American Petroleum Institute

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IMPACTS OF PETROLEUM PRODUCT MARKETING TERMINALS ON THE AQUATIC ENVIRONMENT

HEALTH AND ENVIRONMENTAL SCIENCES DEPARTMENT
PUBLICATION NUMBER 4673
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American Petroleum Institute

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Impacts of Petroleum Product Marketing Terminals on the Aquatic Environment

Health and Environmental Sciences Department

API PUBLICATION NUMBER 4673

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PREFACE

The American Petroleum Institute (API), through its Water Technology Task Force, has been conducting a multi-year program to evaluate and identify practical and environmentally sound technology options for handling and treating waters generated at petroleum product distribution terminals. The results of this program are intended to provide industry and regulatory agencies with technical information to make informed decisions on appropriate alternatives for individual terminal facilities.

The Task Force has sponsored and published a significant amount of work in prior years on handling and treating terminal waters. A listing of some key published reports and guidance documents is provided below. The material in this informational paper is intended to put the results of these technical studies into perspective by comparing treated water discharges at petroleum terminals with common household products and wastes. Also, the paper provides a technical analysis of water discharges on the aquatic environment using EPA water quality criteria and other assessment approaches, plus gives definitions that allow the public to understand technical terminology.

Studies Sponsored by the Water Technology Task Force

Publ 4665 Analysis and Reduction of Toxicity in Biologically Treated Petroleum Product Terminal Tank Bottoms Water, April 1998

Publ 4664 Mixing Zone Modeling and Dilution Analysis for Water-Quality-Based NPDES Permit Limits, April 1998

Publ 4655 Field Evaluation of Biological and Non-Biological Treatment Technologies to Remove MTBE/Oxygenates from Petroleum Product Terminal Wastewaters, August 1997

Publ 1612 Guidance Document for Discharging of Petroleum Distribution Terminal Effluents to Publicly Owned Treatment Works, November 1996

Publ 4602 Minimization, Handling, Treatment and Disposal of Petroleum Products Terminal Wastewaters, September 1994

Publ 4606 Source Control and Treatment of Contaminants Found in Petroleum Product Terminal Tank Bottoms, August 1994

Publ 4582 Comparative Evaluation of Biological Treatment of Petroleum Product Terminal Wastewater by the Sequencing Batch Reactor Process and the Rotating Biological Contactor Process, June 1993

Publ 4581 Evaluation of Technologies for the Treatment of Petroleum Product Terminal Wastewater, June 1993

The assessment made in this study shows that petroleum terminal discharges do not have much of an impact on the aquatic environment. In most situations, the waters contain *de minimus* amounts of contamination, since much effort is taken by terminals to segregate contaminated water from those waters, such as stormwater, that are minimally contaminated. In many cases, the more highly contaminated waters from petroleum product distribution terminals are returned to refineries for oil recovery and recycling. Prior studies sponsored by the Task Force have shown that operations and water characteristics at distribution terminals can vary significantly as to regulatory requirements in different geographical jurisdictions. Hence, it is recommended that the reader carefully consider site-specific terminal water characteristics and regulatory requirements before drawing any conclusions about the aquatic impact of any given petroleum product distribution terminal.

The Task Force greatly acknowledges and appreciates the fine work performed by Exxon Biomedical Sciences, Inc., East Millstone, NJ, in performing this assessment.

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EXECUTIVE SUMMARY

This document examines the potential impact of petroleum product marketing terminal (PPMT) wastewater discharges to aquatic environments to ascertain whether a need exists for more stringent regulations.

Stringent water quality regulations prevent wastewater discharges that produce unacceptable risks to human health or the environment. However, these regulations are now being applied to small and intermittent dischargers, such as PPMTs, that pose little if any risk to human health or the environment. PPMTs do not discharge large volumes of wastewater or large amounts of contaminants. PPMT effluent is primarily from rainfall. Sometimes, PPMTs also discharge water from product storage tanks, but only after it has been treated to remove contaminants.

Wastewaters discharged by PPMTs were evaluated in this report. The constituents normally present in these waste streams were identified and their possible aquatic impacts were investigated. This was done by comparing published U.S. EPA water quality criteria for the individual constituents with the calculated in-stream concentrations of these constituents after assimilation of PPMT effluent into a small volume of the receiving stream referred to as a mixing zone. Using very conservative assumptions, all of the constituent concentrations were less than the strictest published U.S. EPA criteria. Therefore, adverse aquatic impacts due to normal PPMT discharges of these constituents may be considered unlikely.

PPMT wastewater discharges pose little environmental risk. Cost-effective environmental benefits will not result from requiring PPMTs to incur significant costs to comply with stringent regulations designed for other industrial effluents which pose more substantive environmental risks. Stricter regulations for PPMT discharges are unwarranted.

Section 1
INTRODUCTION

Rapid growth of population and industrialization significantly altered the U.S.'s aquatic environments by the mid 20th century. At that time, the discharge of large quantities of untreated or poorly treated wastewaters often exceeded the receiving stream's capacity to assimilate or detoxify contaminants contained in those wastewaters. As a result, populations of many aquatic organisms were reduced or completely eliminated in sections of many water bodies.

Consequently, by the early 1970s the Environmental Protection Agency (EPA), state, and local environmental regulatory agencies began developing and implementing comprehensive regulations to improve the quality of the nation's aquatic environments. These regulations were primarily intended to improve the quality of effluents discharged by large industrial and municipal wastewater dischargers. Improvements in effluent quality were directly achieved by implementing aggressive treatment programs to remove effluent contaminants. As a result, water quality has shown marked improvement during the last two decades.

However, regulations continue to evolve on national, state and local levels. New, strict regulations require increased effluent treatment and contaminant monitoring to ensure compliance. In some instances, there is no treatment technology currently available to meet the proposed regulations. Consequently, expensive research and development programs have developed, and continue to develop, new cost-effective treatment options.

In some situations, dischargers may or may not have to monitor or treat for a particular contaminant depending on the location in which the discharger operates. Due to differences in state and local environmental laws, discharge permit requirements vary among locations.

Increasingly stringent regulations are being applied to small and intermittent dischargers, such as petroleum product marketing terminals (PPMTs). Unnecessary monitoring and treatment may be required at some locations despite the good quality and intermittent low volume of wastewater discharged by PPMTs. This additional cost is unjustified if discharge of the untreated wastewater will not result in undue risk to human health, or to the aquatic environment to which the wastewater is to be discharged. This paper presents a brief overview of PPMT facilities and products; and reviews the sources, quantity and quality of PPMT wastewater streams. It also examines the potential impact of PPMT wastewater discharges to aquatic environments, to ascertain whether a need exists for more stringent regulations and treatment requirements.

Section 2
OVERVIEW OF PETROLEUM PRODUCT MARKETING TERMINAL FACILITIES AND PRODUCTS

PPMT FACILITIES

PPMTs store refined petroleum products and distribute them to wholesale commercial and retail locations. For example, PPMTs distribute gasoline to service stations, heating oil to homes, and aircraft fuel to airports. Although PPMTs may differ from each other in some respects, the basic equipment at all PPMTs is the same: storage tanks and truck loading racks.

Most product storage is in aboveground vertical storage tanks ranging from 10,000 gallons to over one million gallons in capacity. Horizontal tanks are sometimes utilized for small volume storage. A large group of storage tanks is known as a *tank farm.*

A variety of methods is used to deliver petroleum products from the refineries to PPMTs. The most common method of delivering bulk product to a PPMT is by pipeline. In a survey of 57 PPMTs, 63 percent use this method (Brown and Caldwell, 1988). Tankers or barges are used by 30 percent. Lube oil (a more viscous product) is usually delivered by railcar or truck. Upon arrival at the PPMT, product is transferred and stored in the various tanks until needed for delivery.

Product is primarily delivered by truck to consumers. The product is transferred from PPMT storage into trucks at a loading rack consisting of piping, valves and gauging equipment. Loading racks are equipped with containment systems, which collect any spilled product and rainwater and direct it to a holding tank or retention basin. This prevents soil contamination by stormwater runoff.

Other facilities may be present at PPMTs, but the exact combination of ancillary structures varies considerably among locations. The additional structures may include wastewater treatment systems, truck servicing facilities, warehouses, gasoline additive blending facilities, laboratories, and packaging facilities. Packaging facilities handle lube oil, antifreeze, alcohol, and other specialty products. Wastewater treatment systems vary among the surveyed PPMTs, but all have oil/water separators to treat their effluents and remove oil and grease. Most PPMTs have installed vapor recovery units to treat or recycle the volatile petroleum vapors. About half the surveyed PPMTs provide truck washing and maintenance services.

DISTRIBUTED PRODUCTS

The products handled at PPMTs are mainly motor gasolines and middle distillates. Middle distillates are a group of products that include jet fuels, kerosene, diesel, and heating oil. At 57 surveyed PPMTs, 90 percent of the combined storage capacity of 18.5 million barrels (bbl) was for gasolines and middle distillates (Brown and Caldwell, 1988). Several octane grades of motor gasoline are handled at the typical PPMT. Other products less commonly stored at PPMTs include aviation gasoline, lube oil, gasoline additives, and specialty products such as antifreeze. No petroleum or chemical production, beyond blending operations, occurs at PPMT sites.

PPMT SIZE

The physical size of PPMTs varies considerably. Smaller terminals may only be a few acres. In a survey of 57 PPMTs, more than 75 percent were less than 20 acres and had fewer than 10 tanks (Brown and Caldwell, 1988). The remaining 25 percent were larger, and typically covered 60 to 80 acres, having about 20 tanks.

Section 3
WASTEWATER CHARACTERISTICS AND HANDLING PRACTICES

WASTEWATER CLASSIFICATION, SOURCES AND VOLUMES

PPMT wastewater originates from different sources and can be classified in a variety of ways. In this report, wastewater is classified on the basis of where it is collected and the likelihood of its contact with PPMT products. For example, stormwater runoff from vegetated areas, and away from tanks, loading racks, or other facilities, would not likely come into contact with product stored at the facility. This runoff is classified as "**noncontact wastewater**." Areas where contact between stormwater runoff and product is possible would include exposed equipment and loading rack pads. This runoff is classified as "**possible contact wastewater**." Water that infiltrates storage tank seals, aqueous condensate in storage tanks, water that enters storage tanks along with product, and water used to wash facilities or test the integrity of tanks and pipelines definitely does come into contact with product. This water is classified as **"contact wastewater**." The quality of the wastewater stream determines the means by which it is handled, treated and disposed. Additional information on wastewater classification and handling procedures is presented in Table 3-1. The relative volumes of the three types of wastewaters are presented in Figure 3-1 (Klock, 1994).

Noncontact wastewater is by far the largest volume of wastewater, comprising over 98% of wastewater at a typical PPMT. The next highest volume is **possible contact wastewater;** comprising about 1% of PPMT wastewater. The lowest volume is **contact wastewater** at less than 1% of the total wastewater.

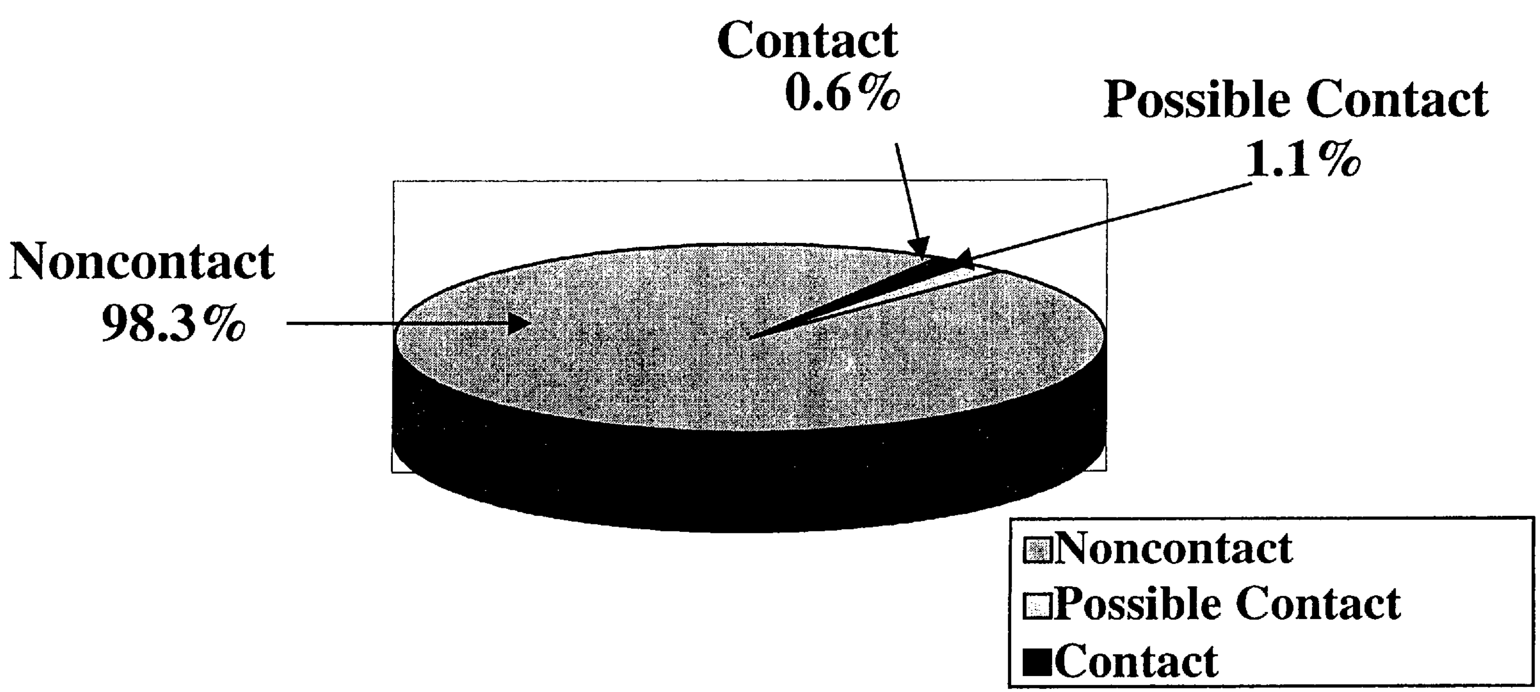
The volume of **noncontact wastewater** at a PPMT site depends upon the size of the terminal grounds and the local climate. The average amount of stormwater discharged in 1986 from the surveyed PPMTs was 20 million gallons per site. This is equivalent to the annual amount of wastewater discharged by approximately 154 households, each containing five people. In most parts of the country, annual precipitation is between 10 and 50 inches per year. Assuming 100%

Table 3-1. Wastewater Characteristics

Type of Wastewater	Area Characteristics	Typical Areas	Handling
Noncontact	No chance of product contact. Minimal chance of other contamination.	Lawns Driveways Building Roofs Parking Lots Undeveloped Land	Route offsite without inspection or treatment.
Possible Contact	Possible contact with product. Possible mixing with contaminated water.	Tank Farms Pipeways	Collect, inspect or analyze. Discharge directly or treat if significantly contaminated.
Contact	Contact with product. Mixing with other contaminated water. Contact with contaminated surface. Mixing with soluble contaminants.	Tank Water Loading Rack Water Contaminated Soil	Treat as needed. Haul off.

Source: Klock, 1994

Marketing Terminal Wastewater



Source: Klock, 1994

Figure 3 - 1: Pie Chart illustrating the relative volumes of PPMT wastewater

runoff, this corresponds to stormwater volumes between 0.27 and 1.35 million gallons/acre/year (Brown and Caldwell, 1988), or 0.54 to 2.7 million gallons per year for the smallest PPMTs to about 5.4 million to 27 million gallons per year for larger PPMTs (assuming 2 and 20 acres for the size of small and large PPMTs, respectively). In reality, a significant fraction of rainfall at PPMTs percolates into the soil or evaporates and does not contribute to surface wastewater flows.

WASTEWATER HANDLING PRACTICES

Wastewaters receive different degrees of handling and treatment depending upon their classification and measurable contamination. This section examines how the different classes of wastewaters are generally handled and the reasons for these practices. The term "handle" in this case refers to how contamination is minimized and to what level of treatment the wastewater is subjected.

Typical PPMTs have been designed to avoid contact between stormwater and product. This is usually achieved by covering loading racks and other facilities to avoid product contact with precipitation, and by routing runoff away from areas where contact with product is possible. Since it is unlikely to be contaminated with terminal products, **noncontact wastewater** is typically discharged without treatment, provided the wastewater meets the requirements specified in the discharge permit.

The volume of **possible contact wastewater** at PPMTs is minimized by the implementation of source reduction practices. These include site modifications to intercept and prevent stormwater runoff from reaching potentially contaminated areas, as well as procedural modifications to minimize areas subject to product spillage, leaks, and accidental releases. The elimination of truck maintenance, washing and other non-essential PPMT activities also helps to reduce **possible contact wastewater** volumes. The volume of **possible contact wastewater** discharged by a typical PPMT is estimated to be between 1,000 (Klock, 1994) to 2,500 (Borey et al., 1989) gallons per week. To put this flow into perspective, the upper range of PPMT **possible contact**

wastewater weekly discharge is similar to the volume of wastewater produced weekly by the typical single home with a family of 5 (Metcalf and Eddy, 1991).

Possible contact wastewater is generally collected from within tank basins, in pipeways, and other areas with possible product-contaminated surfaces. The stormwater is directed to a holding tank or retention basin, where it is periodically analyzed to determine the extent of contamination. If this water contains low levels of contamination, but meets regulatory requirements for acceptable quality, it may be discharged directly. If levels of contamination do not meet regulatory requirements, the wastewater is treated prior to discharge.

The third and final type of wastewater, **contact wastewater,** is contaminated by direct contact with product, from contact with product-contaminated surfaces, or commingled with product-contaminated water. This water often enters tanks by infiltrating seals and combining with other tank bottom waters. Tank bottom water may enter the tank mixed with product, or it may be from condensation formed inside the tank. Tank bottom water is water collected and removed from the bottom of the storage tank.

Contact wastewater is handled in a variety of ways. If the contact wastewater is to be discharged, it is first segregated and treated by oil/water separation and biological treatment to remove contaminants. However, PPMTs often do not have adequate treatment facilities to handle **contact wastewaters,** and so arrange for offsite treatment. Once hauled offsite, **contact wastewaters** may be taken to wastewater treatment facilities for treatment and disposal, or may be hauled to refineries for product recovery and treatment. It is important to stress that **contact wastewaters** at PPMTs are not discharged to streams or surface waters without significant treatment.

Section 4
OVERVIEW OF THE TYPES OF CONSTITUENTS MEASURED IN MARKETING TERMINAL WASTEWATERS

WASTEWATER CONSTITUENTS

Some PPMT wastewaters will be contaminated with petroleum product constituents. Wastewaters are analyzed to determine if unacceptable levels of contamination exist. The following is a brief overview of the types of analyses that are made.

Oil and Grease - This has two components, the free undissolved material suspended in or floating on the water, and the water soluble material. The measure of oil and grease includes organic compounds from petroleum and natural sources, such as decaying vegetation. Some wastewaters may contain microscopic droplets of undissolved oil, called an *emulsion.* Oil and grease in all such forms may be treated by appropriate technology; however, the regulatory intent of oil and grease limits is to prevent the discharge of free-floating oil.

The analysis dissolves material in a solvent and the dissolved material is measured as, and assumed to be, the oil and grease content of the sample.

Total Petroleum Hydrocarbon - This is a measure of hydrocarbons, the principal components of petroleum products. The analysis dissolves material in a solvent and the dissolved material is measured as, and assumed to be, the total petroleum hydrocarbon content of the sample.

Biochemical Oxygen Demand (BOD) - This is a measure of how much oxygen will be consumed by bacteria, in decomposing wastewater contaminants. The BOD analysis uses bacteria that consume oxygen while degrading (principally) organic wastewater contaminants. Since most aquatic life requires oxygen, the measurement of oxygen demand in the receiving water is important to ensure that oxygen depletion does not occur in the receiving water.

Chemical Oxygen Demand (COD) - This is also a measure of total oxidizable material, but this test uses a chemical oxidizing agent rather than bacteria.

Total Organic Carbon (TOC) - TOC is an indicator of total soluble organic contaminants. It does not measure inorganic carbon (e.g., carbon dioxide).

Ammonia - This is a highly water-soluble byproduct of petroleum refining. It is also present in sanitary wastes from households. Ammonia may be toxic to aquatic life if present at high enough concentrations under certain conditions.

pH, Acidity, Alkalinity - pH is a measure of a water's acid or alkaline strength or intensity. Acidity and alkalinity measure the water's base and acid neutralization capacity, respectively.

TSS - Total suspended solids is a measure of the quantity of undissolved solids in water and includes soil particles found in stormwater runoff.

Aromatics – A class of compounds with ring structures. Benzene, toluene, ethylbenzene and xylene, known as BTEX, are the principal aromatic constituents of gasoline.

TDS - Total dissolved solids is generally considered to be an indication of inorganic salt content.

Phenol – A water soluble, slightly acidic aromatic compound often found in gasoline.

Phenols – A class of relatively water soluble aromatics, derived from the parent compound phenol. Phenols are generally found in waters which contact gasoline.

Light Non-Aromatic Hydrocarbons - These are paraffins and olefins of 5 to 9 carbon atoms and are often the main constituents of gasoline.

Ethers and Alcohols - These are constituents which may be added to gasoline to improve octane or to comply with EPA requirements for sale of oxygenated gasoline in certain areas of the country.

Surfactants - These are very common materials and the primary constituents of soaps and detergents. They are periodically used for cleaning purposes at terminals and are used as fuel additives. Two categories of surfactants are sometimes measured in wastewaters. These include: (1) methylene blue activate substances (**MBAS**) or anionic surfactants and (2) cobalt thiocyanate active substances (**CTAS**) or nonionic surfactants.

Metals - Metals are commonly found in terminal wastewater in low concentrations and include: lead, arsenic, iron, copper, zinc, chromium and cadmium. Some of these are found in crude oil, others appear to be from corrosion reactions.

Section 5
LEVELS OF CONSTITUENTS IN THE VARIOUS CLASSES OF PPMT WASTEWATER

NONCONTACT WASTEWATER

Although insufficient data exist to make generalizations about the levels of contaminants in **noncontact wastewater** at PPMTs, it is generally believed that analyses to determine level of PPMT product contamination are unwarranted because these wastewaters do not come into contact with PPMT products. Lack of data does not necessarily imply that **noncontact wastewater** is pristine. Industrial and urban stormwater generally contain low levels of inorganic and organic contaminants.

POSSIBLE CONTACT WASTEWATER

Possible contact wastewater typical of that discharged to surface waters is characterized in Table 5-1. These data were gathered in a survey (Brown and Caldwell, 1995) of possible contact waters from a number of PPMTs. The typical concentrations provided in Table 5-1 are average concentrations. **Possible contact wastewaters** show low levels of BTEX, indicating some type of contact with product-contaminated surfaces or product-contaminated water. However, the BTEX concentrations are quite low, allowing these **possible contact wastewaters** to be readily discriminated from **contact wastewaters**.

CONTACT WASTEWATER

Analytical results for **contact wastewaters** are provided in Table 5-2. These analyses are from a long-term assessment of four PPMT **contact wastewaters**. Average, maximum and minimum concentrations in the four wastewaters are shown in Table 5-2. Several characteristics readily identify the water as **contact wastewater,** including: the high BTEX values; the high oxygen demand produced by the wastewater; and the presence of oxygenates (methanol, ethanol, MTBE) and the MBAS and CTAS surfactant (detergent) components.

Table 5-1. Analytical Results of PPMT Possible Contact Wastewater

Parameter	Units	Typical Concentration	Minimum	Maximum
Oil and Grease	mg/L	5	0.2	18
BOD	mg/L	30	1	342
TOC	mg/L	10	2	23
COD	mg/L	30	9	55.6
TSS	mg/L	80	4	1100
Ammonia	mg/L	0.2	0.05	0.2
Phenol	mg/L	0.005	0.005	0.005
Benzene	μg/L	3	0.13	5
Toluene	μg/L	6	0.6	39
Ethylbenzene	μg/L	5	0.9	20
Xylene	μg/L	7	0.9	37
Lead	μg/L	100	20	200
Arsenic	μg/L	--	--	--

Note: Units presented as published in ppm/ppb, roughly equivalent to mg/L and μg/L, respectively.

Source: Brown and Caldwell, 1995

Though concentrations of some contaminants are high, the contact wastewater can be treated effectively to reduce them. The results of the wastewater analyses before and after biological treatment are shown in Table 5-3. Most of the organic wastes are readily treatable, exhibiting reductions in concentration by a factor of 1/1000 to 1/2000 after treatment. Commensurate with the reduction in organic wastes are reductions in oxygen demand and total organic carbon. The concentrations of metals are also reduced; however, the reductions in metals are often not as much as the reductions observed in the organic constituents.

Data from the study cited in Table 5-3 provide one example of the level of reductions in contaminant concentrations by one method of wastewater treatment. Variations in the efficiency of contaminant concentration reductions can be expected since components of treatment systems vary among different wastewater treatment facilities (i.e., on-site, publicly owned, or off-site refinery treatment works), as do treatment system influent wasteloads. It is believed that reductions of the order observed in this study can be expected, if not exceeded, at other facilities.

Table 5-2. Analytical Results of PPMT Contact Wastewater

Contaminant	Units	Average Concentration	Minimum	Maximum
BOD	mg/L	1412	570	2600
COD	mg/L	3935	1700	6000
TOC	mg/L	999	290	1980
Oil and Grease	mg/L	100	25	240
TSS	mg/L	195	45	768
TDS	mg/L	1893	646	3660
Benzene	mg/L	5.3	0.800	11
Toluene	mg/L	9.3	0.110	19
Xylene	mg/L	5.6	0.011	14
Ethylbenzene	mg/L	2.4	0.180	6.2
Naphthalene	mg/L	0.6	0.097	1.3
2,4 Dimethylphenol	mg/L	0.3	0.054	0.48
Phenols	mg/L	10	0.400	52
Petroleum Hydrocarbons	mg/L	42	2	250
Methanol	mg/L	143	<1	630
Ethanol	mg/L	4.0	<1	12
MTBE	mg/L	105	8.5	290
MBAS	mg/L	5.5	1.1	16.2
CTAS	mg/L	5.3	0.2	14
Arsenic	µg/L	167	28	430
Copper	µg/L	252	30	550
Zinc	µg/L	492	20	1700
Cadmium	µg/L	11	7	14
Chromium	µg/L	135	130	140
Lead	µg/L	258	80	550
Cyanide	µg/L	<10	<5	<10

Source: Vuong *et. al.*, 1993

Table 5-3. Analytical Results of PPMT Contact Wastewaters Before and After Treatment

Contaminant	Units	Average Concentration Before Treatment	Average Concentration After SBR* Treatment
BOD	mg/L	1412	27
COD	mg/L	3935	620
TOC	mg/L	999	170
Oil and Grease	mg/L	100	18
TSS	mg/L	195	35
TDS	mg/L	1893	1372
Benzene	mg/L	5.3	<0.005
Toluene	mg/L	9.3	<0.006
Xylenes	mg/L	5.6	<0.008
Ethylbenzene	mg/L	2.4	<0.005
Naphthalene	mg/L	0.6	<0.005
2,4 Dimethylphenol	mg/L	0.3	<0.005
Phenols	mg/L	10	0.15
Petroleum Hydrocarbons	mg/L	42	0.5
Methanol	mg/L	143	<2
Ethanol	mg/L	4	<1
MTBE	mg/L	105	31
MBAS	mg/L	5.5	2.6
CTAS	mg/L	5.3	1.1
Arsenic	µg/L	167	157
Copper	µg/L	252	<166
Zinc	µg/L	492	313
Cadmium	µg/L	11	<5
Chromium	µg/L	135	70
Lead	µg/L	258	<60
Cyanide	µg/L	<10	<10

* SBR - Sequencing Batch Reactor (Biological Treatment)
Source: Vuong *et. al.*, 1993

Section 6
ASSESSMENT OF POTENTIAL AQUATIC EFFECTS OF PPMT WASTEWATER DISCHARGE

WATER QUALITY CRITERIA

To determine if the concentrations of contaminants in the various types of wastewaters are acceptable for discharge to the environment, one needs to compare them against appropriate benchmark or reference values. In this study, the reference values are water quality criteria. Water quality criteria are established by the U.S. EPA and are frequently adopted by regulatory agencies as the basis for permit limits of constituents discharged into the aquatic environment. Water quality criteria are recommended maximum concentrations in the ambient water bodies. The aquatic limits are developed from the results of studies that examine the effect of constituent exposures on numerous types of organisms representative of those present in the aquatic environment. In practice, these limits target the protection of the majority of aquatic species (95%) against short-term and long-term impacts.

The condition or desired condition of surface receiving waters determines the types of criteria applied to discharges on those waters. The criteria are usually selected to prevent any additional degradation of the water body. For example, streams with active populations of sensitive fish, such as trout, usually receive stricter regulation than streams with less sensitive populations of fish.

A summary of water quality criteria for constituents commonly found in PPMT effluents is presented in Table 6-1. The values presented summarize the most conservatively low values published for freshwater, marine, acute and chronic exposures. In-stream (mixing zone) concentrations of these constituents will be compared with their respective water quality criteria shown in Table 6-1.

The constituents commonly found in PPMT wastewaters do not all have established water quality criteria. In some cases, these constituents have relatively low toxicity and determining criteria for them has not been a regulatory priority. In other cases, the fate of

Table 6-1. Water Quality Criteria for Common Constituents Found in PPMT Wastewaters

Contaminant	Units	Freshwater		Marine	
		Acute	Chronic	Acute	Chronic
BOD		N/A	N/A	N/A	N/A
COD		N/A	N/A	N/A	N/A
TOC		N/A	N/A	N/A	N/A
Oil and Grease		N/A	N/A	N/A	N/A
TSS		N/A	N/A	N/A	N/A
TDS		N/A	N/A	N/A	N/A
Benzene	mg/L	5.300	N/A	5.100	0.700
Toluene	mg/L	17.500	N/A	6.300	5.000
Xylene	mg/L	N/A	N/A	N/A	N/A
Ethylbenzene	mg/L	32.000	N/A	0.430	N/A
Naphthalene	mg/L	2.300	0.620	2.350	N/A
2,4 Dimethylphenol	mg/L	2.120	N/A	N/A	N/A
Phenol	mg/L	10.200	2.560	5.800	N/A
Petroleum Hydrocarbons		N/A	N/A	N/A	N/A
Methanol		N/A	N/A	N/A	N/A
Ethanol		N/A	N/A	N/A	N/A
MTBE		N/A	N/A	N/A	N/A
MBAS		N/A	N/A	N/A	N/A
CTAS		N/A	N/A	N/A	N/A
Arsenic	µg/L	360	190	69	36
Copper	µg/L	17	11	2.4	2.4
Zinc	µg/L	110	100	90	81
Cadmium	µg/L	3.7	1.0	42	9.3
Chromium	µg/L	15	10	1100	50
Lead	µg/L	65	2.5	210	8.1
Cyanide	µg/L	22	5.2	1.0	N/A

CMC (Criteria Maximum Concentration) reported as Acute Value; CCC (Criteria Continuous Concentration) reported as Chronic Value

Source: U.S. EPA Quality Criteria for Water, 1976; 1986; 1992; 1994; 1995 the constituent in water precludes it from concern. Also, in some cases data from which to establish water quality criteria may not be available. From Table 6-1, it can be seen that criteria are unavailable for BOD, COD, TOC, oil and grease, TSS, TDS, petroleum hydrocarbons, methanol, ethanol, MTBE, MBAS, and CTAS. Without water quality criteria to provide a benchmark, further calculation or assessment of the impact of these constituents of PPMT wastewaters is not possible.

WASTEWATER CONCENTRATIONS IN SURFACE WATERS

Discharges by industrial and municipal sources to surface waters are regulated by various government agencies through permits that limit discharge volumes and constituent concentrations. These permits are required under regulations driven by the Clean Water Act and various other federal, state and local regulations. The agencies that prepare and enforce local discharge permits recognize that water quality criteria may not need to be met at the end of the discharge pipe. As a result, discharge permits provide for a mixing zone in which receiving waters may assimilate effluents. A mixing zone is depicted in Figure 6-1.

The size of mixing zones provided for industrial dischargers varies with the magnitude and quality of the discharge as well as with the desired quality of the receiving stream. The exact size of a mixing zone depends upon numerous technical factors that are beyond the scope of this paper. To evaluate the potential aquatic effects of PPMT wastewaters, a small, and hence conservative, mixing zone will be assumed.

In order to examine the possible ecological effects related to PPMT discharges, the concentrations of PPMT wastewater constituents can be compared with water quality criteria after assimilation in the example mixing zone. The constituents of **possible contact** and **contact wastewater** after treatment are presented in Table 6-2. The values presented for **contact wastewater** after treatment are the same values presented in Table 5-3.

Since the volume of water discharged by PPMTs is relatively small, a small mixing zone will be considered in this evaluation. For the purpose of comparison, the mixing zone considered is approximately 1/100 the area of a football field at a depth of 15 feet. The

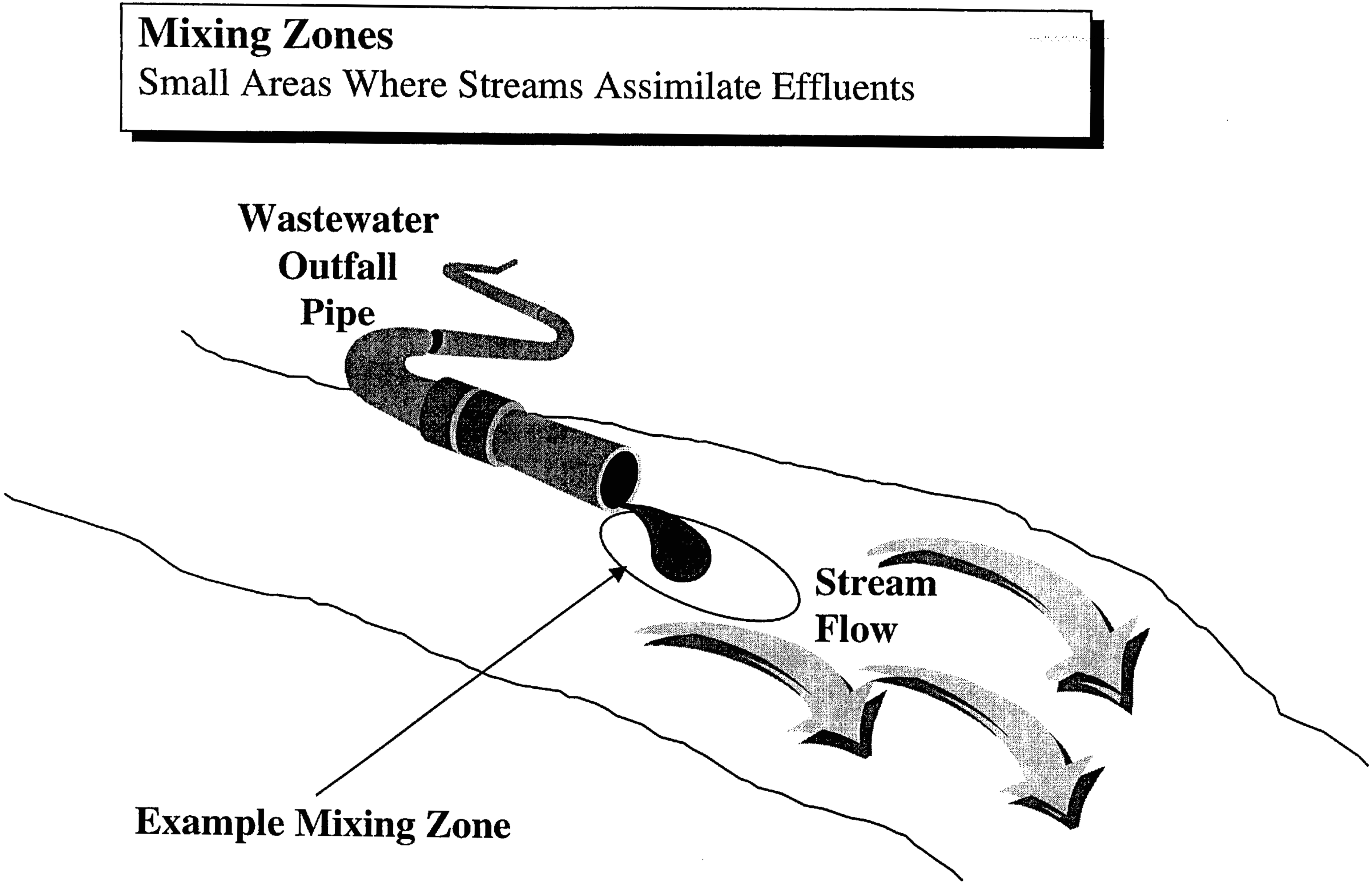


Figure 6 - 1: An illustration of a mixing zone.

Table 6-2. Concentration and Mass of Material in PPMT Wastewaters

Contaminant	Unit	Concentration	Unit	Mass
Possible Contact Wastewater				
Phenol	mg/L	0.005	(lb/1000 gal)	0.00004
Benzene	mg/L	0.003	(lb/1000 gal)	0.00003
Toluene	mg/L	0.006	(lb/1000 gal)	0.00005
Ethylbenzene	mg/L	0.005	(lb/1000 gal)	0.00004
Xylene	mg/L	0.007	(lb/1000 gal)	0.00006
Lead	mg/L	0.1	(lb/1000 gal)	0.00083
Treated Contact Wastewater				
Benzene	mg/L	<0.005	(lb/1000 gal)	<0.00004
Toluene	mg/L	<0.006	(lb/1000 gal)	<0.00005
Xylene	mg/L	<0.008	(lb/1000 gal)	<0.00007
Ethylbenzene	mg/L	<0.005	(lb/1000 gal)	<0.00004
Naphthalene	mg/L	<0.005	(lb/1000 gal)	<0.00004
2,4 Dimethylphenol	mg/L	<0.005	(lb/1000 gal)	<0.00004
Phenols	mg/L	0.150	(lb/1000 gal)	0.00125
Methanol	mg/L	<2	(lb/1000 gal)	<0.01667
Ethanol	mg/L	<1	(lb/1000 gal)	<0.00834
Arsenic	µg/L	157	(lb/1000 gal)	0.00131
Copper	µg/L	<166	(lb/1000 gal)	<0.00138
Zinc	µg/L	313	(lb/1000 gal)	0.00261
Cadmium	µg/L	<5	(lb/1000 gal)	<0.00004
Chromium	µg/L	70	(lb/1000 gal)	0.00058
Lead	µg/L	<60	(lb/1000 gal)	<0.00050
Cyanide	µg/L	<10	(lb/1000 gal)	<0.00008

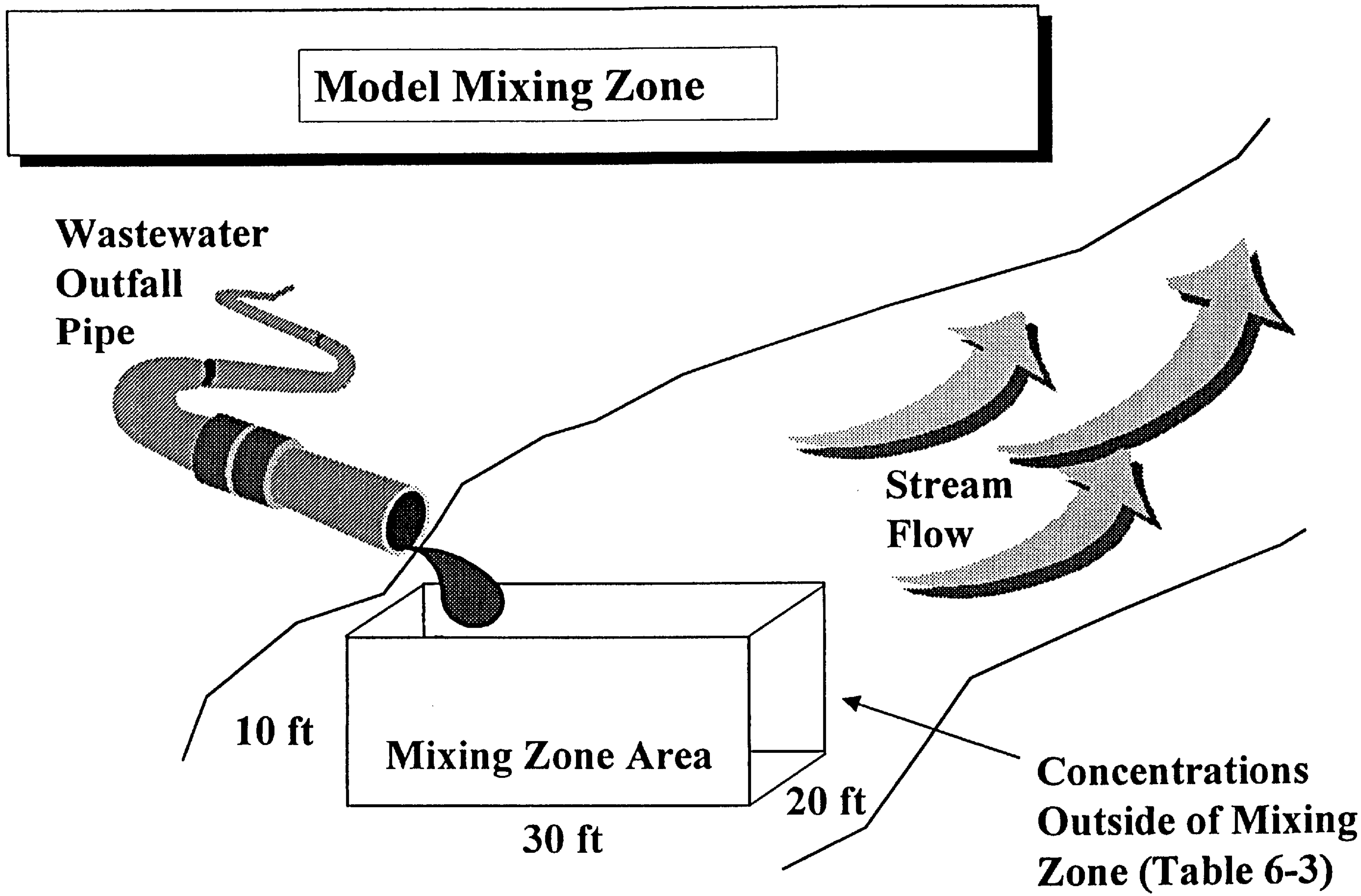


Figure 6 - 2: An illustration of the example mixing zone used for estimating the instream wastewater concentrations

mass of each wastewater component is placed in the example mixing zone (Figure 6-2) measuring 15 feet X 25 feet X 30 feet, and the concentration of each of the individual wastewater parameters is calculated and compared with the water quality criteria.

This is a simplified, but also very conservative, view of the interactions that may take place in a receiving stream. Assumptions and limitations of the calculations include:

1) This calculation considers the mass of material normally discharged in 1000 gallons by a PPMT during a 4-7 day period as a single one time discharge;

2) This calculation does not consider the additional assimilating effects of stream flow; and

3) It is assumed that mixing within the zone provides a completely homogenous mixture.

The mixing zone concentration of the individual parameters is determined by the formula:

$$\left(\frac{\text{Discharge conc. as lbs./1000 gals.)} \times \text{(Discharge flow of 1000 gals.)}}{\text{Mixing zone volume of 11250 ft.}^3}\right) \times \left(\frac{1\ \text{ft.}^3}{28.32\ \text{liters}}\right) \times \left(\frac{454 \times 10^6\ \mu g}{\text{pound}}\right)$$

Under normal discharge rates to flowing streams, the constituents normally discharged by PPMTs should not produce any significant negative effects to the aquatic life present in the stream beyond the model mixing zone. When the mass of material discharged in PPMT wastewater is assimilated into this mixing zone, the strictest published water quality criterion for each wastewater constituent is met both within and beyond the mixing zone (Table 6-3).

It should be reiterated that this is a conservative examination of the potential risk associated with the discharge of PPMT effluents. This examination considered the instantaneous discharge of the mass of materials found in the volume of effluent normally discharged over a period of a week. If we were to consider a continuous discharge from the PPMT rather than an instantaneous discharge, the mixing zone required to meet water quality criteria would be very small, measuring less that 9 feet x 9 feet with a depth of 1 foot.

Table 6-3. Evaluation of Wastewater Consituents in Mixing Zone Versus Most Conservative Water Quality Criteria

Contaminant	Units	Most Conservative Criterion	Type of Wastewater	
			Possible Contact	Treated Contact
Benzene	mg/L	0.700	0.00004	0.00006
Toluene	mg/L	5.000	0.00007	0.00007
Ethylbenzene	mg/L	0.430	0.00006	0.00006
Naphthalene	mg/L	0.620	N/A	0.00006
2,4 Dimethylphenol	mg/L	2.120	N/A	0.00006
Phenol(s)	mg/L	2.560	0.00006	0.00178
Arsenic	µg/L	36	N/A	1.87
Copper	µg/L	2.4	N/A	1.97
Zinc	µg/L	81	N/A	3.72
Cadmium	µg/L	1.0	N/A	0.06
Chromium	µg/L	10	N/A	0.83
Lead	µg/L	2.5	0.00119	0.71
Cyanide	µg/L	1.0	N/A	0.12

Section 7
COMPARING PPMT WASTEWATER COMPONENTS WITH COMMON HOUSEHOLD PRODUCTS AND WASTES

COMPARISON OF ORGANIC COMPONENTS OF WASTEWATERS

Wastewater volumes and associated amounts of constituents of concern released by PPMTs on a weekly basis are quite small. As previously mentioned, a typical family of five produces approximately 2500 gallons of wastewater a week, about the equivalent of the discharge from an 1 8-acre, 1.9 million-barrel (approximately 70 million gallon) capacity PPMT. Comparisons can be made between PPMT wastewaters and common products used in households. Figure 7-1 presents several analogies of the constituent equivalents in weekly PPMT discharges.

- Phenol, the active ingredient used in antiseptic throat sprays sold over the counter, is usually present at about 1.4% of the solution. The phenol in PPMT treated contact wastewater discharges is equivalent to about 0.00125 lb, equivalent to the phenol in 8 teaspoons of throat spray per week.

- The BTEX present in treated contact wastewater during a weeklong discharge amounts to that in about 8 drops of gasoline.

- Ethanol, another additive in some gasoline blends to reduce air emissions and therefore a component of contact wastewater, is less than that contained in a shot of liquor.

- The surfactant present in a week-long discharge of treated **contact wastewater** is about that present in 12 fluid oz of laundry detergent, about the amount used for one week's laundry for a family of 4.

It is agreed that careless handling and disposal practices of wastes are to be avoided; it is also important to understand, however, that complete elimination of constituents in wastewater discharges is often impractical and unnecessary in protecting and maintaining a healthy environment.

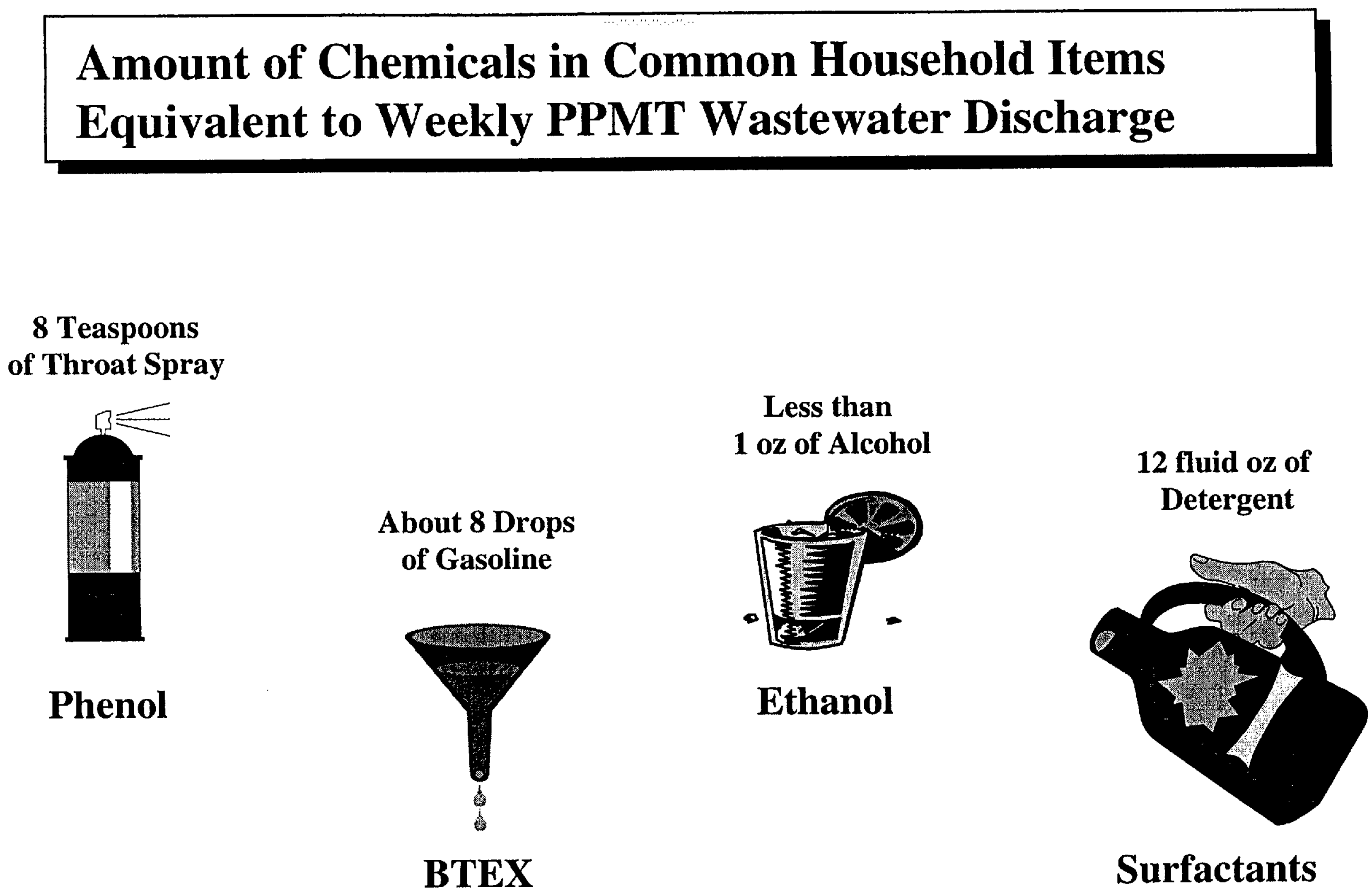


Figure 7 - 1: An illustration of the amount of chemicals in common household items equivalent to weekly PPMT wastewater discharge

COMPARISONS OF HEAVY METAL COMPONENTS OF WASTEWATERS

High concentrations of heavy metals can certainly have deleterious environmental consequences. Most animals and plants, however, require certain amounts of metals to sustain life. These materials are in our foods and vitamins and are necessary for good health. Aquatic organisms also require certain metals and have numerous metabolic activities to maintain the proper levels of metals that can vary seasonally in their availability. Figure 7-2 attempts to put into focus heavy metals in PPMT discharges. This figure compares the concentration of certain heavy metals in:

1) PPMT wastewater which would normally be discharged to surface waters;
2) A common multivitamin (specifications taken from label) when taken with 4 ounces of water; and
3) Canned tomato juice (The Food Processor Software, Version 5.03).

With the exception of chromium, for which tomato juice data were not available, the PPMT wastewater has the lowest concentration.

COMPARISON OF PHYSICAL COMPONENTS OF WASTEWATERS

Levels of the non-specific parameters biological oxygen demand (BOD), chemical oxygen demand (COD), and total organic carbon (COD) often correspond to the concentration of the specific organic constituents present in the wastewater as a result of petroleum product contact. When the amounts of BTEX components are high, as in Table 5-3, then the BOD, COD, and TOC are high.

Figure 7-3 attempts to place these physical components of wastewater into perspective. In this figure, the concentrations of BOD, COD and TOC are shown at the concentrations normally discharged by PPMTs. The concentrations of the individual parameters are compared with the concentrations of the same parameters as present in household wastewater. While it is true that most domestic wastewaters are treated in POTW's (Public Owned Treatment Works) prior to discharge to surface waters, Figure 7-3 allows a rough comparison of PPMT discharges with water that routinely goes down the drain in our homes. These data suggest that concentrations of physical constituents in PPMT discharges are similar to those routinely generated in typical households in the U.S.

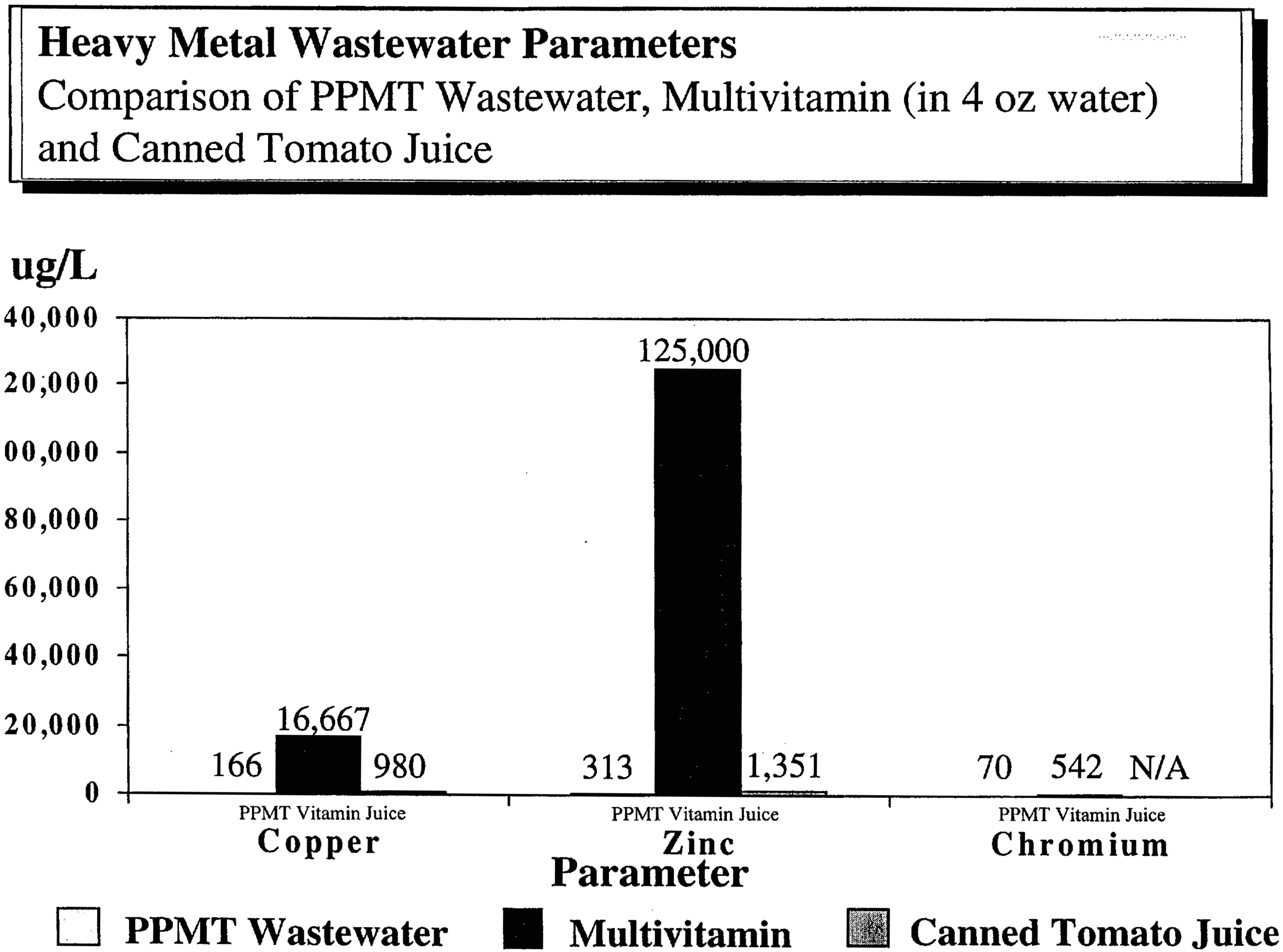
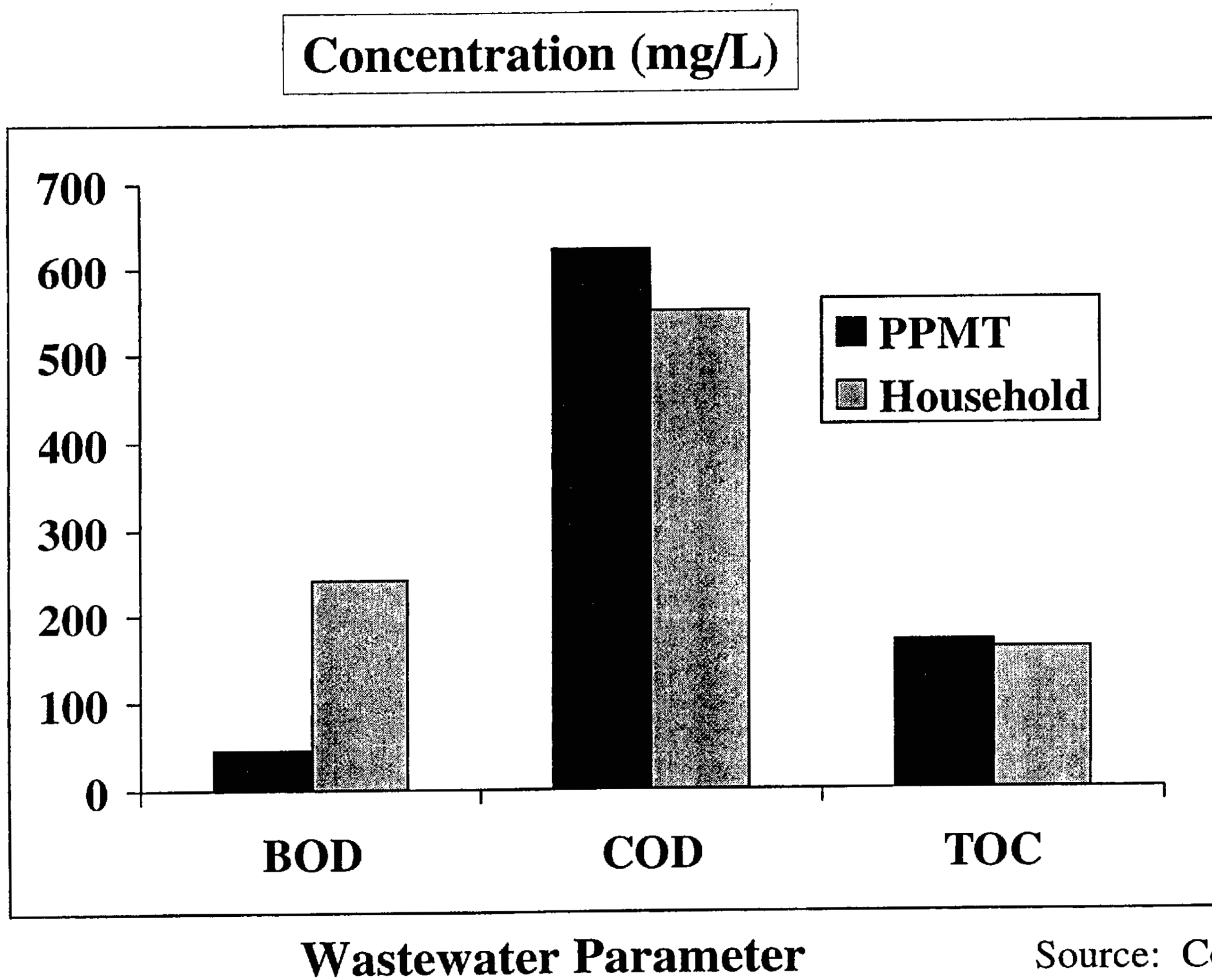


Figure 7 - 2: Bar Chart comparing heavy metal concentrations in PPMT wastewater, multivitamin taken with 4 oz water, and canned tomato juice

Physical and Non-Specific Wastewater Parameters

Comparison of PPMT Effluent and Household Discharge



Source: Corbit, 1990

Figure 7 - 3: Bar Chart comparing BOD, COD, and TOC concentrations in PPMT wastewater and household discharge

Section 8
CONCLUSIONS

Discharge regulations designed to protect the environment from impacts of large industrial and municipal dischargers are being applied to intermittent dischargers of small quantities of **noncontact wastewater** and **possible contact wastewater**. Since compliance with these regulations is extremely costly, this paper examined the potential environmental effects related to these discharges. The potential effects related to discharge of these wastewater streams were evaluated by comparing the water quality criteria with the concentration of contaminants produced after assimilation with the water in a small mixing zone.

In order to make this evaluation as simple and conservative as possible, the contaminant loads were examined as if the mass present in 1000 gallons were discharged at one time. This is the volume of **possible contact wastewater** normally discharged by PPMTs during periods of up to one week. Once this mass of contaminants is assimilated into the mixing zone, the water quality criteria for all related effluent parameters are met. The criteria which were used as benchmarks were the strictest criteria published for those parameters, whether acute or chronic. Also, the conservative assumption of instantaneous discharge of the wastewater was used, rather than the actual situation of discharge over a longer time period.

This evaluation indicates that no significant aquatic effects are expected from exposure to PPMT wastewater streams normally discharged to surface waters. Environmental regulations are written and enforced to prevent degradation of the environment and damage to local populations of aquatic organisms. This evaluation of the potential effects produced by wastewater, which would normally be discharged from PPMT facilities, indicates that there would be negligible benefit in application of more stringent regulations than are currently applied.

Section 9
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