using the observation codes, followed by listings of the codes, severity ratings, and other required information for each type of observation. Attachment B provides more detailed observation descriptions and photographic examples of the defects provided in this section.

3.1 Definitions, General Information, and Guidelines for Using Observation Codes

Manhole. The point of entry into the sewer system is referred to as a "manhole" or "maintenance hole".

Drop Manhole. A manhole with an incoming pipe elevated several feet above the manhole invert is termed a "drop manhole." The pipe usually has a tee type connection that terminates the flow at the manhole with a vertical drop pipe ending near the manhole bottom. If the drop piping is inside the manhole, it is termed an "inside drop." If the drop piping is located outside the manhole barrel and then terminates inside near the manhole bottom, it is termed an "outside drop."

Mainlines. The main pipes of the sewer system are referred to as "mainlines"

Service Lines. The smaller pipes from a parcel discharging into mainlines are referred to as "service lines" or "laterals".

Taps. Service lines join mainlines at "taps." There are three basic categories of taps: factory wyes or tees, cored taps, and hammer taps. Cored and hammer taps are connections made to a mainline at some time after its original construction. Taps should be recorded depending on type, i.e., a factory wye or tee , hammer tap, or cored saddle. The clock position and status of the tap (i.e., active, plugged, unknown) should also be recorded. Any protrusion of a hammer tap should also be recorded as a tap defect and given an appropriate severity rating.

Taps in Manhole. Taps connecting directly into the starting manhole of the CCTV inspection should be recorded at footage location 0.0 using the tap codes. The appropriate clock position (see below) should be recorded in comments.

Clock Position. A clock position must be recorded for all taps, drops, or blind tee connections (see explanation of clock positions later in this section).

Flusher Branches and Stub Lines. The upstream end of a mainline pipe that ends as a cleanout or rodding inlet at ground level with the same size piping as the mainline is called a "flusher branch". A mainline that terminates without access is called a "stub line." A flusher branch may consist of an elbow with an angled riser to the ground surface, or a wye or tee fitting with a vertical riser to the ground surface and a plug or stub line at the end of the pipe. A stub line or flusher branch wye or tee may sometimes have a service line connection at the end.

Camera/Data Entry Direction. The direction of CCTV inspection should be recorded with the camera direction code. Data should be entered in ascending footage in the direction of camera travel as the inspection proceeds from the starting manhole. The first entry of each pipe segment should be at the centerline of the manhole at footage location 0.0.

Camera Set Point. The location at which the camera footage counter is set (typically about 5 to 8 feet into the pipe from the manhole) should be recorded. This is the camera set point. The camera set point is typically equal to half the diameter of the manhole plus the camera length, assuming that the camera cable harness bullet at the back end of the camera is placed at the interface of the manhole wall and the pipe. Some CCTV operators may establish the set point based on the camera length plus focal length. Either method is acceptable as long as the recording of observation footages is consistent (either at the head of the camera or at the focal point, depending on how the set point was established). The footage locations of observations made prior to the camera set point should be estimated by the operator.

Defect Ratings. Some defect observations are broken into three distinct codes which have a severity rating of light, medium or severe. Each of these observations are then assigned a distinct code and grade. For example, Light Roots has a code of RL and a grade of 2. The TV operator should err on the conservative side when judging severity and assigning the distinct severity codes for these defects. Observations that are not defects, but pertain only to sewer features, e.g., manhole, flusher branch, tee, tap, change in pipe material, etc. do not include a severity rating.

Still Images. If directed by the District, still images of defects should be taken for all severe defects and/or as required in the explanation of the codes. At the direction of the District, still images of "typical" pipe condition may also need to be captured at 100-foot intervals along the pipe for pipe materials that are subject to corrosion such as RCP, CIP, etc.

Multiple Defects. Multiple features or defects at a single location should each be recorded as separate observations at the same footage location. For example, a pipe may have a radial crack at the location of hammer tap with roots. This would require three separate entries at the same footage location. If a defect such as roots or infiltration is observed at the same footage location as a crack, protruding tap, or other structural defect, both defects should be recorded at the same footage location. In this case, it would generally be assumed that the roots or infiltration are entering the pipe through the structural defect. Recording every observed defect is very important to accurately assessing the condition of the pipe.

Comments. Comments should be minimized when identifying defects and should be used only in atypical situations such as foreign material found in the pipe, or as otherwise indicated in the code explanations later in this section. Examples of appropriate comments are: "Fence post protruding into top of pipe", "Pipe cleaned during CCTV by _________ due to heavy grease", etc.

3.2 Standard Inspection Codes

The following standard inspection codes are a simplified and modified version of the Pipeline Assessment and Certification Program (PACP) Condition Grading System as developed by NASSCO. The advantage to using an accepted standardized system is that the District can readily find contractors that are trained in the system. The coding system has been simplified for ease of use and implementation into the District's computerized maintenance management system.

3.2.1 Pipeline Inspection Codes

Recommended CCTV inspection codes are shown in **Table 3-1**.

3.2.2 Continuous Grading of Defects

Continuous grading of defects is used to denote where long portions of a sewer pipe are affected by the same defect, e.g., a sag or longitudinal crack. In order to develop a grade score for the pipe reach, a mechanism is needed to translate a continuous defect into an equivalent number of point defects. In order to record a continuous defect, the CCTV operator should repeat the code and the grade of the particular defect for the number of joint-to-joint pipe segments that the defect spans. For example, if the CCTV operator were inspecting an 8-inch VCP pipe with 3-foot segments that has a longitudinal fracture (FL), the operator would repeat the FL code (which is assigned a Grade of 3) once for each 3-foot long pipe segment inspected that contains the longitudinal fracture. So, for a 30-foot long fracture, the operator would record the defect 10 times.

Table 3-1
CCTV Inspection Codes

STRUCTURAL DEFECTS		
Desciptor	**Code**	**Grade**
Crack (<=1/8")		
Circumferential	CC	1
Longitudinal	CL	2
Spiral	CS	2
Multiple	CM	3
Fracture (>1/8")		
Circumferential	FC	2
Longitudinal	FL	3
Spiral	FS	3
Multiple	FM	4
Failures		
Broken	B	5
Hole	H	5
Collapse	X	5
Deformed		
Horizontally	DH	5
Vertically	DV	5
Joints		
Offset		
Medium (<=30% of pipe diameter)	JOM	1
Large (> 30% of pipe diameter)	JOL	2
Separated		
Medium (<=30% of pipe diameter)	JSM	1
Large (> 30% of pipe diameter)	JSL	2
Interior Surface Damage (Corrosion)		
Surface Spalling	SSS	1
Aggregate Visible	SAV	3
Aggregate Projecting	SAP	3
Aggregate Missing	SAM	4
Reinforcement Visible	SRV	5
Reinforcement Corroded	SRC	5
Missing Wall	SMW	5
Corrosion (Metal Pipe)	SC	3

OPERATIONS AND MAINTENANCE		
Desciptor	**Code**	**Grade**
Roots		
Light (No flow disturbance)	RL	2
Medium (Alters flow)	RM	3
Severe (Disrupts flow, cannot pass camera)	RS	5
Debris		
Light (No flow disturbance)	DL	2
Medium (Alters flow)	DM	3
Severe (Disrupts flow, cannot pass camera)	DS	5
Grease		
Light (No flow disturbance)	GL	2
Medium (Alters flow)	GM	3
Severe (Disrupts flow, cannot pass camera)	GS	5
Sags		
Sag Minor	SM	2
Sag Major	SMJ	4
Camera Underwater	MCU	4
Infiltration		
Weeper	IW	2
Dripper	ID	3
Runner	IR	4
Gusher	IG	5
Infiltration from Lateral	IL	3
Other		
Other	O	*

*** Description required.**

CONSTRUCTION FEATURES		
Desciptor	**Code**	**Grade**
Access Points		
Cleanout/Rodding Inlet	ACO	
Junction Box	AJB	
Meter	AM	
Manhole	AMH	
Buried Manhole	AMB	
Tee Connection	ATC	
Miscellaneous		
Dimension/Diam/ Shape Change	MSC	
General Photograph	MPG	
Material Change	MMC	
Joint Length Change	MJL	
Survey Abandoned	MSA	
Laterals		
Factory Made		
Capped	TFC	
Defective	TFD	2
Break in/Hammer		
Capped	TBC	2
Defective	TBD	3
Protruding (based on % of mainline obstructed)		
Minor (<10%)	TBI	2
Medium (>10% and <30%)	TBM	4
Severe (>30%)	TBS	5
Saddle (Cored)		
Capped	TSC	
Defective	TSD	2
Protruding (based on % of mainline obstructed)		2
Minor (<10%)	TSI	
Medium (>10% and <30%)	TSM	4
Severe (>30%)	TSS	5

4 Condition Evaluation Procedures for Pipelines

Formulas and weighting factors are used to convert the descriptive data developed as part of the pipeline coding system provided in Section 3 into general categories of pipe condition. These categories focus attention on the sewer segments that need further evaluation and consideration for renewal and replacement. The condition rating of a pipe should be based on the CCTV results and include all inspected pipes.

As part of this TM, potential pipe defects were assigned a severity value that will be used to assess the overall condition of each pipe reach. These values are provided as part of the coding system as described in Section 3. Procedures for converting the descriptive data into numerical representations of the overall condition of a pipe reach are detailed in this section. A method for using this grading system to develop criticality ratings for each sewer reach within the system is presented in Section 6.

4.1 Pipeline Grading

Each pipeline defect code in Section 3.2.1 (for both structural and maintenance types of defects) is assigned a condition grade of 1 to 5. Grades are assigned based on potential for further deterioration or pipe failure. Pipe failure is defined as when the pipe can no longer convey its design capacity. The grades are defined as follows:

- 5 – Immediate: Defects require immediate attention.
- 4 – Poor: Severe defects that are likely to become Grade 5 defects within the next five years.
- 3 – Fair: Moderate defects that will continue to deteriorate.
- 2 – Good: Defects that have not begun to deteriorate.
- 1 – Excellent: Minor defects.

4.2 Total Defect Score

For each pipeline reach, the severity value is multiplied by the number of occurrences of its associated defect code to obtain a defect score. The Total Defect Score (TDS) for a pipe reach is obtained by summing all of its defect scores and dividing by the inspected length of the pipeline reach (to "normalize" the score). The normalized TDS is multiplied by 100 in order to scale up the value and is referred to as the pipe condition rating. The higher the normalized TDS, the worse shape the pipeline segment is in.

A separate pipe condition rating based upon structural defects vs. operations and maintenance defects should be developed for each reach of pipe. A structural defect rating would be calculated by using Structural Defect grades. Operations and Maintenance defect rating would be calculated using only O&M Defect grades.

An example of the scoring system for a structural defect rating is provided below:

A sample 8-inch diameter pipe has one occurrence of a circumferential crack (CC), three large offset joints (JOL), 3 defective factory made taps (TFD), and 5 defective hammer taps (TBD). The existing length of pipe is 350 feet. Therefore,

1 CC x 1 = 1
3 JOL x 2 = 6
3 TFD x 2 = 6
<u>5 TBD x 3 = 15</u>
TDS = 28

Pipe Total Structural Defect Score = 28/350 feet x 100 = 8

This rating method is based upon a simplified version of the NASSCO Pipeline Assessment and Certification Program (PACP) coding system that is commonly used in the industry to identify pipes requiring rehabilitation and to prioritize rehabilitation projects. As mentioned previously in this TM, pipeline defect codes and grades are also based upon a simplified version of the NASSCO PACP coding system. It should be noted that long reaches of pipeline with one serious defect may not receive a high condition rating. These would be more apparent when looking at the Peak Defect Score described below. Typically, spot repairs are used to correct these deficiencies.

4.3 Peak Defect Score

This is the highest defect score in the pipe segment, regardless of segment length or number of defects. Overall, the pipe may be in fair or excellent condition, but a high peak defect score indicates that one or more pipe segments may have significant problems that could potentially fail.

4.4 Mean Defect Score

This is the average of all defect scores. A higher number signifies that the defects (as a group) trend to a more severe nature. As with peak defect, pipe length is not considered.

All three of the above defect scores are evaluated to determine when several point repairs should be made to a line (as opposed to rehabilitating or replacing the entire line) and when to combine multiple line segments into a single project.

5 Condition Evaluation Procedures for Manholes

The condition rating of the District's manholes should be based on a visual inspection conducted as part of the CCTV inspection effort or during the District's routine maintenance activities. As part of this technical memorandum, information that would be valuable to collect as part of this assessment is identified. A list of coding information for this suggested data is provided in Section 5.1 Manhole Inspection Codes of this Technical Memorandum and is further explained in Sections 5.3 and 5.4. If a manhole is in poor condition, sufficient comments should be noted to describe the specific problems observed, and appropriate photographs taken. See Section 5.2 Record Keeping for more information regarding procedures for doing this.

5.1 Manhole Inspection Codes

Table 5-1 lists recommended codes for recording manhole information and condition.

Table 5-1
Manhole Inspection Codes

MANHOLE CONDITION ASSESSMENT CODING	
Access	
Yes	Y
Could Not Locate	CNL
Could Not Open	CNO
Could Not Access Area	CNA
Object Preventing Access	OPA
Surface Cover	
Asphalt	SCA
Concrete	SCC
Dirt/Gravel	SCD
Turf	SCT
Landscape	SCL
Other	SCO
Material	
Reinforced Concrete	RC
PVC Lined Reinforced Concrete	RLC
Coated Reinforced Concrete	RCC
Fiberglass	RF
Brick	RB
Other	RO
Condition *	
Good	G
Fair	F
Poor	P

* See descriptions in Sections 5.3 and 5.4.

5.2 Record Keeping

The person responsible for inspecting the District's manholes should keep a written record of the inspection. **Figure 5-1** is an example of an inspection form that could be used for this purpose. At the very least, inspection data for each manhole should contain the following information:

- Street (or closest street) where manhole is located
- Location description including nearest cross-section
- Manhole number
- Measured distance from a known location
- 12:00 Reference position (Choose a 12:00 clock position on the subject manhole, e.g., the location of the main outlet pipe, and indicate its location on the inspection form. All defects will

be referenced clockwise from that point along the circumference of the manhole. For example, "large crack at the 2:00 position".)

- Riser diameter measurement
- Configuration of incoming and outgoing lines (including drops) with use of a sketch
- Grade (rim) elevation
- Manhole depth
- Invert elevation (Grade elevation minus depth)
- Rating of Good, Fair, or Poor (See Sections 5.3 and 5.4)

5.3 Identification of Manhole Defects

District staff or CCTV inspectors will be asked to rate existing manholes as good, fair, or poor during the manhole condition assessment. These assessments will be conducted either during CCTV inspection or during the District's routine maintenance of the system.

The following is a list of potential defects or other items of note within an existing manhole. This list serves to augment and further explain the manhole condition coding presented in Section 5.1. These defects should be considered when determining what a manhole should be rated and, consequently, whether or not to remove/replace, rehabilitate, or keep an existing manhole in the District's sanitary sewer system.

1. Frame and Cover
    - Frame/cover cracked?
    - Frame/cover surface spalled/corrosion evident?
    - Frame displaced from centerline of manhole cone?
    - Frame/cover subject to ponding or receipt of surface run-off?
    - Observed infiltration at frame/cover location?
2. Risers, Reducers, Base, and Benching
    - Roots, cracks, holes apparent?
    - Surface spalling/corrosion evident?
    - Staining, deposits, surcharge apparent?
    - Observed infiltration?
3. Steps
    - Note material
    - Safe, unsafe, missing, horseshoe shaped?
4. Atmosphere
    - Pass or fail carbon monoxide, explosive, or oxygen testing?

Figure 5-1
Manhole Inspection Form

ROSS VALLEY SANITARY DISTRICT | **Map #**
MANHOLE/SANITARY STRUCTURE OBSERVATION FORM

Project:
ASSET NUMBER #:
Access:
Date:
Time:
Inspector:

Street No.:
Cross St./Nearest:

Wrong Location on Map?	Y or N	New Pipes?	Y or N

Sketch if not on map or different than map

N↑

Surface Cover Type:		
Structure Material:		
		Drainage Area Ft.
Below grade, subject to runoff?	Y or N	
Riser Diameter:		In.
Number Holes/Size Frame/Cover:		In.
Depth (Rim to Ground):		In.
		In.
Depth (Rim to Invert):		Ft.
		Type
Cross connection?	Y or N	

Surcharge	Y, N, E	Flow split?	Y or N
Rim to Surcharge		Over flow	Y or N

Configuration of incoming and outgoing lines (including drop connections):

N↑

US or DS MH#	Pipe Size (in.)	Pipe Mat.	Depth to Inv.	Clock Position*	Comments

* Relative to main outlet pipe at 12 o'clock

Manhole Rating: Poor ______ Fair ______ Good ______

Other comments: ______

MANHOLE COVER REPLACED ______________________ *Signature*

5.4 Explanation of Manhole Condition Ratings

Compared to the more definitive sewer condition assessment ratings and guidelines described in this technical memorandum, manhole condition assessment for the purposes of the District's needs has been simplified and is somewhat subjective to the individual performing the inspection. Although these ratings are subjective, **Table 5-2** provides a guideline of the rating terms to aid the individual inspectors in assessing and assigning ratings to individual manholes. These guidelines are based on the descriptions of manhole defects as presented in Section 5.3.

Table 5-2
Manhole Condition Rating Guidelines

Rating	Description
Good:	Meets all of the following criteria: ▪ No observed cracking, displacement, or corrosion of manhole frame and cover ▪ No actual or potential ponding or infiltration at surface of manhole ▪ No or minor roots and cracks in the reducer, base, and benching ▪ No observed holes or surface corrosion in the reducer, base, and benching ▪ No or minor deposits or staining in the reducer, base, and benching ▪ No observed infiltration and no sign of apparent surcharge ▪ No blockages in the channel base ▪ Steps are intact and appear safe ▪ Passes any carbon monoxide, oxygen, or explosive tests
Fair:	Has one or more of the following: ▪ Minor cracking (<1/8 inch), displacement (0 – 2 inches), or corrosion of manhole frame or cover ▪ Observed or potential surface ponding or infiltration is light to moderate (water is seeping, dripping, or trickling) ▪ Moderate roots or cracks in the reducer, base, or benching ▪ Presence of minor holes or surface corrosion in the reducer, base, or benching ▪ Moderate deposits or staining in the reducer, base, or benching ▪ Observed infiltration or apparent surcharge is light to moderate and intermittent ▪ Minor obstructions in channel base that do not obstruct flow ▪ Steps are intact and appear safe, but may deteriorate to an unsafe condition in the near future ▪ Passes any carbon monoxide, oxygen, or explosive tests.
Poor:	Has one or more of the following: ▪ Major cracking (>1/8 inch), displacement (>2 inches), or corrosion of manhole frame or cover ▪ Observed or potential surface ponding or infiltration is severe (water is gushing or spurting) ▪ Major roots or cracks in the reducer, base, or benching ▪ Presence of major holes or surface corrosion in the reducer, base, or benching ▪ Major deposits or staining in the reducer base, or benching ▪ Observed infiltration or apparent surcharge is major and constant ▪ Major obstruction in channel base that obstruct flow ▪ Steps are not intact or do not appear safe ▪ Fails any carbon monoxide, oxygen, or explosive tests

6 Sewer Rehabilitation Decision Methodology

In Section 4 of this Technical Memorandum, weighting factors and formulas were developed to convert the descriptive coding data developed during CCTV inspection into numerical representations of the overall relative condition of a pipe reach within the sewer system. Rehabilitation decision methodology as presented in this section will place the rating numbers into general categories of pipe condition that will help the District to prioritize sewers based on their condition and focus attention on the sewer segments that need further evaluation and consideration for renewal or replacement. Information regarding operations and maintenance condition ratings will also provide a source for development of preventive maintenance work activities and recurrence intervals for cleaning in order to avoid blockages and the resultant sanitary sewer overflows.

6.1 Structural Condition Grading of Sewers

The condition grade of a sewer is the estimated condition based on the structural defect score. The condition grades are determined from a range of defect scores, depending on the severity of the defects and assigned deduct values as presented in Section 3. Methodology to determine a pipe reach defect score is presented in Section 4.

The following is a breakdown of condition grading for the District's sewer system. The Structural Condition Grading of a sewer is based on the normalized Total Structural Defect Score and is assigned based on potential for further deterioration or pipe failure. Grades are based upon consultant and industry experience. Pipe failure is defined as when the pipe can no longer convey its design capacity. Peak and mean defect scores as discussed in Section 4 of this TM augment the Structural Condition Grade determined for each sewer reach and are used by the individual evaluator in conjunction with the Structural Condition Grading to help determine relative rehabilitation priority within a given system.

Category A: Pipe reach has received a Total Structural Defect Score of 0 – 4.
Pipe is in excellent to good condition, and failure is unlikely in the foreseeable future. No action required.

Category B: Pipe reach has received a Total Structural Defect Score of 5 – 9.
Pipe is in fair to poor condition and pipe may fail within the next 10 to 20 years. Pipe should be rehabilitated or replaced in the near-term.

Category C: Pipe reach has received a Total Structural Defect Score of 10 or more.
Pipe is in poor to very poor condition and has failed or is likely to fail within the next 5 years. This pipe reach is in need of immediate attention.

6.2 Criticality of Sewers

In addition to providing a structural condition grade to sewer reaches within a sewer system, sewer pipes should also be classified based on criticality issues. Criticality defines the "risk" of failure, which reflects both the probability of failure (a reflection of sewer condition and other factors such as age, material, and soil and groundwater conditions) and the consequences of failure. Factors affecting criticality include sewer size (which indicates the relative size and number of customers in the area served by the sewer), and location (busy streets, hospitals, areas with access difficulties, sewers located within or close to an environmentally sensitive area, etc.). Determining the criticality of sewers is a subjective process that should be used to augment the condition assessment and grading process of the District's sewer system. The use of impact factors as described below help to provide some structure to this subjective process.

6.2.1 Impact Factors

Impact factors reflect an assessment of the "consequences of failure" for any particular sewer reach. Impact factors are assigned to pipes according to four categories:

- **Community/Environmental Impact.** This factor reflects the "sensitivity" of the area in which the pipe is located with respect to environmental or social impacts. Sewers assigned community impact factors include those adjacent to drainage channels, streams, or wetlands, or located in the vicinity of hospitals, schools, parks, or other community facilities.
- **Construction Impact.** This factor reflects the relative difficulty of construction and maintenance due to access limitations or traffic concerns. Sewers assigned construction impact factors include those located in easements and along streets or in intersections with high traffic volume.
- **Critical Crossings.** This factor is assigned to sewers that cross (or are located very close to) flood control channels and major or critical utilities. The impact of these crossings is associated with the potential damage to the above listed with the resulting loss or interruption of service.
- **Pipe Diameter.** The diameter of the pipe is indicative of the size of the tributary area that is served by the sewer. Larger diameter pipe are assigned higher impact factors because of the larger area and number of people that would be affected should the pipe fail or be temporarily out of service. However, six-inch pipes are assigned a slightly higher factor than eight-inch pipes because of the greater likelihood of problems such as overflows or backups should a blockage occur in the sewer.

Each pipe is assigned an impact factor for each of the above four categories. Suggested impact factor values, and the maximum total value for each category, are shown in **Table 6-1** below.

Table 6-1
Recommended Impact Factors

IMPACT FACTORS		
Impact Description	**Condition**	**Impact Factor**
Community/Environmental Impact (Max = 2)	Creek, Marsh, Drainage Channel	2
	Hospital	2
	School	1
Construction Impact (Max = 2)	Easement	1
	Traffic	2
Critical Crossings (Max = 3)	Flood Control Channel or Creek	3
	Major Buried Utilities	2
	Major Overhead Utilities	1
Pipe Diameter (Max = 3)	>30-inch	3
	15- to 30-inch	2
	10- to 12-inch	1
	8-inch	0
	<8-inch	1

Based on the individual impact factors, the overall total impact factor for the pipe is calculated by the following formula:

$$\text{Total IF} = \text{sum(IF)}$$

Where sum(IF) is the sum of the four individual impact factors. The maximum value for the Total IF would be 10. The Total IF is then added to the normalized Total Defect Score as defined in Section 4.2 of the TM to determine a modified condition rating, or "critical rating" for the sewer. The critical rating would therefore elevate the condition category (as defined in Section 6.1) and relative rehabilitation priority for more critical facilities.

6.3 Maintenance Prioritization

The maintenance condition grade of a sewer is the estimated condition based on the operations and maintenance defect score. The maintenance condition grades are determined from a range of defect scores, depending on the severity of the defects and assigned defect values for operations and maintenance defects as presented in Section 3. Methodology to determine a pipe reach defect score is presented in Section 4.

The following is a breakdown of maintenance condition grading for the District's sewer system. Grades are based on Total Defect Score for operations and maintenance defects only and are assigned based on potential for surcharge or overflow. Pipe failure is defined as when the pipe can no longer convey its design capacity.

Category A: Pipe reach has received a Total Defect Score of 0 – 4.
Current routine maintenance practices appear to be adequate at this time.

Category B: Pipe reach has received a Total Defect Score of 5 – 9. Current routine maintenance practices may not be adequate and should be reviewed and updated as needed.

Category C: Pipe reach has received a Total Defect Score of 10 or more. Current routine maintenance practices have failed at this time and maintenance must be performed immediately and possibly more frequently. New maintenance protocols need to be developed or the problem must be addressed by rehabilitation or replacement in order to avoid future blockages and surcharge.

It should be noted that the maintenance score only indicates the pipe condition and/or need for maintenance at the point in time that the inspection took place. It does not account for when the sewer was last maintained or how often it is currently maintained. These factors should be taken into account when categorizing sewers with respect to maintenance condition.

Attachment A

Sample Specifications for Sewer Cleaning & Television Inspection

Attachment B

Descriptions and Photographic Examples of CCTV Inspection Codes

SEWER CLEANING & TELEVISION INSPECTION

PART 1 - GENERAL

1.1 The purpose for this specification section is to collect sewer condition information. In general, the CONTRACTOR shall perform a "light cleaning" (two-pass hydroflush) before performing a closed-circuit television inspection (CCTV). If heavy debris or roots are found that prevents the closed-circuit television inspection, the CONTRACTOR shall contact the OWNER for cleaning. Additional details are presented in the following paragraphs.

1.2 The information on the sewer system provided with this specification is the most current and complete available. However, in the course of the work, this information may be found to be incomplete or even incorrect. When the CONTRACTOR discovers such discrepancies, the condition shall be noted and the OWNER shall be informed within 24 hours. If a manhole is buried or cannot be found, the OWNER shall be notified.

1.3 Work Hours. Work will be performed during the hours of 7:00 a.m. to 4:00 p.m., Monday through Friday, unless nighttime work is indicated because of flow conditions or traffic control requirements. Nighttime work must be approved by OWNER and scheduled in coordination with the OWNER.

1.4 QA/QC. CONTRACTOR shall be responsible for implementing quality assurance/quality control procedures necessary to ensure that all CCTV inspection video, digital photographs, and observation data meet the requirements of the specification. The OWNER will compare the work products submitted as the Five Percent Submittal against the specification requirements contained herein and the sample product submitted by the CONTRACTOR at the start of the work. Necessary quality improvement requirements will be returned to the CONTRACTOR within one (1) week. Thereafter, OWNER will conduct quality review of selected CONTRACTOR preliminary review submittals and notify CONTRACTOR of any deficiencies or rejected work products. CONTRACTOR shall be responsible for correcting or re-televising any rejected segments. OWNER reserves the right to suspend CONTRACTOR's work and retain another contractor to complete the work if CONTRACTOR fails to correct identified deficiencies or consistently submits deficient CCTV inspection work products.

1.5 Before any entry onto private property is made, CONTRACTOR shall obtain permission from resident or business owner or manager. If resident or business owner/manager is not available, then CONTRACTOR shall leave a project door hanger requesting resident or business owner/manager to call CONTRACTOR to schedule a time for inspection. If CONTRACTOR encounters any difficulty in obtaining resident's or business owner/manager's permission to access the easement in order to perform the inspection, then CONTRACTOR shall contact OWNER for assistance. In such cases, CONTRACTOR shall provide a minimum of two weeks notice to the OWNER prior to the need to access private property. CONTRACTOR is responsible for scheduling work such that this two-week notification period does not interfere with the overall work schedule.

1.6 CONTRACTOR shall notify the OWNER immediately of any major problems or emergency situations encountered in the field, including collapsed or severely broken pipe, sewer overflows or significant surcharge, sewer blockages, equipment stuck in pipe that cannot be removed, damage to private property, or injury to CONTRACTOR personnel or members of the public during CONTRACTOR's operations. CONTRACTOR shall provide a 24 hour-a-day contact with required available resources to travel to the site within 30 minutes of notification of a problem.

1.7 CONTRACTOR will be held responsible for any damage that occurs as a result of CONTRACTOR's work, and not deemed a pre-existing condition by OWNER. Any repair of such damage shall be approved by OWNER prior to its execution. All costs associated with such repairs are solely the responsibility of CONTRACTOR.

1.8 List of Submittals

A. Health and Safety Plan

B. Sample Work Products

C. Preliminary Bar Chart Schedule

D. Door Hanger (to schedule time for inspection in easements)

E. Encroachment Permit

F. Traffic Control Plan

G. Daily Work Plan

H. Progress Reports

I. Five Percent Submittal (all work products)

J. Preliminary Review Copies. (video files and CCTV inspection logs)

K. Gas Level Log Sheets

L. Cable Footage Counter Accuracy Check Logs

M. Sewer Cleaning Field Logs

N. CCTV Inspection Logs

O. CCTV Inspection Database

P. Digital Photographs

Q. Digital CCTV Inspection Recordings

R. Corrected Sewer Maps

1.9 Health and Safety Plan. Inspection activities will not begin until Health and Safety Plan is approved. During the course of the field work activities, OWNER's Health and Safety officer may make unannounced visits to CONTRACTOR's operations to verify that the requirements of the Health and Safety Plan are being followed. However, CONTRACTOR shall be fully responsible for the safety of its own employees.

1.10 Sample Work Product. Prior to start of field work, CONTRACTOR shall submit samples of work products that provide an example of the level of professional quality of the CONTRACTOR's anticipated submittals for this project. Sample work products should include CCTV inspection logs, a sample database containing inspection data, digital photographs, and a digital CCTV inspection recording. The submittal will include dates, locations, and type of equipment and software that were used to produce the samples.

1.11 Preliminary Bar Chart Schedule. Prior to start of field work, CONTRACTOR shall submit a preliminary bar chart schedule for the project. The schedule will show when and where the CONTRACTOR will be working.

1.12 Daily Work Plan. Prior to the start of each day's field work, CONTRACTOR shall notify the OWNER designated representatives on the location of field activities for that day.

1.13 Progress Report. Each Monday, CONTRACTOR shall submit a progress report listing the work completed during the previous week, including any specific issues such as inability to locate or access manholes, sewer map corrections, etc.; and, if necessary, an updated project schedule that reflects current progress and any schedule impacts arising from inclement weather, equipment or staffing problems, etc.

1.14 Five Percent Submittal. The CONTRACTOR shall submit a completed work product (CCTV inspection logs, CCTV inspection database, digital photographs, and digital CCTV inspection recording) at the five percent mark (5 percent of total CCTV inspection footage) for formal quality review as described above.

1.15 Preliminary Review Copies. During CCTV inspection activities, one review copy of all video files on CD and one hard copy report of CCTV inspection log for each inspected segment will be provided within one week after completion of each week of CCTV inspection work.

1.16 Cable Footage Counter Accuracy Check Logs. The cable footage counter shall be tested for accuracy weekly, or at the direction of the OWNER, with the procedure described in Part 3.

1.17 Sewer Cleaning Field Logs. CONTRACTOR shall record data about the cleaning operation on field logs provided by the OWNER. The data will include date of cleaning, type of nozzle used, maximum water pressure used, and a qualitative description of the nature of the material removed by the cleaning, using the same types of observations as those used for the CCTV inspection (e.g., heavy grease, light roots, etc.).

1.18 Corrected Sewer Maps. Final deliverables will include one copy of the sewer maps provided to CONTRACTOR at the start of the project with any red line changes to the system configuration that were identified in the field.

PART 2 - PRODUCTS

2.1 SEWER CLEANING EQUIPMENT

A. High-Velocity Jet (Hydrocleaning) Equipment: All high velocity sewer cleaning equipment shall be constructed for ease and safety of operation. The equipment shall have a selection of two or more nozzles. The nozzles shall be capable of producing a scouring action from 15 to 45 degrees in all size lines designated to be cleaned. The equipment will have a minimum working pressure of 2,000 psi at a 60 gpm rate. Equipment shall also include a high-velocity gun for washing and scouring manhole walls and floor. The gun shall be capable of producing flows from a fine spray to a solid stream. The equipment shall carry a nominal 800-gallon minimum water tank, auxiliary engines, pumps, and a minimum of 650 feet of high-pressure hose on a hose reel.

2.2 CCTV EQUIPMENT. CONTRACTOR shall provide the necessary equipment to perform closed circuit television inspection of the designated sewer pipes. The equipment will meet the following specifications:

A. Studio. A mobile studio that contains the controls for the inspection equipment. The studio will be large enough for two (2) people to view a television monitor of the inspection procedure. The studio will be insulated from outside noises that could be inadvertently recorded on the audio channel.

B. Television Monitor. A color television monitor will be available to view live camera action and recorded playback. The displayed picture must be capable of providing a clear, stable image free of electrical interference. The television monitor will measure at least 15 inches across diagonally.

C. Camera. The camera used for sewer pipeline inspections will one that has been specifically made for that purpose. The camera will operate in 100 percent humidity, be waterproof and able to withstand long periods of submergence in wastewater. The camera will be able to pan, tilt and rotate 360 degrees. The tilt arc should not be less than 225 degrees. A variable intensity control of the camera lights and remote control adjustments for focus and iris shall be located at the monitoring station. The remote control of focus and iris will range from 1-inch to infinity. The camera and monitor shall be able to produce a minimum of 460 lines of horizontal resolution and 400 lines of vertical resolution and capture images in full color.

D. Lighting. Illumination shall be adjustable and even around the sewer perimeter without loss of contrast, flare out of picture or shadowing. Lighting and camera quality shall be suitable to allow a clear in-focus picture of a minimum of ten lineal feet of the entire periphery of the sewer pipe. The lighting for the camera shall minimize glare. Lighting sensitivity shall be 3 lux or less.

E. Transporters. The camera should be mounted on skids or a tractor suitably sized for the pipe to be televised that will position the camera lens above the liquid flow line, near the center axis of the pipe. Any motorized transporters should have adjustable speed control. The televising may also be accomplished using camera equipment mounted on a raft or floating pontoon, if the required pipe condition information cannot be obtained by tracked camera equipment within the maximum allowable flow depths.

F. Cable and Footage Counter. A minimum 1,500 feet of TV cable on the spool reel shall be provided. The TV cable will be supported by an equal length tag line for removal of the equipment from the pipeline.

G. Computer System. The computer system shall be capable of recording, indexing, and processing inspection data; printing CCTV inspection logs; and recording, storing, and playing video and images of pipe observations as required for the data documentation requirements of these specifications.

PART 3 – EXECUTION

3.1 TRAFFIC CONTROL. CONTRACTOR shall provide traffic control measures as required by the jurisdiction in which the work is located. In compliance with or in addition to the jurisdiction's requirements, flashing lights shall be used for all night work.

A. For all work sites within the City of XYZ, [insert proper requirements here] appropriate advance signing shall be used in accordance with the WATCH (Work Area Traffic Control Handbook) manual, as well as compliance with City prohibitions against work in primary streets during commute hours, and submittal of traffic control plans and notifications as may be required by the City's traffic safety and right-of-way coordination groups.

B. For work within the unincorporated portion of Marin County or in the City of ABC, [insert proper requirements here] all applicable requirements of the County of Marin Public Works Agency Standards, September 2001, will be followed.

3.2 CONTRACTOR shall adhere to all local, state, and federal health and safety standards and follow the Health and Safety Plan adopted for this project. Cleaning and CCTV inspection will be conducted from above ground. Prior to opening a manhole cover, a gas monitor will be used check the atmosphere of that structure for oxygen level and presence of explosive, flammable, or toxic gases. Gas levels (O2, H2S, CO, LEL) will be recorded on a log sheet. If unsafe levels are recorded, CONTRACTOR shall attempt to ventilate the manhole for a period of up to about 15 minutes and then recheck gas levels. If unsafe levels still remain, CONTRACTOR shall notify the OWNER. CONTRACTOR will not perform any field work in a manhole in which unsafe gas levels are recorded.

3.3 Confined Space Entry. CONTRACTOR will not be permitted to make any confined space entry of OWNER's facilities. Should a confined space entry be required to retrieve equipment or for any other reason, the CONTRACTOR shall notify the OWNER immediately to request assistance.

3.4 SEWER CLEANING

A. General. Sewer cleaning shall be performed with hydraulically propelled high-velocity jet. The equipment selected shall be satisfactory to OWNER. The equipment shall be capable of removing dirt, grease, rocks, sand, and other materials and obstructions from the sewer lines and manholes. As a minimum, jetting of lines must be performed by pulling the high velocity spray nozzle in the direction opposite to the force created by the water pressure.

The intent of sewer line cleaning is to remove all sludge, dirt, sand, rocks, grease, and other solids or semisolid material from the pipe so that defects are not obscured and to allow the water level to drop so that defects are visible. The pipe interior shall be clean enough to allow adequate viewing of the pipe during inspection. Since the success of the other phases of work depends a great deal on the cleanliness of the lines, the importance of this phase of the operation is emphasized. It is recognized that there are some conditions such as broken pipe and major blockages that prevent cleaning from being accomplished or where additional damage would result if cleaning were attempted or continued. Should such conditions be encountered, OWNER shall be notified within 24 hours and shall direct CONTRACTOR on how to proceed with those specific sewer segments. If, in the course of normal cleaning operations, damage does result from preexisting and unforeseen conditions such as broken pipe, CONTRACTOR will not be held responsible.

B. Cleaning Precautions. During sewer cleaning operations, satisfactory precautions shall be taken in the use of cleaning equipment. Precautions shall be taken to insure that the water pressure created does not damage or cause flooding of public or private property being served by the sewer.

C. Water. The CONTRACTOR shall be responsible for obtaining water as necessary. No fire hydrant shall be obstructed in case of a fire in the area served by the hydrant.

D. Major Debris. Whenever lines to be cleaned show evidence of being more than one-half filled with solids, the OWNER shall be notified within 24 hours. After the CONTRACTOR performs a light cleaning (two passes with hydroflushing equipment), the CONTRACTOR shall perform the CCTV inspection. If heavy debris or roots are found that prevents the closed-circuit television inspection equipment from passing, the OWNER shall be notified within 24 hours. The CONTRACTOR can move to the next segment (no payment for segment not inspected). After the OWNER cleans the heavy debris from the sewer segment, the CONTRACTOR shall move back to this segment for inspection.

E. Blockage. If cleaning of an entire section cannot be successfully performed from one manhole, the equipment shall be set up on the other manhole and cleaning again attempted. The cost of additional manhole set-ups shall be borne by CONTRACTOR. If, again, successful cleaning cannot be performed or the equipment fails to traverse the entire manhole section, it will be assumed that a major blockage exists and the OWNER shall be notified as soon as possible. After the OWNER cleans the blockage from the sewer segment, the CONTRACTOR shall move back to this segment for inspection.

F. Material Removal. It is acceptable to perform the light cleaning operation and to allow the material to be carried downstream with the wastewater flow.

H. Final Acceptance. Acceptance of sewer cleaning shall be made upon the successful completion of the television inspection and shall be to the satisfaction of the OWNER. If TV inspection shows the cleaning to be unsatisfactory, CONTRACTOR shall be required to re-clean and re-inspect the sewer line until the cleaning is shown to be satisfactory to the OWNER.

3.5 Sewer Flow Control. CONTRACTOR will not provide bypass pumping or flow control. If flows are too high for CCTV inspection (greater than 20 percent of the pipe diameter for 10-inch and smaller pipe, greater than 25 percent for 12- to 24-inch pipe, and greater than 30 percent for 27-inch and larger pipe), CONTRACTOR shall evaluate if flows are low enough at a different time of day or night to complete the inspection. CONTRACTOR shall notify OWNER in advance when performance of the inspection at night is required. If flow levels do not drop below the maximum flow depths noted above, CONTRACTOR shall consult with OWNER. OWNER may then direct CONTRACTOR to perform the inspection under existing flow levels or provide alternate means of flow control.

3.6 CCTV INSPECTION

A. Sequence of CCTV Inspection. After cleaning, the pipe sections shall be visually inspected by means of closed-circuit television. The inspection will be done one manhole-to-manhole pipe section at a time and the flow in the section being inspected will be suitably controlled as specified. Each series of runs shall be recorded on a separate DVD or CD. For any TV inspection which is redone upon the request of OWNER, the affected lines must be recorded on a separate disc labeled "REDONE."

B. Direction of CCTV. The direction of camera travel shall be in the direction of flow in the pipe unless access to the upstream manhole is not possible, or the camera cannot pass through the pipe from end-to-end in the direction of flow, in which case a reverse setup will be allowed.

C. Severe Defects. If severe defects such as collapses, severe offset joints, or severe sags are encountered that preclude the inspection being completed in one direction, CONTRACTOR shall attempt a reverse setup. If the entire segment cannot be inspected, CONTRACTOR shall notify OWNER the same day.

D. Buried Manholes. If a buried manhole is encountered during the course of the CCTV inspection, CONTRACTOR shall attempt to CCTV through the buried manhole or conduct the inspection in the reverse direction if possible. CONTRACTOR shall notify the OWNER of the buried manhole and/or if the manhole needs to be exposed in order to complete the inspection.

E. Clarity of Picture. If, during a run, the camera lens becomes soiled or fogged, the camera should be shut down and the lens cleaned, even if this requires removing the camera from the line. If the camera is removed from the line for lens cleaning or for cleaning the line of fog, the camera shall be returned to the point where acceptable footage was obtained. Footage of the camera being pulled out of the line for lens cleaning should not be included in the video. If fog is encountered during a run, the CONTRACTOR shall stop the camera and ventilate the line to remove the fog. Unclear footage will not be accepted by OWNER.

F. Camera Travel. The camera shall be moved through the line at a moderate rate, stopping when necessary to permit proper documentation of the sewer's condition. When a defect or other feature is encountered, the progress of camera should be slowed and stopped for a minimum of 15 sections or as needed so that the observation can be panned with the camera, the data recorded, narration made, and still picture captured if required. In no case will the television camera be pulled at a speed greater than 30 feet per minute. Manual winches, power winches, TV cable, and powered rewinds or other devices that do not obstruct the camera view or interfere with proper documentation of the sewer conditions shall be used to move the camera through the sewer line. If, during the inspection operation, the television camera will not pass through the entire segment, CONTRACTOR shall set up his equipment so that the inspection can be performed from the opposite manhole. If, again, the camera fails to pass through the entire segment, the inspection shall be considered complete and no additional inspection work will be required.

G. Communication. When manually operated winches are used to pull the television camera through the line, telephones or other suitable means of communication shall be set up between the two manholes of the segment being inspected to insure good communications between members of the crew.

H. Distance Measurement. The "zero" point of the inspection shall be the centerline of the manhole where the camera is inserted. The footage counter shall be set accordingly by adding the footage from the centerline of the manhole to the edge of the manhole plus the camera length (or the camera length plus the camera focal length). The importance of accurate distance measurement is emphasized. During any inspection procedure, the television cable shall only be removed from the reel by a motorized system. At no time during the inspection is cable to be removed manually, by hand. The television cable between the counter and the camera shall be taught at all times.

I. Cable Footage Counter Accuracy Checks. All cable footage counts shall be in English units and accurate to 0.5 percent = ½ foot per 100 feet. The cable footage counter shall be tested for accuracy weekly, or at the direction of the OWNER, with the following procedure. Four hundred feet (400 feet) of cable shall be pulled off the reel and then checked with a tape measure. If the accuracy is below the tolerance, then the counter may be adjusted. The test procedure will be repeated to evaluate the adjustments. No more than three (3) adjustments may be made to the counter, after which the counter shall be replaced.

J. OWNER Observation. CONTRACTOR shall allow for observation by the OWNER during CCTV inspection work for purposes of verifying that all required CCTV inspection procedures are being followed and CCTV inspection observations are being properly coded. CONTRACTOR shall provide comfortable viewing access to the video tape monitor during the video inspection taping to allow OWNER's representative to compile a log of the inspection. OWNER may make both scheduled and unannounced visits to CCTV inspection operations while work is in progress. Notwithstanding any such observations of the CCTV inspection work by OWNER, CONTRACTOR shall be responsible for the quality of video and documented observations.

3.7 Documentation. Documentation of the CCTV inspection results shall be as follows:

A. CCTV Inspection Logs. Printed location records shall be kept by CONTRACTOR for each inspected pipe segment. The logs shall indicate, at a minimum, the pipe location, including the street name, starting and ending manholes, date and time of inspection, direction of inspection, pipe diameter, material, and joint length, and final inspected length. The logs will clearly show the distance from the centerline of the starting manhole of each observation and other points of significance such as locations of building sewers or other connections, broken or cracked pipe, separated or offset joints, vertical misalignment (sags), presence of roots, scale, corrosion, grease, sediment, debris, or infiltration, and other discernible features or unusual conditions, using the observation codes listed in Table 1 and the OWNER's "Descriptions and Photographic Examples of CCTV Inspection Codes", included at the end of this specification section. Comments shall be noted to document atypical conditions not otherwise described by the observation codes. A copy of each CCTV inspection log will be supplied to OWNER in hard copy and PDF format on standard CD or DVD. The pdf file shall be named in accordance with the same convention as the digital video file (see item D below).

B. CCTV Inspection Database. The data obtained for all inspections shall be provided in digital format compatible to the most recent version of Microsoft Access or Excel. The database shall contain two tables: one containing a single record or row for each inspection (Site Data Table) and one containing a single record or row for each observation (Observation Data Table). Field names or column headers shall be consistent with the OWNER's names (see Table 2 at the end of this specification section). At a minimum, the database tables shall contain the following fields or columns:

Site Data Table

- Site ID – CONTRACTOR's unique ID number for inspected segment, cross-referenced to Observation Data Table
- Project – CONTRACTOR's project ID
- Starting Manhole ID (in OWNER's specified format)
- Ending Manhole ID (in OWNER's specified format)
- Camera Direction – downstream (Dwn) or reverse (Rev)
- Street name on which the inspection is occurring
- Easement – yes or no
- Date of Inspection
- Video disc (CD or DVD) number
- Inspection complete? – yes or no
- Inspection abandoned due to prohibiting fault? – yes or no

- Inspected pipe length (to nearest 0.1 foot)
- Pipe diameter
- Pipe material (using OWNER's codes – see Table 3)
- Pipe joint length
- MPEG video file name
- Television inspection log file name
- Comments

Observation Data Table

- Site ID – cross reference to inspected pipe segment in Site Data Table
- Observation ID – CONTRACTOR's unique ID number for observation
- Footage position of observation (to nearest 0.1 foot)
- Observation code (using OWNER's codes – see Table 1)
- Clock position of observation (if applicable) – 1 through 12
- JPEG file name for observation photograph (if applicable)
- Comments (if applicable)

C. Digital Photographs. Digital format JPEG on standard CD or DVD photographs of all problems, severe defects or atypical observations shall be taken by CONTRACTOR or upon request of OWNER. The files should be named in accordance with the following convention:

Upstream Manhole ID-Downstream Manhole ID-mmddyy-D-xxx.jpg

Where:

- Upstream/Downstream Manhole ID is the full manhole number
- mmddyy is the date of the inspection
- D is the camera direction (Dwn or Rev)
- xxx is the footage location of the defect or observation (to the nearest foot)

For example, a typical still image file name for a defect at footage 123 during an inspection conducted on August 13, 2006, starting at upstream manhole 1989 and extending to downstream manhole 5243 would be:

1989-5243-081306-Dwn.123.jpg

If two or more images are captured at the same footage, an "a", "b", etc. should be added after the footage, e.g.:

1989-5243-081306-Dwn.123a.jpg

1989-5243-081306-Dwn.123b.jpg

Other file name formats may be considered acceptable if approved by the OWNER.

D. Digital CCTV Inspection Recording. The purpose of digital CCTV inspection recording shall be to supply a visual and audio record of the sewer condition. Format is MPEG-2 at 352 X 240 resolution, 30 frames per second, and 1.5 Mbits per second data rate. Other resolution, frame and data rates are acceptable as long as similar or better image quality and acceptable file size are obtained. Each individual pipe segment must be included in a single file, except if a reverse set up is required due to an obstruction, in which case the reverse inspection shall be contained in a separate file.

The following information must be provided as screen text on the video recording:

- Upstream and downstream node numbers
- Direction of camera travel
- Purpose of CCTV
- Location
- Date and time of day
- Job number and/or project name
- CCTV company or District staff
- Operator's name

The text should be clearly displayed on a contrasting background (e.g., white text on dark background or black text on white background). This text should be displayed for approximately 15 seconds or for the duration of the start-up narration, whichever is longer. If an inspection is being performed on consecutive pipe segments with the same setup, this information must be provided at the start of each pipe segment. Note: If the CCTV software being used can only display the "from" and "to" manhole numbers rather than upstream and downstream numbers (as in the case of a reverse inspection), then the upstream and downstream manhole numbers should be clearly stated in the startup video narration.

During CCTV, the running screen must include the following information. The display of this information must in no way obscure the central focus of the pipe being inspected.

- Running footage (distance traveled)
- Upstream and downstream (or "from" and "to") node numbers of inspected pipe segment

The end point of the inspected pipe segment should be indicated with screen text for approximately 15 seconds. The ending screen text should indicate:

- Ending footage
- Date and time of day
- Upstream and downstream node numbers of inspected pipe segment

The CCTV video recordings should not contain inappropriate language, idle chatter, background noise, and discussions between the operator and other crew members. A voice narration must be included in the video recording. All video narration must be live by the CCTV operator. Digital voice narration is only allowed if specifically approved by the OWNER.

This narration must include the following information at the beginning of each pipe segment:

- Upstream and downstream node numbers
- Direction of camera travel
- Type (sewer mainline, service sewer line, storm drain) and purpose of inspection
- Location
- Date
- Job number (if applicable) and/or project name
- Pipe size
- Pipe material
- CCTV company or District staff
- Operator's name

All observations along the length of the pipe must also be narrated, with a description of the observation and clock position, if applicable.

At the conclusion of the inspection of a pipe segment, the operator should state the final CCTV footage and indicate that the CCTV inspection of the pipe segment is complete. If the inspection had to be abandoned before reaching the ending manhole, then a statement to this effect should be made as part of the ending narration with a reason given as to why the inspection could not be completed.

The digital video files should be named in accordance with the following convention:

- Upstream Manhole ID-Downstream Manhole ID-mmddyy-D.mpg

Where:

- Upstream/Downstream Manhole ID
- mmddyy is the date of the inspection
- D is the camera direction (Dwn or Rev)

For example, a typical file name for an inspection conducted on August 13, 2006, starting at upstream manhole 1989 and extending to downstream manhole 5243 would be:

1989-5243-081306-Dwn.mpg

Digital video files are to be copied onto DVD. CONTRACTOR shall provide a copy of each DVD to the OWNER.

The audio and video shall be free of electrical interference and excessive background noise. Digital video recording playback shall be at the same speed that it was recorded. CONTRACTOR shall have all digital video and necessary playback equipment readily accessible for review by OWNER during the project, after which time the digital video shall be given typed labels and presented to OWNER.

E. CD and DVD Labels. Disc labels shall identify the disc #; OWNER's name; project name and contract (if applicable); contractor name, address and phone number; date of inspection; and sewer segment by upstream and downstream manhole numbers (followed by "Rev" if a reverse set-up). All labels shall be typed or computer generated. Handwritten labels are not acceptable.

Table 1
CCTV Inspection Codes

STRUCTURAL DEFECTS	
Desciptor	**Code**
Crack (<=1/8")	
Circumferential	CC
Longitudinal	CL
Spiral	CS
Multiple	CM
Fracture (>1/8")	
Circumferential	FC
Longitudinal	FL
Spiral	FS
Multiple	FM
Failures	
Broken	B
Hole	H
Collapse	X
Deformed	
Horizontally	DH
Vertically	DV
Joints	
Offset	
Medium (<=30% of pipe diameter)	JOM
Large (> 30% of pipe diameter)	JOL
Separated	
Medium (<=30% of pipe diameter)	JSM
Large (> 30% of pipe diameter)	JSL
Interior Surface Damage (Corrosion)	
Surface Spalling	SSS
Aggregate Visible	SAV
Aggregate Projecting	SAP
Aggregate Missing	SAM
Reinforcement Visible	SRV
Reinforcement Corroded	SRC
Missing Wall	SMW
Corrosion (Metal Pipe)	SC

OPERATIONS AND MAINTENANCE	
Desciptor	**Code**
Roots	
Light (No flow disturbance)	RL
Medium (Alters flow)	RM
Severe (Disrupts flow, cannot pass camera)	RS
Debris	
Light (No flow disturbance)	DL
Medium (Alters flow)	DM
Severe (Disrupts flow, cannot pass camera)	DS
Grease	
Light (No flow disturbance)	GL
Medium (Alters flow)	GM
Severe (Disrupts flow, cannot pass camera)	GS
Sags	
Sag Minor	SM
Sag Major	SMJ
Camera Underwater	MCU
Infiltration	
Weeper	IW
Dripper	ID
Runner	IR
Gusher	IG
Infiltration from Lateral	IL
Other	
Other *	O

*** Description required.**

CONSTRUCTION FEATURES	
Desciptor	**Code**
Access Points	
Cleanout/Rodding Inlet	ACO
Junction Box	AJB
Meter	AM
Manhole	AMH
Buried Manhole	AMB
Tee Connection	ATC
Miscellaneous	
Dimension/Diam/ Shape Change	MSC
General Photograph	MPG
Material Change	MMC
Joint Length Change	MJL
Survey Abandoned	MSA
Laterals	
Factory Made	
Capped	TFC
Defective	TFD
Break in/Hammer	
Capped	TBC
Defective	TBD
Protruding (based on % of mainline obstructed)	
Minor (<10%)	TBI
Medium (>10% and <30%)	TBM
Severe (>30%)	TBS
Saddle (Cored)	
Capped	TSC
Defective	TSD
Protruding (based on % of mainline obstructed)	
Minor (<10%)	TSI
Medium (>10% and <30%)	TSM
Severe (>30%)	TSS

Table 2
CCTV Database Table Structure

Table	Field Name	Data Type	Description
Site Data	SiteID	Number	CCTV Contractor's ID for this inspection
	Project	Text	Contractor's Project ID
	FromMH	Text	Starting MH of inspection (District format)
	ToMH	Text	Ending MH of inspection (District format)
	CamDir	Text	Camera direction: Dwn=downstream (forward), Rev=reverse
	StreetName	Text	Street name
	Easement	Text	Is the pipe located in an easement? (Y or N)
	InspDate	Date/Time	Date of pipe inspection
	InspVideoNo	Text	Contractors CD/DVD/videotape number
	Complete	Text	Was inspection of full segment completed? (Y or N)
	Abandoned	Text	Was the inspection abandoned due to a prohibiting fault (e.g., obstruction)? (Y or N)
	InspLength	Number	Inspected length of pipe (feet, to nearest 0.1 ft)
	PipeSize	Number	Pipe diameter (inches)
	PipeMat	Text	Pipe material (District code, see Table 3)
	PipeJLen	Number	Length between pipe joints (feet)
	InspVideo	Text	MPEG video file name
	InspReport	Text	Television inspection report file name
	SIteComm	Text	Comments about inspection
	ValueStatus	Text	Current or Archive (to be populated by District)
Observation Data	SiteID	Number	CCTV Contractor's ID for this inspection (must correspond to Site_ID in Site Data table)
	ObsID	Number	CCTV Contractor's ID for this observation
	ObsLoc	Number	Footage location of observation (to nearest 0.1 ft.)
	ObsCode	Text	Observation code (District code, see Table 1)
	ObsClock	Text	Clock position of observation (1 to 12) (for service connections, tee connections, longitudinal cracks, other defects or features as needed)
	ObsPic	Text	JPEG file name of observation photograph
	ObsComm	Text	Comments about observation

Table 3
Pipe Material Codes

Type of Pipe	Code
Asbestos cement pipe	ACP
Cast iron pipe	CIP
Concrete	CONC
Cured-in-place pipe	CIPP
Ductile iron pipe	DIP
Plastic-lined pipe*	PLP
Polyethylene	PE
Polyvinyl chloride pipe	PVC
PVC C-900	PVC1
PVC sdr26	PVC2
PVC sdr35	PVC3
PVC sch40	PVC4
PVC sch80	PVC5
Reinforced concrete pipe	RCP
Reinforced Plastic Mortar	RPM
Steel pipe	STL
Techite	TEC
Unknown	UNK
Variable material	VAR
Vitrified clay pipe	VCP

* Includes sewer pipe rehabilitated using slip-lining, fold-and form pipe, deformed-reformed pipe, swage lining, or roll-down lining.

- END OF SECTION -

DESCRIPTIONS AND PHOTOGRAPHIC EXAMPLES OF CCTV INSPECTION CODES

Detailed descriptions and representative photographs of CCTV observation codes are presented on the following pages. The descriptions also indicate those observations for which a clock position, comment, or still picture capture are required.

CRACKED AND FRACTURED PIPE (C and F)

Use these code for cracks that are visible on the inside surface of the pipe, but the pipe material is still intact. A longitudinal crack is one that runs along the length of the pipe. A radial crack is one that runs around the circumference of the pipe. A spiral crack is one that is both radial and longitudinal. Cracks can also be multiple, e.g., a combination of radial and spiral cracks or multiple occurrences of the same type of crack too numerous to enter as individual defects.

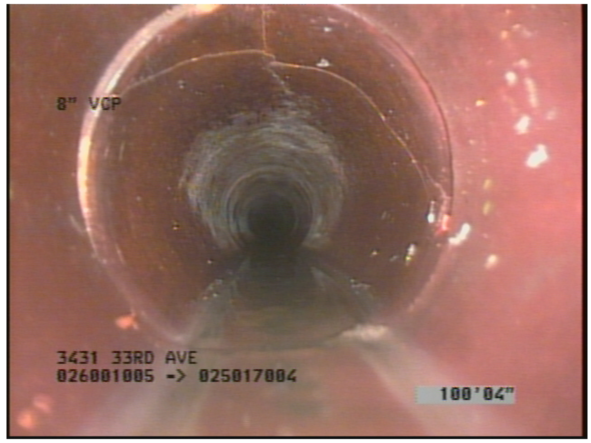
Continuous Defect. If longitudinal cracks and spiral cracks are longer than one the length of one joint-to-joint pipe segment, then every joint length where the crack extends must be recorded. A separate code must also be entered when a crack changes in severity.

CC	Circumferentially cracked pipe.	Crack is defined as <= 1/8-inch in width.
CL	Longitudinally cracked pipe.	Crack is defined as <= 1/8-inch in width.
CS	Spirally cracked pipe.	Crack is defined as <= 1/8-inch in width.
CM	Cracks, multiple at one location.	Crack is defined as <= 1/8-inch in width.
FC	Circumferentially fractured pipe.	Fracture is defined as > 1/8-inch in width.
FL	Longitudinally fractured pipe.	Fracture is defined as > 1/8-inch in width.
FS	Spirally fractured pipe.	Fracture is defined as > 1/8-inch in width.
FM	Fractures, multiple at one location.	Fracture is defined as > 1/8-inch in width.

See pictures on next page

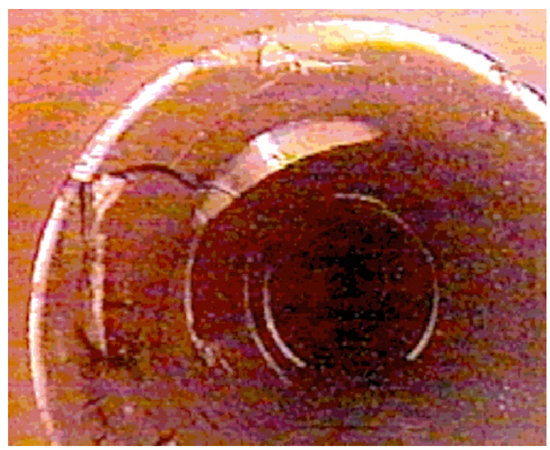
CRACKED PIPE

CL



CM

FL



FM

(Picture Required)

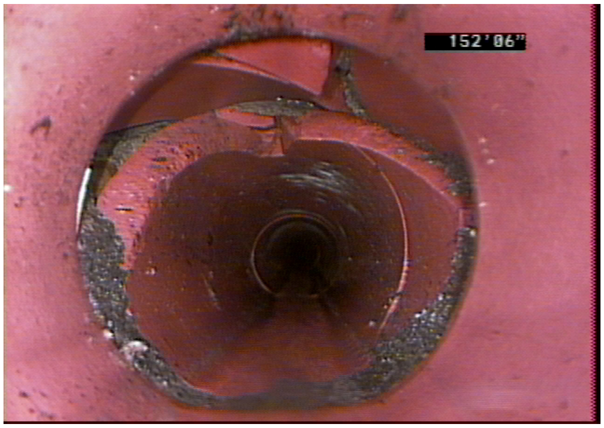
FAILURES

Use this series of codes to indicate where a pipe has a piece of wall visibly displaced or missing or the pipe is deformed.

BROKEN PIPE (B)

Use this code to indicate where a pipe has a pipe has a piece of wall visibly displaced.

This pipe condition should be reported immediately.



B

(Picture Required)

HOLE (H)

Use this code when a pipe has a piece of wall visibly missing.

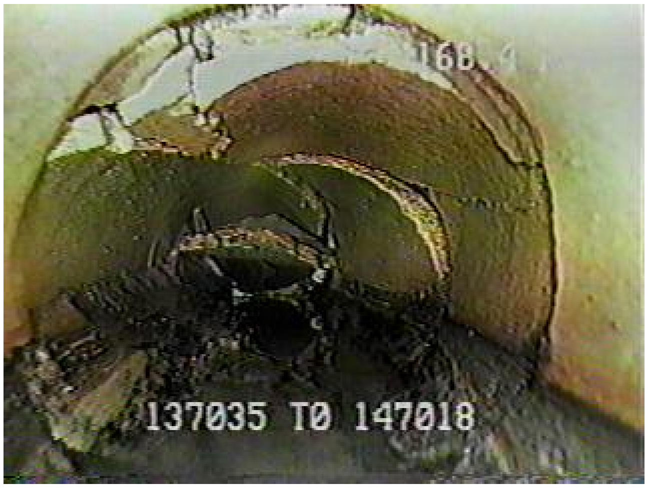
This pipe condition should be reported immediately.

(No Photo Available.)

COLLAPSED PIPE (X)

Use this code when the pipe has fallen in or has lost its structural integrity.

This pipe condition should be reported immediately.



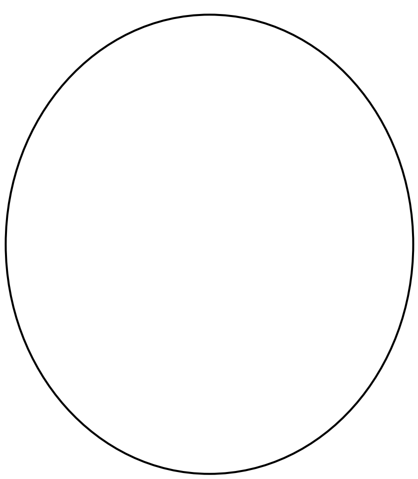
X
(Picture Required)

DEFORMED (D)

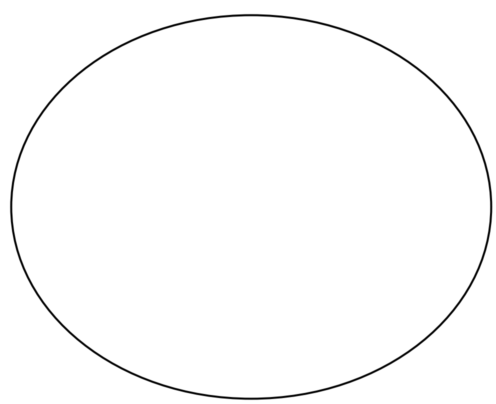
This code should be used primarily for flexible pipes (e.g., PVC, PEP) with an altered original cross-section. In some cases, rigid pipe may become deformed, although other defects such as severe cracking and collapse would also likely be present.

Continuous Defect. If deformity of pipe continues for longer than the length of one joint-to-joint pipe segment, then every joint length where the deformation occurs must be recorded. A separate code must also be entered when a deformity changes in direction.

DH	Out of round in the horizontal direction.
DV	Out of round in the vertical direction.



DV



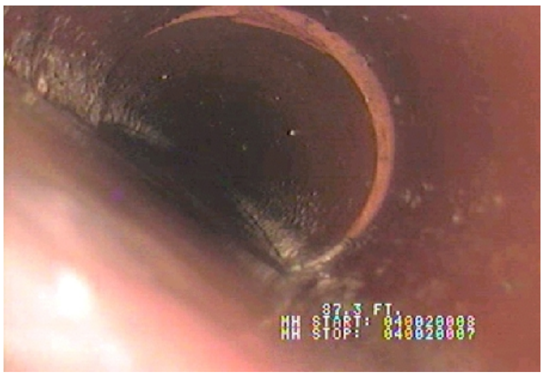
DH

OFFSET JOINT (JO) OR SEPARATED JOINT (JS)

Use this code when the spigot of the pipe is not properly aligned with the bell of the adjacent pipe. Joints may be misaligned horizontally, or open, dropped, or separated.

Comments: Note in comments if joint gasket is visible, hanging, torn, or gone.

JOM	Offset joint, medium	Joint misaligned by <=30% of diameter of pipe.
JOL	Offset joint, large	Joint misaligned by > 30% of diameter of pipe.
JSM	Separated joint, medium	Joint separated by <=30% of diameter of pipe
JSL	Separated joint, large	Joint separated by <=30% of diameter of pipe



JOM

JOL
(Picture Required)

INTERIOR SURFACE DAMAGE (CORROSION)

Use this code for concrete, asbestos cement, or metal pipes that show evidence of corrosion.

Continuous Defect. If corrosion of pipe continues for longer than the length of one joint-to-joint pipe segment, then every joint length where the corrosion occurs must be recorded. A separate code must also be entered when corrosion changes in type or severity.

SSS	Surface Spalling	Yellow staining, softening of interior surface, wear and tear.
SAV	Aggregate Visible	Exposed aggregate.
SAP*	Aggregate Projecting	Large pieces of aggregate protruding from surface of pipe.
SAM*	Aggregate Missing	Protruding aggregate missing, concrete wall thinning.
SRV*	Reinforcement Visible	Rebar ribs or exposed rebar.
SRC*	Reinforcement Corroded	Exposed rebar corroded. Concrete wall thinning.
SMW*	Missing Wall	Rebar gone. Concrete wall missing.
SC	Corrosion (Metal Pipe)	Metal has visible signs of corrosion.

* Photograph required.

SSS

SAP

(Picture Required)

SRV

(Picture Required)

ROOTS (R)

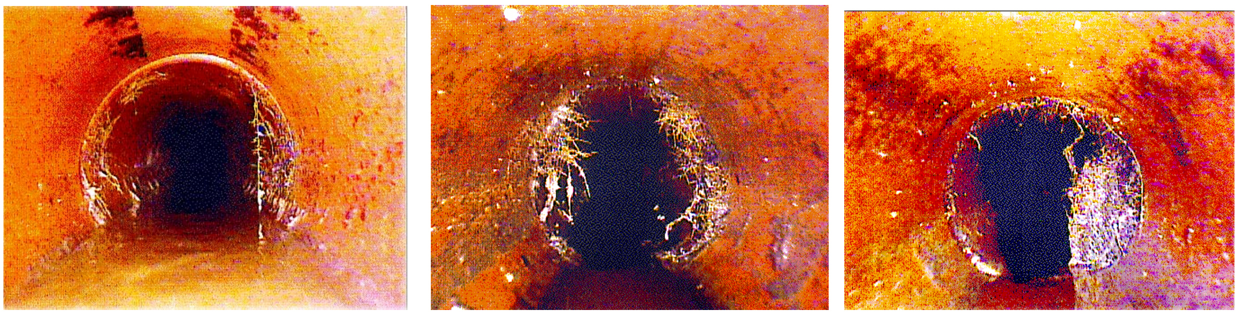
Use this code when roots have intruded into the mainline at joints or through cracks or other pipe defects. If root intrusion occurs at every joint over an extended length of pipe, then each occurrence (i.e., at every joint) must be recorded.

Comments. If severe roots are encountered that require cleaning of the pipe during the CCTV inspection, then the comments should indicate that the cleaning was completed, and a new root rating should be entered at 0.1 feet after the location where the CCTV inspection was resumed after cleaning.

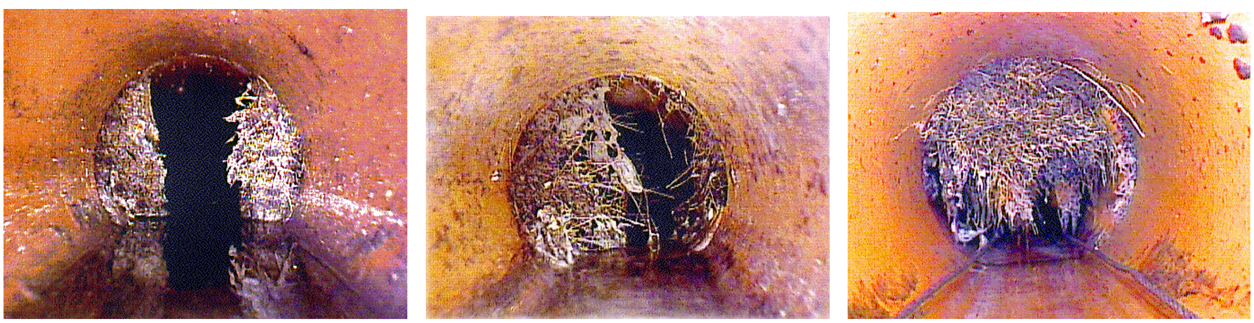
RL	Light Roots	No flow disturbance in pipe.
RM	Medium Roots	Flow in pipe is altered, but camera can pass.
RS	Severe Roots	Flow in pipe is disrupted, camera cannot pass.

See pictures on next page

ROOTS



RL



RM

RS

(Picture Required)

Debris (D)

Use this code for any accumulated material observed in the pipe. Material may include sand, gravel, silt, aggregate, or other matter.

Note: Any large foreign objects not normally encountered in a sewer pipe should be coded as Other (O) and noted in comments.

Continuous Defect. If sediment or solids extend for more than the length of one joint-to-joint pipe segment, then every joint length where the solids deposition occurs must be recorded. A separate code must also be entered when solids deposition changes in severity.

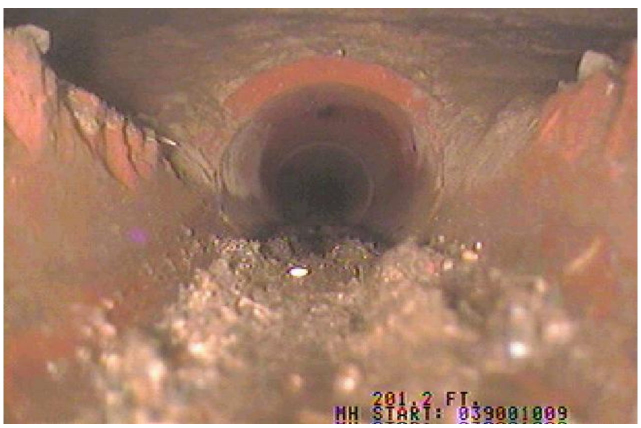
Comments. If severe sediment or solids are encountered that requires cleaning during the CCTV inspection, then the comments should indicate that the cleaning was completed, and a new sediment rating should be entered at 0.1 feet after the location where the CCTV inspection was resumed after cleaning.

DL	Solids or sediment, light	Camera tractor can pass accumulated material and there is no flow disturbance.
DM	Solids or sediment, med.	Camera tractor pushes accumulated material and the flow is altered.
DS	Solids or sediment, severe	Camera tractor stalls and cannot pass accumulated material OR accumulated material blocks flow.

See pictures on next page

SOLIDS OR SEDIMENT IN PIPE

DL



DM

DS

(Picture Required)

GREASE (G)

Enter this code at any location where grease is observed in the pipe.

Continuous Defect. If grease extends for more than the length of one joint-to-joint pipe segment, then every joint length where the grease occurs must be recorded. A separate code must also be entered when grease changes in severity.

Comments. If severe grease is encountered that requires cleaning of the pipe during the CCTV inspection, then the comments should indicate that the cleaning was completed, and a new grease rating should be entered at 0.1 feet after the location where the CCTV inspection was resumed after cleaning.

GL	Grease, light	Thin layer of grease at flowline or on pipe walls
GM	Grease, medium	Medium layer of grease that may distort flow
GS	Grease, severe	Thick layer of grease that alters flow or could result in stoppage

See pictures on next page

SAGS

Enter this code at any location where a sag (horizontal misalignment) is observed in the pipe.

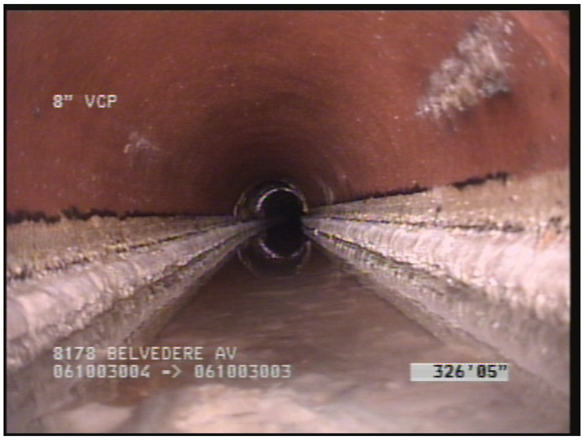
Continuous Defect. If the sag extends for more than the length of one joint-to-joint pipe segment, then every joint length where the sag occurs must be recorded. A separate code must also be entered when the sag changes in severity.

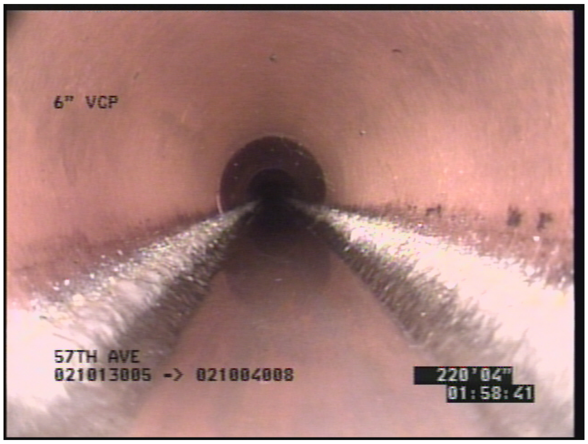
SM	Sag, minor	Horizontal misalignment <=30% of diameter of pipe.
SMJ	Sag, major	Horizontal misalignment > 30% of diameter of pipe.
MCU	Camera under water	Camera lens goes under water due to sag.

(No Photos Available.)

GREASE

GL





GM

GS (Picture Required)

INFILTRATION (I)

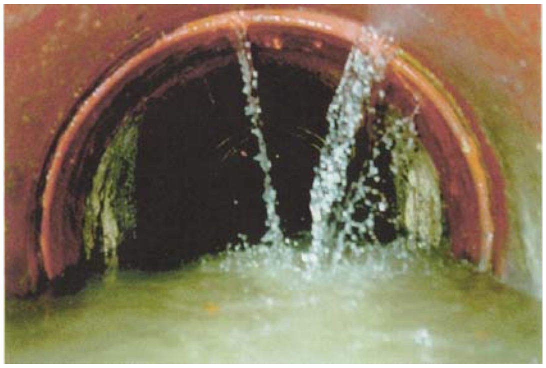
Use this code for infiltration into the mainline at joints or through cracks or other pipe defects.

Note: If the infiltration is occurring at a pipe *defect* (e.g., longitudinal crack or medium offset joint), the defect code (e.g., CL, JOM, etc.) should also be recorded in addition to the infiltration code. .

IW	Infiltration in pipe, weeper	Dampness or water seeping, no dripping water visible
ID	Infiltration in pipe, dripper	Water dripping, <1 gallon per minute
IR	Infiltration in pipe, runner	Water running, between 1 and 10 gallons per minute
IG	Infiltration in pipe, gusher	Water gushing, > 10 gallons per minute
IL	Infiltration from lateral	Clear water from lateral or visible infiltration from lateral joint

IW

ID



IR

(Picture Required)

***No photo of gusher available.**

OTHER (O)

Use this code for any significant defect or feature encountered in the pipe that is not otherwise described by another observation code. Examples would be a lining defect, which may appear as a bulge, missing section, or separation from the sewer wall; or a large obstruction.

Comments. Provide description of observed defect.

O

(Picture Required)

CHANGE IN PIPE MATERIAL (MMC)

Use this observation code when there is a change in pipe material or lining.

Comments: Note the changed pipe or lining material.

MMC

LATERALS (TAPS)

Use these codes to identify the location of sewer service line connections and any observed capped or defective connections. If a cored or break in/hammer tap is protruding into the pipe, use Protruding Tap codes.

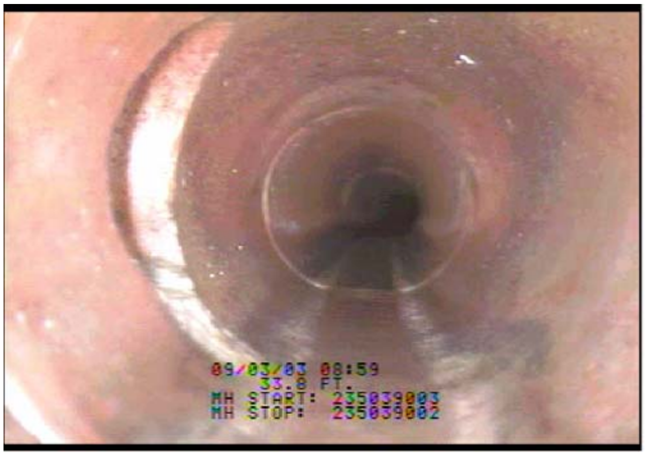
TF	Factory made	Wye or tee sewer service connection to mainline
TFC	Capped	
TFD	Defective	
TS	Saddle (cored tap)	Cored sewer service connection to mainline
TSC	Capped	
TSD	Defective	
TB	Break in/Hammer tap	Sewer service connection hammered into the mainline
TBC	Capped	
TBD	Defective	

Clock Position: Enter the clock position of the connection relative to the circumference of the pipe. The 12:00 position is always at the pipe crown.

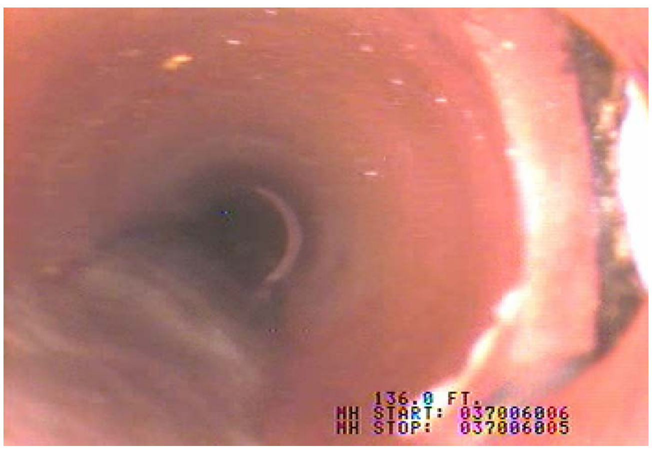
Comments: Note if the lateral appears to be inactive. Describe and note severity of any visible defects or leaks at the connection (in addition, use code noted above) or any defects observed within the service line (e.g., roots, grease, sediment, cracks,).

See pictures on next page

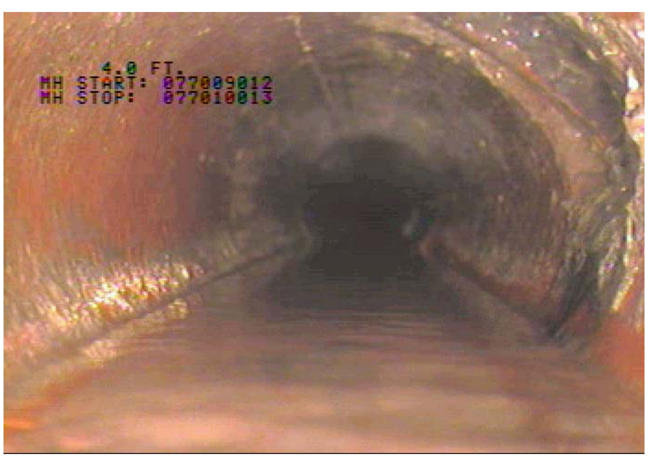
TAPS


09/03/03 08:59
33.0 FT.
MH START: 235039003
MH STOP: 235039002

TF


136.0 FT.
MH START: 037006006
MH STOP: 037006005

TS


4.0 FT.
MH START: 077009012
MH STOP: 077010013

TB

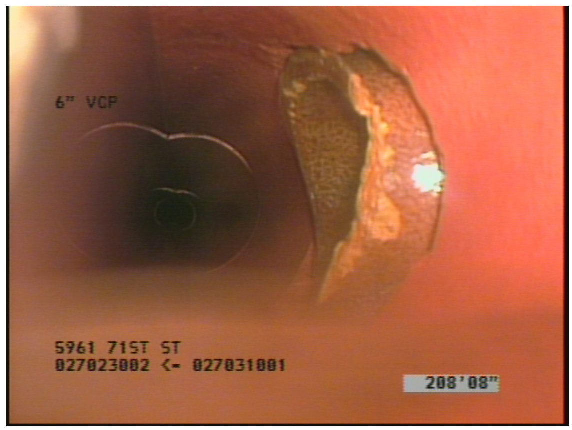
PROTRUDING TAP

Use this code if a hammer or cored tap sewer service connection protrudes into the mainline.

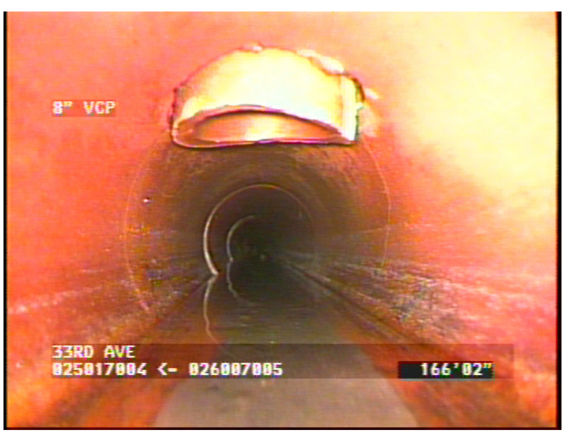
TBI or TSI*	Protruding tap, minor	Sewer service protrudes up to 10% into mainline
TBM or TSM*	Protruding tap, medium	Sewer service protrudes more than 10% but no more than 30% into mainline, but camera can pass
TBS or TSS*	Protruding tap, severe	Sewer service protrudes more than 30% into mainline and camera cannot pass

* Protruding taps can be found on Break in/Hammer taps or Cored taps. Use the appropriate code that coincides with the type of tap found.

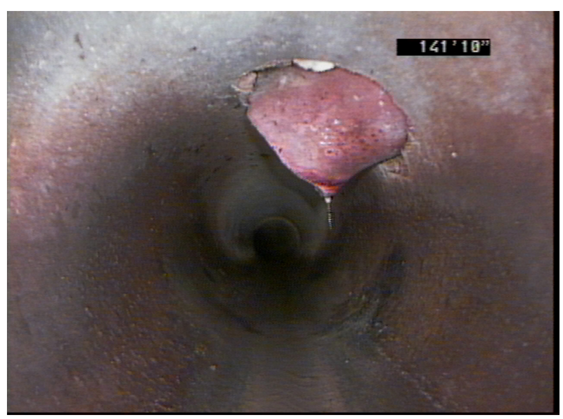
TBI



TBM



TBM



TBS

(Picture Required)

SANITARY DISTRICT NO. 1
of
Marin County, California

FORCE MAIN IMPROVEMENT PROGRAM

W. Edward Nute

W. EDWARD NUTE RCE 15945

REGISTERED PROFESSIONAL ENGINEER
W. Edward Nute
No. 15945
Exp. 6/30/01
CIVIL
STATE OF CALIFORNIA

NUTE ENGINEERING
San Rafael, California

May 1998

NUTE

NUTE ENGINEERING

Civil and Sanitary Consultants

907 Mission Ave.
San Rafael, CA 94901
(415) 453-4480
Fax (415) 453-0343

May 15, 1998

Sanitary District No. 1 of Marin County
2000 Larkspur Landing Circle
Larkspur, CA 94939

Letter of Transmittal

Dear Board Members,

As authorized by you, we have completed our study of the District's system of force mains.

The District maintains seven miles of force mains ranging in size from 6" to 54" in diameter. These force mains transport sewage from the District's 180 miles of collecting sewers and 20 pump stations to the CMSA Treatment Plant.

In recent years, environmental regulations and sanctions have become increasingly restrictive so that now regulatory agencies can levy fines and penalties of $10,000 per day and $10 per gallon for any spillage to the environment. A broken force main can quickly spill large amounts of untreated sewage.

Sewage force mains, like other underground utilities, are subject to damage and deterioration from others excavating in the area, earthquakes, corrosion, etc. All these pipelines have finite service lives and eventually will need to be replaced or rehabilitated.

In order to assure maximum reliability of its force main system, we are recommending that the District undertake a long range program of force main improvements which will involve construction of a system of parallel force mains and rehabilitation of the existing ones. The parallel force mains will become permanent standby lines in the event of a leak or failure of the primary force main and will serve as the bypass line during rehabilitation of the original force main.

Notwithstanding this long range objective, it is recommended that the existing Kentfield Force Main be rehabilitated in the initial phase because it is at the highest risk of failure. The old gravity sewer to the Greenbrae Pump Station can serve as a bypass line during this rehabilitation.

The force main rehabilitation program recommended herein is estimated to cost some $30 million in present day dollars to be spent over a fifty-year period.

Very truly yours,

NUTE ENGINEERING

By W. Edward Nute
W. Edward Nute

lm

TRANSLTR #1

ABBREVIATIONS

ACP	-	Asbestos cement pipe
CIP	-	Cast iron pipe
DI	-	Ductile iron
FM	-	Force main
ft.	-	feet
I/I	-	Infiltration/Inflow
PE	-	Polyethylene
PS	-	Pump station
PVC	-	Polyvinyl chloride
RCCP	-	Reinforced concrete cylinder pipe
WS L/C	-	Welded steel cement lined and coated

SANITARY DISTRICT NO. 1
OF
MARIN COUNTY, CALIFORNIA

FORCE MAIN IMPROVEMENT PROGRAM

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Sanitary District No. 1 of Marin County
CHRONOLOGY

APPENDIX B

Ross Valley Sanitary District
Collection System Corrosion Evaluation
Corrosion Engineering and Research Company
May 31, 1990
Conclusions and Recommendations

APPENDIX C

Ross Valley Sanitary District
42" Greenbrae/Kentfield Force Main, 30" Greenbrae Force Main,
12" Pump Station B Force Main & 54" Ross Valley Interceptor
Phase II - Corrosion Analysis
Corrosion Engineering and Research Company
April 19, 1993
Conclusions and Recommendations

APPENDIX D

Letter from B. Jay Schrock, P E.
JSC International Engineering
dated April 11, 1990

SANITARY DISTRICT NO. 1
OF MARIN COUNTY, CALIFORNIA

FORCE MAIN IMPROVEMENT PROGRAM

PREFACE

Sanitary District No. 1 of Marin County, also known as the Ross Valley Sanitary District, provides sewage service to the incorporated towns of Larkspur, Ross, San Anselmo and Fairfax and the unincorporated communities of Greenbrae, Kentfield, Kent Woodlands and Sleepy Hollow. Sanitary District No. 1 also maintains the pump station and force main which serves the San Quentin Prison.

The District serves approximately 51,000 people within a total service area encompassing some 27 square miles. The sewage which is collected through these facilities is transported to the Central Marin Sanitation Agency (CMSA) Wastewater Treatment Plant in San Rafael where it receives treatment and is disposed of to San Francisco Bay.

Over the past 30 years, the District has been upgrading its sewer system in order to provide better service and to eliminate wet weather overflows. These improvements include the replacement of collecting sewers, some of which are more than 100 years old. As a part of this program, the District has also constructed improvements to its wastewater transport system.

The District's sewer system now consists of some 180 miles of collecting sewers, 20 pump stations, and over seven miles of force mains. Force mains are defined as pipelines through which sewage is pumped. Pollution control requirements and enforcement measures have become increasingly stringent and the District can be subject to large fines and penalties in the event of failure of its facilities which discharges untreated sewage to the environment.

STUDY OBJECTIVE

The purpose of the studies summarized herein is to inventory the District's force mains, estimate their remaining useful life and then set forth a long range plan for their eventual replacement or rehabilitation. The District can then budget for this work so it can be undertaken in an orderly manner in advance of failures which could subject the District to unplanned expenditures, expensive repairs and/or penalties.

DISTRICT SEWER SYSTEM

Sanitary District No. 1 was organized in 1899 and was the first Sanitary District to be formed in Marin County. Once formed, the District responded to the need to solve community sanitation problems in the original sewer systems serving Kentfield, Ross and San Anselmo.

By the 1920's, growth in the District rendered the original sewers inadequate, and in 1923 the District undertook to construct a major trunk sewer through the Ross Valley and a treatment plant at Greenbrae in the vicinity of the present Bon Air Shopping Center. The trunk sewer, much of which is still used as part of the District system, runs westerly from Greenbrae through a tunnel in the hills separating Greenbrae and Kentfield, extending through Kentfield, Ross and San Anselmo to Fairfax.

The size of the trunk sewer varies from 30" diameter at Greenbrae to 10" diameter in Fairfax and was constructed out of concrete pipe and vitrified clay pipe. The concrete pipe was manufactured on the job site; and, over the years, there have been several pipe failures as a result of deterioration. Where the pipe has been uncovered, it has been observed that cement jointing material was completely gone, thus allowing direct entrance of ground water. In 1948 the District relocated its treatment plant from Greenbrae to a site easterly of Highway 101, with a new discharge point closer to the mouth of Corte Madera Creek. At that time, the original treatment plant was converted to a pump station which pumped sewage to the new treatment plant through a 24" steel force main. This 24" diameter steel force main was too small and corroded very quickly, so it was replaced with a 30" diameter concrete lined and coated, welded steel force main in 1959.

In the 1950's the District recognized that there were serious problems resulting from infiltration of ground and surface water to the sewers causing sewage overflows from the system during heavy rains and extended wet weather. Accordingly, in 1955 the District presented a bond issue to the voters to upgrade the sewer system and eliminate the storm water bypasses. The bond issue was defeated and, without any means of financing the work, the project was abandoned. Consequently, by the late 1960's the bypassing and overflows had become critical since the 1923 trunk sewer was inadequate to handle wet weather flows

In 1967, recognizing that the serious problem of wet weather overflows demanded correction and further recognizing the inherent uncertainties in obtaining approval of bond financing from the voters, the District undertook a staged program of system improvements on a pay-as-you-go basis. The basic sewer system improvements consisted of construction of a trunk sewer through the Ross Valley from Kentfield to Fairfax and construction of the Kentfield Pump Station and Force Main.

The first stage of the Ross Valley trunk sewer consisted of a 39" diameter trunk sewer which was installed through Kentfield as a part of the Corte Madera Creek Flood Control Channel Project being constructed by the U.S. Army Corps of Engineers. By 1975, the Ross Valley Trunk Sewer had been extended through Ross and San Anselmo into Fairfax. The Kentfield Pump Station and Force Main went into operation in 1972.

With the Ross Valley trunk sewer and Kentfield Pump Station and Force Main, the District has been able to eliminate wet weather overflows of sewage to Corte Madera Creek.

Concurrent with construction of these major system improvements, the District began an intensive program to locate and eliminate illegal storm drain connections, and to repair broken and defective sewers so that the infiltration of extraneous ground water and storm water to the sanitary sewer system would be mitigated as much as possible. This program of sewer system improvements has continued to the present day.

A chronology of the District activities and major projects is given in Appendix A.

INFILTRATION/INFLOW

The need to rehabilitate old sewers and provide for pumping and transport of high wet weather flows is caused by the fact that the District sewer system, like most older sewer systems, experiences high rates of wet weather infiltration/inflow (I/I).

> ***Infiltration*** is technically defined as the entrance of groundwater into the sewers through defective pipe and pipe joints. However, as a practical matter there is also "***Intensity Related I/I***" which is defined as rainwater which enters defects in sewers during intense rainfalls. The rate of infiltration and intensity related I/I increases after the first few storms of the season when the ground becomes saturated. Elimination of infiltration and intensity related I/I is expensive because it usually involves replacement or sliplining of sewer mains and laterals for their entire length.
>
> ***Inflow*** is defined as rain water which enters the sanitary sewer system through direct connections of storm drains, area drains, roof leaders, etc. The District has an ordinance prohibiting such connections. The elimination of inflow is relatively inexpensive once such illegal connections are located since it involves enforcement of the District's ordinance or disconnection of storm drains from the sewers. Smoke testing is a method by which such illegal connections can be located.

Smoke testing involves the blowing of an innocuous white smoke into the sewers through manholes. Smoke can then be seen exiting from illegal drainage connections or from pipe defects close to the ground surface. Smoke also exits from individual house vents which indicates that the lateral does not have a sag or trap. It should be noted that smoke testing does not reveal all defects in the sewers, particularly those which can take on infiltration or intensity related I/I.

As part of ongoing sewer system investigations, the District has been smoke testing selected areas of the District. The purpose of the smoke testing has been to try to determine if the District's sewer system has points of inflow which could be easily corrected or if the I/I is more pervasive and will require rehabilitation of entire sewer lines.

As a preliminary sampling, the District has smoke tested 9 areas containing 459 homes and found only 9 illegal connections, i.e., 2% These illegal connections violate the District's ordinance and should be eliminated. If projected over the entire Ross Valley, the number of homes with illegal connections does not account for the very large volumes of extraneous rainwater which enter the District's sanitary sewers during rainstorms. Accordingly, it can only be concluded that the I/I problem is due to leaky sewers and is therefore widespread and requires comprehensive rehabilitation of sewer mains and laterals.

SEWER SYSTEM REHABILITATION

Some 80 to 90% of the District's sewers were installed before 1955 when good pipe joints became available. In older areas, sewers date back to the late 1800's. These older sewers are mostly vitrified clay pipe with cement or tar joints every 2 to 3 feet. Over the years sewers can be damaged, particularly by tree roots in times of drought. Also, most of the tar and cement joint compounds have deteriorated and allow roots to enter. Consequently, the sanitary sewer system acts like a large "french drain" and takes on a percentage of the rainfall. The fact that the Ross Valley is located in a "rain shadow" of Mt. Tamalpais serves to aggravate the problem. This extraneous water entering the sewers mixes with the sewage so it must then be pumped to the CMSA plant for treatment.

The District's older sewers are a major source of I/I. In order to reduce I/I in the system, the District has been rehabilitating the older sewers on a systematic basis. The types of problems found in these older sewers include:

- Collapsed or structurally damaged sewers.
- Sewers which lack capacity to handle the tributary sewage flows.
- Sewers damaged by tree roots.
- Sewers which are leaky because they lack joint materials.
- Sewers which are in inaccessible easements or under buildings.

These older sewers were installed at a time when the Ross Valley was sparsely developed. Downtown areas and residential areas are now intensely developed but most of the original sewers are still in service. Occasionally, there are collapses or stoppages which require immediate, unbudgeted repair. Eventually, most of these older sewers should be replaced or rehabilitated.

With 180 miles of sewers in its system, the District should be rehabilitating 1.8 miles of sewers each year in order to replace the system over a 100 year cycle. At the present time, the District spends approximately $500,000 per year on sewer rehabilitation, which replaces about 0.6 miles of sewers and the laterals to the property line. This expenditure will need to be tripled in order to replace 1.8 miles of sewer mains each year.

By eventually eliminating older sewers and laterals, each rehabilitation project will serve to further reduce wet weather infiltration/inflow (I/I). To date, most of the sewers which have been selected for rehabilitation are ones with long standing problems and which are subject to high rates of I/I

It should be noted that the Marin Municipal Water District (MMWD) is now upgrading its water system in older areas of the Ross Valley with the installation of fire flow lines. By coordinating the District's sewer replacement projects with the MMWD projects, the subsequent restoration of streets could be shared

EXISTING WASTEWATER TRANSPORT SYSTEM

Sanitary District No. 1 maintains 20 pump stations and over seven miles of force mains ranging in size from 6" in diameter to 54" in diameter. The pump stations and force mains were constructed over the years as development occurred and as there was need for additional sewage transport capacity. The oldest force main still in use was constructed in the 1950's.

The District's force main system conveys sewage from the Ross Valley to the Central Marin Sanitation Agency (CMSA) Treatment Plant in San Rafael. The final segment of this force main is a 54" diameter tunnel through the San Quentin Ridge. The CMSA Treatment Plant went into operation in 1985.

Force main pipelines have a finite useful life and will eventually require replacement or rehabilitation. A sign of deterioration will be periodic leaks or outright failures. Sometimes force mains are damaged accidentally by backhoes or by a natural event such as an earthquake. Metallic force mains can corrode unless they are coated and/or cathodically protected. Concrete force mains can be subject to internal sulfide attack if there are air pockets. Depending on the type of pipe material used, force mains will eventually deteriorate or otherwise be damaged to the point that some action will need to be taken.

Force mains are an essential part of the District's sewage conveyance system. When a force main experiences a leak or failure, a great deal of untreated sewage can be discharged to the environment in a very short amount of time. In some cases, the force main can be simply dug up in a street and a repair clamp can be installed. In other cases repairs cannot be made so simply. For example, if a force main is located along a creek bank or in a levee which fails, the repair might require reconstructing a levee before the pipeline can be repaired or replaced. Force main repairs are usually expensive and the repaired pipeline is never as good as a new one.

DISTRICT PUMP STATIONS

The District's 20 pump stations are classified as major pump stations, minor pump stations and lift stations as listed in Table 1. All of the pump stations are located in the lower Ross Valley as shown in Figure 1.

The major pump stations are the larger pump stations which pump directly to the CMSA Treatment Plant through a common force main system. The minor pump stations are generally smaller and pump sewage to a gravity sewer or into another force main. Lift stations are local stations which may just lift sewage into a nearby gravity sewer or pump the sewage through a relatively short force main to a gravity sewer.

TABLE 1 SANITARY DISTRICT NO. 1 - PUMP STATIONS

DESIGNATION	NAME	LOCATION	SERVICE AREA	YEAR CONST
MAJOR PUMP STATIONS				
PS-10	Landing B	101 E Sir Francis Drake	Larkspur Landing	1978
PS-11	San Quentin	E Sir Francis Drake & West Gate	San Quentin Prison	1983
PS-12	Bon Air	380 Bon Air Center	Bon Air Shopping Center	1984
PS-13	Greenbrae	70 Bon Air Center	Greenbrae	1982
PS-14	Larkspur Main	200 Doherty Drive	Larkspur	1988
PS-15	Kentfield	Creek & Stadium Way	Kentfield/Upper Ross Valley	1972
MINOR PUMP STATIONS				
PS-20	Landing A	17 E Sir Francis Drake	Larkspur Landing	1978
PS-21	101	Hwy 101 & Corte Placida	Portion of Bon Air	1957
PS-22	Cape Marin	2 Scott Place	Drake's Landing	1987
PS-23	Capurro	48 Elizabeth Circle	Drake's Landing	1989
PS-24	630 S Eliseo (PS #4)	630 S Eliseo Drive	S Eliseo Dr/Greenbrae	1988
PS-25	1350 S Eliseo (PS #5)	1350 S Eliseo Drive	S Eliseo Dr/Greenbrae	1991
LIFT STATIONS				
PS-30	Heather Gardens	92 Diane Lane	Heather Gardens, Larkspur	1940?
PS-31	1 Via la Brisa	1 Via la Brisa	Greenbrae Marina	1968
PS-32	1 Corte del Bayo	1 Corte del Bayo	Greenbrae Marina	1968
PS-33	415 Riviera Circle	415 Riviera Circle	Greenbrae Marina	1968
PS-34	359 Riviera Circle	359 Riviera Circle	Greenbrae Marina	1968
PS-35	2 Corte del Coronado	2 Corte del Coronado	Greenbrae Marina	1968
PS-36	178 Riviera Circle	178 Riviera Circle	Greenbrae Marina	1968
PS-37	Larkspur Plaza	220 Larkspur Plaza Drive	Larkspur Plaza, Larkspur	1962

INVENTORY OF DISTRICT FORCE MAINS

Sewage force mains are the pipelines which convey the discharge from pump stations to another point in the sewer system. The force mains owned and operated by the District are inventoried in Table 2 and described below. For the purpose of the inventory and description, the force mains have been numbered to correspond to the District pump stations' numbering system. The routing of the various force mains is shown in Figure 1 and a schematic of the major force main system which pumps to the CMSA Treatment Plant is shown in Figure 2.

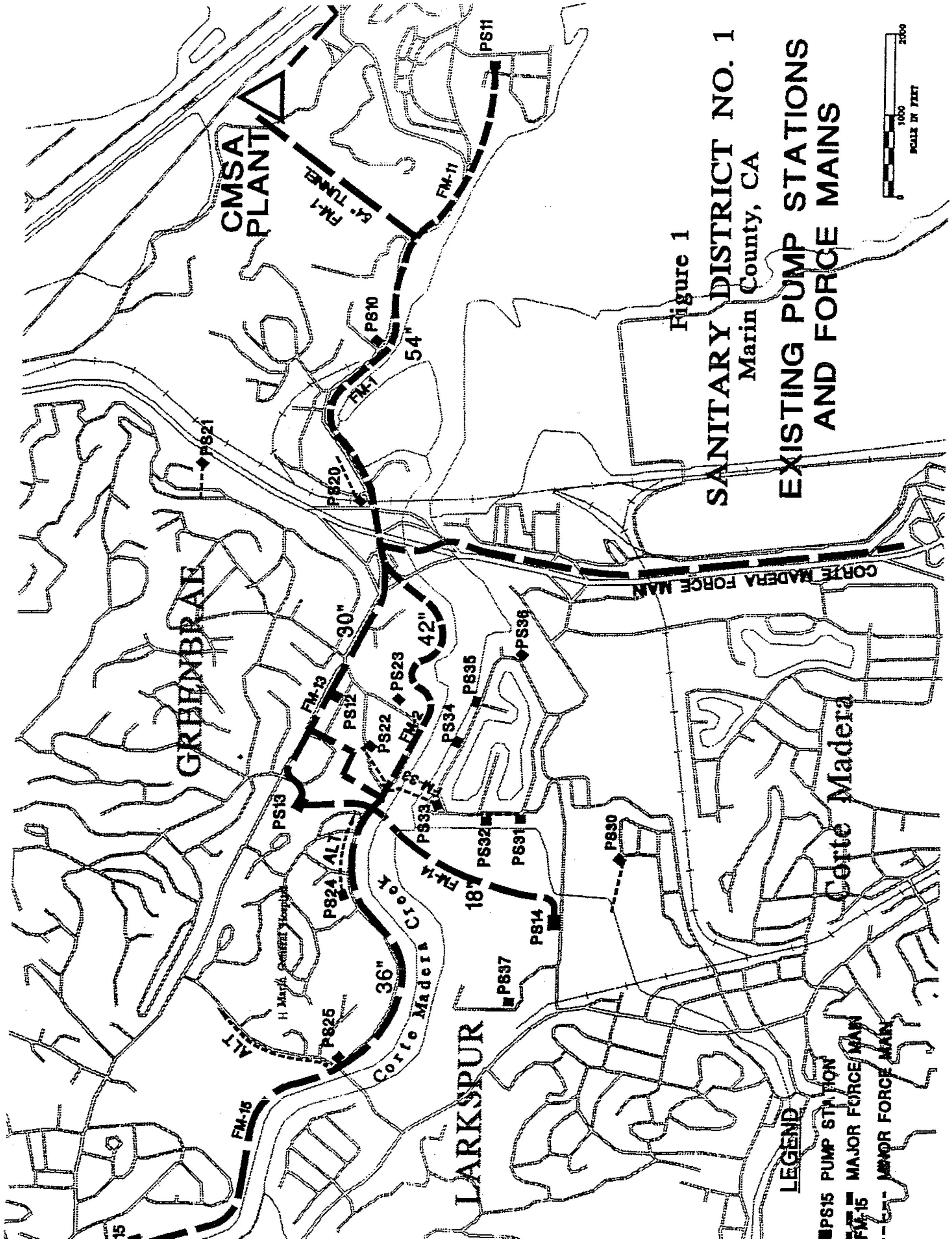


Figure 1
SANITARY DISTRICT NO. 1
Marin County, CA
EXISTING PUMP STATIONS
AND FORCE MAINS
CMSA
PLANT
FM-1
54" TUNNEL
FM-11
PS11
PS10
54"
PS21
PS20
CORTE MADERA FORCE MAIN
GREENBRAE
30"
42"
PS36
PS35
PS23
FM-13
PS12
PS22
FM-2
PS34
PS13
PS33
PS32
PS31
PS30
ALT
PS24
FM-14
18"
PS14
Corte Madera Creek
36"
PS17
PS25
ALT
FM-15
LARKSPUR
Corte Madera
PS15
LEGEND
PS15 PUMP STATION
FM-15 MAJOR FORCE MAIN
MINOR FORCE MAIN
SCALE IN FEET
0
1000
2000

TABLE 2
SANITARY DISTRICT NO. 1
INVENTORY OF FORCE MAIN SYSTEM

April 22, 1998

Desig	Pump Station Or Discharge Point	Length, ft	Diameter, inches	Type of Pipe	Location	Installation Date
COMMON FORCE MAINS						
FM-1	**ROSS VALLEY INTERCEPTOR - Serving PS#10,12,13,14,15,24,25, & Corte Madera**					
	Jct Greenbrae FM				Hwy 101 @ S F Drake Blvd	
	Jct 24" Corte Madera FM	43	54”	RCCP	E Sir Francis Drake Blvd	1983
	Jct Pump Sta B FM	2,557	54”	RCCP		1983
	Jct San Quentin FM	1,515	54”	RCCP		1983
	CMSA Plant	2,075	54”	RCCP	Ross Valley Tunnel	1983
FM-2	**GREENBRAE/KENTFIELD FORCE MAIN - Serving PS #14,15**					
	Jct Larkspur FM					
		4,234	42”	RCCP	Corte Madera Creek Path	1987
	Jct Corte Madera FM					
FORCE MAINS FROM MAJOR PUMP STATIONS						
FM-10	**LANDING B FORCE MAIN - Serving PS#10**					
	Landing B (PS #10)					
		200	12”	WS L/C	Crossing E Sir Francis Drake Blvd	1983
	Jct CMSA FM					
FM-11	**SAN QUENTIN FORCE MAIN - Serving PS#11**					
	San Quentin PS (PS #11)					
		3,110	16” 18”	PE	San Quentin Prison Rds & S F Drake Blv	1984
	Jct CMSA FM					
FM-12	**BON AIR FORCE MAIN - Serving PS#12**					
	Bon Air PS (PS#12)					
		25	8”	WS L/C	Sir Francis Drake Blvd	1984
	Jct Greenbrae FM					
FM-13	**GREENBRAE FORCE MAIN - Serving PS#13**					
	Greenbrae PS (PS #13)					
		60	24”	WS L/C	Greenbrae PS	1983
		1,160	30”	RCCP	Easement @ Bon Air Shopping Ctr	1959
		690	30”	WS L/C	Sir Francis Drake Blvd @ Bon Air PS	1959
		2,660	30”	WS L/C	Sir Francis Drake Blvd	1959
	Jct Grnbre Kntfld FM	33	30”	WS L/C		1984
	Jct Corte Madera FM					

Desig	Pump Station Or Discharge Point	Length, ft	Diameter, inches	Type of Pipe	Location	Installation Date
FM-14	**LARKSPUR FORCE MAIN - Serving PS #14**					
	Larkspur PS (PS #14)					
		2,610	18"	PE	Doherty Dr and Piper Park	1988
		590	16"	PE	Corte Madera Cr Crossing	1989
	Easterly end S Eliseo Dr	85	18"	PE	Easterly end of S Eliseo Dr	1989
	ALTERNATE FORCE MAIN					
		1,000	18"	RCCP	Easement @ Bon Air Shopping Ctr	1966
	Greenbrae PS #13)					
FM-15	**KENTFIELD FORCE MAIN - Serving PS #15**					
	Kentfield Pump Station (PS #15)					
	Jct Pump Sta 25	3,660	36"	Techite	Corte Madera Cr Path	1972
	Jct Pump Sta 24	2,555	36"	Techite	S Eliseo Dr	1972
		1,290	36"	Techite	S Eliseo Dr	1972
	ALTERNATE FORCE MAIN					
		1,443	36"	Techite *	Easement @ Bon Air Shopping Ctr	1972
	Greenbrae Jct					
	* Includes WS L/C at angle Points					
FORCE MAINS FROM MINOR PUMP STATIONS						
FM-20	**LANDING A FORCE MAIN - Serving PS #20**					
	Landing A PS (#20)					
		300	6"	PVC	E Sir Francis Drake Blvd	1978
	MH in Shopping Ctr	788	8"	PVC	Larkspur Landing Shopping Center	1978
FM-21	**101 FORCE MAIN - Serving PS #21**					
	Pump Sta #21					
		265	4"	C I P	Easement	
	MH in Via La Cumbre	410	6"	C I P		1957
FM-22	**CAPE MARIN FORCE MAIN - Serving PS #22**					
	2 Scott Pl					
	Jct PS #33 FM	50	6"	PVC	Laderman Ln	1987
FM-23	**CAPURRO FORCE MAIN - Serving PS #23**					
	Capurro PS @ Elizabeth Cir					
	MH nr Bikepath	361	6"	PVC	Laderman Ln, Gregory Place	1989
FM-24	**630 S ELISEO FORCE MAIN - Serving PS #24**					
	Pump Sta # 24 (Old PS #4)					
	Jct Old FM	10	10"	WS L/C	630 S Eliseo Dr	1989
	Jct Kentfield FM	18	10"	WS L/C		1989
	ALTERNATE FORCE MAIN					
	Jct New FM to Kntfld	10	10"	WS L/C		1961
	to < Pt S Eliseo	35	8"	WS L/C		
		710	6"	ACP		1961

Desig	Pump Station Or Discharge Point	Length, ft	Diameter, inches	Type of Pipe	Location	Installation Date
FM-25	**<u>1350 S ELISEO FORCE MAIN - Serving PS #25</u>**					
	1350 S Eliseo (old PS#5)					
	Jct Kentfield FM	123	10"	DI	S Eliseo Dr	1991
	ALTERNATE FORCE MAIN					
	1350 S Eliseo (old PS#5)	50	8"	DI	Bon Air Rd	1991
		300	8"	ACP	Bon Air Rd	1964
		886	8"	PE	Bon Air Rd	1985
		200	8"	ACP	Bon Air Rd	1964
<u>FORCE MAINS FROM LIFT STATIONS</u>						
FM-30	**<u>HEATHER GARDENS FORCE MAIN - Serving PS #30</u>**					
	92 Dianne Lane					????
	Niven Nursery	730	6"	?	Easements	
FM-31	**<u>1 VIA LA BRISA FORCE MAIN - Serving PS #31</u>**					
	1 Via La Brisa	500	6"	ACP	Riviera Circle	1968
FM-32	**<u>1 CORTE DEL BAYO FORCE MAIN - Serving PS #32</u>**					
	1 Corte Del Bayo	500	6"	ACP	Riviera Circle	1968
FM-33	**<u>415 RIVIERA CIRCLE FORCE MAIN - Serving PS #33</u>**					
	415 Riviera Circle					
		190	6"	WS L/C	Riviera Cir	
		55	6"	WS L/C		1966
		50	6"	Rubber Hose		1966
		200	6"	WS L/C		1966
		50	6"	Rubber Hose		1966
	E'ly end S Eliseo Dr	55	6"	WS L/C	Corte Madera Creek Xing	1966
	Jct PS 22 FM	496	6"	PVC	Laderman Ln, Gregory Pl	1987
	Gregory Place	535	6"	PVC	Laderman Ln, Gregory Pl	1987
FM-34	**<u>359 RIVIERA CIRCLE FORCE MAIN - Serving PS #34</u>**					
	359 Riviera Circle to Gravity Sewer	0				1966
FM-35	**<u>2 CORTE DEL CORONADO FORCE MAIN - Serving PS #35</u>**					
	2 Corte Del Coronado to Gravity Sewer	0				1966
FM-36	**<u>178 RIVIERA CIRCLE FORCE MAIN - Serving PS #36</u>**					
	178 Riviera Circle to Gravity Sewer	0				1963
FM-37	**<u>LARKSPUR PLAZA FORCE MAIN - Serving PS #37</u>**					
	Larkspur Plaza					
		0			Larkspur Plaza	1962

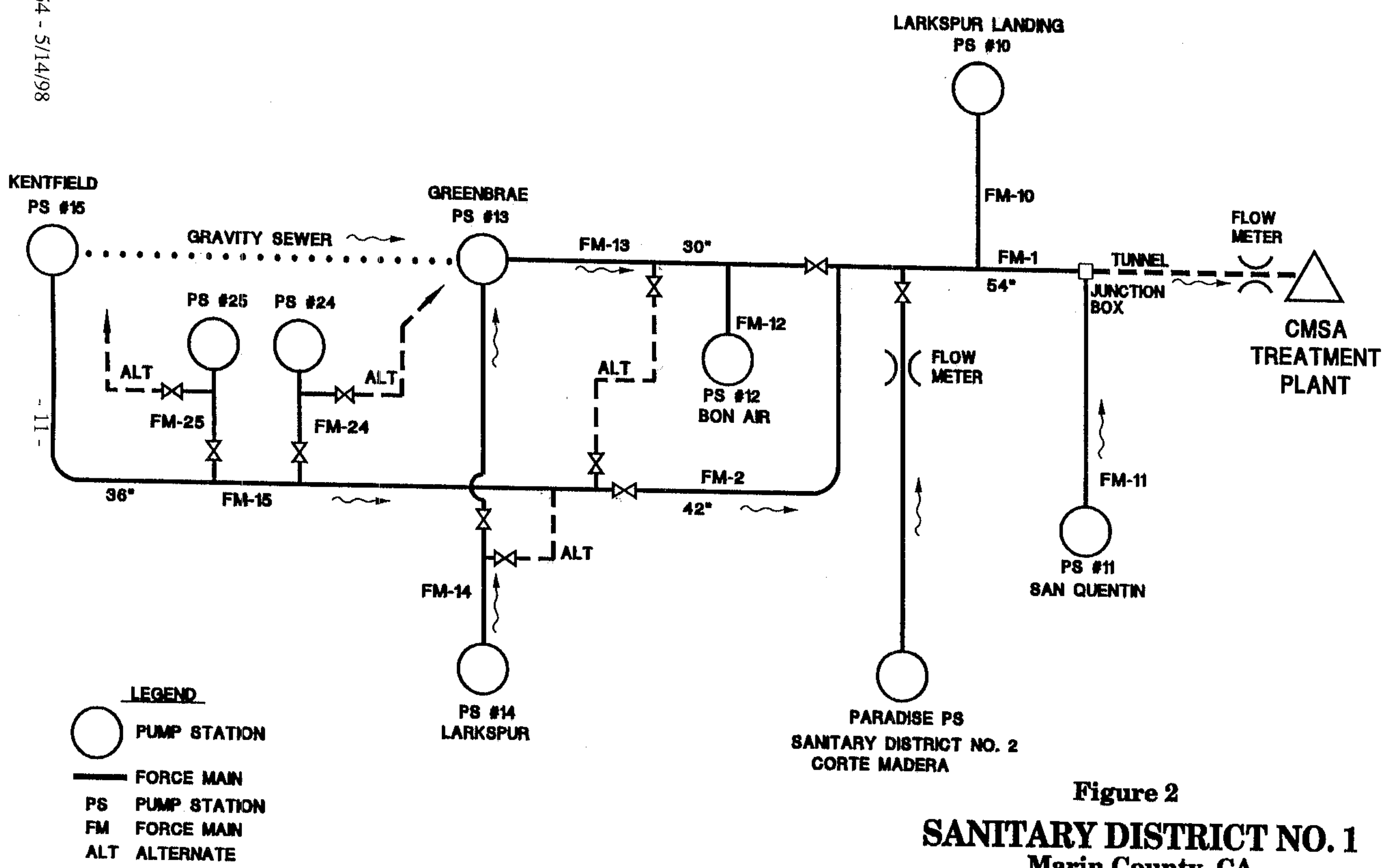


Figure 2

SANITARY DISTRICT NO. 1
Marin County, CA

EXISTING FORCE MAIN SCHEMATIC

Common Force Mains - The common force mains are those force mains which are used in common with several pump stations and which are also part of the system which pumps sewage to the CMSA Treatment Plant. These are large, major facilities and handle essentially all the sewage generated in the Ross Valley. The two common force mains are the Ross Valley Interceptor (FM-1) and the Greenbrae/Kentfield Force Main (FM-2). Both force mains are relatively new, i.e., constructed within the last 15 years.

- The Ross Valley Interceptor (FM-1) is a 6,000 foot long, 54" diameter, concrete lined and coated steel pipeline. This force main also receives sewage from Sanitary District No. 2 which serves Corte Madera. FM-1 runs along East Sir Francis Drake Blvd starting at Highway 101 and includes the 54" diameter tunnel through San Quentin Ridge to the CMSA Treatment Plant.

- The Greenbrae Force Main (FM-2) is a 4,200 foot long, 42" diameter, concrete lined and coated pipe which follows the northerly side of Corte Madera Creek between the easterly end of South Eliseo Drive and Highway 101. This force main is an extension of the Kentfield Force Main (FM-15).

Force Mains From Major Pump Stations - Force mains from major pump stations are designated as FM-10 through 15 and include force mains which connect to the common force mains listed above.

- The Landing B Force Main (FM-10) is a relatively short, 12" diameter, cement lined and coated welded steel pipeline which crosses East Sir Francis Drake Blvd and connects directly into FM-1. This system serves the Larkspur Landing area east of Highway 101.

- The San Quentin Force Main (FM-11) is a 3,100 foot long, 16" diameter, polyethylene pipeline which serves the San Quentin Prison and San Quentin Village. This force main connects to FM-1 at the junction box located at the southerly end of the tunnel which runs through San Quentin Ridge to the CMSA Treatment Plant

- The Bon Air Force Main (FM-12) is a short, 8" diameter force main which connects to the Greenbrae Force Main (FM-13). This system serves the Bon Air Shopping Center, the Drakes Landing development, and the Greenbrae Marina.

- The Greenbrae Force Main (FM-13) is one of the oldest force mains in the District's system. This is a 4,600 foot long, 30" diameter, concrete lined and coated steel pipeline which runs from the Greenbrae Pump Station to a connection with the Ross Valley Interceptor (FM-1) at Highway 101. The Greenbrae Force Main also receives the pumped flow from the Bon Air Pump Station through FM-12.

- The Larkspur Force Main (FM-14) serves the portion of the City of Larkspur to the south of Corte Madera Creek, except for the Greenbrae Marina development. This is a 3,300 foot long, 18" diameter polyethylene pipeline running through Piper Park, which was a former landfill, and crossing Corte Madera Creek to the easterly end of South Eliseo Drive. At the northerly side of Corte Madera Creek, the Larkspur Force Main has valved connections to both the Greenbrae/Kentfield Force Main (FM-2) and to the Greenbrae Pump Station. During wet weather, the Larkspur Pump Station is not able to pump into the Greenbrae/Kentfield Force Main so the flow is directed to the Greenbrae Pump Station where it is repumped.

- The Kentfield Force Main (FM-15) is a 7,500 foot long, 36" diameter, fiberglass "Techite" line which was installed in 1972. This line receives the flow from the Kentfield Pump Station, which is the District's largest pump station, and serves all of the upper Ross Valley from Kentfield to Fairfax. The Kentfield Force Main is located in the levee road along the unlined portion of Corte Madera Creek from the Kentfield Pump Station to Bon Air Road. From Bon Air Road, the Kentfield Force Main follows South Eliseo Drive to its end at the Drakes Landing development. At this point, the Kentfield Force Main has a valved connection with the Greenbrae/Kentfield Force Main (FM-2) and a continuation of the Kentfield Force Main which runs through the Bon Air Shopping Center to a connection with the 30" diameter Greenbrae Force Main (FM-13). Under normal operation, the flow is directed to the Greenbrae/Kentfield Force Main. 42" The inter-connection with the smaller diameter Greenbrae Force Main was used initially but is now available for use in the event of an emergency. However, now that the Bon Air Shopping Center has been fully developed, any leak in this inter-connection would be very damaging. The Kentfield Force Main also receives the pumped flow from Pump Stations #24 and #25 along South Eliseo Drive.

Force Mains from Minor Pump Stations - The force mains from minor pump stations are designated FM-20 thru 25 and serve various smaller areas of the District.

- The Landing A Force Main (FM-20) is a 1,100 foot long, 6" and 8" diameter PVC pipeline and receives the flow from Pump Station #20 which serves the westerly portion of Larkspur Landing and Deer Island. Flow from the Golden Gate Ferry Terminal is pumped into this force main at Larkspur Landing Circle by a non-District pump station. This force main runs through the Larkspur Landing parking lot and discharges to a gravity sewer which is tributary to Pump Station #10.

- The 101 Force Main (FM-21) is a 670 foot long, 4" and 6" diameter force main which receives flow from Pump Station #21, located adjacent to Highway 101 below Corte Placida. This system serves a small northeasterly portion of the Greenbrae development.

- The Cape Marin Force Main (FM-22) and Capurro Force Main (FM-23) are short 6" diameter PVC force mains which serve portions of the Drakes Landing development south of the Bon Air Shopping Center. Force Main FM-33 pumps from the Greenbrae Marina into FM-22.

- Force Mains FM-24 and FM-25 are short connections from the Pump Stations #24 and #25 into the Kentfield Force Main (FM-15). Both of these pump stations have alternate force mains. These are the original force mains and which were retained so they could be used in an emergency.

<u>Force Mains from Lift Stations</u> - The force mains from lift stations are designated FM-30 thru 37 and serve Lift Stations #30 through #37. These facilities generally serve very local areas and pump sewage to a gravity system.

- The Heather Gardens Force Main (FM-30) is a 6" pipeline which receives sewage from Pump Station #30 serving the Heather Gardens subdivision in Larkspur. These facilities were part of the City of Larkspur system and there is very little information available.

- FM-31 and FM-32 are relatively short 6" diameter force mains on Riviera Circle which are used in common with Pump Stations #31 and #32. These pump stations serve small areas of the Greenbrae Marina development.

- FM-33 is a 6" diameter force main which serves the Greenbrae Marina subdivision. Sewage from Pump Station #33 is pumped across Corte Madera Creek to a force main in the Drakes Landing development. This line across Corte Madera Creek is particularly vulnerable to damage from dredging operations.

- FM-34 thru 36 are very short connecting pipelines through which Pump Stations #34, #35 and #36 discharge directly to the adjacent gravity sewers

- FM-37 is a short force main from Pump Station #37 which serves the Larkspur Plaza development. These facilities were part of the City of Larkspur system and there is very little information available

FORCE MAIN EVALUATIONS

In the early 1990's, the District commissioned a corrosion evaluation of the District's largest force mains, FM-1, FM-2, FM-13 and FM-15. This evaluation investigated the corrosiveness of the soils and the continuity of the pipelines. The conclusions and recommendations of the Corrosion Evaluation by Corrosion Engineering and Research Company dated May 31, 1990 are reproduced in Appendix B.

Based on the recommendations in this initial evaluation, the District undertook further field testing of the metallic force mains which included several excavations to check the pipelines and install test stations. Sacrificial anodes were also installed on FM-10. The conclusions of the Phase II Corrosion Analysis by Corrosion Engineering and Research Company dated April 19, 1993 are reproduced in Appendix C.

The Kentfield Force Main (FM-15), which is a fiberglass "Techite" line, was separately evaluated by a consultant experienced in this type of pipe The report on the Techite pipe prepared by B Jay Schrock of JSC International Engineering dated April 11, 1990 is reproduced in Appendix D.

The conclusions and recommendations of these evaluations can be summarized as follows:

54"

- Ross Valley Interceptor (FM-1) - This line is subject to high negative potentials because it is located below the water table and it is in close proximity to impressed current cathodic protection on two nearby pipelines.

42"

- Greenbrae/Kentfield Force Main (FM-2) - This line is subject to high negative potentials because it is located below the water table.

12"

- Landing B Force Main (FM-10) - This pipeline was cathodically protected in 1993 with installation of five buried anodes.

24"/30"

- Greenbrae Force Main (FM-13) - The pipe joints on this force main were not bonded which makes it impractical to cathodically protect. No significant corrosion was found at three locations where the pipe was exposed.

36"

- Kentfield Force Main (FM-15) - This is a fiberglass, "Techite" line and is considered to be extremely fragile under any external and internal stresses. Many Techite lines have failed and it is recommended that this line be carefully monitored, particularly if there are any changes in operation. Within the Bon Air Shopping Center, this pipeline also has welded steel, cement lined and coated pipe segments at bends which could be subject to corrosion.

Other than the installation of test stations and anodes on FM-10, none of these force mains have been cathodically protected.

Although the corrosion investigations performed to date were rather inconclusive, they did not find serious active corrosion. Basically, these studies recommended corrosion monitoring in the future using the test stations which have now been installed. It has been five years since the last corrosion investigation and it is therefore recommended that the District undertake a follow up corrosion investigations at five year intervals to determine if any conditions have changed. The estimated cost of these investigations is $10,000 per year. If cathodic protection becomes necessary, then there would be additional installation costs.

FORCE MAIN DESIGN CRITERIA

Sewage force mains and pump stations are usually designed together. Estimates of the peak flows which must be pumped become the basis for selecting the pumps and sizing the force main. Force mains must be sized so that the velocity of the sewage flow in the pipeline at peak pumping does not exceed 6 to 8 feet per second. At any higher velocity, the pumping heads increase substantially and the pumping efficiencies decrease. The design characteristics of the major force mains is given in Table 3.

Unlike gravity sewers, force mains operate under pressure so they do not have to be laid on a straight downhill grade. Thus, force mains can be routed over hills and above and below obstructions. Force mains are generally not as deep as gravity sewers and route selection is easier.

TABLE 3
DESIGN CHARACTERISTICS OF THE MAJOR ROSS VALLEY FORCE MAINS

Desig- nation	Description	Diameter Inches	ADWF mgd	PWWF mgd	Velocity @ PWWF ft/sec	DESIGN SCENARIO PER NOLTE MODEL	ALL PUMPS
FM-1	Ross Valley Interceptor	54	4.9	75	7.3	6.94	8.48
FM-2	Greenbrae/Kentfield Relief FM	42	3.2	44	7.1	6.15	7.93
FM-13	Greenbrae Force Main [(1)]	30	1.1	18	5.7	4.41	6.56
FM-15	Kentfield Force Main	36	2.7	39	8.5	8.29	9.93

(1) Including flow from the Larkspur Pump Station

Larger diameter force mains take up a great deal of room in a street which makes route selection difficult considering that much of a street is usually taken up by other active and abandoned underground utilities including water mains, gas mains, electric lines, telephone lines, TV lines, fiber optic lines, etc. In some cases, it is necessary to pay for the relocation of other utilities out of the way of a new pipeline. Also, management of traffic and inconvenience to the public during construction are major considerations in route selection.

FORCE MAIN CAPACITY NEEDS

Because of the very high wet weather flows experienced, the District operates relatively large capacity pump stations and force mains. As capacity problems in the wastewater transport system reveal themselves, the only thing that can be done is to attempt to increase the pumping capacity. However, when the pumping capacity of one pump station is increased, the effect is to decrease the pumping capacity of the other pump stations connected to the common force main system. In some cases, it is not possible to achieve substantial increases in the pumping capacity because the system is at a point of diminishing returns due to friction losses in the force main. For example, a pumping station may be able to pump 10,000 gallons per minute (gpm) with one pump operating, 16,000 gpm with two pumps, and 18,000 gpm with three pumps. Adding a fourth pump would barely achieve any increase in pumping capacity.

Essentially, all District pump stations are now equipped with multiple pumps, standby power and alarms. Overflows from the system only occur during extreme storms or if there is some kind of equipment malfunction. The pumping stations with the most significant capacity problems are discussed below.

<u>Greenbrae Pump Station (PS-13)</u> - The Greenbrae Pump Station pumps through the 30" diameter Greenbrae Force Main (FM-13). This is one of the oldest force mains in the District system and runs along Sir Francis Drake Blvd from the Bon Air Shopping Center to Highway 101. It would be possible to rehabilitate this force main by inversion lining. However, if this force main is replaced, it should be increased in size. One possibility would be to construct a new, larger Greenbrae Force Main and use it to accept the flow from a rerouted Kentfield Force

Main. The only route for a new Greenbrae Force Main is along Sir Francis Drake Blvd, which will be expensive construction because of the traffic control and utility interferences.

Larkspur Pump Station (PS-14) - The force main from the Larkspur Pump Station connects to both the Greenbrae/Kentfield Force Main (FM-2) at South Eliseo Drive and to the Greenbrae Pump Station. During wet weather, the pumps in the Larkspur Pump Station cannot pump into the Greenbrae/Kentfield Force Main against the Kentfield Pump Station. Consequently, the flow from the Larkspur Pump Station is diverted to the Greenbrae Pump Station where the flow is repumped. It may be possible to install new pumps with better pump characteristics at the Larkspur Pump Station so that it will be able to pump against the Kentfield Pump Station. However, this will cause a corresponding reduction in the pumping capacity of the Kentfield Pump Station.

Kentfield Pump Station (PS-15) - Since 1972 when the Kentfield Pump Station went into operation, the District has eliminated over 30 direct bypass points to Corte Madera Creek and the other tributary creeks. The Kentfield Pump Station is at the extreme end of a three mile long force main system (FM-1, 2 and 15). This station is equipped with two, and soon three, large wet weather pumps. Because of the long force main, the third pump will only provide a marginal increase in pumping capacity. The pumping capacity of this pump station could be substantially increased with a larger diameter force main. This force main also rises to an elevation of 38.5 feet on South Eliseo Drive, which produces additional pumping head for the pumps. If this force main is replaced or an alternate force main is provided, consideration should be given to upsizing it and constructing it at a lower elevation.

RISK ASSESSMENT

Pipelines such as sewage force mains are subject to damage and deterioration from a variety of factors. Sewage force mains operate under pressure so that when they are damaged, sewage can rapidly exit from the pipeline and cause environmental damage. Regulatory authorities are empowered to levy fines for spillage of untreated sewage of up to $10,000 per day or $10 per gallon. Force mains operate in a completely full condition so that a break at a low point can allow rapid discharge of much of the pipeline's contents.

Some risks to pipelines are avoidable but most are unavoidable. Where risks are unavoidable, the pipelines may be designed with features which serve to lessen the risks. Such mitigating features can include cathodic protection, selection of a non-corroding pipe material, shutoff valves and flexible joints where a pipeline passes from soft ground to hard ground.

The District's force mains have been constructed in public roads and in easements as necessary to convey the sewage from pump stations located at the low points of the service area, to the CMSA Treatment Plant. Major considerations in route selection are interferences with other utilities, disruption to the public, traffic congestion during construction, and minimizing the elevation rise so as to reduce the long term pumping costs. Where alternative routes were available, the route which offered the most economical construction was often chosen.

All pipelines are vulnerable to damage from external factors such as earthquakes or someone digging in the area. Earthquakes are unavoidable; however, pipelines located on solid or rocky ground may experience less damage than pipelines located in soft ground such as bay mud.

The system of Underground Service Alert USA is a coordinated alert system which attempts to minimize the risk of damaging of pipelines by others digging in the area. Anyone proposing to dig anywhere is required to request through USA that the underground utilities in the affected area be marked by the respective utility companies. All the utility companies are notified and they have 48 hours in which to mark their utilities. The USA system works reasonably well and accidental damage to underground facilities has been reduced. However, some utility companies may not be able to accurately locate their utilities due to a lack of tracer wires or because their markings are based on old, inaccurate maps. Also, some contractors are careless and may accidentally damage underground pipelines even though they are properly marked. The USA marking system is less than perfect and external damage to pipelines still occurs, sometimes with disastrous results such as when a high pressure gas main is damaged.

The extent of damage inflicted by someone digging in the wrong place depends on the type of pipe material which is encountered. An experienced backhoe operator can often "feel" a foreign object in the ground such as a pipeline. A concrete coated steel pipeline such as used for some of the District's larger force mains would be difficult to damage with a backhoe. On the other hand, plastic or fiberglass pipelines can be easily damaged. The trade off is that plastic and fiberglass pipelines are immune to galvanic corrosion whereas concrete coated steel pipelines are not.

The various risks to the District's force mains has been considered in estimating their remaining useful life. Although a severe seismic event could damage many force mains at the same time, the risks are considered over the long term. In some cases, mitigation measures such as cathodic protection can be installed to prolong the life of a pipeline.

An assessment of the risks to the District's force mains is summarized in Table 4 and discussed below. The very short force mains from lift stations have been omitted from this table.

Seismic Risk - Seismic risk to force mains was assigned based on whether or not the force main is located on ground underlain by bay muds which are compressible and can be unstable. The most severe damage during a seismic event will occur where soils liquefy and physically displace. There is no way of knowing how the bay muds in individual areas of the District will react during an earthquake. However, many of the District's force mains are located in areas underlain by bay muds because development in the lower portion of the District took place on former mud flats which were originally part of the bay.

The force mains which are considered to be most vulnerable to seismic damage are the Greenbrae/Kentfield Force Main (FM-2) and the Kentfield Force Main (FM-15). Both of these force mains run alongside of Corte Madera Creek and, under a severe earthquake, it is possible that the creek bank could displace, severely damaging the pipeline. Other force mains which are considered to have a high risk of seismic damage are the Larkspur Force Main (FM-14) and FM-33 serving the Greenbrae Marina.

TABLE 4 SANITARY DISTRICT NO. 1
RISK ASSESSMENT AND PROJECTION OF REMAINING USEFUL FORCE MAIN LIFE

Designation	Description	Seismic Risk	External Damage	Corrosion	Water Hammer	Overall Risk	Year Installed	Est RUL
FORCE MAINS FROM MAJOR PUMP STATIONS								
FM-1	Central Marin Interceptor	Med	Low	High [1]	Low	Med	1983	35 yrs
FM-2	Greenbrae/Kentfield Force Main	High	Low	High [1]	Low	Med	1987	40 yrs
COMMON FORCE MAINS								
FM-10	Landing B Force Main	Med	Med	Med	Low	Med	1983	35 yrs
FM-11	San Quentin Force Main	Med	High	Low	Med	Med	1984	35 yrs
FM-12	Bon Air Force Main	Med	Med	High [1]	Low	Med	1984	35 yrs
FM-13	Greenbrae Force Main	High	Med	High [1]	Low	Med	1959	10 yrs
FM-14	Larkspur Force Main	Med	High	Low	Med	High	1989	40 yrs
	Alternate to Greenbrae P S.	Med	High	High	Med	High	1966	15 yrs
FM-15	Kentfield Force Main	High	High	Low	High	High	1972	10 yrs
	Extension thru Bon Air Ctr.	Med	High	Low	High	High	1972	10 yrs
FORCE MAINS FROM MINOR PUMP STATIONS								
FM-20	Landing A Force Main	Med	Med	Low	Low	Med	1983	35 yrs
FM-21	101 Force Main	Low	Med	Low	Med	Med	1957	10 yrs
FM-22	Cape Marin Force Main	Med	Med	Low	Low	Med	1987	40 yrs
FM-23	Capurro Force Main	Med	Med	Low	Low	Med	1985	40 yrs
FM-24	630 S Eliseo Force Main	Med	Med	Med	Low	Med	1989	40 yrs
	Alternate	Med	Med	Med	Low	Med	1961	15 yrs
FM-25	1350 S Eliseo Force Main	Med	Med	Med	Low	Med	1991	40 yrs
	Alternate	Med	Med	Med	Low	Med	1985	35 yrs
FORCE MAINS FROM LIFT STATIONS								
FM-31	1 Via la Brisa Force Main	High	Med	Low	Low	Med	1968	10 yrs
FM-32	1 Corte del Bayo Force Main	High	Med	Low	Low	med	1857	10 yrs
FM-33	415 Riviera Circle Force Main	High	Med	High	Low	High	1966	10 yrs

RUL = Remaining Useful Life

(1) Can be minimized by installation of cathodic protection systems

The majority of remaining District force mains are located in fully improved streets. Although many of these streets are underlain by bay mud, these force mains are considered to have a medium to low risk from seismic damage.

External Damage - Risk from external damage such as backhoes digging in the wrong place was assigned based on the location of the force main, the type of pipe material, and exposed length of pipeline. The District force mains which are considered to be the most vulnerable to external damage are the San Quentin, Larkspur and Kentfield Force Mains and FM-33, which serves the Greenbrae Marina. All of these pipelines except for FM-33 are either plastic or fiberglass. FM-33 is a cement coated steel pipeline about 3' deep in the creek. FM-33 is particularly vulnerable because it crosses Corte Madera Creek at a shallow depth and could be damaged by a dredge. The Larkspur Force Main also crosses Corte Madera Creek but was installed by directional drilling and is relatively deep.

Corrosion - Risk of pipeline damage due to corrosion was assigned based on the type of pipe and assumptions as to the type of soil in the vicinity of the pipeline. Specifically, metallic pipelines installed in soils which could be influenced by salt water from the bay are considered to be the highest risk. These pipelines include the Ross Valley Interceptor (FM-1), Greenbrae/Kentfield Force Main (FM-2), Greenbrae Force Main (FM-13), as well as FM-10, 12 and 14. The corrosion risk can be mitigated and the useful life of these force mains can be extended by installation of cathodic protection systems.

The Greenbrae Force Main (FM-13) is some 40 years old and is considered to have the highest risk of damage from corrosion. This is a concrete lined and coated steel pipeline and has never been cathodically protected, although it does not have a history of leaks.

Water Hammer - Water hammer is a pressure wave which can occur in a pipeline when a valve shuts quickly or a pump shuts down and the water which is traveling inside the pipeline must suddenly stop. The pressure wave takes the form of a positive high pressure which can tend to burst the pipeline followed by a negative pressure which can tend to collapse the pipeline. These waves will oscillate and eventually die off.

Pipelines most vulnerable to water hammer surges are long ones which may go over a high point and have a high static pressure. Steel and concrete pipelines can resist damage from water hammer surges whereas fiberglass and plastic pipelines are more vulnerable. To minimize the pressure wave during a water hammer condition, an air filled surge chamber can be installed at a pump station to provide a cushion. None of the District's pump stations are equipped with surge chambers although one is planned to be installed at the Kentfield Pump Station.

Risk from damage due to water hammer was assigned on the basis of pipeline material and on elevation differential. The Kentfield Force Main (FM-15) is considered to be at the highest risk of damage from water hammer surges because it is a fiberglass line. This line is now over 25 years old and very little is known about how it will react in a water hammer condition. Those pipelines considered to be a medium risk of damage from water hammer are the plastic force mains which include the San Quentin (FM-11) and Larkspur Force Mains (FM-14).

Overall Risk and Projection of Additional Useful Life - Overall risk and projection of additional useful life was assigned on the basis of the risk factors discussed above and general age of the force main.

The force mains considered to be at highest risk and which have the lowest remaining useful life are the Greenbrae (FM-13), Kentfield (FM-15) and Greenbrae Marina (FM-33) Force Mains. All three of these force mains are over 25 years old and are considered to be at high risk. Other lesser force mains projected to have a 10 year life are FM-21, 31 and 32. It is projected that these pipelines will need to be rehabilitated or replaced within the next 10 years.

The newest force mains, the Ross Valley Interceptor, the Greenbrae/Kentfield, San Quentin and others are considered to have a remaining useful life of some 35 to 40 years under the assumption that they are cathodically protected and not damaged by some major seismic event.

FORCE MAIN RELIABILITY

Force mains must be a reliable element of a sewerage system because they are the only connection between the collection sewers and the treatment plant. If a force main breaks, a great deal of untreated sewage can be discharged to the environment in a short period of time. Although force mains are designed with the objective of being reliable, most force mains are single pipes. In other words, there is not a second pipe to serve as a back-up if the first pipe breaks or is damaged. Ideally, major force mains should be designed as a dual pipe system.

At the present time, there are only four places within the District system with alternate force mains and one place between the Kentfield and Greenbrae Pump Stations where a gravity sewer is available for use. These alternative facilities are generally part of the original system and do not have the capacity to handle the peak flows.

Considering that it is becoming increasingly unacceptable to spill or discharge any untreated sewage and that regulatory authorities are empowered to levee fines of up to $10,000 per day or $10 per gallon for each spillage, it is recommended that the District's Force Main Improvement Program have the objective of providing a parallel system of force mains.

The parallel force mains will provide additional reliability as follows:

- Serve in an emergency such as when the primary force main is out of service.
- Provide a bypass system during the time the primary force main is being rehabilitated.
- Provide additional wet weather flow pumping capacity.

The parallel force mains may not necessarily have to be sized to convey the peak wet weather flow, rather they can be designed to provide a reasonable capacity for emergencies. The alternate facilities which now exist are shown in Figure 1.

REPLACEMENT VERSUS REHABILITATION

When a pipeline fails or outlives its useful life one remedy is to replace it with a new pipeline. However, as a community becomes more urbanized, more and more utilities have been installed and there is less and less available space in streets for new pipelines to be installed. Furthermore, easements through private property are less available because properties tend to be fully developed and trees are mature. Fortunately, in recent years a new construction method has developed, known as "Trenchless Technology". By using trenchless methods, it is often possible to install a new pipeline without digging a trench or to rehabilitate existing pipelines in place.

New pipelines can be installed without trenching by boring and jacking, microtunneling and directional drilling. The District has already used several of these technologies on its projects. In the late 1970's, portions of the Ross Valley trunk sewer were "microtunneled" through downtown San Anselmo and in 1988, the Larkspur Force Main was installed across Corte Madera Creek by directional drilling.

Existing pipelines can sometimes be rehabilitated in place by sliplining, inversion lining and pipe-bursting. Sliplining involves insertion of a smaller diameter plastic liner into the existing pipeline, providing the pipeline has a reasonably straight alignment. Inversion lining involves inserting a resin impregnated fabric in an existing pipeline and curing it with hot water or stream. Once cured, the inversion liner becomes hard and takes the form of the inside of the pipeline with a minimal decrease in inside diameter. Pipebursting involves cracking and expanding the original pipeline in place and inserting a larger diameter polyethylene pipeline through the resulting hole. Pipebursting is usually only used on gravity sewers.

It should be noted that rehabilitation of existing pipelines requires that the pipeline be out of service for a period of time, sometimes several days or a week if everything goes well. This will require that an alternate pipeline be available to carry the flow.

In some cases, trenchless methods are more economical than installing a pipeline by traditional direct burial trenching because there is less disruption to the street and to the public, less traffic control, and less utility interference. However, in other cases, trenchless methods may be more expensive than direct burial methods. Hopefully, in the future, new trenchless technology methods will be developed which will allow pipelines to be installed with a minimum of surface disruptions. Unless a parallel pipeline is available, the largest problem in rehabilitating an existing pipeline is diverting the sewage flow around the work area.

FORCE MAIN IMPROVEMENT PROGRAM

It is recommended that the District's Force Main Improvement Program be undertaken in two steps. Where alternate pipelines are not already available, the first step will consist of the establishment of parallel pipelines to allow diversion of the sewage flow during the time the original force main is rehabilitated. These parallel pipelines will also be available for use in an emergency and thereby improve the reliability of the District's wastewater transport system.

The capacity of the parallel force mains should provide at least 70% of the peak weather flow capacity required. Because of the vulnerability of the existing Kentfield Force Main, the new "parallel" force main should be considered as the primary force main and the rehabilitated original force main should be the alternate.

The second step will be to rehabilitate the original force mains in place. This rehabilitation can take the form of sliplining or inversion lining.

Accordingly, the Force Main Improvement Program recommended herein has the objective of maximizing the reliability of the District's force main system thereby minimizing unplanned failures and thereby minimize the risk of environmental damage and the District's exposure to fines and penalties. In accomplishing this objective, the following steps are recommended:

- Construct new force mains parallel to the major force main system.

- Rehabilitate existing force mains after the parallel force main has been constructed.

- Construct a new or parallel force main in a different alignment where the existing force main is exposed to a particularly high risk.

- Where possible, take measures to extend the useful life of existing force mains.

These projects can be staged and constructed as the various force mains approach their useful life.

MAJOR PARALLEL FORCE MAIN SYSTEM

As discussed above, in order to rehabilitate a force main in place it will be necessary to pump the sewage through a bypass force main while the work is being done. For large pipelines rehabilitation in place will take approximately one week per 1000 feet of pipeline. According to the manufacturer of the Insituform process either an above ground bypass pipeline must be installed or where that is not feasible because of traffic or other reasons a separate temporary bypass pipeline must be installed underground. Once the force main is rehabilitated a temporary bypass line would be removed.

For maximum reliability and flexibility, it is recommended that prior to rehabilitation of any major force main, a second, slightly smaller permanent force main be installed. This second force main will become a permanent standby line in case of a leak or failure and will serve as the bypass line during the rehabilitation of the original pipeline. With a parallel force main in place, the cost of the rehabilitation work on the original force main can be minimized because the bypass is already in place. The District's exposure to sanctions or fines by regulatory agencies in the event of a break or failure can also be minimized because the flow can be quickly diverted to the parallel force main.

It is proposed that a new force main be constructed in stages from the Kentfield Pump Station to the junction box at the Ross Valley side of the tunnel through San Quentin Ridge as shown in Figures 3 and 4. The parallel force main will consist of the following segments:

Segment 1 - New force main between the Kentfield Pump Station and the Greenbrae Pump Station.

Segment 2 - New force main parallel to the Greenbrae Force Main (FM-13) between the Greenbrae Pump Station and Highway 101.

Segment 3 - New force main parallel to the Ross Valley Interceptor (FM-1) between Highway 101 and the San Quentin Junction Box.

Construction of these parallel force main segments should be phased to parallel the force mains with the highest need of rehabilitation as described below.

It is proposed that Segment 2 of the parallel force main system be the first parallel segment to be constructed. This pipeline will parallel the Greenbrae Force Main (FM-13), which is the oldest force main and is projected to need rehabilitation within the next decade. The second stage will involve construction of Segment 1 which will extend from the Kentfield Pump Station to the Greenbrae Pump Station to parallel the Kentfield Force Main (FM-15). Finally, within the next thirty years, the Segment 3 will be constructed to parallel the Ross Valley Interceptor (FM-1).

The alignment of this parallel force main will be mostly in Sir Francis Drake Blvd because there is no room to parallel the existing Greenbrae/Kentfield and Kentfield Force Mains in their present alignments. Because of the utilities and traffic issues in Sir Francis Drake Blvd it may be necessary to install portions of the pipeline using micro tunneling techniques. Although expensive, micro tunneling could mitigate these impacts.

This parallel force main system would be sized to take 70% of the peak wet weather flow except for Segment 1 which will serve the Kentfield Pump Station. Segment 1 should be full size because even after rehabilitation the existing Kentfield Force Main (FM-15) is considered to be in a very vulnerable location in the levee along Corte Madera Creek. A new alignment along Sir Francis Drake Blvd would have considerably less static pumping head because it would not go over such a high hill as the existing force main does on South Eliseo Drive.

The alignment of these parallel force main segments is shown in Figure 4. The estimated construction costs of these three parallel force main segments are given below.

Segment 1 - 42" Force Main on Sir Francis Drake Blvd and McAllister Avenue between the Kentfield and Greenbrae Pump Stations which will become the primary force main providing parallel service to the existing 36" Kentfield Force Main.

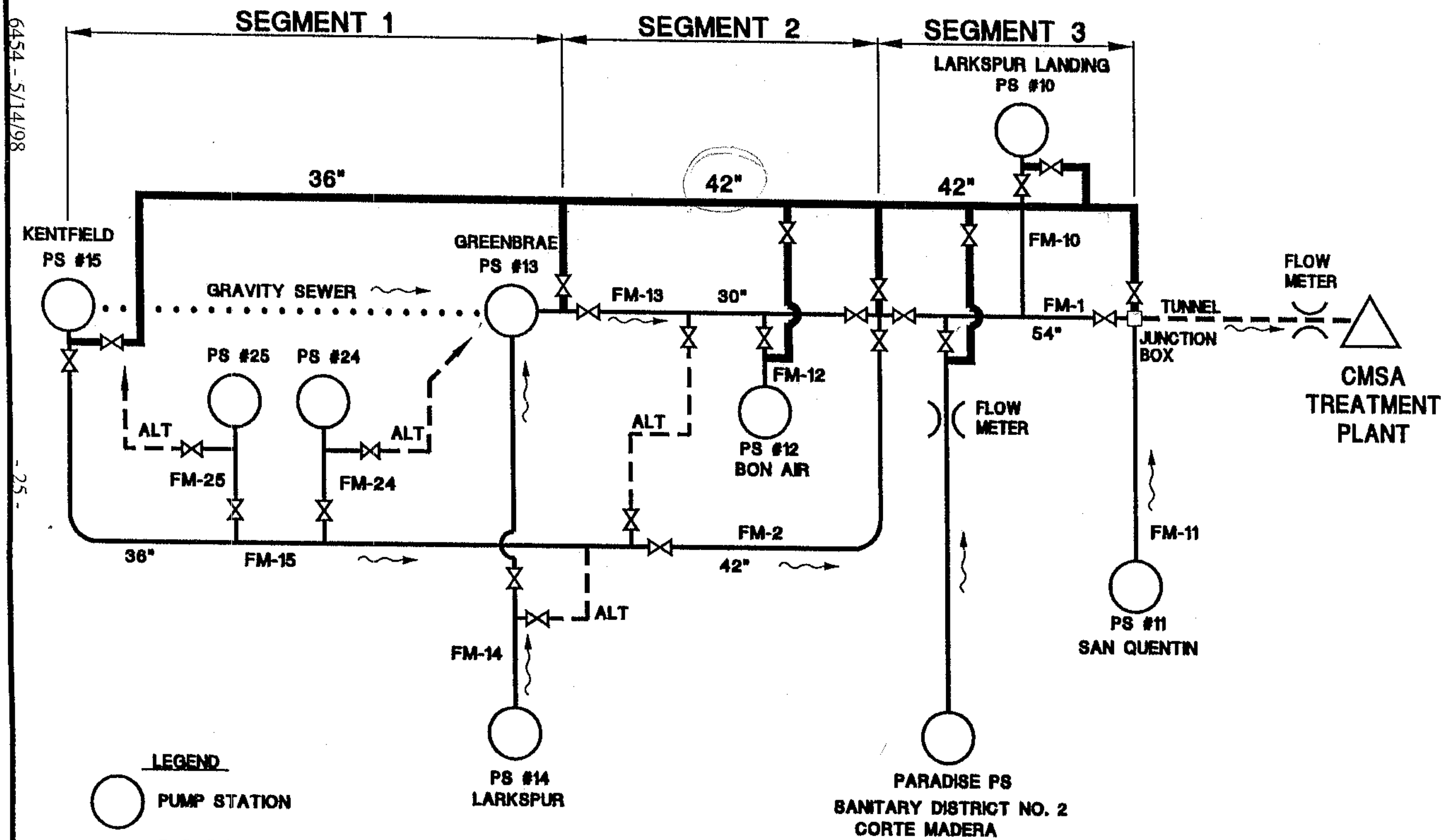


Figure 3

SANITARY DISTRICT NO. 1
Marin County, CA

PARALLEL FORCE MAIN SCHEMATIC

6454 - 5/14/98

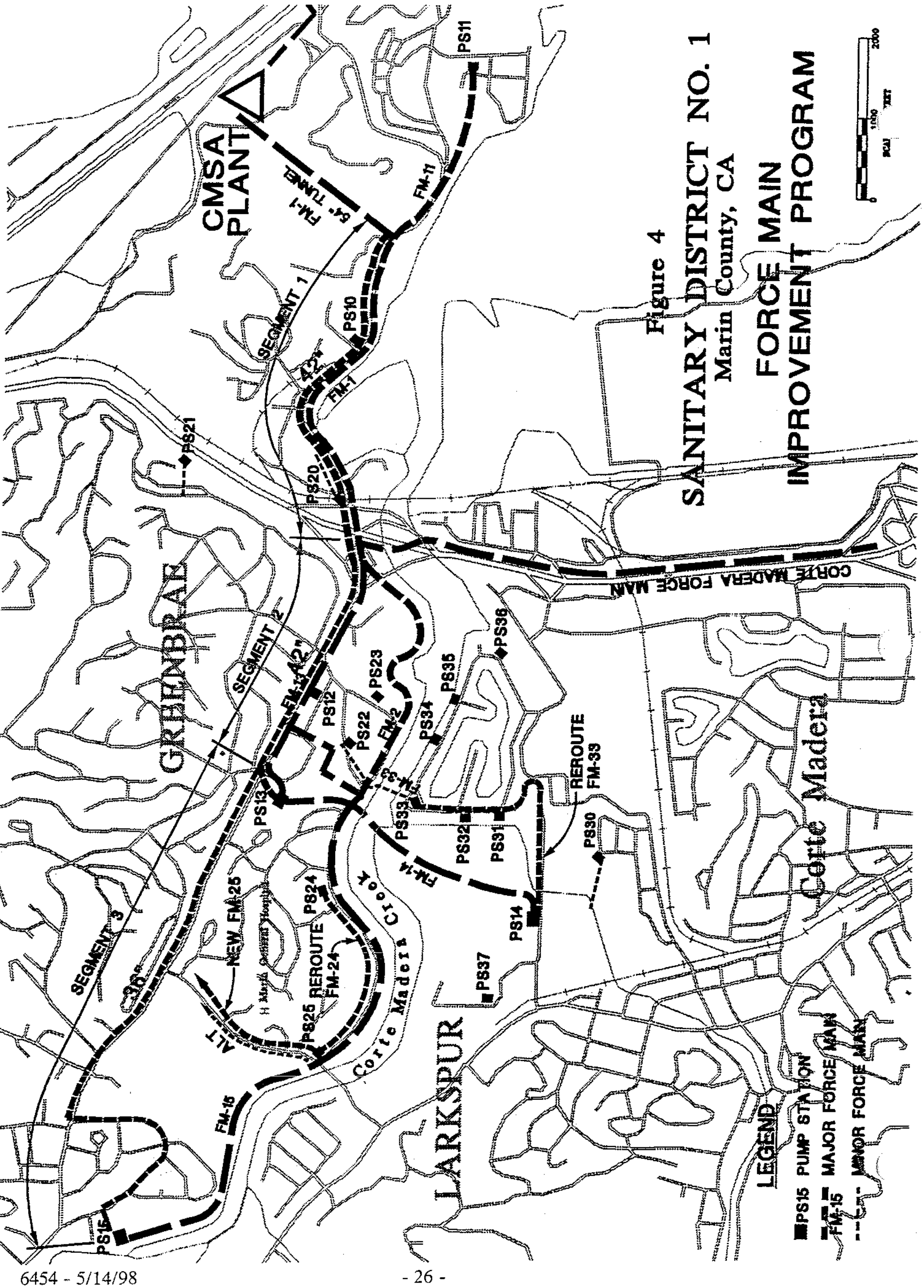


Figure 4
SANITARY DISTRICT NO. 1
Marin County, CA
FORCE MAIN
IMPROVEMENT PROGRAM
CMSA PLANT
54" TUNNEL
FM-1
FM-11
PS11
PS10
42"
SEGMENT 1
SEGMENT 2
SEGMENT 3
42"
36"
PS20
PS21
GREENBRAE
CORTE MADERA FORCE MAIN
PS36
PS35
PS34
PS23
PS22
PS12
FM-13
FM-2
PS13
PS33
PS32
PS31
PS30
REROUTE FM-33
FM-14
PS14
PS24
NEW FM-25
REROUTE FM-24
PS25
ALT
Corte Madera Creek
PS37
LARKSPUR
Corte Madera
FM-15
PS15
LEGEND
PS15 PUMP STATION
FM-15 MAJOR FORCE MAIN
MINOR FORCE MAIN

$119/IN OF DIAM

7,800 LF	42" Force Main @	$500/LF	$3,900,000
Estimated	Valves and Connections		250,000
		Subtotal	$4,150,000
		Contingencies and Incidentals	1,250,000
		TOTAL ESTIMATED PROJECT COST	$5,400,000

Segment 2 - 42" Force Main on Sir Francis Drake Blvd parallel to the existing 30" Greenbrae Force Main (FM-13) between the Greenbrae Pump Station and Highway 101.

$14.3/IN OF DIAMETER

3,300 LF	42" Force Main @	$600/LF	$1,980,000
500 LF	30" Force Main @	$350/LF	175,000
Estimated	Parallel FM-12 Connection		50,000
Estimated	Valves and Connections		250,000
		Subtotal	$2,455,000
		Contingencies and Incidentals	735,000
		TOTAL ESTIMATED PROJECT COST	$3,190,000

Segment 3 - 42" Force Main parallel to the existing 54" Ross Valley Interceptor (FM-1) on East Sir Francis Drake Blvd between Highway 101 and the San Quentin Junction Box

4,200 LF	42" Force Main @	$700/LF	$2,940,000
Estimated	Parallel FM-10 Connection		100,000
Estimated	Valves and Connections		520,000
		Subtotal	$3,560,000
		Contingencies and Incidentals	1,070,000
		TOTAL ESTIMATED PROJECT COST	$4,630,000

REHABILITATION OF MAJOR FORCE MAINS

In order to economically rehabilitate the existing major force mains, parallel force mains or an alternate pipeline must be available. The estimated costs for rehabilitating the major force mains, assuming the use of a parallel force main or alternate pipeline is given below. If there is no way to bypass the flow around the pipeline being rehabilitated, a temporary bypass force main would have to be installed and then removed after the rehabilitation work has been done. This would add substantial costs to the estimates given below.

Ross Valley Interceptor (FM-1) - The 54" diameter Ross Valley Interceptor is one of the newest force mains in the District system. Based on a 50 year useful life, rehabilitation is not projected until the year 2033. In order to assure that this useful life is reached and possibly extend it, this line should be regularly monitored for corrosion and cathodic protection should be installed if necessary.

The assumed method of rehabilitating of this line is the inversion lining process. Rehabilitation of the tunnel to the CMSA Treatment Plant has not been included in this cost estimate. The estimated cost for rehabilitating this line using the inversion lining process, assuming Segment 3 of the parallel force main is in place, is given below.

4,155 LF	54" Inversion Lining @	$650/LF	$2,700,750
Estimated	Rehabilitation of FM-10		75,000
		Subtotal	$2,775,750
	Contingencies and Incidentals		834,250
	TOTAL ESTIMATED PROJECT COST		$3,610,000

Greenbrae/Kentfield Force Main (FM-2) - The Greenbrae/Kentfield Force Main is projected for rehabilitation in the year 2037. As with FM-1, it should be cathodically protected to assure and possibly extend its useful life. Rehabilitation is assumed to be by inversion lining. The estimated cost of rehabilitating this line is given below.

4,234 LF	42" Inversion Lining @	$500/LF	$2,117,000
	Contingencies and Incidentals		633,000
	TOTAL ESTIMATED PROJECT COST		$2,750,000

Greenbrae Force Main (FM-13) - The existing 30" Greenbrae Force Main is 40 years old. Although it has given good service, it is concrete lined and coated steel and could be experiencing corrosion. The estimated cost for rehabilitating this line using the inversion lining process, once Segment 2 of the parallel force main is in place, is given below:

4,543 LF	30" Inversion Lining @	$370/LF	$1,680,910
Estimated	Connections		100,000
		Subtotal	$1,780,910
	Contingencies and Incidentals		539,090
	TOTAL ESTIMATED PROJECT COST		$2,320,000

Kentfield Force Main (FM-15) - The Kentfield Force Main is a fiberglass line with the highest risk of failure. This line should be rehabilitated or replaced within the next five years. Even after rehabilitation, this line is subject to damage during an earthquake because part of it is located in a levee road along Corte Madera Creek. A gravity sewer connection already exists between the Kentfield and Greenbrae Pump Station which can be used for diversion of dry weather sewage flows. The estimated cost for rehabilitating this line using the inversion lining process is given below

7,500 LF	36" Inversion Lining @	$440/LF		$3,300,000
Estimated	Connections			100,000
			Subtotal	$3,400,000
			Contingencies and Incidentals	1,020,000
			TOTAL ESTIMATED PROJECT COST	$4,420,000

Once the parallel force main system which will serve the Kentfield Pump Station has been installed, it is recommended that the existing 36" force main through the Bon Air Shopping Center be abandoned. Because of the shopping center, it is judged that this line is too risky to use.

FORCE MAIN REPLACEMENTS

Some force mains which are considered to have a relatively long life can be replaced with a new pipeline and the old pipeline can be reserved for future rehabilitation. The estimated costs of these force main replacements are given below.

San Quentin Force Main (FM-11) - The San Quentin Force Main is a relatively new polyethylene line. When this line reaches its useful life, it will most likely be replaced with a new line. The estimated cost of replacing the San Quentin Force Main is given below.

3,110 LF	16" Force Main @	$160/LF		$497,600
			Contingencies and Incidentals	152,400
			TOTAL REPLACEMENT PROJECT COST	$650,000

Larkspur Force Main (FM-14) - The Larkspur Force Main is a relatively new polyethylene line. When it reaches its useful life, it will most likely be replaced with a new line. The estimated cost of replacement is given below.

4,285 LF	18" Force Main @	$160/LF		$685,600
1 Only	Creek Crossing			250,000
			Subtotal	$935,600
			Contingencies and Incidentals	284,400
			TOTAL REPLACEMENT PROJECT COST	$1,220,000

Greenbrae Marina Force Main (FM-33) - The Greenbrae Marina Force Main is 6" in diameter and crosses Corte Madera Creek only 500 feet downstream of the Larkspur Force Main (FM-14) crossing. FM-33 is particularly vulnerable to damage from dredges because it is not buried very deep in the creek. On the other hand, the Larkspur Force Main was directionally drilled through rock under the creek bed and is more than 20 feet deep so it is less vulnerable to damage

On the south side of the creek, FM-33 passes between two homes in Greenbrae Marina and has already experienced several leaks at the edge of the creek and about 200' of this line will be replaced this year. The rest of FM-33 will either need to be replaced or rerouted within the next 10 years.

In order to eliminate a second creek crossing, it is recommended that this force main be rerouted back to the Larkspur Pump Station. This rerouted force main would be located in streets where it would be accessible and would also pass by Pump Stations 31 and 32 so that both FM-31 and FM-32 could be eliminated. Consistent with the objective of providing parallel lines wherever possible, it is recommended that two 8" diameter pipelines be installed in the same trench. The estimated cost of rerouting FM-33 serving Greenbrae Marina in public streets to the Larkspur Pump Station is given below:

3,300	Parallel 8" Force Mains @ $120/LF	$396,000
	Contingencies and Incidentals	114,000
	TOTAL ESTIMATED PROJECT COST	$510,000

The alternative to rerouting this force main would be to directional drill a new pipeline across Corte Madera Creek. The estimated cost of directional drilling a pipeline across the creek is $250,000 per crossing. These two pipelines would cost $500,000. Since there would also be major disruptions to the neighborhood and the need to acquire a wider easement between houses, this alternative is not recommended.

MINOR FORCE MAIN REPLACEMENTS

Replacement or rehabilitation of minor force mains are relatively low cost projects. The force mains which connect to the major interceptor system will be replaced or paralleled when the major parallel force mains are constructed. Once replaced, the original force main can be reserved for future rehabilitation by inversion lining so that each of these facilities will eventually consist of parallel pipelines.

A description of the replacement or rehabilitation of these minor force mains is given below

Landing B Force Main (FM-10) - FM-10 is relatively new and short. It is concrete lined and coated and was cathodically protected with sacrificial anodes in 1993. The installation of a replacement line is estimated to cost $100,000.

Bon Air Force Main (FM-12) - The Bon Air Force Main is very short and connects to the Greenbrae Force Main FM-13. When the Greenbrae Force Main is replaced or rehabilitated, the Bon Air Force Main should be replaced. The estimated cost of replacing the Bon Air Force Main is $30,000.

Larkspur Landing Force Main (FM-20) - FM-20 will eventually require replacement as it reaches its useful life. The estimated cost of this replacement is $130,000.

101 Force Main (FM-21) - FM 21, which serves PS-21 adjacent to Highway 101, is more than 40 years old and will require replacement within the next 10 years. The estimated cost of this replacement is $90,000.

Cape Marin Force Main (FM-22) and Capurro Force Main (FM-23) - FM-22 and FM-23 are relatively new and will not need to be replaced in the near future. The estimated cost of replacing these force mains is $50,000.

630 S Eliseo Force Main (FM-24) - The original FM-24, which now serves as an alternate force main, is almost 40 years old. The old force main goes over the hill on South Eliseo Drive and eventually connects to the Greenbrae Pump Station. In order to avoid the hill, it is recommended that a new alternate force main be constructed on South Eliseo Drive and connect with the alternate force main for Pump Station PS-25. An alternate force main must be available when the Kentfield Force Main in South Eliseo Drive is not in use. The estimated cost of this new alternate force main is $340,000.

1350 S Eliseo Force Main (FM-25) - Portions of the original FM-25 force main are almost 40 years old. It is recommended above that the new alternate force main from Pump Station 24 also connect to FM-25. Both of these alternate force mains must be available when the Kentfield Force Main in South Eliseo Drive is not in use. The estimated cost of replacing FM-25 as a 12" pipeline is $250,000.

Heather Gardens Force Main (FM-30) - It is expected that the Heather Gardens Force Main will eventually be replaced in a new alignment when the adjacent land is developed. No cost estimate has been provided since this will be a developer financed project.

FM-31, 32, 33 - The rerouting of these force mains is discussed above.

FM-34, 35, 36 - There are very short pipe connections from lift structures. It is recommended that manholes be installed at the connections of these short pump discharges with the gravity system. This work can be included in the projected pump station upgrades.

Larkspur Plaza Force Main (FM-37) - This is a very short force main and its replacement is estimated to cost $30,000.

OTHER FORCE MAIN IMPROVEMENTS

Immediate improvements which should be made to the District force mains in order to improve their operation and prolong their useful life are listed below.

<u>Cathodic Protection of Force Mains</u> - In order to arrest corrosion of metallic force mains, it is recommended that all metallic force mains be regularly monitored for corrosion. The estimated cost of corrosion monitoring is $10,000 per year. If found necessary, cathodic protection should be installed.

Kentfield Pump Station Surge Chamber - In order to reduce the risk of a catastrophic collapse of the Kentfield Force Main (FM-15) in the event of a water hammer surge, it is recommended that a surge chamber be installed at the Kentfield Pump Station. Installation of a surge chamber at the Kentfield Pump Station is planned as part of the Kentfield Pump Station improvements.

LONG RANGE FORCE MAIN REPLACEMENT AND REHABILITATION

As a long range program, it is recommended that the District establish a system of parallel force mains. A system of parallel force mains will allow economical rehabilitation of the existing force mains as they reach their useful life.

Notwithstanding this long range objective, the most immediate need is rehabilitation of the Kentfield Force Main, which can be bypassed through the old gravity trunk sewer to the Greenbrae Pump Station. Accordingly, the first phase of this program involves rehabilitation of the existing Kentfield Force Main, followed by construction of the three segments of the parallel force main system in subsequent phases.

Table 5 lists the recommended force main replacement and rehabilitation projects and provides the estimated 1998 costs and the projected time period when each project should be implemented.

Implementation of the Force Main Improvement Program is recommended to take place in the following phases.

Phase 1 - 2000 - 2005 - In Phase 1 the existing Kentfield Force Main will be rehabilitated first by inversion lining because it is considered to be the highest risk. A gravity sewer bypass already exists and can be used as long as the rehabilitation is done during dry weather so this rehabilitation can be done before constructing Segment 1 of the parallel force mains.

Phase 2 - 2005 - 2010 - In Phase 2 the following force main projects will be implemented.

- New force main parallel to the Greenbrae Force Main FM-13. This parallel force main should be sized to take flow from the Kentfield Pump Station. Once this new force main has been installed, the existing Greenbrae Force Main can be mothballed for a few years before it is rehabilitated with an inversion lining process.

- Construct replacement force main for FM-21.

- Reroute the force main Greenbrae Marina Force Main (FM-33) to eliminate the very vulnerable crossing of Corte Madera Creek.

TABLE 5 SANITARY DISTRICT NO. 1
FORCE MAIN IMPROVEMENT PROGRAM (All Cost Estimates in 1998 Dollars)

Designation	Description	Project Description	Phase 1 2000-05	Phase 2 2005-10	Phase 3 2010-15	Phase 4 2015-20	Beyond 2020
FORCE MAINS FROM MAJOR PUMP STATIONS							
FM-1	Central Marin Interceptor	Parallel Force Main Rehabilitation of exist. FM					$4,630,000 3,610,000
FM-2	Greenbrae/Kentfield Force Main	Rehabilitation of exist. FM					2,750,000
COMMON FORCE MAINS							
FM-10	Landing B Force Main	Parallel Force Main					100,000
FM-11	San Quentin Force Main	Parallel Force Main					650,000
FM-12	Bon Air Force Main	Parallel w/FM-2 Project					
FM-13	Greenbrae Force Main	Parallel Force Main Rehabilitation of exist.FM		$3,190,000		$2,320,000	
FM-14	Larkspur Force Main	Parallel Force Main					1,220,000
FM-15	Kentfield Force Main	Parallel Force Main Rehabilitation of existing	$4,420,000		$5,400,000		
FORCE MAINS FROM MINOR PUMP STATIONS							
FM-20	Landing A Force Main	Replacement Force Main					130,000
FM-21	101 Force Main from PS-21	Replacement Force Main		90,000			
FM-22 & 23		Replacement					50,000
FM-24	630 Eliseo Force Main	Replace Alternate FM			340,000		
FM-25	1350 S Eliseo Force Main	Replace Alternate FM			250,000		
FORCE MAINS FROM LIFT STATIONS							
FM-30	Heather Gardens Force Main	Replace w/New Developer					
FM-31 & 32		Reroute w/FM-33					
FM-33	415 Riviera Circle Force Main	Reroute to Larkspur		510,000			
FM-34, 35 & 36		Replace w/Pump Sta Rehab					
FM-37	Larkspur Plaza Force Main	Replacement					30,000
	TOTALS		$4,420,000	$3,790,000	$5,990,000	$2,320,000	$13,170,000

Phase 3 - 2010 - 2015 - Phase 3 construction will involve constructing a new force main to serve the Kentfield Pump Station and connect it to the parallel Greenbrae Force Main constructed in Phase 2. In addition, the alternate force mains for Pump Stations 24 and 25 will need to be rerouted because the existing Kentfield Force Main will be taken out of service.

Phase 4 - 2015 - 2020 - In Phase 4, the existing Greenbrae Force Main will be rehabilitated using an inversion lining process.

Beyond 2020 - The remaining force main improvement projects as described hereinabove are projected for implementation after the year 2020. By that time, better projections can be made of the remaining useful life of these force mains and new priorities may present themselves.

The estimated costs for each of these phases as shown in Table 5 are summarized below:

Phase 1	2000 - 2005	$4,420,000
Phase 2	2005 - 2010	3,790,000
Phase 3	2010 - 2015	5,990,000
Phase 4	2015 - 2020	2,320,000
Beyond 2020		13,170,000
	TOTAL	$29,690,000

Projecting the Force Main Rehabilitation Program over a 50 year time period, the projected $30,000,000 expenditure represents an annual expenditure of $600,000.

RECOMMENDATIONS

Based on the investigations of the District's force mains summarized herein, the following recommendations are presented.

1. It is recommended that the District's Force Main Improvement Program have the long range objective of providing a parallel system of force mains in order to reduce the risk to the easement and minimize the District's exposure to fines and penalties.

2. It is recommended that the District undertake a phased program of improving its force main system estimated to cost $30,000,000 over the next 50 years.

3. It is recommended that as the first phase, the District rehabilitate the existing Kentfield Force Main for which a gravity bypass line already exists.

4. It is recommended that the District undertake periodic corrosion investigations of its metallic force mains and install cathodic protection systems if necessary.

5. It is recommended that the District consider increasing its annual expenditures for sewer rehabilitation to further reduce infiltration/inflow of extraneous water into the sanitary sewer system.

APPENDIX A

Sanitary District No. 1 of Marin County

CHRONOLOGY

Sanitary District No. 1 of Marin County, California

CHRONOLOGY

March 31, 1891 - Sanitary District Act of 1891 passes the California State Legislature.

April 19, 1899 - A petition was presented to the Board of Supervisors by residents in Ross Valley asking that an election be called to form a Sanitary District and to issue $25,000 in bonds to build a sewer system. The Board passed a resolution calling for an election. The area affected contained 1,000 acres.

April 22, 1899 - Legal Notice for Formation of Sanitary District No 1 is first published in Marin County Tocsin.

May 27, 1899 - At an election in Ross Valley, Sanitary District No. 1 was formed, the vote being 39 for and 8 against. This district included the towns of San Anselmo, Ross and Tamalpais (Kentfield). The officers elected were: H F Allen, Charles Bach, T. B. Berry, W. S. Davis and James Tunstead, Trustees, and William P. Taylor, Assessor.

August 9, 1900 - Article in newspaper explains that a bond election passed in July, 1900 and that bids to construct a sewer system will be opened August 17. The plans included the construction of ten miles of sewer and flushing tank and outfall near the present Bon Air bridge.

April, 1901 - Archbishop Riordon of San Francisco was sued to provide the right-of-way for the flushing tank and sewer. The settlement awarded the archbishop $1,500 for land and $300 for damages.

May 13, 1915 - Mr. Dockweiler, a noted sanitary expert of the state, gave a talk entitled "Proper Disposal of Sewage". Afterwards a musical program was provided.

1922 - Sanitary District No. 1 was reorganized under the 1918 Sanitary District Act.

1922 - A vote was taken to issue $200,000 in bonds and to build 7 5 miles of trunk sewer and an Imhoff treatment plant at Greenbrae.

1923 - Sanitary District No. 1 constructed a trunk sewer from Greenbrae to Manor and constructed an Imhoff treatment tank at Greenbrae discharging to Corte Madera Creek.

April 4, 1930 - A Sanitary District No. 1 service wagon driven by Ned Ongaro helps celebrate the replacement of a bridge at the San Anselmo hub.

April 3, 1936 - Historical article written by Paul H Vincilione. As of 1936, the District has 54.5 miles of sewers and 12,000 people

March 1938 - Sanitary District No. 1 completed its office building at 11 Library Place in San Anselmo.

March 24, 1938 - Article in the San Anselmo Herald is published explaining how Sanitary District No. 1 was formed. The District has 65 miles of sewers.

May 28, 1945 - The State Bureau of Sanitary Engineering issued a report of five major overflow points of wet weather overflow along the route of the main trunk sewer and stated that the overflows had been reported shortly after the trunk sewer was constructed in 1923.

March 11, 1946 - State Board of Public Health adopted a resolution prohibiting the discharge of raw, untreated sewage into California waters.

July 15, 1949 - Sanitary Districts No. 1 and No. 2 (Corte Madera) enter into a joint agreement for treatment of sewage and disposal of sewage. The treatment capacity for Sanitary District No. 2 is limited to 175,000 gallons per day.

1949 - Sanitary District No. 1 completed construction of a secondary treatment plant on Pt. San Quentin at the site of the present office.

1950 - Sanitary District No. 2 completes construction of its Paradise Drive Pump Station and Force Main connection to the Sanitary District No. 1 sewage treatment plant.

1955 - Dissatisfied with their agreement with Sanitary District No. 1, Sanitary District No. 2 authorizes a study of sewage treatment and disposal alternatives.

1955 - Bond issue to upgrade sewer system and eliminate wet weather bypasses in Sanitary District No. 1 defeated by voters and project was abandoned.

January 13, 1958 - A special bond election in Sanitary District No. 2 for the purpose of constructing their own treatment plant was defeated by the voters.

March 3, 1960 - Sanitary District No. 2 negotiates new agreement with Sanitary District No. 1 which provided funding for a capacity of 1,175,000 gallons per day in the Sanitary District No 1 sewage treatment plant.

1962 - Sanitary District No. 1 completed construction of enlargements to the secondary treatment plant with a treatment capacity of 4.5 million gallons per day.

1967 - Sanitary District No 1 adopted a staged program of sewer system improvements on a pay-as-you go basis using ad valorem taxes.

June, 1967 - Sanitary District No. 1 made a proposal to the Marin County Flood Control and Water Conservation District and the Army Corps of Engineers to place a trunk sewer alongside of and within their right of way for the proposed Corte Madera Creek flood control channel.

October 1967 - The County of Marin received a study by Brown and Caldwell Engineers which recommended that the Central Marin agencies consolidate their treatment plants into a single plant at point San Quentin and construct a single outfall to the deep waters of the bay. All sanitary agencies in Marin County would be reorganized by the County either under the two existing water districts or under three new county sanitation districts.

1968 - Completion of first phase of the Ross Valley trunk sewer being constructed along side the U.S. Army Flood Control channel from the Kentfield Pump Station to the Ross Post Office

June 24, 1971 - Regional Water Quality Control Board adopted Order No. 71-43 which prescribed waste discharge requirements for the treatment plant and required that Sanitary District No. 1 and its tributary agencies of Larkspur and Corte Madera eliminate all wet weather bypassing throughout the sewer system.

June 24, 1971 - Regional Water Quality Control Board adopted Order No. 71-52 requiring Sanitary District No. 1 to cease and desist from discharging waste contrary to the waste discharge orders and establishes April 1, 1974 as the date for elimination of all bypassing to Corte Madera Creek.

December, 1971 - Ross Valley trunk sewer along side Corte Madera Creek channel completed to the Ross Post Office.

1972 - Sanitary District No. 1 submitted to the Regional Water Quality Control Board a list of the locations of wet weather bypasses to Corte Madera, Sleepy Hollow and Fairfax creeks.

1972 - Kentfield Pump Station and Kentfield Force Main to Greenbrae are completed and put into operation to pump the wet weather flows from the new Ross Valley trunk sewer.

March 1972 - Smoke testing program started in Fairfax.

May 1972 - Sanitary District No. 1 receives route study for new trunk sewer through the Ross Valley.

1972 - The US Congress passes the Water Pollution Control Act of 1972 which mandated that all municipal discharges receive secondary treatment.

1974 - Ross Valley trunk sewer completed from Ross Post Office to San Anselmo.

1975 - Interim improvements installed at the Sanitary District No. 1 treatment plant as required by the Regional Water Quality Control Board

April 30, 1975 - Completion of the Marin-Sonoma Wastewater Program Analysis which analyzed numerous wastewater treatment and disposal alternatives including various consolidations for the Marin and Sonoma sewerage agencies.

1975 - Ross Valley trunk sewer completed through San Anselmo into Fairfax.

1975 to Present - Sanitary District No. 1 mandates an annual program to rehabilitate sewers in the collection system with an average expenditure of approximately $500,000 per year.

1976 - Sanitary District No. 1 installs a facility to load tank trucks with reclaimed wastewater to be used for landscape irrigation during drought.

1977 - Sewers in Kent Woodlands and Sleepy Hollow sealed using a gel process.

December 1977 - Eastern Marin Southern Sonoma Wastewater Facilities Plan completed which recommends for Central Marin the consolidation of the Sanitary District No. 1, San Rafael Sanitation District and San Quentin prison treatment plants into a single wastewater treatment plant serving Central Marin with a deep water outfall to the bay.

June, 1979 - Final Environmental Impact Report and Environmental Impact Statement on the Eastern Marin-Southern Sonoma Wastewater Management Plan.

October 15, 1979 - CMSA formed by execution of a joint powers agreement between Sanitary District No. 1, Sanitary District No 2, the City of Larkspur, and the San Rafael Sanitation District.

1982 - Greenbrae Pump Station constructed.

April 12, 1982 - CMSA votes 4-1-1 to award contract for construction of treatment plant.

January, 1985 - Central Marin Sanitation District Treatment Plant opens in San Rafael

1985 - Sanitary District No. 1 enters into an agreement to operate and maintain the pump station and force main serving the San Quentin Prison and San Quentin Sewer Maintenance District.

1987 - Greenbrae/Kentfield Force Main constructed.

1989 - City of Larkspur replaces 18" force main to Sanitary District No. 1.

1993 - Larkspur Sanitation area annexed to Sanitary District No. 1.

APPENDIX B

Ross Valley Sanitary District
Collection System
Corrosion Evaluation
Corrosion Engineering and Research Company
May 31, 1990

Conclusions and Recommendations

CERCO No.9013

Ross Valley Sanitary District
Larkspur, California

ROSS VALLEY SANITARY DISTRICT
COLLECTION SYSTEM

CORROSION EVALUATION

May 31, 1990

Corrosion Engineering and Research Company

5375 Clayton Road
Concord, CA 94521

(415) 687-2954

SECTION II
CONCLUSIONS

2.1 36-INCH KENTFIELD FORCE MAIN

2.1.1 Based upon analysis of soil resistivity data, 33% of the cement lined and coated steel pipe (CL & CSP) sections of this force main are located in "severely corrosive" soil and approximately 67% of the CL & CSP sections are located in "corrosive" soils.

2.1.2 The Techite pipe class is 150 (150 psi) Type 2 (Bishenol A Resin Liner) per Appendix B (Report from Mr. Jay Schrock). See Appendix B for additional details.

2.1.3 The sections of CL & CSP are reported to have welded joints indicating electrical continuity throughout each section. No test stations are available to confirm this fact. There are six sections of CL & CSP located in the areas where restrained joints are used.

2.2 42-INCH GREENBRAE/KENTFIELD FORCE MAIN

2.2.1 Based on analysis of soil resistivity data, 93% of the force main is located in "corrosive" soil and 7% is located in "moderately corrosive" soil.

2.2.2 Approximately 75% of the force main is installed below mean sea level. Due to the close proximity of this force main to the Corte Madera Creek, there is a high probability for brackish water or salt water to come into contact with the force main.

2.2.3 The joints are reportedly either field welded or bonded with bonding cables.

2.2.4 The outer reinforcing steel in the pipe is not bonded to the steel cylinder.

2.2.5 Test stations are installed along the force main.

2.2.6 The pipe-to-soil potential measurements range from -470 mV to -534 mV. These potentials were measured at the test stations and they are indicative of actively corroding pipe.

2.3 18-INCH GREENBRAE FORCE MAIN

2.3.1 Based upon analysis of soil resistivity data, this force main is located in "corrosive" soils.

2.3.2 The pipe joints are reportedly field welded.

2.3.3 No test stations are present on this force main.

2.4 30-INCH GREENBRAE FORCE MAIN

2.4.1 Based upon analysis of soil resistivity data, 67% of the force main is located in "corrosive" soils and 33% is located in "moderately corrosive" soils.

2.4.2 No information is available regrading the type of field joints (i.e., whether welded or not). Several flexible couplings were installed on the force main at the 36-inch Kentfield Force Main Tie-in in 1972.

2.4.3 No test stations are present along the force main.

2.4.4 Approximately 50% of the force main is installed below mean sea level.

2.4.5 Pipe-to-soil potentials could not be measured on this force main.

2.5 54-INCH ROSS VALLEY INTERCEPTOR

2.5.1 Based upon analysis of soil resistivity data, 20% of the force main is located in "severely corrosive" soil, 40% is located in "corrosive" soil and 40% is located in "moderately corrosive" soil.

2.5.2 Approximately 80% of the force main is installed below mean sea level. Due to the close proximity of this force main to the Bay, there is a high probability for brackish water or salt water to come into contact with the force main.

2.5.3 The joints are reportedly bonded with bonding cables.

2.5.4 The outer reinforcing steel cage in the pipe wall is not bonded to the steel cylinder.

2.5.5 Test stations are installed along the force main.

2.5.6 The pipe-to-soil potential measurements range from -280 mV to -693 mV. These potentials were measured at test stations and they are indicative of actively corroding pipe.

2.6 18-INCH SAN QUENTIN FORCE MAIN

2.6.1 Since the pipeline consists of PVC, soil corrosivity data is not warranted. This type of pipe is not subject to soil corrosion. This type of pipe is subject to failure, most often from loss of mechanical properties due to chemical attack resulting from chemical spills and from mechanical failure resulting from external overloading.

2.7 12-INCH PUMP STATION B FORCE MAIN

2.7.1 Based upon analysis of soil resistivity data, the force main is located in "corrosive" soil.

2.7.2 Approximately 50% of the force main is installed below mean sea level. Due to the close proximity of this force main to the Bay, there is a high probability for brackish water or salt water to come into contact with the force main.

2.7.3 The joints are reportedly field welded.

2.8 8-INCH LARKSPUR LANDING CIRCLE FORCE MAIN

2.8.1 Same conclusion as 2.6.1

2.9 6-INCH RIVIERA CIRCLE FORCE MAIN

2.9.1 Based upon analysis of soil resistivity data, the force main is located in "corrosive" soil.

2.9.2 Due to the close proximity of this force main the Corte Madera Creek, there is a high probability for brackish water or salt water to come into contact with the force main.

2.10 6-INCH DRAKE'S LANDING FORCE MAIN

2.10.1 Same conclusion as 2.6.1.

2.11 6-INCH CAPURRO PUMP STATION FORCE MAIN

2.11.1 Same conclusion as 2.6.1.

2.12 6-INCH PUMP STATION NO.4 FORCE MAIN

2.12.1 Since this pipeline consists of asbestos-cement pipe it also is not subject to corrosion and, therefore, soil corrosivity data is not warranted. This type of pipe is subject to failure most often as a result of unevenly distributed external loads.

2.13 8-INCH PUMP STATION NO.5 FORCE MAIN

2.13.1 Same conclusion as 2.6.1 and 2.12.1.

2.14 4-INCH VIA LA CUMBRE FORCE MAIN

2.14.1 The force main is probably located in "corrosive to moderately corrosive" soil based on soil analysis conducted in other nearby areas.

SECTION III
RECOMMENDATIONS

3.1 36-INCH KENTFIELD FORCE MAIN

3.1.1 Continue to monitor the Techite portion of the force main per the recommendations in Appendix B.

3.1.2 Based on the historical performance of Techite pipe, per Appendix B, we recommend keeping a repair clamp on hand in case of a pipe failure.

3.1.3 Provide a galvanic type of cathodic protection system for each section of cement lined and coated steel pipe on this force main. Install each cathodic protection system through a test station.

3.2 42-INCH GREENBRAE/KENTFIELD FORCE MAIN

3.2.1 Investigate the source of high negative potentials on the force main (i.e., appurtenances, steel cylinder, etc.).

3.2.2 Determine if the field joints are welded or if bonding jumpers were used.

3.2.3 Evaluate the need and the feasibility of cathodically protecting the force main.

3.3 18-INCH GREENBRAE FORCE MAIN

3.3.1 Install several test stations along the force main and determine the feasibility of adding cathodic protection.

3.4 30-INCH GREENBRAE FORCE MAIN

3.4.1 Install several test stations along the force main and determine the need and the feasibility of adding cathodic protection to the concrete cylinder pipe portion of the force main.

3.5 54-INCH ROSS VALLEY INTERCEPTOR

3.5.1 Investigate the source of high negative potentials on the force main (i.e., appurtenances, steel cylinder, etc.).

3.5.2 Evaluate the need and the feasibility of cathodically protecting the force main.

3.6 18-INCH SAN QUENTIN FORCE MAIN

3.6.2 No recommendations are warranted at this time.

3.7. 12-INCH PUMP STATION B FORCE MAIN

3.7.1 Conduct additional field testing and possibly install a test station at each end of the force main and determine the feasibility of adding cathodic protection.

3.8 8-INCH LARKSPUR LANDING CIRCLE FORCE MAIN

3.8.1 No recommendations are warranted at this time.

3.9 6-INCH RIVIERA CIRCLE FORCE MAIN

3.9.1 Same recommendations as 3.7.1 for the mortar coated welded steel pipeline sections.

3.10 6-INCH DRAKE'S LANDING FORCE MAIN

3.10.1 No recommendations are warranted at this time.

3.11 6-INCH CAPURRO PUMP STATION FORCE MAIN

3.11.1 No recommendations are warranted at this time.

3.12 6-INCH PUMP STATION NO.4 FORCE MAIN

3.12.1 No recommendations are warranted at this time.

3.13 8-INCH PUMP STATION NO.4 FORCE MAIN

3.13.1 No recommendations are warranted at this time.

3.14 4-INCH VIA LA CUMBRE FORCE MAIN

3.14.1 This pipeline can be expected to fail as a result of external corrosion due the age of the pipe and the corrosivity of the soil in that area. Further evaluation of this pipeline will be expensive and not warranted in our opinion. We recommend budgeting for replacement of this pipeline if a failure cannot be tolerated. Add corrosion control to any new pipelines.

3.15 GENERAL

3.15.1 Establish a District policy regarding the evaluation and addition of proper corrosion control for new and replacement/repair pipeline projects.

APPENDIX C

Ross Valley Sanitary District
42" Greenbrae/Kentfield Force Main, 30" Greenbrae Force Main,
12" Pump Station B Force Main & 54" Ross Valley Interceptor
Phase II - Corrosion Analysis
Corrosion Engineering and Research Company
April 19, 1993

Conclusions and Recommendations

CERCO No. 90013.2

Ross Valley Sanitary District
Larkspur, California

ROSS VALLEY SANITARY DISTRICT
42" GREENBRAE/KENTFIELD FORCE MAIN,
30" GREENBRAE FORCE MAIN, 12" PUMP STATION B
FORCE MAIN, & 54" ROSS VALLEY INTERCEPTOR

PHASE II - CORROSION ANALYSIS

April 19, 1993

Corrosion Engineering and Research Company

1850 Bates Avenue, Suite D
Concord, California

(510) 687-2954

SECTION II

CONCLUSIONS

2.1 42-INCH GREENBRAE/KENTFIELD FORCE MAIN

2.1.1 The survey results indicate that the probable cause of high-negative potentials is from the deprivation of oxygen on the pipe surface caused by the force main being located below the water table, although this cannot be proven based on the information collected to date.

2.1.2 The force main was constructed of both welded and bonded pipe joints. Bonding was made with AWG No. 4 and AWG No. 8 bonding cables but electrical continuity along the pipeline alignment is questionable.

2.1.3 Electrical isolation of the force main is achieved from other pipelines.

2.1.4 Seven test stations for corrosion monitoring were found during the survey.

2.2 30-INCH GREENBRAE FORCE MAIN

2.2.1 Pipe joints were not bonded during construction of the force main making the force main electrically discontinuous and impractical to cathodically protect.

2.2.2 Ultrasonic thickness (UT) testing performed at a likely location for internal corrosion indicates a 1.3 percent metal loss from the original steel cylinder which is negligible. However, only one location was tested and may not be representative of the entire pipeline.

2.2.3 No significant external corrosion was found on the force main at the three excavation locations.

2.3 12-INCH PUMP STATION B FORCE MAIN

2.3.1 Electrical isolation of the force main is provided at its northern end via its connection to a PVC pipeline.

2.3.2 Electrical isolation of the force main at its connection to the 54-inch Ross Valley Interceptor is less than 100 percent effective.

2.3.3 Cathodic protection of the force main has been achieved via the installation of five 32-pound magnesium anodes and a test station near Pump Station B.

2.4 54-INCH ROSS VALLEY INTERCEPTOR

2.4.1 The source of high negative potentials on the force main is due to the fact that it is installed below the water table, thus depriving the pipe surface of oxygen and due also to the close proximity of two foreign-owned impressed current cathodic protection systems.

2.4.2 Electrical continuity of the force main between Station 32+75 and the San Quentin Junction Box is questionable.

2.4.3 Three of the corrosion monitoring test stations installed as part of the original pipeline construction could not be located during the project.

2.4.4 Electrical isolation between the force main and line "CM" could not be verified because of a missing test station.

2.4.5 Less than 100 percent electrical isolation is achieved between the force main and the 12-inch Pump Station B Force Main.

SECTION III

RECOMMENDATIONS

3.1 42-INCH GREENBRAE/KENTFIELD FORCE MAIN

3.1.1 In order to confirm the conclusion that the high negative potentials are the result of oxygen deprivation at the pipe surface, further evaluation of the force main is necessary. Since corrosion on RCCP is most likely to occur at a joint, it is recommended that the District excavate and expose two bell and spigot joints along the force main alignment in order to evaluate to what degree, if any, that corrosion may be occurring at the joints.

3.1.2 Depending on the degree of corrosion found, further investigation of the pipeline may be warranted or design and application of cathodic protection for protection of the joints may be indicated.

3.1.3 If insignificant corrosion is found on the excavated joints, continue to monitor the pipe-to-soil potentials annually. Any significant decrease in these potentials in future years (i.e. potentials becoming more negative) occurs, this may be indicative of the onset of corrosion and will warrant further evaluation at that time.

3.2 30-INCH GREENBRAE FORCE MAIN

3.2.1 Excavate two pipe joints in five years and conduct a pipeline inspection similar to the inspection described in this report. The location of the two pipe joints should be at approximate mid-points between the excavation inspections in this report.

3.3 12-INCH PUMP STATION B FORCE MAIN

3.3.1 Conduct an annual cathodic protection system survey on the force main to ensure that the level of cathodic protection being received is adequate.

3.4 54-INCH ROSS VALLEY INTERCEPTOR

3.4.1 Install three test stations at the same locations as the three test stations that could not be located during the survey.

3.4.2 Excavate and expose two bell and spigot joints along the force main alignment in order to evaluate to what degree corrosion may be occurring.

3.4.3 Depending on the degree of corrosion found, further investigation of the pipeline may be warranted or design and application of cathodic protection for protection of the joints may be indicated.

3.4.4 If insignificant corrosion is found on the excavated joints, continue to monitor the pipe-to-soil potentials annually. Any significant decrease in these potentials in future years (i.e. potentials becoming more negative) occurs, this may be indicative of the onset of corrosion and will warrant further evaluation at that time.

3.4.5 Conduct detailed interference testing of the force main in the vicinity of the PG&E and Marin Municipal Water District pipeline crossings.

APPENDIX D

Letter from B. Jay Schrock, P.E.
JSC International Engineering
dated April 11, 1990

JSC INTERNATIONAL ENGINEERING
PIPE AND PIPELINES
1313 GARY WAY CARMICHAEL, CA 95608
PHONE (916) 483-8170 FAX (916) 483-4462

April 11, 1990

Mr. J. Darby Howard, Jr. P.E.
CERCO
5375 Clayton Road
Concord, CA 94521

Dear Mr. Howard:

The preliminary report on the Techite RPM pipe is enclosed. The subject, Kentfield sewer force main, is of significant interest to me. It most assuredly stands alone as a survivor among so many Techite failures. If I had the time, I would like to find out precisely why? In the past, poor installation, poor pipe quality and/or both of these items have been its nemesis.

I trust you will find my report complete, however, if you have a need for further information or clarification, please contact me at my office.

Sincerely submitted,

B. Jay Schrock, P.E.

BJS/mdl
Enclosures

ROSS VALLEY SANITARY DISTRICT
TECHITE FORCE MAIN
PRELIMINARY REPORT

1. Items Reviewed

   a. W. Edward Nute letter, March 20, 1990 to J. Darby Howard, Jr.

   b. Plans for Kentfield Force Main - Phase I, Feb. 1972

   c. J. Darby Howard, Jr. letter, March 28, 1990 to JSC

   d. JSC Techite Library

2. W. E. Nute Letter (item 1 a) and Plans (item 1 b)

The items 1-8 will be addressed and are discussed as follows.

Item 1. The Kentfield force main has various pipe change transitions throughout the identified 8863 lineal feet. At the extreme summit, Sta 70 + 50, Techite Pipe was required. Steel pipe was required at various locations along the alignment due to the need for restrained joints to handle vertical and horizontal thrusts, etc.

Item 2. Techite pipe class 150 (150 psi) type 2 (Bishenol A resin liner) and reference specification UTC SP-01015. The rating of the pipe was for 150 psi operating pressure. This was supposed to provide initial burst pressure at 900 psi and was hydrostatically tested at the Riverside, Calif plant at 300 psi. the predicted long term strength was approximately 300 psi, however, actual long term test date was not available until June 1974, and that is questionable. The identified type 2 pipe incicates the use of a more corrosion resistant liner than water pipe. During 1972 several liners were researched by United Technology Center (UTC) due to the previously identified strain corrosion failures (1970-71). If type 2 pipe was actually utilized on this project, it was probably the Bisphenol A resin more commonly known as Atlac. This resin has excellent acid corrosion resistance properties.

The reference to UTC SP-01015 (ref. 1) appears to be a mistake in that the document was the product of a test program, rather than a specification. The operating pressure of 43 psi at current peak flows and plans for future changes will be discussed under recommendations.

Item 3. The pipe was manufactured and sold by UTC (ref. 2).

Item 4. A.V. DeBrito Construction installed the pipe (ref. 2).

Item 5. The pipe was installed during 1972 (ref. 2).

Item 6. The combination of Techite and welded steel was discussed earlier and is indicated on the Kentfield plans.

Items 7-8. The only apparent pipe damage was third part caused and will be discussed in the Conclusions.

3. Work Required (Refer to item 1 c. letter)
   a. Techite RPM Pipe history (Sewer Force Mains)
   b. Potential pipe problems and time frame
   c. Techite RPM pipe evaluation methods
   d. Recommendatons on monitoring and maintenance

4. a. Techite RPM History (Sewer Force Mains)

Techite RPM pipe was developed by UTC and was placed on the market during 1967 (circa). There were a few failures of the pipe in the early years, many of which suggest poor installation. Some of these were sewer force mains, however, most problems occurred in deep wet soil sewers and pressure installations. Then during 1970 an Engineering Consultant discovered, through apparatus testing, that the pipe would fail in a deflected or strained condition. He identified this as strain corrosion. UTC and Johns Manville (JM) immediately started work in developing a better pipe liner. JM came up with an acceptable liner during 1971 but UTC did not have an acceptable liner until 1972. During late 1972, UTC developed a better liner for the pipe for sewers and industrial waste discharges. This will be addressed further in the conclusions.

b. Potential Pipe Problems and Time Frame

Techite RPM pipe is made from fiberglass filaments, thermosetting polyester resin and sand fillers. The sand fillers can vary from 40% down to about 5% depending upon the pressure class, i.e. gravity pipes at about 40%. It has been determined that the Techite manufacturing plant has had a history of varying quality control problems. The pipe was subjected to extensive human element involvement throughout the process, which can significantly effect the finished product. It should be noted that any abnormal stress can and will cause premature failure.

c. Techite RPM Pipe Evaluation Methods

The various parameters needed are obtained through destructive testing. These properties are; 1) Physical, 2) Chemical, and 3) Structural. Mechanical tests; a) determine Hoop Tensile Strength (ASTM D-2290), b) tensile strength (ASTM D-638), c) flexural properties (ASTM D-2412). Burst tests; short term hydraulic failure (ASTM D-1599). Also pressurized at lower than burst levels for a time period for determining weeping or burst values. Visual and Microscopic examination and Pyrolysis and dissection.

d. Recommendations on Monitoring and Maintenance.

The Kentfield Force Main, to this point in time, has provided remarkable performance when compared to virtually any other project where Techite Pipe was used. It is recommended to do nothing different at this time. Generally, the pipeline has 2 to 4 feet of cover. It is recommended that any surcharging of dredge material over the pipeline not be premitted. The air release valves must be operating successfully and/or the pipe remains full of sewage, i.e. no entrapped air. This will be discussed in further detail in the conclusions.

5. Conclusions

It has been indicated that the pipeline operating pressure is 43 psi at peak flows. The pipe is rated at 150 psi pressure. This did provide an additional 3 to 1 factor of safety during the early years. The pipe has a record of losing approximately 50% of its strength after 10 to 15 years of operation. The pipe normally experiences fatigue degradation with cyclic operation. It can be significantly weakened in an externally wet environment. The pipe is extremely fragile when excavation is done in near proximity.

It is assumed that the pipeline remains full of sewage under operation and this should be continued. The pipe cannot handle a vacuum due to its low stiffness especially in a wet environment. The cyclic times should be kept to an absolute minimum in order to reduce the fatigue potential.

Various parameters of concern are listed below:

1. Chemical Corrosion
2. Strain Corrosion
3. Mechanical Fracture
   - Tensile Failure
   - Flexural Failure
   - Shear Failure
   - Compressive Failure
   - Buckling Failure

6. Recommendations

When any operational conditions change, e.g. increases in pressure, increases in cyclic condition, land fill over top of pipe, surcharge loadings of any nature, work adjacent to the pipeline, increases in sulfides and/or BOD's, it is suggested to monitor the pipeline very carefully. Any of the above conditions can and probably will cause additional stresses in the pipe and/or pipeline. The pipe has performed quite well considering its history.

B. Jay Schrock, P.E.
JSC International Engineering

July 12, 2006

Ms. Amanda Schmidt
RMC Water and Environment
2868 Prospect Park Suite 130
Rancho Cordova, CA 95670

Subject: **External Corrosion Condition Assessment** ***(Draft Report)***
Sanitary Sewer Forcemain Pipelines
FM-1, FM-2, FM-10, FM-13, FM-14, FM-15 and FM-24
Ross Valley Sanitary District (RVSD)
Larkspur, CA

Dear Amanda:

During April and May 2006, Corrpro engineering personnel conducted an external corrosion assessment of the above referenced buried pipelines. The purpose of the investigation was to determine the relative corrosiveness of the environment in the area surrounding the pipeline, to conduct limited inspections of the pipeline, and to provide a report on the findings. These services were provided in accordance with Corrpro's proposal No. 500-2251 dated February 2, 2006.

Structures

The subject RVSD sanitary sewer pipelines are generally aligned east-west, connecting distributed sewage pump stations and extending to the CMSA wastewater treatment plant (see Figure 1). There are a total of 21 forcemains of various lengths within the district, with the oldest dating back to 1959.

The Ross Valley Interceptor (FM-1) and the Greenbrae/Kentfield Forcemain (FM-2) are constructed of reinforced concrete cylinder pipe (RCCP), 54" diameter by approximately 6,000 linear feet long, and 42" diameter by approximately 4,200 linear feet long, respectively. The Greenbrae Forcemain (FM-13) is constructed of a combination of RCCP and mortar lined and coated welded steel (WS L/C), 30" diameter by approximately 4,600 linear feet long. FM-10 and FM-24 are short lengths of metallic pipeline that connects between pump stations and the major forcemains. As constructed, each metallic forcemain was electrically isolated from the adjoining buried steel pipeline(s) and pump station connections by dielectric insulating pipe couplings.

The Larkspur Forcemain (FM-14) is constructed of polyethylene pipe, 18" diameter by approximately 3,300 linear feet. The Kentfield Forcemain (FM-15) is constructed of Techite (fiberglass pipe), 36" diameter by approximately 7,500 linear feet. Though FM-14 and FM-15 were included in the assessment, this corrosion investigation pertains only to metallic (electrically conductive) pipelines. The test stations listed for FM-14 (#3 and #5) and FM-15 (#1), and included as survey data collection points, are installed on short lengths of metallic pipe or appurtenances associated with these non-metallic pipelines.

Discussion

The field testing part of the assessment included the following tasks:

Task 1A: Pipe-to-Soil Survey
Task 1B: Electrical Continuity Survey
Task 1C: Soil Resistivity Survey

Photographs taken at each test station in conjunction with the field surveys are included in Appendix 4. Two photographs were taken at each test station location, one showing the general location and the second one a close-up detail of the test station.

Pipe-to Soil-Survey

The objective of the corrosion survey with regard to Task Item 1A (pipe-to-soil potential survey at test stations) was to determine the relative corrosion activity and areas of concern for future corrosion failures based on the local potential of the metallic pipelines. The pipe-to-soil electrical potential survey measures the DC voltage between each test station lead wire and a portable copper/copper-sulfate reference electrode (CSE) contacting moist earth within or adjacent to the test station traffic box. Data were collected at 19 of the 27 existing test stations shown on Figure 1, which could be located at the time of this survey. The potential survey data collected are tabulated in Appendix 1.

Pipe-to-soil potential was measured using each lead wire or lead wire pair within each test station. The reference electrode remained fixed for all readings at each test station. A high input impedance digital multimeter was used for the pipe-to-soil potential survey measurements.

The mortar coating on steel cylinder pipeline typically provides good corrosion protection to the embedded steel due to the passivating film formed on it in the high pH cement mortar environment. However, degradation of the mortar coating and/or the presence of dissolved chlorides and other ions in the soil, can lead to depassivation and corrosion of the pipe cylinder. Increased corrosion activity over time may generally be attributed to diminished passivating characteristics of the exterior cement mortar.

The pipe-to-soil potential data was analyzed with regard to the possibility of corrosion activity of the mortar coated steel pipe. In addition, archive data collected in 1992 were compared with the 2006 data. The rate of the corrosion process varies widely with soil characteristics and other factors, such as moisture content, temperature, etc. However, the progression of corrosion can be monitored by the documenting potential survey data, and may be classified into stages. ASTM C-876, *Standard Test Method for Half-Cell Potentials of Uncoated Reinforcing Steel in Concrete*, summarizes the relationship between the pipe-to-soil potential and the corrosion activity of embedded steel:

Corrosion activity of steel in concrete (or mortar) has been defined in ASTM C876 as follows:

- If potentials over an area are more positive than -200 mV CSE, there is greater than 90% probability that no steel corrosion is occurring in that area at the time of the measurement.

- If potentials over an area are in the range of -200 to -350 mV CSE, corrosion activity of the steel in that area is uncertain.

- If potentials over an area are more negative than -350 mV CSE, there is greater than 90% probability that steel corrosion is occurring in that area at the time of the measurement.

In addition to the actual value of the potentials discussed above, corrosion activity is also determined by the difference in potential values measured between locations of interest.

In performing the potential survey, pipe-to-soil potential data were collected at each test station that could be located. A greater frequency of test stations provides for a correspondingly more detailed potential profile that can be established. However, any such survey is only a limited sampling used to predict the electrochemical activity at the interface between the pipeline's total exterior surface and its buried environment. Therefore, a likelihood exist that pipe-to-soil potentials at other locations (not equipped with a test station) may exhibit values indicative of more severe corrosion activity than those surveyed. A close interval survey (which measures the pipe-to-soil potential at 5 feet spacing or less) is usually required to assess the full length of a pipeline.

Where an insulating flange test station (IFTS) was installed and could be found, the dielectric efficiency of the buried insulating assembly component was confirmed in conjunction with the electrical potential survey. The FM-1 is installed within a casing pipe at the rail crossing (T/S 16 and 17) and at the flood control crossing (T/S 18 and 19). Where either of the casing test stations (CATS) were installed and could be located, the electrical isolation between pipe and casing was confirmed in conjunction with the electrical potential survey.

Dissimilar pipe-to-soil potentials with respect to a fixed reference electrode exhibited at insulating flange test stations or casing test stations are indicative of proper electrical isolation between the buried pipelines or pipeline and casing. An electrical potential (or voltage drop) measured between the structure lead wires may also be used to confirm proper electrical isolation of the pipeline components.

Electrical Continuity Survey

The objective with regard to Task Item 1B (electrical continuity survey) was to determine the longitudinal electrical continuity status of the pipelines which have existing test stations. Pipeline electrical continuity is essential of providing cathodic protection (if required) for the pipelines.

Electrical continuity testing of the forcemains with existing test stations (FM-1, FM-2, and FM 13) was conducted by means of potential (voltage) attenuation. Following this procedure, the "static" or baseline pipe-to-soil potential of the pipeline was first measured at each test station. A temporary cathodic protection system comprising a grounded anode and an adjustable voltage DC power supply (rectifier) was set up with the current return connection made to the subject pipeline at selected test station(s). The test current was cycled "On" and "Off" using a timed circuit interrupter, and measurement of the pipe-to-soil potential under the influence of the test current was repeated at test stations. Polarization associated with the test current was calculated as the momentary "Off" potential minus the baseline potential previously measured at the corresponding location.

The temporary cathodic protection system was relocated and the procedure repeated for each pipeline tested. The electrical continuity survey data collected are tabulated in Appendix 2.

Electrical continuity of each bonded pipeline span between the current return locations and successive test stations is determined based on the polarization exhibited at each survey location. The current discharged from the temporary cathodic protection system and collecting on the pipeline will act to cathodically polarize the pipeline. The magnitude of the polarization exhibited at any given location is a function of factors such as the current applied, distance from the temporary anode, etc. However, test current discharge is collected only on the area (length) of the buried pipeline completing the electrical circuit back to the rectifier. Pipe segments electrically discontinuous from the current return connection will not collect current, and consequently will not exhibit any significant cathodic polarization associated with the test current applied.

Soil Resistivity Survey

Task Item 1C (in-situ soil resistivity survey) was conducted to assess and prioritize the requirements for corrosion control measures based on corrosivity of local soils within the pipeline alignments. Soil electrical resistivity was measured at nine (9) locations coinciding with the existing test stations within the alignments of FM-1, FM-2, FM-13, and FM-14, using the Wenner 4-pin method (ASTM G57). These representative test locations were selected based on distribution and convenient access to bare soil for a minimum of 45 linear feet, as necessary for placement of the driven steel pins. The in-situ soil resistivity was measured to 5 ft., 10 ft., and 15 ft. depth at each location. The soil resistivity survey data collected and corresponding corrosion rating at each location are tabulated in Appendix 3.

The soil resistivity value indicates the relative capability of the soil to carry electrical current and is generally recognized as the most significant characteristic with regard to corrosivity of the soil. Areas of low soil resistivity are generally more corrosive than areas of higher resistivity. Soil resistivity will vary substantially with moisture content. Soils exhibiting a high dry resistivity may exhibit a much lower resistivity when wet or saturated depending on such factors as pH and chemical content. Where soil resistivity varies seasonally or otherwise, the degree of corrosivity is usually governed by the lowest measured resistivity. The table below provides a general guide for the relationship of a soil's corrosivity to its resistivity.

Soil Resistivity (ohm-cm)	Degree of Corrosivity
0 – 500	Very Corrosive
501 –2,000	Corrosive
2,001 – 10,000	Moderately Corrosive
10,001 – 30,000	Mildly Corrosive
Above 30,000	Negligible

Results and Conclusions

- An analysis of the pipe-to-soil potential data with regard to ASTM C-876 found all the readings except one to be more negative than -350 mV, indicating possibility of corrosion on the sewer forcemains. Ten (10) of these locations (excluding short cathodically protected sections) exhibited slightly increased electro-negative potentials compared to the values during the 1992 survey. The higher negative potentials may be partially due to the fact that these pipeline are located below the water table. However, based upon the present and historical pipe-to-soil survey data, soil corrosivity, and age of pipe, the conditions are optimum for corrosion initiation at many regions of the pipeline.

- Electrical continuity test data indicate that FM-1 is electrically continuous for its full length. FM-2 is electrically continuous up to test station No. 23; however, continuity between test stations No. 23 and 26 is questionable and can only be properly determined by additional testing after test station No. 25 is located or replaced. FM-13 is determined to be electrically discontinuous based on the surveys conducted. More detailed testing to determine possible electrically continuous sub-spans of FM-13 utilizing test station No. 8 may be performed, if this test station is found or replaced.

- An analysis of the data with regard to soil resistivity found one reading within the “mildly corrosive” range, and one reading within the “corrosive range”. The remaining twenty five (25) readings were all in the “moderately corrosive” range, indicating generally corrosive soils along the pipeline alignment. The 2006 soil resistivity survey was conducted while the soils on the pipeline alignments were generally wet due to rainfall before the test date.

- The pipe casing was electrically isolated from the FM-1 pipeline at the rail crossing, based on data collected at the single casing test station (CATS1FM-1) for this feature found during the 2006 survey. Electrical isolation of the pipe casing from the FM-1 pipeline at the flood control channel was not confirmed as both associated casing test stations (CATS3FM-1 and CATS4FM-1) could not be found during the 2006 survey. Because construction materials for a pipe casing are substantially different from that of the carrier pipe, a shorted pipe casing provides for development of a corrosion cell. Furthermore, a pipeline within a shorted casing is shielded, and typically will not receive adequate cathodic protection (if provided) from any anode external to the casing.

- The buried dielectric insulating assembly components installed on the FM-2 and FM-10 pipelines at locations corresponding to each insulating flange test station that could be found (IFTS1FM-2, IFTS3FM-2, IFTS4FM-10) was confirmed as operational. Electrical isolation of the FM-2 pipeline at the connection to FM-1 was not directly confirmed because IFTS2FM-2 could not be located during the 2006 survey. However, this insulator is believed to be operational, based on the potential survey and attenuation survey data collected at nearby test stations.

- Eight (8) test stations are lost or otherwise could not be located (CNL) during the 2006 resurvey. The ability to assess corrosion activity over the entirety of these pipelines is diminished to the extent of the missing test stations. A summary of the stations that could not be found during each resurvey year is presented in the following table:

Figure 1 Location	Designation	1990	1992	2006
8	ETS7FM-13	Found	Not Found	Not Found
14	IFTS2FM-2	Not Found	Not Found	Not Found
17	CATS2FM-1	Found	Not Found	Not Found*
18	CATS3FM-1	Not Found	Not Found	Not Found
19	CATS4FM-1	Found	Found	Not Found
22	ETS15FM-10	Not Found	Not Found	Not Found
24	ETS16FM-1	Found	Not Found	Found
25	ETS17FM-1	Found	Found	Not Found
27	ETS19FM-1	Not Found	Not Found	Not Found

* CP Test station traffic box without wires.

- The anodes at test station ETS4FM-14 are not connected to the pipeline. These anode wires should be connected to the pipeline wires at this test station for corrosion control of the structure.

<u>Recommendations</u>

- Find or replace each missing test station listed as 'Not Found' in the table above. Existing test stations No. 8, 14, 17, and 25 in Figure 1 may be considered as higher priority for replacement, based on location and type.

- Conduct corrosion inspections of the exposed pipeline at each excavation in conjunction with test station replacement. Further information regarding the condition and continued reliability of the pipelines can be developed based upon the information yielded by such inspections.

- In Corrpro's opinion, cathodic protection systems should be considered for these sewer forcemain pipelines for corrosion control and to extend their future service life.

- Design and install cathodic protection systems for the forcemain pipelines, including the welded steel and reinforced concrete cylinder pipe spans. Perform additional testing to estimate the cathodic protection current requirement for each metallic forcemain pipeline. Based upon this information, a preliminary design and cost estimate for retrofitted cathodic protection systems may be determined.

Corrpro appreciates this opportunity to be of service. Please do not hesitate to contact our office with questions or comments. Our invoice for these services is included.

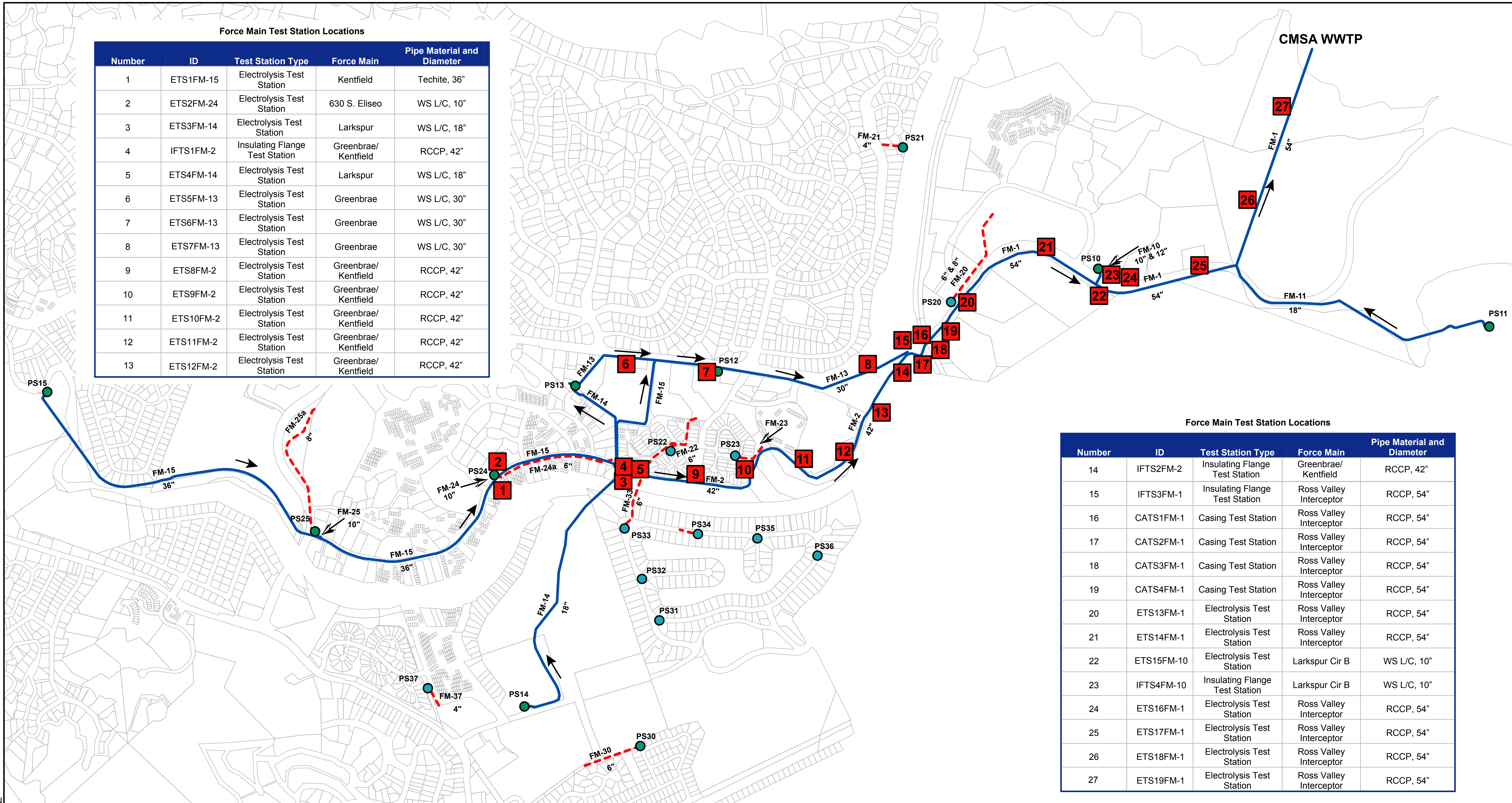
Very truly yours,

Greg Markus
Project Engineer
Corrpro Companies, Inc.

GM/ts/Server G: Regional/All Reports/2006 Reports/572-4396/4396.xls
Encls: Data, Invoice

Force Main Test Station Locations

Number	ID	Test Station Type	Force Main	Pipe Material and Diameter
1	ETS1FM-15	Electrolysis Test Station	Kentfield	Techite, 36"
2	ETS2FM-24	Electrolysis Test Station	630 S. Eliseo	WS L/C, 10"
3	ETS3FM-14	Electrolysis Test Station	Larkspur	WS L/C, 18"
4	IFTS1FM-2	Insulating Flange Test Station	Greenbrae/ Kentfield	RCCP, 42"
5	ETS4FM-14	Electrolysis Test Station	Larkspur	WS L/C, 18"
6	ETS5FM-13	Electrolysis Test Station	Greenbrae	WS L/C, 30"
7	ETS6FM-13	Electrolysis Test Station	Greenbrae	WS L/C, 30"
8	ETS7FM-13	Electrolysis Test Station	Greenbrae	WS L/C, 30"
9	ETS8FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"
10	ETS9FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"
11	ETS10FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"
12	ETS11FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"
13	ETS12FM-2	Electrolysis Test Station	Greenbrae/ Kentfield	RCCP, 42"



Force Main Test Station Locations

Number	ID	Test Station Type	Force Main	Pipe Material and Diameter
14	IFTS2FM-2	Insulating Flange Test Station	Greenbrae/ Kentfield	RCCP, 42"
15	IFTS3FM-1	Insulating Flange Test Station	Ross Valley Interceptor	RCCP, 54"
16	CATS1FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"
17	CATS2FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"
18	CATS3FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"
19	CATS4FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"
20	ETS13FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
21	ETS14FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
22	ETS15FM-10	Electrolysis Test Station	Larkspur Cir B	WS L/C, 10"
23	IFTS4FM-10	Insulating Flange Test Station	Larkspur Cir B	WS L/C, 10"
24	ETS16FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
25	ETS17FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
26	ETS18FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"
27	ETS19FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"

N

0 0.125 0.25 0.5 Miles

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Legend

- Parcels
- Existing Major Force Mains
- Existing Minor Force Mains
- Flow Direction
- Major Pump Stations
- Minor Pump Stations
- Test Stations

RMC Water and Environment

Figure 1
Existing Test Stations

Source: INSERT DATA SOURCE HERE

APPENDIX 1

CORROSION CONDITION ASSESSMENT
ROSS VALLEY WATER DISTRICT

POTENTIAL SURVEY DATA

APRIL 2006

Photos	Figure 1 Location	ID	Test Station Type	Force Main	Pipe Material and Diameter	Lead Wires	Pipe-To-Soil Potential (mV)	Anode Output/Notes
1 & 2	1	ETS1FM-15	Electrolysis Test Station	Kentfield	Techite, 36"	(2) 8 red (2) 8 blk	549 1630	40 mA 20' Metallic Pipe in Fiberglass Line
30 & 31	2	ETS2FM-24	Electrolysis Test Station	630 S. Eliseo	WS L/C, 10"	(2) 10 red 10 blk 10 blk	617 1595 1602	70 mA
6, 7 & 8	3	ETS3FM-14	Electrolysis Test Station	Larkspur	WS L/C, 18"	(2) 10 blk (2) 10 blk	572 568	Figure 1 ID as 18" (36" Per Owner)
4 & 5	4	IFTS1FM-2	Insulating Flange Test Station	Greenbrae / Kentfield	RCCP, 42"	(2) 10 blk (2) 10 blk	568 641	Marked 54" (42" Actual)
43 & 44	5	ETS4FM-14	Electrolysis Test Station	Larkspur	WS L/C, 18"	(2) 10 red (lower) (2) 10 red (upper) 12 wht 12 wht	320 298 1469 1417	Anodes Not Terminated Soil Resistivity Test
9 & 10	6	ETS5FM-13	Electrolysis Test Station	Greenbrae	WS L/C, 30"	8 wht 10 wht	562	Bus Stop Soil Resistivity Test
11 & 12	7	ETS6FM-13	Electrolysis Test Station	Greenbrae	WS L/C, 30"	(2) 8 wht (2) 8 wht (2) 10 blk	593 881 1600	Between Chevron & Calico Corners (BonAir) - No Shunt Soil Resistivity Test
N/A	8	ETS7FM-13	Electrolysis Test Station	Greenbrae	WS L/C, 30"			CNL -Attempted to Locate w/Assistance of RVSD
13 & 14	9	ETS8FM-2	Electrolysis Test Station	Greenbrae / Kentfield	RCCP, 42"	10 blk 10 red	609 609	Ped. Trail at Extension of Barry Soil Resistivity Test

APPENDIX 1

CORROSION CONDITION ASSESSMENT
ROSS VALLEY WATER DISTRICT

POTENTIAL SURVEY DATA

APRIL 2006

Photos	Figure 1 Location	ID	Test Station Type	Force Main	Pipe Material and Diameter	Lead Wires	Pipe-To-Soil Potential (mV)	Anode Output/Notes
45 & 46	10	ETS9FM-2	Electrolysis Test Station	Greenbrae / Kentfield	RCCP, 42"	10 red 10 blk	599 599	Little Fink
16 & 17	11	ETS10FM-2	Electrolysis Test Station	Greenbrae / Kentfield	RCCP, 42"	8 red 10 blk	595 595	Ped/Bike Trail
18 & 19	12	ETS11FM-2	Electrolysis Test Station	Greenbrae / Kentfield	RCCP, 42"	10 blk 10 red	601 601	Ped./Bike Trail (Behind 100 SFD) Soil Resistivity Test
20 & 21	13	ETS12FM-2	Electrolysis Test Station	Greenbrae / Kentfield	RCCP, 42"	10 blk 10 red	602	Ped./Bike Trail (No Cover on Box)
32 & 33	14	IFTS2FM-2	Insulating Flange Test Station	Greenbrae / Kentfield	RCCP, 42"			CNL - Found Cover Marked CP Test (Actually a Valve)
24 & 25	15	IFTS3FM-1	Insulating Flange Test Station	Ross Valley Interceptor	RCCP, 54"	(2) 10 red (54") (2) 10 blk (30")	590 588	30' E. of 101 Over Xing (Blue Big Fink) Soil Resistivity Test
n/a	16	CATS1FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"	10 red, 10 wht 10 blk 10 wht	664 733 724	West Side of Creek Xing. Near Old Trestle
22 & 23	17	CATS2FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"	(No Wires)		Cover Marked CP Test
N/A	18	CATS3FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"			CNL
N/A	19	CATS4FM-1	Casing Test Station	Ross Valley Interceptor	RCCP, 54"			CNL
34 & 35	20	ETS13FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"	10 blk 10 red	545	Ferry Terminal, Exit Driveway (Little Fink)
N/A	21	ETS14FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"	10 blk 10 red	632 632	Edge of Pathway Opposite LLC - Soil Resistivity Test

APPENDIX 1

CORROSION CONDITION ASSESSMENT
ROSS VALLEY WATER DISTRICT

POTENTIAL SURVEY DATA

APRIL 2006

Photos	Figure 1 Location	ID	Test Station Type	Force Main	Pipe Material and Diameter	Lead Wires	Pipe-To-Soil Potential (mV)	Anode Output/Notes
29	22	ETS15FM-10	Electrolysis Test Station	Larkspur Cir B	WS L/C, 10"		-	CNL - Attempted to Locate w/Assistance of RVSD
26 & 27	23	IFTS4FM-10	Insulating Flange Test Station	Larkspur Cir B	WS L/C, 10"	8 wht 10 wht (4) 8 HMWPE	659 659 1595	4 - Mg Anodes Not Terminated
n/a	24	ETS16FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"	(2) 10 red (54") 10 blk (left) 10 blk (right)	650 700 Floating	Across Street from RVSD PS-10 Soil Resistivity Test
	25	ETS17FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"			CNL - Attempted to Locate w/Assistance of RVSD
36 & 37	26	ETS18FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"	(4) 8 HMWPE	555	Post Mount T/S Soil Resistivity Test
38 & 39	27	ETS19FM-1	Electrolysis Test Station	Ross Valley Interceptor	RCCP, 54"			CNL - Found T/S Bollard

APPENDIX 2

CORROSION CONDITION ASSESSMENT
ROSS VALLEY WATER DISTRICT

ELECTRICAL CONTINUITY SURVEY DATA

MAY 2006

TABLE 1.0
FM-2

					Pipe-To-Soil Potential (-mV)			
						Test Current		Attenuation Test
Photos	**Fig 1 Location**	**ID**	**Test Station Type**	**Lead Wires**	**Baseline**	**On**	**Instant-Off**	
4 & 5	4	IFTS1 FM-2	Insulating Flange Test Station	**(2) 10 blk (42")** (2) 10 red (36")	568 641	697	604	**45V, 16.5A**
13 & 14	9	ETS8 FM-2	Electrolysis Test Station	10 blk 10 red	609	648	622	
	10	ETS9 FM-2	Electrolysis Test Station	10 red 10 blk	599	656	643	
16 & 17	11	ETS10 FM-2	Electrolysis Test Station	8 red 10 blk	595	670	660	
18 & 19	12	ETS11 FM-2	Electrolysis Test Station	10 blk 10 red	601 601	634 629	625 620	
20 & 21	13	ETS12 FM-2	Electrolysis Test Station	10 blk 10 red	602	638	632	

TABLE 2.0
FM-1

n/a	16	CATS 1 FM-1	Casing Test Station	10 red, 10 wht 10 blk 10 wht	664 733 725			
24 & 25	15	IFTS3 FM-1	Insulating Flange Test Station	**(2) 10 red (54")** (2) 10 blk (30")	590 588	818 688	609	**46V, 7.0A**
34 & 35	20	ETS14 FM-1	Electrolysis Test Station	10 blk 10 red	545 545	599	573	
n/a	21	ETS14 FM-1	Electrolysis Test Station	10 blk 10 red	632 632	n/a n/a	n/a n/a	
26 & 27	23	IFTS4 FM-10	Insulating Flange Test Station	8 wht, 10 wht (4) 8 HMWPE	659 1595	668 -	657 -	
n/a	24	ETS 16 FM-1	Insulating Flange Test Station	(2) 10 red (54") 10 blk (left) 10 blk (right)	650 700 floating	n/a	n/a	
36 & 37	26	ETS18FM-1	Electrolysis Test Station	(4) 8 HMWPE	555	436	434	

TABLE 3.0
FM-13

24 & 25	15	IFTS3 FM-1	Insulating Flange Test Station	(2) 10 red (54") **(2) 10 blk (30")**	590 588	730 948	 620	**46V, 7.0A**
9 & 10	6	ETS5 FM-13	Electrolysis Test Station	8 wht 10 wht	562 562	583 583	583 583	
11 & 12	7	ETS6 FM-13	Electrolysis Test Station	(2) 8 wht (2) 8 wht (2) 10 blk	593 881 1600	634 959 -	634 959 -	

APPENDIX 3

CORROSION CONDITION ASSESSMENT
ROSS VALLEY WATER DISTRICT

SOIL RESISTIVITY SURVEY DATA

Figure 1 Location	Layer Depth (Feet)	Resistance (Ω)	Resistivity (Ω-cm)	Corrosion Rating
5	5	4.64	4443	Moderately Corrosive
	10	3.95	7564	Moderately Corrosive
	15	2.87	8244	Moderately Corrosive
6	5	4.32	4136	Moderately Corrosive
	10	3.36	6434	Moderately Corrosive
	15	2.4	6894	Moderately Corrosive
7	5	5.61	5372	Moderately Corrosive
	10	4.13	7909	Moderately Corrosive
	15	3.8	10916	Mildly Corrosive
9	5	2.02	1934	Corrosive
	10	1.69	3236	Moderately Corrosive
	15	0.81	2327	Moderately Corrosive
12	5	3.75	3591	Moderately Corrosive
	10	3.1	5937	Moderately Corrosive
	15	1.95	5601	Moderately Corrosive
15	5	3.95	3782	Moderately Corrosive
	10	3.26	6243	Moderately Corrosive
	15	2.54	7296	Moderately Corrosive
21	5	6.05	5793	Moderately Corrosive
	10	4.25	8139	Moderately Corrosive
	15	2.95	8474	Moderately Corrosive
24	5	4.25	4069	Moderately Corrosive
	10	3.67	7028	Moderately Corrosive
	15	2.74	7871	Moderately Corrosive
26	5	4.57	4376	Moderately Corrosive
	10	3.8	7277	Moderately Corrosive
	15	2.36	6779	Moderately Corrosive

APPENDIX 4

PHOTOGRAPHS

ETS 1 FM15 Overview – Photo 1

ETS 1 FM15 Detail View – Photo 2

IFTS 1 FM2 Overview – Photo 4

IFTS 1 FM2 Detail View – Photo 5

ETS 3 FM14 Overview – Photo 6

ETS 3 FM14 Detail View – Photo 7

ETS 5 FM13 Overview – Photo 9

ETS 5 FM13 Detail View – Photo 10

	
ETS 6 FM13 Overview – Photo 11	**ETS 6 FM13 Detail View – Photo 12**
	
ETS 8 FM2 Overview – Photo 13	**ETS 8 FM2 Detail View – Photo 14**

ETS 10 FM2 Overview – Photo 16

ETS 10 FM2 Detail View – Photo 17

ETS 11 FM2 Overview – Photo 18

ETS 11 FM2 Detail View – Photo 19

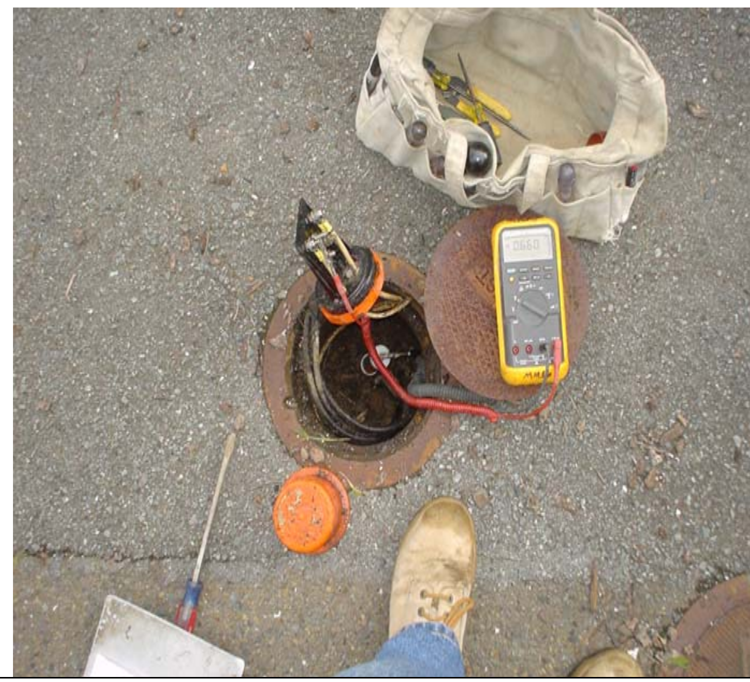
ETS 12 FM2 Overview – Photo 20	ETS 12 FM2 Detail View – Photo 21

CATS 2 FM1 Overview – Photo 22	CATS 2 FM1 Detail View – Photo 23

IFTS 3 FM2 Overview – Photo 24

IFTS 3 FM1 Detail View – Photo 25

IFTS 4 FM10 Overview – Photo 26



IFTS FM10 Detail View – Photo 27

ETS 2 FM24 Overview – Photo 30

ETS 2 FM24 Detail View – Photo 31

IFTS 2 FM2 Overview – Photo 32

IFTS 2 FM2 Detail View – Photo 33

	
ETS 13 FM1 Overview – Photo 34	**ETS 13 FM1 Detail View – Photo 35**
	
ETS 18 FM1 Overview – Photo 36	**ETS 18 FM1 Detail View – Photo 37**

ETS 19 Overview – Photo 38

ETS 19 FM1 Detail View – Photo 39

FM2 Attenuation Survey (Temp. Anode) - Photo 40

FM1 and FM13 Attenuation Survey – Photo 41

FM2 Attenuation Survey – Photo 42

ETS 4 FM14 Overview – Photo 43

ETS 4 FM14 Detail View – Photo 44

ETS 9 FM2 Overview – Photo 45

	
ETS 9 FM2 Detail View – Photo 46	

Technical Memorandum FM-1

Ross Valley Sewer System Assessment and Capital Improvement Planning Project

Subject: **Kentfield Force Main Replacement Alternatives Development and Analysis**

Prepared For: Ross Valley Sanitary District

Prepared by: Amanda Schmidt
Glenn Hermanson

Reviewed by: Vivian Housen

Date: July 21, 2006

Reference: 0147-2.2.4

The objectives of this Technical Memorandum (TM) are to develop and assess conceptual alignment alternatives and possible construction methods required to rehabilitate and/or replace the existing 36-inch Kentfield force main. This effort establishes a conceptual basis for subsequent preliminary design efforts. This TM provides an overview and comparative evaluation of five alternatives, and recommends one alternative for further investigation. This TM is organized as follows:

- Background
- Kentfield Force Main Issues
- Goals
- Criteria Development
- Alternatives Development and Description
- Alternatives Evaluation
- Recommendations

1 Background

Ross Valley Sanitary District maintains a series of force mains and pump stations to deliver wastewater to the Central Marin Sanitation Agency (CMSA) wastewater treatment plant. One of the oldest force mains in the District is the Kentfield force main (FM-15). This force main collects wastewater from the northern area of the District (from Kentfield to Fairfax). The Kentfield force main is located along the levee road along Corte Madera Creek to Bon Air Road. The force main then runs along South Eliseo Road until its end, then turns north and travels through the Bon Air shopping center until it connects with the Greenbrae force main (FM-13). Under normal operation, wastewater flowing through the Kentfield force main flows directly to the Greenbrae Kentfield Relief Force Main (FM-2), a reinforced concrete cylinder pipe installed in 1987. The portion of the Kentfield force main from the end of South Eliseo to the connection with FM-13 is normally closed.

2 Kentfield Force Main Issues

The Kentfield force main is a fiberglass, “Techite” pipeline and is considered to be extremely fragile under any external and internal stresses. Techite pipe is made from fiberglass filaments, thermosetting polyester resin and sand fillers. Techite pipelines are known to fail catastrophically. This force main was installed in 1972 and is nearing the end of its service life. Also, the force main size must be increased to provide adequate capacity as determined by the Sanitary Sewer System Hydraulic Evaluation and

Capacity Assurance Plan (SHECAP). Therefore, rehabilitation and replacement are needed. This alternatives evaluation is being conducted separately from the overall Ross Valley Sewer System Assessment and Capital Improvement Planning Project to ensure it is included it in the Fiscal Year 2006-2007 Capital Improvement Plan (CIP).

3 Goals

The goal of this technical memorandum is to identify a range of constructable alternatives to replace and/or rehabilitate the Kentfield Force Main. Selection of a preferred alternative would be completed during a subsequent predesign effort. Specific objectives of this TM are to:

- Convey the forces driving replacement of the Kentfield force main
- Identify alternatives to replace or rehabilitate (or combination of both) the Kentfield force main
- Evaluate each of the alternatives on the bases of conceptual engineering, economic, and environmental considerations
- Provide a preliminary recommendation for alignment and construction method based on evaluation criteria

4 Criteria Development

Alternative evaluation criteria were chosen based on issues that are relevant to the existing Kentfield force main alignment and setting. Each evaluation criterion is described below along with a discussion of scoring relevance. Scoring utilized a scale of 1 to 5 (1 = poor, 2 = below average, 3 = average, 4 = good, 5 = excellent).

- **Environmental.** This criterion considers potential impact to the environment, from construction related activities and/or the completed pipeline. This TM did not consider alternatives that require open trench construction along the access road between the Kentfield Pump Station and Pump Station 25 (at the corner of South Eliseo and Bon Air Road), in light of the limited area available for construction and the close proximity to sensitive habitat. If an alternative has less potential for environmental impacts it will obtain a higher score.
- **Utility Conflicts.** This criterion considers the potential congestion of utility corridors along a proposed alignment. If an alignment alternative corridor is not used for other utilities like water, sewer and gas, installing a new pipeline will be less problematic. An alignment with fewer utility conflicts will receive a higher score.
- **Easement and Acquisition Availability.** This criterion considers the need to obtain easement access for locations along pipe alignments. An alternative will receive a higher score if the District does not require addition easement, or if acquisition of the required easement or property appears straightforward.
- **Schedule Concerns.** This criterion considers the period of time needed for construction of an alternative. If construction is limited to a particular timeframe (i.e. dry weather periods), then the score will be lower; a higher score will result from an alternative that has more flexibility in construction scheduling.
- **Impact to Traffic.** This criterion considers potential impacts to traffic during construction of the project. If the pipeline alignment travels within a major traffic corridor, it will require traffic control for the duration of construction. An alternative will score higher in this category if there are minimal traffic impacts.
- **Constructability.** This criterion considers the constructability of each alternative. An alternative will be scored higher if construction activities are conventional and present a lower risk of unknowns.

- **Cost.** This criterion considers the total capital cost of an alternative. The lowest cost alternative will receive the highest score.

5 Alternatives Development and Description

Five alternative replacement alignment options are shown in Figure 1, summarized in Table 1, and described below:

Alternative 1 – McAllister/SFDB Alternative. This alignment is the recommended alignment from the 1998 Nute Force Main Improvement Program. The force main begins at the Kentfield Pump Station, runs east across Corte Madera Creek and through open space to McAllister Drive. The pipe alignment moves south along McAllister Road to Sir Francis Drake Blvd. The alignment then runs east along Sir Francis Drake Blvd. and ends at Highway 101. The proposed force main is 39-inches in diameter.

Alternative 2 – McAllister North Alternative. This alignment is a variation of Alternative 1. The pipeline heads north on McAllister and then continues on Sir Francis Drake Blvd. The pipeline continues east along Sir Francis Drake Blvd to the Alternative 1 alignment and ends at Highway 101. This alternative also installs a 39-inch diameter force main.

Alternative 3 – Bon Air Alternative. This option involves isolation of the Kentfield force main during the summer by shutting down the Kentfield Pump Station (PS15) and allowing wastewater to back up in the trunk sewer and flow by gravity through another network of sewers to the Greenbrae Pump Station (PS13). Pump Stations 24 and 25 would pump wastewater into their respective alternative force mains (FM-24a and FM-25a) instead of the Kentfield FM. Flow would end at the Greenbrae pump station. With the Kentfield force main isolated, rehabilitation could proceed with a replacement option from the Kentfield pump station (PS15) to an open area west of Bon Air Road. A new 42" force main would be installed by open cut trenching across the open space to Bon Air Road, would continue north on Bon Air Road to Sir Francis Drake Blvd., and then east on Sir Francis Drake Blvd. to Highway 101.

Alternative 4 – Rehabilitate and Replace Existing Alignment Alternative. The portion of the force main downstream from PS15 would be rehabilitated to a location just downstream of Pump Station 25 (PS25), similar to Alternative 3. Downstream of Pump Station 25, a new 42" pipe would be installed using open cut trenching methods to the connection with the Greenbrae Kentfield Relief Force Main (FM-2). FM-2, a 42-inch diameter reinforced concrete cylinder pipe, was installed in 1987 and has a remaining useful life of approximately 30 years

Alternative 5 – Directional Drill and Replacement of Existing Alignment Alternative. A new pipe from the Kentfield Pump Station would be directionally drilled in two sections. The first 39" pipe section begins at the pump station and continues south across Corte Madera Creek to an open field. The 39" pipe turns approximately 90 degrees and crosses the creek a second time, ending at Bon Air Road. New pipe would then be installed using open cut trenching methods to South Eliseo Drive. This pipeline would continue east on S. Eliseo Drive to the connection with FM-2. Replacing the existing pipe along S. Eliseo Drive requires dewatering of the Kentfield force main.

Although the existing techite force main continues from the end of South Eliseo Drive to the Greenbrae pump station, the pipe alignments in Alternatives 4 and 5 terminate at the junction with FM-2 for several reasons:

- The Kentfield force main discharges to FM-2 during normal operations. As a result, the section of techite pipe from the end of South Eliseo Drive to the Greenbrae force main (FM-13) is normally not in use and is not considered a critical force main facility.
- Replacing the force main from South Eliseo Drive to the Greenbrae force main would be complex, as it requires crossing through numerous residential easements and the Bon Air shopping center. It is recommended that new construction in this area be limited to as-needed repairs.

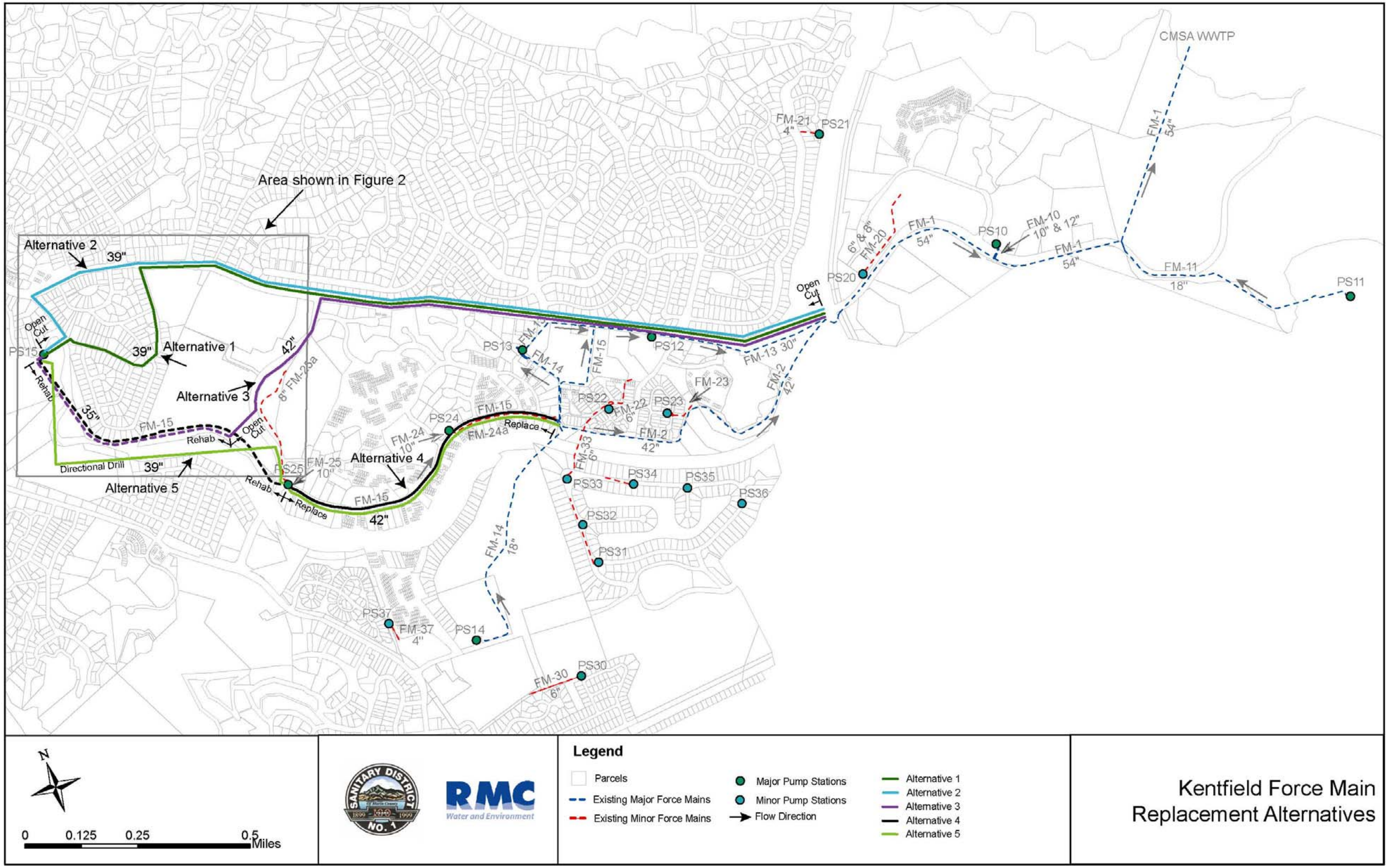


Figure 1: Kentfield Force Main Replacement Alternatives

Table 1: Kentfield Force Main Alternatives

Alternative	Action	Pipe Diameter	Pipe Length (ft)
1	Open Cut New Pipe	39"	10,800
2	Open Cut New Pipe	39"	10,500
3	Rehabilitation	35"	2,900
	Open Cut New Pipe	42"	8,200
4	Rehabilitation	35"	3,800
	Open Cut New Pipe	42"	3,700
5	Directional Drill	39"	4,300
	Open Cut New Pipe	39"	3,700

5.1 Hydraulic Analysis

The SHECAP hydraulic analysis determined that the Kentfield Force Main is undersized. The hydraulic model was run to evaluate various pipe sizes described below.

- Alternatives 1 & 2: The new force main would be upsized to a 39-inch diameter for the entire length of the pipe to allow the design storm to be pumped without sewage backing up in the upstream gravity sewer
- Alternatives 3 & 4: The rehabilitated portion of pipe would have an approximate effective diameter of 35-inches. By upsizing the new pipe section to 42-inch diameter, the pump station would be able to pump flows from the design storm without surcharging upstream gravity sewers
- Alternative 5: This option would replace the entire force main with a directionally drilled 39-inch force main.

5.2 Unit Costs

Capital costs for the project alternatives were based on past projects of a similar nature. Unit cost used to develop the cost estimates are listed in Table 2.

Table 2: Economic Assumptions and Unit Costs

Item	Cost
Open Trench Installation	
Residential Streets (i.e. S. Eliseo Drive)	$12/LF-inch
Highly Traveled Roads (i.e. Sir Francis Drake Blvd.)	$14/LF-inch
Rehabilitation	
Rehab Existing Pipe Using CIPP	$250/LF
Directional Drill	
New Pipe Installation	$1000/LF
Other Cost Estimate Criteria [a]	
Construction Cost Contingency	30% of pipeline costs
Engineering and Administration	25% of pipeline costs

Footnotes:

a. An overhead markup of 62.5% was applied based on a 30% construction cost contingency plus a 25% engineering and administration factor to calculate the capital cost. Hence, for budgeting purposes, it is assumed that the contingency and project implementation multiplier is 1.625 (1.00 x 1.30 x 1.25 = 1.625)

6 Alternatives Evaluation

As described in Section 4, alternative evaluation criteria were selected based on project-specific impacts and issues. Alternatives were then rated using a scale of 1 to 5 (1 = poor, 2 = below average, 3 = average, 4 = good, 5 = excellent).

Table 3: Alternatives Evaluation

Criteria	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Cost	$9,583,000	$9,317,000	$9,014,000	$4,574,000	$9,802,000
Environmental	5	5	4	4	4
Utility Conflicts	2	2	3	5	4
E&A Procurement	4	4	4	4	4
Schedule Concerns	5	5	3	3	3
Impact to Traffic	1	1	2	4	3
Constructability	2	2	4	5	3
Accessibility	3	3	4	4	4
Cost	3	3	4	5	3
Overall Score	**3.125**	**3.125**	**3.5**	**4.25**	**3.5**
Rank	**4**	**4**	**2**	**1**	**3**

Further discussion regarding the ratings assigned in Table 3 is presented below.

- **Environmental.** Alternatives 1 and 2 have little construction or disturbance near Corte Madera Creek, while Alternatives 3, 4, 5 have some disturbance near the Creek. Alternatives 3, 4, and 5 require localized construction around the Kentfield Pump Station for the rehabilitation work. This alternatives analysis does not include any options that require open trench construction along the access road between the Kentfield Pump Station and Pump Station 25 in light of the limited area available for construction and the close proximity to sensitive habitat. An aerial photo of the western portion of the Kentfield Force Main, shown in Figure 2, illustrates the sensitive habitat near Corte Madera Creek.

- **Utility Conflicts.** Alternatives 1, 2, and 3 are primarily located within Sir Francis Drake Blvd. This corridor is highly congested with other utilities, including water, sewer and gas pipelines. The availability of an "open" corridor for a 39" force main along this street will be a challenge to locate. As a result, these alternatives rank lower than Alternatives 4 and 5. Alternatives 4 and 5 follow the existing alignment, which avoids Sir Francis Drake Blvd.
- **Easement and Acquisition Procurement.** None of the identified alternatives presented problematic issues regarding easement or property acquisition. New pipes will be installed in existing public streets and sewer easements.
- **Schedule Concerns.** Alternatives 3, 4, and 5 require dewatering of the Kentfield force main for partial rehabilitation and or replacement. Dewatering can only occur during the summer, and under low flow conditions. Therefore, these alternatives score lower than Alternatives 1 and 2 in this category.
- **Impact to Traffic.** Traffic impacts are significant for Alternatives 1, 2, and 3, which propose an alignment along Sir Francis Drake Blvd. Construction of these alternatives would require significant and continuous traffic control, and may be limited in order to maintain existing traffic patterns. Alternatives 4 and 5 ranked lower than the others because they utilize the existing alignment, which is located within the pump station access road and along South Eliseo Drive, a residential street with lower traffic counts that Sir Francis Drake Blvd. .
- **Constructability.** Alternatives 1 and 2 rate the lowest in this category because they will be difficult to construct due to the traffic and utility constraints noted above, as well as potential permit-related restrictions associated with construction on Sir Francis Drake Boulevard. Alternative 5 is also ranked low because it presents technical and access challenges associated with directional drilling; this alternative crosses underneath Corte Madera Creek twice. Alternative 4 rates the highest in this category, presuming a suitable rehabilitation technique will be confirmed for the portion of force main within the pump station access road.
- **Cost.** Alternative 4 is ranked highest in this category, indicating the most desirable cost.

7 Recommended Alternative

Based on the evaluation criteria described above and the ranking in Table 3, Alternative 4 appears to be the most optimal alternative for replacement of the techite portion of the Kentfield force main. This alternative rehabilitates the techite force main upstream of Pump Station 25 with a structural pipe liner that is designed to withstand all internal and external loads. The specific liner to be used in rehabilitation would be determined during preliminary design. The techite force main downstream of Pump Station 25 would be replaced with a 42" inside diameter high-density polyethylene (HDPE) pipe.

The next preferred alternative is Alternative 3, which also partially rehabilitates the Kentfield force main and also constructs a new HDPE pipeline along Bon Air Road and Sir Francis Drake Blvd. to Highway 101.

Figure 2: Aerial Photo of Western Portion of Kentfield Force Main Alignment Showing Sensitive Habitat Near Corte Madera Creek

Appendix A - Wastewater Pumping Station Reliability Recommendations

APPENDIX A

California Regional Water Quality Control Board
San Francisco Bay Region
Wastewater Pumping Station Reliability Recommendations
Draft October 1996

STATE OF CALIFORNIA - CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY PETE WILSON, Governor

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
SAN FRANCISCO BAY REGION
2101 WEBSTER STREET, Suite 500
OAKLAND, CA 94612
Tel: (510) 286-1255
FAX: (510) 286-1380
BBS: (510) 286-0404

November 7, 1996
File No. 1230.05

To: Bay Area Wastewater Collection System Group Steering / Review Committee

Subject: Review of Final, Final Draft Redline / Strikeout *Wastewater Pumping Station Reliability Recommendations*

Enclosed is the subject document for your review based on the comments received in the May / June 1996 time frame. This is the second redline/strikeout version the committee has reviewed. Please send any comments you may have directly to Randy Fiorucci at the following address:

Black and Veatch
2300 Clayton Road, Suite 1200
Concord, CA 94520-2100
Fax: (510) 674-9458

Please submit your comments by December 6, 1996. I would like to have a meeting with the steering / review committee on **January 8, 1997, at 10:00 AM, here in our office in Room 4A** to discuss the following: 1) any final changes to the subject document; 2) to brainstorm ideas for workshops in 1997 (I will have the survey results available); and 3) any other committees that may need to be formed to address specific issues such as revisions to the spill response protocols or design criteria for collection systems prone to overflowing in sensitive areas such as near schools, parks, and hospitals.

After any final revisions to the document, I will send the document to the complete mailing list. Thank you very much for your review of the document. If you have any questions regarding this letter, please call me at (510) 286-0689.

Sincerely,

John D. Wolfenden

John D. Wolfenden
Senior Water Resource
Control Engineer

Enclosure: Redline/Strikeout *Wastewater Pumping Station Reliability Recommendations, October 1996*

WASTEWATER PUMPING STATION RELIABILITY RECOMMENDATIONS

Prepared for

San Francisco Bay Region
California Regional Water Quality Control Board

DRAFT

October 1996

BLACK & VEATCH

Rpt36j1

Contents

I. Introduction

Raw sewage spills and bypasses are a concern to many California utilities and regulatory agencies. By improving the reliability features and operational practices at many facilities, it would be possible to reduce the frequency of bypasses currently being experienced. The purpose of this document is to provide designers, operators, and regulatory personnel with guidelines for minimizing the frequency of spills both in the design of new pumping stations and in the evaluation on a case by case basis of existing pumping stations for possible upgrade. For the purposes of these recommendations, a small pump station has a capacity of less than 10,000 gallons per day (gal/day); an intermediate pump station has a capacity between 10,000 gal/day and 2 million gallons per day (mgd); a large pump station has a capacity greater than 2 mgd.

Realistically, it is not possible to totally eliminate all risks of raw sewage spill at each pumping station. Natural disasters or "acts of God" cannot be avoided. However, certain steps can and should be taken to minimize the frequency of spills that are caused by either equipment failure or a natural disaster. In general, these steps include the following:

- A quality engineering design with adequate reliability or redundancy for critical items of equipment and power supply.
- A quality construction and construction inspection program to ensure the facility is constructed in accordance with the design, and to minimize failures due to faulty construction.
- Proper operation and maintenance of equipment and systems in accordance with the manufacturer's recommendations, specific site conditions, and standard operating procedures.
- Periodic inspection and testing of equipment and systems, under both normal and emergency conditions, to ensure proper operation.

II. Special Note on Safety

There are many safety issues and hazards which may be encountered in the design, operation, and maintenance of wastewater pumping stations. A few general categories that the reader should be aware of include:

- Proper access and egress facilities (stairs, handrails, etc.).
- Station Security.
- An adequate, properly operating ventilation system.
- Equipment hazards.
- Electrical safety.
- Explosion and fire hazards.
- Bacterial infections and health hazards.
- Confined space entry procedures.
- Pumping station safety equipment.
- Communications equipment.
- Use of lock and tag-out procedures.
- Need for emergency lighting.
- Need for agency electrical standards (e.g., common phase rotation).

However, due to the nature of this document and space limitations, a detailed discussion of safety issues will not be included herein. The reader is advised to refer to other reference sources on safety (see bibliography at the end of this guide), to obtain safety training as necessary, and to follow applicable safety practice rules and guidelines.

III. Design

A. General

1. Reliability

- The objectives of reliability are to prevent the discharge of raw or partially treated sewage to any waters and to protect public health by preventing backup of sewage and subsequent discharge to basements, streets, and other public and private property.

2. Pumping Station Capacity

- The maximum design flow anticipated from the system influent should be determined based on appropriate design loadings, peaking factors, and other system factors such as equalization storage.
- Equalization storage basins or increased wetwell capacity can be used to reduce the maximum design capacity; however, the economics vary from facility to facility. Additional storage may also be considered to handle flows during a power outage or other failure. Equalization storage basins and large wetwells have increased maintenance requirements and they have the potential to increase odors at the pump station and upstream and downstream.

  In most cases, the option of providing standby power is preferable to that of furnishing additional storage in case of power outages, except with small stations handling low flows. Standby power is discussed in further detail later in this guide.
- The firm capacity of the pumping station (i.e., with the largest pumping unit out of service) should equal or exceed the maximum design flow anticipated.
- If necessary for increased flows in the future, the pumping station design should allow for future expansion in capacity by the addition of pumps and/or by replacing existing pumps or impellers with larger units.

3. Flooding

- Pumping stations should be protected from flooding resulting from power failure, excessive infiltration/inflow, or reasonable flooding conditions outside caused by the applicable design year storm event or high tide conditions.

- Provisions protecting against flooding include (a) locating motors and other electrical equipment and wiring in the drywell above the maximum flood level; (b) providing waterproof lighting fixtures and controls; (c) providing sump pumps in dry pits; (d) sealing any wall penetrations between the wetwell and the drywell; (e) locating the ground floor or point of entry above flood level, and (f) using submersible pumps with controls, etc. located above grade.

4. Materials and Equipment

- Materials and coatings used in pumping station construction--including the structure itself, mechanical equipment, electrical equipment, piping and valves--should be selected for long life. Materials should be corrosion-resistant or provided with a suitable corrosion-resistant coating to protect against the corrosive conditions normally found in a wastewater pumping station environment.
- All electrical equipment located in the wetwell should be of explosionproof and sparkproof construction.
- Electrical equipment, systems, and components that are located in spaces where hazardous concentrations of flammable gases or vapors may be present shall comply with the National Electrical Code requirements for Class I, Group D, Division 1, locations.
- Ventilation equipment should be fabricated from non-sparking materials.

5. Labeling

- Pumps, valves, pipelines, flowmeters, motor control centers, and other major items of equipment located in dry pits or above ground should be clearly labeled to indicate number or service type. Such labeling will allow operati~~ng~~on, maintenance, and emergency personnel to more easily determine which equipment may have failed, what items to disconnect or isolate, what alternative equipment or procedures to use, etc. In addition, labeled equipment should also match the numbering system in the O&M manual, allowing equipment to be better maintained by following the manufacturers' recommended schedules.
- Pipelines should be labeled by service type and should have arrows indicating direction of flow. Labels should be applied at 10-foot intervals or when a

pipe enters or exits a space. This identification will also assist personnel in determining items to isolate, alternative operation procedures, etc.

B. Mechanical

1. Screening Equipment

- Suitable screening equipment should be provided wheren necessary to protect pumps from clogging and damage. For lift stations in the collection system, screening equipment may involve only bar racks which are manually cleaned on a periodic basis. For larger influent pumping stations and at treatment plants, automatic, mechanically cleaned bar screens or other suitable screening equipment should be required. Screens can be omitted from smaller stations where large objects are not as much of a problem.
- For mechanically cleaned bar screens and other automatic screening equipment, at least two screens should be provided. The firm capacity of the screens (with the largest screen out of service) should equal or exceed the maximum design flow anticipated.
- For manually cleaned bar screens, a standby screen channel or an overflow bypass channel is often provided.

2. Pumping Units

- At least two pumping units should be installed in each pumping station unless appropriate high level overflow to downstream sewers can be provided. The firm pumping capacity of a pumping station is the sum of the capacity of the pumping units that can be operated together with the largest pumping unit out of service. The firm pumping capacity should equal or exceed the maximum anticipated design flow.
- Pump sizing should be coordinated with wetwell design in order to avoid frequent on-off cycling of pumps. Excessive pump starting can cause undue wear on the motors and starting equipment. ~~Also, s~~Standard motors 25 hp and smaller should not be started more than six times an hour; and standard motors 30 hp and larger should be started less frequently, with the number of allowable starts depending on motor size and design. Where more frequent starting is required, special motors and starters should be provided.

- Pumps should be selected to operate at or near their best efficiency point.
- Pump materials should be selected based on expected environmental conditions to limit corrosion and wear.
- In lieu of constant speed drives, variable speed drives may be considered to match more closely the influent flow rate. Such drives can minimize excessive pump cycling, and allow a smaller capacity wetwell to be used, which will decrease the chance of septicity occurring.

  If variable speed pumps are desired, adjustable frequency drives are recommended over other types of speed control.
- Most wastewater pumps can be furnished with either mechanical seals or stuffing boxes. Both types have advantages and disadvantages. Either mechanical seals or water lubricated stuffing boxes should be provided for larger pumps and for pumps that run continuously. The seal water flow rate should be properly set to lubricate the seal or packing and to continuously flush the seal or packing to keep abrasive material such as grit from entering and wearing the shaft sleeves.

  Grease seals can be used on smaller wastewater pumps which do not run continuously.

3. Ventilation

- NFPA 820 guidelines for ventilation of pumping station should be cited and used as the basis for designing or evaluating ventilation. In addition, local codes and additional measures needed to protect personnel from exposure to toxic gases must be considered.
- Proper ventilation systems should be provided in both the drywell and the wetwell. The ventilation systems are necessary to provide a safe working atmosphere for operators, to minimize corrosion of the equipment and station, and to keep the buildup of flammable and hazardous gases and fumes below explosive or otherwise dangerous levels.
- Mechanical ventilation systems are required for wetwells (except submersible pump stations) and for drywells. Separate ventilation systems should be provided for the drywell and wetwell. Interconnections between the drywell and wetwell ventilation systems are not allowed.

- Ventilation can be continuous and/or intermittent, with the minimum ventilation rate as determined by local code. Signage should be present to indicate confined spaces.
- Indication should be present to notify workers that ventilation system is on and working.
- In many cases, separate ventilation (and air conditioning) may be required to protect electronic equipment. This system may have special requirements and it should be separate from the wetwell ventilation system.

4. *Valves and Piping*

- Suitable isolation valves should be provided in each pump suction and discharge line to allow removal of the pump or check valve for maintenance or repairs.
- Suitable isolation valves, a bypass line, or a replacement spool should be provided around the discharge flowmeter to allow removal of the meter for cleaning or repairs.
- Valve orientation should be such that they can be operated and accessed without interference of walls and other piping.
- Provide means for backflushing piping.
- Consideration should be given to installing a quick-disconnect on the discharge piping to allow the installation of a portable pump with appropriate piping and valves at remote pumping stations under emergency conditions. It would be helpful if a "standard" could be developed to make interagency support possible.
- Design of pressure pipelines should include allowances for hydraulic transients (i.e., surge or water hammer) or provisions for controlling transients.
- Pressure pipelines should be provided with anchorage where required to prevent joint separation. Methods of anchorage include thrust blocks, restrained joints, or tie rods.
- Avoid locating check valves in vertical runs of piping.

5. *Air Compressors*

- Where air compressors are used for bubbler level control systems, pneumatically operated valves, etc., two air compressors and an air receiver should be provided. The second compressor will act as the lag compressor and as the backup compressor in case the first compressor fails.

- Carbon dioxide (CO_2) cylinders may be utilized as a backup to the air compressor system. A pressure control valve allows the CO_2 to start automatically upon air system failure. Proper gages should be installed so the status of the backup cylinders can be determined.

6. Submersible Pump Stations

The modern submersible pump station is a tested alternative to the wetwell/drywell pump station that the designer can consider.

Submersible pump stations utilizing modern submersible pumps offer advantages over traditional wetwell/drywell stations that include: virtual elimination of confined space entry for maintenance personnel, reduced design and construction requirements, and lower pump and station maintenance.

Submersible pump stations are designed with a wetwell only and pumps that are retrievable from the ground surface, making entry into confined spaces unnecessary. The simpler structure required for submersible stations allows for reduced construction costs. Older wetwell/drywell stations can be readily retrofitted to a submersible station, eliminating the drywell by converting to additional wetwell storage. Motor control centers can be self-contained in all weather housings to eliminate the need for aboveground buildings and further reduce construction costs.

C. Electrical

1. General

- To the extent possible, keep all electrical equipment out of areas that are subject to internal or external flooding.
- Explosionproof motors, controls, and other electrical equipment should be provided in all areas of the pump station ~~which may~~ where potentially ~~have~~ explosive gases or fumes may be present.
- Conduit installation should meet the requirements for the hazardous area classification. Conduit materials/coatings should be specified to avoid corrosion.
- Overload protection devices should be provided on all pump motors to disconnect the motor before excessive heat in the motor is generated. The

use of such devices will minimize motor failure due to a breakdown of winding insulation caused by excessive heat during motor overloads.

- Totally enclosed fan cooled (TEFC)/explosionproof motors should be utilized on all below grade installations.

2. Standby Power for Major Equipment

- To ensure continuous operability and prevent overflows of untreated wastewater, a standby source of power is recommended.
- ~~The most~~ One common ~~and preferred source of~~ method of providing standby power is a second electrical feed from a separate source, with automatic switching from the primary feed to the secondary feed in case of a power outage.
- ~~If a~~ A second ~~independent electrical feed is not available,~~ method utilizing a standby engine-driven generator with automatic switching is also acceptable, especially at stations with multiple pumps or when auxiliary systems such as heating, ventilating, and lighting are necessary.
- On smaller pumping stations, the installation of a quick-connect receptacle and transfer switch for portable generators (or air compressors in case of ejector stations) is an alternative to onsite emergency generators.
- Standby-engine driven pumps with automatic startup ~~can~~ may also be ~~provided~~ acceptable; however, if multiple engine drives are required or auxiliary uses are necessary, one large engine generator may be more economical or practical than several smaller engines, pumps, and gear boxes.
- Standby power equipment generally should be in-place equipment. Where adequate storage is provided and if allowed by the regulatory agency, portable standby power equipment may be acceptable.
- Where ~~allowed by the regulatory agency~~appropriate, adequate system storage and/or equalization storage may ~~preclude the requirement~~ be considered as an alternative for standby power.
- Each pumping station should be equipped with emergency lighting or portable lighting as required.

3. *Standby Power for Instrumentation Systems*

- To ensure reliability of alarm systems, standby power should be provided for communications systems (telemetry, telephone dialers, etc.) and for alarms.
- Most communications systems can be provided with a battery backup, which is the most economical type of backup system. Uninterruptible power supply (UPS) can also be provided as a backup system, especially if other instrumentation and alarm systems are desired to have backup power; however, UPS systems are generally much more expensive and require more space than simple battery backup systems.

4. *Controls*

- All equipment should be provided with local manual controls to override any automatic controls.
- Pumps should be automatically controlled based on wetwell level.
- In case of a pump failure, the control system should automatically start the standby pump.
- In case of a power failure to the communications systems, the battery backup or UPS system should provide continuous power to maintain uninterrupted communications.

5. *Instrumentation*

- Metering of pump station discharge should be required for large pump stations and is preferred in all stations. Meters should indicate and record flow and may be provided with a totalizer. Flowmeters should be installed with valves and bypass piping or a replacement pipe spool to allow removal for routine inspection, service, and repair.
- Elapsed time clocks ~~can~~ should be provided on pumps, especially at smaller pumping stations to estimate discharge rate and total discharge volume.
- A level indication system should be provided in all wetwells to allow control of the pumps and to alarm high wetwell level. Where the primary system consists of a bubbler or electronic level indication system, a second wetwell level indication and control system should be provided in case of failure of the first system. The second system could consist of float-switch-initiated controls.

- A gas detection system indicating low oxygen level, high hydrogen sulfide, and high explosive gas levels can warn an operator of unsafe atmospheric conditions in pumping stations.

6. Alarms

a. The following standard alarms should be provided at most pumping stations:

- Incoming power failure
- Pump failure
- High wetwell level
- High-high wetwell level
- Low wetwell cutoff level
- Pump station intrusion
- Ventilation system failure
- Low air pressure
- Drywell flooding
- Loss of telemetry
- Fire
- Control system failure.
- Low seal water pressure.
- Generator malfunction.

b. In addition to the above, the following special alarms may be considered at larger pumping stations or where dictated by special circumstances:

- Unsafe gas levels in drywell or wetwell (high hydrogen sulfide, high explosive gas, low oxygen).
- No flow in discharge line or closed discharge valve while one or more pumps are running.
- Significantly less flow than anticipated for extended period of time (indicating possible upstream line blockage or line break).
- Upstream high level sensor/alarm for bar racks.

c. Alarm reporting and monitoring should be in accordance with the following:

- Alarm conditions should be reported to a central facility that is attended by an operator 24 hours per day.
- For attended pumping stations or pumping stations located at an attended plant site, the alarms should be reported to the main control panel or control system.
- For remote, unattended pumping stations, alarms should be reported to a central attended facility such as a treatment plant. If there is not a central facility attended by an operator 24 hours per day, then alarms should be reported to a police or fire station, a monitoring company, or similar facility that is attended 24 hours per day. This facility should then notify the proper authorities.
- Remote monitoring of alarms can be performed by telephone auto dialers, radio telemetry, telemetry panels, or remote terminal units (RTU's).
- For larger pumping stations, it is desirable to report each alarm condition individually so the operator knows the nature of the problem. For smaller pumping stations, it is often acceptable to combine the alarm signals into a common alarm for each pumping station.
- Alarms should be exercised periodically to ensure proper operation.

IV. Emergency or Abnormal Operating Procedures

A. Purpose

Emergency or abnormal operating procedures may be required at pumping stations when events preclude the normal operation of these facilities. Events which can cause emergency or abnormal operating procedures include the following:

- Natural events such as floods, earthquakes, severe weather, and fires.
- Operational or mechanical failure due to inadequate maintenance, negligent operation, design deficiency, or other cause.
- Civil emergencies such as strikes, civil disorders, and security failures/ sabotage.
- Unsafe environments such as low oxygen levels, high explosive gas levels, or unauthorized discharges of toxic, hazardous, or other chemicals.

The purpose of emergency planning is to protect operating personnel, public health and safety, wastewater system facilities, public and private property, and the environment. Indeed, proper advance planning for such occurrences can minimize the severity of the impact on operations, and may even avoid an emergency situation entirely.

B. Protective Measures

Protective measures can and should be taken to minimize the possibility of emergency or abnormal operating procedures. These protective measures generally fall into three main categories: design criteria; operational procedures; and maintenance, inspection, and testing procedures. Design criteria and maintenance, inspection, and testing procedures are discussed elsewhere in this guide. The following is a discussion of operational procedures.

Normal operational procedures should include procedures which will prevent or minimize the occurrence of emergencies or abnormal operations. Safety procedures must be incorporated into normal operating procedures per California State Law SB198. Some procedures the operator can undertake to minimize emergencies are listed below:

- Prior to employees entering confined spaces, the utility should develop and provide to the employees written, understandable operating and rescue procedures. ~~the operator~~ Employees should be trained ~~and aware of all proper~~ in the operating and rescue procedures ~~and~~ (including the use of portable gas detecting equipment) ~~to determine safeness of atmospheres.~~ All applicable OSHA regulations should be followed. Do <u>not</u> enter unless and until it is safe.

- Have appropriate safety equipment available. Depending on the situation, such equipment can include a self-contained breathing apparatus, special clothing, fire extinguishers, non-sparking tools, traffic safety supplies, and similar items.
- Have appropriate service equipment available. This equipment may include portable generators, pumps, hoses, shovels, tools, etc.
- Be aware of which similar units are duplicate or can be used as temporary backup.

C. Emergency Response Plan

Even though protective measures have been undertaken in design, operation, and maintenance, emergencies can still occur. In order to be prepared for such emergencies, an emergency response plan should be developed to cover each pumping station within the utility's system. Much of the information included in the plan will be similar for all of the pumping stations. However, the plan should also address the differences in each pumping station and the different responses required due to those differences.

Development of an emergency response program (ERP) will require the dedication of individuals knowledgeable with the system. Some of the tasks required to develop an ERP include but are not limited to:

- Selecting the emergency operations coordinator and committee.
- Defining emergency conditions and different priority levels.
- Determining location and facilities required for an emergency operations center.
- Defining chain of command.
- Determining adequacy of existing communications systems and whether additional emergency communications are required.
- Identifying procedures for assessing, reporting, prioritizing, and repairing damage, and for modifying operations. Identify resources necessary (personnel, equipment, supplies, etc.) and whether they will be provided by the utility or obtained from private contractors. Provide necessary training for personnel.

- Identifying emergency response teams such as public agencies (police, fire, public works, etc.), utilities (electric, natural gas, telephone), suppliers of parts and chemicals, or private contractors.
- Defin~~e~~ing the level of training which response team members should possess.
- Development of a notification plan.
- ~~L~~Determining the location and availability of record drawings.
- Developing the information into an emergency operations plan (EOP) manual.

An EOP manual should include the following information:

- Emergency flow chart indicating actions to take.
- Damage assessment forms.
- List of all facilities (pumping stations, plant, administrative offices) including names, addresses, telephone numbers.
- Contact lists of appropriate utility personnel, emergency operations committee members, and emergency response teams. Contact lists should include names, positions, addresses, telephone, cellular phone and pager numbers, and any other types of communications contact, and should be in order based on chain of command or priority, where appropriate.
- List of emergency equipment.
- List of contractors and the type of work or equipment available.
- List of mutual aid agreements and the type of aid provided.
- For each facility (or similar facilities), a separate section with a contact list, checklist for damage assessment, location of emergency supplies (first aid, water), and hazard mitigation procedures.

D. Spills Procedures

Spills greater than 1,000 gallons shall be reported immediately to the Regional Board, at (510) 286-1255 on weekdays during office hours of 8:00 a.m. to 5:00 p.m., and to the Office of Emergency Services at (800) 852-7550 during nonoffice hours. A copy of the "Sewage Spill Notification and Minimum Cleanup Procedures" is included in the Appendix. A written report shall be filed with the Regional Board within five (5) working days and shall contain information relative to: nature of waste or pollutant, quantity spilled, duration of spill, cause of spill, estimated size of affected area, nature of effects (i.e., fishkill, discoloration of receiving waters, etc.), corrective measures that have been taken or planned, and a schedule of these activities, how the corrective measures will prevent spills from occurring in the future, and persons notified. Spills less than 1,000 gallons should be reported in the monthly report unless additional requirements are imposed.

Appropriate containment and cleanup measures include: contain spills in storm drains as much as possible and pump back to pump station and rinse down affected area with clean water. Deodorizing/disinfecting chemicals are not recommended as they may have their own inherent toxicity. For any spill over 10,000 gallons, the discharger should immediately collect receiving water samples upstream and downstream of the spill and have them analyzed for total and fecal coliform. If the sewage has a high industrial waste content, soil samples may be required in the affected area.

V. Maintenance, Inspection, and Testing

A good maintenance, inspection, and testing program will ensure that the pumping station is in good operating condition and will significantly minimize failures due to equipment or system malfunctions.

A. Maintenance

The maintenance schedules listed in the manufacturer's recommendations and operation and maintenance (O&M) manuals should be used as a guide when the utility establishes preventive maintenance programs for each item of equipment requiring maintenance or other attention. A list of after-hours phone numbers for parts and equipment suppliers should be kept. A routine preventative maintenance program should be established that automatically schedules regular maintenance. Checklists and a maintenance accountability system should be established and maintained at the pump stations.

Spare parts, required lubricants, O&M manual, etc. should be kept on hand (or made readily available at designated locations) at each pumping station for key items of equipment. A list of pump stations with identical equipment and spare parts should be established. Depending on the types of equipment furnished, the recommended spare parts will vary. A typical list of spare parts is shown below.

<u>Pumps</u>
Pump bearings
Wearing rings
Shaft sleeves
Gaskets and O-rings
Packing or mechanical seals
Flexible coupling
Lubricant
Universal joints/repair kits

<u>Motor Control Centers and Control Panels</u>
Fuses
Replacement breakers
Contactor tips and coils

Lamps
PLC modules

Engines
Oil
Oil filter
Air filter
V-belts
Gaskets
Lamps for indicating lights
Fuses
Special tools
Lubricant
Fuel filter

Mechanically Cleaned Bar Screens
Limit switches
Tooth rack bushings and pins
Scraper lips
Lubricant

B. Inspection and Testing

Equipment, including normally operated equipment, emergency equipment, and alarm systems, should be functionally inspected and tested on a periodic basis to ensure that they are operational when needed. Metering, level control, and other similar equipment should have the calibration checked periodically as recommended by the manufacturer or as established by the utility.

C. Record Keeping

Complete operating, maintenance, and inspection records should be kept and maintained for each pumping station and should be readily available. Operational records should include daily flow, wetwell level, and pump operation, and are useful in determining any apparent loss of pumping capacity, or meter or level inaccuracies. Maintenance records should include date and type of service or repairs performed on each type of equipment, the next scheduled service date, and an inventory of remaining replacement parts. Inspection records should indicate items reviewed and accountability of inspector.

A program of documented annual, quarterly, and monthly inspections should be established along with a formal system of follow-up on correcting problems.

San Francisco Bay Regional Water Quality Control Board

Sewage Spill Notification and Minimum Cleanup Procedures

Sewage Spill Notification:

- All sewage spills and overflows exceeding 1,000 gallons require an immediate verbal notification and a written follow up report within five working days to the Regional Board. Calls should be directed to (510) 286-1255 or to (510) 286-1036 during working hours (working hours are from 8 am to 5 pm). Calls made after 5pm, weekends and holidays should be made to the State Office of Emergency Services (OES) at (800) 852-7550 and (510) 286-1036 (voice mail).

- In case of a fish kill, notify OES and Department of Fish and Game immediately and provide updates as needed.

- When leaving a message please provide your name, agency, return phone number, City, location of spill/overflow (include, cross streets and nearest address), rate of flow, volume, surface water bodies impacted, agencies that have responded if known, cause of spill and the repair and cleanup actions undertaken.

The written report shall include:

- Include all of the above information and the duration of the incident, size of the affected area, and agency contacts made during the notification, a detailed description of the repair and cleanup actions taken, and a statement on what steps will be taken to minimize or prevent a spill or overflow recurrence.

Dry Weather Posting and Cleanup:

1. Post sign(s) warning the public of the release with at least the wording of "raw sewage".

2. Health warning signs should remain posted until County Health or Regional Board authorizes their removal or sample results show background levels.

3. Contain and divert the flow to the nearest sanitary sewer or into a vactor truck.

4. After the flows have been stopped and repairs made, rake or vacuum up sewage solids.

5. Flush the affected area with clean water. The use of disinfectants is not recommended due to their toxicity to fish and wildlife.

6. Sampling should be conducted upstream and downstream in receiving water if spill volume exceeds 10,000 gallons. Samples should be analyzed for fecal coliform and Ammonia. Dissolved oxygen testing may also be needed to determine impact.

Wet Weather Cleanup:

The same as Dry Weather Posting and Cleanup, steps 5 and 6 may be omitted if storm water flow is high and sample taking is impractical.

VII. Bibliography

"Considerations for Preparation of Operation and Maintenance Manuals," EPA 430/9-74-001, 1974.

"Criteria for Sewage Works Design," State of Washington, Department of Ecology, 1980.

"Design Criteria for Mechanical, Electric, and Fluid System and Component Reliability," EPA 430/9-74-001, 1974.

"Design of Wastewater and Stormwater Pumping Stations," *Manual of Practice No. FD-4*, Water Environment Federation, Alexandria, Virginia, 1981.

"Emergency Planning for Municipal Wastewater Facilities," *Manual of Practice No. SM-8*, Water Environment Federation, Alexandria, Virginia, 1989.

"Field Manual for Performance Evaluation and Troubleshooting at Municipal Wastewater Treatment Facilities," *EPA Manual MO-16*, 1978.

"Maintenance Management System for Municipal Wastewater Facilities," EPA 430/9-74-004, 1973.

"Operation of Wastewater Treatment Plants," *Manual of Practice No. 11*, Water Environment Federation, 1976.

"Recommended Standards for Sewage Works," Great Lakes - Upper Mississippi River Board of State Sanitary Engineers, 1978.

"Safety in Wastewater Works," *Manual of Practice No. 1*, Water Environment Federation, Alexandria, Virginia, 1975.

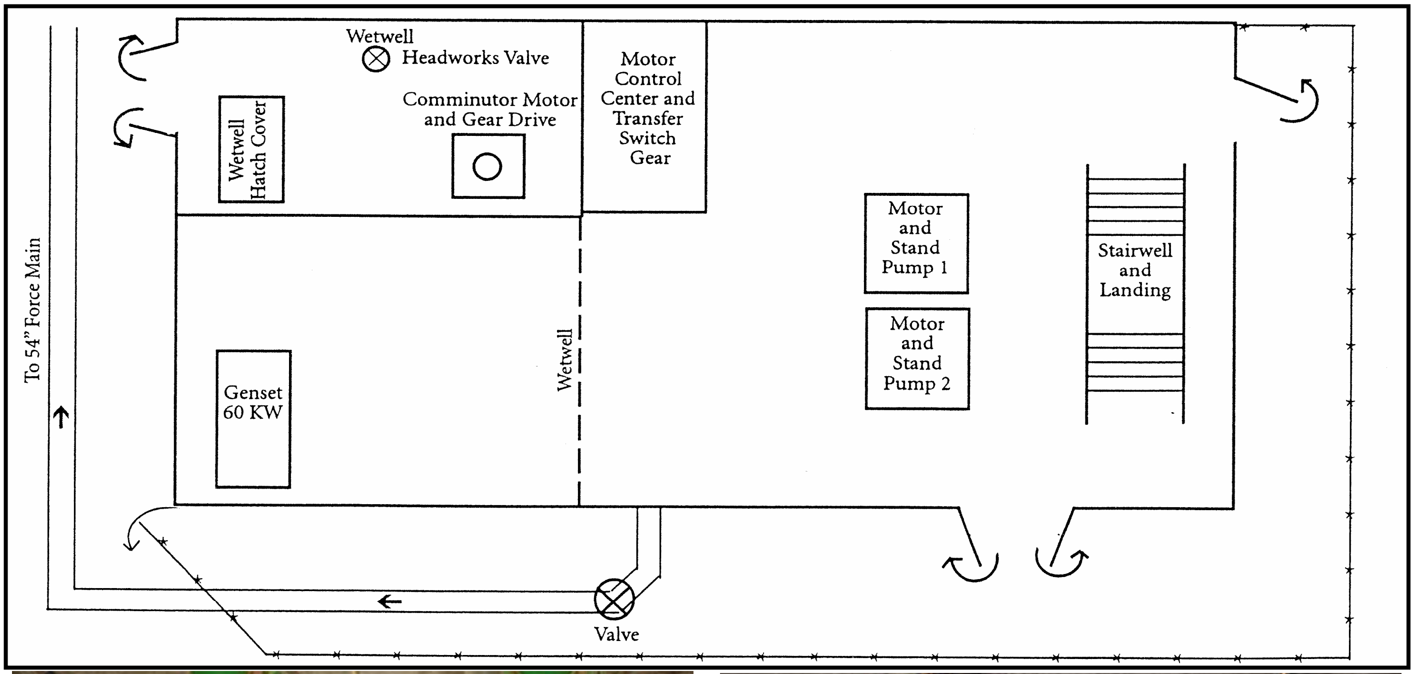
Uniform Building Code (California Building Code - Part 2, Title 24, CCR), latest edition.

National Fire Protection Association (NFPA) 820 (Recommended Practice for Fire Protection in Wastewater Treatment and Collection Facilities).

California Code of Regulations, Title 8.

Field Visit Date	12/1/2005
PS Number & Name	10; Larkspur Circle B
Address	101 East Sir Francis Drake Blvd & Larkspur Landing Circle, Larkspur
Year Constructed; Improvements Past/Future	1978; PS to be rehabilitated in spring 2006. Non submersible pumps will be replaced with submersible, multiple speed drive pumps.
Number of Pumps/Number of Standbys	1/1
Pump Type	2-speed electric
Primary Power Source	PG&E
Standby Generator	Natural gas; 60 kW
Normal Operating Capacity (MGD)	1.37
Firm Capacity (MGD)	1.37
Operating Point (gpm/feet)	500 gpm @ 29'
Influent Sewer Size/Effluent Force Main Size	6"/6"
Horsepower Rating (hp)/Motor Speed	11.6 hp @ 900 rpm/25 hp @1,200 rpm
Pump Elevation (feet)	-7.77
Bypass capabilities	None
Permit Required Confined Space	Permit required for wet well entry (stair access). Alternate procedures may be used for entry into dry well and if all required conditions are met, for wet well entry.
Notes	• Pump station is planned for rehabilitation. Cost of rehabilitation is approximately $1.0 million.
Identified Issues	• Pump enclosure is not well ventilated. • Water system has no back flow preventer.
Recommendations	• **Piping & Valving:** NA • **Electrical:** NA • **Instrumentation & Control:** NA • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA

PS Number & Name	10; Larkspur Circle B



PS Number & Name 10 (Larkspur)

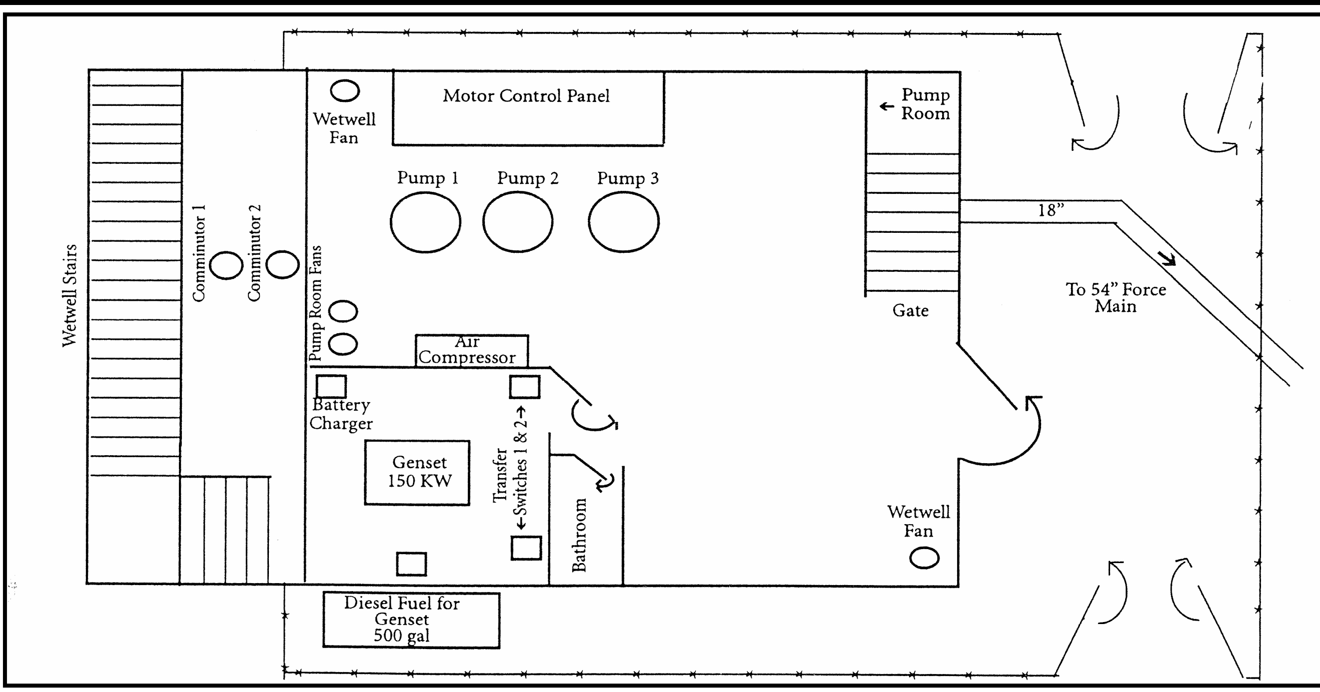
MAJOR ITEMS	Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST			
Piping & Valving			
Replacing Piping & Valving			$ -
Coating			$ -
Flow Meter Vault			$ -
subtotal:			*$ -*
Electrical			
General			$ -
Power Feed			$ -
Motor Control Center (MCC)			$ -
Standby Power			$ -
subtotal:			*$ -*
Instrumentation & Control			
SCADA			$ -
Pump Control			$ -
Flow Meter			$ -
subtotal:			*$ -*
Structural			
General			$ -
Wet Well Concrete			$ -
Structural Condition			$ -
Leaks, Spalling, Cracks			$ -
subtotal:			*$ -*
Health & Safety			
Regulatory Compliance			$ -
Ventilation			$ -
Explosion-Proof Retrofit			$ -
subtotal:			*$ -*
Neighborhood Nuisance			
Odor Control			$ -
Noise Control/Sound Enclosure			$ -
Visual			$ -
Site Security			$ -
subtotal:			*$ -*
Pumps Improvement			
Under Capacity			$ -
New Pumps			$ -
subtotal:			*$ -*
Influent Sewer/Force Main			
Influent Sewer			$ -
Force Main			$ -
subtotal:			*$ -*
Maintenance/Reliability			
Access			$ -
Conversion to Submersible Station			$ -
Configuration Change			$ -
subtotal:			*$ -*
Overflow Potential			
			$ -
subtotal:			*$ -*
Mobilization and Demobilization			
Allowance			$ -
Construction Cost Subtotal:			**$ -**
Contingencies			$ -
Construction Cost Total:			$ -
Engineering/Legal/Admin Costs			$ -
CAPITAL IMPROVEMENT TOTAL COST[a]			**$ -**

Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	NA
PS Number & Name	11; San Quentin
Address	East Sir Francis Drake & West Gate
Year Constructed; Improvements Past/Future	1985; Mostly original other than repair/rebuilding.
Number of Pumps/Number of Standbys	2/1
Pump Type	3 electric dry-pit
Primary Power Source	PG&E, 480 V, 3-phase
Standby Generator	Diesel; 150 KW; 500 gal
Normal Operating Capacity (MGD)	2.88
Firm Capacity (MGD)	2.88
Operating Point (gpm/feet)	1400 gpm @ 53'
Influent Sewer Size/Effluent Force Main Size	8"/6"
Horsepower Rating (hp)/Motor Speed	30 hp
Pump Elevation (feet)	-5.79
Bypass capabilities	None
Notes	Pump station not inspected.
Identified Issues	NA
Recommendations	• **Piping & Valving:** NA • **Electrical:** NA • **Instrumentation & Control:** NA • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA



PS Number & Name 11 (San Quentin)

MAJOR ITEMS	Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST			
Piping & Valving			
Replacing Piping & Valving			$ -
Coating			$ -
Flow Meter Vault			$ -
subtotal:			*$ -*
Electrical			
General			$ -
Power Feed			$ -
Motor Control Center (MCC)			$ -
Standby Power			$ -
subtotal:			*$ -*
Instrumentation & Control			
SCADA			$ -
Pump Control			$ -
Flow Meter			$ -
subtotal:			*$ -*
Structural			
General			$ -
Wet Well Concrete			$ -
Structural Condition			$ -
Leaks, Spalling, Cracks			$ -
subtotal:			*$ -*
Health & Safety			
Regulatory Compliance			$ -
Ventilation			$ -
Explosion-Proof Retrofit			$ -
subtotal:			*$ -*
Neighborhood Nuisance			
Odor Control			$ -
Noise Control/Sound Enclosure			$ -
Visual			$ -
Site Security			$ -
subtotal:			*$ -*
Pumps Improvement			
Under Capacity			$ -
New Pumps			$ -
subtotal:			*$ -*
Influent Sewer/Force Main			
Influent Sewer			$ -
Force Main			$ -
subtotal:			*$ -*
Maintenance/Reliability			
Access			$ -
Conversion to Submersible Station			$ -
Configuration Change			$ -
subtotal:			*$ -*
Overflow Potential			
			$ -
subtotal:			*$ -*
Mobilization and Demobilization			
Allowance			$ -
Construction Cost Subtotal:			**$ -**
Contingencies			$ -
Construction Cost Total:			$ -
Engineering/Legal/Admin Costs			$ -
CAPITAL IMPROVEMENT TOTAL COST[a]			**$ -**

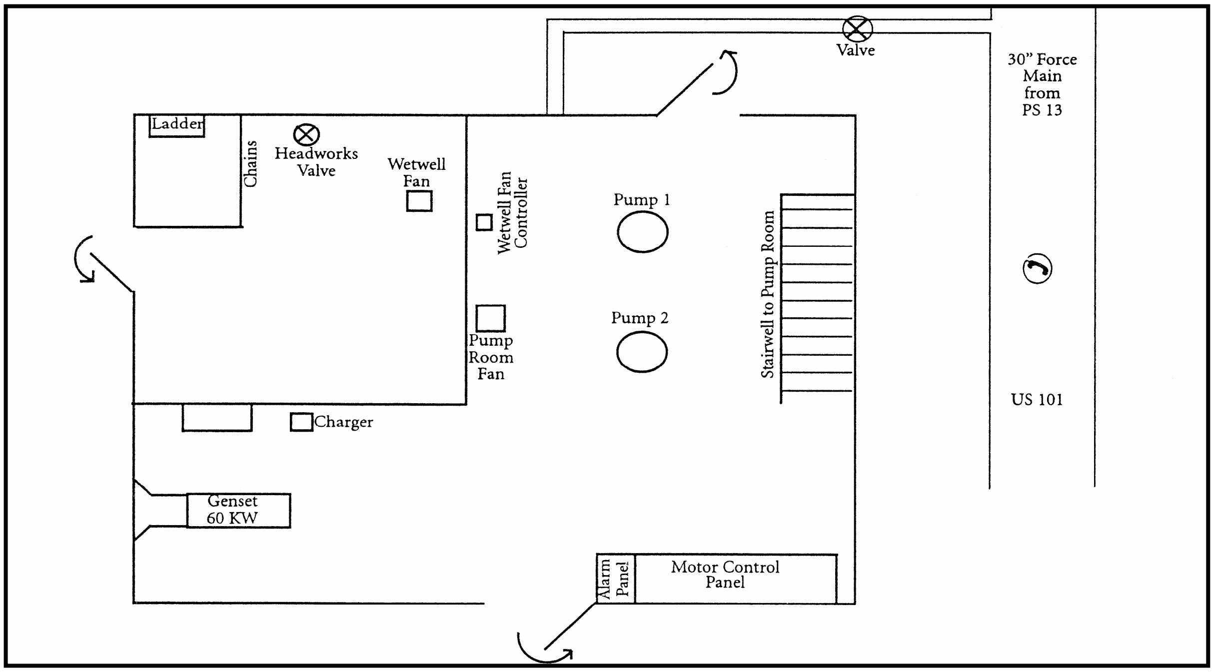
Footnote:

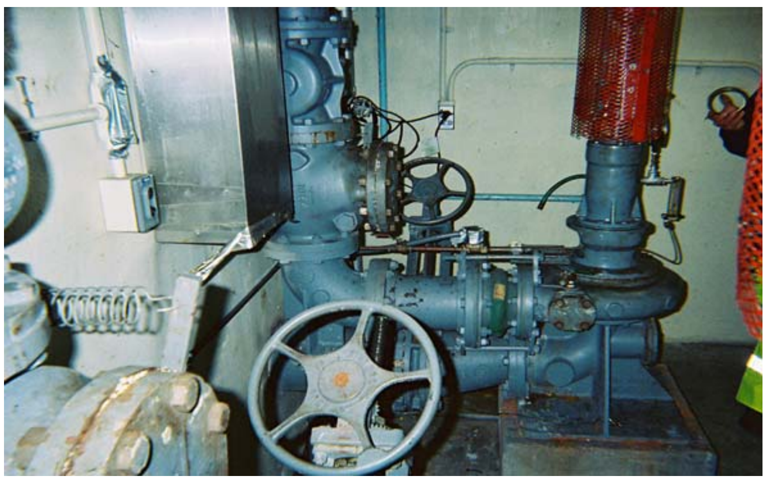
a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	12/1/2005
PS Number & Name	12; Bon Air Center PS
Address	380 Bon Air Shopping Center Sir Francis Drake Blvd & Eliseo Drive, Greenbrae
Year Constructed; Improvements Past/Future	1984; Mostly original other than repair/rebuilding.
Number of Pumps/Number of Standbys	1/1
Pump Type	Dry-pit; two-speed pump
Primary Power Source	PG&E, 220 V
Standby Generator	Natural gas generator; 60 KW
Normal Operating Capacity (MGD)	1.51
Firm Capacity (MGD)	0.68
Operating Point (gpm/feet)	300 gpm @43'
Influent Sewer Size/Effluent Force Main Size	6"/4"
Horsepower Rating (hp)/Motor Speed	15 hp @ 1780 rpm//6.7 hp @ 1185 rpm
Pump Elevation (feet)	-10.5
Bypass capabilities	None
Notes	• Alarm:station is controlled with bubbler. • Outage: Pump station failed on 8/25/2003.
Identified Issues	• Air release valve does not work well. • Suction head problems probably resulting from vacuum on suction line. Bigger suction line to be installed to fix head problems. • Comminutor is not brought back on-line after power outage. • Ventilation: Vent into station is not activated because it pumps air from the wet well and needs to be fixed. No air mechanism other than grate opening to take air out. • Existing odor problem; odor control may be needed in the future, due to the location of the station. • During high flow conditions, 2 pumps are needed to convey peak flows. There is
Recommendations	• **Piping & Valving:** Replace pump suction line. Repair air release valve. • **Electrical:** Allowance for general electrical upgrades. • **Instrumentation & Control:** Install flow meter. Fix pump control. Connect to SCADA. • **Structural:** Allowance for general structural upgrades. • **Health & Safety:** Install adequate ventilation system. • **Neighborhood Nuisance:** Install odor control system. • **Pumps Improvement:** Increase firm capacity of station by replacing the 2 pumps. • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA

PS Number & Name	12; Bon Air Center PS





PS Number & Name 12 (Bon Air)

MAJOR ITEMS	Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST			
Piping & Valving			
Replacing Piping & Valving (Air release valve)	1	$1,000	$ 1,000
Replacing Piping & Valving (Suction line improvements)	1	$30,000	$ 30,000
Coating	1	$2,000	$ 2,000
Flow Meter Vault			$ -
subtotal:			*$ 33,000*
Electrical			
General	1	$20,000	$ 20,000
Power Feed			$ -
Motor Control Center (MCC)	2	$10,000	$ 20,000
Standby Power			$ -
subtotal:			*$ 40,000*
Instrumentation & Control			
SCADA	1	$10,000	$ 10,000
Pump Control (Communitor control)	1	$5,000	$ 5,000
Flow Meter	2	$5,000	$ 10,000
subtotal:			*$ 25,000*
Structural			
General	1	$10,000	$ 10,000
Wet Well Concrete			$ -
Structural Condition			$ -
Leaks, Spalling, Cracks			$ -
subtotal:			*$ 10,000*
Health & Safety			
Regulatory Compliance			$ -
Ventilation	1	$15,000	$ 15,000
Explosion-Proof Retrofit			$ -
subtotal:			*$ 15,000*
Neighborhood Nuisance			
Odor Control	1	$50,000	$ 50,000
Noise Control/Sound Enclosure			$ -
Visual			$ -
Site Security			$ -
subtotal:			*$ 50,000*
Pumps Improvement			
Under Capacity	2	$20,000	$ 40,000
New Pumps			$ -
subtotal:			*$ 40,000*
Influent Sewer/Force Main			
Influent Sewer			$ -
Force Main			$ -
subtotal:			*$ -*
Maintenance/Reliability			
Access			$ -
Conversion to Submersible Station			$ -
Configuration Change			$ -
subtotal:			*$ -*
Overflow Potential			
			$ -
subtotal:			*$ -*
Mobilization and Demobilization			
Allowance		5%	$ 10,700
Construction Cost Subtotal:			**$ 223,700**
Contingencies		30%	$ 67,100
Construction Cost Total:			$ 290,800
Engineering/Legal/Admin Costs		25%	$ 72,700
CAPITAL IMPROVEMENT TOTAL COST[a]			**$ 364,000**

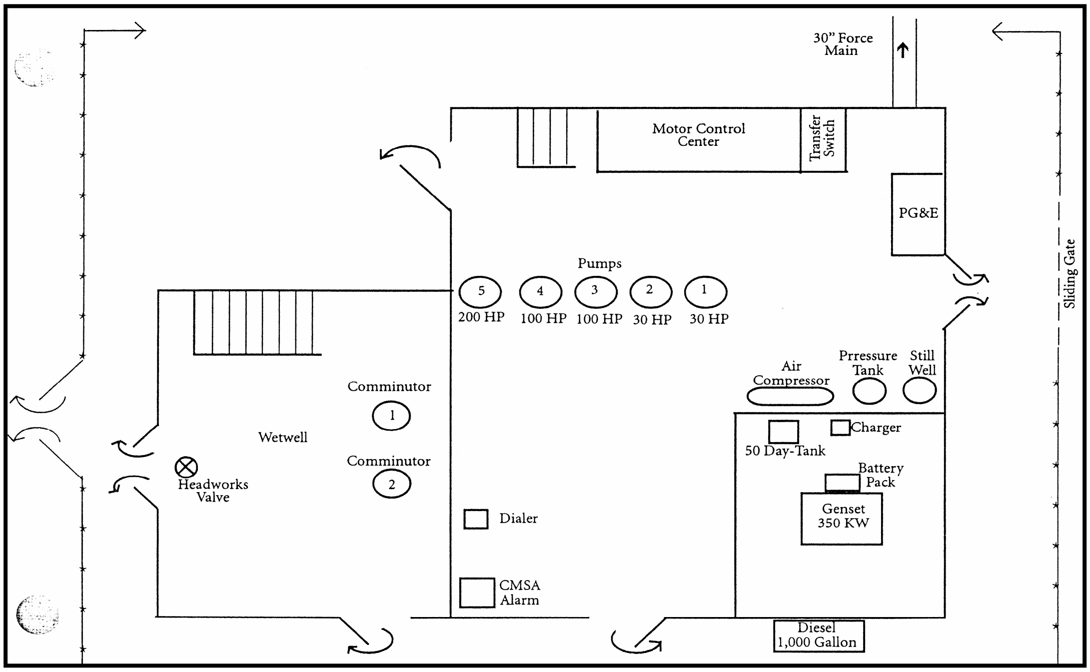
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	12/1/2005
PS Number & Name	13; Greenbrae PS
Address	70 Bon Air Shopping Center & La Cuesta Drive, Greenbrae
Year Constructed; Improvements Past/Future	1984; Mostly original other than repair/rebuilding. Variable Frequency Drives have been replaced.
Number of Pumps/Number of Standbys	26.1/26.2 (Duty/Standby) 26.3/26.4 (Duty/Standby) 26.5 (Standby)
Pump Type	Dry-pit, variable speed.
Primary Power Source	PG&E, 480V
Standby Generator	Diesel generator; 350 KW; 1000 gal; 50 gal day tank
Normal Operating Capacity (MGD)	9.96
Firm Capacity (MGD)	9.96
Operating Point (gpm/feet)	1400 gpm @ 45' (26.1 - 26.2) 4600 gpm @ 60' (26.3 - 26.4) 4500 gpm @ 97' (26.5)
Influent Sewer Size/Effluent Force Main Size	6"/8" (26.1 - 26.2) 10"/12" (26.3 - 26.4 - 26.5)
Horsepower Rating (hp)/Motor Speed (rpm)	30 hp @ 880 rpm 100 hp @ 890 rpm 200 hp @ 880 rpm
Pump Elevation (feet)	-15.96 (26.1 - 26.2) -15.31 (26.3 - 26.4) -14.92 (26.5)
Bypass capabilities	Dry weather bypass to PS 15. Bypass is untested.
Notes	• Ultrasonic Oscillator flow meter. • Outage: Possible water leak identified on 6/21/2004.
Identified Issues	• PS 26.3 has a hole in check valve. • Ventilation: Forced air. Dual ventilation supply/exhaust. Exhaust fan is pushing more air in than pulling out. • Odor control: carbon-activated. Odor control fan to be checked for explosion-proofness. Rest of odor control room functions properly.
Recommendations	• **Piping & Valving:** Replace valve downstream of flow meter. • **Electrical:** Allowance for general electrical upgrades. • **Instrumentation & Control**: Install flow meter on the discharge line of each pump. Install bubbler. Connect to SCADA. • **Structural:** Allowance for general structural upgrades. • **Health & Safety:** Improve ventilation to put building under negative pressure. Replace control odor fan, as needed. • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA

PS Number & Name	13; Greenbrae PS



PS Number & Name 13 (Greenbrae)

MAJOR ITEMS		Quantity	Unit Cost		Extended Cost
BASELINE CONSTRUCTION COST					
Piping & Valving					
Replacing Piping & Valving		1	$20,000	$	20,000
Coating				$	-
Flow Meter Vault				$	-
	subtotal:			*$*	*20,000*
Electrical					
General		1	$30,000	$	30,000
Power Feed				$	-
Motor Control Center (MCC)				$	-
Standby Power				$	-
	subtotal:			*$*	*30,000*
Instrumentation & Control					
SCADA		1	$20,000	$	20,000
Pump Control		1	$5,000	$	5,000
Flow Meter		1	$5,000	$	5,000
	subtotal:			*$*	*30,000*
Structural					
General		1	$20,000	$	20,000
Wet Well Concrete				$	-
Structural Condition				$	-
Leaks, Spalling, Cracks				$	-
	subtotal:			*$*	*20,000*
Health & Safety					
Regulatory Compliance				$	-
Ventilation		1	$25,000	$	25,000
Explosion-Proof Retrofit		1	$30,000	$	30,000
	subtotal:			*$*	*55,000*
Neighborhood Nuisance					
Odor Control				$	-
Noise Control/Sound Enclosure				$	-
Visual				$	-
Site Security				$	-
	subtotal:			*$*	*-*
Pumps Improvement					
Under Capacity				$	-
New Pumps				$	-
	subtotal:			*$*	*-*
Influent Sewer/Force Main					
Influent Sewer				$	-
Force Main				$	-
	subtotal:			*$*	*-*
Maintenance/Reliability					
Access				$	-
Conversion to Submersible Station				$	-
Configuration Change				$	-
	subtotal:			*$*	*-*
Overflow Potential					
				$	-
	subtotal:			*$*	*-*
Mobilization and Demobilization					
Allowance			5%	$	7,800
Construction Cost Subtotal:				**$**	**162,800**
Contingencies			30%	$	48,800
Construction Cost Total:				$	211,600
Engineering/Legal/Admin Costs			25%	$	52,900
CAPITAL IMPROVEMENT TOTAL COST[a]				**$**	**265,000**

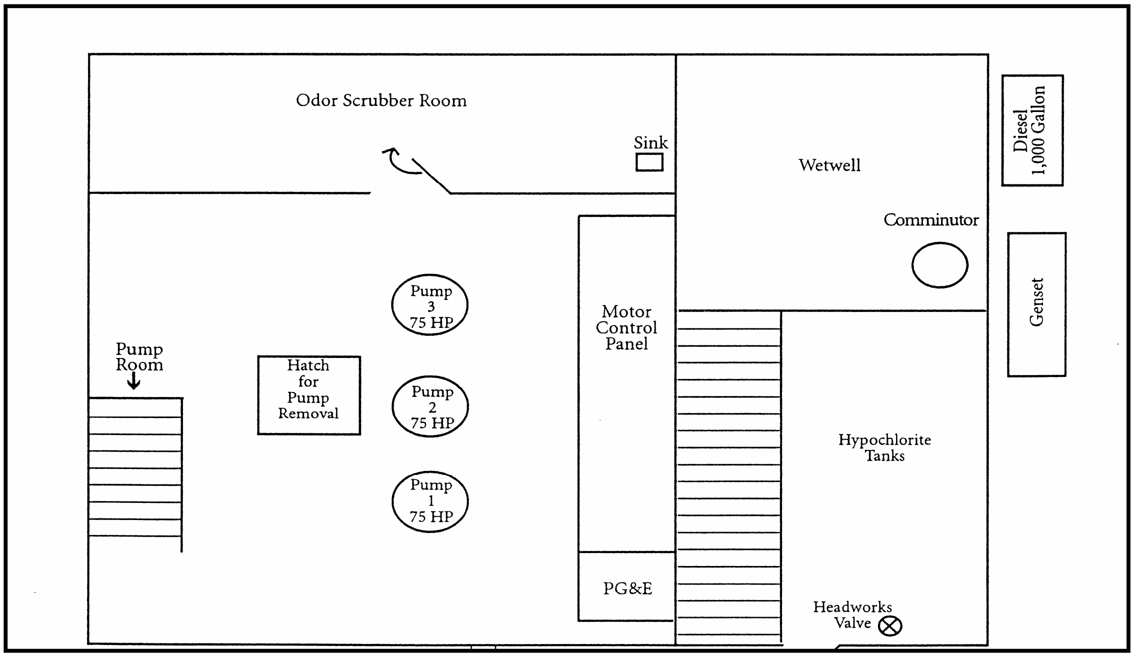
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	19-Apr-06
PS Number & Name	14; Larkspur Main PS
Address	200 Doherty Drive
Year Constructed; Improvements Past/Future	1989; Motors/Rail/Electrical panels rehabilitated in 2005.
Number of Pumps/Number of Standbys	1/1/1 (Lead/Lag/Standby)
Pump Type	Variable speed electric (Lead/Lag); standby is operated at constant speed.
Primary Power Source	PG&E, 480V, 3-phase
Standby Generator	Diesel backup generator; 350 KW; 50 gal
Normal Operating Capacity (MGD)	8.4
Firm Capacity (MGD)	5.9
Operating Point (gpm/feet)	1200 gpm @ 95' (pumps 1 & 2 to PS 13) 1200 gpm @122' (pump 3 to 42-inch pipeline)
Influent Sewer Size/Effluent Force Main Size	5"/ 8"/6"
Horsepower Rating (hp)/Motor Speed (rpm)	75 hp @ 1780 rpm
Pump Elevation (feet)	-8.57
Bypass capabilities	Wet weather bypass to PS 13.
Notes	• Pump station is on data loggers and cell phone since December 31, 2005 flood. • Motors are immersible. • Flow monitoring: There is a flow meter vault installed outside of the pump building but no flow meter has been installed yet.
Identified Issues	• Odor Control: An odor control room was installed at station to address odor problem (proximity to school). • Ventilation: There is only one vent in. A second vent could be installed for more air circulation. • Station is lacking firm capacity (See SHECAP results).
Recommendations	• **Piping & Valving:** NA • **Electrical:** NA • **Instrumentation & Control:** Install flow meter in existing flow meter vault. Install new control for new pumps, as needed. Connect flow meter to SCADA. • **Structural:** NA • **Health & Safety:** Ventilation: Install one additional vent in. • **Neighborhood Nuisance:** NA • **Pumps Improvement:** Investigate whether the horsepower of motors or VFDs can increase the pump speed to reach design and firm capacity requirements. If this can't be accommodated, it may be needed to install 2 new pumps to address lack of firm capacity. • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA

PS Number & Name	14; Larkspur Main PS



PS Number & Name 14 (Larkspur)

MAJOR ITEMS	Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST			
Piping & Valving			
Replacing Piping & Valving			$ -
Coating			$ -
Flow Meter Vault			$ -
subtotal:			*$ -*
Electrical			
General			$ -
Power Feed			$ -
Motor Control Center (MCC)			$ -
Standby Power			$ -
subtotal:			*$ -*
Instrumentation & Control			
SCADA	1	$10,000	$ 10,000
Pump Control	1	$5,000	$ 5,000
Flow Meter	1	$5,000	$ 5,000
subtotal:			*$ 20,000*
Structural			
General			$ -
Wet Well Concrete			$ -
Structural Condition			$ -
Leaks, Spalling, Cracks			$ -
subtotal:			*$ -*
Health & Safety			
Regulatory Compliance			$ -
Ventilation	1	$5,000	$ 5,000
Explosion-Proof Retrofit			$ -
subtotal:			*$ 5,000*
Neighborhood Nuisance			
Odor Control			$ -
Noise Control/Sound Enclosure			$ -
Visual			$ -
Site Security			$ -
subtotal:			*$ -*
Pumps Improvement			
Under Capacity	2	$20,000	$ 40,000
New Pumps			$ -
subtotal:			*$ 40,000*
Influent Sewer/Force Main			
Influent Sewer			$ -
Force Main			$ -
subtotal:			*$ -*
Maintenance/Reliability			
Access			$ -
Conversion to Submersible Station			$ -
Configuration Change			$ -
subtotal:			*$ -*
Overflow Potential			
			$ -
subtotal:			*$ -*
Mobilization and Demobilization			
Allowance		5%	$ 3,300
Construction Cost Subtotal:			**$ 68,300**
Contingencies		30%	$ 20,500
Construction Cost Total:			$ 88,800
Engineering/Legal/Admin Costs		25%	$ 22,200
CAPITAL IMPROVEMENT TOTAL COST[a]			**$ 111,000**

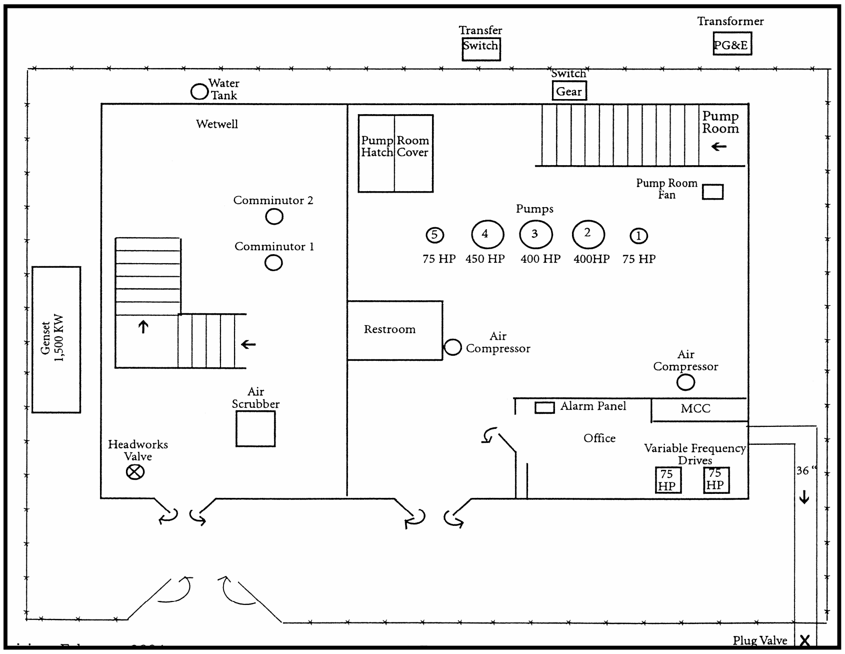
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	12/1/2005
PS Number & Name	15; Kentfield PS
Address	Corte Madera Creek & Stadium Way, Kentfield
Year Constructed; Improvements Past/Future	1971 (original); rehabilitated in 2005; All PS have been rehabilitated recently.
Number of Pumps/Number of Standbys	Pumps 1 & 5 (Dry weather) Pumps 2, 3 & 4 (Wet weather)
Pump Type	Dry-pit, variable speed.
Primary Power Source	PG&E
Standby Generator	Diesel backup generator; 6000 gal; 1,500 KW
Normal Operating Capacity (MGD)	41.9
Firm Capacity (MGD)	36.9
Operating Point (gpm/feet)	4000 gpm @ 56' (Pumps 1 & 5) 16,000 gpm @ 78' (Pumps 2, 3 & 4)
Influent Sewer Size/Effluent Force Main Size	20"/24" (pumps 2, 3 &4)
Horsepower Rating (hp)/Motor Speed (rpm)	75 hp @ 750 rpm (Pumps 1 & 5) 400 hp @ 895 rpm (Pumps 2, 3 & 4)
Pump Elevation (feet)	-16/-14
Bypass capabilities	Dry-weather bypass to PS 13.
Notes	• Insulator between SS header and support. • Pneumatic valves on discharge. • Air tank move water fail safe. • Outage: Various issues, especially in late 2003. Outage in December 2005.
Identified Issues	• Ventilation: Air comes in only one side of station. • Station is lacking firm capacity based on SHECAP analysis. • There is only 1 flow meter for 5 pumps.
Recommendations	• **Piping & Valving:** NA • **Electrical:** Electrical allowance if VFDs need to be replaced. • **Instrumentation & Control:** Install flow meters at discharge end of each pump. Install new control for new pumps, as needed. Connect to SCADA. • **Structural:** NA • **Health & Safety:** Improve ventilation system. • **Neighborhood Nuisance:** NA • **Pumps Improvement:** Firm capacity is likely to be addressed by rehabilitating and upsizing the existing 36" force main to 42" (See Force Main Master Plan). If problem persists after force main size increase, increase the size of 2 dry-weather pumps (possibly by increasing pumps speed, provided motors or VFDs have adequate capacity; otherwise, VFDs would have to be replaced). • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA

PS Number & Name	15; Kentfield PS



PS Number & Name 15 (kentfield)

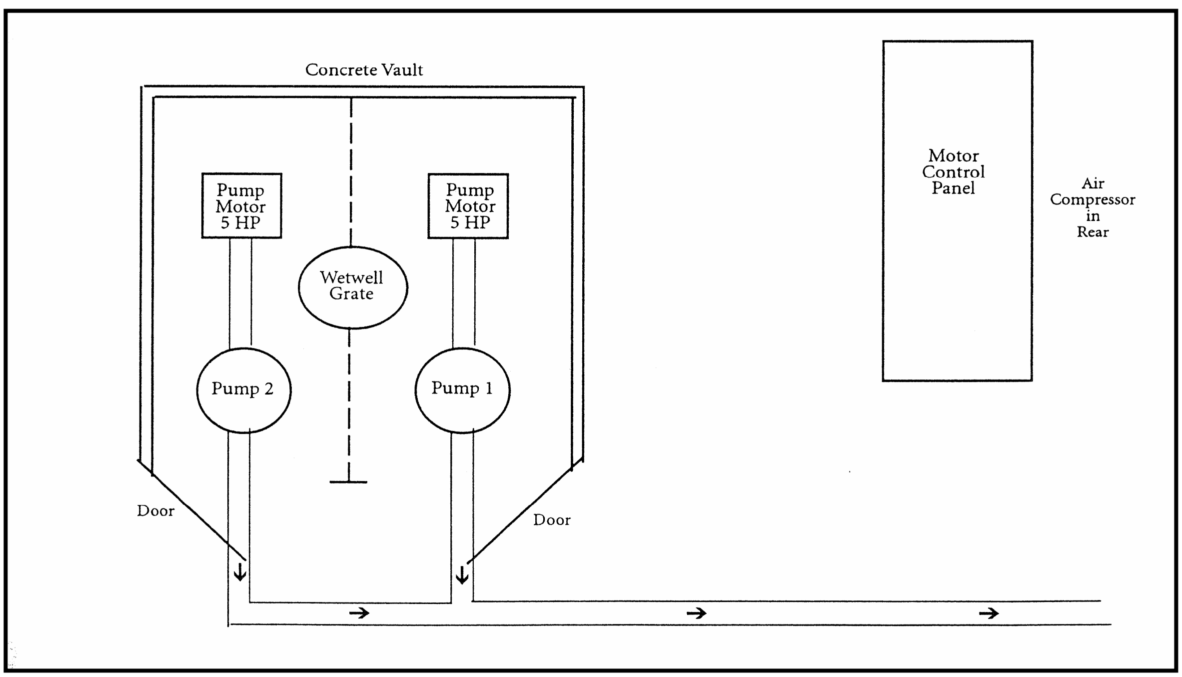
MAJOR ITEMS	Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST			
Piping & Valving			
Replacing Piping & Valving			$ -
Coating			$ -
Flow Meter Vault			$ -
subtotal:			*$ -*
Electrical			
General	1	$10,000	$ 10,000
Power Feed			$ -
Motor Control Center (MCC)			$ -
Standby Power			$ -
subtotal:			*$ 10,000*
Instrumentation & Control			
SCADA	1	$10,000	$ 10,000
Pump Control	1	$10,000	$ 10,000
Flow Meter (wet-weather pumps)	3	$10,000	$ 30,000
Flow Meter (Dry-weather pumps)	2	$7,500	$ 15,000
subtotal:			*$ 65,000*
Structural			
General			$ -
Wet Well Concrete			$ -
Structural Condition			$ -
Leaks, Spalling, Cracks			$ -
subtotal:			*$ -*
Health & Safety			
Regulatory Compliance			$ -
Ventilation	1	$15,000	$ 15,000
Explosion-Proof Retrofit			$ -
subtotal:			*$ 15,000*
Neighborhood Nuisance			
Odor Control			$ -
Noise Control/Sound Enclosure			$ -
Visual			$ -
Site Security			$ -
subtotal:			*$ -*
Pumps Improvement			
Under Capacity			$ -
New Pumps			$ -
subtotal:			*$ -*
Influent Sewer/Force Main			
Influent Sewer			$ -
Force Main			$ -
subtotal:			*$ -*
Maintenance/Reliability			
Access			$ -
Conversion to Submersible Station			$ -
Configuration Change			$ -
subtotal:			*$ -*
Overflow Potential			
			$ -
subtotal:			*$ -*
Mobilization and Demobilization			
Allowance		5%	$ 4,500
Construction Cost Subtotal:			**$ 94,500**
Contingencies		30%	$ 28,400
Construction Cost Total:			$ 122,900
Engineering/Legal/Admin Costs		25%	$ 30,700
CAPITAL IMPROVEMENT TOTAL COST[a]			**$ 154,000**

Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	12/1/2005
PS Number & Name	20; Larkspur Circle A
Address	17 East Sir Francis Drake Blvd & Larspur Landing Circle, Larkspur
Year Constructed; Improvements Past/Future	Mid-1970s; Mostly original other than repair/rebuilding. Electrical panels are planned to be changed.
Number of Pumps/Number of Standbys	1/1
Pump Type	Dry-pit.
Primary Power Source	PG&E, 220 V, 3-phase
Standby Generator	Portable diesel; 60 KW; 125 gal; 7-day run time; 50% loaded
Normal Operating Capacity (MGD)	Unknown (Assumed 0.36 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.36 MGD)
Operating Point (gpm/feet)	Unknown
Influent Sewer Size/Effluent Force Main Size	8"/6"
Horsepower Rating (hp)/Motor Speed (rpm)	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Outage: Power failures on 4/7/2000 and due to heavy rain on 11/8/2002.
Identified Issues	• Busy street can be impacted by closure if back up generator is needed. • Station is not compliant with fire code standards. • Existing pumps are self-priming.
Recommendations	• **Piping & Valving:** Construct flow meter vault; Replace piping and valving as needed. • **Electrical**: Install back-up generator on site. • **Instrumentation & Control:** Install flow meter. Install bubbler. Connect to SCADA. • **Structural:** Modify valve pit and wet well. • **Health & Safety:** Upgrade station to current fire code standards. Upgrade station to be explosion-proof. Install ventilation system within vault. • **Neighborhood Nuisance**: NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** Replace existing self-priming pumps with submersible pumps. • **Overflow Potential:** NA



PS Number & Name 20 (Larkspur A)

MAJOR ITEMS		Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST				
Piping & Valving				
Replacing Piping & Valving		2	$7,500	$ 15,000
Coating				$ -
Flow Meter Vault		1	$10,000	$ 10,000
	subtotal:			*$ 25,000*
Electrical				
General		1	$10,000	$ 10,000
Power Feed				$ -
Motor Control Center (MCC)				$ -
Standby Power		1	$25,000	$ 25,000
	subtotal:			*$ 35,000*
Instrumentation & Control				
SCADA		1	$10,000	$ 10,000
Pump Control				$ -
Flow Meter		1	$5,000	$ 5,000
	subtotal:			*$ 15,000*
Structural				
General				$ -
Wet Well Concrete		1	$5,000	$ 5,000
Structural Condition		1	$5,000	$ 5,000
Leaks, Spalling, Cracks				$ -
	subtotal:			*$ 10,000*
Health & Safety				
Regulatory Compliance		1	$2,500	$ 2,500
Ventilation		1	$1,000	$ 1,000
Explosion-Proof Retrofit		1	$2,500	$ 2,500
	subtotal:			*$ 6,000*
Neighborhood Nuisance				
Odor Control				$ -
Noise Control/Sound Enclosure				$ -
Visual				$ -
Site Security				$ -
	subtotal:			*$ -*
Pumps Improvement				
Under Capacity				$ -
New Pumps				$ -
	subtotal:			*$ -*
Influent Sewer/Force Main				
Influent Sewer				$ -
Force Main				$ -
	subtotal:			*$ -*
Maintenance/Reliability				
Access				$ -
Conversion to Submersible Station		2	$30,000	$ 60,000
Configuration Change				$ -
	subtotal:			*$ 60,000*
Overflow Potential				
				$ -
	subtotal:			*$ -*
Mobilization and Demobilization				
Allowance			5%	$ 7,600
Construction Cost Subtotal:				**$ 158,600**
Contingencies			30%	$ 47,600
Construction Cost Total:				$ 206,200
Engineering/Legal/Admin Costs			25%	$ 51,600
CAPITAL IMPROVEMENT TOTAL COST[a]				**$ 258,000**

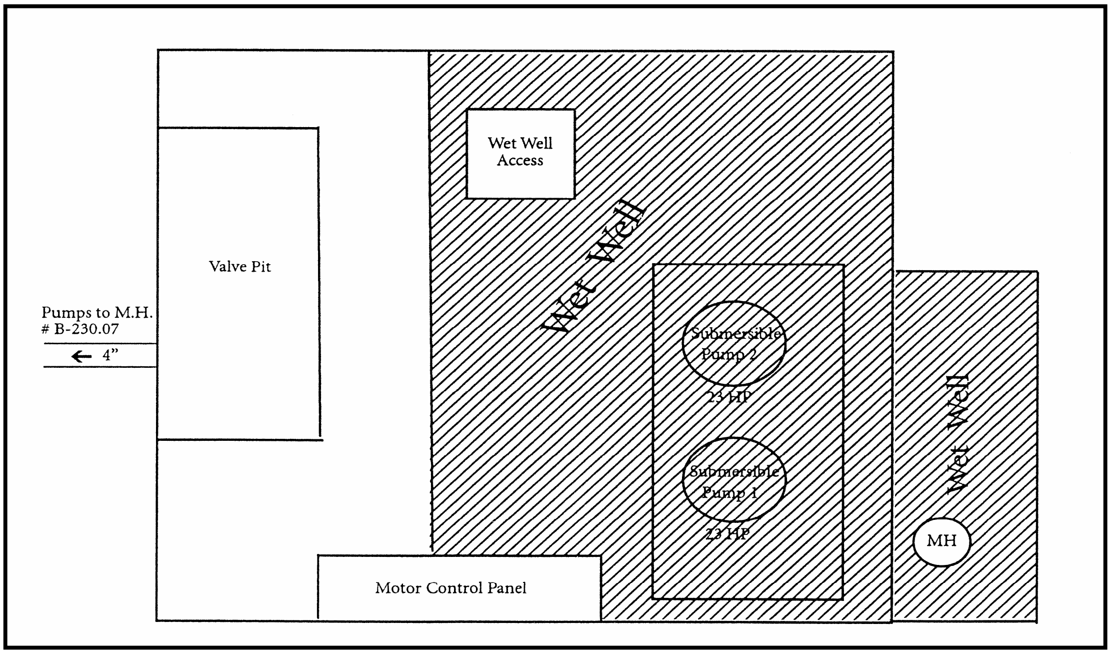
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	21; 101
Address	Highway 101 & Corte Placida, Greenbrae
Year Constructed; Improvements Past/Future	Mid-1040s; 2000
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Portable diesel; 60 KW; 125 gal
Normal Operating Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Operating Point (gpm/feet)	150 gpm
Influent Sewer Size/Effluent Force Main Size	6"/4" to pumps to MH#B-230.07
Horsepower Rating (hp)/Motor Speed	23 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Ultrasonic level in wet well.
Identified Issues	• Original ductile iron force main needs to be replaced (see Force Main Master Plan). • Limited access to station from Highway 101.
Recommendations	• **Piping & Valving:** Construct flow meter vault. • **Electrical:** NA • **Instrumentation & Control:** Install flow meter. Install bubbler sensor. Connect to SCADA. • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** Evaluate possibility to raise the manhole to increase wet well volume and delay overflow. Replace force main. • **Maintenance/Reliability:** NA • **Overflow Potential:** NA • **Redundancy:** Evaluate possibility of eliminating pump station by boring & jacking below HWY 101 and connecting to gravity sewer discharging to PS 20.

PS Number & Name	21; 101



PS Number & Name 21 (Highway 101)

MAJOR ITEMS		Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST				
Piping & Valving				
Replacing Piping & Valving				$ -
Coating				$ -
Flow Meter Vault		1	$10,000	$ 10,000
	subtotal:			*$ 10,000*
Electrical				
General				$ -
Power Feed				$ -
Motor Control Center (MCC)				$ -
Standby Power				$ -
	subtotal:			*$ -*
Instrumentation & Control				
SCADA		1	$10,000	$ 10,000
Pump Control (Bubbler)		1	$5,000	$ 5,000
Flow Meter		1	$5,000	$ 5,000
	subtotal:			*$ 20,000*
Structural				
General				$ -
Wet Well Concrete				$ -
Structural Condition				$ -
Leaks, Spalling, Cracks				$ -
	subtotal:			*$ -*
Health & Safety				
Regulatory Compliance				$ -
Ventilation				$ -
Explosion-Proof Retrofit				$ -
	subtotal:			*$ -*
Neighborhood Nuisance				
Odor Control				$ -
Noise Control/Sound Enclosure				$ -
Visual				$ -
Site Security				$ -
	subtotal:			*$ -*
Pumps Improvement				
Under Capacity				$ -
New Pumps				$ -
	subtotal:			*$ -*
Influent Sewer/Force Main				
Influent Sewer (Manhole raising)		1	$5,000	$ 5,000
Force Main				$ -
	subtotal:			*$ 5,000*
Maintenance/Reliability				
Access				$ -
Conversion to Submersible Station				$ -
Configuration Change				$ -
	subtotal:			*$ -*
Overflow Potential				
				$ -
	subtotal:			*$ -*
Mobilization and Demobilization				
Allowance			5%	$ 1,800
Construction Cost Subtotal:				**$ 36,800**
Contingencies			30%	$ 11,000
Construction Cost Total:				$ 47,800
Engineering/Legal/Admin Costs			25%	$ 12,000
CAPITAL IMPROVEMENT TOTAL COST[a]				**$ 60,000**

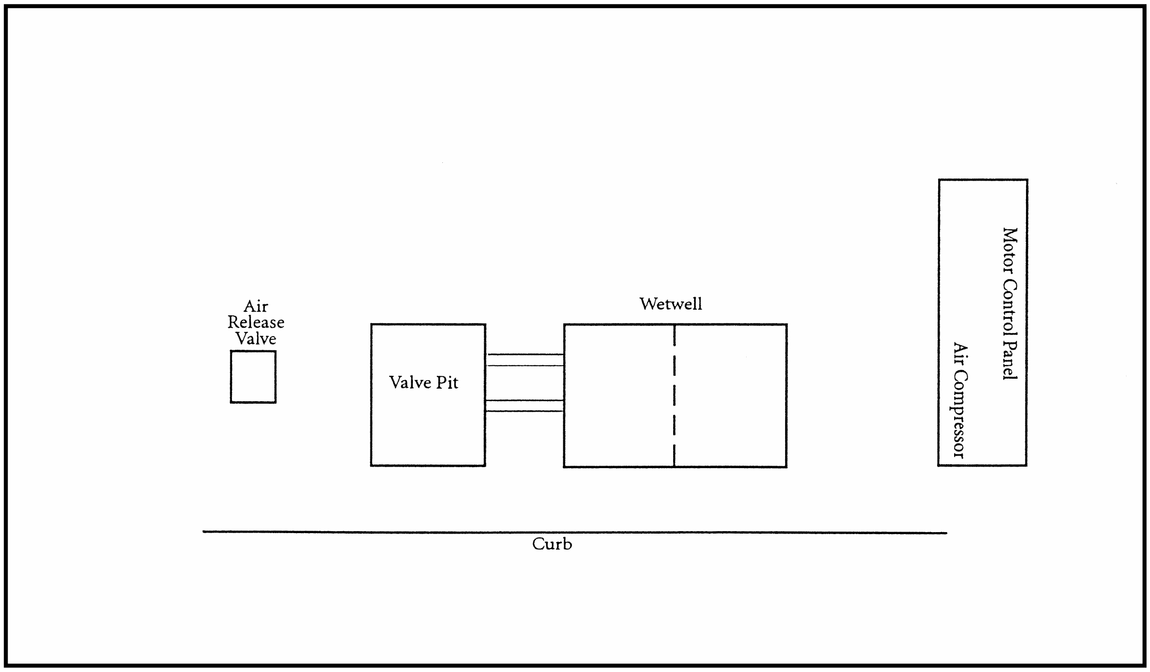
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	12/1/2005
PS Number & Name	22; Cape Marin
Address	2 Scott Place
Year Constructed; Improvements Past/Future	Late 1990s (Mostly original other than repair/rebuilding)
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Portable diesel; 60 KW; 125 gal
Normal Operating Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Operating Point (gpm/feet)	150 gpm
Influent Sewer Size/Effluent Force Main Size	6"/6"
Horsepower Rating (hp)/Motor Speed (rpm)	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Station cleaning occurs 1 to 2 times per year. • Outage: Power failures on 4/7/2000 and due to heavy rain on 11/8/2002. Water in pump #1 on 3/27/2000.
Identified Issues	• None
Recommendations	• **Piping & Valving:** Construct flow meter vault. • **Electrical:** NA • **Instrumentation & Control:** Install flow meter. Connect to SCADA. • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA • **Redundancy:** Evaluate possibility of eliminating pump station or Capurro pump station (PS 23) (both stations are in the same vicinity).

PS Number & Name	22; Cape Marin



PS Number & Name 22 (Cape Marin)

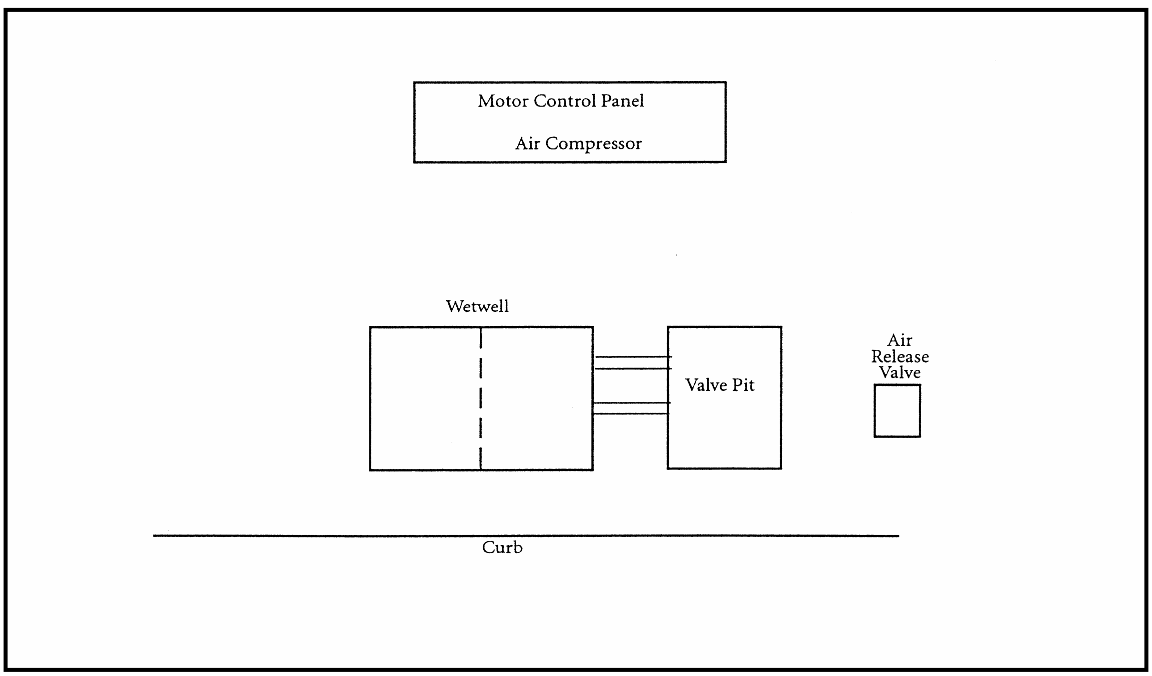
MAJOR ITEMS		Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST				
Piping & Valving				
Replacing Piping & Valving				$ -
Coating				$ -
Flow Meter Vault		1	$10,000	$ 10,000
	subtotal:			*$ 10,000*
Electrical				
General				$ -
Power Feed				$ -
Motor Control Center (MCC)				$ -
Standby Power				$ -
	subtotal:			*$ -*
Instrumentation & Control				
SCADA		1	$10,000	$ 10,000
Pump Control				$ -
Flow Meter		1	$5,000	$ 5,000
	subtotal:			*$ 15,000*
Structural				
General				$ -
Wet Well Concrete				$ -
Structural Condition				$ -
Leaks, Spalling, Cracks				$ -
	subtotal:			*$ -*
Health & Safety				
Regulatory Compliance				$ -
Ventilation				$ -
Explosion-Proof Retrofit				$ -
	subtotal:			*$ -*
Neighborhood Nuisance				
Odor Control				$ -
Noise Control/Sound Enclosure				$ -
Visual				$ -
Site Security				$ -
	subtotal:			*$ -*
Pumps Improvement				
Under Capacity				$ -
New Pumps				$ -
	subtotal:			*$ -*
Influent Sewer/Force Main				
Influent Sewer				$ -
Force Main				$ -
	subtotal:			*$ -*
Maintenance/Reliability				
Access				$ -
Conversion to Submersible Station				$ -
Configuration Change				$ -
	subtotal:			*$ -*
Overflow Potential				
				$ -
	subtotal:			*$ -*
Mobilization and Demobilization				
Allowance			5%	$ 1,300
Construction Cost Subtotal:				**$ 26,300**
Contingencies			30%	$ 7,900
Construction Cost Total:				$ 34,200
Engineering/Legal/Admin Costs			25%	$ 8,600
CAPITAL IMPROVEMENT TOTAL COST[a]				**$ 43,000**

Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	23; Capurro
Address	48 Elizabeth
Year Constructed; Improvements Past/Future	Late 1990s
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Portable diesel; 60 KW; 125 gal
Normal Operating Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Operating Point (gpm/feet)	150 gpm
Influent Sewer Size/Effluent Force Main Size	8"/6"
Horsepower Rating (hp)/Motor Speed (rpm)	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Station cleaning occurs 1 to 2 times per year.
Identified Issues	• None
Recommendations	• **Piping & Valving:** Construct flow meter vault. • **Electrical:** NA • **Instrumentation & Control:** Install flow meter. Connect to SCADA. • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA • **Redundancy:** Evaluate possibility of eliminating pump station or Capurro pump station (PS 23) (both stations are in the same vicinity).



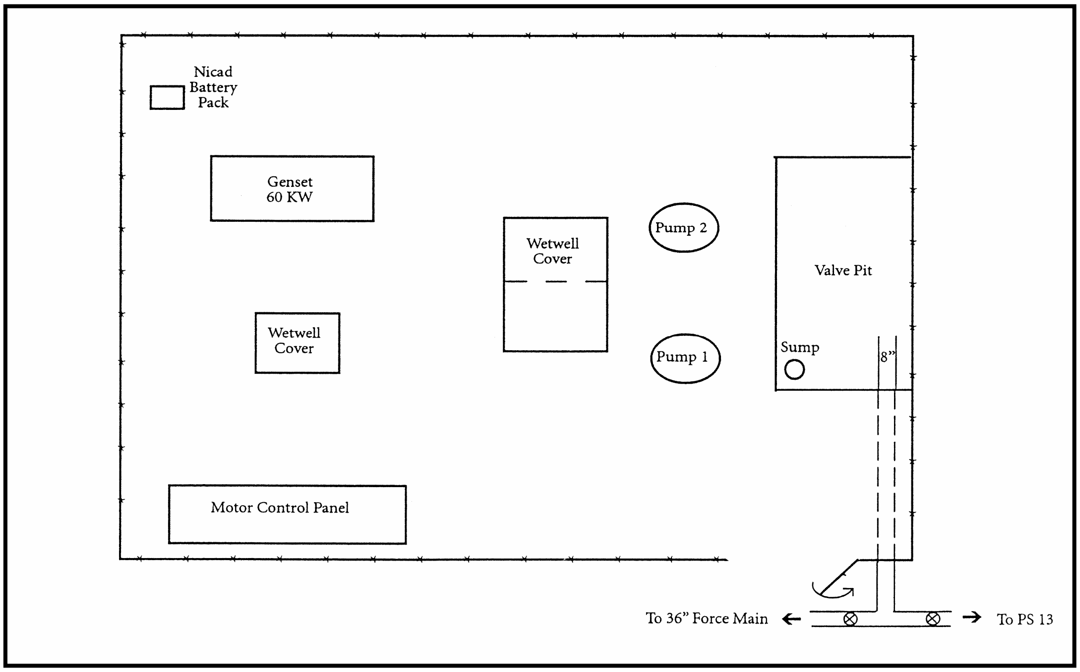
PS Number & Name 23 (Capurro)

MAJOR ITEMS	Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST			
Piping & Valving			
Replacing Piping & Valving			$ -
Coating			$ -
Flow Meter Vault	1	$10,000	$ 10,000
subtotal:			*$ 10,000*
Electrical			
General			$ -
Power Feed			$ -
Motor Control Center (MCC)			$ -
Standby Power			$ -
subtotal:			*$ -*
Instrumentation & Control			
SCADA	1	$10,000	$ 10,000
Pump Control			$ -
Flow Meter	1	$5,000	$ 5,000
subtotal:			*$ 15,000*
Structural			
General			$ -
Wet Well Concrete			$ -
Structural Condition			$ -
Leaks, Spalling, Cracks			$ -
subtotal:			*$ -*
Health & Safety			
Regulatory Compliance			$ -
Ventilation			$ -
Explosion-Proof Retrofit			$ -
subtotal:			*$ -*
Neighborhood Nuisance			
Odor Control			$ -
Noise Control/Sound Enclosure			$ -
Visual			$ -
Site Security			$ -
subtotal:			*$ -*
Pumps Improvement			
Under Capacity			$ -
New Pumps			$ -
subtotal:			*$ -*
Influent Sewer/Force Main			
Influent Sewer			$ -
Force Main			$ -
subtotal:			*$ -*
Maintenance/Reliability			
Access			$ -
Conversion to Submersible Station			$ -
Configuration Change			$ -
subtotal:			*$ -*
Overflow Potential			
			$ -
subtotal:			*$ -*
Mobilization and Demobilization			
Allowance		5%	$ 1,300
Construction Cost Subtotal:			**$ 26,300**
Contingencies		30%	$ 7,900
Construction Cost Total:			$ 34,200
Engineering/Legal/Admin Costs		25%	$ 8,600
CAPITAL IMPROVEMENT TOTAL COST[a]			**$ 43,000**

Footnote:
a. Cost estimates are rounded to the nearest $1,000.
b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	12/1/2005
PS Number & Name	24; So. Eliseo Tennis Court PS
Address	630 South Eliseo Drive & Via Holon, Larskpur
Year Constructed; Improvements Past/Future	1984; Mostly original other than repair/rebuilding.
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Natural gas; 60 KW
Normal Operating Capacity (MGD)	1.52
Firm Capacity (MGD)	1.52
Operating Point (gpm/feet)	500 gpm @ 86'
Influent Sewer Size/Effluent Force Main Size	12"/10"
Horsepower Rating (hp)/Motor Speed (rpm)	20 hp
Pump Elevation (feet)	-5.4
Bypass capabilities	Bypass to Grenbrae PS 13. Open 8" line to PS 13 and close 10" line to 36" Force main.
Notes	• Outage: Power failure due to heavy rain on 11/8/2002.
Identified Issues	• Sound issue due to proximity to residential housing.
Recommendations	• **Piping & Valving:** Construct flow meter vault. • **Electrical:** Install generator sound enclosure. • **Instrumentation & Control:** Install flow meter. Connect to SCADA. • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA

PS Number & Name	24; So. Eliseo Tennis Court PS



PS Number & Name 24 (So. Eliseo Tennis Court)

MAJOR ITEMS		Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST				
Piping & Valving				
Replacing Piping & Valving				$ -
Coating				$ -
Flow Meter Vault		1	$10,000	$ 10,000
	subtotal:			*$ 10,000*
Electrical				
General				$ -
Power Feed				$ -
Motor Control Center (MCC)				$ -
Standby Power (Generator Enclosure)		1	$15,000	$ 15,000
	subtotal:			*$ 15,000*
Instrumentation & Control				
SCADA		1	$10,000	$ 10,000
Pump Control				$ -
Flow Meter		1	$5,000	$ 5,000
	subtotal:			*$ 15,000*
Structural				
General				$ -
Wet Well Concrete				$ -
Structural Condition				$ -
Leaks, Spalling, Cracks				$ -
	subtotal:			*$ -*
Health & Safety				
Regulatory Compliance				$ -
Ventilation				$ -
Explosion-Proof Retrofit				$ -
	subtotal:			*$ -*
Neighborhood Nuisance				
Odor Control				$ -
Noise Control/Sound Enclosure				$ -
Visual				$ -
Site Security				$ -
	subtotal:			*$ -*
Pumps Improvement				
Under Capacity				$ -
New Pumps				$ -
	subtotal:			*$ -*
Influent Sewer/Force Main				
Influent Sewer				$ -
Force Main				$ -
	subtotal:			*$ -*
Maintenance/Reliability				
Access				$ -
Conversion to Submersible Station				$ -
Configuration Change				$ -
	subtotal:			*$ -*
Overflow Potential				
				$ -
	subtotal:			*$ -*
Mobilization and Demobilization				
Allowance			5%	$ 2,000
Construction Cost Subtotal:				**$ 42,000**
Contingencies			30%	$ 12,600
Construction Cost Total:				$ 54,600
Engineering/Legal/Admin Costs			25%	$ 13,700
CAPITAL IMPROVEMENT TOTAL COST[a]				**$ 68,000**

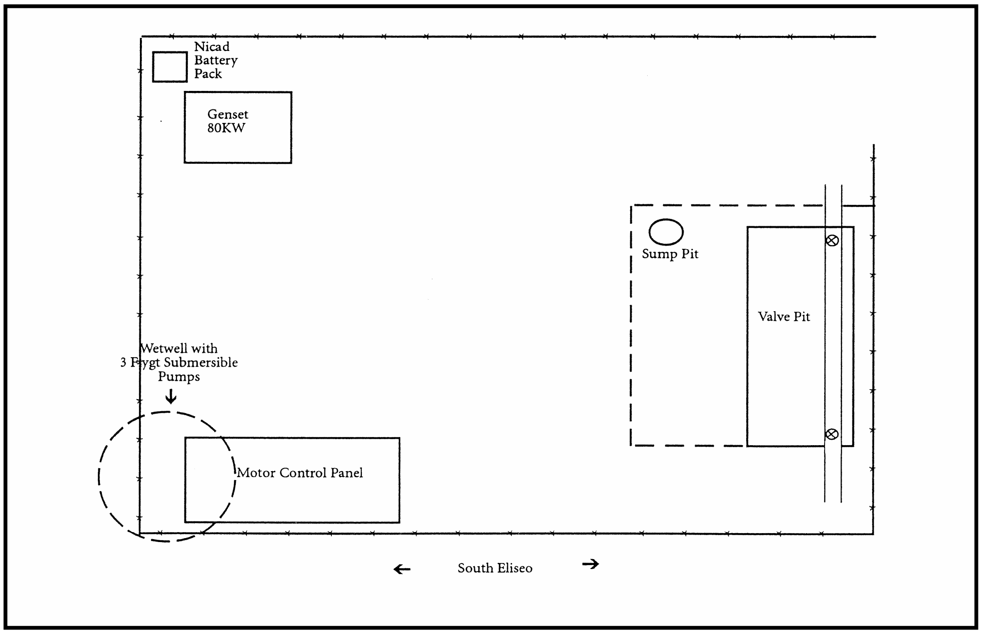
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	25; 1350 South Eliseo
Address	1350 South Eliseo
Year Constructed; Improvements Past/Future	1988
Number of Pumps/Number of Standbys	1/1/1 (Lead/Lag/Standby)
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Natural gas-powered 80 kW generator
Normal Operating Capacity (MGD)	1.41
Firm Capacity (MGD)	1.41
Operating Point (gpm/feet)	500 gpm @ 86'
Influent Sewer Size/Effluent Force Main Size	10"/8"
Horsepower Rating (hp)/Motor Speed (rpm)	Unknown
Pump Elevation (feet)	-10.2
Bypass capabilities	Bypass to PS 13. Open hospital line and close 10" valve to 36" force main.
Notes	• Outage: Power failure due to heavy rain on 11/8/2002. • Electronic level senser (Milltronics Multi-Range Plus). Typical District level monitoring is bubbler. • Cleaning of the station occurs once a year. • Local sewers experience surcharging resulting in flooding during storms. • Emergency bypass pipe access in case 8" and 10" FM fail.
Identified Issues	• Sound issue due to proximity to commercial development. • Traffic issue due to location of the pump at turning lane.
Recommendations	• **Piping & Valving:** Construct flow meter vault. • **Electrical:** Install generator sound enclosure. • **Instrumentation & Control:** Install flow meter. Install bubbler sensor. Connect to SCADA. • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** Improve station access. • **Overflow Potential:** NA

PS Number & Name	25; 1350 South Eliseo



PS Number & Name 25 (1350 South Eliseo)

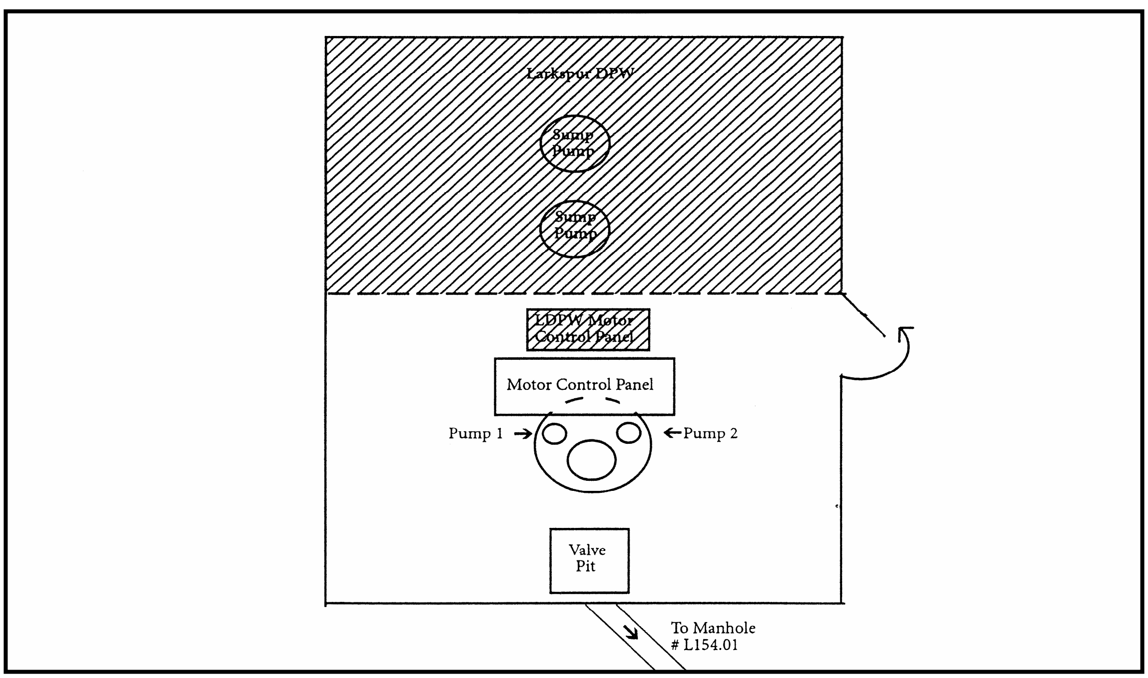
MAJOR ITEMS	Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST			
Piping & Valving			
Replacing Piping & Valving			$ -
Coating			$ -
Flow Meter Vault	1	$10,000	$ 10,000
subtotal:			*$ 10,000*
Electrical			
General			$ -
Power Feed			$ -
Motor Control Center (MCC)			$ -
Standby Power (Generator Enclosure)	1	$15,000	$ 15,000
subtotal:			*$ 15,000*
Instrumentation & Control			
SCADA	1	$10,000	$ 10,000
Pump Control (Bubbler)	1	$5,000	$ 5,000
Flow Meter	1	$5,000	$ 5,000
subtotal:			*$ 20,000*
Structural			
General			$ -
Wet Well Concrete			$ -
Structural Condition			$ -
Leaks, Spalling, Cracks			$ -
subtotal:			*$ -*
Health & Safety			
Regulatory Compliance			$ -
Ventilation			$ -
Explosion-Proof Retrofit			$ -
subtotal:			*$ -*
Neighborhood Nuisance			
Odor Control			$ -
Noise Control/Sound Enclosure			$ -
Visual			$ -
Site Security			$ -
subtotal:			*$ -*
Pumps Improvement			
Under Capacity			$ -
New Pumps			$ -
subtotal:			*$ -*
Influent Sewer/Force Main			
Influent Sewer			$ -
Force Main			$ -
subtotal:			*$ -*
Maintenance/Reliability			
Access	1	$10,000	$ 10,000
Conversion to Submersible Station			$ -
Configuration Change			$ -
subtotal:			*$ 10,000*
Overflow Potential			
			$ -
subtotal:			*$ -*
Mobilization and Demobilization			
Allowance		5%	$ 2,800
Construction Cost Subtotal:			**$ 57,800**
Contingencies		30%	$ 17,300
Construction Cost Total:			$ 75,100
Engineering/Legal/Admin Costs		25%	$ 18,800
CAPITAL IMPROVEMENT TOTAL COST[a]			**$ 94,000**

Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	NA
PS Number & Name	30; Heather Garden
Address	92 Diane Lane, Larskpur
Year Constructed; Improvements Past/Future	-
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Diesel generator (maintained by Larkspur DPW)
Normal Operating Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Operating Point (gpm/feet)	150 gpm
Influent Sewer Size/Effluent Force Main Size	8"/6"
Horsepower Rating (hp)/Motor Speed (rpm)	2.3 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Sewers are surcharged. May require pump station upsizing if sewers surcharging is addressed.
Identified Issues	• Surcharging mains during wet-weather flows.
Recommendations	• **Piping & Valving:** Construct flow meter vault; Replace piping and valving as needed. • **Electrical:** NA • **Instrumentation & Control:** Install flow meter. Install controls for new pumps, as needed. Connect to SCADA. • **Structural:** General structural modifications. • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** Replace pumps to alleviate surcharging problems. • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA



PS Number & Name 30 (Heather Garden)

MAJOR ITEMS		Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST				
Piping & Valving				
Replacing Piping & Valving		1	$2,000	$ 2,000
Coating				$ -
Flow Meter Vault		1	$10,000	$ 10,000
	subtotal:			*$ 12,000*
Electrical				
General				$ -
Power Feed				$ -
Motor Control Center (MCC)				$ -
Standby Power				$ -
	subtotal:			*$ -*
Instrumentation & Control				
SCADA		1	$10,000	$ 10,000
Pump Control		1	$5,000	$ 5,000
Flow Meter		1	$5,000	$ 5,000
	subtotal:			*$ 20,000*
Structural				
General		1	$2,000	$ 2,000
Wet Well Concrete				$ -
Structural Condition				$ -
Leaks, Spalling, Cracks				$ -
	subtotal:			*$ 2,000*
Health & Safety				
Regulatory Compliance				$ -
Ventilation				$ -
Explosion-Proof Retrofit				$ -
	subtotal:			*$ -*
Neighborhood Nuisance				
Odor Control				$ -
Noise Control/Sound Enclosure				$ -
Visual				$ -
Site Security				$ -
	subtotal:			*$ -*
Pumps Improvement				
Under Capacity		2	$10,000	$ 20,000
New Pumps				$ -
	subtotal:			*$ 20,000*
Influent Sewer/Force Main				
Influent Sewer				$ -
Force Main				$ -
	subtotal:			*$ -*
Maintenance/Reliability				
Access				$ -
Conversion to Submersible Station				$ -
Configuration Change				$ -
	subtotal:			*$ -*
Overflow Potential				
				$ -
	subtotal:			*$ -*
Mobilization and Demobilization				
Allowance			5%	$ 2,700
Construction Cost Subtotal:				**$ 56,700**
Contingencies			30%	$ 17,000
Construction Cost Total:				$ 73,700
Engineering/Legal/Admin Costs			25%	$ 18,400
CAPITAL IMPROVEMENT TOTAL COST[a]				**$ 92,000**

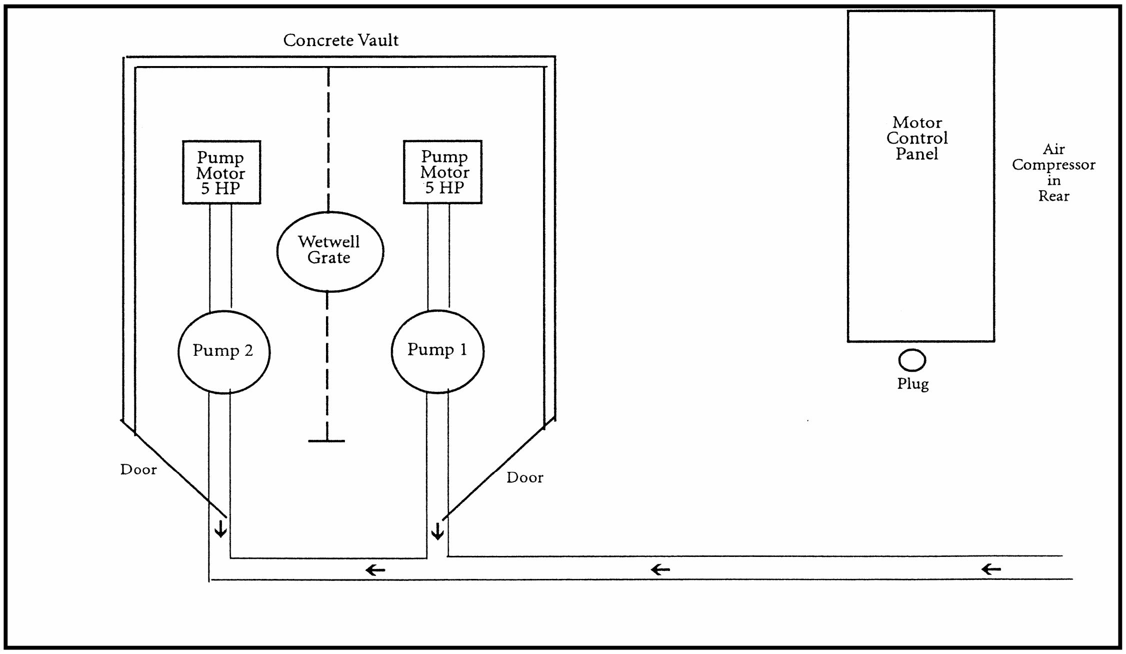
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	31; 1 Via la Brisa
Address	1 Via La Brisa
Year Constructed; Improvements Past/Future	Mid-1960s
Number of Pumps/Number of Standbys	1/1
Pump Type	Dry-pit electric
Primary Power Source	PG&E
Standby Generator	Portable diesel powered 60 KW generator; 125 gal
Normal Operating Capacity (MGD)	Unknown
Firm Capacity (MGD)	Unknown
Operating Point (gpm/feet)	Unknown
Influent Sewer Size/Effluent Force Main Size	6"/6"
Horsepower Rating (hp)/Motor Speed (rpm)	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Flooding and infiltration/Inflow are an issue in the area. All joints are leaking. Pipeline built in 1964 on bay fill. • 6" FM exterior to be recoated (see Force Main Master Plan).
Identified Issues	• Existing pumps have to be primed.
Recommendations	• **Piping & Valving:** Construct flow meter vault; Replace piping and valving as needed. • **Electrical:** NA • **Instrumentation & Control:** Install flow meter. Install controls for new pumps. Connect to SCADA. • **Structural:** Modify valve pit and wet well. • **Health & Safety:** Install ventilation system. • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** Replace existing pumps with submersible pumps.

PS Number & Name	31; 1 Via la Brisa



PS Number & Name 31 (1 Via la Brisa)

MAJOR ITEMS		Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST				
Piping & Valving				
Replacing Piping & Valving		2	$7,500	$ 15,000
Coating		1	$3,000	$ 3,000
Flow Meter Vault		1	$10,000	$ 10,000
	subtotal:			*$ 28,000*
Electrical				
General		1	$10,000	$ 10,000
Power Feed				$ -
Motor Control Center (MCC)				$ -
Standby Power				$ -
	subtotal:			*$ 10,000*
Instrumentation & Control				
SCADA		1	$10,000	$ 10,000
Pump Control		1	$10,000	$ 10,000
Flow Meter		1	$5,000	$ 5,000
	subtotal:			*$ 25,000*
Structural				
General				$ -
Wet Well Concrete		1	$10,000	$ 10,000
Structural Condition		1	$10,000	$ 10,000
Leaks, Spalling, Cracks				$ -
	subtotal:			*$ 20,000*
Health & Safety				
Regulatory Compliance				$ -
Ventilation		1	$2,000	$ 2,000
Explosion-Proof Retrofit				$ -
	subtotal:			*$ 2,000*
Neighborhood Nuisance				
Odor Control				$ -
Noise Control/Sound Enclosure				$ -
Visual				$ -
Site Security				$ -
	subtotal:			*$ -*
Pumps Improvement				
Under Capacity				$ -
New Pumps				$ -
	subtotal:			*$ -*
Influent Sewer/Force Main				
Influent Sewer				$ -
Force Main				$ -
	subtotal:			*$ -*
Maintenance/Reliability				
Access				$ -
Conversion to Submersible Station		2	$20,000	$ 40,000
Configuration Change				$ -
	subtotal:			*$ 40,000*
Overflow Potential				
				$ -
	subtotal:			*$ -*
Mobilization and Demobilization				
Allowance			5%	$ 6,300
Construction Cost Subtotal:				**$ 131,300**
Contingencies			30%	$ 39,400
Construction Cost Total:				$ 170,700
Engineering/Legal/Admin Costs			25%	$ 42,700
CAPITAL IMPROVEMENT TOTAL COST[a]				**$ 213,000**

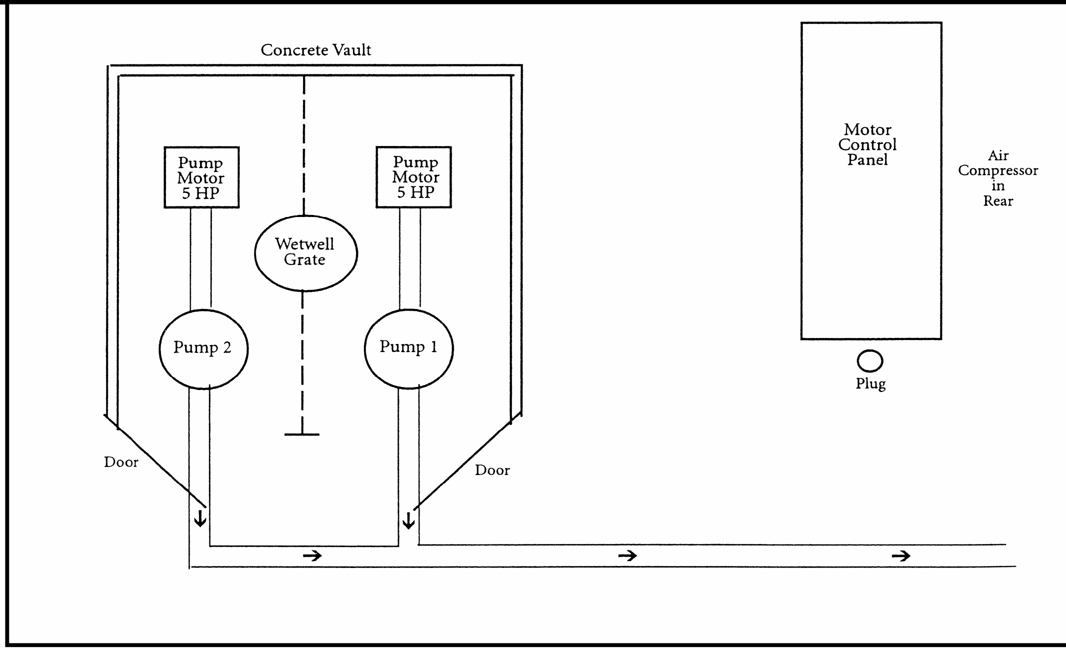
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	32; 1 Corte del Bayo
Address	1 Corte del Bayo
Year Constructed; Improvements Past/Future	Mid-1960s
Number of Pumps/Number of Standbys	1/1
Pump Type	Dry-pit electric
Primary Power Source	PG&E
Standby Generator	Portable diesel powered 60 KW generator; 125 gal
Normal Operating Capacity (MGD)	Unknown
Firm Capacity (MGD)	Unknown
Operating Point (gpm/feet)	Unknown
Influent Sewer Size/Effluent Force Main Size	8"/5"
Horsepower Rating (hp)/Motor Speed	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Flooding and infiltration/Inflow are an issue in the area. All joints are leaking
Identified Issues	• Existing pumps have to be primed.
Recommendations	• **Piping & Valving:** Construct flow meter vault; Replace piping and valving as needed. • **Electrical:** NA • **Instrumentation & Control:** Install flow meter. Install controls for new pumps. Connect to SCADA. • **Structural:** Modify valve pit and wet well. • **Health & Safety:** Install ventilation system. • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** Replace existing pumps with submersible pumps.

PS Number & Name	32; 1 Corte del Bayo



PS Number & Name 32 (1 Corte del Bayo)

MAJOR ITEMS		Quantity	Unit Cost	Extended Cost	
BASELINE CONSTRUCTION COST					
Piping & Valving					
Replacing Piping & Valving		2	$7,500	$	15,000
Coating		1	$3,000	$	3,000
Flow Meter Vault		1	$10,000	$	10,000
	subtotal:			*$*	*28,000*
Electrical					
General		1	$10,000	$	10,000
Power Feed				$	-
Motor Control Center (MCC)				$	-
Standby Power				$	-
	subtotal:			*$*	*10,000*
Instrumentation & Control					
SCADA		1	$10,000	$	10,000
Pump Control		1	$10,000	$	10,000
Flow Meter		1	$5,000	$	5,000
	subtotal:			*$*	*25,000*
Structural					
General				$	-
Wet Well Concrete		1	$10,000	$	10,000
Structural Condition		1	$10,000	$	10,000
Leaks, Spalling, Cracks				$	-
	subtotal:			*$*	*20,000*
Health & Safety					
Regulatory Compliance				$	-
Ventilation		1	$2,000	$	2,000
Explosion-Proof Retrofit				$	-
	subtotal:			*$*	*2,000*
Neighborhood Nuisance					
Odor Control				$	-
Noise Control/Sound Enclosure				$	-
Visual				$	-
Site Security				$	-
	subtotal:			*$*	*-*
Pumps Improvement					
Under Capacity				$	-
New Pumps				$	-
	subtotal:			*$*	*-*
Influent Sewer/Force Main					
Influent Sewer				$	-
Force Main				$	-
	subtotal:			*$*	*-*
Maintenance/Reliability					
Access				$	-
Conversion to Submersible Station		2	$20,000	$	40,000
Configuration Change				$	-
	subtotal:			*$*	*40,000*
Overflow Potential					
				$	-
	subtotal:			*$*	*-*
Mobilization and Demobilization					
Allowance			5%	$	6,300
Construction Cost Subtotal:				**$**	**131,300**
Contingencies			30%	$	39,400
Construction Cost Total:				$	170,700
Engineering/Legal/Admin Costs			25%	$	42,700
CAPITAL IMPROVEMENT TOTAL COST[a]				**$**	**213,000**

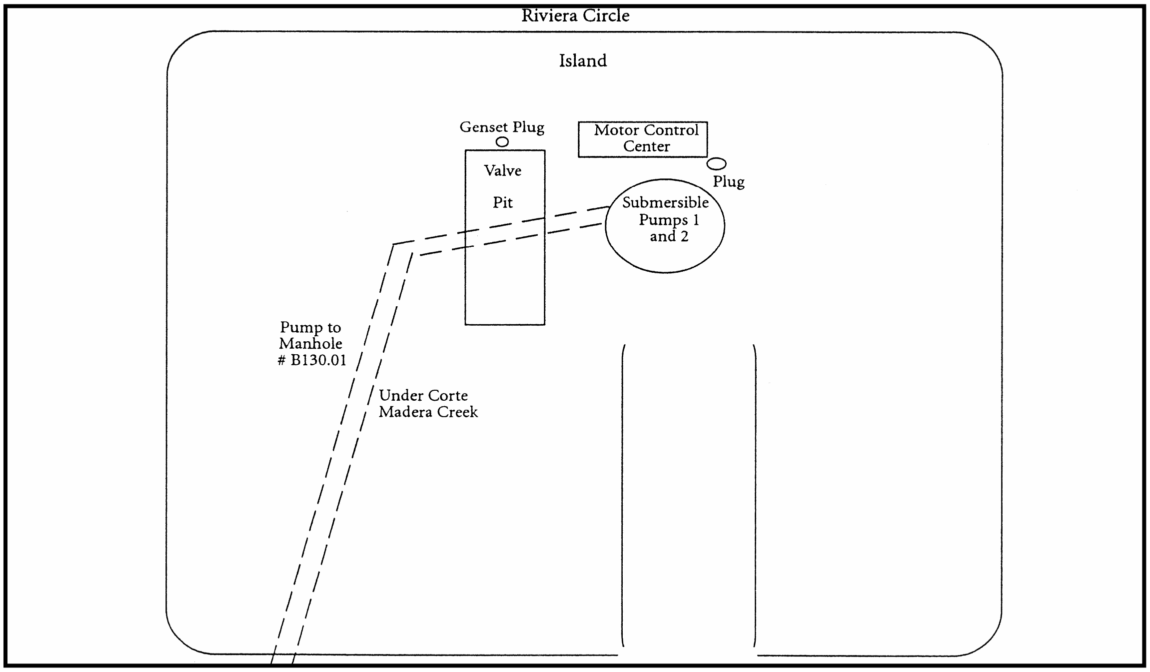
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	33; 415 Riviera Circle
Address	415 Riviera Circle, Larkspur
Year Constructed; Improvements Past/Future	Early 2000
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Portable diesel powered 60 KW generator; 125 gal
Normal Operating Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Operating Point (gpm/feet)	150 gpm
Influent Sewer Size/Effluent Force Main Size	8"/6"
Horsepower Rating (hp)/Motor Speed (rpm)	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Flooding and infiltration/Inflow are an issue in the area. All joints are leaking. • Section of 6" steel FM in the mud needs to be replaced (approximately 300 feet) (see Force Main Master Plan).
Identified Issues	• None
Recommendations	• **Piping & Valving**: Construct flow meter vault. • **Electrical:** NA • **Instrumentation & Control**: Install flow meter. Connect to SCADA. • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA

PS Number & Name	33; 415 Riviera Circle



PS Number & Name 33 (415 Riviera Circle)

MAJOR ITEMS		**Quantity**	**Unit Cost**	**Extended Cost**
BASELINE CONSTRUCTION COST				
Piping & Valving				
Replacing Piping & Valving				$ -
Coating				$ -
Flow Meter Vault		1	$10,000	$ 10,000
	subtotal:			*$ 10,000*
Electrical				
General				$ -
Power Feed				$ -
Motor Control Center (MCC)				$ -
Standby Power				$ -
	subtotal:			*$ -*
Instrumentation & Control				
SCADA		1	$10,000	$ 10,000
Pump Control				$ -
Flow Meter		1	$5,000	$ 5,000
	subtotal:			*$ 15,000*
Structural				
General				$ -
Wet Well Concrete				$ -
Structural Condition				$ -
Leaks, Spalling, Cracks				$ -
	subtotal:			*$ -*
Health & Safety				
Regulatory Compliance				$ -
Ventilation				$ -
Explosion-Proof Retrofit				$ -
	subtotal:			*$ -*
Neighborhood Nuisance				
Odor Control				$ -
Noise Control/Sound Enclosure				$ -
Visual				$ -
Site Security				$ -
	subtotal:			*$ -*
Pumps Improvement				
Under Capacity				$ -
New Pumps				$ -
	subtotal:			*$ -*
Influent Sewer/Force Main				
Influent Sewer				$ -
Force Main				$ -
	subtotal:			*$ -*
Maintenance/Reliability				
Access				$ -
Conversion to Submersible Station				$ -
Configuration Change				$ -
	subtotal:			*$ -*
Overflow Potential				
				$ -
	subtotal:			*$ -*
Mobilization and Demobilization				
Allowance			5%	$ 1,300
Construction Cost Subtotal:				**$ 26,300**
Contingencies			30%	$ 7,900
Construction Cost Total:				$ 34,200
Engineering/Legal/Admin Costs			25%	$ 8,600
CAPITAL IMPROVEMENT TOTAL COST[a]				**$ 43,000**

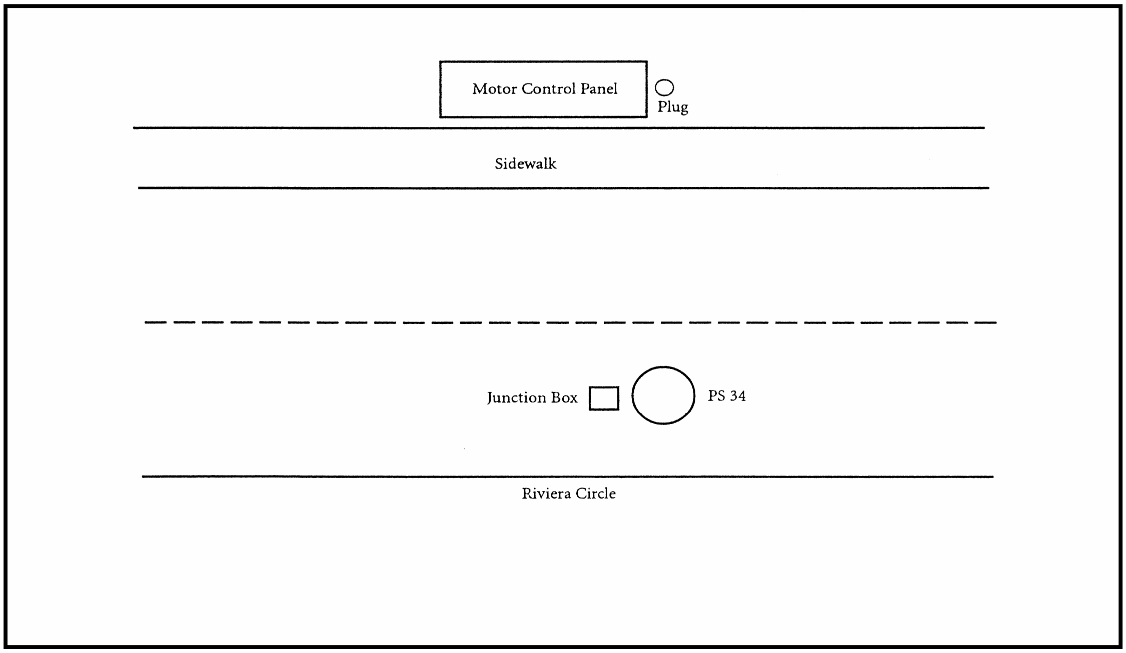
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	34; 359 Riviera Circle
Address	359 Riviera Circle, Larkspur
Year Constructed; Improvements Past/Future	Mid-1960s
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Portable diesel powered 60 KW generator; 125 gal
Normal Operating Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Operating Point (gpm/feet)	150 gpm
Influent Sewer Size/Effluent Force Main Size	8"/8"
Horsepower Rating (hp)/Motor Speed (rpm)	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Noise has been a problem for local residents. District has built a 6" force main parallel to the existing 8" line to address noise problem. • Flooding and infiltration/Inflow are an issue in the area. All joints are leaking.
Identified Issues	• Maintenance of station is difficult due to difficult access through necked-down manhole.
Recommendations	• **Piping & Valving:** Install new piping and valving. • **Electrical:** NA • **Instrumentation & Control:** Install flow meter. Install controls for new pumps. Connect to SCADA. • **Structural:** Modify wet well; Construct concrete pad. • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** Install 2 new pumps. • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** Rebuild new pump station including street vaults with wet well, rails and aluminum top. • **Overflow Potential:** NA

PS Number & Name	34; 359 Riviera Circle



PS Number & Name 34 (359 Riviera Circle)

MAJOR ITEMS		Quantity	Unit	Extended	
BASELINE CONSTRUCTION COST					
Piping & Valving					
Replacing Piping & Valving		1	$20,000	$	20,000
Coating				$	-
Flow Meter Vault		1	$10,000	$	10,000
	subtotal:			*$*	*30,000*
Electrical					
General		1	$10,000	$	10,000
Power Feed				$	-
Motor Control Center (MCC)				$	-
Standby Power				$	-
	subtotal:			*$*	*10,000*
Instrumentation & Control					
SCADA		1	$10,000	$	10,000
Pump Control		1	$10,000	$	10,000
Flow Meter		1	$5,000	$	5,000
	subtotal:			*$*	*25,000*
Structural					
General (Concrete pad with hatches)		1	$20,000	$	20,000
Wet Well Concrete		1	$10,000	$	10,000
Structural Condition				$	-
Leaks, Spalling, Cracks				$	-
	subtotal:			*$*	*30,000*
Health & Safety					
Regulatory Compliance				$	-
Ventilation				$	-
Explosion-Proof Retrofit				$	-
	subtotal:			*$*	*-*
Neighborhood Nuisance					
Odor Control				$	-
Noise Control/Sound Enclosure				$	-
Visual				$	-
Site Security				$	-
	subtotal:			*$*	*-*
Pumps Improvement					
Under Capacity				$	-
New Pumps		2	$10,000	$	20,000
	subtotal:			*$*	*20,000*
Influent Sewer/Force Main					
Influent Sewer				$	-
Force Main				$	-
	subtotal:			*$*	*-*
Maintenance/Reliability					
Access				$	-
Conversion to Submersible Station				$	-
Configuration Change		1	$30,000	$	30,000
	subtotal:			*$*	*30,000*
Overflow Potential					
				$	-
	subtotal:			*$*	*-*
Mobilization and Demobilization					
Allowance			5%	$	7,300
Construction Cost Subtotal:				**$**	**152,300**
Contingencies			30%	$	45,700
Construction Cost Total:				$	198,000
Engineering/Legal/Admin Costs			25%	$	49,500
CAPITAL IMPROVEMENT TOTAL COST[a]				**$**	**248,000**

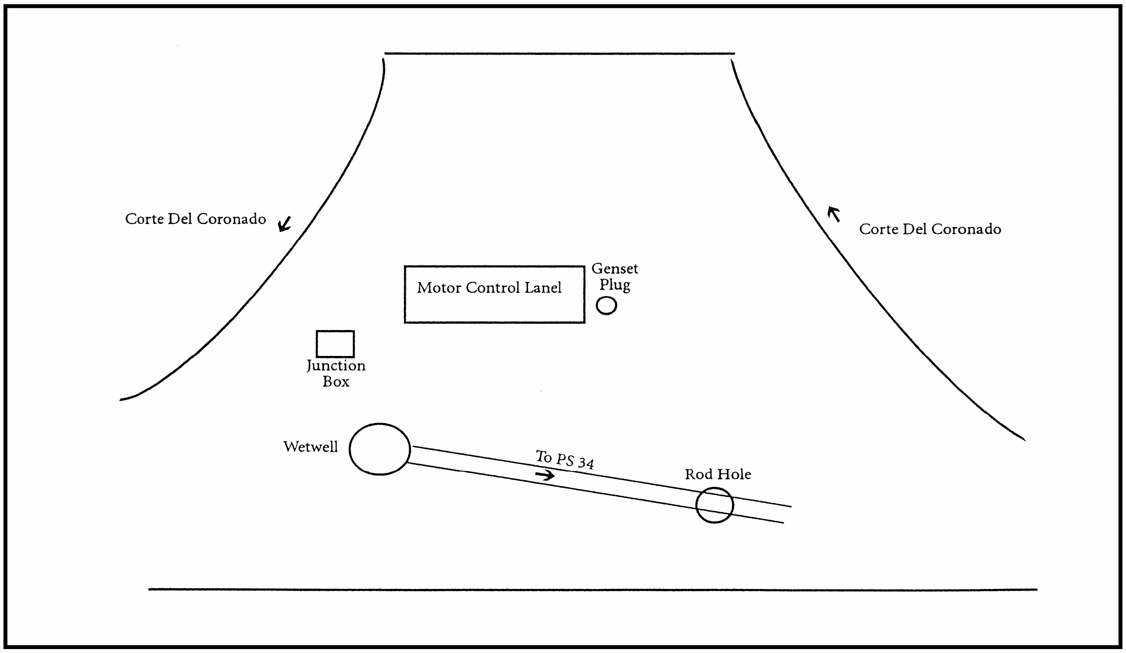
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	35; 2 Corte del Coronado
Address	2 Corte Del Coronado
Year Constructed; Improvements Past/Future	Mid-1960s
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Portable diesel powered 60 KW generator; 125 gal
Normal Operating Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Operating Point (gpm/feet)	150 gpm
Influent Sewer Size/Effluent Force Main Size	8"/8"
Horsepower Rating (hp)/Motor Speed (rpm)	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Flooding and infiltration/Inflow are an issue in the area. All joints are leaking. • Force main is ductile iron and clay.
Identified Issues	• Maintenance of station is difficult due to difficult access through necked-down manhole.
Recommendations	• **Piping & Valving:** Install new piping and valving. • **Electrical:** NA • **Instrumentation & Control:** Install flow meter. Install controls for new pumps. Connect to SCADA. • **Structural:** Modify wet well; Construct concrete pad. • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** Install 2 new pumps. • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** Rebuild new pump station including street vault with wet well, rails and aluminum top. • **Overflow Potential:** NA

PS Number & Name	35; 2 Corte del Coronado



PS Number & Name 35 (2 Corte del Coronado)

MAJOR ITEMS		Quantity	Unit		Extended
BASELINE CONSTRUCTION COST					
Piping & Valving					
Replacing Piping & Valving		1	$20,000	$	20,000
Coating				$	-
Flow Meter Vault		1	$10,000	$	10,000
	subtotal:			*$*	*30,000*
Electrical					
General		1	$10,000	$	10,000
Power Feed				$	-
Motor Control Center (MCC)				$	-
Standby Power				$	-
	subtotal:			*$*	*10,000*
Instrumentation & Control					
SCADA		1	$10,000	$	10,000
Pump Control		1	$10,000	$	10,000
Flow Meter		1	$5,000	$	5,000
	subtotal:			*$*	*25,000*
Structural					
General (Concrete pad with hatches)		1	$20,000	$	20,000
Wet Well Concrete		1	$10,000	$	10,000
Structural Condition				$	-
Leaks, Spalling, Cracks				$	-
	subtotal:			*$*	*30,000*
Health & Safety					
Regulatory Compliance				$	-
Ventilation				$	-
Explosion-Proof Retrofit				$	-
	subtotal:			*$*	-
Neighborhood Nuisance					
Odor Control				$	-
Noise Control/Sound Enclosure				$	-
Visual				$	-
Site Security				$	-
	subtotal:			*$*	-
Pumps Improvement					
Under Capacity				$	-
New Pumps		2	$10,000	$	20,000
	subtotal:			*$*	*20,000*
Influent Sewer/Force Main					
Influent Sewer				$	-
Force Main				$	-
	subtotal:			*$*	-
Maintenance/Reliability					
Access				$	-
Conversion to Submersible Station				$	-
Configuration Change		1	$30,000	$	30,000
	subtotal:			*$*	*30,000*
Overflow Potential					
				$	-
	subtotal:			*$*	-
Mobilization and Demobilization					
Allowance			5%	$	7,300
Construction Cost Subtotal:				**$**	**152,300**
Contingencies			30%	$	45,700
Construction Cost Total:				$	198,000
Engineering/Legal/Admin Costs			25%	$	49,500
CAPITAL IMPROVEMENT TOTAL COST[a]				**$**	**248,000**

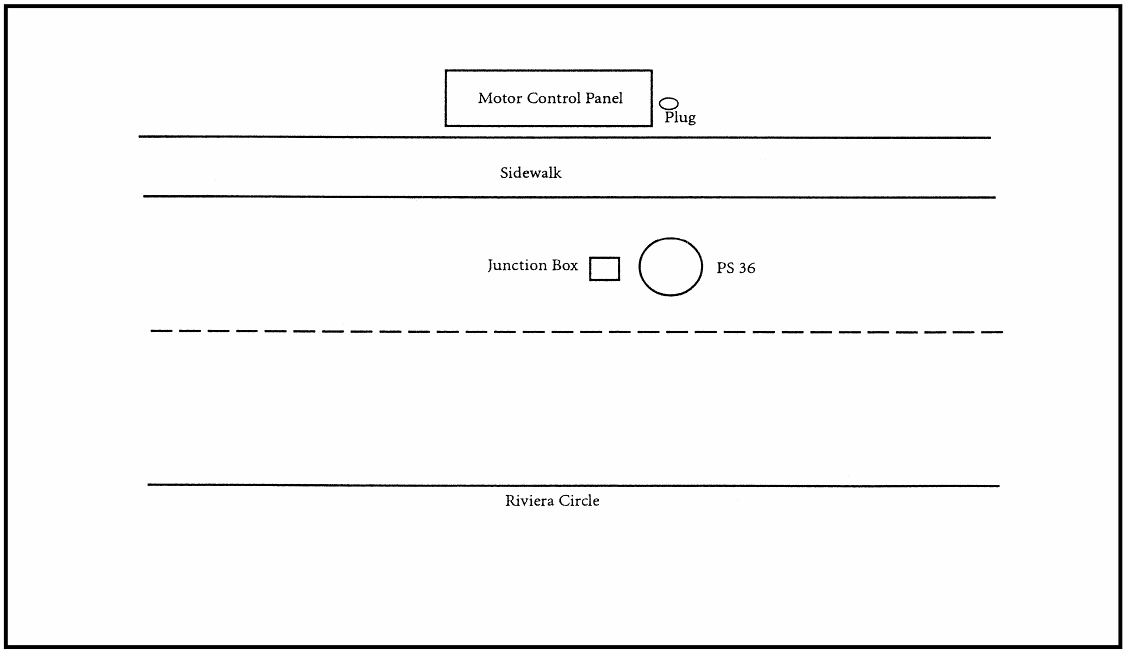
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	36; 178 Riviera Circle
Address	178 Riviera Circle, Larkspur
Year Constructed; Improvements Past/Future	Mid-1960s
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Portable diesel powered 60 KW generator; 125 gal
Normal Operating Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.22 MGD)
Operating Point (gpm/feet)	150 gpm
Influent Sewer Size/Effluent Force Main Size	8"/8"
Horsepower Rating (hp)/Motor Speed (rpm)	5 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Flooding and infiltration/Inflow are an issue in the area. All joints are leaking.
Identified Issues	• Maintenance of station is difficult due to difficult access through necked-down manhole.
Recommendations	• **Piping & Valving:** Install new piping and valving. • **Electrical:** NA • **Instrumentation & Control**: Install flow meter. Install controls for new pumps. Connect to SCADA. • **Structural:** Modify wet well; Construct concrete pad. • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** Install 2 new pumps. • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** Rebuild new pump station including street vault with wet well, rails and aluminum top. • **Overflow Potential:** NA

PS Number & Name	36; 178 Riviera Circle



PS Number & Name 36 (178 Riviera Circle)

MAJOR ITEMS		Quantity	Unit	Extended	
BASELINE CONSTRUCTION COST					
Piping & Valving					
Replacing Piping & Valving		1	$20,000	$	20,000
Coating				$	-
Flow Meter Vault		1	$10,000	$	10,000
	subtotal:			*$*	*30,000*
Electrical					
General		1	$10,000	$	10,000
Power Feed				$	-
Motor Control Center (MCC)				$	-
Standby Power				$	-
	subtotal:			*$*	*10,000*
Instrumentation & Control					
SCADA		1	$10,000	$	10,000
Pump Control		1	$10,000	$	10,000
Flow Meter		1	$5,000	$	5,000
	subtotal:			*$*	*25,000*
Structural					
General (Concrete pad with hatches)		1	$20,000	$	20,000
Wet Well Concrete		1	$10,000	$	10,000
Structural Condition				$	-
Leaks, Spalling, Cracks				$	-
	subtotal:			*$*	*30,000*
Health & Safety					
Regulatory Compliance				$	-
Ventilation				$	-
Explosion-Proof Retrofit				$	-
	subtotal:			*$*	*-*
Neighborhood Nuisance					
Odor Control				$	-
Noise Control/Sound Enclosure				$	-
Visual				$	-
Site Security				$	-
	subtotal:			*$*	*-*
Pumps Improvement					
Under Capacity				$	-
New Pumps		2	$10,000	$	20,000
	subtotal:			*$*	*20,000*
Influent Sewer/Force Main					
Influent Sewer				$	-
Force Main				$	-
	subtotal:			*$*	*-*
Maintenance/Reliability					
Access				$	-
Conversion to Submersible Station				$	-
Configuration Change		1	$30,000	$	30,000
	subtotal:			*$*	*30,000*
Overflow Potential					
				$	-
	subtotal:			*$*	*-*
Mobilization and Demobilization					
Allowance			5%	$	7,300
Construction Cost Subtotal:				**$**	**152,300**
Contingencies			30%	$	45,700
Construction Cost Total:				$	198,000
Engineering/Legal/Admin Costs			25%	$	49,500
CAPITAL IMPROVEMENT TOTAL COST[a]				**$**	**248,000**

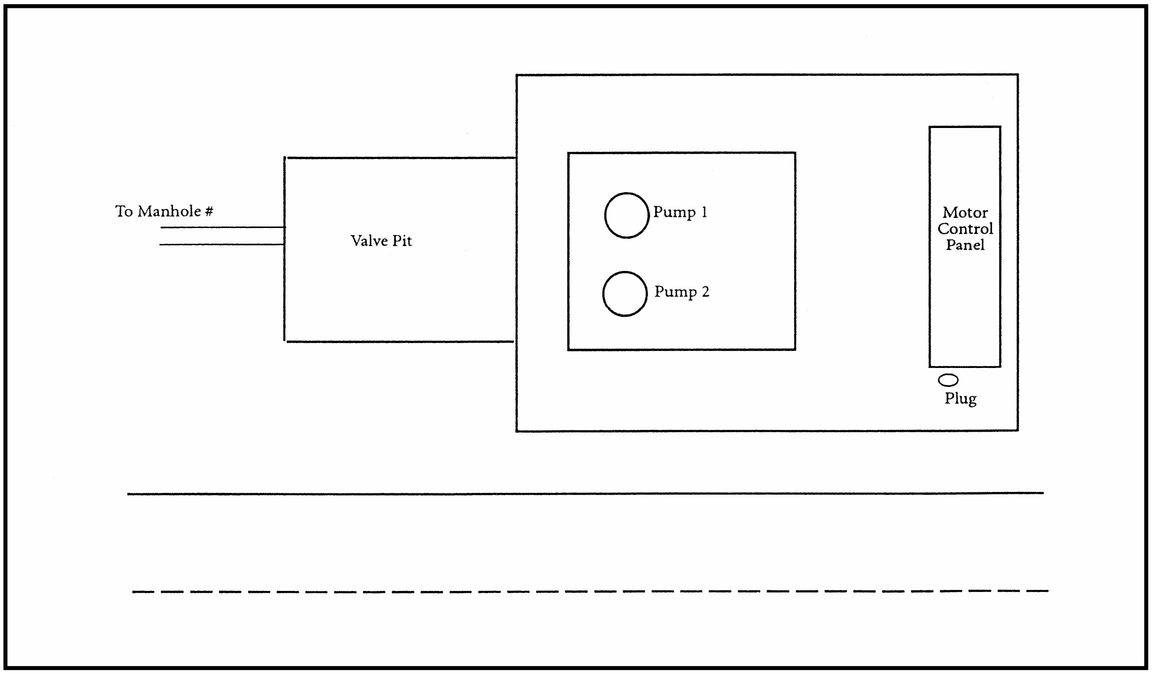
Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)

Field Visit Date	4/19/2006
PS Number & Name	37; Larkspur Plaza
Address	Larkspur Plaza, across from Larkspur Plaza Drive, Larskpur
Year Constructed; Improvements Past/Future	-
Number of Pumps/Number of Standbys	1/1
Pump Type	Submersible
Primary Power Source	PG&E
Standby Generator	Portable diesel powered 60 KW generator; 125 gal
Normal Operating Capacity (MGD)	Unknown (Assumed 0.09 MGD)
Firm Capacity (MGD)	Unknown (Assumed 0.09 MGD)
Operating Point (gpm/feet)	60 gpm
Influent Sewer Size/Effluent Force Main Size	6"/4"
Horsepower Rating (hp)/Motor Speed (rpm)	3 hp
Pump Elevation (feet)	Unknown
Bypass capabilities	None
Notes	• Station lost power in the 1990s for 3 days. When flooding, all sewers overflow to PS 14 through gravity line. • Grease problem in sewer.
Identified Issues	• Defective valving system. • District and City of Larkspur share 3-line power. It is recommended that City of Larkspur and District have separate power lines. • Area subject to frequent flooding.
Recommendations	• **Piping & Valving:** Replace valves. • **Electrical:** Construct separate power line for District pump station. • **Instrumentation & Control:** Install flow meter. Connect to SCADA. • **Structural:** NA • **Health & Safety:** NA • **Neighborhood Nuisance:** NA • **Pumps Improvement:** NA • **Influent Sewer/Force Main:** NA • **Maintenance/Reliability:** NA • **Overflow Potential:** NA

PS Number & Name	37; Larkspur Plaza



PS Number & Name 37 (Larkspur Plaza)

MAJOR ITEMS		Quantity	Unit Cost	Extended Cost
BASELINE CONSTRUCTION COST				
Piping & Valving				
Replacing Piping & Valving		1	$5,000	$ 5,000
Coating				$ -
Flow Meter Vault		1	$10,000	$ 10,000
	subtotal:			*$ 15,000*
Electrical				
General				$ -
Power Feed		1	$10,000	$ 10,000
Motor Control Center (MCC)				$ -
Standby Power				$ -
	subtotal:			*$ 10,000*
Instrumentation & Control				
SCADA		1	$10,000	$ 10,000
Pump Control				$ -
Flow Meter		1	$5,000	$ 5,000
	subtotal:			*$ 15,000*
Structural				
General				$ -
Wet Well Concrete				$ -
Structural Condition				$ -
Leaks, Spalling, Cracks				$ -
	subtotal:			*$ -*
Health & Safety				
Regulatory Compliance				$ -
Ventilation				$ -
Explosion-Proof Retrofit				$ -
	subtotal:			*$ -*
Neighborhood Nuisance				
Odor Control				$ -
Noise Control/Sound Enclosure				$ -
Visual				$ -
Site Security				$ -
	subtotal:			*$ -*
Pumps Improvement				
Under Capacity				$ -
New Pumps				$ -
	subtotal:			*$ -*
Influent Sewer/Force Main				
Influent Sewer				$ -
Force Main				$ -
	subtotal:			*$ -*
Maintenance/Reliability				
Access				$ -
Conversion to Submersible Station				$ -
Configuration Change				$ -
	subtotal:			*$ -*
Overflow Potential				
				$ -
	subtotal:			*$ -*
Mobilization and Demobilization				
Allowance			5%	$ 2,000
Construction Cost Subtotal:				**$ 42,000**
Contingencies			30%	$ 12,600
Construction Cost Total:				$ 54,600
Engineering/Legal/Admin Costs			25%	$ 13,700
CAPITAL IMPROVEMENT TOTAL COST[a]				**$ 68,000**

Footnote:

a. Cost estimates are rounded to the nearest $1,000.

b. Costs are in August 2006 dollars (ENR SF CCI = 8464)