CITY OF LOS ANGELES

SEWER ODOR CONTROL MASTER PLAN ANNUAL REPORT

Wastewater Engineering Services Division
Bureau of Sanitation
AUGUST 2013

CITY OF LOS ANGELES

CALIFORNIA

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September 1, 2013

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Greetings:

RE: Settlement Agreement and Final Order – Civil Action No. 01-191-RSWL and Civil Action No. 98-9039-RSWL Consolidated – Odor Master Plan Update

Pursuant to Paragraph 45 of the Collection System Settlement Agreement and Final Order, Modification #1, the City has updated the Odor Control Master Plan to include results of new investigations, new odor control activities, progress towards completion of ongoing odor control activities, completed odor control activities, and results. Enclosed is a copy of the updated Odor Control Master Plan for 2013.

Odor control remains a high priority as the City continues to aggressively and proactively respond, investigate, and address all sewer odors. The two Air Treatment Facilities (ATFs) in operation are effectively depressurizing the connecting sewers and the third ATF is under construction as are three air dampers in the drop structures. Once operational, these are also expected to further improve our ability to limit sewer odors.

If you have any questions, please contact Scott Hare at (323) 342-1583.

Sincerely,

Ali Poosti, Division Manager
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AP:SH/tn

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CERTIFICATION DECLARATION

I certify under penalty of law that this Annual Odor Master Plan for the year ending June 30, 2013 was prepared either by me personally or under my direction or supervision in a manner designed to ensure that qualified and knowledgeable personnel properly gathered and presented the information contained herein. I further certify, based on my personal knowledge or on my inquiry of those individuals immediately responsible for obtaining the information, that to the best of my knowledge and belief the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information and willful submission of a material false statement.

8/30/13

Ali Poosti
Division Manager
Wastewater Engineering Services Division
Bureau of Sanitation

Date

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ACRONYMS and ABBREVIATIONS

AOC	Area of Concern
AOS	Area of Study
ATF	Air Treatment Facility
AVORS	Additional Valley Outfall Relief Sewer
BOD	Biochemical Oxygen Demand
BOS	Bureau of Sanitation
CBD	Central Business District (Sewer)
CFM	Cubic Feet per Minute
CIP	Capital Improvement Program
CIS	Coastal Interceptor Sewer
CSSA	Collection System Settlement Agreement
ECIS	East Central Interceptor Sewer
EVIS	East Valley Interceptor Sewer
EVRS	East Valley Relief Sewer
GBIS	Glendale-Burbank Interceptor Sewer
H_2S	Hydrogen Sulfide
HSA	Hyperion Service Area
HTP	Hyperion Treatment Plant
LAGWRP	L.A.-Glendale Water Reclamation Plant
LARWQCB	L.A. Regional Water Quality Control Board
LCIS	La Cienega Interceptor Sewer
LCSFVRS	La Cienega-San Fernando Valley Relief Sewer
MH	Maintenance Hole
NCOS	North Central Outfall Sewer
NEIS	North-East Interceptor Sewer
NHIS	North Hollywood Interceptor Sewer
NORS	North Outfall Replacement Sewer
NOS	North Outfall Sewer
NOTF	North Outfall Treatment Facility
NPDES	National Pollutants Discharge Elimination System
OAB	Odor Advisory Board
PPM	Parts per Million
SLA	South Los Angeles
SSO	Sanitary Sewer Overflow
TISA	Terminal Island Service Area
TIWRP	Terminal Island Water Reclamation Plant
TWRP	Tillman Water Reclamation Plant
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compounds
VORS	Valley Outfall Relief Sewer
VSF	Valley Spring (Lane) – Forman (Ave) Intersection
WCED	Wastewater Collection Engineering Division

WCSD	Wastewater Collection Services Division
WHIS	West Hollywood Interceptor Sewer
WLAIS	West L.A. Interceptor Sewer
WRS	Westwood Relief Sewer

EXECUTIVE SUMMARY

INTRODUCTION

The City of Los Angeles operates a wastewater collection system that consists of approximately 6,700 miles of sewers, 47 pumping plants, diversion structures, and various support facilities. This system collects sewage from 550 square miles and transports it to one of four sewage treatment plants operated by the City.

A natural phenomenon within any wastewater collection system is the production of odorous gases, especially hydrogen sulfide (H_2S), the diurnal ventilation of sewers, and the consequential release of that H_2S. The City has been working diligently to address these odor issues and has made significant progress in controlling odors within its sewer system.

Many odor control measures are being implemented. The use of air scrubbers at various problem locations in the collection system has significantly reduced gas pressure in the sewer system and two state-of-the art Air Treatment Facilities (ATFs) utilizing biotrickling filters have been constructed and are in operation. The City has also been installing “air curtains” at strategic points in the sewer system to block the unwanted movement of gas within the sewers. Air curtains have been installed at each of the three diversion structures that used to divert flow away from the NOS and into the NORS during the NOS rehabilitation. The City recently installed an air curtain at the drop structure at Mission & Jesse to prevent air traveling up that drop structure. Furthermore, the City continues to apply odor control chemicals to sewage which has reduced hydrogen sulfide levels in treated sewers by up to 90 percent.

The City’s on-going operation and maintenance efforts have also provided significant benefits to the odor control program. The trap maintenance hole modification and upgrade program, and construction of local sewers has alleviated the migration of odors from large-diameter sewers into residential sewer systems while perpetual sewer cleaning has decreased the potential for septic conditions to occur. The multi-year rehabilitation of the lower NOS is complete and flow has been routed back into the NOS away from the North Outfall Replacement Sewer (NORS). This has greatly reduced the flow in the NORS, resulting in a noticeable reduction in gas pressure in the NORS and at the NORS siphon. This, in combination with the new ATFs, has greatly reduced gas pressure within sewers in the Crenshaw/Baldwin Hills/Culver City areas, reducing odor complaints and improving the quality of life for the residents.

The ATF at Mission and Jesse that was recommended by the ATF Study is under construction and scheduled to be finished in 2014. The air dampers recommended by the study are designed and beginning construction and the City continues to manage sewer flow to control gas movement.

These odor control measures have produced a successful odor control program in the City of Los Angeles and odor complaints continue to decline steadily. The City continues to operate an odor complaint hotline, which allows for a more timely response and a quick resolution to sewer-related odor complaints.

The Master Plan evaluates the current odor control program, conducts studies in strategic areas throughout the city, identifies causes of odors, and provides recommendations for improvements. It is updated on an annual basis to assure that odor control strategies/measures are periodically challenged, solutions remain proactive, and technologies are current and effective. This Master Plan covers activities from June 30th 2012 through June 30th, 2013.

EVALUATION OF THE COLLECTION SYSTEM

Through analysis of odor complaints and testing of sewer pressure, the City identifies several key areas to study. Specific sewers in these areas are targeted for detailed testing and analysis based on the location of odor complaints as well as the physical characteristics of the sewers such as insufficient pipe slope, severe slope reductions, and the proximity of problematic structures such as inverted siphons, drop structures, and junction structures.

Four areas with the highest levels of complaints are identified as “Areas of Concern” (AOC) and the sewers in these areas receive the most investigation. They are:

- AOC1 - East NOS Corridor – NOS
- AOC2 - La Cienega/San Fernando Corridor – LCSFVRS/WHIS/LCIS
- AOC3 - Baldwin Hills/Culver City Area – NORS/ECIS/NOS/WLAIS/WRS/NCOS/North and South Maze
- AOC4 - East Valley Area – AVORS/EVRS/VORS/NHIS/NOS

In order to gain a more complete and accurate overview of the collection system, additional but less troublesome areas have been identified as “Areas of Study” (AOS) and are analyzed as well. They are:

- AOS1 - Coastal Interceptor Sewer – CIS
- AOS2 - Harbor Area
- AOS3 - West Valley Area – VORS/AVORS/EVIS

Air pressure and hydrogen sulfide (H_2S) levels in the sewers in each area are monitored in order to qualify and quantify the odors, help identify the causes of odor complaints, and help determine the optimum solutions.

RECOMMENDATIONS/CONSIDERATIONS

For the Areas of Concern, the following options are being considered:

AOC1 - East NOS Corridor

- Moved more flow towards the Enterprise Siphon to achieve a minimum scouring velocity and minimize debris build-up in the siphon *(Completed).*
- An Air Treatment Facility (ATF) is under construction and expected to be operational by mid 2014.
- An emergency carbon scrubber is in operation at Atwater Village.
- MgOH injection at LAGWRP started in July 2013.

AOC2 - La Cienega/San Fernando Corridor

- Continue to monitor both pressure and hydrogen sulfide levels in this area
- Control air flow dynamics by manipulating sewage flow through various sewers
- Continue chemical injection at the Tillman Treatment Plant

AOC3 - Baldwin Hills/Culver City Area

This area has had the greatest improvement due to the many odor control efforts.

- Continue monitoring the NOS and NCOS in the vicinity of the airline connection between these two sewers
- Continue monitoring the WLAIS and WRS for any increase in pressure
- Continue to monitor the effectiveness of the Jefferson and La Cienega ATF and the 6000 Jefferson ATF

AOC4 - East Valley Area

- Continue monitoring pressures on the EVRS, the NHIS, the VSF, and the VORS with special attention further downstream on the VORS
- Seal maintenance holes where necessary

For all of the Areas of Study, the recommendation is to re-test pressure and/or H_2S levels periodically to allow adequate time to address any odor issues that may occur in the future.

CONCLUSION

To meet the immediate needs of the collection system, the City will continue all odor control activities including odor complaint response and investigation, routine sewer maintenance, chemical addition, air withdraw1 and treatment using scrubbers, sewer construction and repair, and on-going monitoring of sewer air pressure and odor concentration.

1.0 INTRODUCTION

1.1 History of the Sewer System

The City of Los Angeles operates and maintains a complex wastewater collection system that serves a 550 square mile area with a network of pipes that range in size from 6-inches to 150-inches in diameter. The pipes running beneath the City total approximately 6,700 linear miles. This does not include the hundreds of miles of privately owned sewer laterals which connect private residences and industrial clients to the City's sewers. Although the City of Los Angeles has had some type of sewer conveyance system since the late 1800's, it consisted of transporting the sewage in pipes to the edge of town or low population areas and discharging it into a field or ditch. The system expanded and by 1908 could accommodate a population of 750,000 and discharged into the ocean at the present location of the Hyperion Treatment Plant. However, the sewage was not being treated at all. It was not until 1920 that the residents voted to begin sewage treatment, beginning our modern sewage conveyance and treatment system. Odors have always been an issue with residents from the very beginnings of the sewer system and as the City has enlarged its sewer system, odor control has become a larger area of concern.

The City of Los Angeles is expanding and will continue to expand in the future. Upgrading the sewer system and the treatment plants has been and will continue to be an on-going process in order to handle the anticipated increase in sewage that accompanies an increasing population and to address the aging infrastructure. This will need to be accompanied by a continuous and increasingly sophisticated effort to control sewer odors.

A key part of the City's odor control efforts is the formulation of this Odor Control Master Plan which evaluates the current odor control program and provides recommendations for future efforts. As part of the evaluation process, the City reviewed its existing odor complaint procedures, investigation and cleaning practices, preventive maintenance schedules, operation and maintenance policies and practices, and mitigation measures including manhole sealing, trap maintenance hole repair, and chemical treatment. This Master Plan presents the results of this evaluation along with the recommendations.

1.2 Odor Generation

Prior to 1923, very little was known about the generation and release of sewer odors in Los Angeles or elsewhere. It was generally known that air ventilating from sewers could be offensive at times, but little was known about the specific odor compounds or how they were formed. Sewer gases can include nitrogen, oxygen, carbon dioxide, hydrogen sulfide, ammonia, and methane. Organic gases such as volatile organic compounds (VOCs) contribute to the nuisance odors but the major cause of odors in wastewater is hydrogen sulfide (H2S), an inorganic gas that is detectable even in very low concentrations. Hydrogen sulfide has a rotten egg smell and is heavier than air, so it does not disperse into the atmosphere.

A natural phenomenon within any wastewater collection system is the production of odorous gases. Over the last decade the potential for odorous air release from the sewer system has increased due to the effectiveness of the City's industrial pretreatment program, which includes the removal of heavy metals that would otherwise precipitate dissolved sulfide from solution. The City has been working diligently to address these odor issues and has made significant progress in controlling odors within its sewer system.

Hydrogen sulfide is generated within sewage when sulfates, naturally present in wastewater, are converted to hydrogen sulfide by bacteria residing in the slime layer on the pipe walls, or on debris in the wastewater. This activity increases when certain conditions exist in the collection system such as low dissolved oxygen content, high-strength wastewater, long detention times, and elevated wastewater temperatures. For example, low sloping sewers cause the flow to slow down, resulting in the increased settling of organic solids and grit in the sewer. This debris deposition further slows down the flow. Consequently, this condition increases sewage detention times in the sewer, allowing the sewage to become oxygen deficient or septic.

Hydrogen sulfide and other dissolved gases are released in areas of turbulent flow. For that reason, higher hydrogen sulfide concentrations are generally found near line bends, pipe size changes, areas of dynamic slope changes, junction structures, diversion structure, siphons, etc. This gas will typically escape the sewer system through maintenance holes as part of the natural movement of air in and out of the sewer system caused by the daily rise and fall of flow levels in the sewers. However, constrictions in the sewer or reduced sewer headspace due to continuous high flows can result in venting of gases from the sewers.

1.3 History of Odor Control

During the design and construction of the North Outfall Sewer (NOS) in the mid 1920s, it was recognized that settled debris in the bottom of sewers can increase odor production. Therefore, the NOS was designed with a slope which would provide the highest possible water velocity to prevent debris deposition. Furthermore, the NOS was constructed with a semi-elliptical cross section and lined with corrosion-resistant clay tiles above the spring line. However, an inspection in 1936 found that large portions of the sewer were missing tiles, mortar joints between the tiles were reduced to mushy gypsum, and the concrete behind the tiles was found to be soft and porous. Engineers realized that the solution to preventing damage and deterioration of the sewer pipes was to prevent the formation of hydrogen sulfide gas and its oxidation to sulfuric acid, thus reducing the accumulation of acid on the pipe walls.

On February 24, 1937, the Board of Public Works adopted the Board report recommending that the City conduct an experiment to ventilate a portion of the NOS to reduce the formation of acid producing gas. The experiment used a fan to evacuate air at one location and admitted fresh air at various intervals along the sewer. Ventilation started on January 3, 1938. Daily records were kept of the following items: fan speed, quantity of exhausted air, temperatures of the exhaust air and atmosphere, H2S content of the exhaust air, amount of vacuum in suction line, and quantity of air admitted at the various openings in the sewer. At the end of the experiment in November 1938, the condition of the entire outfall was so greatly improved that the City Engineer recommended that a permanent ventilation station be built at the test site. More ventilation stations were constructed to ventilate other sections of the NOS and the Central Outfall sewer as well. In the 1940s, it was discovered that inverted siphons were a significant cause of gas ventilating from the NOS due to the blockage of the sewer's headspace caused by the siphon. Ventilation and deodorization systems were installed on the upstream side of the siphons to prevent odors releasing into the atmosphere.

In the 1950s and 60s the City of Los Angeles grew considerably and the volume of wastewater had subsequently increased. As existing collection systems began to reach capacity, additional sewers were constructed to carry the increased flow. This increased flow and its gas ended up in the NOS and other outfall sewers, increasing the ventilation of gas from these outfalls. Since the principles of natural sewer ventilation were not understood at this time, it was decided to seal the offending maintenance holes with tar and sand, and occasionally, insert trays filled with activated charcoal to adsorb the odor compounds.

Unknown at the time, sealing maintenance holes to prevent the release of gas resulted in increased pressure in the sewer. With no pathway for release, the pressure increased at those locations, causing sewer odors to vent through other maintenance holes nearby and in many cases, be forced up house connections and released through the roof vents of homes. The City began installing "gas traps" on tributary sewers to prevent the upstream migration of sewer pressure. In some cases, new sewers were built to intercept tributary sewers and route the flow to a location where air pressure could be controlled.

The increase in sewage and subsequent increase in pressure led to more odor complaints and the City began an aggressive program of chemical addition in the early 1990s. Chemicals are commonly used today to react with or remove dissolved sulfide and hydrogen sulfide from wastewater. Since hydrogen sulfide gas is the main compound responsible for odor complaints, chemical addition strategies for eliminating it were developed as far back as the early 1940s when the City was adding chemicals to control odors from sewers on an as-needed basis. Chlorine or hypochlorite solutions were used due to availability and effectiveness. In the 1950s, iron-containing solutions such as ferrous chloride and ferric chloride dominated as supplies increased and costs became more reasonable. Iron solutions are still a very common chemical used for sulfide control in sewers and have a high degree of effectiveness; however, due to their rising cost, the City of Los Angeles has shifted to magnesium hydroxide, which is less costly and more effective. The City also utilizes sodium hydroxide to shock dose sewers with high sulfide generation. The chemical addition program targeted those locations most susceptible to generating sewer odors and therefore, where it would have the greatest benefit for the entire system.

It was not until the mid-1990s that the dynamics of natural sewer pressurization were identified and better understood by scientists and engineers. Many large-diameter sewer depressurization projects were designed and installed in various parts of the country based on the new natural pressurization dynamics research. These successful projects demonstrated that the pressure effect in sewers could be calculated to a high degree of certainty and that control measures could be successfully designed, installed and operated.

The odor control program consists of systematic monitoring of the wastewater system, an effective operation and maintenance program, effective response procedures, adequate design standards, construction of relief sewers, construction of new odor control facilities, and implementation of new technologies. Additionally, in an on-going effort to better understand the nature of sewer odors and provide for continued improvements, the odor control program includes field investigations and analysis to identify the character of odors throughout the collection system.

The odor-control measures employed/planned by the City all work in concert with each other. It is these elements, when put together, that make the City's wastewater collection odor control program effective. The City has developed an odor complaint hotline, which allows for a more timely response, and quicker resolution of sewer-related odor complaints. The application of odor control chemicals has reduced hydrogen sulfide concentration in treated sewers by up to 90%. The use of air scrubbers at various hotspot locations in the collection system has contributed to a reduction in the release of odors in known venting areas. The construction of relief sewers such as East Central Interceptor Sewer and North East Interceptor Sewer Phase I have provided relief and reduced the high air pressures occurring in the sewer due to hydraulically overloaded pipes. The on-going repair of trap maintenance holes and construction of local sewers has alleviated the migration of odors from large-diameter sewers into neighborhoods and properties. The on-going maintenance program has decreased the potential for septic conditions. These odor control measures have led to a successful odor control program. While it is impossible to completely eliminate odor complaints, the City has and will continue to mitigate sewer odors through monitoring, complaint response, and effective implementation of odor control technologies.

The City's overall goal is to implement a cost effective and community-supported odor control program that will mitigate and control sewer odors, effectively inform the neighborhood councils, community groups and the Odor Advisory Board of the odor issues, and inform and advise the Board of Public Works and the City Council on the odor control program.

1.4 Collection System Settlement Agreement and Origin of the Master Plan

The City was required to develop an Odor Control Master Plan as part of the Collection System Settlement Agreement (CSSA). The CSSA is a settlement between the City and several organizations including the USEPA, the LARWQCB, the Santa Monica Baykeeper, and community groups representing residents in South Los Angeles. In January 2001, the parties filed a lawsuit against the City of Los Angeles which alleged that the City's Sanitary Sewer Overflows (SSOs) and odor problems violated the Clean Water Act and the terms and conditions of the National Pollutants Discharge Elimination System (NPDES) Permits for the Hyperion Treatment Plant and the Terminal Island Water Reclamation Plant for the operation and maintenance of the City's sewer system. In October 29, 2004, the Court officially approved and implemented the Collection System Settlement Agreement (CSSA) between the City of Los Angeles and the EPA.

Sewer odor was a major and pervasive issue in some South Los Angeles areas. The CSSA addressed the odor problems by requiring the City to complete and institute numerous studies, projects, programs and capital improvement projects. One of the major requirements was the preparation of a City-wide odor control master plan. The master plan was to include an assessment of known problem areas, additional testing and monitoring, and recommended actions. The City was to develop the plan in consultation with the Odor Advisory Board. The first Odor Control Master Plan was issued in 2006 and was the first comprehensive odor control master plan produced by the City. Prior to this, there were standard operating procedures and measures in place to control odors, but no detailed plan on how to systematically reduce odors throughout the collection system.

In November 2009, a Modification to the Settlement Agreement was entered by the Court. The modification contained additional measures that the City needed to address including updating the Odor Master Plan annually.

1.5 Purpose and Objectives

The purpose of the Odor Control Master Plan is to be both educational and functional. This document will provide a history of the odor issues in the City's wastewater collection system, establish an understanding of the science of sewer odor production and the technologies available, and present a proactive plan to manage and address the sewer odors.

The general objectives of the Odor Control Master Plan are:

- Provide an overview of odor issues associated with the wastewater collection system.
- Document and evaluate the current odor control program.
- Document the effort to characterize odors and identify their causes within the collection system.
- Provide recommendations to effectively manage odors in the collection system.

- Provide a proactive systematic approach to odor prevention and control.

The objective of the City's wastewater collection system odor control program is to proactively address sewer odor issues in the wastewater collection system by performing the following activities:

- Monitoring the wastewater collection system;
- Documenting and respond to odor complaints;
- Improving the design of the sewer system;
- Installing/building odor-control units/facilities;
- Dosing selected pipelines with chemicals to eliminate components that lead to odors and;
- Investigating new technologies to identify better materials or processes to control odors.

Additionally, in an on-going effort to better understand the nature of sewer odors, the odor control program includes an effort to investigate the character of odors throughout the collection system and evaluate the current operation and maintenance policies and practices.

The effort to monitor the sewer system will involve developing and implementing a city-wide odor and ventilation monitoring system including installing hydrogen sulfide gas monitors (data loggers) in sewer maintenance holes, installing sewer air pressure monitors to measure pressure differences in key locations to detect the potential for off-gassing to the atmosphere, and collecting data to determine the odor-causing characteristics of sewage. After sufficient amounts of this data have been collected, it will be analyzed along with the sewer system's physical characteristics including the location of system restrictions and sewer gas constrictions such as siphons, in order to identify and prioritize potential causes and sources of odors. The City will also conduct various innovative tests such as concurrent air withdrawal and air pressure measurement tests (fan tests) to verify the cause of venting gasses from the sewer system and to help identify and validate appropriate solutions.

The City already has a system in place for documenting and responding to odor complaints. The City will continue this effort and will work with the residents to promptly and effectively address their concerns.

The City has developed and implemented an extensive system of capital improvement projects to reduce odors and improve the overall operation of the collection system. These projects include the reconstruction of major sewers which reduce the system's off-gassing by increasing sewer headspace, the construction of permanent gas/odor removal and filtering facilities, and chemical injection systems that will inhibit the generation of hydrogen sulfide gas within the sewage.

The City has also embarked on an effort to identify and evaluate new technologies to mitigate and resolve odor issues. The City will implement the new technologies, where appropriate, through either the operation and maintenance program or the capital improvement program. The City will also optimize the operation of this technology, monitoring and adjusting the systems to ensure maximum effectiveness.

The overall strategy and goal is to implement a community-supported odor control program that will keep the public informed at various levels and to inform and advise the Board of Public Works and the City Council at every stage of the program.

1.6 Task Descriptions

The following general tasks are the basis of the odor control program:

- Monitor and respond to odor complaints.
- Measure hydrogen sulfide levels and air pressure in sewers to determine the quantity and quality of sewer venting gas.
- Collect and test samples to determine the characteristics of the sewage
- Research physical characteristics of the sewer system including the location of restriction and sewer gas constrictions such as siphons and slope reductions.
- Analyze all data and information collected and determine the causes of the odors.
- Identify available, appropriate solutions and any technology available to help manage, mitigate, or eliminate odors.
- Evaluate the various alternatives and technologies.
- Recommend cost effective alternatives that are supported by the community.
- Keep the community informed through meetings with the Odor Advisory Board and public outreach efforts such as attending community meetings and distributing informative literature.
- Implement the recommendations through the operation and maintenance program or the capital improvement program.
- Monitor the performance of new applied technologies and make improvements as necessary.
- Summarize all of the findings, requirements, recommendations, and results in this master plan so that it becomes the blue print for mitigating sewer odors in our neighborhoods.
- Manage the odor control program and monitor its effectiveness. Make adjustments and improvements to the system as necessary to maximize performance.

2.0 EXISTING COLLECTION SYSTEM

The City's wastewater collection system is comprised of a network of underground pipes that extend throughout the city, conveying wastewater to one of four treatment plants for processing. The City-owned and operated system consists of approximately 6,700 miles of major interceptor and mainline sewers. Approximately 750 miles of these sewers are primary sewers, which range in size from 16 inches to over 12 feet in diameter. Approximately 170 miles of the primary sewers are major interceptor and outfall sewers. The rest of the sewers (approx. 5,850 miles) are smaller secondary sewers that range in diameter from 6 inches to 15 inches. The system also includes 47 pumping plants, diversion structures, and various other support facilities such as maintenance yards.

The City owns and operates four major wastewater treatment facilities: Hyperion Treatment Plant (HTP) in Playa del Rey, the Donald C. Tillman Water Reclamation Plant (TWRP) in the Sepulveda Basin, Los Angeles-Glendale Water Reclamation Plant (LAGWRP) across the freeway from Griffith Park, and the Terminal Island Water Reclamation Plant (TIWRP) near the Los Angeles Harbor.

The system provides service to approximately 600,000 private residences, commercial establishments and industries within the City. The private sewer laterals, which connect buildings to the City's mainline sewers, are privately owned and maintained, and their total length is approximately 11,000 miles. The City also has contracts to provide waste water services to 29 satellite agencies. The agencies contracting with the City operate their own collection systems, which discharge into the City's system. Payment is based on the amount and volume of flow measured at their connection to the City's system.

The City's wastewater service area consists of two distinct drainage basin areas: the Hyperion Service Area (HSA) and the Terminal Island Service Area (TISA). The HSA covers over 500 square miles (mi^2) and serves the majority of the Los Angeles population. In addition, this service area includes several non-City agencies that contract with the City for wastewater service. The TISA is approximately 18 mi^2 and serves the Los Angeles Harbor area.

2.1 Hyperion Service Area Interceptor and Outfall Sewers

The following sixteen sewers comprise the major interceptor and outfall system for the HSA:

2.1.1 Coastal Interceptor Sewer (CIS)

The CIS serves the coastal area of the Santa Monica Bay north of the Hyperion Treatment Plant (HTP) to Topanga State Beach near Malibu. This sewer conveys wastewater directly to the HTP from Pacific Palisades, Venice, Mar Vista, the City of Santa Monica, and adjacent areas served by the Los Angeles County Sanitation District (such as Marina Del Rey).

The CIS is a circular pipe that ranges in diameter from 24 to 72 inches and is approximately 9.4 miles in length. Some parts are constructed of vitrified clay and other parts are reinforced concrete pipe. The concrete pipe is lined with polyvinyl chloride (PVC) to prevent corrosion of the concrete by sewer gasses.

2.1.2 Central Outfall Sewer (COS)

The COS was constructed in 1907 and originally conveyed wastewater directly to the Pacific Ocean. Now it conveys wastewater to the HTP. The COS is about 10 miles long and is, for the most part, elliptical in shape measuring 60 inches wide by 73 inches high, although some portions are 57-inch and 69-inch-diameter circular sections. Its original construction was brick and mortar. It was rehabilitated in the 1940s by replacing some of the brick and mortar, and subsequently lining the sewer with steel mesh and gunite. Currently the COS is undergoing rehabilitation to be completed by 2017.

2.1.3 North Outfall Sewer (NOS)

The NOS is one of the primary outfall sewers used to convey wastewater to the HTP. The NOS extends upstream from the HTP through Culver City, into downtown Los Angeles, continuing east of the Elysian Hills, turning north to travel around the Santa Monica Mountains, and then west through the southern portion of the San Fernando Valley (approximately 58 miles in length).

The NOS was constructed from the mid 1920s to the early 1930s. It is a combination circular and semi-elliptical sewer constructed of concrete, reinforced concrete, and vitrified clay. The portions of the NOS constructed of concrete are lined with clay tiles to resist corrosion. The downstream portion of the NOS (from the HTP to the intersection of La Cienega Boulevard and Rodeo Road) has been rehabilitated and therefore, flow is being diverted back to this section relieving the NORS.

2.1.4 North Central Outfall Sewer (NCOS)

The North Central Outfall Sewer (NCOS) was constructed in 1957 to provide additional capacity to the system between the Baldwin Hills area and the HTP. This sewer relieves the lower portion of the NOS. The NCOS is a circular sewer with a maximum diameter of 114 inches and is close to 8 miles long. It is constructed of reinforced concrete pipe lined with PVC.

2.1.5 North Outfall Replacement Sewer (NORS)

The North Outfall Replacement Sewer (NORS) was completed in 1993. The NORS is a circular pipe, which ranges in diameter from 96 to 150 inches. The NORS is constructed from reinforced concrete pipe lined with PVC.

2.1.6 West Los Angeles Interceptor Sewer (WLAIS)

The WLAIS primarily serves the West Los Angeles area by conveying wastewater to the NOS. The upstream portion of the WLAIS varies in size from 33 to 60 inches and is comprised of circular and semi-elliptical segments constructed in the 1920s. The lower section was constructed in 1950 with circular, reinforced concrete pipe lined with PVC, and includes an elevated box section (4’ H x 6’ W) crossing over Ballona Creek in Culver City. The entire WLAIS is approximately 4 miles long.

2.1.7 Westwood Relief Sewer (WRS)

The WRS was constructed in 1962 to provide additional capacity for overloaded sewers in the Westwood area. It also accepts some wastewater from Beverly Hills. The WRS is about 4.5 miles long, is circular in shape, varies in size from 33 inches to 60 inches, and is constructed of vitrified clay pipe and reinforced concrete pipe. The sewer crosses the creek using a concrete box similar to that used by the WLAIS, discharging into the NOS in Culver City.

2.1.8 Wilshire-Hollywood Interceptor Sewer (WHIS)

The WHIS was constructed in the early to mid 1970s in order to intercept wastewater from trunk sewers in the Hollywood area and convey this flow to the La Cienega-San Fernando Valley

Relief Sewer. This sewer ranges in diameter from 24 to 69 inches and is constructed of vitrified clay pipe and reinforced concrete pipe lined with PVC.

2.1.9 La Cienega Interceptor Sewer (LCIS)

The LCIS serves West Hollywood and the area that lies roughly between West Hollywood and Baldwin Hills. It was constructed in the 1920s with circular and semi-elliptical reinforced concrete pipe ranging in size from 27 inch diameter circular pipe to 63 inch-tall elliptical pipe. The LCIS is slightly over 6 miles long and outlets into the NOS at Jefferson and Rodeo. The LCIS has been undergoing rehabilitation in various phases to be completed by 2015.

2.1.10 La Cienega-San Fernando Valley Relief Sewer (LCSFVRS)

The LCSFVRS was constructed in 1955 to relieve the NOS at the downstream (east) end of the San Fernando Valley near Toluca Lake. The LCSFVRS routes sewage directly through the Santa Monica Mountains and to the West Hollywood area. At Sierra Bonita Avenue, it splits into twin 42-inch pipes that join back into one 60-inch pipe downstream. The sewer travels through the Genesee Siphon near Venice Boulevard and along Genesee Avenue before reconnecting with the NOS near the intersection of Rodeo Road and Jefferson Boulevard. The LCSFVRS is approximately 11 miles long and is primarily constructed of reinforced concrete pipe lined with PVC, and ranges in diameter from 48 to 84 inches. The downstream portion of the LCSFVRS is a combination of 99-inch semi-elliptical and 99-inch by 115-inch rectangular sections.

2.1.11 Valley Outfall Relief Sewer (VORS)

The VORS was constructed between 1953 and 1962 to relieve the NOS in the San Fernando Valley and essentially parallels the NOS for much of the Valley (approximately 16 miles). The VORS is constructed of PVC-lined, reinforced concrete pipe and ranges in diameter from 24 to 66 inches.

2.1.12 Additional Valley Outfall Relief Sewer (AVORS)

The AVORS was installed in the late 1960s to provide additional hydraulic relief to the NOS and the VORS in the western portion of the San Fernando Valley. This sewer is one of the major pipelines conveying flow to the Tillman Water Reclamation Plant. The AVORS also parallels the NOS. It is constructed of vitrified clay pipe and PVC-lined reinforced concrete pipe ranging in diameter from 48 to 96 inches, and is over 10 miles long.

2.1.13 East Valley Relief Sewer (EVRS)

The EVRS was constructed in the early 1980s to relieve the AVORS and the NOS near Kester Avenue and Magnolia Boulevard. Wastewater within this relief sewer can be routed through the NOS towards either the LA/Glendale Water Reclamation Plant or through the Santa Monica Mountains via the LCSFVRS to the HTP. The EVRS is almost 7 miles long. It varies in diameter from 39 inches to 51 inches, and is constructed of vitrified clay pipe and reinforced concrete pipe lined with PVC.

2.1.14 East Valley Interceptor Sewer (EVIS)

The EVIS was constructed in 1987 and routes wastewater from the northeastern areas of the San Fernando Valley (City of San Fernando, Sylmar, Pacoima, Mission Hills, Panorama City, etc.) to the Tillman Plant. This sewer is constructed of vitrified clay pipe and PVC lined-reinforced concrete pipe. It varies in diameter from 36 inches to 84 inches, and is close to 9 miles long.

2.1.15 East Central Interceptor Sewer (ECIS)

The ECIS was constructed in 2004. It relieves the east-west segment of the NOS, from its outlet connection to the NCOS to the vicinity of Mission Road and Jesse Street near the Los Angeles River. The ECIS is approximately 11.5 miles long and 11 feet in diameter.

2.1.16 Northeast Interceptor Sewer (NEIS)

The NEIS phase I was constructed in 2005. NEIS is a circular reinforced concrete pipe with a pipe size of up to 96-inch in diameter and a distance of approximately 5.3 miles. NEIS's upstream terminus is San Fernando Rd and Division Street and it conveys flow to ECIS at the intersection of Mission Road and Jesse Street.

NEIS was designed in two phases; Phase II is currently in the design phase, and will extend north of LAGWRP. After NEIS Phase II and its associated diversion projects are constructed, wastewater will be diverted away from the NOS, which will then be rehabilitated.

2.1.17 Eagle Rock Interceptor Sewer (ERIS)

The ERIS was constructed in 2006. ERIS is a circular lined clay pipe, 12 to 48-inch in diameter that was micro-tunneled and trenched. It runs northward from San Fernando Road and Eagle Rock Boulevard then branches into two lines, ending at Eagle Rock Boulevard and Fairpark Avenue and the vicinity of Avenue 51 and York Boulevard. ERIS intercepts flow in the Eagle Rock and Highland Park area and conveys it to NEIS.

2.2 Terminal Island Service Area Interceptor Sewers and Force Mains

The TISA collection system consists of a network of major interceptor sewers and force mains that ultimately discharge into TITP for treatment and disposal. TISA collection system is comprised of four interceptor sewer systems. The four interceptor sewer systems are named after the respective force main through which their flow is pumped to the TITP. The following sections discuss the four interceptor sewer systems further.

2.2.1 Fries Avenue Interceptor Sewer System (FISS)

Wastewater collected from the Wilmington Basin is discharged into the Fries Avenue Interceptor Sewer System (FISS). The FISS also serves various industrial dischargers, some of which are on Harbor Department property. The FISS consists of four major pumping plants serving their respective interceptor (primary) sewers. The first three major pumping plants are Hawaiian and B Pumping Plant (No. 677), East Wilmington Pumping Plant (No. 676), and Fries Avenue Pumping Plant (No. 666). These three major pumping plants discharge directly to TITP via a common 30-inch force main known as the Fries Avenue Force Main. The Fries Avenue Force Main receives additional flow from a connecting pumping plant located in the northern portion of Terminal Island. This fourth pumping plant is the Harris Avenue Pumping Plant (No. 669) and is tributary to only the TITP via the Fries Avenue Force Main. The 30-inch Fries Avenue Force Main is the single major means of wastewater conveyance from the Wilmington Basin to Terminal Island, and crosses under the East Basin Channel of the Los Angeles Harbor.

2.2.2 San Pedro Interceptor Sewer System (SPISS)

The San Pedro Interceptor Sewer System (SPISS) serves most of the residential areas of San Pedro, the industrial area consisting primarily of the Phillips Conoco Refinery, and some industrial facilities located on Harbor Department property. The SPISS contains one major pumping plant serving its respective primary sewers. The major pumping plant is San Pedro Pumping Plant (No. 691). This pumping plant discharges directly to TITP via a 30-inch force main, the principle means of wastewater conveyance from San Pedro Basin. The 30-inch San Pedro force main traverses the Los Angeles Harbor Main Channel near the Vincent Thomas Memorial Bridge. A supplement to the SPISS system allows all flows from the Wilmington Basin into FISS to be diverted to the San Pedro Pumping Plant.

2.2.3 Terminal Way Interceptor Sewer System (TISS)

Terminal Way Interceptor Sewer System (TISS) collects wastewater from the residential areas of the Coastal Zone of San Pedro Basin, the land use areas along Harbor Boulevard, the heavy industrial area south of 22nd Street, and Terminal Island not tributary to Harris Avenue Pumping Plant. Wastewater collected by the TISS from the Coastal Zone and industrial area south of 22nd Street is conveyed by means of a double-barrel siphon traversing the Main Channel of Los Angeles Harbor toward the sole major pumping plant of the TISS: the Terminal Way Pumping Plant (No. 671). This pumping plant is connected to TITP via a dual force main system (24-inch and 20-inch) that provides system redundancy.

2.2.4 Former U.S. Navy Sewer System and Facility

The former "U.S. Navy Sewer System and Facility" consists of four separate force mains (two 6-inch, one 12-inch, and one 20-inch), a pumping plant, and collector sewers that previously served the U.S. Naval Reservation on Terminal Island. After the decommissioning of the U.S. Navy facilities, the City of Long Beach took over the assets of the U.S. Navy Sewer System and Facility that continues to deliver wastewater to the TITP.

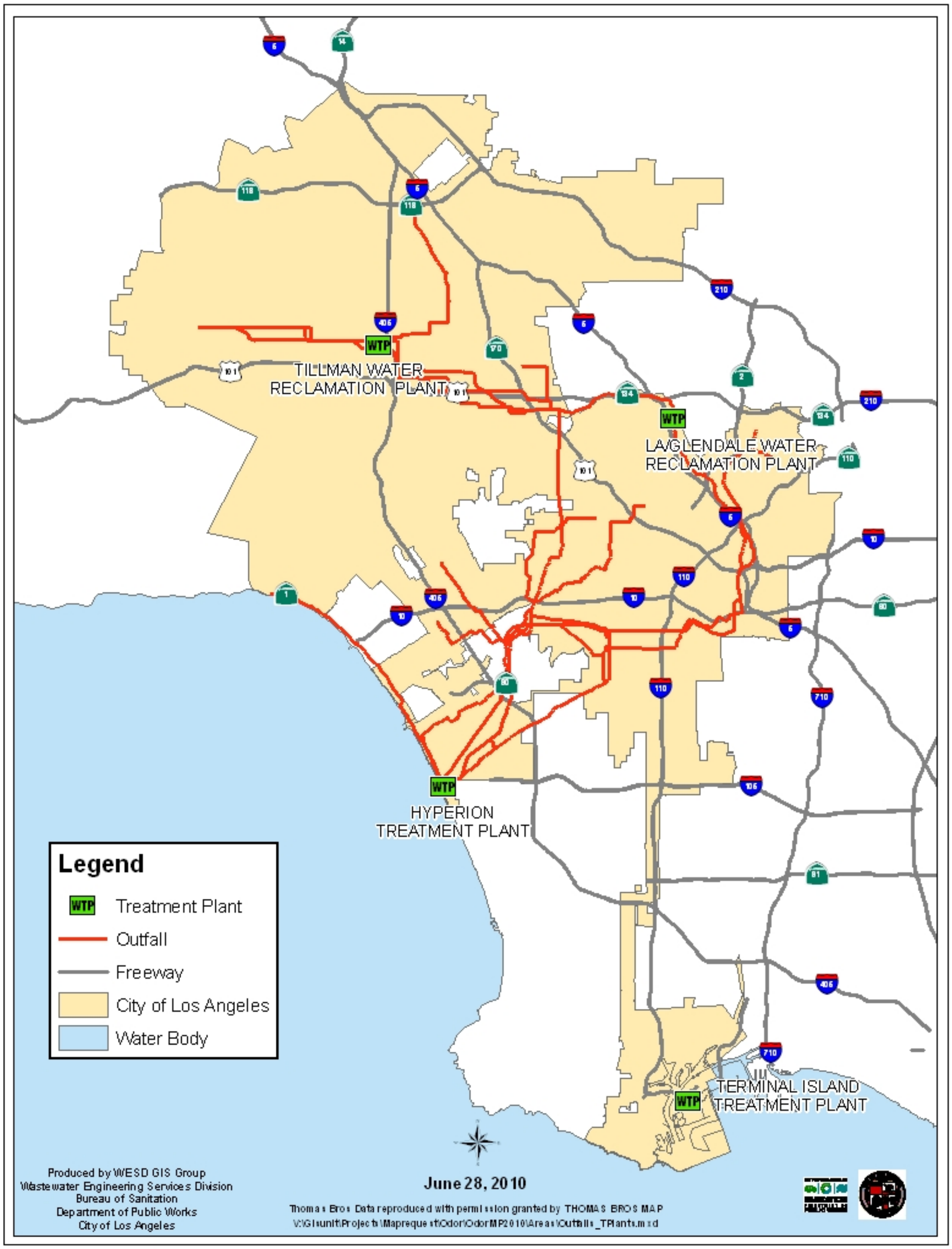
TILLMAN WATER
RECLAMATION PLANT
LA/GLENDALE WATER
RECLAMATION PLANT
HYPERION
TREATMENT PLANT
TERMINAL ISLAND
TREATMENT PLANT
Legend
WTP Treatment Plant
Outfall
Freeway
City of Los Angeles
Water Body
Produced by WESD GIS Group
Wastewater Engineering Services Division
Bureau of Sanitation
Department of Public Works
City of Los Angeles
June 28, 2010
Thomas Bros Data reproduced with permission granted by THOMAS BROS MAP
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FIG. 2.1

3.0 OUTREACH

The City has been actively engaged in outreach activities for the residents of Los Angeles regarding the Bureau's Sewer Odor Control Program. The outreach has multiple purposes. The first is to educate the public about the City's efforts to control odors and about tools the City has made available to the public to facilitate their communication with the City. The other goal is to gather feedback from the public about the City's odor control efforts in order to measure the effectiveness of our programs and re-evaluate and modify them if necessary.

The odor control outreach program can be divided into three principal components:

1. Communication and coordination with the community-based Odor Control Advisory Board,
2. Distribution of flyers and refrigerator magnets containing odor control information and means of contacting the City for sewer odor issues,
3. Conducting an annual survey of the public in those areas where odors are the worst in order to gather feedback.

3.1 Odor Advisory Board

As part of the CSSA, the City was also required to create an Odor Advisory Board with members representing South Los Angeles communities to help assess the odor issues and review the City's mitigation efforts. The CSSA authorized the Odor Advisory Board to work closely with the City in its effort to resolve and mitigate sewer odors to the maximum extent practicable. The CSSA states that the Odor Advisory Board's role will last for the term of the Settlement Agreement (10 yr-term), unless it is terminated by mutual consent of all the parties. The Board serves as the City's primary point-of-contact with residents of south Los Angeles regarding sewer odor control issues.

The Odor Advisory Board interest focuses mostly in the south Los Angeles communities (mainly around MLK/Rodeo between La Cienega and Arlington) which fall within the 8th, 9th and 10th Council Districts. The Odor Advisory Board was formed in September 2002 and began meeting on a monthly basis. Odor complaints, odor investigation procedure, the mitigation measures and the long-term odor control efforts underway by the City were provided to the Odor Advisory Board for review and input.

The Air Treatment Facilities (ATFs) were to be placed at strategic points throughout the City, concentrated in those areas with the most odor complaints, many of which were in South Los Angeles. The original locations of the ATFs were presented to the OAB and subsequently, when the construction of five of the ATFs were placed on hold until the outcome of the ATF Review Study, the City again approached the Board for input and comments. The City reported to the OAB on the progress of the study. The Board members have attended several field trips including a fan test, a tour of the Hyperion Treatment Plant, the East Central Interceptor Sewer (ECIS) construction site, and the ATF at Jefferson & La Cienega. The Odor Advisory Board also met with the independent odor expert to provide input for the independent review of the odor control report called for in the CSSA.

The Board members made several recommendations for improving both the City's odor hotline and the outreach effort to inform residents about the hotline, and assisted in the Odor Hotline public outreach by distributing the flyers. The City, along with the Community Liaison, has attempted to recruit new members. As part of the Modification to the Settlement Agreement, the

OAB was expanded. The OAB meets now on an as-needed basis and continues to communicate with the Community Liaison.

The Odor Advisory Board continues to provide valuable input in the City's odor control effort including outreach efforts and providing feedback regarding the effectiveness of the odor control facilities and concerns of the community.

3.2 Odor Expert and Community Liaison

As part of the Modification to the CSSA that was entered into in November 2009, the City hired an Independent Odor Expert (Expert) and a Community Liaison. The role of the Independent Odor Expert was to review ATF Review Study reports and provide comments and recommendations. The Expert also attended OAB meetings where he discussed any material he received from the City and answered questions from the OAB. The Odor Expert worked closely with the City and served through the completion of the study. The Community Liaison facilitates information exchange and discussion between the community and the City regarding odor conditions, sewer odor control activities, and the ATF Review Study. The Community Liaison will serve until June 30, 2014, which is the completion date for the CSSA.

3.3 Odor Outreach Program

3.3.1 Annual Survey

Since June 2006, the City has conducted annual feedback interviews to measure the effectiveness of the Sewer Odor Hotline. The interview process includes conducting street interviews at problematic locations throughout the City, mailing questionnaires to residents that complained through the Odor Hotline, and distributing surveys to community groups. All of the results are compiled and the survey results are reported in the CSSA Annual Report.

The 2012 odor survey was conducted by mail focusing on residents who called the City with sewer odor issues in the FY 2011/2012. Overall, the community feedback regarding the City's level of service was very good. The majority of the respondents were satisfied with the City's Odor Reporting Hotline. The comments were very favorable towards City's rapid response and personnel, but less favorable on actually resolving the odor problem in particular to one area which the City is aware and working diligently to resolve. Some of the suggestions made regarding the improvement of the hotline were to have a direct line and make follow up calls.

3.3.2 Newspaper Advertising

The City has advertised the hotline in community-based newspapers in the South Los Angeles area in previous years. The odor issues in the area have become less frequent to non existent. The Bureau may continue to use this method as a tool to inform residents about the hotline as needed.

3.3.3 Flyer Distribution

Odor control hotline flyers and magnets are distributed at community fairs, BOS Open Houses, neighborhood council presentations, and any other community meeting. The City distributes educational flyers that explain the City's odor control program and advertise the odor control hotline and a web site which the City operates as well. A sample of the odor control outreach flyer is attached at the end of this section.

4.0 SEWER ODOR GENERATION AND EMMISION

4.1 Odor (H_2S) Generation

Hydrogen sulfide is generated within sewage when sulfates, naturally present in wastewater, are converted to hydrogen sulfide by bacteria residing in the slime layer on the pipe walls, or on debris in the wastewater. This activity increases when certain conditions exist in the collection system such as low dissolved oxygen content, high-strength wastewater, long detention times, and elevated wastewater temperatures. For example, low sloping sewers cause the flow to slow down, resulting in the increased settling of organic solids and grit in the sewer. This debris deposition further slows down the flow. Consequently, this condition increases sewage detention times in the sewer, allowing the sewage to become oxygen deficient or septic.

4.2 The Phenomenon of Sewer Pressurization

Studies of air flow in the City's sewer system, especially in those areas that are experiencing strong and frequent sewer odors, show that the primary cause of odor release is pressurization of the sewer headspace.

Pressurization of the headspace is directly related to the following:

- Friction drag, influenced by wastewater velocity
- Change in wastewater velocity, influenced by change in slopes
- Physical characteristics of the system which influence airflow, such as:

  a- Depth of flow (d/D) and headspace constriction
  b- Diameter changes in downstream direction
  c- Inverted siphons
  d- Confluence of major tributary sewers
  e- Negative slope change

Friction Drag and Air Movement in Conduits

The driving force which moves air within sewer pipes is friction between the sewer headspace air and the moving wastewater. For most of the sewer system, the only resistance to air movement in a sewer pipe is friction between the air and the walls of the pipe. Given these two principals, it is possible to generate a velocity gradient profile for air movement in sewers (Fig. 4.2.1). As might be anticipated, the velocity of the air is at a maximum near the surface of the water and decreases rapidly with increasing distance from the sewage. It is important to note that there are no stagnant air zones and that virtually *all* air in a sewer is moving with the wastewater.

There are many minor factors which act to enhance or diminish this friction and therefore the velocity and pressure of air in sewers. The friction factor between the water and air increases when the surface of the water is "roughened" by the generation of waves and "whitecaps" through turbulence or water velocities in excess of 5-feet-per-second (fps). This type of turbulence can be generated by steep slopes or drops.

Strong turbulence, such as that generated by large hydraulic jumps, long gravity drops, or a spraying force main, increases friction dramatically since the water is churned into individual droplets. The droplets have many times the surface area of smooth water flow and therefore generate increased friction with the air. This high friction added to the effects of increased sewage velocity can move high volumes of air down sewers. To make matters worse, turbulence in wastewater also increases the release of odors and corrosion-causing compounds from wastewater, such as hydrogen sulfide gas.

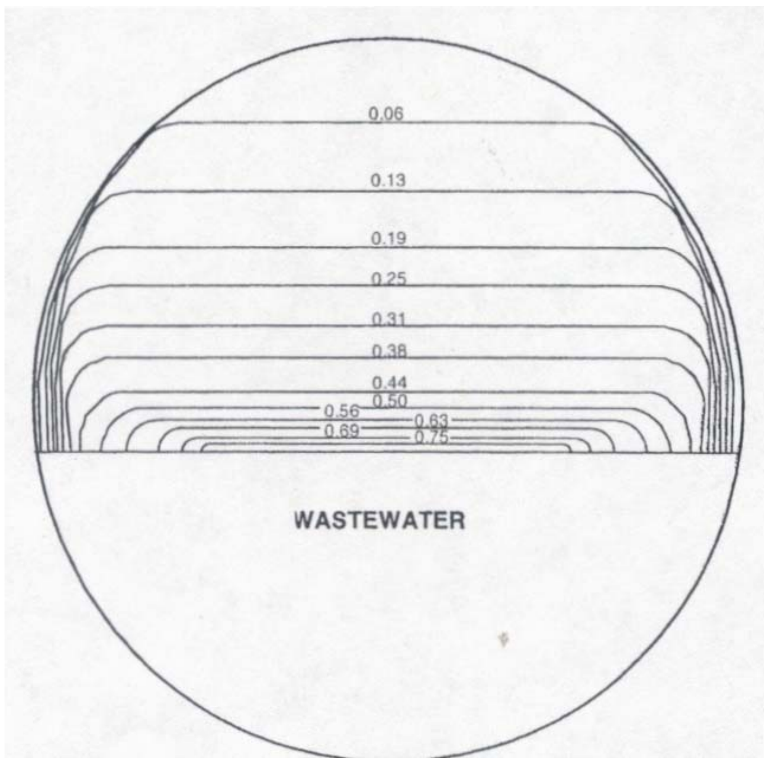


FIGURE 4.2.1
IDEALIZED AIR VELOCITY CONTOURS
IN PERCENT OF WASTEWATER VELOCITY

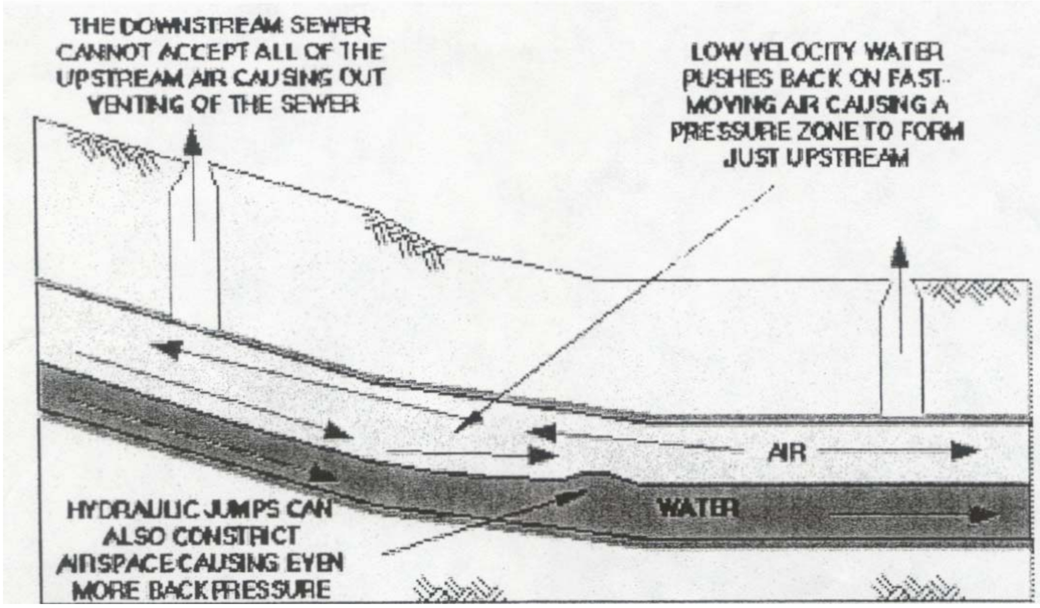


FIGURE 4.2.2
PRESSURIZATION DUE TO SLOPE CHANGE

4.2.1 Pressurization Due to Slope Reduction

Just as fast-moving wastewater can accelerate air movement; conversely, a slow-moving, calm water surface will exert minimal drag on the air and move relatively small volumes of air. Additionally, if the wastewater flow decelerates, then the friction between the fast-moving air and the slow-moving sewage will slow the air movement. Therefore, when the velocity of wastewater decreases due to a flattening of sewer slopes, the fast-moving air from upstream collides into the slower air in the flatter segment, generating high gas pressure. This high pressure pushes sewer gasses through the nearest openings and into the atmosphere, causing complaints (Fig. 4.2.2).

4.2.2 Pressurization Due to Air Headspace Constriction

The ratio of wastewater flow depth to the pipe diameter is expressed as d/D. When the pipe is half full, this ratio equals 0.5 and it equals 1 when the pipe is running full. Since the headspace above the wastewater conveys moving air, a constriction in this space will "squeeze" this air and it will become pressurized. Headspace constriction is one of the main causes of pressurization in the collection system. As the wastewater flow increases, it takes up more space in the pipe (the d/D increases) and the gasses are forced out and escape through any available routes such as house connections or vent holes.

4.2.3 Reducing Pipe Diameter in the Downstream Direction

A pipe's diameter is sometimes reduced in the downstream direction in order to "squeeze" past an existing underground structure. This creates a choke point in the pipe. The surface of the flow approaching this bottleneck tends to rise, forcing the air above into wave fronts that are pushed backwards. When these air waves collide with the air traveling downstream, pressurization occurs, forcing the gasses out of the sewer system.

4.2.4 Inverted Siphons

Any extensive sewage collection system in a metropolitan area is usually designed with inverted siphons due to the abundance of interfering structures. Inverted siphons are pipes or other conduits that dips down in order to pass under a structure blocking the path of the pipe. Because they have to dip down, they are always full of water and have no headspace in the pipe available for the movement of air. They therefore block the flow of any air that is traveling down the pipe towards them. Alternate air pipes called “air jumpers” are built for the air movement past the siphon and they join with the sewer once the siphon ends. Some jumpers are undersized and have become a source of gas pressurization.

4.2.5 Confluence of Major Tributary Sewers

Turbulence in wastewater flow not only leads to higher gas pressures in the sewers but also facilitates the release of hydrogen sulfide gas from the sewage into the headspace. When gas vents from a sewer into the atmosphere, it is the hydrogen sulfide gas that people smell and find so offensive. When one flow stream enters into another at a strong angle (i.e. perpendicular), it generates significant turbulence and leads to pressure and strong odor releases.

5.0 ODOR CONTROL TECHNOLOGIES

There are many technologies and strategies available to address odors in the collection system including liquid phase treatment, vapor phase treatment, and hydraulic improvements.

5.1 Liquid Phase Treatment

Liquid Phase Treatment is the addition of chemicals into the sewage in order to limit the generation of hydrogen sulfide (H2S). Various chemicals can be employed for this purpose. The most common chemicals used are discussed below.

5.1.1 Calcium Nitrate (BIOXIDE)

Adding nitrates reduces sulfide generation in the sewage by replacing sulfates as the source of oxygen for the bacteria. This reduces the conversion of sulfates to sulfides. Calcium nitrate can affect sewage plant operations if overdosed. The increased nitrate levels in the sewage may result in the formation of nitrogen gas bubbles that inhibit settling in the treatment plant's primary clarifiers. But, when properly dosed, calcium nitrate will not have any negative impact on either pump station or treatment plant operations. As a benefit, the addition of calcium nitrate may result in a small reduction of BOD5 in the plant influent, and furthermore, calcium is a required micro-nutrient for biomass growth.

5.1.2 Iron Salt

Ferrous chloride is an iron salt that reacts with sulfides and precipitates them out of the liquid. When this salt is added to wastewater, it immediately separates into ferrous iron and chloride. The ferrous iron then reacts with the sulfides to form ferrous sulfide, an iron-bound sulfide molecule that cannot dissolve in the wastewater. The subsequent decrease in dissolved sulfides reduces vapor phase H2S concentrations, reducing odor emissions. Its disadvantages include its proclivity, depending on the relative solubility of the potential resultant compounds, to react with negatively charged ions in the wastewater other than sulfide.

5.1.3 Metal Salts

Metal salts, such as ferrous sulfate, react with hydrogen sulfide and precipitate it out of solution by forming an insoluble metallic sulfide. The dose is 4.5 grams of ferrous sulfate for each gram of sulfide to be oxidized. This is less expensive than peroxide or chlorine.

The primary disadvantage of the above products is that they may contain a high free acid content which will increase the pH of the sewage. This can interfere with biodegradation of the waste.

5.1.4 Potassium Permanganate

This is a strong oxidizing agent that reacts with hydrogen sulfide in a variety of ways, depending on whether the stream is acidic or alkaline. In waste streams in which the pH is neutral, a variety of reactions occur, yielding elemental sulfur, sulfate, thionates, dithionates, and manganese sulfide end products. Potassium permanganate has been fairly effective when added to sludge dewatering operations, where it is added to the suction side of the sludge pumps feeding the dewatering unit. It has a few disadvantages. Dosages are difficult to predict and control in most liquid applications. The high cost and high dose, 6 or 7 parts of potassium permanganate are needed for each part of hydrogen sulfide, are discouraging. Safety precautions are required for handling and storage.

5.1.5 Chlorine and Sodium Hypochlorite

Chlorine combines with water to form hypochlorous and hydrochloric acid which kills the bacteria that produce hydrogen sulfide. It also oxidizes the sewage, which helps prevent the production of hydrogen sulfide. There are several disadvantages associated with chlorine. Chlorine also kills the beneficial, waste-degrading bacteria used to treat sewage. It also combines with urine in the waste stream to form chloramines, which are difficult to remove. Toxic or carcinogenic chlorinated hydrocarbons may form during treatment of chlorinated sewage. Additionally, chlorine is a hazardous material, requiring special safety precautions.

5.1.6 Hydrogen Peroxide

Hydrogen peroxide reacts with hydrogen sulfide, forming sulfur and water (see the chemical equation below). The reaction occurs quickly. Generally, 90% of the reaction occurs within 10 to 15 minutes and is completed within 20 to 30 minutes. For this reason, it is used to treat local problems only, since it doesn't have long-lasting or far-reaching effects. Any excess hydrogen peroxide decomposes, releasing oxygen and water, thereby increasing the dissolved oxygen in the stream. There are some disadvantages. It is relatively expensive and dangerous. It requires special safety procedures when handling, including the use of protective clothing. Face shields must be worn during bulk storage loading, repair, and maintenance of the facility. Spontaneous combustion is possible.

hydrogen peroxide + hydrogen sulfide ⟶ elemental sulfur + water

pH < 8.5 $$H_2O + H_2S \longrightarrow S + 2H_2O$$

hydrogen peroxide + sulfide ion ⟶ sulfite ion + water

pH > 8.5 $$2H_2O_2 + S^{2-} \longrightarrow SO_2^{2-} + 2H_2O$$

5.1.7 Oxygen/Air Injection

Oxygenation helps beneficial aerobic and facultative anaerobic bacteria reproduce faster than undesirable anaerobes. This allows the beneficial bacteria to consume more of the available nutrients. Its beneficial use is typically limited to force main applications due to its low saturation characteristics under atmospheric conditions.

oxygen + ionized hydrogen sulfide $\xrightarrow{bacteria^*}$ thiosulfate ion + water

$$2O_2 + 2HS^{+} \xrightarrow{bacteria^*} S_2O_3^{2-} + H_2O$$

* anaerobic or facultative anaerobic bacteria

5.1.8 Caustic Shock Dosing

Sodium hydroxide is added directly to the sewage through a maintenance hole upstream of the sulfide producing zone. It is added at a volume and rate to elevate and pH above 12.5 for at least 30 minutes to inactivate or kill the sulfate reducing bacteria. Periodic caustic shock dosing can effectively remove all sulfide forms.

5.1.9 Magnesium Hydroxide

Continuous Addition – As the pH of wastewater rises, the natural state of sulfides in the wastewater shifts away from offensive H2S gas and towards dissolved sulfides in solution. Magnesium hydroxide raises the pH of wastewater and has a residual buffering capacity that maintains an elevated pH for a significant distance downstream of the application point. For this reason, magnesium hydroxide is continuously added to wastewater to raise and buffer it pH to within a range of 7.5 to 8.6. At a pH of 8.6, only 3% of sulfides exist as H2S gas while the vast majority of sulfides are held in solution in the form of disulfide and dissolved sulfide. Consequently, maintaining a high pH provides effective odor control.

5.2 Vapor Phase Treatment

Another strategy is Vapor Phase Treatment, which involves containing or treating the gasses and odors directly. Treatment methods involve either containing the gasses or filtering odors from gasses escaping from the collection system. Applications include sealing maintenance holes, inserting devices into maintenance holes, or constructing large facilities such as carbon scrubbers, biofilters, or biotrickling filters, the technology that the ATFs employ.

5.2.1 Sealing Maintenance holes

The most straightforward method to treat odors in the vapor phase is to contain the vapors. The simplest solution is to simply prevent the gas from venting from the sewer system through the maintenance holes by sealing the maintenance hole lid with a mixture of roofing tar and sand. Sealing of maintenance holes is performed mostly on maintenance holes located on the large diameter sewers that experience headspace pressurization.

5.2.2 Gas Trap Maintenance Hole

Another solution to trapping the gas is to construct a gas trap maintenance hole. A gas trap maintenance hole forms a water seal similar to a p-trap, which blocks sewer gasses from traveling upstream past the structure. They are constructed at locations where small diameter sewers discharge into large outfall sewers and they prevent pressurized sewer gases from being forced from the large sewer into the smaller sewers.

5.2.3 Maintenance Hole Inserts

Inserts (e.g. Bioteg MH Biofilter) filter odors from sewer gases traveling up maintenance holes and are used at several locations throughout the city. Microorganisms in the filter media oxidize and remove odors from the gas before it exits the maintenance hole lid.

5.2.4 Large Air Treatment Facilities

Large air treatment facilities can be constructed to reduce the air pressure in sewers and remove the odors from large volumes of sewer gases before releasing it into the atmosphere. These facilities include carbon scrubbers, biofilters, and biotrickling filters.

5.2.4.1 Carbon scrubbers

Carbon scrubbers use activated carbon to adsorb H_2S as it passes through the media. Advantages of carbon scrubbers include having a small footprint and a H_2S removal rate of up to 99.5%. Scrubbers have several disadvantages including:

- Can only handle small flow rates (typically less than 20,000-CFM)
- Carbon media can require frequent replacement, depending on loadings
- Significant O&M cost
- Upgrading is difficult if flows increase due to process expansion
- Can let other odorous compounds pass through when media becomes "spent"
- Requires frequent operator attention to check state of media

5.2.4.2 Biofilters

Biofilters have proven to be an effective technology for removing VOC-type odors, hydrogen sulfide, and ammonia from air exhausted from livestock facilities. Biofilters are used quite frequently in waste water treatment systems. Proper biofilter design is critical for providing effective and economical treatment. To ensure proper performance, information regarding the relationship between unit flow rate through the biofilter media and the unit pressure drop across the media is needed. A biofilter uses microorganisms supported on organic media (bark, wood chips, compost) to convert odorous gases into non-odorous compounds. An organic media biofilter can destroy up to 90% of the VOCs in a foul air stream. Contaminated air passes through the filter where the microorganisms consume the organic carbon and produce CO2, water, and biomass. The bacteria residing in the water film on the media oxidize hydrogen sulfide to sulfuric acid, much of which is washed out of the bed as a result of the irrigation process or during wet weather events.

Organic media biofilters uses non-hazardous compounds, employ a relatively simple concept and require little maintenance; however they do have several disadvantages which include the following:

- Large footprint required (up to 2,500 sq ft. for 30,000 CFM @ 20 PPM H2S)
- Large capital cost
- Difficult to upgrade for increased air flows
- Settling of biofilter media can cause air channels to form in the media bed, reducing performance over time
- Organic media needs to be replaced after 3-5 years

5.2.4.3 Biotrickling Filter

Biotricking filters use the most current technology available. Water trickles over the filters, which are columns filled with inert packing media and a biofilm develops on the surface of the media. The biofilm is nourished by nutrients fed into the trickling stream to support biofilm growth. Most of the pollutant degradation occurs in the biofilm by a mass transfer and biological process. Natural media used in the filters can include soil, peat, compost, or bark. However, most biotrickling filters use engineered media which provide the advantages of natural media with a lower rate of fouling and longer life. The water is recycled over the media and the system is also supplied with essential nutrients for the biological organisms, which are the primary method in which contaminants are removed from the air. The organisms responsible for odor removal are usually aerobic since the system is well aerated. Contaminated gas is supplied either co-current or countercurrent to the water's direction. Biotrickling filters operate similar to biofilters with a more complex removal system that is suited to treat compounds that when degraded, produce an acidic by-product such as H2S.

5.3 Hydraulic Design Improvements

In some cases odors vent from the sewer due to poor or inadequate hydraulic design. Another strategy for reducing odors venting from the collection system is implementing the adequate sewer design criteria to avoid hydraulic and geometric characteristics that either increase the production of odors or constrict the flow of gas in the sewer headspace, forcing it out of the sewer.

5.3.1 Low Flow Velocity

If sewage flows too slowly, sediment within the sewage settles out and deposits within the pipe. These deposits provide an ideal environment for an anaerobic slime layer where hydrogen sulfide is produced. Sewers should be designed to provide an adequate flow velocity to reduce the deposition of solids within the sewage and help eliminate the development of H2S.

5.3.2 Inverted Siphons

Significant odor issues have been associated with air pressure build-up on the upstream side of inverted siphons. It lies with the fact that the sewer pipe in a siphon flows completely full with no headspace within the pipe to convey the gas. Therefore, air ducts or "air jumpers" are needed to transport the gases across the siphon. These air jumpers have historically been undersized. Air jumper should be designed to provide sufficient headspace to convey the air across.

6.0 ODOR CONTROL MEASURES

Municipalities face daily challenges in their effort to control and mitigate sewer-related odors. The City has implemented a successful program to control and reduce odors within its collection system which has made significant improvements. Various measures are employed to reduce the generation and release of odors from the sewer system. They include:

- odor complaint response and investigation;
- routine sewer maintenance;
- chemical addition;
- air withdrawal and treatment from the collection system;
- sewer construction and repair; and
- On-going monitoring of sewer air pressure and odor concentration.

This section discusses these various odor control measures and procedures the City uses as part of the Odor Control Program.

Odor Complaint Response and Investigation

The Bureau of Sanitation, Wastewater Collection Systems Division (WCSD) responds to various odor complaints from the public. However, complaint investigation is geared toward identifying and mitigating sewer-related odors. Non-sewer issues are referred to other city departments or outside agencies for follow-up investigation and mitigation efforts.

The public can file an odor complaint through a 24-hour, operator-assisted odor complaint hotline (1-866-44SEWER) or use the City's website at www.lasewers.org. The City is trying to emphasize the 3-1-1 phone number for government services and information as the best way to file an odor complaint. Additional complaints are received through direct contact from the public and referrals from council offices and other city departments.

The odor complaint response and investigation involves the following process:

1. The complaint is directed to the appropriate maintenance yard
2. A field crew investigates the complaint, identifies the source and determines/implements necessary actions to mitigate the odor such as cleaning the sewer, sealing maintenance holes, inspecting trap maintenance holes for structural integrity and function, or referring the matter to other city departments or outside agencies if it is not related to sewers.

3. The crew documents its findings and actions on an Odor Complaint Response Form and submits document for review and data entry.
4. For hotline complaints, WCSD informs the complainant within 7 days of the complaint about the findings, actions, and/or status of investigation and also gathers feedback. A 30-day callback is conducted if the complainant so requests.
5. Follow-up inspections are conducted if necessary
6. Problems not correctable by maintenance staff are referred to WCSD's Engineering Section for further investigation and possible solution. Typical engineering activities include:
   - reviewing sewer plans
   - conducting on-site field visits
   - reviewing odor complaints in the surrounding area
   - reviewing available flow monitoring data
   - monitoring pressure and H_2S levels and evaluating the data
   - requesting repair of trap maintenance holes or other sewer structures by an on-call contractor
   - Proposing a capital improvement project (CIP) such as hydraulic relief pipes, air treatment facilities, chemical addition systems, etc.

Sewer related complaints are caused by sewer ventilation in which foul air is forced out and released from maintenance holes and trap maintenance holes or other sewer structures or facilities such as pump plant and treatment plants; or by sewers that have become septic due to debris build-up causing a surcharged or hydraulically loaded system; or by properties with house connection laterals directly connected to large diameter sewers. Sewer related odors account for 24% complaints received or 123 complaints. Compared to last fiscal year 2011/12, sewer related complaints increased by 37%. The increase in complaints was mainly attributed by sewer ventilation along the North Outfall Sewer (NOS) in the Atwater Village. Over 100 homes are directly connected to the NOS allowing air to migrate towards the properties. Plans to construct individual house connection traps are underway for the properties along the NOS. This project should significantly mitigate the complaints stemming from Atwater Village. The City continues to pursue odor remediation measures to reduce complaints when possible. On-going measures include: upgrading over 300 poorly performing traps in the collection system, installing an air curtain at Mission and Jesse NOS/ECIS diversion structure, construction of third ATF at Mission and Jesse, plans to install air dampers on the air return line on Humboldt, Mission and Jesse, and 23rd and San Pedro drop structures, continued operation of the carbon scrubbers and ATFs, and addition of magnesium hydroxide to the NOS from LAGWRP. Overall, the implementation of the projects mentioned above and continued maintenance has made a marked improvement to the reduction of the sewer related odor complaints. Compared to the baseline year (FY 03/04), sewer-related odor complaints have been reduced by 42%. The City continues to be proactive and pursue odor remediation measures to reduce complaints when possible.

The remaining 76% of odor complaints investigated were non-sewer related. They include odors from standing water, dirty alley, stormwater catch basin sources, owner plumbing trouble, etc. All sewer-related odor complaints were properly investigated and addressed, while non-sewer related odors were referred to the appropriate City department or other government agencies. For the break down of odor complaints please see table 6.1.1, and figure 6.1.2.

	Q1	Q2	Q3	Q4	Total
Trap MH	0	0	0	0	0
Sewer Ventilation	32	5	19	25	81
HC to Lines >18"	3	1	0	0	4
Septic Condition	9	9	12	8	38
					123

TABLE 6.1.1

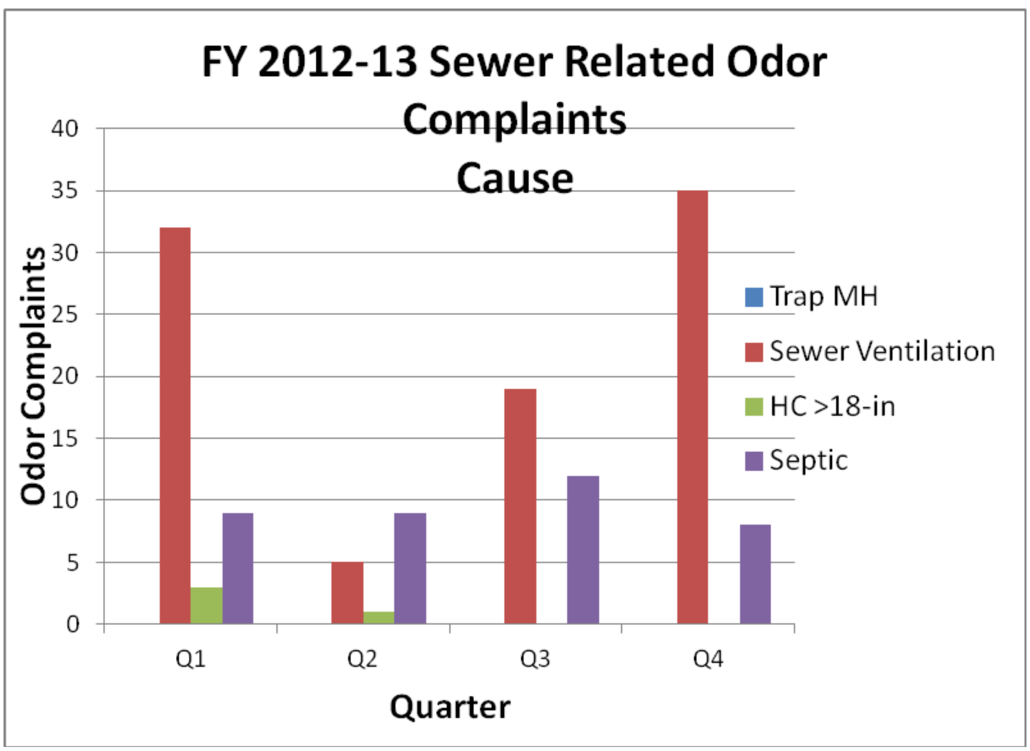


FIG. 6.1.2

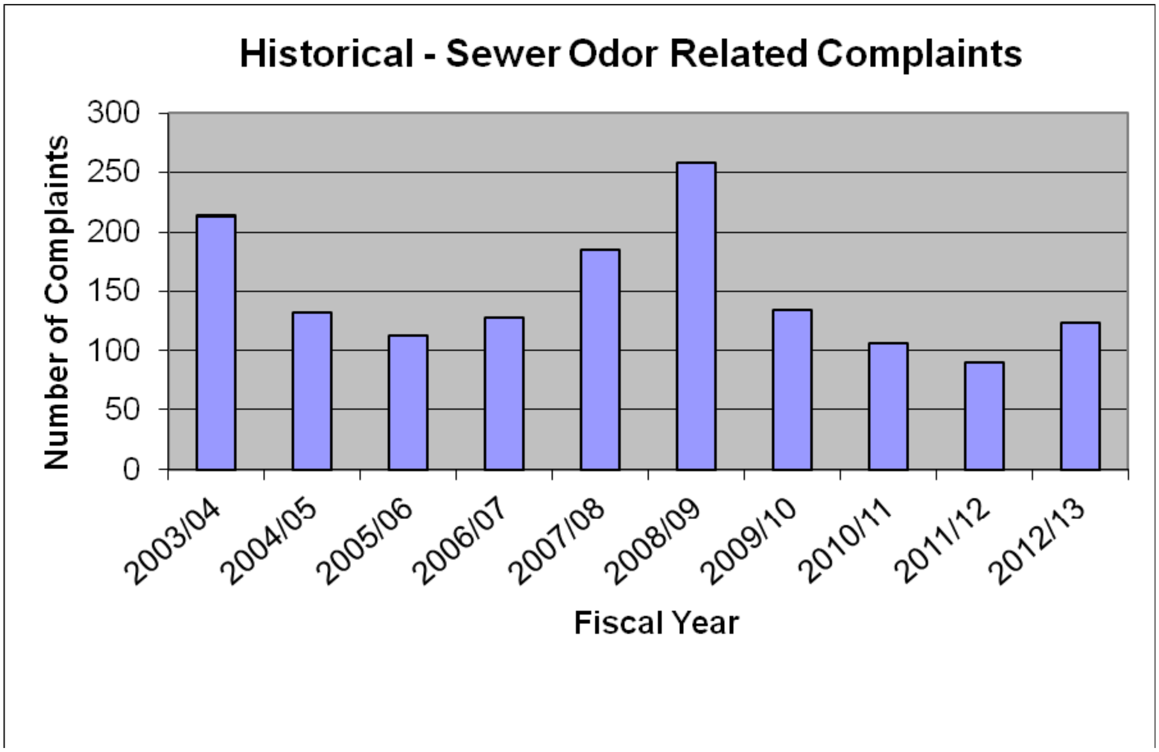


FIG. 6.1.3

Routine Sewer Maintenance

Routine sewer maintenance is necessary to allow the wastewater to flow freely and unimpeded in the sewer pipe. Obstructions in the sewer slow the sewage and cause debris to settle. As discussed earlier, this promotes the generation of hydrogen sulfide. Preventive maintenance includes sewer cleaning, root control, and trap inspection and/or maintenance. Other maintenance includes sealing sewer maintenance holes or other access points, where needed, to prevent the release of foul odors.

- **Sewer Cleaning and Root Control**

Sewer pipes are inspected and cleaned periodically to prevent conditions that exacerbate hydrogen sulfide generation. There are several traditional cleaning techniques used to clear blockages. They include hydroflushing, rodding, and bucketing.

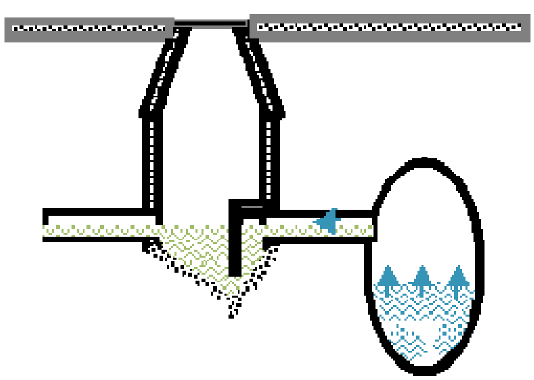
Hydroflushing – Directs a high-velocity stream of water against the pipe wall. This process removes debris and grease build-up and clears blockages within small-diameter pipes.

Rodding – A continuous or sectional rod with a blade at the end is inserted into the pipe and rotated. This action breaks-up grease deposits, cuts roots, and loosens debris.

Bucketing – A cylindrical "bucket" with one closed end is pulled through the line, removing sediment and other material. This process partially removes large deposits of silt, sand, gravel, and some types of solid waste.

All sewers are cleaned at least once every five years and more frequently in known "hot spots". Approximately 65,000 pipe segments (2800 miles) are cleaned annually. In addition to hydraulic and mechanical cleaning, chemicals are applied into root infested sewers to clear the roots from the pipe. Approximately 400 miles of sewers are treated annually.

- **Trap Maintenance Hole Inspection and Cleaning**

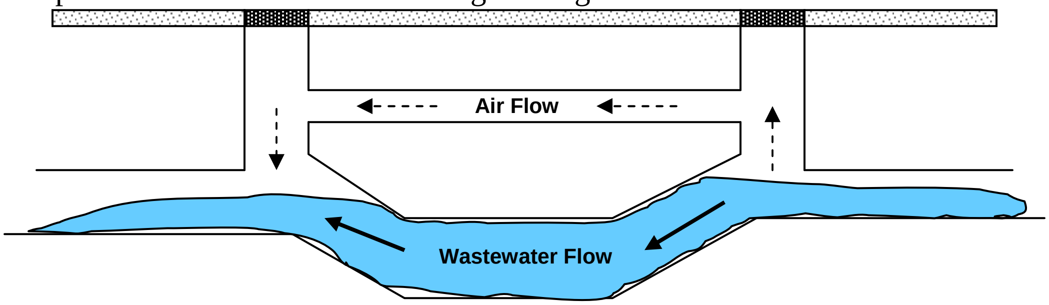


Trap maintenance holes are inspected and cleaned on a quarterly basis. These structures are used to prevent the migration of sewer gases throughout the collection system. They are typically located where small sewers, 6-inches to 15-inches, connect to large interceptor and outfall sewers since high gas pressures are more prevalent in large sewers. Trap maintenance holes act similarly to p-traps used in residential plumbing by creating a water seal that blocks the sewer gases.

- **Siphon Inspection and Cleaning**

Sewer siphons descend to carry sewage under obstructions such as rivers, storm drains, or other utilities, and then regain elevation after passing the obstruction. The siphon always remains full of water, causing the sewage to move very slowly through a siphon during periods of low flow. For this reason, siphons and other submerged lines are prone to debris deposition and are likely sources of high H_2S generation. To prevent this, siphons are cleaned quarterly.

Siphons are also noted for releasing venting odors at the inlet structure because the



full pipe blocks the air flowing downstream with the sewage. High turbulence at the siphon inlet aggravates this problem by stripping H_2S out of solution and sending it airborne, adding to the odor. An air duct called an "air jumper" conveys the airflow past the siphon from the inlet to the outlet structure. Air jumpers often follow the sunken (inverted) path of the siphon line, allowing condensate to collect and impede the air movement unless it is drained. To prevent this, inverted airlines either drain automatically with pump systems or are dewatered manually using a vacuum truck. The pump systems are inspected periodically and manual vacuuming is performed on an as-needed basis.

- **Sealing Maintenance Holes**

Sewer maintenance holes provide access for maintenance crews. However, they also provide a route for sewer gases to escape when pressures build up. Sewer gasses can become pressurized for multiple reasons. At times of high sewage flow, the sewage

occupies a greater proportion of sewer volume than at times of low flow. As a consequence, some air in the sewer is displaced and finds its way out through maintenance holes or other access structures. Conversely, as flows decrease, fresh air is drawn into the sewers. This is a natural ventilation process that occurs in the collection system. As sewage flows, air in the pipe's headspace is dragged with it. Higher velocity flows will tend to pull in and drag more air down the pipes. When this air is blocked by an obstruction, it will vent through any relief available such as nearby maintenance holes. In areas where odors continuously vent, maintenance holes are sealed. Typically, this is done as part of regular maintenance activities or in response to odor complaints.

Chemical Control Technologies

Chemical or "liquid phase" control technologies limit the production of hydrogen sulfide by preventing sulfides from forming in sewage. There are numerous chemicals and methods employed for controlling sulfides, depending on the conditions under which they are being employed. For example, chemicals can halt new sulfide production or neutralize existing sulfides. The Bureau of Sanitation has researched and tested many types of liquid phase treatment since the early 1990s. Pilot studies were conducted to measure the performance of various chemical applications such as sodium hydroxide (caustic soda), ferric chloride addition, ferrous chloride, hydrogen peroxide, calcium nitrate (Bioxide), and magnesium hydroxide (Thioguard). The City began routine application of odor control chemicals in 1997.

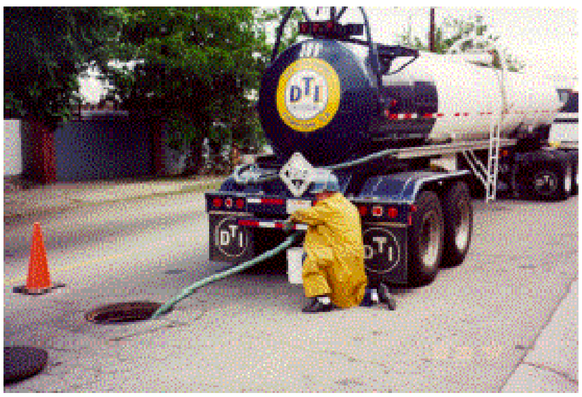
Developing a chemical control program requires an extensive survey of the collection system in order to accurately choose a chemical and locate an injection point that will be effective. This process is described below.

1. Review odor complaint history – Look for repeat odor complaints in a community.
2. Review collection system maps - Check size and type of nearby sewers(local sewer, interceptor sewer, or outfall sewer), pipe slope, flow rates and levels, locations of maintenance holes, junctions or tributary structures, and any pump plants or siphons.
3. Preliminary sampling – Sample the wastewater for total and dissolved sulfides, pH, and temperature. Hydrogen sulfide is measured using hand held meters and/or continuous data logging monitors. Sample all major tributary points to the problem area and proceed toward the upstream reaches. This is a quick and effective method to isolate problem areas requiring further investigation.
4. Determine baseline H_2S profile and sulfide mass loading – Once a problem area is isolated, additional samples are taken to develop the baseline data profile which includes maximum, minimum, and average H_2S levels over a period of 24-hours or more. This will be compared with data taken during the trial-and-error applications to measure effectiveness. Analysis of dissolved sulfide concentrations in samples along with known flow information helps determine the amount of sulfide present and where it is coming from.
5. Determine location for chemical injection – The monitoring data will identify the area generating sulfide. The injection point will be located at the most upstream reach of the generation zone to ensure adequate treatment.

Although there are theoretical formulas and rules regarding the dosing requirements for each liquid phase treatment process, it is not an exact science. Field analysis of the results and subsequent adjustments are required. Therefore, trial and error applications are common until an adequate dose level is achieved. Continuous monitoring is necessary to determine a cause-and-effect relationship of each treatment. Monitoring for H_2S is typically performed inside the maintenance holes because hydrogen sulfide dilutes immediately after exhausting into ambient air making concentrations much lower in the air outside the maintenance hole. Along with monitoring, each application should be correlated with the corresponding number of odor complaints in the affected area. A reduction in the number of odor complaints is an indication that the dosing levels are working.

Currently the Bureau of Sanitation is using a 50% sodium hydroxide solution called caustic soda and continuous Thioguard (magnesium hydroxide) addition to chemically control odors in the collection system.

- **Caustic Shock Dosing Application**



The Bureau of Sanitation has been using caustic soda in a process called "caustic shock dosing" routinely since 1997 to control sulfide generation. The selection of this treatment was based on positive past experiences and its success in neighboring municipalities such as Los Angeles County and Orange County. Additionally, this treatment is ideal for the sewers targeted due to their long detention times which allow adequate contact time for treatment. Furthermore, caustic shock dosing is a very flexible process and can be mobilized quickly to treat any area of the collection system.

Periodic caustic shock dosing can effectively remove all sulfide forms. It inactivates, or kills, the biological slime layer where sulfates are transformed to sulfides. Monitoring has shown that the slime layer requires 3 to 5 days to re-form and reach full sulfide production again, depending upon pH, temperature, and contact time of the caustic soda. It rebounds more quickly in warmer weather. Therefore, the frequency of the shock dosing schedule varies with the seasons so as to prevent a complete rebound of hydrogen sulfide production.

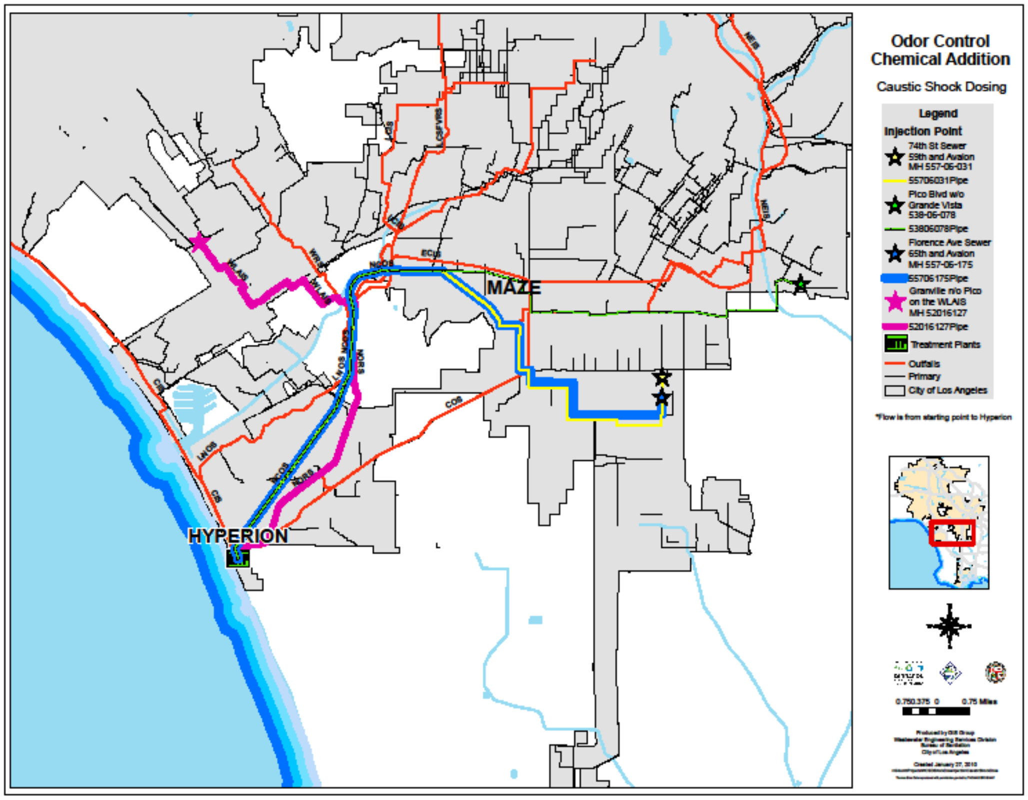


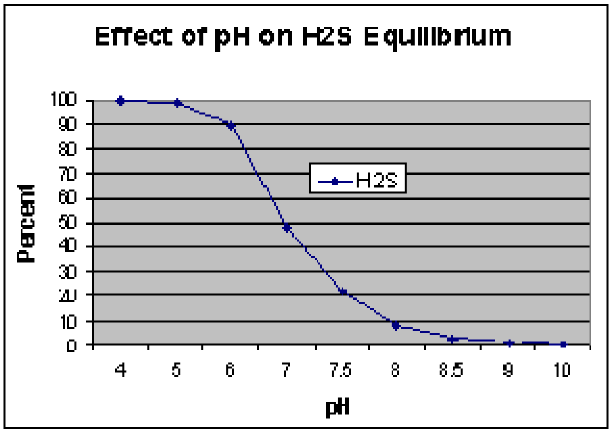
FIG. 6.3.1

Caustic soda is added directly to the wastewater stream through a maintenance hole upstream of the area to be treated and at the sulfide-producing zone. It is added at a volume and rate sufficient to elevate the pH above 12.5 for at least 30 minutes to inactivate or kill the sulfate-reducing bacteria. Continuous pH monitors are placed downstream of the application point to confirm that adequate treatment levels are attained. Caustic soda is applied upstream of the sulfide-generating area 1 to 3 times per week, depending on the generation rate and time of year. It is currently being applied to sewer reaches upstream of the Maze area which accounts for approximately 46% of the sulfide loading to the Maze Area Sewer System. The caustic injection in the South Los Angeles area is conducted on the Florence Ave Sewer and 74th Street Sewer. Both sewers are tributary to the South Branch of the Maze. Caustic shock dose application continues in the WLAIS due to higher H2S concentrations as a result of high dissolved sulfide generation caused by solids deposition in the large diameter sewer. See figure 6.3.1 for the chemical flow path.

As a safety precaution, all chemical applications are scheduled in advance and announced to all collection system personnel to avoid accidental contact with the chemical as it passes down the sewer system. Additionally, the treatment plant is notified prior to application. A shock dose schedule bulletin is distributed to wastewater collection system personnel, including those at treatment plants and the

Bureaus of Engineering and Contract Administration. The bulletin includes location, date, time and volume of caustic soda to be added to the collection system.

- **Magnesium Hydroxide Continuous Addition**



As the pH of wastewater rises, the natural state of sulfides in the wastewater shifts away from offensive H_2S gas and towards dissolved sulfides in solution. Magnesium hydroxide raises the pH of wastewater and has a residual buffering capacity that maintains an elevated pH for a significant distance downstream of the application point. For this reason, magnesium hydroxide is continuously added to wastewater to raise and buffer its pH to within a range of 7.5 and 8.6. As the graph shows, at a pH of 7, approximately 50% of all sulfides exist as H_2S gas. At pH 8, that number falls to10% and at pH 8.6, only 3% of sulfides exist as H_2S gas while the vast majority of sulfides are held in solution in the form of disulfide and dissolved sulfide. A slight drop in pH results in a significant increase in H_2S produced and thus emitted into the atmosphere. Consequently, maintaining a high pH provides effective odor control.

The City has been using a 65% magnesium hydroxide slurry as a non-hazardous means to regulate the pH of its wastewater since September 2003 as the result of a successful pilot testing. This application requires 20 to 25 gallons of magnesium hydroxide per million gallons of wastewater to control odors. Currently, magnesium hydroxide is injected from the Tillman Water Reclamation Plant and is introduced to AVORS to raise the pH of the downstream sewers in the NOS, EVRS, and the LCSFVRS. See figure 6.3.2 for the chemical flow path. This benefits both the Studio City area, Hollywood and Mid-City areas. In July 2013, Thioguard application on the NOS from LAGWRP started to address the high concentration of H2S resulting from the release of biosolids back to the NOS from the LAGWRP.

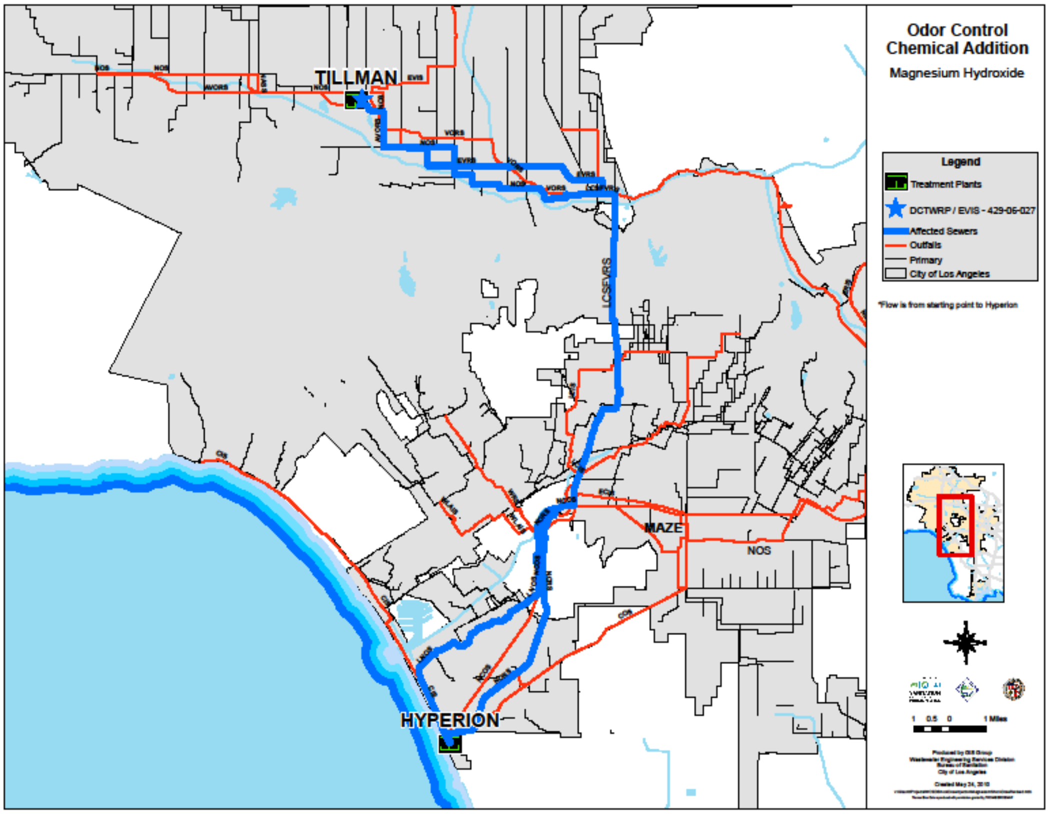


FIG. 6.3.2

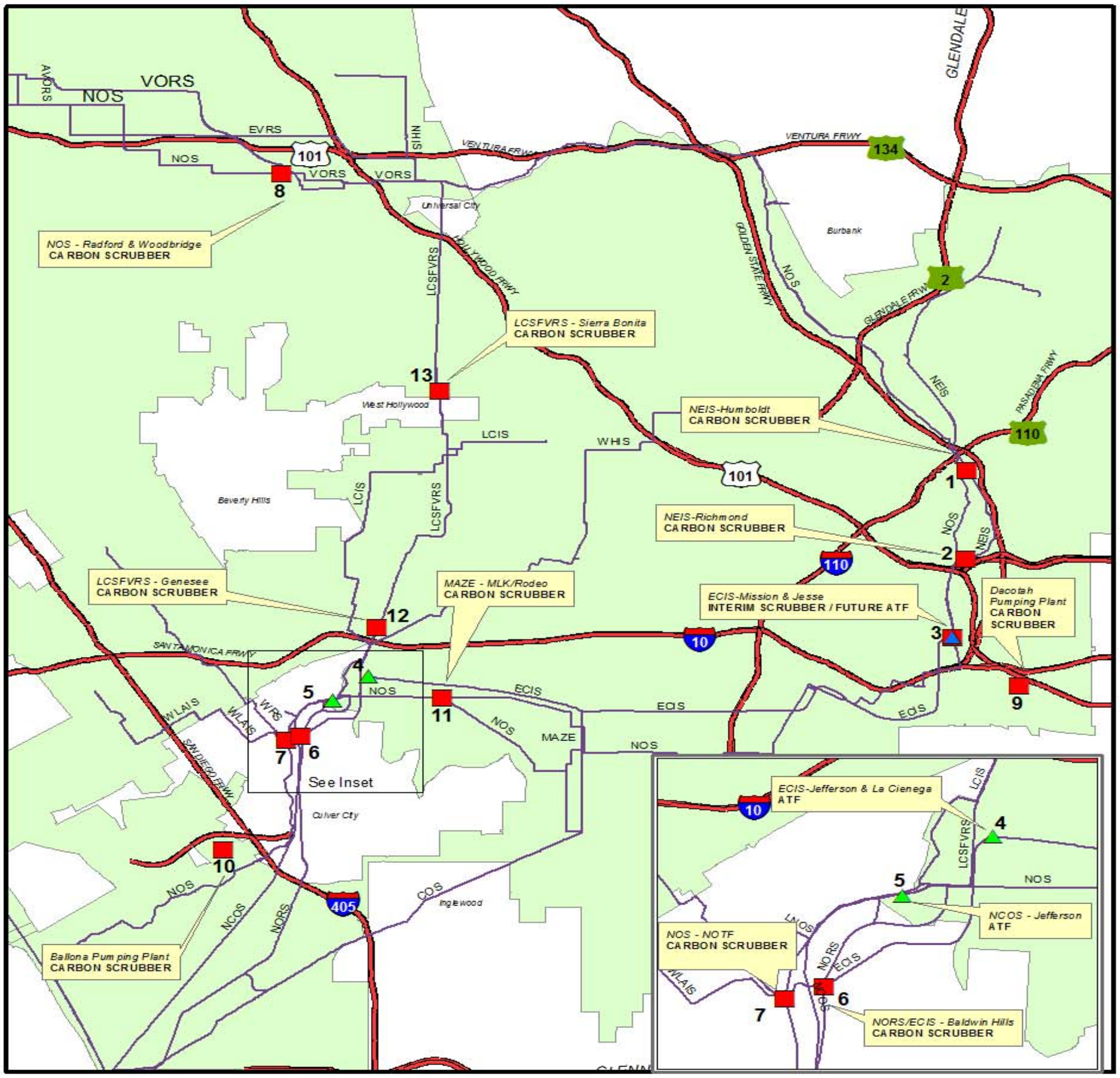
Air Treatment

The City has conducted multiple studies of sewer gas pressure and odors. The studies have identified distinct high pressure zones in sewers around the South LA area including:

- North Outfall Sewer (NOS)
- Maze Area Sewer System (Maze)
- La Cienega San Fernando Valley Relief Sewer (LCSFVRS)
- North Outfall Replacement Sewer (NORS)
- West Los Angeles Interceptor Sewer (WLAIS)
- Westwood Relief Sewer (WRS)

To address the high pressure zones and localize odor hot spots in the collection system, carbon scrubbers and permanent air treatment facilities were constructed to alleviate and mitigate the odor emissions from the collection system (see figure 6.4).

Operating & Planned Sewer Air Treatment Systems



Sewer Air Treatment Systems

No.	Name	Type	Size(cfm)
1	NEIS - Humboldt	Carbon Scrubber	10,000
2	NEIS - Richmond	Carbon Scrubber	10,000
3	ECIS - Mission & Jesse	Interim Carbon Scrubber/ Future ATF	10,000 12,000
4	ECIS - Jefferson/La Cienega	ATF	20,000
5	NCOS - 6000 Jefferson	ATF	12,000
6	NORS ECIS - Baldwin Hills	Carbon Scrubber	10,000
7	NOS - NOTF	Carbon Scrubber	10,000
8	NOS - Radford & Woodbridge	Carbon Scrubber	5,000
9	Dacotah Pumping Plant	Carbon Scrubber	3,000
10	Ballona Pumping Plant	Carbon Scrubber	5,000
11	MAZE - MLK & Rodeo	Carbon Scrubber	5,000
12	LCSFVRS - Genesee	Carbon Scrubber	5,000
13	LCSFVRS - Sierra Bonita	Carbon Scrubber	10,000

Existing Air Treatment Facility (ATF)
Future Air Treatment Facility (ATF) or Carbon Scrubber
Existing Carbon Scrubber
Outfalls
Freeway
Los Angeles City
Outside Los Angeles City

Definitions: **INTERIM: Future ATF Planned**

Wastewater Collection Systems Division
Wastewater Engineering Services Division
Bureau of Sanitation
City of Los Angeles

Created 12/21/09
Updated 08/05/2013

0 2,700 5,400 10,800 16,200 21,600 Feet

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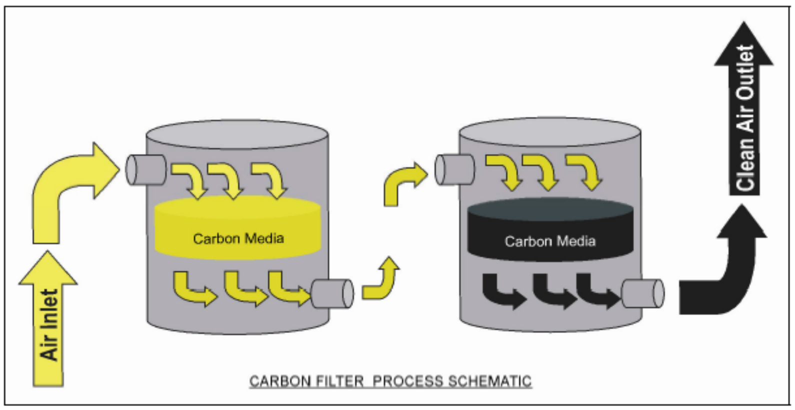
Thomas Bros Data reproduced with permission granted by THOMAS BROS MAP

Figure 6.4

Figure **6.4** shows locations and information on the existing Odor Control units and the planned ATF.

- **Carbon Adsorption**

Conventional carbon adsorption systems offer an effective approach to controlling odors in many situations. In municipal installations, odorous air is typically directed through a vessel containing adsorption media, such as activated carbon. Odorous compounds in sewer gases are adsorbed onto the media. Adsorption systems in the City's wastewater collection system are generally configured as single media bed system. Activated carbons



are highly porous materials. Due to large surface areas, activated carbon is able to adsorb hydrogen sulfide, other reduced sulfur compounds and volatile organic compounds

(VOC). These odor-causing compounds are attracted to and adhere to the carbon's pore structure. This process relieves the air pressure in the system while preventing the release of odors. There are currently thirteen carbon scrubbers operating in the wastewater collection system.

Scrubbers are operated under a permit issued by the South Coast Air Quality Management District (SCAQMD). As required by the permit, an operations staff monitors the hydrogen sulfide concentration of the influent air and the treated emissions in order to gage the performance of the scrubber. The typical hydrogen sulfide removal rate is 99%. These readings are posted on a quarterly basis on the City's odor website at www.lasewers.org. Carbon media in each unit is replaced periodically before expected odor contaminant breakthrough. The frequency of change-out, range from monthly to quarterly to bi-annually depending on the contaminant loadings to the carbon scrubber. An interim carbon scrubber at the ECIS drop structure at Mission and Jesse is in operation with plans to replace this unit with permanent air treatment facility (ATF).

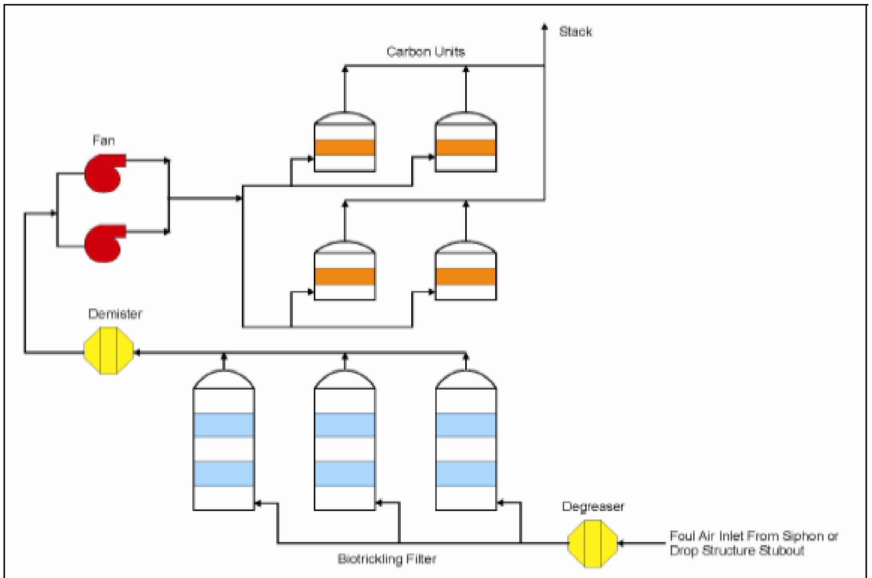
Ten additional carbon scrubbers are installed at other sites to address localized odor hotspots within the collection system. They include:

1. NORS/ECIS Junction
2. NEIS Drop Structure - Humboldt and San Fernando Rd
3. NEIS - Richmond
4. LCSFVRS – Sierra Bonita
5. LCSFVRS Siphon – Genesee
6. NOS Siphon – Radford
7. Maze/NOS Junction – Rodeo and Martin Luther King
8. WLAIS/NOS Junction – North Outfall Treatment Facility (NOTF)
9. Ballona Pump Plant
10. Dakotah Pump Plant

These units have been in operation for 10 years and have reached their operational useful life. There are plans to upgrade existing units to insure continued operability.

- **Air Treatment Facilities (ATF)**

The City has elected to use Air Treatment Facilities (ATF) using a 2-stage odor control system employing biotrickling filtration technology followed by a carbon adsorption polishing step.



ODOR CONTROL PROCESS SCHEMATIC

Biotrickling filter technology utilizes microbial cells that are attached to a medium inside the reactor, which then oxidize the odorous constituents to odorless compounds. The odor contaminants transfer from the gas to the liquid phase and subsequently to the microbial biofilm, or it is transferred directly from the gas to the biofilm, where it is oxidized biologically to odorless compounds. The oxidative by-products, namely sulfuric acid, are the removed through the trickling effluent. The treated effluent is then polished by carbon adsorption.

Two ATFs have been constructed and are in operation. One is the ATF at East Central Interceptor Sewer Siphon and LCSFVRS (Jefferson & La Cienega) and the other is the ATF at North Central Outfall Sewer Siphon (NCOS). The ATFs were strategically placed to reduce the long standing odor issues in the South Los Angeles/Baldwin Hills area. The ATF at ECIS is designed to ventilate and treat the ECIS at the siphon and the LCSFVRS to mitigate sewer gas emissions. The facility treats 20,000 cfm of foul air. The ATF located at 6000 Jefferson Blvd is designed to ventilate the pressurized North Central Outfall Sewer (NCOS) in order to mitigate emission of sewer gas. The facility will treat 12,000 cfm of foul air. A third ATF at Mission and Jesse with a capacity to treat 12,000 cfm of foul air is currently under construction. This ATF will withdraw air from the ECIS/NEIS Junction and the NOS.

Hydraulic Flow Management

Flow management plays a major role in odor control, especially in the area of air dynamics and ventilation. Hydraulic flow has an influence on air movement. It is well documented that on major interceptor and outfall sewers, hydraulic flow will drag the air above it. As a result, air moves within the pipe. Throughout the day, as part of the diurnal pattern of flow, the wastewater flow will rise and fall. When flows rise, air is pushed out the system. Conversely, when flows fall, air is pulled into the system. The air pressure is significant especially in sewers that are at or reaching capacity, meaning the hydraulic flow levels are high. Balancing flows in the system will relieve air pressure in the system.

Air Curtains

Air curtains play a vital role in controlling the air movement in the sewers. The purpose of the air curtain is to isolate the air movement in the interceptor sewer and control movement of sewer air from entering other portions of the collections system. Air curtains are installed at major diversion structures. Air curtains have been installed at NORS Diversion Structures 1, 2, and 3; NOS/NCOS to LCSFVFRS diversion structure; and 23rd and Trinity NOS to ECIS diversion structure. Another air curtain was added in August 2012 to control the air movement from the Mission and Jesse drop structure to the NOS.

Sewer Construction and Repair

Sewer construction and repair play an important role in the City's odor control effort. Some odor problems are inherent in a given sewer's design and require auxiliary sewers to be built. Some problems are the result of failing components which need repair or replacement. Additionally, the City has been engaged in a large capital improvement program constructing new, major sewers which have multiple benefits for the collection system as a whole, one of which is odor control.

The City is continuously identifying locations where house connection laterals from private properties tie directly into a large outfall sewer instead of a small, local sewer. This is a direct source of odors since large sewers are much more likely to have high odor levels and high gas pressures. A direct connection allows odors from the large line to escape up the house connection and into the house or property. To address this issue, the City constructs local sewers adjacent to the large sewer to which the house connections will be reconnected in order to isolate the properties from the odor source. A trap maintenance hole is constructed at the end of the local line before connecting back to the large diameter sewer. In special circumstances, the City will also install house connection traps on the private sewer lateral to control the migration of sewer gases from the City sewer to the private property. This requires consent from the property owner to install such a device on to their private lateral and agreement from the property owner to maintain the house connection trap.

Trap maintenance holes are inspected quarterly and as part of an odor complaint investigation. The Bureau has identified all known problematic trap maintenance holes and has begun a program of replacing them on a systematic basis. The City is replacing existing trap maintenance holes with a new standard design. The new design will ensure a continuous seal and allow crews better accessibility to maintain the trap maintenance hole without compromising the seal. The City replaced and upgraded over 300 trap maintenance holes to meet the June 30, 2013 CSSA deadline for replacement of all poorly performing traps city-wide. It is expected that these upgrades will significantly improve sewer odor releases where trap maintenance holes are located.

The City has a project to install adjustable air dampers on the air return lines of the Humboldt, Mission and Jesse and 23rd and San Pedro drop structures. The air damper will control the ventilation of foul air from the air return line and possible migration towards the interconnecting shallow sewer.

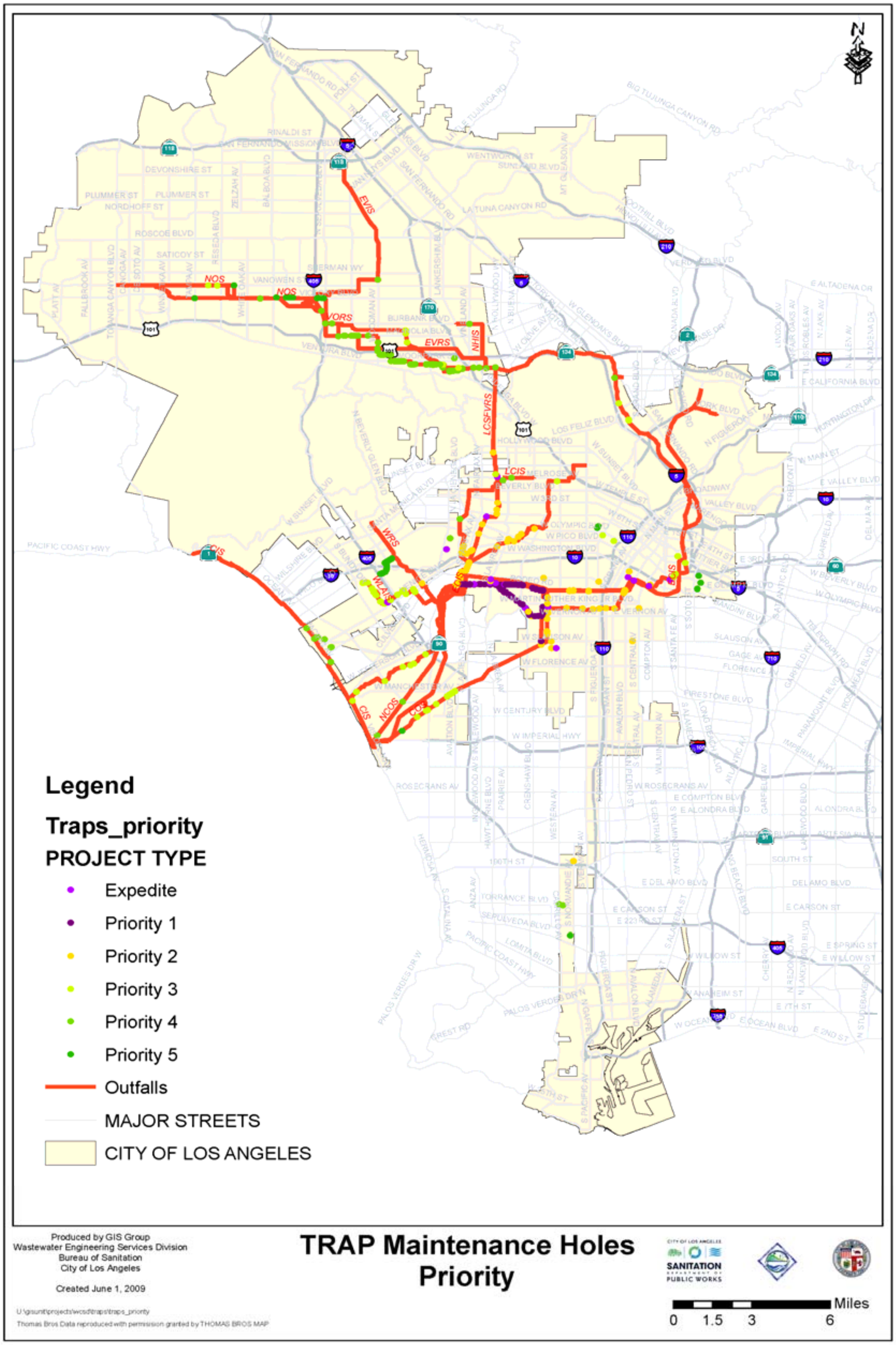

Legend
Traps_priority
PROJECT TYPE
Expedite
Priority 1
Priority 2
Priority 3
Priority 4
Priority 5
Outfalls
MAJOR STREETS
CITY OF LOS ANGELES
Produced by GIS Group
Wastewater Engineering Services Division
Bureau of Sanitation
City of Los Angeles
Created June 1, 2009
TRAP Maintenance Holes
Priority
SANITATION
Miles
0 1.5 3 6
NOS
EVIS
VORS
EVRS
NHIS
LCSFVRS
LCIS
CIS
WRS
NCOS

FIG. 6.5

The City's program of constructing new, major sewers has many benefits, including odor control. The new sewers provide much-needed additional capacity to the collection system and relieve the existing sewers, which are carrying flows over their intended capacity. This not only improves the hydraulic capacity of the system, but also decreases the air pressures in the pipe's headspace above the flow. As flow is diverted from the existing sewers, the air space in these pipes increases and the air pressure therefore decreases. This reduces the likelihood of sewer gases venting out of the sewer system. The City continues to assess the hydraulic needs of the wastewater collection system and provide hydraulic relief where needed, reducing air pressure in the system.

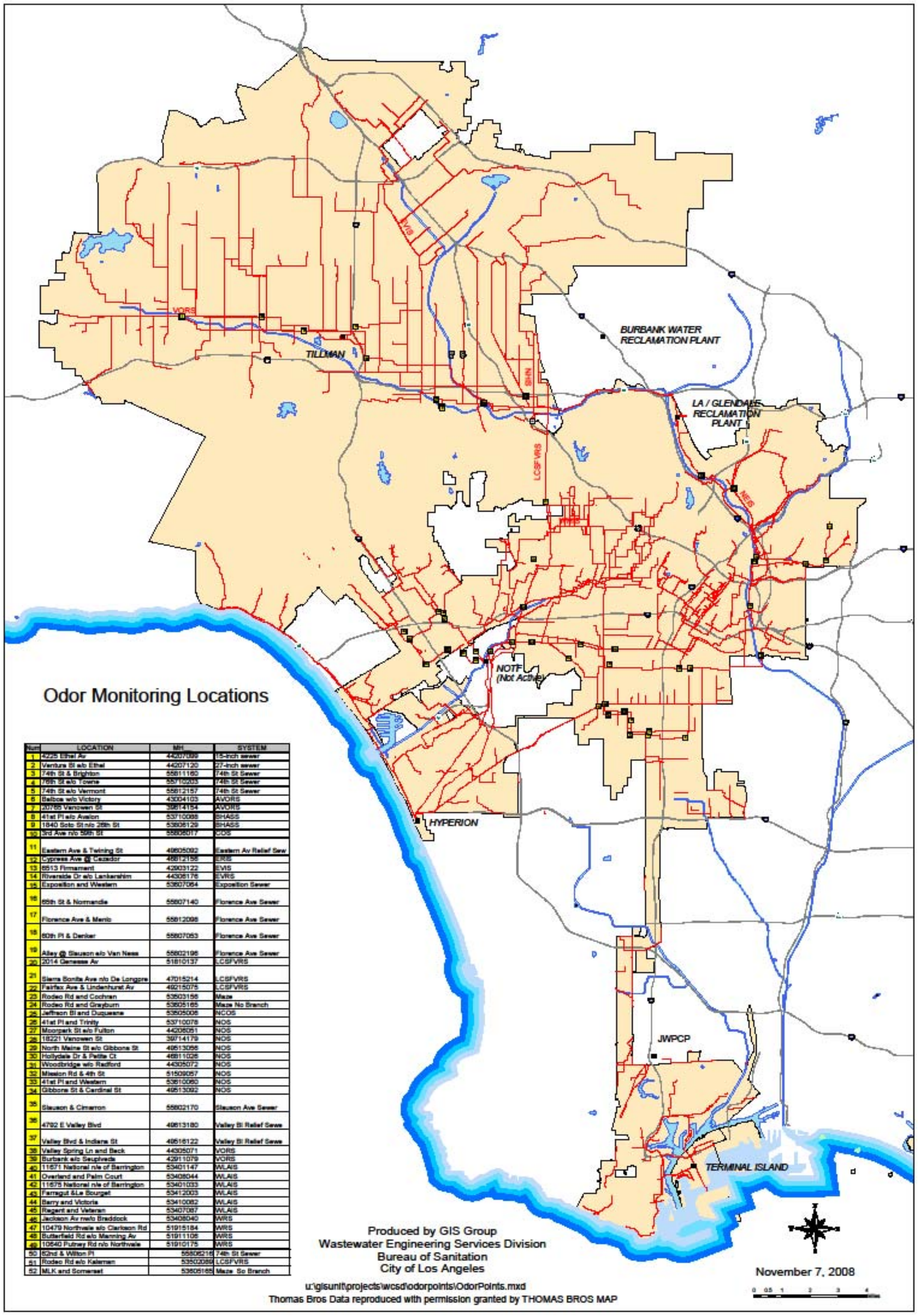
Monitoring

The collection system is regularly monitored in order to identify the source and cause of sewer related odors. A number of monitoring stations have been established at strategic locations in order to measure the parameter associated with odors (See Fig 6.6).

These locations include known odor hotspots, outfall and interceptor sewers, pressure zones, areas of turbulence, sharp slope change in sewer pipes (grade breaks), and sewer pipes with long detention times such as flat, low-velocity sewers. Parameters evaluated are:

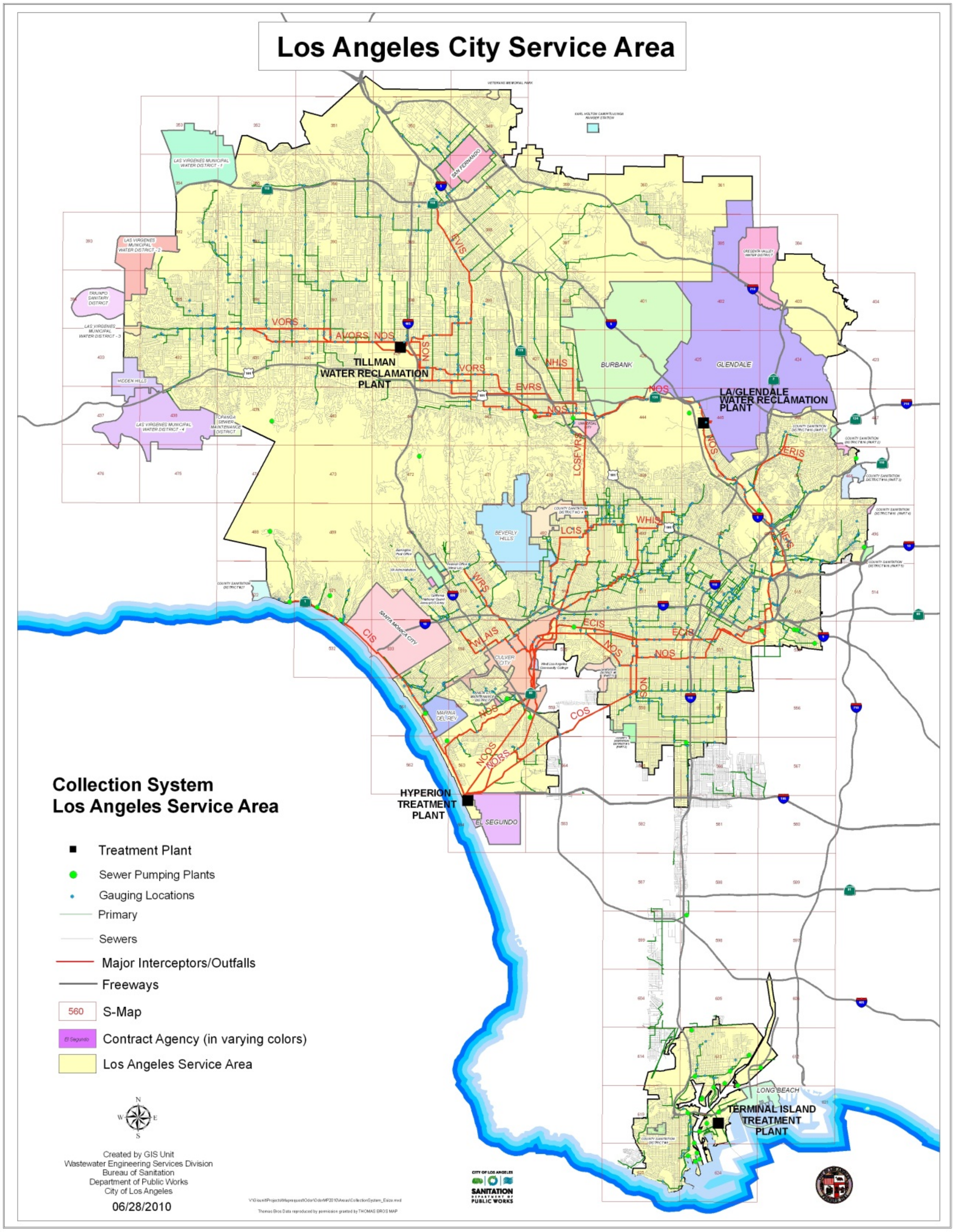
a. Wastewater Characteristics – includes total and dissolved sulfides, pH, and temperature. These characteristics determine the potential for H_2S formation.
b. H_2S Gas Concentration – determines potential for odor complaints if released.
c. Air Pressure – determines potential sites of odor release
d. Sewer Odor Complaints – helps evaluate effectiveness of odor control measures and helps identify potential hotspots in the collection system

Monitoring is conducted at least semi-annually at designated points to gage the seasonal variation in odor generation and to monitor the adequacy and effectiveness of any chemical treatment. It is also used to confirm the location and potential of odor hotspots locations. This information is used as part of the odor master planning efforts.



Num	LOCATION	MH	SYSTEM
1	4225 Ethel Av	44207089	15-inch sewer
2	Ventura Bl e/o Ethel	44207120	27-inch sewer
3	74th St & Brighton	55811160	74th St Sewer
4	76th St e/o Towne	55710203	74th St Sewer
5	74th St e/o Vermont	55812157	74th St Sewer
6	Balboa w/o Victory	43004103	AVORS
7	20765 Vanowen St	39814154	AVORS
8	41st Pl e/o Avalon	53710088	BHASS
9	1840 Soto St n/o 28th St	53806129	BHASS
10	3rd Ave n/o 59th St	55808017	COS
11	Eastern Ave & Twining St	49605092	Eastern Av Relief Sew
12	Cypress Ave @ Cazador	46812158	ERIS
13	6513 Firmament	42903122	EVIS
14	Riverside Dr e/o Lankershim	44306176	EVRS
15	Exposition and Western	53607064	Exposition Sewer
16	65th St & Normandie	55807140	Florence Ave Sewer
17	Florence Ave & Menlo	55812098	Florence Ave Sewer
18	60th Pl & Denker	55807053	Florence Ave Sewer
19	Alley @ Slauson e/o Van Ness	55802196	Florence Ave Sewer
20	2014 Genesee Av	51810137	LCSFVRS
21	Sierra Bonita Ave n/o De Longpre	47015214	LCSFVRS
22	Fairfax Ave & Lindenhurst Av	49215075	LCSFVRS
23	Rodeo Rd and Cochran	53603158	Maze
24	Rodeo Rd and Grayburn	53605165	Maze No Branch
25	Jeffrson Bl and Duquesne	53505008	NCOS
26	41st Pl and Trinity	53710078	NOS
27	Moorpark St e/o Fulton	44206051	NOS
28	18221 Vanowen St	39714179	NOS
29	North Maine St e/o Gibbons St	49513056	NOS
30	Hollydale Dr & Petite Ct	46811026	NOS
31	Woodbridge w/o Radford	44305072	NOS
32	Mission Rd & 4th St	51509057	NOS
33	41st Pl and Western	53610060	NOS
34	Gibbons St & Cardinal St	49513092	NOS
35	Slauson & Cimarron	55802170	Slauson Ave Sewer
36	4792 E Valley Blvd	49613180	Valley Bl Relief Sewe
37	Valley Blvd & Indiana St	49516122	Valley Bl Relief Sewe
38	Valley Spring Ln and Beck	44305071	VORS
39	Burbank e/o Seuplveda	42911079	VORS
40	11671 National n/e of Barrington	53401147	WLAIS
41	Overland and Palm Court	53408044	WLAIS
42	11675 National n/e of Barrington	53401033	WLAIS
43	Farragut &Le Bourget	53412003	WLAIS
44	Barry and Victoria	53410082	WLAIS
45	Regent and Veteran	53407087	WLAIS
46	Jackson Av nw/o Braddock	53408040	WRS
47	10479 Northvale e/o Clarkson Rd	51915184	WRS
48	Butterfield Rd e/o Manning Av	51911108	WRS
49	10640 Putney Rd n/o Northvale	51910175	WRS
50	82nd & Wilton Pl	55808216	74th St Sewer
51	Rodeo Rd e/o Kalsman	53502089	LCSFVRS
52	MLK and Somerset	53605165	Maze So Branch

FIG. 6.6


Los Angeles City Service Area
TILLMAN
WATER RECLAMATION
PLANT
LA/GLENDALE
WATER RECLAMATION
PLANT
HYPERION
TREATMENT
PLANT
TERMINAL ISLAND
TREATMENT
PLANT
BURBANK
GLENDALE
BEVERLY HILLS
SANTA MONICA CITY
CULVER CITY
MARINA DEL REY
EL SEGUNDO
LONG BEACH
VORS
AVORS
NOS
EVRS
NHIS
LCSFVRI
ERIS
WHIS
LCIS
NEIS
WRS
WLAIS
ECIS
COS
CIS
NCOS
NORS
Collection System
Los Angeles Service Area
Treatment Plant
Sewer Pumping Plants
Gauging Locations
Primary
Sewers
Major Interceptors/Outfalls
Freeways
560
S-Map
Contract Agency (in varying colors)
Los Angeles Service Area
Created by GIS Unit
Wastewater Engineering Services Division
Bureau of Sanitation
Department of Public Works
City of Los Angeles
06/28/2010
SANITATION

7.0 STUDIED AREAS

This section will provide an analysis for each of the four locations identified as Areas of Concern (AOC) and three locations identified as Areas of Study (AOS). Figure 7.2 identifies each of these areas on a map of Los Angeles. Testing locations within these areas were selected based on a detailed study of the physical characteristics of the collection system in the area as well as history of odor complaints. Fig. 7.1 shows the locations of all sewer-related odor complaints. Each analysis contains an introduction, test results, data analysis, conclusion, and recommendation.

AOC - Areas of Concern

- East NOS Corridor
- La Cienega/San Fernando Corridor
- Baldwin Hills/Culver City Area
- East Valley Area

AOS - Areas of Study

- Coastal Interceptor Sewer
- Harbor
- West Valley Area

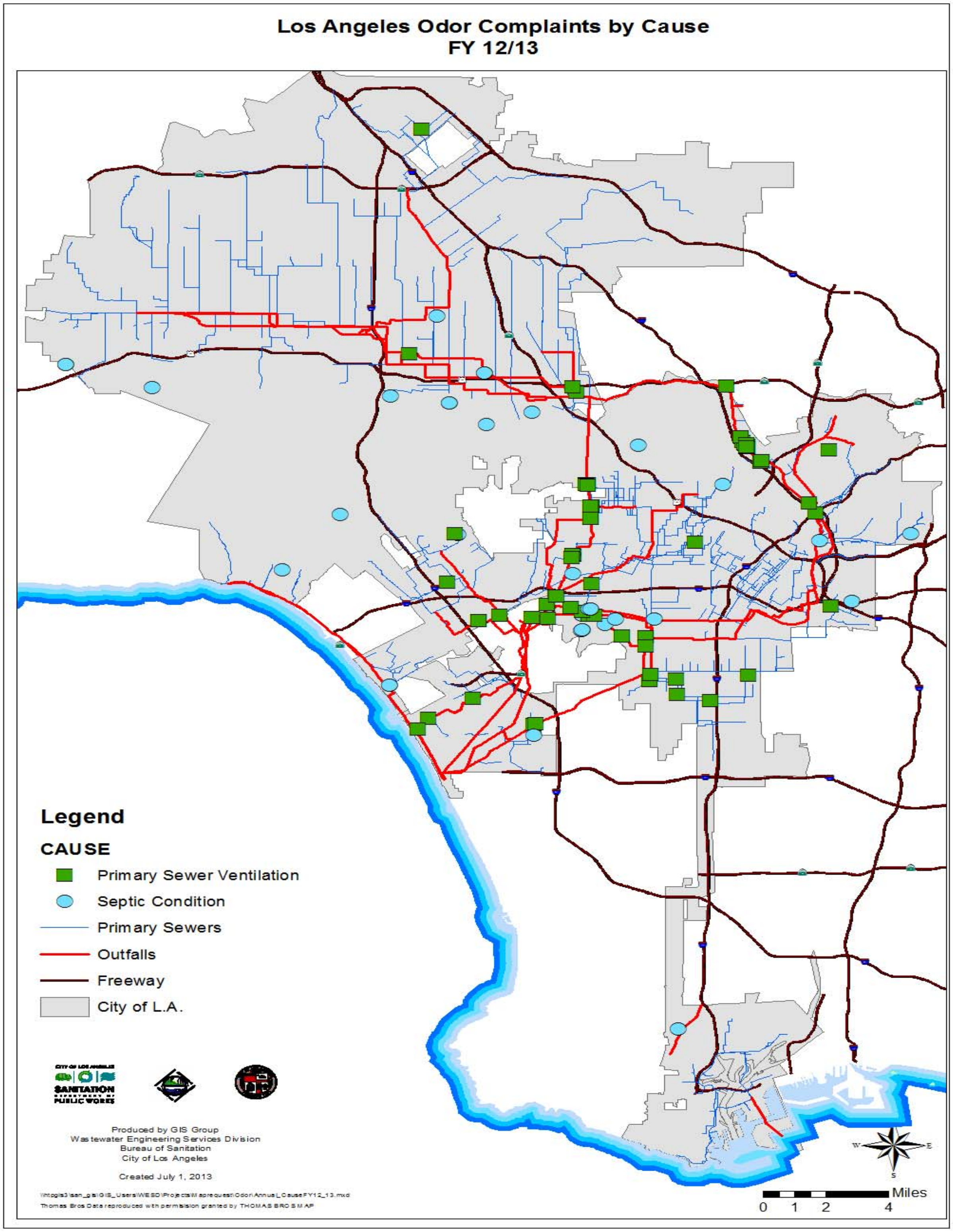

Los Angeles Odor Complaints by Cause
FY 12/13
Legend
CAUSE
Primary Sewer Ventilation
Septic Condition
Primary Sewers
Outfalls
Freeway
City of L.A.
Produced by GIS Group
Wastewater Engineering Services Division
Bureau of Sanitation
City of Los Angeles
Created July 1, 2013
Miles
0 1 2 4

FIG. 7.1

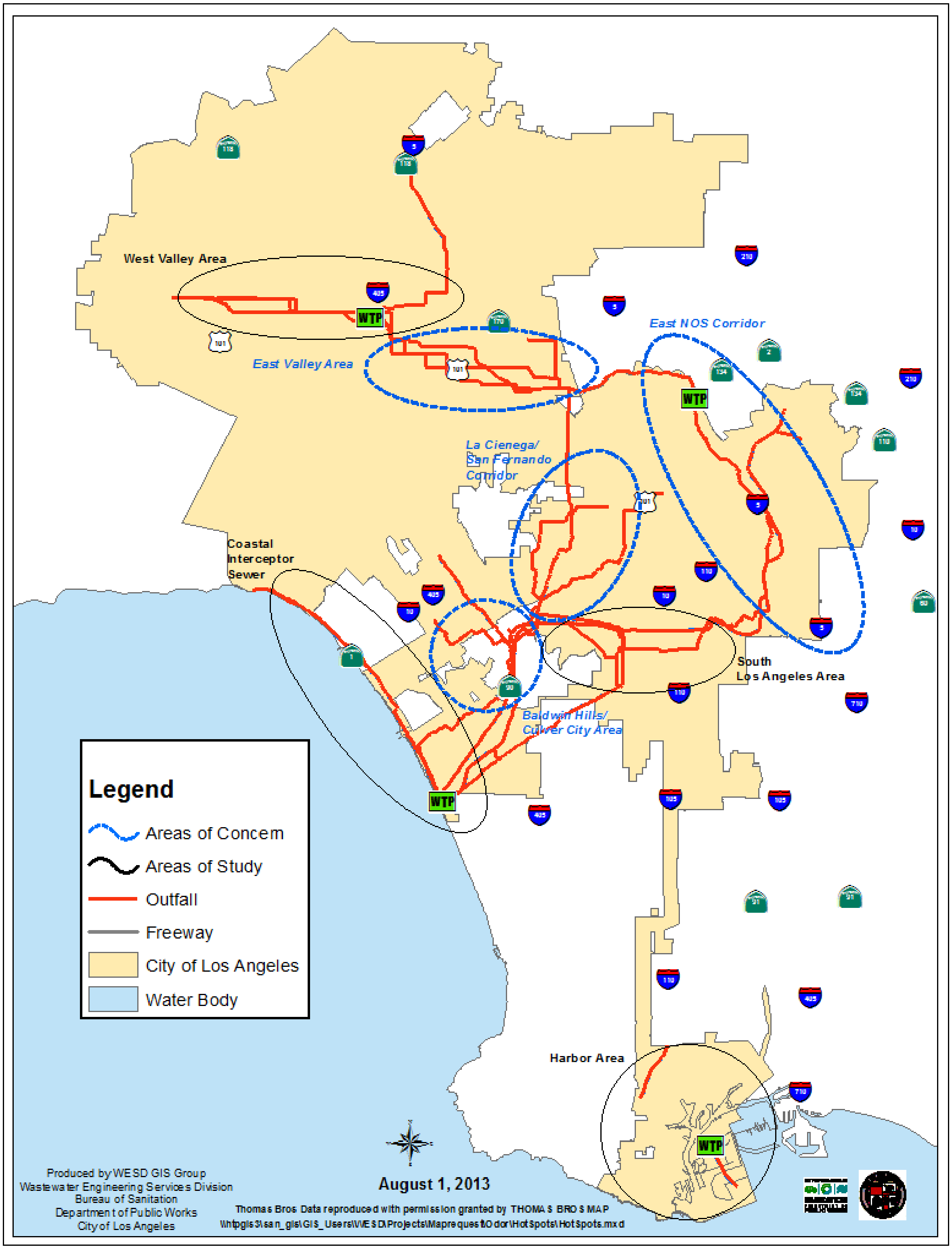

West Valley Area
East Valley Area
East NOS Corridor
La Cienega/
San Fernando
Corridor
Coastal
Interceptor
Sewer
South
Los Angeles Area
Baldwin Hills/
Culver City Area
Harbor Area
WTP
Legend
Areas of Concern
Areas of Study
Outfall
Freeway
City of Los Angeles
Water Body
Produced by WESD GIS Group
Wastewater Engineering Services Division
Bureau of Sanitation
Department of Public Works
City of Los Angeles
August 1, 2013
Thomas Bros Data reproduced with permission granted by THOMAS BROS MAP

FIG. 7.2

7.0 AREAS OF CONCERN

7.1 AOC1 - East NOS Corridor

INTRODUCTION

This report provides a discussion and analysis of the sewer air pressure test conducted for the east corridor of the North Outfall Sewer System in February and June 2013. The area of concern covers the NOS starting at the Los Angeles Glendale Water Reclamation Plant (LAG) and moving southerly to the Enterprise Siphon located at Mission and Enterprise in the Boyle Heights area. The NOS receives returned biosolids from LAG which makes it more susceptible to venting odorous gas, which could lead to odor complaints. The entire area along the East NOS corridor was monitored using continuous pressure monitors.

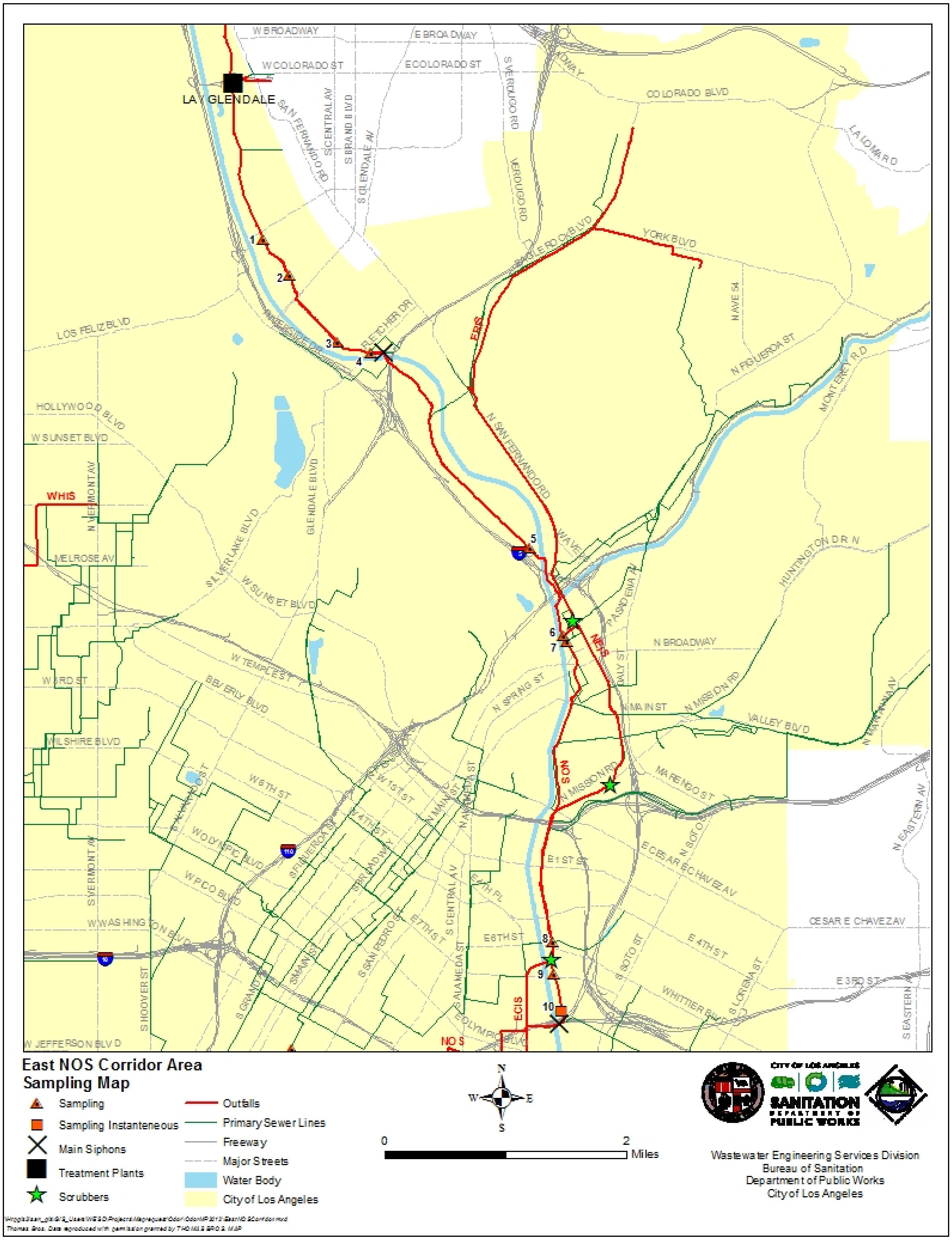
MONITORING LOCATIONS

Table 8.1 shows the list of maintenance holes tested along the East NOS Corridor from LAG to the Enterprise Siphon at the Los Angeles River. Figure 8.1 displays a map of these locations. There are several sewer structures and pipeline conditions along this segment that may increase sewer gas pressure and cause odor complaints. These include the Gilroy Siphon and the Enterprise Siphon. Also included are junction structures, diversion structures, and drop structures. The reason each monitoring location was chosen is stated in Table 8.1.

TEST RESULTS
Table 8.1

ID	LOCATION	MH NO.	SEWER	JUSTIFICATION	PRESSURE (IN-WC) 2013	2012	2011	H2S AVG/ MAX (ppm)	FLOW (cfs)
1	Glenfeliz & Hollypark	468-02-060	NOS	Siphon Pressure Effect	-0.04	0.07	-0.08	6.8/88	42
2	Hollydale & Petite Ct.	468-11-026	NOS	Siphon Pressure Effect	-0.46	0.19	0.19	9/32	
3	Fletcher / 2 Frwy	468-11-045	NOS	Siphon Pressure Effect	-0.52	0.25	0.17	8.5/40	-
4	Blake & Oros	495-05-024	NOS	Slope Reduction (Alternate for Blake & Barclay)	0.03	0.11	0.05	-	53
5	Barranca & 18TH	495-09-097	NOS	D/S of Humboldt Diversion	-0.20	-0.26	-0.21	1/9	60
6	Mission & 6th	515-09-154	NOS	NOS Diversion to ECIS	0.21	0.19-	0.31	-	-
7	NOS near Drop Structure	515-13-137	NOS	Drop Structure	0.36	0.21	0.28	-	-
8	Mission & 7th Street	515-13-001	NOS	Siphon Pressure Effect	0.23	0.30	0.37	-	-

TESTING LOCATIONS



DATA ANALYSIS

The eastern corridor of the NOS is currently experiencing very negative pressure due to installing an emergency carbon scrubber at the corner of Hollydale Dr. and Silver Lake Boulevard. The emergency scrubber will remain in place until a comprehensive project is in place to control the gas migration in the Atwater Village area.

The average sewer pressure upstream of the Enterprise Siphon remained about the same as last year (0.25 in.-wc). An Air Treatment facility (ATF) is under construction at the corner of Mission Road and Jesse Street with completion expected in 2014. This ATF should reduce the pressure along that reach.

In 2007, flow entering the Mission & Jesse drop structure from the NOS was significantly reduced by diverting more flow from the NOS to NEIS at the upstream Humboldt drop structure. The reduced flow at the Mission and Jesse drop structure allowed more air to escape up the drop structure and into the NOS. In 2010, following the ATF Review Study, wastewater flow configurations in the NOS were changed in order to balance airflow throughout the system downstream of the Humboldt drop structure. As a result, more flow was sent down to the NOS so that the Mission & Jesse and 23rd & San Pedro drops received additional wastewater. This configuration reduced some of the air backflow through the drops and into the shallower NOS but is not enough to prevent it entirely.

CONCLUSIONS

There are two areas of high pressure that need to be addressed along the East NOS. One is at the upper reach where high pressures are building upstream of the Gilroy Siphon and the other is at the downstream reach as a result of the Enterprise siphon.

POTENTIAL SOLUTIONS

The combination of high pressure and high H_2S has been the cause of odor complaints in the area. To address pressure behind the Gilroy Siphon, a project is underway to construct traps at each house connection along Hollydale Dr. which will isolate homes from the NOS will significantly reduce odor complaints. The ATF at Mission and Jesse should reduce the pressure in the lower reach of the NOS once it is operational. An air curtain was installed at the Mission & Jesse drop to block any gas migration from the deep tunnel into the shallower NOS.

RECOMMENDATIONS/CONSIDERATIONS

- Continue to monitor this area's pressure and hydrogen sulfide levels
- Control air flow dynamics by manipulating sewage flow throughout the various sewers
- Keep the interim carbon scrubber upstream of the Gilroy Street siphon until the house connection traps are completed.
- Evaluate the entire system after completion of traps and the ATF.
- Evaluate the effect of the air curtain at Mission and Jessee.

7.2 AOC2 - La Cienega/San Fernando Corridor - LCSFVRS-WHIS-LCIS

INTRODUCTION

The 11-mile La Cienega San Fernando Valley Relief Sewer (LCSFVRS) was constructed in the mid 1950's to relieve the NOS in the southeast San Fernando Valley. The upper reach of the LCSFVRS starts at the intersection of Valley Spring Lane and Forman Avenue and travels south through the Santa Monica Mountains to Sierra Bonita Avenue where it splits into twin 42-inch diameter pipes at Sierra Bonita Avenue and Hollywood Boulevard. It becomes a single 60-inch diameter pipe at the intersection of Martel Avenue and Clinton Street. The sewer continues south and travels through the Genesee Siphon situated just south of Venice Boulevard and Genesee Avenue and eventually reconnects with the NOS near the intersection of Rodeo Road and Jefferson Boulevard in Baldwin Hills.

The upper reach of the LCSFVRS, which travels between the Hollywood Hills and the Fairfax District, has a history of high gas pressure due to the combined effect of a high approach velocity and geometric slope reduction downstream of Sierra Bonita and Hollywood Boulevard. Odor complaints along the LCSFVRS prompted the City to construct two carbon scrubbers along the LCSFVRS. The 5,000 cfm Genesee Scrubber was constructed at the Genesee Siphon along the lower reach of the LCSFVRS. The 10,000 cfm Sierra Bonita Scrubber was constructed at the upper reach of the LCSFVRS at De Longpre Street and Gardner Avenue. Furthermore, a chemical addition program, utilizing a continuous addition of magnesium hydroxide, was implemented for this area in September 2005. Since the completion of the Sierra Bonita Scrubber, the sewer gas pressure has decreased to below atmospheric levels, in most cases.

The area of concern along the LCSFVRS corridor was expanded to incorporate tributary sewers including the West Hollywood Interceptor Sewer (WHIS), and the La Cienega Interceptor Sewer (LCIS). Testing on these sewers primarily utilizes instantaneous pressure samples taken between 11:00 AM and noon since diurnal pressure patterns show that this time period best represents the sewer's average pressure.

TEST RESULTS

Table 8.2

ID	LOCATION	STRUCT. NO.	SEWER	PRESSURE (Avg.IN-WC) 2013	2012	2011	H_2S Avg/max (ppm)	FLOW (cfs)
1	300 Hauser St	49216010	LCSFVRS	0.00	-0.03	0.09	-	99
2	700 8th St.	51803209	LCSFVRS	0.00	-0.04	0.30	-	113
3	1500 Genesee	51807165	LCSFVRS	0.06	-0.01	0.47	-	113
4	5900 Genesee N/O siphon	51810137	LCSFVRS	0.11	0.05	0.75	0/5	120
5	La Cienega @ KLOS	53502024	LCSFVRS	0.03	-0.03	-0.03	-	148
6	La Cienega @ See's Candy	53502052	LCSFVRS	0.02	-0.04	-0.10	-	148
7	Rodeo Rd & Kalsman	53502089	LCSFVRS & NOS	-0.05	-	0.04	-	148

TESTING LOCATIONS

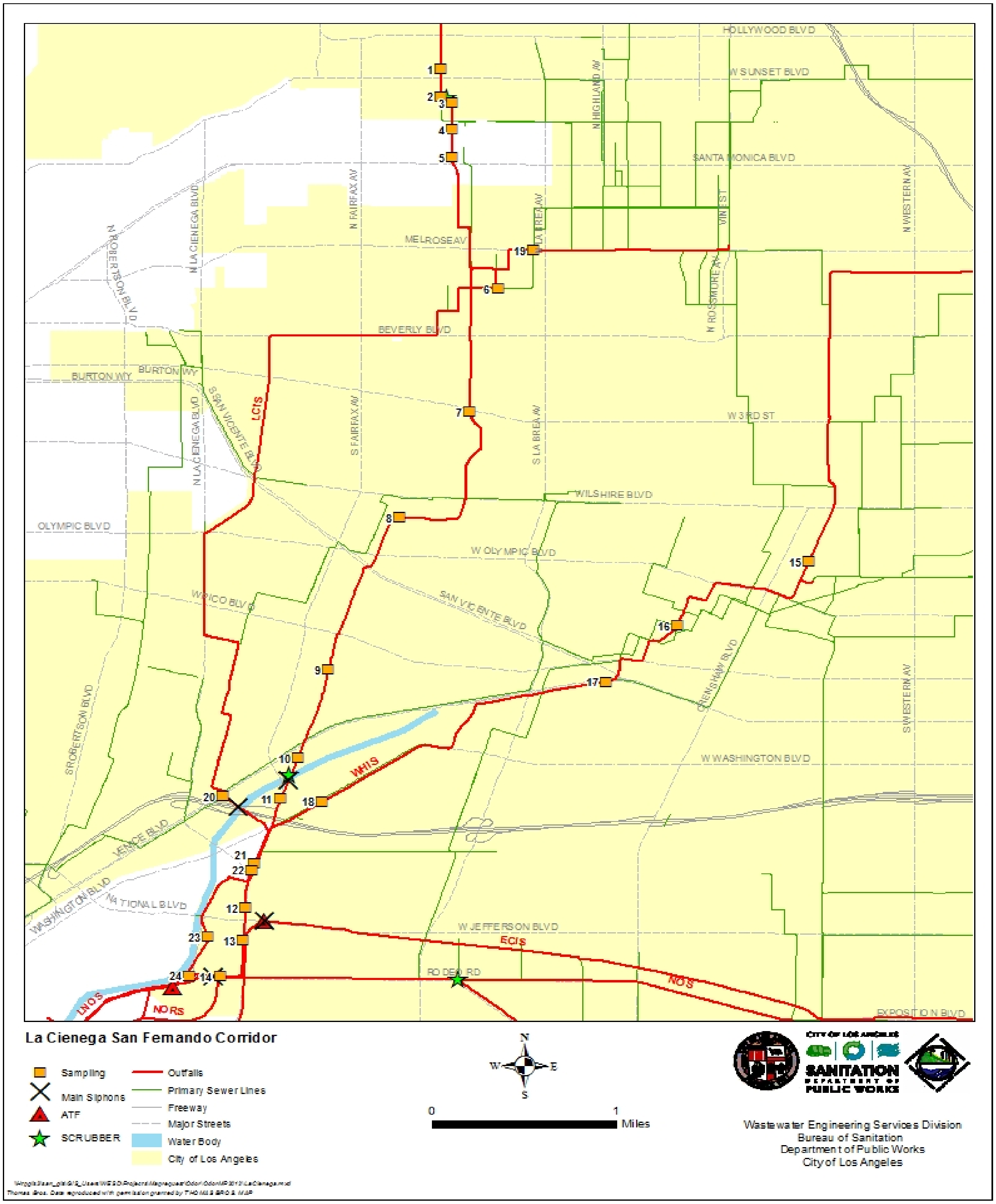
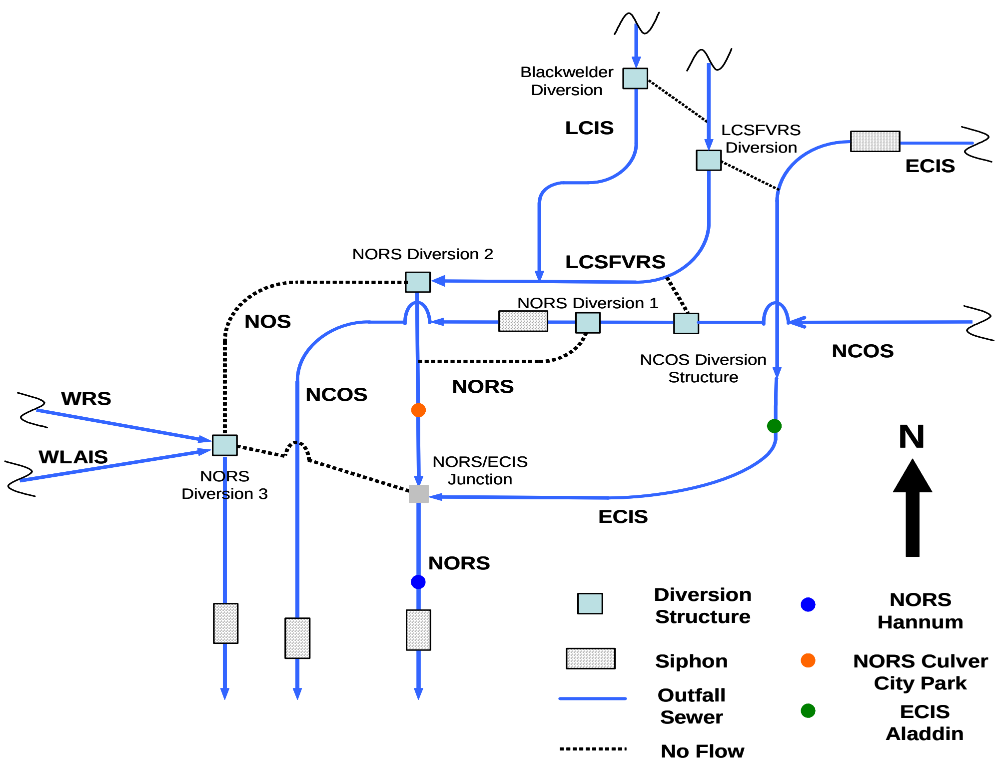


FIG. 8.2

DATA ANALYSIS

The diurnal pressure along the lower reach of this corridor was slightly higher than last year's pressure measurements. The pressure at the manhole just upstream the siphon averaged 0.11 in.-wc verses 0.05 in.-wc in 2013. The aging Genesee Scrubber will be upgraded in the near future which may help reduce pressures some. However, the pressure is still far less than the level experienced in the previous years. The source of pressure is back-pressure from the siphon located just south of Genesee and Venice Boulevard. The upper reach of the LCSFVRS experienced no major pressure issues and there are no odor complaints in this area.

Baldwin Hills Outfall Sewer System



CONCLUSION

Generally speaking, the upper reach of the LCSFVRS is depressurized since the operation of the Sierra Bonita Scrubber. As for the lower reach, the pressure had been greatly reduced since reconnecting the air line at the Genesee Siphon but slight pressure still exists.

RECOMMENDATIONS/CONSIDERATIONS

- Continue to monitor both pressure and hydrogen sulfide in this area
- Control air flow dynamics by manipulating sewage flow through various sewers
- Continue chemical injection at the Tillman Treatment Plant

8.3 AOC3 - Baldwin Hills/Culver City Area NORS-ECIS-NOS-WLAIS-WRS-NCOS

INTRODUCTION

The Baldwin Hills/Culver City Area is bounded by Jefferson Boulevard to the north, the 405 Freeway to the south, La Cienega Boulevard to the east, and the Palms community to the west. The sewers in this area include the North Outfall Replacement Sewer (NORS), East Central Interceptor Sewer (ECIS), North Outfall Sewer (NOS), the West Los Angeles Interceptor Sewer (WLAIS), the Westwood Relief Sewer (WRS), and the North Central Outfall Sewer (NCOS). The area covered is presented in Figure 8.3.

The West Los Angeles, Culver City, and Baldwin Hills sewers are currently experiencing low gas pressure due to the ATFs and diverting flow from the NORS to the NOS. The NORS had been highly pressurized for many years and was the source of significant sewer gas ventilation due to its limited headspace resulting from excessive flow. The large volume of gas traveling into the NORS from upstream sewers such as the NOS, the ECIS, the WLAIS, and the WRS, aggravated the problem as did the undersized air jumpers at the NORS Siphon. Once the rehabilitation of the NOS was completed, flow was returned from the NORS to the NOS, reducing flow in NORS and increasing headspace.

Currently two permanent Air Treatment Facilities (ATFs) are in operation. One ATF is at Jefferson and La Cienega at the ECIS siphon and the other is at 6000 Jefferson at the NCOS siphon.

TEST RESULTS
Table 8.3

ID	LOCATION	DESCRIPTION	MH No.	SEWER	PRESSURE (Avg.IN/WC) 2013	2012	2011	H_2S AVG/MAX (ppm)	FLOW (cfs)
1	JEFFERSON W/O COCHRAN	Direct U/S of ATF	53503213	ECIS	0.15	0.1	0.05	72/148	141
2	9940 JEFFERSON	Junction Structure	53509022	ECIS/NORS	0.02	0.02	0.00	-	141
3	9450 JEFFERSON	D/S NORS div.2	53505026	L NOS	0.07	0.06	-	-	-
4	WLA COLLEGE	Flow Div. Effect	53513013	NOS	0.04	-	-	-	127
5	FOX HILL MALL U/S SIPHON	Siphon	55905008	NOS	0.08	-	-0.03	-	127
6	AIRLINE BTWN NOS & NCOS	Airline	56008055	NOS/NCOS	0.09	-	0.01	-	-
7	Rodeo Rd at La Cienega Blvd	NOS/NCOS us of ATF	53502090	NCOS	0.02	-0.02	-	-	-
8	IVY & PERHAM	U/S Junction Structure	53506132	NORS	0.06	0.06	0	14/30	-
9	CULVER CITY PARK	U/S Junction Structure	53505021	NORS	0.05	0.05	0.07	-	100
10	DIVERSION 3 (TO NORS)	ATF Effect	53509006	NORS	0.07	0.03	0.00	-	-
11	WLA COLLEGE BEHIND THE SOUND WALL	D/S Junction Structure	53513007	NORS	0.09	0.06	0.06	-	230
12	HANNUM & BRISTOL PKWY	U/S Siphon	55905006	NORS	0.08	-0.02	0.02	55/85	230
13	FARRAGUT & LE BOURGET	ATF Effect	53408044	WLAIS	0.04	-	-	-	28
14	4100 JACKSON		53408042	WRS	0.05	-	-	-	-
15	Rodeo Rd & Grayburn		53605166	N. Maze	0.06	-	-	-	-
16	MLK & Somerset		53605165	S. Maze	0.05	-	-	-	-
17	Rodeo Rd & Cochran		53503156	NOS	0.08	-	-	-	-
18	Rodeo Rd at La Cienega Blvd		53502090	NOS/NCOS Us of ATF	0.04	-	-	-	-

LOCATIONS

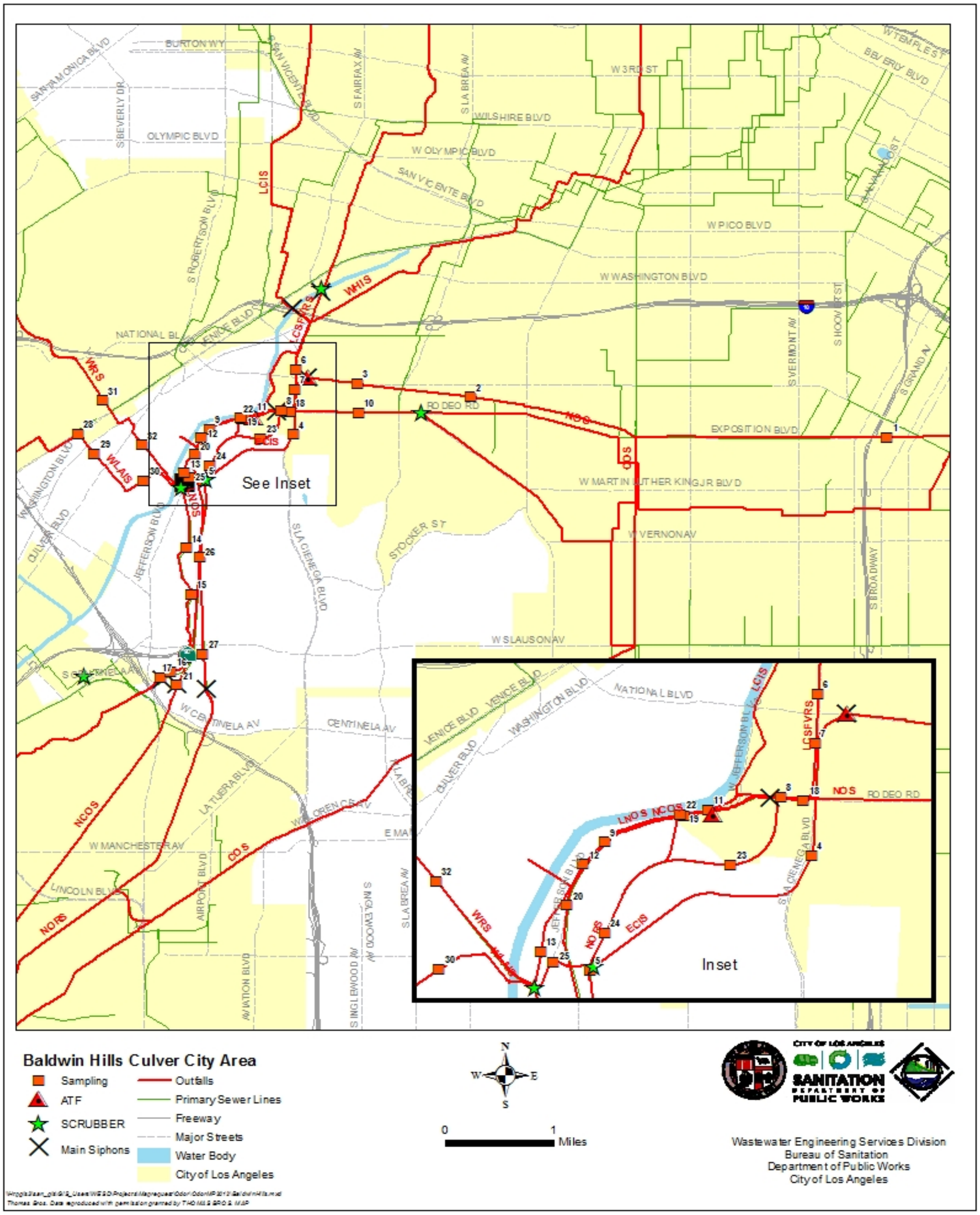


FIG. 8.3

DATA ANALYSIS

The average pressure in the ECIS at Jefferson and Cochran directly upstream of the Jefferson & La Cienega ATF was 0.15 in.-wc. This moderate high pressure is mainly due to the siphon at Jefferson and La Cienega. The average pressure at the NORS/ECIS junction was 0.02 in.-wc. These pressures are the same as last year's. The average pressure in the NOS at 9450 Jefferson, which is downstream of the NORS Diversion 2, was 0.07 in.-wc. The average pressure in the NCOS, upstream of the 6000 Jefferson ATF was 0.02 in-wc, which is higher than last year (-0.02). In west LA, both the WLAIS, and the WRS were monitored at 0.05 inches. The average pressure in the NORS ranged from 0.06 upstream of the NORS/ECIS junction to 0.08 near the NORS siphon. These pressures have not varied much since last year.

CONCLUSION

The 6000 Jefferson ATF is effectively depressurizing the NCOS and the pressure in the West LA sewers is generally low due to the NOTF scrubber.

Since the diversion of flow to the NOS, odor complaints have not risen around the NOS and the pressure has remained close to atmospheric.

There were significant and positive changes in the NORS and the ECIS due to the NOS diversion and the presence of the ATFs. Average pressures in the NORS have declined steadily and have stayed close to atmospheric. Flow management will continue to be used to balance sewer headspace and therefore air pressure throughout this area.

RECOMMENDATIONS/CONSIDERATIONS

- Continue to monitor pressure and hydrogen sulfide levels in this area
- Control air flow dynamics through sewer flow management
- Continue monitoring the NOS and NCOS in the vicinity of the airline connection between these two sewers
- Continue monitoring the WLAIS and WRS for any increase in pressure
- Continue to monitor the effectiveness of the Jefferson and La Cienega ATF and the 6000 Jefferson ATF

8.4 AOC4 - East Valley Area - AVORS-EVRS-VORS-NHIS-NOS

INTRODUCTION

The significant sewers in the East Valley Area are the Additional Valley Outfall Relief Sewer (AVORS), the East Valley Relief Sewer (EVRS), and portions of the North Outfall Sewer (NOS) and the Valley Outfall Relief Sewer (VORS), and the North Hollywood Interceptor Sewer (NHIS). These outfall sewers were tested to locate any high gas pressure and to determine the cause.

Effluent from the Tillman Water Reclamation Plant (TWRP) flows through these sewers. The TWRP does not treat biosolids but instead returns it to the sewer system to be conveyed to the Hyperion Treatment Plant. The concentrated biosolids initially travel through AVORS then through the EVRS and the NOS to the Toluca Lake area. At the intersection of Valley Spring Lane and Forman Avenue, this flow is split between the La Cienega/San Fernando Valley Relief Sewer (LCSFVRS) and the NOS on its way to Hyperion. The high concentration of biosolids causes the sewage to produce excessive H_2S, leading to odor problems.

Several previous recommendations have been implemented that have reduced gas pressure and hydrogen sulfide concentrations in the area. The construction of a carbon scrubber at the Radford Siphon in Studio City and the addition of magnesium hydroxide to the sewer system at the TWRP are two measures that have had significant benefit. Diverting flow from the Forman Avenue Sewer to the NOS lowered gas pressure in the Forman Avenue Sewer, reducing odor complaints in this area. Furthermore, a trap maintenance hole on the Forman Avenue Sewer was removed, allowing backed-up gas to flow downstream, greatly reducing gas pressure.

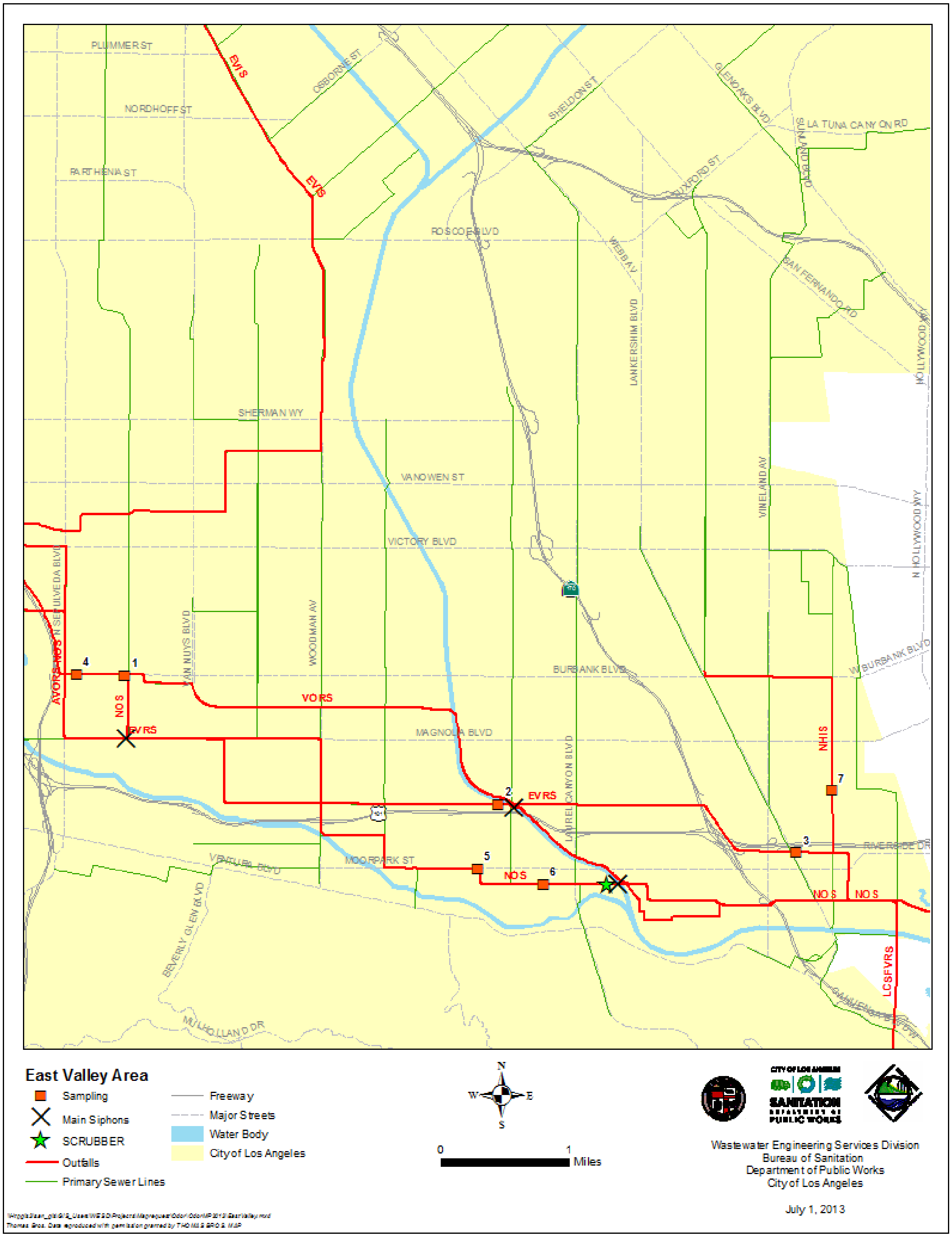
This report discusses the gas pressure testing performed on sewers in this area in March of 2013. It discusses the analysis of the data, and provides some conclusions and recommendations. Table 8.4 provides a list of the monitoring locations and Figure 8.4 shows these locations on a map.

EAST VALLEY TEST RESULTS

TABLE 8.4

ID	LOCATION	STRUCT. NO.	SEWER	PRESSURE (AVG. IN-WC) 2013	2012	2011	H_2S Avg/max (ppm)	FLOW (cfs)
1	Burbank & Kester	42912083	VORS	0.12	0.13	0.11	-	11
2	Riverside & Whitsett (Siphon)	44203172	EVRS	0.14	0.10	0.11	3/39	46
3	Riverside & Lankershim	44306176	EVRS	0.20	0.28	0.24	1/17	46
4	Burbank E/O Sepulveda	42911080	NOS	0.05	-0.03	0.05	-	5
5	Moorpark & Bellair	44207032	NOS	0.06	0.02	0.07	3/11	16
6	Woodbridge & Laurel Grove	44208090	NOS	0.06	0.05	0.04	5/18	16
7	Cahuenga & Huston	44303148	NHIS	0.20	0.24	0.15	-	4

TESTING LOCATIONS



DATA ANALYSIS

The VORS has not historically been a problem except for one area near the intersection of Burbank Boulevard and Sepulveda Boulevard. This was the area tested for this sewer. Location 1 at Burbank Boulevard east of Sepulveda had an average pressure of 0.05 inches of water, compared to -0.03 in 2012. Downstream on the VORS at location 2, the average pressure was 0.14 in.-wc compared to 0.13 in.-wc in 2012.

Not to scale

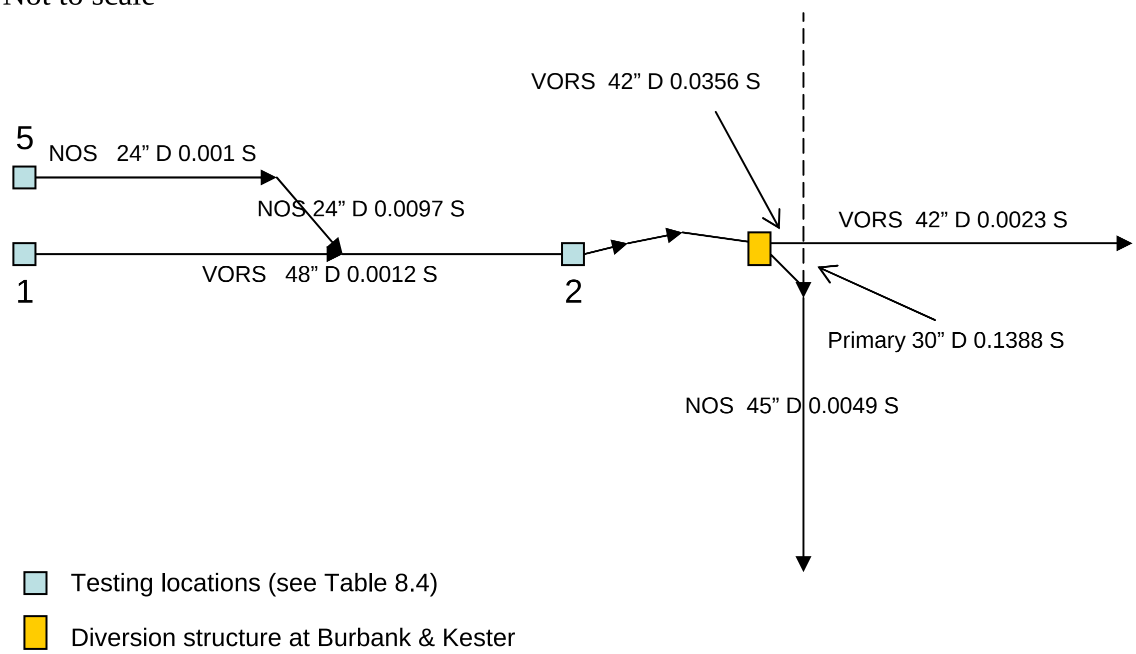


FIG. 8.4.1

The NOS has had no ventilation problems for several years due to low flow levels and the benefit of the scrubber at the Woodbridge Siphon. The average pressure at Laurel and Woodbridge was at 0.06 in.-wc, comparing to last year's data of 0.05 in-wc.

Two test locations were selected on the EVRS because they showed moderate to high pressure readings in the previous years. The location upstream of the Riverside and Whitsett siphon had an average pressure 0.14 in.-wc, up from last year's (0.11 in.-wc). The second location, approximately 3 miles downstream at Riverside and Lankershim, had an average pressure of 0.20 in.-wc, which is slightly down from last year (0.24). The pressure at this location has been increasing since 2006.

The NHIS flows into the EVRS at the intersection of Cahuenga Blvd. and Riverside Blvd. Sewer pressure was measured at Cahuenga and Huston (Location No. 12). The average pressure was 0.20 which is slightly down compared to last year's pressure of 0.24 inches. The existing pressure in this reach is mainly due to back pressure from the EVRS.

CONCLUSION

The diurnal pressure in the East Valley area has remained consistent for the last 3 years. There are no significant, nor persistent odor complaints in the area tested.

RECOMMENDATIONS/CONSIDERATIONS

- Continue to monitor pressure and H_2S levels in this area
- Control air flow dynamics through sewer flow management
- Continue monitoring pressures on the EVRS, the NHIS, and the VORS
- Seal maintenance holes where necessary

9.0 AREAS OF STUDY

9.1 AOS1 - Coastal Interceptor Sewer (CIS)

INTRODUCTION

The Coastal Interceptor Sewer (CIS) is the major outfall serving Venice Westchester area. This area is relatively mountainous in the north, around Pacific Palisades, and relatively flat through Santa Monica and Venice to the south.

The CIS originates at Los Angeles County Sanitation District No. 27. It then follows the coastline along the Pacific Coast Highway, south easterly through Pacific Palisades, to a siphon just upstream of the City of Santa Monica. The CIS serves the coastal area of the Santa Monica Bay north of the HTP to Topanga State Beach near Malibu. This sewer conveys wastewater directly to the HTP from Pacific Palisades, Venice, Mar Vista, the City of Santa Monica, and adjacent areas (such as Marina Del Rey) served by the Los Angeles County Sanitation District no. 27. The CIS is a circular pipeline that ranges in diameter from 24 to 72 inches and is approximately 9.4 miles in length. It is constructed of vitrified clay pipe and reinforced concrete lined with polyvinyl chloride (PVC).

The Venice Pumping Plant is the largest pumping plant in the wastewater collection system, and the only pumping plant located on one of the wastewater collection system outfalls. The Venice Pumping Plant is located at the south end of Venice on the CIS, at Hurricane Street and the Grand Canal. The pumping plant was constructed in 1958, and modified in 1987 and again in 1997 to increase its capacity and reliability. The pumping plant currently has a theoretical capacity of 99 cfs with four pumps operating and one pump on standby. The pumping plant discharges into the CIS through a 48-inch-diameter force main extending south across the Marina Del Rey harbor entrance channel.

TEST RESULTS

Table 9.2

ID	LOCATION	STRUCT. NO.	SEWER	2013	2012	2011	FLOW (cfs)
1	PCH	52115199	CIS	-0.04	-0.05	-	6
2	PCH	53203005	CIS	-0.05	-0.03	-0.05	5
3	PCH & Entrada	53203016	CIS	-0.03	-0.03	-	5
4	PCH	53203029	CIS	0.00	-	-0.01	10
5	Main St (Santa Monica)	53314073	CIS	0.00	-	-0.02	-
6	Main St (Santa Monica)	53314037	CIS	0.00	0.01	-	-
7	Via Dolce R/W	56111066	CIS	0.00	0.00	0.01	-
8	Vista Del Mar	56208041	CIS	-0.20	-0.23	-0.67	55
9	Vista Del Mar	56313039	CIS	-0.21	-0.25	-0.67	55

DATA ANALYSIS

Instantaneous pressure readings were taken along the CIS on July 24th, 2013 between 10:00 AM and noon. Pressures were generally negative at the upstream reach and very negative at the downstream reach of the CIS.

CONCLUSION

The test shows that there is no sewer gas pressure in this area.

RECOMMENDATIONS/CONSIDERATIONS

- Continue to monitor this area for pressure and hydrogen sulfide
- Control air flow dynamics through sewer flow management by manipulating sewage flow through various sewers

TESTING LOCATIONS

FIG. 9.2

9.2 AOS2 - Harbor Area

INTRODUCTION

This section discusses the pressure test conducted in the Harbor Area Primary Sewer System in July 29th of 2013. There are four interceptor sewer systems in the Harbor area that convey the wastewater generated in this area to the Terminal Island Treatment Plant. The interceptor sewer systems are named after their respective force mains through which their flow is pumped to the TITP.

Fries Avenue Interceptor Sewer System (FISS), consists of three major pumping plants and their respective interceptor sewers, all of which serve the community of Wilmington. The FISS also serves various industrial dischargers, some of which are on Harbor Department property.

Terminal Way Interceptor Sewer System (TISS) collects and transports wastewater from the San Pedro area to the TITP. The TISS also serves the industrial area south of 22nd Street and Terminal Island. The main pumping plant on this system is the Terminal Way Pumping Plant.

San Pedro Interceptor Sewer System (SPISS) serves the residential areas of San Pedro and Wilmington and the industrial area consisting primarily of the Phillips Conoco Refinery. It also serves some industrial discharges located on Harbor Department property.

A supplement to this system allows all flows from the FISS to be diverted to the San Pedro Pumping Plant. The only exception to this is that the flow from the Harris Avenue Pumping Plant remains tributary to TITP via the Fries Avenue Force Main. The “U.S. Navy Sewer System and Facility” consists of four separate force mains (two 6”, one 12”, and one 20”), a pumping plant, and collector sewers that used to serve the U.S. Navy facility on Terminal Island. After the decommissioning of the Navy’s facility, the City of Long Beach took over the assets of the US Navy Sewer System and Facility that deliver the wastewater to the TITP.

TEST RESULTS

Table 9.3

ID	LOCATION	STRUCT. NO.	SEWER	2013	2012	2011	FLOW (cfs)
1	ALAMEDA N/O F ST	61311139	Harbor	0.00	0.02	0.012	-
2	MCFARLAND AV R/W	61311112	Harbor	0.00	0.01	0.015	-
3	HARRY BRIDGE BL	61313048	Harbor	0.00	0.00	No Access	-
4	JOHN S GIBSON	61908038	Harbor	0.00	0.00	-0.01	-
5	CHANNEL ST	61908083	Harbor	0.01	0.02	0.00	-
6	PACIFIC AV	62005014	Harbor	0.01	0.02	0.033	-
7	HARBOR BL	62009041	Harbor	0.01	0.015	0.02	2.17
8	PACIFIC AV	62516010	Harbor	0.00	0.00	0.00	0.5
9	CRESCENT AV R/W	62401114	Harbor	0.01	0.013	0.012	0.5
10	HARBOR BL R/W	62013030	Harbor	0.00	0.00	0.01	-

DATA ANALYSIS

Instantaneous pressures were taken on July 31, 2013 between 10:40 AM and 11:40 AM. Pressures varied between 0.00 and 0.01. This is similar to previous years with pressure hovering close to atmospheric level.

CONCLUSION

The test indicated that sewer gas pressure in this area is near atmospheric levels and is not a problem.

RECOMMENDATIONS/CONSIDERATIONS

- Continue to monitor this area for pressure and hydrogen sulfide
- Control air flow dynamics through flow management when necessary.

TESTING LOCATIONS

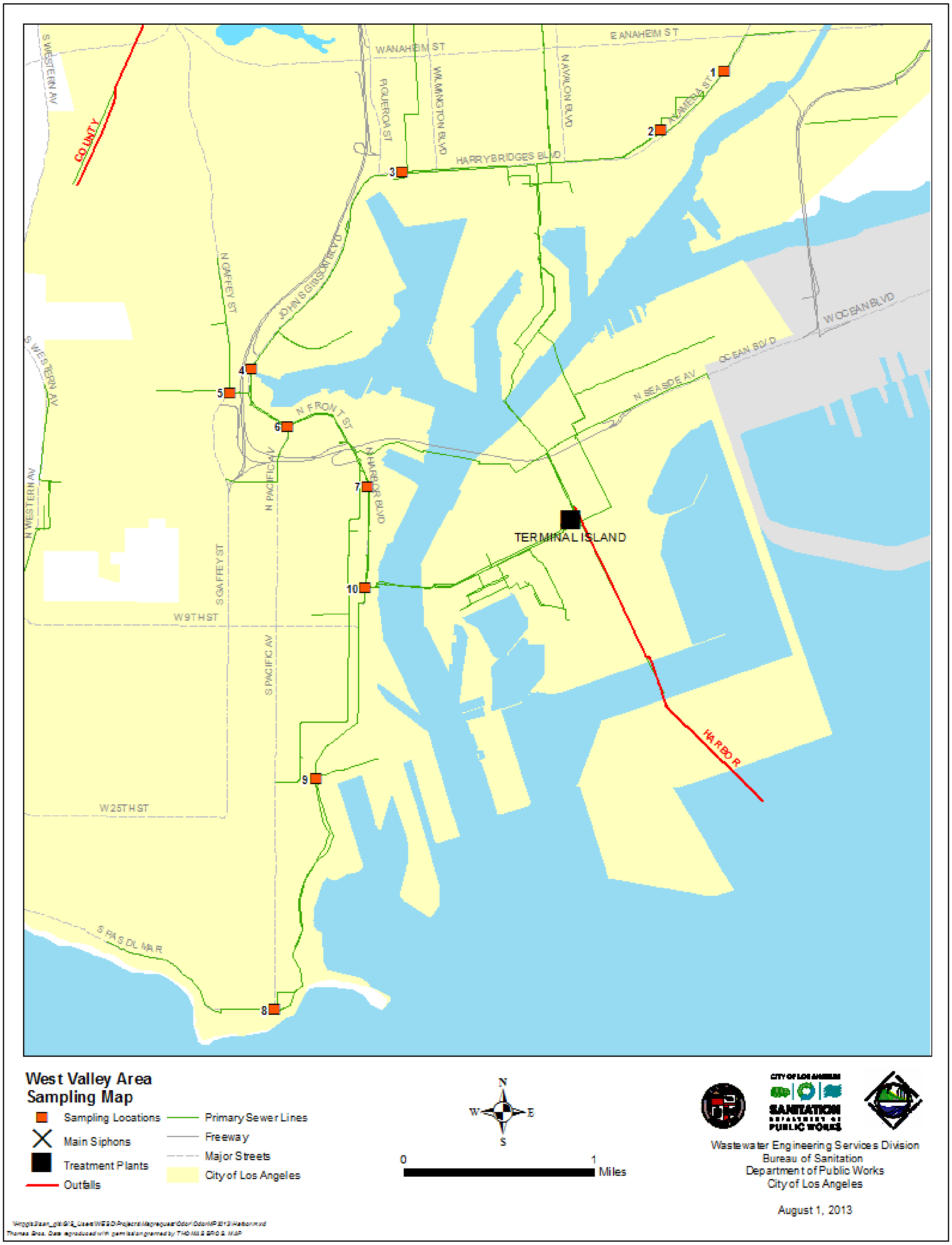


FIG. 9.3

9.3 AOS3 - West Valley Area

INTRODUCTION

This section discusses the instantaneous pressure test conducted in the West San Fernando Valley sewers in July of 2013 between 9:45 and 11:15 am. Wastewater generated in the west valley is conveyed to four interceptor sewers: the North Outfall Sewer (NOS), the Valley Outfall Relief Sewer (VORS), the Additional Valley Outfall Relief Sewer (AVORS), and the East Valley Interceptor Sewer (EVIS). Most of the wastewater flow is routed to the Tillman Water Reclamation Plant (TWRP).

TEST RESULTS

Table 9.4

ID	LOCATION	STRUCT. NO.	SEWER	2013	2012	2011	FLOW (cfs)
1	Vanowen & Etiwanda	39714176	VORS	0.02	0.0	-0.01	13
2	Victory E/O Etiwanda	43002139	AVORS	0.03	0.07	0.04	33
3	Woodman & Hart	39914195	EVIS	0.00	0.0	0.02	36
4	Victory & Haskell	42902209	EVIS	0.025	0.035	0.04	18

DATA ANALYSIS

Pressures were generally near atmospheric levels in the VORS and EVIS sewers. Location 3 on the AVORS at Victory Bl. east of Etiwanda had the highest pressure of 0.03 in.-wc, which is still quite low. This location is upstream of a siphon, which is probably why pressures here were highest.

CONCLUSION

The test indicated that sewer gas pressure in this area is generally near atmospheric levels and is therefore not a problem.

RECOMMENDATIONS/CONSIDERATIONS

- Continue to monitor this area for any pressure and hydrogen sulfide.
- Control air flow dynamics through sewer flow management by manipulating sewage flow through various sewers.

TESTING LOCATIONS

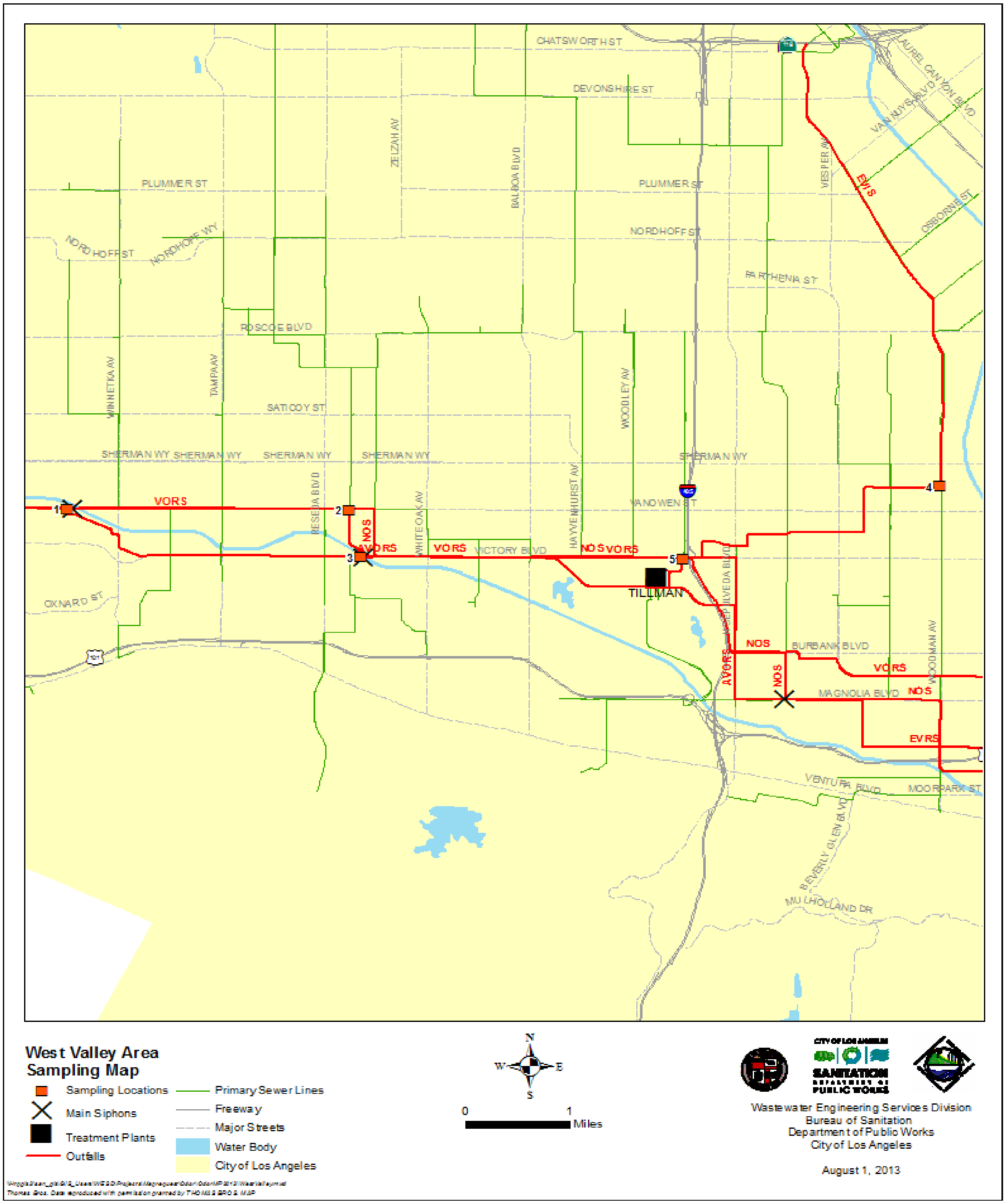


FIG. 9.4

10.0 RECOMMENDATIONS/CONSIDERATIONS

TABLE 10.1
ODOR CONTROL IMPLEMENTATION PLAN

	Short-term Plan	Intermediate Plan	Long-term Plan
East NOS Corridor	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management - Scrubber @ Gilroy Siphon (Completed) - Mission and Jesse ATF (On going)	- Continue to Monitor - Flow Management - Mission and Jesse ATF
La Cienega / San Fernando Corridor	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management - Upgrade Trap MHs	- Continue to Monitor - Flow Management
Baldwin Hills / Culver City Area	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management - Upgrade Trap MHs	- Continue to Monitor - Flow Management - Upgrade Trap MHs
East Valley Area	- Flow Management - Continue pressure and H_2S monitoring on EVRS/NHIS and VORS - Seal MHs where necessary	- Continue to Monitor - Flow Management - Upgrade Trap MHs	- Continue to Monitor - Flow Management - Upgrade Trap MHs
South Los Angeles	- Continue to Monitor - Flow Management - Upgrade Trap MHs	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management
Coastal Interceptor Sewer (CIS)	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management - Upgrade Trap MHs
Harbor Area	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management
West Valley Area	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management	- Continue to Monitor - Flow Management - Upgrade Trap MHs
Odor Hotline Outreach	On-going	On-going	On-going

TABLE 10.2
ODOR CONTROL PROJECT/PROGRAM COST

Title	Estimated Cost ($)	Estimated Completion Date
Construction of Mission & Jesse ATF	16,000,000	6/2014
Atwater Village Sewer Odor Mitigation Plan (HC Traps)	740,000	1/2014
Chemical Treatment Application	3,500,000/yr	On-going
Carbon for 13 Odor Control Units	1,600,000/yr	On-going
Trap Maintenance Hole Program	3,100,000	2013
Outreach	50,000/yr	On-going
Odor Control – Future	500,000/yr	On-going

Source: WCIP Project Description and 10-Year Expenditure Plan 2011/12 – 2021/22