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TECHNICAL ASSESSMENT DOCUMENT:

POTENTIAL CONTROL STRATEGIES TO REDUCE EMISSIONS FROM REFINERY WASTEWATER COLLECTION AND TREATMENT SYSTEMS

MAY 2004

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TABLE OF CONTENTS

I. SUMMARY 1
A. Scope of Technical Assessment 1
B. Findings 1
1. Emission Inventory 1
2. Potential Control Strategies 2
3. Cost and Cost-Effectiveness 3

II. RECOMMENDATIONS 4
A. Changes to Emission Inventory 4
B. Control Measure Development 4
C. Areas of Future Further Study 4

III. INTRODUCTION 6
A. Background 6
B. Existing Regulations 6
1. District Regulation 8, Rule 8 6
2. District NSR Requirements 7

IV. REVIEW OF OTHER EXISTING REGULATORY REQUIREMENTS 9
A. U.S. EPA Requirements for Wastewater Streams 9
B. Wastewater Regulations in Other California Air Districts 10
C. Comparison of the BAAQMD Regulation 8, Rule 8 to Other Wastewater Rules 11

V. DESCRIPTION OF WASTEWATER COLLECTION AND TREATMENT SYSTEMS 12
A. Process Background 12
B. Refinery Wastewater Collection Systems 12
C. Refinery Wastewater Treatment Systems 14

VI. SCOPE OF TECHNICAL ASSESSMENT 16
A. Scope of Technical Assessment 16
B. Future Work 16

VII. METHODS AVAILABLE FOR ESTIMATING EMISSIONS FROM WASTEWATER COLLECTION SYSTEMS 18
A. Source Testing 18
B. Material Balance 19
C. Emission Modeling 19
1. WATER9 20
2. TOXCHEM+ 20
D. Factors Influencing VOC Emissions from wastewater Systems 21

VIII. SOURCE TESTING AND SAMPLE ANALYSIS ACTIVITIES 22
A. Overview 22
B. Site Visits 22
C. Source Tests 23
1. Sampling Plans 23
2. Sampling Protocols 24
3. Field Sampling 24
D. Sample Analysis 25
1. Wastewater samples 25
2. Air samples 27
E. Quality Assurance and Quality Control 27
1. Sample collection 27
2. Sample analysis 27

IX. EMISSION MODELING 29
A. TOXCHEM+ Emission Modeling 29
B. Model Inputs 29
1. Wastewater Collection System Layout 29
2. Wastewater Flow Parameters 31
3. Wastewater Composition 32
C. Emission Contribution from Other Wastewater Collection Components 34
D. Factors Influencing Emission Calculations 34

X. EMISSIONS FROM WASTEWATER COLLECTION SYSTEMS 35
A. Existing VOC Emission Inventory for Refinery Wastewater Systems 35
B. Estimated Emissions from Refinery Drains and Junction Box Vents 35
C. Comparison of TAD Emission Estimates to Existing District Inventory 36
D. Comparison of TAD Emission Estimates to Other Emission Estimates 36

XI. POTENTIAL CONTROL STRATEGIES 38
A. Equipment Control Strategies 38
1. Water Seals 38
2. Inspection and Maintenance Programs 40
3. Vent Control Devices 42
4. Performance Based Standards 43
5. Hard Piping 43
B. Pollution Prevention Strategies 44
1. Pollution Prevention Programs 44

XII. POTENTIAL CONTROL STRATEGY COSTS AND COST-EFFECTIVENESS 46
A. Control Costs 46
1. Water Seals on Drains 46
2. Water Seals on Junction Box Vents 48
3. Other types of Vapor Recovery and Control Equipment 49
4. Performance Based Standards 50
5. Hard Piping 50

B. Control Cost-Effectiveness 50
1. Overall Cost-Effectiveness 51
2. Incremental Cost-Effectiveness for Water Seals on Drains 51
3. Incremental Cost-Effectiveness for Water Seals on Junction Box Vents.....52

XIII. REFERENCES 53

APPENDICES

A. Bay Area Air Quality Management District:
Regulation 8, Rule 8 (Emissions of Volatile Organic Compounds (VOC) from Wastewater Separators)

B. United States Environmental Protection Agency New Source Performance Standards For Refinery Process Drains (40CFR60.692-2)

C. South Coast Air Quality Management District:
Rule 1176 (VOC Emissions from Wastewater Systems)

D. San Joaquin Valley Unified Air Pollution Control District
Rule 4625: (Wastewater Separators)

E. Refinery Specific Site Visit Information

F. Refinery Sampling Plans

G. Correspondence between U.S. Environmental Protection Agency and California Air Resources Board staff regarding Wastewater Methodologies

H. Refinery Wastewater Laboratory Analysis

I. Predicting VOC Emissions from Wastewater Processes Using General Fate Models

J. Comparison of General Fate Models WATER9 and TOXCHEM+

K. Calculating VOC Emissions from Wastewater Collection Using WATER9 and TOXCHEM+

L. Explanation on the Use of Surrogates and Surrogate Selection for Modeling

M. Description of Methodology Used to Determine Cost Estimates

I. SUMMARY

As part of the San Francisco Bay Area 2001 Ozone Attainment Plan for the 1-Hour National Ozone Standard (2001 Plan), the staffs of the Bay Area Air Quality Management District (District) and the Air Resources Board (ARB or Board) have completed an initial assessment of the wastewater systems for the Bay Area refineries. This assessment was conducted to determine whether there are significant potential emission reductions from control of uncontrolled components of refinery wastewater collection systems. The assessment examined the wastewater system for the refineries to identify the potential for further VOC emission reductions from drains and junction box vents. This technical assessment document (TAD) presents the findings of this assessment.

A. Scope of Technical Assessment

Refinery wastewater collection and treatment (wastewater) systems are large systems that encompass an entire facility, which can span hundreds of acres. They serve every unit in operation at a refinery, and because of the unique layout of each refinery, each wastewater system is different. Because of the significant resources necessary to evaluate every portion of each refinery wastewater system, and the limited resources available, the scope of this report is limited to only a portion of the refinery wastewater system. This TAD includes data from estimation and direct measurement of refinery VOC emissions from collection components, specifically drains, junction box vents and manholes used in the refinery wastewater system. Emission estimates from treatment components, e.g. biological reactors and clarifiers, were not performed. However, study of treatment systems is recommended for further study.

B. Findings

Based on this assessment, several potential control strategies have been identified for further evaluation for potential rulemaking.

1. Emission Inventory

Prior emission inventory estimates suggested that District-wide refinery wastewater collection and treatment systems emitted about 4 tons per day (tpd) of VOCs. This inventory includes VOC emissions associated with the oil/water, or API separator, fugitive emissions from drains, vents and manholes, and in some cases, VOC emissions from the wastewater treatment system. These wastewater treatment systems include aerators, biological oxidation systems, marshes and settling ponds. This VOC emission estimate includes 2.6 tpd from the collection systems – drains, manholes, junction box vents, and sewer reaches and 1.4 tpd from wastewater treatment systems. These are the 2001 estimated emissions as reported from District.

This TAD does not provide a complete quantification of wastewater VOC emissions from the collection and treatment system. Therefore, it is not possible to directly compare the prior District emission inventory figures to those estimates provided as part of this TAD. However, based on the analytical work performed as part of this TAD, it is estimated that wastewater collection drains, junction box vents, and manholes contribute at least 3.3 tpd to District VOC emissions. It should be noted that, significant amounts of diesel range materials were found in the wastewater samples and the emission significance of these materials has not been established as part of this TAD. It is recommended that determination of the emission impact from diesel range components in the wastewater be included in future studies.

2. Potential Control Strategies

Based on this assessment, two types of potential control strategies to control emissions from wastewater collection systems have been identified. These can be grouped into two types:

- Equipment Control
- Pollution Prevention

Equipment control strategies are those that require the installation of new equipment or devices, or can include physical changes to the wastewater system. Potential equipment control strategies applicable for refinery wastewater systems include:

- installing water seals on vents and drains open to the atmosphere can provide 1.8 tpd of VOC emission reductions
- sealing manholes open to the atmosphere can provide 0.32 tpd of VOC emission reductions
- collecting and venting the emissions to a control device,
- setting performance based standards (such as an emission limit), and
- enclosing open weirs and lines with direct piping (also called hard piping).

Refineries in the District currently employ some of these control strategies. For instance, of the nearly 11,800 wastewater drains at refineries in the District, about 3,200, or 27 percent, are controlled with water seals. Also, several refineries use other types of control devices, such as: carbon adsorption, venturi-type scrubbers, collection and venting of wastewater gases to the refinery flare system. These devices are typically used to control benzene emissions from District refinery wastewater streams like wastewater from crude desalting units.

Pollution Prevention strategies are designed to reduce the source of the VOC emissions through changes in the operation of the refinery, as opposed to controlling the emissions with equipment.

Additional measures, such as the use of inspection and maintenance programs, can further serve to reduce emissions from wastewater collection systems. Such types of inspection and maintenance programs are common at refineries within the District for other source categories (i.e., fugitive emissions from valves and flanges). However, they are not currently used with wastewater systems.

3. Cost and Cost-Effectiveness

Equipment control strategy costs can vary greatly. Installing water seals on drains can cost between $400 and $1000 per drain, with each refinery potentially needing 500 to 4,800 of these devices. Control costs for manholes are in the same range as drains, $400 to $1000 per manhole. There are over 5800 refinery manholes in the district. However, many manholes are sealed or in areas with no VOC emission potential. Control costs for water seals on junction box vents are more expensive, between $2,000 and $2,500 per unit, but fewer are needed. It is estimated that approximately 2000 refinery wastewater junction box vents need to be controlled District wide. In addition, it is likely that any control strategy based on minimized venting of wastewater collection system gases will require an inspection program, with a dedicated refinery inspector. This inspector would be a refinery employee, costing each refinery about $65,000 per year.

The estimated annual costs to control the uncontrolled refinery wastewater collection system emissions within the District range from approximately $1.5 million to $3.3 million dollars. These are total capital costs annualized over ten years and include the costs for a dedicated, regular inspection and maintenance program. These costs translate into an estimated overall cost-effectiveness of $1,900 to $4,200 per ton of VOC controlled.

Process control strategy costs are difficult to quantify since this strategy requires refinery operational changes. Either, in the way wastewater feeds the collection system, and/or how the wastewater system is operated. These process changes vary from refinery to refinery due to each refinery's unique operating characteristics. In many cases, these changes result in cost savings to the refinery operator by reducing raw material inputs or through reduced waste handling. Changes in process control can provide cost savings in addition to providing emission reductions. Refinery specific process control strategies, and their associated cost-effectiveness, were not calculated as part of this TAD, because of the difficulties in quantification of these costs, and the significant variability between refineries.

II. RECOMMENDATIONS

This chapter summarizes staff's recommendations based on the findings of this TAD.

A. Changes to Emission Inventory

It is recommended that the emission inventory for wastewater systems at petroleum refineries be updated pending the completion of all areas of study outlined in this report. In general, these changes would better characterize the VOC emissions from refinery wastewater systems, especially the contribution from process drains, wastewater collection system vents, and manholes. An assessment of the overall wastewater system emission inventory cannot be performed at this time without additional information.

B. Control Measure Development

It is recommended that the existing regulation (Regulation 8, Rule 8) pertaining to wastewater systems at refineries be considered for amendment. Potential amendments for evaluation should include new requirements for the wastewater collection components (process drains, vents, manholes, and open sewers) of wastewater systems. Similar provisions already exist within the South Coast Air Quality Management District's Rule 1176, VOC Emissions from Wastewater Systems, and U.S. EPA New Source Performance Standards.

C. Areas of Future Further Study

As discussed in more detail in Chapter V, it is recommended that other components of the wastewater system be evaluated. Potential future areas of further study should include:

- Monitoring and characterization of VOC emissions from the wastewater collection system caused by heavier hydrocarbons, i.e., diesel fuel, fuel oils, etc.
- Monitoring and characterization of emissions from oil-water, or API, separators.
- Investigation of other wastewater treatment components, including
  - Equalizer basins
  - Clarifiers
  - Biological treatment basins
  - Sludge handling processes

These areas are potential sources of additional VOC emissions not determined by this TAD. Also, emissions from these refinery areas may not be accurately reflected or captured in the current District VOC emission inventory.

The lack of information on current manhole and junction box vents at each facility required the emission estimates for these components to be based on data previously submitted by each refinery in 1999. It is recommended that a new inventory of manholes and junction box vents be compiled at each refinery. This information and the wastewater data collected as part of TAD can be used to revise refinery emission inventories for each District refinery.

Although not specifically part of the wastewater system, it was observed that coke cutting operations at some facilities generated significant quantities of oily wastewater and steam at elevated temperatures. This wastewater is often recycled for future use in the coke cutting operation and not sent to the wastewater collection and treatment system. However, there do not appear to be any VOC controls on these potential sources of VOC emissions. It is recommended that the use of water for coke cutting operations be evaluated as a potential source of additional VOC emissions.

III. INTRODUCTION

This chapter provides background information on the requirements to conduct a technical assessment of refinery wastewater systems, and a description of existing District rules and regulations applicable to refinery wastewater systems.

A. Background

On November 1, 2001, the ARB approved the 2001 Plan as a revision to the State Implementation Plan (SIP). The District prepared the 2001 Plan because the Bay Area failed to attain the federal ozone standard by its 2000 deadline. The 2001 Plan contains control strategies with seven new stationary source control measures, five new transportation control measures, and eleven further-study measures. Five of the stationary source control measures, and 4 of the further-study measures concern refinery operations. The new measures and on-going programs will provide 271 tons per day of combined volatile organic compound (VOC) and oxides of nitrogen (NOx) emission reductions between 2000 and 2006.

One of the further-study measures identified in the 2001 Plan is Further Study Measure 9 (FS-9), Refinery Wastewater Systems. As part of FS-9, the District, in cooperation with the ARB and the United States Environmental Protection Agency (U.S. EPA), is to examine the wastewater system for each of the Bay Area refineries to determine whether there are significant potential emission reductions that could result from control of any remaining uncontrolled components of the wastewater system, or through other measures. This study would examine the wastewater system for each refinery to identify both means and costs for further VOC emission reductions from each wastewater system.

B. Existing Regulations

Within the District, some components of refinery wastewater systems are already controlled through compliance with District Regulation 8, Rule 8 (Wastewater Separators), District New Source Review (NSR) requirements, and U.S. EPA's National Emission Standard for Benzene Waste Operations (40 CFR Part 61, Subpart FF).

In addition, several other air pollution control districts (APCD) and air quality management districts (AQMD) in the State have adopted rules and regulations to control VOC emissions from refinery wastewater systems.

1. District Regulation 8, Rule 8

Regulation 8, Rule 8 is designed to limit the emissions of VOCs from wastewater (oil/water) separators, forebays, air flotation units which remove floating oil, floating emulsified oil, or other liquid VOCs. A copy of Regulation 8, Rule 8 is provided in Appendix A.

The current requirements for wastewater separators are that the separation is done in gasketed or vapor tight tanks, external floating roof tanks with primary and secondary seals, or units equipped with a vapor recovery system that achieves 95 percent destruction efficiency. Typically, any emission leaks or seal gaps must be repaired within 15 to 30 days, depending on the type of incident. Regulation 8, Rule 8 has semi-annual inspection requirements for gaskets and seals on wastewater separators.

Other requirements of the rule pertain to slop oil vessels and air flotation tanks. Requirements for these types of units include gasketed covers (with less stringent gap requirements than for oil/water separators) or a vapor recovery system with a destruction efficiency of at least 70 percent. Regulation 8, Rule 8 does not have time requirements for repair of any emission leaks or seal gaps detected, but similar to oil/water separators, has semi-annual inspection requirements for gaskets and seals on these units.

Regulation 8, Rule 8 also requires that junction boxes be equipped with solid, gasketed covers or manholes. However, openings in the covers or manholes are permitted. There are no inspection requirements for manholes under Regulation 8, Rule 8.

Currently, Regulation 8, Rule 8 does not have provisions to control VOC emissions from some components in refinery wastewater collection systems, including drains, vents, and manholes which are a significant source of VOC emissions from the refinery wastewater system.

2. District NSR Requirements

Within the District, when an emissions source is installed or an existing source is modified, the District's NSR requirements must be met. NSR requires the use of the most stringent emission control device or technique, which is known as Best Available Control Technology (BACT). BACT is required for new or modified sources which have the potential to emit 10 pounds per day or more of VOC, carbon monoxide, oxides of nitrogen, particulate matter, and sulfur dioxide.

In the District, for refinery wastewater systems, BACT has only been identified for wastewater (oil/water) separators. The District BACT requirements for oil/water separators is provided below in Table III-1.

Table III-1:
District BACT Requirements for Wastewater (Oil/Water) Separators[1]

Flowrate (gallons per minute)	
Greater than or Equal to 250	**Less than 250**
Vapor-tight fixed cover and vented to vapor recovery system w/ combined collection and destruction/recovery efficiency of 95%	Vapor-tight fixed cover totally enclosing the separator tank liquid contents

1 Achieved in practice. More technologically feasible and cost-effective requirements may be available.

IV. REVIEW OF OTHER EXISTING REGULATORY REQUIREMENTS

This chapter discusses other regulatory requirements, both within California and at the federal level, which apply to refinery wastewater systems.

A. U.S. EPA Requirements for Wastewater Streams

The U.S. EPA has promulgated standards for both the emissions of VOCs and toxic compounds from refinery wastewater systems.

New Source Review (NSR) and New Source Performance Standards (NSPS) were components of the 1990 federal Clean Air Act Amendments (CAAA). Under the CAAA, the District is responsible for implementing NSR (the District's NSR program was described in the previous section). However, while the U.S. EPA does not implement NSR in the District, it does, at a minimum, require new facilities, expansions of existing facilities, or process modifications to meet lowest achievable emission rate (LAER) standards (these standards are often not as stringent as District BACT). The U.S. EPA has set minimum standards for LAER for petroleum refinery NSR in its NSPS, Title 40 CFR Part 60, including Subpart QQQ (Standards of Performance for VOC Emissions from Petroleum Wastewater Systems).

Under Title 40 CFR Part 60, Subpart QQQ, performance standards have been established for individual drain systems, including:

- Each drain shall be equipped with a water seal
- Junction boxes shall be equipped with a cover and may have an open vent
- Sewer lines shall not be open to the atmosphere
- Regular inspection and maintenance requirements.

Also under Title 40 CFR Part 60, Subpart QQQ, performance standards have been established for closed vent systems and control devices, including:

- Any control device shall operate with an efficiency of 95 percent or greater to reduce VOC emissions vented to them
- All control devices shall be operated with no detectable emissions, as indicated by an instrument reading of 500 parts per million VOC above background.

A copy of these requirements is provided in Appendix B.

The National Emission Standards for Hazardous Air Pollutants (NESHAP)[1] for refineries were promulgated in August 1995. These regulations are applicable at refineries that emit 10 tons per year (tpy) of any one hazardous air pollutant (HAP), or 25 tons per year

[1] Petroleum Refinery MACT Standard Guidance, EPA/456-B-00-001

or more of total HAPs. The refineries in the District meet this threshold requirement and are subject to the refinery NESHAP requirements.

Under Title 40, CFR, Part 61, Subpart FF, the benzene NESHAP regulations require, among other things, that petroleum refineries use maximum achievable control technology (MACT) to control emissions of benzene from waste operations, including certain wastewater systems. Typically, refineries use carbon absorption or collection and venting of wastewater gases to the refinery flare system (vent flap system) to control benzene emissions from wastewater systems in compliance with the refinery NESHAP requirements.

B. Wastewater Regulations in Other California Air Districts

In addition to the District's Regulation 8, Rule 8, within California, other AQMDs have adopted regulations to control emissions from refinery wastewater systems.

Rule 1176 (VOC Emissions from Wastewater Systems) in the South Coast AQMD is designed to limit VOC emissions from the wastewater system. In general, Rule 1176 is more stringent than Regulation 8, Rule 8. This is because not only does Rule 1176 specify requirements for wastewater separators, but also the entire wastewater collection system. A copy of Rule 1176 is provided in Appendix C.

For wastewater separators, Rule 1176 requires either a floating roof tank or a fixed roof tank vented to an air pollution control device that can achieve 95 percent VOC destruction efficiency. Rule 1176 has monthly inspection and maintenance requirements for wastewater separators.

For drain system components at refineries (which include process drains, manhole covers, and junction box or other system vents), the system must be a closed system. This requires the use of water seals on all process drains, and the enclosure of all sewer lines and junction boxes with solid, gasketed fixed covers or manhole covers. In addition, these components are subject to performance standard of no detectable leaks in excess of 500-parts-per-million (ppm) VOC. Depending on the type of drain system component, there are inspection and maintenance requirements that can be monthly, quarterly, semi-annual or annual.

Rule 4625 (Wastewater Separators) in the San Joaquin Valley Unified APCD is similar to the District's Regulation 8, Rule 8 in its applicability. This rule applies to wastewater separator units, air flotation units, and forebays. The rule is designed to limit VOC emissions from wastewater separators by requiring a solid cover, a floating pontoon or double-deck cover, or a vapor loss control device that has at least 90 percent control efficiency. There are no specific provisions for junction boxes, nor provisions for an inspection and maintenance program. A copy of Rule 4625 is provided in Appendix D.

C. Comparison of the BAAQMD Regulation 8, Rule 8 to Other Wastewater Rules

In general, Regulation 8, Rule 8 is less stringent than both the SCAQMD Rule 1176 process drain standards and the U.S. EPA's NSPS standards for drain systems. In addition, the District has also not established BACT standards for process drains at industrial facilities, including refineries.

As discussed above, Regulation 8, Rule 8 does not have provisions to control refinery process drains. The SCAQMD requires all refinery process drains to have, at a minimum, water seals (which are estimated by the SCAQMD to achieve a 65 percent emission control efficiency) and comply with a prescriptive inspection and maintenance program. This requirement is similar to the U.S. EPA's NSPS standard as well for new drains. The SCAQMD also requires the process drains and junction box vents to meet a 500-ppm VOC performance standard. However, for junction boxes, Regulation 8, Rule 8 is similar to both Rule 1176 and the NSPS standards in that they must be closed and gasketed, with allowances for vents.

The provisions for wastewater treatment systems, including API and oil/water separators in Regulation 8, Rule 8 and Rule 1176 in the SCAQMD are similar in their stringency, and both are more stringent than the wastewater system rule currently effective in the San Joaquin Valley APCD. Provisions for control of emissions from wastewater treatment systems by the U.S. EPA were not evaluated. It is important to note that refinery wastewater treatment systems were not evaluated as part of this TAD.

V. DESCRIPTION OF WASTEWATER COLLECTION AND TREATMENT SYSTEMS

This chapter describes the types of components that are contained in refinery wastewater systems in the Bay Area[2]. These components are segregated into two types: wastewater collection systems and wastewater treatment systems.

A. Process Background

Refineries are industrial facilities that process crude oil or unfinished petroleum derivatives into motor gasoline, naphtha, kerosene, jet fuels, distillate fuel oils, residual fuel oils, lubricants, or other petroleum products. During this refining process, a significant quantity of industrial wastewater is produced. This wastewater typically passes through a complex series of on-site collection and treatment units. Many of these collection and treatment units are open to the atmosphere and allow for volatilization of VOCs from the wastewater. Final discharge for Bay Area refineries is to a receiving water body, e.g. San Pablo or Suisun Bays. A block flow diagram of a typical refinery wastewater system is shown below in Figure V-1.

B. Refinery Wastewater Collection Systems

This section describes typical components of refinery wastewater collection systems. Because of the unique layout of the wastewater collection system at each refinery, all of the components described below may not be present at each refinery.

Process drains normally are the point in the wastewater collection system where streams from the various sources throughout a given process area are normally introduced. Drains may be designed as a trapped or untrapped device, i.e. with or without a water seal. Individual drains are usually connected directly to the main process sewer line. However, they may also drain to trenches, sumps, or ditches.

Manholes are service entrances into sewer lines that permit inspection and cleaning of the sewer line. They are normally placed at periodic lengths along the sewer line. They may also be located where sewers intersect (such as junction boxes) or where there is a significant change in direction, grade, or sewer line diameter. The opening is normally covered with a heavy cast-iron plate with two to four holes for ventilation and for cover removal.

Reaches are segments of sewer pipe that convey wastewater between two manholes or other sewer components such as lift stations or junction boxes.

[2] The information contained in this chapter is excerpted from the report Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment, Final Report, Prepared by the Eastern Research Group for the Point Sources Committee of the STAPPA/ALAPCO Emission Inventory Program, March 1997.

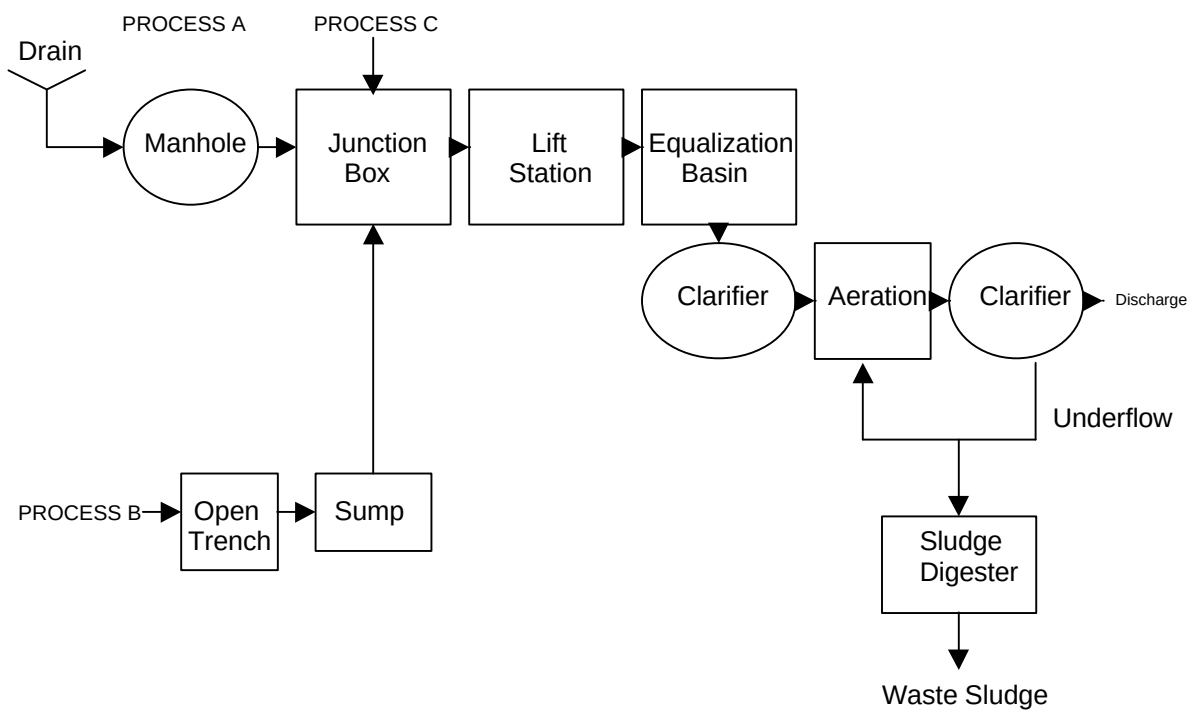
Junction boxes normally serve several process sewer lines. Process lines meet at the junction box to combine the multiple wastewater streams into one stream that flows downstream from the junction box. Liquid level in the junction box depends on the flow rate of the wastewater. They may also be water-sealed or covered and vented.

Weirs act as dams in open channels in order to maintain constant water level upstream. The weir face is normally aligned perpendicular to the bed and walls of the channel. Weirs provide some control of the level and flow rate through the channel.

Trenches are used to transport wastewater from the point of process equipment discharge to subsequent wastewater collection units such as junction boxes and lift stations. This mode of transport replaces the drain scenario as a method for introducing process wastewater into the downstream collection system. Trenches are often interconnected throughout the process area to accommodate pad water runoff, water from equipment washes and spill cleanups, as well as process wastewater discharges.

Sumps are typically used for collection and equalization of wastewater flow from trenches prior to treatment. They are usually quiescent and open to the atmosphere.

Figure V-1:
Typical Refinery Wastewater Collection and Treatment System



Source: Preferred & Alternative Methods for Estimating Air Emissions from Wastewater Collection & Treatment. Figure 5.2-1

Lift stations are usually the last collection unit prior to the treatment system, accepting wastewater from one or several sewer lines. The main function of the lift station is to provide sufficient pressure to transport the collected wastewater to the treatment system.

C. Refinery Wastewater Treatment Systems

This section describes typical components of refinery wastewater treatment systems. Because of the unique layout of the wastewater treatment system at each refinery, all of the components described below may not be present at each refinery.

Oil/Water separators, a.k.a. API separators, are the first step in the wastewater treatment plant. The purpose of these units is to separate liquid phases of different specific gravity; they also serve to remove free oil and suspended solids contained in the wastewater. Most of the separation occurs as the wastewater stream passes through a quiescent zone in the unit. Oils and scum with specific gravity less than water float to the top of the aqueous phase. Heavier solids sink to the bottom. Most of the organics contained in the wastewater tend to partition to the oil phase. For this reason, most of these organic compounds are removed with the skimmed oil leaving the separator and are typically sent to slop tanks for recovery.

Equalization basins are used to reduce fluctuations in the wastewater flow rate and organic content to the downstream treatment processes and may be covered, stirred, and/or aerated. Equalization of wastewater flow rate results in more uniform effluent quality from downstream settling units such as clarifiers. Biological treatment performance can also benefit significantly from the damping of concentration and flow fluctuations.

Dissolved Air Flotation (DAF)/Dissolved Nitrogen Flotation (DNF) tanks that use flotation to remove oils, grease, scum and solids remaining in the wastewater after the API separator. DAF/DNF tanks are equipped with surface skimmers to clear the water of floating oil deposits and scum prior to biological oxidation.

Clarifiers tanks located downstream of biological treatment that separate biomass and, in some cases, powdered activated carbon, from the wastewater. Clarifiers normally use gravity settling for separation, but flotation is used at one Bay Area refinery.

Biological treatment basins are large aeration basins where microorganisms metabolize organic compounds aerobically resulting in energy and biomass production. The aerobic environment in the basin is normally achieved by the use of diffused or mechanical aeration. This aeration also serves to maintain the biomass in a well-mixed regime.

Sludge digesters are used to treat organic sludges produced from various treatment operations. In aerobic digestion, the sludge is aerated for an extended period of time in

an open, unheated tank using conventional air diffusers or surface aeration equipment. The process may be operated in a continuous or batch mode.

Treatment tanks include biological treatment tanks and pH adjustment tanks that may be used for treatment of wastewater after and before biological treatment, respectively. Tanks designed for pH adjustment typically precede the biological treatment step. In these tanks, the wastewater pH is adjusted, using acidic or alkaline additives, to prevent shocking of the biological system downstream.

Surface impoundments are typically used for evaporation, polishing, equalization, storage prior to further treatment or disposal, leachate collection, and as emergency surge basins. They may be either quiescent or mechanically agitated.

Air and steam stripping may be used to remove organic constituents in wastewater streams prior to secondary and tertiary treatment devices. Air stripping involves the contact of wastewater and air to strip out volatile organic constituents. As the volume of air contacting the contaminated water increases, an increase in the transfer rate of the organic compounds into the vapor phase is achieved. Steam stripping is the distillation of wastewater to remove volatile organic constituents; with the basic operating principle being the direct contact of steam with wastewater. The steam provides the heat of vaporization for the more volatile organic constituents.

VI. SCOPE OF TECHNICAL ASSESSMENT

This chapter describes the scope of the TAD prepared for refinery wastewater systems in the Bay Area.

A. Scope of Technical Assessment

Refinery wastewater systems are large systems that encompass an entire facility that can span hundreds of acres. They serve every unit in operation at a refinery, and because of the unique layout of each refinery, each refinery wastewater system is different. In addition, unlike those refineries operating in the South Coast AQMD where effluent from the refinery is further treated at a publicly owned wastewater treatment facility, in the Bay Area, this effluent is further treated through biological means (marshes and ponds) and discharged directly into a marine environment. Some refineries complete treatment in tanks and do not use marshes or ponds.

Because of the significant resources necessary to evaluate every portion of each refinery wastewater systems and in consideration of available resources, the scope of this report is limited to a portion of the entire refinery wastewater system. This TAD involves estimation and direct measurement of refinery VOC emissions for the wastewater collection components of refinery wastewater systems; predominately composed of drains, manholes, reaches, and junction box vents.

The assessment included visiting each of the 5 refineries, determining the design of the individual refinery wastewater collection system, collecting 213 waste water samples and 19 air samples, and the use of models to estimate emissions to the atmosphere. These activities are described in greater detail in Chapters VIII and IX.

B. Future Work

For the next phase of the technical assessment of wastewater systems, it is recommended that the remaining work on the wastewater collection system be completed. This includes additional characterization of emissions from manholes and junction box vents with an evaluation of potential control strategies. Also, it is necessary to better characterize the emission contributions from heavier hydrocarbons in the wastewater stream, e.g., diesel fuel, fuel oils, etc. These materials are typically determined as the diesel fraction when performing a total petroleum hydrocarbon wastewater analysis, i.e. TPHd. These materials may be a major source of VOC emissions especially in those areas of the wastewater system that is above 100^0 Fahrenheit (37.8^0 Celsius).

Based on information gathered as part of this TAD, a number of areas have been identified as possible emissions sources for benzene. These include blow-down systems, temporary storage tanks and vacuum trucks. These systems are in need of

further study to determine compliance with current U.S. EPA standards and for inclusion in further emissions inventories.

Also as part of the next phase of the technical assessment, the treatment components of the wastewater system should be evaluated. This effort to continue the technical assessment of wastewater systems should occur during the next year, and should include an assessment of the oil-water, or API separators, as well as other wastewater treatment components. These units would include equalization basins or tanks, clarifiers, biological treatment basins, and sludge digesters.

In addition, while not specifically part of the wastewater system, during the refinery site visits it was observed that coke cutting operations at some facilities generated significant quantities of wastewater and steam at elevated temperatures. While this wastewater is often recycled for future use in the coke cutting operation and not sent to the wastewater collection and treatment system, there do not appear to be any existing VOC controls on these potential emissions. It is recommended that the use of water for coke cutting operations be evaluated in the future for the potential for additional emission reductions from this operation.

It is also recommended that components of the wastewater system that move wastewater “outside of the sewer system” also be evaluated. In particular, it is appropriate to evaluate the use of wastewater vacuum trucks and their impact on VOC emissions. Several refineries utilize these vacuum trucks to, among other activities, clean up spills and remove wastewater from catch basins. These activities have the potential to contribute to the overall emission inventory for wastewater at refineries, and are not captured in the current VOC emission inventory.

VII. METHODS AVAILABLE FOR ESTIMATING EMISSIONS FROM WASTEWATER COLLECTION SYSTEMS

Several methodologies exist to determine emissions from refinery wastewater collection systems. This chapter describes the available methodologies for estimating VOC emissions from wastewater systems[3]. District and U.S. EPA regulations require refineries to quantify emissions of volatile organic compounds (VOC) for all refinery areas including wastewater collection and treatment systems. Available methods include published emission factors, source testing, emissions determined by engineering mass balance equations, and general fate models (GFMs). This technical assessment document used two GFMs to calculated VOC emissions for individual refinery areas of each refinery. BACT/LAER emission factor equations published by U.S. EPA were used to confirm the overall accuracy of the GFM calculations.

A. AP-42, BACT/LAER, and API Drain Model

The typical method used to estimate VOC emissions is the use of emission factors and/or emission factor equations. The simplest method to estimate VOC emissions involves the use of an AP-42 emission factor. U.S. EPA data from industry specific source tests were used to determine AP-42 source specific emission rates. In the case of drains and manholes U.S. EPA estimates that these components emit 0.07lb/hr lbs. VOC per hour[4]. AP-42 assumes that all wastewater units, i.e., drains, manholes, and junction boxes emit at a fixed rate and therefore, is less accurate for variable process like refinery wastewater. The best available technology/lowest achievable emission rate (BACT/LAER) approach refines the AP-42 emission factor. A standard set of process parameters such as flow rate, chemical composition, and temperature are assumed[5]. BACT/LAER emission factor equations better approximate VOC emissions however these factors do not adjust for drain water seals. The American Petroleum Institute (API) drain model does model water sealed drains, however, it doesn't model open drains or other wastewater collection structures. For these reasons, BACT/LAER emission factor equations and the API drain model were only used to confirm this assessment's computer modeling calculations.

B. Source Testing

Source tests, i.e., field stack testing, can be used to determine the emissions of VOCs from each wastewater collection component. Air samples are collected from the various emission points in the wastewater collection system (drains, sumps, manholes, etc). These air samples are analyzed for VOC concentration. Other information such as

[3] Information contained in this chapter is excerpted from the report Preferred and Alternative Methods for Estimating Air Emissions from Wastewater Collection and Treatment, Final Report, Prepared by the Eastern Research Group for the Point Sources Committee of the STAPPA/ALAPCO Emission Inventory Program, March 1997.

[4] US EPA document, EPA-450/3-85-001a, February 1985, "VOC Emissions from Petroleum Refinery Wastewater Systems - Background information for Proposed Standards".

[5] U.S. EPA, Industrial Wastewater Volatile Organic Compound Emissions - Background Information for BACT/LAER Determinations. EPA 450/3-90-004. Research Triangle Park, NC. January 1990.

airflow rates for each sample point combined with the air sample concentrations is used to determine the emissions for each emission point in the wastewater collection system.

While this methodology is highly accurate in determining individual emission points of the refinery wastewater collection systems, it is not a practical methodology to use. Since the wastewater collection system consists of thousands of components at each refinery, this methodology is too time and resource consuming to be the sole methodology used to estimate emissions from wastewater collection systems. However, as discussed later, a limited and focused source-testing program can be used to provide valuable data necessary to confirm emission estimates derived from GFMs like WATER9 and TOXCHEM+.

C. Material Balance

The simplest estimation method to determine VOC emissions from wastewater collection systems is through material balance. These emissions are determined by production mass balance equations Using a material balance approach to calculate emissions from wastewater systems is straightforward if all input and output data are available and if the emissions estimate does not require extreme accuracy. Material balance calculations rely on wastewater flow rate, influent /effluent chemical concentrations, and characterization sludge disposal. Compound mass that cannot be accounted for in the effluent or sludge is assumed to be volatilized. However, the use of this methodology assumes that both the influent and effluent concentrations at each point in the wastewater collection system are known. Also this method does not account for biodegradation, sorption onto solids, or other removal mechanisms. Furthermore, an accurate mass balance requires collection and analysis of many samples over a long period, because refinery wastewater concentrations are constantly changing, so they must be averaged before calculating removals. In most cases, a material balance calculation will provide an emission estimate that is biased toward overestimating emissions due to the fact that the other pollutant removal mechanisms (sorption and biodegradation) are not considered. This approach may be a viable option for collection systems and non-biologically activated treatment where inlet and outlet pollutant concentrations are known. Because of these limitations, this VOC estimation method was not used in this assessment.

D. Emission Modeling

The preferred method for estimating emissions from wastewater systems is the use of computer-based emissions models. There are numerous emissions estimation models available to calculate emissions from wastewater systems. These include publicly available models as well as proprietary models. Differences in the models include applicability to the types of collection and treatment systems, the level of site-specific data accepted, the level of default data provided, and whether or not the models account for the full spectrum of pollutant pathways (volatilization, biodegradation, and sorption). Models may also contain different default data (e.g., Henry's Law constants,

biodegradation rate constants). Many of these models allow for user input of data. The use of site-specific data is always preferred over the use of default data.

Emission models for wastewater collection systems calculate average emission rate for each of the wastewater collection system components (drain, junction box, etc.) and apply these emissions to each component at the refinery to determine the overall refinery wastewater collection system emissions. Typically, the types of data needed are the chemical and physical properties of the wastewater stream, as well as collection and treatment device parameters, including:

- Wastewater temperature,
- Flow rate,
- Sewer channel slope,
- Relative depth of flow,
- Pipe diameter,
- Wastewater component design,
- Ventilation rate, and additionally for vents,
- Physical dimensions of the vent structure.

While emission models provide powerful tools for estimating emissions from wastewater system components, without all of the necessary data these models have limited applicability. Also, not all models can handle all collection/treatment devices, and results are likely to vary between models. Two of the more commonly used models to estimate emissions from refinery wastewater systems are described below.

1. WATER9

WATER9 is a publicly available computer program model developed by U.S. EPA that models the fate of organic compounds in various wastewater treatment units, including collection systems, aerated basins, and other units. WATER9 contains useful features such as the ability to link treatment units to form a treatment system, the ability to recycle among units, and the ability to generate and save site-specific compound properties. WATER9 has a database with compound-specific data for over 950 chemicals. The mathematical equations used to calculate emissions in this model are based on the approaches described in Air Emissions Models for Waste and Wastewater (EPA, 1994). The WATER9 model is publicly available in the Clearinghouse for Inventories and Emission Factors (CHIEF) system. WATER9 was used to calculate open drain emissions in this assessment.

2. TOXCHEM+

Enviromega Ltd. Company (Campbellville, Ontario) developed TOXCHEM+ (Toxic Chemical Modeling Program for Water Pollution Control Plants), in cooperation with the Environment Canada Wastewater Technology Centre. This proprietary database includes 204 chemicals (including metals) and detailed information on physical properties. The model also includes Henry's Law constants, sorption coefficients, and

biodegradation rate constants. The model simulates volatilization, stripping, sorption, and biodegradation removal mechanisms from weirs, surface volatilization, surface aeration, and subsurface aeration. A wide variety of wastewater unit operations can be represented including grit chambers, primary clarifiers, collection reaches, sludge digestion, aeration basins, and secondary clarifiers. Both steady state and dynamic results can be obtained. TOXCHEM+ is available through the Enviromega Ltd. Company. TOXCHEM+ was used to calculate closed drain, manhole, and junction box vent emissions in this assessment.

E. Factors Influencing VOC Emissions from wastewater Systems

During wastewater treatment, volatilization/stripping, sorption, and biodegradation primarily determine the fate of VOCs. Of these, volatilization and stripping result in air emissions. Biodegradation and sorption onto sludge serve to suppress air emissions. Stripping is the pollutant loss from the wastewater due to water movement caused by mechanical agitation, head loss, or air bubbles, while volatilization may be defined as quiescent or wind-driven loss. The magnitude of emissions from volatilization/stripping depends on factors such as the physical properties of the pollutants (vapor pressure, Henry's Law constants, solubility in water, etc.), the temperature of the wastewater, and the design of the individual collection and treatment units (including surface area and depth of the wastewater in the system). Wastewater unit design is important in determining the surface area of the air-water interface and the degree of mixing occurring in the wastewater.

VIII. SOURCE TESTING AND SAMPLE ANALYSIS ACTIVITIES

This chapter describes the data gathering and analytical methods used to collect data to allow the determination of the VOC emissions from the five San Francisco Bay Area refineries.

A. Overview

As mentioned previously, each refinery's wastewater system is unique. As such, it is necessary to estimate emissions from each refinery individually (instead of estimating VOC emissions over the entire source category simultaneously) and sum the individual inventories to determine the emissions for the whole source category. To do this, the following activities were conducted:

- Refinery site visits
- Source tests
- Emission modeling

The results of these activities were used to estimate the emissions from each refinery wastewater collection system in the District.

B. Site Visits

In initiating staff's efforts to estimate VOC emissions from refinery wastewater collection systems, it was first necessary to gather information on the layout and operation of each refinery's wastewater system. To accomplish this, site visits to each refinery were performed. These site visits included collecting information about the configuration of each refinery wastewater system, including:

- Wastewater temperature
- Flow rate
- Sewer channel slope
- Relative depth of flow
- Pipe diameter
- Wastewater component design (plot plans)
  - Including location and number of drains
  - Identification of controlled versus uncontrolled components
- Ventilation rate

A description of on-site processes that contribute to storm and wastewater flows (e.g., pathways of process waters and the system components through which it flows) was obtained. Also, where available, descriptions of any on-site monitoring performed by the refineries on storm and wastewater flows and the results of that monitoring was also collected. Additional information on each of these site visits is provided in Appendix E.

The number of drains and junction boxes at each refinery was verified as one of the first tasks during the site visits. Table VIII-1 shows the number of controlled and uncontrolled drains, manholes, and junction boxes, reported by refineries in 1995. It is believed most if not all junction box vents are uncontrolled.

Table VIII-1:
Number of Drains, Manholes and Junction Boxes in District Refineries

Refinery	Oil/Water Separators	Uncontrolled Drains	Controlled Drains	Manholes	Junction Boxes
1	3	1,677	837	1,965	655
2	4	1,100	1,300	570	190
3	1	572[1]	500[1]	1,941	647
4	1	500[1]	500[1]	402	134
5	1	4,750	50	900	300
Totals	10	8,599	3,187	5,778	1,926

[1] Estimated

For those refineries that did not report information in 1995, estimates based on the site inspection observations were utilized.

Site inspections and consultations on refinery wastewater design and layout began on March 26, 2002 and continued through September 2002.

C. Source Tests

Upon review of the specific layouts of each of the five refineries, source tests were performed at each refinery to gather information necessary to perform emission estimates using available emission modeling software.

1. Sampling Plans

Prior to conducting any source testing at a refinery, a sampling plan was developed. Because of the uniqueness of each facility, each sampling plan was specific to a particular refinery. Each sampling plan was developed in coordination with the staff's of the ARB, the District, and representatives of that refinery, and was based on information gathered through the site visits. The sampling plans identified:

- Number of samples to be collected
- Location of each sampling point
- Sampling protocols to be used
- Necessary resource needs (both ARB/District and refinery personnel)

Copies of each of the sampling plans developed for this TAD are contained in Appendix F.

2. Sampling Protocols

In conducting the field study, both air samples and water samples were collected from each refinery.

Water samples were collected according to either the American Society for Testing and Materials (ASTM) method D5495-94 (2001), *Standard Practice for Sampling With a Composite Liquid Waste Sampler* (also known as a coliwasa sample), or by using ASTM method D6759-02*, Standard Practice for Sampling Liquids Using Grab and Discrete Depth Samplers*. Coliwasa sampling was the preferred method used to retrieve a sample for Volatile Organic Analysis (VOA). However, if the depth of the wastewater was less than 1 foot, coliwasa sampling was not feasible and a grab sampler was used to collect VOA samples. All wastewater samples were analyzed within seven calendar days.

VOA samples collected for total gasoline range petroleum hydrocarbon analysis (as described later in this chapter) were transferred into 40-ml VOA vials containing a hydrochloric acid preservative. These vials used tetrafluoroethylene (TFE) lined septa caps, were stored in wet ice (4 degrees Fahrenheit), and transported to the laboratory for analysis at the end of each day.

Samples designated for total diesel range petroleum hydrocarbon analysis (as described later in this chapter) were retrieved using a grab sampler and transferred to a 1-liter amber glass sample bottle without hydrochloric acid preservative. The bottles used a TFE lined cap, were stored in wet ice (4 degrees Fahrenheit) and transported to the laboratory for analysis at the end of each day.

Air samples were collected according to ASTM method D5466-93 *Determination of Volatile Organic Chemicals in Atmospheres (Canister Sampling Methodology)*. Samples of the air were taken using a TFE sampling tube positioned one foot above the liquid layer. These air samples were taken over a one-minute period. Samples were taken from wastewater areas, e.g., sumps, freeboard areas of treatment tanks, and sewer openings. Samples were collected into a 6-liter stainless steel canister that was evacuated prior to sampling. Samples were collected by allowing the canister to return to ambient pressure using air collected from the sampling tube. After collection, samples were taken to the District laboratory for analysis at the end of each day's sampling. Samples were analyzed within seven calendar days.

3. Field Sampling

The field sampling was conducted in two parts. The first part consisted of a pilot sampling program to determine the efficacy of the sampling protocol and to provide ARB, District and refinery staff the opportunity to gain experience and familiarity with the sampling procedures. The pilot sampling was conducted at one refinery on July 2 and 3, 2002. The Pilot sampling included the collection of ambient air samples and wastewater samples, and confirmed that the wastewater sampling protocols met both

field and laboratory quality assurance and quality control standards. The pilot sampling also identified the need for additional sample collection to identify gasoline and diesel range hydrocarbons (the initial sampling plans called for identification of gasoline range hydrocarbons only).

Upon completion of the pilot sampling program, sampling plans (with the revisions identified from the pilot sampling program) were developed. Refinery wastewater sampling began on July 22, 2002 and continued through August 20, 2002, and included sampling at all five Bay Area refineries. Table VIII-2 summarizes the number of samples obtained from each refinery. A description of each type of sample collected is provided in the next section below.

Table VIII-2:
Number of Samples Obtained from Each Refinery

Refinery	Number of Samples Collected (By Type)		
	Total Gasoline Petroleum Hydrocarbon[1]	Total Diesel Petroleum Hydrocarbon[2]	Air Samples
1	22	21	5
2	33	32	4
3	23	21	3
4	10	8	0
5	23	23	7
Totals	111	105	19

[1] These were 40 ml water samples collected to quantify the gasoline range hydrocarbons in the wastewater.
[2] These were 1-liter water samples collected to quantify the diesel range hydrocarbons in the wastewater.

D. Sample Analysis

1. Wastewater samples

A variety of U.S. EPA analytical methods can be used to determine of petroleum VOC concentrations in wastewater, e.g., 25D, 304/305, 624/625, 8015, 8021, 8260 and 8270. Methods 25D, 304/305, 624/625 are emission testing methods designed to determine compliance with U.S. EPA regulatory thresholds. These methods are used to determine if a liquid stream is subject to provisions of the federal HON rule (Hazardous Organic National Emission Standards for Hazardous Air Pollutants[6]). Also, these methods are primarily used in predicting the efficiency of wastewater biological treatment systems. Prior versions of WATER9, i.e., WATER7, used analytical data from Methods 25D, 304/305, 624/625. However, newer versions of these emission models require more accurate identification of individual VOC compounds.

[6] See 29876 Federal Register / Vol. 61, No. 114 / Wednesday, June 12, 1996 / Rules and Regulations for clarification of regulatory text of the ''National Emission Standards for Hazardous Air Pollutants: Petroleum Refineries,'' issued as a final rule on August 18, 1995.

Recent developments in petroleum wastewater analysis have show that methods 8015, 8021, 8260 and 8270 are preferred for identification of petroleum VOCs. The U.S. EPA and State agencies have published a number of documents designed to assist in the selection of analytical methods for petroleum contaminated wastewater[7,8]. Methods 8260 and 8270 use mass spectroscopy for compound identification. However, Methods 8015 and 8021 are preferred for accurate determination of total petroleum hydrocarbon (TPH).

Therefore, this technical assessment used the most current versions of Methods 8015 and 8021 suitable petroleum wastewater. The analytical methods for total petroleum hydrocarbons as gasoline (TPHg) and total petroleum hydrocarbons as diesel (TPHd) were performed as:

1. TPHg analysis was carried out as a simultaneous 8015/8021 method using direct injection of sample using:
   - SW-846[9] Method 8015C as modified by California Department of Toxic Substances (8015Cm), and
   - SW-846 Method 8021B.

   Note: This combination method essentially splits the output from a gas chromatograph to a flame ionization (8015) and photoionization detector (8021).

2. TPHd analysis was carried out as a Method 8015C. This involves extraction of wastewater sample and analysis of extract via gas chromatograph with flame ionization detector.

Since the WATER9 model can use alternative methods, ARB staff requested approval from U.S. EPA for the use of Methods 8015 and 8021 for the emission-modeling portion of this TAD. Subsequent to this request, U.S. EPA approved the use of 8015 and 8021 for use in the emission modeling of refinery wastewater collection systems. Copies of the correspondence between the staff of the U.S. EPA and ARB regarding wastewater methodologies are contained in Appendix G.

U.S. EPA Method 8021, commonly referred to as a BTEX (benzene, toluene, ethylbenzene and xylene) analysis, is performed using a gas chromatograph with flame ionization detector (GC/FID). Method 8021 also includes an analysis of the total gasoline petroleum hydrocarbons (TPHg) components, roughly hydrocarbons in the carbon number range of 6 (hexane) through 12 (dodecane).

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[7] See discussion and references, Chapter 6, "Expedited Site Assessment Tools For Underground Storage Tank Sites: A Guide for Regulators. (EPA 510-B-97-001). March 1997."

[8] Analytical Issues for MTBE and Related Oxygenate Compounds by Deana M. Crumbling and Barry Lesnik, LUSTLine Bulletin 36,, November 2000, pp.16-18, New England Interstate Water Pollution Control Commission.

[9] SW-846 is an acronym for US EPA publication SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.

U.S. EPA Method 8015, commonly referred to as a total diesel petroleum hydrocarbon (TPHd) test, is also performed using a GC/FID. The analysis includes an analysis of petroleum range hydrocarbons with carbon numbers from 10 (decane) through 22 (docosane), which roughly corresponds to distillate range hydrocarbons (diesel fuel oil).

2. Air samples

Air samples were analyzed using the District's Laboratory's method. This method is used for the determination of non-methane organic compounds (NMOC) with carbon numbers from 2 (ethane) through 10 (decane) in ambient air using gas chromatography with flame ionization detection/photoionization detection (GC/FID).

E. Quality Assurance and Quality Control

Strict quality assurance and quality control (QA/QC) procedures were utilized for every portion of the sample collection and sample analysis activities conducted as part of this TAD.

1. Sample collection

Sample collection QA/QC activities were focused on ensuring that all samples were collected in a consistent manner. The same staff members performed all sampling to ensure that the sampling protocols and methodologies were consistently undertaken. A precise log noting the sample number, location, facility, time, and sampling method used was kept. A strict chain of custody procedures was utilized from the field to the analytical laboratory to ensure sample integrity.

The sampling procedures were subjected to a pilot program to ensure feasibility and increase reliability and familiarity with the sampling protocols. The sampling procedures were designed for use in conjunction with analyses for the most common types of petroleum contaminants (e.g., TPHd and TPHg). While in some cases the sampling procedures depended upon site conditions and equipment limitations or limitations imposed by the facility conditions, the exact sampling procedure employed was documented for each sample.

All equipment was cleaned thoroughly prior to reuse. Blank samples (de-ionized water) were used to identify cross-contamination between samples due to improper cleaning. All blank samples collected showed non-detectable hydrocarbon levels. Sample analysis QA/QC included the use of equipment blanks (samples of deionized water using coliwasa-sampling apparatus) for analysis by the laboratory for verification of the analytical results. Laboratory analysis of equipment blanks showed non-detectable or very low levels of petroleum contamination of the sample collection equipment.

2. Sample analysis

In addition, duplicate samples were taken at each refinery. Results of the duplicate sample analysis demonstrated that duplicate results were within experimental error for U.S. EPA methods 8015 and 8021. All established laboratory QA/QC procedures were followed for equipment calibration.

IX. EMISSION MODELING

This chapter describes the methodology used in modeling the emissions from refinery wastewater collection systems.

A. Emission Modeling

As discussed in Chapter VII, the preferred method for estimating emissions from refinery wastewater collection systems is through the use of computer based emissions models. This is because each refinery contains thousands of individual wastewater collection components, and measuring VOC emissions or wastewater petroleum concentrations from each of these sources was beyond the resources available for this TAD. Therefore, modeling wastewater collection systems provides a means by which VOC emissions from the entire wastewater collection system can be estimated with minimal source data requirements. The modeling was based on field data collected (such as drain inventories, systems layouts, wastewater flowrates) and observed wastewater petroleum concentrations, as identified from the laboratory analytical analysis. The modeling was performed independently on each refinery in the District, based on data collected specific to that refinery.

There are several models available to calculate emissions from wastewater systems. TOXCHEM+ and Water9 model were used to estimate the emissions from refinery wastewater collection systems for this TAD. The significant difference between TOXCHEM+ and Water9 are:

- TOXCHEM+ assumes all drains use a water seal and manholes are identified as open reaches with no fluid drop. Also, the TOXCHEM+ mathematical emission expressions have been calibrated using field emission testing.

- Water9 allows the inclusion of drains, both with and without water seals, and manholes. However, the Water9 mathematical emission expressions are based on theoretical parameters that have not been calibrated with field emission testing.

B. Model Inputs

The primary contributing factors used to estimate VOC emissions from refinery wastewater collection systems were the layout of the wastewater collection system, the number of drains, manholes and junction boxes used in the system, and the concentration and composition of gasoline hydrocarbons in the wastewater.

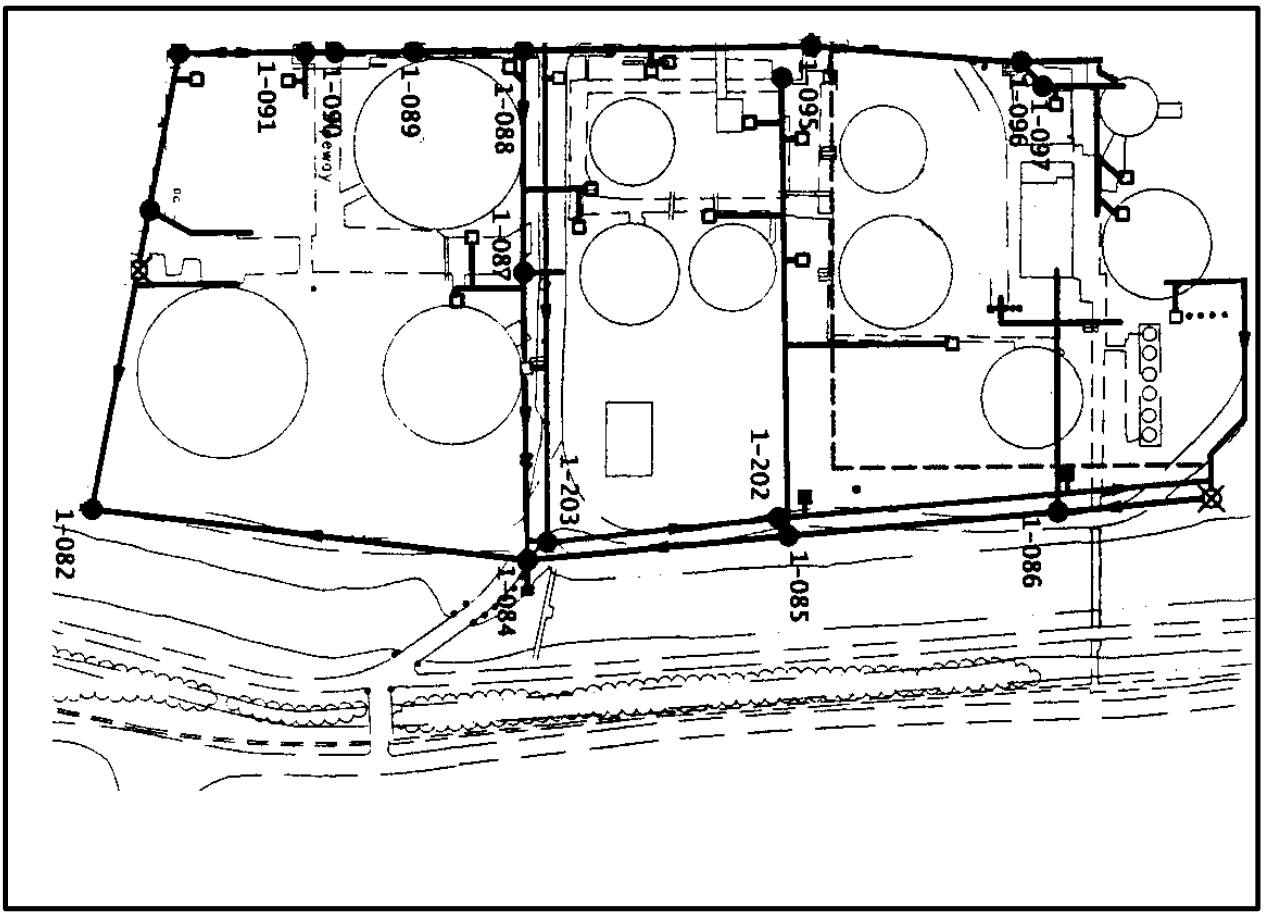
1. Wastewater Collection System Layout

The layout of the wastewater collection system at a refinery is complex. When evaluating wastewater collection systems, it is often convenient to segregate portions of the refinery into “process blocks”. By using this approach, a wastewater collection

system comprising hundreds of acres can be compartmentalized into much smaller pieces that can be managed much more easily. Using this methodology, the emissions from the entire system are simply the sum of emissions from each of the process blocks.

The process blocks are usually comprised of several refining process or storage units (tanks) that are served by a common wastewater lateral line. The flow to this wastewater lateral line originates from the drains located at each process unit. The flow from each of these drains is usually fed through a drain line to a junction box downstream of the drains. The wastewater flow from these junction boxes is further consolidated downstream in a trunk sewer that conveys it to the treatment plant. An example of a refinery process block is provided below in Figure IX-1.

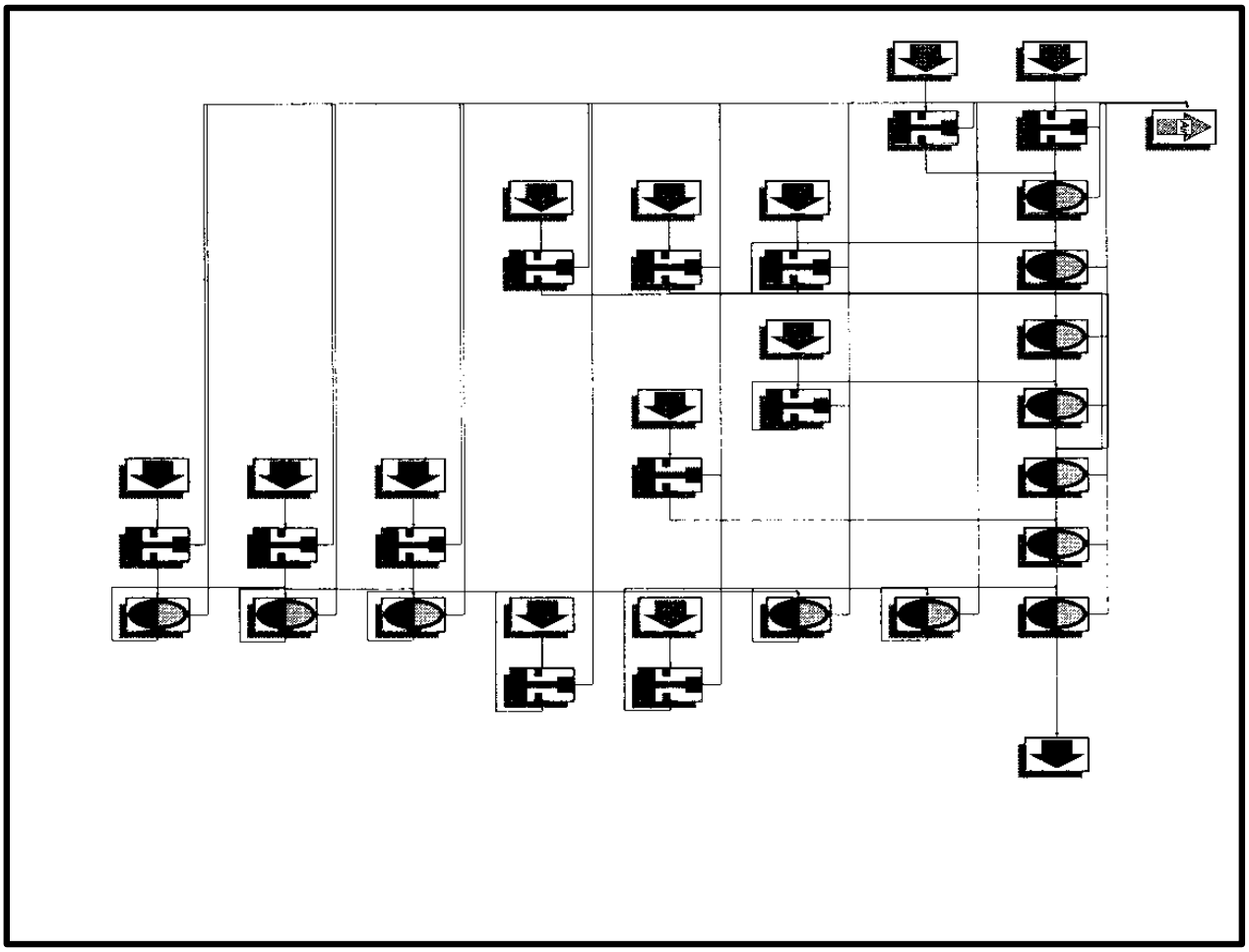
Figure IX-1:
Example Refinery Process Block Diagram



In order to model the wastewater collection system, it is necessary to describe the layout of the system in a block flow diagram format. A block flow diagram is a simplified diagram of the wastewater collection system from inflow (drains) to outflow (flow out of the trunk line). An example block flow diagram for the refinery process block diagram

shown in Figure IX-1 is shown in Figure IX-2. As can be seen in Figure IX-2, by using a block flow diagram, it is possible to simplify a number of drains into significantly fewer drains, thereby simplifying the emission estimation process. While this simplifies the emission estimation process, it does not affect the final results of the emission estimate.

Figure IX-2:
Example Refinery Wastewater Block Flow Diagram



The refinery wastewater block flow diagrams used for the emission modeling in this TAD were developed from schematic diagrams of the individual refinery wastewater systems provided by each refinery, as well as through the site visits conducted at each refinery. Additional information on the development of the wastewater block flow diagrams for use in the TOXCHEM+ model is provided in Appendix J.

2. Wastewater Flow Parameters

Once the wastewater collection system block flow diagram has been developed, it is necessary to input the parameters for each of the components in the diagram into the

model. These inputs provide the necessary physical parameters in the wastewater system to model emissions. This includes providing information on:

- pipe diameters of the lines,
- grade (slope) of the lines,
- temperature,
- flowrate, and
- type of control equipment installed, if any.

The wastewater flow property information used to model the wastewater collection emissions for this TAD was developed from information provided by each refiner, information collected from the site visits, and information collected as part of the wastewater sampling activities. Additional information on the wastewater flow property information used in the TOXCHEM+ model is provided in Appendix K.

3. Wastewater Composition

In modeling refinery wastewater collection systems, the single largest factor affecting emissions is the type and concentration of petroleum products in the wastewater. These petroleum products include gasoline, diesel and jet fuel, as well as intermediate unfinished products, all of which are comprised of many individual compounds. Each of these compounds has unique physical properties that determine its contribution to the overall emissions from the wastewater system. The emissions are primarily dependent upon the volatility of each compound, i.e., the tendency of a liquid to volatilize to a gas. Some compounds tend to contribute to the overall emissions more than others do. Therefore to predict overall emissions, chemical properties are used to determine emission potential. In this technical assessment primary emphasis was focused on chemical properties.

Calculating the volatile emission contribution from every individual chemical contained in a wastewater sample is not feasible. Identification of individual compounds is limited not only because of the shear number of compounds involved, but also due to the limitations of any analytical method. As discussed previously, U.S. EPA methods 8015 and 8020 do not generally identify each hydrocarbon present in the sample, but report the relative amounts of hydrocarbons present based on carbon number (i.e., TPHg [carbon numbers 5 through 12] and TPHd [carbon numbers 10 through 22]).

It is therefore desirable in emission calculations to group hydrocarbon compounds into a small number of fractions having similar volatility and solubility to simplify modeling. This provides suitable accuracy, given the simplifying assumptions and uncertainty inherent in modeling the behavior of hydrocarbons.[10,11] These fractions are represented by a range in equivalent carbon number, EC. By using the chromatograms generated

[10] Bischoff, K.B., A. Nigam, and M.T. Klein (1991). "Lumping of discrete kinetic systems" in G. Astarita and S. I. Sandler (eds.). Kinetic and Thermodynamic Lumping of Multicomponent Mixtures. Elsevier Science Publishers, Amsterdam, The Netherlands, pp. 33-48.

[11] Peterson, D. (1994). "Calculating the aquatic toxicity of hydrocarbon mixtures." *Chemosphere*, 29(12):2493-2506.

from the analysis, the TPHg and TPHd results can be further refined into smaller carbon number ranges, as shown below in Table IX-1. Further study needs to be performed to speciate the TPH diesel compounds identified as part of this study. More detailed analysis is recommended for these compounds as well as air sampling to determine the fraction of these compounds that are volatilized and will lead to better emissions inventory numbers.

Table IX-1:
TPH Surrogate Fractions

Carbon Number Range	TPH Surrogate Fraction Compound	Solubility (parts per billion)
2 – 6.5	Cyclohexane	55,000
6.5 – 7	n-Hexane	22,152
7 – 8.5	Methyl Cyclohexane	14,000
8.5 – 10	1,2,4-Trimethylbenzene	57,000
10 – 12	Naphthalene	31,000
12 - 14	2,-Methylnaphthalene	24,600

With the relative amounts of hydrocarbons in each of the above categories known, it is next necessary to define the properties of each fraction. Each fraction approximates the physical properties of a majority of compounds in each category. To accomplish this, available information on the types of hydrocarbons typically present in gasoline and diesel fuel was used[12]. Based on this information "TPH surrogate fraction compounds" were selected. The chemical properties of the TPH surrogate fraction compounds and their relative concentrations were used as inputs in the model. VOC emission estimates using this technique are a reasonable method given the assumptions used in modeling the behavior of hydrocarbons in water and are consistent with other approaches dealing with complex mixtures[13]. A more detailed explanation of the use of surrogate fractions and surrogate selection is provided in Appendix L.

One exception to this methodology was the modeling of certain aromatic hydrocarbon compounds. While the use of surrogate fractions was necessary to characterize most hydrocarbons, the amounts of benzene, toluene, ethylbenzene, xylene, as well as methyl tertiary butyl ether (MTBE), were specifically identified and reported in U.S. EPA methods 8015 and 8020. As such, these specific compounds were included in the model. Also, the concentration of hydrocarbons with carbon numbers greater than C14 were input into the model as "oil and grease", for which the model is designed to assign generic chemical properties to this group of compounds.

[12] Ibid.
[13] Bischoff, et al., 199, Bischoff, K.B., A. Nigam, and M.T. Klein (1991). "Lumping of discrete kinetic systems" in G. Astarita and S. I. Sandler (eds.). *Kinetic and Thermodynamic Lumping of Multicomponent Mixtures*. Elsevier Science Publishers, Amsterdam, The Netherlands, pp. 33-48.

C. Emission Contribution from Other Wastewater Collection Components

As discussed earlier, because of the number of wastewater collection components at each refinery, it was not possible to source test each component. For most components, this is not significant since the emission model is designed to estimate emissions from these components. However, some intermediate components (such as junction box vents) do not fit well within the model since all of the necessary wastewater flow parameters and the physical configuration of each junction box are not known.

For these limited instances, the use of emission factors was employed. An emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant. For the purposes of this TAD, emission factors as provided by the U.S. EPA[14] were utilized. The emissions from these components were summed with the results of the emission modeling to provide the overall emissions for each refinery wastewater collection system. A more detailed discussion on the use of emission factors to estimate emissions from these components is provided in Appendix K.

D. Factors Influencing Emission Calculations

VOCs vary significantly in their degree of volatility. Selection of surrogates used in the drain estimates and model calculations can have a significant impact on the emission estimates. The surrogates used in model and drain estimate calculations included inputs for concentrations of high, medium, and low volatility organic compounds as represented by the chromatogram and carbon number. The high correlation between relative VOC volatility and carbon number suggests that emission calculations based on this criteria accurately reflects VOC emissions of a given wastewater composition. Other factors influencing VOC emission are the design and arrangement of wastewater systems. All of the calculations used facility-specific data, accurate estimations for water depth, flow rates, wastewater temperatures, etc. Use of the individual facility data ensures the VOC estimates are sensitive to individual facility parameters.

[14] Industrial Wastewater Volatile Organic Compound Emissions-Background Information for BACT/LAER Determinations, EPA-450/3-90-004, United States Environmental Protection Agency, January 1990.

X. EMISSIONS FROM WASTEWATER COLLECTION SYSTEMS

This chapter discusses the VOC emission inventory for refinery wastewater systems, and the estimated emissions from drains and junction box vents from the wastewater collection system, as determined from the emission modeling.

A. Existing VOC Emission Inventory for Refinery Wastewater Systems

Currently, the District estimates that the emissions from wastewater collection and treatment systems of all five refineries are about 4 tpd of VOCs. This inventory is shown in below in Table X-1, by refinery.

Table X-1:
2001 VOC Emission Inventory for Refinery Wastewater Systems[1]
(By Refinery)

Refinery	Wastewater Treatment System VOC Inventory (tpd)	Wastewater Collection System VOC Inventory (tpd)	VOC Emission Inventory (tpd)
1	0.2	1.1	1.3
2	0.2	1.0	1.2
3	0.1	0.2	0.3
4	0.1	0.1	0.2
5	0.8	0.3	1.0
Total	1.4	2.6	4.0

[1] Numbers may not sum due to rounding. Source: Bay Area Air Quality Management District

Also shown in Table X-1 the contribution of refinery drains and other wastewater collection system components, by refinery. As can be seen in Table X-1, based on the current emission inventory, drains and other wastewater collection components comprise approximately 65 percent of all VOC emissions from refinery wastewater systems.

B. Emissions from Refinery Drains, Manholes, and Junction Box Vents

Based on the analytical work performed as part of this TAD, it is estimated that District refinery drains, manholes, and junction box vents emit about 3.3 tons per day of VOC emissions from the gasoline fraction contained in the wastewater. Table X-2 shows these VOC emissions, by refinery, for wastewater systems at the refineries in the District.

Significant amounts of diesel range materials were found in the wastewater samples analyzed as part of this TAD. The emissions significance of these materials has not

been established as part of this assessment and has been recommended for further study.

Table X-2:
VOC Emission Estimates for Refinery
Wastewater Drains, Manholes, and Junction Box Vents
(By Refinery)[1]

Refinery	Drain Emissions (tpd)	Manhole Emissions (tpd)	Junction Box Vent Emissions (tpd)	Total [2] (tpd)
1	0.41[2]	0.17	0.13[2]	0.70
2	0.27	0.048	0.17	0.49
3	0.14	0.16	0.17	0.47
4	0.12	0.034	0.084[2]	0.24
5	1.16	0.076	0.17	1.4
Total[3]	2.1[4]	0.49	0.71	3.3

[1] Number do not sum due to rounding.
[2] Partial emissions. Additional information is needed to complete the assessment of drain and junction box vents from these facilities.
[3] The emissions reported in this table do not represent the total emissions from the wastewater collection system. As discussed earlier, additional work is needed to estimate emissions from wastewater treatment and TPHd compounds.
[4] 2.02 tpd emissions from uncontrolled drains.

In evaluating the data in Table X-2, it is important to note that the VOC emission estimates for Refinery 1 is incomplete. For Refinery 1, only part of the refinery was sampled during the source tests due to ongoing maintenance to the wastewater system. This did not allow for the full implementation of the refinery sampling plan at Refinery 1 during the source test period. Also, VOC emissions from the four trunk sewer junction boxes were only estimated for Refinery 3 due to a lack of information.

C. Comparison of TAD Emission Estimates to Existing District Inventory

The work to quantify the VOC emissions from the wastewater collection system is not complete; therefore it is not possible to compare the existing District emission inventory to the emissions estimated as part of this TAD. Future work includes estimating emissions from wastewater treatment systems and emissions from TPHd compounds.

D. Comparison of TAD Emission Estimates to Other Emission Estimates

While a comparison of the TAD emission estimates to the existing District emission inventory is not possible at this time, it is useful to compare the emission estimates for drains and junction box vents to similar estimates by the South Coast AQMD during their development of amendments to Rule 1176.

In developing the amendments to Rule 1176, staff of the South Coast AQMD performed VOC emission estimates from uncontrolled drains and junction box vents. In the South Coast AQMD, it was estimated that there were approximately 12,000 uncontrolled

drains emitting about 1.5 tpd of VOCs. If this number is adjusted to be consistent with the approximately 8,900 uncontrolled drains in the District (as shown in Table VIII-1), it is expected that about 2.0 tpd of VOC emissions would have been estimated in the South Coast AQMD for an equivalent number of drains. This result shows very good agreement with the 2.1 tpd developed for drain emissions in this TAD.

A similar analysis is not possible for junction box vents because the number of junction box vents in the South Coast AQMD is significantly different than in the District, and the methodology used to estimate emissions in the South Coast AQMD is also significantly different. Additional work will be needed to further investigate the differences in the number of junction box vents between the two districts, and the differences in emission estimation methodologies.

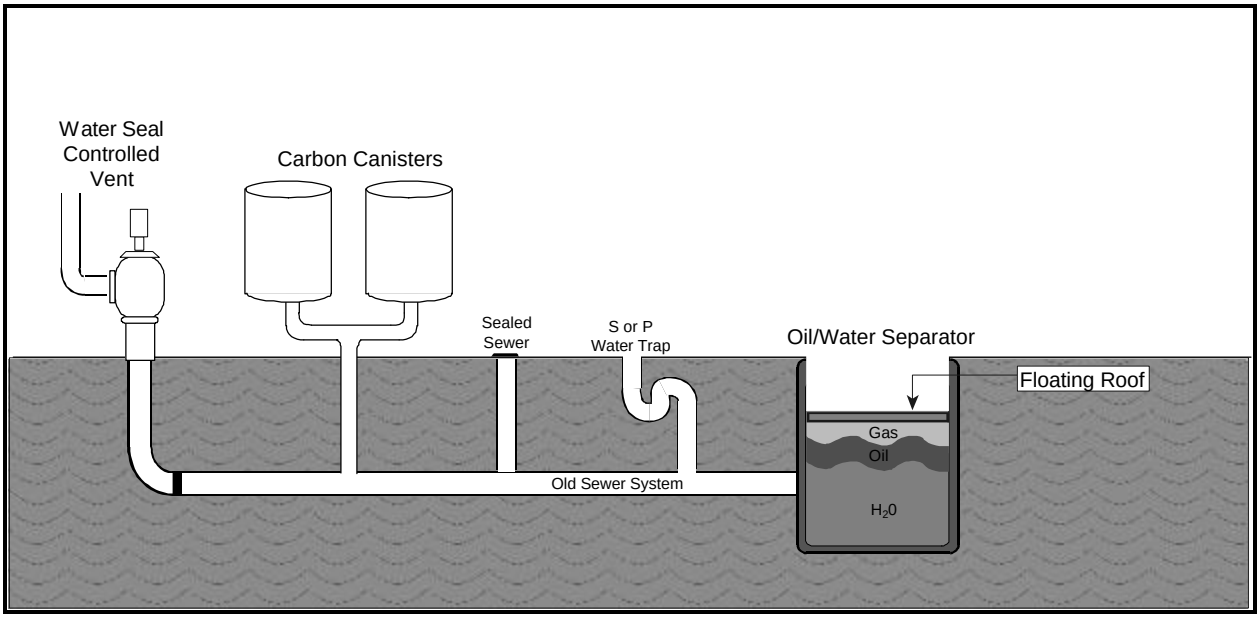
XI. POTENTIAL CONTROL STRATEGIES

VOC emissions from wastewater collection systems can be controlled in a variety of ways including enclosing or controlling all openings, changing the operation of the units that are feeding the wastewater collection system, having a rigid inspection and maintenance (I&M) program or using a combination of controls. The following is a discussion of various control technologies that can be grouped into either engineering control strategies and process control strategies.

A. Equipment Control Strategies

Equipment control strategies can require the installation of new equipment or devices, or can include physical changes to the wastewater system. Potential equipment control strategies applicable for refinery wastewater systems can include a number of different components. Figure XI-1 schematically shows the application of these control strategies in a wastewater system.

Figure XI-1:
Potential Equipment Control Strategies



Source: U.S. EPA

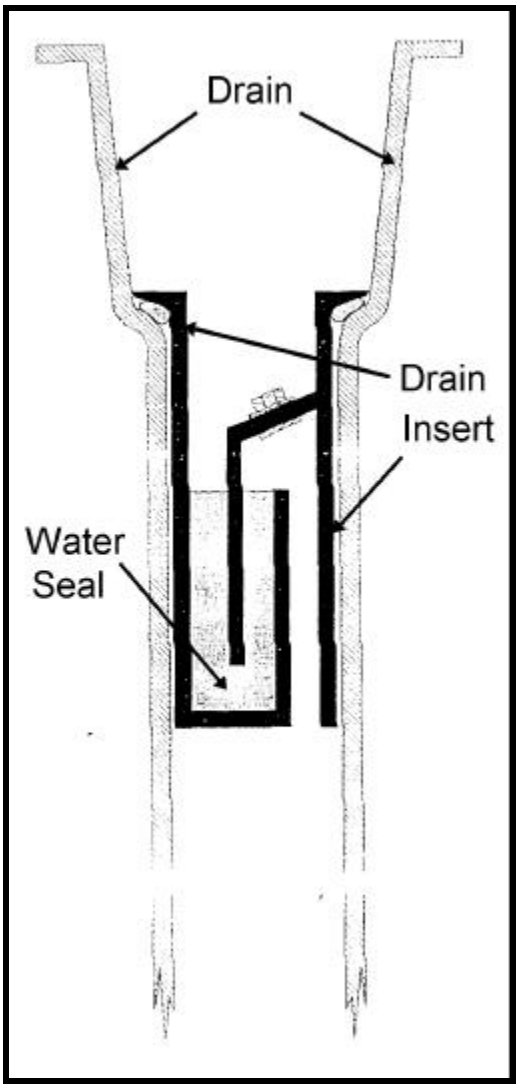
1. Water Seals on Drains and Junction Box Vents

Installing water seals on process drains and vents open to the atmosphere would help prevent emissions from the downstream sewer lines from escaping back out of the drain or vent opening. Even with water seals installed in drains, emissions have been reported from VOC-containing liquid left standing in the water seal that was not flushed into the sewer line. Also, if the water were allowed to evaporate from the water seal

control, the emissions from the drain or vent would be similar to those from uncontrolled units. Below are two types of water seal configurations:

- P-leg seal configuration (similar to a kitchen sink drain).
- Liquid seal inserts that can be placed in existing process drains (Figure XI-2) and junction box vents (Figure XI-3).

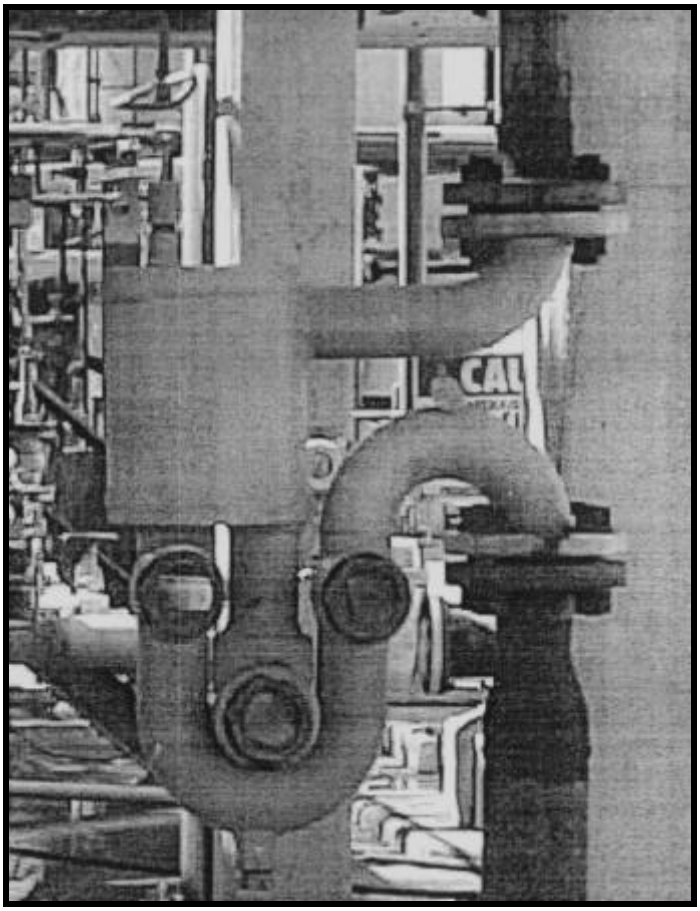
Figure XI-2:
Typical Design of a Liquid Seal Insert for Process Drains



The overall control efficiency of this method is estimated at an average of 65%[15], and varies depending on the proper maintenance of the water seal. It is estimated that the application of water seals to uncontrolled drains and junction box vents in the District can achieve about 1.8 tpd of VOC reductions.

[15] Ibid.

Figure XI-3:
Typical Design of a Liquid Seal Insert
For Junction Box Vents



Source: Chevron

2. Sealing Manholes

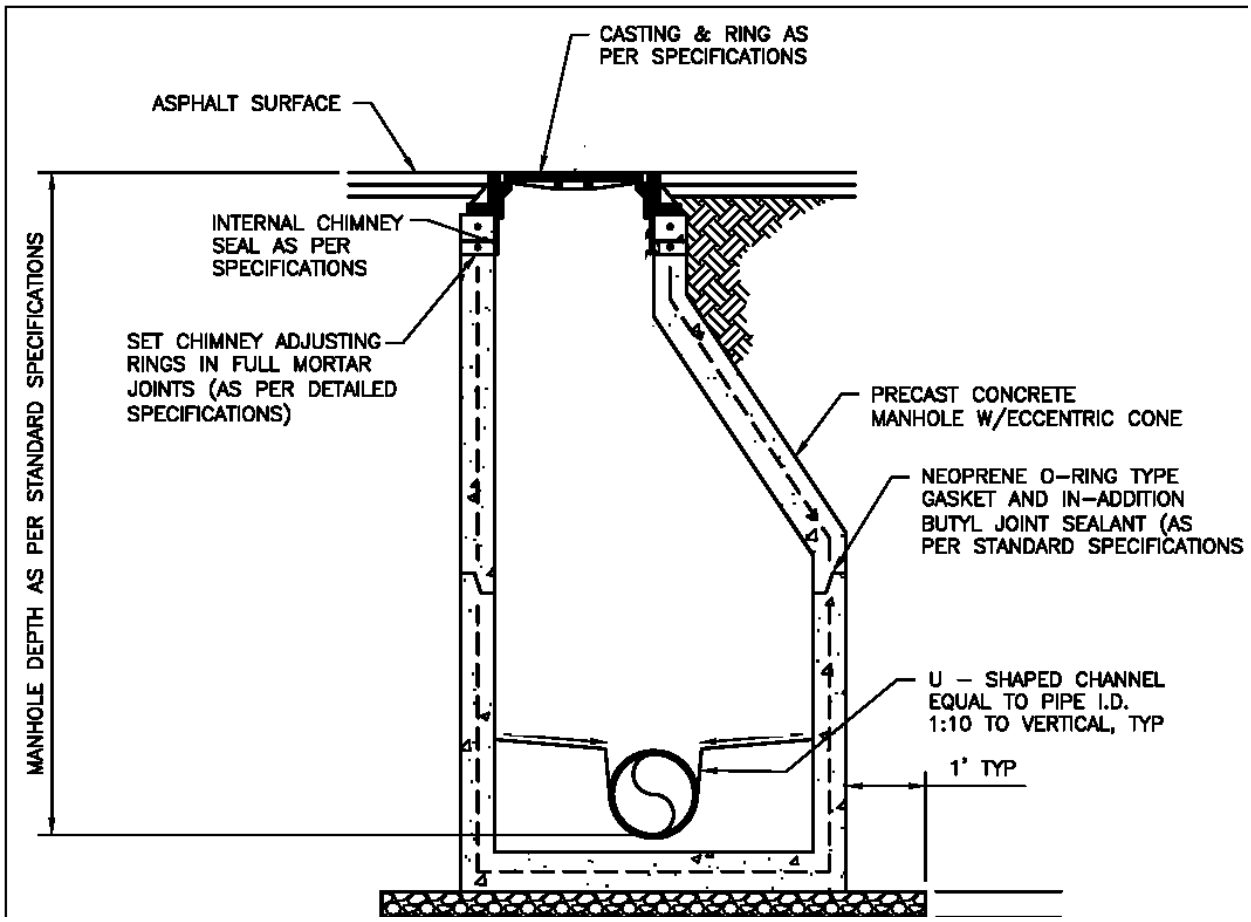
Installing gasket seals on manholes and plugging holes in manhole covers would help prevent emissions from the sewer lines from escaping back out of the manhole structure or cover. Even with gaskets and plugs installed emissions have been reported from manholes structures. These emissions are usually from cracks and gaps in the manhole chimney seal or cover ring. In refinery areas with high temperature process water flow the emissions from unsealed manhole structures these drain or vent would be similar to those from uncontrolled drains. Figure XI-4 shows a typical detail of refinery manhole.

The overall control efficiency of sealing manholes is estimated at an average of 65%[16]. This varies depending on the proper maintenance of the manhole cover seal and overall

[16] Ibid.

manhole structural integrity. It is estimated that sealing manholes can achieve about 0.32 tpd of VOC reductions**.**

Figure XI-4:
Typical Design of Refinery Sewer Manhole



3. Inspection and Maintenance Programs

Some control measures, such as water seals, can require an extensive inspection and maintenance (I&M) program in order to be effective. I&M programs are also useful and necessary tools to ensure that the emission reductions achieved through the use of equipment controls are realized. An effective I&M program is designed to inspect (on a regular basis), maintain and repair (as necessary) the pertinent components of a pollution control system for proper operation. These inspectors will be refinery personnel. This could include:

- Inspection of sealed manholes for corrosion and leaks
- Inspection of water seals for evaporated water or accumulation of trapped VOC containing material
- Inspection and repair of visible leaks from a sealed wastewater system

- Regular replacement of activated carbon in a carbon adsorption system
- Measurement of VOC concentrations in and around controlled systems (leak detection program)

4. Vent Control Devices

Collecting and venting the emissions to a control device can achieve a control efficiency of greater than 95 percent. Potential emission control devices for wastewater collection systems (predominately junction box vents) include:

- carbon absorption
- thermal oxidation
- catalytic oxidation
- condensation

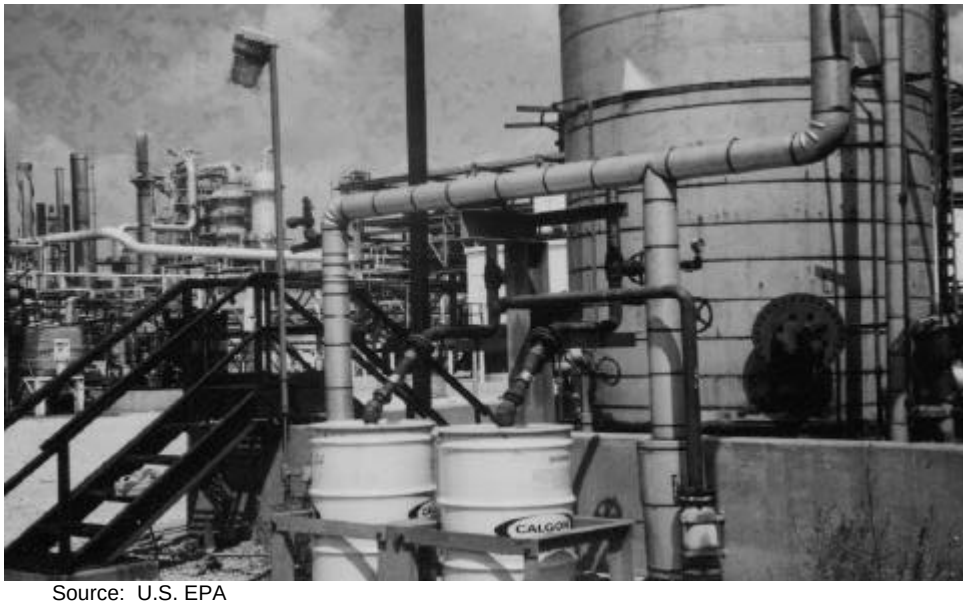
Table XI-1 below provides information of the operating range and control efficiencies for each of the emission control devices identified above. An application of an emission control device (carbon adsorption) in a refinery wastewater system is shown in Figure XI-5.

Table XI-1:
Operating Ranges for Potential Vapor Recovery And Control Equipment

Control Technology	Applicable Range (ppm)	Capacity (cfm)	Removal Efficiency
Carbon Absorption	20-5000	60,000	90-98%
Thermal Oxidation	100-2000	500,000	95-99%
Catalytic Oxidation	100-2000	100,000	90-95%
Condensation	>5000	20,000	50-90%

Source: Shen, Almon M. "Stationary Source VOC and NOx Emissions and Controls", Presentation at the 1995 Air Pollution Prevention Conference, Taipei, Taiwan, October 1995.

Figure XI-5:
Use of Carbon Adsorption for Control of Wastewater Collection Systems at a Petroleum Refinery



Source: U.S. EPA

5. Performance Based Standards

Setting performance based standards allows a wastewater system operator to consider the optimal type(s) of control strategies that meet a particular need based upon system design and emission levels from each wastewater component. By establishing performance-based standards, such as setting an emission limit of 500-ppm VOC from a drain or vent, equivalent emission reduction can be achieved without specifying a particular control technology.

6. Hard Piping

Enclosing open weirs and lines with direct piping (also called hard piping) is the most stringent control option and could result in the greatest amounts of VOC emission reductions. Complete drainage system enclosure can be accomplished in the following manner:

- Hard-pipe process units to the wastewater separator and then remove or cap all existing process drains.
- Hard-pipe process units to a drain box enclosure.
- Hard-pipe those process units identified as the largest contributors to process drain emissions.
- Hard-pipe junction boxes that are completely covered and sealed with no openings.

This method is considered to have up to 100% control efficiency[17]. However, the safety issues and reconstruction complexity may be two prohibiting factors that reduce the likelihood of converting an existing open drainage system to a totally enclosed system.

B. Pollution Prevention Strategies

In addition to the use of equipment control strategies to reduce VOC emissions from wastewater collection systems, there are also several control strategies that could be implemented to reduce emissions from these systems. This approach differs from the equipment control strategies in that it is designed to reduce the source of the VOC emissions (pollution prevention) through changes to the operation of the refinery, as opposed to controlling the emissions themselves with equipment. Additional measures, such as the use of I&M programs, can further serve to reduce emissions from wastewater collection systems.

1. Pollution Prevention Programs

For refinery wastewater collection systems, the following pollution prevention control measures have been identified as potential control measures to reduce VOC emissions[18]:

- Reduce the generation of tank bottoms
- Minimize solids leaving the desalter unit
- Minimize and/or segregate cooling tower blowdown condensate from wastewater collection
- Minimize fluid catalytic cracking unit decant oil sludge
- Control heat exchanger cleaning solids and sludge
- Minimize discharge of surfactants into wastewater collection system
- Thermal treatment of sludge
- Reduce use of open pits, tanks, and ponds
- Remove unnecessary storage tanks from service
- Segregate storm, process, and septic wastewater collection
- Improve recovery of petroleum product from wastewater collection systems
- Identify VOC sources and install upstream water treatment and/or separation
- Use oily sludges as feedstock
- Control and reuse FCCU and coke fines
- Train personnel to reduce solids in sewers to (reduction of VOCs from volume from sludge treatment

An I&M program, in addition to that discussed for equipment controls, can be designed to ensure that pollution prevention programs, such as reduced waste generation and solids control, are being followed. These types of procedures could include monitoring

[17] "Final Staff Report for Proposed Rule 1176 – VOC Emissions from Wastewater Systems", South Coast Air Quality Management District, September 13, 1996.
[18] Profile of the Petroleum Refining Industry, US EP{A 310-R-013, 9/1993

of waste generation, either through continuous samplers or regular testing, monitoring of use of open pits and ponds, and regular training of refinery inspectors.

XII. POTENTIAL CONTROL STRATEGY COSTS AND COST-EFFECTIVENESS

This chapter discusses the costs and cost-effectiveness associated with the various potential control strategies discussed in the previous chapter. Because of the difficulties associated with estimating costs and quantifying the benefits of pollution prevention strategies, the costs of these types of strategies are not discussed in this chapter.

A. Control Costs

In estimating the costs associated with the potential control strategies identified in the previous chapter, both the capital costs and the recurring annual costs were considered.

The methodology used to evaluate the capital costs consisted of considering the annualized capital costs using the capital recovery method. The annualized capital costs were determined using the following equation:

Annualized Cost = (*Capital Recovery Factor*)×(*Capital Expenditure*)

Where:

Capital Expenditure – Equipment and installation costs
Capital Recovery Factor – 14.2% (7% per year over 10 years)

In evaluating the recurring annual costs, cost considerations were provided for such expenditures as operating costs (i.e. utilities, adsorption material replacement, etc.) and potential I&M compliance costs.

1. Water Seals on Drains

Capital costs associated with sealing inserting water seals in drains are not significant in terms of the cost per emission point. It is estimated that the capital costs are between $400 and $1000 per drain. However, in considering this cost, it is important to consider that a refinery wastewater collection system may contain over one thousand uncontrolled drains.

The total anticipated capital costs to install wastewater water seals on all of the existing uncontrolled refinery process drains in the District are estimated to be between about $3.4 million and $8.6 million, as shown in Table XII-1. When annualized over ten years, these costs are between $540,000 and $1.5 million per year, including annual I&M cost. Table XII-1 shows these costs by refinery.

Annual recurring costs are comprised mainly of an anticipated need for an I&M program and equipment depreciation. The I&M program will likely be necessary to ensure the

operability of each control device (this is already required for drains under the U.S. EPA's NSPS, as well as under the SCAQMD Rule 1176). It is estimated that the annual costs of employing an inspector, who would be a refinery employee, is about $65,000 per year[19]. It is possible that some refineries will need more than one inspector per facility. Also, each inspector will require the use of monitoring equipment (such as an organic vapor analyzer) which costs about $3,000 per unit. It is assumed that inspectors could be hired part-time or be included in current I&M programs if an annual I&M program for wastewater systems would require less than one full-time position, so pro-rated costs are shown in Table XII-1. (Note: Appendix M provides a more detailed listing of the cost estimate calculations.)

Table XII-1:
Annual Costs for Water Seals on Uncontrolled Drains[1]
(By Refinery)

Refinery	Number of Uncontrolled Drains	Capital Cost (Thousand Dollars)	Annualized Capital Cost (Thousand Dollars per Year)	Annual I&M Costs (Thousand Dollars per Year)	Total Annual Cost (Thousand Dollars per Year over 10 years)
1	1,677	670 – 1,700	100 – 240	10 – 60	100 – 300
2	1,100	440 – 1,100	60– 160	6– 40	70 – 190
3	572[2]	230 – 570	30 – 80	3 – 20	40 – 100
4	500[2]	200 – 500	30 – 70	3 – 20	30 – 90
5	4,750	1,900 – 4,800	270 – 680	30 – 160	300 – 840
Total	8,599	3,400 – 8,600	490 – 1,200	50 – 290	540 – 1,500

[1] Numbers may not due to rounding.
[2] Estimated from field data.

2. Sealing Manhole Structures

Capital costs associated with sealing manholes and inserting water seals are typically not significant in terms of the cost per emission point. It is estimated that the capital costs are between $400 and $1000 per manhole. Installing gaskets or seals and plugging holes in manhole covers is a straightforward maintenance operation. However, in considering this cost, it is important to consider that sealing a manhole structure may require replacement of the complete manhole structure due to cracks and gaps in the manhole chimney (see Figure XI-4 of refinery manhole). Sealing emission sources from a failed manhole structure can require significant underground repair and expense.

The total anticipated capital costs to seal manhole structures on all of the existing refinery manholes in the District are estimated to be between about $2.3 million and $5.8 million, as shown in Table XII-2. When annualized over ten years, these costs are between $360,000 and $1 million per year, including annual I&M cost. Table XII-2 shows these costs by refinery.

Annual recurring costs are comprised mainly of an anticipated need for an I&M program and equipment depreciation. The I&M program will likely be necessary to ensure the

[19] Ibid. [Note that the cost identified in the SCAQMD report was increased due to inflation.]

operability of each control device (this is already required for drains under the U.S. EPA's NSPS, as well as under the SCAQMD Rule 1176). It is estimated that the annual costs of employing an inspector, who would be a refinery employee, is about $65,000 per year[20]. It is possible that some refineries will need more than one inspector per facility. Also, each inspector will require the use of monitoring equipment (such as an organic vapor analyzer) which costs about $3,000 per unit. It is assumed that inspectors could be hired part-time or be included in current I&M programs if an annual I&M program for wastewater systems would require less than one full-time position, so pro-rated costs are shown in Tables XII-2.

It is important to note that annual I&M costs are dependent upon the frequency of inspections necessary. As such, costs for a monthly, quarterly and semi-annual inspection program were estimated. These range of annual costs (by refinery) for an I&M program are shown in Table XII-2, along with the total anticipated annual costs associated with controlling manhole emissions from refinery wastewater systems. (Note: Appendix M provides a more detailed listing of the cost estimate calculations.)

Table XII-2:
Annual Costs for I&M and Sealing Manholes[1]
(By Refinery)

Refinery	Number of Manholes	Capital Cost (Thousand Dollars)	Annualized Capital Cost (Thousand Dollars per Year)	Annual I&M Costs (Thousand Dollars per Year)	Total Annual Cost (Thousand Dollars per Year)
1	1,965	790 -2000	110 - 280	11 – 70	120 – 350
2	570	230 -570	30 - 80	3 – 20	35 – 100
3	1941	780 -1900	110 - 280	11 – 70	120 – 340
4	400	160 - 400	20 - 60	2 – 14	25 – 70
5	900	360 - 900	50 - 130	5 – 30	56 – 160
Total	5,778	2,300-5,800	330 - 820	30 - 200	360 - 1000

[1] Numbers may not sum due to rounding.

2. Water Seals on Junction Boxes

Unlike the case for water seals on drains, the total number of uncontrolled junction box vents at refineries is unknown. Because of this, a conservative approach was taken to assume that all junction boxes would need controls. In reality, this is not likely the case as some junction boxes are already controlled, or are not vented to the atmosphere. As such, the costs identified below are likely higher than could be expected to comply with any future rule.

Capital costs associated with water seals for junction box vents are estimated to be between $2000 and $2500 per vent, based on data provided by refiners. It was indicated that these costs include installation costs. The total anticipated capital costs

[20] Ibid. [Note that the cost identified in the SCAQMD report was increased due to inflation.]

to install wastewater water seals on all of the existing uncontrolled refinery junction box vents in the District are estimated to be between about $3.9 million and $4.8 million, as shown in Table XII-3. When annualized over ten years, these costs are between about $560,000 and $750,000 per year, including annual I&M cost. Table XII-3 also shows these costs by refinery.

Annual recurring costs are comprised mainly of an anticipated need for an I&M program. It is estimated that the annual costs of employing an inspector, who would be a refinery employee, dedicated to monitoring and maintaining the water seals is about $65,000 per year[21], with potentially more than one inspector being required per facility. Also, each inspector may require the use of monitoring equipment (such as an organic vapor analyzer) which costs about $3,000 per unit. It is assumed that inspectors could be hired part-time or be included in current (such as fugitive) I&M programs if an annual I&M program for wastewater systems would require less than one full-time position, so pro-rated costs are shown in Table XII-3.

It is important to note that annual I&M costs are dependent upon the frequency of inspections necessary. As such, costs for a monthly, quarterly and semi-annual inspection program were estimated. These range of annual costs (by refinery) for an I&M program are shown in the previous tables, along with the total anticipated annual costs associated with controlling uncontrolled junction box vent emissions from refinery wastewater collection systems. (Note: Appendix M provides a more detailed listing of the cost estimate calculations.)

Table XII-3:
Annual Costs for Water Seals for
Wastewater Junction Box Vents[1] (By Refinery)

Refinery	Number of Junction Boxes	Capital Cost (Thousand Dollars)	Annualized Capital Cost (Thousand Dollars per Year)	Annual I&M Costs (Thousand Dollars per Year)	Total Annual Cost (Thousand Dollars per Year)
1	655	1,300 – 1,640	190 - 230	4 - 22	190 – 260
2	190	380 – 480	54 – 67	1 – 6	55 – 73
3	647	1,300 – 1,600	180 - 230	4 – 22	190 – 250
4	134	270 - 340	38 - 48	1 – 5	39 – 53
5	300	600 - 750	85 - 110	2 - 10	87 - 120
Total	1,926	3,900 – 4,800	550 - 690	12 - 65	560 - 750

[1]Numbers may not sum due to rounding.

3. Other types of Vapor Recovery and Control Equipment

While a detailed cost analysis was not performed on all types of emission control devices potentially available for use with wastewater junction boxes, Table XII-3 provides some generic cost information on other potential vapor recovery and control equipment. In general, it is expected that the costs associated with the application of

[21] Ibid. [Note that the cost identified in the SCAQMD report was increased due to inflation.]

control equipment to junction box vents are significantly higher than with the use of water seals, although larger emission reductions could be achieved.

Table XII-3:
Operating Costs for Potential Vapor Recovery And Control Equipment

Control Technology		Capital Cost ($)	Annual Operating Cost ($)
Carbon Absorption		15-120/cfm	10-35/cfm
Thermal Oxidation	Recuperative	10-200/cfm	15-90/cfm
	Regenerative	30-450/cfm	20-150/cfm
Catalytic Oxidation	Fixed bed	20-250/cfm	10-75/cfm
	Fluidized Bed	35-220/cfm	15-90/cfm
Condensation		10-80/cfm	20-120/cfm

Source: Shen, Almon M. "Stationary Source VOC and NOx Emissions and Controls", Presentation at the 1995 Air Pollution Prevention Conference, Taipei, Taiwan, October 1995.

4. Performance Based Standards

While the costs associated with implementing performance-based standards are difficult to quantify, in general, the establishment of performance based standards provides one of the lowest cost options for control. This is because performance based standards allow each refiner to utilize the control option or options that result in the lowest cost (both in terms of capital costs and operating costs). As such, it is believed that the costs associated with performance based standards would be in the range of, or even less than, the costs identified above for specific prescriptive control strategies.

5. Hard Piping

The costs associated with hard piping are uncertain at this time. This is because additional work is needed to identify the specific requirements at each refinery if this control strategy was considered. Costs would be dependent on a number of variables, including the physical characteristics of the piping necessary (length, diameter, and material), as well as any necessary construction requirements, such as minimum required depth and soil/ground conditions in the area.

B. Control Cost-Effectiveness

This section describes the overall cost-effectiveness to control emissions from drains and junction box vents with water seals, as well as the incremental cost-effectiveness to control each of these wastewater collection system components separately.

1. Overall Cost-Effectiveness

Based on the estimates of 3.2 tpd of VOC emissions (Table X-2) from uncontrolled drains, manholes, and junction box vents, it is expected that 2.1 tpd of emission reductions can be achieved by sealing manholes and installing water seals in drains and junction box vents. This estimate is based on a 65% control efficiency achieved by sealing manholes and installing water seals in drains and junction box vents. The estimated total annual costs for control at each of the refineries in the District is in the range of $1.4 million to $3.3 million. It is estimated that the cost-effectiveness to reduce emissions from drains, manholes, and junction box vents ranges from $1900 to $4200 per ton of VOC reduced. This is within the range of cost-effectiveness determined for other VOC control measures adopted by the District, as well as by the ARB.

In considering this cost-effectiveness, it is important to consider that the emission estimates for two of the refineries, as discussed in Chapter X, are not complete, and that characterization of emissions from wastewater treatment and emissions from TPHd in the wastewater still need to be evaluated. As such, the cost-effectiveness numbers above are conservative, and the cost-effectiveness of control measures will improve as additional data is developed.

2. Incremental Cost-Effectiveness for Water Seals on Drains

Based on the estimates of 2.1 tpd of VOC emissions (Table X-2) from refinery drains, it is expected that 1.3 tpd of emission reductions can be achieved. With estimated total annual costs for control of all uncontrolled drains at each of the refineries in the District of $540,000 to $1.5 million (Table XII-1), it is estimated that the cost-effectiveness to require water seals on uncontrolled drains is between $1,200 and $3200 per ton of VOC reduced. This is in the range of cost-effectiveness determined for other VOC control measures adopted by the District, as well as by the ARB.

In considering this cost-effectiveness, it is important to consider that the emission estimates for two of the refineries, as discussed in Chapter X, are not complete, and that characterization of emissions from wastewater treatment and emissions from TPHd in the wastewater still need to be evaluated. As such, the cost-effectiveness numbers above are conservative, and the cost-effectiveness of control measures will improve as additional data is developed.

3. Incremental Cost-Effectiveness for Sealing Manholes

Based on the estimates of 0.49 tpd of VOC emissions (Table X-2) from refinery manholes, it is expected that 0.32 tpd of emission reductions can be achieved. With estimated total annual costs for control of all unsealed manholes at all of the refineries in the District of $360,000 to $1 million (Table XII-2), it is estimated that the cost-effectiveness to seal manholes is between $3100 and $8800 per ton of VOC reduced.

This is in the range of cost-effectiveness determined for other VOC control measures adopted by the District, as well as by the ARB.
In considering this cost-effectiveness, it is important to consider that the emission estimates for two of the refineries, as discussed in Chapter X, are not complete, and that characterization of emissions from wastewater treatment and emissions from TPHd in the wastewater still need to be evaluated. As such, the cost-effectiveness numbers above are conservative, and the cost-effectiveness of control measures will improve as additional data is developed.

4. Incremental Cost-Effectiveness for Water Seals on Junction Boxes

Based on the estimates of 0.71 tpd of VOC emissions (Table X-2) from junction box vents, it is expected that 0.46 tpd of emission reductions can be achieved. With estimated total annual costs for control of all junction box vents at all of the refineries in the District of $560,000 to $750,000 (Table XII-3), it is estimated that the cost-effectiveness to require water seals on junction box vents is between $3300 and $4400 per ton of VOC reduced. This is in the range of cost-effectiveness determined for other VOC control measures adopted by the District, as well as by the ARB.

In considering this cost-effectiveness, it is important to consider that the emission estimates for two of the refineries, as discussed in Chapter X, are not complete, and that characterization of emissions from wastewater treatment and emissions from TPHd in the wastewater still need to be evaluated. As such, the cost-effectiveness numbers above are conservative, and the cost-effectiveness of control measures will improve as additional data is developed.

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Appendix A

Bay Area Air Quality Management District Regulation 8 Rule 8 (Emissions of Volatile Organic Compounds (VOC) from Wastewater Separators)

BAY AREA AIR QUALITY MANAGEMENT DISTRICT

REGULATION 8
ORGANIC COMPOUNDS
RULE 8
WASTEWATER (OIL-WATER) SEPARATORS

INDEX

8-8-100 GENERAL
8-8-101 Description
8-8-110 Exemption, Less Than 760 Liters
8-8-111 Deleted November 1, 1989
8-8-112 Exemption, Wastewater Critical OC Concentration and/or Temperature
8-8-113 Exemption, Secondary Wastewater Treatment Processes and Stormwater Sewer Systems
8-8-114 Exemption, Bypassed Oil-Water Separator or Air Flotation Influent
8-8-115 Exemption, Municipal Wastewater Treatment Facilities
8-8-200 DEFINITIONS
8-8-201 Organic Compounds
8-8-202 Wastewater (Oil-Water) Separator
8-8-203 Wastewater Separator Forebay
8-8-204 Vapor-tight
8-8-205 Oil-Water Separator Slop Oil
8-8-206 Oil-Water Separator Effluent Channel/Pond
8-8-207 Full Contact Fixed Cover
8-8-208 Secondary Treatment Processes
8-8-209 Air Flotation Unit
8-8-210 Critical Organic Compound (OC)
8-8-211 Wastewater
8-8-212 Pre-Air Flotation Unit Flocculation Sump, Basin, Chamber, or Tank
8-8-213 Oil-Water Separator Slop Oil Vessel
8-8-214 Oil-Water Separator Effluent
8-8-215 Sludge-dewatering Unit
8-8-216 Stormwater Sewer System
8-8-217 Junction Box
8-8-218 Sewer Line
8-8-300 STANDARDS
8-8-301 Wastewater Separators Designed Rated Capacity Greater Than 760 Liters per Day and Smaller Than 18.9 Liters per Second
8-8-302 Wastewater Separators Rated Capacity Larger Than or Equal to 18.9 Liters per Seconds
8-8-303 Gauging and Sampling Devices
8-8-304 Sludge-dewatering Unit
8-8-305 Oil-Water Separator and/or Air Flotation Unit Slop Oil Vessels
8-8-306 Oil-Water Separator Effluent Channel, Pond, Trench, or Basin
8-8-307 Air Flotation Unit
8-8-308 Junction Box

8-8-309 Deleted October 6, 1993
8-8-310 Deleted October 6, 1993
8-8-311 Deleted October 6, 1993
8-8-400 ADMINISTRATIVE REQUIREMENTS
8-8-401 Deleted October 6, 1993
8-8-500 MONITORING AND RECORDS
8-8-501 API Separator or Air Flotation Bypassed Wastewater Records
8-8-502 Wastewater Critical OC Concentration and/or Temperature Records
8-8-503 Inspection and Repair Records
8-8-504 Portable Hydrocarbon Detector
8-8-600 MANUAL OF PROCEDURES
8-8-601 Wastewater Analysis for Critical OCs
8-8-602 Determination of Emissions
8-8-603 Inspection Procedures

REGULATION 8
ORGANIC COMPOUNDS
RULE 8
WASTEWATER (OIL-WATER) SEPARATORS

(Adopted January 17, 1979)

8-8-100 GENERAL

8-8-101 Description: The purpose of this Rule is to limit the emissions of precursor organic compounds from wastewater (oil-water) separators, forebays, and air flotation units which remove floating oil, floating emulsified oil, or other liquid precursor organic compounds. (Amended November 1, 1989)

8-8-110 Exemption, Less Than 760 Liters: The requirements of Section 8-8-301 shall not apply to any wastewater separator which processes less than 760 liters (200 gals.) per day of wastewater containing organic liquids. This exemption shall not apply to wastewater separators at petroleum refinery complexes after March 1, 1980.

8-8-111 Deleted November 1, 1989

8-8-112 Exemption, Wastewater Critical OC Concentration and/or Temperature: The requirements of Sections 8-8-301, 302, 306, 307, and 308 shall not apply to any wastewater separator that processes influent wastewater less than 20 degrees C (68 ^{o}F) and/or wastewater comprised of less than 1.0 ppm (volume) critical organic compounds, as defined in Section 8-8-210, dissolved in the water samples, provided that the requirements of Section 8-8-502 are met. (Adopted November 1, 1989)

8-8-113 Exemption, Secondary Wastewater Treatment Processes And Stormwater Sewer Systems: The requirements of Sections 8-8-301, 302, 306, and 308 shall not apply to any secondary wastewater treatment processes or stormwater sewer systems, as defined in Sections 8-8-208 and 216, which are used as a wastewater polishing step or collection of stormwater which is segregated from the process wastewater collection system. (Adopted November 1, 1989)

8-8-114 Exemption, Bypassed Oil-Water Separator or Air Flotation Influent: The requirements of Sections 8-8-301, 302, and 307 shall not apply for wastewater which

bypasses either the oil-water separator or air flotation unit provided that: (1) the requirements of Section 8-8-501 are met; and (2) on that day the District did not predict an excess of the Federal Ambient Air Quality Standard for ozone. (Adopted November 1, 1989)

8-8-115 Exemption, Municipal Wastewater Treatment Facilities: The requirements of Sections 8-8-301, 302, 303, 304, 305, 306, 307, and 308 shall not apply to any publicly owned municipal wastewater treatment facility. (Adopted November 1, 1989)

8-8-200 DEFINITIONS

8-8-201 Organic Compounds: For the purposes of this Rule, any organic compound as defined in Section 8-8-210. (Amended November 1, 1989)

8-8-202 Wastewater (Oil-Water) Separator: Any device used to separate liquid organic compounds from oil-water waste streams (excluding Wastewater Separator Forebay, Air Flotation (AF) units, Sludge-dewatering Units, Oil-Water Separator and /or AF Unit Slop Oil Vessels, and Junction Boxes). (Amended November 1, 1989)

8-8-203 Wastewater Separator Forebay: That section of a gravity-type separator which (a) receives the untreated, contaminated wastewater from the pre-separator flume, and (b) acts as a header which distributes the influent to the separator channels. (Amended November 1, 1989)

8-8-204 Vapor-tight: The concentration of precursor organic compounds, measured one centimeter from the source, shall not exceed 500 ppm (expressed as methane) above background. (Adopted November 1, 1989)

8-8-205 Oil-Water Separator Slop Oil: Floating oil, flocculent sludge, and solids that accumulate in an oil-water separator or air flotation unit. (Adopted November 1, 1989)

8-8-206 Oil-Water Separator Effluent Channel/Pond: An open channel, trench, pond, or basin that handles wastewater downstream of an oil-water separator that has not been treated by an air flotation unit (usually located between the separator and the air flotation unit). (Adopted November 1, 1989)

8-8-207 Full Contact Fixed Cover: A stationary separator cover which is always in full contact with the liquid surface of the oil-water separator. (Adopted November 1, 1989)

8-8-208 Secondary Treatment Processes: Any wastewater treatment process which is downstream of the air flotation unit, any other biological treatment process at a refinery, or any treatment process which is regulated by the U.S. EPA National Categorical Pretreatment Standards. These treatment processes are considered to be wastewater polishing steps and include: activated sludge tanks/basins, trickling or sand filters, aerated lagoons, oxidation ponds, rotating biological contactors, and other biological wastewater treatment processes. (Adopted November 1, 1989)

8-8-209 Air Flotation Unit: Any device, equipment, or apparatus in which wastewater is saturated with air or gas under pressure and removes floating oil, floating emulsified oil, or other floating liquid precursor organic compounds by skimming. Also included in this definition are: induced air flotation units and pre-air flotation unit flocculent sumps, tanks, or basins. (Adopted November 1, 1989)

8-8-210 Critical Organic Compound (OC): Any compound of carbon, excluding methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides, carbonates and ammonium carbonate, or non-precursor organic compounds (Methylene chloride, 1,1,1 trichloroethane, 1,1,2 trichlorotrifluoroethane (CFC-113), trichlorofluoromethane (CFC-11), dichlorodifluoromethane (CFC-12), dichlorotetrafluoroethane (CFC-114), and chloropentafluoroethane (CFC-115), emitted during separation, processing, or storage of wastewater, and having a carbon number of C-14 or less (excluding phenolic compounds).(Adopted November 1, 1989)

8-8-211 Wastewater: Any process water which contains oil, emulsified oil, or other organic compounds which is not recycled or otherwise used within a facility. (Adopted November 1, 1989)

8-8-212 Pre-Air Flotation Unit Flocculation Sump, Basin, Chamber, or Tank: Any facility which pretreats the air flotation unit's influent with chemical coagulants, and/or adjusts the influent's pH. (Adopted November 1, 1989)

8-8-213 Oil-Water Separator Slop Oil Vessel: Any vessel which, as its sole function, treats or dewaters oil-water separator slop oil. (Adopted November 1, 1989)

8-8-214 Oil-Water Separator Effluent: Any process wastewater downstream of the oil-water separator that has not been treated by an air flotation unit. (Adopted November 1, 1989)

8-8-215 Sludge-dewatering Unit: Any device which, as its sole function, is used to dewater oil-water separator and air flotation slop oil/sludge. (Adopted November 1, 1989)

8-8-216 Stormwater Sewer System: A drain and collection system designed and operated for the sole purpose of collecting stormwater and which is segregated from the wastewater collection system. (Adopted November 1, 1989)

8-8-217 Junction Box: A manhole or access point to a wastewater sewer system line. (Adopted November 1, 1989)

8-8-218 Sewer Line: A lateral, trunk line, branch line, ditch, channel, or other conduit used to convey wastewater to downstream oil-water separators. (Adopted November 1, 1989)

8-8-300 STANDARDS

8-8-301 Wastewater Separators Greater than 760 Liters per Day and Smaller than 18.9 Liters per Second: A person shall not operate any wastewater separator and/or forebay with a design rated or maximum allowable capacity greater than 760 liters per day and smaller than 18.9 liters per second (oil-water separators and/or forebays between 200 gals per day to 300 gals per min.) unless such wastewater separator and/or forebay is operated within its design rated or maximum allowable capacity and is equipped with one of the following:

301.1 A solid, gasketed, fixed cover totally enclosing the separator tank, chamber, or basin (compartment) liquid contents, with all cover openings closed, except when the opening is being used for inspection, maintenance, or wastewater sampling. Roof seals, access doors, and other openings shall be checked by visual inspection initially and semiannually thereafter to ensure

that no cracks or gaps greater than 0.32 cm (0.125 inch) occur in the roof or between the roof and wall; and that the access doors and other openings are closed and gasketed properly; or

301.2 A floating pontoon or double-deck vapor-tight type cover. All floating roofs must rest entirely on the liquid surface. The floating roof shall consist of two seals, one above the other, the one below shall be referred to as the primary seal, while the other seal shall be referred to as the secondary seal.

2.1 Oil-Water Separator Liquid-Mounted Primary Seal Gap Criteria: No gap between the separator wall and the liquid-mounted primary seal shall exceed 3.8 cm (1.5 inch). No continuous gap greater than 0.32 cm (0.125 inch) shall exceed 10 percent of the perimeter of the separator. The cumulative length of all primary seal gaps exceeding 1.3 cm (0.5 inch) shall be not more than 10 percent of the perimeter and the cumulative length of all primary seal gaps exceeding 0.32 cm (0.125 inch) shall be not more than 40 percent of the perimeter.

2.2 Oil-Water Separator Secondary And Wiper Seals Gap Criteria: No gap between the separator wall and the secondary and wiper seals shall exceed 1.5 mm (0.06 inch). The cumulative length of all secondary and wiper seals gaps exceeding 0.5 mm (0.02 inch) shall be not more than 5 percent of the perimeter of the separator. The secondary and wiper seals must exert a positive pressure against the separator such that the seal surface in contact with the separator wall does not pull away from the separator wall more than the gaps allowed.

2.3 Primary And Secondary Seal Gap Inspection: The primary seal shall be inspected within 60 calendar days after initial installation of the floating roof and once every 5 years thereafter in accordance with the requirements of Subsection 8-8-301.2.2.1. The secondary seal shall be inspected within 60 calendar days after initial installation of the floating roof and once every year thereafter in accordance with the requirements of Subsection 8-8-301.2.2.2. The owner or operator shall make necessary repairs within 30 calendar days of identification of seals not meeting the requirements listed in Subsections 8-8-301.2.1 and 301.2.2.2.; or

301.3 An OC vapor recovery system with a combined collection and destruction efficiency of at least 95 percent, by weight.

301.4 **Deleted October 6, 1993** (Amended November 1, 1989; October 6, 1993)

8-8-302 Wastewater Separators Larger than or Equal to 18.9 Liters per Second: A person shall not operate any wastewater separator and/or forebay with a rated or maximum allowable capacity larger than or equal to 18.9 liters per second (300 gals per min.) unless such wastewater separator and/or forebay is operated within its design rated or maximum allowable capacity and is equipped with one of the following:

302.1 A solid, vapor-tight, full contact fixed cover which totally encloses the separator tank, chamber, or basin (compartment) liquid contents, with all cover openings closed and sealed, except when the opening is being used for inspection, maintenance, or wastewater sampling; or

302.2 A floating pontoon or double-deck vapor-tight type cover. All floating roofs must rest on the liquid surface. The floating roof shall consist of two seals, one above the other, the one below shall be referred to as the primary seal, while the other seal shall be referred to as the secondary seal.

2.1 Oil-Water Separator Liquid-Mounted Primary Seal Gap Criteria: No gap between the separator wall and the liquid-mounted primary seal shall exceed 3.8 cm (1.5 inch). No continuous gap greater than 0.32 cm (0.125 inch) shall exceed 10 percent of the perimeter of the separator. The cumulative length of all primary seal gaps exceeding 1.3 cm (0.5 inch) shall be not more than 10 percent of the perimeter and the cumulative length of all primary seal gaps exceeding 0.32 cm (0.125 inch) shall be not more than 40 percent of the perimeter.

2.2 Oil-Water Separator Secondary And Wiper Seals Gap Criteria: No gap between the separator wall and the secondary and wiper seals shall exceed 1.5 mm (0.06 inch). The cumulative length of all secondary and wiper seals gaps exceeding 0.5 mm (0.02 inch) shall be not more than 5 percent of the perimeter of the separator. The secondary and wiper seals must exert a positive pressure against the separator such that the seal surface in contact with the separator wall does not pull away from the separator wall more than the gaps allowed; or

2.3 Primary And Secondary Seal Gap Inspection: The primary seal shall be inspected within 60 calendar days after initial installation of the floating roof and once every 5 years thereafter in accordance with the requirements of Subsection 8-8-302.2.2.1. The secondary seal shall be inspected within 60 calendar days after initial installation of the floating roof and once every year thereafter in accordance with the requirements of Subsection 8-8-302.2.2.2. The owner or operator shall make necessary repairs within 30 calendar days of identification of seals not meeting the requirements listed in Subsections 8-8-302.2.2.1 and 302.2.2.2.; or

302.3 A vapor-tight fixed cover with an OC vapor recovery system which has a combined collection and destruction efficiency of at least 95 percent, by weight, inspection and access hatches shall be closed except when the opening is being used for inspection, maintenance, or wastewater sampling, or

302.4 A solid, sealed, gasketed, fixed cover which totally encloses the separator tank, chamber, or basin (compartment) liquid contents, with all cover openings closed and sealed, except when the opening is being used for inspection, maintenance, or wastewater sampling. The cover may include a pressure/vacuum valve. The concentration of precursor organic compounds, measured one centimeter from the roof seals, fixed cover,

access doors, pressure/vacuum valve, and other openings shall not exceed 1,000 ppm (expressed as methane) above background. Roof seals, fixed cover, access doors, and other openings shall be inspected initially and semiannually thereafter to ensure that there are no emission leaks greater than 1,000 ppm. Any emission leak greater than 1,000 ppm must be reported to the APCO and repaired within 15 days.

302.5 **Deleted October 6, 1993** (Adopted November 1, 1989; Amended October 6, 1993)

8-8-303 Gauging and Sampling Devices: Any compartment or access hatch shall have a vapor tight cover. Any gauging and sampling device in the compartment cover shall be equipped with a vapor tight cover, seal, or lid. The compartment cover and gauging or sampling device cover shall at all times be in a closed position, except when the device is in use for inspection, maintenance, or wastewater sampling. (Amended, Renumbered November 1, 1989)

8-8-304 Sludge-dewatering Unit: Any sludge-dewatering unit, equipment, machinery, apparatus, or device shall be totally enclosed and vented to a control device which has a minimum combined collection and destruction efficiency of 95 percent by weight; or shall have vapor-tight covers on the unit, conveyer belts, and storage bins or tanks except during inspection, maintenance or when the solids storage bin is in use. (Adopted November 1, 1989; Amended October 6, 1993)

8-8-305 Oil-Water Separator And/Or Air Flotation Unit Slop Oil Vessels: A person shall not store any oil-water separator and/or air flotation unit sludges in an oil-water separator slop oil vessel unless such oil-water separator slop oil vessel is equipped with one of the following:

305.1 A solid, gasketed, fixed cover totally enclosing the vessel liquid contents, with all cover openings closed, except when the opening is being used for inspection, maintenance, or wastewater sampling. The cover may include an atmospheric vent or a pressure/vacuum valve. Roof seals, access doors, and other openings shall be checked by visual inspection initially and semiannually thereafter to ensure that no cracks or gaps greater than 0.32 cm (0.125 inch) occur in the roof or between the roof and wall; and that the access doors and other openings are closed and gasketed properly; or

305.2 An OC vapor recovery system with a combined collection and destruction efficiency of at least 70 percent, by weight.

305.3 **Deleted October 6, 1993** (Adopted November 1, 1989; Amended October 6, 1993)

8-8-306 Oil-Water Separator Effluent Channel, Pond, Trench, or Basin: A person shall not operate any oil-water separator effluent channel, pond, trench, or basin a design rated or maximum allowable capacity greater than 25.2 liters per second (any oil-water separator effluent channel, pond, trench, or basin greater than 400 gals per min) unless such oil-water separator effluent channel,

pond, trench, or basin is operated within its design rated or maximum allowable capacity and is equipped with one of the following:

306.1 A solid, gasketed, fixed cover totally enclosing the oil-water separator effluent channel, pond, trench, or basin (compartment) liquid contents, with all cover openings closed, except when the opening is being used for inspection, maintenance, or wastewater sampling. Roof seals, access doors, and other openings shall be checked by visual inspection initially and semiannually thereafter to ensure that no cracks or gaps greater than 0.32 cm (0.125 inch) occur in the roof or between the roof and wall; and that the access doors and other openings are closed and gasketed properly; or

306.2 An OC vapor recovery system with a combined collection and destruction efficiency of at least 70 percent, by weight.

306.3 **Deleted October 6, 1993** (Adopted November 1, 1989; Amended October 6, 1993)

8-8-307 Air Flotation Unit: A person shall not operate any air flotation unit and/or pre-air flotation unit flocculation sump, basin, chamber, or tank with a design rated or maximum allowable capacity greater than 25.2 liters per second (air flotation units and/or pre-air flotation unit flocculation sump, basin, chamber, or tank greater than 400 gals per min.) unless such air flotation unit and/or pre-air flotation unit flocculation sump, basin, chamber, or tank is operated within its design rated or maximum allowable capacity and is equipped with one of the following:

307.1 A solid, gasketed, fixed cover totally enclosing the air flotation and pre-air-flotation-unit flocculation tank, chamber, or basin (compartment) liquid contents, with all cover openings closed, except when the opening is being used for inspection, maintenance, or wastewater sampling. The cover may include an atmospheric vent or pressure/vacuum valve. Roof seals, access doors, and other openings shall be checked by visual inspection initially and semiannually thereafter to ensure that no cracks or gaps greater than 0.32 cm (0.125 inch) occur in the roof or between the roof and wall; and that the access doors and other openings are closed and gasketed properly; or

307.2 An OC vapor recovery system with a combined collection and destruction efficiency of at least 70 percent, by weight.

307.3 Deleted October 6, 1993 (Adopted November 1, 1989; Amended October 6, 1993)

8-8-308 Junction Box: Any junction box shall be equipped with either a solid, gasketed, fixed cover totally enclosing the junction box or a solid manhole cover. Junction boxes may include openings in the covers and vent pipes if the total open area of the junction box does not exceed 81.3 cm^2 (12.6 in^2) and all vent pipes are at least 3 feet in length.(Adopted November 1, 1989; Amended October 6, 1993)

8-8-309 Deleted October 6, 1993

8-8-310 Deleted October 6, 1993

8-8-311 Deleted October 6, 1993

8-8-400 ADMINISTRATIVE REQUIREMENTS

8-8-401 Deleted October 6, 1993

8-8-500 MONITORING AND RECORDS

8-8-501 API Separator or Air Flotation Bypassed Wastewater Records: Any person who bypasses wastewater past their API Separator or Air Flotation unit shall maintain records on the amount of bypassed wastewater, duration, date, causes for bypasses, and dissolved critical OC concentration (volume). These records shall be retained and available for inspection by the APCO for at least 24 months. (Adopted November 1, 1989)

8-8-502 Wastewater Critical OC Concentration And/Or Temperature Records: Any person who exempts their wastewater separator because of either wastewater critical OC concentration or temperature shall sample and test the wastewater initially and semiannually thereafter and maintain records on the date, time of test, location, and wastewater temperature and/or critical OC concentration (volume). These records shall be retained and available for inspection by the APCO for at least 24 months. (Adopted November 1, 1989)

8-8-503 Inspection and Repair Records: Records of inspections and repairs as required by Sections 8-8-301, 302, 305, 306 or 307 shall be retained and made available for inspection by the APCO for at least 24 months. (Adopted October 6, 1993)

8-8-504 Portable Hydrocarbon Detector: Any instrument used for the measurement of organic compounds shall be a gas detector that meets the specifications and performance criteria of and has been calibrated in accordance with U.S. EPA Reference Method 21 (40 CFR 60, Appendix A). Adopted June 15, 1994)

8-8-600 MANUAL OF PROCEDURES

8-8-601 Wastewater Analysis for Critical OCs: Samples of wastewater as specified in this rule shall be taken at the influent stream for each unit and analyzed for the concentration of dissolved critical organic compounds as prescribed in the Manual of Procedures, Volume III, Lab Method 33.(Amended November 1, 1989; October 6, 1993)

8-8-602 Determination of Emissions: Emissions of precursor organic compounds as specified in Sections 8-8-301.3, 8-8-302.3, 8-8-304, 8-8-305.2, 8-8-306.2, and 8-8-307.2 shall be measured as prescribed by any of the following methods: 1)

BAAMQD Manual of Procedures, Volume IV, ST-7, 2) U.S. EPA Method 25, or 25A). A source shall be considered in violation if the VOC emissions measured by any of the referenced test methods exceed the standards of this rule.(Amended November 1, 1989; October 6, 1993, June15, 1994)

8-8-603 Inspection Procedures: For the purposes of Sections 8-8-301, 302, 303 and 304, leaks shall be measured using a portable gas detector as prescribed in U.S. EPA Reference Method 21 (40 CFR 60, Appendix A). (Adopted June 15, 1994)

Appendix B

United States Environmental Protection Agency
New Source Performance Standards
For Refinery Process Drains

(40CFR60.692-2)

§60.692-2 Standards: Individual drain systems.

(a)(1) Each drain shall be equipped with water seal controls.

(2) Each drain in active service shall be checked by visual or physical inspection initially and monthly thereafter for indications of low water levels or other conditions that would reduce the effectiveness of the water seal controls.

(3) Except as provided in paragraph (a)(4) of this section, each drain out of active service shall be checked by visual or physical inspection initially and weekly thereafter for indications of low water levels or other problems that could result in VOC emissions.

(4) As an alternative to the requirements in paragraph (a)(3) of this section, if an owner or operator elects to install a tightly sealed cap or plug over a drain that is out of service, inspections shall be conducted initially and semiannually to ensure caps or plugs are in place and properly installed.

(5) Whenever low water levels or missing or improperly installed caps or plugs are identified, water shall be added or first efforts at repair shall be made as soon as practicable, but not later than 24 hours after detection, except as provided in §60.692-6.

(b)(1) Junction boxes shall be equipped with a cover and may have an open vent pipe. The vent pipe shall be at least 90 cm (3 ft) in length and shall not exceed 10.2 cm (4 in) in diameter.

(2) Junction box covers shall have a tight seal around the edge and shall be kept in place at all times, except during inspection and maintenance.

(3) Junction boxes shall be visually inspected initially and semiannually thereafter to ensure that the cover is in place and to ensure that the cover has a tight seal around the edge.

(4) If a broken seal or gap is identified, first effort at repair shall be made as soon as practicable, but not later than 15 calendar days after the broken seal or gap is identified, except as provided in §60.692-6.

(c)(1) Sewer lines shall not be open to the atmosphere and shall be covered or enclosed in a manner so as to have no visual gaps or cracks in joints, seals, or other emission interfaces.

(2) The portion of each unburied sewer line shall be visually inspected initially and semiannually thereafter for indication of cracks, gaps, or other problems that could result in VOC emissions.

(3) Whenever cracks, gaps, or other problems are detected, repairs shall be made as soon as practicable, but not later than 15 calendar days after identification, except as provided in §60.692-6.

(d) Except as provided in paragraph (e) of this section, each modified or reconstructed individual drain system that has a catch basin in the existing configuration prior to May 4, 1987 shall be exempt from the provisions of this section.

(e) Refinery wastewater routed through new process drains and a new first common downstream junction box, either as part of a new individual drain system or an existing individual drain system, shall not be routed through a downstream catch basin.

§60.692-5 Standards: Closed vent systems and control devices.

(a) Enclosed combustion devices shall be designed and operated to reduce the VOC emissions vented to them with an efficiency of 95 percent or greater or to provide a

minimum residence time of 0.75 seconds at a minimum temperature of 816 °C (1,500 °F).
(b) Vapor recovery systems (for example, condensers and adsorbers) shall be designed and operated to recover the VOC emissions vented to them with an efficiency of 95 percent or greater.
(c) Flares used to comply with this subpart shall comply with the requirements of 40 CFR 60.18.
(d) Closed vent systems and control devices used to comply with provisions of this subpart shall be operated at all times when emissions may be vented to them.
(e)(1) Closed vent systems shall be designed and operated with no detectable emissions, as indicated by an instrument reading of less than 500 ppm above background, as determined during the initial and semiannual inspections by the methods specified in §60.696.
(2) Closed vent systems shall be purged to direct vapor to the control device.
(3) A flow indicator shall be installed on a vent stream to a control device to ensure that the vapors are being routed to the device.
(4) All gauging and sampling devices shall be gas-tight except when gauging or sampling is taking place.
(5) When emissions from a closed system are detected, first efforts at repair to eliminate the emissions shall be made as soon as practicable, but not later than 30 calendar days from the date the emissions are detected, except as provided in §60.692-6.

Appendix C

South Coast Air Quality Management District Rule 1176
(VOC Emissions from Wastewater Systems)

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

(Adopted November 3, 1989)(Amended January 5, 1990)
(Amended May 13, 1994) (Amended September 13, 1996)

RULE 1176. VOC EMISSIONS FROM WASTEWATER SYSTEMS

(a) Purpose

This rule is intended to limit volatile organic compound (VOC) emissions from wastewater systems.

(b) Applicability

This rule applies to wastewater systems and associated control equipment located at petroleum refineries, on-shore oil production fields, off-shore oil production platforms, chemical plants, and industrial facilities.

(c) Definitions

For purposes of this rule, the following definitions apply:

1. CATCH BASIN is an open basin which serves as a single collection point for rainwater or stormwater run-off directly from ground surfaces.
2. AIR POLLUTION CONTROL (APC) DEVICE means air pollution control equipment which eliminates, reduces or controls the issuance of air contaminants.
3. BACKGROUND LEVEL is the ambient concentration of VOC in the air as measured pursuant to paragraph (h)(1).
4. CERTIFIED INSPECTOR is a person who has successfully completed a District approved fugitive emissions compliance inspection program and holds a current valid inspector certificate issued by the Executive Officer.
5. CERTIFIED INSTRUCTOR is a person who has successfully completed a District fugitive emissions compliance inspection program or any other program determined to be equivalent and approved by the Executive Officer and holds a current valid instructors certificate issued by the Executive Officer.
6. CHEMICAL PLANT is any facility engaged in producing chemicals, and/or manufacturing products by chemical processes. Any facility or operation that has 282 as the first three digits in its Standard Industrial Classification Code as defined in the Standard Industrial Classification Manual is included in this definition.
7. CLOSED VENT SYSTEM is a system that is not open to the atmosphere and that is composed of piping, ductwork, connections, and if necessary, flow-inducing devices that collect and transport gas or vapor from an emission source to an APC device or into gas recovery and/or combustion equipment. In that case, gas recovery and/or combustion equipment shall not be considered a closed vent system and is not subject to closed vent system standards.
8. DRAIN SYSTEM COMPONENT (DSC) is a process drain, manhole cover, junction box vent or other wastewater system vent, excluding closed vent systems. DSCs are categorized as follows:
   (A) NON-EMITTING DSC is a DSC which is controlled using a gas tight barrier between the sewer and the atmosphere that for the most recent six month period does not emit VOC emissions, or is a DSC which is uncontrolled that for the most

recent 24 month period does not emit VOC emissions, as measured pursuant to paragraph (h)(1) in excess of 10 ppm above background level.

(B) LOW-EMITTING DSC is a DSC that has not emitted excess emissions for the most recent six month period or is effectively controlled pursuant to subparagraph (e)(7)(A).

(C) HIGH-EMITTING DSC is a DSC that has at least one excess emission in the most recent six months.

(D) REPEAT-EMITTING DSC is a petroleum refinery DSC that has emitted excess emissions at least three times during any consecutive 12 months, unless it has been effectively controlled pursuant to subparagraph (e)(7)(A).

9. DSC CONTROL is any control measure for a DSC which utilizes water seal controls, APC devices, hardpiping, or complete capping, plugging, or source elimination. Any other alternate control measure such as permanent source reduction may qualify as a DSC control, if approved in writing by the Executive Officer.
10. EXCESS EMISSIONS are VOC emissions measured pursuant to paragraph (h)(1) to be greater than 500 ppm above background levels.
11. FIXED COVER is any impermeable cover installed in a permanent stationary position.
12. FLOATING COVER is any impermeable cover which is in contact with a liquid surface at all times.
13. INACCESSIBLE DSC is any DSC located over 15 feet above ground when access is required from the ground; or any component located over six feet away from a platform when access is required from a platform; or any component which would require the elevation of monitoring personnel higher than six feet above permanent support surfaces. Inaccessible DSCs do not include DSC vents and wastewater system associated vents, where the vent pipes are extended more than four feet in length.
14. INDUSTRIAL FACILITIES are those engaged in the production and distribution of natural gas, pipeline distribution or wholesale distribution of crude petroleum and petroleum products , as classified under the Standard Industrial Classification group numbers 492, or 461, respectively, of the Standard Industrial Classification Manual.
15. JUNCTION BOX is a structure with a manhole or access point to a wastewater sewer system lines.
16. NON-CONTACT WATER is any water which does not come into contact with wastewater.
17. OIL PRODUCTION FIELD is a facility at which crude petroleum production and handling are conducted, as defined in the Standard Industrial Classification Manual as Industry No. 1311, Crude Petroleum and Natural Gas.
18. PETROLEUM REFINERY is a facility that processes petroleum, as defined in the Standard Industrial Classification Manual as Industry No. 2911, Petroleum Refining.
19. PROCESS DRAIN is any opening (including covered or controlled openings) which is installed or used to receive or convey wastewater into the wastewater system.

20. SEPARATOR FOREBAY is that section of a gravity-type separator which receives the untreated wastewater from the preseparator flume and acts as a header which distributes the influent to the separator channels.
21. SEWER LINE is a lateral trunk line, branch line, ditch, channel, or other conduit used to convey wastewater.
22. SUMP is a surface impoundment or excavated depression in the ground, which is part of the wastewater system and used for storage of wastewater or separation of petroleum liquids, VOC containing liquids, water, and/or solids.
23. VOLATILE ORGANIC COMPOUND (VOC) is as defined in Rule 102.
24. WASTEWATER is a water stream or other liquid waste stream generated in a manner which may contain petroleum liquid, emulsified oil, VOC, or other hydrocarbons.
25. WASTEWATER SEPARATOR is any device, used to separate petroleum liquids and/or VOC containing liquids from wastewater including such devices as separator forebays, clarifiers and tanks including dissolved air flotation tanks, induced gas flotation tanks and induced air flotation tanks.
26. WASTEWATER SYSTEM is any system which consists of one or more process drains, sewer lines, junction boxes, manholes, sumps, or wastewater separators, including all of their associated components, used to receive, convey, separate, treat, or process wastewater.
27. WATER SEAL CONTROL is a seal pot, p-leg trap, or other type of trap filled with any non-VOC containing liquid to create a liquid barrier between the sewer and the atmosphere.

(d) Identification Requirements

The facility operator shall comply with the following provisions:

1. Requirements for Facilities other than Petroleum Refineries:
   Within 60 days of written request by the Executive Officer, submit a detailed schematic drawing identifying the location within the facility of all the components of the wastewater system and all associated APC devices. In lieu of identifying the locations of the DSCs on the schematic, the DSCs locations may be identified on a separate list attached to the schematic.
2. Requirements for Petroleum Refineries:
   By June 30, 1997, submit to the District a compliance plan which shall include the following:
   (A) A statement regarding which compliance option listed in either subparagraphs (e)(7)(A) or (e)(7)(B) has been chosen; and
   (B) A detailed schematic drawing of the location of the wastewater system, within the facility. The schematic shall also include all of the APC devices associated with the wastewater system; and
   (C) A complete DSC list identifying their total number, individual location and if controlled, the type of DSC control. The list shall also identify each DSC as either non-emitting, low-emitting, high-emitting, or repeat-emitting according to the initial monitoring frequency in subparagraph (f)(1)(A). Historical monitoring data collected during the most recent 12 months may be used to categorize each DSC in lieu of subparagraph (f)(1)(A), except for uncontrolled non-emitting DSCs

which shall be required to use the most recent 24 months of historical data. Any inaccessible DSC shall be identified for District's verification and approval; and
(D) Historical monitoring data and/or the monitoring data collected pursuant to subparagraph (f)(1)(A) used to categorize each DSC, and
(E) An identification of the proposed methods of control, if necessary, for each junction box vent based on its emission characteristics; and
(F) Any alternate DSC control which is not already identified in paragraph (c)(9) and the operator requests approval in advance by the Executive Officer for use as a DSC control. A complete description of the proposed DSC control and its specific applications shall be included.

(e) Operation and Control Requirements

The facility operator shall comply with the following provisions:

1. Wastewater System Emissions:
   Wastewater systems and closed vent systems, except sump and wastewater separator covers in compliance with clause (e)(2)(B)(vi), shall not emit VOC emissions measured pursuant to paragraph (h)(2) to be greater than 500 ppm above background levels according to the compliance dates in Table 1. The compliance date in Table 1 may be extended pursuant to subparagraphs (e)(2)(C) and (e)(5)(B).

Table 1	
EQUIPMENT	COMPLIANCE DATE
Separator forebays, clarifiers, dissolved air flotation tanks, induced gas flotation tanks, and induced air flotation tanks which are not controlled.	June 30, 1997
Sumps which are not controlled.	June 30, 1997
Junction box vents and manhole cover openings.	June 30, 1997
All other parts of the wastewater system not specifically listed above.	November 3, 1989

2. Sumps and Wastewater Separators :
   (A) Sumps and Wastewater Separators shall be provided with one of the following except as provided in subparagraph (e)(2)(C):

   (i) A floating cover equipped with seals.

   (ii) A fixed cover, equipped with a closed vent system vented to an APC device as specified in paragraph (e)(6).

   (iii) Any other alternate control measure which is demonstrated by the facility operator to be equivalent to, or more effective in reducing VOC emissions than the requirements of clauses (e)(2)(A)(i) or (e)(2)(A)(ii), and approved in writing by the Executive Officer.

   (B) Sump and Wastewater Separator Covers, both fixed and floating, shall meet all of the following requirements:

   (i) The cover material shall be impermeable to VOCs, and free from holes, tears, or openings.

(ii) Drains on covers shall be provided with a slotted membrane fabric cover, or equivalent, over at least 90 percent of the open area.

(iii) Gauging or sampling openings on the separator shall be covered. The covers shall be kept closed, with no visible gaps between the cover and the separator, except when the gauging or sampling device is actively being used.

(iv) Hatches on covers shall be kept closed and free of gaps, except when opened for active inspection, maintenance, sampling, or repair.

(v) The perimeter of a cover, except for a floating cover, shall form a seal free of gaps with the foundation to which it is attached.

(vi) A floating cover shall be designed and maintained so that the gap between the separator or sump wall and the seal does not exceed 1/8 inch for a cumulative length of 97 percent of the perimeter of the separator. No gap between the wall and the seal shall exceed 1/2 inch.

(C) For initial modification of sumps, separator forebays, clarifiers, dissolved air flotation tanks, induced gas flotation tanks, or induced air flotation tanks to comply with subparagraphs (e)(2)(A) and (e)(2)(B) which require a permit to construct, compliance with paragraph (e)(1) and subparagraphs (e)(2)(A) and (e)(2)(B) shall be achieved no later than six months after the District issues the initial permit to construct, provided that a complete application for a permit to construct is submitted to the District on or before November 13, 1996.

3. Sewer lines:
   (A) All sewer lines shall be completely enclosed so that no liquid surface is exposed to the atmosphere. The manhole cover shall remain fully closed, except when opened for active inspection, maintenance, sampling, or repair.
   (B) By June 30, 1997, all openings in the sewer line manhole covers shall be completely sealed.
4. Process drains:
   Any new process drain installed after September 13, 1996, shall be equipped with water seal controls or any other alternative control measure which is demonstrated by the applicant to be equivalent, or more effective than water seal controls in reducing VOC emissions, as approved in writing by the Executive Officer.
5. Junction boxes:
   (A) Junction boxes shall be totally enclosed with a solid, gasketed, fixed cover or a manhole cover. Each fixed cover shall be allowed to have an open vent pipe no more than four inches in diameter and at least three feet in length. Each manhole cover on junction boxes shall be allowed to have openings totaling no more than 12 square inches. The manhole cover shall remain fully closed, except when opened for active inspection, maintenance, sampling, or repair.
   (B) For initial modification of junction boxes to comply with paragraph (e)(1), compliance shall be achieved no later than six months after the District issues the initial permit to construct for the DSC controls which require a permit to

construct, provided that a complete application for a permit to construct is submitted to the District on or before June 30, 1997.

6. APC Devices shall meet one of the following requirements:
   (A) An APC device receiving vapors from a closed vent system shall achieve a control efficiency of 95 percent by weight or greater of VOC. An annual performance test shall be conducted to determine the APC device control efficiency according to the test method specified in paragraph (h)(3),
   (B) The outlet of the APC device shall not emit VOC emissions measured pursuant to paragraphs (h)(1) or (h)(2) to be greater than 500 ppm above background. The frequency of monitoring shall be at least monthly, or
   (C) Any APC device or other alternate system that collects vapors through a closed vent system and subsequently controls the vapors in a device, which has been issued a permit to construct or a permit to operate by the Executive Officer, and determined by the Executive Officer to provide an equivalent level of VOC emission controls as specified in subparagraphs (e)(6)(A) or (e)(6)(B).
7. Additional Requirements for DSCs at Petroleum Refineries:
   Comply with the control requirements of either subparagraphs (e)(7)(A) or (e)(7)(B) according to the schedule specified in these subparagraphs.
   (A) Control of Repeat Emitting DSCs:
   Within 60 days or longer, as approved by the Executive Officer, after a DSC becomes a repeat emitting DSC, effectively control the DSC by installing a DSC control, if previously uncontrolled, or a more efficient DSC control to eliminate excess emissions from the DSC.
   (B) Control of All DSCs:
   DSC controls shall be installed on all DSCs that are uncontrolled as of September 13, 1996, according to the following schedule:

   (i) At least 25 percent of uncontrolled DSCs by December 31, 1997,

   (ii) At least 50 percent of uncontrolled DSCs by December 31, 1998,

   (iii) At least 75 percent of uncontrolled DSCs by December 31, 1999, and

   (iv) 100 percent of uncontrolled DSCs by December 31, 2000.

(f) Inspection, Monitoring and Maintenance Requirements

The facility operator shall comply with the following provisions:

1. Inspection and Monitoring Frequency:
   Wastewater systems and closed vent system(s) shall be inspected and monitored according to the following monitoring frequency:
   (A) For Petroleum Refineries Choosing Option (e)(7)(A):
   Inspect and monitor wastewater separators, closed vent systems, and all DSCs monthly until the compliance plan is submitted pursuant to paragraph (d)(2). After the compliance plan is submitted:

   (i) Inspect and monitor the wastewater system according to Table 2, or

   (ii) After June 30, 1997, inspect and monitor the wastewater system according to Table 2, except that low-emitting DSCs may be monitored

semi-annually, provided that:

(I) 0.5 percent or less of all DSCs, have emitted excess emissions as measured pursuant to paragraph (h)(1) for the most recent 12 month period, and

(II) The above is substantiated by documentation of the verified inspection and monitoring records, and submitted to the District for written approval by the Executive Officer.

The inspection and monitoring frequency, approved in clause (f)(1)(A)(ii), shall revert to clause (f)(1)(A)(i), should the facility operator's inspection records or District inspection show that greater than 0.5 percent of all DSCs have emitted excess emissions measured pursuant to paragraph (h)(1) in excess of the level specified in subclause (f)(1)(A)(ii)(I).

Table 2	
EQUIPMENT	FREQUENCY
Wastewater separator(s) and associated closed vent system(s)	Monthly
High-Emitting DSCs	Monthly
Low-Emitting DSCs	Quarterly
Non-Emitting DSCs	Semi-annually
Inaccessible DSCs	Annually

(B) Petroleum Refineries Choosing Option (e)(7)(B):

(i) Inspect and monitor wastewater separators, closed vent systems, and all DSCs monthly until the compliance plan is submitted pursuant to paragraph (d)(2).

(ii) After the compliance plan is submitted, inspect and monitor the wastewater system according to Table 3.

Table 3	
EQUIPMENT	FREQUENCY
Wastewater separator(s) and associated closed vent system(s).	Monthly
DSCs (Excluding Non-Emitting DSCs)	Quarterly
Non-Emitting DSCs	Semi-annually
Inaccessible DSCs	Annually

(C) For Oil Production Fields, Chemical Plants, and Industrial Facilities: Effective September 13, 1996, inspect and monitor wastewater separator(s), associated closed vent system(s) and DSCs quarterly, except that non-emitting DSCs and inaccessible DSCs, may be inspected annually.

2. On or after July 1, 1997, or a later date as approved in writing by the Executive Officer, all inspections and monitoring required under paragraph (f)(1) shall be done by a certified inspector.
3. Wastewater systems with excess emissions or otherwise found in violation through either operator inspection or District inspection shall be repaired or rectified within three calendar days of detection. The repaired or rectified

component shall be reinspected by the facility operator between 24 hours to 48 hours for petroleum refineries and between 24 hours to 15 calendar days for other facilities after the repair or rectification to ensure that the repaired or rectified component is in compliance with this rule. The operator shall take all feasible steps to minimize emissions during the repair or replacement period.

(g) Recordkeeping, Reporting and Verification of Records Requirements

The facility operator shall comply with the following provisions:

1. Recordkeeping:
   (A) All records shall be maintained at the facility for a period of two years and made available to District staff upon request.
   (B) Any operator using an APC device for a wastewater system as a means of complying with this rule, shall maintain records of system operation or maintenance which will demonstrate proper operation and compliance of the APC device during periods of emission producing activities.
   (C) Inspection records for the wastewater system shall be made and documented as follows:

   (i) The inspection record shall include and document all written or machine recorded operator inspections, VOC measurements including corresponding background levels, source tests, repairs, replacements, and reinspection records.

   (ii) The inspection record shall include the date(s) they were taken.

   (iii) The inspection record shall include the name and signature of the certified inspector(s). An electronic identification code may be used instead of a signature provided that the certified inspector verifies, in writing, that he or she has conducted the inspection and monitoring.

2. Reporting requirements for refineries:
   (A) Any change to the wastewater system or any other component required to be identified by paragraph (d)(2), shall be submitted to the District within 60 calendar days after construction is completed.
   (B) For facility operators complying with subparagraph (e)(7)(A), a quarterly report shall be submitted to the District in a format approved by the Executive Officer, within 30 calendar days after the end of each quarter. The report shall include all of the following:

   (i) The identification of all DSCs with recordings of excess emissions and the corresponding levels of emissions in ppm,

   (ii) The identification of repeat emitting drains including each record of excess emissions and subsequent repairs within the last 12 months before corrective actions,

   (iii) The corrective actions taken pursuant to subpara-graph (e)(7)(A), and

   (iv) Each monitoring record after corrective actions until the report is submitted.

(C) For facility operators complying with subparagraph (e)(7)(B), semi-annual reports shall be submitted to the District, each within 30 days after the end of each six month period, showing:

(i) Which DSCs identified in paragraph (d)(2) have been controlled and the type of control, until all DSCs are controlled, and

(ii) All DSCs identified to have an excess emission.

3. Verification of Records:
   All inspection records and reports submitted to the District, shall be signed by the facility official with responsibility for operation of the equipment subject to this rule, to verify that the inspection(s) have been conducted by certified inspectors consistent with the requirements of this rule.
4. Any inaccurate verification of inspection records shall constitute a violation of this rule.

(h) Test Methods

1. U.S. EPA Reference Method 21:
   Measurement of gaseous VOC concentration shall be conducted according to U.S. EPA Reference Method 21, using an appropriate analyzer calibrated with methane, or any other method demonstrated by the applicant to be equivalent and approved in writing by the Executive Officers of the District, the California Air Resources Board (CARB), and the Regional Administrator of the United States Environmental Protection Agency (U.S. EPA), Region IX, or their designees. Background level shall be measured using the Method 21 procedure for determining local ambient concentration around the source.
2. District Grab Sample Method:
   Sampling and analysis shall be conducted according to the test methods contained in Attachment A, or any other procedure and method demonstrated by the applicant to be equivalent and approved in writing by the Executive Officers of the District, the CARB, and the Regional Administrator of the U.S. EPA, Regio n IX, or their designees.
3. U.S. EPA Reference Method 25:
   Measurement of control efficiency of an air pollution control device shall be conducted according to U.S. EPA Reference Method 25, District Test Method 25.1, or any other method demonstrated by the applicant to be equivalent and approved in writing by the Executive Officers of the District, the CARB, and the Regional Administrator of the U.S. EPA, Region IX, or their designees. Emissions determined to exceed any limits established by this rule through either of the referenced test methods in paragraph (h)(3) shall constitute a violation of this rule. Test procedures shall be performed in accordance with a protocol approved by the Executive Officer.

(i) Exemptions

Specified provisions of this rule shall not apply if the wastewater system meets the applicable criteria shown below. Any person seeking to qualify for any one of the following exemptions has the burden of proving its wastewater system meets the applicable specified criteria:

1. The provisions of subdivision (e) shall not apply to equipment which, if covered, would present unavoidable explosion or fire hazards, as approved in writing by the Executive Officer.
2. The provisions of paragraph (e)(1) shall not apply to process drains while receiving petroleum liquids and/or VOC containing liquids.
3. The provisions of paragraph (e)(1) and subparagraph (e)(2)(B) shall not apply to components which the facility operator has detected and recorded to be in violation or to emit excess emissions, prior to District discovery and which is repaired and reinspected pursuant to paragraph (f)(3). This exemption is limited to the period of time between recording and reinspection.
4. The provisions of paragraph (e)(6) and subparagraph (f)(1)(C) shall not apply to natural gas handling facilities which are primarily operated to receive and inject natural gas into the ground for underground storage and subsequent processing and distribution with at least 80 percent methane (by volume), and of pipeline quality, such as the gas sold or distributed by any utility company regulated by the California Public Untilities Commission, provided that:
   (A) None of the wastewater separators, DSCs, closed vent systems and APC devices at the facility emit VOC emissions greater than 500 ppm as measured pursuant to paragraph (h)(2) at any time, and
   (B) The facility operator requests this exemption and provides inspection and monitoring records for the most recent two years, which demonstrates compliance with subparagraph (i)(4)(A), for the most recent two years, and the request is approved in writing by the Executive Officer.
   This approval and exemption shall automatically expire should facility operator's subsequent inspection records or District inspection show that the facility does not comply with the requirements of subpara-graph (i)(4)(A). If the exemption is lost due to non-compliance with subparagraph (i)(4)(A), the facility may reapply for an exemption pursuant to subparagraph (i)(4)(B)
5. All the provisions of this rule shall not apply to the following:
   (A) Components which present a safety hazard for inspection as documented and established in a previous safety manual or policy, or with the prior written approval of the Executive Officer except that these components shall be monitored for excess emissions when it is safe to do so. Upon detection, the excess emission shall be corrected as soon as the repairs or replacement can be carried out safely.
   (B) Wastewater separator pressure-vacuum valves when open, due to a vacuum produced within the wastewater system.
   (C) Spill containments for tanks.
   (D) Open pipe channels designed for spill containment.
   (E) Tanks subject to Rule 463.
   (F) Valves, fittings, pumps, compressors, pressure relief devices, diaphragms, hatches, site-glasses, and meters which are subject to or exempt from the requirements of Rule 1173.
   (G) Equipment, including catch basins, that exclusively receive, hold, or discharge rainwater, stormwater runoff, or non-contact water.

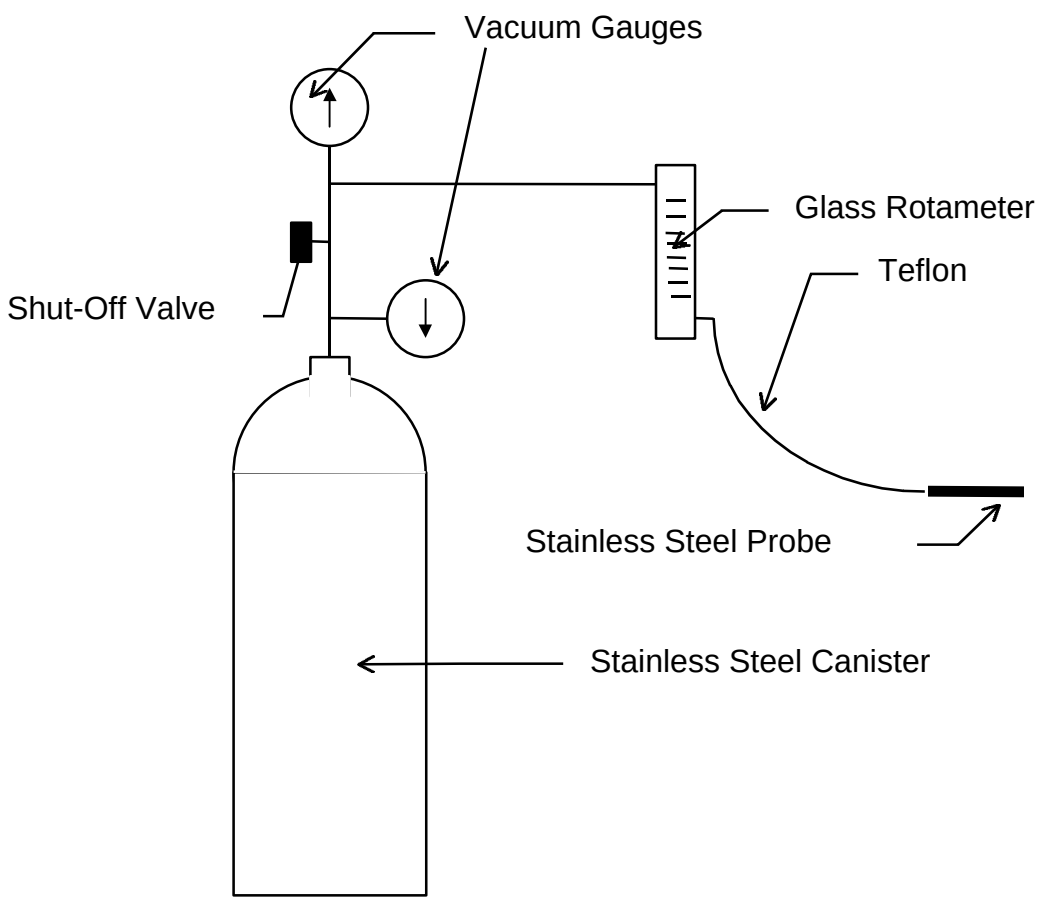
(H) Well cellars used in emergencies at oil production fields, if clean-up procedures are implemented within 24 hours after each emergency occurrence and completed within ten (10) calendar days.
(I) Sampling junction boxes of the wastewater system prior to discharge into the municipal sewer lines and which are designated as the legal sample point on the facility's industrial wastewater permit.
(J) Wastewater system(s), if the VOC content of each liquid stream entering each sump and/or wastewater separator does not exceed at all times 5 mg per liter, as determined by U.S. EPA Test Method 8240 or any other method demonstrated by the applicant to be equivalent and approved in writing by the Executive Officers of the District, the CARB, and the Regional Administrator of the U.S.-EPA, Region IX, or their designees. Samples of the liquid stream shall be collected from each inlet to the sump and/or wastewater separator. A safe sampling site or sampling port to meet the requirements of this subparagraph shall be installed upon request of the Executive Officer. The sampling site or port shall be installed within two weeks after request by the Executive Officer or by any other date as approved by the Executive Officer.
(K) Biological wastewater treatment units and their downstream equipment in a secondary treatment system that is installed and operated to meet the National Pollutant Discharge Elimination System (NPDES) discharge requirements if the VOC content of each liquid stream entering the secondary treatment system does not exceed at all times 5 mg per liter, as determined by U.S. EPA Test Method 8240 or any other method demonstrated by the applicant to be equivalent and approved in writing by the Executive Officers of the District, the CARB, and the Regional Administrator of the U.S. EPA, Region IX, or their designees. Samples of the liquid stream shall be collected from each inlet to the sump and/or wastewater separator. A safe sampling site or sampling port to meet the requirements of this subparagraph shall be installed upon request of the Executive Officer. The sampling site or port shall be installed within two weeks after request by the Executive Officer or by any other date as approved by the Executive Officer.
(L) Sanitary sewers and sanitary sewer systems not processing wastewater.

ATTACHMENT A
District Grab Sample Method

The grab sample procedure and method of analysis shall be according to the following:

1. **Sampling Apparatus**
   The sampling system shall consist of at a minimum:
   a. A 3 liter volume type 316 stainless steel tank.
   b. A valve for leak tight shut off.
   c. Two vacuum gauges which can measure 0 inch Hg to 30 inches of Hg.
   d. A glass rotameter which can accurately measure a flowrate of 1 liter per minute and larger.
   e. A one-eighth inch diameter Teflon connector.
   f. An inlet probe, and metallic fittings.
   The dead space volume in the sample line shall be kept to a minimum. All metallic components including the gauges shall be constructed of stainless steel. A type 304 stainless steel tank may be allowed provided there are no acids in the sample. Refer to Figure 1 for a schematic diagram of the sampling apparatus. The glass rotameter shall be calibrated once every three months.
2. **Sample Tank Evacuation and Leak Check**
   The evacuation and leak check of the sample tank shall be performed according to the corresponding section of U.S. EPA Method 25.
3. **Leak Check the Sampling Line**
   3.1. The sampling line shall be leak checked at the site before and after sampling using the following procedure:
   a. Cap the inlet probe.
   b. Open the shut off valve slowly and briefly to allow 1 inch of Hg of vacuum in the line.
   c. Close the valve immediately.
   d. The sampling line is leak free if there is no change in vacuum for one minute.
   3.2. As an alternative, the sampling line may be leak checked before and after sampling using the following procedure:
   a. Insert one end of a vacuum gauge at the inlet probe.
   b. Cap or seal the other end of the vacuum gauge attached to the probe.
   c. Follow procedures 3.1.b. through 3.1.d.
4. **Sampling**
   a. Purge the sample line.
   b. Record the vacuum prior to sampling.
   c. Use the section on “Individual Source Surveys” of U.S. EPA Reference Method 21 to take samples with the inlet probe of the sampling apparatus.
   d. The rotameter shall be level to the horizon.
   e. Open the shut off valve slowly.
   f. Adjust the rotameter to a constant 1 liter per minute flowrate. Maintain this constant flowrate throughout sampling.
   g. Close the shut off valve when the vacuum has dropped to between 5-10 inches of Hg.
   h. Record the vacuum after sampling is completed.
5. **Analysis of Sampling**

The sample shall be analyzed according to the applicable analytical gaseous sections of U.S. EPA Method 25, or District Test Method 25.1.



Schematic Diagram of Sampling Apparatus
U.S. EPA Method 25 / District Test Method 25.1

Appendix D

San Joaquin Valley Unified Air Pollution Control District Rule 4625 (Wastewater Separators)

RULE 4625 - WASTEWATER SEPARATORS

(Adopted April 11, 1991, Amended December 17, 1992)

1.0 Purpose

The purpose of this rule is to limit VOC emissions from wastewater separators by requiring a vapor loss control device.

2.0 Applicability

This rule applies to wastewater separators as defined in this rule. The requirements of this rule are not intended to apply to the separation of crude oil and water prior to custody transfer.

3.0 Definitions

3.1 Air flotation unit: equipment used to remove suspended matter, both oil and solid, from water by dissolving air under pressure and then releasing the air at atmospheric pressure in a tank or basin.

3.2 Wastewater Separator: any device or piece of equipment that is used to remove oil and associated chemicals from water, or any device, such as a flocculation tank, clarifier, etc. that removes petroleum-derived compounds from wastewater.

3.3 Wastewater Separator Forbay: that section of a gravity-type wastewater separator which receives the untreated, oil-water waste from the preseparator flume; and acts as a header which distributes the influent to the separator channels.

4.0 Exemptions

4.1 This rule shall not apply to any wastewater separator for which:

$$\frac{A}{f \times V} \text{ exceeds } 420,$$

where:

A = the area to be covered in square feet

V = the oil recovery rate in gallons/day on a annual basis

f = the estimated fractional volume loss of oil and is computed as:

= -.0663 + .000319 x (annual mean ambient temperature ^{o}F)

- [.000286 x (10% true boiling point, ^{o}F)]

+ [.00215 x (annual average influent temperature ^{o}F)]

4.2 Air Flotation Units

4.3 For existing facilities, if an incineration device is added or modified for the sole purpose of complying with the requirements of this rule, such a device shall be exempt from the Best Available Control Technology and the Offset requirements of Rule 2201 (New and Modified Stationary Source Review Rule).

5.0 Requirements

5.1 A person shall not use any compartment of any vessel or device operated for the recovery of oil or tar from effluent water, from any equipment which processes, refines, stores or handles petroleum or coal tar products unless such compartments are equipped with one of the following vapor loss control devices, except when gauging or sampling is taking place:

5.1.1 A solid cover with all openings sealed and totally enclosing the liquid contents of the compartment, except for such breathing vents as are structurally necessary; or

5.1.2 A floating pontoon or double-deck type cover, equipped with closure seals that have no holes or tears, installed and maintained so that gaps between the compartment wall and seal shall not exceed one-eighth (1/8) inch for an accumulative length of 97 percent of the perimeter of the tank, and shall not exceed one-half (1/2) inch for an accumulative length of the remaining three (3) percent of the perimeter of the tank. No gap between the compartment wall and the seal shall exceed one-half (1/2) inch; or

5.1.3 A vapor recovery system with a combined collection and control efficiency of at least 90 percent by weight.

5.2 Any gauging and sampling device in the compartment cover shall be equipped with a cover or lid. The cover shall be in a closed position at all times, except when the device is in actual use.

5.3 All wastewater separator forbays shall be covered.

5.4 Skimmed oil or tar removed from wastewater separating devices shall be either charged to process units with feed or transferred to a container with a

control system with at least 90 percent control efficiency by weight. A control device must be under District permit.

6.0 Administrative Requirements

6.1 Test Methods

6.1.1 Efficiency of VOC control device shall be determined by U.S. EPA Test Method 25 and analysis of halogenated exempt compounds shall be by ARB Method 422.

6.1.2 Analysis of halogenated exempt compounds shall be by ARB Method 432.

6.1.3 Where add-on control equipment is utilized, collection efficiency shall be determined by the U.S. EPA document "Model Regulatory Language for Capture Efficiency Testing", August 3, 1990.

7.0. Compliance Schedule

7.1 The owner or operator of any existing wastewater separator, not previously subject to the requirements of this rule, which requires modification to comply with this rule must meet the following compliance schedule:

7.1.1 Submit applications for Authority to Construct by January 1, 1992.

7.1.2 Complete on site construction and achieve final compliance by July 1, 1993.

Appendix E

Summary of Refinery Specific Site Visit Information

Overview of Chevron Oil Refinery (Richmond) Wastewater System

Overview of Chevron Oil Refinery (Richmond) Wastewater System

- Introduction

  The Chevron Oil Refinery (Plant #A0010) in Richmond, CA occupies an approximately 2,500 acre site in Richmond, California. This refinery has a typical daily throughput of 225,000 barrels (1 barrel = 42 gallons) of crude oil, primarily from the Alaskan North Slope. Crude oil is refined at the facility to produce gasoline, marine fuel oil, jet fuel, diesel, home and industrial fuels, propylene/polymer base stocks and 14,000 barrels of lube oils. In addition, Plant #A0010 also produces 350 tons of sulfur daily as a by-product of the on-site processes. As part of the Bay Area Air Quality Management Districts' (the District) 2001 Clean Air Plan, the District, in cooperation with the California Air Resources Board (ARB) and the United States Environmental Protection Agency (U.S. EPA), is examining process wastewater systems for each of the Bay Area refineries. This effort is directed at determining whether there are significant potential emission reductions from the control of any remaining uncontrolled components of the process wastewater systems, or through other measures. Most components of refinery wastewater systems are already controlled through compliance with District Regulation 8, Rule 8 (8-8), District New Source Review requirements, and U.S. EPA's National Emission Standard for Benzene Waste Operations (40 CFR Part 61, Subpart FF). As part of this project, a two day site visit (4/10/02 and 4/11/02) was conducted at Plant #A0010 to assess the availability of information related to the process wastewater system, and to review the on-site collection and treatment of water management processes which may have Volatile Organic Compounds (VOC) emissions impacts.

  Site History Plant #A0010 has been located in Richmond since the beginning of the 20th Century. Initially established in 1901. The Richmond site was ideal because of its natural deepwater port. Initially the facility engaged in the production of kerosene, tar and fuel oil. This production occurred in large horizontal batteries located in what is now known as the "south yard" area of the refinery. This is the oldest area of the facility and with the exception of tank storage, blending and shipping areas, it has for the most part been decommissioned. In the 1920's the refining capacity of the facility was expanded to include gasoline production for the expanding automobile markets. During the war years of the 1940's that the initial elements of today's modern refinery processes began to take shape. The early development of distillation process and thermolytic cracking meant replacement of horizontal batteries in the south yard area of the refinery with four modern distillate column crude units, and the addition of a number of steam plants. This greatly increased the gasoline production capacity of the site. The 1950's saw the construction of the fluid catalytic (cat.) cracker and related process units. While the majority of these were retrofitted in the mid-199O's to accommodate State-mandated fuels programs, a number of these units are still functioning in the "central yard." The major addition to the site in the 1960's was the construction of the "ISOMAX" complex in the "north yard" area. This unit consists of a number of hydro-

processing units, a catalytic hydrogen plant and solvent de-asphalting unit that was modified in the early 1990's. Increased demand for low sulfur fuels in the 1970's drove the need to construct the Low Sulfur Fuel Oils (LSFO) complex. The LSFO project consisted of a new crude unit in addition to jet and gasoline hydro-treaters, sulfur plants and a Rheniformer. In the 1980's, Plant #A0010 further expanded the ISOMAX complex by approximately 20% with a modernized lube oil production facility. The lube oil facility, RLOP, is currently in operation manufacturing high grade base oil products, however, part of the facility, which received waxy feed from a number of different operations, was shutdown in 1999. The final iteration of the current construction occurred in the mid 1990's with imposition of California clean fuels requirements for gasoline. This necessitated the modernization of the fluid catalytic cracking unit (FCCU) in the north yard area of the refinery. This construction also included building a new alkylation plant, TAME and MTBE plant.

On-site Waste Water Treatment At Plant #A0010, the process wastewater treatment system is segregated into three collection areas, along the lines of the facility's own nominal division system, north yard, central yard and south yard. Each of these denominations accepts flows from the process units in their area and routes them via three separate oil water separators to the 165 million-gallon biological treatment unit. Temperatures at each of the separators are estimated at approximately 26.7 ^{0}C (80 ^{0}F) year round while temperatures in the bioreactor vary from 26.7 ^{0}C (80 ^{0}F) in the aggressive treatment area to between 15.6 ^{0}C (60 ^{0}F) and 18.3 ^{0}C (65 ^{0}F) in the settling basin area. The Aggressive Biological Treatment Unit (ABTU) has approximately 900 subsurface air aerators operated by two compressors that deliver approximately 17,000 CFM of air to the bio-mass. From the bioreactor treatment segment, there are two options for effluent treatment. Effluent can either be routed directly to the deepwater outfall point (DWOP) sump for discharge to the bay via the granular activated carbon (GAC) unit or a portion may be routed through the three tier constructed wetlands for secondary polishing and selenium removal. Effluent from the wetlands rejoins the main waste water stream at the DWOP sump and these commingled streams are discharged via the GAC unit to a 36" diffuser outfall at an average depth of 30-50 feet into San Pablo Bay, approximately 2000 feet offshore to the north of Point San Pablo. North Yard Collection System The North Yard collection system is responsible for the conveyance of process water effluent from the catalytic cracking and hydroprocessing areas. This effluent consists specifically of outfall from the following: Alkylation plants, polypropylene unit, sulfur recovery unit, stripped sour water, and a small amount of ground water, MTBE plant, FCC plant, TAME plant, ISOMAX plant and the Richmond Lube Oil Plant (RLOP). Flows from these process collect into three main inputs to an oil water separator (13 Separator). These inputs are the 27" SRU line which flows at 190 gallons per minute (gpm) from the decommissioned alkylation plant, and operating sulfur recovery units, the 36" FCC line which flows at 765 gpm from the FCC and polypropylene units and the 60" Hydro line which flows at 845 gpm from the ISOMAX and RLOP plants. At 13 Separator, these flows are commingled in an

underground two-cell separator system. Solids are settled out by gravity and the effluent is piped via 60" line to the Bioreactor. The temperature at 13 separator is estimated at 26.7 ^{0}C (80 ^{0}F). This separator is covered and complies with existing regulation for VOC fugitive emissions control and design. It has three pressure ventilation (PV) valves, a debris removal system and an oil removal system. The outflow from 13 separator is estimated at 1,870 gpm or 2.6 million gallons per day (mgd) and comprises approximately 50% of the effluent produced at the facility. Central Yard Collection System This system routes process flows primarily from the low sulfur fuel oil (LSFO) complex and its associated process units to an oil water separator (2A separator). The effluent consists specifically of outfall from the following: hydrotreating plants, crude desalter plant, rheniformer plants, DEBRU unit and crude process units. Flows are routed via three main trunk lines to 2A separator. However, unlike at the 13 Separator, in this case the three streams are combined prior to entering the 2A Separator. Flows are input to this point by the 48" D&R North line at 35 gpm from the DHT unit, from the 12" LSFO line at 71 gpm from LSFO rheniformers and cat crackers, and the 18" Foundation Street line at 793 gpm from LSFO catalytic cracker process. The total flow to 2A separator is estimated at approximately 1,160 gpm. 2A separator consists of a two-cell oil water separator supplied by two 4.3 million gallon per day (MGD) pumps. This separator is above ground and has both debris removal and oil recycling facilities as well as standard gravity solids settlement. The separator is completely covered and is only opened twice daily for approximately 1 hour at an approximately 2'X2' gasketed area to remove gross debris. The separator is covered as required, and is equipped with three PV (pressure-vacuum) valves. This unit also has the capability to accept vacuum truck input. This unit may also accept storm waters from a co-located sump associated with the 50-100 foot storm water impoundment area. The temperature at 2A separator is estimated at 26.7 ^{0}C (80 ^{0}F) and the outflow is estimated at 1,160 gpm or 1.6 million gallons per day (mgd). South Yard Collection System This collection system is by far the most complicated at the facility and routes process flows from tank areas, the research center, marketing and distribution operations and miscellaneous operations to an oil water separator (1A separator) via a diversion box. The effluent consists specifically of wastewater from the following: lube tanks, general tank storage areas, the blending area, stormwater retention areas, Altamont loading racks and boiler blow down. These flows are routed via five main lines to a flow splitter (five cell diversion box) and lifted via four pumps into the 1A separator. These lines are as follows: a 36" main line that inputs boiler blow down and tank run off at 30 gpm, a 48" center line which inputs tank and blending area effluent at 415 gpm, a 48" line that runs along Pipe Street and that routes process sewer water from the main tank field (stormwater retention areas) at 115 gpm, a 60" line that runs along Division Street and inputs various effluents and tank draw effluents at 385 gpm and finally, the 36" CALOL line which inputs various tank effluents at 337 gpm. Following the diversion box these flows are joined by three additional trunk lines prior to the flow splitter at 1A separator. These lines are as follows: a 38" sewer line from the south yard, a 12" line that runs along Channel Street and

a 24" line from the PETROLITE area of the south yard at 85 to 225 gpm. From each portion of the flow splitter effluent can be pumped via four 4.3 mgd pumps to the above ground oil water separator. 1A separator is a four cell "in train" separator similar to 2A separator. Both have debris removal and oil recycling facilities as well as standard gravity solids settlement. The separator is completely covered and is only opened twice daily for approximately 1 hour at an approximately 2'X2' gasketed area to remove gross debris. The separator is covered as required by current regulations and is equipped with three PV valves. This unit also has the capability to accept vacuum truck input. The temperature at 1A separator is estimated at 26.7 ^{0}C (80 ^{0}F) and the outflow is estimated at 1,435 gpm or 2.0 million gallons per day (mgd). Aggressive Biological Treatment Unit and Bioreactor Effluent from each of the three on-site effluent collection systems is hard piped to a single junction point and then this commingled flow is sent via a 60" line to the Aggressive Biological Treatment Unit and bioreactor. The bioreactor consists of a 165 million-gallon pond varying in depth to between 24 and 26 feet. This pond has four distinct regions further divided by a curtain wall into the Aggressive Biological Treatment Unit (ABTU) and the settling basin. It is estimated that the total retention time of the bioreactor ranges from as low as 3 – 7 days to a high of 2–3 weeks depending on operational conditions and weather conditions. The Aggressive Biological Treatment Unit contains approximately 85 millions gallons of effluent that is aerated by 900 subsurface aerators. These aerators receive airflow from two compressors that produce between 17,000 to a maximum 23,000 CFM. Temperature for this area is estimated to be constant at 26.7 ^{0}C (80 ^{0}F). The settling basin portion of the bioreactor is designed to polish the effluent that flows from the Aggressive Biological Treatment Unit at the end of the curtain wall where the 2nd and 3rd quadrants meet. This area lets the biomass settle out of the effluent. This area contains approximately 80 millions gallons of effluent and varies in temperature between 15.6 ^{0}C (60 ^{0}F) to 18.3 ^{0}C (65 ^{0}F) seasonally. As this area precipitates solids from the aggressive biotreatment area, dredging operations must be conducted on an as-needed periodic basis. The finished effluent from this activity, is estimated at an annual average flow of 6.8 mgd and is primarily directed to the DWOP sump or may be directed to the Water Enhancement Wetlands Treatment Area for further polishing prior to carbon treatment (GAC), and discharge to San Pablo Bay. Wetlands Plant #A0010's Water Enhancement Wetland project (an explicit treatment option) is an experimental natural treatment and polishing system primarily for solids and metals removal. This system consists of three passes containing approximately 30 million gallons of effluent. This effluent is supplied from the bioreactor at approximately 1.5 MGD, however, this flow may be increased depending on seasonal conditions and Department of Fish and Game requirements. The flow is supplied to the first pass via a hardpipe system directly from bioreactor settling area. The majority of growth in the passes consists of cattails and bulrushes that remain unharvested to assist in biotreatment. The system is claimed to effect up to a 60% reduction of selenium from bioreactor effluent. Effluent from the wetlands is pumped to the DWOP sump to rejoin outfall from the Bioreactor. DWOP Sump and GAC Unit Effluent from the

bioreactor and wetlands are commingled at the DWOP sump before being pumped to the Granular Activated Carbon (GAC) facility for final treatment. This sump is 8' deep and is designed to remove any gross debris and biomaterial The GAC facility is the final step of onsite treatment for Plant #A0010's effluent. It consists of 24 GAC units on 12 skids and serves to remove turbidity, hydrocarbons, and aquatic toxicity from the final effluent. From here the final effluent is pumped to the bay via a 36" line to a diffuser at an average depth of 30-50 feet into San Pablo Bay, approximately 2000 feet offshore to the north of Point San Pablo.

Oil/Water Separator Solids In addition to the effluent treatment onsite, solids from both the bioreactor and the three onsite separators are treated prior to disposal. Solids that precipitate out of the effluent in each of the three API oil-water separators are removed periodically by vacuum truck. This material is transported to the hazardous waste annex on-site and dewatered using two centrifuges. Vapors from this process are controlled via a caustic solution wet scrubber, vapor chiller, and carbon bed. Wastewater from this process is disposed via an open sump to the head works for 1A separator. This effluent is stated to be at ambient temperature. As previously stated solids from the bioreactor are dredged from the settling area periodically. It is assumed that this material is de-watered and than landfilled after meeting all hazardous waste regulatory specifications. This matter is currently undergoing further investigation.

Storm Water Due to the nature and size of this site there are numerous discharge points and impoundment areas; these were identified by Chevron and in their Regional Water Quality Control Board NPDES (RWQCB) permit. Permitted (SF-RWQCB Order 01-067) stormwater discharge can occur in many instances either directly to the waters of SF/San Pablo Bay(s), and may be routed through the refinery Effluent Treatment System at the facilities discretion, and dependent upon analytical qualitative factors. Prior to any direct discharge of impound basins to SF Bay, or San Pablo Bay, the NPDES permit specifies sampling programs and qualitative permit limits. Sheetflow runoff areas have specific sampling plans, but due to the very nature of this discharge, its flow to the Bay(s) is monitored, but not controlled. In addition to the stormwater water collected by the on-site wastewater treatment system, some stormwater runoff from the ChevronTexaco Energy Research and Technology Center is also processed. The final discharge of this system is through a deepwater outfall at an average depth of 30-50 feet into San Pablo Bay, approximately 2000 feet offshore to the north of Point San Pablo. This discharge point is referred to as E-001. Stormwater runoff from an area of approximately 4 acres located in a former Point Orient Tankfield discharges into San Francisco Bay at outfall location E-005. Runoff from an area of approximately 48 acres located in a former Point Orient Tankfield area, the 12-Basin area (approximately 3 acres) and from the Horse Pasture area (approximately 17 acres) discharges into San Francisco Bay at outfall location E-006. In addition, stormwater runoff from the Horse Pasture

(approximately 17 acres) located in a former Point Orient Tankfield area discharges into San Francisco Bay at outfall location E-007. Stormwater runoff may commingled with incidental amounts of steam condensate, groundwater seepage, and water from the fire protection systems from the 496 acres in and around the Main Tankfield, Distillation and Reforming facilities, Main and South Yard areas, rail car loading areas, Asphalt Plant, and Cogeneration Facility may discharge into San Pablo Bay at outfall location E-008, or may be transferred to the North Yard Impound Basin for discharge as part of the North Yard Impound Basin discharge operation. Runoff commingled with steam condensate and water from the fire protection systems that originates from an area of approximately 26 acres within the Quarry Tankfield may discharge into San Francisco Bay at outfall location E-009. Sheetflow stormwater runoff from an area of approximately 6 acres which is a portion of the Reclamation Yard area discharges into Wildcat Creek via the Gertrude Street Ditch, which then drains to Castro Creek and San Pablo Bay. The discharge of Waste 010 is monitored at outfall E-010. Stormwater runoff commingled with groundwater (both seepage and extracted from various subsurface hydraulic containment systems), steam condensate, and potable water used in the facility's fire protection systems and facility washdown originates from an area of approximately 28.4 acres from areas within the Chevron Chemical Company LLC Hensley Street facility is collected in the Castro Acres surge pond (located along the east side of Castro Street) prior to being pumped into sections of Chevron Chemical Company LLC's Integrated Wastewater Pond System (IWPS) or it can be pumped directly to the IWPS, located at the Castro Street facility. The Castro Acres surge pond is not permitted to discharge to surface waters under typical rainfall conditions as it may contain trace contaminants. Typically, this water is discharged to the IWPS, which provides necessary surge capacity before discharge to the City of Richmond sanitary sewer system (POTW). However, during periods of high intensity rainfall (in excess of a 25-year, 24-hour rainfall event), this pond may discharge into Castro Creek via a drainage ditch on the east side of Castro Street, identified as Outfall E-011. Stormwater runoff commingled with groundwater (both seepage and extracted from various subsurface hydraulic containment systems), steam condensate, and potable water used in the facility's fire protection systems and for facility washdown originates from an area of approximately 19 acres within the Chevron Chemical Company LLC's Castro Street facility which was formerly used to manufacture fertilizer. This runoff is collected in evaporation ponds located along the west side of Castro Street. This runoff, which collects in the fertilizer ponds, is not permitted to discharge to surface waters under typical rainfall conditions as it may contain trace contaminants. Typically, it is discharged to the fertilizer ponds, which provide necessary surge capacity before discharge to the City of Richmond POTW. However, during periods of high intensity rainfall (in excess of a 25-year, 24-hour rainfall event), Waste 012 may be discharged into Castro Creek at an outfall identified as E-012. Runoff from direct rainfall onto sections of Chevron Chemical Company LLC's IWPS, an area of approximately 81 acres of synthetically lined surface impoundments, is accumulated. Depending on annual precipitation,

various sections of the IWPS receive water from other on-site surface impoundments. When this occurs, these sections are no longer considered as solely containing storm water runoff and the accumulated water is discharged to the City of Richmond's POTW. This area also receives rainfall runoff from an adjacent 4 acre capped Class II waste management unit (Soil Management Unit No.1) and may be discharged into Castro Creek, at a point approximately 1000 feet upstream of its confluence with Wildcat Creek at an outfall identified as E-013. Stormwater runoff from an area of approximately 4 acres in a former tankfield area of the Office Hill Tankfield discharges to San Pablo Bay via the City of Richmond's stormwater management system. This system routes stormwater from storm sewers to the Castro Street Pump Station. The Pump Station pumps water to Chevron's 38-Foot Channel, which discharges into Castro Creek. Stormwater runoff from an area of approximately 5 acres in a former tankfield area of the Office Hill Tankfield discharges to San Pablo Bay via the City of Richmond's stormwater management system. This system routes water from storm-sewers to the Castro Street Pump Station. The Pump Station pumps water to Chevron's 38-Foot Channel, which discharges into Castro Creek. Stormwater runoff from an area of approximately 7 acres in a former tankfield area of the Office Hill Tankfield may discharge into San Francisco Bay. Stormwater runoff commingled with steam condensate and water from the fire protection systems from approximately 20 acres in the SP Hill Tankfield may discharge into San Francisco Bay or be returned to the process water system. Stormwater runoff commingled with steam condensate and water from the fire protection systems from approximately 29 acres in the Quarry Tankfield may discharge to San Francisco Bay or be returned to the process water system. Stormwater runoff from an area of approximately 3 acres in the former Point Orient Tankfield discharges to San Francisco Bay. This runoff may also be transferred and discharged at E-006. Runoff from the City of Richmond's stormwater management system drains an area of approximately 260 acres (encompassing City owned property on the Castro Street Roadway, North Richmond, and Point Richmond suburban areas) and routes water from City of Richmond storm sewers to the Castro Street Pump Station. The Pump Station pumps water to Chevron's 38-Foot Channel, which discharges into Castro Creek, which flows to San Pablo Bay. Stormwater sheetflow runoff from a capped waste management unit area of approximately 5 acres is discharged to Castro Creek. Castro Creek flows into San Pablo Bay. Stormwater sheetflow runoff from a capped waste management unit area of approximately 3 acres is routed to the Gertrude Street ditch that drains to Wildcat Creek. Wildcat Creek flows to Castro Creek then to San Pablo Bay. Stormwater sheetflow runoff from a capped waste management unit area of approximately 41 acres discharges to Castro Creek, which flows to San Pablo Bay. The North Yard Impound Basin (formerly 1st Pass #1 Oxidation Pond) discharge consists of stormwater commingled with steam condensate, groundwater seepage, and water from fire protection systems. The North Yard Impound Basin is a remediated containment basin formerly used in wastewater treatment. Runoff originates from an area of approximately 341 acres from areas within the: Poleyard and Alkane Tankfields and adjacent hill

sides; LPG and Ammonia Storage Facilities; Cracking and Hydroprocessing facilities; Petrochemical facilities; FCC, RLOP, Isomax, MTBE/TAME cooling water towers; Hydrogen Plant; former Alkane and HF Plant areas; Sulfur Recovery Unit and sulfur sales facilities; and Hydropits Cap. The North Yard Impound Basin discharges may contain transferred stormwater W-008, and may discharge to Castro Creek or may be processed through the Refinery effluent treatment system. Castro Creek flows into San Pablo Bay. Stormwater sheetflow runoff from a capped waste management unit area of approximately 7 acres of the Parr-Richmond Site discharges to Wildcat Creek and Gertrude Street ditch (which drains to Wildcat Creek). Wildcat Creek drains to Castro Creek, which flows to San Pablo Bay.

Drains and Junction Boxes During the course of the site visit to Plant #A0010, a number of different drain formations were observed in the process areas. The formations observed were generally consistent with the phases of construction at the site. Drains in the LSFO area with the more modern construction (1990's cat. crackers and rheniformers) had P-trap water seal drains and Chevron box-type water seal drains. The older areas of construction such as 1970's rheniformer #5 tended to have a mixture of P-trap water seal drains, Chevron box-type water seal drains and what appeared to be unsealed drains. These apparently unsealed drains were for the most part associated with pump stands and were in the minority of the drains observed. This was also the case at 1950's rheniformer #4, where the same mixture of sealed drains and occurrence of apparently unsealed drains repeated itself. This was again the case at the #4 crude unit. Junction boxes observed in this area were linked to vent pipes that opened in most cases approximately 20 to 30 feet above the ground surface exceeding current BAAQMD minimum standards. In other areas of Plant #A0010 this scenario replayed itself. Newer construction such as the "new alkylation plant" and FCC units were observed to have P-trap water seal drains and Chevron box-type water seal drains. In the older areas of the facility such as the "old alkylation plant" and polypropylene unit apparently uncontrolled drains were located on the outer "older" edges of the construction. Investigation is currently being conducted into the format of the pump stand drains and other drains from the 1940's, 1950's and 1970's to confirm their configuration. The site visit also indicated that the older 1940's drains at the site had, for the most part, been blinded. Inspection of the ISOMAX process area revealed two sets of distinct drain constructions corresponding to distinct phase of development at that site. Both the north and south ISOMAX complexes were developed in the 1960's with later construction in the 1990's. Pump stand drains for the north and south 1960's construction appeared for the most part to be open and varied in size from 2" to 4". Box seals were observed in a number of areas and junction boxes were for the most part under water seals. Also, one area of open surface drains was observed in the south ISOMAX complex. In the newer area only three-inch drains were observed and all were covered with steel plates. Also, a number of 1' x1' box seal drains were observed. Drains in the RLOP area date from the mid to late 1980's and it appears that this construction mirrored the

1960’s construction at the site. A number of what appear to be 4" open drains were observed at pump stands within the complex and a number of 1’ x1’ box seal drains were also observed. This complex also included some 6" drains that also appeared to be open.

Overview of The ConocoPhillips San Francisco Refinery (Rodeo) Wastewater System

Overview of The ConocoPhillips San Francisco Refinery (RODEO) Wastewater System

Introduction

The ConocoPhillips San Francisco Refinery (SFR) in Rodeo, CA operates two crude distillation units and several separate downstream units to produce a variety of petroleum products. These products include butane, various grades of gasoline, diesel fuel, jet fuel, fuel oils, sulfur, and petroleum coke. The fuels produced are used for numerous transportation applications, including automobiles, heavy trucks, ships, and aircraft. The petroleum coke produced is sent offsite either as fuel or for further processing at the Carbon Plant. The refinery processes several different types of crudes. The crudes are delivered to the refinery by pipeline and tanker. Built in 1896, Rodeo Refinery was the first major oil refinery in the Bay Area. The original site occupied only 22 acres and processed 1,600 barrels of crude oil per day. Today, the site occupies approximately 1,100 acres and employs about 470 people. The refinery is located on approximately 320 acres of land adjacent to the Marine Terminal and is bisected by San Pablo Avenue.

Major Products and Capacities

Refinery throughput data for crude, cracking/coking and reforming/alkylation processes is approximately 73,000 barrels of per day. Crude oil and intermediate streams are refined at the facility to produce gasoline, diesel and jet fuel. In addition, Plant #A0016 also produces petroleum coke and sulfur as a co-products.

As part of the Bay Area Air Quality Management District's 2001 Clean Air Plan, the District, in cooperation with the California Air Resources Board (ARB) and the United States Environmental Protection Agency (U.S. EPA), is examining the wastewater systems for each of the Bay Area refineries to determine whether there are significant potential emission reductions from control of any remaining uncontrolled components of the wastewater systems, or through other measures. Most components of refinery wastewater systems are already controlled through compliance with District Regulation 8, Rule 8 (8-8), District New Source Review requirements, and U.S. EPA's National Emission Standard for Benzene Waste Operations (40 CFR Part 61, Subpart FF).
As part of this project a two day site visit (5/1/02 and 5/2/02) was conducted at Plant #A0016 to assess the availability of information related to the waste water system and to review the on-site collection and treatment of water which may have Volatile Organic Compounds (VOC) emissions impacts.

Refinery Areas

At Plant #A0016, process water trunk lines originate in four geographic areas that flow through separate trunk lines to the Wastewater Treatment Plant. These areas may be conveniently referred to as "West Refinery" "East Refinery/Tormey Hill", "Lower Tank Farm", and "Sulfur/MP-30/Seasonal Storage". Each area includes units of varying construction dates.

West Refinery

The oldest area is the West Refinery located west of San Pablo Avenue. Existing construction in this area ranges from 1940 to 1994. This area includes a Marine Terminal, butane storage, railcar loading, crude oil and product storage, hydrogen plant Unit 110, a Cogeneration steam/power plant, shop areas, warehouse, laboratory, and administration buildings. This area also has a number of decommissioned units including Unit 32 (wax processing), Unit 67 (crude processing), Unit 105 (lubrication oil and wax processing).

The decommissioned areas typically have open drain channels with below-grade sumps covered by grates or platforms and no underground wastewater structures. The decommissioned areas appear to be abandoned in place.

The primary sources of wastewater from the West Refinery include:

- Stormwater runoff,
- Rainwater drained from tank blocks,
- Flow from decommissioned Unit 210 in the East Refinery/Tormey Hill area that runs under San Pablo Avenue to the West Refinery area,
- A cogeneration steam/power plant,
- Groundwater remediation water, and
- Sewer discharge from buildings, e.g. lab, administration, warehouse, and shop.

Combined wastewater (e.g. stormwater runoff, process water, sanitary sewage, and groundwater remediation) is discharged from the West Refinery area via a 48-inch underground pipe. This drainage pipe connects to the main refinery wastewater collection and storage system. All refinery wastewater is collected and pumped to tanks 130, 104, 105 prior to treatment.

All drains inspected (except for those installed in the hydrogen plant, Unit 110) in the West Refinery area were open and typically varied in size from 3 to 4 inches. Refinery drawings suggest that drains flow to water sealed junction boxes. Confirmation of junction box design will occur during future visits.

Also, located in the West Refinery area is the inlet for a 42 million gallon per day (MGD) saltwater single pass cooling system. This inlet is located just north of the Marine Terminal causeway. Discharge of the single pass saltwater cooling occurs in two outfall locations, E-001 and E-003. The E-001 outfall is at the southern boundary of the West Refinery area near butane tank 302. The E-003 outfall is located approximately 700 feet south of E-001.The Rodeo refinery is the only Bay Area refinery currently using single pass saltwater cooling in refinery operations.

South of the West Refinery area is an area containing equipment salvage, parking, the saltwater "safety basin" and the associated "safety basin" bypass channel. The safety basin and channel are located in the southern tip of the refinery bounded by San Pablo Avenue and the Union Pacific Railroad tracks. The open safety basin and bypass channel are holding structures for single pass saltwater discharge that is regulated by a

National Pollution Discharge Elimination Permit (NPDES) permit issued by the San Francisco Bay Regional Water Quality Control Board.

The most recent refinery process construction at the West Refinery area is the hydrogen production plant, Unit 110. This area appears to be the only major process area in West Refinery Area equipped with water seal drains. These drains are equipped with box type water seal inserts draining to below grade 3'x3' sumps. However, one of these sumps appeared to be an open sump without a water seal. Other drains in active refinery areas appear to be open units without water seals. These open drains connect to a variety of sumps, junction boxes and manholes. Some of these sumps appear to be open collection units without water seals.

East Refinery/Tormey Hill

East Refinery/Tormey Hill is located east of San Pablo Avenue. This area contains the refinery's major petroleum processing areas. Construction in this area ranges from 1940 to present. This area generates process wastewaters from product storage, product shipping via pipeline, delayed coking, crude distillation, desalting, gas fractionation, catalytic reforming, prefractionation, hydrogen production, hydrotreating, fractionation and utility operations. This area also has a number of decommissioned units including Unit 210 (dewaxing), Unit 212 (deoiling), and Unit 220 (Duo Sol). Surface runoff at the decommissioned Duo Sol unit currently flows through a concrete structure that was used historically to contain and pump out process liquids that could not be discharged to directly the process sewer. Sources of wastewater in this area also include stormwater runoff, domestic sewage, and drainage from tank blocks.

The decommissioned units typically have open drains connected to below-grade sumps covered by grates. The decommissioned areas appear to be abandoned in place. Product storage is located on the northeastern boundary of the East Refinery/Tormey Hill area and east of Highway 80. Wastewater and stormwater drains in these areas are open and connected to sumps or manholes. These sumps or manholes are in or adjacent to the perimeter impoundment structures surrounding the product storage tanks. Some of the sumps or manholes in this area appeared to be without water seals. Manually operated valves regulate discharges from large tank impoundment areas. Water draws and tank cleanout from product tanks discharge into open sumps immediately adjacent to tanks. Pipeline shipping operations occur at Unit 80 , which is located near San Pablo Avenue in the East Refinery/Tormey Hill area. Most of the refinery's liquid product is distributed through this unit to northern California pipelines. The unit has open 4" drains connected to below grade open sumps.

The coking unit (Unit 200), crude oil desalter (Unit 267), fuel gas recovery (Unit 233), and butane fractionator (Unit 215) are located in the lower center portion of the East Refinery/Tormey Hill area. Most if not all of the drains in these units were open and connected to below grade sumps. Drain size ranged from 4" to 6". Some of the sumps appear to be open and without water seals. Horizontal dimensions for sumps were typically 3'x3'. The desalter 6" open drain is the location of the initial refinery NESHAP sampling point for Benzene.

The coking unit uses the MOSC process (Mobil Oil Sludge Coking) and is the primary destination for oily sludge from the API separator and residual oils left from refining crude petroleum byproduct materials. These materials are converted to delayed or “green” petroleum coke via the MOSC process. Discharge from the coking drums is carried out via hydraulic cutting using oily water routed from the de-coking process. Green coke and oily hydraulic cutting water discharges to a large open pit below the coke unit. Oily cutting water is recycled to a storage tank adjacent to the coke unit. Green coke is removed from the pit via clamshell and sold as a direct product or shipped to the refinery Carbon Plant. The Carbon Plant is a petroleum coke calciner that makes anode grade calcined coke from green coke. The Carbon Plant is located approximately five miles from the main refinery. The Carbon Plant was not surveyed during the May inspection due to time constraints.

Units 240 (prefractionation, hydrotreating, fractionation and hydrogen production), 244 (catalytic reforming) and 248 (aromatic saturation) are located in the southern portion of the East Refinery/Tormey Hill area. These units were constructed during the 1970's. Most if not all of the drains in these units were open and connected to below grade sumps. Size of the drains range from 4” to 6". Some of the sumps appear to be open and without water seals. Typical horizontal dimensions for sumps were 3'x3'.

Sulfur/MP-30/Seasonal Storage

The Sulfur/MP-30/Seasonal Storage area is adjacent to East Refinery/Tormey Hill. This area includes Units 234, 236 and 238 (sulfur recovery), MP-30 consisting of Units 228 (isomerization), 229 (catalytic hydrotreating), 230 (distillation and olefin saturation), 231 (catalytic reforming), and Seasonal Storage (i.e. finished product storage) located east of Interstate Highway 80. Primary design and construction of this area occurred from 1940 to 1970. The primary sources of wastewater in the Sulfur/MP-30/Seasonal Storage area are:

- Stormwater runoff,
- Product storage,
- Seasonal Storage wastewater (connects to the Sulfur/MP-30area wastewater system via an underground pipe below Interstate Highway 80),
- Stretford process sulfur removal,
- Incoming pipeline operations,
- Units 228, 229, 230 and 231.

This area is reported to be similar to all other refinery product storage areas. The Seasonal Storage area was not inspected due to time constraints. Wastewater and stormwater drains in the product storage areas inspected were typically 4" open drains connected to sumps or manholes. These sumps or manholes are in or adjacent to the perimeter impoundment structures surrounding the product storage tanks.

Refinery sulfur removal uses the Stretford process. The Stretford Process is a wet-type desulfurization process where hydrogen sulfide is removed from gas streams and fine particle sulfur is recovered. Drains in the sulfur units (units 234, 238, 236) were typically

4" open drains connected to open sumps. Concrete berms and paving in the sulfur units appeared highly corroded most likely due to acidic properties associated with biological breakdown of fine particle sulfur. Incoming pipeline operations and MP-30, were closed due to process operations during the inspection. The area will be inspected in the future. The MP-30 units (Units 228, 229, 230, 231), typically contained 4" open drains connected to open sumps.

Lower Tank Farm

Interstate Highway 80 runs parallel to the eastern boundary of the Lower Tank Farm. Sulfur/MP-30/Seasonal Storage forms the northern boundary and the refinery wastewater treatment system is located to the southwest. This area includes product storage, gasoline blending (Unit 76), and wastewater storage. The primary sources of wastewater from the Lower Tank Farm are from:

- ""Stormwater runoff,
- ""Product storage
- ""Gasoline blending
- ""Raw materials receiving (Unit 40)
- ""Fire Training area

Product storage is located throughout the Lower Tank Farm area. Wastewater and stormwater drains in these areas are typically 4" open drains connected to sumps or manholes. These sumps or manholes are in or adjacent to the perimeter impoundment structures surrounding the product storage tanks. The east main trunk line (a 42" underground pipe) connects all refinery wastewater discharge and lies along the western boundary of the Lower Tank Farm area. Primary design and construction of this area occurred from 1950 to 1970. Current operations in this area include product storage, tank water draws, tank cleanout, and wastewater storage, tanks 130, 104, and 105). Gasoline and mid-barrel blending at Unit 76 produces finished gasoline and diesel fuels. Some additional retail gasoline product blending occurs off site.

On-Site Waste Water Treatment

Selenium treatment occurs on the western boundary of the Lower Tank Farm area. The refinery segregates sour water from process units, strips out hydrogen sulfide, and hard pipes this stripped sour water to the Selenium Removal Plant (SRP). This treatment unit uses primary copper and secondary ferrous precipitation to remove selenium and excess copper from stripped sour water. Precipitated selenium and copper containing solids are dewatered in a filter press and disposed as hazardous waste. The filter press system does not need to use vapor recovery. Treated effluent from the SRP is routed to the main refinery wastewater storage and treated through the wastewater system.
The waste water collection system (Unit 100) at Plant #A0016 flows by gravity to dry and wet weather sumps, from which it is pumped to the three-tank wastewater storage system, equalization tanks 130, 104, 105. Total volume of tank storage is approximately 18 million gallons. During periods of extreme rainfall, if the equalization tanks are full, wastewater is diverted to a surface impoundment, the “Primary Basin” (2.3 million gallons capacity). The primary basin is permitted as a RCRA secondary containment

structure since it may contain hazardous petroleum constituents. If the Primary Basin reaches capacity it will overflow into a second surface impoundment, the “Main Basin” (7.2 million gallons capacity).

All onsite wastewaters (process, stormwater runoff and sanitary waste) are combined for treatment at Unit 100. Wastewater from the equalization tanks is gravity fed to a four-cell oil/water separator (API) at ambient temperature. The API does not use screens to remove gross debris from the effluent stream since trash is removed at the inlets to the dry and wet weather sumps. The API is completely enclosed. These cells allow product from process waters to settle out via gravity. Oily surface waters and oily solids are removed from the cells by top and bottom chain driven skimmers for oil recovery or conversion to delayed petroleum coke via the MOSC process. From the API cells, water flows under gravity into a four-cell Dissolved Air Flotation (DAF) unit to remove additional oil and suspended solids. This unit is also completely enclosed. Here air bubbles are used to remove any suspended product from the effluent prior to PACT treatment.

Biological treatment occurs in a Powdered Activated Carbon Treatment (PACT) unit followed by clarification and sand filtration. The PACT treatment unit biologically oxidizes organic materials with aggressive aeration and adsorbs toxics using powdered activated carbon. Carbon is recycled from the PACT system and is regenerated using a Wet Air Regeneration (WAR) unit. The WAR unit reactivates the carbon and oxidizes biological growth. Makeup carbon is supplied from tankage adjacent to the PACT system. Biosolids generated in the PACT unit are settled out in the clarifiers. Discharge from the clarifiers is filtered through sand media, disinfected with chlorine, dechlorinated with sodium bisulfite, and discharged to San Pablo Bay

Solid Waste

Off-site removal of solid waste from the wastewater treatment system at this facility occurs primarily at the Selenium Reduction Plant. Solids separation of selenium filter cake does not require vapor control. It is estimated that 250 tons of sludge (70 to 75% moisture content) were removed for landfilling in 2001. All organic waste is destroyed via WAR unit or transferred to the Coker.

Storm Water

As well as treating process wastewater, stormwater runoff from process and industrial areas is routed through the on-site wastewater treatment plant prior to being discharged to San Pablo Bay through a 6,000-foot, 18-inch diameter outfall pipe. The outfall, referred to as E-002, terminates with a multi-port diffuser. Permitted discharges of stormwater runoff flow to San Pablo Bay from the refinery’s Marine Terminal and causeway. Stormwater runoff from these areas is estimated at 0.006 MGD.

Sumps, Junction Boxes and Drains

As part of this site visit, an extensive tour of the various operating units was conducted at Plant #A0016 that incorporated construction from all phases of building. A range of drain, sump and junction box designs were observed at the facility and these

components varied with construction date and location. However, most drains and sumps were open without water seals.

Overview of Shell Oil Products US (Martinez) Refinery Wastewater System

Overview of Shell Oil Products US, Martinez Refinery Wastewater System

Introduction

The Shell Oil Products US, Martinez Refinery (Plant #A0011) in Martinez, CA occupies an approximately 850 acre site in Martinez, California. This refinery has an average daily throughput of 155,000 barrels (1 barrel = 42 gallons) of crude oil primarily from the San Joaquin Valley area. This crude oil is refined at the facility to produce 83,000 barrels of gasoline, 16,000 barrels of marine fuel oil, 27,000 barrels of jet fuel, 4,000 barrels of lube oils, 17,000 barrels of diesel, 7,000 barrels of asphalt and 7 tons of petroleum coke. In addition, Plant #A0011 also produces 150 to 175 tons of sulfur daily as a by- product of the on-site processes. These production rates generally reflect averages from the 2000-2001 time period.

As part of the Bay Area Air Quality Management Districts' (the District) 2001 Clean Air Plan, the District, in cooperation with the California Air Resources Board (ARB) and the United States Environmental Protection Agency (U.S. EPA), is examining the wastewater systems for each of the Bay Area refineries to determine whether there are significant potential emission reductions from control of any remaining uncontrolled components of the wastewater systems, or through other measures. Most components of refinery wastewater systems are already controlled through compliance with District Regulation 8, Rule 8 (8-8), District New Source Review requirements, and U.S. EPA's National Emission Standard for Benzene Waste Operations (40 CFR Part 61, Subpart FF).

As part of this project a two day site visit (3/26/02 and 3/28/02) was conducted at Plant #A0011 to assess the availability of information related to the waste water system and to review the on-site collection and treatment of water which may have Volatile Organic Compounds (VOC) emissions impacts.

Site History

Plant #A0011 has been located in Martinez since early in the 20th Century. Initially established in 1915 by the Royal Dutch Petroleum Company, the Martinez site was ideal because of its natural deepwater port, potential for receiving crude oil via pipeline, and available markets. Initially the facility engaged in the production of kerosene, lubricating oil and asphalt. By the 1930's production of gasoline and various aviation fuels were included. The western side of the current refinery (west of Shell Avenue) is built on the initial site of the 1915 facility and is know as the "Heavy Oil Processing " area. This site is currently used primarily for the processing and storage of lube oils, fuel oils, asphalt, and other "heavy end" products.

In the 1960's the refining capacity of the facility was expanded to include a new crude unit, a hydrocracker, a catalytic cracker, an alkylation plant, a catalytic reformer, two sulfur recovery plants, numerous hydrotreaters and a hydrogen plant. This increased the facility's ability to convert San Joaquin crude into the gasoline needed for the expanding California automobile markets.

In 1982, the "Operations Central Area" was added to the refinery, again to optimize production capability. The most notable addition was the Flexicoker, which produces low BTU gas from coke for use as furnace fuel for the refinery. The project also increased hydrogen and sulfur production at the site. The final phase of the current construction was completed in the 1990's and added further hydrotreating capabilities, another hydrogen plant and a delayed coker to the facility.

On-site Waste Water Treatment

To understand the structure of the wastewater treatment at Plant #A0011, one needs to understand the phases of construction at the facility. Pre-1960's construction led to the building of Effluent Treatment Plant One biotreater (ETP-1). ETP-1 remains the main secondary treatment unit for wastewater created in the western side of the refinery. It is a 4 million-gallon biotreatment pond with floating aerators. The typical operating temperature is in the range of 32.2 ^{o}C (90°F) to 37.8 ^{o}C (100°F). Discharge from ETP-1 is hard piped to three dissolved air flotation clarifiers, then to a polishing pond, then to selenium treatment, next to a polishing pond, next to carbon filtration, and finally discharge via marine outfall adjacent to deepwater terminal. Overall the western side of the refinery wastewater system has open drains feeding to the API separator. The wastewater system immediately prior to the API and running to the dissolved nitrogen floatation tanks (DNF) is a closed vapor recovery system.

Primary factors influencing VOC emissions from the ETP-1 system is the temperature of the wastewater, and the potential emission sources that include an equalization tank (Tk-1067, floating roof, 3 million gallons) and the bioreactor ETP-1 itself. Tk-1067 is a floating roof tank which meets the control standards of the District tank rule: Regulation 8 Rule 5 and is considered Best Available Control Technology. Both Tk-1067 and the bioreactor may be VOC emission sources.

The post 1960's wastewater expansions were initially handled by the original effluent collection and treatment system that discharges to ETP-1. In the 1990s, selected streams were hard piped to a new treatment system that discharges to Effluent Treatment Plant Two (ETP-2), a 2 million-gallon tank with 4600-cfm jet aeration. Effluent discharging to ETP-2 is for the most part regulated by District Regulation 8, Rule 8 and the U.S. EPA's 40 CFR Part 61, Subpart FF. ETP-2 is the more modern of the two treatment schemes at the facility and boasts a totally enclosed system with vapor recovery from wastewater generation up to the ETP-2 aerator.

ETP-1 System

As previously stated the ETP-1 system is the main treatment conduit for wastewater created in the western side of the refinery. This area contains mostly "heavy end" production that includes lube oil production, cooling tower blow down, flexicoker stripped sour water, boiler blow downs, chemical waste water, sanitary sewage and crude storage area run off. In addition to these waste streams, process water from the co-generation plant, the lube oil hydrotreater, and sulfur plant #4 is commingled with the effluent to ETP-1.

The average daily flow in to ETP1 is estimated at 2,600 gallons per minute (gpm). This is usually gravity flowed via 30" and 18" lines to the head works of the main oil water separator for the treatment plant, the API. If the flow is excessive due to storms and rainwater run off, the facility has the ability to shunt water to uncovered Ponds 6 and 8 for temporary storage. Water stored in the ponds can then be mixed back into the effluent stream under normal conditions at a point before ETP-1's main aeration pond or to ETP-2.

At the API gross oil and solids are separated from the wastewater stream in a sealed system, consisting of two fore bays and two main bays. Primary control of VOC emissions from the API is by use of a water scrubbing system using ambient temperature domestic water with an approximate temperature of 15.6 ^{o}C (60°F). The scrubber system also uses one 55-gallon barrel of activated carbon as a secondary “back-up” VOC control. The carbon barrel is designed to control VOCs in the 500-ppm range.

Effluent from the API is then sent to two Dissolved Nitrogen Flotation (DNF) tanks to further remove any suspended oils/petroleum contained in the waste stream following initial treatment. The effluent temperature at this part of treatment is estimated to be between 37.8^{o}C (100°F) and 48.9 ^{o}C (120°F). The DNF units are a closed system with VOC emissions minimized by a water scrubbing system with an activated carbon barrel system like that used at the API.

From the DNF's wastewater is sent directly to Tank 1067 for equalization and then to ETP-1's primary aeration pond. Tank 1067 is a 3 million-gallon floating roof tank that is used for surge storage. From Tank 1067 the wastewater is sent to ETP1's main bio-aeration pond. This bio-aerator consists of a 4 million-gallon open pond approximately 9 feet deep at any point. This pond contains between 10 and 13 floating aerators moored by lines attached to perimeter anchors. Total horsepower of aerators is 675 horsepower. The numbers of aerators used varies depending on process and maintenance schedules. The temperature of the effluent at this point of treatment is usually between 26.7 ^{o}C (80°F) to 37.8 ^{o}C (100°F). From this point the effluent is separated into two streams. Bio-solids are removed and sent to the bio-solids thickener, and liquid effluent is sent through primary clarification to three dissolved air flotation clarifiers for secondary clarification.

From secondary clarification the effluent is commingled with effluent from ETP-2 and proceeds through two "polishing" ponds to the Selenium Treatment plant. This plant consists of a continuous ferrous flocculation system that precipitates approximately 20 tons per day of iron hydroxide sludge containing eight pounds of selenium. This sludge is dredged from the outfall pond of the flocculation plant and belt pressed for removal off-site. The outfall pond itself contains six 5 horse power aerators which continue to "polish" the effluent prior to treatment in the granular activated carbon (GAC) unit. The final part of on-site wastewater treatment is the GAC unit. This unit consists of twenty-four vessels containing up to 480,000 pounds of GAC. This filtration removes any remaining turbidity, particulates or chemicals from the effluent stream. Maximum

flow though GAC is 7,000 gpm, although flow rates at this level will quickly plug the GAC units with silt in one or two days. The final effluent then proceeds to the bay via a 24-inch multiport diffuser, located 20 feet under the Martinez Complex Wharf.
ETP-2 System

Most of the more modern construction (post 1990's) at Plant #A0011 is hard piped to ETP2. This consists of process drain out fall from the, stripped sour water, crude desalter and brine desalter effluent, cat reformer effluent, delayed coker effluent and recovered oil waste water. This effluent is initially pumped to two 1 million-gallon equalization tanks, located in the central operations zone of the refinery; both tanks have closed cone roofs and are linked to a vapor recovery system.
From these fixed roof tanks effluent is pumped in hard pipe to Tank 12519, a 6 million-gallon floating roof equalization/surge tank located in the wastewater treatment plant. Daily flows to this tank average 650 gpm.

From this point the effluent is piped to two fixed-roof DNF tanks where oils and solids are removed from the effluent and VOC emissions are controlled by a vapor recovery compressor system, refrigeration system or activated carbon canisters. This system represents the end of the hard piping for this effluent.

From the DNF's effluent is piped to the main aeration basin for ETP-2. Here subsurface air jets force 4600 CFM of air through the two million-gallon biomass contained in the tank. At this point the effluent steam is at a temperature of between 32.2 ^{o}C (90°F) to 37.8 ^{o}C (100°F).

Having left the bio-aerator the effluent stream separates into two parallel gravity clarifiers. Here again the effluent is separated into two streams. Bio-solids are removed and sent to the bio-solids thickener, while liquid effluent is sent to pond 5E for "polishing."

Pond 5E is a one-million-gallon settling pond that flows to the selenium treatment plant on-site. Here the effluents from ETP-1 and ETP-2 are commingled and flow to the selenium plant via a number of other "polishing" ponds and are then routed to the bay via the GAC (see ETP1 above).

Bio-solids
When the waste streams separate at ETP-1 and ETP-2, bio-solids are sent via return lines to the biosolids thickener at a rate of approximately 20 gpm. From here there are two different paths to final wasting of this material. Thickened sludge is removed and stored temporarily on site, until it is centrifuged by an outside contractor and landfilled at a rate of 3,000 tons per year.

However, the preferred method of disposal is incineration at the facility's three CO boilers. This occurs continuously at a rate of up to 30 gpm. It is also possible to return bio-solids to the biotreater from the thickener. This mechanism is also used to treat soaps produced at the facility. Rather than have huge slugs of soaps produced on-site

being dumped directly to the waste water treatment system, they are collected in tankers, commingled with bio-solids at the thickener and returned to the clarifiers for biological treatment. This is done to avoid problems with foaming and up-sets of the biological treatment system.

Storm Water

In addition to these three treatment systems, Plant #A0011 also has five additional storm water collection systems which function in tandem with and separately from ETP-1 and ETP-2. According to storm water flow maps provided by Shell, as well as their Regional Water Quality Control Board (RWQCB) permits, all storm water collected in the "western side" of the refinery is discharged via ETP-1 to the San Francisco bay. Storm water collected in the light oils processing area (LOP area) combines with runoff from tank farms in the same drainage basin and is contained by three ponds in series (commonly referred to as the Lake Slobodnik system), this system discharges directly into Peyton Slough which flows into the Carquinez Strait.

Storm water runoff from a 234-acre eastern tank farm area is collected in two ponds in series, which are each equipped with an oil baffle/weir and valve which is normally kept closed. The discharge point from the ponds is to an unnamed earthen drainage course at a point about 1500 feet south from the Mt. View Sanitary District treatment plant, then into Peyton Slough which flows into the Carquinez Strait.

Storm water runoff from a central 31-acre area containing an emergency flare is discharged from a pond equipped with an oil baffle/weir and valve (normally kept closed) into a drainage course at a point about 900 feet south of the Mt. View Sanitary District treatment plant, then into Payton Slough which flows into the Carquinez Strait. Storm water runoff from a 7-acre propane/butane storage area is discharged from a pond which is equipped with an oil baffle/weir and a valve (normally kept closed) into a drainage course at a point about 600 feet south of the Mt. View Sanitary District treatment plant, then into Payton Slough which flows into the Carquinez Strait. Finally, storm water runoff from an approximately 5-acre central maintenance and purchasing warehouse area is discharged to Contra Costa County storm drain culvert where it in turn discharges to an unnamed earthen drainage course and eventually to Payton Slough which flows into the Carquinez Strait.

Oil/Water Separators, Low Point Sumps and Drains

During the course of the site visit to Plant #A0011, two oil/water separators and one low point sump were identified as well as numerous drain and drain box configurations. As part of the review of materials available for Plant #A0011 it was possible, from detail diagrams available for each phase of construction, to correlate the different drain designs with the drains observed on site. It has also been possible to "trace back" the 18" and 30" effluent lines from ETP-1 to the western side of the refinery. At present, information provided by drawings indicates three main drain collection stems in this area, one proceeding north down Shell Avenue, one proceeding west along Marina Vista and a third main conduit proceeding north by the main office building. All of these

lines cross into the effluent treatment plant and are commingled at the head works for ETP-1.

The two oil water separators identified are also associated with the wastewater flow to ETP-1. Both the Corrugated Plate Interceptor (CPI) and the Gross Oil Separator (GOS) are located in the central area of the refinery and direct effluent flows into the main trunk lines for transport to ETP-1.

The CPI contrary to its name does not contain any corrugated plates. The plates were removed due to clogging by excess solids in the 500-gpm flow from the flexicoker plant. The CPI is a closed system and now functions as an oil water separator. VOC emissions are controlled by a water scrubber system backed up by an activated carbon barrel identical to those previously described. Effluent at this point is estimated to be at a temperature of 48.9 ^{o}C (120 ^{o}F). On the day of the site visit, two flat bed coke recovery vessels were positioned at the CPI to recover coke solids being pumped off the effluent at this point.

The GOS is of similar construction to the API at ETP-1 but does not utilize “flight scrapers” to push oil into the collection trough. Nor does it have solids collection sumps. It consists of a single bay and is primarily a gravity sump up stream of the API used to remove heavy oils and solids. Again this is a closed system with VOC emissions controlled by a water scrubber system backed up by an activated carbon barrel. This system accommodates a flow of approximately 650 gpm. Solids are recovered from this unit using a Vacuum truck and transported to the delayed coker for recycling.

One low point sump was identified in the eastern production areas. This sump is the main collection point for the stormwater run off for the light oils processing area. The contents of this sump are pumped to the Lake Slobodnik system that is discharged directly to Peyton Slough. This concrete sump did have some apparent residual hydrocarbon staining and maybe of interest as a VOC source in this study.

Drains and Junction Boxes

As part of this survey an extensive survey of the on site drain and junction boxes was under taken at this site. A range of construction was observed for the units at the facility, this survey was conducted on 6/12/02 and started in the Op’s Central area of the refinery.

At the Hydrogen, Flexi-gas, Dimersol and Sulfur plants a range of different drain construction was observed. Pump stand drains varied between 6” to 4” and appeared to be open. Junction boxes in the units were more mixed with three prevailing types of construction 4’ x 4’ open boxes, 4’ x 4’ water sealed boxes and 4’ x 4’ “plug” sealed boxes. Similar drain and junction box construction was observed in the Flexicoker, cat cracker, cat gas plant and crude unit.

The only area that differed significantly from this construction was the Lubes area that represents the oldest construction at the facility. Here 1’ x 1’ and 3’ x 2’ open surface drains were observed around the pump stands.

Overview of Golden Eagle Oil Refinery (Avon) Wastewater System

Overview of Golden Eagle Oil Refinery (Avon) Wastewater System

Introduction

The Golden Eagle Oil Refinery (Plant #B2758) in Avon, CA occupies an approximately 2,200 acre site in Martinez, California. This refinery has a daily throughput of approximately 160,000 barrels (1 barrel = 42 gallons) of crude oil primarily from the San Joaquin Valley and Alaskan North Slope areas. This crude oil is refined at the facility to produce gasoline, diesel and petroleum coke. In addition, Plant #B2758 also produces approximately 140 tons of sulfur daily as a by- product of the on-site processes.
As part of the Bay Area Air Quality Management Districts' (the District) 2001 Clean Air Plan, the District, in cooperation with the California Air Resources Board (ARB) and the United States Environmental Protection Agency (U.S. EPA), is examining the wastewater systems for each of the Bay Area refineries to determine whether there are significant potential emission reductions from control of any remaining uncontrolled components of the wastewater systems, or through other measures. Most components of refinery wastewater systems are already controlled through compliance with District Regulation 8, Rule 8 (8-8), District New Source Review requirements, and U.S. EPA's National Emission Standard for Benzene Waste Operations (40 CFR Part 61, Subpart FF).

As part of this project a two day site visit (4/16/02 and 4/17/02) was conducted at Plant #B2758 to assess the availability of information related to the waste water system and to review the on-site collection and treatment of water which may have Volatile Organic Compounds (VOC) emissions impacts.

Site History

At Plant #B2758, the refinery consists of several units of varying construction dates. A review of these operating units reveals a number of phases of construction from the 1930's to 1996. The oldest operating unit at the facility is the #3 crude unit which was constructed in 1937. This unit has an associated desalter unit and the unit itself has been retrofitted during a number of the subsequent projects at the site.

The 1940's construction at the site saw the development of the #50 crude unit, #1 feed prep plant, the FCC and #4 gas plant. Again many of these units have been retrofitted as part of subsequent construction projects. The 1950's saw a further expansion of the facility with the construction of the #2 feed prep plant, the coker plant, the #5 gas plant, the coker flasher, #1 hydrodesulfurization (#1 HDS) and reformer plant, #2 HDS and reformer plant, the #1 hydrodearomatization (#1 HDA) plant and acid plant. This construction occurred on the eastern side of tract 1 and is the most homogenous area of the plant.

Additional expansion occurred in the 1960's with the construction of a Hydrocracker plant, #1 Hydrogen plant, a sulfur recovery unit and #7 boiler. This provided excess gasoline production at the facility that was sufficient for approximately the next decade.

The second last phase of construction at the facility occurred in the 1980's and consisted of further gasoline production expansion. This occurred with the building of #3 reformer, #3 HDS, an FCC unit, a scot unit and an ammonia recovery unit. The final stage of construction at the facility occurred in the 1990's and was associated with the clean fuels and Benzene NESHAPS requirements. The construction included the MTBE unit and the Benzene unit.

On-Site Waste Water Treatment

The waste water system at Plant #B2758 is defined by the location of the major process units. The facility itself is divided into five "tracts," numbers 1, 2, 3, 4 and 6. The main refinery units are located in tract #1 and #2 and effluent discharge from the process units in these two areas are piped via process drains to a central pump station (#1 pump).

No.1 pump station is the beginning point in the effluent treatment system and from here, wastewater flows into a "head channel" and then a four cell oil/water separator (API). It is estimated that the temperature of the process water flows is in the range of 32.2 ^{o}C (90°F) to 35 ^{o}C (95°F). From the API the effluent is routed through a four-cell dissolved nitrogen floatation (DNF) unit to remove suspended oil solids. The API and DNF are covered and under a nitrogen blanket. Following these units is an air stripper. This unit is under vapor recovery, with gaseous emissions being routed to a furnace destruction system.

Effluent from the API is sent via #6 pump station to #1 surge pond for biological treatment using aeration and bio-augmentation. It is estimated that the effluent temperature at this point is at a minimum temperature of 21.1 ^{o}C (70°F). From #1 surge pond effluent is routed to #2 surge pond for further settling of bio-solids prior to being routed to the 150 million gallon oxidation pond in Tract 3 for further treatment.
From the oxidation pond effluent is routed to the RBC unit. This unit was initially used to provide secondary biotreatment, but now is essentially a head works for the final treatment since it was taken out of service with RWQCB approval. At the RBC unit the effluent is dosed with ferric chloride and then proceeds through two clarifiers, followed by two separate filtration systems operated in parallel. From these two filters water proceeds through a granulated activated carbon unit (GAC) to either the clean water canal or coke pond system.

The coke pond system consists of coke sluice water and effluent that is used in the coke pile misting system. The commingled effluent from these ponds is routed via the on-site clean canal system to a pump station for the 27-inch diameter outfall pipe equipped with a diffuser, located under the Avon Wharf, 45 feet below mean lower low water level.

API and DNF Systems

All onsite wastewater is commingled at #1 pump station prior to the head works to the API with the exception of the acid plant effluent, the ammonia recovery unit, and the foul water strippers. These streams are commingled at the neutralization tank which

discharges downstream of the API head works. #1 pump station contains two pumps, a high speed 14,000 gallons per minute (gpm) pump and a low speed 5,000 gpm pump, that supply an average of 3,500 gpm to the four cells of the API. This area also contains a coarse screen to remove gross debris from the effluent stream. The effluent at this point consists of process water from the following: refinery process wastewater; coke pond overflow; cooling tower blowdown; boiler blowdown; non-segregated ballast water; tank draws; neutralized demineralizer regeneration water from the water treatment system; groundwater from remediation activities; and, non-hazardous wastewater generated from off-site facilities; process waste water from the Monsanto Company Catalyst Plant, cooling tower and boiler blowdown from Foster-Wheeler Cogeneration Plant, cooling tower blowdown from Air Liquide Carbon Dioxide Plant, and boiler blowdown from Air Products Hydrogen Plan. Sanitary wastewater enters the system at the foul water pump station, which is then lifted to the neutralization tanks, which in turn is discharged downstream of the DNF.

As previously stated, the API consists of four working cells all of which are covered completely with the exception of a number of gasketed hatches. These cells allow product from process waters to settle out via gravity. Oily surface waters and oily solids are removed from the cells by top and bottom chain driven skimmers. Product removed at this point is hard piped to tanks 669 and 700 for recovery. These cells are under nitrogen and the temperature of the effluent at this point is estimated in the 32.2 ^{o}C (90°F) to 35 ^{o}C (95°F) range.

From the API cells, water flows under gravity into a four cell DNF unit. Here nitrogen bubbles are used to remove any suspended product from the effluent prior to air sparging. This unit is completely enclosed except for seven gasketed hatches that are used to periodically test the effluent stream for benzene content.
Following treatment in the DNF unit all waters flow under gravity to an air stripping system prior to being pumped to #1 surge pond. This unit consists of an air sparging system that removes any hydrocarbon volatiles from the effluent steam for destruction in an on-site thermal furnace. This furnace treatment system is supported in case of break down by a caustic wash and vapor pack carbon bed system.
From the air sparging system water is pumped via #6 pump station through two pumps, a high speed 6,750 gpm pump and a low speed 3,750 gpm pump, that supply an average of 3,500 gpm to #1 surge pond. This represents the end of the “enclosed” section of the treatment works.

#1 and #2 Surge Ponds
This activated bio-sludge system provides the primary treatment for effluent at the facility. #1 surge pond consists of a five cell activated sludge treatment unit with aggressive aeration in the first of the five cells. This pond is approximately 3 to 4 feet deep and 1,400 feet long and the effluent temperature is estimated to be at a minimum of 21.1 ^{o}C (70°F). There are approximately 41 aerators in the aggressive biological treatment area of the pond. These are floating pontoon aerators operating at between 10 and 15 horse power (Hp). Sub surface curtains separate the pond into 6 cells. Additional treatment is stimulated through out the system by bio-augmentation (addition

of appropriate bacteria) and by use of a number of differing types of aerators. These include two 50 Hp lagoon master brush aerators, one 15 Hp brush aerator and several pontoon aerators.

Biosolids settle out in the #1 and #2 surge ponds. The #2 surge pond acts a secondary settling vessel for the effluent from #1 surge pond and contains four aerators. Effluent in the first cell of #1 Surge pond has been measured at 21.1 ^{o}C (70°F). From here effluent is either sent to the oxidation pond or routed at 187 gpm to the facility industrial water system to be used in various on site processes.

Oxidation Pond and RBC Unit

Effluent not used in industrial processes from #2 surge pond is pumped to the oxidation pond. The oxidation pond is a 150 million gallon, 104 acre settling, storage , equalization, and treatment system. This pond contains three to four 15 Hp aerators at its southern tip and consists of a number of curtained separated cells with subsurface flow through ports. Retention time in this pond is estimated at thirty days and the average flows back to the final water treatment system are some where between 1 to 6 million gallons daily (MGD). It is estimated that the temperature of the waters leaving the oxidation pond is ambient.

From the oxidation pond effluent is returned via two pump lines to a sump adjacent to #2 surge pond. From this point the commingled pump station water is routed to the RBC unit. The RBC unit was initially designed as a secondary biological treatment unit. This treatment was to be provided by biological film growing on the plates of the RBC unit, however, the treatment was discontinued. The unit still remains in the wastewater circuit and provides a head works for the operating parts of the system. Effluent from the RBC unit is dosed using a flocculent and routed to two clarifiers via a surface pipe.

Clarifiers and Filters

Flow from the RBC unit is split between two solids clarifiers that operate in parallel to remove the flocculent-formed solids from the effluent via a weir system. Solids from this system are returned to #1 surge pond for biological treatment. Both of these 140,000-gallon tanks are open and receive flows of between 2 to 6 mgd.

From this point the flow is again commingled and then re-split to flow through two different filter types that operate in parallel. These filters, a granular round filter and a Zimpro filter (a six-cell sand filter), are designed to remove any remaining effluent solids and turbidity. Both filters are back washed frequently to improve efficiency and the backwash is discharged in to a sump adjacent to the round filter unit for return to #1 surge pond. Effluent from this point is then sent to an open sump for final treatment at the GAC unit.

GAC Unit, Coke Storage Ponds and the Clean Water Canal

The GAC unit at this facility consists of twelve 20,000 lb. carbon beds operated in pairs that are designed to remove any remaining toxins or turbidity in the final effluent from

Plant #B2758. From this point the wastewater can be discharged directly to the bay via the clean water canal or more commonly shunted to the coke ponds for use. Effluent pumped to the coke pond is commingled with coke sluice water and is used in the coke pile misting system to prevent particulate emissions. This water is retained in the coke ponds as yet another equalization step prior to discharge to the clean water canal.

The clean water canal head channel begins at the area adjacent to the API/DNF unit and proceeds to northwards to the diffusion outlet head works. This area provides Plant #B2758 with a failsafe system as the canal has a two to one and one half day retention time and can be sampled at the head works to ensure the effluent meets all RWQCB permit requirements. The facility has the ability to shunt water from this canal to either the oxidation pond or #1 surge pond.

The final facility effluent is pumped from the end of the clean canal by three vertical pumps, to the 27-inch diameter outfall pipe and diffuser located under the Avon Wharf 45 feet below mean lower low water level.

Solid Waste

Solid Waste removal from the wastewater treatment system at this facility consists of only one action, yearly dredging. This operation is undertaken primarily in #1 surge pond and consists of a cell dredging unit that supplies a portable sludge dewatering centrifuge. This unit is supplied by an outside contractor and is generally not vapor controlled. It is estimated that 8,723 tons of sludge (70 to 75% moisture content) were removed for landfilling in 2001. Any water generated is returned via out fall line to #1 surge pond.

Storm Water

In addition to the wastewater treatment system, Plant #B2758 also has four additional storm water collection systems which function in tandem with and separately from the waste water system. Stormwater runoff from various on-site developed areas of Tracts 1, 2 and 3, and off-site facilities is commingled with the waste water steam and is discharged via the 27-inch diameter outfall pipe located under the Avon Wharf.

Stormwater runoff from an area of approximately 120 acres in the central and western portions of the Tract 4 tank farm is discharged from a series of holding ponds to a holding ditch to Pacheco Creek at two possible locations. Since these two locations are in proximity to each other, they are collectively designated as E-003.

Stormwater runoff from an area of 140 to 150 acres including the southeast portion of the Tract 4 tank farm and all of the Tract 6 tank farm, and off-site facilities including Air Liquide, Chevron Bulk Terminal Station, Kinder Morgan Energy Partners, Texaco Pump Station, and PG&E Substation is discharged to the head of Hastings Slough via six launders (L-shaped overflow pipes). These six discharge locations are approximately a foot away from each other. These discharge locations are collectively designated as E-

004. Stormwater runoff from various small areas throughout the Avon Refinery and the Terminal correspond to the discharge locations shown in the following table:

Location	Current E-005 Discharges
East side of Tract 1	**None**
North end of Tract 2	E-005-T2N
Northwest Corner of Tract 2	E-005-T2NW
South end of Tract 2	E-005-T2S(a, b, and c)
Southwest Corner of Tract 2	E-005-T2SW
North end of Tract 3	None
Southeast portion of Tract 3	None
Southwest portion of Tract 3	None
Northwest corner of Tract 4	E-005-T4NW
Southwest corner of Tract 4	E-005-T4SW
Northeast corner of Tract 6	E-005-T6NW
Southwest portion of Tract 6	E-005-T6SW
West end of Amorco Terminal	E-005-AW
South side of Amorco Terminal	E-005-AS

Sumps, Junction Boxes and Drains

As part of this site visit, an extensive tour of the various operating units was conducted at Plant #B2758 that incorporated construction from all phases of building. A wide range of drain, sump and junction box designs were observed at the facility and these components varied with construction date and location.

The #3 crude unit at the facility represents the oldest part of the current facility having being built in 1937. This area had numerous drain and sump designs. Typically, in the older area of the construction, pump stands and pads were drained via grated surface drains to 4’ x 4’ water sealed junction boxes and pad sumps. Also, one open junction box was noted in this area adjacent to the vacuum crude units. In the newer area of this unit, extensive retrofit had been done especially in the desalter area. Here, drains consist of water sealed box drains and grated 4” p-trap type drains at pump stands.

The initial stop on the site visit was the process units on the western side of refinery tract #1. The units observed the fluid coker, #5 gas plant, #4 gas plant #2 reformer and #4 FCCU, while representing a homogenous 1950’s construction, presented a wide range of differing drain and sump types. These areas generally contained a number of 2’ x 2’ junction boxes and low point sumps with and without water seals, a number of 6” p-trap drains at the majority of pump stands, a number of 6” open or dry drains at pump stands and a number of open or dry 4” and 6” shallow drains at and adjacent to pump stands. It is assumed that the range of construction observed is associated with the

numerous upgrades and overhauls which have occurred at these units over the lifetime of the refinery.

Also constructed in the 1940's, #50 crude unit represents the oldest and most unchanged drain and sewer system observed at the site. In this case, numerous open junction boxes and sumps of varying sizes were observed, as well as numerous open 6" and 12" drains at pump stands and process units. While a number of p-trap controlled drains were observed at pump stands adjacent to the desalter area, they were by far the minority.

The alkylation plant at the facility was constructed in the 1960's and was again observed to have a mixture of drain and sump types. The areas observed had a majority of 6" p-trap sealed drains at pump stands, with various sealed and unsealed 2' x 2' junction boxes and sumps. In addition a 2' x 4' grated open drain was observed, which flowed from various process area pads to various junction boxes and sumps. The MTBE and Benzene Saturation unit at the facility represent the most recent phase of construction at the refinery and were built in the early 1990's. These areas boast a totally enclosed drain system (hard piped) from which treated effluent eventually flows to a p-trap controlled sewer line.

It must be noted that with the exception of the MTBE and Benzene Saturation units, numerous steam and "hot" process flows were observed to be free flowing to the sewer and drain systems.

Overview of Valero Oil Refinery (Benicia) Wastewater System

Overview of Valero Oil Refinery (Benicia) Wastewater System

Introduction

The Valero Oil Refinery (Plant #B2626) in Benicia, CA occupies an approximately 350 acre site in Benicia, California. This refinery has a daily throughput of approximately 135,000 barrels (1 barrel = 42 gallons) of crude oil primarily from the San Joaquin Valley and Alaskan North Slope areas. This crude throughput is refined at the facility to produce approximately 115,000 barrels of gasoline, diesel, jet fuel and 1,080 tons of petroleum coke. In addition, Plant #B2626 is permitted to produce up to 286 long tons per day of sulfur as a by- product of the on-site processes.

As part of the Bay Area Air Quality Management Districts' (the District) 2001 Clean Air Plan, the District, in cooperation with the California Air Resources Board (ARB) and the United States Environmental Protection Agency (U.S. EPA), is examining the wastewater systems for each of the Bay Area refineries to determine whether there are significant potential emission reductions from control of any remaining uncontrolled components of the wastewater systems, or through other measures. Most components of refinery wastewater systems are already controlled through compliance with District Regulation 8, Rule 8 (8-8), District New Source Review requirements, and U.S. EPA's National Emission Standard for Benzene Waste Operations (40 CFR Part 61, Subpart FF).

As part of this project a two day site visit (4/23/02 and 4/25/02) was conducted at Plant #B2626 to assess the availability of information related to the waste water system and to review the on-site collection and treatment of water which may have Volatile Organic Compounds (VOC) emissions impacts. Subsequently, two additional site visits were conducted on July 1 and 2, 2002, and on August 20, 2002, to collect sewer and wastewater treatment plant samples.

Site History

Plant #B2626 is located on the site of a former United States Army base which dated back to the American Civil War. The refinery itself was constructed for the most part between 1968 and 1969. This means that the facility's construction is for the most part homogeneous and integrated with the exception of only two other periods of minor construction, the mid 1980's and 1990's.

As previously stated the bulk of the construction at this facility was performed between 1968 and 1969. Operating process units of this vintage are as follows: crude unit, catalytic (cat.) feed hydrofiner unit, sulfur recovery unit, coker unit, alkylation plant, fluid cat. cracking unit, hydrogen plants, powerformer unit and the hydrocracker unit. This represents the bulk of the on-site process units.

In 1982, the adjacent asphalt unit, formerly owned by Huntway, was constructed. This facility, purchased by Valero in June 2001, converts "heavy" crudes to asphalt flux. This site has its own on-site waste water pretreatment system that discharges partially-

treated effluent to the City of Benicia's Publicly Owned Treatment Works for final treatment.

In the main refinery, a propylene dimerization unit was added in the process block in 1985. The final phase of construction at this facility was associated with the clean fuels initiative in the early/mid 1990's. This involved the construction of the on-site MTBE plant in 1993 and the MRU unit in 1996.

Interestingly, drain construction from all periods in the main process block has been performed to a uniform set of design specifications that dates from the original 1968 schematic.

On-Site Waste Water Treatment

The waste water collection system at Plant #B2626 is simple and well-defined due to the nature of the construction at the facility. It essentially consists of four separate collection trains, three of which are commingled at the central treatment area. The fourth system, the system serving the asphalt plant, is routed separately to the City of Benicia sewer treatment facility.

Storm water runoff, process water, boiler and cooling tower blowdown are routed to the sewer system in the main process block. Sour process water, and intermediate tank water draws and finished product water draws, are routed through a separate hard pipe system to a sour water stripper. Potentially oily water, such as desalter water and crude tank draw water are routed through a deoiler system prior to being hard-piped to the on-site equalization tanks. These equalization tanks represent the beginning of the waste water treatment facility. Here process block runoff and deoiler water are commingled before being sent to oil/water separation. The temperature at these tanks typically ranges between 24 ^{o}C (75°F) and 35 ^{o}C (95°F).

The treatment train for this commingled effluent consists of two parallel corrugated plate separators (CPS) followed by two induced flotation separators (IFS) to remove oil and solids. This system typically processes flows of approximately 1,200 gallons per minute (gpm). From here effluent is routed to three parallel bio-oxidation units ("biox") for main treatment. At the biox units, effluent from the sour water stripper is commingled with the other effluent at the site. A portion of the sour water stripper effluent is first passed through a preparatory bio-oxidation ("pre-biox") system located adjacent to the main biological treatment area. The effluent temperature at this point is approximately 32.2 ^{o}C (90°F). The flow out of these biox units is generally about 1,500 gpm.

From the biological aeration treatment cells the effluent passes through three clarifiers in parallel that remove bio-mass. From this point the flow is directed through an induced air flotation separator to remove residual bio-solids prior to selenium treatment. Selenium treatment consists of a flocculation tank and inclined plate clarifier. This is the final part of the treatment process prior to discharge to Suisun Bay. Discharge is via a deep water outfall located about 1,100 feet offshore at a depth of 18 feet west of the

Suisun Reserve Fleet Anchorage. The outfall is a 12-inch diameter pipe with 3 diffusion ports.

Sour Water Strippers, Deoiler and Equalization Tanks

As previously stated the sour process water produced in the main refinery block is hardpiped to a single sour water storage tank (Tank #2801), which has a fixed roof and is linked to vapor and oil recovery systems. From here water is fed to a single sour water stripper column (T2831) in the sulfur plant. The stripped sour water is hard piped directly from this point to a tank for equalization and then to the waste water treatment plant. It is estimated that the water at this point has a flow of 300 gpm and is at a temperature of 37.8 ^{o}C (100 ^{o}F).

Water draw streams from the intermediate and finished product tanks are routed to two cracked slop tanks operated in series for separation of oil and water. These tanks include: TK-1753, an 87,000 barrel EFR tank with a secondary seal; and TK-1795, an 83,000 barrel EFR tank with a secondary seal. Miscellaneous aqueous and oily slop are also offloaded into these tanks from vacuum trucks. The recovered oil is fed to the Fluid Catalytic Cracking Unit or the Fluid Coker, while the sour water is hard-piped to the sour water storage tank, TK-2801.

Other minor process and storm waters from the main refinery block are routed to the sewer system via drains that flow to two tanks that provide equalization capacity for the waste water treatment train at the facility.

The remaining effluent at the facility, water from the crude desalter unit and the crude tank water draws, is processed in a deoiler unit. Crude desalter water is piped directly to the deoiler unit. Crude water draws are piped to two tanks in series for separation of oil and water, before processing in the deoiler. The two tanks include: TK-1757, a 30,000 barrel EFR tank with a secondary seal; and TK-1793, a 16,000 barrel IFR tank with a primary seal. From this point water is pumped through a deoiler system.

The deoiler consists of a CPS unit followed by an ISF unit under a nitrogen blanket with vapor recovery routed to the flare gas recovery header. Recovered oil is routed back to a crude slop oil tank and the waste water is hard piped to the main equalization tanks to be commingled with process water from the refinery process block.

At the equalization tanks the main sewer from the process block enters the waste water treatment facility. This flow is estimated to be an average of 1,200 gpm and at maximum can be 2,600 gpm. Flows in excess of 2,600 gpm are automatically routed via spill overflow control to 12 million gallon storm water ponds for retention and then treatment.

The equalization tank system itself consists of two large particulate strainers followed by two 700 barrel fixed roof surge tanks that flow into two 20,000 barrel main tanks, both in parallel trains. Effluent from the deoiler system, estimated at a flow rate of 350 gpm is commingled with the sewer effluent in the main equalization tanks, and it is estimated

that the water temperature at this point is 32.2 ^{o}C (90°F). This system is totally enclosed and vapors are routed to two 1,200 lbs. carbon canisters in series for control. It was also noted during the site visit that two Baker tanks were situated next to this system. Both were uncontrolled and were being used for sludge and heavy particulate removal.

Oil/Water Separation, Aeration and Clarification

Effluent from the equalization tanks is pumped via a ½ mile hard pipe to oil water separation at the main waste water treatment plant. Oil/water separation is achieved in two 1,500 gpm CPS units followed by two ISF units under nitrogen, both in parallel trains. Again, this system is totally enclosed with vapors routed to two 700 lbs activated carbon beds in series. The total flow rate at this point is approximately 1,200 gpm.

Effluent from this point is routed to the main biotreatment unit at the facility via hard pipe. It is at this point that all effluent streams at the facility are finally commingled. Effluent from the sour water stripper is routed to a tank that provides equalization capacity. After the equalization tank, the effluent is routed to the three main biotreatment cells in the waste water treatment train. A portion of the sour water stripper effluent is first passed through two small biological treatment units (prebiox 1, a 60' diameter open top tank 11'' deep and prebiox 2, a 59'x10'x24' rectangular open top tank). Temperatures in the prebiox and biox units are estimated to be between 32.2 ^{o}C (90°F) and 37.8 ^{o}C (100 ^{o}F).

As previously stated, the main biological treatment unit at the facility consists of three aeration cells linked to three clarifiers, all of which operate in parallel. Influent into this system is also treated with approximately 300 lbs of carbon per cell daily for odor control and to aid in the removal of toxic compounds. The aeration units have subsurface air spargers laid out in 6" lines that provide air to the bio mass at a total average rate of 3,400 CFM. The clarifiers in this system act to remove carbon slurry and biomass from the effluent stream and are weir type with hopper bottom sludge recovery. Each aeration cell and clarifier is 47'x47'x16' and the units' retention time is approximately 17 hrs at normal flow rates. Effluent at this point is estimated to be at a temperature of 32.2 ^{o}C (90°F).

Selenium and Final Effluent Treatment

Following clarification, all effluent trains are again commingled and passed through an induced air flotation unit (IAF).This unit is a portable Wemco unit used to remove biomass and carbon left in the effluent after clarification. Flow rates at this point are estimated at 1,500 gpm. From this point water flows to an open top surge tank (9' diameter x 8' high) prior to be being treated for selenium.

Selenium treatment at the facility consists of a reactor clarifier with $FeCl_3$ treating in a central mixing area followed by sedimentation in an inclined-plate (Lamella) clarifier and bottom wasting to thickening and dewatering. Following selenium treatment, water is treated with caustic for final pH control and then routed to the bay through the deep water outfall.

Asphalt Plant

As part of a recent purchase, Plant #B2626 acquired the former Huntway asphalt plant. This plant consists of a small crude unit that processes primarily crude bottoms and heavy product used in the production of numerous grades of asphalt flux. As this unit was previously not part of the adjacent Valero facility, it has its own separate waste water system.

Sour water, boiler blow down, contact cooler water and desalter water produced in the main process block flow at a rate of 30 gpm via hard pipe from the onsite sewer system to oil/water separation. At the oil/water separator (API) oil is removed via gravity separation and returned to crude oil tankage. Heavy sludges are removed via vacuum truck for oil recovery in Valero's fluid coker unit.

Following the API, effluent is passed through an IAF to remove excess oils and particulates carried in solution. Again recovered oil is removed to crude tankage. Effluent from this unit is then sent to a 3,800 gallon tank for equalization and in-line chemical treatment. This tank is vapor controlled to a carbon canister. Following this tank, waste water is pumped to two 2,100 barrel final holding tanks for testing prior to discharge to the City of Benicia municipal sewer treatment system. All wastewater equipment at the asphalt plant is abated by either a thermal oxidizer or carbon.

Solid Waste

Solid Waste removal from the main refinery's waste water treatment system consists of four actions: sludge and gross debris removal from the equalization tanks, sludge removal from the deoiler, CPS and ISF units, biological sludge removal and selenium sludge removal.

As previously stated, gross debris including coke fines and heavy petroleum is removed at the inlet filters to the equalization tanks. This material is stored in uncontrolled Baker tanks and is eventually transported to the coker for oil recovery.

Sludges from the deoiler and the two CPS/ISF waste water treatment trains are routed to a primary sludge thickener for water removal. This is a fixed roof tank which is hard piped to a fixed cone roof tank under nitrogen. Sludge from this system is pumped via a pipe line to the coker for oil recovery.

Biological sludge and carbon slurry from the aerators and clarifiers at this facility are removed to an open top bio thickener at an approximate rate of 150 gpm. This sludge is for the most part processed via centrifuge dewatering to about 16% solids final sludge and removed for landfilling at a rate of about 17 tons per week. Finally, sludges removed during the selenium removal are processed onsite via centrifuge dewatering prior to being removed and landfilled by a private contractor. In both cases, no vapor controls were observed or required on either the biox or selenium dewatering systems.

Storm Water

In addition to the storm water collected from the process block and treated in the main effluent treatment facility, Plant #B2626 has a number of other systems which manage rain water produced at the facility. Runoff from the paved process area of the asphalt plant is treated in the on-site waste water facility. This runoff discharges into the city of Benicia municipal sewer system for treatment at the POTW, and ultimately discharges into the Carquinez Strait. Storm water runoff from selected non-process areas of the asphalt plant is collected in Tank 33 and analyzed prior to discharge into the creek known as "Beaver Creek". From there, the water flows through the ditch known as "Buffalow Wallow", through a 72-inch culvert into Sulfur Springs Creek and ultimately Suisun Bay.

The Refinery has fifteen (15) discreet stormwater outfalls identified in the NPDES permit as follows:

E-002: Storm water runoff from an unpaved area of approximately 1.8 acres, located along the western boundary of the wastewater treatment plant is discharged through a ditch and several pipes into Sulfur Springs Creek which is contiguous with Suisun Bay.

E-003: Runoff from a 19 acre unpaved area is discharged near the Raw Water Break Tank at the north end of Avenue A via a culvert to Sulfur Springs Creek.

E-004: Storm water runoff from a 0.51 acre gravel area between First Street and the railway, on the south side of First Street is discharged west of Gate No. 4 into the eastern end of a ditch (Beaver Creek), followed by a culvert, another ditch (Buffalo Wallow), and a 72-inch culvert into Sulfur Springs Creek and ultimately Suisun Bay.

E-005: Runoff from a 69 acre area that is primarily unpaved (1% paved surface) located west of the processing area is discharged west of Gate No. 4, on the south side of the processing area via a spillway into the western end of a ditch (Beaver Creek), followed by a culvert, another ditch (Buffalo Wallow), and a 72-inch culvert into Sulfur Springs creek and ultimately Suisun Bay. A natural spring also discharges to this drainage.

E-006: Condensate from steam traps on the crude pipeline, groundwater seepage, and storm water runoff from a 3.5 acre unpaved area along and under the crude pipeline, starting at the southwest corner of the crude tank field and running northeast along the perimeter of the tank field and Park Road collects in a concrete sump equipped with a containment valve and a hydrocarbon detector. This sump discharges to a ditch to Sulfur Springs Creek and ultimately Suisun Bay.

E-007: Storm water runoff from a 0.69 acre gravel and paved area that is about 60% paved discharges just east of Gate 4 via a tributary ditch (Buffalo Wallow) followed by a 72-inch culvert into Sulfur Springs Creek and ultimately to Suisun Bay.

E-008: Runoff from a 0.92 acre graveled railway area located east of the processing area is discharged east of Gate No. 4 via a Culvert, into a ditch (Buffalo Wallow), followed by a 72-inch culvert into Sulfur Springs creek and ultimately Suisun Bay.

E-009: Storm water runoff from a 0.25 acre 50% gravel and 50% paved area, located between the railway and Avenue A is discharged along Avenue A on the southeast side of the processing area via a culvert into Sulfur Springs creek and ultimately to Suisun Bay.

E-010: Runoff from a 0.84 acre gravel and paved area that is 30% paved located between the railway and Avenue A is discharged along Avenue A on the southeast side of the processing area via a culvert into Sulfur Springs creek and ultimately Suisun Bay.

E-011: Storm water runoff from a 0.38 acre unpaved area under and along the crude pipeline on the north side of Park Road collects in a concrete sump equipped with a containment valve, normally kept closed, and with a hydrocarbon detector. The runoff is discharged on the north side of Park Road, where the refinery crude pipeline crosses Park road, via a culvert that discharges into Sulfur Springs creek and ultimately to Suisun Bay.

E-012: Runoff from a 0.78 acre primarily gravel area (10% paved) under a section of the crude pipeline southwest of the crude tank field collects in a concrete sump equipped with a containment valve, normally kept closed, and with a hydrocarbon detector. The runoff discharges into the city of Benicia municipal sewer system and ultimately into the Carquinez Strait.

E-013: Storm water runoff from a 1.2 acre (5% paved) area under the crude pipeline southwest of Outfall 012 collects in a concrete sump equipped with a containment valve, normally kept closed, and with a hydrocarbon detector. The runoff discharges into the city of Benicia municipal sewer system and ultimately into the Carquinez Strait.

E-014: Runoff from a 0.35 acre unpaved area under the crude pipeline collects in a concrete sump equipped with a containment valve, normally kept closed, and with a hydrocarbon detector. The runoff discharges into the city of Benicia municipal sewer system and ultimately into the Carquinez Strait.

E-015: Storm water runoff from a 0.50 acre unpaved area under the crude pipeline collects in a concrete sump equipped with an automatic valve, and hydrocarbon detector. The runoff is discharges into the city of Benicia municipal sewer system and ultimately into the Carquinez Strait.

E-016: Runoff from a 0.07 acre unpaved area under the crude pipeline near the refinery dock collects in a concrete sump equipped with a containment valve, normally kept closed, and with a hydrocarbon detector. The runoff discharges via a culvert into the Carquinez Strait.

Discharges from these areas are permitted and monitored in accordance with the site's NPDES permit.

<u>Sumps, Junction Boxes and Drains</u>

As part of this site visit, an extensive review of all drainage, sewer and water collection systems was undertaken. However, Plant #B2626 is unique in that even though there were three phases of construction over a 30-year period, it appears that all piping systems are homogenous.

In the main process block the piping and junction boxes observed in the cat. feed hydrofiner, the hydrocracker unit, the sulfur plant, the cat. cracking unit, the alky plant and the MTBE plant are all similar. They generally consist of 4” open drains at pump pads feeding either 4’ x 4’ or 2’ x 4’ water sealed junction boxes. While a number of open surface drains and two open junction boxes were observed in the alkylation plant these were by far the minority and were not typical.

In the Asphalt plant the process drain structure is different from the main refinery as it was designed by a different company. These drains were constructed to be a 4” open design but have been retrofitted with a box seal insert that achieves a seal similar to that of a p- trap design. District permit conditions require water seals, P-traps, caps, covers or equivalent on all process water drains.

Appendix F

Refinery Specific Sampling Plans

Chevron Products Company
(BAAQMD Plant #A0010)

Sampling Sites Wastewater VOC survey
July 22 - 24, 2002

Chevron Products Company (BAAQMD Plant #A0010)
841 Chevron Way
Richmond, California 94802-0627
Sampling Sites
Wastewater VOC survey, July 22, 23, 24 2002

Intention of the study is to determine VOC emissions from wastewater, ambient air locations, and VOC emissions from ancillary wastewater system process units.
Water Sample = Coliwasa (Sample size = 250 ml glass open mouth jar) The term stands for composite liquid waste sampler. A coliwasa is designed to take a composite (from top to bottom) sample. The device used in this study is manufactured in high-density polyethylene with and Teflon coated topper. Sample size = 250 (see: ASTM D5495-94 (2001) Standard Practice for Sampling with a Composite Liquid Waste Sampler).

Air Sample = air ambient air grab sample into a 6 liter Stainless steel Summa® passivated canisters. Canisters begin evacuated and will be allowed to return to ambient in wastewater areas and sewer openings.
Mechanics of Sampling: Sewer manholes and junction boxes will be sampled via coliwasa or bucket. Bucket samples will be taken for those sample locations with water depth less than one (1) foot. Process line sampling will be use standard Chevron sampling procedures. The sample locations using coliwasa sampling will use the following procedure:

Sample prep and organizational meeting:

Non-Refinery Personnel	Damian Breen, Tim Dunn, Matt Gerhardt
Refinery Personnel	Richard Sandman, Bob Chamberlain
Chevron Labor:	Two (2) technicians with confined space equipment (plus one laborer, if necessary)
Chevron Equipment:	forklift, LEL & OVA meters
Brown & Caldwell Equipment	1 liter caged bottle sampler
BAAQMD & ARB Equipment	plastic pipe: (a four foot section of three inch PVC) coliwasa tubes, associated plastic pipe to lower sampling device, measuring tape, plumb bob, 14 Summa® passivated canisters, one ice chest, ice. 10 250-ml sample glass wide mouth bottles, 80 VOA glass 40-ml sampling vials, 40 1-liter glass sampling containers, and two (2) alcohol thermometers.

Time: 30 minutes maximum per wastewater sampling location
Ambient air sampling, 15 minutes maximum per air sample.

Sampling Procedure for coliwasa sampling locations

28. Confirm if sampling area is a confined space entry using LEL meter and OVA meter. If lowering sampling device is considered a confined space activity,

and then use Chevron confined space entry procedures. Monitor for explosive gases using LEL throughout sampling activity, if necessary.

29. Take a measurement of organic gases at 2 inches below manhole lip using OVA. and record measurement.
30. Take dimensions of sampling area and piping.
31. Measure depth of flow
32. Lower 3-inch pipe containing coliwasa into sampling area if flow exist. Sample wastewater inside 3-inch pipe using coliwasa.
33. Retrieve coliwasa. Place sample in secure location
34. Measure and record sample temperature using glass thermometer
35. Store sample in wet ice.
36. Retrieve 3inch plastic pipe
37. Place used coliwasa samplers in plastic bag.
38. Place used 3inch PVC pipe place in plastic bag.
39. If no flow, collect air sample using Summa canister using sampling procedure detailed in ARB QA manual Volume II Appendix Q.
40. Close sampling area.

Sampling Locations

Sample Date	Chevron Drawing	Sample Point	Sample Location	Sample Type
7/22/2002	F-252053-5	5	MH 1-4-0-6 on 36-inch Main Street line	**Air**
		7	MH 1-3-0-5 on 48-inch Pipe Street line	Air
		8	MH 1-6-0-2 on 60-inch Division Street line	Water – Coliwasa
		9	MH 1-5-0-6 on 36-inch Calol Street line	Water – sample thief
	F-252052-4	3	Feed to 1A Separator Cell C	Water – sample thief
	F-252051-4	17B	MH 2-2-0-3 on Foundation Street where 18-inch line enters	Water – Coliwasa
		18	MH 2-3-0-4 on 12-inch line north of cooling tower	Water – sample thief
		16B	Box 2-1-0-1 on 48-inch Distillation and Reforming line	Water – tap
		16	Box 2-3-0-1 on 12-inch LSFO line	Air
		17	Box 2-2-0-1 on 18-inch Foundation Street line	Water – Coliwasa
7/23/2002	F-252018-2	25D	24-inch Hill Street line at Sulfur Plant	Water – Coliwasa
		25C	27-inch Hill Street line near Octane Street	Air

	F-252026-3	25	Drain near 13 Separator	Water – sample thief
		28B	MH 3-3-0-2 or 3-3-0-3 on 60-inch Hydro line	Air
		28	MH 3-2-0-4 or 3-2-0-5 on 36-inch FCC line	Water – sample thief
		25B	42" Storm Sewer between 13 Separator and Channel Street	Water - Coliwasa
		28D	MH 3-3-0-4 or 3-3-0-5 on 60-inch Hydro line	Water - Coliwasa
7/24/2002		30	MH 3-3-0-8 on Hydro line	Water - Coliwasa
	F-252027-2	32	MH 3-3-0-10 on Hydro line	Water – sample thief
		34	MH 3-2-0-12 on 24-inch FCC line in polypropylene plant	Water – sample thief
		33	MH 3-2-0-9 on 24-inch FCC line in between Cutter and Alkylate Streets	Water – sample thief
	F-252026-3	31	MH 3-2-0-7 on 24-inch FCC line in between Polymer and Cutter Streets	Water – sample thief
		31B	MH 3-2-0-6 on 24-inch FCC line at turn to cross Channel Streets	Water – sample thief
	-	51	Equipment blank	Water – Coliwasa

Notes:

3. Spiking – lab will spike a 1 out of ever ten water samples.
4. Preservation - lab will filter and preserve wastewater samples on day samples were taken.
5. Trip/equipment blank prepared using laboratory deionized / low organic water using unused coliwasa.
6. One duplicate will use a coliwasa (using new coliwasa) a new section of 3-inch PVC pipe.
7. Sample Labeling Code example: C-1 for Chevron sample point #1.
8. Field staff will measure the relative volumes of aqueous phase and oil phase using a graduated cylinder. Staff will record phases present in sample (e.g., solids, emulsion, water layer, and oily layer).

Procedure for analyzing the wastewater samples will be U.S. EPA method 8015/8021. The wastewater samples are one phase (water). Each wastewater sample will result in two analyses (TPH gasoline & TPH diesel). McCampbell Analytical 110, Second Avenue South, D#7, Pacheco, CA 94553.

Phillips San Francisco Oil Refinery (Plant #A0016) Rodeo, California

Sampling Sites - Wastewater VOC survey
August 5 - 6, 2002

Phillips San Francisco Oil Refinery (Plant #A0016) Rodeo, California
Sampling Sites
Wastewater VOC survey, August 5, 6 2002

Intention of the study is to determine VOC emissions from wastewater, ambient air locations, and VOC emissions from ancillary wastewater system process units.

Water Sample procedures: Two methods will be used to collect water samples. A coliwasa sampler is the preferred method. However, If the depth of the wastewater is less than one foot a grab sample method shall be used.

1. Coliwasa sample: Sample size = 250 ml glass open mouth jar. (Coliwasa stands for composite liquid waste sampler). A coliwasa is designed to take a composite (from top to bottom) sample. The device used in this study is manufactured in high-density polyethylene with and Teflon coated topper, maximum sample size = 250 ml. (Reference: ASTM method D5495-94 (2001) Standard Practice for Sampling with a Composite Liquid Waste Sampler).

2. Grab sample (Sample size = 1 liter container) A grab sample is designed to collect a liquid samples whose upper surface can be accessed by the suitable device, i.e., manhole. The device used in this study uses a caged, i.e., protected, 1-liter glass sample container. (see ASTM method D6759-02 Standard Practice for Sampling Liquids Using grab and Discrete Depth samplers).

3. Air Sample = air ambient air grab sample into a 6 liter Stainless steel Summa® passivated canisters. Canisters begin evacuated and will be allowed to return to ambient in wastewater areas and sewer openings.

Mechanics of Sampling: Sewer manholes and junction boxes will be sampled via coliwasa or grab container. Process line sampling will be use standard Phillips 66 sampling procedures.

Sample prep and organizational meeting:

Non-Refinery Personnel	Damian Breen, Tim Dunn, Matt Gerhardt
Refinery Personnel	Dennis Quilici
Phillips 66 Labor:	Two (2) technicians with confined space equipment (plus one laborer, if necessary)
Phillips 66 Equipment:	LEL meter, equipment to open sewer manholes, fork lift if necessary.

Brown & Caldwell Equipment	1-liter caged bottle sampler, i.e. grab sampler.
BAAQMD & ARB Equipment	plastic pipe: (a four foot section of three inch PVC) coliwasa tubes, associated plastic pipe to lower sampling device, measuring tape, plumb bob, 10 Summa® passivated canisters, one ice chest, ice. 24 250-ml sample glass wide mouth bottles, 72 VOA glass 40-ml sampling vials, 40 1-liter glass sampling containers, OVA meter, one (1) thermometer.
Time	30 minutes maximum per wastewater sampling location. Ambient air sampling, 15 minutes maximum per air sample.

Sampling Procedure for coliwasa and grab sampling locations

1. Confirm if sampling area is a confined space entry using LEL meter and OVA meter. If lowering sampling device is considered a confined space activity, and then use Phillips 66 confined space entry procedures. Monitor for explosive gases using LEL throughout sampling activity, if necessary.
2. Take a measurement of organic gases at 2 inches below manhole lip using OVA. and record measurement.
3. Record dimensions of sampling area and piping.
4. Measure depth of flow
5. Lower 3-inch pipe containing coliwasa (or grab sampler) into sampling area if flow exist. Sample wastewater using coliwasa or grab device.
6. Retrieve sampler. Place sample in secure location
7. Repeat sample collection as necessary. Secure a separate sample for sample temperature measurement and observation of sample visual parameters using a graduated cylinder. Measure and record sample temperature using thermometer
8. Store sample in wet ice.
9. Retrieve 3-inch plastic pipe
10. Place used coliwasa samplers in plastic bag.
11. Place used 3-inch PVC pipe place in plastic bag.
12. If no flow, collect air sample using Summa canister using sampling procedure detailed in ARB QA manual Volume II Appendix Q.
13. Close sampling area

Sampling Locations

All sampling locations are shown on Phillips 66 drawing SFE 46-70-Y-1

Date & Sample #	Location	Type
8/5/2002		
1	Sump near Marine Terminal	Air
2	Groundwater extraction	Water – tap
3	Box 1272	Water – sample thief
6	Box 1426	Water – Coliwasa
9	Laboratory sump	Water – sample thief
8	Box 1056 while Laboratory discharging, sampled thief from box	Water – sample sump pump was not
30	Dry weather sump	Water – tap
25	Box 2410	Water – sample thief
23	Box 2348	Water – Coliwasa
24	Box 2312	Water – Coliwasa
22	Box 2421	Air
21	Box 2173	Water – Coliwasa
31	API Separator feed	Water – tap
31B	API Separator effluent	Water – sample thief
32	DAF outlet	Water – sample thief
33	PACT mixed liquor	Water – tap
28	Box 1968	Water – sample thief
27	Box 1961	Water – sample thief

Date & Sample #	Location	Type
8/6/2002		
15	Box 1786	Air
16	Box 1848	Water – Coliwasa
17	Coke cutting water	Water – tap
19	Salt water cooling	Water – sample thief
18	Unicracker east	Water – Coliwasa
19C	Unicracker west	Water – Coliwasa
19D	Unit 220	Water – sample thief
19B	Box 20036	Water – Coliwasa
13	Box 1723	Water – Coliwasa
14	Box 1752	Water – Coliwasa
12	Box 2041	Water – sample thief
34	Equipment blank	Water – Coliwasa

Notes:

1. Spiking – lab will spike a 1 out of ever ten water samples.
2. Preservation - Samples will be taken with sample containers supplied by McCampbell Analytical Inc. with preservative. Preserve wastewater samples will be stored in wet ice and transported to lab on same day samples were taken.
3. Trip/equipment blank prepared using laboratory deionized / low organic water using unused coliwasa.
4. One duplicate will use a coliwasa (using new coliwasa) a new section of 3-inch PVC pipe.
5. Sample Labeling Code example: P-1 for Phillips 66 sample point #1.
6. Field staff will measure the relative volumes of aqueous phase and oil phase using a graduated cylinder. Staff will record phases present in sample (e.g., solids, emulsion, water layer, and oily layer).
7. Procedure for analyzing the wastewater samples will be U.U. EPA methods 8015/8021. The wastewater samples are one phase (water). Each wastewater sample will result in two analyses (TPH gasoline & TPH diesel). McCampbell Analytical 110, Second Avenue South, D#7, Pacheco, CA 94553.

Shell Oil, Martinez, California
(BAAQMD Plant #A0011)

Sampling Sites - Wastewater VOC survey
July 31, 2002 and August 1, 2002

Shell Oil, Martinez, California, (BAAQMD Plant #A0011)
Sampling Sites Wastewater VOC survey
7/31/02 Wednesday and 8/1/02 Thursday

Intention of the study is to determine VOC emissions from wastewater, ambient air locations, and VOC emissions from ancillary wastewater system process units.

Water Sample procedures: Two methods will be used to collect water samples. A coliwasa is the preferred sampling method to be used for TPH gasoline analysis. However, if the depth of the wastewater is less than one foot or a manhole/junction box opening is not available then a 1-liter grab sample method shall be used to retrieve a representative sample.

1. Coliwasa sample (Maximum sample size = 250 ml glass open mouth jar) (The term stands for composite liquid waste sampler). A coliwasa is designed to take a composite (from top to bottom) sample. The device used in this study is manufactured in high-density polyethylene with and Teflon coated topper. (Reference: ASTM method D5495-94 (2001) Standard Practice for Sampling with a Composite Liquid Waste Sampler). Samples will be transferred to 40-ml VOA for TPH gasoline analysis.
2. Grab sample (Sample size = 1 liter container, with an aliquot transferred to 40-ml VOA if coliwasa not used.) The grab sample is designed to collect a liquid sample from a process pipe or from a fluid surface that can be accessed by the suitable device, i.e. manhole. The device used in this study uses a caged, i.e., protected, 1-liter glass sample container. (See ASTM method D6759-02 Standard Practice for Sampling Liquids Using grab and Discrete Depth samplers).
3. Air Sample = air ambient air grab sample into a 6 liter Stainless steel Summa® passivated canisters. Canisters begin evacuated and will be allowed to return to ambient in wastewater areas and sewer openings.

Mechanics of Sampling: Sewer manholes and junction boxes will be sampled via coliwasa or grab container. Process line sampling will be use standard Shell sampling procedures.

Sample prep and organizational meeting:

Non-Refinery Personnel	Damian Breen, Tim Dunn, Matt Gerhardt, and one additional BAAQMD staff to operate OVA meter.
Refinery Personnel	Dan Glaze

Shell Labor:	One (1) technician with confined space equipment (plus one laborer, if necessary)
Shell Equipment:	LEL meter, equipment to open sewer manholes, and a forklift if necessary.
Brown & Caldwell Equipment	1-liter caged bottle sampler, i.e. grab sampler.
BAAQMD & ARB Equipment	Plastic pipe: (a four foot section of three-inch PVC) coliwasa tubes, associated plastic pipe to lower sampling device, measuring tape, plumb bob, 10 Summa® passivated canisters, one ice chest, ice. 24 250-ml sample glass wide mouth bottles, 72 VOA glass 40-ml sampling vials, 40 1-liter glass sampling containers, one (1) thermometer, and OVA meter.
Time:	30 minutes maximum per wastewater sampling location Ambient air sampling, 15 minutes maximum per air sample.

Sampling Procedure for coliwasa and grab sampling locations

1. Confirm if sampling area is a confined space entry using LEL meter and OVA meter. If lowering sampling device is considered a confined space activity, and then use Phillips 66 confined space entry procedures. Monitor for explosive gases using LEL throughout sampling activity, if necessary.
2. Take a measurement of organic gases at 2 inches below manhole lip using OVA. and record measurement.
3. Record dimensions of sampling area and piping.
4. Measure depth of flow
5. Lower 3-inch pipe containing coliwasa (or grab sampler) into sampling area if flow exist. Sample wastewater using coliwasa or grab device.
6. Retrieve sampler. Place sample in secure location
7. Repeat sample collection as necessary. Secure a separate sample for sample temperature measurement and observation of sample visual parameters using a graduated cylinder. Measure and record sample temperature using thermometer
8. Store sample in wet ice.
9. Retrieve 3-inch plastic pipe
10. Place used coliwasa samplers in plastic bag.
11. Place used 3-inch PVC pipe place in plastic bag.
12. If no flow, collect air sample using Summa canister using sampling procedure detailed in ARB QA manual Volume II Appendix Q.
13. Close sampling area

Sampling Locations

(From Shell wastewater treatment schematic diagram DCN=665641)

Date: 7/31/2002

Sample #	Sample Location	Sample Type
30	ETP-2 equalization tank effluent	Water – tap
15	ETP-1 equalization tank influent	Water – tap
18	ETP-1 equalization tank effluent	Water – tap
23	ETP-1 clarifier effluent	Water – tap
36	ETP-2 equalization tank influent	Water – tap
10	ETP-1 API separator influent	Water – tap
11	ETP-1 influent (18"& 30" line)	Water – tap
5	ETP-1 influent (18" line alone)	Water – tap
12	ETP-1 API separator effluent	Water – tap
20	ETP-1 mixed liquor	Water – sample thief
22	Pond 8	Water – sample thief
21	Pond 6	Water – sample thief
8C	Lube west	Water – sample thief
8D	Lube east	Water – sample thief
2	CPI influent	Water – sample thief
1B	OpCen cooling tower blowdown	Water – tap
35	SWS No. 7 bottoms	Water – tap
3	Chemical plant	Water – sample thief

8/1/2002

39	ETP-2 aeration basin feed	Water – tap
32	Delayed coking unit pad sump for Air pumps P-14401/14402	Water – tap
32A	Delayed coking unit pad sump for Air pumps P-13508/13509	Water – tap
32B	Delayed coking unit pad sump for Air pumps P-14498/14499	Water – tap
35B	Coke cutting water	Water – tap
32C	Delayed coking unit pad sump for Air pumps P-13942/13943	Water – tap
6	SWS No. 3 bottoms	Water – tap
1	LOP cooling tower blowdown	Water – tap
7A	LOP north	Water – sample thief
7B	LOP south	Water – sample thief
31	Desalter brine deoiler	Water – tap
32D	Cat. reformer column 31 stripper	Water –caustic tap
32E	Cat. reformer column 31 stripper	Water – tap water wash

7F	LOP manhole 6	Water – Coliwasa
7E	LOP manhole 5	Water – Coliwasa
7C	LOP manhole 3	Water – Coliwasa
8	Gross oil separator effluent	Water – tap
33	Process water tank 13188	Water – tap

Notes:

1. Spiking – lab will spike a 1 out of ever ten water samples.
2. Preservation - Samples will be taken with sample containers supplied by McCampbell Analytical Inc. with preservative. Preserve wastewater samples will be stored in wet ice and transported to lab on same day samples were taken.
3. Trip/equipment blank prepared using laboratory deionized / low organic water using unused coliwasa.
4. One duplicate will use a coliwasa (using new coliwasa) a new section of 3-inch PVC pipe.
5. Sample Labeling Code example: P-1 for Phillips 66 sample point #1.
6. Field staff will measure the relative volumes of aqueous phase and oil phase using a graduated cylinder. Staff will record phases present in sample (e.g., solids, emulsion, water layer, and oily layer).
7. Procedure for analyzing the wastewater samples will be U.S. EPA methods 8015/8021. The wastewater samples are one phase (water). Each wastewater sample will result in two analyses (TPH gasoline & TPH diesel). McCampbell Analytical 110, Second Avenue South, D#7, Pacheco, CA 94553.

Tesoro Refinery, (Golden Eagle Oil Refinery) (BAAQMD Plant #B2758)

Sampling Sites - Wastewater VOC survey
August 5, 6 2002

Tesoro Refinery, a.k.a. Golden Eagle Oil Refinery (BAAQMD Plant #B2758)
Sampling Sites
Wastewater VOC survey, August 5, 6 2002
150 Solano Way, Martinez California

Refinery Background: The Golden Eagle Refinery is in Contra Costa County on the eastside of San Francisco Bay in the city of Martinez. It has the capacity to process 168,000 barrels of petroleum daily. It converts crude oil primarily into gasoline. The plant has fluid catalytic cracking, hydrocracking, reforming, alkylation and fluid coking capabilities. The refinery processes heavier crude oil from Alaska's North Slope and California's San Joaquin Valley. Crude oil arrives at Golden Eagle via tanker through docks located on San Francisco Bay and via pipeline links to California oil fields. Products are shipped to customers by truck, rail, tanker, barge and a product pipeline network serving Northern California and Western Nevada.

Project Study: The study intends to determine VOC emissions from wastewater, ambient air locations, and VOC emissions from ancillary wastewater system process units.

Water Sample procedures: Two methods will be used to collect water samples. A coliwasa sampler is the preferred method. However, If the depth of the wastewater is less than one foot a grab sample method shall be used.

1. Coliwasa sample: Sample size = 250 ml glass open mouth jar. (Coliwasa stands for composite liquid waste sampler). A coliwasa is designed to take a composite (from top to bottom) sample. The device used in this study is manufactured in high-density polyethylene with and Teflon coated topper, maximum sample size = 250 ml. (Reference: ASTM method D5495-94 (2001) Standard Practice for Sampling with a Composite Liquid Waste Sampler).

2. Grab sample (Sample size = 1 liter container) A grab sample is designed to collect a liquid samples whose upper surface can be accessed by the suitable device, i.e., manhole. The device used in this study uses a caged, i.e., protected, 1-liter glass sample container. (see ASTM method D6759-02 Standard Practice for Sampling Liquids Using grab and Discrete Depth samplers).

3. Air Sample = air ambient air grab sample into a 6 liter Stainless steel Summa® passivated canisters. Canisters begin evacuated and will be allowed to return to ambient in wastewater areas and sewer openings.

Mechanics of Sampling: Sewer manholes and junction boxes will be sampled via coliwasa or grab container. Process line sampling will be use standard Tesoro sampling procedures.

Sample prep and organizational meeting:

Non-Refinery Personnel	Damian Breen, Tim Dunn, Matt Gerhardt
Refinery Personnel	Michael De Leon, Sharon Lim, Marcus Cole, Susan Leavitt
Tesoro Labor:	Two (2) technicians with confined space equipment (plus one laborer, if necessary)
Tesoro Equipment:	LEL meter, equipment to open sewer manholes, fork lift if necessary.
Brown & Caldwell Equipment	1-liter caged bottle sampler, i.e. grab sampler.
BAAQMD & ARB Equipment	Plastic pipe: (a four foot section of three inch PVC) coliwasa tubes, associated plastic pipe to lower sampling device, measuring tape, plumb bob, 10 Summa® passivated canisters, one ice chest, ice. 24 250-ml sample glass wide mouth bottles, 72 VOA glass 40-ml sampling vials, 40 1-liter glass sampling containers, OVA meter, one (1) thermometer.
Time:	30 minutes maximum per wastewater sampling location. Ambient air sampling, 15 minutes maximum per air sample.

Sampling Procedure for coliwasa and grab sampling locations

1. Confirm if sampling area is a confined space entry using LEL meter and OVA meter. If lowering sampling device is considered a confined space activity, and then use Phillips 66 confined space entry procedures. Monitor for explosive gases using LEL throughout sampling activity, if necessary.
2. Take a measurement of organic gases at 2 inches below manhole lip using OVA. and record measurement.
3. Record dimensions of sampling area and piping.
4. Measure depth of flow
5. Lower 3-inch pipe containing coliwasa (or grab sampler) into sampling area if flow exist. Sample wastewater using coliwasa or grab device.
6. Retrieve sampler. Place sample in secure location
7. Repeat sample collection as necessary. Secure a separate sample for sample temperature measurement and observation of sample visual parameters using a graduated cylinder. Measure and record sample temperature using thermometer
8. Store sample in wet ice.
9. Retrieve 3-inch plastic pipe
10. Place used coliwasa samplers in plastic bag.
11. Place used 3-inch PVC pipe place in plastic bag.

12. If no flow, collect air sample using Summa canister using sampling procedure detailed in ARB QA manual Volume II Appendix Q.
13. Close sampling area

Sampling Locations

See Sewer Map, Tosco Refining Company, Avon, CA (Used for 1999 Benzene NESHAPS Report/Study)

Date: 8/13/2002

Sample Point	Location	Sample Type
16	Manhole 1-120	Water –oliwasa
15	Manhole 1-122	Water –Coliwasa
14	Manhole 1-058	Water –Coliwasa
13	Manhole 1-053	Water –Coliwasa
10	Manhole 1-030	Water –Coliwasa
8	Manhole 1-060	Water –Coliwasa
6	Manhole 1-025	Water –Coliwasa
4	Box V-004	Air
12	Manhole 1-017	Water –sample thief
7	Manhole 1-010	Air
5	Manhole 1-012	Water –Coliwasa
17	Manhole 1-021B	Water – Coliwasa
	1-021 south of Manhole 1-013	
3	Manhole 1-008	Water –sample thief
2	Manhole 1-004	Air
22	Manhole 1-006	Water – Coliwasa
1	Manhole 1-081	Water –sample thief
23	Manhole 1-069	Water – Coliwasa

8/14/2002

11	Manhole 1-021A (Manhole	Water – Coliwasa 1-021 west of Tank 622)
18	Manhole 1-047 – only stream	Water – sample thief from 3 HDS plant
19	Manhole 1-042 – only stream entering from 3 Reformer	Water – sampled with cup on pole
21	Manhole 1-036	Water – Coliwasa
24	Manhole 1-204	Air
25	Manhole 1-098	Water – sample thief
26	Manhole 1-210	Water – sample thief
27	Manhole 1-211	Air
28	Manhole 2-018	Water – sample thief
29	Manhole 2-004	Water – sample thief

33	Tract 3 drain by railroad	Air tracks at NW corner of Can Filling Warehouse
32	Tract 3 near Speeder tracks	Water – Coliwasa adjacent to West Canal
36	Tract 4 sump	Air

Notes:

1. Spiking – lab will spike a 1 out of ever ten water samples.
2. Preservation - Samples will be taken with sample containers supplied by McCampbell Analytical Inc. with preservative. Preserve wastewater samples will be stored in wet ice and transported to lab on same day samples were taken.
3. Trip/equipment blank prepared using laboratory deionized / low organic water using unused coliwasa.
4. One duplicate will use a coliwasa (using new coliwasa) a new section of 3-inch PVC pipe.
5. Sample Labeling Code example: P-1 for Phillips 66 sample point #1.
6. Field staff will measure the relative volumes of aqueous phase and oil phase using a graduated cylinder. Staff will record phases present in sample (e.g., solids, emulsion, water layer, and oily layer).
7. Procedure for analyzing the wastewater samples will be U.S. EPA methods 8015/8021. The wastewater samples are one phase (water). Each wastewater sample will result in two analyses (TPH gasoline & TPH diesel). McCampbell Analytical 110, Second Avenue South, D#7, Pacheco, CA 94553.

Procedure for analyzing the wastewater samples will be U.S. EPA method 8015/8021. The wastewater samples are one phase (water). Each wastewater sample will result in two analyses (TPH gasoline & TPH diesel). McCampbell Analytical 110, Second Avenue South, D#7, Pacheco, CA 94553.

Valero Refining Company California
(BAAQMD Plant #12626 and Plant #12611

Sampling Sites - Wastewater VOC survey
August 20, 2002

Valero Refining Company California (BAAQMD Plant #12626 and Plant #12611)
Sampling Sites
Wastewater VOC survey, August 20, 2002
3400 East Second Street
Benicia, California 94510-1097

Project Study: The study intends to determine VOC emissions from wastewater, ambient air locations, and VOC emissions from ancillary wastewater system process units.

Water Sample procedures: Two methods will be used to collect water samples. A coliwasa sampler is the preferred method. However, If the depth of the wastewater is less than one foot a grab sample method shall be used.

Coliwasa sample: Sample size = 250 ml glass open mouth jar. (Coliwasa stands for composite liquid waste sampler). A coliwasa is designed to take a composite (from top to bottom) sample. The device used in this study is manufactured in high-density polyethylene with and Teflon coated topper, maximum sample size = 250 ml. (Reference: ASTM method D5495-94 (2001) Standard Practice for Sampling with a Composite Liquid Waste Sampler).

Grab sample (Sample size = 1 liter container) A grab sample is designed to collect a liquid samples whose upper surface can be accessed by the suitable device, i.e., manhole. The device used in this study uses a caged, i.e., protected, 1-liter glass sample container. (See ASTM method D6759-02 Standard Practice for Sampling Liquids Using grab and Discrete Depth samplers).

Air Sample = air ambient air grab sample into a 6 liter Stainless steel Summa® passivated canisters. Canisters begin evacuated and will be allowed to return to ambient in wastewater areas and sewer openings.
Mechanics of Sampling: Sewer manholes and junction boxes will be sampled via coliwasa or grab container. Process line sampling will be use standard Valero sampling procedures.

Sample prep and organizational meeting:

Non-Refinery Personnel	Damian Breen, Tim Dunn, Matt Gerhardt
Refinery Personnel	Eric Hengst
Valero Labor:	One (1) technician (plus one laborer, if necessary)
Valero Equipment:	LEL meter, equipment to open sewer manholes, forklift if necessary.
Brown & Caldwell Equipment	1 liter caged bottle sampler, i.e. grab sampler.
BAAQMD & ARB Equipment	plastic pipe: (a four foot section of three inch PVC) coliwasa tubes, associated plastic pipe to lower sampling device, measuring tape, plumb bob, 10 Summa® passivated canisters, one ice chest, ice. 24 250-ml sample glass wide mouth bottles,

	72 VOA glass 40-ml sampling vials, 40 1-liter glass sampling containers, OVA meter, one (1) thermometer.
Time:	30 minutes maximum per wastewater sampling location Ambient air sampling, 15 minutes maximum per air sample.

Sampling Procedure for coliwasa and grab sampling locations

2. Confirm if sampling area is a confined space entry using LEL meter and OVA meter. If lowering sampling device is considered a confined space activity, and then use Valero confined space entry procedures. Monitor for explosive gases using LEL throughout sampling activity, if necessary.
3. Take a measurement of organic gases at 2 inches below manhole lip using OVA. and record measurement.
4. Record dimensions of sampling area and piping.
5. Measure depth of flow
6. Lower 3-inch pipe containing coliwasa (or grab sampler) into sampling area if flow exist. Sample wastewater using coliwasa or grab device.
7. Retrieve sampler. Place sample in secure location
8. Repeat sample collection as necessary. Secure a separate sample for sample temperature measurement and observation of sample visual parameters using a graduated cylinder. Measure and record sample temperature using thermometer
9. Store sample in wet ice.
10. Retrieve 3-inch plastic pipe
11. Place used coliwasa samplers in plastic bag.
12. Place used 3-inch PVC pipe place in plastic bag.
13. If no flow, collect air sample using Summa canister using sampling procedure detailed in ARB QA manual Volume II Appendix Q.
14. Close sampling area.

Sampling Locations

Sample Date	Sample Point	Sample Location	Sample Type
8/20/2002	5	ISF Effluent	Water - tap
	4	Chem Sewer Effl.	Water - tap
	6	Manhole 14	Water – sample thief
	7	Manhole 15	Water – sample thief
	3	Manhole 16	Water – Coliwasa
	8	Manhole 6	Water – sample thief
	11	Manhole 3	Water – Coliwasa
	9	Manhole 11	Water – sample thief
	12	Equipment blank	Water – Coliwasa

Sample Date	Sample Point	Sample Location	Sample Type
6/19/2003	1	Lift Station	Water - tap
	2	Deoiler	Water - tap
		Desalter	Water - tap
	3	NESHAP 3	Water - tap
	4	NESHAP 6	Water – Coliwasa
	5	NESHAP 12	Water – Coliwasa
	6	NESHAP 11	Water – sample thief

Sample Labeling Code example: 14-1 for Valero sample point 14 for 40 ml VOA, BTEX analysis. Field staff will measure the relative volumes of aqueous phase and oil phase using a graduated cylinder. Staff will record phases present in sample (e.g., solids, emulsion, water layer, and oily layer).

Note: procedure for analyzing the wastewater samples will be U.S. EPA method 8015/8021. The wastewater sample are two phases (oily & water). Each wastewater sample will result in two analyses.

Expected number of samples = 24-one phase samples (approx. 99% water & <1% oil) (TPHg - 40 ml VOA & TPHd - 1 liter)

2-water trip blanks (100% water 40 ml VOA)
1-duplicate BTEX sample (approx. 99% water & <1% oil 40 ml VOA)

27 = Total # of samples expected to be delivered to McCampbell Analytical by 7 p.m. on each sampling day.

Notes:

1. Spiking – lab will spike a 1 out of ever ten water samples.
2. Preservation - Samples will be taken with sample containers supplied by McCampbell Analytical Inc. with preservative. Preserve wastewater samples will be stored in wet ice and transported to lab on same day samples were taken.
3. Trip/equipment blank prepared using laboratory deionized / low organic water using unused coliwasa.
4. One duplicate will use a coliwasa (using new coliwasa) a new section of 3-inch PVC pipe.
5. Sample Labeling Code example: P-1 for Phillips 66 sample point #1.
6. Field staff will measure the relative volumes of aqueous phase and oil phase using a graduated cylinder. Staff will record phases present in sample (e.g., solids, emulsion, water layer, and oily layer).
7. Procedure for analyzing the wastewater samples will be U.S. EPA methods 8015/8021. The wastewater samples are one phase (water). Each wastewater

sample will result in two analyses (TPH gasoline & TPH diesel). McCampbell Analytical 110, Second Avenue South, D#7, Pacheco, CA 94553.

Procedure for analyzing the wastewater samples will be U.S. EPA method 8015/8021. The wastewater samples are one phase (water). Each wastewater sample will result in two analyses (TPH gasoline & TPH diesel). McCampbell Analytical 110, Second Avenue South, D#7, Pacheco, CA 94553.

Appendix G

Correspondence between U.S. Environmental Protection Agency and California Air Resources Board staff regarding Wastewater Methodologies

June 26, 2002

Ms. Ginger Vagenas, Environmental Scientist
United States Environmental Protection Agency
75 Hawthorne Street
San Francisco, California 94105

Dear Ms. Vagenas:

This is to request approval from the United States Environmental Protection Agency (U.S. EPA) to use U.S. EPA method 8015/8021 for necessary volatile organic carbon (VOC) laboratory analysis of wastewater samples. These samples will be collected as part of a technical assessment being performed by the staffs of the Air Resources Board (ARB) and the Bay Area Air Quality Management District (BAAQMD) to characterize VOC emissions from refinery wastewater systems.

As part of this assessment, staff is in the process of characterizing the emissions from wastewater systems for each of the five refineries in the San Francisco Bay area. This characterization includes the collection of wastewater samples from each refinery for VOC analysis. For your information, a proposed sampling plan for the collection of wastewater samples at the Valero refinery in Benicia is provided in Attachment 1. The results of the wastewater analysis will then be input into an emission model to develop a VOC emission inventory specific to each refinery.

The current U.S. EPA VOC emission model references the use of U.S. EPA methods 25D and 305 for the determination of the VOC content of the wastewater samples. Because of concerns regarding the use of U.S. EPA methods 25D and 305 for this assessment, we are proposing the use of U.S. EPA methods 8015/8021 for wastewater analysis. We believe that U.S. EPA methods 8015/8021 will provide results similar to that of U.S. EPA methods 25D and 305, and since U.S. EPA methods 8015/8021 are more commonly performed in California, will provide a cost savings over the use of U.S. EPA methods 25D and 305. A more detailed justification for the use of alternative U.S. EPA methods 8015/8021 is provided in Attachment 2.

I look forward to your reply and your continued support of this assessment. If you have any questions please feel free to contact me at (916) 324-8029, or Mr. Jim Karas, Manager, Air Quality Engineering at (415) 749-4742.

Sincerely,

Erik White, Manager
Engineering Evaluation Section

Attachments

cc: Ms. Rima Howell
D205-02
USEPA Mailroom
Research Triangle Park, NC 27711

Mr. Jim Karas, Manager
Air Quality Engineering
Bay Area Air Quality Management District
939 Ellis Street
San Francisco, California 94109

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

July 25, 2002

Mr. Erik White
Manager, Engineering Evaluation Section
California Air Resources Board
1001 I Street
Sacramento, CA 95812

Subject: Use of EPA Methods 8015/8021 in the Water9 Model

Dear Mr. White:

The California Air Resources Board (CARB) requested U.S. EPA approval to use Methods SW 846 8015/8021 as alternatives to EPA Methods 25D/305 for analysis of Volatile Organic Compounds (VOC) in wastewater samples. Based on discussions with your staff, the purpose of the wastewater analysis is to gather data to input into an emissions model such as Water9 to evaluate the effectiveness of various control strategies for refinery wastewater systems. If this is the case, then EPA approval is not required and CARB may use SW 846 8015/8021 in Water9.

If, however, the intent of using SW 846 8015/8021 as alternatives to EPA 25D/305 is to determine whether a facility is covered under a rule such as a New Source Performance Standard (NSPS), or the National Emission Standards Hazardous for Air Pollutants (NESHAP), or for determining compliance with any emission standard in a rule, then CARB needs to identify the applicable rule and section so we can better evaluate your request. Attachment 2 of your letter states that EPA methods 8015/8021 "has extensive validation, including U.S. EPA Method 301...". For clarification, EPA's Emission Measurement Center's records do not indicate that Methods SW 846 8015/8021 have undergone a Method 301 validation to be equivalent to EPA Methods 25D/305. However, as stated above, this does not preclude CARB from using SW 846 8015/8021 as long as the methods are not used to determine compliance.

The following recommendations are provided regarding the sampling procedure and the use of the Water9 model:

a. To minimize the loss of volatile compounds, volatile organic analysis (VOA) vials should be used to collect any wastewater samples that are not two phase samples. CARB staff is aware of this concern.

b. Attachment 2 of your letter implies that laboratory results may be reported as total gasoline range organics (GRO) or as total diesel range organics (DRO). Water9 accepts data inputs for individual chemicals and for compounds not in its database, it can accept information describing the properties of a chemical. Because GRO/DRO is not in the

model's database, their concentrations cannot be inputted directly into Water9. We understand that you plan to use the chromatograms to select representative compounds to input into the model. Please note that the accuracy of Water9's estimated emissions will be dependent on accuracy of the information inputted into the model.

If you have any questions, please do not hesitate to have your staff contact Stanley Tong at (415) 947-4122.

Sincerely,

Andrew Steckel
Chief, Rulemaking Office

cc: Rima Howell, EMC
Robin Segall, EMC
Valerie Cooper, EPA-R9
Ginger Vagenas, EPA-R9
Dean Bloudoff, CARB
Tim Dunn, CARB
Jim Karas, BAAQMD
Damian Breen, BAAQMD

Appendix H

Refinery Wastewater Laboratory Analysis

Refinery 1	TPH(d)	TPH(g)	cyclohexane	MTBE	Benzene	Heptane	Toluene	Methyl Cyclohexane	Ethyl benzene	m-Xylene	p-Xylene	o-Xylene	1,2,4-Trimethyl benzene	Naphthalene	Methyl Naphthalene,2-
ppb	1,600	130	3.5	ND	0.7	10	2.2	1.3	ND	0.5	0.5	4	22	10.6	75
Toxchem+ closed drain			86%		80%	81%	79%	84%		78%	75%	78%	67%	36%	35%
Toxchem+Jbox			24%		17%	25%	18%	25%		18%	18%	17%	18%	4%	4%
Water9 open drain			99%		99%	99%	99%	99%		99%	99%	99%	99%	58%	56%
Water9 manholes			4%		4%	4%	4%	4%		4%	4%	4%	4%	2%	2%
	240,000	21,000	128	ND	61	101	530	27	28	234	95	141	4,570	253	14,832
Toxchem+ closed drain			77%		68%	72%	67%	75%	66%	65%	62%	66%	50%	21%	20%
Toxchem+Jbox			24%		17%	25%	18%	25%	19%	18%	17%	18%	18%	4%	4%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	79%	33%	32%
Water9 manholes			4%		4%	4%	4%	4%	4%	4%	4%	4%	3%	1%	1%
	240	71	2.2	ND	ND	8.9	0.5	0.7	ND	0.1	ND	1.5	11.4	12.9	32.8
Toxchem+ closed drain			78%			74%	70%	76%		68%		69%	55%	25%	25%
Toxchem+Jbox			24%			25%	18%	25%		18%		17%	18%	4%	4%
Water9 open drain			99%			99%	99%	99%		99%		99%	88%	41%	40%
Water9 manholes			4%			4%	4%	4%		4%		4%	3%	2%	2%
	650,000	8,000	41	ND	300	82	140	74	21	27	48	16	712	1,127	5,413
Toxchem+ closed drain			89%		85%	84%	83%	87%	84%	82%	80%	82%	74%	45%	43%
Toxchem+Jbox			24%		17%	25%	18%	25%	19%	18%	18%	17%	18%	4%	4%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	72%	69%
Water9 manholes			4%		4%	4%	4%	4%	4%	4%	4%	4%	4%	3%	3%
	180	90	1.4	ND	1.1	9.1	ND	1.1	ND	ND	ND	ND	30.3	34	ND
Toxchem+ closed drain			89%		81%	84%		87%					74%	45%	
Toxchem+Jbox			24%		17%	25%		25%				17%	18%	4%	4%
Water9 open drain			99%		99%	99%		99%					99%	72%	
Water9 manholes			4%		4%	4%		4%					4%	3%	
	140,000	2,000	11.6	ND	1.1	9.4	0.6	4.0	0.6	0.7	0.3	1.9	56.0	287.0	ND
Toxchem+ closed drain			93%		90%	89%	75%	91%	90%	88%	86%	88%	83%	60%	
Toxchem+Jbox			24%		17%	25%		25%				17%	18%	4%	4%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	96%	
Water9 manholes			4%		4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	
	3,000,000	170,000	239		ND	110	110	2,835	520	53	407	60	22,717	30,254	112,695
Toxchem+ closed drain			91%			88%	87%	90%	88%	86%	85%	86%	81%	57%	55%
Toxchem+Jbox			24%		17%	25%		25%				17%	18%	4%	4%
Water9 open drain			99%		0%	99%	99%	99%	99%	99%	99%	99%	99%	91%	88%
Water9 manholes			4%		0%	4%	4%	4%	4%	4%	4%	4%	4%	3%	3%
	2,400,00	14,000	37.0	ND	42.0	237.0	150.0	136.0	90.0	178.0	87.0	215.0	1,914.0	1,841.0	ND

	0														
Toxchem+ closed drain			91%		89%	88%	87%	90%	88%	86%	85%	86%	81%	57%	
Toxchem+Jbox			24%		17%	25%	18%	25%	19%	18%	18%	17%	18%	4%	4%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	91%	
Water9 manholes			6%		5%	5%	5%	5%	5%	5%	5%	5%	5%	3%	
	2,200,000	33,000	268.0	ND	ND	121.0	26.0	545.0	87.0	17.0	15.0	43.0	323.0	3,051.0	ND
Toxchem+ closed drain			90%			86%	85%	88%	86%	83%	82%	84%	77%	50%	
Toxchem+Jbox			24%		17%	25%	18%	25%		18%	18%	17%	18%	4%	4%
Water9 open drain			99%			99%	99%	99%	99%	99%	99%	99%	99%	80%	
Water9 manholes			4%			4%	4%	4%	4%	4%	4%	4%	4%	3%	

Refinery 2	TPH(d)	TPH(g)	cyclo hexane	MTBE	Benzene	Heptane	Toluene	Methyl Cyclo hexane	Ethyl benzene	m-Xylene	p-Xylene	o-Xylene	1,2,4-Trimethyl benzene	Naph thalene	Methyl Naph thalene,2-
	9,500	1,200	226	ND	24	111	130	31	13	37	31	20	126	121	330
Toxchem+ closed drain			0.8495		0.7893	0.8105	0.7769	0.8327	0.7837	0.7659	0.7697	0.7403	0.6558	0.3442	0.3350
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	54%
Water9 manholes			3%		3%	3%	3%	3%	3%	3%	3%	3%	3%	1%	1%
	2,700	740	12.7	ND	ND	42.5	420	1.9	2.1	1.1	4.6	0.3	11.5	30.6	213
Toxchem+ closed drain			0.8495			0.8118	0.777	0.8327	0.7837	0.7661	0.77	0.7404	0.6564	0.3446	0.3360
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	54%
Water9 manholes			3%	0%	0%	3%	3%	3%	3%	3%	3%	3%	3%	1%	1%
	37,000	80	17	ND	ND	12	2	ND	ND	1	ND	ND	13	ND	36
Toxchem+ closed drain			0.9624			0.9377	0.9421			0.9366			0.9184		0.7831
Toxchem+Jbox			24.3%			24.7%	17.9%			18.3%			17.5%		4.2%
Water9 open drain			99%	99%	99%	99%	99%	`		99%			99%		125%
Water9 manholes			4%	0%	0%	4%	4%			4%			4%		3%
	110,000	7,900	104	ND	40	604	410	110	34	34	154	12	730	481	5,187
Toxchem+ closed drain			0.9476		0.9310	0.9145	0.9197	0.9367	0.9269	0.9119	0.9150	0.9025	0.8807	0.7152	0.6909
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	111%

Water9 manholes			4%		4%	3%	4%	4%	4%	3%	3%	3%	3%	3%	3%
	250,000	12,000	43	ND	310	261	2,200	130	100	283	238	99	703	592	7,041
Toxchem+ closed drain			0.8850		0.8420	0.8393	0.8273	0.8678	0.8347	0.8142	0.8186	0.7965	0.7275	0.4373	0.4194
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	67%
Water9 manholes			3%		3%	3%	3%	3%	3%	3%	3%	3%	3%	2%	2%
	610	110	4	ND	ND	10	2	2	ND	ND	3	ND	18	13	58
Toxchem+ closed drain			0.9513			0.9289	0.9256	0.9419			0.9227		0.8953	0.7405	0.7232
Toxchem+Jbox			24.3%			24.7%	17.9%	24.6%			18.1%		17.5%	3.7%	4.2%
Water9 open drain			99%			99%	99%	99%			99%		99%	99%	116%
Water9 manholes			4%			4%	4%	4%			4%		3%	3%	3%
	21,000	1,900	9	ND	53	92	110	5	13	28	74	18	278	337	884
Toxchem+ closed drain			0.9842		0.9803	0.9699	0.9750	0.9796	0.9781	0.9720	0.9733	0.9683	0.9670	0.9333	0.9188
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	147%
Water9 manholes			4%		4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
	670,000	10,000	57	ND	600	307	2,200	17	99	482	419	199	655	215	4,750
Toxchem+ closed drain			0.9004		0.8661	0.8564	0.8495	0.8825	0.8557	0.8350	0.8395	0.8214	0.7628	0.4913	
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	0%
Water9 manholes			3%		3%	3%	3%	3%	3%	3%	3%	3%	3%	2%	0%
	100,000	5,600	78	ND	110	196	710	43	59	252	143	95	498	253	3,163
Toxchem+ closed drain			0.9382		0.9178	0.9033	0.9058	0.9264	0.9139	0.8975	0.9008	0.8863	0.8587	0.6644	0.6411
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	103%
Water9 manholes			4%		4%	3%	3%	4%	3%	3%	3%	3%	3%	3%	2%
	83,000	18,000	ND	ND	ND	1518	41	10.7	ND	ND	42	1	81	106.6	ND
Toxchem+ closed drain						0.859	0.849	0.8847			0.8428	0.8211	0.7667	0.4918	
Toxchem+Jbox						24.7%	17.9%	24.6%			18.1%	16.6%	17.5%	3.7%	
Water9 open drain						99%	99%	99%			99%	99%	99%	99%	
Water9 manholes						3%	3%	3%			3%	3%	3%	2%	
	830,000	1,300	9	ND	ND	44	210	4	2	ND	15	1	116	457	442

Toxchem+ closed drain			0.7732			0.7219	0.6716	0.7505	0.6569		0.6552	0.6246	0.4948	0.2062	0.1990
Toxchem+Jbox			24.3%			24.7%	17.9%	24.6%	18.7%		18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%			99%	99%	99%	99%		99%	99%	99%	99%	32%
Water9 manholes			3%			3%	3%	3%	3%		3%	2%	2%	1%	1%
	250,000	22,000	531	ND	3,100	845	2,900	226	230	407	528	165	1,070	1,212	10,786
Toxchem+ closed drain			0.9399		0.9209	0.9027	0.9081	0.9272	0.9147	0.8981	0.9017	0.8889	0.8593	0.6712	0.6463
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	103%
Water9 manholes			4%		4%	3%	3%	4%	3%	3%	3%	3%	3%	3%	2%
	36,000	580,000	952	ND	46,000	17,556	110,000	12,127	47,000	23,334	23,646	9,020	15,234	62,232	212,899
Toxchem+ closed drain			0.8276		0.7581	0.7836	0.7463	0.8097	0.7486	0.7337	0.7374	0.7063	0.6071	0.2964	0.2870
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	46%
Water9 manholes			3%		3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	300,000	1,700,000	1,378	ND	10,000	26,204	81,000	6,225	15,000	8,175	3,468	3,357	335,747	126,302	1,083,144
Toxchem+ closed drain			0.8173		0.7448	0.7666	0.7316	0.7971	0.7292	0.7151	0.7192	0.6899	0.5787	0.2727	0.2615
Toxchem+Jbox			24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	42%
Water9 manholes			3%		3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	160,000	140	36	ND	0.61	15	ND	3.5	ND	0.1	1.1	ND	10.8	16.7	56
Toxchem+ closed drain			0.8060		0.7280	0.7558		0.7863		0.7007			0.5584	0.2553	0.2448
Toxchem+Jbox			24.3%		17.0%	24.7%		24.6%		18.3%	18.1%		17.5%	3.7%	4.2%
Water9 open drain			99%		99%	99%		99%		99%	99%		99%	99%	39%
Water9 manholes			3%		3%	3%		3%		3%	0%		2%	1%	1%

Refinery 3	TPH(d)	cyclo hexane	MTBE	Benzene	Heptane	Toluene	Methyl Cyclo hexane	Ethyl benzene	m-Xylene	p-Xylene	o-Xylene	1,2,4-Trimethyl benzene	Naph thalene	Methyl Naph thalene,2-
	3,500	7.168	0.023	0.227	82.6	0.263	40	0.867	0.304	0.304	0.2	0.108	0.02	0
	280,000	657	0	48	146	13	99	4	9	3	16	813	180	1,812
	340	7,217	0	4,000	12,355	33,000	2,144	5,900	22,237	9,646	3,117	25,461	5,471	99,452
	52,000	0	0	0	0	0	0	0	0	0	0	0	0	0

		22	ND	19	397	790	113	76	286	129	86	398	503	1,181
Toxchem+ closed drain		81.82%		74.49%	77.26%	73.33%	79.98%	73.36%	72.00%	72.37%	69.21%	58.73%	27.91%	26.96%
Toxchem+Jbox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		131%	0%	119%	124%	117%	128%	117%	115%	116%	111%	94%	45%	43%
Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
92,000		975	0	740	6,630	8,200	992	2,300	10,411	4,754	2,835	25,659	7,156	59,348
Toxchem+ closed drain		85.84%	ND	80.82%	81.33%	78.95%	84.11%	79.61%	77.27%	78.14%	75.42%	62.12%	36.42%	35.04%
Toxchem+Jbox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		137%		129%	130%	126%	135%	127%	124%	125%	121%	99%	58%	56%
Water9 manholes		3%		3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	710,000	2,009	0	450	1,714	12,000	987	200	716	313	270	4,586	4,611	25,144
	1,800	1,538	0	600	1,762	1,600	103	120	643	322	635	751	826	
	1,600	97	0	810	916	2,600	61	250	1,103	467	430	746	220	3,300
	270	13	0	5	31	10	5	1	6	3	10	25	22	220
	860	12	0	1	42	17	21	5	3	14	9	49	38	110
	95,000	160	0	410	311	2,100	181	160	509	193	288	1,859	1,411	7,418
	81,000	192	0	390	394	1,900	145	150	373	143	384	1,167	1,046	5,716
	97,000	172	0	370	362	1,700	113	140	369	143	387	968	535	4,241
	680	0	0	1	0	2	0	0	1			0		
	740,000	1,116	0	190	1,001	2,300	251	310	1,369	646	185	2,577	1,386	10,669
Toxchem+ closed drain		81.77%		74.71%	76.79%	73.19%	79.60%	72.88%	71.40%	71.82%	69.01%	57.95%	27.29%	26.31%
Toxchem+Jbox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		131%		120%	123%	117%	127%	117%	114%	115%	110%	93%	44%	42%
Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	92,000	975	0	740	6,630	8,200	992	2,300	10,411	4,754	2,835	25,659	7,156	59,348
Toxchem+ closed drain		85.84%		80.82%	81.33%	78.95%	84.11%	79.61%	77.27%	78.14%	75.42%	62.12%	36.42%	35.04%
Toxchem+Jbox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		137%		129%	130%	126%	135%	127%	124%	125%	121%	99%	58%	56%
Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	1,000,000	315	0	76	340	310	135	50	208	92	80	1,320	1,755	4,019
Toxchem+ closed drain		83.09%		76.67%	78.23%	75.01%	80.92%	74.96%	73.62%	73.96%	71.02%	60.74%	29.84%	28.82%
Toxchem+Jbox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		133%		123%	125%	120%	129%	120%	118%	118%	114%	97%	48%	46%
Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%

		980,000	41	0	18	113	100	124	55	138	65	117	4355	9719	32,155
		Oil phase	27	0	0	160	29	372	43	0	0	0	7314	16448	19,607
		59,000	28	0	49	114	300	95	95	339	146	155	3221	3018	10,440
		310	0	0	0	0	0	0	0	0	0	0	0	0	0
		310	0	0	0	0	0	0	0	0	0	0	0	0	0
		490	0	0	0	0	0	0	0	0	0	0	0	0	0
		5,000,000	78	0	290	341	460	43	29	75	29	216	1282	2785	7,372
		3,200	0	0	0	0	0	0	0	0	0	0	0	0	110
		2,200	1,158	190	460	508	4,300	35	170	1,312	651	237	814	374	3,791
		100	24	24	4	23	7	7	3	6	3	6	25	9	0
		710,000	53,164	0	2,300	81,514	63,000	36,649	9,900	29,851	12,824	12,326	201,412	216,488	1,380,572
			60	0	5	259	97	121	120	560	325	95	1,554	1,140	1,864
		710,000	2,009	0	450	1,714	12,000	987	200	716	313	270	4,586	4,611	25,144
		1,800	1,538	0	600	1,762	1,600	103	120	643	322	635	751	826	
		1,600	97	0	810	916	2,600	61	250	1,103	467	430	746	220	3,300
		270	13	0	5	31	10	5	1	6	3	10	25	22	220
		860	12	0	1	42	17	21	5	3	14	9	49	38	110
		95,000	160	0	410	311	2,100	181	160	509	193	288	1,859	1,411	7,418
		81,000	192	0	390	394	1,900	145	150	373	143	384	1,167	1,046	5,716
		97,000	172	0	370	362	1,700	113	140	369	143	387	968	535	4,241
		680	0	0	1	0	2	0	0	1			0		
		740,000	1,116	0	190	1,001	2,300	251	310	1,369	646	185	2,577	1,386	10,669
		1,000,000	315	0	76	340	310	135	50	208	92	80	1,320	1,755	4,019
		980,000	41	0	18	113	100	124	55	138	65	117	4355	9719	32,155
		oil phase	27	0	0	160	29	372	43	0	0	0	7314	16448	19,607
		59,000	28	0	49	114	300	95	95	339	146	155	3221	3018	10,440
		310	0	0	0	0	0	0	0	0	0	0	0	0	0
		310	0	0	0	0	0	0	0	0	0	0	0	0	0
		490	0	0	0	0	0	0	0	0	0	0	0	0	0
		5,000,000	78	0	290	341	460	43	29	75	29	216	1282	2785	7,372
		3,200	0	0	0	0	0	0	0	0	0	0	0	0	110
		2,200	1,158	190	460	508	4,300	35	170	1,312	651	237	814	374	3,791
		100	24	24	4	23	7	7	3	6	3	6	25	9	0
		710,000	53,164	0	2,300	81,514	63,000	36,649	9,900	29,851	12,824	12,326	201,412	216,488	1,380,572
			60	0	5	259	97	121	120	560	325	95	1,554	1,140	1,864

Refinery 3	TPH(d)	cyclo hexane	MTBE	Benzene	Heptane	Toluene	Methyl Cyclo hexane	Ethyl benzene	m-Xylene	p-Xylene	o-Xylene	1,2,4-Trimethyl benzene	Naph thalene	Methyl Naph thalene,2-
		7.168	0.023	0.227	82.6	0.263	40	0.867	0.304	0.304	0.2	0.108	0.02	0
	3,500	657	0	48	146	13	99	4	9	3	16	813	180	1,812
	280,000	7,217	0	4,000	12,355	33,000	2,144	5,900	22,237	9,646	3,117	25,461	5,471	99,452
	340	0	0	0	0	0	0	0	0	0	0	0	0	0
	52,000	22	ND	19	397	790	113	76	286	129	86	398	503	1,181
Toxchem+ closed drain		81.82%		74.49%	77.26%	73.33%	79.98%	73.36%	72.00%	72.37%	69.21%	58.73%	27.91%	26.96%
Toxchem+Jb ox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		131%	0%	119%	124%	117%	128%	117%	115%	116%	111%	94%	45%	43%
Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	92,000	975	0	740	6,630	8,200	992	2,300	10,411	4,754	2,835	25,659	7,156	59,348
Toxchem+ closed drain		85.84%	ND	80.82%	81.33%	78.95%	84.11%	79.61%	77.27%	78.14%	75.42%	62.12%	36.42%	35.04%
Toxchem+Jb ox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		137%		129%	130%	126%	135%	127%	124%	125%	121%	99%	58%	56%
Water9 manholes		3%		3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	710,000	2,009	0	450	1,714	12,000	987	200	716	313	270	4,586	4,611	25,144
	1,800	1,538	0	600	1,762	1,600	103	120	643	322	635	751	826	
	1,600	97	0	810	916	2,600	61	250	1,103	467	430	746	220	3,300
	270	13	0	5	31	10	5	1	6	3	10	25	22	220
	860	12	0	1	42	17	21	5	3	14	9	49	38	110
	95,000	160	0	410	311	2,100	181	160	509	193	288	1,859	1,411	7,418
	81,000	192	0	390	394	1,900	145	150	373	143	384	1,167	1,046	5,716
	97,000	172	0	370	362	1,700	113	140	369	143	387	968	535	4,241
	680	0	0	1	0	2	0	0	1			0		
	740,000	1,116	0	190	1,001	2,300	251	310	1,369	646	185	2,577	1,386	10,669
Toxchem+ closed drain		81.77%		74.71%	76.79%	73.19%	79.60%	72.88%	71.40%	71.82%	69.01%	57.95%	27.29%	26.31%
Toxchem+Jb ox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		131%		120%	123%	117%	127%	117%	114%	115%	110%	93%	44%	42%

Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	92,000	975	0	740	6,630	8,200	992	2,300	10,411	4,754	2,835	25,659	7,156	59,348
Toxchem+ closed drain		85.84%		80.82%	81.33%	78.95%	84.11%	79.61%	77.27%	78.14%	75.42%	62.12%	36.42%	35.04%
Toxchem+Jb ox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		137%		129%	130%	126%	135%	127%	124%	125%	121%	99%	58%	56%
Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	1,000,000	315	0	76	340	310	135	50	208	92	80	1,320	1,755	4,019
Toxchem+ closed drain		83.09%		76.67%	78.23%	75.01%	80.92%	74.96%	73.62%	73.96%	71.02%	60.74%	29.84%	28.82%
Toxchem+Jb ox		24.3%		17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain		133%		123%	125%	120%	129%	120%	118%	118%	114%	97%	48%	46%
Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	980,000	41	0	18	113	100	124	55	138	65	117	4355	9719	32,155
	oil phase	27	0	0	160	29	372	43	0	0	0	7314	16448	19,607
	59,000	28	0	49	114	300	95	95	339	146	155	3221	3018	10,440
	310	0	0	0	0	0	0	0	0	0	0	0	0	0
	310	0	0	0	0	0	0	0	0	0	0	0	0	0
	490	0	0	0	0	0	0	0	0	0	0	0	0	0
	5,000,000	78	0	290	341	460	43	29	75	29	216	1282	2785	7,372
	3,200	0	0	0	0	0	0	0	0	0	0	0	0	110
	2,200	1,158	190	460	508	4,300	35	170	1,312	651	237	814	374	3,791
	100	24	24	4	23	7	7	3	6	3	6	25	9	0
	710,000	53,164	0	2,300	81,514	63,000	36,649	9,900	29,851	12,824	12,326	201,412	216,488	1,380,572
		60	0	5	259	97	121	120	560	325	95	1,554	1,140	1,864
	710,000	2,009	0	450	1,714	12,000	987	200	716	313	270	4,586	4,611	25,144
	1,800	1,538	0	600	1,762	1,600	103	120	643	322	635	751	826	
	1,600	97	0	810	916	2,600	61	250	1,103	467	430	746	220	3,300
	270	13	0	5	31	10	5	1	6	3	10	25	22	220
	860	12	0	1	42	17	21	5	3	14	9	49	38	110
	95,000	160	0	410	311	2,100	181	160	509	193	288	1,859	1,411	7,418
	81,000	192	0	390	394	1,900	145	150	373	143	384	1,167	1,046	5,716
	97,000	172	0	370	362	1,700	113	140	369	143	387	968	535	4,241
	680	0	0	1	0	2	0	0	1			0		
	740,000	1,116	0	190	1,001	2,300	251	310	1,369	646	185	2,577	1,386	10,669

	1,000,000	315	0	76	340	310	135	50	208	92	80	1,320	1,755	4,019
	980,000	41	0	18	113	100	124	55	138	65	117	4355	9719	32,155
	oil phase	27	0	0	160	29	372	43	0	0	0	7314	16448	19,607
	59,000	28	0	49	114	300	95	95	339	146	155	3221	3018	10,440
	310	0	0	0	0	0	0	0	0	0	0	0	0	0
	310	0	0	0	0	0	0	0	0	0	0	0	0	0
	490	0	0	0	0	0	0	0	0	0	0	0	0	0
	5,000,000	78	0	290	341	460	43	29	75	29	216	1282	2785	7,372
	3,200	0	0	0	0	0	0	0	0	0	0	0	0	110
	2,200	1,158	190	460	508	4,300	35	170	1,312	651	237	814	374	3,791
	100	24	24	4	23	7	7	3	6	3	6	25	9	0
	710,000	53,164	0	2,300	81,514	63,000	36,649	9,900	29,851	12,824	12,326	201,412	216,488	1,380,572
		60	0	5	259	97	121	120	560	325	95	1,554	1,140	1,864

Refinery 4	TPH(d)	TPH(g)	cyclohexane	MTBE	Benzene	Heptane	Toluene	Methyl Cyclo hexane	Ethyl benzene	m-Xylene	p-Xylene	o-Xylene	1,2,4-Trimethyl benzene	Naph thalene	Methyl Naph thalene,2-
ppb	6,700	62,000	567	0	9100	2227	18000	512	2400	7597	2937	1465	2919	1463	12,813
	43,000	ND		26,000			0.8			0.7					
	25,000	<500	252	26,000	16	175	20	36	9.2	1	26	74	163	163	
	3,000	67	7.7	2,200	2.1		2	4	2.1	3	1	7	38.1	0	
	45,000	160	7	29	4.1	17.5	24	4.2	5.5	31.3	19.8	8.9	18.9	18.8	
Toxchem+ closed drain			83.32%	36.97%	76.61%	78.87%	75.40%	81.53%	75.73%	74.14%	74.53%	71.48%	61.82%	30.72%	
Toxchem+Jb ox			24.3%	4.7%	17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			133%	59%	123%	126%	121%	130%	121%	119%	119%	114%	99%	49%	0%
Water9 manholes			3%	1%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	0%
	15,000	64	6.1		0.9	16.6	4.1		2.8	9.3	6.6	7.1	5.2	5.3	
Toxchem+ closed drain			80.37%		72.40%	76.10%	71.35%		71.09%	71.00%	70.37%	67.05%	56.06%	25.53%	
Toxchem+Jb ox			24.3%	4.7%	17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			129%	0%	116%	122%	114%	0%	114%	112%	113%	107%	90%	41%	0%
Water9 manholes			3%	0%	3%	3%	3%	0%	3%	3%	3%	3%	2%	1%	0%
	11,000	ND					2.4			0.6	0.4	2.6			
	11,000	ND				1				0.2		1			

	16,000	2,200	7.6		38	100.3	300	50	65	303	105	152	313	146	620
Toxchem+ closed drain			89.25%		85.15%	85.66%	83.85%	87.77%	84.90%	81.33%	83.32%	80.94%	75.36%	46.80%	45.45%
Toxchem+Jbox			24.3%	4.7%	17.0%	24.7%	17.9%	24.6%	18.7%	18.3%	18.1%	16.6%	17.5%	3.7%	4.2%
Water9 open drain			143%	0%	136%	137%	134%	140%	136%	133%	133%	130%	121%	75%	73%
Water9 manholes			`	0%	3%	3%	3%	3%	3%	3%	3%	3%	3%	2%	2%

Refinery 5	TPH(d)	TPH(g)	cyclo hexane	MTBE	Benzene	Heptane	Toluene	Methyl Cyclo hexane	Ethyl benzene	m-Xylene	p-Xylene	o-Xylene	1,2,4-Trimethyl benzene	Naph thalene	Methyl Naph thalene,2-
	300,000	270	15	0	1.3	11	4.7	2	1.7	0.3	1.9	6.4	25	85	116
	1,700	400	92	0	4.5	60	11	27	3.8	1.9	9.1	11	92	57	31
	62,000	210	8.8	0	1.1	12.4	3.4	2.3	1.4	0.3	1.4	5.9	17.6	72.8	83
Toxchem+ closed drain		89.80%		85.98%	85.81%	84.65%	88.31%	86.63%	83.65%	84.05%	81.83%	76.36%	48.59%		
Toxchem+Jbox		12.59%	14.47%	11.62%	5.99%	13.18%		2.84%	11.92%	7.56%	10.81%	3.66%	10.84%	11.08%	
Water9 open drain		99%	0%	99%	99%	135%	99%	99%	134%	134%	131%	122%	78%	0%	
Water9 manholes		3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	3%	2%	0%	
	70,000	5,600	408	0	200	413	640	49	100	525.2	243.3	171.5	906	750	1,194
	56,000	2,400	157	0	52	296	190	98	40	111.9	55.7	72.4	410	345	572
	250,000	7,000	260	0	1200	496	1400	82	110	233	104	204	228	214	2,469
	360,000	19,000	261	0	190	18.3	480	51	95	499	268	93	220	3237	13,588
	630,000	27,000	670	0	290	1855	650	60.4	120	275.5	150.5	454	1447	5146	15,882
Toxchem+ closed drain			82.44%		75.63%	77.42%	74.11%	80.31%	73.92%	72.35%	72.78%	70.02%	59.22%	28.45%	27.38%
Toxchem+Jbox			4.93%	4.76%	2.60%	0.43%	3.42%		0.34%	3.88%	1.06%	2.40%	0.75%	3.40%	2.55%
Water9 open drain			99%	0%	121%	99%	99%	99%	118%	116%	116%	112%	95%	46%	44%
Water9 manholes			3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	2%	1%	1%
	330	0	0	0	0	0	0	0	0	0	0	0	0	0	0

	93,000	8,247	382	53	380	311	970	98.5	130	494	229	87	740	473	3,953
Toxchem+ closed drain			89.96%	56.89%	86.24%	85.85%	84.89%	88.46%	85.83%	83.85%	84.25%	82.10%	76.62%	49.13%	
Toxchem+Jbox			0.50%	9.89%	0.89%	6.56%	15.99%	0.07%	0.04%	0.53%	0.21%	0.56%	0.05%	0.42%	0.60%
Water9 open drain			99%	91%	138%	137%	99%	99%	99%	134%	135%	131%	123%	79%	0%
Water9 manholes			2.52%	1.80%	2.53%	0.81%	2.30%	2.23%	2.04%	1.96%	2.00%	2.12%	1.41%	1.26%	0.85%
	22,000	5,300	10.3	0	69	97	740	13	140	465	183	162	504	327	2,590
Toxchem+ closed drain			86.89%		81.74%	82.96%	80.45%	85.28%	81.33%	79.41%	79.80%	77.10%	69.83%	39.37%	38.19%
Toxchem+Jbox			3.52%	22.98%	5.85%	15.73%	24.17%		0.31%	3.90%	1.68%	4.23%	0.34%	3.09%	4.53%
Water9 open drain			99%	0%	131%	99%	99%	99%	99%	127%	128%	123%	112%	63%	61%
Water9 manholes			1.78%		1.78%	0.52%	1.61%	1.56%	1.40%	1.35%	1.38%	1.48%	9.30%	0.81%	0.53%
	530,000	25,000	973	0	680	471	2400	221	460	1594	718	88	2160	598	14,637
Water9 manholes			2.51%		2.73%	0.25%	2.16%	1.86%	1.50%	1.38%	1.47%	1.94%	0.70%	0.77%	0.34%
	61,000	36,941	1687	59	0	3240	870	449	26	21	11	98	325	665	29,549
Toxchem+ closed drain			89.80%	56.18%	85.98%	85.82%	84.65%	88.31%	85.63%	83.66%	84.05%	81.83%	76.37%	48.60%	46.89%
Toxchem+Jbox			14.56%	17.96%	13.93%	7.62%	16.44%	4.63%	2.64%	13.97%	8.45%	12.82%	3.35%	12.58%	13.17%
Water9 open drain			99%	90%	99%	99%	99%	99%	99%	134%	134%	131%	122%	78%	75%
Water9 manholes			3%	2%	3%	3%	3%	3%	3%	3%	3%	3%	3%	2%	2%
	9,900	11,000	572	0	300	536	910	163	160	754	362	184	1749	2688	2,622
	2,600	590	9.9	0	2.2	24.9	11	4.7	3.7	24.5	16.7	8.8	137	164	183
	3,100	55,000	258	0	4600	2098	9100	651	1100	2526	1206	2468	1850	1004	28,139
	3,200	1,000	81.9	0	64	108.5	190	13.1	22	76.9	24.9	38.2	128	20.18	232
	61,000	110,000	957	0	940	4453	4800	2415	810	1218	496	2686	11514	10809	68,902
Toxchem+ closed drain			85.39%		79.63%	80.75%	78.30%	83.62%	78.87%	77.02%	77.43%	74.69%	65.98%	35.16%	33.78%
Toxchem+Jbox			6.72%	7.20%	5.54%	2.16%	6.36%		1.32%	6.19%	3.40%	5.27%	1.93%	5.62%	5.41%

Water9 open drain			99%	99%	99%	99%	99%	99%	99%	160%	160%	160%	160%	160%	160%
Water9 manholes			3%	0%	3%	3%	3%	3%	3%	3%	3%	3%	3%	1%	1%
	23,000	20,520	1108	480	1100	1318	4800	175	290	739	319	342	882	687	8,760
	15,000	15,000	1848	0	320	3314	1300	888	96	60	25	225	1144	1065	4,715
Toxchem+ closed drain			83.89%		77.41%	79.81%	76.20%	82.15%	76.68%	75.04%	75.42%	72.37%	63.23%	32.02%	31.12%
Toxchem+Jbox			6.65%	7.35%	6.14%	4.51%	6.83%		1.91%	6.35%	4.48%	5.93%	2.13%	5.80%	6.01%
Water9 open drain			99%	0%	99%	99%	122%	99%	99%	120%	121%	116%	101%	51%	50%
Water9 manholes			1.35%		1.33%	0.81%	1.24%	1.25%	1.16%	1.14%	1.15%	1.15%	0.94%	0.78%	0.66%
	5,800	1,900	207	0	150	489	390	123	32	27.2	4.8	44	32	40	361
	31,000	3,320		2100	540	1300			180	1300					

Appendix I

Predicting VOC Emissions from Wastewater Processes Using General Fate Models

Introduction[22]

District and U.S. EPA regulations require refineries to quantify emissions of volatile organic compounds (VOC) for all refinery areas including wastewater collection and treatment facilities. Available methods include stack/field testing, published emission factors, engineering equations, and general fate modeling (GFM). This technical assessment document uses two GFMs to calculate area VOC emissions. Emissions are based on refinery process area, flow rate, wastewater temperature and composition. BACT/LAER emission factor equations were used to confirm the overall accuracy of the GFM calculations.

What Are GFMs?

GFMs are computer models that can perform a mass balance for each specified wastewater unit operation or the whole wastewater treatment facility. Use of GFMs for air emissions is preferred due to the complexity and high cost of direct air sampling from wastewater systems. GFMs estimate emissions losses from volatilization, stripping, adsorption onto solids, and biodegradation. By using GFMs, it is possible to estimate emissions from complex treatment configurations while considering split flows, liquid streams, quiescent surfaces, weirs, drops, as well as aerated, biological, and covered processes or any single operation or process.

Facility Data Used

GFMs are designed to be specific to each wastewater treatment facility. Knowledge of facility-specific data is used to setup and run these models. The facility data used in this assessment can be divided into three groups listed below:

- Influent Wastewater Characteristics - includes wastewater flow rate, temperature, VOC compound concentrations from lab analysis, ambient temperature and wind speed. Note: ambient temperature was set at 85°F and wind speed at 3.5 mph.
- Physical Design Characteristics - such as unit process dimensions (length, width, depth, etc.), weir characteristics, and other features (are processes covered or open to the atmosphere?)
- Operational Data - including the type of biological treatment, air flow rates, ventilation rates of covered processes.

Advantages of GFMs

GFMs are widely accepted for estimating emissions generated from wastewater treatment facilities. The U.S. EPA accepts emission estimates from both WATER9 and TOXCHEM+. GFMs are particularly advantageous when projecting potential emissions under varying existing and future flow and design conditions. GFMs can be employed as an important planning tool for understanding where emissions are released, what compounds are predominately emitted and how emissions may change based on

[22] Predicting VOC Emissions from Wastewater Processes using General Fate Models (GFMs) by Mark E, Curto, etc. al.; http://www.pirnie.com/readings/air_crnt/ac0995_2.htm

changing operational conditions. They can also be used to assess methods to reduce emissions.

Appendix J

Comparison of General Fate Models
WATER9 and TOXCHEM+

Comparison of WATER9 and TOXCHEM+ Models

WATER9 and TOXCHEM+ are GFMs suitable for estimating VOCs in refinery settings. Although these two models may be successfully used to estimate air emissions from wastewater treatment facilities, some caution should be taken when using these GFMs and interpreting their results. In general, the algorithms for these two models are the same but some of the default assumptions made for each model may result in different VOC estimates. However, calculating wastewater collection VOC emissions WATER9 and TOXCHEM+ provide similar results.

WATER9 has been shown to overestimate VOC emissions from sealed drains and some treatment processes like bioreactors. This overestimation is primarily due to the lack of temperature correction for Henry's law coefficients[23]and an underestimation of the effects caused by sorption and biodegradation. WATER9 algorithms and mathematical expression are based on BACT/LAER calculations and assumptions. The primary BACT/LAER assumptions used are:

- Sewers are operated at 50% of design capacity
- Flow is 40% of design capacity
- Air VOC concentrations are in equilibrium with wastewater
- Wind Speed is 3.5 mph

WATER9 emission calculations are not corrected to reflect field measurements or published correlations. Therefore WATER9 underestimation of emissions may occur when target VOC compounds interact causing increased emissions, e.g. the impact of azeotrope[24] mixtures. However, these WATER9 limitations do not effect most wastewater collection activities. Limitations of WATER9 primarily occur when the model is used to predict emissions from unsteady treatment processes with changing flow.

TOXCHEM+ has been modified to include field based correlation data and can simulate the dynamic response of treatment systems. TOXCHEM+ is typically considered more accurate when estimating emissions from complex treatment and collection systems. Note however, TOXCHEM+ assumes wastewater drains and manholes are sealed. Therefore, the following factors should be considered when using these models:

- WATER9 and TOXCHEM+ provide very similar results for VOC emissions in wastewater collection systems. However, TOXCHEM+ assumes all drains include a water seal and manholes are sealed. Therefore, one needs to modify the TOXCHEM+ program to identify unsealed refinery process drains and manholes or use WATER9 to estimate open drain emissions. This assessment used WATER9 to calculate open drain and manhole emissions.

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[23] Bailod, C.R. etc. al. Critical Evaluation of the State of Technologies and Fate of Toxic Compounds in Wastewater Facilities. Water Pollution Control Federation Research Foundation Project Report 90-1, 1990.

[24] Azeotrope: a mixture of liquids that boils at a constant temperature, at a given pressure, without change of composition, e.g. mixtures of benzene and cyclohexane.

- WATER9 may overestimate some VOC treatment emissions since the model was not calibrated using field test data. Therefore, results from TOXCHEM+ are preferred for analysis of wastewater treatment operations, e.g. biological reactors, clarifiers, selenium treatment. This assessment did not estimate emissions from treatment operations.

Appendix K

Calculating VOC Emissions Using WATER9 and TOXCHEM+

Overview

This appendix describes the methodology used in the calculation of VOC emissions from wastewater collection system components using TOXCHEM+ and WATER9 software modeling. Volatile organic compounds (VOCs) are emitted from wastewater collection and treatment systems through volatilization of organic compounds at the liquid surface. Emissions can occur by diffusion or convection mechanisms, or both. Diffusion occurs when organic concentrations at the water surface are much higher than ambient concentrations. Petroleum hydrocarbons volatilize or diffuse into the air, in an attempt to reach equilibrium between aqueous and vapor phases. Convection occurs when air flows over the water surface, sweeping organic vapors from the water surface into the air. The convection rate relates directly to the speed of the airflow over the water surface. In this technical assessment the calculations assume that the airflow rate is equal to the water flow rate. Other primary factors that affect the rate of volatilization include wastewater:

- surface area
- temperature
- turbulence
- retention time in the system
- concentration of organic compounds in the wastewater and their physical properties, such as volatility and diffusion in water
- presence of a mechanism that inhibits volatilization, such as an oil film.

Calculating Wastewater System VOC emissions

The following method was used to calculate VOC emissions:

1. Wastewater analytical data chromatograms were used to determine concentration and identity of VOCs for specific refinery areas.

2. Model VOC emissions using block flow diagrams. A model was built to represent the wastewater components and flow through a typical refinery area.

3. WATER9 and TOXCHEM+ were used to determine percent emitted for each compound in each wastewater collection component.

4. Refinery wastewater collection VOC emissions were calculated for special cases.

5. Total refinery wastewater collection VOC emissions were calculated by summing mass emissions from individual refinery areas.

6. Review of additional modeling assumptions to confirm model suitability.

A. Determining Concentration and Identity of VOCs

Wastewater analytical data was derived from gas chromatography (GC) analysis using SW 846[25] method 8015C as modified by California Department of Toxic Substances (8015Cm) and SW 846 method 8021B (8021B). The concentration of each VOC compound was calculated using the GC response factor and the mean calibration factor obtained from laboratory prepared fuel standards. Method 8051Cm was used to determine the total concentration of gasoline range C_6-C_{12} petroleum compounds in the sample. This result was reported as TPHg and this number excluded MTBE concentration. Method 8021B was used to determine MTBE, benzene, toluene, ethylbenzene, and total xylene concentration (BTEX).

Determination of VOC compounds not specifically reported, e.g., specific xylenes and unidentified chromatograhphic peaks were assigned by analysis of the chromatograms. Surrogates were selected for unassigned chromatographic peaks. Appendix L details the selection of surrogates.

The laboratory analysis reported TPHg, TPHd, MTBE, benzene, toluene, ethylbenzene, and total xylene concentration, i.e. the sum of ortho-, meta-, and para-xylenes. In the VOC modeling calculations Total wastewater VOC concentration for each refinery area was set to equal the sum of TPHg and MTBE concentration. Typical values for speciated wastewater analytical values are listed in Table K-1.

Table K-1:
Typical Speciated Wastewater Analytical Values

	Surrogate	Comment	PPB
Benzene	No		4.1
Ethylbenzene	No		5.5
MTBE	No		29.0
Toluene	No		24.0
m- Xylene	No	by chromatogram	31.3
o- Xylene	No	by chromatogram	8.9
p- Xylene	No	by chromatogram	19.8
Cyclohexane	Yes	by chromatogram	7.0
Heptane	Yes	by chromatogram	17.5
Methyl Cyclohexane	Yes	by chromatogram	4.2
Methyl Naphthalene,2-	Yes	by chromatogram	0.0
Naphthalene	Yes	by chromatogram	18.8
1,2,4-Trimethyl benzene	Yes	by chromatogram	18.9
TPH(gasoline)	No	Sum of above except MTBE	160
TPH(diesel)	No	Oil & Grease concentration	45,000

[25] SW-846 is an acronym for US EPA publication SW-846 Test Methods for Evaluating Solid Waste, Physical/Chemical Methods.

B. Modeling VOC emissions with Block Flow Diagrams

Refinery wastewater systems are large structures that encompass thousands of wastewater collection devices over the entire facility. It is not possible to input the whole collection structure into a computer model. Therefore, each refinery was partitioned into representative areas to accommodate this limitation. This required between 3 and 15 subparts depending on the facility, (see Table K-2). The boundaries of each subpart roughly corresponded to major equipment process blocks within the refinery, e.g., crude units, cracking units, pipe-still areas, etc. Once each subpart within each refinery was defined, a representative block flow model was created using WATER9 and TOXCHEM+ software. A block flow diagram is a simplified diagram of the wastewater collection path from inflow (drains), to outflow (flow out to a trunk line or treatment system process). Using TOXCHEM+ and WATER9 block flow diagrams were created for each refinery area. These diagrams only identified collection components: drains (open and closed), junction box vents, manholes, 24-inch lateral sewer lines, and 18-inch lateral sewer lines.

Table K-2 details number and type of collection components in each block flow model. The ratio of controlled/uncontrolled drains, manholes and junction boxes was based on previously submitted refinery data, (see Section VIII Table VIII-1).

Table K-2:
Collection Units in Each Refinery Block Flow Model

Refinery	Uncontrolled Drains	Controlled Drains	Manholes	Junction Box Vents	Number of Refinery Areas
1	29	15	34	11	9
2	20	24	10	3	15
3	23	21	80	27	4
4	22	22	18	6	3
5	44	0	8	3	14

C. Determining Percent Emitted for Compounds

To efficiently model VOC emissions from a wastewater collection system, it is necessary to describe (or model) a chemical's ability to volatilize and be emitted from each wastewater collection device. The software automatically determined the appropriate mathematical expression to calculate each collection component's emissions. This included calculating percent emitted for each compound and each wastewater collection device, i.e., drains, manholes, and junction box vents. Table K-3 details the primary model default values.

The software models also allow one to condense the number of drains, junction boxes, and manholes in a block flow diagram and still provide accurate emission factors for individual VOC compounds being released from a specific wastewater collection component. The ability to condense the number of wastewater components is based on the fact that the underlying equations for a collection component (e.g. open & closed

drains) simplify at a defined range of flows. For example, percent VOC emitted from ten 4-inch open drains is the same for 100 4-inch drains if wastewater temperature, total flow, and chemical concentration remain the same. The modeling calculations confirmed this approach through multiple runs of the software models WATER9 and TOXCHEM+. Therefore, each block flow diagram consisted of forty-four drains, with proportional numbers of manholes and junction box vents as listed in Table K-2. This technique simplifies the block flow diagram and allows one to use limited wastewater sampling to accurately calculate percent emitted for individual compounds in wastewater collection.

The changing data for a refinery area model calculation only included changes in compound concentrations and changes in wastewater temperature for that area. Default model assumptions were used for the other parameters in the wastewater block flow diagrams. The default data for WATER9 and TOXCHEM+ are listed in Table K-3. Additional modeling assumptions for WATER9 and TOXCHEM+ are listed at the end of this appendix.

Table K-3:
WATER9 and TOXCHEM+ Default Values

Suspended Solids	100 mg/L
Flow	250 gpm
Volatile Suspended Solids Ratio	75%
Sewer slope	0.0344%
CSTR[1]	5
Main Lateral diameter	24 inches
Minor Lateral diameters	18 inches
Coefficient of roughness for components	0.14
Drain Diameter[2]	4 inches
Drain/Manhole drop height	24 inches
Jbox drop height	24 inches
Jbox Diameter	4 inches

1. Sewer reach mixing properties are modeled in TOXCHEM+ using a prescribed number of continuous-flow stirred tank reactors (CSTRs). For a sewer reach, the number of CSTRs will divide the sewer in equal portions for both the liquid and gas phases and for each CSTR the contents will be completely mixed.
2. Drain diameter in refinery wastewater process areas was four (4) inches.

The software provides an emission factor for each VOC chemical released from each wastewater component based on wastewater data parameters such as concentration, flow rate, and temperature. Using laboratory analysis data the model software calculates the percent emitted for individual compounds for a specific wastewater collection component. In the case of benzene for Refinery 2, area 1, the following series of modeling calculations were performed:

- % benzene emitted from open drains in Refinery 2 area 1, (WATER9)
- % benzene emitted from closed drains in Refinery 2 area 1, (TOXCHEM+)
- % benzene emitted from manholes in Refinery 2 area 1, (WATER9)
- % benzene emitted from junction box vents in Refinery 2 area 1, (TOXCHEM+)

D. Determining VOC Emissions for Special Cases

In the case of Refinery 3 staff also calculated VOC emissions from large sewer junction diversion boxes 1 through 4 using TOXCHEM+. Each box was modeled using Refinery 3 specific dimensions, chemical concentrations, flow rates, etc. for each box. TOXCHEM+ provided specific VOC emissions for these boxes. Staff was unable to determine VOC emissions from this type of boxes at other refineries since complete structure dimensions were not available. Future site visits should allow staff to determine these box dimensions and calculate VOC emissions from large diversion boxes.

E. Refinery Area VOC Emissions and Total Refinery Emissions

The block flow model calculates a percent emitted for each compound or surrogate identified from wastewater analysis. Area emissions (Lbs./day VOC) were calculated by multiplying the identified species percent emitted by the total mass concentration of that chemical species. Refinery area VOC emissions are based on chemical species and concentration, percent emitted and the wastewater flow rate through each refinery area. Total refinery wastewater collection VOC emission is the sum of each area VOC emission. The calculation of each area's VOC emissions can be calculated using the following equation:

Lbs. VOC emitted per day = $_{i}$ (Q * VOC_i * percent emitted * 60 MINUTES * 24 HOURS)

Where: Q = Flow rate through refinery area in pounds per minute
VOC_i = Concentration of compound or surrogate I, in ppm.

In conclusion, WATER9 and TOXCHEM+ were used to calculate the percent of each individual chemical species emitted from each area collection component using a unique block flow model for each Refinery. The sum of these area emissions equaled the total refinery VOC emissions for wastewater collection. These calculations were checked using equations from BACT/LAER documentation [26]. Individual tables listing the results of the VOC calculations for each refinery area are available upon request, tdunn@arb.ca.gov.

F. Review of Additional Modeling Assumptions to Confirm Model Suitability.

The following assumptions were reviewed and confirmed to as suitable default setting for area models by duplicate software runs.

1. **Ventilation Rate of Drop structures:** Calculations set liquid flow-rate equal to air-flow rate. Model liquid flow rate = 250 gpm and air flow rate = 33.42 cubic ft/min.

[26] Industrial Wastewater Volatile Organic Compound Emissions, EPA-450/3-90-004, January 1990.

2. **Drop Height:** Averaging drop heights taken from sewer drawings lead to overestimating emissions by setting an arbitrarily high evaporation area. Therefore, the model set default drain drop height to twenty-four (24) inches and equals zero for sewer T connections. Twenty-four inches is the median drop height for drain structures.

3. **Tailwater Depth**. Used 40% of design fraction as depth of wastewater in laterals.

4. **Stream Width**. Use Pipe diameter (24 and 18 inches) found at time of sampling.

5. Sewer Reach Properties

Diameter: used 18 and 24 inches

Slope use topographic maps => average slope over land area = .0344%

Pipe Length	used lateral lengths of 50, 100, 200, 300, 400 feet in TOXCHEM+ calculations. WATER9 did not use pipe data for open drain and manhole calculations.
Pipe Roughness	use default WATER9 and TOXCHEM+ roughness coefficient
No. of CSTRs	use 5 as number of CSTRs (only used in TOXCHEM+)

6. **Influent to Collection System:** Assumed no forced air input. Air-flow is equal to water flow.

7. **Compound Identification**
   a. Take reported known compounds (benzene, toluene, ethylbenzene, total xylenes, and MTBE from lab data
   b. Total TPHg - (BTEX) = (C6 - C12) total ppb of surrogates. Exclude MTBE since MTBE is not included in TPH(g) total
   c. Use chromatogram of C6 - C12 to identify surrogates Assign concentrations of surrogates to chromatogram ranges. Surrogates concentrations are proportional to chromatogram peak areas.

8. **Connections between sewers:** Ignored "loop" or "cross" connections between lateral lines since these flows have no effect on total area flow.

9. **Non-sampled Inputs to sewers:** Ignored since percent emitted for compound or surrogate does not change unless average flow and concentration through refinery area changes.

10. **Sample concentrations:** For samples collected in manholes downstream of inputs, assume upstream calculations are terminated. Initiate new area according to sampling plan.

Appendix L

Use of Surrogates and Surrogate Selection for Modeling

A. Modeling and the use of Surrogates for Data Analysis

It is desirable to group hydrocarbon compounds into a small number of fractions having similar transport properties to simplify modeling. This data analysis grouped surrogate compounds having specific equivalent carbon number ranges. This is a reasonable level of accuracy, given the assumptions in modeling the behavior of hydrocarbons in water and is consistent with other approaches dealing with complex mixtures[27]. The surrogates used in this study are shown in Table K-1.

Table L-1:
TPH Surrogate Fractions

Carbon Number Range	TPH Surrogate Fraction Compound	Solubility (parts per billion)
2 – 6.5	Cyclohexane	55,000
6.5 – 7	Heptane	3,400
7 – 8.5	Methyl Cyclohexane	14,000
8.5 – 10	1,2,4-Trimethylbenzene	57,000
10 – 12	Naphthalene	31,000
12 - 14	2,-Methylnaphthalene	24,600

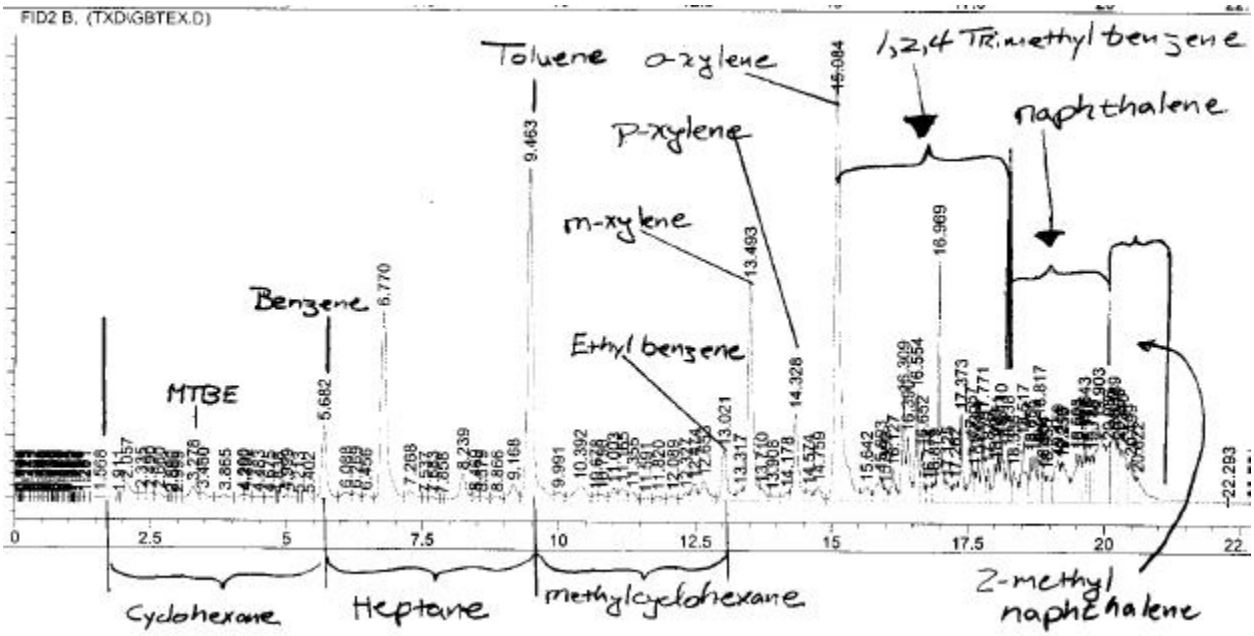
Significant effort was made to ensure the chemical concentration (ppb) assigned to each surrogate fraction was correct and the total mass balance of petroleum fractions for each sample was maintained. Computer modeling with Toxchem+ can determine if these assumptions are sensitive to this simplification. This sensitivity analysis was performed and it was shown that the choice of the surrogates shown in Table J-1 versus other chemical candidates with similar equivalent carbon numbers does not result in changes in predicted VOC emissions.

B. Analytical Requirements for Surrogates

The identification of the surrogates must be consistent with available analytical results. The relative percent of each petroleum fraction in the mixture is needed when calculating a mixture-specific petroleum VOC concentration. U.S. EPA method 8015/8021 provides total petroleum hydrocarbon concentrations for gasoline and diesel fractions plus specific concentrations for benzene, toluene, ethylbenzene, total xylenes, and MTBE. The concentration of each representative fraction in the wastewater was used in predicting the VOC emissions. The speciated distinct chemical results used in the VOC calculations were provided in Appendix H. The selection of surrogates is based on the principle of equivalent carbon number (EC) and retention time in a boiling point gas chromatographic (GC) column. The chromatogram shown below in Figure J-1 identifies areas of the chromatogram that to correspond to known compounds and surrogates.

[27] Selection of Representative TPH Fractions Based on Fate and Transport Considerations, John B. Gustafson, Ph.D., Joan Griffith Tell, Ph.D., Doug Orem, © 1997 by Amherst Scientific Publishers.

Figure L-1
Typical Refinery Wastewater TPH(G) Chromatogram



EC Vs Boiling Point

C. Equivalent Carbon Number

The EC is related to the boiling point of a chemical, normalized to either the boiling point of the n-alkanes or its retention time in a boiling point GC column. This relationship, displayed in Figure J-2, was empirically determined[28]. Thus, for chemicals where the boiling point is known, an equivalent carbon number can be easily calculated. For example, hexane contains six carbons and has a boiling point of 69°C. Its equivalent carbon number is six. Benzene, also containing six carbons, has a boiling point of 80 ^{o}C.

Based on benzene's boiling point and its retention time in a boiling point GC column, benzene's equivalent carbon number is 6.5. This approach is consistent with methods routinely used in the petroleum industry for separating complex mixtures. The use of EC values are typical of how analytical laboratories report carbon numbers for chemicals evaluated on a boiling point GC column.

D. Summary of Surrogate Properties used in Data Analysis

The laboratory chromatograms for each sample were used to identify concentrations of surrogates. Each specific compound, as listed in Table J-1, was used as a representative surrogate for a specific area of the chromatogram. For example, in the

[28] Ibid.

EC range of 7 to 8.5 methyl cyclohexane was chosen to represent all petroleum species that were detected between benzene and toluene. This technique ensures that the relative percent of each fraction is maintained and known compounds, e.g. benzene and toluene qualify the ranges.

Appendix M

Description of Methodology Used to Determine Cost Estimates

Cost Estimates for Refinery Drains and Manholes

Cost Calculations to Water Seal all District Refinery Drains	Refinery Totals
Total # of uncontrolled Refinery drains	8,599
# of Refinery drains to be controlled	8,599
Drain I&M program (Monthly Inspections)	
# of inspections required for the total drain population	103188
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for monthly I & M program	4.30
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$12,899
Annual cost of monthly I& M drain inspections	$292,366
Drain I&M program (Quarterly Inspections)	
# of inspections requires for the total Drain population	34396
# of operators required for Drain I & M program	1.43
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$6,000
Annual cost of I & M (quarterly inspections)	$99,156
Drain I&M program (Semi-annually Inspections)	
# of inspections requires for the total drain population	17198
# of operators required for drain I & M program	0.72
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$3,000
Annual cost of I & M (semi-annually inspections)	$49,578

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each drain	$400
Capital cost for all drains	$3,439,600
Annualized Cost @ 7%	$488,423
Cap Costs + Annualized Cost + Monthly drain I&M	$4,220,389
Cap Costs + Annualized Cost + Quarterly drain I&M	$4,807,968
Cap Costs + Annualized Cost + Semi-annual drain I&M	$3,977,601

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each drain	$1,000
Capital cost for all uncontrolled drain	$8,599,000
Annualized Cost @ 7%	$1,221,058
Cap Costs + Annualized Cost + Monthly drain I&M	$10,112,424
Cap Costs + Annualized Cost + Quarterly drain I&M	$9,919,214
Cap Costs + Annualized Cost + Semi-annual drain I&M	$9,869,636

Cost Calculations to Seal all drains Refinery 1

Total # of uncontrolled Refinery drains	1,677
# of Refinery drains to be controlled	1,677
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

drain I&M program (Monthly Inspections)

# of inspections required for the total drain population	20124
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.84
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$2,516
Annual cost of monthly I& M drain inspections	$57,018

drain I&M program (Quarterly Inspections)

# of inspections requires for the total drain population	6708
# of operators required for drain I & M program	0.28
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$839
Annual cost of I & M (quarterly inspections)	$19,006

drain I&M program (Semi-annually Inspections)

# of inspections requires for the total drain population	3354
# of operators required for drain I & M program	0.140
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$419
Annual cost of I & M (semi-annually inspections)	$9,503

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each drain	$400
Capital cost for all drains	$670,800
Annualized Cost @ 7%	$95,254
Cap Costs + Annualized Cost + Monthly drain I&M	$823,072
Cap Costs + Annualized Cost + Quarterly drain I&M	$785,060
Cap Costs + Annualized Cost + Semi-annual drain I&M	$775,557

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled drain	$1,000
Capital cost for all uncontrolled drain	$1,677,000
Annualized Cost @ 7%	$238,134
Cap Costs + Annualized Cost + Monthly drain I&M	$1,972,152
Cap Costs + Annualized Cost + Quarterly drain I&M	$1,934,140
Cap Costs + Annualized Cost + Semi-annual drain I&M	$1,924,637

Cost Calculations to Seal all drains Refinery 2

Total # of Refinery drains	1,100
# of Refinery drains to be controlled	1,100
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

drain I&M program (Monthly Inspections)

# of inspections required for the total drain population	13200
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.55
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$1,650
Annual cost of monthly I& M drain inspections	$37,400

drain I&M program (Quarterly Inspections)

# of inspections requires for the total drain population	4400
# of operators required for drain I & M program	0.18
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$550
Annual cost of I & M (quarterly inspections)	$12,467

drain I&M program (Semi-annually Inspections)

# of inspections requires for the total drain population	2200
# of operators required for drain I & M program	0.092
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$275
Annual cost of I & M (semi-annually inspections)	$6,233

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each drain	$400
Capital cost for all drains	$440,000
Annualized Cost @ 7%	$62,480
Cap Costs + Annualized Cost + Monthly drain I&M	$539,880
Cap Costs + Annualized Cost + Quarterly drain I&M	$514,947
Cap Costs + Annualized Cost + Semi-annual drain I&M	$508,713

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled drain	$1,000
Capital cost for all uncontrolled drain	$1,100,000
Annualized Cost @ 7%	$156,200
Cap Costs + Annualized Cost + Monthly drain I&M	$1,293,600
Cap Costs + Annualized Cost + Quarterly drain I&M	$1,268,667
Cap Costs + Annualized Cost + Semi-annual drain I&M	$1,262,433

Cost Calculations to Seal all drains Refinery 3

Total # of Refinery drains	572
# of sealed drains	none
# of Refinery drains to be controlled	572
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

drain I&M program (Monthly Inspections)

# of inspections required for the total drain population	6864
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.29
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$858
Annual cost of monthly I& M drain inspections	$19,448

drain I&M program (Quarterly Inspections)

# of inspections requires for the total drain population	2288
# of operators required for drain I & M program	0.10
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$286
Annual cost of I & M (quarterly inspections)	$6,483

drain I&M program (Semi-annually Inspections)

# of inspections requires for the total drain population	1144
# of operators required for drain I & M program	0.047666667
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$143
Annual cost of I & M (semi-annually inspections)	$3,241

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each drain	$400
Capital cost for all drains	$228,800
Annualized Cost @ 7%	$32,490
Cap Costs + Annualized Cost + Monthly drain I&M	$280,738
Cap Costs + Annualized Cost + Quarterly drain I&M	$267,772
Cap Costs + Annualized Cost + Semi-annual drain I&M	$264,531

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled drain	$1,000
Capital cost for all uncontrolled drain	$572,000
Annualized Cost @ 7%	$81,224
Cap Costs + Annualized Cost + Monthly drain I&M	$672,672
Cap Costs + Annualized Cost + Quarterly drain I&M	$659,707
Cap Costs + Annualized Cost + Semi-annual drain I&M	$656,465

Cost Calculations to Seal all drains Refinery 4		500
# of sealed drains	none	
# of Refinery drains to be controlled		500
Total # of Refinery Drains (refinery% of total)		1
# of Refinery drains to be controlled (refinery% of total)		1

drain I&M program (Monthly Inspections)	
# of inspections required for the total drain population	6000
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.25
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$750
Annual cost of monthly I& M drain inspections	$17,000

drain I&M program (Quarterly Inspections)	
# of inspections requires for the total drain population	2000
# of operators required for drain I & M program	0.08
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$250
Annual cost of I & M (quarterly inspections)	$5,667

drain I&M program (Semi-annually Inspections)	
# of inspections requires for the total drain population	1000
# of operators required for drain I & M program	0.04
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$125
Annual cost of I & M (semi-annually inspections)	$2,833

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each drain	$400
Capital cost for all drains	$200,000
Annualized Cost @ 7%	$28,400
Cap Costs + Annualized Cost + Monthly drain I&M	$245,400
Cap Costs + Annualized Cost + Quarterly drain I&M	$234,067
Cap Costs + Annualized Cost + Semi-annual drain I&M	$231,233

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled drain	$1,000
Capital cost for all uncontrolled drain	$500,000
Annualized Cost @ 7%	$71,000
Cap Costs + Annualized Cost + Monthly drain I&M	$588,000
Cap Costs + Annualized Cost + Quarterly drain I&M	$576,667
Cap Costs + Annualized Cost + Semi-annual drain I&M	$573,833

Cost Calculations to Seal all drains Refinery 5	4,750
# of sealed drains	none
# of Refinery drains to be controlled	4,750
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

drain I&M program (Monthly Inspections)	
# of inspections required for the total drain population	57000
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	2.38
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$7,125
Annual cost of monthly I& M drain inspections	$161,500

drain I&M program (Quarterly Inspections)	
# of inspections requires for the total drain population	19000
# of operators required for drain I & M program	0.79
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$2,375
Annual cost of I & M (quarterly inspections)	$53,833

drain I&M program (Semi-annually Inspections)	
# of inspections requires for the total drain population	9500
# of operators required for drain I & M program	0.395833333
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$1,188
Annual cost of I & M (semi-annually inspections)	$26,917

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each drain	$400
Capital cost for all drains	$1,900,000
Annualized Cost @ 7%	$269,800
Cap Costs + Annualized Cost + Monthly drain I&M	$2,331,300
Cap Costs + Annualized Cost + Quarterly drain I&M	$2,223,633
Cap Costs + Annualized Cost + Semi-annual drain I&M	$2,196,717

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled drain	$1,000
Capital cost for all uncontrolled drain	$4,750,000
Annualized Cost @ 7%	$674,500
Cap Costs + Annualized Cost + Monthly drain I&M	$5,586,000
Cap Costs + Annualized Cost + Quarterly drain I&M	$5,478,333
Cap Costs + Annualized Cost + Semi-annual drain I&M	$5,451,417

Cost Calculations for Water Seal on all Drains Refinery 5	**Totals**
Total # of Refinery Drains	11786
# of controlled drains	3187
# of Refinery drains to be controlled	8599
Total # of Refinery Drains (refinery% of total)	1.00
# of Refinery drains to be controlled (refinery% of total)	1.00
Current I&M program (Monthly Inspections)	
# of inspections requires for the total drain population	141432
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000/yr
# of operators required for current I & M program	5.9
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$27,000
Annual cost of I & M (monthly inspections)	$410,500
Current I&M program (Quarterly Inspections)	
# of inspections requires for the total drain population	47144
# of operators required for current I & M program	1.96
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$15,000
Annual cost of I & M (quarterly inspections)	$142,400
Current I&M program (Semi-annually Inspections)	
# of inspections requires for the total drain population	23572
# of operators required for current I & M program	0.98
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$15,000
Annual cost of I & M (semi-annually inspections)	$78,700
Annualized Cost = (Capital Recovery Factor)X(Capital Expenditure)	
Capital cost for each drain	$400
Capital cost for all uncontrolled drains	$3,439,600
Annualized Cost @ 7%	$488,423
Annual Cost @ 7% (monthly, $400)	$898,923
Annual Cost @ 7% (quarterly, $400)	$630,823
Annual Cost @ 7% (bi-annually, $400)	$567,123
Annualized Cost = (Capital Recovery Factor)X(Capital Expenditure)	
Capital cost for each drain	$1,000
Capital cost for all uncontrolled drains	$8,599,000
Annualized Cost @ 7%	$1,221,058
Annual Cost @ 7% (monthly, $1000)	$1,631,558
Annual Cost @ 7% (quarterly, $1000)	$1,363,458
Annual Cost @ 7% (bi-annually, $1000)	$1,299,758

Cost Calculations to Seal all District Manholes	Refinery Totals
Total # of Refinery Manholes	5,778
# of sealed manholes	none
# of Refinery drains to be controlled	5,778
Manhole I&M program (Monthly Inspections)	
# of inspections required for the total manhole population	69336
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for monthly I & M program	2.889
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$8,667
Annual cost of monthly I& M Manhole inspections	$196,452
Manhole I&M program (Quarterly Inspections)	
# of inspections requires for the total manhole population	23112
# of operators required for manhole I & M program	0.963
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$6,000
Annual cost of I & M (quarterly inspections)	$68,595
Manhole I&M program (Semi-annually Inspections)	
# of inspections requires for the total manhole population	11556
# of operators required for manhole I & M program	0.4815
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$3,000
Annual cost of I & M (semi-annually inspections)	$34,298
Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)	
Capital cost for each manhole	$400
Capital cost for all manholes	$2,311,200
Annualized Cost @ 7%	$328,190
Cap Costs + Annualized Cost + Monthly manhole I&M	$2,835,842
Cap Costs + Annualized Cost + Quarterly manhole I&M	$3,232,628
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$2,673,688
Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)	
Capital cost for each manhole	$1,000
Capital cost for all uncontrolled manhole	$5,778,000
Annualized Cost @ 7%	$820,476
Cap Costs + Annualized Cost + Monthly manhole I&M	$6,794,928
Cap Costs + Annualized Cost + Quarterly manhole I&M	$6,667,071
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$6,632,774

Cost Calculations to Seal all Manholes Refinery 1

Total # of Refinery Manholes	1,965
# of sealed manholes	none
# of Refinery manholes to be controlled	1,965
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

Manhole I&M program (Monthly Inspections)

# of inspections required for the total manhole population	23580
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.9825
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$2,948
Annual cost of monthly I& M Manhole inspections	$66,810

Manhole I&M program (Quarterly Inspections)

# of inspections requires for the total manhole population	7860
# of operators required for manhole I & M program	0.3275
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$983
Annual cost of I & M (quarterly inspections)	$22,270

Manhole I&M program (Semi-annually Inspections)

# of inspections requires for the total manhole population	3930
# of operators required for manhole I & M program	0.16375
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$491
Annual cost of I & M (semi-annually inspections)	$11,135

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each manhole	$400
Capital cost for all manholes	$786,000
Annualized Cost @ 7%	$111,612
Cap Costs + Annualized Cost + Monthly manhole I&M	$964,422
Cap Costs + Annualized Cost + Quarterly manhole I&M	$919,882
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$908,747

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled manhole	$1,000
Capital cost for all uncontrolled manhole	$1,965,000
Annualized Cost @ 7%	$279,030
Cap Costs + Annualized Cost + Monthly manhole I&M	$2,310,840
Cap Costs + Annualized Cost + Quarterly manhole I&M	$2,266,300
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$2,255,165

Cost Calculations to Seal all Manholes Refinery 2

Total # of Refinery Manholes	570
# of sealed manholes	none
# of Refinery manholes to be controlled	570
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

Manhole I&M program (Monthly Inspections)

# of inspections required for the total manhole population	6840
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.285
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$855
Annual cost of monthly I& M Manhole inspections	$19,380

Manhole I&M program (Quarterly Inspections)

# of inspections requires for the total manhole population	2280
# of operators required for manhole I & M program	0.095
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$285
Annual cost of I & M (quarterly inspections)	$6,460

Manhole I&M program (Semi-annually Inspections)

# of inspections requires for the total manhole population	1140
# of operators required for manhole I & M program	0.0475
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$143
Annual cost of I & M (semi-annually inspections)	$3,230

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each manhole	$400
Capital cost for all manholes	$228,000
Annualized Cost @ 7%	$32,376
Cap Costs + Annualized Cost + Monthly manhole I&M	$279,756
Cap Costs + Annualized Cost + Quarterly manhole I&M	$266,836
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$263,606

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled manhole	$1,000
Capital cost for all uncontrolled manhole	$570,000
Annualized Cost @ 7%	$80,940
Cap Costs + Annualized Cost + Monthly manhole I&M	$670,320
Cap Costs + Annualized Cost + Quarterly manhole I&M	$657,400
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$654,170

Cost Calculations to Seal all Manholes Refinery 3

Total # of Refinery Manholes	1,941
# of sealed manholes	none
# of Refinery manholes to be controlled	1,941
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

Manhole I&M program (Monthly Inspections)

# of inspections required for the total manhole population	23292
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.9705
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$2,912
Annual cost of monthly I& M Manhole inspections	$65,994

Manhole I&M program (Quarterly Inspections)

# of inspections requires for the total manhole population	7764
# of operators required for manhole I & M program	0.3235
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$971
Annual cost of I & M (quarterly inspections)	$21,998

Manhole I&M program (Semi-annually Inspections)

# of inspections requires for the total manhole population	3882
# of operators required for manhole I & M program	0.16175
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$485
Annual cost of I & M (semi-annually inspections)	$10,999

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each manhole	$400
Capital cost for all manholes	$776,400
Annualized Cost @ 7%	$110,249
Cap Costs + Annualized Cost + Monthly manhole I&M	$952,643
Cap Costs + Annualized Cost + Quarterly manhole I&M	$908,647
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$897,648

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled manhole	$1,000
Capital cost for all uncontrolled manhole	$1,941,000
Annualized Cost @ 7%	$275,622
Cap Costs + Annualized Cost + Monthly manhole I&M	$2,282,616
Cap Costs + Annualized Cost + Quarterly manhole I&M	$2,238,620
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$2,227,621

Cost Calculations to Seal all Manholes Refinery 4		402
# of sealed manholes	none	
# of Refinery manholes to be controlled		402
Total # of Refinery Drains (refinery% of total)		1
# of Refinery drains to be controlled (refinery% of total)		1

Manhole I&M program (Monthly Inspections)	
# of inspections required for the total manhole population	4824
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.201
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$603
Annual cost of monthly I& M Manhole inspections	$13,668

Manhole I&M program (Quarterly Inspections)	
# of inspections requires for the total manhole population	1608
# of operators required for manhole I & M program	0.067
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$201
Annual cost of I & M (quarterly inspections)	$4,556

Manhole I&M program (Semi-annually Inspections)	
# of inspections requires for the total manhole population	804
# of operators required for manhole I & M program	0.0335
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$101
Annual cost of I & M (semi-annually inspections)	$2,278

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each manhole	$400
Capital cost for all manholes	$160,800
Annualized Cost @ 7%	$22,834
Cap Costs + Annualized Cost + Monthly manhole I&M	$197,302
Cap Costs + Annualized Cost + Quarterly manhole I&M	$188,190
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$185,912

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled manhole	$1,000
Capital cost for all uncontrolled manhole	$402,000
Annualized Cost @ 7%	$57,084
Cap Costs + Annualized Cost + Monthly manhole I&M	$472,752
Cap Costs + Annualized Cost + Quarterly manhole I&M	$463,640
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$461,362

Cost Calculations to Seal all Manholes Refinery 5		900
# of sealed manholes	none	
# of Refinery manholes to be controlled		900
Total # of Refinery Drains (refinery% of total)		1
# of Refinery drains to be controlled (refinery% of total)		1

Manhole I&M program (Monthly Inspections)	
# of inspections required for the total manhole population	10800
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.45
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$1,350
Annual cost of monthly I& M Manhole inspections	$30,600

Manhole I&M program (Quarterly Inspections)	
# of inspections requires for the total manhole population	3600
# of operators required for manhole I & M program	0.15
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$450
Annual cost of I & M (quarterly inspections)	$10,200

Manhole I&M program (Semi-annually Inspections)	
# of inspections requires for the total manhole population	1800
# of operators required for manhole I & M program	0.075
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$225
Annual cost of I & M (semi-annually inspections)	$5,100

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each manhole	$400
Capital cost for all manholes	$360,000
Annualized Cost @ 7%	$51,120
Cap Costs + Annualized Cost + Monthly manhole I&M	$441,720
Cap Costs + Annualized Cost + Quarterly manhole I&M	$421,320
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$416,220

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled manhole	$1,000
Capital cost for all uncontrolled manhole	$900,000
Annualized Cost @ 7%	$127,800
Cap Costs + Annualized Cost + Monthly manhole I&M	$1,058,400
Cap Costs + Annualized Cost + Quarterly manhole I&M	$1,038,000
Cap Costs + Annualized Cost + Semi-annual manhole I&M	$1,032,900

Cost Estimates for Refinery Junction Boxes

Cost Calculations to Seal all District Junction Boxes	Refinery Totals
Total # of Refinery Junction Boxes	1,926
# of sealed Junction Boxes	none
# of Refinery drains to be controlled	1,926
Junction Box I&M program (Monthly Inspections)	
# of inspections required for the total Junction Box population	23112
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for monthly I & M program	0.963
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$2,889
Annual cost of monthly I& M Junction Box inspections	$65,484
Junction Box I&M program (Quarterly Inspections)	
# of inspections requires for the total Junction Box population	7704
# of operators required for Junction Box I & M program	0.321
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$6,000
Annual cost of I & M (quarterly inspections)	$26,865
Junction Box I&M program (Semi-annually Inspections)	
# of inspections requires for the total Junction Box population	3852
# of operators required for Junction Box I & M program	0.1605
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$3,000
Annual cost of I & M (semi-annually inspections)	$13,433

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each Junction Box	$2,000
Capital cost for all Junction Boxes	$3,852,000
Annualized Cost @ 7%	$546,984
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$4,464,468
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$5,038,317
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$4,412,417

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each Junction Box	$2,500
Capital cost for all uncontrolled Junction Box	$4,815,000
Annualized Cost @ 7%	$683,730
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$5,564,214
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$5,525,595
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$5,512,163

Cost Calculations to Seal all Junction Boxes Refinery 1

Total # of Refinery Junction Boxes		655
# of sealed Junction Boxes	none	
# of Refinery Junction Boxes to be controlled		655
Total # of Refinery Drains (refinery% of total)		1
# of Refinery drains to be controlled (refinery% of total)		1

Junction Box I&M program (Monthly Inspections)

# of inspections required for the total Junction Box population	7860
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for monthly I & M program	0.3275
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$983
Annual cost of monthly I& M Junction Box inspections	$22,270

Junction Box I&M program (Quarterly Inspections)

# of inspections requires for the total Junction Box population	2620
# of operators required for quarterly I & M program	0.109
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$328
Annual cost of I & M (quarterly inspections)	$7,423

Junction Box I&M program (Semi-annually Inspections)

# of inspections requires for the total Junction Box population	1310
# of operators required for Junction Box I & M program	0.05
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$164
Annual cost of I & M (semi-annually inspections)	$3,712

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each Junction Box	$2,000
Capital cost for all Junction Boxes	$1,310,000
Annualized Cost @ 7%	$186,020
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$1,518,290
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$1,503,443
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$1,499,732

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled Junction Box	$2,500
Capital cost for all uncontrolled Junction Box	$1,637,500
Annualized Cost @ 7%	$232,525
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$1,892,295
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$1,877,448
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$1,873,737

Cost Calculations to Seal all Junction Boxes Refinery 2

Total # of Refinery Junction Boxes	190
# of sealed Junction Boxes	none
# of Refinery Junction Boxes to be controlled	190
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

Junction Box I&M program (Monthly Inspections)

# of inspections required for the total Junction Box population	2280
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.095
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$285
Annual cost of monthly I& M Junction Box inspections	$6,460

Junction Box I&M program (Quarterly Inspections)

# of inspections requires for the total Junction Box population	760
# of operators required for Junction Box I & M program	0.031666667
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$95
Annual cost of I & M (quarterly inspections)	$2,153

Junction Box I&M program (Semi-annually Inspections)

# of inspections requires for the total Junction Box population	380
# of operators required for Junction Box I & M program	0.015833333
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$48
Annual cost of I & M (semi-annually inspections)	$1,077

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each Junction Box	$2,000
Capital cost for all Junction Boxes	$380,000
Annualized Cost @ 7%	$53,960
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$440,420
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$436,113
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$435,037

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled Junction Box	$2,500
Capital cost for all uncontrolled Junction Box	$475,000
Annualized Cost @ 7%	$67,450
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$548,910
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$544,603
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$543,527

Cost Calculations to Seal all Junction Boxes Refinery 3

Total # of Refinery Junction Boxes	647
# of sealed Junction Boxes	none
# of Refinery Junction Boxes to be controlled	647
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

Junction Box I&M program (Monthly Inspections)

# of inspections required for the total Junction Box population	7764
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.3235
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$971
Annual cost of monthly I& M Junction Box inspections	$21,998

Junction Box I&M program (Quarterly Inspections)

# of inspections requires for the total Junction Box population	2588
# of operators required for Junction Box I & M program	0.107833333
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$324
Annual cost of I & M (quarterly inspections)	$7,333

Junction Box I&M program (Semi-annually Inspections)

# of inspections requires for the total Junction Box population	1294
# of operators required for Junction Box I & M program	0.053916667
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$162
Annual cost of I & M (semi-annually inspections)	$3,666

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each Junction Box	$2,000
Capital cost for all Junction Boxes	$1,294,000
Annualized Cost @ 7%	$183,748
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$1,499,746
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$1,485,081
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$1,481,414

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled Junction Box	$2,500
Capital cost for all uncontrolled Junction Box	$1,617,500
Annualized Cost @ 7%	$229,685
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$1,869,183
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$1,854,518
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$1,850,851

Cost Calculations to Seal all Junction Boxes Refinery 4	134
# of sealed Junction Boxes	none
# of Refinery Junction Boxes to be controlled	134
Total # of Refinery Drains (refinery% of total)	1
# of Refinery drains to be controlled (refinery% of total)	1

Junction Box I&M program (Monthly Inspections)	
# of inspections required for the total Junction Box population	1608
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.067
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$201
Annual cost of monthly I& M Junction Box inspections	$4,556

Junction Box I&M program (Quarterly Inspections)	
# of inspections requires for the total Junction Box population	536
# of operators required for Junction Box I & M program	0.022333333
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$67
Annual cost of I & M (quarterly inspections)	$1,519

Junction Box I&M program (Semi-annually Inspections)	
# of inspections requires for the total Junction Box population	268
# of operators required for Junction Box I & M program	0.011166667
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$34
Annual cost of I & M (semi-annually inspections)	$759

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each Junction Box	$2,000
Capital cost for all Junction Boxes	$268,000
Annualized Cost @ 7%	$38,056
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$310,612
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$307,575
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$306,815

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled Junction Box	$2,500
Capital cost for all uncontrolled Junction Box	$335,000
Annualized Cost @ 7%	$47,570
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$387,126
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$384,089
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$383,329

Cost Calculations to Seal all Junction Boxes Refinery 5		300
# of sealed Junction Boxes	none	
# of Refinery Junction Boxes to be controlled		300
Total # of Refinery Drains (refinery% of total)		1
# of Refinery drains to be controlled (refinery% of total)		1

Junction Box I&M program (Monthly Inspections)	
# of inspections required for the total Junction Box population	3600
# of inspections per operator (Assume 100 inspections/day, 5 day/week, 48 wks/yr)	24000
# of operators required for current I & M program	0.15
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$450
Annual cost of monthly I& M Junction Box inspections	$10,200

Junction Box I&M program (Quarterly Inspections)	
# of inspections requires for the total Junction Box population	1200
# of operators required for Junction Box I & M program	0.05
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation ($3k per unit per year)	$150
Annual cost of I & M (quarterly inspections)	$3,400

Junction Box I&M program (Semi-annually Inspections)	
# of inspections requires for the total Junction Box population	600
# of operators required for Junction Box I & M program	0.025
Annual cost of 1 Operator	$65,000
Annual cost of OVA operation	$75
Annual cost of I & M (semi-annually inspections)	$1,700

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for each Junction Box	$2,000
Capital cost for all Junction Boxes	$600,000
Annualized Cost @ 7%	$85,200
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$695,400
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$688,600
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$686,900

Annualized Cost = (Capital Recovery Factor = .142) X (Capital Expenditure)

Capital cost for uncontrolled Junction Box	$2,500
Capital cost for all uncontrolled Junction Box	$750,000
Annualized Cost @ 7%	$106,500
Cap Costs + Annualized Cost + Monthly Junction Box I&M	$866,700
Cap Costs + Annualized Cost + Quarterly Junction Box I&M	$859,900
Cap Costs + Annualized Cost + Semi-annual Junction Box I&M	$858,200