Addendum No. 1 **May 20, 2025**

Project: Sanitary Sewer Master Plan

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1. Do you have a previous sewer master plan? If so, possible to get a copy? I couldn't find one on the City's website.
   Answer: Yes. Attached find the last SSMP (Attachment "A" – 2014 SSMP Report)

2. Do you have any stats on the sewer system? E.g. total miles of pipe and ranges of diameters? Any lift stations?
   Answer: The City has 42 miles of sewer mains. The diameters range from 4 to 24 inch

3. What's the main driver for this project?
   Answer: The City needs to determine if the system's capacity is adequate and be able to develop a capital improvement project program

4. Given there's currently no GIS of the City's sewer system and that 75% of the as-builts for the system have been destroyed, you're really looking at needing the system field surveyed in order to create the GIS and the hydraulic model. Is the City open to this approach?
   Answer: The City has some shape file that will be shared with the selected firm. We are open to discuss tasks that may need to be involved to complete the task.

5. How many miles of CCTV inspection videos and reports does the City have? And of what portion of the system?
   Answer: See Figure 5.1 of 2014 SSMP. Only videos are available.

6. How many sewer spills has the City had in the past 5 years? What were the causes of those spills?
   Answer: Three spills have occured in the past 5 years related to FOG's

7. Does the City have any known capacity issues?
   Answer: Yes

8. Is the City anticipating any major redevelopment or annexation of other areas? Or is the City essentially built out and not foreseeing much growth moving forward?
   Answer: The City is built out, however numerous ADUs have been built since the previous SSMP Report and more are being added.

Indicate the receipt of Addendum 1 on your Proposal. **FAILURE TO DO SO WILL RENDER YOUR BID NON-RESPONSIVE**

Approved by:

05/20/2025

Wendell Johnson, P.E.
Director of Public Works

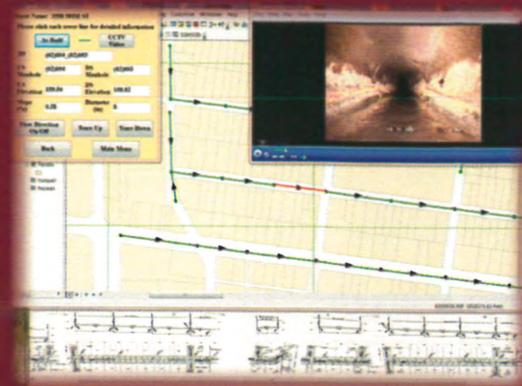
Date

ATTACHMENT "A"

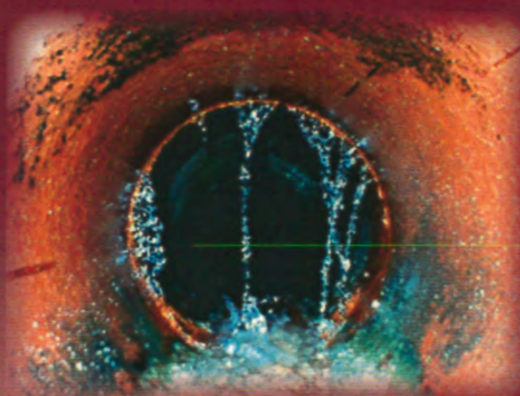
Hall & Foreman, Inc.

Engineering ▪ Planning ▪ Surveying

Final Report for Sewer Master Plan



City of San Fernando
March 31, 2014



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City of San Fernando
Sewer Master Plan
(Final Report)

117 Macneil Street
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March 31, 2014

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EXECUTIVE SUMMARY

Introduction

The City of San Fernando is located in Los Angeles County and is bordered by the districts of Sylmar to the north, Lake View Terrace to the east, Pacoima to the south, and Mission Hills to the west. It is served by the Golden State (Interstate 5), Foothill (Interstate 210), Ronald Reagan (State Route 118), and San Diego (Interstate 405) freeways. The City encompasses approximately 2.37 square miles and serves approximately 23,645 residents. The City incorporated in August 1911.

Description of the Study Area

The City encompasses an area of approximately 1,300 acres. The predominant land use in the City is residential land use at 48% of the total land use and is primarily single family. There is also a blend of commercial land uses distributed across the City with industrial land use primarily located in the northeast. Although the City is almost fully developed, re-development projects are ongoing and planned as part of City Specific Plans. The Corridors Specific Plan (SP-4), which totals approximately 128 acres, is a revitalization of the Maclay Avenue, Truman Street and San Fernando Road corridors.

The City operates its wastewater collection system under the jurisdiction of the Los Angeles Regional Water Quality Control Board, the State Water Resources Control Board, and the U.S. Environmental Protection Agency.

The City's goal is to develop a comprehensive sewer master plan that accomplishes the following four main objectives:

- Developing a GIS based sewer map and modernizing its sewer system mapping by scanning and creating digital copies of its existing sewer maps
- Identifying areas of current system capacity deficiencies, if any, and areas of necessary upgrades or new systems based upon future growth and development as anticipated by the General Plan
- Identifying a timeframe, based on priority, and the cost of maintaining, repairing, replacing, upgrading, and installing of new sewer system improvements based upon the growth forecast and condition, age, and capacity of existing sewer lines

Existing System

The existing contiguous gravity sewer system within the City boundary contains 219,346 linear feet of sewer line. However, for hydraulic modeling purposes, the area analyzed include lines that are outside the City boundary. Therefore, the system analyzed in this study contains 224,852 linear feet of sewer line and 834 manholes.

Land Use

There are 1,314 acres of land inside the City boundaries. City land use presented herein is based on the City's current General Plan and zoning map. As shown in Table 2-1 and on Figure

EXECUTIVE SUMMARY

2-1, Based the predominant land use in the City is residential land use at 67% of the total land use (874 acres) including single family (R1), multi-family dwelling (R2), and multi-family (R3). Of the residential land use categories, low density residential (R1) is predominant at 73% of the total residential land use.

General Criteria
Establishing performance standards is an important part of evaluating existing wastewater collection systems, as it forms the basis for system analysis and system improvement recommendations. These standards include methodology for estimating wastewater design flows and minimum design standards for the collection system pipes.

Average wastewater flows can be reasonably estimated from flow monitoring data as well as land use and their corresponding unit flow factors. Peaking factors are needed for estimating peak dry weather and peak wet weather flows. Peak wet weather flows also include an allowance for inflow / infiltration (I/I). Collection system design standards include minimum pipe size, minimum flow velocity, and depth of flow to pipe diameter ratio. Finally, facility useful lives are needed for adequately scheduling replacement of the aging infrastructure.

Sewer Design Criteria
Design criteria are established to ensure that the wastewater collection system can operate effectively under all flow conditions. Each pipe segment must be capable of carrying peak flows without surcharging the system. Low flows must be conveyed at a velocity that will prevent solids from settling and blocking the system. At a minimum, all pipes should be 8 inches or larger in diameter and the velocity of flow should be greater than 2 feet per second at average flow. This velocity will prevent deposition of solids in the sewer. A velocity of 3 feet per second is desired at peak dry weather flow, to re-suspend any materials that may have already settled in the pipe.

Sewer Basin Boundaries
For this study, HFI utilized the City's sewer atlas maps and record drawings as well as the City's GIS database to delineate the basin boundaries. There are a total of five basins developed for this project.

System Analysis
The analysis of the City's existing gravity sewer system was based upon the calculated peak dry weather flows. Separate analyses were run using the existing and ultimate unit flow factors. Analysis was based upon using the greater of the measured flows obtained from the flow meters installed and the latest zoning data obtained from the City. The hydraulic models assume that the City is fully developed. We also reviewed the CCTV'd lines for structural deficiency. The total length of sewer found to be capacity deficient under ultimate conditions or structurally deficient was 37,000 feet. This is approximately 17 percent of the total system.

Maintenance
Currently, there is no official maintenance program for the City's sewer system. All repairs are done by City forces. A comprehensive maintenance program is an important tool in assuring reliable system operation. This not only includes regular inspections and preventative maintenance, but also good record keeping. Accurate records are the backbone of any

maintenance operation. They can be used for many purposes including: scheduling regular maintenance activities; allocating manpower; budgeting; pinpointing persistent problems; tracking equipment performance and maintenance history; and the identification of equipment which may be showing signs of failure. The Sewer Geographic Information System prepared as part of this study can be used for this purpose.

Capital Improvement Program General
The primary goal of the Capital Improvement Program (CIP) is to provide the City of San Fernando with a long range-planning tool for implementing its sewer infrastructure improvements in an orderly manner, and providing a basis for financing of these improvements. To accomplish this goal, the program is phased based upon the implementation cost of the facilities, the quantity of work the City can reasonably administer each year, and the funds available for these projects. The needed capital improvements were identified as a result of assessment of the system through capacity analyses and physical TV inspections.

Capital Improvement Project Priorities
The capital improvement projects were selected primarily with consideration of the health and safety of the public and protection of the environment by minimizing the possibility of overflows. The projects were prioritized based upon the following:

The highest priority has been assigned to the projects that will help alleviate known maintenance problems and line segments that have been shown through CCTV to be hydraulically deficient. The second priority has been assigned to projects identified by hydraulic evaluations and modeling with existing capacity deficiencies.

Capital Improvement Program
The total cost to implement the Sewer Master Plan's (SMP) recommendations is $10,775,859 These programs have been detailed as part of the Capital Improvement Program (CIP) recommendations in Table 7-1. The total cost of ***$10,775,859*** is comprised of three components; namely the cost to upsize hydraulically deficient lines ***($7,573,421)*** through hydraulic modeling, the cost to replace structurally deficient lines ***(2,422,436)*** through CCTV inspection, and to complete City's CCTV inspection, perform an I/I field study & analysis and to implement a Work Order System ***($780,000)***. These cost estimates are based upon recent information for similar projects in the Southern California area, and include contingencies for this planning level study.

The recommended CIP has been based upon the best information currently available. It should be updated as new information becomes available from sources such as CCTV inspections and from maintenance crew observations. The project priorities may be adjusted to take advantage of concurrent construction such as street paving projects or adjacent infrastructure work.

1 – INTRODUCTION

1.0 Introduction

The City of San Fernando is located in Los Angeles County and is bordered by the districts of Sylmar to the north, Lake View Terrace to the east, Pacoima to the south, and Mission Hills to the west. It is served by the Golden State (Interstate 5), Foothill (Interstate 210), Ronald Reagan (State Route 118), and San Diego (Interstate 405) freeways. The City encompasses approximately 2.37 square miles and was incorporated in August 1911.

The Public Works Maintenance Division performs maintenance of the City's sanitary sewer system by scheduled routine cleaning of sewer main lines and manholes. The sewer system is made up of approximately 41.5 miles (219,346 linear feet) of mains and 834 manholes. The City contracts with the City of Los Angeles for sewage treatment and disposal. Since 1985, the City has contracted with the County of Los Angeles for the enforcement of the City's Industrial Waste Program. Industrial waste permit fees cover the cost of this program. The January 2013 City population was documented at 24,079 and the total number of City dwelling units was documented at 6,351.

The City encompasses an area of approximately 1,300 acres. The predominant land use in the City is residential land use at 48% of the total land use and is primarily single family. There is also a blend of commercial land uses distributed across the City with industrial land use primarily located in the northeast. Although the City is almost fully developed, re-development projects are ongoing and planned as part of City Specific Plans. The Corridors Specific Plan (SP-4), which totals approximately 128 acres, is a revitalization of the Maclay Avenue, Truman Street and San Fernando Road corridors.

The City operates its wastewater collection system under the jurisdiction of the Los Angeles Regional Water Quality Control Board, the State Water Resources Control Board, and the U.S. Environmental Protection Agency.

The City contracted with Hall & Foreman to prepare a Municipal Sewer System Master, which is presented herein.

1.1 Objectives of Master Plan

The objectives of the Master Plan are as follows:

- Document City land use, existing and future City re-development projects, and develop a City GIS land use map in order to estimate wastewater generation across the City relating to the various land use types in the City, and then allocate wastewater generation in the City's hydraulic model of their wastewater collection system.

- Document historical City population growth and housing, and document future City population and housing estimates in order to estimate wastewater generation across the City consistent with typical per-capital and per-household wastewater generation.

- The City's sewer system base maps will be reviewed and updated to reflect correct pipe attribute data.

- Through the review of as-built drawings, atlas maps, and other records develop a horizontal and vertical Geographic Information System (GIS) representation of the City's collection system populating the GIS data base with collection system attribute data including sewer diameters, sewer lengths, sewer invert elevations, sewer slopes, sewer construction materials, sewer installation dates, manhole invert elevations, manhole rim elevations, manhole diameters and other connecting collection appurtenances.

- Through the GIS data, characterize the quantities and locations of sewers by diameter, material of construction, and installation year.

- Conduct temporary sewer flow monitoring at four locations in the City for two consecutive weeks in order to characterize average and peak wastewater flows across the City, develop unit wastewater generation by land use types, and on a per-capita basis, and input flows into the City's hydraulic model of their wastewater collection system.

- Document current strategies and methods to rehabilitate sanitary sewer infrastructure components and develop planning-level unit costs for these rehabilitation methods in order develop project costs in the recommended Capital Improvement Program.

- Videotape using closed circuit television (CCTV) approximately 25% of City sewers in order to identify structural and operation and maintenance defects; rate defects; and then incorporate recommended improvements into the Capital Improvement Program.

- Utilize state-of-the-art hydraulic analysis software in conjunction with City sewer system GIS to develop a hydraulic model of the City's sanitary sewer system in order to evaluate hydraulic system performance and identify hydraulic deficiencies.

- Establish sanitary sewer analysis criteria for maximum depth of flow in the pipe, minimum pipe velocity at peak dry-weather flow, minimum pipe slope, and pipe friction factors.

- Based on the hydraulic deficiencies identified, develop hydraulic capacity improvement projects for incorporation into the recommended Capital Improvement Program.

- Conduct the Master Plan work in consideration of SSMP requirements

- Based on project evaluations, investigations, and hydraulic analyses recommend project improvements, develop planning-level project cost estimates, and implement the projects into a scheduled 10-year Capital Improvement Program.

1.2 Definitions and Abbreviations

This section contains definitions and abbreviations commonly used throughout this report.

Infiltration (as defined by USEPA) - the water entering a sewer system and service connections from the ground through such means as, but not limited to, defective pipes, pipe joints, service connections, service laterals, or manhole walls.

1 – INTRODUCTION

Inflow (as defined by USEPA) - the water discharged into a sewer system, including service connections, from such sources as roof leaders; cellar, yard, and area drains; foundation drains; cooling water discharges; drains from springs and swampy areas; manhole covers; cross connections from storm sewers, combined sewers, or catch basins; storm waters; surface runoff; or drainage.

Excessive Infiltration and Inflow (I/I) - the extraneous clean water that enters the sanitary sewer system which can be eliminated on a cost-effective basis.

Minimum Monitored Flow - wastewater flow during dry-weather/low groundwater periods. Includes wastewater flow from water consumption and permanent infiltration.

Base Flow - wastewater flow exclusive of infiltration or inflow. Generally determined from water records during months when most of the water consumption is returned to the wastewater collection system.

Base Flow Peaking Factor - the ratio between peak hourly flow rate and average daily flow.

Permanent Infiltration - the difference between minimum monitored flow (dry-weather/low groundwater) and base flow as determined from water billing records. Assumed to occur 365 days per year.

Peak Infiltration - the maximum extraneous flow that enters the wastewater collection system during high groundwater conditions after the inflow effects of a rain event have ended.

Total Peak Infiltration - the sum of peak infiltration and permanent infiltration.

5-Year/60-Minute Storm - a storm event that produces 0.81 inches of rain per hour and is expected to occur at least once before five years have elapsed.

10-Year/60-Minute Storm - a storm event that produces 1.23 inches of rain per hour and is expected to occur at least once before 10 years have elapsed.

Relief Sewer - a new sewer required to transport projected flows during a design storm event without surcharge.

Design Storm Event - a storm event selected for purposes of analyzing its effect on the wastewater collection system.

Service and Contingency Factor - this factor includes 10 percent for engineering, 20 percent for contingency, and 7 percent for legal, fiscal, and administrative costs. The service and contingency factor is used to convert estimated construction costs to capital costs.

gpd - gallons per day.

gpy - gallons per year.

1 – INTRODUCTION

mgd - million gallons per day.

idm - inch-diameter-miles. The product of sewer pipe diameter in inches and length of sewer in feet divided by 5280 ft.

gpd/idm - gallons per day per inch-diameter-mile.

O&M cost - operation and maintenance cost.

$/gpd - rehabilitation cost divided by flow rate in gallons per day.

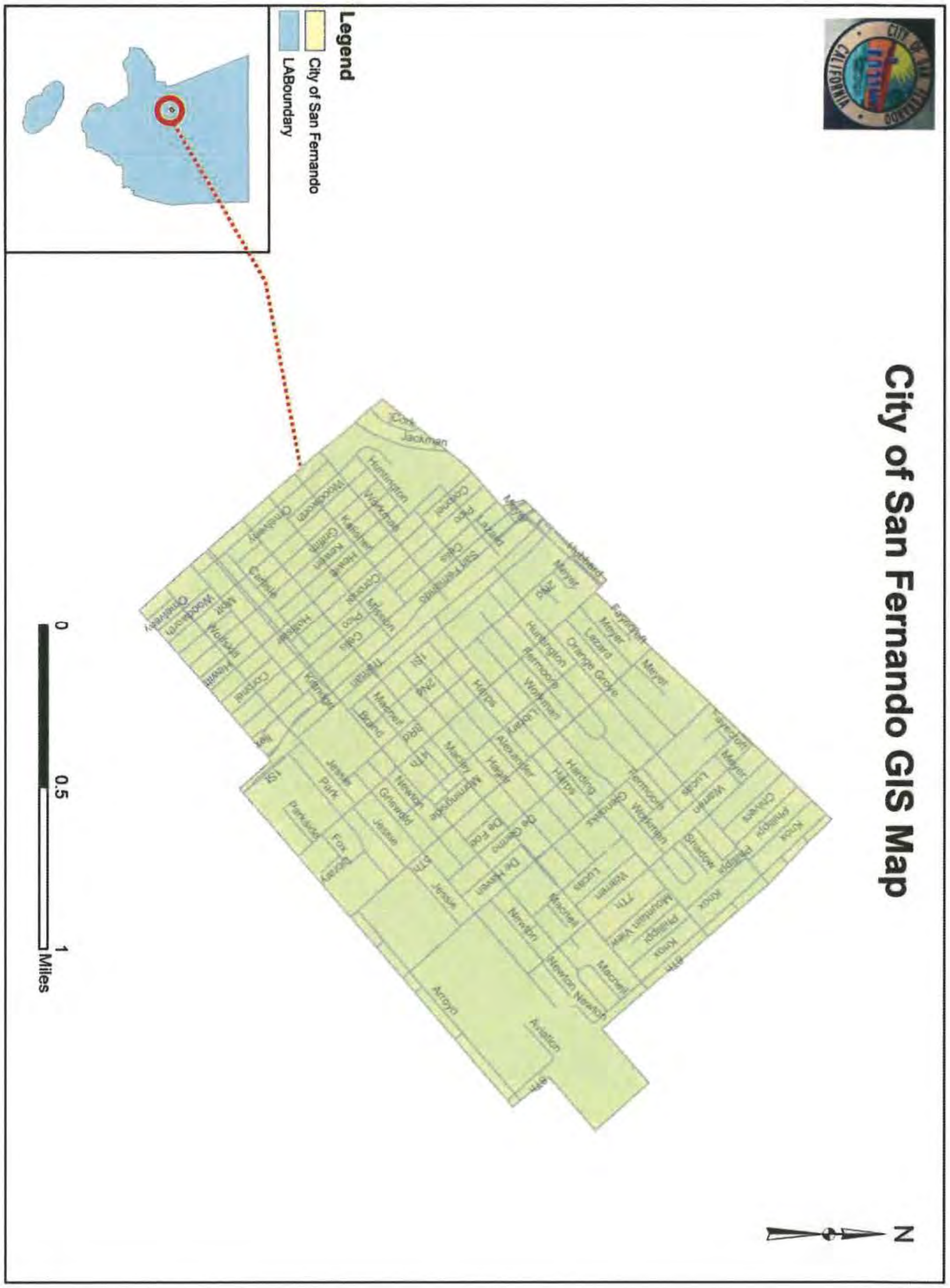


Figure 1 – San Fernando Locational GIS Map

1.3 Project Start-Up Activities

Existing sanitary sewer maps were used for defining sewer tributary areas (basins). City's manhole numbers were used, however, HFI delineated basins for flow monitoring activities and assigned basin numbers accordingly. During the course of the project several manholes that did not have IDs were discovered. These manholes were given manhole number 2000 and higher.

The sanitary sewer manhole numbering system used by HFI, Inc. includes the basin number and a manhole identification number (ID). The initial basin boundaries were determined by review of sewer maps and determining the outfalls for each basin. The outfall locations were later confirmed by field inspection during the flow meter installation. All manholes on an Atlas Sheet were numbered consecutively. The next three characters in the manhole number identify the specific manhole on the atlas sheet. The combination of basin numbers and manhole ID uniquely identify each manhole in the sewer system. During the master plan project, the study area was divided into five basins. Each manhole number was preceded by the corresponding basin number.

1.4 System Review, Research, & Database Design

In this phase HFI performed a comprehensive research of all available documents related to this project. We gathered all related map sheets, as-builts, and plan and profiles for the City's sewer system. However, the City only had about 1/3 of its sewer as-builts. HFI used City's atlas maps in conjunction with the City's as-builts to digitize the sewer lines and build the GIS database attributes.

1.5 Database / Data Dictionary Design

The database dictionary or a schema serves two important purposes. First it identifies all features and their associated attributes for data extraction. Second it identifies the source documents from which, information for the features and attributes should be extracted from. For this project, most of the attributes were extracted from the City's existing as-built drawings and gaps were filled in using City's atlas maps. To develop the hydraulic model, several attributes including line segment diameter, length, material as well as manhole invert elevations and ground elevation data were needed. In addition to these attributes additional attributes were built into the final database design. The database design also includes the design for Arcview themes for the GIS system.

1.6 Scanning of Existing Sewer Atlas Sheets

This was one of the first tasks completed in order to build the sewer network. City scanned all of its as-builts and has made the files available to HFI. HFI has linked all available as-builts geographically to the appropriate digitized sewer lines. In this manner a scanned image of the as-built drawings opens every time the user clicks on the desired line segment. The City now has a comprehensive spatial database of all of its original drawing that can be accessed utilizing its GIS system.

1.7 Development of GIS Sewer Map and Sewer Database

Utilizing the documents mentioned herein, HFI digitized all sanitary sewer line segments within the City's boundary. We also digitized some of the neighboring system's sanitary sewer system including a portion of the unincorporated areas surrounding the City. This was done to account for the neighboring systems' flow contribution to the City's system. Map sheets were edge matched such that common lines and arcs between adjacent polygons exactly coincide without overlaps. Also, lines between adjacent sheets were matched to coincide at the endpoints. Once the digitizing task was completed HFI technicians started the work on data extraction and data entry of the needed attributes for the GIS database. These attributes were extracted based on the database design described earlier. Next, HFI proceeded with populating the database with sewer attribute features.

2 – LAND USE, POPULATION

2.0 City Land Use

There are 1,314 acres of land inside the City boundaries. City land use presented herein is based on the City's current General Plan and zoning map. As shown in Table 2-1 and on Figure 2-1, Based the predominant land use in the City is residential land use at 67% of the total land use (874 acres) including single family (R1), multi-family dwelling (R2), and multi-family (R3). Of the residential land use categories, low density residential (R1) is predominant at 73% of the total residential land use.

Most of the R2 residential is located in the southern portion of the City, south of Celis Street. Most of the R3 residential is located between First Street and Fourth Street; in the south central area of the City.

There are 65 acres of commercial land use distributed across the City. Most of the Limited Commercial land use is intermixed with the R3 residential south of Celis Street. Industrial land uses total 190 acres with most located in the northeast. Industrial land use is also located on the south side of First St. east of Maclay Ave. Approximately 161 acres is land that will be re-developed in the future as part of City Specific Plans or other planned development.

2.1 Future Redevelopment

The City has identified four specific plans to redevelop parts of the City:

2.1.1 Corridors Specific Plan (SP-4)

The Corridors Specific Plan (SP-4), which totals approximately 128 acres, is a revitalization of the Maclay Avenue, Truman Street and San Fernando Road corridors. SP-4 encompasses the full lengths of Truman Street and San Fernando Road within the City, from the eastern boundary with Pacoima to the western boundary with Sylmar. The project boundaries include the entire public rights-of-way as well as parcels located to the north and south of these roads. On Maclay Avenue, the plan area includes the entire public right-of-way and all its fronting properties from San Fernando Road to Eighth Street at the city's northern border with Sylmar.

Along the entire length of Maclay Avenue the zoning prior to the adoption of this plan was "General Commercial". However, this corridor contains a wide range of land uses including single- and multi-family homes, retail, office, and civic institutions such as libraries, churches, and public schools. Implementation of SP-4 will enable new corridor-oriented home sites for City residents along Maclay Avenue. New shops and services will compliment new residential development with locally-serving clusters of retail and services developed.

The Downtown District along Maclay Avenue, between First Street and Fourth Street, contains most of the City's primary destinations: the shopping district along Maclay Avenue, the adjacent Civic Center, and the San Fernando Mall. This area will be revitalized with new investment in the form of retail shops, restaurants and cafes. Complimentary uses like offices and homes will occupy the upper stories of many of the new commercial buildings.

2 – LAND USE, POPULATION

Table 2-1. City Land Use

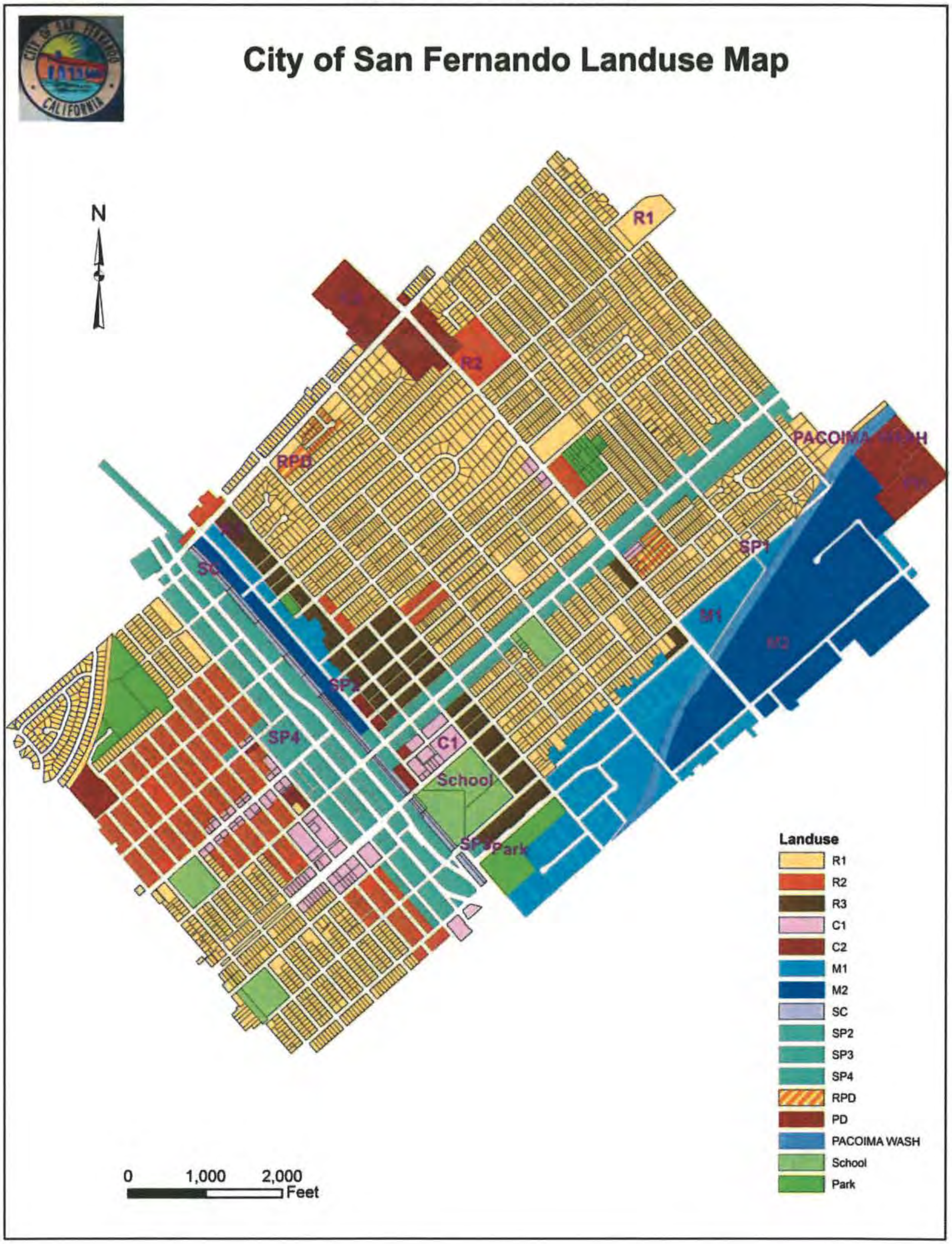
Land Use Category	Acres	% Total Land Use
Residential		
R1 - Single Family Residential	633.6	48.2%
R2 - Multiple Family Dwelling	135.5	10.3%
R3 - Multiple Family	105.0	8.0%
Subtotal	874.1	66.5%
Commercial		
C1 - Limited Commercial	33.1	2.5%
C2 - Commercial	18.9	1.4%
SC - Service Commercial	12.9	1.0%
Subtotal	64.9	4.9%
Industrial		
M1- Limited Industrial	91.4	7.0%
M2 - Light Industrial	98.6	7.5%
Subtotal	190.0	14.5%
Other		
School		0.0%
Park		0.0%
Pacoima Wash	24.1	1.8%
Subtotal	24.1	1.8%
Specific Plans/Planned Development		
SP-1	1.0	0.1%
SP-2	0.9	0.1%
SP-3	2.8	0.2%
SP-4 Corridors Specific Plan	127.5	9.7%
Residential Planned Develop. (RPD)	9.1	0.7%
Precise Development Overlay (PD)	19.5	1.5%
Subtotal	160.8	12.2%
Total	1,313.9	100%

The previous zoning for San Fernando Road was "Commercial" (C-2) to the west; "Limited Commercial" in the vicinity of San Fernando Mall; and "Service Commercial" east of the mall. Truman Street west of San Fernando Mission Boulevard was zoned "Light Industrial" prior to the adoption of this specific plan; "Commercial" between Workman Street and Maclay Avenue; and was also zoned "Commercial" east of Maclay Avenue.

With the implementation of SP-4, new residences, businesses and services will infill undeveloped areas along Truman Street and San Fernando Road and new mixed-use development will inter-mix residences with shops and services to the east and south of the Downtown District.

2 – LAND USE, POPULATION

Figure 2-1 - Land Use Map



2.1.2 Other Specific Plans

SP-1 and SP-2, both approximately 1-acre in size, are planned for re-development with a mix of new residential and commercial (mixed-use). SP-1 is located in the northeast at the intersection of Seventh Street and Griswold Avenue and SP-2 is located off of First Street just west of City Hall. SP-3 is a 2.8 acre site located between the San Fernando Middle School and San Fernando Recreation Park that is planned for senior residential housing.

2.2 City Population and Housing Characteristics

Historical population and housing was obtained from census data and from State Department of Finance data. As shown in Table 2-2 and on Figure 2-2, the City's population increased from 22,580 in 1990 to 23,560 in 2000, which was an average annual increase of 0.43%. The population grew at a lesser annual rate of 0.03% between 2000 and 2010 as the City approached full development. The City's population was 24,079 as of January 2013.

Housing grew at an annual rate of 0.25% between 1990 and 20000, but grew at a higher rate of 0.57% between 2000 and 2010. There were 6,351 dwelling units in the City as of January 2013. The number of vacant dwelling units increased from 159 in 2000 (2.68% vacancy) to 327 (5.15% vacancy) in 2013. The number of people per occupied dwelling unit (population density) has remained relatively constant at approximately 4.0 since 1990.

Projected population and housing for the City in 5-year increments through 2035 was provided by the Southern California Association of Governments (SCAG) 2012 Regional Transportation Plan Growth Forecast.

As shown in Table 2-2 and on Figure 2-2, the City's population is projected to increase to 25,500 by the year 2035, which is an average annual increase of 0.28% and a total increase of 5.9% relative to January 2013. New housing is projected to increase by 3.9% to 6,600 dwelling units in 2025. Assuming that vacancy will remain at 5.15%, the City's population density would be approximately 4.1 people per occupied dwelling unit through the year 2035.

2.3 Sanitary Sewer Characteristics

Hall & Foreman, Inc. analyzed approximately 43 miles of sewers in and tributary to the City's sanitary sewer collection system with sewer pipe sizes varying in diameter from 4 inches to 24 inches as shown in Table 2-3. The City's collection system is shown on Figure 2-3. Most of the City sewers are 8 inches in diameter (78%) and are made of vitrified clay pipe (VCP) material (97%). There are approximately 834 manholes in the City's collection system. The newer manholes are made of concrete, with the older manholes constructed of brick.

All flow from the City's sewer system discharges to the County Sanitation Districts of Los Angeles County (County) sewer system at Wolfskill St. and Amboy Street on Figure 2-3.

City sewers still in operation date back to the 1920s. However, most of the system was constructed in the 1950s when the City had its largest growth period.

2 – LAND USE, POPULATION

Table 2-2. Historical and Projected City Population and Housing (1990 - 2035)

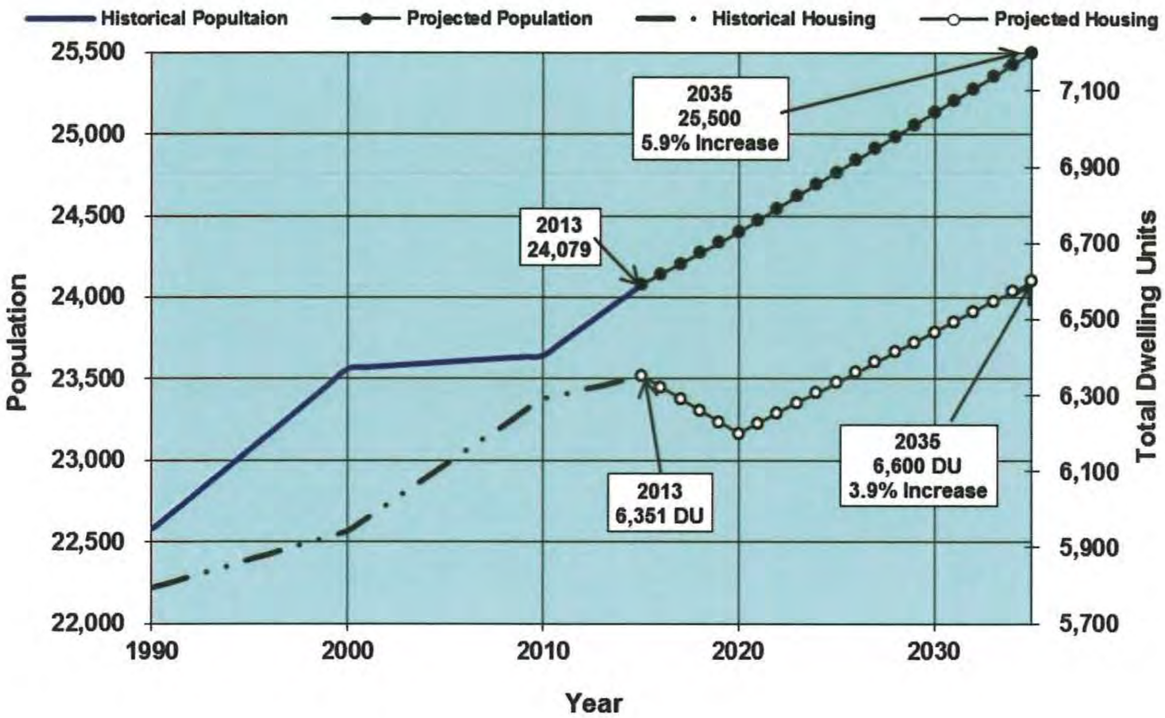
	Historical City Population and Housing				Projected[a]			
	1990	2000	2010	2013	2020	2025	2030	2035
Population	22,580	23,564	23,645	24,079	24,400	24,767	25,133	25,500
Annual % Increase	-	0.43%	0.03%	0.46%	0.22%	0.30%	0.29%	0.29%
Total Dwelling Units	5,794	5,943	6,291	6,351	6,200	6,333	6,467	6,600
Annual % Increase	-	0.25%	0.57%	0.24%	-0.40%	0.43%	0.42%	0.41%
Vacant Dwelling Units	161	159	324	327	319	326	333	340
% Vacant[b]	2.78%	2.68%	5.15%	5.15%	5.15%	5.15%	5.15%	5.15%
Population/Occ. DU	4.01	4.07	3.96	4.00	4.15	4.12	4.10	4.07

a) From Southern California Association of Governments, 2012 Regional Transportation Plan Growth Forecast.

b) Vacant dwelling units for 2020 - 2035 assumed equal to 5.15% consistent with 2010-2013 vacancy %.

2 – LAND USE, POPULATION

Figure 2-2. City Historical/Projected Population & Housing



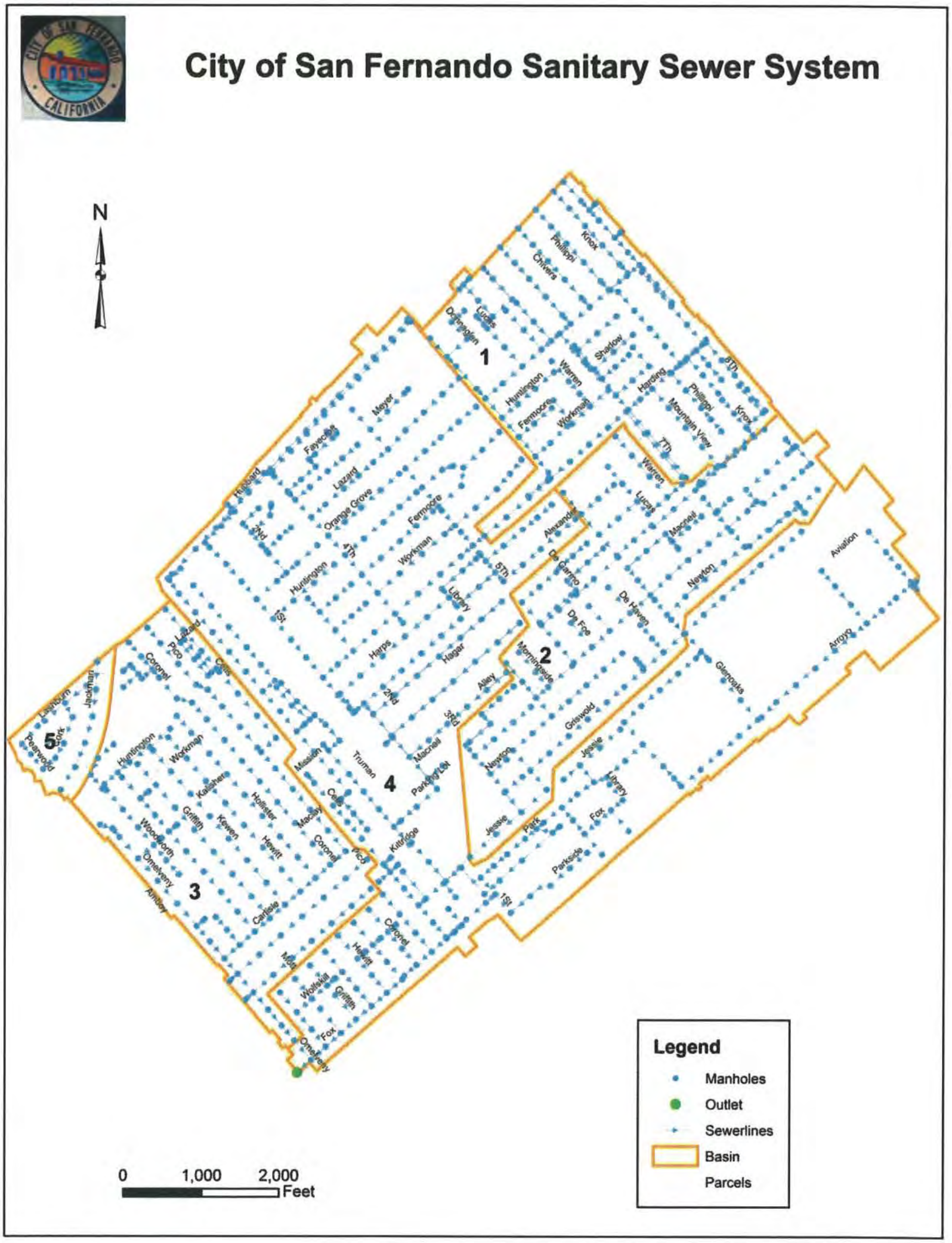
2 – LAND USE, POPULATION

Table 2-3. Sewer Diameters and Lengths

Sewer Diameter (in)	Length (ft)	Length (mi)	% Total Sewer Length
4	1,215	0.2	0.5%
6	481	0.1	0.2%
8	175,827	33.3	78.2%
10	14,023	2.7	6.2%
12	8,521	1.6	3.8%
15	16,978	3.2	7.6%
18	6,944	1.3	3.1%
24	863	0.2	0.4%
Total	**224,852**	**42.6**	**100.0%**

2 – LAND USE, POPULATION

Figure 2-3 - Sanitary Sewer System



3 – FLOW MONITORING

3.0 Project Flow Monitoring

Temporary sewer flow monitoring was conducted at 4 locations to meter wastewater flows in the City for 23 consecutive days from November 13, 2013 through December 5, 2013. The metering site locations as well as the area or zone metered by each flow meter (meter basin) is shown on Figure 3-1.

Hourly flow data for each metering site for the 23-day flow monitoring period is included in the Appendix. The flow monitoring period included Thanksgiving week from November 25th through December 1st with Thanksgiving day occurring on November 28th. As would be expected, the wastewater peak flow on Thanksgiving was higher than normal and the flows for the week were atypical of normal wastewater flows in the City as evidenced by the other flow monitoring data collected during the monitoring period. The data for this week was not used to develop typical diurnal wastewater flow in the City.

Rainfall did not occur on 21 of the 23 days of project flow monitoring. Light Rain occurred on two consecutive days, November 21st and 22nd, with the rain totaling approximately 0.5 inches each day. The low rainfall had little to no impact on normal dry-weather wastewater flows. However, these two days were not used to develop typical dry-weather diurnal wastewater flow in the City. Without significant rainfall, only dry-weather flows were measured and evaluated in the hydraulic model (Chapter 6). Peak wet-weather flows are accounted for by designing sewers to carry peak-dry weather flows at maximum sewer flow depth over diameter (d/D) ratios. The remainder of the pipe flow area is reserved to carry wet weather flow on top of peak dry-weather flow.

In the future, the City should set up meters during higher rainfall months such as January and February in hopes of metering wet-weather flows from significant storms, with this data then used to hydraulically model wet-weather flows in the sewer system.

Other than Thanksgiving week and the two rain days, week-day flows were used to develop 24-hour flow patterns, average flows, peak flows, and peaking factors (the ratio of peak flow over average flow) for the four meter basins. Week-day flows provide definitive diurnal flows and peak flow times that typically occur at approximately 8:00 am and 9:00 pm each week day. Week end flows and peaking times are typically more variable and peak flows are typically less than more defined peak flows during the week.

For this monitoring period, the four week end days evaluated actually had peaking factors similar to the week day peaking factors, but a larger sample of week end days would most likely show a smaller peaking factor. Although only week day flows will be evaluated in the model, the peaking factor used in the analysis (1.5) will also be reflective of the peaking factors recorded on the four weekend days.

Nine week days during the monitoring period were used to develop characteristic flow data used for analysis. This data is shown in Tables 3-1, 3-2, 3-3, and 3-4 for Metered Basins 1, 2, 3 and 4, respectively.

3 – FLOW MONITORING

Table 3-1. Meter Basin No. 1 Hourly Flows (mgd)

	14-Nov	15-Nov	18-Nov	19-Nov	20-Nov	2-Dec	3-Dec	4-Dec	5-Dec	
	Thu	Fri	Mon	Tue	Wed	Mon	Tue	Wed	Thu	Average
1 am	0.36	0.37	0.33	0.39	0.39	0.35	0.41	0.40	0.38	0.37
2 am	0.23	0.23	0.21	0.27	0.28	0.26	0.27	0.25	0.25	0.25
3 am	0.20	0.19	0.19	0.21	0.26	0.23	0.23	0.21	0.22	0.22
4 am	0.21	0.19	0.19	0.21	0.21	0.23	0.25	0.21	0.23	0.21
5 am	0.28	0.29	0.21	0.30	0.31	0.30	0.29	0.26	0.30	0.28
6 am	0.50	0.47	0.48	0.52	0.50	0.50	0.50	0.52	0.50	0.50
7 am	0.69	0.68	0.67	0.72	0.68	0.65	0.61	0.68	0.64	0.67
8 am	**0.84**	**0.83**	**0.82**	**0.88**	0.81	**0.83**	**0.84**	**0.83**	**0.82**	**0.83**
9 am	0.62	0.59	0.62	0.65	0.63	0.70	0.68	0.61	0.66	0.64
10 am	0.58	0.60	0.59	0.63	0.64	0.69	0.50	0.59	0.63	0.61
11 am	0.58	0.63	0.64	0.62	0.63	0.64	0.28	0.58	0.65	0.58
12 pm	0.59	0.61	0.62	0.62	0.61	0.64	0.22	0.59	0.63	0.57
1 pm	0.59	0.61	0.62	0.63	0.61	0.60	0.44	0.58	0.62	0.59
2 pm	0.53	0.59	0.60	0.60	0.59	0.59	0.43	0.59	0.60	0.57
3 pm	0.54	0.54	0.59	0.62	0.57	0.56	0.43	0.53	0.58	0.55
4 pm	0.51	0.57	0.58	0.61	0.58	0.56	0.59	0.56	0.57	0.57
5 pm	0.50	0.58	0.59	0.63	0.57	0.56	0.59	0.56	0.62	0.58
6 pm	0.58	0.63	0.66	0.71	0.65	0.59	0.60	0.61	0.63	0.63
7 pm	0.65	0.64	0.72	0.77	0.71	0.58	0.82	0.66	0.69	0.69
8 pm	0.71	0.63	0.79	0.83	0.81	0.69	0.79	0.75	0.71	0.74
9 pm	0.76	0.59	0.77	0.83	**0.86**	0.72	0.81	0.83	0.70	0.77
10 pm	0.74	0.58	0.72	0.80	0.80	0.69	0.78	0.78	0.70	0.73
11 pm	0.64	0.52	0.63	0.61	0.67	0.62	0.67	0.63	0.62	0.62
12 am	0.48	0.45	0.48	0.48	0.54	0.52	0.52	0.51	0.48	0.50
Avg	0.54	0.53	0.56	0.59	0.58	0.55	0.52	0.55	0.56	**0.55**
Peak	0.84	0.83	0.82	0.88	0.86	0.83	0.84	0.83	0.82	**0.83**
PF	1.56	1.57	1.48	1.49	1.48	1.50	1.61	1.50	1.47	**1.51**

Daily Peak Flow

3 – FLOW MONITORING

Table 3-2. Meter Basin No. 2 Hourly Flows (mgd)

	14-Nov	15-Nov	18-Nov	19-Nov	20-Nov	2-Dec	3-Dec	4-Dec	5-Dec	
	Thu	Fri	Mon	Tue	Wed	Mon	Tue	Wed	Thu	Average
1 am	0.21	0.20	0.19	0.20	0.20	0.21	0.19	0.20	0.19	0.20
2 am	0.15	0.13	0.15	0.15	0.15	0.17	0.16	0.16	0.16	0.15
3 am	0.13	0.13	0.11	0.14	0.12	0.16	0.13	0.15	0.15	0.13
4 am	0.13	0.13	0.11	0.13	0.11	0.15	0.11	0.15	0.12	0.13
5 am	0.15	0.16	0.13	0.15	0.13	0.17	0.13	0.16	0.16	0.15
6 am	0.24	0.23	0.22	0.23	0.22	0.21	0.22	0.23	0.23	0.23
7 am	0.40	0.37	0.34	0.36	0.35	0.33	0.34	0.36	0.35	0.36
8 am	**0.55**	**0.47**	0.47	**0.46**	**0.46**	0.45	**0.44**	0.45	0.47	**0.47**
9 am	0.42	0.38	0.40	0.36	0.35	0.38	0.39	0.38	0.39	0.38
10 am	0.39	0.38	0.40	0.37	0.34	0.40	0.39	0.36	0.36	0.38
11 am	0.36	0.40	0.41	0.40	0.37	0.40	0.36	0.36	0.37	0.38
12 pm	0.40	0.39	0.42	0.40	0.36	0.42	0.36	0.34	0.36	0.38
1 pm	0.38	0.36	0.40	0.37	0.39	0.39	0.37	0.36	0.35	0.37
2 pm	0.36	0.38	0.38	0.35	0.37	0.38	0.34	0.37	0.38	0.37
3 pm	0.35	0.33	0.37	0.37	0.33	0.39	0.31	0.35	0.36	0.35
4 pm	0.33	0.34	0.37	0.40	0.31	0.38	0.36	0.34	0.32	0.35
5 pm	0.39	0.39	0.36	0.39	0.36	0.38	0.38	0.35	0.35	0.37
6 pm	0.39	0.41	0.40	0.44	0.39	0.43	0.39	0.39	0.39	0.40
7 pm	0.43	0.43	0.44	**0.46**	0.40	0.46	0.42	0.40	0.41	0.43
8 pm	0.46	0.37	**0.48**	**0.46**	0.42	0.44	0.42	**0.46**	0.45	0.44
9 pm	0.49	0.38	0.47	**0.46**	0.43	**0.47**	**0.44**	**0.46**	**0.49**	0.46
10 pm	0.44	0.35	0.44	0.44	0.41	0.44	0.42	0.44	0.46	0.43
11 pm	0.36	0.29	0.38	0.33	0.36	0.37	0.36	0.38	0.37	0.36
12 am	0.24	0.23	0.25	0.25	0.27	0.26	0.25	0.26	0.28	0.25
Avg	0.34	0.32	0.34	0.34	0.32	0.34	0.32	0.33	0.33	**0.33**
Peak	0.55	0.47	0.48	0.46	0.46	0.47	0.44	0.46	0.49	**0.47**
PF	1.60	1.48	1.43	1.38	1.46	1.38	1.38	1.42	1.50	**1.42**

Daily Peak Flow

3 – FLOW MONITORING

Table 3-3. Meter Basin No. 3 Hourly Flows (mgd)

	13-Nov	14-Nov	15-Nov	18-Nov	19-Nov	20-Nov	2-Dec	3-Dec	4-Dec	5-Dec	
	Wed	Thu	Fri	Mon	Tue	Wed	Mon	Tue	Wed	Thu	Average
1 am	0.14	0.17	0.18	0.15	0.15	0.16	0.16	0.19	0.16	0.14	0.16
2 am	0.11	0.09	0.11	0.10	0.11	0.12	0.12	0.12	0.12	0.09	0.11
3 am	0.08	0.09	0.10	0.10	0.10	0.11	0.10	0.09	0.10	0.09	0.10
4 am	0.05	0.07	0.08	0.08	0.09	0.08	0.09	0.07	0.09	0.07	0.08
5 am	0.07	0.08	0.10	0.09	0.11	0.09	0.09	0.09	0.10	0.08	0.09
6 am	0.17	0.18	0.20	0.16	0.21	0.19	0.19	0.18	0.17	0.14	0.18
7 am	0.29	0.33	0.33	0.33	0.32	0.33	0.29	0.28	0.27	0.27	0.30
8 am	**0.41**	**0.42**	**0.46**	0.42	**0.42**	**0.43**	0.35	**0.37**	0.34	0.37	**0.40**
9 am	0.29	0.32	0.30	0.34	0.36	0.34	0.29	0.29	0.29	0.31	0.31
10 am	0.30	0.35	0.37	0.37	0.35	0.34	0.29	0.29	0.29	0.31	0.32
11 am	0.32	0.34	0.36	0.38	0.36	0.35	0.32	0.31	0.33	0.32	0.34
12 pm	0.31	0.33	0.37	**0.43**	0.35	0.36	0.30	0.31	0.32	0.33	0.34
1 pm	0.31	0.36	0.41	0.40	0.37	0.37	**0.37**	0.33	0.34	0.32	0.36
2 pm	0.29	0.30	0.33	0.37	0.34	0.35	0.31	0.32	0.31	0.34	0.33
3 pm	0.33	0.29	0.34	0.36	0.34	0.35	0.29	0.29	0.29	0.31	0.32
4 pm	0.28	0.27	0.31	0.36	0.35	0.34	0.27	0.32	0.29	0.29	0.31
5 pm	0.28	0.34	0.33	0.35	0.32	0.35	0.28	0.31	0.31	0.30	0.32
6 pm	0.34	0.40	0.33	0.34	0.35	0.37	0.31	0.35	0.30	0.31	0.34
7 pm	0.34	**0.42**	0.37	0.39	0.37	0.35	0.32	0.34	0.33	**0.39**	0.36
8 pm	0.35	0.38	0.34	0.39	0.38	0.38	**0.37**	0.36	0.33	0.36	0.36
9 pm	0.40	0.41	0.34	0.37	0.38	0.36	0.32	0.35	0.35	0.34	0.36
10 pm	0.38	0.41	0.31	0.38	0.36	0.37	0.32	0.35	**0.36**	0.32	0.36
11 pm	0.30	0.32	0.29	0.30	0.33	0.34	0.27	0.27	0.31	0.29	0.30
12 am	0.24	0.27	0.28	0.24	0.24	0.30	0.24	0.24	0.23	0.23	0.25
Avg	0.27	0.29	0.29	0.30	0.29	0.30	0.26	0.27	0.26	0.26	**0.28**
Peak	0.41	0.42	0.46	0.43	0.42	0.43	0.37	0.37	0.36	0.39	**0.40**
PF	1.54	1.46	1.60	1.42	1.42	1.45	1.42	1.38	1.38	1.49	**1.43**

Daily Peak Flow

3 – FLOW MONITORING

Table 3-4. Meter Basin No. 4 Hourly Flows (mgd)

	13-Nov	14-Nov	15-Nov	18-Nov	19-Nov	20-Nov	2-Dec	3-Dec	4-Dec	Average
	Wed	Thu	Fri	Mon	Tue	Wed	Mon	Tue	Wed	
1 am	1.32	1.41	1.47	1.48	1.53	1.57	1.64	1.61	1.63	1.52
2 am	1.18	1.25	1.29	1.16	1.41	1.50	1.24	1.32	1.34	1.30
3 am	1.06	0.91	1.01	0.92	1.19	1.27	1.08	1.09	1.10	1.07
4 am	1.01	0.95	1.02	0.91	1.10	1.23	1.02	1.01	1.08	1.04
5 am	1.17	1.20	1.27	0.93	1.20	1.34	1.03	0.98	1.13	1.14
6 am	1.65	1.53	1.54	1.28	1.63	1.71	1.37	1.59	1.32	1.51
7 am	2.24	2.11	2.00	2.05	2.18	2.10	1.83	1.92	2.16	2.07
8 am	**2.45**	**2.36**	**2.37**	**2.78**	**2.86**	**2.59**	2.79	**2.76**	2.70	2.63
9 am	2.34	2.17	2.08	2.50	2.44	2.22	2.40	2.40	2.40	2.33
10 am	2.28	2.19	2.09	2.52	2.42	2.10	2.43	2.41	2.21	2.29
11 am	2.28	2.09	2.15	2.42	2.39	2.23	2.67	2.47	2.28	2.33
12 pm	2.38	2.08	2.22	2.51	2.49	2.35	2.67	2.42	2.29	2.38
1 pm	2.31	2.14	2.15	2.48	2.40	2.29	2.55	2.48	2.33	2.35
2 pm	2.26	2.15	2.24	2.32	2.34	2.30	2.55	2.46	2.38	2.33
3 pm	2.29	2.06	2.22	2.34	2.32	2.27	2.52	2.35	2.33	2.30
4 pm	2.25	2.03	2.22	2.27	2.44	2.20	2.54	2.34	2.29	2.29
5 pm	2.36	2.07	2.29	2.29	2.49	2.30	2.63	2.49	2.39	2.37
6 pm	2.32	2.09	2.33	2.34	2.41	2.42	2.65	2.43	2.46	2.39
7 pm	2.24	2.26	2.34	2.45	2.46	2.41	2.68	2.59	2.69	2.46
8 pm	2.27	2.35	2.25	2.51	2.52	2.50	2.67	2.63	2.74	2.49
9 pm	2.37	2.29	2.15	2.69	2.42	2.48	**2.82**	2.68	**2.82**	2.52
10 pm	2.31	2.24	2.18	2.51	2.53	2.53	2.74	2.64	2.78	2.50
11 pm	2.21	2.15	2.05	2.28	2.22	2.33	2.49	2.38	2.40	2.28
12 am	1.94	1.85	1.85	1.91	1.89	2.01	1.83	1.81	1.77	1.87
Avg	2.02	1.91	1.95	2.08	2.14	2.09	2.20	2.14	2.13	**2.07**
Peak	2.45	2.36	2.37	2.78	2.86	2.59	2.82	2.76	2.82	**2.63**
PF	1.21	1.24	1.21	1.34	1.34	1.24	1.28	1.29	1.32	**1.27**

Daily Peak Flow

3 – FLOW MONITORING

Figure 3-2. Meter Basin No. 1 Average Hourly Flows

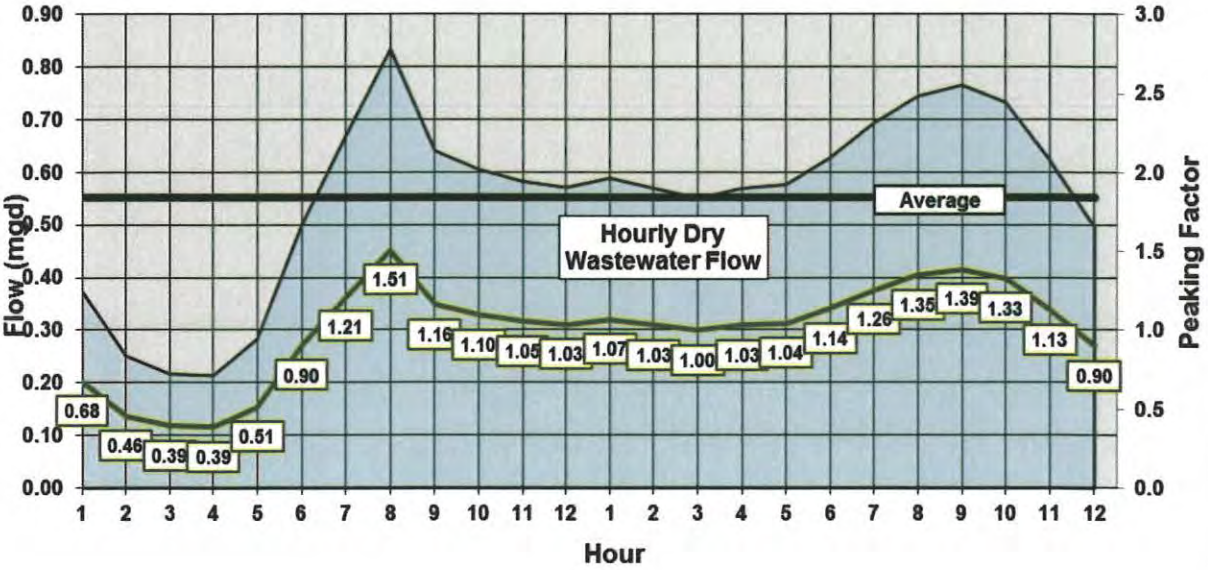
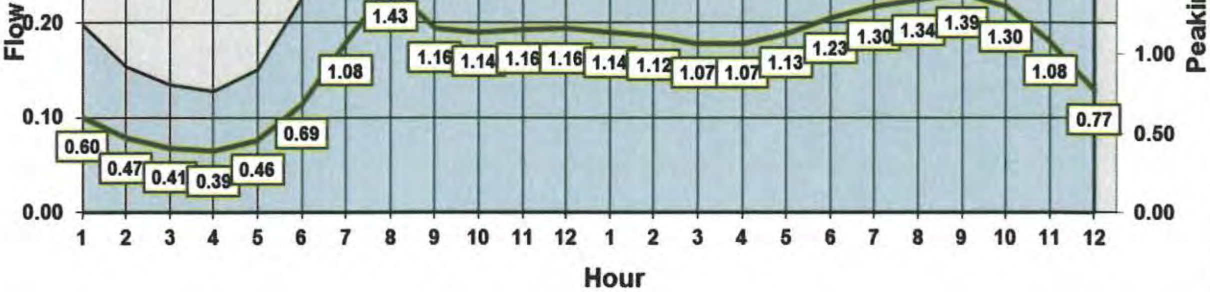
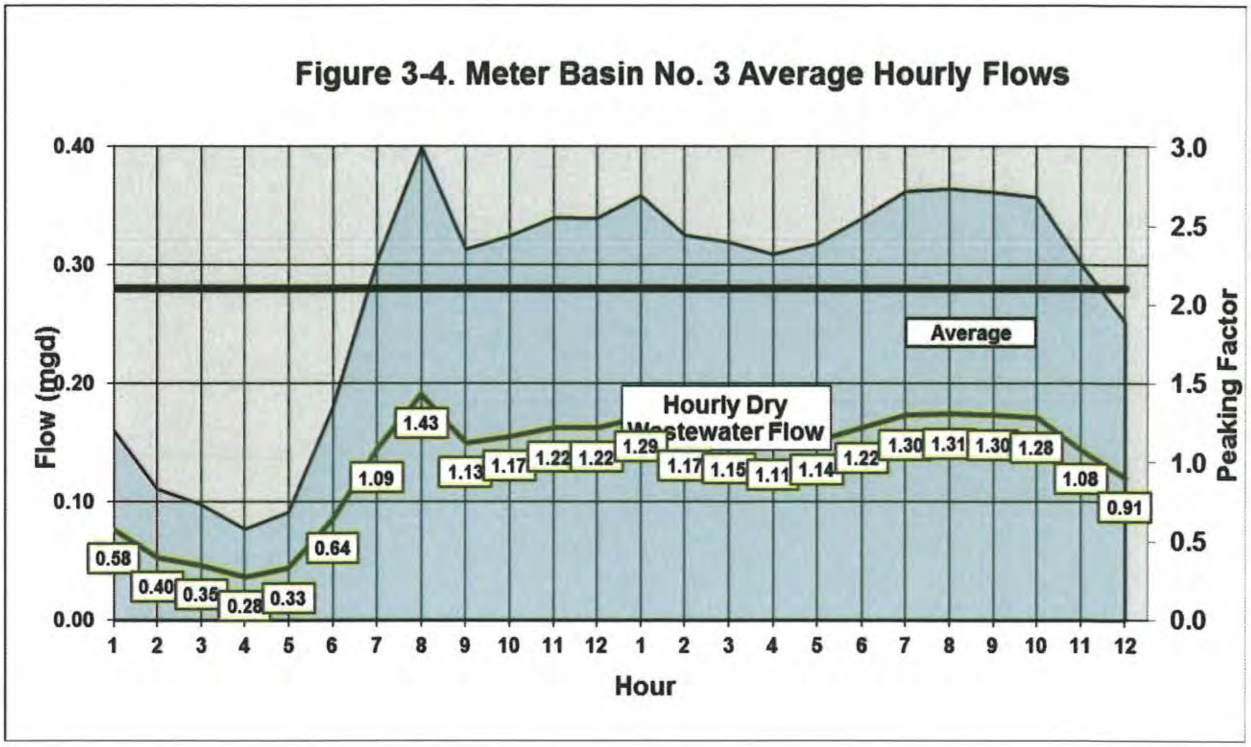
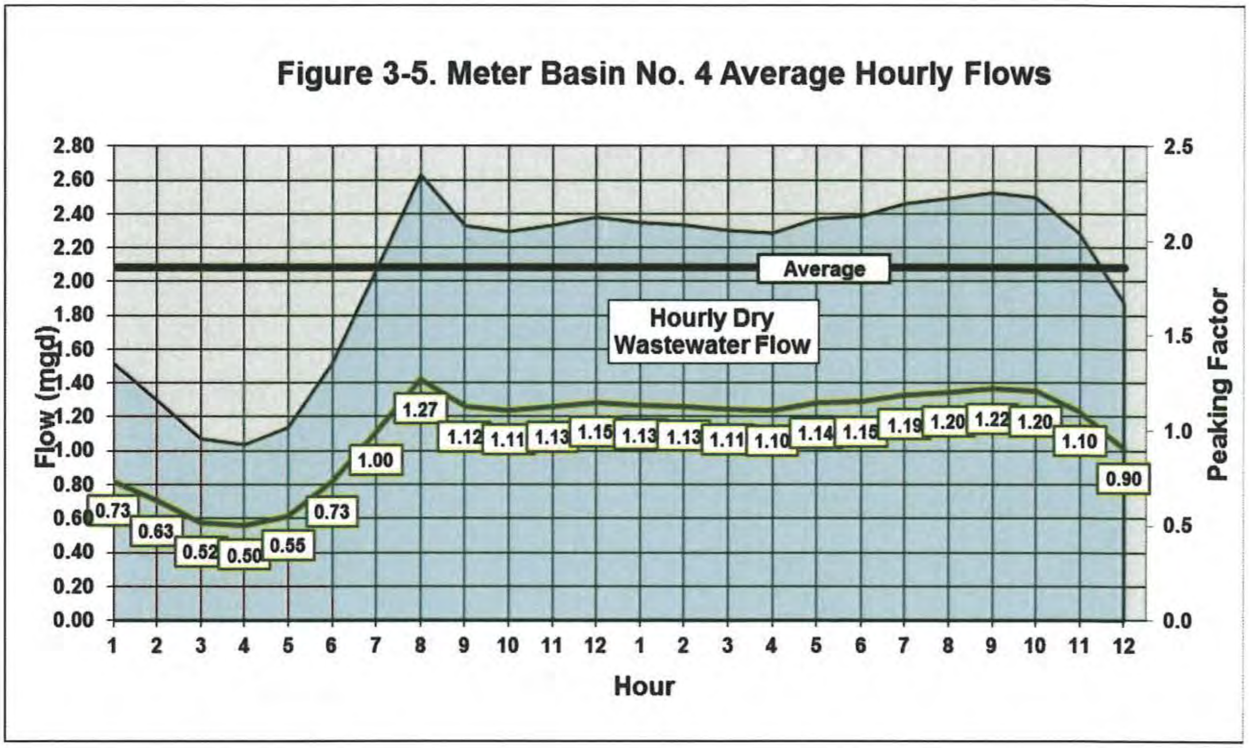


Figure 3-3. Meter Basin No. 2 Average Hourly Flows



3 – FLOW MONITORING





3 – FLOW MONITORING

Flow patterns and peaking factors in a meter basin is defined by the land use within the basin. Table 3-5 shows the land use in each of the four meter basins.

3.01 Meter Basin 1

Meter Basin 1 is located in the northwest corner of the City and totals 557 acres of which 90% is residential land use. As such, the flow monitoring data is indicative of residential flow patterns and peaking factors. As shown in Table 3-1 and on Figure 3-2, the flows consistently peaked at 8:00 a.m. (1.51 peaking factor) with a second peak occurring at 9:00 pm (1.39 peaking factor). which is typical for residential wastewater flow. The basin is an upstream basin with no basins flowing into it.

3.02 Meter Basin 2

Meter Basin 1 is located in the north central portion of the City and totals 229 acres of which 83% is residential land use. As such, the flow monitoring data is also indicative of residential flow patterns and peaking factors. As shown in Table 3-2 and on Figure 3-3, the flows consistently peaked at 8:00 a.m. (1.43 peaking factor) with a second peak occurring at 9:00 pm (1.39 peaking factor). The basin is an upstream basin with no basins flowing into it.

3.03 Meter Basin 3

Meter Basin 3 is located in the southern end of the City and totals 191 acres of which 77% is residential land use. As such, the flow monitoring data is also indicative of residential flow patterns and peaking factors. However, there are 25 acres of commercial land use (13%). As shown in Table 3-3 and on Figure 3-4, the flows consistently peaked at 8:00 a.m. (1.43 peaking factor), but the second peak was flatter, occurring between 7:00 pm at 10:00 pm (approximately 1.30 peaking factor), and the flows were slightly higher in the middle of the day. This is due to the commercial land use in the basin, which has higher flows in the middle of the day (during normal work hours) without defined peaks in the morning and the evening, The basin also has no basins flowing into it.

3.03 Meter Basin 4

Meter Basin 4 is the largest meter basin and is a downstream receiving basin that has upstream basins 1 and 2 flowing into it. The flows metered consist of flows from Meter Basins 1 and 2 as well as flows from Meter Basin 4. Meter Basin 4 covers the northwest corner of the City, which is primarily industrial land use; the central portion of the City, which includes City Hall and other public land uses as well as high-density multiple family residential land use and a portion of the Corridors Specific Plan; and the southwest corner of the City, which is primarily residential land use.

Approximately 58% of the land use in Meter Basin 4 is residential (380 acres), but there is a large amount of industrial land use in the northwest that totals 190 acres (29%) and also 30 acres of commercial land use. Like commercial, Industrial land (in general) has higher flows in the middle of the day (during normal work hours) without defined peaks in the morning and the evening. As shown in Table 3-4 and on Figure 3-5, the flows consistently peaked at 8:00 a.m., but the peaking factor is reduced to 1.27 and the second peak is almost indiscernible with the midday flows almost equivalent to the morning and evening peaks.

Although this flattening of the flow pattern in Meter Basin 4 is partly due to the industrial land use inside the basin, it is primarily because of the long travel times for flows from the upstream basins to reach Meter 4 at the far downstream end of the sewer system, which provides time for peak flows to equalize (time of concentration).

Meter 4 measured all wastewater flows in the City's sewer system except for Basin 3 wastewater flows. The average flow for the City's sewer system is calculated to be 2.35 mgd by adding the average flows recorded at Meter 4 (2.07 mgd) and Meter 3 (0.28 mgd).

3.1 Existing (Year 2013) Average Dry-Weather Wastewater Flows

Based on the dry-weather flow meter results, existing, average-day, unit-wastewater-generation factors (gallons per day per acre (gpd/ac)) were developed for the various land use categories in the City as shown in Table 3-5. The wastewater generation factors are average values for that type of land use.

The average unit wastewater generation factors were applied to the corresponding existing total acreage for that land use, and the average flows were added together to arrive at a total average-day wastewater flow of 2.35 million gallons per day (mgd) as shown in Table 3-5, which matches the flow monitoring results for total City average day flow as discussed in Section 3.0 (adding the average day flows for Meter 3 and Meter 4).

The existing, average-day, unit-wastewater-generation factors and flows for each land use category is reflective of an average housing vacancy rate of approximately 5% with the exception of existing land use for the Corridors Specific Plan (SP-4) where a 15% vacancy rate (combining both housing and land vacancies) was estimated. This results in a unit-wastewater generation factor (2,100 gpd/ac) that is approximately 9% lower than the factor that would have been estimated with a 5% vacancy rate (2,300 gpd/ac).

As discussed in Chapter 6, the City's land use map was used as a base map in the development of the hydraulic model of the City's sanitary sewer system. Unit wastewater generation factors were applied to the land use map to develop average wastewater flows in the hydraulic model. Unit factors were adjusted up or down from their average value to better calibrate flow for that basin.

Existing per-capita and per-dwelling-unit residential wastewater generation were estimated to be 71 gpcd and 283 gpd/du by dividing the total estimated residential wastewater generation by the 2013 population and 2013 occupied dwelling units, respectively, as shown in Table 3-6. Approximately half of the acreage for the Corridors Specific Plan was assumed to be multi-family residential (the other half was assumed to be commercial) with a corresponding wastewater generation coefficient of 2,250 gpd/ac.

3 – FLOW MONITORING

Table 3-5. Existing Wastewater Generation Factors and Average Flows

Land Use Category	Acres	Wastewater Generation Factor[a] (gpd/ac)	Flow (gpd)
Residential			
R1 - Single Family Residential	633.6	1,250	792,025
R2 - Multiple Family Dwelling	135.5	2,500	338,750
R3 - Multiple Family	105.0	3,500	367,570
Subtotal	874.1	-	1,498,345
Commercial			
C1 - Limited Commercial	33.1	2,000	66,160
C2 - Commercial	18.9	2,000	37,880
SC - Service Commercial	12.9	2,000	25,760
Subtotal	64.9	-	129,800
Industrial			
M1- Limited Industrial	91.4	1,500	137,130
M2 - Light Industrial	98.6	1,500	147,870
Subtotal	190.0	-	285,000
Other			
School		800	-
Park		300	-
Pacoima Wash	24.1	-	-
Subtotal	24.1	-	-
Specific Plans/Planned Development			
SP-1	1.0	2,100	2,142
SP-2	0.9	2,100	1,848
SP-3	2.8	2,100	5,943
SP-4 Corridors Specific Plan	127.5	2,100	267,729
Residential Planned Develop.	9.1	1,900	17,195
Precise Development Overlay	19.5	1,900	37,107
Subtotal	160.8	-	331,964
Total	1,313.9	-	2,245,109

a) Wastewater generation factors were estimated assuming a 5% vacancy rate, including vacant residential & commercial properties and vacant land, except for the SP-4 vacancy rate, which was estimated at 15%

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Table 3-6. Existing Residential Generation Factors and Average Flows

Land Use Category	Acres	Wastewater Generation Factor[a] (gpd/ac)	Flow (gpd)	Population	Dwelling Units
Residential					
R1 - Single Family Residential	633.6	1,250	792,025	-	-
R2 - Multiple Family Dwelling	135.5	2,500	338,750	-	-
R3 - Multiple Family	105.0	3,500	367,570	-	-
SP-1	1.0	2,100	2,142	-	-
SP-2	0.9	2,100	1,848	-	-
SP-3	2.8	2,100	5,943	-	-
SP-4 Corridors Specific Plan	63.8	2,250	143,438	-	-
Residential Planned Develop.	9.1	1,900	17,195	-	-
Precise Development Overlay	19.5	1,900	37,107	-	-
Total	971.2	-	1,706,018	24,079	6,024
Residential Unit Flow	-	-	-	71	283

3.2 Ultimate (Year 2035) Average Dry-Weather Wastewater Flows

Ultimate, average-day, wastewater flow for the City was estimated by increasing the residential unit-wastewater-generation factors by 6% to reflect the estimated population increase for the year 2035 (relative to the year 2013). Also, the vacancy rate for the Corridors Specific Plan area was estimated at 5% (as opposed to the estimated 15% for the existing SP-4 land use), which is the average vacancy rate estimated for the entire City. This increased the unit wastewater generation factor for the SP-4 land use from 2,100 (existing system) to 2,325. Based on these modifications and holding other variables constant relative to the existing system, the Ultimate System average-day wastewater flow for the City is estimated at 2.45 mgd, which is an increase of approximately 4% relative to the existing system flow (2.35 mgd).

3.3 Peaking Factors and Dry-Weather Flow Hydrographs

As discussed in Section 3.0, selected week-day flows during the flow monitoring period provided definitive diurnal flows and peak flow times that typically occurred at approximately 8:00 am and 9:00 pm each week day. Although weekend flows and peaking times are typically more variable

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Table 3-7. Ultimate Wastewater Generation Factors and Average Flows

Land Use Category	Acres	Wastewater Generation Factor[a] (gpd/ac)	Flow (gpd)
Residential			
R1 - Single Family Residential	633.6	1,325	839,547
R2 - Multiple Family Dwelling	135.5	2,650	359,075
R3 - Multiple Family	105.0	3,710	389,624
Subtotal	874.1	-	1,588,246
Commercial			
C1 - Limited Commercial	33.1	2,000	66,160
C2 - Commercial	18.9	2,000	37,880
SC - Service Commercial	12.9	2,000	25,760
Subtotal	64.9	-	129,800
Industrial			
M1- Limited Industrial	91.4	1,500	137,130
M2 - Light Industrial	98.6	1,500	147,870
Subtotal	190.0	-	285,000
Other			
School		800	-
Park		300	-
Pacoima Wash	24.1	-	-
Subtotal	24.1	-	-
Specific Plans/Planned Development			
SP-1	1.0	2,100	2,142
SP-2	0.9	2,100	1,848
SP-3	2.8	2,100	5,943
SP-4 Corridors Specific Plan	127.5	2,325	296,414
Residential Planned Develop.	9.1	1,900	17,195
Precise Development Overlay	19.5	1,900	37,107
Subtotal	160.8	-	360,649
Total	1,313.9	-	2,363,695

a) Wastewater generation factors were estimated assuming a 5% vacancy rate, including vacant residential & commercial properties and vacant land. The SP-4 vacancy rate was also estimated to be 5%.

b) Ultimate System residential unit wastewater generation factors were calculated by multiplying Existing System residential unit wastewater generation factors by the estimated year 2035 population increase of 6.0%

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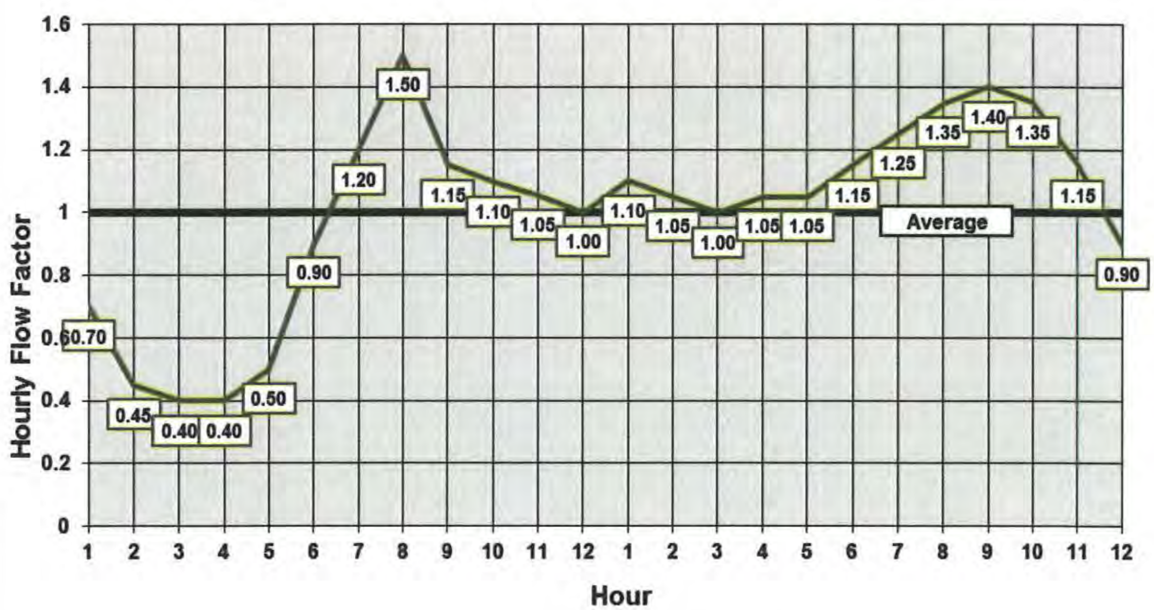
and peak flows are typically less than more defined peak flows during the week, for this monitoring period, the four weekend days evaluated actually had peaking factors similar to the weekday peaking factors. Although only weekday flows will be evaluated in the model, the peaking factor used in the analysis will also be reflective of the peaking factors recorded on the four weekend days.

Based on the flow monitoring data as well as common flow patterns for industrial and commercial land use, unit dry-weather flow hydrographs (hourly flow factors relative to an average flow factor of 1.0) were developed for the following land use categories:

1. Residential including R1, R2, R3 and SP3 (Senior Residential)
2. Commercial and Industrial
3. Mixed-Use including SP1, SP2, and primarily SP4

As discussed in Chapter 6, these hydrographs were applied to respective land uses in the hydraulic model to create hourly (24-hour) flows in the model. As the land use in Meter Basin 1 is 90% residential, the residential dry-weather flow hydrograph was based primarily on Meter Basin 1 flows. As shown on Figure 3-6, the primary peaking factor of 1.5 occurs at 8:00 a.m. with a secondary peaking factor of 1.40 occurring at 9:00 pm.

Figure 3-6. Residential Dry-Weather Flow Hydrograph[a]



(a) Includes all residential including SP3 (senior residential)

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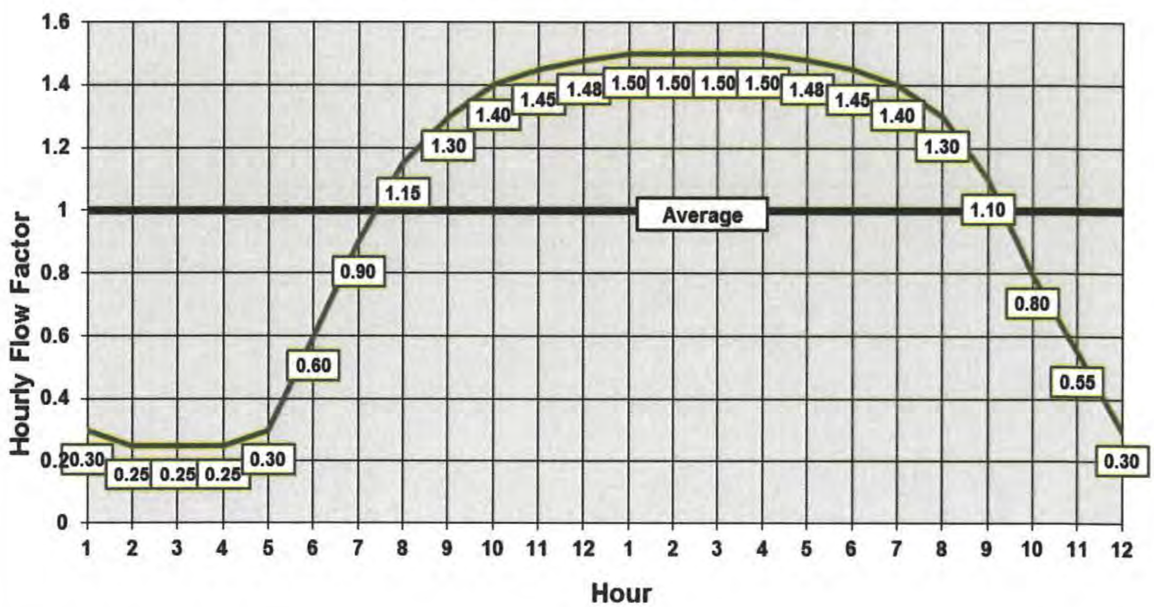
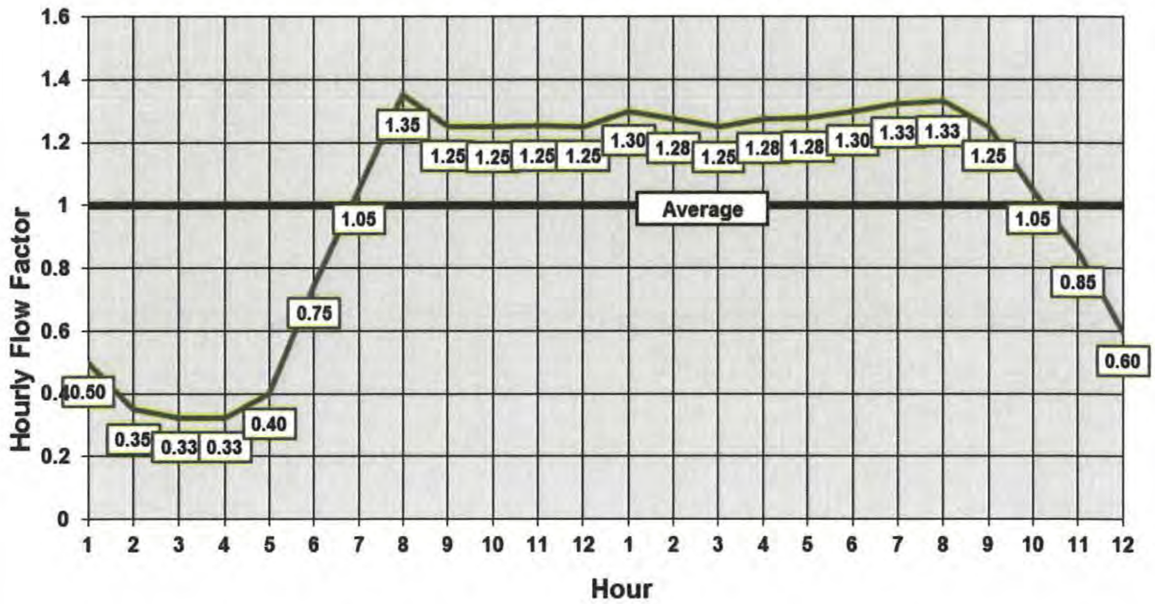
The hydrograph for commercial and industrial land use is shown on Figure 3-7 and is reflective of higher flows occurring primarily during the normal working hours during the week. A peaking factor of 1.5 for dry weather flow was calibrated in the hydraulic model.

Figure 3-7. Commercial & Industrial Dry-Weather Flow Hydrograph



The hydrograph for mixed-use land, which is a combination of residential (primarily multi-family) and commercial land use), is shown on Figure 3-8 and was developed as an hourly average of the residential and commercial/industrial hydrographs.

Figure 3-8. Mixed-Use Dry-Weather Flow Hydrograph[a]



(a) SP-4 (Corridors Specific Plan), SP-1 and SP-2 Specific Plans

Wet Weather flows

As mentioned previously, there were two storm events recorded during the flow monitoring period, however, hydraulically, these were not significant storm events and did not generate significant rainfall induced inflow and infiltration (RDII). Therefore Peak Wet Weather Flows (PWWF) were determined by utilizing empirical formulas obtained from the County's Hydrology Manual. Peak wet weather flow can be estimated as the larger of the two following equations:

1. Peak Wet Weather Flow (PWWF) = 1.35 x Peak Dry Weather Flow (PDWF)
2. Peak Wet Weather Flow (PWWF) = 3.10 x Average Dry Weather Flow (ADWF)

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Table 3-8 lists the location of the four flow meters and Figure 3-9 shows the location of the flow meters.

Table 3-8
FLOW MONITORING LOCATIONS

Basin Number	Manhole Number	Probe Location	Pipe Diameter (in)
1	B3-0789	Outgoing Pipe	8
2	B4_0662	Outgoing Pipe	18
3	B2_0500	Outgoing Pipe	12
4	B1_0165	Outgoing Pipe	10

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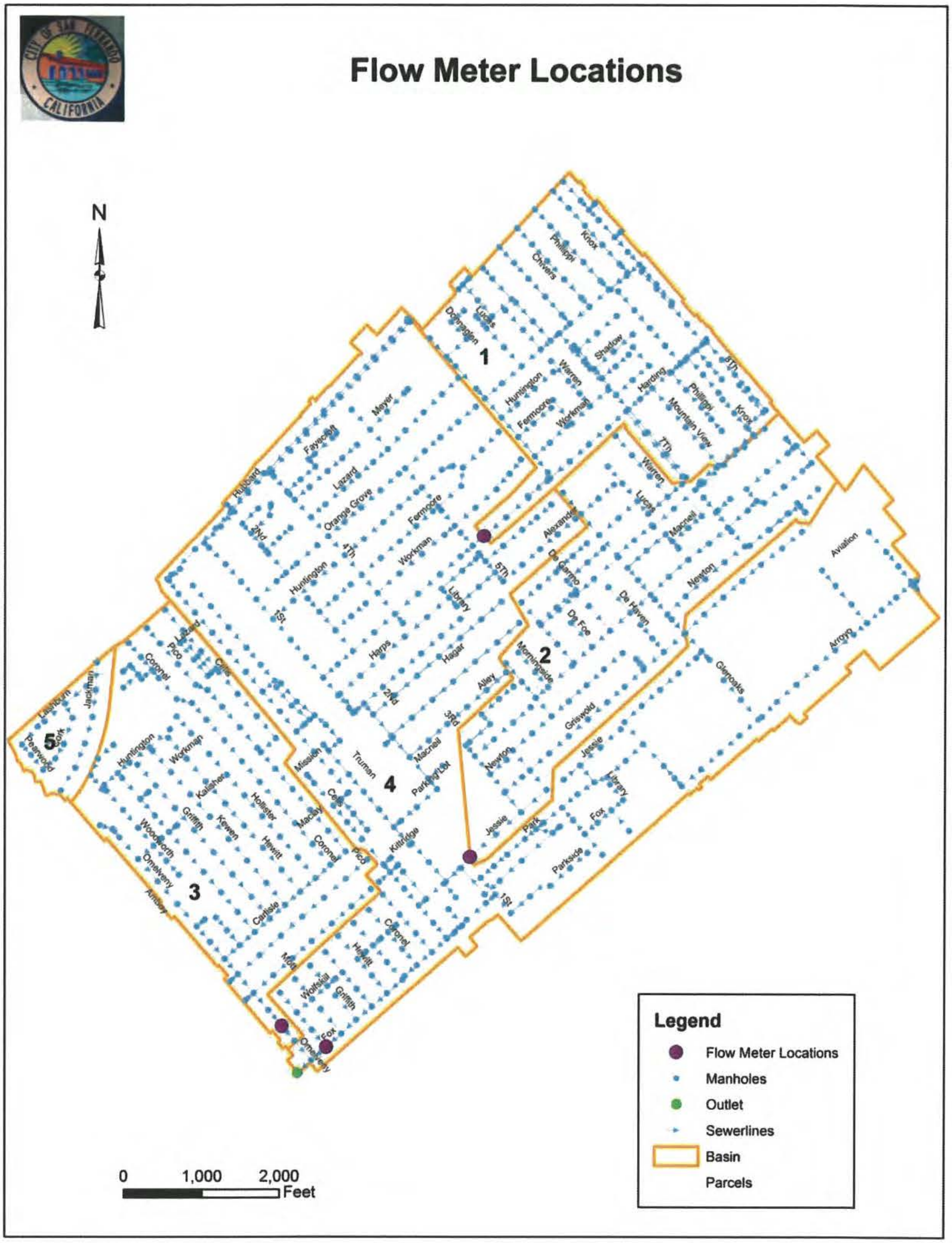
Figure 3-9, Flow Meter Locations



4 – REHABILITATION METHODS

4.0 Overview

Aged and defective sanitary sewers should be replaced periodically as part of an on-going investigation and rehabilitation program to both ensure structural integrity of infrastructure components and to help prevent wet-weather inflow and infiltration (I/I) into the collection system through system defects such as cracked and broken pipe. This chapter discusses various strategies and methods to rehabilitate sanitary sewers and develops planning-level unit costs that will be used in this Master Plan to develop project costs in the recommended Capital Improvement Program.

4.1 Sanitary Sewer Rehabilitation Methods

Sewers need rehabilitation if they are in a deteriorated condition and/or they need additional hydraulic capacity. In the past, the most common construction approach to rehabilitating a sewer for either reason was sewer replacement via open cut excavation. However, over the past 30 years, sewer rehabilitation via trenchless technology has become more practical and less expensive than traditional open cut excavation if the sewer is only in a deteriorated condition, i.e. does not need increased hydraulic capacity. There are also several trenchless methods now available that are also more practical and in some cases less expensive when the sewer also needs increased hydraulic capacity.

With trenchless technology, the surface and ground depth in the vicinity of a sewer to be rehabilitated is significantly less disturbed compared with open cut excavation. Sewer rehabilitation via trenchless technology avoids most conflicts with adjacent and crossing utilities and pipelines, and also avoids most surface disruptions to traffic, property, and the surrounding environment in general. Most trenchless technologies utilize the existing sewer as a host pipe and utilize existing manholes to conduct the rehabilitation. In some cases, pits must be excavated to accommodate a trenchless technology.

These trenchless technologies are less expensive than sewer replacement via open cut excavation. However, in utilizing the existing sewer as a host pipe, the sewer diameter is decreased, not increased. The new sewer lining might offer slightly better capacity resulting from less pipe friction, but because a slime layer eventually builds up on any sewer pipe surface, this increased capacity might not be significant.

4.1.1 Sewer Rehabilitation via Pipe Replacement

In order to increase hydraulic capacity significantly, the sewer can be replaced with a new larger sewer either by open cut excavation and/or bore and jack construction, or a new sewer can be constructed parallel to the existing sewer by either of these same two construction methods. Open cut excavation causes disruptions to the surface environment. As an alternative, bore and jack construction can be employed where two pits are excavated (a bore pit and a receiving pit), a steel casing is bored and jacked between the two pits, and the sewer is grouted inside the casing. The only excavation occurs at the bore pit and the receiving pit.

However, bore and jack construction is significantly more expensive than open cut excavation. For example, as average planning estimates, it might cost approximately $200/linear foot (lf) to construct a 12-inch sewer by open cut excavation (including traffic control and pavement replacement, but not including project mobilization, flow bypassing, and lateral reconnection) and approximately $1,000/lf to construct the same 12-inch sewer by bore and jack construction.

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Because of the high cost, open cut excavation is typically employed. However, bore and jack construction is used to go below major road intersections where traffic cannot be disrupted, and below major surface obstructions such as railroad tracks, freeways, etc.

Directional drilling and micro-tunneling can also provide for trenchless construction of a new sewer. However, both methods are more expensive than bore and jack construction, and their benefits such as directional change are not needed to construct a sewer below a road or intersection in most cases.

In order to increase hydraulic capacity, the existing sewer can be replaced with a larger sewer, or a new sewer can be constructed in parallel with the existing sewer, which remains in service. If the existing sewer is also in a deteriorated condition and requires rehabilitation anyway, then it will be recommended in the Master Plan that the existing sewer be replaced with a new sewer. If the existing sewer is in good condition with very few defects and is relatively young, then it will be recommended in the Master Plan that the existing sewer be kept in service and a new parallel sewer be constructed in order to increase hydraulic capacity.

City sewers are constructed of VCP, PVC, and ACP pipe materials, which are all considered sturdy sewer pipe materials. However, any sewer constructed prior to 1950 will be recommended for replacement regardless of condition if the sewer requires additional hydraulic capacity.

Flow bypassing at an upstream manhole is required when replacing an existing sewer. Also, existing laterals must be serviced by a temporary pipeline while the new sewer is set in the trench and bedded. The existing laterals are connected as soon as a new sewer segment is bedded. An advantage to constructing a parallel sewer (relief sewer) is that the existing sewer is kept in service while the relief sewer is being constructed. Less flow bypassing is required. Additionally, sewer laterals on the side of the existing sewer away from the parallel sewer can remain connected to the existing sewer, or if they are to be connected to the new sewer, the connections can be made after the new sewer has been constructed.

Pipe Bursting

Another trenchless alternative for constructing a larger sewer is pipe bursting. Pipe bursting can be less expensive and faster than open cut construction. Pipe bursting is accomplished by pulling a bursting device through the existing pipe. This device by virtue of its size or its radial expansion ability shatters the old pipe and forces the fragments into the surrounding soil. The new pipe is attached to the bursting device and is thus pulled into place as the device advances. An advantage of pipe bursting compared with other trenchless pipe rehabilitation is that the existing pipe can be upgraded with a completely new pipe of equal diameter or greater, thus maintaining or increasing the capacity of the line being rehabilitated. Also, the pipe is a complete structural replacement that functions independently of the original line. Flow bypassing is required with pipe bursting because the existing pipe is being replaced.

Installations are either continuous or sectional. In continuous installations, pipe materials such as high-density polyethylene (HDPE), PVC, and steel are connected or fused to form continuous strings of pipe. These strings are then installed over a length longer than the length of one individual pipe segment. In sectional installations, individual pipe sections are installed one section at a time. Continuous installation is preferred over sectional replacement, as it minimizes the stoppage of the product line during the burst, and requires less equipment to perform the installation.

A continuous installation is divided into lengths of pipe segments that the bursting equipment being used can burst based on the geometry and layout of the existing pipe being replaced. The length that can be burst is highly dependent on the type of pipe being burst, degree of upsize, soil conditions, and geometry of the original installation. Access pits are excavated on each end of the pipe to be replaced. The pipe-bursting machine that pulls the bursting head is located in the machine pit. The new or product pipe and bursting head are inserted into the existing or host pipe at the insertion pit, which is located at the other end of the pipe.

Machine pits are typically 12-feet long by 6 to 8-feet wide, but can vary in size depending on the size and type of the pipe bursting equipment used. The insertion pit has a flat section and a sloped section that runs from the bottom of the pit to the ground surface. The length of the flat section is typically 12 times the outside diameter of the replacement pipe and the length of the sloped section is typically 2.5 times the depth.

Sections of the product pipe are fused or connected for a continuous installation. The end of the product string is attached to the bursting head, which is attached to the drive rod string, which is attached to the bursting machine in the machine pit. The bursting machine then pulls the drive string. As the bursting head advances, the host pipe is burst and the product line is simultaneously installed. Other bursting methods employ a pneumatic bursting head that "hammers" the pipe forward rather than being pulled. The static bursting system or pneumatic pipe bursting system employed must be capable of delivering the required bursting forces necessary to fragment the existing pipe, push the broken pieces into the ground and simultaneously install the new HDPE replacement pipe.

The bursting force and equipment capacity of the pipe bursting equipment is a function of the replacement section, which is the length of pipe to be bursted and replaced between the machine pit and the installation pit. Longer replacement sections require larger-capacity equipment. The length of the replacement section is also a function of the geometry of the existing pipe to be replaced. Pipe bursting can accommodate only gradual horizontal curves. A replacement section must be terminated at a tight bend.

The depth of cover is important in pipe bursting especially when the existing pipe lies below an asphalt road because the bursting head can cause an upheaval (surface hump) of the asphalt surface if there is insufficient cover. The potential for upheaval is also a function of soil density. Less dense (softer) soils can absorb more of the uplifted soil and pipe fragments and this decreases the upheaval potential. The potential for upheaval is greater for ground covers less than 4 feet. This is typically not an issue with sanitary sewers as they are usually installed deeper than 4 feet.

Minor surface upheaval can be rectified by rolling down the hump with an adequately-sized road roller on a relatively hot day. Where the potential for upheaval exists, the Contractor can drill a relief bore hole above the host pipe to absorb the soil displacement caused by the bursting head, but this adds construction cost.

The sections of the HDPE pipe are fused together and the entire length of replacement pipe for a given replacement section is strung out directly behind the installation pit, i.e. a 300 lf replacement section would have 300 feet of pipe strung out behind the installation pit. Traffic control would be required for the installation pit and the pipe layout area behind the pit as well as at the machine pit. One lane of traffic or a bike lane would need to be closed down in these work areas.

Pipe installed within a steel casing via bore and jacked construction cannot be replaced through pipe bursting because the steel casing does not allow sufficient space for pipe fragmentation. Concrete encasement may also preclude pipe bursting for that specific pipe segment depending on the thickness of the encasement. Utilities that are too close to the bursting "sphere of influence" would need to be relocated prior to bursting. Also, sewer laterals would have to be removed within the sphere of influence, and then reconstructed and connected to the new sewer.

For straight runs, pipe bursting can be implemented as a continuous installation through existing manholes. The manholes would then need to be rehabilitated and sealed after the bursting is complete. Pipe bursting can be more cost effective than open cut excavation, if you have long sections of straight sewers that can accommodate long continuous installations. Often times pipe bursting can be faster than open cut construction because there is significantly less excavation and pavement replacement. Pipe bursting could conceivably be 20 to 25% faster than open cut construction depending on actual conditions.

However, if the sewer segments are in residential areas with many lateral connections, then the length of installation must be shortened, which adds construction time and cost. The shortened installation length and the cost to dig up and reconstruct laterals in the area of influence typically make open-cut excavation more cost effective in residential areas with many sewer laterals.

Earth Tool Company and Miller Pipeline Corp. are two of the manufacturers of pipe bursting equipment on the market. Earth Tool Company manufacturers Hammerhead™ moles and various pipe-bursting products that are marketed through Vermeer dealerships located throughout the United States and internationally. Miller Pipeline Corp. manufactures the XPANDIT pipe bursting system.

4.1.2 Sewer Rehabilitation via Trenchless Technology using Existing Pipe as Host

Cured-in-Place lining, segmental sliplining, spiral wound sliplining, and tight-fit lining are trenchless technologies that utilize the existing pipe as a host pipe in the pipe rehabilitation process. The liner of each of these systems can provide complete structural support, i.e. assume all dead, live, and construction loads as well as any surcharge pressures, independent of any structural support remaining in the host pipe. All of these technologies are typically less expensive than sewer replacement via open-cut excavation and via pipe bursting. However, the pipe flow area is reduced to some degree by a reduction in pipe diameter with each of these technologies.

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With each of these trenchless technologies, the surface and ground depth in the vicinity of a sewer to be rehabilitated is significantly less disturbed compared with open cut excavation. These technologies avoids most conflicts with adjacent and crossing utilities and pipelines, and also avoids most surface disruptions to traffic, property, and the surrounding environment in general. Some of these trenchless technologies utilize existing manholes to conduct the rehabilitation. In some cases, pits must be excavated to accommodate liner insertion into the host pipe.

The County Sanitation Districts of Los Angeles County (County) utilizes all of these trenchless technologies to a certain extent and have developed detailed specifications for each. These technologies are described as follows:

Cured-in-Place Pipe Lining

In the Cured-in-place pipe (CIPP) lining process, a liner composed of a fabric reconstruction tube impregnated with a thermosetting resin is inserted into the pipe to be repaired through an existing manhole, an excavated pit, or another entry point. The tube is either winched or inverted into place with water pressure. Injected steam or hot water cures the resin and shapes the tube into the form of the existing pipe. Application of heat hardens the resin after a few hours, forming a jointless inner pipe surface. The rehabilitation liner serves to repair the deteriorated structure of the existing pipe.

The lining process requires no excavation if existing manholes are available as insertion pits. The process can accommodate pipe bends up to 90 degrees. The pipe requires careful cleaning and video inspection prior to installation. Flow bypassing is required with CIPP because the existing pipe is rehabilitated.

Service laterals remain connected to the host pipe during the rehabilitation process, but the laterals are out of service until openings can be cut through the CIPP lining at the connection points. A camera with a cutting device is run through the lined pipe to reopen the laterals remotely. Dimples occur in the CIPP lining prior to curing that indicate the lateral connection points. With some other trenchless technologies such as sliplining with a rigid lining material, dimples do not occur, and the lateral locations must be surveyed as part of the pre-work video inspection in order to map out the lateral locations. This makes lateral connection more efficient for CIPP relative to these other trenchless methods.

Several companies have developed CIPP systems and these systems vary in material type, coating type and method of construction. Most of the fabrics are made of woven or non-woven (needle punched) polyester. Other materials such as fiberglass are sometimes incorporated into the fabric as reinforcement. Tubes are typically layered with at least one fabric layer and another layer which is impermeable to the flow of the liquid resin.

The resin is typically unsaturated polyester. Vinyl ester and epoxy resins are sometimes used for better corrosion resistance or for unusual thermal conditions. The composition of the resin material can be varied to meet specific design conditions. Fabric tubes are manufactured to be the same size or slightly smaller than the inner diameter of the existing pipe to be rehabilitated. The saturated fabric stretches to conform to the inner surface of the pipe. Some mechanical bonding of the resin to the inner pipe surface does occur. The structural performance of the liner depends on the thickness of the liner as well as upon the condition of the existing pipe to a certain extent.

Insituform Technologies Inc., Nu Flow Technologies, Inc., Inliner Technologies, are some of the CIPP manufacturers on the market. As an example, Insituform installations have been accomplished in pipe sizes up to 108 inches. Insitupipe is a gravity CIPP lining system manufactured by Insituform that is designed to accommodate specific pipe conditions and structural requirements. The thickness of the Insitupipe varies from 0.12 to 1.59 inches as required by each project. The physical characteristics of the finished Insitupipe are largely a function of the resin system used.

Resin systems used in the Insituform process are unsaturated polyesters, vinyl esters, and epoxies. The resin is specifically designed on a project-by-project basis and the type selected is dependent on pipe function and condition among other factors.

Traditional Segmental Sliplining
In the traditional segmental sliplining process, a polyethylene or PVC liner of a slightly smaller diameter is inserted into an existing pipeline and the annulus between the two pipes is grouted to form one unified pipe. Sliplining can be used if the host pipe does not have excessive joint settlements, severe misalignments, or large deformations. The host pipe should be relatively straight between the insertion pit and the receiving manhole. The new pipe can form a continuous watertight pipe within the existing pipe after installation.

In segmental sliplining, individual sections of pipe (typically 15-feet in length) are pushed into the host pipe at insertion pits that are strategically located at points along the host pipeline alignment. The liner pipe is inserted fully rounded into the host pipe, with new segments added on and pushed through as needed. Pushes approaching 3,000 feet of pipe have been reported. The pipe liner segments are typically joined with tongue and groove joints. Lap joints are used with some liners. After the new pipe is positioned in place, the annular space is grouted.

It is necessary for the host pipe to reasonably straight and reasonably round, as slip liners are not pliable inserts. Some adaptation to bends in the pipe is possible through the use of short segments. Also, the liner can be deflected up to 2 degrees at each joint. However, sliplining is more practical for straight pipe segments.

An insertion pit must be excavated large enough to accommodate the pipe segment being inserted. An insertion pit on the order of 20 feet long by 8 feet wide by the depth of the host pipe is required to insert 15-foot pipe segments. The need for excavated insertion pits is a disadvantage compared with other technologies that are able to utilize existing manholes for liner insertion, i.e. spiral wound sliplining, cured-in-place liners, and fold and form liners.

The annulus space between the host pipe and the liner pipe represents a loss of hydraulic capacity for the pipe. As a potential offset to this lost hydraulic capacity, the newer and smoother sewer lining would offer less friction than the existing sewer pipe surface, but because a slime layer eventually builds up on any sewer pipe surface, increased capacity due to a smoother pipe surface might not be significant. However, sliplining an existing VCP sewer would eliminate headloss associated with the VCP pipe joints as the slipline would have nearly seamless joints.

An advantage for sliplining relative to CIPP, is that sliplining can take place with flow in the existing pipe, whereas CIPP requires damming of an upstream manhole and/or flow bypassing to ensure that the existing pipe is free of all flow. For sliplining to occur with flow in the pipe, the maximum low depth in the existing pipe should not exceed approximately 30% of the pipe diameter.

Service laterals remain connected to the host pipe during the rehabilitation process, but the laterals are out of service until openings can be cut through the CIPP lining at the connection points. A camera with a cutting device is run through the lined pipe to reopen the laterals remotely. The lateral locations must be surveyed as part of the pre-work video inspection in order to map out the lateral locations.

Lamson Vylon Pipe (PVC), Hobas (RMP), and Polypipe (PE) are some of the slipline manufacturers on the market. For example, Lamson Vylon Pipe manufactures a PVC slipliner pipe with an I-beam profile wall and gasketed joints rated for 11 psi. The pipe is available in diameters ranging from 21 to 48 inches. The standard pipe length is 15 feet. Lamson Vylon Pipe also manufactures a PVC slipliner pipe called "The Insider". The pipe is available in diameters ranging from 12 to 18 inches. The joint is a flush joint system with elastomeric seals. The pipe is very similar to SDR 35 pipe. The pipe is not pressure rated and it is suitable only for gravity-flow.

Spiral-Wound Sliplining

In spiral-wound sliplining a winding machine helically winds a PVC strip into a tube which is simultaneously propelled directly into the existing host pipe. The spiral wound PVC pipe liner is composed of an extruded PVC profile strip with dual male and female locking elements on opposite sides of the strip. The profile strips have a ribbed design and range in width from 3.35 to 4.96 inches, which translates to a large number of joints. The profile strip, which is stored on a spool, is fed into an existing manhole via a winding machine. The winding machine forms the profile strip into a spiral pipe of a specified fixed diameter by sealing the male and female locking elements.

There is an expandable pipe liner version in which the pipe liner is expanded radially until the liner contacts the host pipe. This version is primarily applicable to sewers less than 24 inches in diameter. In the second version, the pipe liner remains a fixed diameter less than the inside diameter of the host pipe and grout is injected to fill the annulus between the two pipes. This second version, which can incorporate a steel reinforcing strip, is primarily applicable to sewers greater than 24 inches in diameter.

In the expansion version, after the liner is fully expanded, sealant is applied to the ends of the pipe. As discussed below, service connections are re-established similar to segmental sliplining. However, the ribbed profile of the spiral wound pipe liner creates small voids around the circumference of the connection that must be sealed.

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In the fixed-diameter version, a secondary lock for the sliplined machine spiral wound PVC pipe liner remains intact in order to hold the pipe liner at a fixed diameter. The profile strips have a higher stiffness than the strips used for the expansion version. The maximum outside diameter of the fixed-diameter liner is limited to 2 inches less than the inside diameter of the existing pipe to ensure proper placement of grout.

An advantage of spiral-wound sliplining relative to segmental sliplining is that the liner can be inserted at existing manholes. The tube or liner is made in one continuous length from manhole to manhole. Unlike segmental sliplining, spiral-wound sliplining can accommodate pipe bends and more severe pipe deformations due to the flexible nature of the winding process.

Service laterals remain connected to the host pipe during the rehabilitation process, but the laterals are plugged and out of service until openings can be cut through the lining at the connection points. A camera with a cutting device is run through the lined pipe to reopen the laterals remotely. The lateral locations must be surveyed as part of the pre-work video inspection in order to map out the lateral locations.

Like segmental sliplining, spiral-wound sliplining can take place with flow in the existing pipe. For sliplining to occur with flow in the pipe, the maximum low depth in the existing pipe should not exceed approximately 30% of the pipe diameter.

Danby of North America, Inc (Twin Lock) and PipeTec, Inc. (Rib-Loc) are two of the spiral-wound sliplining companies.

Tight-Fit Lining
A roll-down, die-reduction, or a folded-pipe lining process are similar trenchless technologies that are all included under a "tight-fit" classification by AWWA. In the tight-fit technologies, HDPE of a diameter either slightly greater or approximately the same diameter as the host pipe is reduced in diameter or deformed by mechanical means so that it can then be pulled through the host pipe. The HDPE pipe then expands naturally or is expanded to nearly its original diameter to fit tightly within the inside diameter of the host pipe. In contrast to segmental sliplining and fixed-diameter spiral-wound sliplining, these processes minimize the loss of inside diameter and eliminate the need for grouting as no annular space is left between the HDPE and the host pipe.

The equipment to perform the "roll-down" method consists of winching equipment used to pull the HDPE through the existing pipe and a roll-down box (a series of mechanical rollers) that physically rolls the outside diameter of the HDPE down to provide clearance to the inside diameter of the host pipe. Once rolled down, the HDPE is maintained under tension to prevent expansion as it is winched through the host pipe. When the entire run is installed, tension is released and the HDPE gradually returns to its original outside diameter and is a close fit to the host pipe.

The HDPE pipe is typically oversized by approximately 10% relative to the inside diameter of the host pipe because the original diameter is sometimes not achieved in the subsequent expansion, i.e. the HDPE sometimes expands to a diameter that is slightly less than its original diameter.

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Factory produced lengths of HDPE are delivered to the jobsite, where they are fusion welded together to produce the full length of pipe for a specific installation or "pull". An entrance pit is excavated at the beginning of the rehabilitation area. A pit width of at least 5' is required. The length is generally 4 times the depth to invert, and may taper to grade away from the pipe. The length is to allow the stiff HDPE pipe to transition from surface elevation to centerline of pipe.

A receiving pit is excavated at the termination point. This pit length is typically in the 10 to15 foot range. The winching equipment is set up at the receiving end and the roll down box is located at the entrance pit. The winch line is run through the pipe to connect the HDPE pipe to the winching equipment. The HDPE pipe is pulled through the roll down box and into the host pipe by the winch, with the line under continuous tension to maintain size and clearance with the host pipe. Once the line is installed, tension is released and the HDPE pipe gradually resumes its original outside diameter, which is in close fit with the host pipe.

The length of an installation pull is dependent on the geometry of the host pipe. The HDPE pipe can usually be pulled through horizontal curves on the order of 5 to 7 degrees. However, depending on where the curve occurs in the pull, the condition and material of the host pipe, and other factors, larger curves up to 22 degrees have been achieved in some installations. A run must be terminated and a pit located at bends that cannot be pulled. Also there is a maximum length of straight pipe that can be pulled. Pulls up to 1,500 lf have been accomplished. Project cost and construction time increase as the number of pits required on a project increases.

A "die-reduction" lining method is very similar to roll-down with the exception that the HDPE pipe is pulled through a static reduction die instead of mechanical rollers. United Pipeline Services, which is a wholly owned subsidiary of Insituform Technologies, Inc., is one of the companies that perform roll-down pipe rehabilitation (Tite Liner). Swagelining is a patented die-reduction lining method. ARB, Inc. Constructors is a company that performs pipe rehabilitation using Swagelining.

The fold-and-formed lining process is similar in concept to the other tight-fit lining systems. In the fold-and-formed pipe (FFP) lining process, a folded thermoplastic relining product is inserted into the pipe to be repaired through an existing manhole or another entry point. The thermoplastic material, typically extruded PVC or high density polyethylene pipe (HDPE), is folded into a U-shape to produce a smaller net-cross-sectional area so it can be more easily inserted into the existing pipeline.

After the plastic-liner pipe is inserted, hot water or steam is applied to expand the liner pipe into a snug fit with the host pipe (rounding). The liner is then gradually cooled while held in place by internal pressure. As it cools, the liner pipe interlocks with the irregularities of the host pipe. Although tight, mechanical bonding between the liner and the host pipe does not occur.

Subcoil as developed by Subterra is a folded-liner pipe in which the HDPE pipe is factory folded and held in a heart shape by restraints. The folded liner pipe is then inserted into the existing host pipe. Once inserted, the folded-pipe liner is pressurized to snap the restraints allowing it to revert back to its original circular shape. The expanded HDPE pipe then forms a tight fit with the host pipe. Doty Brothers is a company that performs pipe rehabilitation using the Subterra folded liner pipe. Kinsel Industries, which is a wholly owned subsidiary of Insituform Technologies, Inc., also installs a folded-pipe liner called Close Fit.

All of these tight-fit lining systems are similar to segmental sliplining in that 1) it is necessary for the host pipe to reasonably straight and reasonably round, as the liners are not pliable inserts, 2) an insertion pit must be excavated large enough to accommodate the pipe segment being inserted, 3) lining can take place with flow in the existing pipe, and 4) service laterals remain connected to the host pipe during the rehabilitation process, but the laterals are out of service until openings can be cut through the lining via a camera with a cutting device.

These processes are typically a little more expensive than traditional segmental sliplining. However, there is less loss in hydraulic capacity as a result of a reduction in pipe diameter.

Suitability of Trenchless Technologies
The County typically rehabilitates sewers greater than 48-inches in diameter by sliplining with segmented plastic pipe and then grouting the annulus between the pipes because 1) these large sewers carries large flows and flow bypassing is not practical in most cases, and 2) a loss in diameter is not as significant with these larger pipes. The County typically rehabilitates sewers between 27 and 42 inches in diameter by CIPP or sliplining. The advantage to using CIPP is that it has minimal impact on capacity. Traditional segmental sliplining begins to negatively impact sewer capacity in these pipe sizes.

For sewers 24 inches and smaller, the County typically utilize CIPP, the expansion-version spiral-wound sliplining, and any of the tight-fit lining systems.

The County has reported troubles with wrinkles and folds using CIPP on larger diameter sewers, but no such troubles using CIPP on smaller diameter sewers. Tight-fit lining systems can typically be installed more quickly than CIPP and has better quality control in terms of material properties than CIPP liner. However, CIPP can be less expensive than a tight-fit technology and offers advantages such as more efficient re-establishment of service laterals. Traditional segmental sliplining can be less expensive than the CIPP or tight-fit lining technologies on a given project. However, segmental sliplining results in a greater loss in pipe diameter.

Given the specific conditions of a given sewer rehabilitation project, several of these trenchless technologies could be effective and price competitive on the same project. Some technologies might be excluded on a specific project, if a reduction in pipe diameter cannot be tolerated, if flow bypassing is not practical, or because of specific deformations of the existing sewer among other factors to consider in the design process.

4.1.3 Other Types of Sewer Repairs

Often times a sewer segment will be in overall good condition with the exception of severe defects that occur at a specific location or several locations along the segment. These point defects include broken pipe, severe cracking, or other damage that occurs within a limited length of pipe, i.e. approximately 5 linear feet or less. If there are a limited number of these spot defects, then it is more economical to excavate and repair these specific locations rather than to replace the entire sewer segment. If there are four or more such locations in a 300 or 400 lf sewer segment, then it becomes more practical to replace the segment.

Because CIPP forms against the existing pipe wall, most point defects need to be repaired prior to lining the sewer. Most point repairs also need to be made in front of spiral wound sliplining. If the damage is not overly severe, then sometimes these repairs do not need to be made in front of segmental sliplining and possibly some types of tight-fit lining systems. However, if a sewer is collapsed at a point, then this repair will need to be made prior to any lining method.

Unauthorized sewer lateral connections (also referred to as break-in taps) are often discovered when a sewer is videotaped. As opposed to factory taps, unauthorized taps are often crudely hammered into the sewer. Wet-weather infiltration can enter the sewer via the unsealed and often cracked periphery of the connection. Sometimes these unauthorized connections were made to collect storm water from house roof drains and other area drains. In these cases, they become a major source of wet-weather inflow. Wet-weather inflow and infiltration can overflow and surcharge a sewer and can lead to sewer overflows.

The connection could also prove to be some type of chemical or hazardous waste drain. In rehabilitating these unauthorized connections, the lateral pipe should to be smoke tested to see what it is connected to. If it is found to be connected to storm drain or some other inappropriate drain, then the lateral should be disconnected and the sewer should be plugged and repaired at the point of connection. The owner of the inappropriate drain should then be required to reroute the discharge to an appropriate receiving connection. If connected to a sanitary sewer, the connection can be reconnected, sealed and repaired as required to block infiltration into the sewer.

4.2 Sewer Replacement & Rehabilitation Unit Costs

Planning level unit construction cost estimates for sewer replacement and rehabilitation are shown in Table 4-1. These unit costs will be used to develop planning level project cost estimates to develop Capital Improvement Program costs for this Master Plan. These unit costs do not include project mobilization, which will need to be added to project cost estimates. Project mobilization is estimated at 5 to 10% of the total project construction cost depending on the size and complexity of the project. All sewer rehabilitation and replacement unit costs shown in Table 4-1 include re-establishment of service laterals. Costs for all rehabilitation methods include heavy sewer cleaning and pre and post rehabilitation sewer videotaping.

Design-level cost estimates will need to be developed to refine project costs based on project conditions determined during the design phase of each project. For example, soil conditions determined in the design phase might preclude pipe bursting as a possible sewer replacement alternative. Flow conditions might make CIPP less attractive as a rehabilitation method if extensive flow bypassing is required, etc.

Table 4-1. Unit Construction Costs for Sewer Replacement or Rehabilitation[a]

Replacement or Rehabilitation Method	Unit Costs per Sewer Diameter (in)				
	8"	10"	12"	15"	18"
CIPP[b]	$55/lf	$62/lf	$68/lf	$105/lf	$140/lf
CIPP (bypass)	$3	$4	$5	$10	$15
Segmental Slipline[b][c][d]	$70/lf	$78/lf	$85/lf	$110/lf	$145/lf
Expansion Spiral Wound Slipline[b][c]	$75/lf	$83/lf	$90/lf	$115/lf	$150/lf
Tight-Fit Lining[b][c][d]	$75/lf	$83/lf	$90/lf	$115/lf	$150/lf
Rehab Break-in Tap	$7,000/ea	$7,000/ea	$7,000/ea	$7,000/ea	$7,000/ea
Sewer Point Repair	$7,000/ea	$7,000/ea	$7,500/ea	$8,000/ea	$8,000/ea
Pipe Bursting[b][d]	$165/lf	$180/lf	$215/lf	$250/lf	$300/lf
Open-Cut Sewer Replacement[b]	$150/lf	$175/lf	$195/lf	$220/lf	$240/lf
Open-Cut Parallel Sewer[b]	$130/lf	$155/lf	$175/lf	$200/lf	$220lf
Bypass for Pipe Bursting or Open-Cut Replace	$3/lf	$4/lf	$5/lf	$10/lf	$15/lf
Open-Cut Pavement Replacement	$13/lf	$14/lf	$15/lf	$16/lf	$17/lf
Open-Cut Traffic Control	$3/lf	$4/lf	$5/lf	$5/lf	$5/lf
Bore and Jack[e]	$800/lf	$900/lf	$1,000/lf	$1,200/lf	$1,500/lf

a) Not including project mobilization, which is estimated at 5 to 10% of total project construction cost
b) Including re-establishment of service laterals
c) Estimated that flow bypassing will not be necessary as construction work will be done during low flow periods with flow in the pipe
d) Includes installation pit excavation, pavement replacement and traffic control
e) Includes installation and receiving pit excavation, pavement replacement and traffic control

For planning purposes, it is estimated that CIPP is slightly less expensive than the other trenchless technologies for rehabilitating 8-inch, 10-inch and 12-inch sewers especially if flow bypassing can be limited by low flows or possibly eliminated if damming an upstream manhole during installation and curing is possible. It is also estimated that segmental sliplining is slightly less expensive than expansion spiral-wound sliplining or tight-fit sliplining. The slightly higher cost could be warranted if a reduction in pipe diameter cannot be tolerated.

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It is estimated that segmental sliplining and even spiral-wound sliplining or tight-fit sliplining can become more cost effective relative to CIPP for sewer diameters greater than 12 inches if extensive flow bypassing is required. Expansion spiral-wound sliplining and tight-fit lining are estimated to be more expensive than segmental sliplining at all diameters. However, these two methods or CIPP might be required if the reduction in diameter resulting from segmental sliplining cannot be tolerated.

Construction conditions as determined in the design phase might preclude a rehabilitation method from inclusion in the contract bid. However, it would be appropriate to include as many of these rehabilitation methods in a competitive bid as warranted if there are no fatal flaws with the rehabilitation method specific to the project. In a competitive bid environment, any of the viable rehabilitation methods could conceivably end up having a lower cost.

The costs to excavate and make point repairs for breaks, severe misalignment, severe cracking, or other damage that occurs within a limited length of pipe, i.e. approximately 5 linear feet or less, are also shown in Table 4-1. If there are four or more such locations in a 300 or 400 lf sewer segment, then it typically becomes more cost effective to replace the segment. Point repairs will need to be made prior to conducting lining rehabilitation depending on the severity of the defect and the type of rehabilitation method used.

The costs to smoke test an unauthorized lateral connection (break-in tap) and then repair and seal the sewer at the point of connection are shown in Table 4-1. It is assumed that the cost to reroute an unauthorized lateral connection to an appropriate receiving location will be burdened by the owner of the unauthorized lateral connection.

For planning purposes, it is estimated that pipe bursting has the same unit cost as sewer replacement by open-cut excavation. However, the unit costs for pipe bursting includes installation pit excavation, pavement replacement, and traffic control, whereas pavement replacement and traffic control are additional costs for sewer replacement by open-cut excavation as shown in Table 4-1. Flow bypassing is an additional cost for both sewer replacement by open cut excavation and pipe bursting in Table 4-1.

The cost to construct a parallel sewer is estimated to be less expensive than the cost to construct a replacement sewer of the same size. In constructing a parallel sewer, the need to perform bypass pumping is greatly reduced and in some cases might be eliminated altogether. Additionally, sewer laterals on the side of the existing sewer away from the parallel sewer can remain connected to the existing sewer, or if they are to be connected to the new sewer, the connections can be made after the new sewer has been constructed. Sewer laterals on the side of the existing sewer where the parallel sewer is being constructed will typically need to be connected to the new sewer at the end of each work day. The estimated cost to employ bore and jack construction to go below major road intersections and major surface obstructions such as railroad tracks, freeways, etc, are also shown in Table 4-1.

5 – CCTV INSPECTION

5.0 Overview

As part of the Master Plan, approximately 56,127 linear feet (10.63 miles) of City sewers were videotaped using closed circuit television (CCTV), which is 25.6 percent of the City's total collection system (219,346 LF). The sewer CCTV inspections were conducted in order to identify defects, rate defects, and then incorporate recommended improvements into the Capital Improvement Program. Sewers videotaped as part of this project are shown on Figure 5-1.

Sewer structural defects include cracked pipe, broken pipe, offset joints, and unauthorized service connections (break-in taps). Sewer operation and maintenance (O&M) defects including heavy roots and grease deposits can lead to sewer blockages that can then lead to overflows. Sewer defects can undermine the integrity of the sewer system infrastructure, can allow wastewater to exfiltrate into the soil and groundwater, and can allow excessive rainwater in the form of inflow and infiltration to enter the sewer leading to potential overflow conditions.

5.1 Sewer CCTV Inspections

Sewers were first prioritized for inclusion into the CCTV inspection program conducted as part of this Master Plan if they are: 1) located in the older sections of the City, 2) in areas of high and recurring maintenance problems such as roots and grease, and/or 4) have suspected sewer defects. It should be noted that HFI focused on sewer lines that had not been recently televised by the City.

The Pipeline Assessment and Certification (PACP) software developed by the National Association of Sewer Service Companies (NASSCO) was used to assess and categorize sewer defects. NASSCO is a non-profit trade association consisting of contractors, manufacturers/ suppliers and professionals (engineers, cities, etc.) involved with many sewer technologies. The PACP Condition Rating System provides condition ratings for sewer structural defects, and operation and maintenance defects. Grades are assigned for each category based on the grading criteria shown in Table 5-1.

Table 5-1. Sewer Defect Grade Descriptions

Defects Grade	Description
5 – Severe	Severe defects requiring immediate attention
4 – Heavy	Defects that will become Grade 5 in the near future
3 – Moderate	Defects that will continue to deteriorate
2 – Fair	Defects that have not begun to deteriorate
1 – Light	Minor defects

The Pipe Defects Rating is the addition of all grade defect occurrences multiplied by their respective grade levels for a given pipe segment (a pipe segment is the length of sewer pipe between two manholes). For example, a pipe with four Grade 5 occurrences, three Grade 3 occurrences, and three Grade 1 defects with no other defects found would have a Pipe Defects Rating of 32. The Pipe Defects Rating Index is the Pipe Defects Rating divided by the total

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Figure 5-1 - City Sewers Videotaped

number of defect occurrences. In the example above, the Pipe Defects Rating Index would be 3.2 (32 divided by 10). The Pipe Defects Quick Rating is the number of occurrences of the two highest grades. In the above example, the Pipe Defects Quick Rating would be 5(4) 3(3).

The PACP continuous defect feature is used to denote where long portions of a sewer pipe are affected by the same defect, without the user having to repetitively enter point defects. The equivalent number of uninterrupted and joint repeating continuous defects is converted to equivalent point defects by dividing the length of the continuous defect by 5. For example, a 250-foot-long continuous defect, Grade 3, would equate to 50 equivalent Grade 3 point defects.

The sewers were rated separately for structural defects and O&M defects. Both were sorted by highest Pipe Defects Rating. The ratings for all sewers videotaped as part of the Master Plan are shown in the Appendix.

5.1.1 Sewer Structural Defects

The vast majority of sewers in the City are constructed of VCP, and a majority of City sewers were constructed in the 1920s. In general, the majority of City sewers videotaped were found to be in good shape structurally. However, there were some sewers that had major to moderate defects that should be repaired within the 10-year CIP. In terms of a structural defect, a category 5 defect can be a broken pipe where the soil is visible through the hole in the pipe, or it can be collapsed pipe, or it can be a severe offset joint where the flow way in the pipe is reduced by over 50%. Any category 5 defect is recommended for repair within the 10-year CIP as a high priority project.

A category 4 defect is a severe fracture or breaking of the pipe that could become a category 5 defect in the near future, or it can be a severe offset joint. A lone category 4 defect was typically not recommended for repair within the 10-year CIP, but a sewer segment with multiple category 4 defects was recommended for repair, especially if they were occurring in conjunction with other category 3 and 2 defects. Most category 4 defects can be repaired by lining the sewer segment as opposed to constructing point repairs.

A category 3 defect is multiple cracking at a location in the pipe. Multiple cracking can continue to spread, i.e. deteriorate, over time. A pipe segment with many and/or recurring category 3 defects is recommended for repair, which can be accomplished by lining the entire sewer segment. A category 2 defect is s a single deep crack where the sides of the crack have separated. A type 1 defect is a single hairline crack that has not separated. Type 2 and Type 1 defects do not need to be repaired in the 10-year CIP, and most likely, will not require attention for 10 years or more.

Sewer segments with Structural or Operations and Maintenance (O&M) defects are shown on Figure 5-2. The defects to be repaired are associated with videotaped sewer segments totaling just over 11,000 linear feet (structural & O&M defects), which is the total length of sewer segments videotaped and not the length of sewer defects themselves. For example, a 300-foot-long sewer might have one severe pipe break that is 2-feet long and it is recommended that only that 2-foot-long defect be repaired as a point repair. The length of sewer segment associated with this defect is 300 linear feet. A 300-foot-long sewer segment might have severe cracking at 50% of its joints and it is recommended that the entire sewer segment be replaced. Again, length of sewer segment associated with this defect is 300 linear feet.

Recommended sewer repairs include all sewers with a category 5 defect as well as sewers with numerous category 4 and 3 defects. Within the CIP time frame of 1 to 10 years, sewer repairs for category 5 defects should be prioritized first. In cases where a sewer has a category 5 defect and not many other significant defects, it is recommended that the category 5 defect be repaired via open cut spot repairs. Recommended sewer repairs identified through CCTV inspection along with their repair costs are listed in Table 5-2. As can be seen there are over 11,000 linear feet of pipe recommended for replacement along with six line segments that need to have spot repairs done. The total estimated cost for these repairs is $2,422,436. The recommended prioritization by basin for these repairs is also shown in Table 5-2.

5.1.2 Sewer Break-In Taps

Factory manufactured sewer laterals are professionally installed when the sewer is constructed or sometimes after a sewer is constructed to receive sanitary wastewater from buildings. Sometimes laterals are connected to a sewer without City authorization and discovered only as a result of video inspection of the sewer. As opposed to factory connections, these "break-in taps" are often crudely hammered into a sewer. Wet-weather infiltration can enter the sewer via the unsealed and often cracked periphery of the connection. Sometimes these break-in taps were made to collect storm water from house roof drains and other area drains. In these cases, they become a major source of wet-weather inflow.

PACP does not categorize break-in taps as structural defects, but rather as "constructional" defects. Sewer segments discovered to have break-in taps are recommended for smoke testing in order to determine the source of the connection and to determine if storm water is being routed into the sewer. Storm water connections need to be disconnected and then rerouted to a nearby storm drain. The sewer pipe will then need to be sealed.

Even if the lateral is determined to convey appropriate sanitary wastewater, the connection will still need to be reconstructed. Break-in taps were typically not constructed per City standards that stipulate a wye fitting for the connection. As a result, water jetting from sewer cleaning can shoot up the lateral connection. It is recommended that new, sealed City standard lateral connections be constructed at these break-in tap locations.

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Figure 5-2. Sewer System Defects Identified Through CCTV

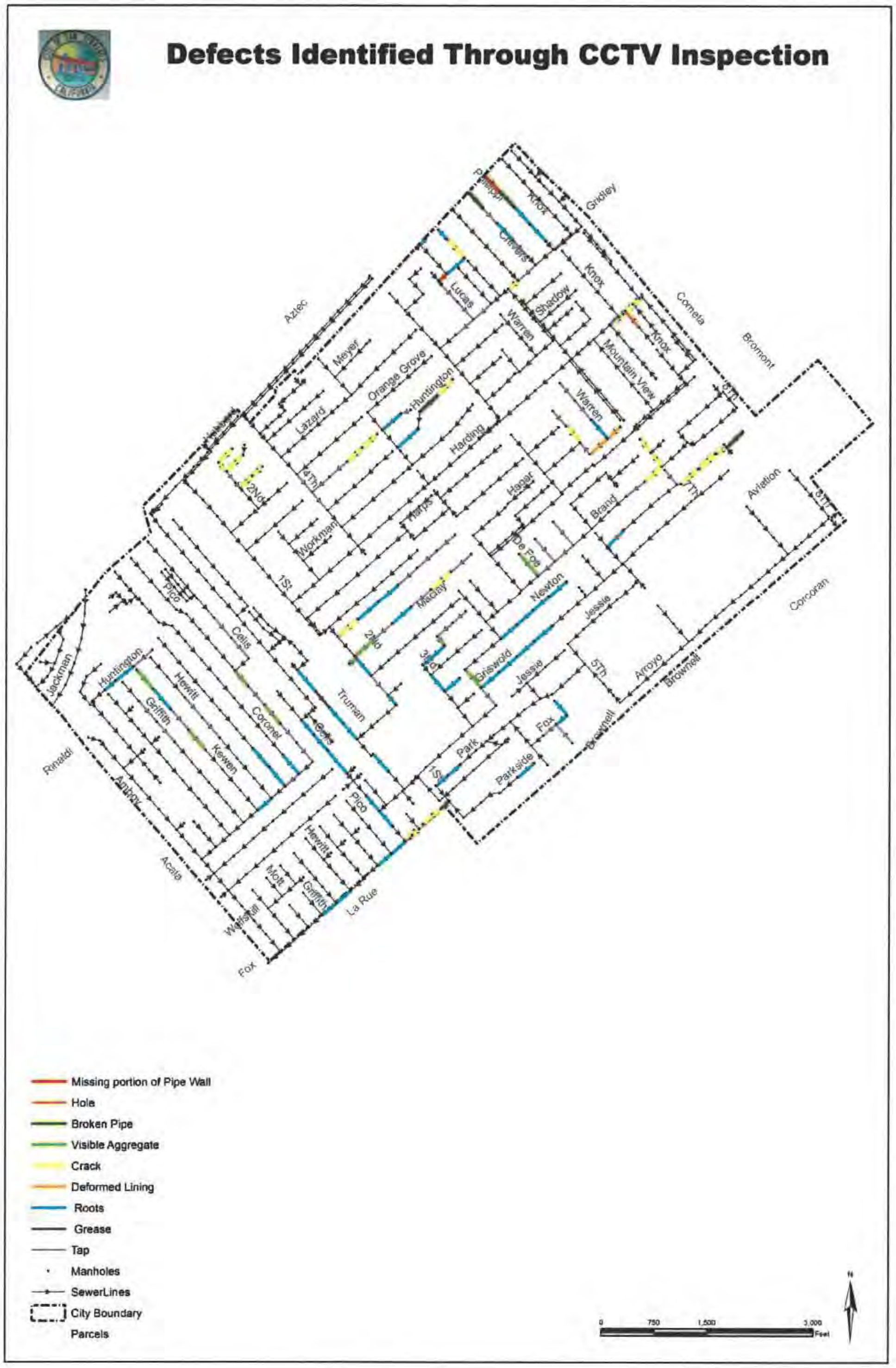

Table 5-2 Recommended Sewer Rehabilitation – Structural Defects 1/

						Structural Defects					
HFI Pipe No.	Street	Sewer Length (ft)	Sewer CCTV Length (ft)	Pipe Material	Pipe Dia (in)	Pipe Defects Rating	Total Number Defects	Recommended Rehabilitation	Cost/LF ($)	Total Cost ($)	Project Group Priority
B1_0018-B1_0019	Knox St	295	300	VCP	8	146	51	Replace Entire Segment	165	49,500	A
B1_0019-B1_0020	Knox St	0	0	VCP	8	18	6	One Point Repair	-	7,000	A
B1_0024-B1_0025	Phillippi St	0	0	VCP	8	16	9	One Point Repair	-	7,000	A
B1_0035-B1_0037	Orange Grove	0	0	VCP	8	10	2	One Point Repair	-	7,000	A
B1_0051-B1_0053	Meyer St	152	152	VCP	8	130	40	Replace Entire Segment	165	25,080	A
B1_0053-B1_0054	Lucas St	67	67	VCP	8	45	14	Replace Entire Segment	165	11,055	A
B1_0095-B1_0098	Harding Av	126	124	VCP	8	37	13	Replace Entire Segment	165	20,460	A
B1_0098-B1_0101	Harding Av	150	149	VCP	8	92	30	Replace Entire Segment	165	24,585	A
B1_0100-B1_0101	Knox St	302	304	VCP	8	95	29	Replace Entire Segment	165	50,160	A
B1_0101-B1_0106	Harding Av	118	125	VCP	8	32	10	Replace Entire Segment	165	20,625	A
B1_0106-B1_0119	Harding Av	180	187	VCP	8	111	36	Replace Entire Segment	165	30,855	A
B1_0112-B1_0113	Harding Av	294	377	DIP	8	216	71	Replace Entire Segment	165	62,205	A
B1_0113-B1_0114	Harding Av	248	236	VCP	8	135	45	Replace Entire Segment	165	38,940	A
B2_0361-B2_0362	4th St	166	173	CP	8	32	17	Replace Entire Segment	165	28,545	B
B2_0369-B2_0370	Newton	278	281	VCP	8	O&M		Replace Entire Segment	165	46,398	B
B2_0374-B2_0378	Warren St	250	251	CP	8	30	10	Replace Entire Segment	165	41,415	B

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Table 5-2 Recommended Sewer Rehabilitation – Structural Defects

HFI Pipe No.	Street	Sewer Length (ft)	Sewer CCTV Length (ft)	Pipe Material	Pipe Dia (in)	Structural Defects		Recommended Rehabilitation	Cost/LF ($)	Total Cost ($)	Project Group Priority
						Pipe Defects Rating	Total Number Defects				
B2_0378-B2_0379	Warren St	0	0	CP	8	**5**	1	One Point Repair	-	7,000	B
B2_0439-B2_0442	7th St	245	245	VCP	8	**130**	43	Replace Entire Segment	165	40,425	B
B2_0442-B2_0443	7th St	246	245	VCP	8	**159**	52	Replace Entire Segment	165	40,425	B
B2_0452-B2_0453	De Foe St	435	256	CP	8	**144**	48	Replace Entire Segment	165	42,240	B
B2_0464-B2_0465	Newton	306	310	VCP	8	**O&M**		Replace Entire Segment	165	51,134	B
B2_0468-B2_0496	4th St	340	340	CP	12	**201**	67	Replace Entire Segment	215	73,100	B
B2_0469-B2_0472	Newton Pl	366	323	VCP	8	**194**	64	Replace Entire Segment	165	53,295	B
B2_0472-B2_0473	Newton Pl	170	160	VCP	8	**83**	28	Replace Entire Segment	165	26,400	B
B2_0473-B2_0474	Newton St	320	329	VCP	8	**174**	58	Replace Entire Segment	165	54,285	B
B2_0475-B2_0476	Newton St	320	323	VCP	8	**192**	66	Replace Entire Segment	165	53,295	B
B2_0476-B2_0477	Newton St	220	323	VCP	8	**202**	67	Replace Entire Segment	165	53,295	B
B3_0678-B3_0679	Pico St	285	285	VCP	8	**178**	61	Replace Entire Segment	165	47,025	C
B3_0680-B3_0681	Pico St	342	345	CP	8	**205**	70	Replace Entire Segment	165	56,925	C
B3_0696-B3_0697	Coronel	350	357	VCP	8	**O&M**		Replace Entire Segment	165	58,905	C

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Table 5-2 Recommended Sewer Rehabilitation – Structural Defects

HFI Pipe No.	Street	Sewer Length (ft)	Sewer CCTV Length (ft)	Pipe Material	Pipe Dia (in)	Structural Defects: Pipe Defects Rating	Structural Defects: Total Number Defects	Recommended Rehabilitation	Cost/LF ($)	Total Cost ($)	Project Group Priority
B3_0697-B3_0698	Coronel	352	357	VCP	8	O&M		Replace Entire Segment	165	58,839	C
B3_0705-B3_0706	Hollister St	352	257	VCP	8	O&M		Replace Entire Segment	165	42,455	C
B3_0706-B3_0707	Hollister St	350	355	VCP	8	O&M		Replace Entire Segment	165	58,526	C
B3_0716-B3_0717	Kewen St	375	356	CP	8	213	74	Replace Entire Segment	165	58,740	C
B3_0719-B3_0720	Kewen St	375	378	CP	8	224	75	Replace Entire Segment	165	62,370	C
B4_0205-B4_0206	Huntington	284	295	VCP	8	65	22	Replace Entire Segment	165	48,675	D
B4_0206-B4_0207	Huntington	284	288	VCP	8	179	59	Replace Entire Segment	165	47,520	D
B4_0223-B4_0224	Huntington	315	315	VCP	8	96	30	Replace Entire Segment	165	51,975	D
B4_0224-B4_0225	Huntington	331	332	VCP	8	144	47	Replace Entire Segment	165	54,780	D
B4_0260-B4_0263	2nd St	167	170	VCP	8	55	23	Replace Entire Segment	165	28,050	D
B4_0262-B4_0263	Meyer St	328	330	VCP	8	180	61	Replace Entire Segment	165	54,450	D
B4_0266-B4_0267	Lazard St	243	350	VCP	8	49	17	Replace Entire Segment	165	57,750	D
B4_0320-B4_0321	Alley	0	0	CP	8	7	2	One Point Repair	-	7,000	D
B4_0323-B4_0324	Maclay Alley	0	0	RCP	8	10	2	One Point Repair	-	7,000	D
B4_0327-B4_0328	Alley Way	350	351	CP	8	208	72	Replace Entire Segment	165	57,915	D
B4_0581-B4_0582	Fox St	0	0	VCP	12	6	2	One Point Repair	-	7,500	D

5 – CCTV INSPECTION

Table 5-2 Recommended Sewer Rehabilitation – Structural Defects

1/ We have included six segments that had severe O&M issues as part of the rehabilitation plan.

HFI Pipe No.	Street	Sewer Length (ft)	Sewer CCTV Length (ft)	Pipe Material	Pipe Dia (in)	Structural Defects: Pipe Defects Rating	Structural Defects: Total Number Defects	Recommended Rehabilitation	Cost/LF ($)	Total Cost ($)	Project Group Priority
B4_0583-B4_0624	Fox St	346	350	VCP	12	118	45	Replace Entire Segment	215	75,315	D
TOTALS		**11,023**	**11,051**							**1,907,430**	
								Estimated Engineering Design @ 10%		**190,743**	
								Contingency @10%		**190,743**	
								Mobilization @ 7%		**133,520**	
								Grand Total		**2,422,436**	

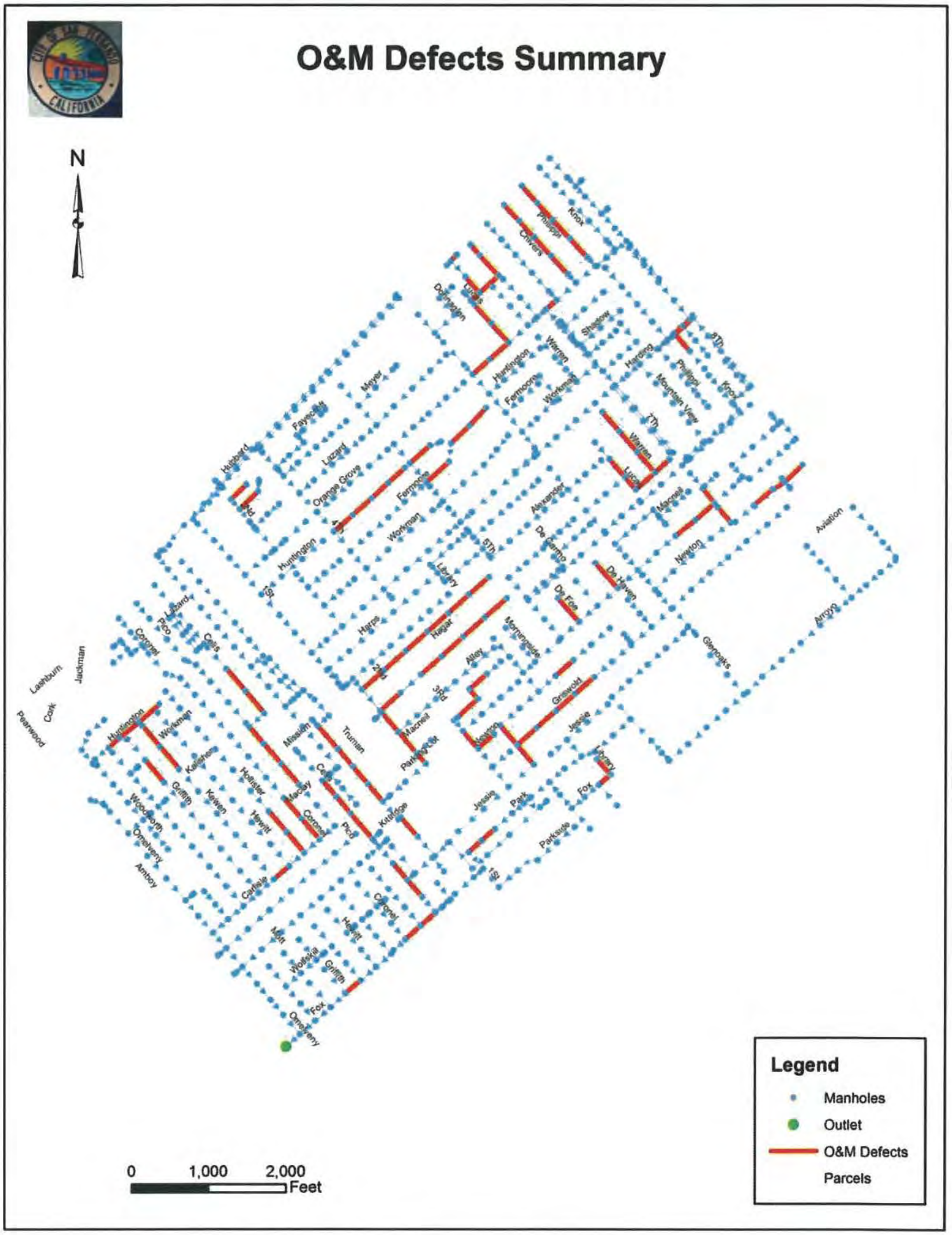
5.2.2 Sewer System Operation and Maintenance Defects

O&M defects include roots and fats oil and grease grease deposits (FOG). Roots occur at pipe joints and at lateral connections. As part of the sewer CCTV conducted for the project, sewers were cleaned in front of the sewer videotaping. However, sewers with different magnitudes of root growth and FOG were still evident. Sewers with high, moderate, or light root growth or FOG are shown on Figure 5-3. "High" is primarily category 4 and 5 defects; "Moderate" is primarily category 3 defects or a high number of category 2 defects; and "Light" is primarily category 2 defects. Category 1 defects are not shown on Figure 5-3, but could be categorized as "Very Light".

The City has identified system hot spots that are susceptible to recurring root and FOG buildup. The City has established its FOG program and its implementing it. HFI has identified several line segments that have O&M issues that need to be monitored and maintained by the City on a regular basis. Additionally, since a FOG Control Program must be tailored to accommodate the specific needs of the City, as the FOG Control Program evolves, the City should evaluate the program and its various components to determine any revisions necessary to further reduce the quantity of FOG being discharged into the sewer system. This section provides draft ordinances for the City to adopt for its FOG Control Program, recommendation on staffing, and a description of the initial efforts to implement a FOG Control Program.

5 – CCTV INSPECTION

Figure 5-3. Sewers with Videotaped O&M Defects



6 – HYDRAULIC MODELING/CAPACITY ANALYSIS

6.0 Sewer System Evaluation Overview

This chapter evaluates the existing wastewater collection system's ability to convey existing peak wet weather flows from current land uses; and future peak wet weather flows. Because most of the City is built out, significant increases in future flows are not projected by the system model. However, flexibility for future redevelopment is established using a system-wide design contingency called reserve capacity. The concept of a reserve capacity contingency is an important consideration because the size and location of future re-development projects is undefined.

The wastewater collection system was evaluated for existing and future conditions using a hydraulic model called InfoSewer, a computer simulation model developed by Innovyze. The model was developed using the physical system information from the GIS. Land use tributary to manholes on the system are then defined and average flows are estimated using the Thiessen Polygon methodology. Collection lines are evaluated based on their ability to convey the projected peak wet weather flow.

Modeling Approach

To minimize the potential for wastewater overflows, the system is sized to convey the peak wet weather flow (PWWF). The PWWF is defined to be equal to the peak dry weather flow (PDWF); plus a contingency for groundwater/seawater infiltration and rainfall dependent inflow , commonly referred to as Infiltration and Inflow (I&I).

The peak dry weather flow is estimated by multiplying projected average daily flows by a peaking factor. The peak wet weather flow was estimated utilizing the County of LA hydrology manual guidelines.

Hydraulic Model Software

InfoSewer (Version 7.6, Update 8) software as manufactured by Innovyze was used to develop a hydraulic model of the City's sanitary sewer system in order to evaluate hydraulic performance and identify hydraulic deficiencies. A 6,000-pipe version software was utilized for this project. Geographic Information System (GIS) of the City's sanitary sewer system was also developed as part of this project. InfoSewer software works directly with GIS shape files.

6.1 Hydraulic Model Development and Flowchart

A modeling flowchart for the development of the sanitary sewer hydraulic model and the model analysis is shown on Figure 6-1. City as-built drawings and atlas maps were used to develop GIS shape files of the City's sanitary sewer system. Attribute data developed include sewer and manhole invert elevations; pipe slope; manhole rim elevations; pipe diameter; and pipe material.

The sewer geodatabase developed by HFI was then imported into the InfoSewer software. The sewer geometry data was then adjusted in the model to resolve GIS connectivity issues. Other adjustments were made as required to conform the GIS data into accurate model data of the City's collection system. The model includes all City sewers in the City's collection system excluding service laterals.

6 – HYDRAULIC MODELING/CAPACITY ANALYSIS

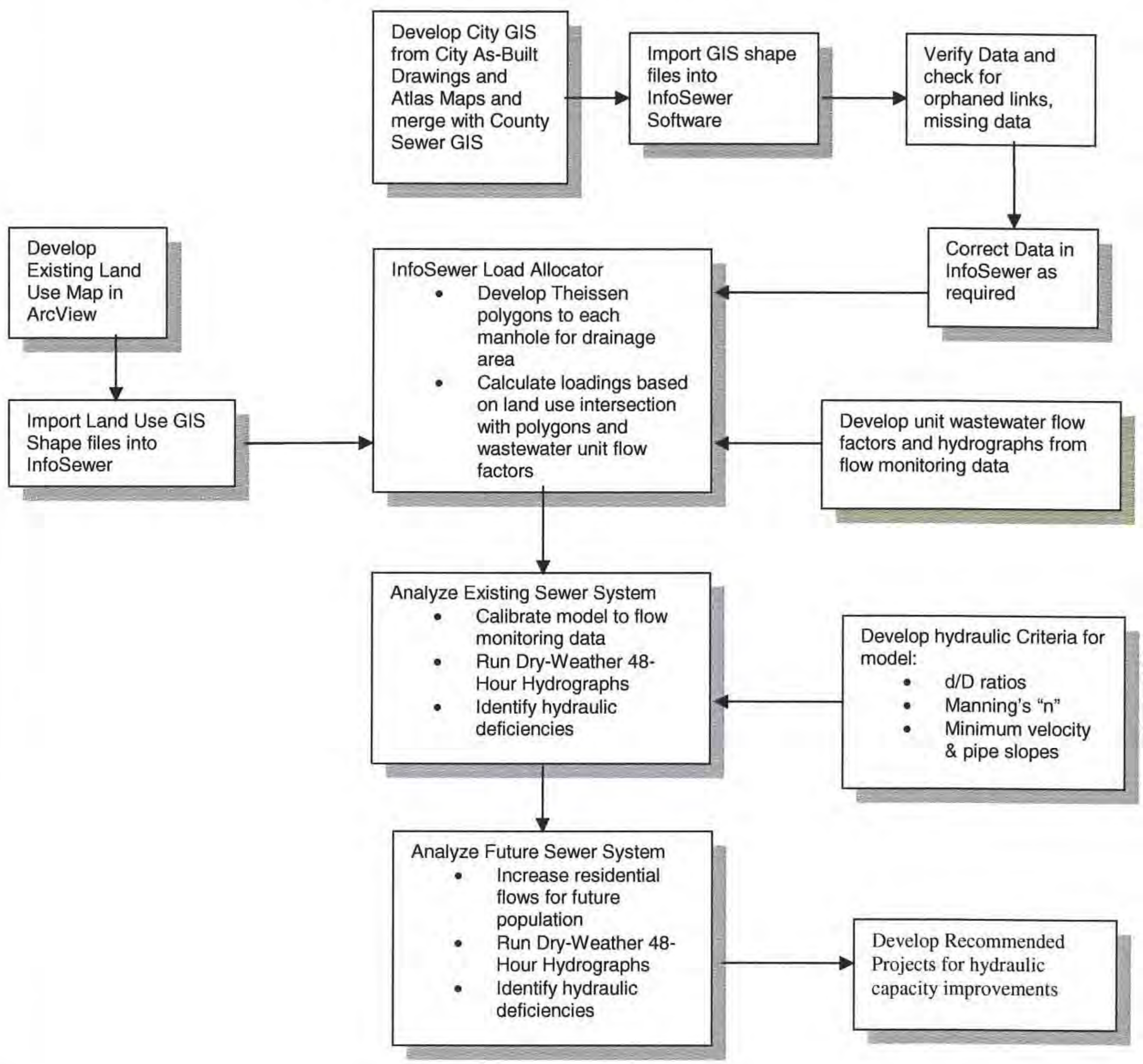
The Load Allocation Module of the InfoSewer software allocates wastewater flows to each manhole based on tributary land use areas, type of development, and unit wastewater generation factors. Polygons were drawn around each manhole drainage area and unit wastewater generation factors developed as developed in Chapter 3 were applied to the respective land uses within each manhole drainage area to develop average dry-weather flow for system manholes. The program then generates Theissen polygons around each of the manholes in the system and assigns the wastewater flow rates.

Average dry-weather flow hydrographs were applied at appropriate locations in the model to simulate 24-hour dry-weather flow variations. Average dry-weather flow hydrographs for residential, industrial/commercial, and industrial land use were developed and are presented in Chapter 3.

The Existing System model was then calibrated by adjusting wastewater generation, 24-hour curves, and other model variables until the model results matched the field flow monitoring results for each of the four meter basins within an acceptable level of accuracy. A Future System model of the City's sanitary sewer system was developed to analyze hydraulic performance and identify hydraulic deficiencies in the year 2035.

6 – HYDRAULIC MODELING/CAPACITY ANALYSIS

Figure 6-1. Hydraulic Model Flowchart



Average dry-weather flow hydrographs were applied at appropriate locations in the model to simulate 24-hour dry-weather flow variations. Average dry-weather flow hydrographs for residential, commercial, and industrial land use were applied to manholes receiving flows from that type of land use. These average dry-weather hydrographs are shown in Chapter 3.

The Existing System model was then calibrated by adjusting wastewater generation, 24-hour curves, and other model variables until the model results matched the field flow monitoring results for each of the four meter basins within an acceptable level of accuracy. A Future System model of the City's sanitary sewer system was developed to analyze hydraulic performance and identify hydraulic deficiencies in the year 2035. The Future System model was developed by adjusting demands to reflect future population and land use changes in the City.

Recommended guidelines and criteria to be used in evaluating the collection system with the hydraulic model was then developed including depth over diameter (d/D) ratios, sewer friction coefficients, and minimum velocities and slopes. The City's existing and future sewer systems were analyzed for hydraulic performance and hydraulic deficiencies were identified. Projects were then developed to address hydraulic deficiencies in the system.

6.2 Sanitary Sewer Analysis Criteria

Sanitary sewer analysis criteria were established for maximum depth of flow in the pipe, minimum pipe velocity at peak dry-weather flow, minimum pipe slope, and pipe friction factors.

6.2.1 Depth over Diameter (d/D) Ratios

When it rains, rain water in the form of inflow and infiltration (I/I) enters the sewer system via openings in the system. This results in wet-weather peak flows that can occur on top of dry-weather peak flows. Peak wet-weather flows are accounted for by designing sewers to carry peak-dry weather flows at maximum sewer flow depth over diameter (d/D) ratios. The remainder of the pipe flow area is reserved to carry wet weather flow on top of peak dry-weather flow. In evaluating sewer capacity as part of this Master Plan, the maximum d/D ratio to carry peak dry-weather flow will be 0.50 for sewers 12 inches in diameter or smaller and will be 0.75 for sewers 15 inches in diameter or greater as shown in Table 6-1. This d/D criterion is consistent with industry standards.

Table 6-1. Peak Dry-Weather Flow Depth/Pipe Diameter (d/D)

Pipe Size (in)	Maximum Depth/Diameter (d/D)
8 to 12	0.50
15 and larger	0.75

6.2.2 Minimum Velocity

From an operational perspective, a minimum peak flow velocity of 2 feet per second at is desirable to scour the line and prevent significant solids deposition. Lines in the system that do not develop adequate cleansing velocity (flat lines, low spots, or lines with low flows) need to be given priority status in the City's line cleaning program. Every attempt was made to utilize data from as-builts for the modeling. However, because of lack of available as-builts, extrapolation was utilized to calculate missing inverts and slopes.

6.2.3 Minimum Pipe Slopes

Minimum pipe slope by pipe diameter is shown in Table 6-2. These are typical of minimum pipe slopes used by other agencies and cities to help ensure adequate pipe capacities. Minimum slope is a construction standard that helps ensure that d/D ratios and other hydraulic criteria are met. Pipes that have slopes less than the minimum will have higher levels and lower velocities at normal flows and are more likely to surcharge at high flows.

Table 6-2. Minimum Slopes for Sanitary Sewers

Pipe Diameter (inches)	Slope (ft/ft)
8	0.0040
10	0.0032
12	0.0024
15	0.0016
18	0.0014
21	0.0012
24	0.0010
27 and larger	0.0008

6.2.4 Pipe Friction Factors

Friction occurs when a liquid flows over a pipe surface. The friction resists and retards the flow and causes the flow depth to increase. The magnitude of the resistance depends on the pipe material, the types of pipe joints, and the age of the pipe. Pipes generally become rougher with age. Bell and spigot joints associated with vitrified clay pipe (VCP) have more friction than joints that are more seamless such as a plastic slipline.

Friction for sewer pipe is typically measured using Manning's "n" coefficients. Friction increases with higher n values. PVC and other plastics such as high-density polyethylene (HDPE) are very smooth and do not degrade much over time. New, these plastics have an n value of approximately 0.009, and the n value increases to only 0.010 after 20 years. The material is associated with trenchless pipe rehabilitation such as cured-in-place (CIPP) pipe and plastic sliplines have similar n values.

VCP is less smooth and also degrades more over time. The bell and spigot joints of VCP also contribute to a higher friction coefficient. New, VCP (including the joints) has an n value of approximately 0.011 and the n value increases to 0.013 after 20 years.

However, the actual pipe material might not be completely relevant in determining actual pipe friction. Some research studies have shown that a slime layer eventually builds up on any municipal sanitary sewer pipe surface and that the slime layer effectively becomes the pipe surface. These studies have indicated that the average Manning's n value for any sewer pipe material with a slime layer is 0.013. The pipes evaluated for the City are generally 60-80 years old. To be conservative, a Manning's n value of 0.015 was used to hydraulically evaluate all sewers in this Master Plan.

6.2.5 Future Conditions - Wet Weather Analysis

The Future System model was developed by adjusting demands to reflect future population and land use changes in the City and was analyzed for Peak Wet Weather Flow (PWWF) conditions. The analyses assumed the storm would occur during the peak diurnal period of dry weather flow conditions with peak infiltration. Flow data was used to calculate peak wet weather storm. This scenario (PWWF, Year 2035) proved to be the worst case scenario and generated 105 line segments that were hydraulically deficient. Appendix A shows the tabular result of the model run for this scenario.

6.2.6 Design Capacity

Recommended guidelines and criteria to be used in evaluating the collection system with the hydraulic model was then developed including depth over diameter (d/D) ratios, sewer friction coefficients, and minimum velocities and slopes. The design capacity of collection lines are established in the model as previously mentioned and summarized as follows. Lines will be considered over- capacity if they cannot convey the peak dry weather flow using 50 percent of actual capacity (for pipes 12 inches and smaller) and 75 percent of actual capacity (for pipes 15 inches and larger) based on the hydraulic criteria. The remaining 25 percent capacity is allocated for Infiltration and Inflow, Reserve Capacity Contingency and variations in flows.

6.3 Hydraulic Model Calibration

The Existing System model was calibrated by adjusting wastewater generation, 24-hour curves, and other model variables until the model results matched the field flow monitoring results for each of the four meter basins within an acceptable level of accuracy. The output results compared with the meter data are within 10% accuracy for all four basins.

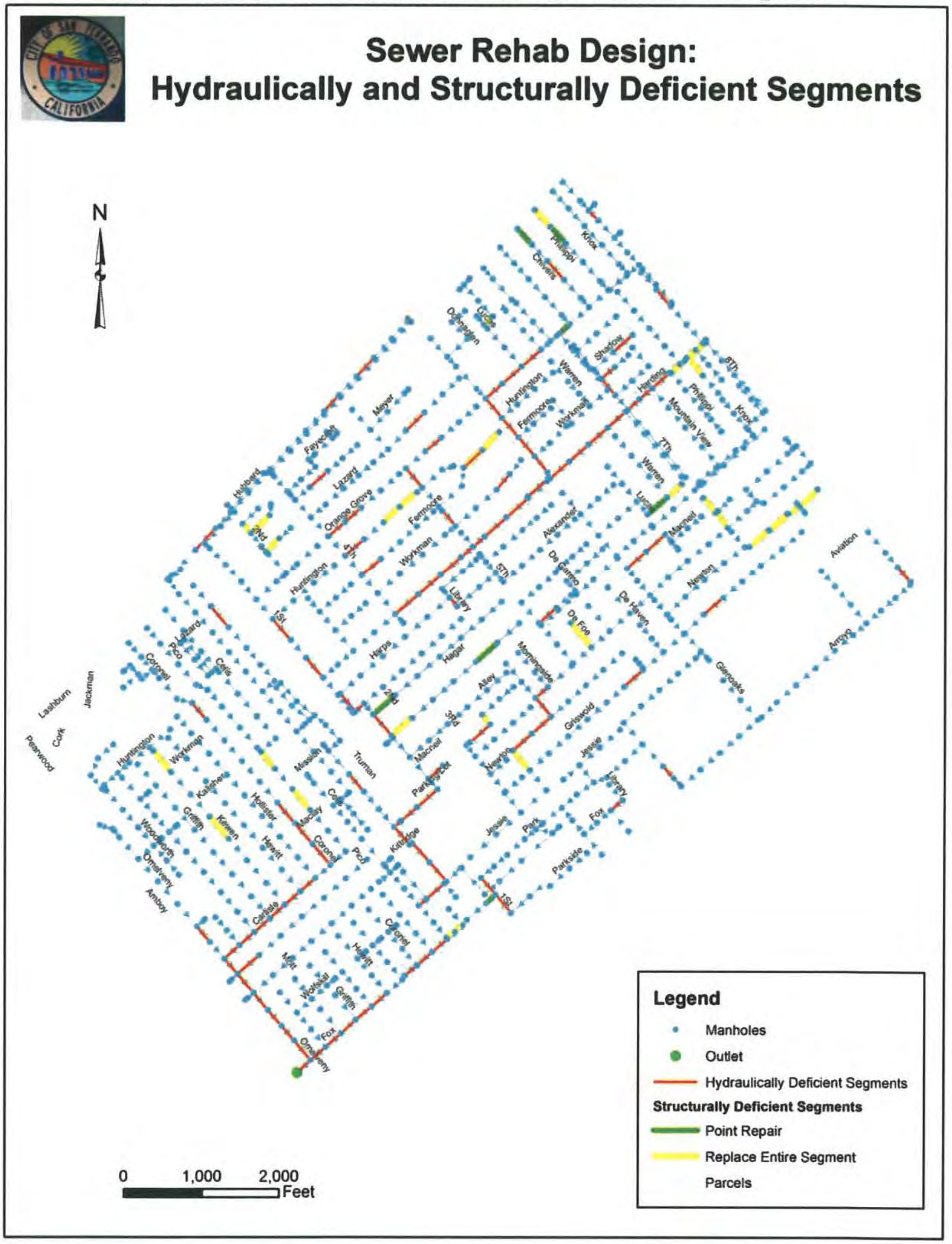
6.4 Comparison of Existing and Future Model Flows

A Future System model of the City's sanitary sewer system was developed to analyze hydraulic performance and identify hydraulic deficiencies in the year 2035. The makeup of the Future System model is the same as the Existing System model with the following exceptions: wastewater generation for all of the R residential land use categories were increased by approximately 6% to account for the projected population increase in 2035. Also, properties planned for future redevelopment that impact the City's sanitary sewers were adjusted to the appropriate future wastewater generation corresponding to their planned land use and adjusted flows were developed at the appropriate locations in Future System model.

6.5 Recommended Hydraulic Improvements

The City's existing and future sewer systems were analyzed for hydraulic performance and hydraulic deficiencies were identified. Projects were then developed to address hydraulic deficiencies in the system under worst conditions which in this case was PWWF, Year 2035. Combining the results of the hydraulic model with the CCTV inspection yielded only one segment which was both hydraulically and structurally deficient. Figure 6-2 shows a map of this combination.

Figure 6-2, Hydraulically and Structurally Deficient Line Segments

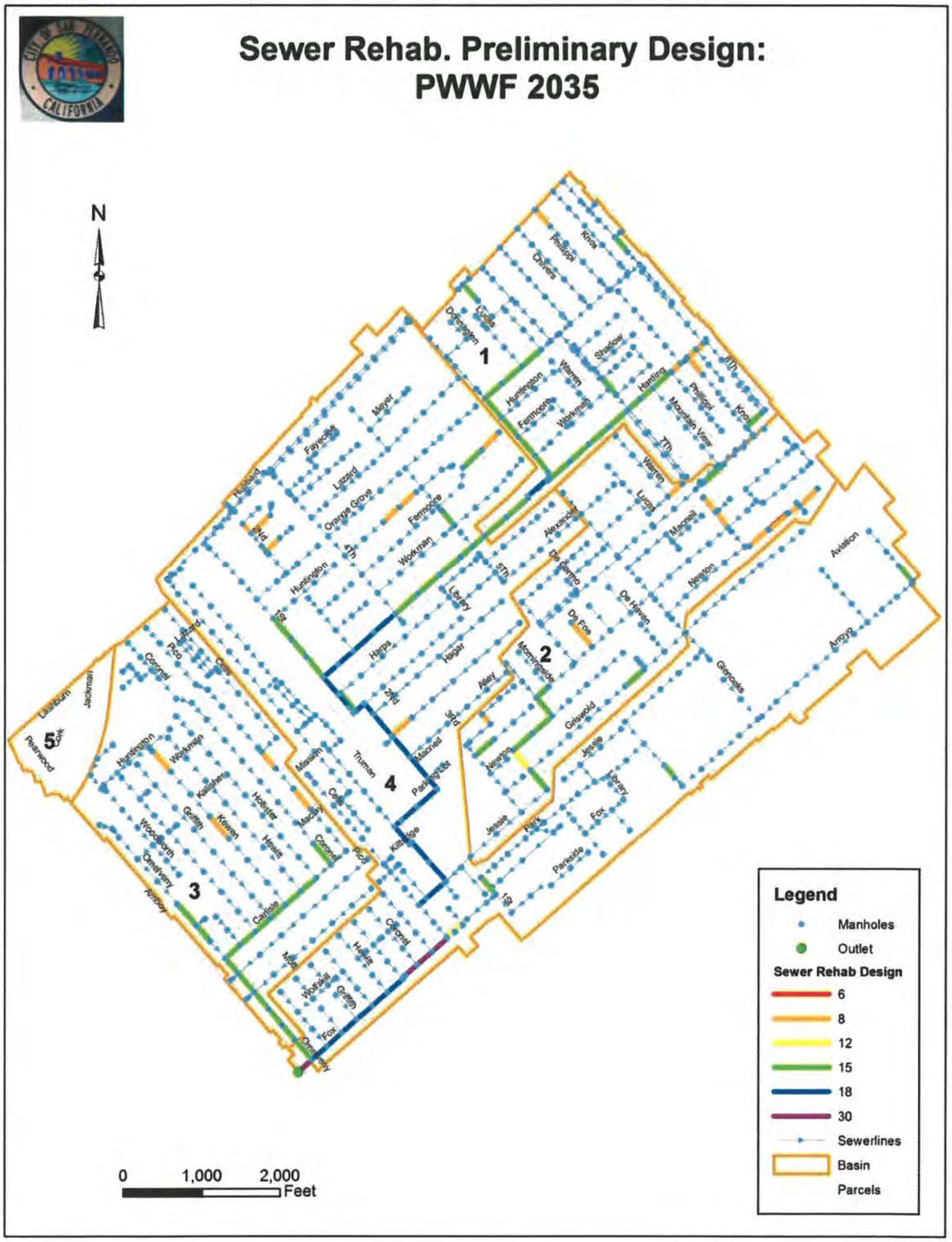


6 – HYDRAULIC MODELING/CAPACITY ANALYSIS

Based on the results of the hydraulic analysis, and CCTV inspection, recommended improvement projects addressing both are shown in Table 6-3 and are shown on Figure 6-3. These projects have sewer pipe segments that exceed d/D criteria. Note: There are several relief lines as part of this design in Basin 4, upstream of the outlet.

6 – HYDRAULIC MODELING/CAPACITY ANALYSIS

Figure 6-3 – Sewer Rehabilitation Preliminary Design



6 – HYDRAULIC MODELING/CAPACITY ANALYSIS

A project is a run of sewer segments that ultimately discharge to a larger sewer. Some intermediate or downstream segments might not have a d/D hydraulic deficiency. However, it is not good engineering practice to improve an upstream segment while leaving a downstream segment the same. Therefore all segments in a run are recommended to either be replaced with a larger sewer or paralleled with a second sewer. A total of approximately 26,000 feet of sewers are recommended for hydraulic improvement. A total of just over 11,000 linear feet of sewers are recommended for structural improvement.

7 – CIP DEVELOPMENT/COST ANALYSIS

7.0 Overview

Capital costs were estimated for all projects recommended in previous chapters of the sewer system master plan. The projects were prioritized consistent with the severity of a deficiency and were allocated to a recommended 10-year Sewer Capital Improvement Program (CIP) schedule.

7.1 Recommended Projects

Brief description and estimated capital costs of recommended projects are provided below. Construction costs were estimated assuming 7% for project mobilization, 10% for engineering design and using a 10% construction contingency. Capital costs were developed as 30% of construction costs to account for technical, legal, and administrative costs associated with a project. Table 7-1 shows the prioritized list of hydraulically deficient lines.

Table 7-1 is shown in Exhibit A.

7 – CIP DEVELOPMENT/COST ANALYSIS

7.1.1 Sewer Rehabilitation

Severe structural defects associated with sewers totaling 11,000 feet were identified. These severe defects warrant repair within the 10-year CIP.

Recommended sewer repairs include all sewers with a category 5 defect as well as sewers with numerous category 4 and 3 defects. Within the CIP time frame of 1 to 5 years, sewer repairs for category 5 defects should be prioritized first. In cases where a sewer has a category 5 defect and not many other significant defects, it is recommended that the category 5 defect be repaired via open cut spot repairs.

If a sewer has category 5 defects as well as significant other defects, then it is recommended that the entire sewer segment be lined via an appropriate trenchless technology as described in Chapter 5. Category 5 defects can be rehabilitated by lining, without first repairing the category 5 defects by open cut spot repair, if the pipe is not collapsed or the defect does not block intrude into the pipe flowway. Otherwise the category 5 defect will need to be repaired first.

A category 4 defect is a severe fracture or breaking of the pipe that could become a category 5 defect in the near future, or it can be a severe offset joint. A lone category 4 defect was typically not recommended for repair within the 10-year CIP, but a sewer segment with multiple category 4 defects was recommended for repair, especially if they were occurring in conjunction with other category 3 and 2 defects.

A category 4 defect is a severe fracture or breaking of the pipe that could become a category 5 defect in the near future, or it can be a severe offset joint. Most category 4 defects can be repaired by lining the sewer segment as opposed to constructing point repairs. A category 3 defect is multiple cracking at a location in the pipe. Multiple cracking can continue to spread, i.e. deteriorate, over time. A pipe segment with many and/or recurring category 3 defects is recommended for repair, which can be accomplished by lining the entire sewer segment.

The capital cost to implement sewer rehabilitation is estimated at $9.96 million dollars. Detailed cost estimates are provided in the Appendix of this report.

7.1.2 Additional Sewer CCTV

As part of the Master Plan, approximately 56,127 linear feet (10.63 miles) of City sewers were videotaped using closed circuit television (CCTV), which is 25.6 percent of the City's total collection system. The sewer CCTV was conducted to identify defects, rate defects, and then incorporate recommended improvements into the CIP.

It is recommended that the City CCTV an additional 25% of its system for the next three years out of its 10-Year CIP to achieve 100% completion, (fiscal years 2014/2015, 2015/2016, and 2016/2017) at an estimated cost of $60,000 per year for three years, to identify additional sewer defects that need rehabilitation, and then include the rehabilitation of defective sewers as projects in a revised/expanded CIP.

7.1.3 Manhole Investigations

Manholes are structural cornerstones of the collection system and should be inspected periodically and rehabilitated or replaced as required to ensure collection system structural integrity. Manholes can exhibit wall cracking, damaged/corroded frames and lids, corroded and damaged ladders, and damaged benches, among other defects. Consequently, defective or poorly located manholes are primary sources of sewer system inflow and infiltration.

Infiltration via rain-induced groundwater percolation can enter the sewer system through openings/cracks in manhole walls. Manholes can also receive excessive surface runoff (inflow) because of their location in or adjacent to surface drainage such as in or near street gutters or because they are located in confined and/or recessed areas that make the manhole act as a surface drain.

There are approximately 834 manholes in the City's sewer system. It is recommended that the City inspect these manholes as well as perform Smoke Testing, Dye Testing, and other I/I related field investigations within the first two years of the 10-year CIP. This I/I field investigation to quantify additional I/I sources is estimated at $200,000. Once the I/I project is done it will identify needed funding to include the rehabilitation or replacement of defective manholes as projects in a revised/expanded CIP.

7.1.4 Sewer Capacity Projects

The City's existing and future sewer systems were analyzed for hydraulic performance and hydraulic deficiencies were identified. Projects were then developed to address hydraulic deficiencies in the system.

The total capital cost of the hydraulic improvement projects is estimated at $7,573,421. The total capital cost for structural improvement projects is estimated at $2,422,436 million in year 2014 dollars. The Grand Total for sewer system rehabilitation is then estimated at $9,995,857. Detailed cost estimates are provided in Table 5-2 as well as the Appendix of this report. The sewer costs were based on open-cut excavation. There are also a series of pipe recommended to be paralleled with a second sewer. There are pros and cons to any of these methods and the decision to replace or parallel a sewer should be decided in design. For this Master Plan, open-cut pipe replacement is assumed.

7 – CIP DEVELOPMENT/COST ANALYSIS

7.2 Recommended Capital Improvement Program

The recommended Sewer Capital Improvement Program is shown in Table 7-2.

7 – CIP DEVELOPMENT/COST ANALYSIS

Table 7-2. Recommended 10-Year Capital Improvement Program

Table 7-2
10-Year Capital Improvement Program

CAPITAL PROJECT	FY 14-15	FY 15-16	FY 16-17	FY 17-18	FY 18-19	FY 19-20	FY 20-21	FY 21-22	FY 22-23	FY 23-24	TOTALS
Engineering Design for Sewer Rehab.	300,000										300,000
I/I Field Study & Analysis		200,000									200,000
CCTV of Sewer Lines	60,000	60,000	60,000								180,000
Work Order System		100,000									100,000
Collection System Rehabilitation											-
Sewer Rehab. Projects		1,110,651	1,110,651	1,110,651	1,110,651	1,110,651	1,110,651	1,110,651	1,110,651	1,110,651	9,995,859
Total Capital Expenses	360,000	1,470,651	1,170,651	1,110,651	1,110,651	1,110,651	1,110,651	1,110,651	1,110,651	1,110,651	10,775,859

APPENDIX A

APPENDIX B

ID	From ID	To ID	Diameter (in)	Length (ft)	Existing Flow (cfs)	Existing Velocity (ft/s)	d/D Ratio	Analysis Flow (cfs)	Analysis Excess (cfs)	Analysis d/D Ratio	Design Flow (cfs)	Design Excess (cfs)	Design d/D Ratio	Replacement Diameter (in)	Replacement Velocity (ft/s)	Replacement d/D Ratio	Unit Cost ($)	Replacement Cost ($)	Parallel Diameter (in)	Parallel Velocity (ft/s)	Parallel d/D Ratio	Parallel Cost ($)
B4_0625-B4_0629	B4_0625	B4_0629	18	260	9.21	5.21	1.00	5.24	-3.97	0.75	5.24	-3.97	0.75	30	4.83	0.41	340	88311				
B4_0629-B4_0634	B4_0629	B4_0634	18	257	9.27	5.24	1.00	5.24	-4.03	0.75	5.24	-4.03	0.75	30	4.84	0.41	340	87484				
B4_0240-B4_0248	B4_0240	B4_0248	15	363	3.69	4.64	0.62	2.63	-1.06	0.5	2.63	-1.06	0.50	18	5.18	0.42	240	87125				
B4_0336-B4_0338	B4_0336	B4_0338	15	360	5.17	5.71	0.69	3.14	-2.04	0.5	3.14	-2.04	0.50	18	6.45	0.46	240	86395				
B4_0321-B4_0328	B4_0321	B4_0328	15	360	4.87	3.97	1.00	1.72	-3.16	0.5	1.72	-3.16	0.50	18	4.01	0.65	240	86394				
B4_0239-B4_0240	B4_0239	B4_0240	15	359	3.67	4.64	0.62	2.63	-1.04	0.5	2.63	-1.04	0.50	18	5.18	0.42	240	86150				
B4_0170-B4_0239	B4_0170	B4_0239	10	391	2.86	5.24	1.00	1.25	-1.61	0.5	1.25	-1.61	0.50	15	6.24	0.40	220	86018				
B4_0339-B4_0340	B4_0339	B4_0340	15	348	5.24	4.27	1.00	1.88	-3.36	0.5	1.88	-3.36	0.50	18	4.37	0.64	240	83577				
B3_0767-B3_0769	B3_0767	B3_0769	8	379	0.30	1.71	0.50	0.30	0.00	0.5	0.30	0.00	0.50	15	1.80	0.19	220	83487				
B4_0169-B4_0170	B4_0169	B4_0170	10	376	2.84	5.22	1.00	1.13	-1.72	0.5	1.13	-1.72	0.50	15	5.78	0.42	220	82719				
B1_0160-B1_0161	B1_0160	B1_0161	15	345	2.73	2.22	1.00	1.10	-1.63	0.5	1.10	-1.63	0.50	18	2.50	0.59	240	82694				
B1_0164-B1_0165	B1_0164	B1_0165	10	375	2.80	5.13	1.00	1.39	-1.41	0.5	1.39	-1.41	0.50	15	6.71	0.37	220	82498				
B1_0163-B1_0164	B1_0163	B1_0164	10	375	2.77	5.08	1.00	1.14	-1.64	0.5	1.14	-1.64	0.50	15	5.77	0.41	220	82498				
B4_0791-OUTLET	B4_0791	OUTLET	18	238	10.83	6.13	1.00	8.31	-2.52	0.75	8.31	-2.52	0.75	30	7.06	0.35	340	80879				
B4_0357-B4_0358	B4_0357	B4_0358	15	331	5.42	4.42	1.00	1.99	-3.44	0.5	1.99	-3.44	0.50	18	4.60	0.63	240	79511				
B4_0358-B4_0507	B4_0358	B4_0507	15	330	5.45	4.44	1.00	2.51	-2.94	0.5	2.51	-2.94	0.50	18	5.52	0.55	240	79142				
B4_0330-B4_0336	B4_0330	B4_0336	15	327	5.05	5.69	0.68	3.14	-1.91	0.5	3.14	-1.91	0.50	18	6.41	0.46	240	78597				
B4_0277-B4_0278	B4_0277	B4_0278	8	355	0.50	2.79	0.51	0.48	-0.02	0.5	0.48	-0.02	0.50	15	2.94	0.20	220	78154				
B3_0697-B3_0698	B3_0697	B3_0698	8	352	0.22	1.95	0.36	0.40	0.18	0.5	0.40	0.18	0.50	15	2.02	0.15	220	77449				
B4_0168-B4_0169	B4_0168	B4_0169	10	349	2.83	5.20	1.00	1.08	-1.75	0.5	1.08	-1.75	0.50	15	5.60	0.43	220	76779				
B2_0390-B2_0391	B2_0390	B2_0391	8	346	0.06	1.98	0.14	0.71	0.65	0.5	0.71	0.65	0.50	15	2.01	0.06	220	76124				
B4_0279-B4_0280	B4_0279	B4_0280	8	335	0.56	2.52	0.61	0.41	-0.15	0.5	0.41	-0.15	0.50	15	2.71	0.23	220	73705				
B4_0224-B4_0225	B4_0224	B4_0225	8	331	0.05	0.19	0.73	0.03	-0.02	0.5	0.03	-0.02	0.50	15	0.21	0.26	220	72817				
B2_0466-B2_0467	B2_0466	B2_0467	10	330	1.07	3.59	0.54	0.95	-0.12	0.5	0.95	-0.12	0.50	15	3.90	0.28	220	72619				
B2_0467-B2_0468	B2_0467	B2_0468	10	330	1.09	3.60	0.54	0.95	-0.13	0.5	0.95	-0.13	0.50	15	3.92	0.28	220	72619				
B1_0156-B1_0157	B1_0156	B1_0157	8	330	1.13	4.80	0.64	0.77	-0.36	0.5	0.77	-0.36	0.50	15	5.19	0.23	220	72604				
B1_0158-B1_0159	B1_0158	B1_0159	8	330	1.19	5.06	0.64	0.81	-0.38	0.5	0.81	-0.38	0.50	15	5.46	0.23	220	72604				
B1_0056-B1_0057	B1_0056	B1_0057	8	330	1.00	3.32	0.80	0.51	-0.49	0.5	0.51	-0.49	0.50	15	3.73	0.27	220	72599				
B1_0157-B1_0158	B1_0157	B1_0158	8	330	1.15	4.83	0.65	0.77	-0.39	0.5	0.77	-0.39	0.50	15	5.22	0.24	220	72590				
B2_0496-B2_0497	B2_0496	B2_0497	12	330	1.41	3.54	0.51	1.38	-0.03	0.5	1.38	-0.03	0.50	15	3.89	0.34	220	72588				
B1_0043-B1_0056	B1_0043	B1_0056	8	329	0.75	3.57	0.58	0.59	-0.17	0.5	0.59	-0.17	0.50	15	3.82	0.22	220	72375				
B4_0355-B4_0356	B4_0355	B4_0356	15	301	5.40	4.40	1.00	1.99	-3.41	0.5	1.99	-3.41	0.50	18	4.60	0.63	240	72237				
B3_0790-B4_0791	B3_0790	B4_0791	8	327	1.65	4.72	1.00	0.60	-1.05	0.5	0.60	-1.05	0.50	15	4.84	0.32	220	71999				
B4_0280-B4_0281	B4_0280	B4_0281	15	299	4.32	4.70	0.70	2.57	-1.75	0.5	2.57	-1.75	0.50	18	5.31	0.47	240	71746				
B1_0065-B1_0069	B1_0065	B1_0069	10	326	1.35	4.65	0.53	1.24	-0.11	0.5	1.24	-0.11	0.50	15	5.05	0.27	220	71626				
B1_0072-B1_0086	B1_0072	B1_0086	10	325	1.48	3.16	0.80	0.76	-0.72	0.5	0.76	-0.72	0.50	15	3.62	0.37	220	71589				
B4_0509-B4_0511	B4_0509	B4_0511	15	298	6.96	5.67	1.00	3.04	-3.92	0.5	3.04	-3.92	0.50	18	6.78	0.56	240	71561				
B1_0069-B1_0072	B1_0069	B1_0072	10	325	1.42	3.15	0.77	0.75	-0.67	0.5	0.75	-0.67	0.50	15	3.58	0.36	220	71507				
B2_0367-B2_0368	B2_0367	B2_0368	8	325	0.06	1.99	0.14	0.70	0.65	0.5	0.70	0.65	0.50	15	2.02	0.06	220	71504				
B2_0490-B2_0491	B2_0490	B2_0491	8	324	0.29	3.10	0.31	0.69	0.40	0.5	0.69	0.40	0.50	15	3.20	0.13	220	71279				
B4_0634-B4_0635	B4_0634	B4_0635	18	206	9.32	5.28	1.00	5.22	-4.10	0.75	5.22	-4.10	0.75	30	4.83	0.42	340	70007				
B3_0779-B3_0787	B3_0779	B3_0787	12	315	1.56	3.24	0.59	1.20	-0.37	0.5	1.20	-0.37	0.50	15	3.60	0.38	220	69339				
B2_0461-B2_0466	B2_0461	B2_0466	10	313	1.01	3.36	0.54	0.89	-0.12	0.5	0.89	-0.12	0.50	15	3.66	0.28	220	68853				
B1_0155-B1_0156	B1_0155	B1_0156	8	310	1.11	4.05	0.73	0.63	-0.49	0.5	0.63	-0.49	0.50	15	4.47	0.26	220	68239				
B4_0307-B4_0308	B4_0307	B4_0308	8	301	1.30	3.72	1.00	0.32	-0.98	0.5	0.32	-0.98	0.50	15	2.91	0.39	220	66183				
B1_0119-B1_0132	B1_0119	B1_0132	8	300	0.51	3.69	0.42	0.70	0.18	0.5	0.70	0.18	0.50	15	3.85	0.17	220	66097				
B4_0278-B4_0279	B4_0278	B4_0279	8	300	0.53	2.99	0.51	0.52	-0.01	0.5	0.52	-0.01	0.50	15	3.16	0.19	220	65998				
B1_0057-B1_0065	B1_0057	B1_0065	8	294	1.05	3.01	1.00	0.51	-0.54	0.5	0.51	-0.54	0.50	15	3.79	0.28	220	64678				
B3_0787-B3_0788	B3_0787	B3_0788	12	289	1.62	3.51	0.57	1.31	-0.32	0.5	1.31	-0.32	0.50	15	3.88	0.37	220	63595				
B4_0649-B4_0651	B4_0649	B4_0651	18	264	9.43	5.34	1.00	8.31	-1.12	0.75	8.31	-1.12	0.75				220		18	5.89	0.49	57997
B4_0340-B4_0341	B4_0340	B4_0341	15	263	5.27	4.30	1.00	2.55	-2.72	0.5	2.55	-2.72	0.50	18	5.55	0.53	240	63012				
B4_0248-B4_0249	B4_0248	B4_0249	15	262	3.84	4.51	0.65	2.51	-1.33	0.5	2.51	-1.33	0.50	18	5.06	0.44	240	62858				
B4_0645-B4_0649	B4_0645	B4_0649	18	262	9.40	5.32	1.00	8.31	-1.09	0.75	8.31	-1.09	0.75				220		18	5.89	0.49	57562
B4_0653-B4_0662	B4_0653	B4_0662	18	261	9.47	5.36	1.00	8.32	-1.15	0.75	8.32	-1.15	0.75				220		18	5.90	0.49	57498
B4_0575-B4_0581	B4_0575	B4_0581	12	285	1.80	5.14	0.46	2.10	0.30	0.5	2.10	0.30	0.50	15	5.63	0.31	220	62698				
B1_0122-B1_0125	B1_0122	B1_0125	8	284	0.05	2.00	0.12	0.78	0.73	0.5	0.78	0.73	0.50	15	2.02	0.05	220	62436				
B4_0640-B4_0645	B4_0640	B4_0645	18	260	9.37	5.30	1.00	8.32	-1.05	0.75	8.32	-1.05	0.75				220		18	5.88	0.49	57092
B4_0662-B4_0791	B4_0662	B4_0791	18	258	9.53	5.39	1.00	8.32	-1.21	0.75	8.32	-1.21	0.75				220		18	5.91	0.49	56817
B4_0651-B4_0653	B4_0651	B4_0653	18	257	9.45	5.35	1.00	8.32	-1.13	0.75	8.32	-1.13	0.75				220		18	5.90	0.49	56591
B1_0143-B1_0147	B1_0143	B1_0147	8	277	0.18	1.97	0.31	0.43	0.25	0.5	0.43	0.25	0.50	15	2.03	0.13	220	60987				
B1_0049-B1_0050	B1_0049	B1_0050	8	277	0.04	1.98	0.10	0.85	0.82	0.5	0.85	0.82	0.50	15	2.00	0.04	220	60973				
B4_0249-B4_0280	B4_0249	B4_0280	15	250	3.87	4.51	0.66	2.51	-1.36	0.5	2.51	-1.36	0.50	18	5.07	0.45	240	60003				
B3_0788-B3_0789	B3_0788	B3_0789	8	270	1.63	4.67	1.00	0.44	-1.19	0.5	0.44	-1.19	0.50	15	3.89	0.38	220	59363				
B1_0086-B1_0087	B1_0086	B1_0087	10	263	1.67	3.07	1.00	0.75	-0.92	0.5	0.75	-0.92	0.50	15	3.74	0.39	220	57801				
B3_0731-B3_0742	B3_0731	B3_0742	10	261	1.09	3.38	0.57	0.87	-0.21	0.5	0.87	-0.21	0.50	15	3.69	0.29	220	57491				
B3_0745-B3_0771	B3_0745	B3_0771	10	261	1.23	3.25	0.65	0.80	-0.42	0.5	0.80	-0.42	0.50	15	3.60	0.32	220	57364				
B3_0723-B3_0731	B3_0723	B3_0731	8	261	0.97	3.87	0.68	0.61	-0.37	0.5	0.61	-0.37	0.50	15	4.22	0.24	220	57345				
B3_0769-B3_0770	B3_0769	B3_0770	8	260	0.31	1.73	0.51	0.30	-0.01	0.5	0.30	-0.01	0.50	15	1.83	0.20	220	57284				
B3_0771-B3_0779	B3_0771	B3_0779	12	260	1.50	3.04	0.60	1.12	-0.38	0.5	1.12	-0.38	0.50	15	3.38	0.39	220	57215				
B3_0707-B3_0715	B3_0707	B3_0715	8	260	0.70	3.61	0.54	0.61	-0.09	0.5	0.61	-0.09	0.50	15	3.84	0.21	220	57212				
B4_0228-B4_0233	B4_0228	B4_0233	8	260	0.22	1.98	0.36	0.41	0.19	0.5	0.41	0.19	0.50	15	2.05	0.14	220	57204				
B3_0715-B3_0723	B3_0715	B3_0723	8	260	0.85	3.76	0.61	0.61	-0.24	0.5	0.61	-0.24	0.50	15	4.05	0.23	220	57199				
B3_0742-B3_0745	B3_0742	B3_0745	10	257	1.21	3.24	0.65	0.80	-0.40	0.5	0.80	-0.40	0.50	15	3.58	0.32	220	56480				
B1_0007-B1_0008	B1_0007	B1_0008	8	254	0.08	1.99	0.17	0.61	0.53	0.5	0.61	0.53	0.50	15	2.02	0.07	220	55776				
B4_0528-B4_0529	B4_0528	B4_0529	10	253	0.20	0.70	0.51	0.19	-0.01	0.5	0.19	-0.01	0.50	15	0.76	0.27	220	55711				
B3_0789-B3_0790	B3_0789	B3_0790	8	251	1.64	4.69	1.00	0.44	-1.19	0.5	0.44	-1.19	0.50	15	3.90	0.38	220	55182				
B4_0281-B4_0282	B4_0281	B4_0282	15	216	3.47	3.35	0.79	1.80	-1.67	0.5	1.80	-1.67	0.50	18	3.85	0.51	240	51815				
B2_0458-B2_0461	B2_0458	B2_0461	10	211	0.99	3.23	0.55	0.85	-0.14	0.5	0.85	-0.14	0.50	15	3.51	0.28	220	46374				
B4_0550-B4_0551	B4_0550	B4_0551	8	210	1.04	2.98	1.00	0.42	-0.63	0.5	0.42	-0.63	0.50	15	3.27	0.31	220	46206				
B1_0132-B1_0133	B1_0132	B1_0133	8	207	0.76	3.77	0.56	0.63	-0.13	0.5	0.63	-0.13	0.50	15	4.01	0.21	220	45631				
B1_0133-B1_0151	B1_0133	B1_0151	8	206	0.78	3.54	0.60	0.58	-0.20	0.5	0.58	-0.20	0.50	15	3.80	0.22	220	45313				
B4_0167-B4_0168	B4_0167	B4_0168	10	204	2.83	5.18	1.00	1.13	-1.69	0.5	1.13	-1.69	0.50	15	5.80	0.42	220	44962				
B4_0314-B4_0321	B4_0314	B4_0321	15	180	4.73	5.62	0.65	3.14	-1.60	0.5	3.14	-1.60	0.50	18	6.30	0.44	240	43198				
B1_0165-B4_0167	B1_0165	B4_0167	10	196	2.82	5.16	1.00	1.14	-1.68	0.5	1.14	-1.68	0.50	15	5.80	0.42	220	43119				
B4_0338-B4_0339	B4_0338	B4_0339	15	180	5.22	5.48	0.72	2.98	-2.23	0.5	2.98	-2.23	0.50	18	6.23	0.48	240	43092				
B4_0308-B4_0314	B4_0308	B4_0314	15	150	4.64	3.78	1.00	1.66	-2.98	0.5	1.66	-2.98	0.50	18	3.85	0.64	240	35900				
B4_0511-B4_0622	B4_0511	B4_0622	15	130	6.98	5.69	1.00	3.04	-3.95	0.5	3.04	-3.95	0.50	18	6.77	0.57	240	31203				
B4_0341-B4_0355	B4_0341	B4_0355	15	124	5.28	4.30	1.00	2.55	-2.73	0.5	2.55	-2.73	0.50	18	5.54	0.53	240	29761				
B4_0264-B4_0267	B4_0264	B4_0267	8	97	0.12	1.98	0.23	0.53	0.41	0.5	0.53	0.41	0.50	15	2.02	0.09	220	21374				
B4_0635-B4_0640	B4_0635	B4_0640	18	57	9.33	5.28	1.00	5.28	-4.04	0.75	5.28	-4.04	0.75	30	4.88	0.41	340	19404				
B1_0087-B1_0159	B1_0087	B1_0159	10	86	1.69	4.12	0.70	1.00	-0.68	0.5	1.00	-0.68	0.50	15	4.60	0.34	220	18875				

Design Table 6-3

B4_0282-B4_0283	B4_0282	B4_0283	15	65	3.54	3.30	0.82	1.78	-1.77	0.5	1.78	-1.77	0.50	18	3.83	0.52	240	15599					
B4_0227-B4_0228	B4_0227	B4_0228	8	64	0.21	1.94	0.35	0.40	0.19	0.5	0.40	0.19	0.50	15	2.01	0.14	220	13991					
B4_0594-B4_0595	B4_0594	B4_0595	15	30	0.26	1.99	0.16	2.23	1.97	0.5	2.23	1.97	0.50	30	2.00	0.06	340	10204					
B4_0356-B4_0357	B4_0356	B4_0357	15	40	5.41	4.41	1.00	2.22	-3.19	0.5	2.22	-3.19	0.50	18	5.02	0.59	240	9600					
B4_0507-B4_0509	B4_0507	B4_0509	15	37	6.94	5.66	1.00	2.83	-4.11	0.5	2.83	-4.11	0.50	18	6.41	0.59	240	8951					
B4_0328-B4_0330	B4_0328	B4_0330	15	33	5.02	4.09	1.00	1.71	-3.32	0.5	1.71	-3.32	0.50	18	4.01	0.67	240	7802					
B1_0151-B1_0155	B1_0151	B1_0155	8	35	1.05	3.02	1.00	0.41	-0.65	0.5	0.41	-0.65	0.50	15	3.23	0.31	220	7767					
B4_0284-B4_0308	B4_0284	B4_0308	15	30	3.55	2.89	1.00	1.70	-1.85	0.5	1.70	-1.85	0.50	18	3.71	0.53	240	7179					
B2_0399-B2_0400	B2_0399	B2_0400	8	30	0.35	0.99	1.00	0.17	-0.18	0.5	0.17	-0.18	0.50	15	1.24	0.28	220	6643					
B4_0281-B4_0307	B4_0281	B4_0307	8	30	0.86	2.45	1.00	0.43	-0.43	0.5	0.43	-0.43	0.50	15	3.17	0.27	220	6612					
B1_0159-B1_0160	B1_0159	B1_0160	10	28	2.73	8.11	0.59	2.07	-0.66	0.5	2.07	-0.66	0.50	15	8.89	0.30	220	6265					
B1_0161-B1_0163	B1_0161	B1_0163	15	22	2.75	2.24	1.00	1.19	-1.56	0.5	1.19	-1.56	0.50	18	2.66	0.57	240	5338					
B4_0283-B4_0284	B4_0283	B4_0284	15	20	3.54	3.30	0.82	1.78	-1.77	0.5	1.78	-1.77	0.50	18	3.83	0.52	240	4800					
B4_0624-B4_0625	B4_0624	B4_0625	18	18	9.18	5.19	1.00	8.24	-0.94	0.75	8.24	-0.94	0.75				220		18	5.81	0.48	4044	
Subtotal 1				25,987														5,615,723				347,601	5,963,323
																	Estimated Engineering:	**596,332**					
																	Contingency	**596,332**					
																	Mobilization	**417,433**					
																	Grand Total 1	**7,573,421**					

Prioritization by Basin for Hydraulically Deficient Line Segments
Table 7-1

ID	From ID	To ID	Diameter (in)	Length (ft)	Replacement Diameter (in)	Project Group Label
B1_0007-B1_0008	B1_0007	B1_0008	8	254	15	A
B1_0043-B1_0056	B1_0043	B1_0056	8	329	15	A
B1_0049-B1_0050	B1_0049	B1_0050	8	277	15	A
B1_0056-B1_0057	B1_0056	B1_0057	8	330	15	A
B1_0057-B1_0065	B1_0057	B1_0065	8	294	15	A
B1_0065-B1_0069	B1_0065	B1_0069	10	326	15	A
B1_0069-B1_0072	B1_0069	B1_0072	10	325	15	A
B1_0072-B1_0086	B1_0072	B1_0086	10	325	15	A
B1_0086-B1_0087	B1_0086	B1_0087	10	263	15	A
B1_0087-B1_0159	B1_0087	B1_0159	10	86	15	A
B1_0119-B1_0132	B1_0119	B1_0132	8	300	15	A
B1_0122-B1_0125	B1_0122	B1_0125	8	284	15	A
B1_0132-B1_0133	B1_0132	B1_0133	8	207	15	A
B1_0133-B1_0151	B1_0133	B1_0151	8	206	15	A
B1_0143-B1_0147	B1_0143	B1_0147	8	277	15	A
B1_0151-B1_0155	B1_0151	B1_0155	8	35	15	A
B1_0155-B1_0156	B1_0155	B1_0156	8	310	15	A
B1_0156-B1_0157	B1_0156	B1_0157	8	330	15	A
B1_0157-B1_0158	B1_0157	B1_0158	8	330	15	A
B1_0158-B1_0159	B1_0158	B1_0159	8	330	15	A
B1_0159-B1_0160	B1_0159	B1_0160	10	28	15	A
B1_0160-B1_0161	B1_0160	B1_0161	15	345	18	A
B1_0161-B1_0163	B1_0161	B1_0163	15	22	18	A
B1_0163-B1_0164	B1_0163	B1_0164	10	375	15	A
B1_0164-B1_0165	B1_0164	B1_0165	10	375	15	A
B1_0165-B4_0167	B1_0165	B4_0167	10	196	15	A
B2_0367-B2_0368	B2_0367	B2_0368	8	325	15	B
B2_0390-B2_0391	B2_0390	B2_0391	8	346	15	B
B2_0399-B2_0400	B2_0399	B2_0400	8	30	15	B
B2_0458-B2_0461	B2_0458	B2_0461	10	211	15	B
B2_0461-B2_0466	B2_0461	B2_0466	10	313	15	B
B2_0466-B2_0467	B2_0466	B2_0467	10	330	15	B
B2_0467-B2_0468	B2_0467	B2_0468	10	330	15	B
B2_0490-B2_0491	B2_0490	B2_0491	8	324	15	B
B2_0496-B2_0497	B2_0496	B2_0497	12	330	15	B
B3_0697-B3_0698	B3_0697	B3_0698	8	352	15	C
B3_0707-B3_0715	B3_0707	B3_0715	8	260	15	C
B3_0715-B3_0723	B3_0715	B3_0723	8	260	15	C
B3_0723-B3_0731	B3_0723	B3_0731	8	261	15	C
B3_0731-B3_0742	B3_0731	B3_0742	10	261	15	C
B3_0742-B3_0745	B3_0742	B3_0745	10	257	15	C
B3_0745-B3_0771	B3_0745	B3_0771	10	261	15	C
B3_0767-B3_0769	B3_0767	B3_0769	8	379	15	C
B3_0769-B3_0770	B3_0769	B3_0770	8	260	15	C
B3_0771-B3_0779	B3_0771	B3_0779	12	260	15	C
B3_0779-B3_0787	B3_0779	B3_0787	12	315	15	C
B3_0787-B3_0788	B3_0787	B3_0788	12	289	15	C
B3_0788-B3_0789	B3_0788	B3_0789	8	270	15	C
B3_0789-B3_0790	B3_0789	B3_0790	8	251	15	C
B3_0790-B4_0791	B3_0790	B4_0791	8	327	15	C
B4_0167-B4_0168	B4_0167	B4_0168	10	204	15	D
B4_0168-B4_0169	B4_0168	B4_0169	10	349	15	D
B4_0169-B4_0170	B4_0169	B4_0170	10	376	15	D
B4_0170-B4_0239	B4_0170	B4_0239	10	391	15	D
B4_0224-B4_0225	B4_0224	B4_0225	8	331	15	D
B4_0227-B4_0228	B4_0227	B4_0228	8	64	15	D
B4_0228-B4_0233	B4_0228	B4_0233	8	260	15	D
B4_0239-B4_0240	B4_0239	B4_0240	15	359	18	D
B4_0240-B4_0248	B4_0240	B4_0248	15	363	18	D
B4_0248-B4_0249	B4_0248	B4_0249	15	262	18	D
B4_0249-B4_0280	B4_0249	B4_0280	15	250	18	D
B4_0264-B4_0267	B4_0264	B4_0267	8	97	15	D
B4_0277-B4_0278	B4_0277	B4_0278	8	355	15	D
B4_0278-B4_0279	B4_0278	B4_0279	8	300	15	D
B4_0279-B4_0280	B4_0279	B4_0280	8	335	15	D
B4_0280-B4_0281	B4_0280	B4_0281	15	299	18	D
B4_0281-B4_0282	B4_0281	B4_0282	15	216	18	D
B4_0281-B4_0307	B4_0281	B4_0307	8	30	15	D
B4_0282-B4_0283	B4_0282	B4_0283	15	65	18	D
B4_0283-B4_0284	B4_0283	B4_0284	15	20	18	D
B4_0284-B4_0308	B4_0284	B4_0308	15	30	18	D
B4_0307-B4_0308	B4_0307	B4_0308	8	301	15	D
B4_0308-B4_0314	B4_0308	B4_0314	15	150	18	D
B4_0314-B4_0321	B4_0314	B4_0321	15	180	18	D
B4_0321-B4_0328	B4_0321	B4_0328	15	360	18	D
B4_0328-B4_0330	B4_0328	B4_0330	15	33	18	D
B4_0330-B4_0336	B4_0330	B4_0336	15	327	18	D
B4_0336-B4_0338	B4_0336	B4_0338	15	360	18	D
B4_0338-B4_0339	B4_0338	B4_0339	15	180	18	D
B4_0339-B4_0340	B4_0339	B4_0340	15	348	18	D
B4_0340-B4_0341	B4_0340	B4_0341	15	263	18	D
B4_0341-B4_0355	B4_0341	B4_0355	15	124	18	D
B4_0355-B4_0356	B4_0355	B4_0356	15	301	18	D
B4_0356-B4_0357	B4_0356	B4_0357	15	40	18	D
B4_0357-B4_0358	B4_0357	B4_0358	15	331	18	D
B4_0358-B4_0507	B4_0358	B4_0507	15	330	18	D
B4_0507-B4_0509	B4_0507	B4_0509	15	37	18	D
B4_0509-B4_0511	B4_0509	B4_0511	15	298	18	D
B4_0511-B4_0622	B4_0511	B4_0622	15	130	18	D
B4_0528-B4_0529	B4_0528	B4_0529	10	253	15	D
B4_0550-B4_0551	B4_0550	B4_0551	8	210	15	D
B4_0575-B4_0581	B4_0575	B4_0581	12	285	15	D
B4_0594-B4_0595	B4_0594	B4_0595	15	30	30	D
B4_0624-B4_0625	B4_0624	B4_0625	18	18	Parallel Lines	D
B4_0625-B4_0629	B4_0625	B4_0629	18	260	30	D
B4_0629-B4_0634	B4_0629	B4_0634	18	257	30	D
B4_0634-B4_0635	B4_0634	B4_0635	18	206	30	D
B4_0635-B4_0640	B4_0635	B4_0640	18	57	30	D
B4_0640-B4_0645	B4_0640	B4_0645	18	260	Parallel Lines	D
B4_0645-B4_0649	B4_0645	B4_0649	18	262	Parallel Lines	D
B4_0649-B4_0651	B4_0649	B4_0651	18	264	Parallel Lines	D
B4_0651-B4_0653	B4_0651	B4_0653	18	257	Parallel Lines	D
B4_0653-B4_0662	B4_0653	B4_0662	18	261	Parallel Lines	D
B4_0662-B4_0791	B4_0662	B4_0791	18	258	Parallel Lines	D
B4_0791-OUTLET	B4_0791	OUTLET	18	238	30	D
Subtotal 1				25,404		