ENVIRONMENTAL ASSESSMENT

of

WASTEWATER AMMONIA DISCHARGE

from

THE UNO-VEN REFINERY
Lemont, Illinois

Prepared by:

James E. Huff, P.E.
James Paulson, E.I.T.
Sean D. LaDieu, E.I.T.

December, 1992

HUFF & HUFF, INC.
ENVIRONMENTAL CONSULTANTS
LaGRANGE, ILLINOIS

Exhibit 3

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CHAPTER 1
INTRODUCTION

The UNO-VEN Company (UNO-VEN), operates a petroleum refinery near Lemont, Illinois, with a current rated capacity of 153,000 barrels per day. Nitrogenous compounds are present in crude oil and a large fraction of this nitrogen is removed by various refinery operations. Ammonia and organic nitrogen in the wastewater are a direct result of the nitrogenous compounds from the crude oil.

UNO-VEN operates a physical/chemical and biological wastewater treatment plant at the refinery. The treatment plant performs primary, secondary, and tertiary treatment on the generated wastewater before it is discharged into the Chicago Sanitary and Ship Canal (Ship Canal). The Ship Canal is part of the Chicago Waterway classified as a secondary contact waterway under Title 35: Subtitle C: Chapter I of the Illinois Administrative Code. The Illinois Pollution Control Board adopted Title 35: Part 304.122 to control ammonia discharges to the Chicago River System. Rule 304.122(b), limits larger industrial discharges (greater than 100 lbs/day ammonia) to 3.0 mg/l.

The U.S. EPA has established effluent guidelines for wastewater discharges by industry category. The petroleum refining industry is divided into five subcategories based upon the processes utilized and the products produced. The UNO-VEN Refinery is classified as a Subcategory-B cracking refinery, under the federal regulations. Effluent limits under the federal effluent guidelines are based upon production, and are computed on a pounds per day basis. Historically, UNO-VEN has achieved compliance with the federal effluent guidelines; however, the 3.0 mg/l state effluent limit has not been attainable on a consistent basis.

From 1977 through 1984, UNO-VEN operated under several variances from the Illinois Pollution Control Board (IPCB). In 1982, the IPCB granted UNO-VEN its fourth variance, contingent that by May, 1984, UNO-VEN submit a program to ensure compliance to Rule 304.122 or prepare a proposal for a site-specific regulatory change. In December of 1984, UNO-VEN appeared before the Illinois Pollution Control Board requesting a site-specific regulatory change. The IPCB granted UNO-VEN site-specific effluent limits set at the U.S. EPA's Best Available Treatment (BAT) pursuant to 40 CFR 419.23 (1985). This site specific rule change terminates December 31, 1993.

UNO-VEN has operated under two National Pollutant Discharge Elimination System (NPDES) permits since being granted the site specific rule change. The current ammonia effluent discharge limits are set in the NPDES permit (No. IL0001587) at 749.19 lbs/day (30 day average) and 1,648.21 lbs/day (daily maximum). These values were derived based upon a crude oil throughput of 143,400 bbls/per day. Based on the most recent five years production, BAT limits are 772 and 1,698 lbs/day, monthly maximum and daily maximum, respectively.

The IPCB has established water quality standards for state waters, including the Chicago Waterways to further protect water quality. The Ship Canal water quality standards are regulated by secondary contact water standards. The ammonia in secondary contact waters is regulated as un-ionized ammonia and is limited to 0.1 mg/l.

The purpose of this report is to assess the environmental impact of the ammonia content in UNO-VEN's wastewater effluent. Both the localized impact upon the Ship Canal as well as downstream Illinois River basin quality are described herein. Chemical and biological sampling were used to determine the localized impacts by comparing upstream and downstream conditions as well as conditions found in 1983, obtained from the previous rule change request. A water quality computer model was used to assess the overall impact attributable to UNO-VEN's ammonia discharge on the Illinois River System.

With the adoption of the toxic control strategies by both the U.S. EPA and the Illinois Pollution Control Board, localized water quality issues must also be considered. The Mixing Zone and Zone of Initial Dilution (ZID) for UNO-VEN's discharge are described herein to address localized water quality concerns.

CHAPTER 2

BACKGROUND INFORMATION

2.1 Site Description

The UNO-VEN Refinery is located southwest of Lemont, Illinois, east of Romeoville, as depicted in Figure 2-1. The Chicago Sanitary and Ship Canal (Ship Canal) is situated to the north and east of UNO-VEN. The Ship Canal runs parallel to the Des Plaines River generally flowing southwest until Romeoville where the canal turns to the south.

The Chicago Waterway is part of the Corps of Engineer River Mile system. River Mile point 0.0 is the confluence of the Illinois River and the Mississippi River in Grafton, Illinois. The Ship Canal ends at river mile 290 where the Des Plaines River and the Ship Canal merge. UNO-VEN's outfall 001 is located at river mile 296.5 on the Ship Canal, 5.5 miles upstream from the Lockport Lock and Dam. The Chicago Waterway and the Illinois River System are shown on Figure 2-2.

2.2 Production Trends

UNO-VEN refines domestic and foreign sour crude oil to produce gasoline, kerosene, home heating oil, aviation fuel, diesel oil and petroleum coke. Petroleum in general contains 85% carbon, 12% hydrogen, and the remaining 3% oxygen, nitrogen and sulfur (Nemerow, 1971). Refining of crude oil includes the removal of the nitrogen and sulfur compounds through distillation, desalting, and fractionation processes.

The nitrogen that is removed during the refining process typically ends up in an aqueous waste stream, often along with sulfur compounds in the form of sulfides. The sulfide and nitrogen bearing aqueous waste streams are processed through one of two sour water strippers at the refinery where most of the sulfides and ammonia are steam stripped from the wastewater.

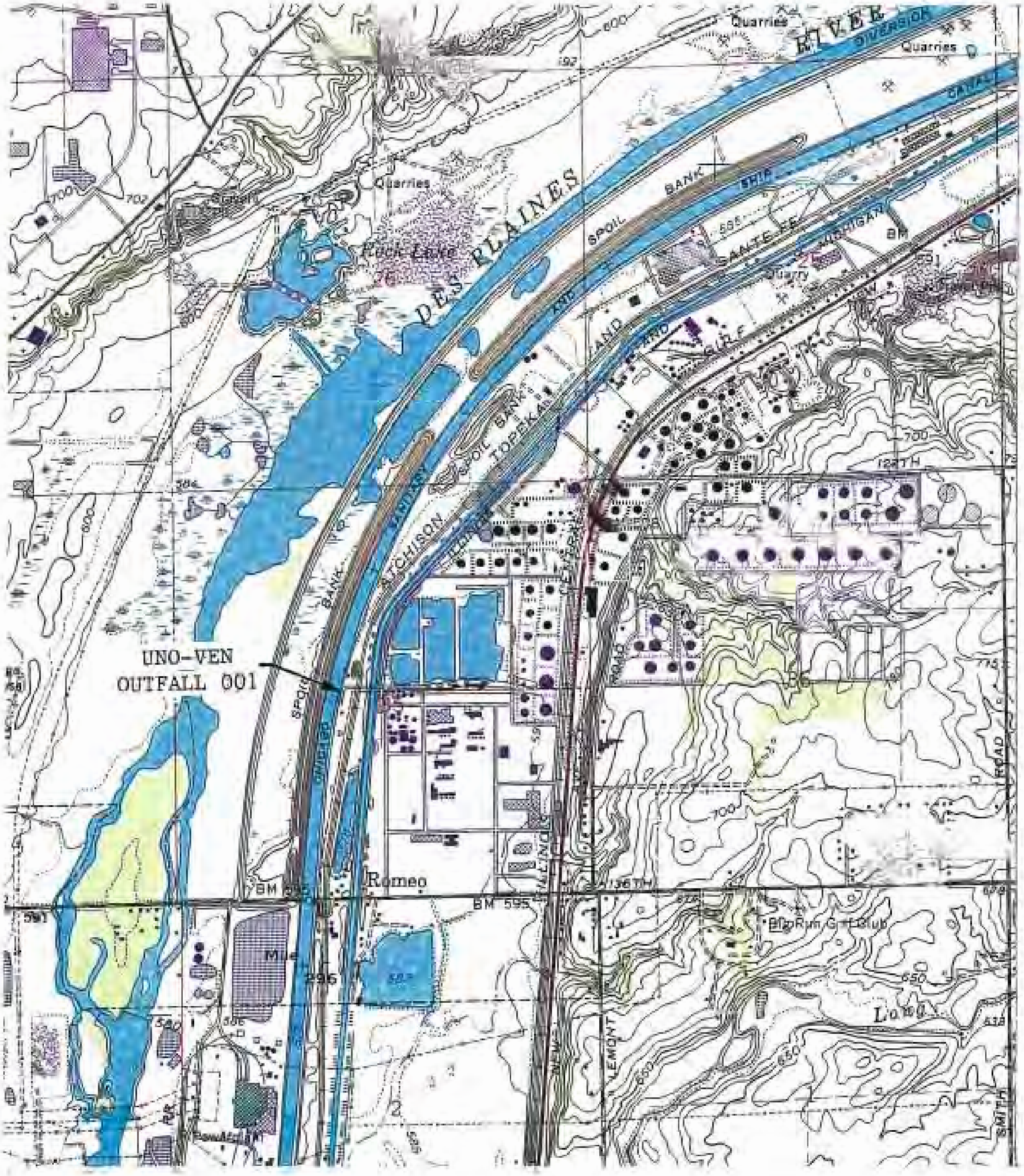


FIGURE 2-1
SITE LOCATION MAP
UNO-VEN OIL REFINERY
LEMONT, ILLINOIS
SCALE: 1" = 2000'

NORTH

SOURCE: UNITED STATES DEPARTMENT OF THE INTERIOR, GEOLOGICAL SURVEY
ROMEOVILLE QUADRANGLE

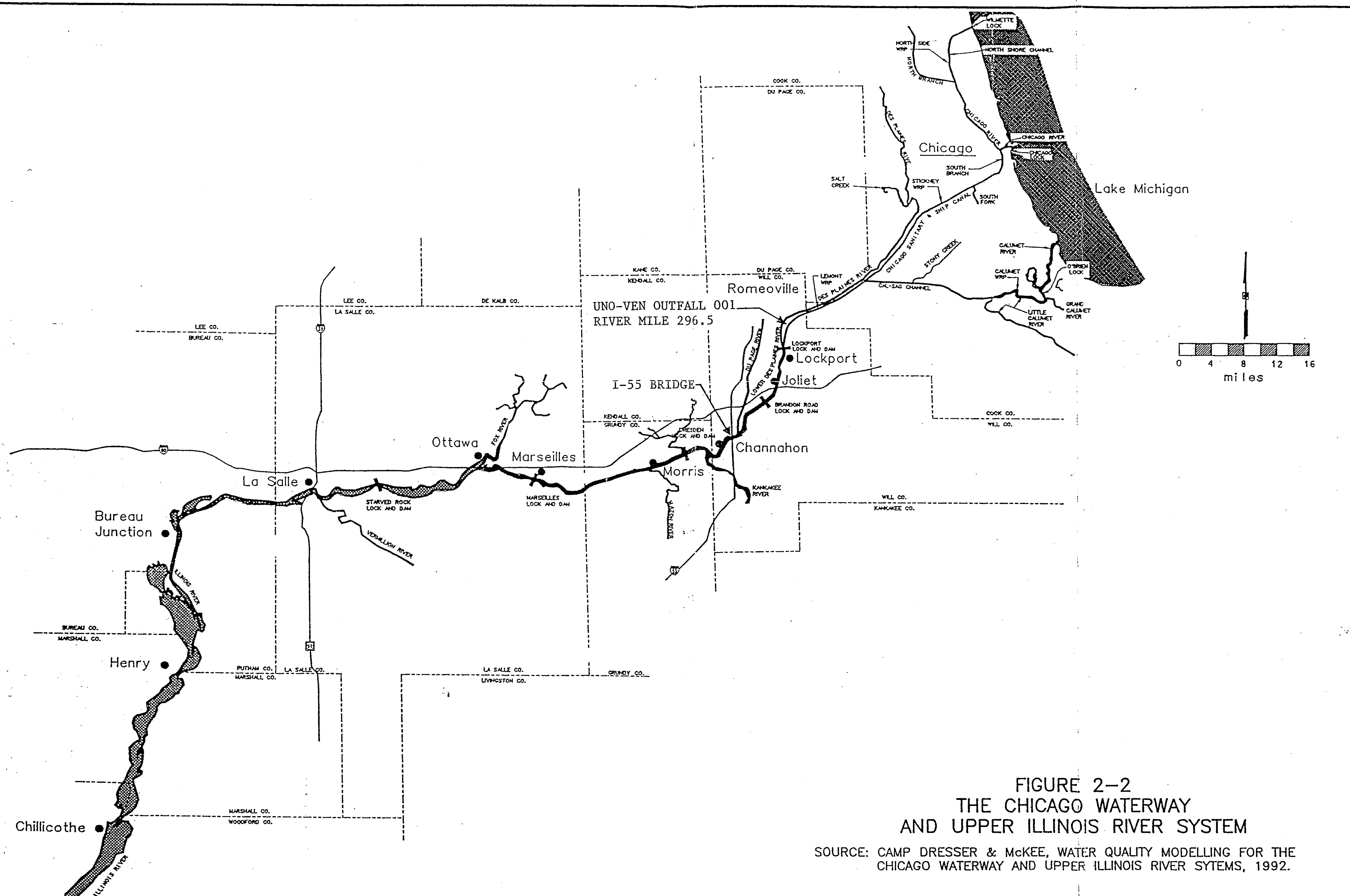


FIGURE 2-2
THE CHICAGO WATERWAY
AND UPPER ILLINOIS RIVER SYSTEM

SOURCE: CAMP DRESSER & McKEE, WATER QUALITY MODELLING FOR THE CHICAGO WATERWAY AND UPPER ILLINOIS RIVER SYTEMS, 1992.

Several refinery processes contribute to the nitrogen wastewater loading, including the following:

	Process	Pollutants
1.	Cracking and distillation	Organic nitrogen compounds
2.	Hydrodesulfurization	Ammonia
3.	Sweetening, neutralization	Organic nitrogen compounds
4.	Oil storage	Ammonium sulfide
5.	Gas purification and recovery	Organic nitrogen compounds

Organic nitrogen compounds formed include amines, amides, quinolines, and pyridines. As the organic nitrogen compounds are biologically degraded during wastewater treatment, ammonia is formed.

The UNO-VEN Refinery's capacity for oil production is currently 153,000 bbls/day. Average production has generally increased over the last eight years, peaking in 1990 at 138,000 bbls/day. The peak month production occurred in 1992, at 147,700 bbls/day. Figure 2-3 graphically depicts the annual average crude oil throughput.

Figure 2-4 presents the trend in nitrogen content in the crude since 1974. Nitrogen increased from approximately 0.007% in the mid-70's to approximately 0.017% in the most recent five years, or a 157% increase.

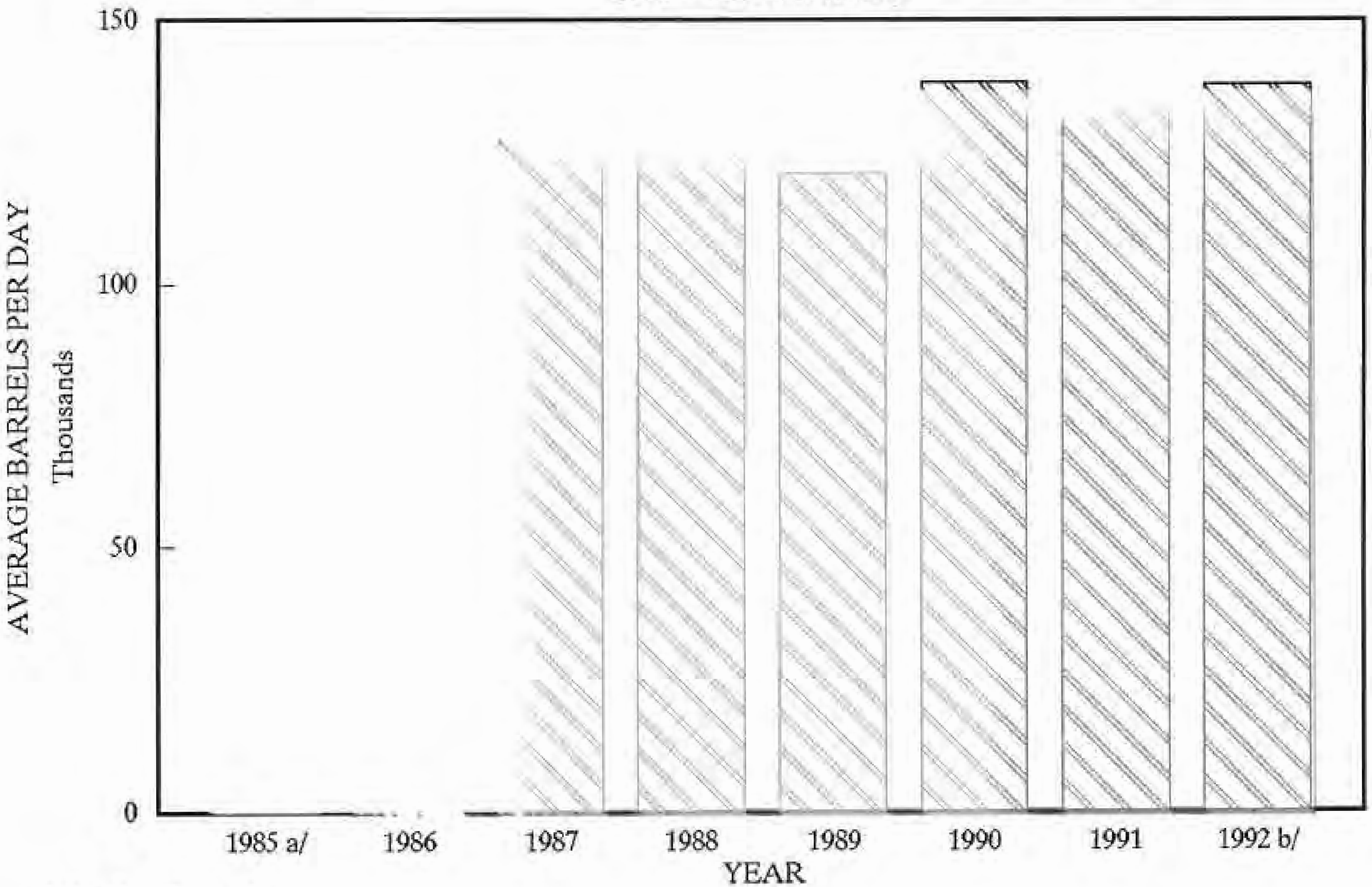
The trend in sulfur content in crude oil is presented in Figure 2-5. The sulfur content steadily increased from 1% in 1974/75 to 1.8% in 1982. During the most recent two years, the sulfur level has declined to the 1.2 to 1.3% range.

The nitrogen level in the crude has a direct bearing on the ammonia loading in the wastewater. Coupling the 157% increase in nitrogen with the 25% increase in crude oil throughput has more than doubled the nitrogen loading on the wastewater treatment facilities at the refinery. The impact of this increase in nitrogen loading is described in detailed in the following Chapter.

FIGURE 2-3

BARRELS of OIL PROCESSED PER DAY

UNO–VEN REFINERY



a/ April – December
b/ January – August

FIGURE 2-4

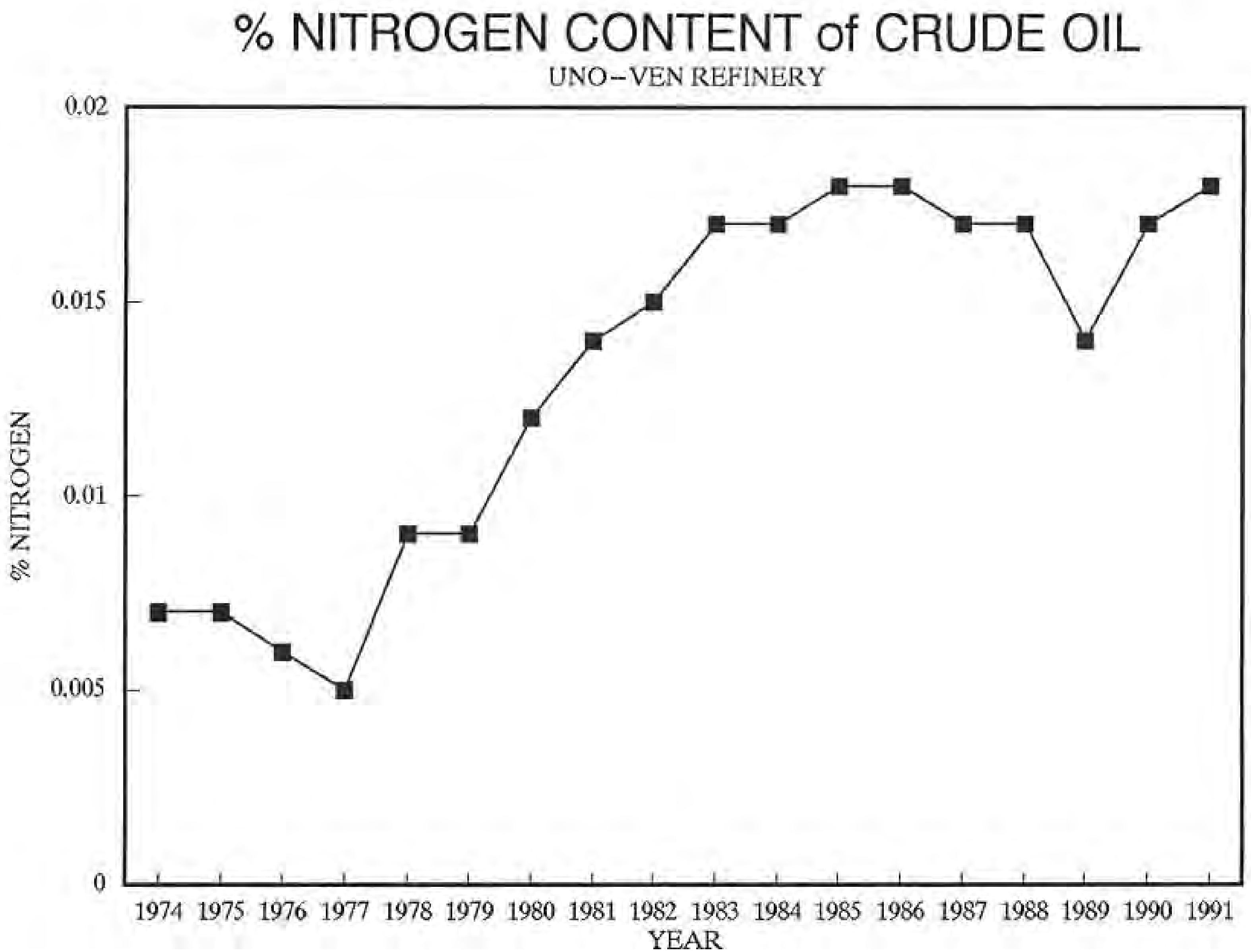
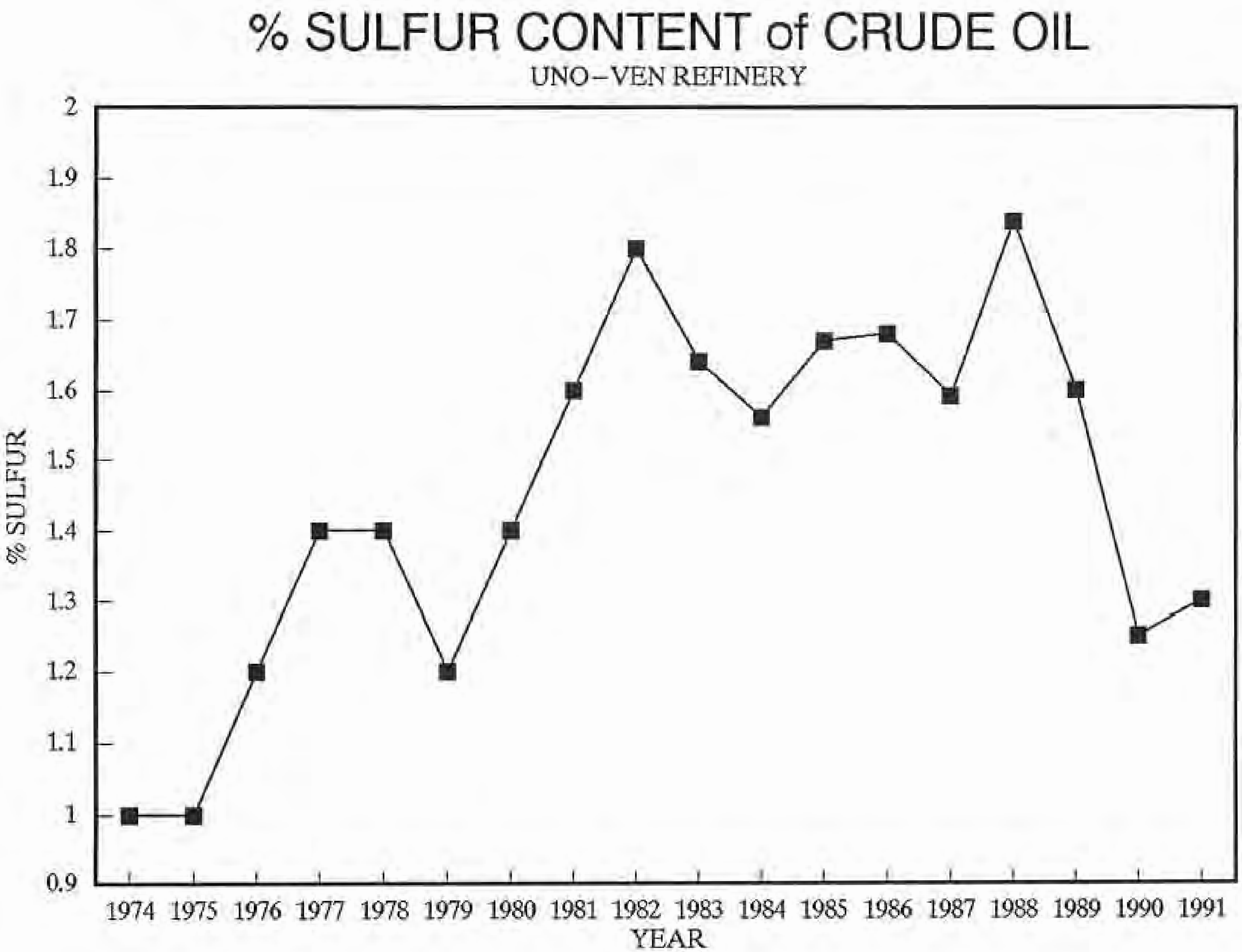

% NITROGEN CONTENT of CRUDE OIL
UNO-VEN REFINERY
% NITROGEN
0.02
0.015
0.01
0.005
0
1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991
YEAR

FIGURE 2-5



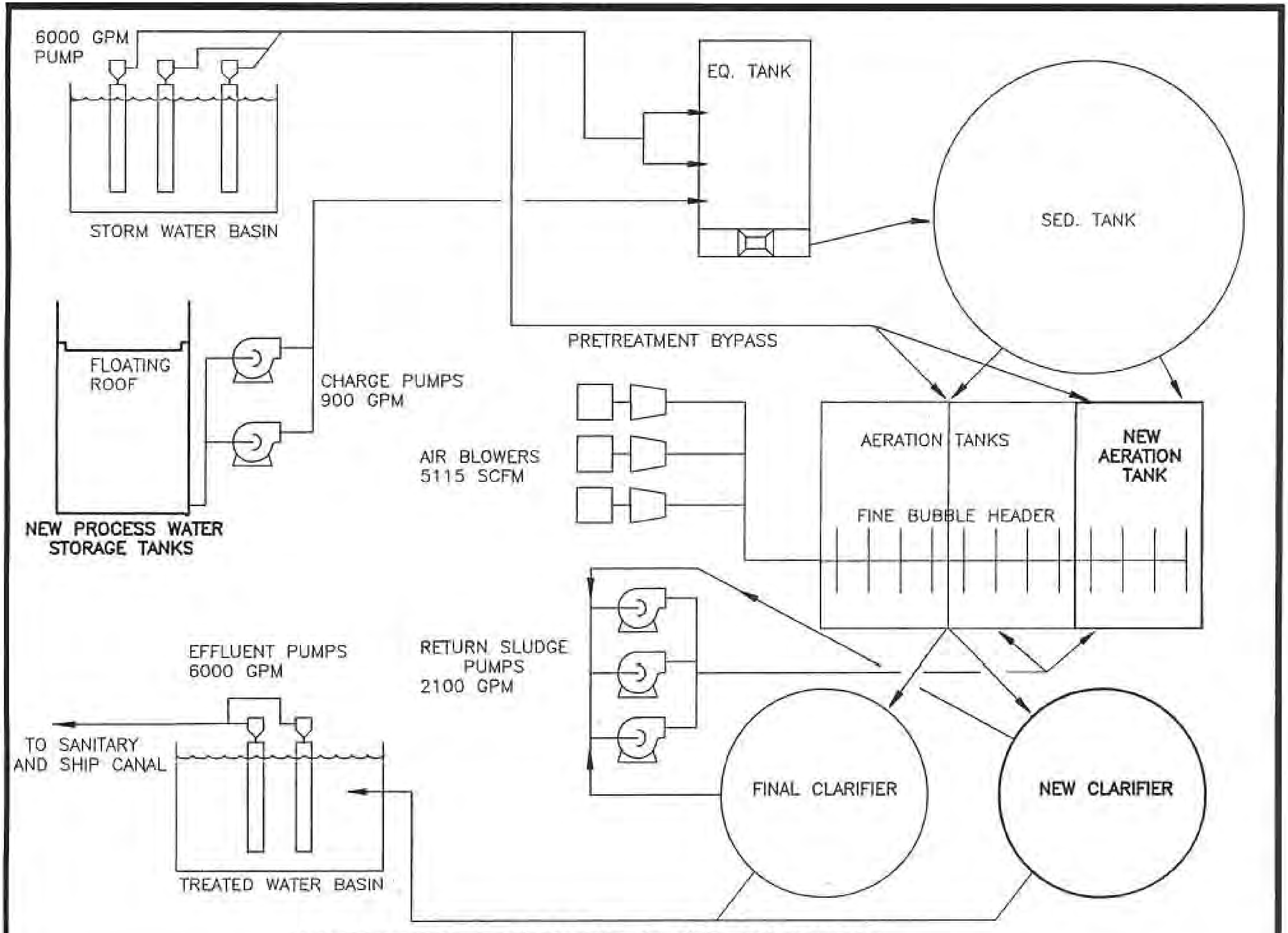
% SULFUR CONTENT of CRUDE OIL
UNO-VEN REFINERY
% SULFUR
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991
YEAR

2.3 Description of Wastewater Treatment Facility and Modifications Since 1983

The UNO-VEN wastewater treatment plant began operation in 1969. The original design included two oil/water separators, a flow equalization tank, a primary clarifier, an activated sludge system and a polishing pond prior to discharge. Several wastewater treatment plant modifications have been made since the original installation. Figure 2-6 depicts the process as it currently exists. Major changes to the system include covered process water storage tanks, new oil/water separators, a new aeration basin, a new clarifier, and new fine bubble diffusers.

Since UNO-VEN was granted its first ammonia variance in 1977, the wastewater treatment plant and refinery have undergone numerous modifications in efforts to reduce the ammonia concentration and other constituents in the effluent. Progress has been made in the reduction of ammonia despite increasing nitrogen in the crude oil and higher crude oil throughputs. In the previous report, "Environmental Assessment of Ammonia Concentration in the Wastewater Discharge of Union Oil Company, Chicago Refinery," December, 1984 by L.L. Huff and J.E. Huff, costs incurred from 1977 to 1983 associated with improving wastewater quality were itemized. Table 2-1 presents a summary of costs incurred since 1983 directed toward improving effluent quality. Over $7 million has been expended over the last nine years with an additional $13 million appropriated to improve effluent quality and maintain the wastewater treatment.

The ammonia loading to the two sour water strippers has increased since 1984, resulting in more ammonia removal through the strippers prior to sewering the water. Improved maintenance and operation practices on the strippers have also occurred due to increased awareness. All of these projects have impacted ammonia effluent quality.



WASTEWATER TREATMENT PLANT SCHEMATIC

FIGURE 2-6

TABLE 2-1

WASTE TREATMENT MODIFICATIONS AND OPERATION COSTS

Year	Project	Cost
1984	. Modify piping to treatment plant	$ 12,000
	. Provide temporary aerators to treatment plant	13,000
1985	. DO analyzers for two aeration tanks	6,000
	. Replace effluent weir	6,000
	. Provide additional aerators to waste treatment	16,000
	. Replace stripper overhead piping with aluminum	22,000
	. Upgrade pump casings of reflux pumps for sour water strippers	30,000
1986	. Modify activated sludge clarifier	89,000
	. Eliminate stormwater basin overflows	2,151,000
	. Replace two overhead coolers - sulfur unit	72,000
1988	. Provide additional aerators to waste treatment	45,000
1989	. Improve waste treatment handling	19,000
	. Reduce MEA System corrosion - rates and chem losses - sulfur unit 19	55,000
	. Isolation block valves for overhead condenser	37,000
1990	. Improve operation of sour water stripper by upgrading local control	197,000
	. Improve desalter efficiency - reduce CN in effluent	36,000
	. Increase aeration capacity	37,000
	. Upgrade wastewater treatment system (New clarifier, aeration, tank, blowers, new lines, larger pumps, controls)	4,290,000

TABLE 2-1

WASTE TREATMENT MODIFICATIONS AND OPERATION COSTS
(continued)

Year		Project	Cost
1991	.	Increase vent line size on stripper tower	$ 62,000
	.	Eliminate stormwater basin - engineering study	113,000
1992	.	Improve oil/water separator efficiency	57,000
		TOTAL	$7,365,000
Ongoing	.	Wastewater segregation	7,300,000
Ongoing	.	New process water storage tanks	5,500,000
		TOTAL	$12,800,000

2.4 Applicable Regulations

UNO-VEN discharges effluent from the wastewater treatment plant into the Ship Canal. The plant's discharge quality is permitted under a National Pollutant Discharge Elimination System (NPDES) permit issued by the Illinois Environmental Protection Agency (IEPA). The Ship Canal is classified as a secondary contact water under Title 35: Environmental Protection; Subtitle C: Water Pollution; Chapter I: Pollution Control Board; Part 302: Subpart D. A secondary contact water is defined as a water:

> . . . not suited for general use activities but which will be appropriate for all secondary contact uses and which will be capable of supporting an indigenous aquatic life limited only by the physical configuration of the body of water, characteristics and origin of the water and the presence of contaminants in the amounts that do not exceed the water quality standards listed in Subpart D.

The regulations establish water quality standards for secondary contact waters under Subpart D. No discharger shall discharge effluent such that it causes the receiving stream to exceed the water quality standard. Water quality standards are generally established as maximum limits. Section 302.407 limits the water quality for un-ionized ammonia concentration in a secondary contact water to 0.1 mg/l. Un-ionized ammonia is a function of the ammonia concentration, pH and temperature. The 0.1 mg/l as un-ionized ammonia is based upon consideration of the 96-hour LC_{50} value for fish species presently found in Metropolitan Water Reclamation District of Greater Chicago waterways (Huff & Huff, Inc., 1992).

The Illinois regulations also include general effluent limitations for discharges to State Waters. These standards are given in Part 304: Effluent Standards; Subpart A: General Effluent Standards. Section 304.122 contains the effluent standards for ammonia discharges. Without the existing site specific rule change, UNO-VEN's monthly average effluent limit would be 3.0 mg/l, all year around.

In addition to the Illinois effluent limitation, UNO-VEN is required to achieve Best Available Treatment (BAT) limits as promulgated by the U.S. EPA in 40 CFR 419.23. The applicable BAT limitations are based upon the crude oil throughput. The current BAT limits for ammonia are 749.19 lbs/day monthly average and 1,648.21 lbs/day daily maximum, as contained in the facility's NPDES permit. BAT limits based upon the most recent five years production are 772 and 1,698 lbs/day. A comparison of the U.S. EPA model plant to UNO-VEN's plant in 1984 indicated that the UNO-VEN plant is a model treatment plant and is therefore employing the Best Available Technology that is consistent with achieving BAT standards (Aware, 1984).

In September, 1977, UNO-VEN was granted a one-year variance allowing the plant to discharge ammonia at 575 lbs/day (monthly average) and a 1,260 lbs/day maximum, contingent that UNO-VEN investigate methods for additional ammonia removal. In 1978, the IPCB granted a two-year variance to UNO-VEN acknowledging that progress in reducing the ammonia content in the discharge had been made. In June, 1980, an additional two-year variance was arranged by the IPCB allowing UNO-VEN to continue its research and source control efforts. Modifications were made to the treatment plant including increasing the efficiency of the sour water stripper, sour water oil separators, and the installation of new lime slakers.

UNO-VEN, in 1982, then requested another variance which IPCB granted for an additional two years. However, IPCB requested that UNO-VEN either submit a program to ensure compliance to Rule 304.122 by May, 1984 or consider an application for site-specific relief. UNO-VEN chose to apply for site-specific relief and appeared before the board on December 12, 1984. IPCB granted UNO-VEN's site-specific request for its discharge. UNO-VEN's discharge is currently regulated under Part 304: Effluent Standards; Subpart B: Site Specific Rules and Exceptions not of General Applicability; Section 304.213. UNO-VEN

> . . . must meet applicable Best Available Technology Economically Achievable (BAT) limitations pursuant to 4O CFR 419.23 (1985) incorporated by reference in subsection (c). . . . provisions of this Section shall terminate on December 31, 1993.

UNO-VEN currently operates under NPDES Permit No. IL0001589 (see Attachments), which expires June 1, 1993. The ammonia nitrogen (NH_3-N) is limited under this permit to 749.19 lbs/day (30 day average) and 1,648.21 lbs/day (daily maximum), the BAT limits. The permit ammonia limits derived are based on a maximum crude throughput of 143,400 bbls/day. BAT limits based on the most recent five years production are 772 lbs (30 day average) and 1,698 lbs/day (daily maximum).

2.5 Mixing Zone and Zone of Initial Dilution

Mixing Zone and Zone of Initial Dilution (ZID) are integral parts of the State's program to protect water quality. Mixing Zone and ZID are defined in Title 35: Environmental Protection; Subtitle C: Water Pollution; Chapter 1: Pollution Control Board; Part 302 Water Quality Standards; Subpart A: General Water Quality Provisions; Section 302.100 Definitions:

> " 'Mixing Zone' means a portion of the waters of the State identified as a region within which mixing is allowed pursuant to Section 302.102(d)."

Under the definitions in Section 302.100, Zone of Initial Dilution means,

> . . . a portion of a mixing zone, identified pursuant to Section 302.102(e), within which acute toxicity standards need not be met.

A Zone of Initial Dilution is a component of the mixing zone ". . . within which effluent dispersion is immediate and rapid." (Section 302.102(e)).

> "'Immediate' dispersion means an effluent's merging with receiving waters without delay in time after its discharge within close proximity of the end of the discharge pipe, so as to minimize the length of exposure time to aquatic life to undiluted effluent."

"'Rapid' dispersion means an effluent's merging with receiving waters so as to minimize the length of exposure time of aquatic life to undiluted effluent."

According to Section 302.101(a), Part 302 which contains the mixing zone and ZID regulations described above, are applicable "throughout the State as designated in 35 Ill Adm. Code 303." The secondary contact waters are designated in Part 303 (Section 303.411).

Section 302.102, defines allowable Mixing Zone areas. Section (b)(8) limits the width of the Mixing Zone to a maximum of 25% of the cross-sectional area of a stream (except for those streams where a dilution ratio of less than 3:1). UNO-VEN's average flow is 4 mgd compared to the canal 7-day, 10 year low flow of approximately 1,100 mgd (Singh and Stall, 1973). This is a ratio of 275:1, or greater dilution than 3:1. The width of the canal at UNO-VEN's outfall is 172 feet, therefore the Mixing Zone allowed would be a maximum of 43 feet, 25% of 172 feet.

Section 302.102 (b)(12) allows for the maximum area of the Mixing Zone to be no larger than the area of 26 acres. Assuming that the entire length of the Mixing Zone was 43 feet wide and based on an area of 26 acres (1,132,560 sq ft), UNO-VEN would be allowed a maximum Mixing Zone of up to 26,340 feet downstream, or five miles in length.

U.S. EPA has issued a guidance document entitled "Technical Support Document for Water Quality-based Toxics Control" (U.S. EPA, 1991). In general, the U.S. EPA policy specifies that at the edge of the Zone of Initial Dilution that the acute criteria be met and at the edge of the Mixing Zone, the water quality standards be achieved. The un-ionized ammonia water quality standard (0.1 mg/l) for the Ship Canal should be achieved at the edge of the Mixing Zone. U.S. EPA specifies for acute protection, the Criteria Maximum Concentration (CMC) for specific compounds is to be set at 0.5 times the final acute value. As explained in the U.S. EPA document:

"The CMC describes the condition under which lethality will not occur if the duration of the exposure to the CMC level is less than 1 hour." (U.S. EPA, 1991).

U.S. EPA policy also restricts the size of the ZID, and provides for alternatives for determining the size of the ZID (U.S. EPA, 1991). The pertinent alternative in UNO-VEN's case is limiting the exposure to a drifting organism to 1 hour at an average concentration not exceeding the CMC. The Technical Document suggests the collection of chemical samples, field tracer studies or modeling estimates of concentration or dilution isopleths to determine the size of the ZID (U.S. EPA, 1991).

From the above discussion of state regulations and federal policies, the ZID and Mixing Zone can be determined through actual field studies on the effluent plume. UNO-VEN appears eligible for both a ZID and Mixing Zone under federal and state criteria.

2.6 Ammonia Acute Toxicity on Indigenous Fish

Based upon the Zone of Initial Dilution regulations and policies described in the previous section, the acute toxicity of ammonia to indigenous aquatic species is an important consideration. As will be discussed in a future chapter, UNO-VEN's effluent is a surface plume, so benthic organisms will not be exposed to elevated ammonia levels from the discharge.

Fish collected by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) in 1991 in the Ship Canal at Lockport included the following (Dennison, et al., 1991):

	No.
Gizzard Shad	1
Goldfish	12
Carp	35
Green Sunfish	2
Pumpkinseed	3
Golden Shiner	2
Emerald Shiner	1
Bluegill	1

A reasonable assumption is that these same fish species would also be present near UNO-VEN's discharge, which is 4.5 miles upstream of the Lockport sampling point.

Average un-ionized ammonia Lethal Concentration Values (LC50) for the above fish, taken from U.S. EPA's "Ambient Water Quality Criteria for Ammonia - 1984" (1985) are as follows:

	Average LC50, mg/l [a/]
Golden Shiner	0.72
Green Sunfish	1.2
Pumpkinseed	0.60
Bluegill	1.4

---

a/ Where more than one study reported, mean value utilized

Using the U.S. EPA's policy of protecting the most sensitive species, the Pumpkinseed LC50 of 0.60 mg/l should be utilized. Under the U.S. EPA policy, then the Criteria Maximum Concentration (CMC) is to be set at 0.5 times the LC50 of 0.60 mg/l, or in this case, 0.30 mg/l. This then is the un-ionized ammonia concentration that is to be achieved at the edge of the ZID.

CHAPTER 3

EFFLUENT WATER QUALITY

3.1 Introduction

The UNO-VEN Refinery processes crude oil into various petroleum products including gasoline, diesel fuel, aviation fuel, petrochemical solvents, and petroleum coke. UNO-VEN's wastewater is different from domestic wastewater in terms of chemical parameters and their concentrations, in part because of the high nitrogen and sulfur content of the crude oil processed and the water conservation practices. Since 1977, the refinery has implemented a variety of programs, both in-plant and end-of-pipe, to reduce effluent ammonia loadings. Results of these efforts and the resultant effluent quality are described herein.

As discussed in Chapter 2, the production of refined oil has increased 25% over the last eight years, accompanied by a 157% increase in the nitrogen content of the crude oil. These two parameters have caused an increased ammonia loading on the treatment facilities at the refinery.

3.2 Influent and Effluent Monitoring Database

UNO-VEN monitors several chemical parameters in both the water intake to the refinery as well as the discharge from the refinery. Intake water is taken from the Ship Canal and used primarily for utility and cooling water. The water intake is located 400 feet upstream of UNO-VEN's discharge and is representative of upstream water quality. The influent and effluent parameters monitored by UNO-VEN are listed in Table 3-1.

Data summarized herein for the period of January, 1984 to September, 1992 were collected by UNO-VEN; twice per week for most constituents in the effluent and once per week for the intake water constituents. Data from 1978-1983 were obtained from the

TABLE 3-1

PARAMETERS MONITORED BY UNO-VEN

Parameter	Influent	Effluent
Flow, mgd	X	X
pH	X	X
Temperature	X	X
Total Suspended Solids	X	X
COD	X	X
BOD	X	X
$CBOD_5$	X	--
Chromium $^{+6}$	X	X
Total Chromium	X	X
Oil & Grease	X	X
Ammonia - Nitrogen	X	X
Phenol	X	X
Total Cyanide	X	X
Sulfide	X	X
Total Dissolved Solids	X	X
Fluoride	X	X
Nitrite (as N)	X	--
Free Cyanide	X	--
Methylene Blue Active Substances (MBAS) and Foam	X	X

previous report, "Environmental Assessment of Ammonia Concentrations in the Wastewater Discharge of Union Oil Company, Chicago Refinery" (Huff and Huff, 1984).

The raw data from January, 1985 to September, 1992 are included in the Attachments, along with computed monthly average values. Monthly data from 1984 is also included in the Attachments.

3.3 Effluent Quality

Figure 3-1 presents the annual average and maximum monthly average ammonia levels in UNO-VEN's effluent since 1978. From 1978 through June, 1984, the annual averages ranged from 290 to 509 pounds per day, with no clear trend. The maximum month values during this same period of time ranged from 503 pounds per day ammonia to 567 pounds per day. Since 1986, when the ammonia levels peaked, there has been a declining trend in the ammonia discharged. Since 1989, the annual average has been less than 100 pounds per day and the maximum monthly discharge has been 259 pounds per day over the same period. From 1986 to 1991, the annual average ammonia discharged by UNO-VEN has declined 85%, from 493 lbs/day in 1986 to 72 lbs/day in 1991, with further improvement in 1992 apparent.

Since 1985, the volume of UNO-VEN's discharge has ranged from 2.99 mgd to 4.22 mgd on an annual average basis. Figure 3-2 presents the annual average flow rates which shows a generally increasing trend since 1985, with the current discharge rate of 4.0 mgd 25% higher than the rate in 1986. Therefore, the 85% of the reduction in the pounds of ammonia discharge is due to improved removal efficiency and not due to lower flow rates.

Table 3-2 summarizes the annual average, monthly maximum, and daily maximum ammonia effluent concentrations since 1984. Effluent quality, as measured by the monthly maximum and daily maximum concentrations, has improved similarly to the annual average ammonia discharge. The monthly maximum was decreased 88% from 1986 to 1991 and the

FIGURE 3-1

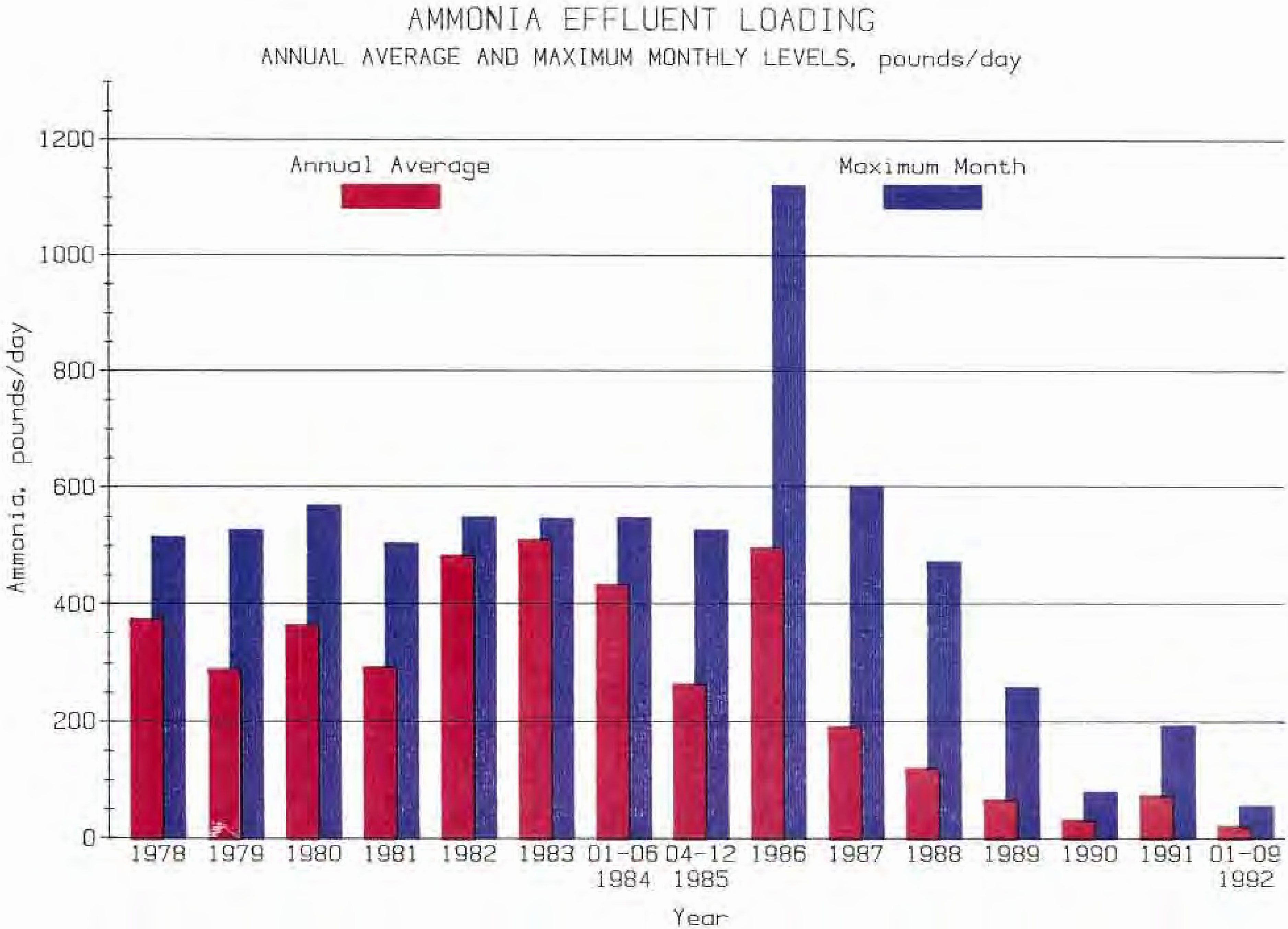
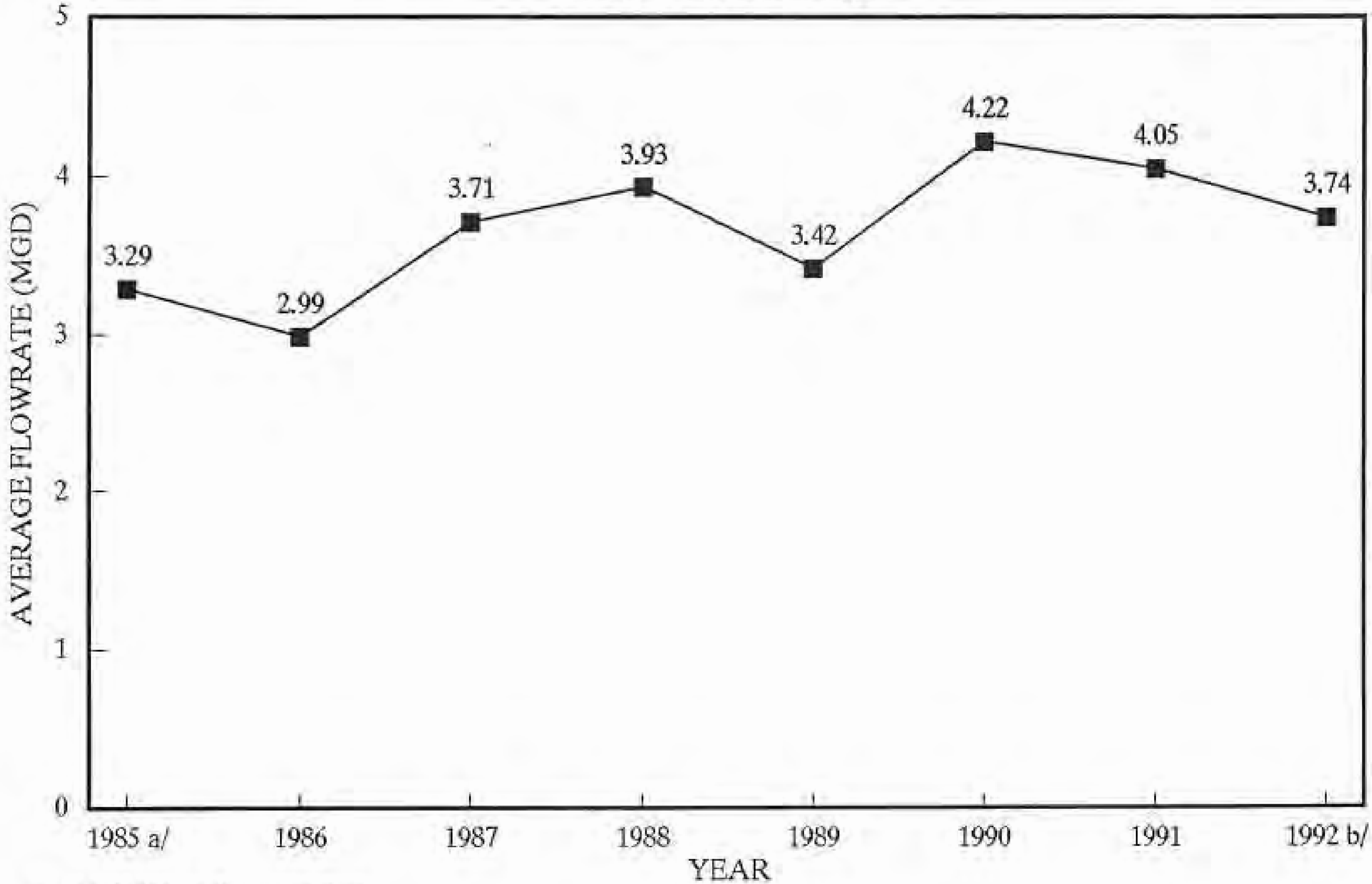

AMMONIA EFFLUENT LOADING
ANNUAL AVERAGE AND MAXIMUM MONTHLY LEVELS, pounds/day
Annual Average
Maximum Month
Ammonia, pounds/day
0
200
400
600
800
1000
1200
1978
1979
1980
1981
1982
1983
01-06 1984
04-12 1985
1986
1987
1988
1989
1990
1991
01-09 1992
Year

FIGURE 3-2

YEARLY AVERAGE WASTEWATER FLOWRATE (MGD)

UNO–VEN REFINERY



a/ April through December
b/ January through September

TABLE 3-2

UNO-VEN EFFLUENT AMMONIA DISCHARGED
SINCE 1984

YEAR	ANNUAL AVG. AMMONIA CONC., mg/l	MONTHLY MAX. AMMONIA CONC., mg/l	DAILY MAX. AMMONIA CONC., mg/l
1984 a/	22.4	41.0	52.0
1985 b/	9.9	21.3	30.0
1986	22.2	57.3	78.0
1987	6.6	23.6	29.0
1988	3.9	16.2	23.0
1989	2.8	10.0	26.0
1990	0.9	2.6	11.6
1991	2.4	6.7	21.9
1992 c/	0.7	1.8	10.7

a/ January through June
b/ April through December
c/ January through September

and the daily maximum has declined 72% for the same time period. Figure 3-3 depicts the change in effluent ammonia concentrations with time. From 1986 to 1991, the annual average ammonia concentration has declined from 22.2 to 2.4 mg/l. This reduction has occurred despite the higher nitrogen in the crude, higher crude oil throughput, and the increase in the wastewater volume. As is apparent from Figure 3-3, the percentage of the time nitrification has been achieved has increased over the past five years.

Table 3-3 presents a listing of effluent ammonia levels, by months, since April, 1985. The effluent ammonia trend clearly shows that UNO-VEN's treatment plant is capable of nitrification. However, there are periods, despite the upgradings described in Chapter 2, when a 3.0 mg/l monthly average ammonia and a 6.0 mg/l daily maximum ammonia cannot be achieved.

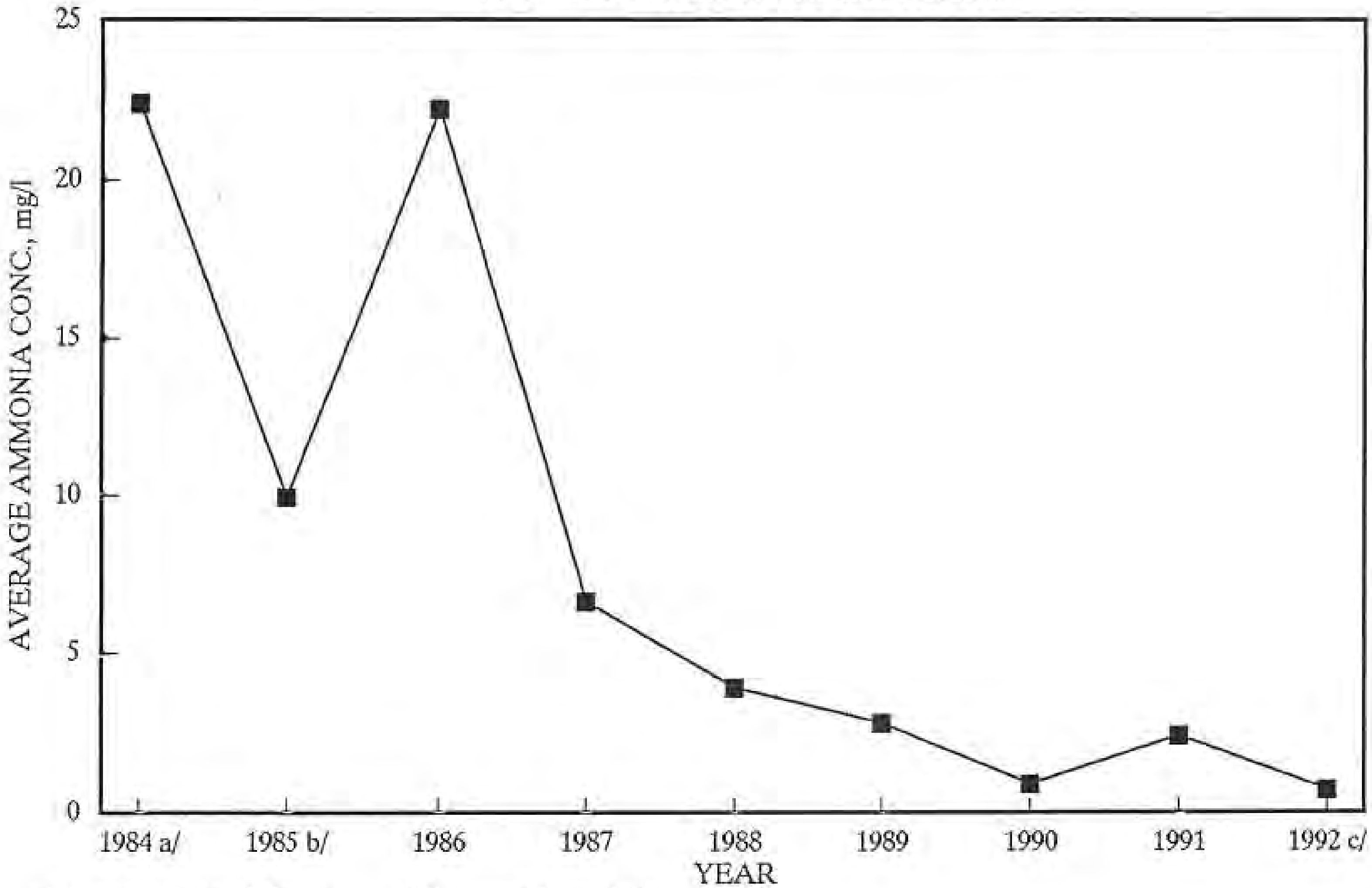
3.4 Un-ionized Effluent Ammonia Levels

UNO-VEN discharges into the Ship Canal, a secondary contact waterway. The un-ionized ammonia level in Ship Canal is regulated by the IPCB and not total ammonia. As discussed in Chapter 2, the edge of the Zone of Initial Dilution (ZID) must achieve a certain un-ionized concentration (0.30 mg/l). To address this water quality issue, UNO-VEN's ammonia concentrations have been converted to un-ionized ammonia. The un-ionized ammonia in the effluent was calculated using monthly average data for pH, temperature and ammonia concentration. These data are presented in Table 3-4 from 1989 to September, 1992, which can be considered representative of what the refinery is currently capable of achieving. Figure 3-4 illustrates the average effluent un-ionized ammonia compared to the secondary contact water quality standard as well as the Criteria Maximum Concentration (CMC) derived in Chapter 2. Since 1989, the peak monthly average un-ionized ammonia was 0.264 mg/l in July, 1991, below the CMC of 0.30 mg/l, required to be achieved at the edge of the ZID.

FIGURE 3-3

ANNUAL AVERAGE EFFLUENT AMMONIA CONC., mg/l

UNO–VEN EFFLUENT TO S&S CANAL



a/ January through June
c/ April through December
c/ January through September

TABLE 3-3
UNO-VEN EFFLUENT AMMONIA LEVELS, BY MONTH

DATE	AVG FLOW, a/ mgd	AVG NH3-N, mg/l	AVG NH3-N, lbs/day
APR 1985	3.31	3.2	86
MAY	2.31	3.6	69
JUN	2.76	15.0	346
JUL	3.00	21.3	525
AUG	3.63	3.3	83
SEP	3.08	2.9	75
OCT	3.11	14.3	385
NOV	5.05	8.1	302
DEC	3.33	15.4	502
JAN 1986	1.88	40.1	664
FEB	2.54	57.3	1121
MAR	3.14	40.9	1052
APR	2.10	40.0	597
MAY	3.68	17.6	514
JUN	3.39	3.0	71
JUL	3.56	14.1	449
AUG	3.03	15.1	361
SEP	3.38	4.9	141
OCT	3.77	8.0	204
NOV	3.01	9.5	228
DEC	3.60	18.4	539
JAN 1987	3.50	15.0	440
FEB	3.24	23.6	600
MAR	3.07	11.9	325
APR	3.15	9.6	244
MAY	2.76	2.1	49
JUN	3.22	2.5	75
JUL	4.59	11.5	381
AUG	4.94	0.2	8
SEPT	3.87	0.1	4
OCT	3.27	2.9	67
NOV	4.03	2.6	56
DEC	4.87	1.1	45
JAN 1988	4.65	0.6	25
FEB	4.35	4.1	120
MAR	4.24	1.4	56
APR	4.30	7.7	257
MAY	3.78	5.8	155
JUN	3.39	16.2	472
JUL	2.93	1.2	26
AUG	3.51	0.6	19
SEP	2.90	1.3	27
OCT	4.17	1.0	31
NOV	4.19	5.0	178
DEC	4.23	3.3	90
JAN 1989	3.11	3.8	115
FEB	3.91	10.0	259
MAR	4.67	0.7	26
APR	2.04	8.5	97
MAY	2.54	0.4	7
JUN	3.56	0.6	13
JUL	3.32	4.6	117
AUG	3.33	2.5	80
SEP	3.52	0.5	13
OCT	3.09	1.0	27
NOV	3.71	0.8	24
DEC	2.98	0.8	24

TABLE 3-3
UNO-VEN EFFLUENT AMMONIA LEVELS, BY MONTH

DATE	AVG FLOW, a/ mgd	AVG NH3-N, mg/l	AVG NH3-N, lbs/day
JAN 1990	4.65	0.7	19
FEB	4.70	1.5	68
MAR	5.54	1.2	50
APR	3.81	0.6	25
MAY	5.17	0.2	10
JUN	3.42	0.8	20
JUL	4.19	0.4	13
AUG	3.35	1.9	53
SEP	2.74	0.3	6
OCT	4.06	0.6	17
NOV	4.17	0.3	10
DEC	4.70	2.6	79
JAN 1991	4.40	0.9	29
FEB	4.12	0.3	8
MAR	4.34	0.1	5
APR	4.72	0.3	16
MAY	4.34	0.8	28
JUN	3.58	5.1	113
JUL	3.14	6.7	193
AUG	3.37	5.1	168
SEP	3.08	0.6	17
OCT	4.29	4.0	116
NOV	4.88	4.9	161
DEC	4.12	0.9	26
JAN 1992	3.78	0.5	13
FEB	4.10	0.6	21
MAR	4.13	0.3	10
APR	3.90	0.4	13
MAY	3.20	0.3	8
JUN	3.46	0.2	5
JUL	3.53	1.8	52
AUG	3.44	1.8	55
SEP	4.08	0.2	7
1985-1992			
MINIMUM	1.88	0.1	4
AVERAGES	3.67	6.3	159
MAXIMUM	5.54	57.3	1121 b/
1989-1992			
MINIMUM	2.04	0.1	5
AVERAGES	3.83	1.8	50
MAXIMUM	5.54	10.0	259 b/

a/ FLOWRATE IS MONITORED DAILY
b/ MAXIMUM MONTHLY AVERAGE

TABLE 3-4

UNO-VEN EFFLUENT UN-IONZED AMMONIA

DATE	FLOW, mgd	pH	MONTHLY AVERAGE AMMONIA, mg/l	TEMP., deg. C	AVERAGE UN-IONIZED AMMONIA, mg/l
JAN 1989	3.11	7.4	3.8	10.6	0.020
FEB	3.91	7.4	10.0	15.6	0.075
MAR	4.67	7.2	0.7	19.4	0.004
APR	2.04	7.6	8.5	20.0	0.140
MAY	2.54	7.7	0.4	21.1	0.009
JUN	3.56	7.6	0.6	27.2	0.016
JUL	3.32	7.7	4.6	28.3	0.169
AUG	3.33	7.2	2.5	25.6	0.025
SEP	3.52	7.2	0.5	25.0	0.005
OCT	3.09	7.2	1.0	21.7	0.007
NOV	3.71	7.2	0.8	18.9	0.005
DEC	2.98	7.3	0.8	14.4	0.004
JAN 1990	4.65	7.0	0.7	18.3	0.003
FEB	4.70	7.3	1.5	17.8	0.011
MAR	5.44	7.3	1.2	18.9	0.009
APR	3.81	7.2	0.6	21.7	0.004
MAY	5.17	7.3	0.2	22.8	0.002
JUN	3.42	7.4	0.8	26.7	0.013
JUL	4.19	7.2	0.4	28.9	0.005
AUG	3.35	7.1	1.9	29.4	0.019
SEP	2.74	7.6	0.3	26.7	0.008
OCT	4.06	7.2	0.5	20.6	0.003
NOV	4.17	7.1	0.3	17.8	0.001
DEC	4.70	7.0	2.6	18.3	0.010
JAN 1991	4.40	7.2	0.9	16.7	0.005
FEB	4.12	7.5	0.3	17.8	0.003
MAR	4.34	7.3	0.1	18.9	0.001
APR	4.72	6.8	0.3	22.2	0.001
MAY	4.34	7.5	0.8	28.3	0.019
JUN	3.58	7.6	5.1	30.0	0.167
JUL	3.14	7.7	6.7	29.4	0.264
AUG	3.37	7.5	5.1	29.4	0.129
SEP	3.08	7.4	0.4	26.7	0.007
OCT	4.29	7.4	4.0	21.7	0.047
NOV	4.88	7.3	4.9	19.4	0.039
DEC	4.12	7.4	0.9	17.2	0.008
JAN 1992	3.78	7.1	0.5	15.0	0.002
FEB	4.10	7.3	0.6	19.4	0.005
MAR	4.13	7.4	0.3	20.0	0.003
APR	3.90	7.8	0.4	21.7	0.012
MAY	3.20	7.6	0.3	25.0	0.007
JUN	3.46	7.5	0.2	28.3	0.005
JUL	3.53	7.3	1.6	30.6	0.028
AUG	3.44	7.3	1.8	29.4	0.029
SEP	4.08	7.3	0.2	27.2	0.003

$$U = \frac{N}{0.94412\ (1+10^{\wedge}x)+.0559}$$

$$x = 0.09018 + \frac{2729.12}{(T+273.16)} - pH$$

U=UN-IONIZED AMMONIA, mg/l
N=AMMONIA NITROGEN, mg/l
T=TEMPERATURE, deg C

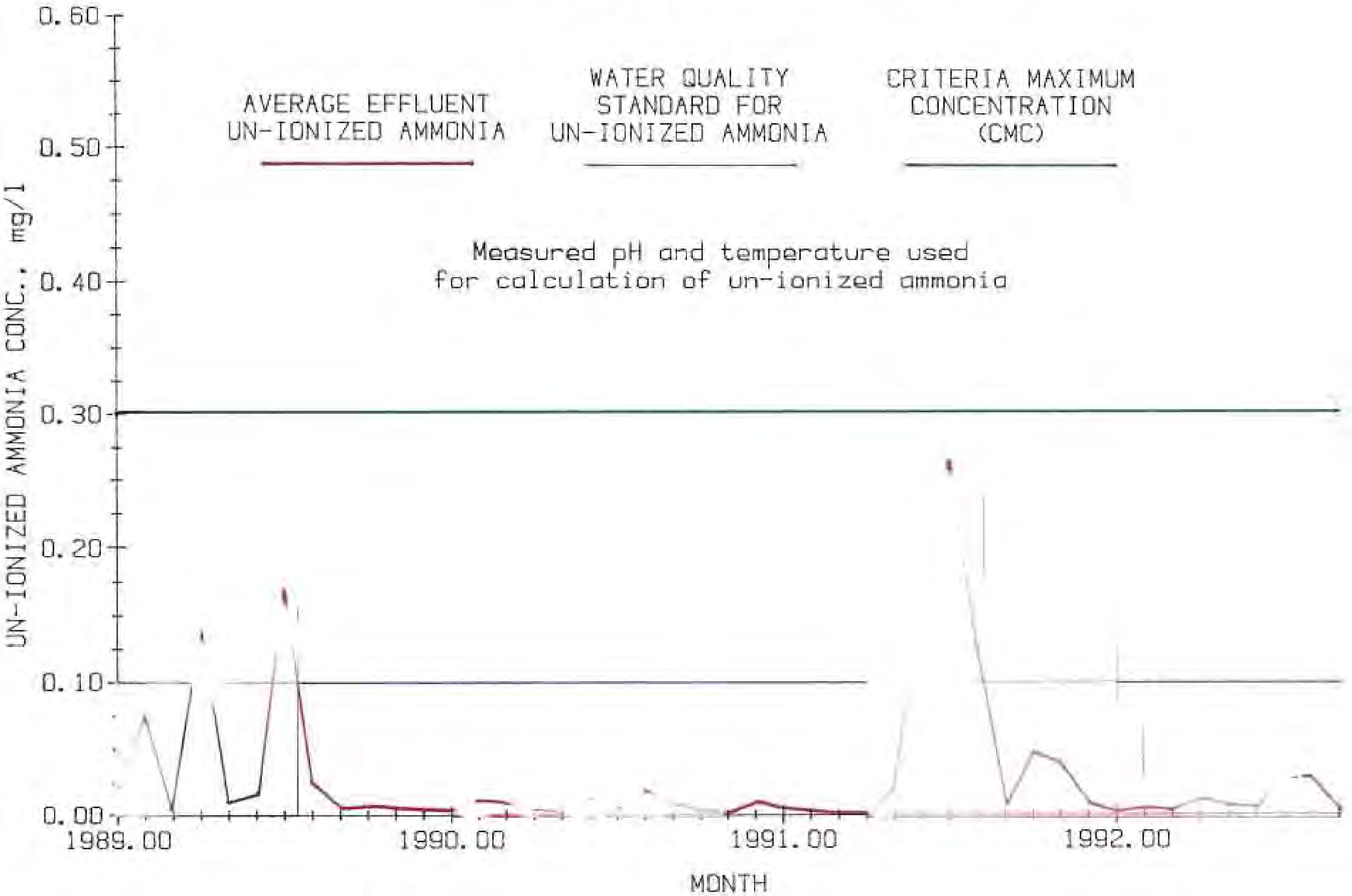
NOTE: mg/l = ppm

FIGURE 3-4

MONTHLY AVERAGE UN-IONIZED AMMONIA, mg/l

UNO-VEN EFFLUENT TO SHIP CANAL

1989 - SEPT. 1992



On a daily basis, the effluent un-ionized concentration was calculated for the five months when the average un-ionized ammonia in the discharge exceeded 0.1 mg/l standard. (April and July 1989 and June, July, and August 1991). Table 3-5 presents these data. The peak calculated un-ionized discharge was 1.006 mg/l on July 6, 1989. Thus, to achieve the CMC of 0.30 mg/l, the effluent must be diluted:

$$\text{Required Dilution Ratio} = \frac{\text{Maximum Effluent Value}}{\text{CMC}} = \frac{1.006 \text{ mg/l}}{0.30 \text{ mg/l}} = 3:1$$

in the Zone of Initial Dilution.

3.5 Influent Ammonia Levels

UNO-VEN uses water from the Ship Canal for its primary water source. The intake is upstream of UNO-VEN's outfall and is therefore not effected by the effluent quality. Two of the major uses for the influent wastewater are utilities and cooling water. The average influent flow rate is 4.4 mgd compared to the effluent flow rate of 3.8 mgd for the 1989 to 1992 time period. The resulting reduction in flow rate is due to the evaporation from the cooling towers.

Table 3-6 summarizes the ammonia levels and flow rate in the intake water since 1985, by month. Since 1987, an average 85.9 pounds per day of ammonia has been withdrawn from the Ship Canal.

Figure 3-5 depicts the average ammonia concentrations in the intake water since 1985. A general declining trend is apparent since 1987, when the ammonia peaked at 3.8 mg/l, declining to 1.8 mg/l in 1990 and 2.1 mg/l in 1991, or approximately a 50% reduction in ammonia. Through the first nine months of 1992, the Ship Canal ammonia has averaged 1.1 mg/l.

TABLE 3-5

UNO-VEN UN-IONIZED AMMONIA FOR MONTHS WITH MONTHLY AVERAGES EXCEEDING THE WATER QUALITY STANDARD

DATE	pH	NH3-N, mg/l	TEMP., deg. C	UN-IONIZED AMMONIA mg/l	MONTHLY AVERAGE, mg/l
4/4/89	7.1	0.6	21	0.003	
4/6/89	7.0	0.9	19	0.004	
4/11/89	7.8	8.6	16	0.167	
4/13/89	7.8	12.2	17	0.257	
4/18/89	7.8	16.2	19	0.386	
4/20/89	7.9	16.0	19	0.496	
4/25/89	7.8	9.1	23	0.297	
4/27/89	7.7	4.7	24	0.132	0.22
7/5/89	8.2	6.5	31	0.826	
7/6/89	8.3	6.5	31	1.006	
7/11/89	7.9	2.5	32	0.176	
7/13/89	7.9	3.1	27	0.158	
7/18/89	7.3	0.8	27	0.011	
7/20/89	7.4	0.4	26	0.006	
7/25/89	7.1	1.3	27	0.011	
7/27/89	7.2	5.3	27	0.056	0.28
6/4/91	6.6	1.2	31	0.004	
6/6/91	7.3	14.6	28	0.218	
6/11/91	7.4	16.1	30	0.337	
6/13/91	7.6	6.6	29	0.208	
6/18/91	8.0	0.4	30	0.031	
6/20/91	7.8	0.3	31	0.016	
6/25/91	8.0	1.6	30	0.125	
6/27/91	8.0	0.2	30	0.016	0.12
7/2/91	8.3	0.4	30	0.058	
7/3/91	8.0	0.4	30	0.031	
7/9/91	7.8	0.4	32	0.024	
7/11/91	7.7	0.4	32	0.018	
7/16/91	7.4	9.6	31	0.209	
7/18/91	7.2	21.9	32	0.338	
7/24/91	7.4	10.3	26	0.159	
7/25/91	8.1	10.3	27	0.808	
7/30/91	7.4	2.8	28	0.050	0.19
8/1/91	8.1	2.8	28	0.236	
8/6/91	7.3	10.6	29	0.164	
8/8/91	6.9	20.8	29	0.129	
8/13/91	7.4	5.7	29	0.111	
8/15/91	7.9	2.2	30	0.139	
8/20/91	7.2	0.7	29	0.009	
8/22/91	7.4	0.3	29	0.006	
8/27/91	7.6	0.2	28	0.006	
8/29/91	7.7	0.1	32	0.005	0.09

TABLE 3-6

UNO-VEN INFLUENT FROM S&S CANAL

DATE	AVG FLOW, mgd	AVG NH3-N, mg/l	AVG NH3-N, lbs/day
APR 1985	2.82	3.1	72.9
MAY	3.61	5.0	150.5
JUN	3.96	4.2	138.7
JUL		2.3	
AUG	4.06	2.7	91.4
SEP	4.24	2.2	77.8
OCT	3.90	2.2	71.6
NOV	3.88	2.3	74.4
DEC	4.74	2.9	114.6
JAN 1986	3.71	4.5	139.2
FEB	3.47	4.3	124.4
MAR	3.44	6.4	183.6
APR	4.49	6.3	235.9
MAY	4.75	4.9	194.1
JUN	5.08	2.6	110.2
JUL	5.02	2.3	96.3
AUG	5.60	2.0	93.4
SEP	5.60	2.1	98.1
OCT	4.52	1.3	49.0
NOV	4.30	2.9	104.0
DEC	4.10	4.6	157.3
JAN 1987	4.36	4.1	149.1
FEB	4.58	6.3	240.6
MAR	4.25	5.9	209.1
APR	3.25	4.4	119.3
MAY	4.17	4.9	170.4
JUN	4.55	3.3	125.2
JUL	4.75	2.0	79.2
AUG	4.38	1.3	47.5
SEP	4.31	1.5	53.9
OCT	4.53	3.5	132.2
NOV	4.44	4.6	170.3
DEC	4.55	3.4	129.0
JAN 1988	4.33	3.2	115.6
FEB	5.22	5.2	226.4
MAR	4.88	6.7	272.7
APR	4.63	3.8	146.7
MAY	5.01	3.0	125.4
JUN	4.32	1.1	39.6
JUL	4.65	1.0	38.8
AUG	4.74	0.9	35.6
SEP	4.65	0.5	19.4
OCT	4.71	1.9	74.6
NOV	4.37	1.0	36.4
DEC	4.83	1.4	56.4

TABLE 3–6

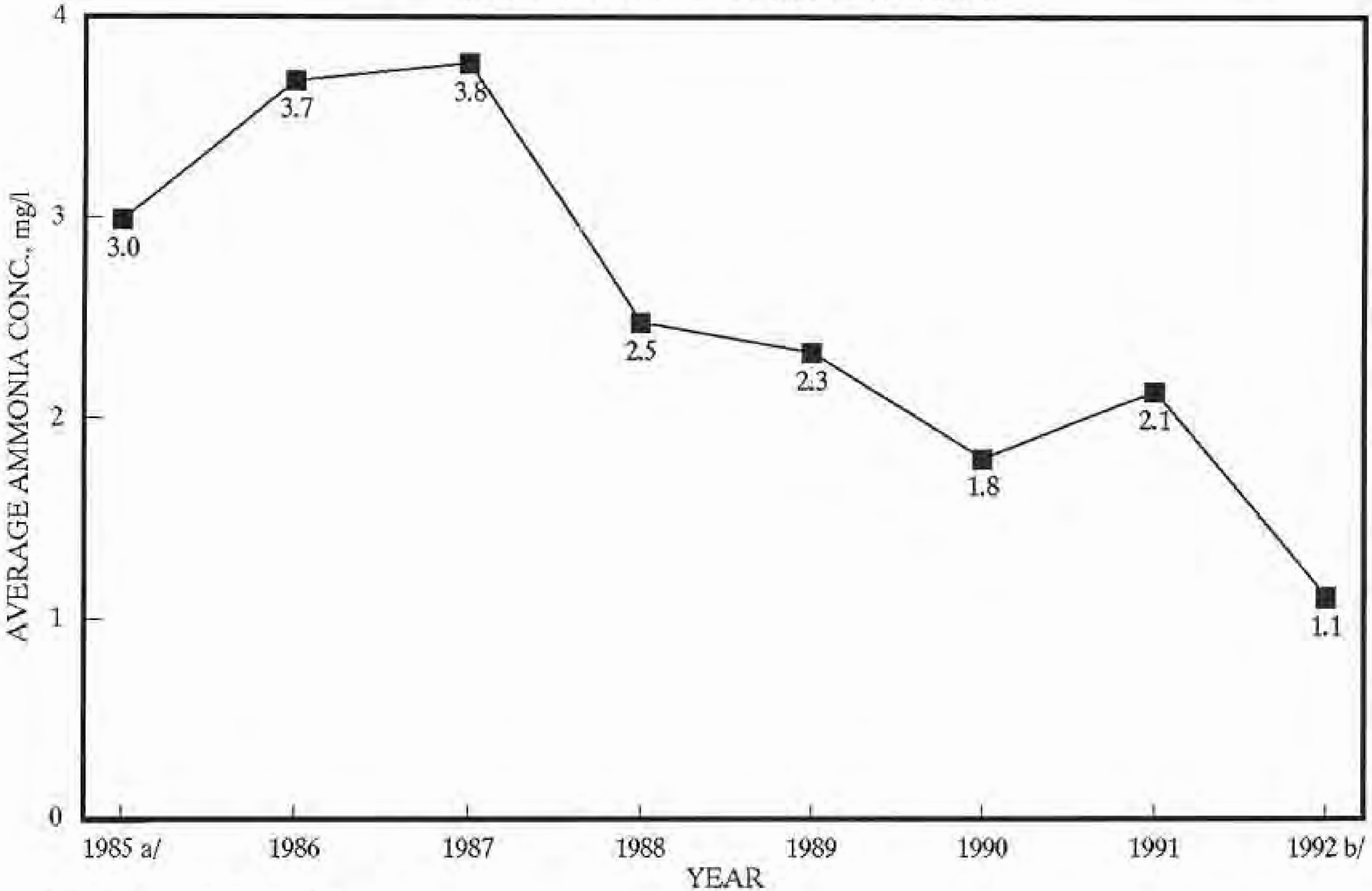
UNO–VEN INFLUENT FROM S&S CANAL

DATE	AVG FLOW, mgd	AVG NH3–N, mg/l	AVG NH3–N, lbs/day
JAN 1989	4.24	3.2	113.2
FEB	4.74	2.9	114.6
MAR	5.11	5.0	213.1
APR	2.86	2.2	52.5
MAY	2.10	2.5	43.8
JUN	3.84	1.6	51.2
JUL	3.23	2.4	64.7
AUG	5.06	0.8	33.8
SEP	3.00	1.2	30.0
OCT	4.52	1.9	71.6
NOV	4.61	2.0	76.9
DEC	4.71	2.2	86.4
JAN 1990	4.97	5.2	215.5
FEB	5.06	2.8	118.2
MAR	4.66	1.8	70.0
APR	4.87	2.4	97.5
MAY	3.57	1.3	38.7
JUN	4.37	1.7	62.0
JUL	4.24	1.1	38.9
AUG	4.09	0.5	17.1
SEP	4.21	0.4	14.0
OCT	4.45	1.4	52.0
NOV	4.26	1.3	46.2
DEC	4.38	1.6	58.4
JAN 1991	4.94	2.8	115.4
FEB	4.64	3.2	123.8
MAR	4.50	1.8	67.6
APR	4.30	1.1	39.4
MAY	4.29	1.8	64.4
JUN	3.27	1.7	46.4
JUL	4.58	1.2	45.8
AUG	4.51	3.6	135.4
SEP	4.42	2.0	73.7
OCT	3.99	3.3	109.8
NOV	4.26	1.7	60.4
DEC	4.43	1.3	48.0
JAN 1992	4.94	1.6	65.9
FEB	4.93	2.7	111.0
MAR	4.89	1.1	44.9
APR	4.73	1.2	47.3
MAY	4.65	0.4	11.6
JUN	4.70	1.1	43.1
JUL	4.71	0.8	31.4
AUG	4.69	0.7	27.4
SEP	4.01	0.3	17.5
AVERAGES			
1985–1992	4.37	2.6	93.3
1987–1992	4.41	2.3	85.9
1989–1992	4.35	1.9	69.1

FIGURE 3-5

YEARLY AVG. INFLUENT AMMONIA CONC., mg/l

UNO-VEN INFLUENT FROM S&S CANAL



a/ April through December
b/ January through September

3.6 Net Ammonia Loading

As noted in the previous section, UNO-VEN since 1987 has withdrawn an average of 85.9 pounds of ammonia from the Ship Canal per day. This is a significant quantity when compared to the ammonia discharged by UNO-VEN. Table 3-7 compares the intake and discharge ammonia levels, by month and annually since 1985.

From Table 3-7, since 1989, UNO-VEN has removed more pounds of ammonia from the Ship Canal than the refinery has discharged on an annual basis. Figure 3-6 graphically depicts the influent/effluent ammonia levels on an annual basis.

On a monthly average basis, UNO-VEN has removed more ammonia than it has discharged to the canal 31 out of the last 45 months (since 1989), or 69% of the time. The peak net ammonia discharged since 1989 was 147 pounds per day in July, 1991.

TABLE 3-7

NET AMMONIA LOAD TO S&S CANAL

DATE	EFFLUENT AVG NH_3-N, lbs/day	INFLUENT AVG NH_3-N, lbs/day	NET DISCHARGE EFFLUENT, lbs/day	YEARLY AVG EFFLUENT, lbs/day	YEARLY AVG INFLUENT, lbs/day	YEARLY AVG NET EFF., lbs/day
APR 1985	86.0	72.9	13.1			
MAY	69.0	150.5	-81.5			
JUN	346.0	138.7	207.3			
JUL	525.0		525.0			
AUG	83.0	91.4	-8.4			
SEP	75.0	77.8	-2.8			
OCT	385.0	71.6	313.4			
NOV	302.0	74.4	227.6			
DEC	502.0	114.6	387.4	263.7	99.0	175.7
JAN 1986	664.0	139.2	524.8			
FEB	1121.0	124.4	996.6			
MAR	1052.0	183.6	868.4			
APR	597.0	235.9	361.1			
MAY	514.0	194.1	319.9			
JUN	71.0	110.2	-39.2			
JUL	449.0	96.3	352.7			
AUG	361.0	93.4	267.6			
SEP	141.0	98.1	42.9			
OCT	204.0	49.0	155.0			
NOV	228.0	104.0	124.0			
DEC	539.0	157.3	381.7	495.1	132.1	363.0
JAN 1987	440.0	149.1	290.9			
FEB	600.0	240.6	359.4			
MAR	325.0	209.1	115.9			
APR	244.0	119.3	124.7			
MAY	49.0	170.4	-121.4			
JUN	75.0	125.2	-50.2			
JUL	381.0	79.2	301.8			
AUG	8.0	47.5	-39.5			
SEP	4.0	53.9	-49.9			
OCT	67.0	132.2	-65.2			
NOV	56.0	170.3	-114.3			
DEC	45.0	129.0	-84.0	191.2	135.5	55.7
JAN 1988	25.0	115.6	-90.6			
FEB	120.0	226.4	-106.4			
MAR	56.0	272.7	-216.7			
APR	257.0	146.7	110.3			
MAY	155.0	125.4	29.6			
JUN	471.0	39.6	431.4			
JUL	16.0	38.8	-22.8			
AUG	19.0	35.6	-16.6			
SEP	27.0	19.4	7.6			
OCT	31.0	74.6	-43.6			
NOV	178.0	36.4	141.6			
DEC	90.0	56.4	33.6	120.4	99.0	21.5

TABLE 3-7

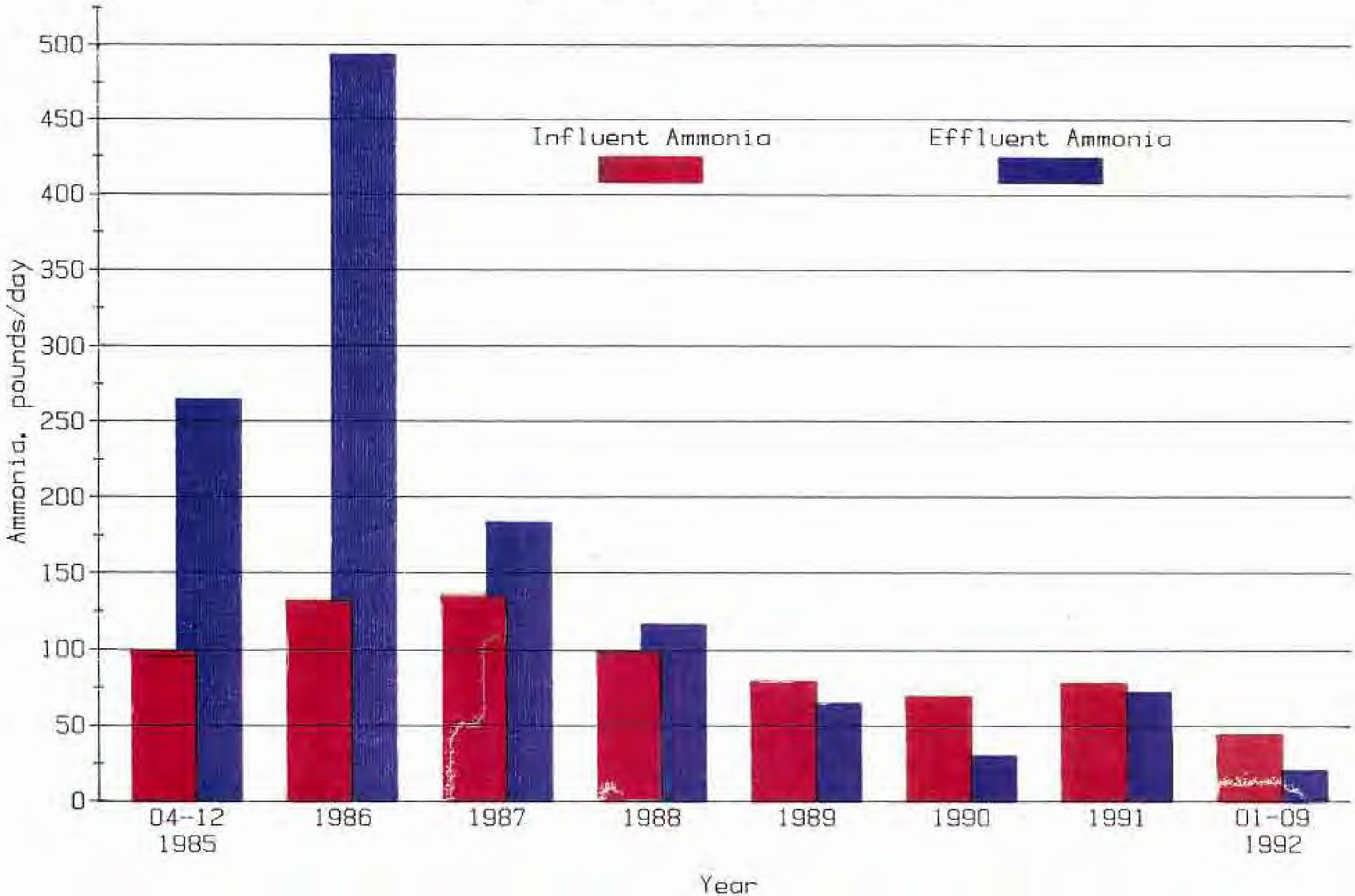
NET AMMONIA LOAD TO S&S CANAL

DATE	EFFLUENT AVG NH3-N, lbs/day	INFLUENT AVG NH3-N, lbs/day	NET DISCHARGE EFFLUENT, lbs/day	YEARLY AVG EFFLUENT, lbs/day	YEARLY AVG INFLUENT, lbs/day	YEARLY AVG NET EFF., lbs/day
JAN 1989	115.0	113.2	1.8			
FEB	259.0	114.6	144.4			
MAR	16.0	213.1	-197.1			
APR	97.0	52.5	44.5			
MAY	7.0	43.8	-36.8			
JUN	13.0	51.2	-38.2			
JUL	117.0	64.7	52.3			
AUG	80.0	33.8	46.2			
SEP	13.0	30.0	-17.0			
OCT	27.0	71.6	-44.6			
NOV	24.0	76.9	-52.9			
DEC	24.0	86.4	-62.4	66.0	79.3	-13.3
JAN 1990	19.0	215.5	-196.5			
FEB	68.0	118.2	-50.2			
MAR	50.0	70.0	-20.0			
APR	25.0	97.5	-72.5			
MAY	10.0	38.7	-28.7			
JUN	20.0	62.0	-42.0			
JUL	13.0	38.9	-25.9			
AUG	53.0	17.1	35.9			
SEP	6.0	14.0	-8.0			
OCT	17.0	52.0	-35.0			
NOV	10.0	46.2	-36.2			
DEC	79.0	58.4	20.6	30.8	69.0	-38.2
JAN 1991	29.0	115.4	-86.4			
FEB	8.0	123.8	-115.8			
MAR	5.0	67.6	-62.6			
APR	16.0	39.4	-23.4			
MAY	28.0	64.4	-36.4			
JUN	113.0	46.4	66.6			
JUL	193.0	45.8	147.2			
AUG	168.0	135.4	32.6			
SEP	17.0	73.7	-56.7			
OCT	116.0	109.8	6.2			
NOV	161.0	60.4	100.6			
DEC	26.0	48.0	-22.0	73.3	77.5	-4.2
JAN 1992	13.0	65.9	-52.9			
FEB	21.0	111.0	-90.0			
MAR	10.0	44.9	-34.9			
APR	13.0	47.3	-34.3			
MAY	8.0	11.6	-3.6			
JUN	5.0	43.1	-38.1			
JUL	52.0	31.4	20.6			
AUG	55.0	27.4	27.6			
SEP	7.0	17.5	-10.5	20.4	44.5	-24.0
AVERAGES						
1985-1992	158.7	93.3	66.4			
1989-1992	49.5	69.1	-19.7			

FIGURE 3-6

AVERAGE INFLUENT AND EFFLUENT AMMONIA, lbs/day

UNO-VEN ON S&S CANAL



CHAPTER 4

LOCALIZED IMPACTS OF UNO-VEN'S DISCHARGE

4.1 Introduction

In order to assess the impact of UNO-VEN's discharge, both the localized impact as well as the river basin impact must be evaluated. This chapter focuses on the localized impact of the discharge on the Chicago Sanitary & Ship Canal in the vicinity of UNO-VEN's outfall.

To characterize the localized impact, a Mixing Zone study was conducted, measuring ammonia, chlorides, temperature, and conductivity. In addition, benthic samples were collected to describe the biological community upstream and downstream of the outfall. The results of the biological sampling are also compared to the results of a previous benthic study, completed in 1983.

4.2 Site Description

The Ship Canal runs approximately 30 miles from the south branch of the Chicago River to one mile below the Lockport Dam. This segment carries all of the wastewater discharges of the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) as well as stormwater runoff from the Chicago area downstream into the Illinois River system.

When the Ship Canal was constructed, the material collected from the river channel was disposed of in various places, including the river banks. Where the UNO-VEN Refinery is located at river mile 296.5, there is no access to the Ship Canal on the north bank because of the spoil banks which extend 2,800 feet downstream of the discharge point to the Romeo Highway Bridge. Portions of the spoil bank were removed in 1991, but access is still limited. Commonwealth Edison's Will County generating station property extends on the north side from the bridge several hundred feet downstream to the Material Service Corporation property. Thus, on the north bank of the Ship Canal, there is no access for recreational purposes. UNO-VEN does not permit recreational access to the Ship Canal through its property. Thus, there is no access for recreational purposes on the Ship Canal in the vicinity of UNO-VEN's outfall.

The Lockport Lock and Dam is approximately 5.5 miles downstream of the Refinery. Although there is not access for recreational purposes, pleasure boats do traverse the Ship Canal in order to reach desirable recreational locations. There are no swimming, fishing, or shore activities near the refinery location, primarily because of marine safety considerations, poor access, and water quality.

According to the U.S. Army Corps of Engineers navigational maps, the Ship Canal is approximately 160 feet wide at this point. During the field sampling, the width directly across from UNO-VEN's outfall was measured to be 172 feet. The average depth in the vicinity of UNO-VEN's outfall is 25 feet.

The flow rate in the Ship Canal is dependent upon the effluent volumes from the three large MWRDGC treatment plants, volume of diversion water, and any runoff occurring. The total average MWRDGC wastewater flow is 1,350 million gallons per day and the diversion flow has an annual average of 207 mgd. The 7-day, 10-year low flow in the canal is 1,100 mgd at Lockport (Singh and Stall, 1973), and the average flow rate in the Sanitary & Ship Canal is 1,950 mgd according to the U.S. Geological Survey's data (U.S.G.S., 1991).

Because the Ship Canal is a manmade waterway, it is completely channelized without any meanders, riffles, or other physical features which enhance it as an aquatic habitat. The walls and the stream bottom of the Ship Canal are composed primarily of bedrock with some accumulation of sediment, generally closest to the shorelines. The thickness of the sediment varies throughout the Chicago River system; however, in the area of the UNO-VEN Refinery there is little sediment deposition.

UNO-VEN's discharge is through a 15 inch pipe that originates in a large sampling/flow measuring structure. The treated wastewater overflows a weir, then enters the discharge pipe which discharges the wastewater in a downward direction at a depth of 15 feet. Air is entrained in the wastewater as it overflows the weir, and the entrained air is released along with the wastewater at the 15 foot depth. The entrained air makes the effluent buoyant, resulting in the effluent plume literally rising to the Ship Canal's surface at the outfall pipe.

4.3 Sampling Protocol

Sampling in the immediate vicinity of UNO-VEN's discharge was conducted on June 1 and 3, 1992. The sampling included the delineation of the wastewater plume and benthic sampling of the Ship Canal, both upstream and downstream of UNO-VEN's discharge. Using the results from the analysis, the area of local impact was determined.

The Ship Canal's depth is typically 25 feet in the area of the outfall. UNO-VEN's effluent discharge on June 1, 1992, was 3.83 mgd. The flow in the Ship Canal during the two days of sampling was 2020 mgd (Morgan, 1991) based on mean daily flow data from the U.S.G.S. Station in Romoeville. Upstream temperature on June 1 was in the 61^{o}F to 62^{o}F range, with conductivities near 620 µmhos/cm . The effluent temperature was 78^{o}F and had a conductivity of 3,100 µmhos/cm.

4.3.1 Plume Delineation

On June 1, 1992, a three-member team from Huff & Huff and a boat operator from UNO-VEN conducted a preliminary reconnaissance of the plume using a YSI Model 33 conductivity meter and a Digi Sense Model 8520-40K Thermocouple Thermometer. First, conductivity and temperature measurements were taken in situ adjacent to the vertical outfall. As expected, the plume rose immediately to the surface before spreading laterally, based on both conductivity and temperature readings. Downstream of the outfall, conductivity and temperature readings were consistently highest near the surface, dropping off by a 3 foot depth to near background values (62.2^{o}F and 620 μmhos/cm). By 150 feet downstream and less than 50 feet off the near shore, the plume could no longer by tracked by conductivity or temperature. From this preliminary reconnaissance, a buoyant plume was apparent, and so the grid sampling focused on a surface plume.

Based upon these findings, the detailed Mixing Zone delineation was conducted at a one foot depth from the surface on a grid pattern. Samples were collected with a Subsurface Grab Sample II Water Sampler and borosilicate glass bottles. Conductivity and temperature probes, attached to the water sampler pole, were used to measure both parameters during the filling of the sample bottles at the 1 foot depth. Each sample location was determined using a Lietz Set 4B Total Station, set up directly over the concrete effluent structure and a range pole with four prisms located on the boat. A portion of each water sample was transferred to two bottles. One 150 ml bottle with no preservative was filled to analyze for chlorides and one 500 ml bottle with H_2SO_4 for preservative to analyze for ammonia. The ammonia samples were analyzed the same day at UNO-VEN's laboratory. The chloride samples were delivered on ice to NET Midwest the next day. As a conservative constituent, chloride can be used to delineate the Mixing Zone.

4.3.2 Benthic Sampling

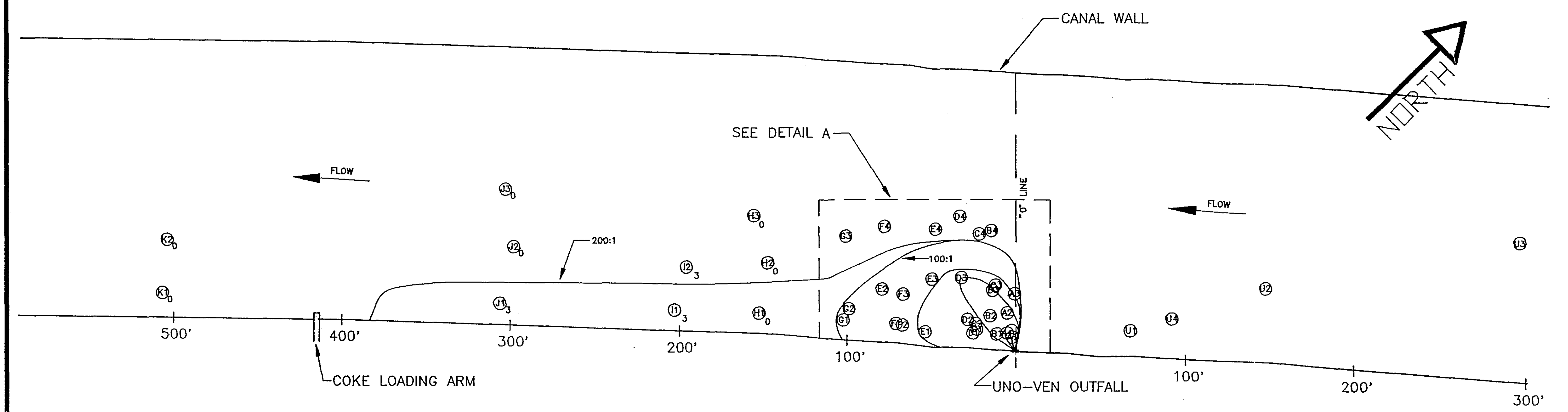
On June 3, 1992, the same personnel returned to the canal to collect benthic samples from the canal bottom. Samples were collected using 9" x 9" x 9" Ekman Bottom Dredge and a handwinch. Samples were collected along the southeastern bank, the center, and the opposite wall of the canal, upstream and downstream UNO-VEN's outfall. Fourteen sample sites were examined with varied success in retrieving sediment. The canal bottom is primarily flat bedrock, with occasional sediment deposits because of the turbulence created by the barge traffic.

The sediment samples were collected in separate, labelled, five-gallon buckets for each sampling location and transported to shore. The samples were screened and washed using a No. 30 sieve. Once the sediment was washed through the sieve, benthic organisms were hand picked and placed in bottles filled with 70% isopropyl alcohol. These samples were then delivered to Dr. Richard Whitman of Great Lakes Environmental for identification. The specimens were identified to Genus taxonomic levels. The reference used for identification was Handbook of Common Methods and Limnology (Lind, 1985). The specimens were observed with two microscopes, depending on the sample, a Baush & Lomb Dissecting Stereo Zoom 7 Microscope, 4x - 30x or a Compound Spencer Microscope, 40x - 1000x.

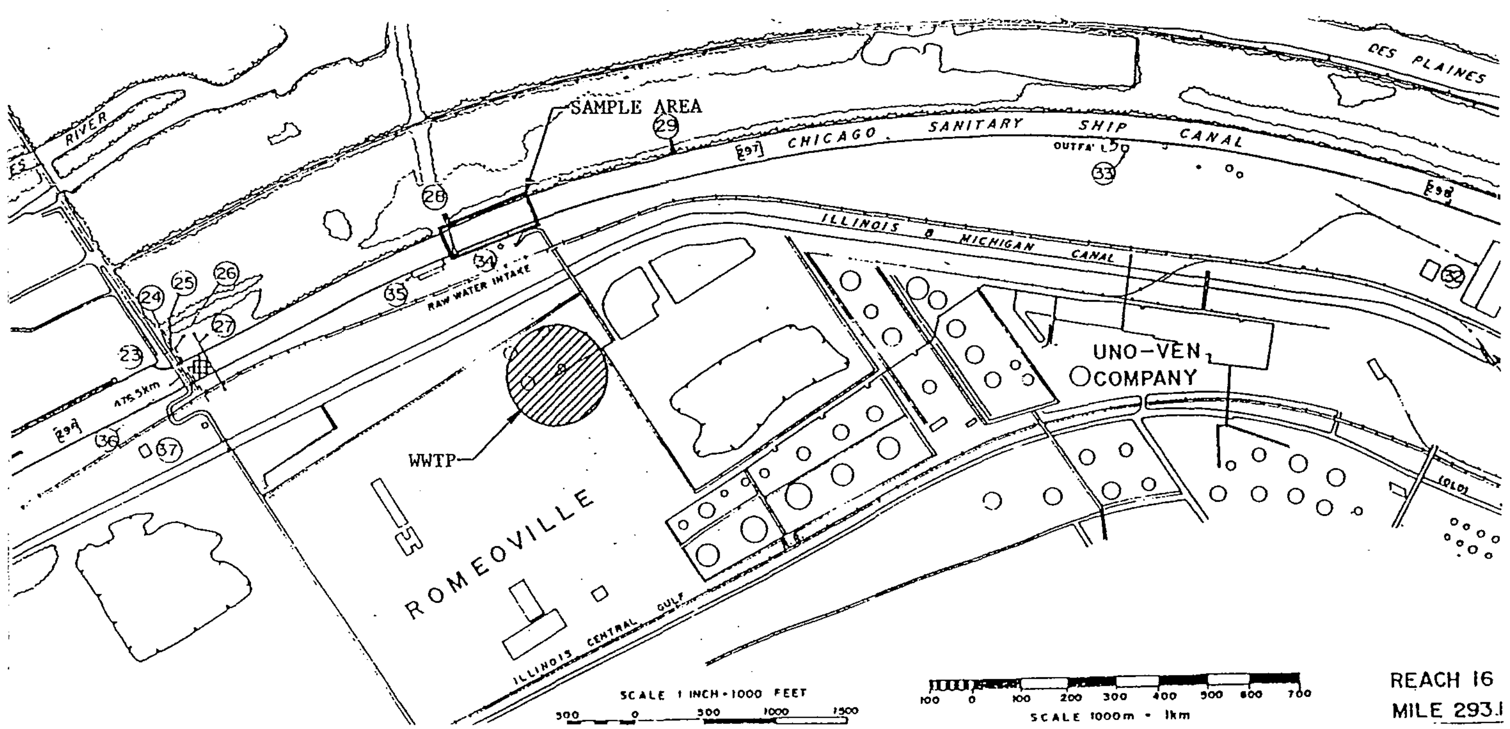
4.4 Mixing Zone Delineation

Water quality sampling in the immediate area of UNO-VEN's outfall was conducted to determine the Zone of Initial Dilution and Mixing Zone associated with UNO-VEN's outfall. Four parameters were measured at each sample location; conductivity, temperature, chlorides, and ammonia. Temperature and ammonia are affected by atmospheric conditions, and, in the case of ammonia, by biological activity. These parameters therefore were not used to delineate the plume. Chloride is a conservative constituent that changes strictly due to mixing. Conductivity was used to track the plume and for verification of the chloride results.

The samples were collected in a semi-grid pattern as shown by the locations on Figure 4-1 through 4-4. Results from the water quality analysis are tabulated in Table 4-1. Upstream water quality was measured four times during the sampling period to define background levels and any changes. The effluent water quality was measured five times to detect changes in the effluent characteristics.



MEASURED BACKGROUND CHLORIDE CONCENTRATIONS, mg/l



SAMPLING SITE LOCATION

TIME	UNO-VEN EFFLUENT CHLORIDE mg/l	BACKGROUND CHLORIDE mg/l	EFFLUENT CHLORIDES ABOVE BACKGROUND mg/l
8:15 A.M.	582	73	509
8:45 A.M.	586	75	511
9:15 A.M.	632	75	557
9:45 A.M.	584	75	509
10:15 A.M.	576	75	501

FIGURE 4-1

CHLORIDE CONCENTRATIONS (mg/l) ABOVE BACKGROUND

CHICAGO SANITARY AND SHIP CANAL SAMPLING LOCATIONS

UNO-VEN COMPANY, LEMONT IL

SAMPLED JUNE 1, 1992

SCALE: 1:60

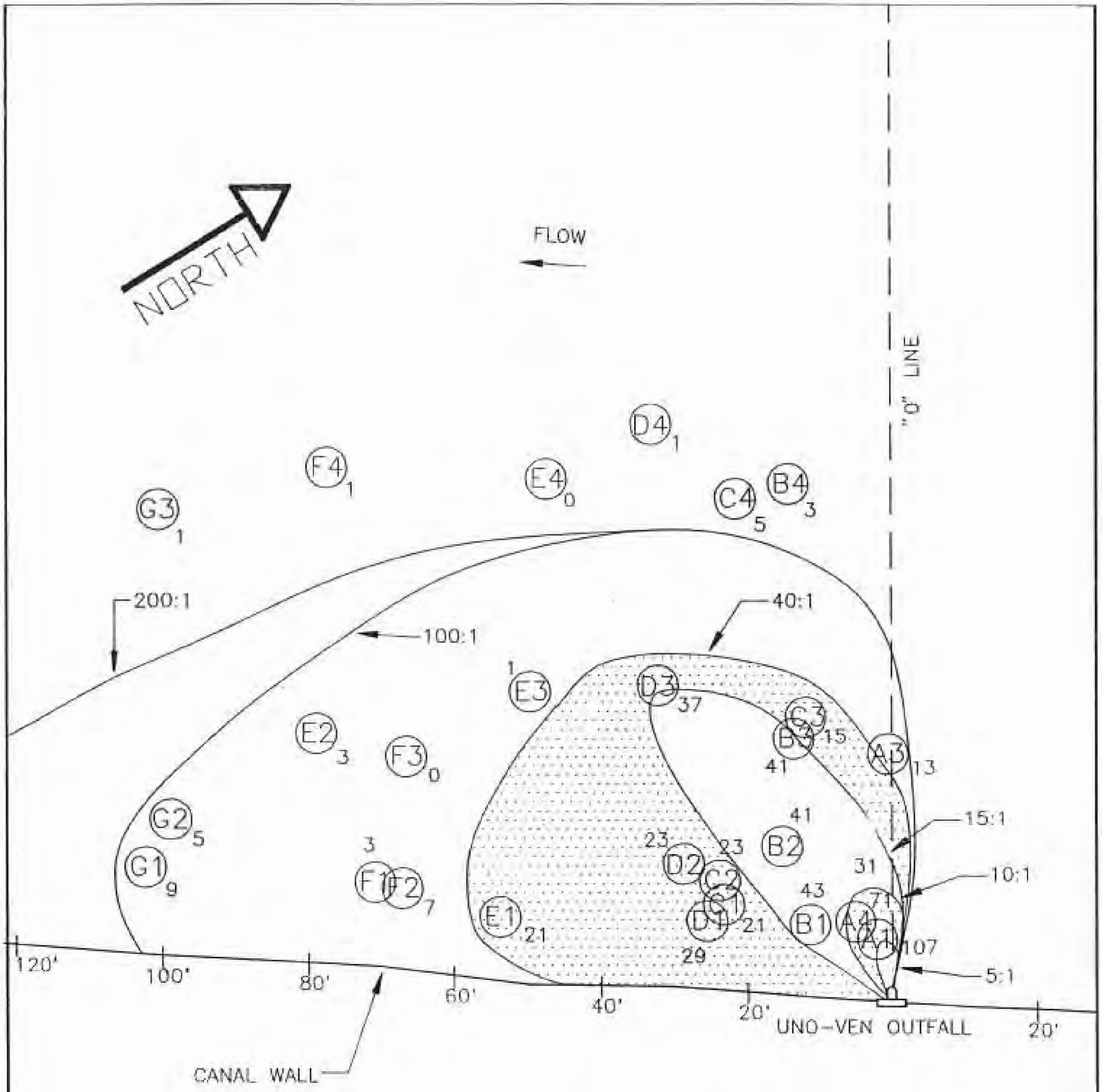
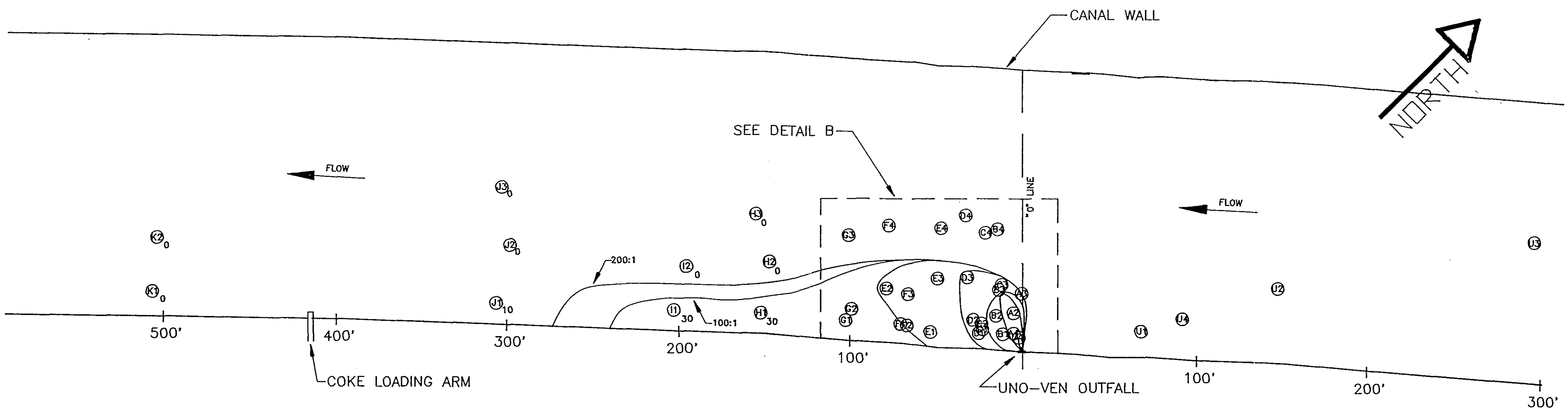


FIGURE 4-2
DETAIL A

CHLORIDE CONCENTRATIONS (mg/l) ABOVE BACKGROUND

CHICAGO SANITARY AND SHIP CANAL
SAMPLING LOCATIONS

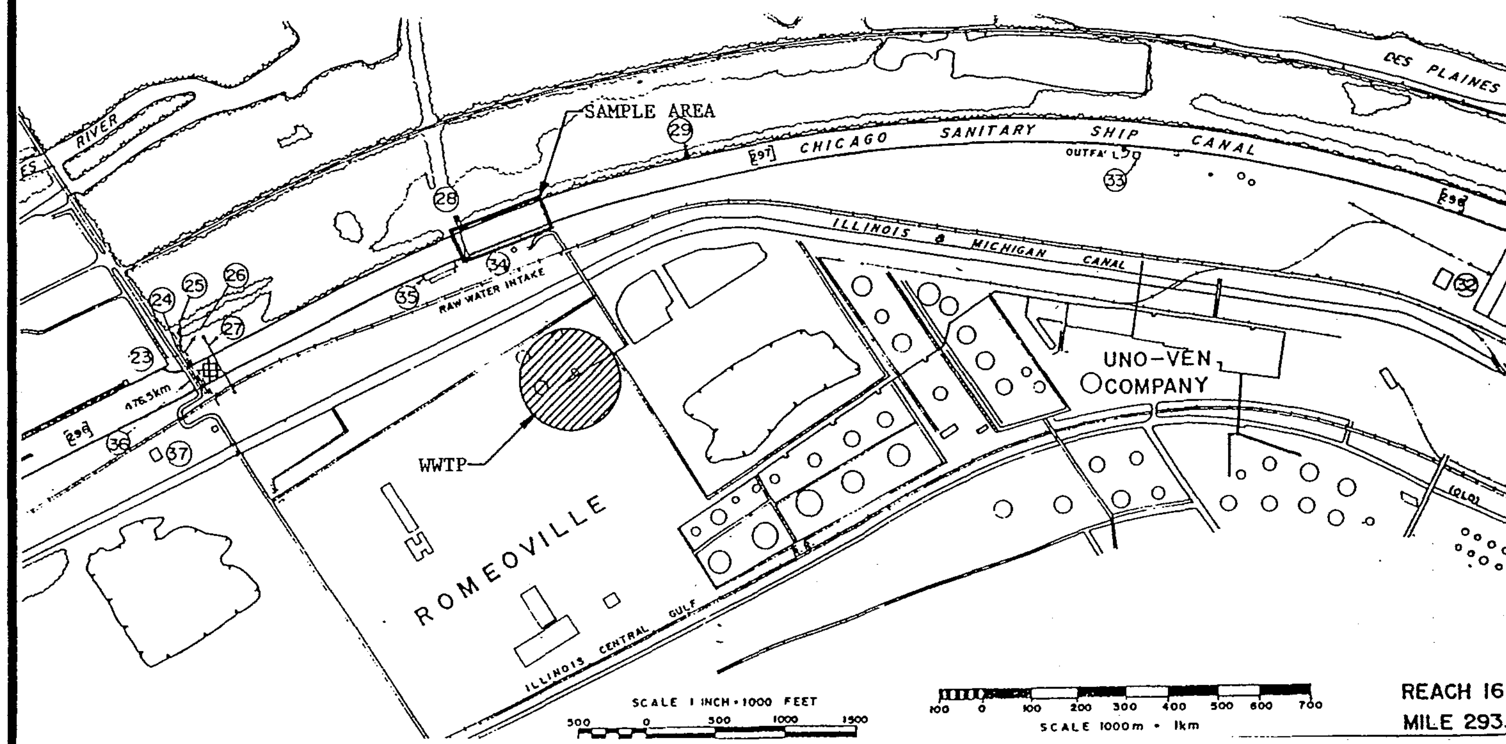
UNO-VEN COMPANY, LEMONT IL
SAMPLED JUNE 1, 1992
SCALE: 1:20



MEASURED BACKGROUND
CONDUCTIVITY LEVELS (umhos/cm)

UNO-VEN EFFLUENT CONDUCTIVITY = 3600 umhos/cm
BACKGROUND CONDUCTIVITY = 620 umhos/cm

EFFLUENT CONDUCTIVITY ABOVE BACKGROUND = 2480 umhos/cm



SAMPLING SITE LOCATION

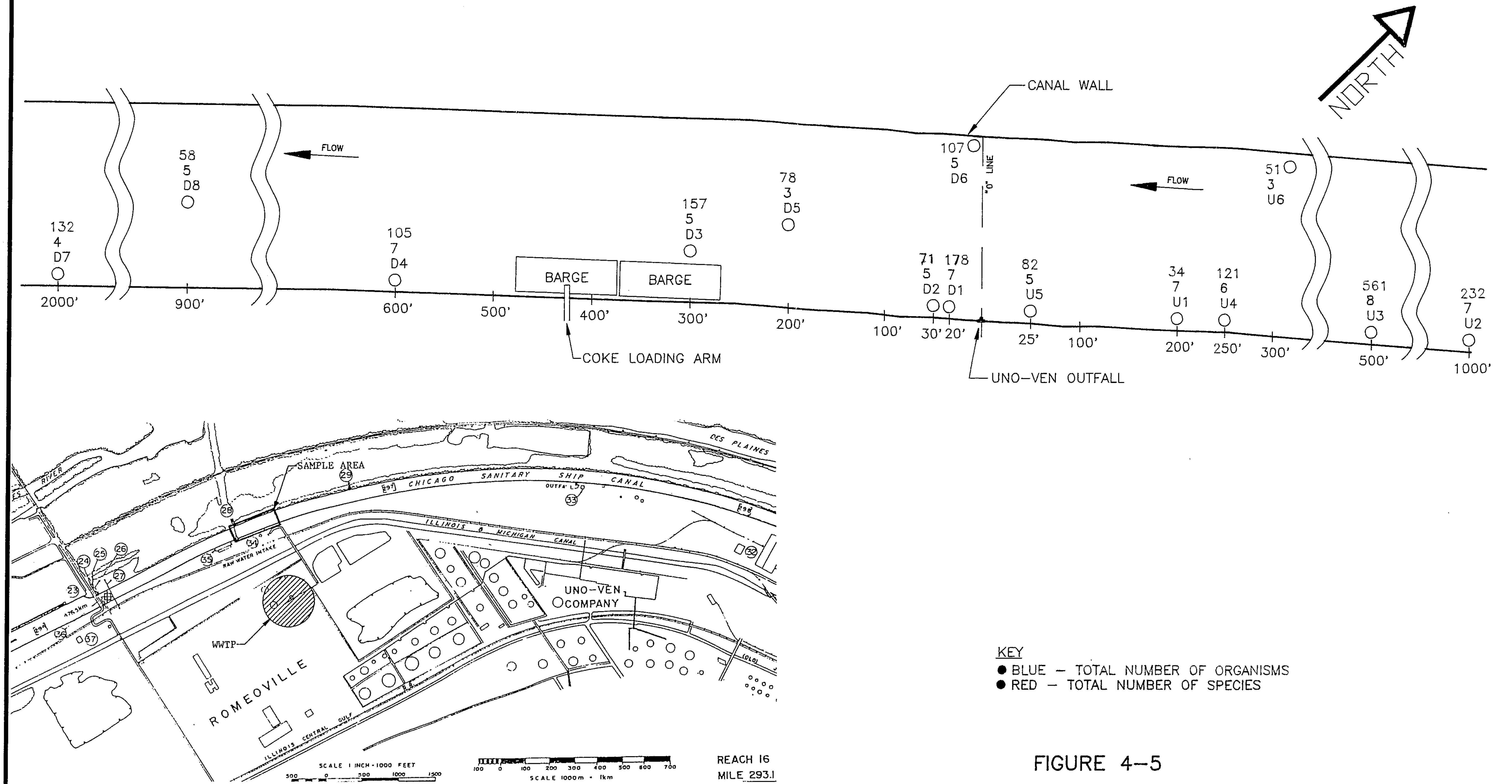
FIGURE 4-3

CONDUCTIVITY MEASUREMENTS (umhos/cm) ABOVE BACKGROUND

CHICAGO SANITARY AND SHIP CANAL SAMPLING LOCATIONS

UNO-VEN COMPANY, LEMONT IL
SAMPLED JUNE 1, 1992

SCALE: 1:60



SAMPLING SITE LOCATION

KEY
- ● BLUE – TOTAL NUMBER OF ORGANISMS
- ● RED – TOTAL NUMBER OF SPECIES

FIGURE 4-5

BENTHIC SAMPLING OF THE CHICAGO SANITARY AND SHIP CANAL
UNO-VEN COMPANY, LEMONT IL
SAMPLED JUNE 3, 1992

SCALE: 1:100

TABLE 4–5

BENTHIC COLLECTION DATA
SAMPLING DATE: JUNE 6, 1992

SAMPLE ID#	LOCATION FROM OUTFALL	DISTANCE FROM OUTFALL, ft.	DISTANCE FROM SOUTH BANK, ft.	NUMBER OF DROPS a/
U1	UPSTREAM	200	(near) 10	3
U2	UPSTREAM	1000	(near) 10	1
U3	UPSTREAM	500	(near) 10	2
U4	UPSTREAM	250	(near) 10	2
U5	UPSTREAM	25	(near) 10	2
U6	UPSTREAM	300	(far) 172	1
D1	DOWNSTREAM	20	(near) 10	3
D2	DOWNSTREAM	30	(near) 10	3
D3	DOWNSTREAM	300	(near) 50	3
D4	DOWNSTREAM	600	(near) 10	4
D5	DOWNSTREAM	200	(center) 86	1
D6	DOWNSTREAM	10	(far) 172	2
D7	DOWNSTREAM	2000	(near) 10	3
D8	DOWNSTREAM	900	(center) 86	2

a/ NUMBER OF DROPS WITH ECKMAN DREDGE VARIED DEPENDING ON THE VOLUME OF SEDIMENT COLLECTED

TABLE 4-6

Benthic Macroinvertebrates Counts Collected in the Chicago Sanitary and Ship Canal

TAXA	IEPA TOLERANCE VALUE	COMMON NAME	STATION U-1	U-2	U-3	U-4	U-5	U-6	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8	TOTAL
Asellidae	6																
Asellus		Aquatic pillbug													2		2
Gastropoda																	
Bithynia	not listed	Bythnia snail (Great Lakes species)	7	1	12		1		5	1		5		5	13		50
Pelecypoda																	
Dressnia	not listed	Zebra mussel	1		24	1			1		1	10		6			44
Gammaridae																	
Gammarus	3	Scud, Sideswimmer	1		192	9		47	3	1		4	18	12		8	296
Coelenterata																	
Hydra	not listed	Hydra		2								14					16
Coleopetera																	
Laccophilus	not listed	Predatious diving beetle		1													1
Libelluildae																	
Libelula	8	Dragon fly			1												1
Oligchaeta	10																
Naididae		Naidid worm														1	1
Tubifex		Sludge worm	15	145	48	4	71		5	1	3	6			2		300
Stylaria		Naidid worm														1	1
Physidae																	
Physa	9	Physa snail	3	73	264	95	3	1	149	58	100	61	4	76	115	41	1043
Rhynchobdellida																	
Piscicolidae	7	Leech	2	1	8	2	3		2		8						26
Sphaeriidae			5	9	12	10	4	3	13	10	45	5	56	8		7	187
Pisidium	5	Fingernail clam															
Sparerium	5	Fingernail clam															
		TOTAL	34	232	561	121	82	51	178	71	157	105	78	107	132	58	1967
		# SPECIES	7	7	8	6	6	3	7	6	5	7	3	5	4	5	14
MACROINVERTBRATE BIOTIC INDEX			6	9	6	8	9	3	8	8	7	6	5	7	8	8	

	Upstream		Downstream	
	Nearshore Sites [a]	Standard Deviation	Nearshore Sites [b]	Standard Deviation
Avg. Density of Organisms (#/m^2)	2,400	2,300	790	301
Avg. No. of Species collected per site	6.6	1.1	5.6	1.3
Mean MBI Value	7.6	1.5	7.4	0.9

a/ U1 through U5
b/ D1, D2, D3, D4, D7

The higher number of organisms upstream reflect the greater quantity of sediment found upstream, requiring fewer drops of the Ekman Dredge to collect a sample. The MBI values and number of species collected per site are statistically similar. Therefore, no measurable impact from UNO-VEN's discharge on the benthic organisms within the Mixing Zone could be discerned.

In 1983, a similar study of benthic organisms was conducted by Huff & Huff, Inc. In 1983, the pollution tolerant organisms Tubifex tubifex (sludge worm, tolerance value of 10), with Chironomidae (midges) and Helobdella fusca (leeches), both pollution tolerant, were found. The MBI index upstream and downstream in 1983 would be approximately 10, because of the sludge worm domination. The 1992 results show a dramatic improvement, with sludge worms present at most sites, but no longer dominating (15% of all organisms recovered). Gammaridae gammarus (sideswimmer scud, tolerance value 3, 15%) Physidae physa (snail, tolerance value 9, 53%) and Sphaeridae pisidium (fingernail clam, tolerance value 5, 10%) were also found in large quantities.

The zebra mussel was also found at 7 of the 14 sites. A total of 14 species were collected, compared to the three species in 1983. The 1983 to 1992 average MBI values (from 10 to 7) also show the overall improvement in water quality.

As part of Ruling R87-27 by the Illinois Pollution Control Board, a comprehensive water quality evaluation including the Ship Canal was conducted by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC). As part of this evaluation, benthic invertebrate species and fish surveys were conducted in the Chicago Waterways. The evaluation was conducted from 1989 to mid-1991.

Benthic invertebrates were collected on 84 miles of the Chicago Waterway System. Samples were collected during April, July, and November of 1989 and 1990 and April and June of 1991. The MWRDGC recovered similar macroinvertebrates during their sampling. The predominate species collected each year were the Tubifex worm, which represented an average of 78% over the sample period, and Naidid worms, 17% over the sample period. These are both classified as pollution tolerant species with tolerance values of 10.

The latest benthic sampling round was conducted in June of 1991 by the MWRDGC. This corresponds with the sampling conducted by Huff & Huff in June of 1992, as seasonal variations have been eliminated. The nearest upstream sampling locations were upstream of the Ship Canal and Cal-Sag confluence. These were both located at the Route 83 Bridges on the respective waterways, each 7.5 miles upstream. The nearest downstream sampling location was 16th Street in Lockport, 4.3 miles down the Ship Canal. Sampling occurred in two locations at each site, one in the center and the other along either bank of the Ship Canal.

Macroinvertebrate Biotic Index values were calculated from the MWRDGC Comprehensive Water Quality Evaluation data from each of the referenced locations (Polls, et al., 1991). The MBI values for the stations are presented in Table 4-7. The MBI upstream on the Cal Sag was 10.0, while the upstream MBI on the Ship Canal ranged from 5.2 in the center to 8.8 on the right bank. Downstream 4.3 miles from UNO-VEN, MBI values of 9.9 were reported for both the right bank and center stream.

TABLE 4-7

MBI VALUES FROM MWRDGC - June, 1991 - Benthic Data

Sample Location	Location in Ship Canal [a/]	Location From UNO-VEN	MBI Value
Ship Canal at Route 83	Right Bank	Upstream	8.8
	Center	Upstream	5.2
Cal Sag Channel Route 83	Left Bank	Upstream	10
	Center	Upstream	10
Ship Canal at 16th Street	Right Bank	Downstream	9.9
	Center	Downstream	9.9

a/ Facing upstream in waterway.

SOURCE: Polls, et al., 1991

To further define the aquatic community, the MWRDGC conducted an electrofishing survey. The electrofishing survey was made at 20 locations on the Chicago Waterway. The sample stations were at the same stations as the benthic sampling. The classification system used to describe water quality from the electrofishing survey is based on the Index of Biotic Integrity (IBI) (Dennison, et al., 1991). The IBI assesses the health of a fish community using 12 fish community measures or metrics, which fall into three broad categories: Species composition, trophic composition, and fish abundance and condition. The Illinois Department of Conservation (IDOC) and the Illinois Environmental Protection Agency have used the IBI to develop a five tiered stream classification system as shown below:

Index of Biotic Integrity

Class	Waterway Quality	IBI Range
A	Excellent	60-51
B	Good	50-41
C	Fair	40-31
D	Poor	30-21
E	Very Poor	$\leq$ 20

The results of the fish quality survey indicate that the Ship Canal varies between a class D to E Waterway. The IBI average values for each sample site are listed in Table 4-8. Water quality, as measured by the fish quality improves downstream on the Ship Canal. No effect on the fish quality, can be attributed to UNO-VEN's discharge.

In summary, the benthic and fish sampling conducted by the MWRDGC upstream and downstream of UNO-VEN's discharge revealed similar biological quality. A significant improvement in the benthic community has occurred when comparing the 1983 and 1992 results on the Ship Canal near the refinery, both upstream and downstream, reflecting the overall improvement in water quality in the Ship Canal. No impact on the biological community could be discerned attributable to UNO-VEN's effluent, from either the present study or from the MWRDGC investigations.

TABLE 4-8

ELECTROFISHING RESULTS

Station	Location	Year	IBI Avg.	Overall IBI Avg.	Class
Willow Springs	Upstream	1989	21		D
		1990	21	20	D
		1991	17		E
Route 83	Upstream	1989	21		D
		1990	19	20	E
		1991	21		D
16th Street Lockport	Downstream	1989	21		D
		1990	29	23	D
		1991	20		D

SOURCE: Patterson and Associates, Inc., 1991

CHAPTER 5

WATER QUALITY OF THE CHICAGO WATERWAY AND ILLINOIS RIVER SYSTEM

5.1 Introduction

The UNO-VEN Refinery is located near Lemont in Will County, Illinois. The wastewater discharge from the refinery into the Chicago Sanitary & Ship Canal occurs at River Mile 296.5, 5.5 miles upstream of the Lockport Lock and Dam. Before discussing river basin environmental impacts associated with UNO-VEN's discharge, the existing water quality conditions with respect to ammonia and dissolved oxygen are briefly described. In addition, the historical trends in water quality are provided. The river system has been studied by the Illinois Environmental Protection Agency (IEPA), the Illinois State Water Survey (ISWS), the MWRDGC, and the U.S. Geological Survey (USGS). In addition, Camp Dresser and McKee, Inc. (CDM) has modelled the Chicago Waterway and Illinois River System using the QUAL2E Modeling Program for the MWRDGC under present and various future scenarios, and the results of this modeling are summarized herein.

The Ship Canal receives treated domestic waste from three major water reclamations plants, combined sewer overflows, non-point source runoff, and numerous smaller municipal discharges and industrial discharges. The combination of these sources effects the quality of water in the Ship Canal. The Chicago Waterways have been designated secondary contact waters up to the Des Plaines River at the I-55 Bridge. Figure 2-2 of Chapter 2 depicted the location of the MWRDGC's three major plants and UNO-VEN's discharge. The water quality standards for secondary contact waters are intended to protect indigenous aquatic life and secondary contact uses. Parameters which are important to this study have the following water quality standards for the Ship Canal.

Un-ionized Ammonia	0.1 mg/l
pH	6.0 to 9.0 standard units
Dissolved Oxygen	4.9 mg/l
Temperature	37.8 ^{o} C

5.2 USGS Water Quality Sampling

The United States Geological Survey has maintained a water quality station (No. 05537000) near the Lockport Lock and Dam, 5.3 miles downstream from UNO-VEN's outfall. Water Quality data have been tabulated from November, 1977 through September, 1991 (Water Years 1978 to 1991) from this USGS Station. The USGS has recently been utilizing station No. 05536995 near Romeoville to collect water quality data (April, 1987 - September, 1991) which is 0.3 miles downstream from UNO-VEN's outfall. Water quality is determined 0-4 times per month at each of these stations. (Not all parameters are monitored each time.)

Both water quality stations provide a historical perspective of ammonia and dissolved oxygen water quality. Data from the Lockport USGS Station in Lockport are tabulated in Table 5-1. The average monthly un-ionized ammonia is plotted in Figures 5-1A and 5-1B. These figures compare the Ship Canal un-ionized ammonia concentration to the water quality standard of 0.1 mg/l. The un-ionized ammonia standard has been exceeded twice since 1977 in the USGS data, out of 127 data sets. In both excursions, the total ammonia was less than or equal to 1.5 mg/l.

Table 5-2 presents the data from USGS Station No. 05536995 in Romeoville. This station is 0.3 miles downstream from UNO-VEN's outfall and therefore would be more responsive to any changes in water quality associated with UNO-VEN's discharge. Figure 5-2 is a similar plot to 5-1, showing the average monthly un-ionized ammonia levels compared to the water quality standard. The un-ionized ammonia exceeded the water quality standard once since 1987 (in August, 1987) at the Romeoville station. This was caused by a high pH (8.78) recorded for that sample, since the ammonia concentration was only 1.1 mg/l. The average pH at this station is 7.27, and the average ammonia concentration is 2.1 mg/l since 1987.

TABLE 5-1

WATER QUALITY DATA FROM USGS STATION (05537000)
AT LOCKPORT ON THE S & S CANAL

DATE	YEAR	AMMONIA, mg/l	DO, mg/l	pH, UNITS	TEMPERATURE, deg. C	UN-IONIZED AMMONIA AS N, mg/l
NOV 16	1977	4.8	1.0	7.4	16.0	0.037
DEC 2		5.1	3.1	7.2	8.0	0.014
DEC16		7.0	4.2	7.4		
JAN 19	1978	5.7	5.4	7.6	5.5	0.031
FEB 01		6.6			5.0	
FEB 23		5.6	4.4	7.6	3.5	0.026
MAR 22		3.6	4.4	6.8	8.5	0.004
APR 28		3.3	1.1	7.6	16.0	0.040
MAY 24		3.7	0.5	7.6	21.0	0.065
JUN 28		2.4	1.2	7.6	26.5	0.062
JUL 27		1.6		7.4	22.0	0.019
AUG 22		2.0		7.4		
SEP 21		1.6	0.0	7.0	26.5	0.011
OCT 30		8.9	2.0	7.5	17.0	0.094
NOV 30		9.3	3.7		11.0	
NOV 30		9.4			11.0	
DEC 22		7.1	4.2	7.5	13.0	0.055
FEB 06	1979	6.8	4.5	7.4	5.0	0.022
MAR 01		4.8	3.2	8.1		
MAR 26		2.8	4.1	7.1	10.0	0.007
APR 11		6.5	3.8		10.5	
MAY 10		2.7	0.4	7.3	21.0	0.024
JUN 05		6.3			23.5	
JUL 10		4.1	1.0	7.4	25.0	0.061
JUL 10		4.3	1.3	7.1	25.0	0.032
AUG 15		2.1	0.4	7.5	25.0	0.039
SEP 13		4.3	1.5	7.1	25.0	0.032
OCT 09		3.2	2.1	7.3	20.0	0.027
NOV 13		6.5	2.8	7.3	11.0	0.027
DEC 03		2.5		7.3	13.5	0.013
JAN 29	1980	4.5	5.2	7.5	8.0	0.024
JAN 29		4.4	5.2	7.5	8.0	0.023
FEB 19		5.3	5.2	7.4	10.0	0.026
MAR 18		4.3	5.9	7.3	6.0	0.012
APR 15		4.0	4.7	7.3	11.0	0.017
APR 15		4.0	4.8	7.3	11.0	0.017
MAY 20		5.1	1.7	7.3	19.0	0.039
JUN 17		2.8	0.5	7.1	20.5	0.015
JUL 15		2.8	2.0	7.3	29.5	0.045
AUG 19		2.3	2.2	6.7	24.5	0.007
SEP 16		1.7	3.7	6.7	21.0	0.004
OCT 22		3.0	1.7	6.9	19.0	0.009
NOV 20		4.8		7.4	16.0	0.037
DEC 16		2.2	4.8	7.3	13.0	0.011
JAN 20	1981	2.4	9.6	7.5	11.0	0.016
FEB 20		3.6	5.1	7.3	9.0	0.013
MAR 18		6.0	4.9	7.2	12.0	0.022
APR 07		6.2	2.5	6.2	17.5	0.003
MAY 21		0.2	12.2	7.7	14.0	0.002
JUL 07		1.8	1.2	7.3	26.0	0.023
JUL 14		2.6	10.2	7.0	25.5	0.016
AUG 13		1.5	5.0	8.4	25.0	0.197 a/
OCT 06		3.0	2.1	7.3	19.0	0.023
JAN 13	1982	3.1	6.8	8.0	6.0	0.044
MAR 08		5.4	5.5	5.8	8.5	0.001
MAR 23		1.6	6.2	6.6	9.5	0.002
APR 16		3.1	4.7	6.6	12.5	0.003
JUN 01		2.6	1.1	6.6	20.0	0.004
JUL 08		2.3		6.5	25.0	0.004
JUL 20		1.5	1.4	6.6	25.5	0.004
SEP 29		2.2	4.7		20.0	
OCT 26		4.7	1.0	7.1	15.0	0.017
DEC 20		3.2	5.3	6.3	10.0	0.001

TABLE 5-1

WATER QUALITY DATA FROM USGS STATION (05537000)
AT LOCKPORT ON THE S & S CANAL

DATE	YEAR	AMMONIA, mg/l	DO, mg/l	pH, UNITS	TEMPERATURE, deg. C	UN-IONIZED AMMONIA AS N, mg/l
JAN 19	1983	3.1	7.7	6.9	10.0	0.005
MAR 02		3.4	6.2	6.6	12.0	0.003
APR 01		1.4	6.0	6.9	10.0	0.002
APR 27		2.9	2.8	6.7	16.0	0.005
JUN 16		3.9	2.5	6.6	27.0	0.011
AUG 16		1.9	2.5	6.8	26.0	0.008
SEP 29		2.6	4.8	6.6	22.0	0.005
OCT 26		1.4	2.3			0.001
NOV 21		4.2	6.2			0.001
JAN 23	1984	5.8				0.041
FEB 21		3.1	6.9			0.003
APR 04		4.9	1.5			0.004
MAY 09						
JUL 10		2.2	4.9			0.012
JUL 27		2.8	2.5			0.010
SEP 25		3.1				
OCT 29		4.4	1.6			0.001
NOV 26		4.4	4.1			0.004
JAN 16	1985	4.4	6.8			0.001
MAR 08		1.8	7.4			0.001
APR 12		2.5	4.1			0.007
MAY 16		5.0	2.3			0.002
JUN 20		2.9	1.3			0.001
JUL 25		2.1	2.5			0.009
SEP 16		2.8	3.8			0.002
OCT 11		1.7	4.0			0.003
NOV 26		1.1	5.5			0.002
JAN 10	1986	3.9	6.7			0.005
FEB 05		5.6	6.8			0.003
APR 04		4.7	4.4			0.003
MAY 13		5.0	1.2			0.017
JUN 10		2.4	0.7			0.004
AUG 01		2.1	2.8			0.024
SEP 04		2.1	3.1			0.013
OCT 09		2.4	3.4			0.013
NOV 26		3.1	6.5			0.015
JAN 14	1987	3.3	6.6			0.017
MAR 18		5.1	5.8			0.012
APR 07		6.2	4.4			0.011
MAY 18		5.1	2.8			0.024
JUL 02		4.0	1.8			0.018
JUL 31		2.4	2.0			0.016
SEP 10		1.3	2.4			0.009
OCT 09		4.1	3.7			0.015
NOV 19		5.2	4.6			0.030
JAN 05	1988	2.4	7.8			0.003
FEB 05		4.4	6.4			0.013
MAR 18		6.8	5.9			0.039
APR 28		2.8	4.8			0.014
JUN 24		1.0	3.6			0.047
AUG 12		0.8	1.3			0.003
SEP 30		0.6	5.5			0.004
OCT 25		1.7	4.8			0.055
NOV 29		1.1	5.5			
JAN 23	1989	3.8	7.0			0.028
MAR 10		3.8	5.9			0.033
APR 12		1.6	6.0			0.019
MAY 30		1.4	4.3			0.108 a/
JUN 27		1.7	4.7			0.021
OCT 16		0.7	4.8			0.077
DEC 08		2.2	6.6			0.092

TABLE 5-1

WATER QUALITY DATA FROM USGS STATION (05537000)
AT LOCKPORT ON THE S & S CANAL

DATE	YEAR	AMMONIA, mg/l	DO, mg/l	pH, UNITS	TEMPERATURE, deg. C	UN-IONIZED AMMONIA AS N, mg/l
FEB 01	1990	2.1	7.7			0.013
MAR 01		1.1	6.9			0.013
APR 17		2.5	6.4			0.028
MAY 11		0.8	4.9			0.001
JUN 25		1.4	4.3			0.014
AUG 09		0.9	4.1			0.008
SEP 14		1.0	4.1			0.020
NOV 01		0.5	7.5			0.002
DEC 04		0.8	7.8			
JAN 17	1991	3.4	6.3			0.006
FEB 14		2.2	7.5			0.003
MAR 22		0.9	7.4			0.004
MAY 03		1.1	5.6			0.017
JUN 03		1.2	4.5			0.004
AUG 06		1.2	8.0			0.076
SEP 13		0.9	4.3			0.024
AVERAGES						
NOV. 1977 - SEP. 1991		3.3	4.3	7.2	16.1	0.021
APR. 1967 - SEP. 1991		2.2	5.2			0.025

a/ Un-ionized Ammonia Water Quality Standard Exceeded

FIGURE 5-1A

DOWNSTREAM CANAL UN-IONIZED AMMONIA LEVELS, mg/l

WATER RESOURCE DATA FROM STATION #05537000

SAMPLE DATES: JAN. 1978 - NOV. 1984

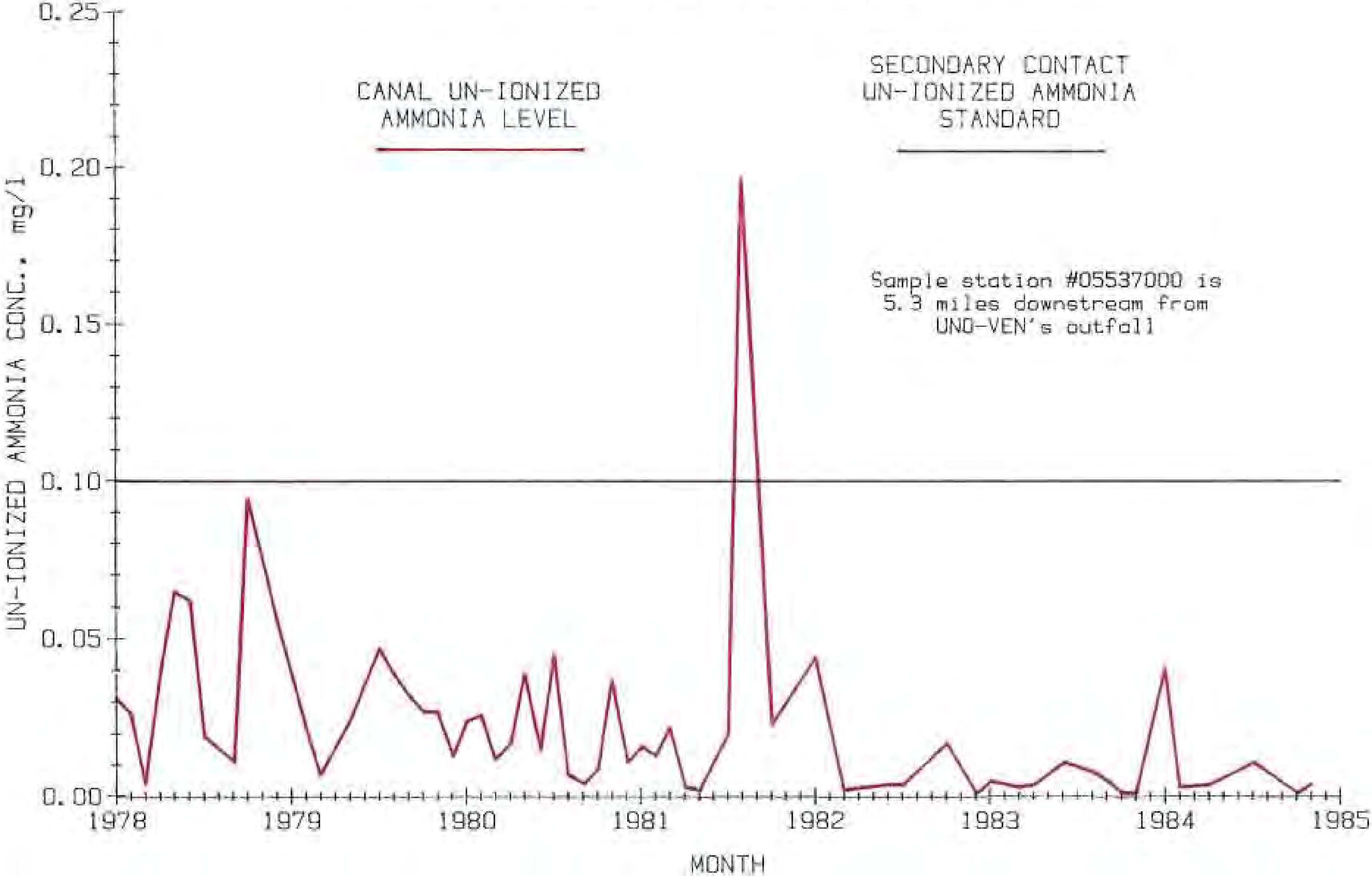


FIGURE 5-IB
DOWNSTREAM CANAL UN-IONIZED AMMONIA LEVELS, mg/l
WATER RESOURCE DATA FROM STATION #05537000
SAMPLE DATES: JAN. 1985 - SEPT. 1991

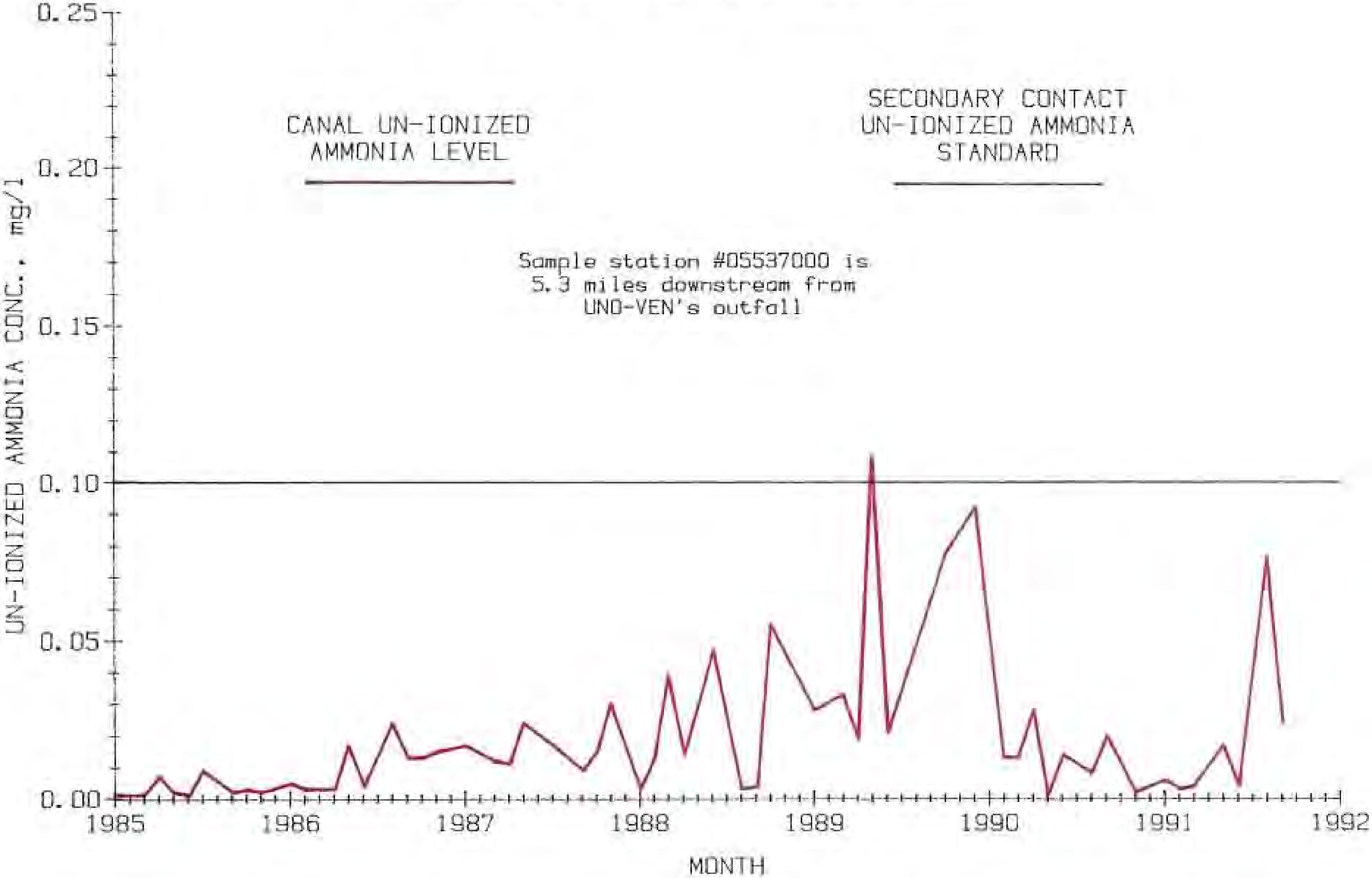


TABLE 5-2

WATER QUALITY DATA FROM USGS STATION (05536995)
AT ROMEOVILLE ON THE S&S CANAL

DATE	YEAR	AMMONIA, mg/l	DO, mg/l	pH, units	TEMPERATURE, deg. C	UN-IONIZED AMMONIA, mg/l
APR 09	1987			7.00		
APR 21		4.4				
APR 22		5.7		7.40		
MAY 05				7.60		
JUN 10				7.52		
JUL 08		4.3	3.6	7.34	25.5	0.058
AUG 12		1.6	0.6	7.78	26.5	0.061
AUG 14		1.9	3.6	7.25	25.5	0.021
AUG 27		1.1	1.7	8.78	19.5	0.214
SEP 09		1.1				0.032
OCT 07		2.6	3.7	6.74	16.5	0.005
NOV 10		6.63	2.8	7.60	14.0	0.069
DEC 09		3.5	5.8	7.60	9.3	0.024 a/
JAN 05	1988	2.9	6.4	7.65	4.0	0.016
FEB 10		4.6	8.5	7.30	3.0	0.01
MAR 10		7.4	6.9	7.00	8.5	0.013
APR 06		3.2	3.9	7.30	12.5	0.015
APR 06		3.2	3.9	7.30	12.5	0.015
MAY 05		3.0	3.6	7.20	15.5	0.014
JUN 07		1.2	3.5	6.90	22.0	0.005
JUL 06		1.2	5.9	7.10	24.0	0.008
AUG 10		1.2	2.4	7.00	25.0	0.007
AUG 23		0.6	9.3	7.30	25.0	0.007
SEP 12		0.8	4.9	8.00	21.0	0.033
OCT 12		0.4	5.3	7.70	16.5	0.004
NOV 08		0.7	4.3	7.10	12.0	0.003
DEC 07		1.2	6.0	8.70	8.5	0.095
JAN 12	1989	1.0	8.4	8.20	4.5	0.013
FEB 08		1.2	7.5	7.00	4.5	0.002
MAR 09		4.7	7.2	6.70	6.0	0.003
APR 08		2.7	4.8	7.50	10.0	0.017
MAY 12		2.2	4.8	6.80	14.5	0.004
JUN 07		1.0	1.8	6.70	19.5	0.002
JUL 12		2.2	2.9	6.90	27.0	0.012
JUL 12		1.8	2.9	6.90	25.5	
AUG 09		0.8	3.4	7.10	23.5	0.006
AUG 31		1.7	2.6	7.10	24.5	0.013
OCT 04		0.8	5.1	7.00	18.5	0.003
NOV 02		2.1	5.0	7.20	15.0	0.009
DEC 06		2.2	6.1	7.20	8.5	0.006
JAN 10	1990	4.1	6.3	7.00	6.5	0.006
FEB 10		2.0	6.1	6.80	8.5	0.002
MAR 08		2.0	7.8	7.00	7.0	0.003
APR 03		2.2	4.9	7.10	11.5	0.006
MAY 02		2.4	4.1	7.30	18.5	0.018
JUN 06		1.5	4.0	7.20	18.5	0.009
JUL 12		1.4	4.2	7.10	23.0	0.009
AUG 08		0.8	3.5	6.90	23.5	0.003
SEP 04		0.8	3.8		25.5	0.02
OCT 05		2.9	3.7	7.10	19.5	0.016
NOV 09		0.6	4.0	7.40	10.5	0.003
DEC 07		0.6	7.0	7.30	8.0	0.002
JAN 09	1991	1.1	7.9	7.30	5.5	0.003
FEB 08		4.4	8.3	7.50	7.0	0.02
MAR 08		1.9	6.4	7.60	7.0	0.013
MAR 08		1.9	6.4	7.60	7.0	
APR 12		1.6	3.7	7.10	11.5	0.004
MAY 10		0.9	3.3	7.10	16.0	0.003
JUN 06		1.0	3.3	7.00	21.0	0.004
JUL 12		0.5	4.0	7.20	25.0	0.005
AUG 08		1.4	3.5	7.10	23.5	0.011
SEP 06		1.0	3.2	7.00	24.5	0.005
AVERAGE		2.1	4.8	7.27	15.7	0.018

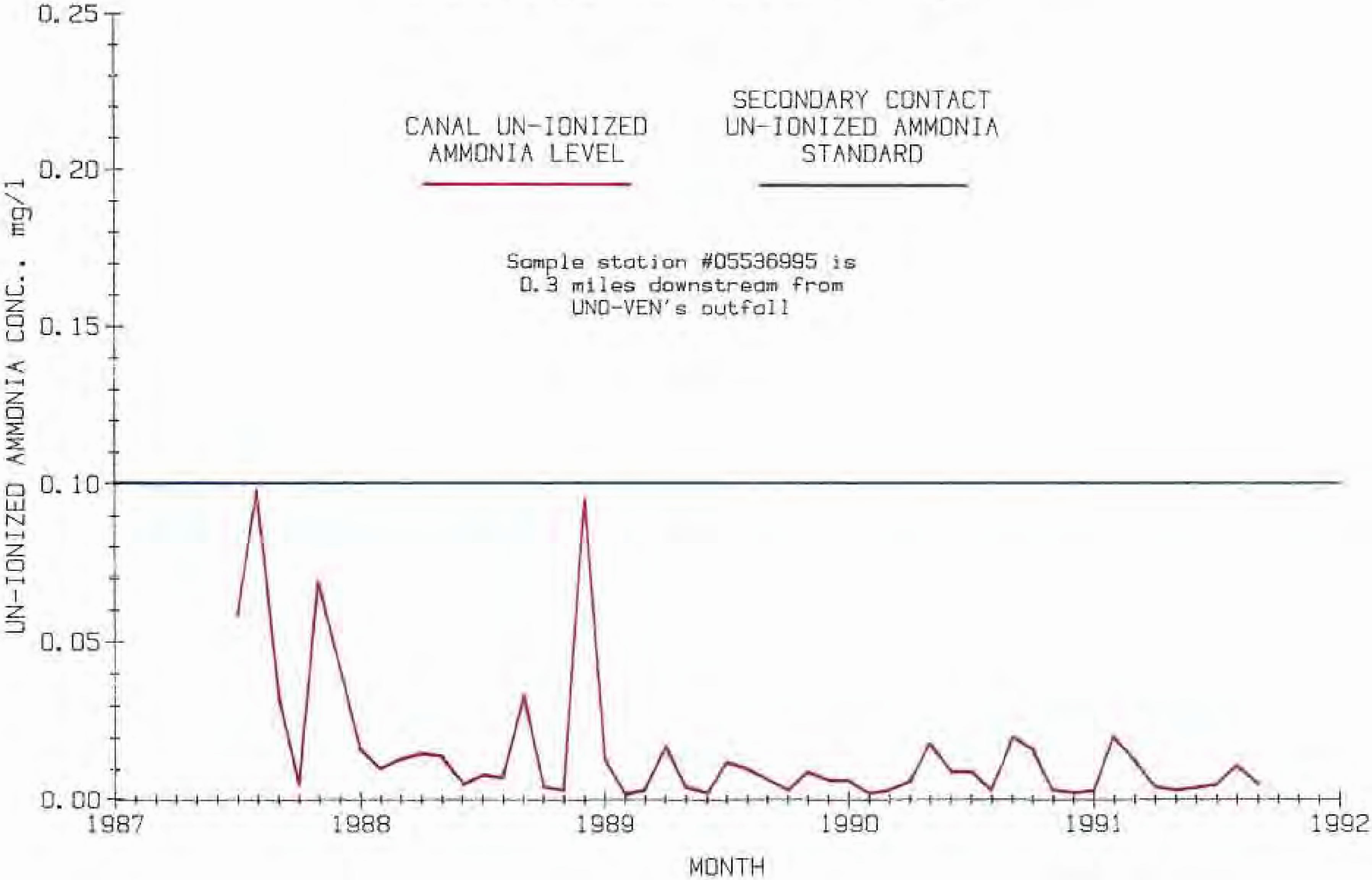
a/ Temperature reported as 93.00 C – Assumed this was to actually be 9.30 C

FIGURE 5-2

DOWNSTREAM CANAL UN-IONIZED AMMONIA LEVELS, mg/1

WATER RESOURCE DATA FROM STATION #05536995

SAMPLE DATES: JUL. 1987 - SEPT. 1991



In comparing the two stations, average conditions were calculated for the same time period (April, 1987 to September, 1991). These averages are presented below:

Station	Miles Downstream from UNO-VEN	Mean Ammonia as N, mg/l	Mean Un-ionized Ammonia, mg/l	Mean DO, mg/l
Romeoville	0.3	2.1	0.018	4.8
Lockport	5.3	2.2	0.025	5.2

The total ammonia values are similar, while the un-ionized ammonia downstream is higher, reflecting the effect of pH and temperature on the un-ionized factor. However, the overall un-ionized ammonia levels average well below the 0.1 mg/l water quality standard.

Dissolved oxygen (DO) is another important indicator of water quality and potential stream use. The minimum DO specified for the Ship Canal is 4.0 mg/l. Dissolved oxygen (DO) is monitored at the Lockport USGS station. From Figure 5-3A and 5-3B, a gradual improvement in the minimum DO levels and duration of low DO levels is apparent. Since 1989, the minimum DO values recorded at Lockport have been above the minimum water quality standard of 4.0 mg/l.

Figure 5-4 presents the DO levels recorded at Romeoville (0.3 miles downstream of UNO-VEN), since mid-1987. DO values below 4.0 mg/l have been recorded each summer, although the 1990 and 1991 minimum DO values have improved over previous years.

In summary, the DO levels downstream of UNO-VEN's outfall have shown a gradual improvement since 1978. The minimum DO levels experienced in the summer months are approaching the 4.0 mg/l levels.

FIGURE 5-3A
DOWNSTREAM CANAL DISSOLVED OXYGEN LEVELS, mg/l

WATER RESOURCE DATA FROM STATION #05537000

SAMPLE DATES: JAN. 1978 - NOV. 1984

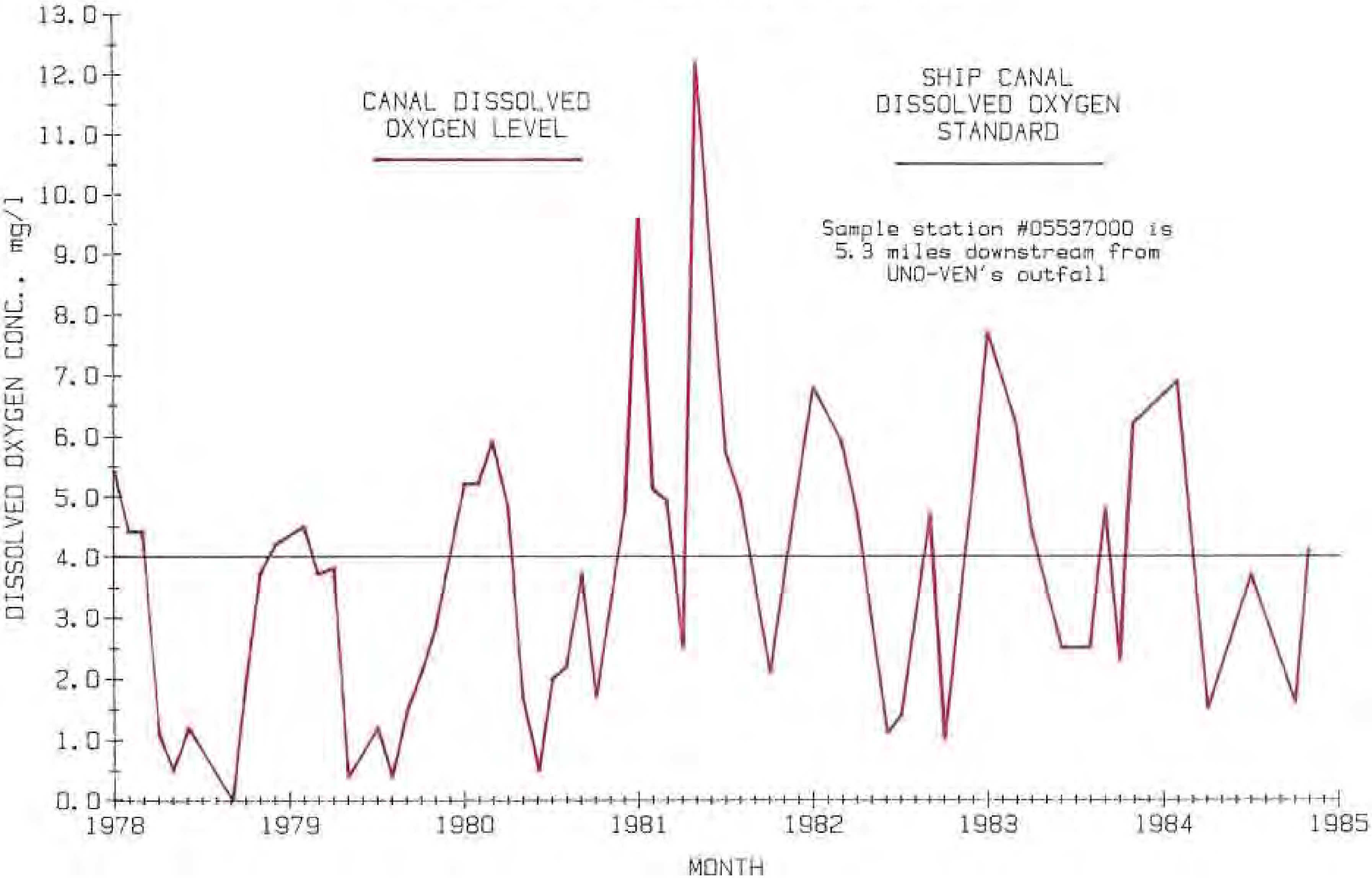


FIGURE 5-3B
DOWNSTREAM CANAL DISSOLVED OXYGEN LEVELS, mg/l

WATER RESOURCE DATA FROM STATION #05537000

SAMPLE DATES: JAN. 1985 - SEPT. 1991

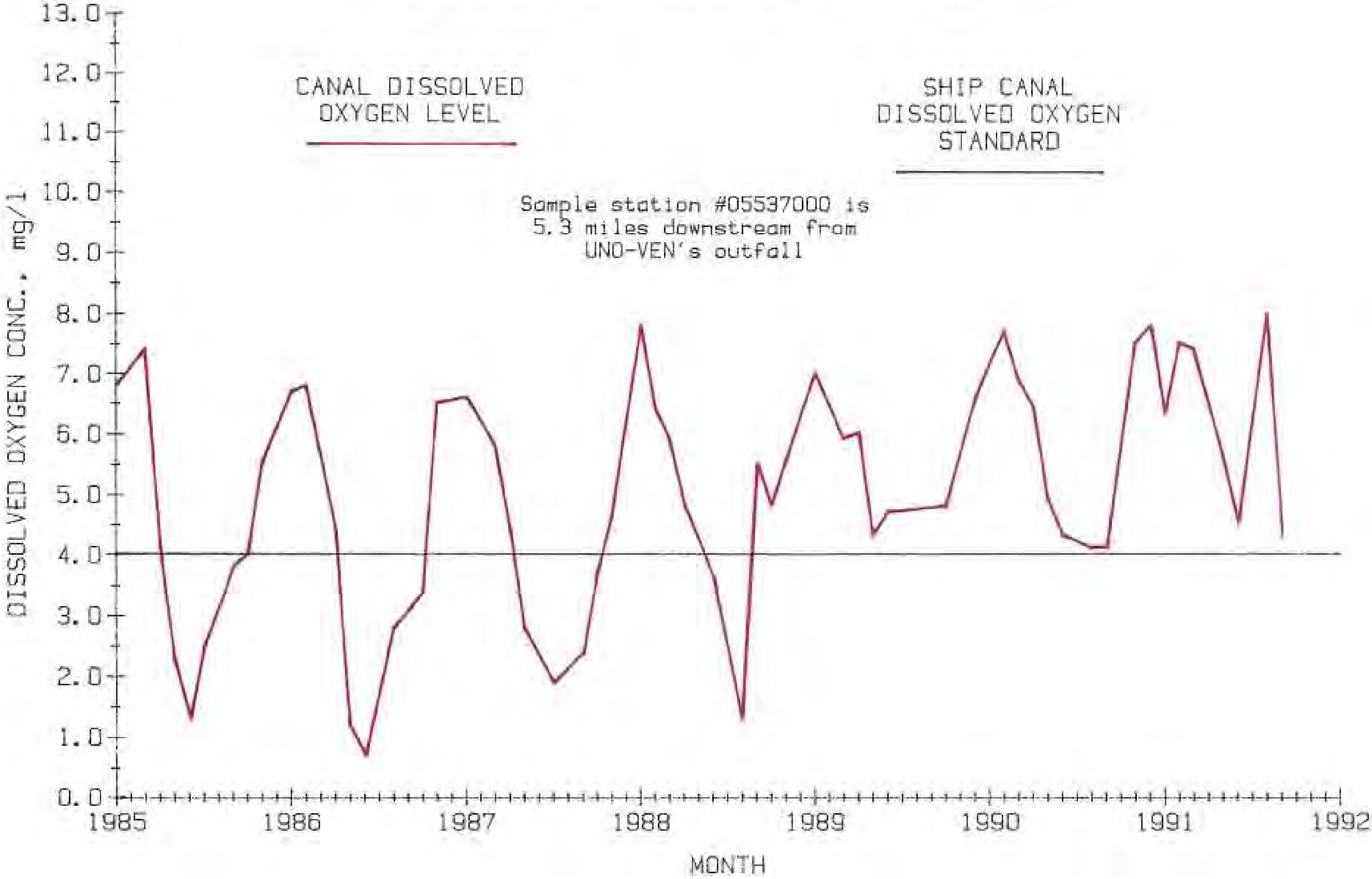
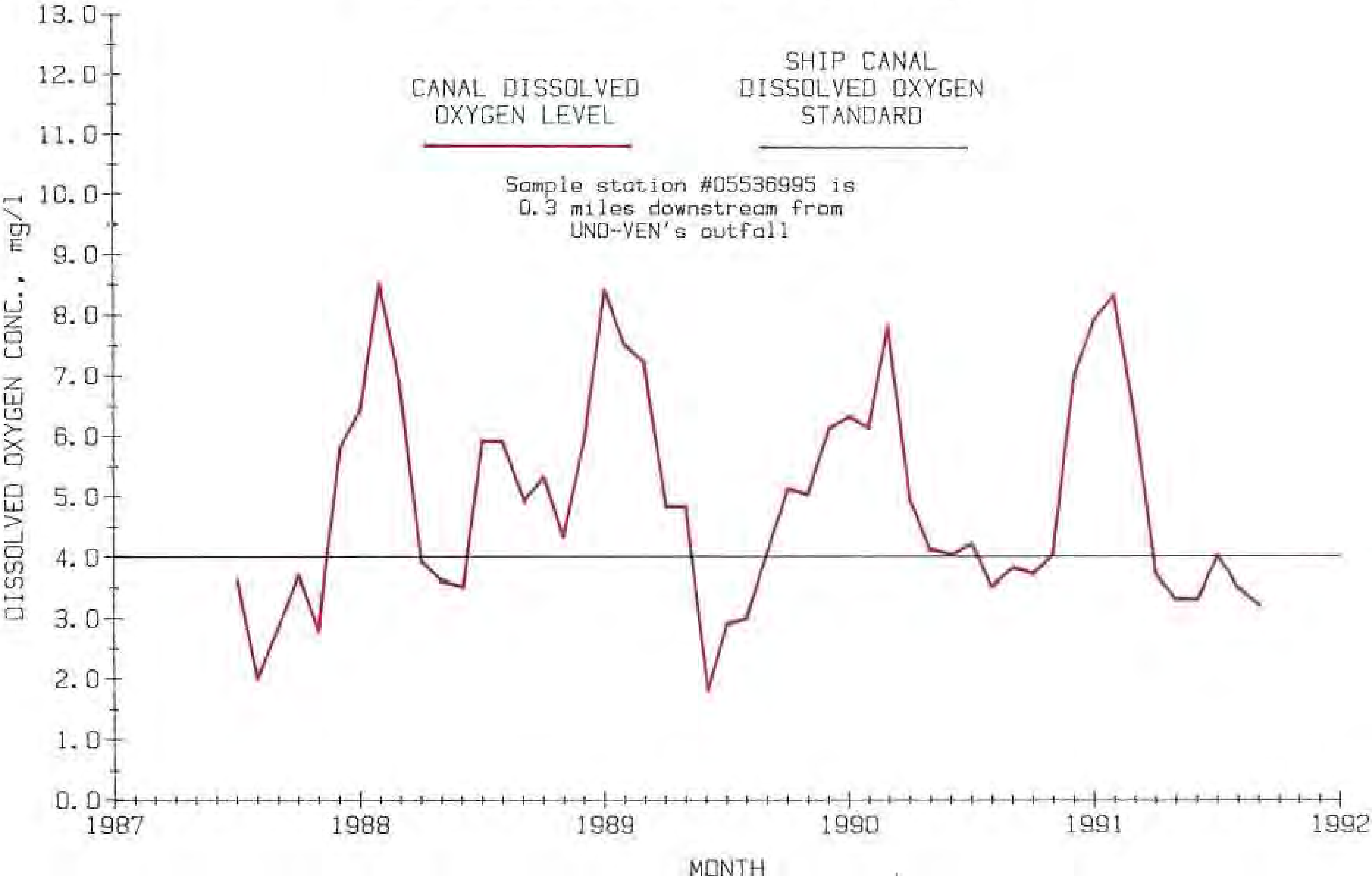


FIGURE 5-4

DOWNSTREAM CANAL DISSOLVED OXYGEN LEVELS, mg/1

WATER RESOURCE DATA FROM STATION #05536995

SAMPLE DATES: JUL. 1987 - SEPT. 1991



5.3 Metropolitan Water District of Greater Chicago Water Quality Evaluation

5.3.1 Introduction

As a part of the Illinois Pollution Control Board's Order in R87-27, the Metropolitan Water District of Greater Chicago (MWRDGC) was required to conduct a comprehensive water quality study over a three-year period from January 1, 1989 through December 31, 1991. The study consisted of eight components and are as follows:

Study 1:	Water Quality in the Chicago Man-Made Water System
Study 2:	Benthic Invertebrates in the Chicago Man-Made Waterway System
Study 3:	Fish Survey of the Chicago Man-Made Waterway System
Study 4:	Calumet, North Side, and Stickney Water Reclamation Plants Effluent Quality
Study 5:	Biomonitoring of the Effluent from the Calumet, North Side, and Stickney Water Reclamation Plants
Study 6:	Calumet, Mainstream, and O'Hare TARP System Pollutant Load Reductions
Study 7:	Water Quality in the Illinois Waterway from the Lockport Lock and Dam to the Peoria Lock and Dam
Study 8:	Water Quality in the Illinois Waterway at Lockport, Morris, Starved Rock, Henry and Peoria.

These studies pull together all of the relevant water quality data on the Chicago and Illinois Waterways. Although this information maybe pertinent to understanding the potential impact of UNO-VEN's ammonia discharge on the Chicago and Illinois Waterways, UNO-VEN's potential must be measured on a much smaller scale than that of the MWRDGC. Summarized herein is a brief overview of the relevant reports.

5.3.2 Water Quality in the Chicago Man-Made Water System

Study 1 evaluated the water quality of the Chicago Man-Made Waterways, the North Shore Channel, the Chicago Sanitary and Ship Canal and the Cal-Sag Channel. The Ship

Canal was sampled four times per month for three years. The sample locations relative to UNO-VEN are depicted in Figure 5-5. After the merger of the Cal-Sag and the Ship Canal, the first MWRDGC Sampling Station, No. 8, is the 16th Street Bridge in Lockport 4.5 miles downstream from UNO-VEN. Sample Station No. 42 on the Ship Canal, just before the merger with the Cal-Sag and No. 43 on the Cal-Sag represent upstream water quality. Samples were analyzed for DO, pH, temperature, and ammonia nitrogen. Un-ionized ammonia was calculated from ammonia nitrogen. Tables 5-3 and 5-4 summarize the results of the study. Minimum DO levels as low as 1.2 mg/l were observed on the Cal-Sag Channel, while the upstream Ship Canal minimum DO was 2.1 mg/l and downstream 1.9 mg/l. DO levels were above the water quality standards (4.0 mg/l Ship Canal; 3.0 mg/l, Cal Sag) 79% of the time at the downstream station compared to 96% and 89% for the upstream stations.

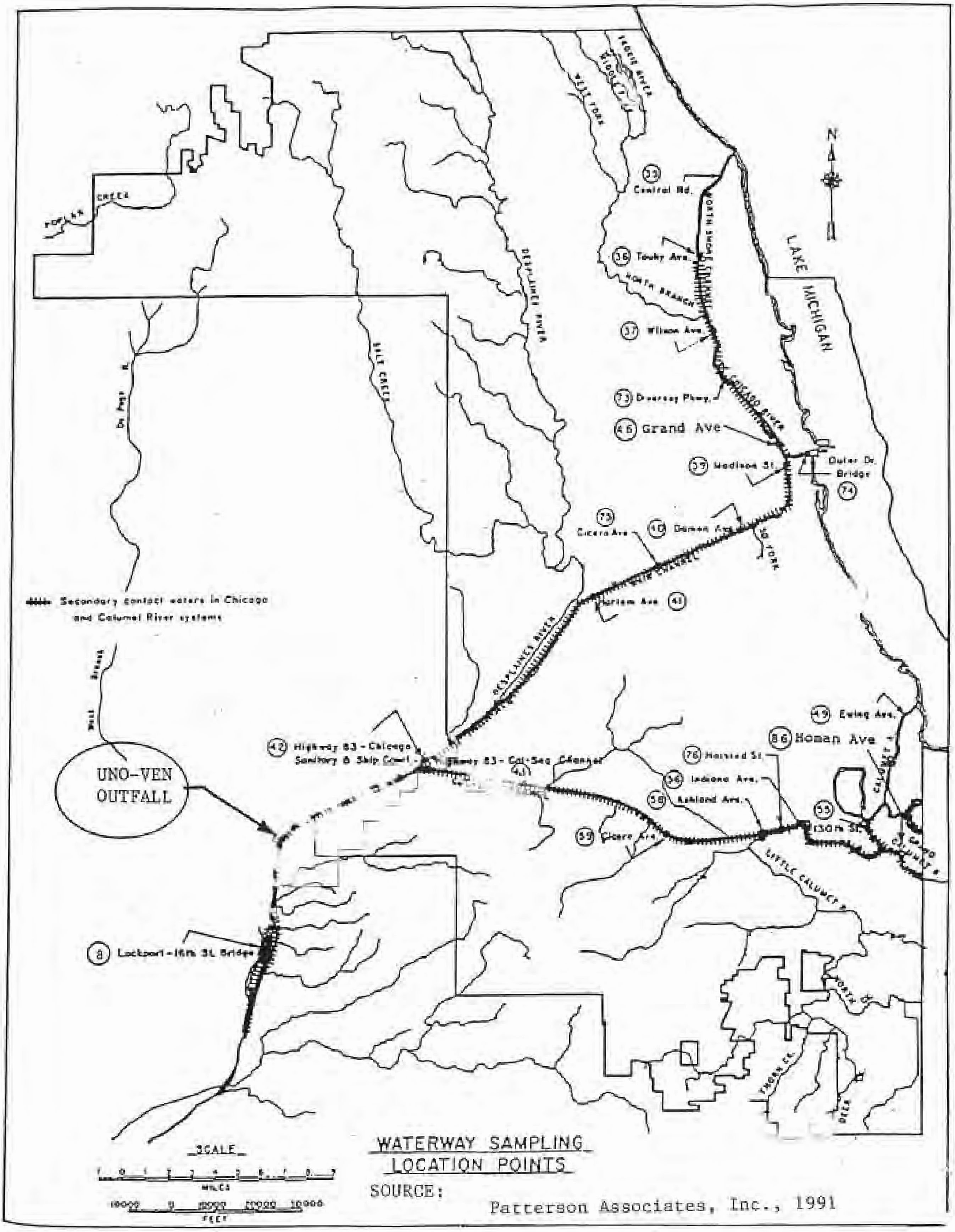
From Table 5-4, un-ionized ammonia downstream of UNO-VEN remained below the 0.1 mg/l level for the entire study period. Upstream on the Ship Canal also remained below the 0.1 mg/l level, while the Cal-Sag exceeded 0.1 mg/l un-ionized ammonia in one of the 113 observations.

5.3.3. Illinois Waterway Quality

The MWRDGC, as required in IPCB R87-27, conducted a water quality evaluation along the Illinois Waterway from the Lockport Lock and Dam to the Peoria Lock and Dam. Forty-nine sampling locations were monitored for temperature, DO, pH, total ammonia nitrogen and calculated un-ionized ammonia. The Illinois Waterway is composed of eight navigational pools listed in Table 5-5. The sample stations are depicted in Figure 5-6A and 5-6B, and begin at mile point 291.5, five miles downstream of UNO-VEN.

The summer conditions of 1989 represented "typical" warm weather water quality conditions. Figures 5-7, 5-8, and 5-9 present the 1989 summer (May through October) DO, total ammonia, and un-ionized ammonia levels.

FIGURE 5-5



WATERWAY SAMPLING LOCATION POINTS

SOURCE: Patterson Associates, Inc., 1991

TABLE 5-3

DISSOLVED OXYGEN RESULTS UPSTREAM & DOWNSTREAM OF UNO-VEN

STATION	WATERWAY	IPCB STANDARD, mg/l	YEAR	NO. OF OBSER-VATIONS	DO LEVELS, mg/l AVG.	MIN.	MAX.	NO. OF OBSER-VATIONS ABOVE IPCB STANDARD	PERCENT OBSER-VATIONS ABOVE IPCB STANDARD
UPSTREAM									
42 (Highway 83)	Ship Canal	4.0	1989	45	6.1	3.1	9.1	42	93
			1990	48	6.0	2.1	8.7	46	96
			1991	27	6.3	4.0	9.7	27	100
			Overall	120	6.1	2.1	9.7	115	96
43 (Highway 83)	Cal-Sag Channel	3.0	1989	45	5.0	1.2	10.2	37	82
			1990	48	5.1	1.2	8.5	45	94
			1991	21	5.3	1.3	8.5	19	90
			Overall	114	5.1	1.2	10.2	101	89
DOWNSTREAM									
8 (16th Street)	Ship Canal	4.0	1989	33	5.7	2.7	8.4	24	73
			1990	36	5.3	1.9	8.1	31	86
			1991	21	6.3	3.0	16.0	16	76
			Overall	90	5.7	1.9	16.0	71	79

SOURCE: Patterson Associates, Inc., 1991.

TABLE 5-4

UN-IONIZED AMMONIA RESULTS UPSTREAM & DOWNSTREAM OF UNO-VEN

STATION	WATERWAY	IPCB WQ STANDARD, mg/l	YEAR	NO. OF OBSER-VATIONS	UN-IONIZED AMMONIA, mg/l AVG.	MIN.	MAX.	NO. VALUES LESS THAN 0.1 mg/l	% OF VALUES LESS THAN 0.1 mg/l
UPSTREAM									
42 (Highway 83)	Ship Canal	0.1	1989	45	0.01	0.00	0.04	45	100
			1990	48	0.00	0.00	0.05	48	100
			1991	27	0.01	0.00	0.09	27	100
			Overall	120	0.01	0.00	0.09	120	100
43 (Highway 83)	Cal-Sag Channel	0.1	1989	44	0.02	0.00	0.10	44	100
			1990	48	0.01	0.00	0.11	47	98
			1991	21	0.02	0.00	0.04	21	100
			Overall	113	0.02	0.00	0.11	112	99
DOWNSTREAM									
8 (16th Street)	Ship Canal	0.1	1989	33	0.01	0.00	0.05	33	100
			1990	36	0.00	0.00	0.02	36	100
			1991	21	0.01	0.00	0.03	21	100
			Overall	90	0.01	0.00	0.05	90	100

SOURCE: Patterson Associates, Inc., 1991.

TABLE 5–5

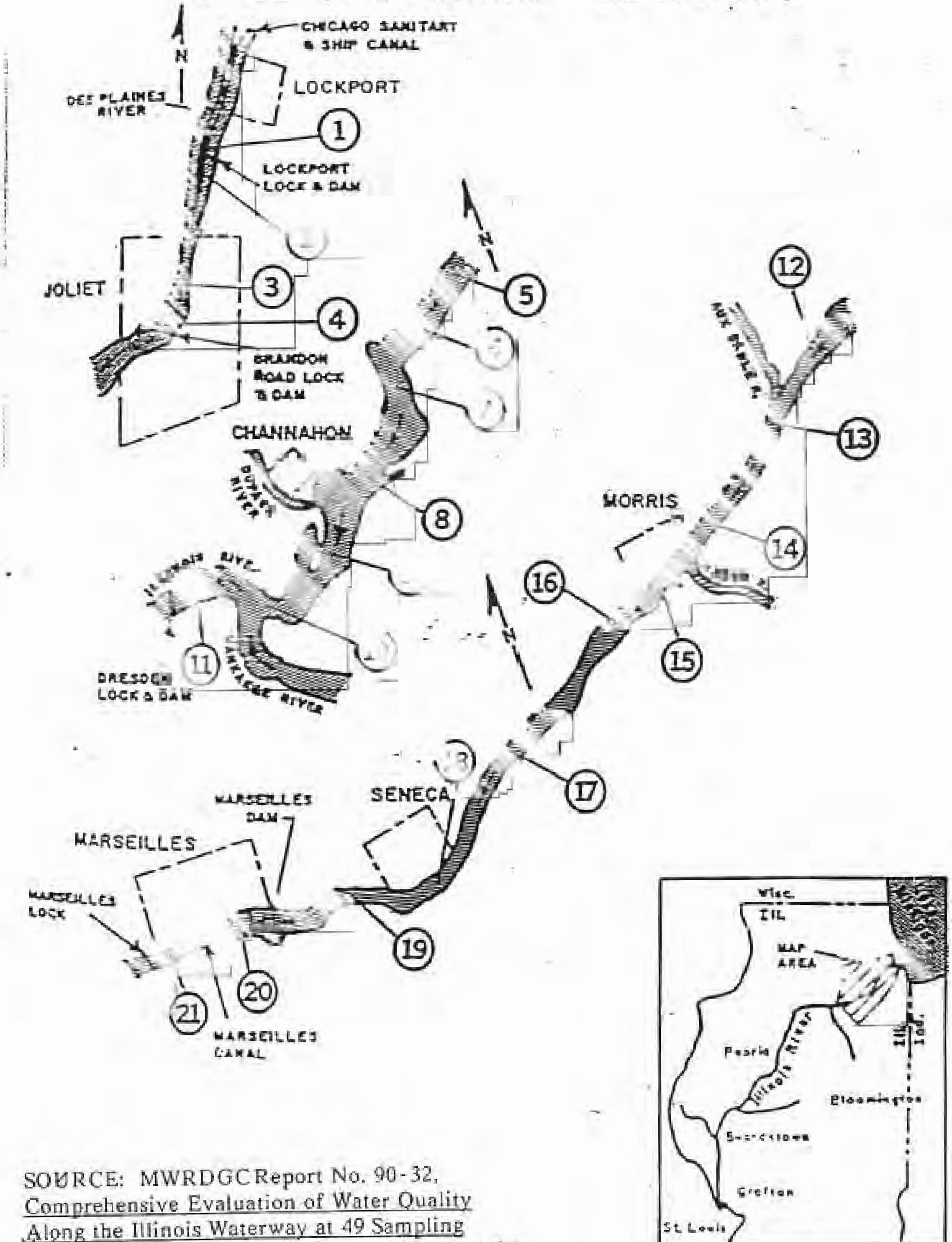
ILLINOIS WATERWAY NAVIGATION POOLS

POOL	INCLUSIVE WATERWAY MILE–POINTS	LENGTH (MILES)
Lockport	327.2 – 291.0	36.2
Brandon Road	291.0 – 286.0	4.7
Dresden Island	271.5 – 247.0	14.5
Marseilles	271.5 – 247.0	24.5
Starved Rock	247.0 – 231.0	15.4
Peoria	231.0 – 157.6	73.4
LaGrange	157.6 – 80.2	77.4
Alton	82.0 – 0.0	80.2

SOURCE: Patterson Associates, Inc., 1991.

FIGURE 5-6A

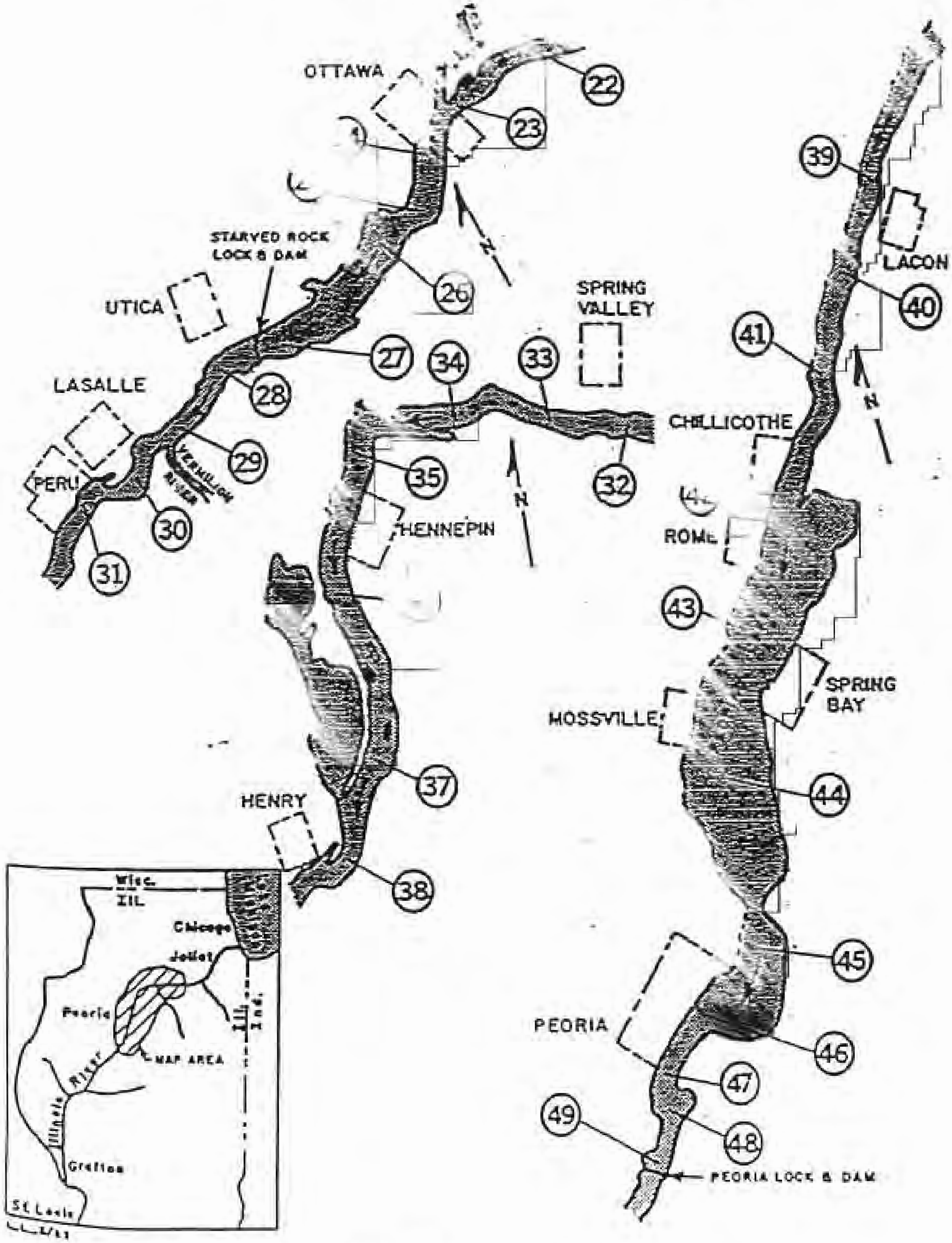
MAP OF ILLINOIS WATERWAY SHOWING SAMPLING STATIONS 1-21 (NUMBERED CIRCLES)



SOURCE: MWRDGC Report No. 90-32, Comprehensive Evaluation of Water Quality Along the Illinois Waterway at 49 Sampling Stations from the Lockport Lock and Dam to the Peoria Lock and Dam During 1989, 1990, pg 3.

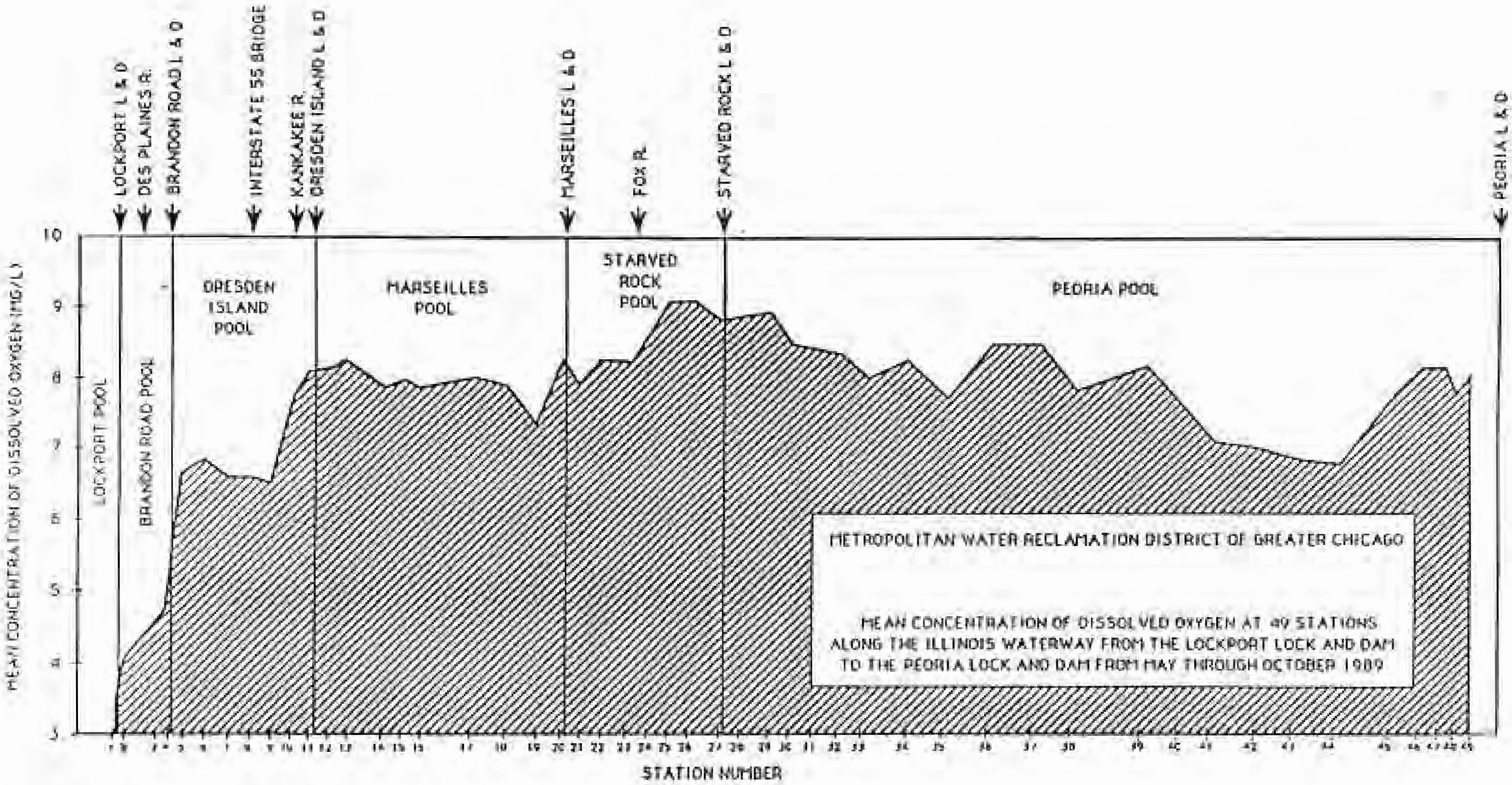
FIGURE 5-6B

MAP OF ILLINOIS WATERWAY SHOWING SAMPLING STATIONS 22-49 (NUMBERED CIRCLES)



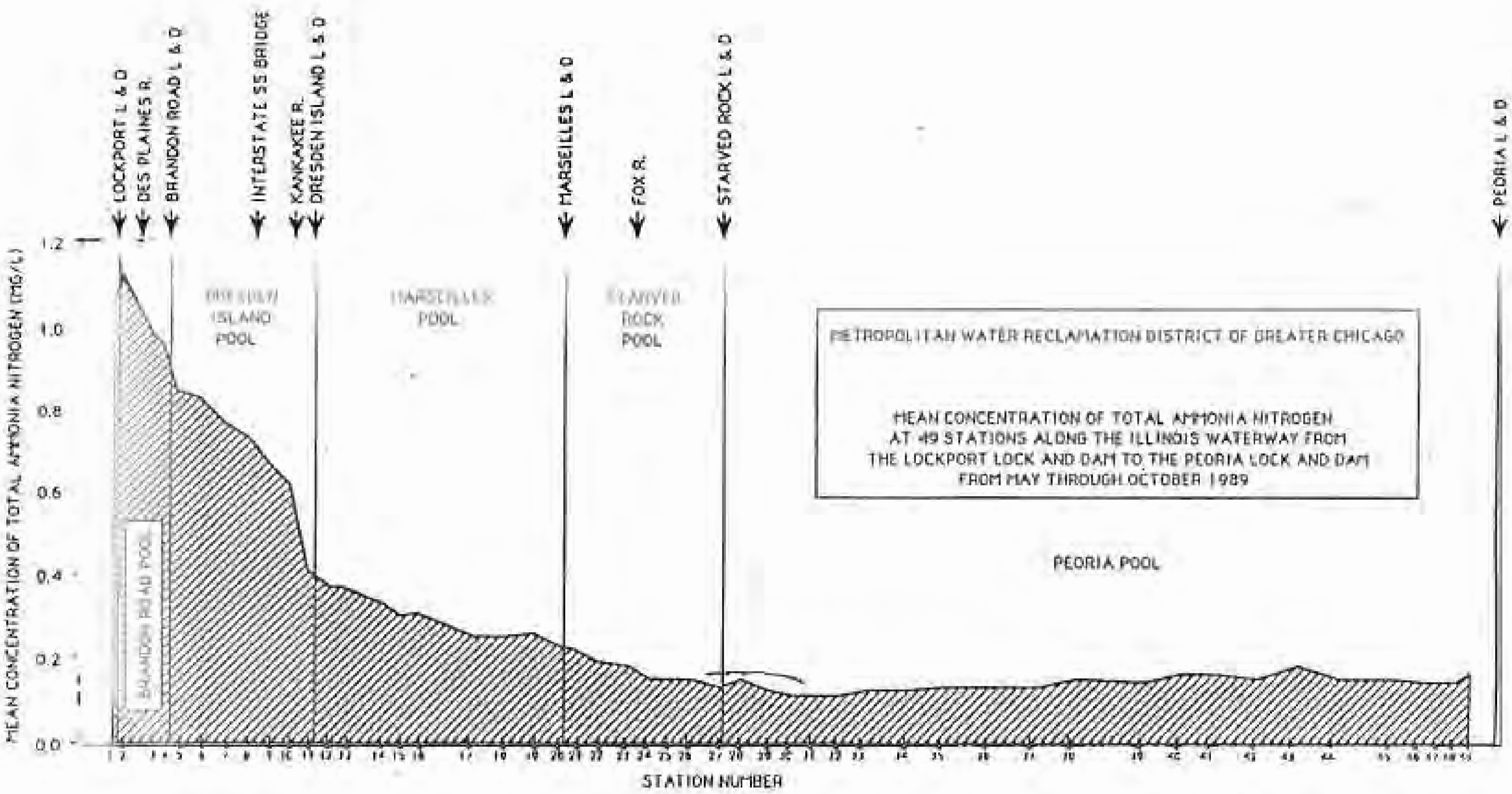
SOURCE: MWRDGC Report No. 90-32, 1990, pg 4

FIGURE 5-7



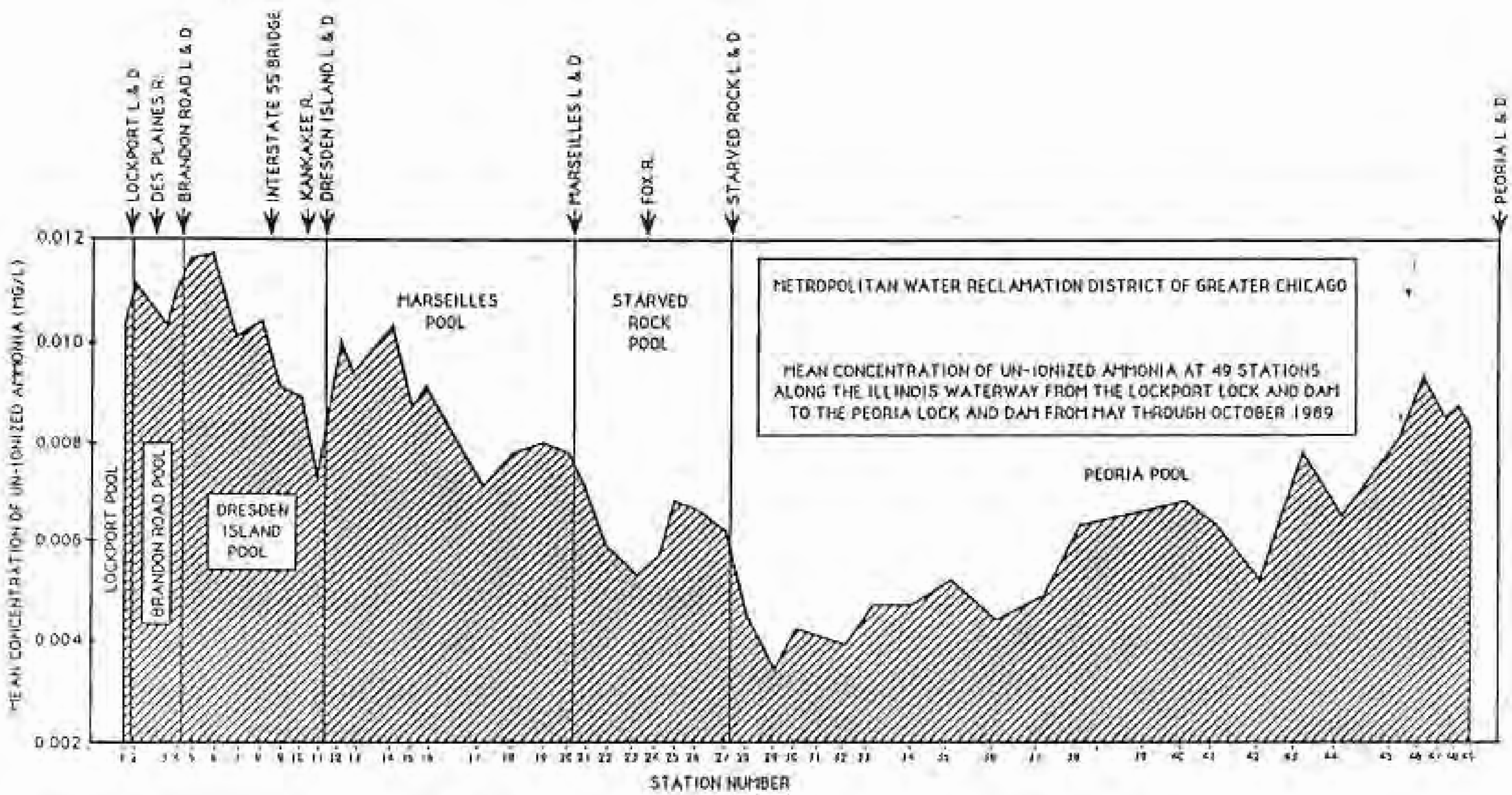
SOURCE: MWRDGC Report No. 90-32, Comprehensive Evaluation of Water Quality Along the Illinois Waterway at 49 Sampling Stations from the Lockport Lock and Dam to the Peoria Lock and Dam During 1989, 1990, pg 18.

FIGURE 5-8



SOURCE: MWRDGCReport No. 90-32, 1990, pg 20

FIGURE 5-9



SOURCE: MWRDGC, Report No. 90-32, 1990, pg 21

The DO trend depicted in Figure 5-7, shows generally increasing DO levels with distance downstream of the Lockport Lock & Dam. By the Brandon Road Lock & Dam, DO levels above 6 mg/l are attained, and the DO generally remains above the 6 mg/l through the remainder of the 139.3 mile study reach.

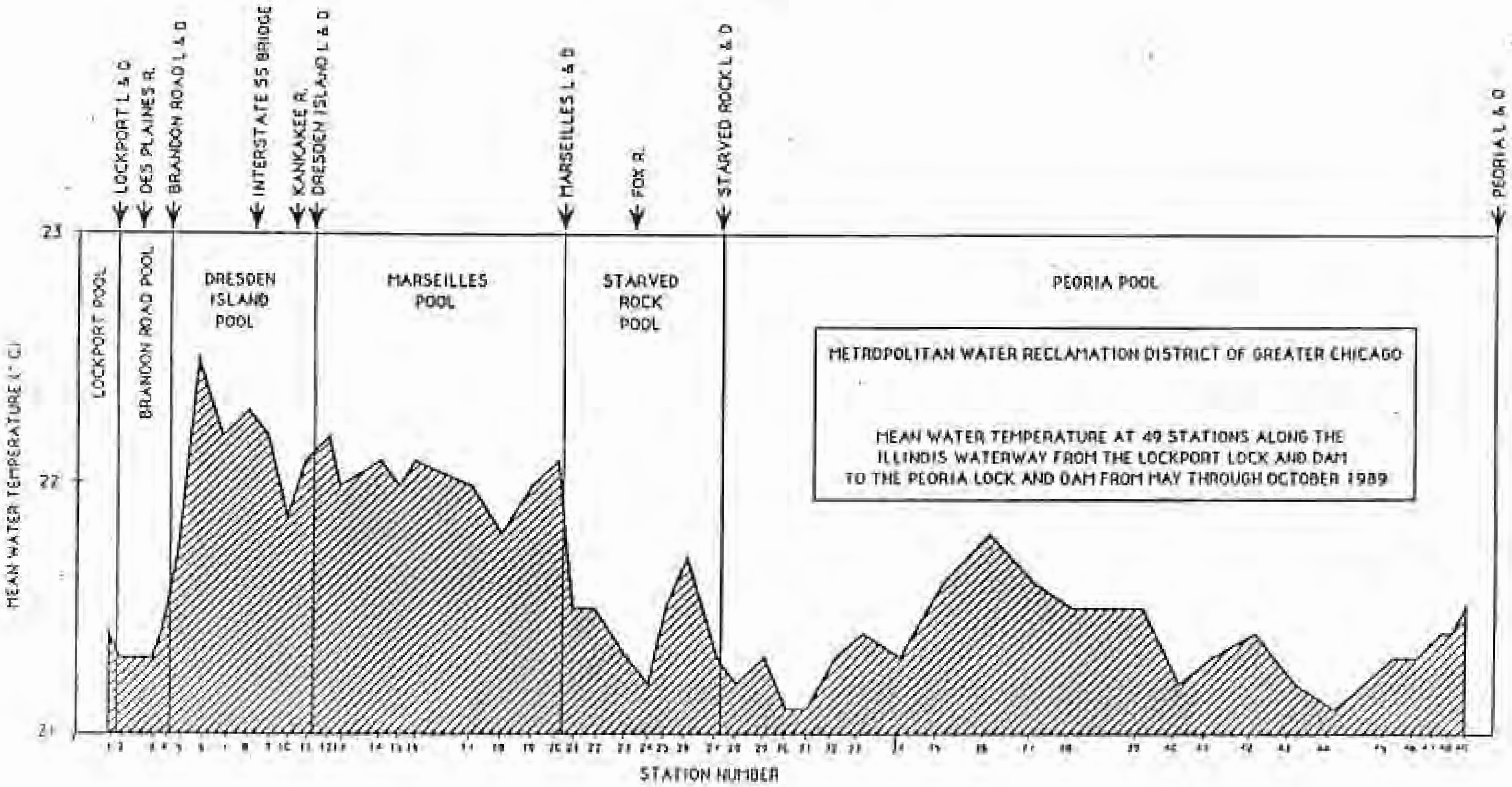
Ammonia nitrogen steadily declines from the Lockport Lock and Dam to Starved Rock, as depicted in Figure 5-8. The ammonia decreases rapidly from the Lockport Lock and Dam from about 1.1 mg/l, to the Starved Rock Pool where ammonia levels remain below 0.2 mg/l. Un-ionized ammonia also shows a similarly decreasing trend from the Lockport Lock and Dam, as illustrated in Figure 5-9. By the I-55 Bridge, un-ionized ammonia is at 0.01 mg/l compared to the general use water quality standard of 0.04 mg/l. In the Peoria Pool, the un-ionized ammonia begins to increase. Figure 5-10 presents the average summer temperature in the waterway. The highest average temperatures were generally experienced in the Dresdon and Marseilles Pools.

The MWRDGC selected five sampling locations to evaluate the Illinois Waterway Quality. The stations were equally spaced to ensure representative coverage. These sample locations are listed in Table 5-6 and referenced by distance to UNO-VEN. The Lockport sample location is on the Ship Canal, where the waterway is regulated as secondary contact water. The remaining sample locations are on general use waters and therefore have different water quality standards. The sample stations were sampled three times per week during the sampling period of April, 1989 to July, 1991. The results of the data collection are summarized in Table 5-7 for dissolved oxygen and un-ionized ammonia, as these are the parameters of interest.

Over the three-year study period in the warmer months, the DO has achieved the water quality limits 68% of the time at Lockport, increasing to 96% and 98% at Morris and Starved Rock, respectively. [1/] By Henry, DO levels achieved 5.0 mg/l 100% of the time.

1/ For discussion purposes, 5.0 mg/l DO was utilized as the water quality standard for general use. The regulations also require a minimum of 16 hours per day above 6.0 mg/l.

FIGURE 5-10



SOURCE: MWRDGC Report No. 90-32, 1990, pg 16

TABLE 5-6

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

DESCRIPTION OF FIVE SAMPLING STATIONS ALONG THE ILLINOIS WATERWAY

SAMPLING STATION	WATERWAY	DESCRIPTION MILE-POINT LOCATION	DESCRIPTION OF SAMPLING STATION 1/	DISTANCE FROM UNO-VEN Miles
Lockport	Chicago Sanitary & Ship Canal	292.7	Division Street along left bank of the canal	3.8
Morris	Illinois River	263.4	Approximately 600 feet below Route 47 bridge along left bank of river	33.1
Starved Rock	Illinois River	229.7	Approximately 2,600 feet above Route 178 Bridge along right bank of river	66.8
Henry	Illinois River	195.9	Approximately 600 feet above Route 18 Bridge along left bank of river	100.6
Peoria	Illinois River	166.1	Approximately 600 feet above Route 150 Bridge along left bank of river	130.4

1/ STATION LOCATION FACING UPSTREAM IN WATERWAY

SOURCE: Patterson Associates, Inc., 1991.

TABLE 5-7

SUMMARY OF MWRDGC DATA FOR ILLINOIS WATERWAY

WATERWAY	YEAR	DISSOLVED OXYGEN, mg/l MIN.	AVG.	% COMPLIANCE	TOTAL AMMONIA, mg/l AVG.	MAX.	UN-IONIZED AMMONIA, mg/l AVG.	MAX.	% COMPLIANCE
LOCKPORT	1989	2.1	5.0	78	1.54	4.30	0.03	0.29	95
(Mile 292.7)	1990	1.0	4.0	48	1.66	6.11	0.01	0.07	100
	1991	2.7	6.3	91	1.30	3.88	0.01	0.02	100
	Overall	1.0	4.9	68	1.53	6.11	0.01	0.29	99
MORRIS	1989	4.8	9.1	99	0.53	1.88	0.01	0.09	97
(Mile 263.4)	1990	3.8	7.9	92	0.45	1.93	0.01	0.05	99
	1991	5.3	8.9	100	0.28	0.77	<0.01	0.01	100
	Overall	3.8	8.5	96	0.43	1.93	0.01	0.09	99
STARVED ROCK	1989	4.9	9.6	99	0.37	1.91	0.01	0.15	97
(Mile 229.7)	1990	3.8	8.2	96	0.34	2.37	0.01	0.04	100
	1991	6.1	9.2	100	0.22	0.68	<0.01	0.20	99
	Overall	3.8	8.9	98	0.32	2.37	0.01	0.20	99
HENRY	1989	5.3	12.2	100	0.45	1.17	0.02	0.13	95
(Mile 196.9)	1990	5.5	10.7	100	0.41	1.73	0.01	0.06	97
	1991	5.9	10.3	100	0.29	0.97	0.01	0.05	99
	Overall	5.3	10.8	100	0.38	1.73	0.01	0.13	97
PEORIA	1989	5.8	11.5	100	0.37	1.21	0.01	0.23	94
(Mile 166.1)	1990	5.5	10.4	100	0.28	1.23	0.01	0.05	99
	1991	6.1	10.3	100	0.18	0.62	<0.01	0.06	99
	Overall	5.5	10.5	100	0.27	1.23	0.01	0.23	97

SOURCE: Patterson Associates, Inc., 1991.

From Table 5-7, the un-ionized ammonia water quality standard was achieved a high percentage of the time, throughout the waterway; from 97% at Henry and Peoria to 99% at Lockport, Morris and Starved Rock. Figures 5-11 and 5-12 graphically present the DO and ammonia results for the three-year study period.

In summary, the water quality standards are generally being achieved in the Illinois River System. However, achieving a consistent DO level above 4.0 mg/l in the Ship Canal has not be attained. From 1989 through 1991, DO levels in the warmer months were above 4.0 mg/l only 68% of the time.

Both total ammonia and un-ionized ammonia have shown a general decrease in concentration from 1989 to 1992. The total ammonia at the Peoria station has shown the greatest improvement of the five monitoring stations with a 51% reduction in total ammonia. The un-ionized ammonia has been in compliance 94% to 100% of the time at the various sampling stations along the river system. The total ammonia decreases as it traverses downstream. The greatest reduction occurs from the Lockport to the Morris sample station reducing the total ammonia by 72% 1989 to 1991.

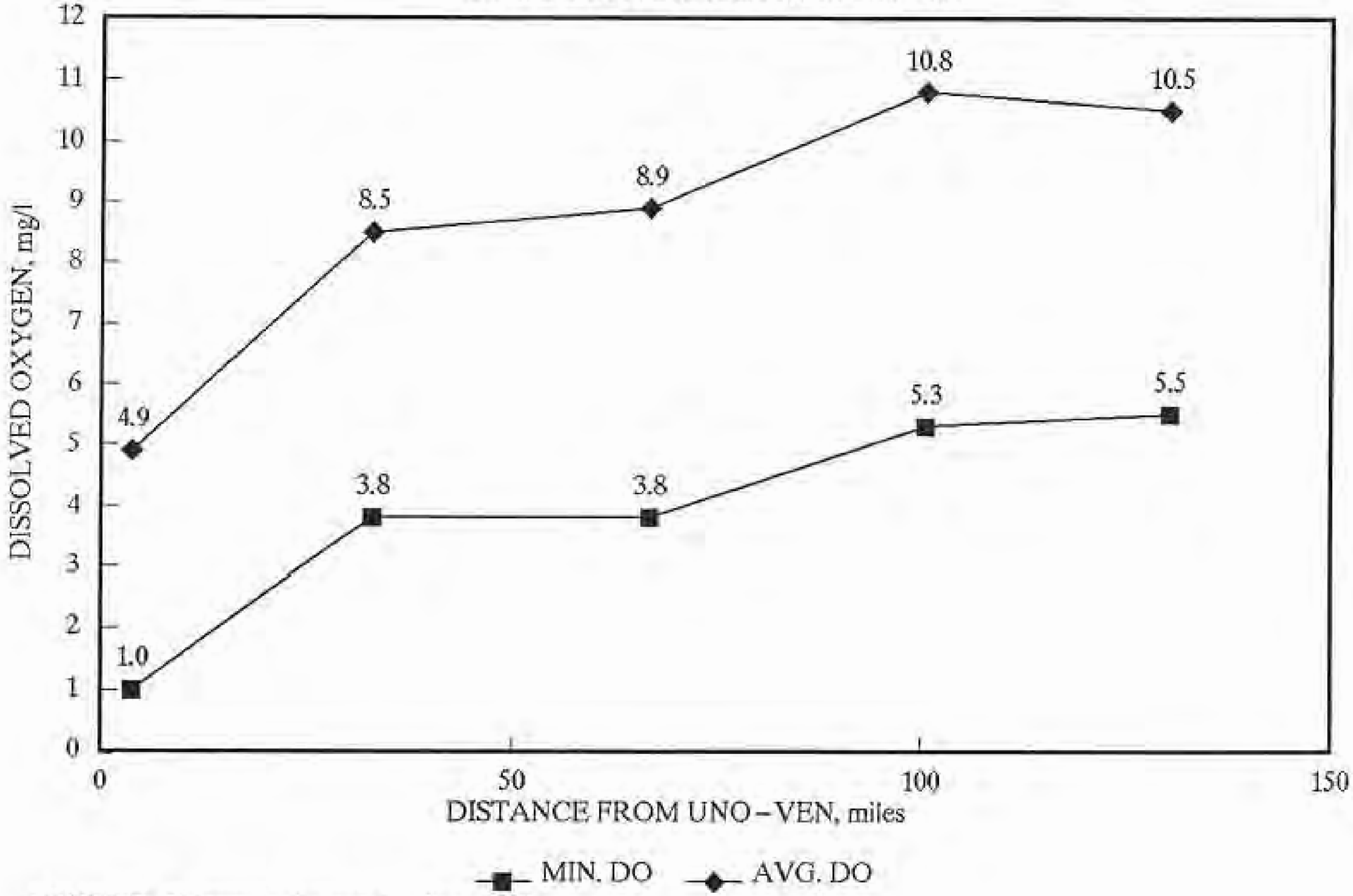
5.4 Point Sources on the Chicago Waterway

Point sources on the Chicago Waterway greatly influence the water quality of the Chicago Waterway and Illinois River System. The three major MWRDGC Water Reclamation Plants (WRPs) are upstream of UNO-VEN and contribute a large portion of the ammonia loading to the Chicago Waterway. Table 5-8 lists the most recent data from the discharge monitoring reports (DMRs) for the three MWRDGC WRPs. Figure 2-2 of Chapter 2 depicts the location of the WRPs in the Chicago area. The total ammonia loading added to the Chicago Waterway from all three WRPs is 21,320 pounds per day. The Calumet WRP contributes 69% of the ammonia loading of the three WRPs based on an annual average. The Calumet WRP currently operates under a site-specific rule (Section 204.201 of the IPCB Rules and Regulation) allowing Calumet WRP a monthly average of

FIGURE 5-11

DISSOLVED OXYGEN ON THE ILLINOIS WATERWAY

OVERALL AVERAGE FROM 1989–1991

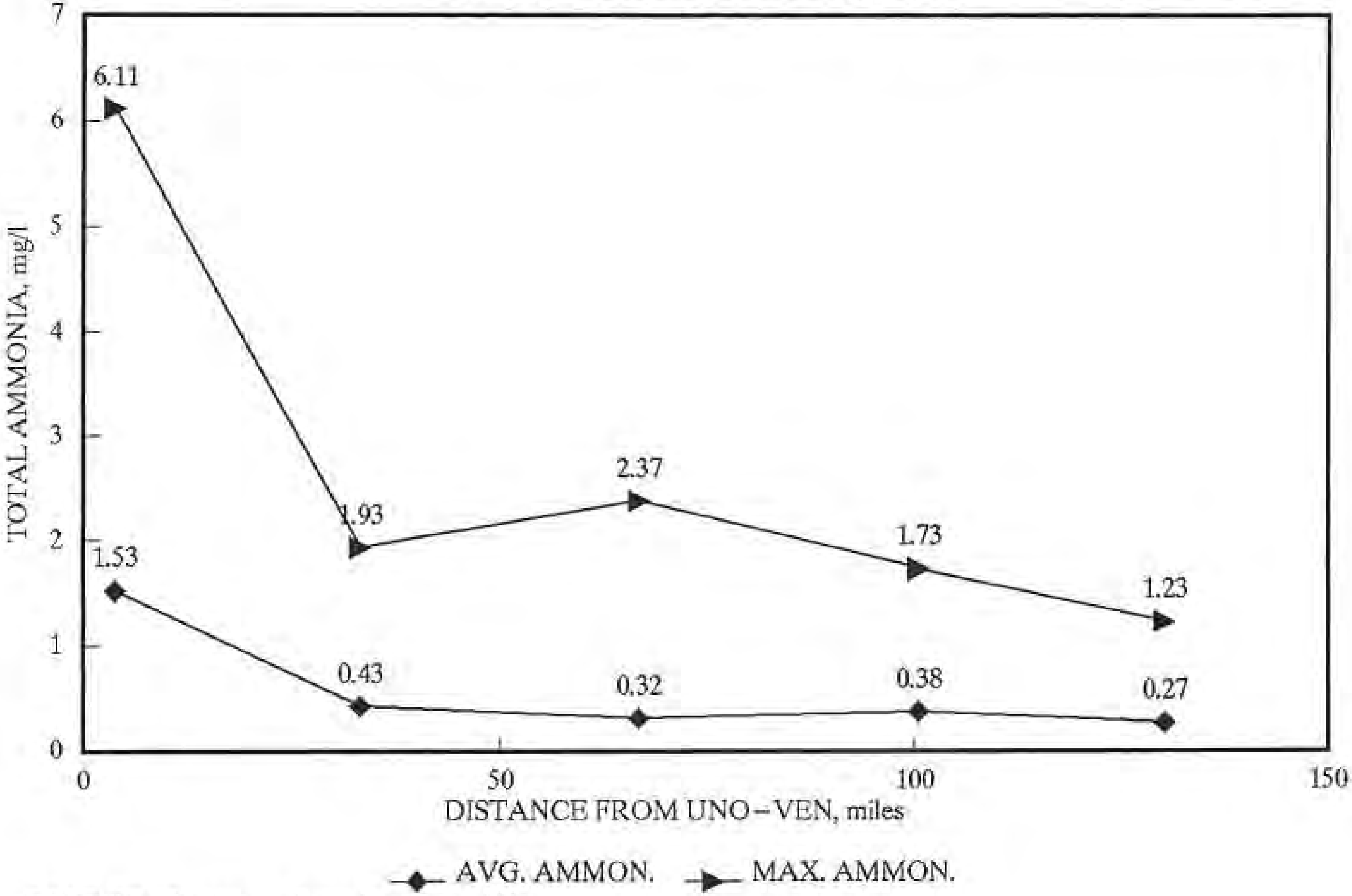


SOURCE: Patterson Associates, Inc., 1991.

FIGURE 5-12

TOTAL AMMONIA ON THE ILLINOIS WATERWAY

OVERALL AVERAGE FROM 1989–1991



SOURCE: Patterson Associates, Inc., 1991.

TABLE 5-8

EFFLUENT AMMONIA LOADINGS OF MWRDGC WATER RECLAMATION PLANTS

MONTH	STICKNEY			CALUMET			NORTH SIDE		
	AVERAGE FLOW, mgd	AMMONIA NITROGEN, mg/l	AMMONIA LOADING, lbs/day	AVERAGE FLOW, mgd	AMMONIA NITROGEN, mg/l	AMMONIA LOADING, lbs/day	AVERAGE FLOW, mgd	AMMONIA NITROGEN, mg/l	AMMONIA LOADING, lbs/day
JAN 1991	764	2.0	12744	279	8.10	18848	271	1.80	4068
FEB	698	1.4	8150	285	9.00	21392	277	1.30	3003
MAR	864	0.3	2162	352	6.10	17908	316	0.90	2372
APR	922	0.4	3076	330	3.30	9082	335	0.40	1118
MAY	827	0.3	2069	330	5.20	14311	311	0.30	778
JUN	772	0.4	2575	248	7.50	15512	271	0.50	1130
JUL	722	0.6	3613	236	5.60	11022	258	1.00	2152
AUG	778	0.9	5840	252	8.46	17780	258	0.70	1506
SEP	711	0.2	1186	239	7.36	14670	259	0.60	1296
OCT	846	0.2	1411	302	4.08	10276	307	0.50	1280
NOV	841	0.3	2104	326	5.00	13594	320	0.30	801
DEC	746	0.3	1866	320	5.50	14678	304	0.50	1268
JAN 1992	631	1.2	6315	246	11.20	22978	263	1.10	2413
FEB	668	1.8	10028	278	7.60	17621	280	1.20	2802
MAR	772	0.4	2575	286	3.76	8969	316	1.70	4480
APR	743	1.2	7436	264	3.23	7112	298	0.70	1740
AVERAGES	769	0.7	4572	286	6.3	14735	290	0.8	2013
PERMIT LIMITS	1200	2.5/4.0 a/		354	13.00 b/		333	2.5/4.0 a/	

a/ Summer/Winter
b/ 13.0 mg/l monthly average limit, 26.0 mg/l daily maximum limit

of 13.0 mg/l of ammonia. Based on an average flow for 1991 to April 1992, of 286 mgd, an ammonia concentration limit of 13 mg/l would contribute 31,000 pounds per day of ammonia to the Cal Sag Channel.

The MWRDGC conducted a comprehensive water quality evaluation of the Calumet, Northside and Stickney Water Reclamation Plant Effluent Data from 1989 to July, 1991, as required in IPCB R87-27. The data obtained are summarized in Table 5-9 along with the IPCB effluent standards.

The ammonia trend form 1989 to July, 1991, has shown a general decrease in concentration at the Stickney and Northside WRP. Overall, the reduction has been 47% and 36%, respectively. The ammonia trend at the Calumet WRP plant, however, has generally increased by 1 mg/l from 5.4 mg/l in 1989 to 6.4 mg/l in 1991. This 1.0 mg/l ammonia increase results in an additional 2,400 pounds per day of ammonia being added to the Cal Sag Channel, compared to 1989/1990.

5.5 Metropolitan Water Reclamation District of Greater Chicago Water Quality Modeling

5.5.1 Introduction

A computer model of the Chicago Waterway and Illinois River System has been developed by the Metropolitan Water Reclamation District of Greater Chicago (MWRDGC) with assistance from Camp Dresser and McKee (CDM). The model was developed in two sections, the first section includes the Chicago Waterway from the three inlet points on Lake Michigan (Wilmette Lock, Chicago River, and the O'Brien Lock) to the I-55 Bridge. The second section continues from the I-55 Bridge to the Peoria Lake in Chillicothe, Illinois.

TABLE 5-9

AMMONIA EFFLUENT QUALITY OF MWRDGC WRPs

1989 - 1991

		AMMONIA, mg/l		
PLANT	YEAR	EFFLUENT LIMIT	AVG.	DAILY MAXIMUM
Calumet	1989	13.0 Monthly Average	5.4	18.7
	1990		4.4	13.8
	1991		6.4	16.8
	Overall		5.2	18.7
Stickney	1989	2.5 (Apr-Oct) 4.0 (Nov-Dec)	1.5	11.5
	1990		1.0	6.9
	1991		0.8	4.5
	Overall		1.2	11.5
Northside	1989	2.5 (Apr-Oct) 4.0 (Nov-Dec)	1.4	5.6
	1990		1.2	3.6
	1991		0.9	3.3
	Overall		1.2	5.6

5.5.2 Overview of QUAL2EU Model

QUAL2EU was developed by the U.S. Environmental Protection Agency to model the physical, chemical, and biological processes that affect dissolved oxygen (DO) in a river system and is typically used for waste allocation studies by the U.S.EPA (CDM, Main Report, 1992). QUAL2EU can simulate up to 15 water quality constituents, including DO, biochemical oxygen demand (BOD), and nitrogen. It is applicable to diverging and non-diverging waterways that are well mixed. QUAL2EU is essentially a steady-state model in that it is assumed that stream flow and input waste loads are constant.

5.5.3 Data Acquisition

The major portion of the data acquired for the model was provided by the Illinois State Water Survey (ISWS) from sampling between 1989 to 1991. Data for the model were also obtained from MWRDGC, U.S. Army Corps of Engineers (COE), the National Weather Service of the National Oceanic and Atmospheric Administration, the IEPA and the U.S. EPA. Point source contributions of 1 mgd per day or more to the Chicago Waterway and Illinois River System were obtained by CDM from Discharge Monitoring Reports (DMRs) submitted to the IEPA from October, 1989 to December, 1990.

Data from the three MWRDGC WRPs were obtained from 1986 to 1990. Non-MWRDGC facilities also included in the model are listed in Table 5-10. Loadings for the smaller wastewater treatment plants were kept constant throughout the modeling. The loadings from the three MWRDGC WRPs were varied depending upon the flow condition being modeled. Table 5-11 presents the ammonia loadings in lbs/day for the principal ammonia dischargers to the Illinois Waterway. In most cases, the loadings were obtained from the Discharge Monitoring Reports for January, 1991 to April, 1992.

TABLE 5-10

DISCHARGE CONCENTRATIONS FOR WASTEWATER TREATMENT PLANTS AS USED IN FIRST AND SECOND SECTIONS OF QUAL2EU MODEL

	RIVER MILE	FLOW, 1/ mgd	DO, 2/ mg/l	CBOD, 2/ mg/l	NH3-N, 2/ mg/l
Chicago Waterway/ Des Plaines River					
LTV Steel	333.0	35	7.7	32.0	2.50
Lemont WRP	300.6	1.4	6.4	12.8	1.24
UNO-VEN Ref	297.5 a/	3.94	7.7	32.0	2.50
Comm Edison			5.9	4.0	1.24
Lockport WRP	292.5	2.15	7.7	10.1	0.40
Joliet WRP	286.6	17.15	7.7	8.0	0.30
Joliet Army	283.7	4.67 b/	7.7	1.8	0.30
Joliet West WRP	278.7	4.71	7.7	3.2	0.30
Mobil Oil		14.32 b/	7.7	4.8	0.04
Upper Illinois River					
Comm Edison		606.39	8.6	5.0	0.27
Quantum Refinery		3.91	7.7	8.9	1.30
Morris WRP	262.8	1.8	7.7	18.2	2.32
ETI Explosives	253.5	1.01	7.7	22.7	1.55
Marseilles WRP	246.0	1.2	7.7	11.2	1.30
Ottawa WRP	239.3	3.62	7.7	7.5	1.30
Carus Chemical	225.7	1.30	7.7	5.8	0.89
LaSalle WRP	223.2	1.91	7.7	3.5	1.30
Peru WRP	222.0	2.68	7.7	16.0	1.30
LTV Steel		7.15	7.7	32.0	1.30
BF Goodrich	197.8	0.97	7.7	5.8	1.30

a/ UNO-VEN mile point as input in model
UNO-VEN's discharge mile point is actually 296.5

b/ Total Flows

Source 1/: CDM, Data Acquisition, 1991.

Source 2/: CDM, Main Report, 1992.

TABLE 5–11

DISCHARGED AMMONIA LOADINGS

January 1991 – April 1992

	FLOW, mgd	NH3–N, mg/l	NH3–N, lbs/day
Chicago Waterway/ Des Plaines River			
North Side WRP	290	0.8	2013
LTV Steel	27.6	0.2	58
Calumet WRP	286	6.3	14735
Stickney WRP	769	0.7	4572
Lemont WRP	1.7	2.2	36
UNO–VEN Ref	3.8	1.8	49 a/
Lockport WRP	2.1	1.6	30
Joliet WRP	18.0	1.0	159
Joliet Army	1.2	0.8	3 c/
Joliet West WRP	3.6	1.1	35
Mobil Oil	2.8	1.6	39
Upper Illinois River			
Comm Edison	622	0.4	1972 d/
Quantum Refinery	1.3	0.9	8
Morris WRP	1.8	2.3	35 b/
ETI Explosives	1.0	7.0	51
Marseilles WRP	1.2	1.3	13 b/
GE Plastics	1.2	2.3	23 e/
Ottawa WRP	3.6	1.3	39 b/
Carus Chemical	1.2	1.3	13
LaSalle WRP	1.9	1.3	21 b/
Peru WRP	2.7	1.3	29 b/
LTV Steel	7.2	1.3	78 b/
BF Goodrich	1.0	1.3	11 b/

a/ From UNO–VEN monthly monitoring reports, Jan 91 – Sep 92
b/ Calculated from Table 5–10
c/ Total from outfall 009 and 014
d/ Average flow from Jan 91 – Apr 92
and ammonia conc. measured on 3/92
e/ From 1991 DMRs – formerly Borg Warner Chemicals

SOURCE: Discharge Monitoring Reports issued to IEPA from Jan. 1991 – Apr. 1992

Details of the data acquisition efforts and results are included in several reports prepared by CDM for MWRDGC on the modeling efforts. The data collected were used to calibrate and verify the model. Once the model was calibrated and verified, the model was used to simulate three scenarios; existing conditions in the waterways, future conditions through 1999 that account for water quality improvement projects underway by the MWRDGC such as the Tunnel and Reservoir Project - Phase I (TARP I) and sidestream elevated pool aeration (SEPA), and future conditions in 2010 that reflect the District's loss of annual discretionary diversion allowance from the current 320 cfs to 101 cfs in the year 2001.

5.5.4 Model Simulations

Two models were developed, one for flow conditions with diversion and one for flow conditions without diversion. Diversion generally occurs as a result of low flows in the waterway system typically experienced during summer dry weather.

Simulations using the QUAL2EU model were run for average dry weather flows and two extraordinary hydrologic conditions; wet weather flows when reclamation plants would operate at maximum capacity, and low flows representing 7-day, 10-year low flow conditions. The average dry weather simulations assumed that the reclamation plants achieved average 1991 effluent quality, and the extraordinary conditions were simulated using NPDES permit limits of maximum weekly average limit for wet weather flows and average monthly limit for low flows (CDM, Executive Summary, 1992).

5.5.5. Modeling Results

The following highlights the results of CDM's modeling efforts and is taken from the Executive Summary of CDM's report on Water Quality Modeling for the Chicago Waterway and Upper Illinois River Systems, January, 1992 Average Dry Weather Flows - Existing Conditions. Dissolved oxygen (DO) standards are not achieved in the Cal Sag Channel, and in the lower reach of the Chicago River during warmer, average dry weather conditions. DO standards are met in the Upper Illinois River. Total ammonia nitrogen does not exceed 0.4 mg/l at the I-55 Bridge because of nitrification during the summer in the Chicago Waterway, and the un-ionized ammonia remains below 0.1 mg/l throughout Average Dry Weather Flows - Future Conditions 1999 - Chicago Waterway. The completion of SEPA and most of TARP 1 will improve average dry weather water quality. TARP will improve DO concentrations by reducing combined sewer overflows (CSO) which reduces BOD and ammonia loadings, and also sediment oxygen demand (SOD). Un-ionized ammonia is projected to meet the water quality standards of less than 0.1 mg/l in the Chicago Waterway and less than 0.04 mg/l in the Upper Illinois River.

As a result of TARP 1, the lowest dissolved oxygen concentration improves to 4.0 mg/l in 1999 from 3.0 in 1991. SEPA will add up to 6 mg/l of DO to the Cal Sag Channel raising the spring DO concentrations from 2.0 mg/l to 5.0 mg/l at the downstream end of the Cal Sag Channel. Completion of TARP and SEPA will assure that the minimum are at or above the standard on the Chicago Waterway except for a short reach on the lower North Branch of the Chicago River. Dissolved oxygen on the Upper Illinois River will exceed the 5.0 mg/l standard under future average flow conditions.

Average Dry Weather Flow - Future Conditions 2010: Following the reduction of discretionary diversion in the year 2001, DO concentrations throughout the Chicago Waterway are expected to decrease by 0.5 to 1.0 mg/l. DO water quality standards will not be achieved during some periods of the year and the discretionary diversion reduction will offset some of the benefits of MWRDGC's improvements.

Low Flow Conditions: Un-ionized ammonia standards will continue to be met through the year 2010 except in the Cal Sag Channel. Dissolved oxygen standards will not be met on a consistent basis at monthly average permit limits and low flow conditions. DO in the Calumet and Chicago Waterways does not meet all the standards in 1991 or 2010 for all seasons. Because of the reduced discretionary diversion flows after 2001, the benefits of the SEPA stations will be reduced. For the Upper Illinois River, the DO standard is not met under existing conditions with low flows in the spring only. The DO for summer and winter simulations exceeds the standard for all years and spring simulations exceed the standard in 2010 only.

Wet Weather Flow Conditions: Wet weather flow simulated severe conditions of design maximum flows from the District's plants and zero discretionary flow. This resulted in $CBOD_{20}$ loads 8 to 14 times greater than average conditions. DO on the Chicago Waterway was below the 4.0 mg/l standard for all seasons modeled for 1991 and 2010. Minimum DO occurs on the Ship Canal below the Cal Sag Channel confluence. For the 2010 simulations, the decreased discretionary diversion flow and increased reclamation plant flows tend to offset the benefits of TARP and SEPA.

DO would be below the standard of 5.0 mg/l on the Upper Illinois River upstream of the Starved Rock Dam under three simulations; spring 1991, summer 1991, and summer of 2010. DO recovers to above 5.0 mg/l immediately below the dam under all three scenarios.

For the 1991 simulations, the un-ionized ammonia standard would only be exceeded for a short reach of the Cal Sag Channel. The un-ionized ammonia standards were met for all the 2010 simulations.

The simulation of the extraordinary hydrologic events indicates that water quality standards for dissolved oxygen and un-ionized ammonia could fail to be met for short periods of time of extreme conditions. Past operational experience at the District's plants indicates that the extreme conditions modeled, effluent concentrations as high as the permitted weekly maximum average, would rarely occur.

5.5.6 Uncertainty Analysis

Uncertainty analysis of the calibrated and verified models was performed using the UNCAS routine of the QUAL2EU mode. The uncertainty analysis examines the variability is predicted water quality values based on the variability of the model input values. For this model, the analysis indicated that temperature and the atmospheric reaeration rate, K_2, have the largest influence on DO in the Chicago Waterway and for the Upper Illinois River. DO is most affected by headwater loadings, temperature, and velocity. The uncertainty analysis of the model predicted a variability in the dissolved oxygen concentration ranging from 4% to 33% which compares favorably with the variability in the sampling data which ranged from 6% to 25%. Thus, the model can predict dissolved oxygen concentrations with an error that approximates the measurement error.

CHAPTER 6

UNO-VEN'S IMPACT ON THE ILLINOIS RIVER SYSTEM

6.1 Introduction

The principal local effect associated with UNO-VEN's discharge is the change in ammonia concentration within the Zone of Initial Dilution as discussed in Chapter 4. Ammonia discharged to waterways also impacts dissolved oxygen (DO) levels, as 4.57 pounds of oxygen are consumed for every pound of ammonia biologically oxidized. This chapter focuses on the impact of UNO-VEN's ammonia discharge has on both ammonia and DO levels downstream, including the Illinois River System.

The QUAL2EU Model developed by the MWRDGC has been used to simulate the impact of UNO-VEN's ammonia loading on both the Chicago Waterway and the Illinois River system. The model was developed in two simulations; the Chicago Waterway from Lake Michigan to the I-55 Bridge on the Des Plaines River, and the Illinois River system from the I-55-Bridge to Peoria Lake. For our purposes, average summer flow rates and average summer ammonia and BOD_5 loadings for 1991 are used to describe the existing water quality. This model will be referred to as the base model. The base model uses 2.5 mg/l ammonia effluent concentration and 3.36 mgd for the discharge rate for the UNO-VEN Refinery, as modeled by the MWRDGC. This yields an ammonia loading of 70 lbs/day from the refinery. The MWRDGC model inputs UNO-VEN's discharge at river mile 297.5 as opposed to the actual discharge location at river mile 296.5. To remain consistent with MRWDGC's work, the discharge point was not corrected in the model.

6.2 Simulated UNO-VEN Loadings

Three simulations were modeled to evaluate the impact of various ammonia loadings from UNO-VEN. These were first simulated on the Chicago Waterway to the I-55 Bridge, which is the beginning of general use waters and the extent of the first model. The second section of the model, simulating the Illinois Waterway, was run if a change in water quality was occurring in the first model at the I-55 Bridge.

The ammonia loadings from UNO-VEN used for the simulations are shown in Table 6-1. These data are from January, 1989 to May, 1992 and are representative of the UNO-VEN's actual capacity.

The model was run to predict the changes an increased ammonia loading would have on the downstream water quality. From Table 6-1, the mean ammonia loading discharged since 1989 is 51 lbs/day, less than the base model loading of 70 lbs/day (2.5 mg/l and 3.36 mgd) obviously resulting in better water quality than the base model. Therefore, the average loadings were not modeled.

6.3 Simulation Results

The monthly maximum and daily maximum simulations were run on the QUAL2EU computer model. Other input variables were not changed from the base model to isolate the changes caused by an increased ammonia loading.

Figure 6-1 and 6-2 present the ammonia concentrations for river miles 299 to 278. UNO-VEN's discharge occurs at river mile 297.5 in the model, and the river flow is from higher to lower river miles (right to left on the figures). The daily maximum loading from UNO-VEN between 1989 and 1992 was 744 lbs/day, and this loading increased the ammonia concentration in the canal a maximum of 0.03 mg/l for approximately 2.5 miles downstream, then the ammonia incremental change gradually diminishes. By the end of the first section of the model, river mile 278, the ammonia concentration is predicted for the daily maximum discharge to be 0.02 mg/l above the base model, 0.47 mg/l compared to 0.45 mg/l. Both levels are less than the 1.5 mg/l water quality standard that begins at river mile 278.0. The monthly maximum ammonia loading increases the ammonia concentration by 0.01 mg/l initially in the Ship Canal, and stream concentrations are virtually the same as the base model after river mile 278.

TABLE 6-1

QUAL2EU UNO-VEN INPUT PARAMETERS

1989 TO APRIL, 1992

Condition	Flow, mgd	NH_3/N, mg/l	NH_3/N, lbs/day
Base Model	3.36	2.5	70
Average Load	3.90	1.57 a/	51
Monthly Maximum	3.93	7.9 b/	259
Daily Maximum	4.29	20.80	742

a/ Calculated using average ammonia loading and average flow for 1989 to June, 1992.

b/ Calculated using monthly maximum ammonia load and monthly average flow for the month of the maximum loading.

FIGURE 6-1
COMPARISON OF AMMONIA CONCENTRATION DATA, mg/l
MWRDGC QUAL2EU MODEL OF CHICAGO WATERWAY
River Miles: 286.5 - 299.0

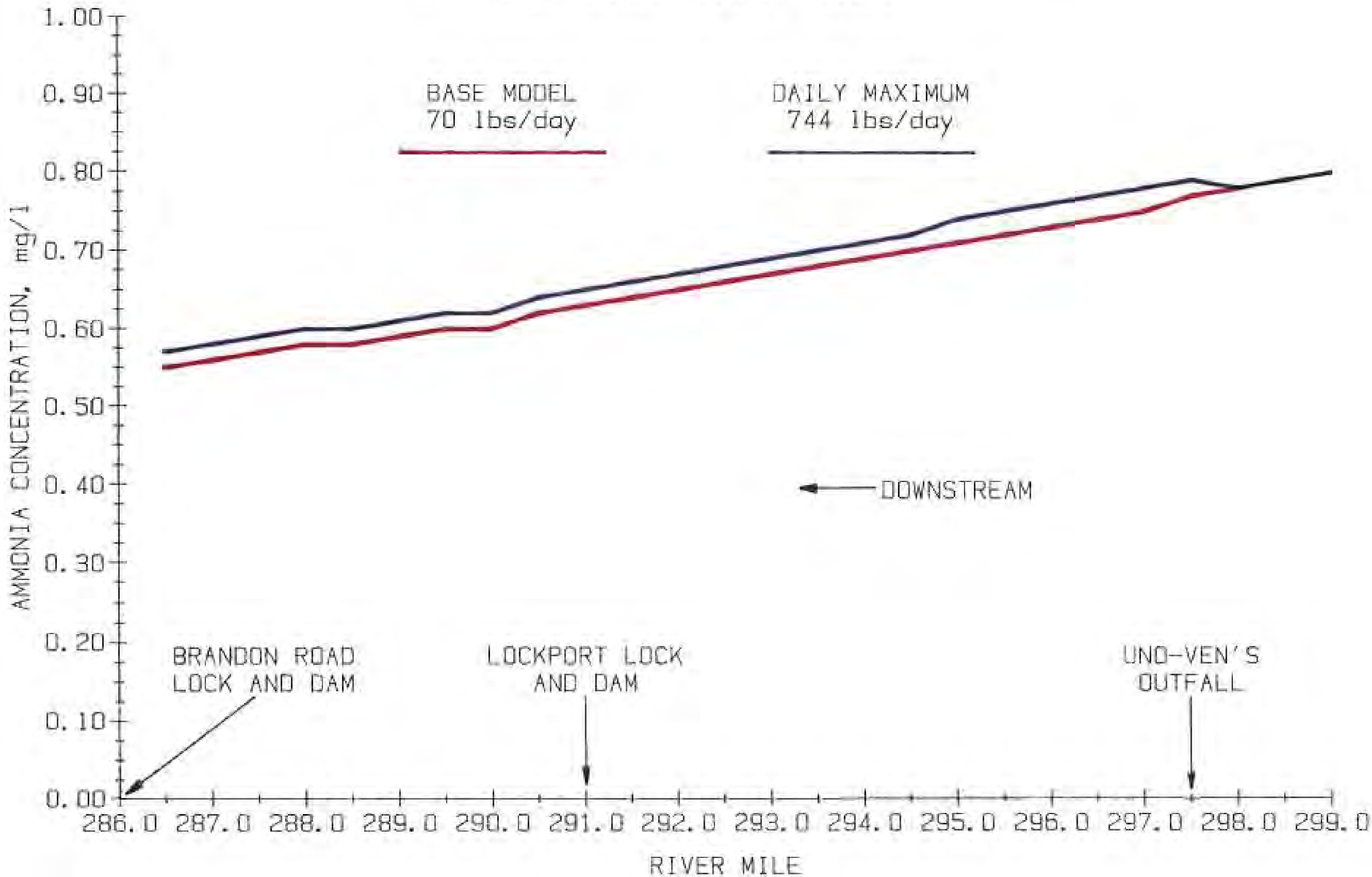


FIGURE 6-2
COMPARISON OF AMMONIA CONCENTRATION DATA, mg/l
MWRDGC QUAL2EU MODEL OF CHICAGO WATERWAY
River Miles: 278.5 - 286.0

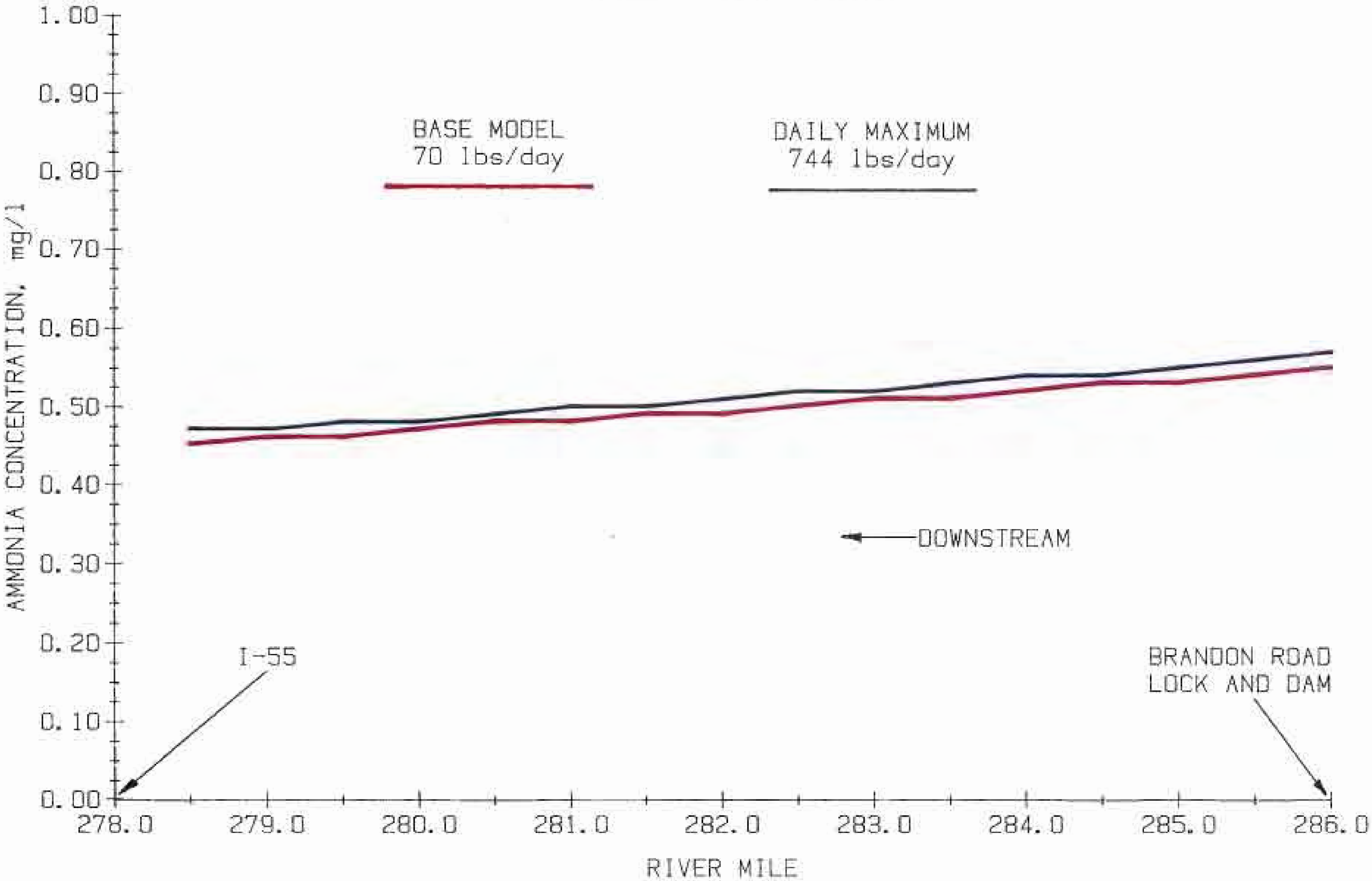


Figure 6-3 depicts the ammonia concentrations predicted by the second section of the QUAL2EU model. Nitrification continues to oxidize the ammonia in the waterway. At the end of this model, the Peoria Lake (river mile 180.00), the ammonia concentration has been reduced to 0.17 mg/l in both the model, and under maximum ammonia loading from UNO-VEN. From Figure 6-3, the Fox River enters the Illinois waterway at river mile 240. The ammonia increases at this point from 0.28 mg/l to 0.33 mg/l, and the ammonia levels under the maximum daily load are virtually identical to the base model below river mile 240.

The dissolved oxygen (DO) predicted by the model for the Chicago Waterway is shown in Figure 6-4. This figure presents the change in oxygen concentration caused by the maximum ammonia loading from UNO-VEN. The daily maximum loading from 1989 to 1992 again decreased the DO in the Ship Canal by a maximum of 0.03 mg/l. At the end of the first part of the model, at river mile 278.5 or 19 miles downstream, the predicted DO change is down to 0.01 mg/l.

The dissolved oxygen depicted in Figure 6-4 indicates that the DO is below the secondary contact water standard of 4.0 mg/l from before UNO-VEN's outfall until river mile 287.5. The Lockport Lock and Dam at river mile 291.0 increases the DO level by 0.40 mg/l, increasing the DO to approximately 3.7 mg/l. The Brandon Road Lock and Dam at river mile 286.0, however, increases the DO approximately 3 mg/l to above the water quality standard as shown in Figure 6-4. The computer model does not include the two currently operating sidestream aeration systems or the three others under construction by the MWRDGC.

The DO in the second section of the model is presented in Figure 6-5. From this figure, there is no discernable difference in DO levels at the daily maximum discharge from UNO-VEN and the base model. Figure 6-5 also illustrates the 0.5 mg/l to 1.5 mg/l of DO

FIGURE 6-3
AMMONIA CONCENTRATIONS DOWNSTREAM, mg/l
MWRDGC QUAL2EU MODEL OF UPPER ILLINOIS RIVER SYSTEM
River Miles: 180.0 - 278.0

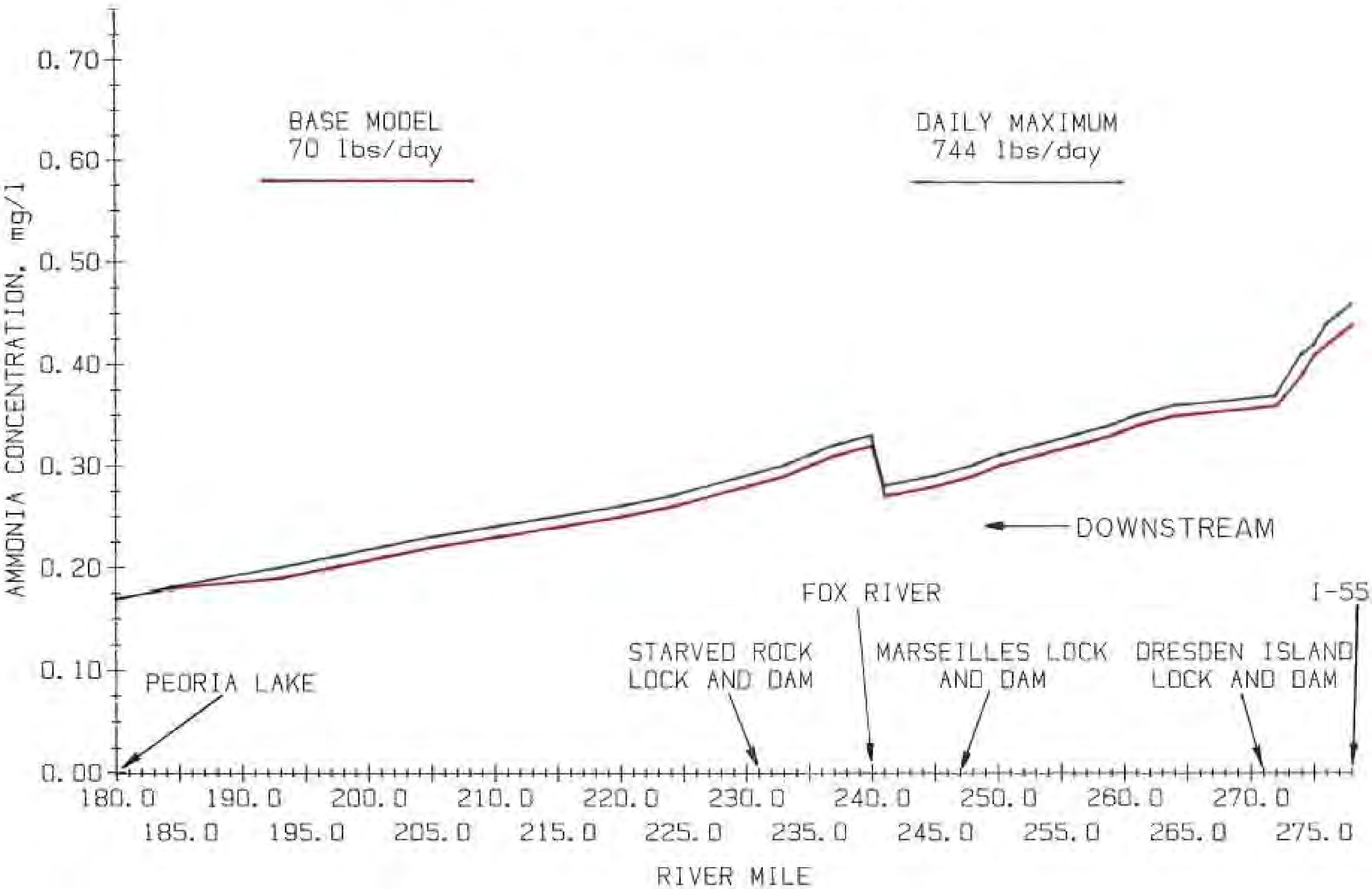


FIGURE 6-4

DISSOLVED OXYGEN CONCENTRATIONS DOWNSTREAM, mg/l

MWRDGC QUAL2EU MODEL OF CHICAGO WATERWAY

River Miles: 278.5 - 299.0

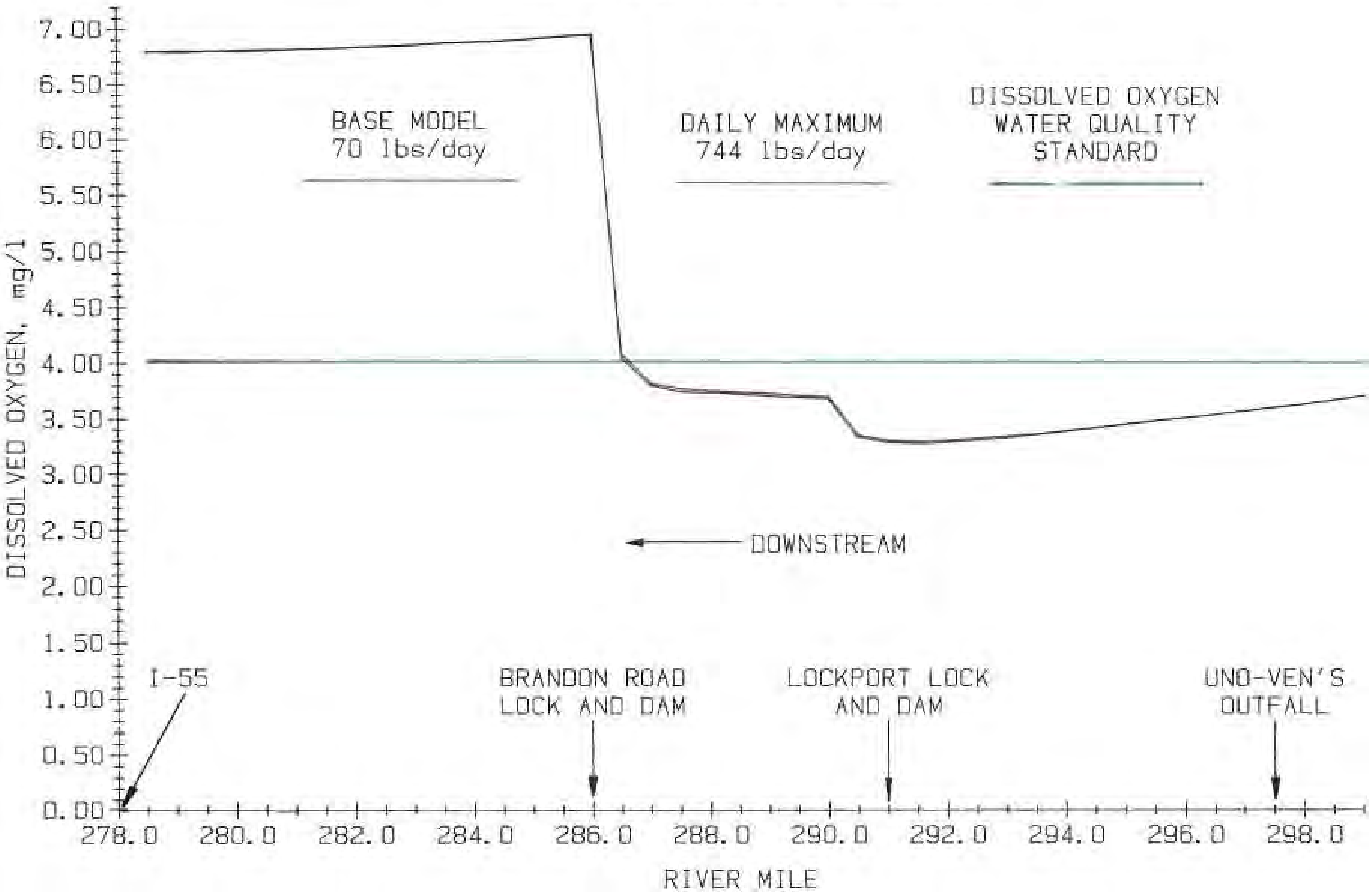
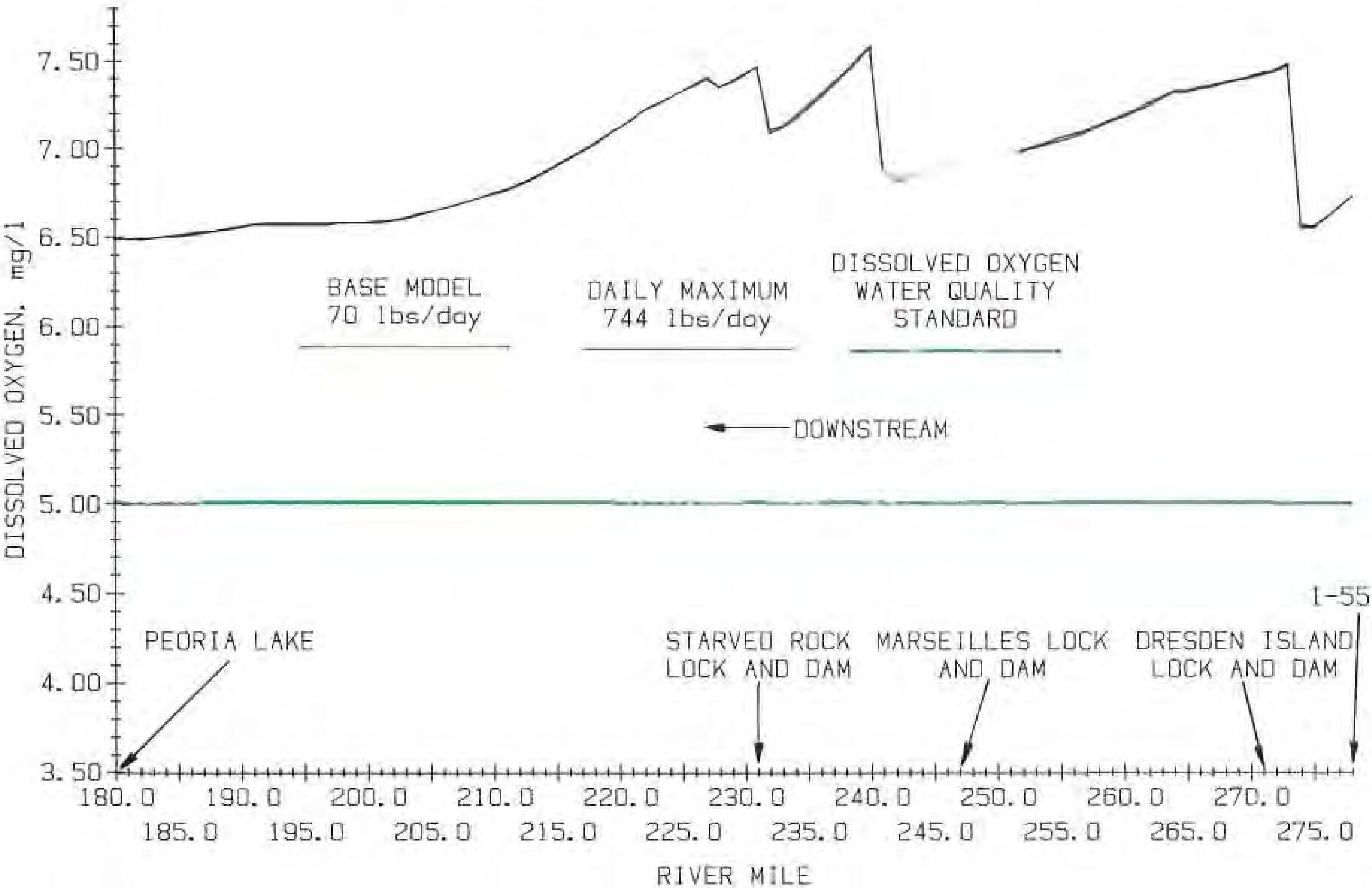


FIGURE 6-5

DISSOLVED OXYGEN CONCENTRATIONS DOWNSTREAM, mg/l

MWRDGC QUAL2EU MODEL OF UPPER ILLINOIS RIVER SYSTEM

River Miles: 180.0 - 278.0



added by three dams (Dresden Island, Marseilles, and Starved Rock) on the Upper Illinois Water. The DO level at the lowest point is 6.5 mg/l, well above the minimum DO general use water quality standard of 5.0 mg/l.

These modeled trends in the Upper Illinois Waterway are consistent with the water quality measurements previously presented in Chapter 5. Figures 5-7 and 5-8 of Chapter 5 presented the downstream DO and ammonia levels as recorded in 1989 for the Upper Illinois River. The DO generally increased at the Brandon Road, Dresden, Marseilles and Starved Rock Locks and Dams, with a general decline across the Peoria pool.

Table 6-2 and 6-3 present the incremental changes in ammonia and DO predicted by the computer model at selected river miles. Under UNO-VEN's maximum month discharge rate, the ammonia in the Ship Canal will increase 0.01 mg/l, while with UNO-VEN's peak day ammonia discharge, the ammonia concentration will increase a maximum of 0.03 mg/l, before declining. The peak increase results in ammonia levels of 0.78 mg/l versus 0.75 mg/l in the base model. By river mile 229, the ammonia levels under all scenarios are back to the base model levels.

The DO results are similar, with the DO declining 0.01 mg/l under the maximum month loading and 0.03 mg/l under the peak day loading. By river mile 209, DO levels under the worse scenario (peak day) are virtually identical to the base model.

The QUAL2EU model is a numerical model and is therefore capable of predicting concentrations as high of a degree of precision as required by the user. For all practical purposes, a change in ammonia concentration of 0.00 mg/l to 0.03 mg/l as predicted by the model runs for UNO-VEN can be considered not measurable. "Standards Methods" (Clesceri, et al., 1989) indicate that at levels of ammonia of 1.0 mg/l, the standard deviation using the Ammonia Selective Electrode Method is ± 0.04 mg/l. Higher degrees of precision are attainable using different methods if no interferences in the sample are present. The Ammonia Selective Electrode Method is recommended for surface waters and industrial wastes.

TABLE 6–2

UNO–VEN's IMPACT ON AMMONIA

INCREMENTAL WATER QUALITY CHANGES PREDICTED BY QUAL2EU

River Mile	Base Model NH3–N, mg/l	Incremental NH3–N Change, mg/l Max. Month	Daily Max.
298.0	0.78	0.00	0.00
297.5	0.77	0.01	0.03
297.0	0.75	0.01	0.03
296.0	0.73	0.01	0.03
291.5	0.64	0.01	0.02
286.5	0.55	0.01	0.02
283.5	0.51	0.01	0.02
274.0	0.39	0.01	0.02
271.0	0.35	0.01	0.02
264.0	0.35	0.00	0.01
253.0	0.31	0.00	0.01
229.0	0.28	0.00	0.00

TABLE 6-3

UNO-VEN's IMPACT ON DISSOLVED OXYGEN

INCREMENTAL WATER QUALITY CHANGES

River Mile	DO, mg/l Base Model	Incremental DO Change, mg/l Max. Month	Daily Max.
298.0	3.63	0.00	0.00
297.5	3.60	0.00	0.00
297.0	3.57	0.01	0.00
296.0	3.51	-0.01	-0.01
291.5	3.28	-0.01	-0.02
286.5	4.07	-0.01	-0.03
283.5	6.88	-0.01	-0.02
274.0	6.57	-0.01	-0.02
271.0	7.44	0.00	-0.01
264.0	7.34	0.00	-0.01
253.0	7.02	0.00	-0.01
229.0	7.39	0.00	-0.01
221.0	7.17	0.00	-0.01
209.0	6.72	0.00	-0.01
202.0	6.59	0.00	0.00
191.0	6.57	0.00	0.00
180.0	6.48	0.00	0.00

The model results are consistent with the field sampling. Ammonia water quality is consistently being achieved on the entire waterway, while DO in the Chicago Waterway does decline below 4.0 mg/l under certain conditions.. The MWRDGC's side stream aeration systems are expected to eliminate the low DO levels through the year 2000, when the discretionary diversion may be lost. The resulting DO levels after the year 2000 are difficult to predict because of the many unresolved issues including diversion water and completion of the TARP program.

CHAPTER 7
SUMMARY AND DISCUSSION

In 1983, Union Oil petitioned the Pollution Control Board for relief from the effluent ammonia standards. The Board granted the refinery's request, limiting the effluent to the U.S. EPA's Best Available Treatment effluent guidelines. These limits were as follows in the most recent NPDES Permit:

Monthly Maximum	749 pounds/day
Daily Maximum	1,648 pounds/day

UNO-VEN has consistently achieved these limits and has significantly reduced the total ammonia loadings during the last six years. The site specific limits will end on December 31, 1993, and the establishment of future effluent limits can be based upon water quality impacts and current operating practices, consistent with other Pollution Control Board decisions relating to dischargers to secondary contact waterways.

Since 1983, UNO-VEN has continued to upgrade its wastewater treatment capabilities. Over $7 million has been expended to date, with an additional $13 million appropriated for further upgrading work (see Table 2-2). These efforts and the conscientious operating practices have resulted in declining effluent ammonia levels (see Figure 3-1). These improvements have occurred during a period of higher crude oil throughput (25%) and higher nitrogen in the crude oil (157%). Since 1989, the refinery has achieved a 3.0 mg/l monthly ammonia level 36 out of 45 months, or 80% of the time. Since 1989, UNO-VEN has also discharged fewer pounds of ammonia than it has drawn from the Ship Canal (see Table 3-7 and Figure 3-6).

Table 7-1 summarizes the ammonia loading from 1989 to 1992. This time period can be considered representative of what the refinery is capable of achieving. The peak month discharge over the last 3.75 years was 259 pounds per day, compared to the BAT limit in the current NPDES Permit of 749 pounds per day. The peak day discharge of 744 pounds per day is also below the BAT permit limit of 1,648 pounds per day.

TABLE 7-1

EFFLUENT AMMONIA LOADS FROM 1989 - 1992

Year	Avg. Load lbs/day	Monthly Maximum, lbs/day		Daily Maximum, lbs/day
1989	65	259	(02/89)	742 (02/08/89)
1990	30	79	(12/90)	335 (12/26/90)
1991	72	193	(07/91)	744 (08/07/91)
1992 a/	20	55	(08/92)	356 (07/30/92)
1989-1992 a/	48.5	259		744

a/ January - September

While UNO-VEN has made significant improvements in ammonia effluent quality, achievement of a 3.0 mg/l effluent ammonia level on a consistent basis has remained impossible to meet with the present facilities.

The difficulty with maintaining the 3.0 mg/l ammonia limit is that the current system depends upon biological nitrification, and nitrification systems are sensitive to influent quality fluctuations. UNO-VEN retained AWARE Environmental, Inc., to evaluate alternatives for achieving 3.0 mg/l on a consistent basis. The AWARE Report (1992) concluded the addition of two fluidized bed attached growth aerobic biological reactors would be the most cost effective approach for achieving a 3.0 mg/l ammonia level on a consistent basis. AWARE's projected capital cost was $7,093,000 and the annual operating costs were estimated at $1,682,000. The annualized cost for this approach, assuming a 10 year life and 9% interest was $2,787,000.

From Table 7-1, UNO-VEN has discharged an average 48.5 pounds of ammonia per day over the last 3.75 years. Assuming the average effluent from the fluidized bed will be 0.5 mg/l ammonia, the discharge will contain an average 16.7 lbs/day. Thus, the additional treatment will remove an average 31.8 lbs/day ammonia, or 11,600 lbs/yr. The unit cost for this incremental removal would be as follows:

$$\frac{\$2,787,000/\text{yr}}{11,600\ \text{lbs/yr}} = \$240 \text{ per pound } NH_3 \text{ removed.}$$

In the 1983 Report entitled "Environmental Assessment of Ammonia Concentrations in the Wastewater Discharge of Union Oil Company, Chicago Refinery" (Huff & Huff, 1984) ammonia removed at the Calumet WRP was estimated at $1.40 per pound. Updating to 1992 dollars, this number is currently closer to $3.00 per pound, well below the unit costs UNO-VEN would be required to expend.

The primary concern with ammonia discharged to the Chicago Waterway is the impact on dissolved oxygen. The MWRDGC is expending $35 million (MWRDGC, 1990) for five sidestream aerations. These systems are capable of adding 2.0 to 6.0 mg/l of DO in the spring and summer. Assuming an average of 4.0 mg/l DO addition into the Cal Sag (550 mgd), (CDM, Data Acquisition, 1991) six months per year, these systems will add 18,000 pounds of oxygen per day or compensating for the equivalent of 4,000 pounds ammonia oxidation per day. Over six months, this yields 720,000 pounds of ammonia compensated. Assuming an operating cost of $1.5 million for the sidestream aeration systems, and $3.5 million for the annualized capital cost, $5.0 million will be expended annually, or a unit cost as follows:

$$\text{Unit Cost} = \frac{\$5{,}000{,}000/\text{yr}}{720{,}000 \text{ pounds per yr}}$$

Unit Cost = $6.94/pound of ammonia oxidized

Note that the above costs are approximations and are not intended to be definitive costs. The above costs assume that the side-stream aeration is simply for ammonia compensation, while in reality they are to increase the waterway DO levels. However, when compared to the unit costs facing UNO-VEN ($240/lb), it is clear that if further ammonia reduction is appropriate on this waterway, there are more cost effective approaches than requiring UNO-VEN to install additional treatment operations.

Since Union Oil's previous site specific rule change, the MWRDGC has obtained similar relief for the Calumet WRP. The Illinois Pollution Control Board has imposed effluent ammonia limits of 13 mg/l monthly and 26 mg/l daily maximum on the Calumet WRP. These values are similar to UNO-VEN's daily maximum ammonia concentrations from UNO-VEN of 26.0 mg/l and monthly maximum of 10 mg/l (since 1989). Thus, limits identical to the ammonia limits applicable to the Calumet WRP would be appropriate for UNO-VEN, and would provide consistency. On a pound basis, assuming average flows, the concentrations convert into the following loadings from the refinery:

Ammonia Proposed Effluent Limit

	Concentration, mg/l	Loading, [a/] lbs/day	BAT Limits, [b/] lbs/day
Monthly Maximum	13.0	656	772
Daily Maximum	26.0	1,873	1,698

---

a/ Based upon a design average flow and maximum pumping rates for monthly maximum and daily maximum values.

b/ Based upon production values over the last five years.

From Table 7-1, the above proposed effluent limits would have been achieved over the past 3.75 years.

The proposed monthly average discharge of 656 pounds per day can be compared to the current ammonia loading in the Ship Canal. The average flow, as monitored at the Romeoville USGS station for October, 1990 to September, 1991 was 1,950 mgd. The average UNO-VEN influent ammonia concentration for the same period was 1.95 mg/l. From this data, the Canal's average ammonia loading immediately upstream of UNO-VEN is 32,000 lbs/day.

Thus, under the proposed limit, the maximum monthly average discharge from UNO-VEN would account for 2% of the total Ship Canal ammonia load. Under the average loading of the last 3.75 years, UNO-VEN has discharged 48.5 pounds per day, less than it has taken in from the Ship Canal (69 pounds per day), and accounting for only 0.15% of the total ammonia load in the Ship Canal.

The localized impact from UNO-VEN's discharge was presented in Chapter 4. The Zone of Initial Dilution and Mixing Zone determined were both consistent with the Pollution Control Board's definitions as well as with the U.S. EPA's toxic control policies. The benthic community in the Ship Canal has shown a significant improvement since 1983, reflecting the overall improvement in water quality. No difference in the benthic community between the upstream and downstream sampling stations was discerned.

Water quality on the Ship Canal was presented in Chapter 5. Ammonia water quality has consistently been below the 0.1 un-ionized ammonia water quality standard. However, DO on the Ship Canal, both upstream and downstream of UNO-VEN has not consistently attained the 4.0 mg/l water quality standard.

To address this DO concern, the MWRDGC is installing five side-stream aeration facilities on the Chicago Waterway. These five aeration systems will go a long way toward achieving the DO water quality standard through the year 2000. In the year 2000, the MWRDGC is scheduled to lose its discretionary Lake Michigan water, which will result once again in DO levels below the water quality standards on the Chicago Waterways. As there is uncertainty at this time as to the discretionary diversion and additional steps the MWRDGC may implement, water quality concerns beyond the year 2000 are too speculative at this point to seriously address. Once the year 2000 is reached, these future concerns could be addressed using actual field measurement data. Currently, UNO-VEN's maximum day discharge increases the ammonia a maximum of 0.03 mg/l in the Ship Canal, while the peak month discharge increases the Ship Canal ammonia by 0.01 mg/l. The maximum dissolved oxygen consumption attributable to UNO-VEN's maximum day discharge is 0.03 mg/l on the Illinois Waterway, and only 0.01 mg/l for the maximum month loading.

In summary, UNO-VEN has continued to reduce ammonia levels since the 1984 rule change. For the past 3.75 years, the refinery has discharged fewer pounds of ammonia than it has withdrawn from the Ship Canal in the intake water. No localized impact could be identified and under the worse case scenario, UNO-VEN would depress the DO in the Ship

Canal a maximum 0.03 mg/l. While the ammonia 3.0 mg/l effluent limit can be achieved 80% of the time, to raise the compliance level to 100% will require an annualized expenditure of $2.79 million. This cost will result in an incremental removal of 11,600 pounds of ammonia per year, or an average 31.8 pounds per day. No measurable improvement in water quality will occur for this expenditure. As the refinery has done under the existing site-specific limits, UNO-VEN will continue to seek cost-effective improvements in reducing effluent ammonia levels. Adoption of effluent limits on a pounds per day basis, derived from the Calumet WRP ammonia limits of 13/26 mg/l, would encourage further water conservation practices at the refinery while being consistent with previous Pollution Control Board decisions.

BIBLIOGRAPHY

AWARE Corporation, Treatment Alternatives for Ammonia Removal from Refinery Wastewater, Prepared for Union Oil Company, 1984

AWARE Environmental, Inc., Treatment Alternatives for Ammonia Removal from Refinery Wastewater, 1992

Camp Dresser and McKee, Inc., MWRDGC, Data Acquisition for Water Quality Modeling of Chicago Waterway and Upper Illinois River System, 1991.

Camp Dresser and McKee, Inc., MWRDGC, Water Quality Modeling for the Chicago Waterway and Upper Illinois River System, Executive Summary, 1992.

Camp Dresser and McKee, Inc., MWRDGC, Water Quality Modeling for the Chicago Waterway and Upper Illinois River System, Main Report, 1992.

Clesceri, L.S., A.E. Greenberg, R.R. Trussell, Standard Methods for the Examination of Water and Wastewater, 17th Edition, Port City Press, Baltimore, MD, 1989.

Dennison, S.G., S.J. Sedita, B. Sawyer, D.R. Zenz, C. Lue-Hing, MWRDGC, R&D Report No. 91-50, Comprehensive Water Quality Evaluation, Fish Survey of the Chicago Waterway from April through July 1991, 1991.

Huff, L.L. and J.E. Huff, Environmental Assessment of Ammonia Concentration in the Wastewater Discharge of Union Oil Company, Chicago, Refinery, 1984.

Huff & Huff, Inc., "Technical Memorandum: On Ammonia Water Quality Data and Toxicity for Chicago Inland Waterways and Illinois River System," CDM, Water Quality Modeling for the Chicago Waterways and Upper Illinois River Systems, Appendices, 1992.

IEPA, Field Methods Manual, Section C, Macroinvertebrate Monitoring, 1987.

Lind, O.T., Handbook of Common Methods and Limnology, Kendall/Hunt Publishing, DeButte, Iowa, 1985, 199 pages.

Morgan, D., personal communications USGS Office, Springfield, November 2, 1992.

MWRDGC, Chief Engineers Report, 1990.

Nemerow, N.L., Liquid Waste of Industry, Addison-Wesley Publishing Company, Reading, MA, 1971.

Patterson and Associates, Inc., MWRDGC, R&D Report No. 91-52, Comprehensive Water Quality Evaluation, Summary Report for the Period of 1989-1991, 1991.

Polls, I., S.J. Sedita, B. Sawyer, D.R. Zenz, and C. Lue-Hing, MWRDGC, R&D Report No. 91-48, Comprehensive Water Quality Evaluation, Distribution of Benthic Invertebrate Species in the Chicago Waterway System during April and June, 1991, 1991.

Singh, K.P., and J.B. Stall, "The 7-Day 10-Year Low Flows of Illinois Streams," ISWS Bulletin 57, 1973.

U.S. EPA, EPA/440/5-85-001, Ambient Water Quality Criteria for Ammonia - 1984, 1985.

U.S. EPA, EPA/505/290-001, Technical Support Document for Water Quality-based Toxics Control, 1991.

U.S. Geological Survey, Report IL-91-2, Water Resources Data, Illinois Water Year 1991, Volume 2. Illinois River Basin, 1991.

.ATTACHMENTS

CHAPTER I

APPENDICES

a ratio of 2.2 to 1 to the applicable effluent limitations for BOD_5.

[2] Within the range of 6.0 to 9.0.

[47 FR 46446, Oct. 18, 1982, as amended at 50 FR 28522, 28523, July 12, 1985; 50 FR 32414, Aug. 12, 1985]

§ 419.23 Effluent limitations guidelines representing the degree of effluent reduction attainable by the application of the best available technology economically achievable (BAT).

(a) Except as provided in 40 CFR 125.30 through 125.32, any existing point source subject to this subpart must achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best available technology economically achievable:

Pollutant or pollutant property	BAT Effluent limitations	
	Maximum for any 1 day	Average of daily values for 30 consecutive days shall not exceed
	Metric units (kilograms per 1,000 m^3 of feedstock)	
COD [1]	210	109
Ammonia as N	18.8	8.5
Sulfide	0.18	0.082
	English units (pounds per 1,000 bbl of feedstock)	
COD [1]	74.0	38.4
Ammonia as N	6.6	3.0
Sulfide	0.065	0.029

[1] See footnote following table in § 419.13(d).

(b) The limits set forth in paragraph (a) of this section are to be multiplied by the following factors to calculate the maximum for any one day and maximum average of daily values for thirty consecutive days.

(1) Size factor.

1,000 bbl of feedstock per stream day	Size factor
Less than 24.9	0.91
25.0 to 49.9	0.95
50.0 to 74.9	1.04
75.0 to 99.9	1.13
100.0 to 124.9	1.23
125.0 to 149.9	1.35
150.0 or greater	1.41

(2) Process factor.

Process configuration	Process factor
Less than 2.49	0.58
2.5 to 3.49	0.63
3.5 to 4.49	0.74
4.5 to 5.49	0.88
5.5 to 5.99	1.00
6.0 to 6.49	1.09
6.5 to 6.99	1.19
7.0 to 7.49	1.29
7.5 to 7.99	1.41
8.0 to 8.49	1.53
8.5 to 8.99	1.67
9.0 to 9.49	1.82
9.5 or greater	1.89

(3) See the comprehensive example in subpart D, § 419.42(b)(3).

(c)(1) In addition to the provisions contained above pertaining to COD, ammonia and sulfide, any existing point source subject to this subpart must achieve the following effluent limitations representing the degree of effluent reduction attainable by the application of the best available technology economically achievable (BAT):

(i) For each of the regulated pollutant parameters listed below, the effluent limitation for a given refinery is the sum of the products of each effluent limitation factor times the applicable process feedstock rate, calculated as provided in 40 CFR 122.45(b). Applicable production processes are presented in Appendix A, by process type. The process identification numbers presented in this Appendix A are for the convenience of the reader. They can be cross-referenced in the *Development Document for Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Petroleum Refining Point Source Category* (EPA 440/1-82/014), Table III-7, pp. 49-54.

NPDES Permit No. IL0001589

Illinois Environmental Protection Agency

Division of Water Pollution Control

2200 Churchill Road

P.O. Box 19276

Springfield, Illinois 62794-9276

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

Modified (NPDES) Permit

Expiration Date: June 1, 1993

Issue Date: September 30, 1988
Effective Date: November 1, 1988
Modification Issue Date: August 21, 1990
Modification Effective Date: Sept. 20, 1990

Name and Address of Permittee:

The UNO-VEN Company
135th Street and New Avenue
Lemont, Illinois 60439

Facility Name and Address:

The UNO-VEN Company
Chicago Refinery
135th Street and New Avenue
Lemont, Illinois 60439
(Will County)

Discharge Number and Name:

001 Industrial, Sanitary and Stormwater
002 Overflow from Stormwater Basin

Receiving Waters

Chicago Sanitary and Ship Canal
Illinois and Michigan Canal

In compliance with the provisions of the Illinois Environmental Protection Act, Subtitle C and/or Subtitle D Rules and Regulations of the Illinois Pollution Control Board, and the Clean Water Act, the above-named permittee is hereby authorized to discharge at the above location to the above-named receiving stream in accordance with the standard conditions and attachments herein.

Permittee is not authorized to discharge after the above expiration date. In order to receive authorization to discharge beyond the expiration date, the permittee shall submit the proper application as required by the Illinois Environmental Protection Agency (IEPA) not later than 180 days prior to the expiration date.

Thomas G. McSwiggin, P.E.
Manager, Permit Section
Division of Water Pollution Control

TGM:JOP:jd/1729j.sp

NPDES Permit No. IL0001589

Effluent Limitations and Monitoring

PARAMETER	LOAD LIMITS lbs/day 30 DAY AVG.	DAILY MAX.	CONCENTRATION LIMITS mg/l 30 DAY AVG.	DAILY MAX.	SAMPLE FREQUENCY	SAMPLE TYPE

1. From the effective date of this Permit until June 1, 1993, the effluent of the following discharge(s) shall be monitored and limited at all times as follows:

Outfall: 001 Treated Refinery Wastewater, Sanitary Waste and Stormwater

PARAMETER	30 DAY AVG.	DAILY MAX.	30 DAY AVG.	DAILY MAX.	SAMPLE FREQUENCY	SAMPLE TYPE
Flow (MGD)	Report as a monthly average and a monthly maximum				Daily	Continuous
BOD_5	1009.41	2472.32			2/Week	Composite
$CBOD_5$			20	40	2/Week	Composite
TSS	1098.81	1723.13	25	50	2/Week	Composite
Fats, Oil, and Grease	399.56	749.19	15	30	2/Week	Mathematical Comp.*
pH	See Special Condition 1				2/Week	Grab
Phenol	7.06	29.18	0.3	0.6	2/Week	Composite
NH_3-N	749.19	1648.21			2/Week	Composite
COD	9589.63	18480.02			2/Week	Composite
Chromium(total)	8.27	23.79	1.0	2.0	2/Week	Composite
Chromium(+6)	0.67	1.52	0.1	0.3	2/Week	Grab
Sulfide	7.24	16.23			2/Week	Composite
Cyanide	5.04	14.42	0.1	0.2	2/Week	Composite
Fluoride	757.05	2163.00	15	30	2/Week	Composite

*See Special Condition 2

NPDES Permit No. IL0001589

Effluent Limitations and Monitoring

PARAMETER	LOAD LIMITS lbs/day 30 DAY AVG.	DAILY MAX.	CONCENTRATION LIMITS mg/l 30 DAY AVG.	DAILY MAX.	SAMPLE FREQUENCY	SAMPLE TYPE

2. From the effective date of this Permit until June 1, 1993, for each week in which wastewater from the Lemont, Unocal Chemicals Division Polymer Plant is being treated with the refinery wastewater, the effluent of the following discharge(s) shall be monitored** and limited at all times as follows:

Outfall: 001 Treated Refinery and Polymer Plant Wastewater, Sanitary Waste and Stormwater

PARAMETER	30 DAY AVG. (lbs/day)	DAILY MAX. (lbs/day)	30 DAY AVG. (mg/l)	DAILY MAX. (mg/l)	SAMPLE FREQUENCY	SAMPLE TYPE
Flow (MGD)	Report as a monthly average and a monthly maximum				Daily	Continuous
BOD_5	1010.21	2474.45			2/Week	Composite
$CBOD_5$			20	40	2/Week	Composite
TSS	1100.14	1727.46	25	50	2/Week	Composite
Fats, Oil, and Grease	399.56	749.19	15	30	2/Week	Mathematical Comp.*
pH	See Special Condition 1				2/Week	Grab
Phenol	7.06	29.18	0.3	0.6	2/Week	Composite
NH_3-N	749.19	1648.21			2/Week	Composite
COD	9589.63	18480.02			2/Week	Composite
Chromium(total)	8.30	23.88	1.0	2.0	2/Week	Composite
Chromium(+6)	0.67	1.52	0.1	0.3	2/Week	Grab
Sulfide	7.24	16.23			2/Week	Composite
Cyanide	5.05	14.46	0.1	0.2	2/Week	Composite
Fluoride	757.05	2163.00	15	30	2/Week	Composite

*See Special Condition 2
**See Special Condition 16

NPDES Permit No. IL0001589

Effluent Limitations and Monitoring

PARAMETER	LOAD LIMITS lbs/day 30 DAY AVG.	LOAD LIMITS lbs/day DAILY MAX.	CONCENTRATION LIMITS mg/l 30 DAY AVG.	CONCENTRATION LIMITS mg/l DAILY MAX.	SAMPLE FREQUENCY	SAMPLE TYPE

1. From the effective date of this Permit until June 1, 1993, the effluent of the following discharge(s) shall be monitored and limited at all times as follows:

Outfall: 002 Stormwater Retention Basin Overflow

					***When Discharge Occurs	
Flow (MGD)	Report as a monthly average and a monthly maximum				1/day	Estimate
BOD_5			20	40	1/day	Grab
TSS			25	50	1/day	Grab
Fats, Oil and Grease			15	30	1/day	Grab
Phenols			0.3	0.6	1/day	Grab
Chromium(total)			1.0	2.0	1/day	Grab
Chromium(+6)			0.1	0.3	1/day	Grab****
Cyanide			0.1	0.2	1/day	Grab
Fluoride			15	30	1/day	Grab
NH_3-N	See Special Condition 9				1/day	Grab
pH	See Special Condition 1				1/day	Grab

***When no discharge occurs for one month, the DMR for that month shall be submitted with the words "no discharge" written on the top of the form.
****Analysis for Cr(+6) shall be completed within 24 hours of collection (40 CFR 136).

Special Conditions

1. The pH shall be in the range 6.0 to 9.0. A monthly minimum and a monthly maximum shall be reported on the DMR form.

2. Mathematical composites for oil, fats and greases shall consist of a series of grab samples collected over any 24-hour consecutive period. Each sample shall be analyzed separately and the arithmetic mean of all grab samples collected during a 24-hour period shall constitute a mathematical composite. No single grab sample shall exceed a concentration of 75 mg/l.

3. Samples taken in compliance with the effluent monitoring requirements for Outfalls 001 and 002 shall be taken at a point representative of the discharge, but prior to entry into the receiving stream.

4. The permittee shall record monitoring results on Discharge Monitoring Report Forms using one such form for each discharge each month.

   The completed Discharge Monitoring Report forms shall be submitted to IEPA no later than the 15th day of the following month, unless otherwise specified by the permitting authority.

   Discharge Monitoring Reports shall be mailed to the IEPA at the following address:

   Illinois Environmental Protection Agency
   Division of Water Pollution Control
   2200 Churchill Road
   P.O. Box 19276
   Springfield, Illinois 62794-9276

   Attention: Compliance Assurance Section

5. Storm Water Credit for Outfall 001:

   An additional storm water credit for the following parameters shall be calculated based on 100% of the storm water flow as defined below.

Parameter	Pounds per 1000 gallons of storm water Average	Maximum
BOD_5	0.22	0.40
Total Suspended Solids	0.18	0.28
COD	1.5	3.0
Oil and Grease	0.067	0.13
Phenol	0.0014	0.0029
Cr (tot)	0.0018	0.0050
Cr (+6)	0.00023	0.00052

Special Conditions

Dry Weather Flow -- The average flow from the waste water treatment facility for the last three consecutive zero precipitation days. Previously collected storm water shall not be included.

Storm Water Flows -- The storm water runoff which is treated in the waste water treatment facility shall be defined as that portion of the flow greater than the dry weather flow.

In computing monthly average permit limits to include storm water credit, the pound credit calculated above shall be averaged along with process pound limits over the 30 day period. Explanatory calculations and flow data shall be submitted together with discharge monitoring reports.

The storm water credit does not authorize the permittee to exceed the concentration limits contained in Effluent Limitations and Monitoring, Page 2.

6. The permittee shall monitor, twice per year, for outfall 002, for the following, if discharge occurs:

   Benzene, toluene and ethyl benzene using USEPA method #602 49 FR 43272).

   Sample type shall be a grab sample. The results shall be submitted with the April and October DMR to both IEPA and USEPA unless otherwise specified by the Agency.

If the Agency determines that any of the parameters are being discharged at a level of environmental or human health significance, the permit may be reopened to incorporate the limitations, in accordance with the Federal and State of Illinois Rules and Regulations.

7. The effluent total dissolved solids concentration in the subject discharge (outfall 001) shall be limited to a level that will not cause the receiving stream to exceed the water quality standard in Rule 302.407 of the IPCB, Chapter 1 Rules and Regulations.

8. This permit does not allow The UNO-VEN Company to operate onsite sludge disposal facility. A proper permit shall be obtained from this Agency to operate onsite sludge disposal facility.

9. The effluent ammonia-nitrogen concentration (outfall 002) shall be limited to a level that will comply with the provisions of Illinois Pollution Control Board Rules and Regulations, Chapter 1, Rules 304.301 during its period of effectiveness, and thereafter to a level that will not cause the receiving stream to exceed the water quality standard in Rule 302.212, Chapter 1.

10. The effluent total dissolved solids concentration in the subject discharge (outfall 002) shall be limited to a level that will not cause the receiving stream to exceed the water quality standards in Rule 302.208 of the IPCB, Chapter 1, Rules and Regulations.

11. The permittee shall monitor the nitrogen concentration of its oil feedstocks and report on an annual basis such concentrations to the Agency.

12. The permittee shall submit the reports described in Special Condition 11 no later than 30 days after the end of a calendar year.

13. The provisions of IPCB Order R84-13 shall terminate on December 31, 1993.

14. The permittee may use the upset provision as an affirmative defense, however all the requirements listed in 40 CFR 122.41(n) have to be met.

Special Conditions

15. One year prior to the expiration date of this permit, the permittee shall perform the following tests to be submitted to the IEPA with the renewal application for NPDES Permit:

1. Aquatic Toxicity Screening

Acute toxicity testing will be performed in accordance with "Methods for Measuring Acute Toxicity of Effluents to Aquatic Organisms" (Third Edition). USEPA 600/4-85-013, and "Environmental Effects Tests Guidelines" USEPA 560/6-82-002. The testing will be performed utilizing fathead minnows (Pimephales promelas) and Daphnia magna, Daphnia pulex, or Ceriodaphnia dubia. Chronic testing will be conducted using the green alga Selenastrum capricornutum in accordance with "Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms" USEPA 600/4-85-014. The test duration for fish and algal tests will be 96 hours, while the test period for Daphnia or Cerodaphnia will be 48 hours. The testing should be performed on 100% effluent samples and effluent diluted with receiving stream water at effluent concentrations of 50%, 25%, 12.5%, and 6.25%.

2. Chemical Specific Testing

Chemical specific testing should analyze the effluent for 113 priority pollutants (see 40 CFR 136 Appendix A, Methods 624 and 625) and for non-priority pollutants. Samples will be handled, prepared, and analyzed by GC/MS in accordance with 40 CFR 136 Methods 624 and 625 (October 26, 1984 Federal Register). A reasonable attempt to identify and quantify non-priority pollutant compounds in each GC/MS fraction shown to be present by peaks on the total ion plots (reconstructed gas chromatogram) more than ten times higher than the adjacent background noise which produce identifiable spectra, more than five scans wide. Identification will be attempted by a laboratory whose computer data processing programs are capable of comparing the sample mass spectrum to a computerized library of mass spectra, with visual confirmation by an experienced analyst. Quantification may be an order of magnitude estimate based on comparison with an internal standard. In addition, samples will be handled, prepared, and analyzed by high pressure liquid chromatography using methods such as 40 CFR 136 Methods 605 and 610, or other appropriate HPLC methods to identify and quantify organic compounds, using extraction procedures outlined in the regulations or column extraction techniques such as C18 or silica gel.

All sample collection, preservation, and storage times will conform to 40 CFR 136 or other approved USEPA procedures and requirements. Detection limits for USEPA Methods, or alternative methods, will be comparable with the method detection limit in 40 CFR 136 regulations. The detection limit for the direct injection protocol will be as sensitive as possible utilizing sound laboratory practices.

Following chemical analysis, an evaluation of the toxicological properties will be provided for any identified compounds, based on available toxicology data bases. If a class of chemicals is identified as being present in the discharge, but the compound cannot be specifically identified, toxicology information available for other members of that class will be used to evaluate the potential for human exposure to any hazardous compounds identified and evaluated.

16. The Lemont, Unocal Chemicals Division Polymer Plant wastewater shall initially be analyzed once per week for a minimum of four weeks when hauling and treatment of this wastewater at the Chicago Refinery commences. The Polymer Plant wastewater sample shall be collected at the point where it is discharged from the tank truck into the sewer at the refinery. The Polymer Plant wastewater shall be analyzed for the pollutants listed in 40 CFR 414.91. Discharge from the Treated Water Basin (Outfall 001) at the Refinery shall be analyzed once per week for four weeks after commencement of treatment of polymer plant wastewater at the refinery and analyzed for the pollutants listed in 40 CFR 414.91.

Detection limits for the list of pollutants in 40 CFR 414.91 shall be in accordance with Attachment A, of this Permit. Sampling results shall be submitted to the Agency Industrial Unit, Division of Water Pollution Control within 45 days of the sample collection date. After review of the sampling data this Agency may modify this Permit by imposing monitoring requirements and/or limitations on the influent and/or effluent following public notice and opportunity for public hearing.

Attachment A
Detection Limits

All units are micrograms per liter.

Acenaphthene	10
Arcylonitrile	5
Benzene	5
Carbon Tetrachloride	5
Chlorobenzene	5
1,2,4-Trichlorobenzene	10
Hexachlorobenzene	10
1,2-Dichloroethane	5
1,1,1-Trichloroethane	5
Hexachloroethane	10
Chloroethane	10
Chloroform	5
2-Chlorophenol	10
1,2-Dichlorobenzene	10
1,3-Dichlorobenzene	10
1,4-Dichlorobenzene	10
1,1-Dichloroethylene	5
1,2-trans-Dichloroethylene	5
2,4-Dichlorophenol	10
1,2-Dichloropropane	5
1,3-Dichloropropylene	10
2,4-Dimethylphenol	10
2,4-Dinitrotoluene	10
2,6-Dinitrotoluene	10
Ethylbenzene	5
Fluoranthene	10
Bis(2-Chloroisopropyl) ether	10
Methylene Chloride	5
Methyl Chloride	100
Hexachlorobutadiene	10
Naphthalene	10
Nitrobenzene	10
2-Nitrophenol	50
4-Nitrophenol	50
2,4-Dinitrophenol	50
4,6-Dinitro-o-cresol	100
Phenol	10
Bis(2-ethylhexyl) phthalate	10
Di-n-butyl phthalate	10
Diethyl phthalate	10
Dimethyl phthalate	10
Benzo(a)anthracene	10
Benzo(a)pyrene	10
3,4-Benzofluoranthene	10
Benzo(k)fluoranthene	10
Chrysene	10
Acenaphthylene	10
Anthracene	10
Fluorene	10
Phenanthrene	10
Pyrene	10
Tetrachloroethylene	5
Toluene	5
Trichloroethylene	5
Vinyl Chloride	10
Total Chromium	10
Total Copper	25
Total Cyanide	10
Total Lead	5
Total Nickel	40
Total Zinc	20

ATTACHMENT H

Standard Conditions

Definitions

Act means the Illinois Environmental Protection Act, Ch. 111 1/2 Ill. Rev. Stat. Sec. 1001-1052 as Amended.

Agency means the Illinois Environmental Protection Agency.

Board means the Illinois Pollution Control Board.

Clean Water Act (formerly referred to as the Federal Water Pollution Control Act) means Pub. L. 92-500, as amended. 33 U.S.C. 1251 et seq.

NPDES (National Pollutant Discharge Elimination System) means the national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements, under Sections 307, 402, 318 and 405 of the Clean Water Act.

USEPA means the United States Environmental Protection Agency.

Daily Discharge means the discharge of a pollutant measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. For pollutants with limitations expressed in units of mass, the "daily discharge" is calculated as the total mass of the pollutant discharged over the day. For pollutants with limitations expressed in other units of measurements, the "daily discharge" is calculated as the average measurement of the pollutant over the day.

Maximum Daily Discharge Limitation (daily maximum) means the highest allowable daily discharge.

Average Monthly Discharge Limitation (30 day average) means the highest allowable average of daily discharges over a calendar month, calculated as the sum of all daily discharges measured during a calendar month divided by the number of daily discharges measured during that month.

Average Weekly Discharge Limitation (7 day average) means the highest allowable average of daily discharges over a calendar week, calculated as the sum of all daily discharges measured during a calendar week divided by the number of daily discharges measured during that week.

Best Management Practices (BMPs) means schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters of the State. BMPs also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

Aliquot means a sample of specified volume used to make up a total composite sample.

Grab Sample means an individual sample of at least 100 milliliters collected at a randomly-selected time over a period not exceeding 15 minutes.

24 Hour Composite Sample means a combination of at least 8 sample aliquots of at least 100 milliliters, collected at periodic intervals during the operating hours of a facility over a 24-hour period.

8 Hour Composite Sample means a combination of at least 3 sample aliquots of at least 100 milliliters, collected at periodic intervals during the operating hours of a facility over an 8-hour period.

Flow Proportional Composite Sample means a combination of sample aliquots of at least 100 milliliters collected at periodic intervals such that either the time interval between each aliquot or the volume of each aliquot is proportional to either the stream flow at the time of sampling or the total stream flow since the collection of the previous aliquot.

(1) **Duty to comply.** The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Act and is grounds for enforcement action, permit termination, revocation and reissuance, modification, or for denial of a permit renewal application. The permittee shall comply with effluent standards or prohibitions established under Section 307(a) of the Clean Water Act for toxic pollutants within the time provided in the regulations that establish these standards or prohibitions, even if the permit has not yet been modified to incorporate the requirement.

(2) **Duty to reapply.** If the permittee wishes to continue an activity regulated by this permit after the expiration date of this permit, the permittee must apply for and obtain a new permit. If the permittee submits a proper application as required by the Agency no later than 180 days prior to the expiration date, this permit shall continue in full force and effect until the final Agency decision on the application has been made.

(3) **Need to halt or reduce activity not a defense.** It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity in order to maintain compliance with the conditions of this permit.

(4) **Duty to mitigate.** The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health or the environment.

(5) **Proper operation and maintenance.** The permittee shall at all times properly operate and maintain all facilities and systems of treatment and control (and related appurtenances) which are installed or used by the permittee to achieve compliance with the conditions of this permit. Proper operation and maintenance includes effective performance, adequate funding, adequate operator staffing and training, and adequate laboratory and process controls, including appropriate quality assurance procedures. This provision requires the operation of back-up, or auxiliary facilities, or similar systems only when necessary to achieve compliance with the conditions of the permit.

(6) **Permit actions.** This permit may be modified, revoked and reissued, or terminated for cause by the Agency pursuant to 40 CFR 122.62. The filing of a request by the permittee for a permit modification, revocation and reissuance, or termination, or a notification of planned changes or anticipated noncompliance, does not stay any permit condition.

(7) **Property rights.** This permit does not convey any property rights of any sort, or any exclusive privilege.

(8) **Duty to provide information.** The permittee shall furnish to the Agency within a reasonable time, any information which the Agency may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit, or to determine compliance with the permit. The permittee shall also furnish to the Agency, upon request, copies of records required to be kept by this permit.

(9) **Inspection and entry.** The permittee shall allow an authorized representative of the Agency, upon the presentation of credentials and other documents as may be required by law, to:

- (a) Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;
- (b) Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;
- (c) Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and
- (d) Sample or monitor at reasonable times, for the purpose of assuring permit compliance, or as otherwise authorized by the Act, any substances or parameters at any location.

(10) **Monitoring and records.**

- (a) Samples and measurements taken for the purpose of monitoring shall be representative of the monitored activity.
- (b) The permittee shall retain records of all monitoring information, including all calibration and maintenance records, and all original strip chart recordings for continuous monitoring instrumentation, copies of all reports required by this permit, and records of all data used to complete the application for this permit, for a period of at least 3 years from the date of this permit, measurement, report or application. This period may be extended by request of the Agency at any time.
- (c) Records of monitoring information shall include:
  - (1) The date, exact place, and time of sampling or measurements;
  - (2) The individual(s) who performed the sampling or measurements;
  - (3) The date(s) analyses were performed;
  - (4) The individual(s) who performed the analyses;
  - (5) The analytical techniques or methods used; and
  - (6) The results of such analyses.
- (d) Monitoring must be conducted according to test procedures approved under 40 CFR Part 136, unless other test procedures have been specified in this permit. Where no test procedure under 40 CFR Part 136 has been approved, the permittee must submit to the Agency a test method for approval. The permittee shall calibrate and perform maintenance procedures on all monitoring and analytical instrumentation at intervals to ensure accuracy of measurements.

(11) **Signatory requirement.** All applications, reports or information submitted to the Agency shall be signed and certified.

- (a) **Application.** All permit applications shall be signed as follows:
  - (1) **For a corporation:** by a principal executive officer of at least the level of vice president or a person or position having overall responsibility for environmental matters for the corporation;
  - (2) **For a partnership or sole proprietorship:** by a general partner or the proprietor, respectively; or
  - (3) **For a municipality, State, Federal, or other public agency:** by either a principal executive officer or ranking elected official.
- (b) **Reports.** All reports required by permits, or other information requested by the Agency shall be signed by a person described in paragraph (a) or by a duly authorized representative of that person. A person is a duly authorized representative only if:
  - (1) The authorization is made in writing by a person described in paragraph (a); and
  - (2) The authorization specifies either an individual or a position responsible for the overall operation of the facility, from which the discharge originates, such as a plant manager, superintendent or person of equivalent responsibility; and
  - (3) The written authorization is submitted to the Agency.

(c) Changes of Authorization. If an authorization under (b) is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, a new authorization satisfying the requirements of (b) must be submitted to the Agency prior to or together with any reports, information, or applications to be signed by an authorized representative.

(12) Reporting requirements.

(a) Planned changes. The permittee shall give notice to the Agency as soon as possible of any planned physical alterations or additions to the permitted facility.

(b) Anticipated noncompliance. The permittee shall give advance notice to the Agency of any planned changes in the permitted facility or activity which may result in noncompliance with permit requirements.

(c) Compliance schedules. Reports of compliance or noncompliance with, or any progress reports on, interim and final requirements contained in any compliance schedule of this permit shall be submitted no later than 14 days following each schedule date.

(d) Monitoring reports. Monitoring results shall be reported at the intervals specified elsewhere in this permit.

(1) Monitoring results must be reported on a Discharge Monitoring Report (DMR).

(2) If the permittee monitors any pollutant more frequently than required by the permit, using test procedures approved under 40 CFR 136 or as specified in the permit, the results of this monitoring shall be included in the calculation and reporting of the data submitted in the DMR.

(3) Calculations for all limitations which require averaging of measurements shall utilize an arithmetic mean unless otherwise specified by the Agency in the permit.

(e) Twenty-four hour reporting. The permittee shall report any noncompliance which may endanger health or the environment. Any information shall be provided orally within 24 hours from the time the permittee becomes aware of the circumstances. A written submission shall also be provided within 5 days of the time the permittee becomes aware of the circumstances. The written submission shall contain a description of the noncompliance and its cause; the period of noncompliance, including exact dates and times; and if the noncompliance has not been corrected, the anticipated time it is expected to continue; and steps taken or planned to reduce, eliminate, and prevent reoccurrence of the noncompliance. The following shall be included as information which must be reported within 24 hours:

(1) Any unanticipated bypass which exceeds any effluent limitation in the permit;

(2) Violation of a maximum daily discharge limitation for any of the pollutants listed by the Agency in the permit to be reported within 24 hours.

The Agency may waive the written report on a case-by-case basis if the oral report has been received within 24 hours.

(f) Other noncompliance. The permittee shall report all instances of noncompliance not reported under paragraphs (12)(c), (d), or (e), at the time monitoring reports are submitted. The reports shall contain the information listed in paragraph (12)(e).

(g) Other information. Where the permittee becomes aware that it failed to submit any relevant facts in a permit application, or submitted incorrect information in a permit application, or in any report to the Agency, it shall promptly submit such facts or information.

(13) Transfer of permits. A permit may be automatically transferred to a new permittee if:

(a) The current permittee notifies the Agency at least 30 days in advance of the proposed transfer date;

(b) The notice includes a written agreement between the existing and new permittees containing a specific date for transfer of permit responsibility, coverage and liability between the current and new permittees; and

(c) The Agency does not notify the existing permittee and the proposed new permittee of its intent to modify or revoke and reissue the permit. If this notice is not received, the transfer is effective on the date specified in the agreement.

(14) All manufacturing, commercial, mining, and silvicultural dischargers must notify the Agency as soon as they know or have reason to believe:

(a) That any activity has occurred or will occur which would result in the discharge of any toxic pollutant identified under Section 307 of the Clean Water Act which is not limited in the permit, if that discharge will exceed the highest of the following notification levels:

(1) One hundred micrograms per liter (100 ug/l);

(2) Two hundred micrograms per liter (200 ug/l) for acrolein and acrylonitrile; five hundred micrograms per liter (500 ug/l) for 2,4-dinitrophenol and for 2-methyl-4,6-dinitrophenol; and one milligram per liter (1 mg/l) for antimony;

(3) Five (5) times the maximum concentration value reported for that pollutant in the NPDES permit application; or

(4) The level established by the Agency in this permit.

(b) That they have begun or expect to begin to use or manufacture as an intermediate or final product or byproduct any toxic pollutant which was not reported in the NPDES permit application.

(15) All Publicly Owned Treatment Works (POTWs) must provide adequate notice to the Agency of the following:

(a) Any new introduction of pollutants into that POTW from an indirect discharger which would be subject to Sections 301 or 306 of the Clean Water Act if it were directly discharging those pollutants; and

(b) Any substantial change in the volume or character of pollutants being introduced into that POTW by a source introducing pollutants into the POTW at the time of issuance of the permit.

(c) For purposes of this paragraph, adequate notice shall include information on (i) the quality and quantity of effluent introduced into the POTW, and (ii) any anticipated impact of the change on the quantity or quality of effluent to be discharged from the POTW.

(16) If the permit is issued to a publicly owned or publicly regulated treatment works, the permittee shall require any industrial user of such treatment works to comply with federal requirements concerning:

(1) User charges pursuant to Section 204(b) of the Clean Water Act, and applicable regulations appearing in 40 CFR 35;

(2) Toxic pollutant effluent standards and pretreatment standards pursuant to Section 307 of the Clean Water Act; and

(3) Inspection, monitoring and entry pursuant to Section 308 of the Clean Water Act.

(17) If an applicable standard or limitation is promulgated under Section 301(b)(2)(C) and (D), 304(b)(2), or 307(a)(2) and that effluent standard or limitation is more stringent than any effluent limitation in the permit, or controls a pollutant not limited in the permit, the permit shall be promptly modified or revoked, and reissued to conform to that effluent standard or limitation.

(18) Any authorization to construct issued to the permittee pursuant to 35 Ill. Adm. Code 309.154 is hereby incorporated by reference as a condition of this permit.

(19) The permittee shall not make any false statement, representation or certification in any application, record, report, plan or other document submitted to the Agency or the USEPA, or required to be maintained under this permit.

(20) The Clean Water Act provides that any person who violates a permit condition implementing Sections 301, 302, 306, 307, 308, 318, or 405 of the Clean Water Act is subject to a civil penalty not to exceed $10,000 per day of such violation. Any person who willfully or negligently violates permit conditions implementing Sections 301, 302, 306, 307, or 308 of the Clean Water Act is subject to a fine of not less than $2,500, nor more than $25,000 per day of violation, or by imprisonment for not more than one year, or both.

(21) The Clean Water Act provides that any person who falsifies, tampers with, or knowingly renders inaccurate any monitoring device or method required to be maintained under permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

(22) The Clean Water Act provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit shall, including monitoring reports or reports of compliance or non-compliance shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than 6 months per violation, or by both.

(23) Collected screening, slurries, sludges, and other solids shall be disposed of in such a manner as to prevent entry of those wastes (or runoff from the wastes) into waters of the State. The proper authorization for such disposal shall be obtained from the Agency and is incorporated as part hereof by reference.

(24) In case of conflict between these standard conditions and any other condition(s) included in this permit, the other condition(s) shall govern.

(25) The permittee shall comply with, in addition to the requirements of the permit, all applicable provisions of 35 Ill. Adm. Code, Subtitle C, Subtitle D, Subtitle E, and all applicable orders of the Board.

(26) The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit is held invalid, the remaining provisions of this permit shall continue in full force and effect.

Rev. 12-1-86)

CHAPTER 2

APPENDICES

Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

REPORT NO. 91-50

COMPREHENSIVE WATER QUALITY EVALUATION

FISH SURVEY OF THE CHICAGO WATERWAY SYSTEM FROM APRIL THROUGH JULY 1991

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December 1991

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-11

NUMBER AND WEIGHT OF FISH COLLECTED FROM STATION NUMBER 11
AT 16TH STREET, LOCKPORT ON THE CHICAGO SANITARY AND SHIP CANAL
FROM APRIL THROUGH JULY 1991

Date of Sample and Fish Species Collected	Number of Fish		Weight (grams)	
	Total Catch	Per 30 Minutes	Total Catch	Per 30 Minutes
4/11/91 Sample				
Gizzard shad	1	0.79	10.83	8.55
Goldfish	1	0.79	9.92	7.83
Carp	14	11.05	24,918.50	19,672.50
Green sunfish	1	0.79	4.09	3.23
Pumpkinseed	3	2.37	6.25	4.93
Total for 4/11/91	20	15.79	24,949.59	19,697.04
6/18/91 Sample				
Goldfish	11	7.33	1,614.50	1,076.33
Carp	21	14.00	30,460.00	20,306.67
Golden shiner	2	1.33	10.10	6.73
Emerald shiner	1	0.67	5.92	3.95
Green sunfish	1	0.67	6.05	4.03
Bluegill	1	0.67	16.48	10.99
Total for 6/18/91	37	24.67	32,113.05	21,408.70

TX Ammonia
WQ - Toxicity
& Chemistry

WATER QUALITY CRITERIA FOR THE PROTECTION OF AQUATIC LIFE AND ITS USES

AMMONIA

Final Draft

20 January 1983

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Table 1. Acute values for ammonia.

Species	Life Stage or Size	Chemical	Method[a]	Effect[b]	Concentration (mg/L NH_3)	pH	Temperature (°C)	D.O. (mg/L)	Reference
				FRESHWATER SPECIES					
Flatworm, *Dendrocoelum lacteum* (*Procotyla fluviatilis*)	-	NH_4Cl	S,U	LC50	1.4[d,f]	8.2	18	-	Stammer 1953
Tubificid worm, *Tubifex tubifex*	-	NH_4Cl	S,U	LC50	2.7[d,f]	8.2	12	-	Stammer 1953
Cladoceran, *Ceriodaphnia acanthina*	<2-h old	NH_4Cl	FT,M	LC50	0.770[d]	7.06	24	4.8-5.3	Mount 1982
Cladoceran, *Daphnia magna*	Mixed ages	NH_4Cl	S,M	LC50	2.08	8.2	25	7.0-8.5	Parkhurst et al. 1979, 1981[j]
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	2.45	7.95	22.0	-	Russo et al. (in prep.)
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	2.69	8.07	19.6	7.4	Russo et al. (in prep.)
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	2.50	8.09	20.9	6.8	Russo et al. (in prep.)
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	2.77	8.15	22.0	-	Russo et al. (in prep.)
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	2.38	8.04	22.8	-	Russo et al. (in prep.)
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	0.75	7.51	20.1	7.6	Russo et al. (in prep.)
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	0.90	7.53	20.1	8.0	Russo et al. (in prep.)
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	0.53	7.4	20.6	8.0	Russo et al. (in prep.)
Cladoceran, *Daphnia magna*	<24-h old	NH_4Cl	S,M	LC50	0.67	7.5	20.3	8.0	Russo et al. (in prep.)

Table 1. (Continued)

Species	Life Stage or Size	Chemical	Methods[a]	Effect[b]	Concentration (mg/L NH_3)	pH	Temperature (°C)	D.O. (mg/L)	Reference
Rainbow trout, Salmo gairdneri	0.86 g	NH_4Cl	FT,M	LC50	1.02	8.03-8.29	14.2	76-93% Saturated	Reinbold & Pescitelli 1982b
Rainbow trout, Salmo gairdneri	0.76 g	NH_4Cl	FT,M	LC50	0.77	8.45-8.76	3.3	74-95% Saturated	Reinbold & Pescitelli 1982b
Rainbow trout, Salmo gairdneri	1.47 g	NH_4Cl	FT,M	LC50	0.97	8.32-8.69	14.9	74-87% Saturated	Reinbold & Pescitelli 1982b
Common carp, Cyprinus carpio	4-5 cm	NH_4Cl	R,M	LC50	1.1[d]	7.4	28	>5	Rao et al. 1975
Golden shiner, Notemigonus crysoleucas	-	-	S,M	LC50	1.20[c]	7.9-8.25	-	-	Baird et al. 1979
Red shiner, Notropis lutrensis	0.43 g	NH_4Cl	FT,M	LC50	2.83[c]	8.2-8.4	24	7.6-8.2	Hazel et al. 1979
Spotfin shiner, Notropis spilopterus	31-85 mm	NH_4Cl	FT,M	LC50	1.20[c]	7.7-8.2	26.5	81-89% Saturated	Rosage et al. 1979
Spotfin shiner, Notropis spilopterus	41-78 mm	NH_4Cl	FT,M	LC50	1.62[c]	7.8-8.5	26.5	86-91% Saturated	Rosage et al. 1979
Fathead minnow, Pimephales promelas	-	NH_4Cl	FT,M	LC50	1.59	8.0-8.1	14	7.2-7.4	DeGraeve et al. 1980
Fathead minnow, Pimephales promelas	0.09 g	NH_4Cl	FT,M	LC50	1.50	7.91	16.3	8.1	Thurston et al. (in press,
Fathead minnow, Pimephales promelas	0.09 g	NH_4Cl	FT,M	LC50	1.10	7.89	13.1	8.7	Thurston et al. (in press,
Fathead minnow, Pimephales promelas	0.13 g	NH_4Cl	FT,M	LC50	0.754	7.64	13.6	8.8	Thurston et al. (in press,
Fathead minnow, Pimephales promelas	0.19 g	NH_4Cl	FT,M	LC50	0.908	7.68	13.5	8.8	Thurston et al. (in press,
Fathead minnow, Pimephales promelas	0.22 g	NH_4Cl	FT,M	LC50	2.73	8.03	22.1	7.6	Thurston et al. (in press,
Fathead minnow, Pimephales promelas	0.22 g	NH_4Cl	FT,M	LC50	2.59	8.06	22.0	7.6	Thurston et al. (in press,

Table 1. (Continued)

Species	Life Stage or Size	Chemical	Methods[a]	Effect[b]	Concentration (mg/L NH_3)	pH	Temperature (°C)	D.O. (mg/L)	Reference
Mosquitofish, *Gambusia affinis*	Adult females	NH_4OH	S,U	LC50	2.4[d]	8.2-8.8	20-26	-	Wallen et al. 1957
Mosquitofish, *Gambusia affinis*	Adult females	$(NH_4)_2SO_4$	S,U	LC50	0.48[d]	6.3-7.4	20-21	-	Wallen et al. 1957
Guppy, *Poecilia reticulata*	8.0 mm	NH_4Cl	S,M	LC50	1.47[c]	6.95-7.50	25	6.8-8.2	Rubin & Elmaraghy 1976, 1977
Guppy, *Poecilia reticulata*	8.2 mm	NH_4Cl	S,M	LC50	1.59[c]	7.40-7.50	25	6.6-8.2	Rubin & Elmaraghy 1976, 1977
Guppy, *Poecilia reticulata*	8.7 mm	NH_4Cl	S,M	LC50	1.45[c]	7.40-7.50	25	7.1-8.2	Rubin & Elmaraghy 1976, 1977
White perch, *Morone americana*	76 mm	NH_4Cl	S,M	LC50	0.15	6.0	16	-	Stevenson 1977
White perch, *Morone americana*	76 mm	NH_4Cl	S,M	LC50	0.52	8.0	16	-	Stevenson 1977
White perch, *Morone americana*	76 mm	NH_4Cl	S,M	LC50	0.20	6.0	16	-	Stevenson 1977
White perch, *Morone americana*	76 mm	NH_4Cl	S,M	LC50	2.13	8.0	16	-	Stevenson 1977
Green sunfish, *Lepomis cyanellus*	8.4 g	NH_4Cl	FT,M	LC50	0.61[d]	7.84	12.3	8.3	Jude 1973
Green sunfish, *Lepomis cyanellus*	9-d old	NH_4Cl	FT,M	LC50	1.08[c]	8.09-8.46	26.2	88% Saturated	Reinbold & Pescitelli 1982a
Green sunfish, *Lepomis cyanellus*	63.1 mg	NH_4Cl	FT,M	LC50	0.594	6.61	22.4	8.0	McCormick et al. (in prep.)
Green sunfish, *Lepomis cyanellus*	63.1 mg	NH_4Cl	FT,M	LC50	1.29	7.20	22.4	8.1	McCormick et al. (in prep.)
Green sunfish, *Lepomis cyanellus*	63.1 mg	NH_4Cl	FT,M	LC50	1.64	7.72	22.4	8.1	McCormick et al. (in prep.)
Green sunfish, *Lepomis cyanellus*	63.1 mg	NH_4Cl	FT,M	LC50	2.11	8.69	22.4	8.1	McCormick et al. (in prep.)

Table 1. (Continued)

Species	Life Stage or Size	Chemical	Methods[a]	Effect[b]	Concentration (mg/L NH_3)	pH	Temperature (°C)	D.O. (mg/L)	Reference
Pumpkinseed, *Lepomis gibbosus*	4.5 g	NH_4Cl	FT,M	LC50	0.14[d]	7.77	12.0	8.4	Jude 1973
Pumpkinseed, *Lepomis gibbosus*	16.7 g	NH_4Cl	FT,M	LC50	0.78	7.77	14.5	8.37	Thurston 1981
Pumpkinseed, *Lepomis gibbosus*	18.0 g	NH_4Cl	FT,M	LC50	0.86	7.77	14.0	8.36	Thurston 1981
Pumpkinseed, *Lepomis gibbosus*	18.9 g	NH_4Cl	FT,M	LC50	0.61	7.71	15.7	7.16	Thurston 1981
Bluegill, *Lepomis macrochirus*	22.0-55.2 mm	NH_4Cl	FT,M	LC50	0.89	7.96-8.26	18.5	9.1	Emery & Welch 1969
Bluegill, *Lepomis macrochirus*	41.0-67.1 mm	NH_4Cl	FT,M	LC50	2.97	7.95-8.54	18.5	9.1	Emery & Welch 1969
Bluegill, *Lepomis macrochirus*	42.5-67.5 mm	NH_4Cl	FT,M	LC50	4.60	8.43-8.89	18.5	9.1	Emery & Welch 1969
Bluegill, *Lepomis macrochirus*	35.3-65.5 mm	NH_4Cl	FT,M	LC50	2.57	8.50-9.00	18.5	9.1	Emery & Welch 1969
Bluegill, *Lepomis macrochirus*	0.072 g	NH_4Cl	FT,M	LC50	0.55[k]	8.01-8.13	22	95% Saturated	Roseboom & Richey 1977
Bluegill, *Lepomis macrochirus*	0.217 g	NH_4Cl	FT,M	LC50	0.68[k]	7.89-8.12	22	95% Saturated	Roseboom & Richey 1977
Bluegill, *Lepomis macrochirus*	0.646 g	NH_4Cl	FT,M	LC50	1.1[k]	7.89-7.97	22	93% Saturated	Roseboom & Richey 1977
Bluegill, *Lepomis macrochirus*	0.342 g	NH_4Cl	FT,M	LC50	1.8[k]	8.12-8.28	28	91% Saturated	Roseboom & Richey 1977
Bluegill, *Lepomis macrochirus*	0.078 g	NH_4Cl	FT,M	LC50	0.50[c]	8.32-8.47	4.0	73-100% Saturated	Reinbold & Pescitelli 1982b
Bluegill, *Lepomis macrochirus*	0.111 g	NH_4Cl	FT,M	LC50	1.98[c]	7.98-8.25	25.0	74-83% Saturated	Reinbold & Pescitelli 1982b
Bluegill, *Lepomis macrochirus*	0.250 g	NH_4Cl	FT,M	LC50	0.26[c]	8.06-8.26	4.5	87-97% Saturated	Reinbold & Pescitelli 1982b

Table 1. (Continued)

Species	Life Stage or Size	Chemical	Methods[a]	Effect[b]	Concentration (mg/L NH_3)	pH	Temperature (°C)	D.O. (mg/L)	Reference
Bluegill, *Lepomis macrochirus*	0.267 g	NH_4Cl	FT,M	LC50	1.35[c]	7.98-8.20	24.8	74-89% Saturated	Reinbold & Pescitelli 1982b
Bluegill, *Lepomis macrochirus*	49.2 mg	NH_4Cl	FT,M	LC50	0.94	7.60	21.7	7.89	Smith & Roush (in prep.)
Smallmouth bass, *Micropterus dolomieui*	265 mg	NH_4Cl	FT,M	LC50	0.694	6.53	22.3	7.93	Broderius et al. (in prep.)
Smallmouth bass, *Micropterus dolomieui*	265 mg	NH_4Cl	FT,M	LC50	1.01	7.16	22.3	7.90	Broderius et al. (in prep.)
Smallmouth bass, *Micropterus dolomieui*	265 mg	NH_4Cl	FT,M	LC50	1.20	7.74	22.3	7.97	Broderius et al. (in prep.)
Smallmouth bass, *Micropterus dolomieui*	265 mg	NH_4Cl	FT,M	LC50	1.78	8.71	22.3	8.00	Broderius et al. (in prep.)
Largemouth bass, *Micropterus salmoides*	2.0-6.3 g	NH_4Cl	FT,M	LC50	1.0[k]	7.82-8.11	22	85-94% Saturated	Roseboom & Richey 1977
Largemouth bass, *Micropterus salmoides*	0.09-0.32 g	NH_4Cl	FT,M	LC50	1.7[k]	7.98-8.10	28	83-88% Saturated	Roseboom & Richey 1977
Orangethroat darter, *Etheostoma spectabile*	0.78 g	NH_4Cl	FT,M	LC50	0.90[c]	8.4'	21	7.6-8.1	Hazel et al. 1979
Orangethroat darter, *Etheostoma spectabile*	0.71 g	NH_4Cl	FT,M	LC50	1.07[c]	7.7-8.5	22	7.5-8.1	Hazel et al. 1979
Walleye, *Stizostedion vitreum vitreum*	4-d old	NH_4Cl	FT,M	LC50	0.36[c]	8.17-8.61	18.3	100% Saturated	Reinbold & Pescitelli 1982a
Walleye, *Stizostedion vitreum vitreum*	6-d old	NH_4Cl	FT,M	LC50	0.85[c]	7.84-8.31	18.2	97% Saturated	Reinbold & Pescitelli 1982a
Mottled sculpin, *Cottus bairdi*	1.8 g	NH_4Cl	FT,M	LC50	1.39	8.02	12.4	8.9	Thurston & Russo 1981

CHAPTER 3

APPENDICES

AMMONIA EFFLUENT LOADINGS, pounds/day

YEAR	ANNUAL AVERAGE, lbs/day	MAXIMUM MONTH, lbs/day
1978	372	513
1979	290	525
1980	363	567
1981	293	503
1982	482	547
1983 a/	509	544
1984 b/	432	546
1985 c/	264	525
1986	493	1121
1987	183	600
1988	117	472
1989	65	259
1990	30	79
1991	72	193
1992 d/	20	55

a/ Data from Jan. through Nov.
b/ Data from Jan. through June
c/ Data from April through Dec.
d/ Data from Jan. through Sep.

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Parameter	Flow ave	Flow Max	pH min	pH max	Temp Ave	Temp Max	TSS Ave PPM	TSS Max PPM
Spec			6	9			25	50
Jan '84	0.8	1.4	6.7	7.3	42	50	17	27
Feb '84	2.70	4.80	6.5	7.5	58	63	12	15
March '84	3.54	7.16	7.1	7.6	58	62	9	15
April '84	4.25	6.09	6.8	7.6	62	64	11	12
May '84	2.85	5.52	6.8	7.9	64	70	10	28
June '84	3.74	6.74	7.0	7.9	78	81	12	27
July '84	0.62	5.70	6.1	6.9	77	77	7	13
Aug '84	1.93	5.09	(12.0)	(12.6) ⑤	72	77	13	26
Sept '84	2.11	5.56	7.2	7.8	66	70	6	8
Oct '84	2.48	4.62	6.2	7.5	59	63	7	14
Nov '84	2.45	4.16	7.3	7.8	54	60	6	11
Dec '84	3.17	4.71	7.2	7.5	48	57	4	9
- Ave								
Jan '85	3.08	6.83	7.5	9.0	46	52	10	15
Feb 85	2.39	6.33	7.4	7.9	54	56	9	15
March '85	3.18	6.80	7.4	7.9	57	60	6	13
April '85	3.31	5.85	7.3	7.8	64	74	9	12
May '85	2.31	4.43	6.9	7.6	73	75	6	10
June '85	2.76	4.54	6.5	7.4	77	81	3	8
July 85	3.00	4.91	7.0	7.8	82	84	3	6
Aug '85	3.63	6.12	7.2	7.6	79	81	10	44
Sept '85	3.08	4.66	7.0	7.5	73	80	5	8
Oct '85	3.11	6.14	7.3	7.9	62	68	8	9
Nov '85	5.06	6.35	7.1	7.5	54	58	15	25
Dec '85	3.33	5.96	6.6	8.1	50	54	13	29

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MONTHLY MAX

Parameter	TDS Ave PPM	TDS Max PPM	O+G Ave PPM	O+G Max PPM	O+G Ave #'s	O+G Max #'s	NH_3-N Ave PPM	NH_3-N Max PPM
Spec			15	30	413	775		
Jan '84	3961	4404	3.2	4.7	19	42	41	52
Feb '84	3629	4699	2.0	4.3	42	77	24	32
March '84	2942	3375	1.5	2.0	43	83	28	36
April '84	1967	2392	2.1	3.3	73	146	12	18
May '84	1749	1968	2.8	6.1	86	226	18.3	48
June '84	1768	2179	4.0	7.3	110	243	11.3	18
July '84	3021	3021	1.0	1.0	27	27	12.4	16
Aug '84	—	—	8.4	14	192	455	12.6	17
Sept '84	—	—	4.4	6.5	110	191	0.2	0.3
Oct '84	—	—	5.4	10.0	98	226	2.3	4.9
Nov '84	—	—	5.7	9.5	149	323	1.6	4.6
Dec '84			4.0	7.0	105	167	1.9	4.3
Ave								
Jan '85	—	—	3.1	5.5	74	192	0.2	0.3
Feb '85	—	—	3.2	5.5	57	132	0.1	0.2
March '85	788	1189	4.9	8.5	180	367	<.1	0.3
April '85	1032	1446	0.9	1.8	26	50	3.1	10.0
May '85	1191	1625	2.2	6.1	50	195	3.0	11.0
June '85	1529	1618	1.7	5.0	43	130	13.3	35
July '85	1352	1698	1.1	2.0	27	75	21	30
Aug '85	1015	1290	2.7	10.0	73	186	3.2	9.0
Sept '85	1270	1533	2.8	4.7	76	167	3.0	5.9
Oct '85	1240	1491	2.0	4.7	46	137	13.2	28.0
Nov '85	1153	1364	1.3	2.2	53	104	7.1	18.2
Dec '85	1608	1755	1.6	6.2	51	91	16	21
Ave								

Parameter	NH_3-N Ave #'s	NH_3-N Max #'s	Phen Ave PPM	Phen Max PPM	Phen Ave #'s	Phen Max #'s	CN Ave PPM	CN Max PPM
Spec	550	1010	.3	.6	9.3	19	.1	.2
Jan '84	245	401	.105	.136	.68	1.34	.098	.147
Feb '84	520	829	.089	.108	2.06	3.40	.084	.118
March '84	546	971	.048	.069	1.35	2.53	.069	.091
April '84	419	762	.052	.079	1.85	2.92	.021	.032
May '84	536	991	.030	.038	0.93	1.22	.069	.150
June '84	328	685	.029	.040	0.81	1.15	.041	.057
July '84	237	298	.079	.110	1.51	1.81	.031	.037
Aug '84	287	552	(4.4)	([illegible].2) (5)	(100)	(216) (4)	.040	.078
Sept '84	6	7	.015	.020	.38	.50	.036	.054
Oct '84	40	93	.012	.025	.23	.57	.023	.053
Nov '84	43	92	.016	.021	.43	.54	.011	.026
Dec '84	49	75	.013	.017	.34	.57	.019	.025
Ave	271							
Jan '85	4	7	.011	.020	.26	.49	.013	.018
Feb '85	3	8	.020	.025	.36	1.32	.016	.018
March '85	<4	<6	.015	.028	.56	.94	.008	.013
April '85	85	333	.031	.100	.88	1.75	.031	.077
May '85	56	231	.017	.027	.31	.63	.042	.062
June '85	293	644	.033	.050	.78	1.17	.067	.138
July '85	490	782	.068	.082	1.52	2.15	.057	.100
Aug '85	83	248	.040	.052	1.04	1.82	.084	.140
Sept '85	75	203	.033	.049	0.82	1.21	.089	.150
Oct '85	387	758	.040	.080	1.16	3.01	.052	.070
Nov '85	303	595	.047	.079	2.00	2.80	.050	.110
Dec '85	501	959	.038	.058	1.21	1.82	.088	.130

PLANT EFFLUENT AMMONIA

POUNDS FACTOR
8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
01/03/85	0.20	4.02	7		
01/08/85	0.15	4.19	5		
01/10/85	0.17	3.22	5		
01/15/85	0.23	3.11	6		
01/17/85	0.18	2.41	4		
01/23/85	0.20	1.99	3		
01/24/85	0.10	1.39	1		
01/29/85	0.10	2.21	2		
01/31/85	0.30	2.14	5	0.18	4
02/05/85	0.10	1.56	1		
02/07/85	0.15	0.96	1		
02/12/85	0.15	1.34	2		
02/14/85	0.13	1.33	1		
02/19/85	0.20	1.53	3		
02/21/85	0.15	0.35	0		
02/26/85	0.15	6.33	8		
02/28/85	0.15	3.54	4	0.15	3
03/05/85	0.10	5.18	4		
03/07/85	0.10	6.80	6		
03/12/85	0.10	5.05	4		
03/14/85	0.10	4.52	4		
03/26/85	0.30	0.98	2		
03/28/85	0.10	3.61	3	0.13	4
04/02/85	0.20	5.25	9		
04/04/85	0.14	2.43	3		
04/09/85	0.16	4.33	6		
04/11/85	2.40	4.09	82		
04/16/85	8.70	4.60	334		
04/18/85	10.00	2.44	203		
04/23/85	3.90	1.56	51		
04/25/89	2.60	3.32	72		
04/30/85	0.60	2.10	11	3.19	86
05/02/85 /a	0.10	2.31	2		
05/06/86 /a	10.00	2.31	193		
05/09/85 /a	11	2.31	212		
05/13/85 /a	3	2.31	58		
05/22/85 /a	0.3	2.31	6		
05/27/85 /a	0.1	2.31	2		
05/29/85 /a	0.7	2.31	13	3.60	69
06/03/85 /a	3	2.76	69		
06/05/85 /a	1.9	2.76	44		
06/10/85 /a	18	2.76	414		
06/13/85 /a	22	2.76	506		
06/17/85 /a	10	2.76	230		
06/19/85 /a	8.2	2.76	189		
06/24/85 /a	13	2.76	299		
06/26/85 /a	35	2.76	806		
06/27/85 /a	24	2.76	552	15.01	346
07/02/89	23.00	2.39	458		
07/08/85	30.00	3.13	783		
07/10/85	29.00	3.13	757		
07/15/85	23.00	2.91	558		
07/16/85	28.00	2.76	645		
07/22/85	14.00	2.88	336		
07/24/85	11.00	3.49	320		
07/28/85	14.00	4.30	502		
07/29/85	20.00	2.21	369	21.33	525
08/05/85	7.10	4.20	249		
08/07/85	9.00	2.27	170		
08/12/85	2.20	3.27	60		
08/14/85	1.20	3.93	39		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR
8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
08/19/85	0.30	3.90	10		
08/21/85	0.40	2.20	7		
08/26/85	1.30	2.65	29		
08/28/85	4.70	2.60	102	3.28	83
09/02/85	5.90	4.14	204		
09/04/85	3.70	2.78	86		
09/09/85	4.00	3.24	108		
09/11/85	1.20	4.34	43		
09/16/85	1.60	2.24	30		
09/18/85	0.90	2.43	18		
09/23/85	2.30	2.70	52		
09/25/85	2.00	2.50	42		
09/30/85	4.20	2.70	95	2.87	75
10/01/85	11.30	1.80	170		
10/09/85	28.00	3.25	759		
10/10/85	24.00	2.88	576		
10/15/85	15.00	3.25	407		
10/16/85	14.00	3.25	379		
10/20/85	13.50	3.25	366		
10/21/85	10.60	3.25	287		
10/28/85	5.10	6.14	261		
10/30/85	6.80	4.52	256	14.26	385
11/04/85	6.30	5.32	280		
11/06/85	3.50	5.10	149		
11/11/85	4.10	5.90	202		
11/13/85	4.70	5.24	205		
11/18/85	6.10	6.07	309		
11/21/85	5.00	5.93	247		
11/25/85	16.80	4.25	595		
11/26/85	18.20	2.83	430	8.09	302
12/02/85	21.00	4.23	741		
12/04/85	20.00	5.76	961		
12/10/85	15.00	4.53	567		
12/11/85	14.00	3.80	444		
12/16/85	12.00	4.09	409		
12/17/85	15.00	3.58	448		
12/23/85	13.00	2.14	232		
12/24/85	13.00	1.97	214	15.38	502
01/01/86	45.00	2.12	796		
01/07/86	27.00	0.79	178		
01/09/86	30.00	2.63	658		
01/13/86	36.00	1.27	381		
01/15/86	39.00	2.14	696		
01/19/86	41.00	3.20	1094		
01/21/86	44.00	1.95	716		
01/27/86	52.00	1.48	642		
01/29/86	47.00	2.07	811	40.11	664
02/03/86	50.00	2.16	901		
02/05/86	48.00	2.14	857		
02/10/86	54.00	2.05	923		
02/12/86	61.00	1.64	834		
02/18/86	78.00	1.74	1132		
02/20/86	66.00	1.74	958		
02/24/86	52.00	2.56	1110		
02/26/86	49.00	5.51	2252	57.25	1121
03/03/86	46.00	2.64	1013		
03/04/86	48.00	2.53	1013		
03/13/86	41.00	2.80	957		
03/15/86	37.00	3.67	1132		
03/18/86	32.00	4.20	1121		
03/19/86	33.00	3.62	996		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR
8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
03/23/86	40.00	3.17	1058		
03/25/86	43.00	3.17	1137		
03/31/86	48.00	2.59	1037	40.89	1052
04/02/86	54.00	2.30	1036		
04/07/86	53.00	1.31	579		
04/09/86	52.00	1.24	538		
04/14/86	23.00	1.96	376		
04/16/86	26.00	2.62	568		
04/21/86	36.00	1.77	531		
04/24/86	38.00	1.88	596		
04/28/86	38.00	1.73	548	40.00	597
05/01/86	27.00	4.58	1031		
05/05/86	21.00	1.72	301		
05/07/86	21.00	1.66	291		
05/12/86	18.00	3.93	590		
05/14/86	18.00	4.38	658		
05/19/86	16.00	4.59	612		
05/21/86	12.00	4.40	440		
05/26/86	13.00	2.96	321		
05/28/86	12.00	3.80	380	17.56	514
06/02/86	5.70	2.67	127		
06/04/86	1.90	2.64	42		
06/09/86	3.80	4.15	132		
06/11/86	1.70	2.86	41		
06/16/86	1.40	3.06	36		
06/18/86	0.80	3.70	25		
06/23/86	1.60	2.32	31		
06/25/86	1.20	1.42	14		
06/30/86	8.90	2.56	190	3.00	71
07/02/86	14.00	2.51	293		
07/07/86	11.00	3.32	305		
07/09/86	6.90	4.86	280		
07/14/86	14.00	4.44	518		
07/16/86	16.00	3.51	468		
07/21/86	19.00	3.85	610		
07/23/86	18.00	4.47	671	14.13	449
08/05/86	12.00	3.69	369		
08/07/86	15.00	3.26	408		
08/11/86	9.60	3.46	277		
08/13/86	12.00	4.23	423		
08/19/86	29.00	2.57	622		
08/20/86	26.00	2.43	527		
08/25/86	11.00	1.46	134		
08/27/86	6.30	2.50	131	15.11	361
09/01/86	2.30	2.58	49		
09/03/86	1.20	1.45	15		
09/08/86	2.20	3.06	56		
09/10/86	3.00	2.86	72		
09/15/86	6.10	2.58	131		
09/17/86	7.30	3.16	192		
09/22/86	11.00	3.95	362		
09/24/86	8.20	4.01	274		
09/29/86	3.10	4.42	114	4.93	141
10/01/86	1.30	4.47	48		
10/06/86	0.90	5.99	45		
10/08/86	4.80	5.74	230		
10/13/86	15.00	3.69	462		
10/15/86	15.00	2.49	311		
10/20/86	16.00	1.99	266		
10/22/86	13.00	2.89	313		
10/27/86	3.80	2.79	88		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR
8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
10/29/86	2.60	3.32	72	8.04	204
11/03/86	9.80	2.07	169		
11/05/86	15.00	2.14	268		
11/12/86	4.60	3.11	119		
11/13/86	3.90	2.81	91		
11/17/86	7.50	2.04	128		
11/19/86	11.00	3.26	299		
11/24/86	12.00	4.03	403		
11/25/86	12.00	3.44	344	9.48	228
12/02/86	18.00	4.00	600		
12/03/86	20.00	4.71	786		
12/08/86	17.00	3.74	530		
12/10/86	14.00	4.47	522		
12/17/86	18.00	3.71	557		
12/19/86	18.00	3.02	453		
12/22/86	21.00	3.37	590		
12/24/86	20.00	2.60	434		
12/29/86	20.00	2.82	470		
12/30/86	18.00	2.97	446	18.40	539
01/07/87	14.00	3.52	411		
01/12/87	20.00	3.28	547		
01/14/87	21.00	3.21	562		
01/19/87	15.00	3.72	465		
01/27/87	10.00	3.78	315		
01/28/87	10.00	4.10	342	15.00	440
02/02/87	22.00	2.68	492		
02/04/87	28.00	2.85	666		
02/09/87	24.00	3.19	639		
02/11/87	22.00	3.94	723		
02/17/87	19.00	3.65	578		
02/19/87	19.00	3.81	604		
02/23/87	29.00	3.01	728		
02/25/87	26.00	1.73	375	23.63	600
03/02/87	21.00	3.83	671		
03/04/87	18.00	3.77	566		
03/09/87	15.00	3.10	388		
03/11/87	15.00	3.50	438		
03/16/87	11.00	1.94	178		
03/18/87	8.90	2.87	213		
03/23/87	6.70	3.52	197		
03/25/87	6.10	2.60	132		
03/30/87	5.20	3.19	138	11.88	325
04/01/87	7.50	3.47	217		
04/06/87	16.00	2.44	326		
04/08/87	17.00	2.02	286		
04/13/87	12.00	3.16	316		
04/15/87	5.90	4.73	233		
04/21/87	3.70	4.40	136		
04/22/87	5.90	3.32	163		
04/27/87	9.10	3.61	274		
04/29/87	9.40	3.09	242	9.61	244
05/04/87	5.20	2.57	111		
05/06/87	1.20	2.60	26		
05/11/87	2.70	2.91	66		
05/13/87	2.90	3.06	74		
05/19/87	0.50	4.13	17		
05/20/87	1.10	5.53	51		
05/25/87	1.90	2.31	37		
05/27/87	1.60	0.93	12	2.14	49
06/01/87	2.40	5.02	100		
06/03/87	2.50	5.91	123		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR
8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
06/08/87	0.20	4.06	7		
06/10/87	0.30	3.78	9		
06/15/87	0.20	2.09	3		
06/17/87	0.10	1.64	1		
06/22/87	0.30	2.77	7		
06/26/87	2.50	1.54	32		
06/29/87	14.00	3.36	392	2.50	75
07/01/87	24.00	3.07	614		
07/06/87	23.00	3.75	719		
07/08/87	18.00	4.02	603		
07/13/87	4.90	6.05	247		
07/15/87	5.10	4.90	208		
07/20/87	11.00	5.71	524		
07/22/87	7.50	3.53	221		
07/27/87	6.40	3.52	188		
07/29/87	3.70	3.50	108	11.51	381
08/03/87	0.40	4.14	14		
08/05/87	0.50	4.67	19		
08/10/87	0.40	3.57	12		
08/12/87	0.20	2.38	4		
08/17/87	0.10	5.73	5		
08/19/87	0.10	6.00	5		
08/24/87	0.10	5.25	4		
08/26/87	0.10	6.47	5		
08/31/87	0.10	7.25	6	0.22	8
09/02/87	0.10	7.32	6		
09/07/87	0.10	5.00	4		
09/09/87	0.20	3.14	5		
09/14/87	0.10	3.23	3		
09/16/87	0.10	2.63	2		
09/21/87	0.10	3.16	3		
09/23/87	0.10	2.42	2		
09/28/87	0.20	2.81	5		
09/30/87	0.30	2.88	7	0.14	4
10/05/87	0.50	2.88	12		
10/07/87	0.20	3.05	5		
10/12/87	0.10	3.18	3		
10/14/87	1.20	2.78	28		
10/19/87	9.60	2.25	180		
10/21/87	8.00	2.58	172		
10/26/87	2.60	4.31	93		
10/28/87	1.10	4.36	40	2.91	67
11/02/87	0.30	4.75	12		
11/04/87	0.30	4.61	12		
11/09/87	3.00	4.61	115		
11/12/87	4.60	4.19	161		
11/16/87	6.50	1.11	60		
11/18/87	6.30	0.69	36		
11/23/87	1.40	5.59	65		
11/24/87	1.00	4.78	40		
11/30/87	0.20	4.32	7	2.62	56
12/02/87	0.20	4.26	7		
12/07/87	1.20	6.63	66		
12/09/87	3.70	5.61	173		
12/15/87	2.30	4.03	77		
12/16/87	1.50	4.11	51		
12/21/87	0.30	4.39	11		
12/23/87	0.20	5.09	8		
12/28/87	0.20	4.74	8		
12/30/87	0.10	4.53	4	1.08	45
01/02/88	3.50	5.48	160		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR
8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
01/04/88	0.20	5.20	9		
01/06/88	0.10	3.51	3		
01/11/88	0.10	3.00	3		
01/13/88	0.10	4.02	3		
01/18/88	0.20	5.13	9		
01/20/88	0.10	5.78	5		
01/25/88	0.20	6.65	11		
01/27/88	0.50	4.65	19	0.56	25
02/01/88	0.60	4.89	24		
02/04/88	0.30	4.27	11		
02/08/88	1.80	4.83	73		
02/10/88	1.50	2.36	30		
02/15/88	7.30	5.60	341		
02/17/88	18.00	2.43	365		
02/22/88	3.20	4.27	114		
02/24/88	3.00	3.70	93		
02/29/88	1.00	4.20	35	4.08	120
03/02/88	0.50	4.90	20		
03/07/88	0.20	5.95	10		
03/09/88	0.30	5.65	14		
03/14/88	0.30	4.67	12		
03/16/88	0.30	3.69	9		
03/21/88	0.10	3.09	3		
03/23/88	0.10	4.26	4		
03/28/88	5.00	4.97	207		
03/30/88	5.70	4.69	223	1.39	56
04/04/88	7.10	3.12	185		
04/06/88	4.10	3.53	121		
04/11/88	2.90	5.46	132		
04/13/88	5.80	4.12	199		
04/18/88	7.00	5.79	338		
04/20/88	9.90	2.81	232		
04/25/88	10.90	4.54	413		
04/27/88	14.00	3.75	438	7.71	257
05/02/88	6.60	3.13	172		
05/04/88	12.00	2.97	297		
05/09/88	4.30	3.14	113		
05/12/88	2.70	3.43	77		
05/16/88	9.70	2.71	219		
05/18/88	8.90	2.57	191		
05/23/88	1.80	4.50	68		
05/25/88	2.50	6.29	131		
05/30/88	3.40	4.32	122	5.77	155
06/02/88	2.20	3.12	57		
06/06/88	5.70	2.00	95		
06/14/88	21.00	4.19	734		
06/15/88	21.00	4.19	734		
06/21/88	23.00	3.87	742		
06/22/88	23.00	3.96	760		
06/27/88	18.00	2.30	345		
06/29/88	16.00	2.32	310	16.24	472
07/04/88	4.30	2.36	85		
07/07/88	2.60	2.42	52		
07/12/88	0.50	1.35	6		
07/13/88	0.60	4.22	21		
07/14/88	0.30	4.46	11		
07/18/88	0.80	1.84	12		
07/20/88	0.50	2.62	11		
07/26/88	0.60	3.54	18		
07/27/88	0.60	3.75	19	1.20	26
08/01/88	0.60	5.11	26		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR 8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
08/03/88	0.50	4.21	18		
08/08/88	0.80	4.90	33		
08/10/88	1.00	4.18	35		
08/15/88	0.70	4.29	25		
08/17/88	0.70	2.60	15		
08/25/88	0.40	2.80	9		
08/26/88	0.20	3.56	6		
08/29/88	0.30	3.55	9		
08/31/88	0.30	4.07	10	0.55	19
09/05/88	0.60	2.35	12		
09/07/88	0.50	2.68	11		
09/12/88	0.40	2.45	8		
09/14/88	0.40	2.80	9		
09/19/88	0.50	2.75	11		
09/21/88	0.40	1.84	6		
09/27/88	4.30	2.82	101		
09/28/88	3.50	1.87	55	1.33	27
10/03/88	2.20	2.79	51		
10/05/88	1.50	5.28	66		
10/10/88	0.80	2.96	20		
10/12/88	0.40	2.65	9		
10/17/88	0.30	4.94	12		
10/19/88	0.40	7.32	24		
10/24/88	0.20	6.28	10		
10/26/88	0.60	5.77	29		
10/31/88	2.20	3.32	61	0.96	31
11/02/88	4.50	2.66	100		
11/07/88	1.40	2.78	32		
11/09/88	1.60	2.04	27		
11/14/88	1.20	5.27	53		
11/16/88	2.70	6.94	156		
11/21/88	5.60	5.87	274		
11/22/88	6.30	5.55	292		
11/28/88	10.70	4.82	430		
11/30/88	10.80	2.61	235	4.98	178
12/05/88	1.40	5.32	62		
12/07/88	0.60	4.95	25		
12/12/88	5.90	4.41	217		
12/14/88	5.50	2.80	128		
12/19/88	6.40	2.41	129		
12/21/88	5.40	2.42	109		
12/26/88	0.50	5.49	23		
12/28/88	0.50	5.68	24	3.28	90
01/02/89	3.50	1.09	32		
01/11/89	4.30	1.43	51		
01/12/89	3.10	5.01	130		
01/16/89	1.20	3.85	39		
01/18/89	1.30	3.73	40		
01/23/89	5.80	4.64	224		
01/25/89	6.50	2.90	157		
01/31/89	5.00	5.85	244	3.84	115
02/03/89	20.70	3.44	594		
02/06/89	22.50	2.29	430		
02/08/89	26.00	3.42	742		
02/13/89	6.10	2.29	117		
02/15/89	3.30	4.36	120		
02/20/89	0.50	5.89	25		
02/22/89	0.60	5.83	29		
02/27/89	0.50	3.91	16	10.03	259
03/02/89	0.50	3.41	14		
03/06/89	0.50	4.86	20		

PLANT EFFLUENT AMMONIA

				POUNDS FACTOR 8.34	
	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
03/08/89	0.40	5.82	19		
03/13/89	1.10	3.52	32		
03/15/89	0.70	4.48	26		
03/20/89	0.70	5.90	34		
03/22/89	0.70	5.69	33		
03/27/89	0.70	4.24	25		
03/29/89	0.60	5.89	29	0.66	26
04/03/89	0.60	3.91	20		
04/05/89	0.90	2.82	21		
04/10/89	8.60	0.36	26		
04/12/89	12.20	1.14	116		
04/17/89	16.20	0.81	109		
04/19/89	16.00	0.75	100		
04/24/89	9.10	3.46	263		
04/26/89	4.70	3.03	119	8.54	97
05/01/89	1.60	1.23	16		
05/03/89	0.10	4.21	4		
05/08/89	0.43	0.73	3		
05/10/89	0.20	0.71	1		
05/15/89	0.12	1.43	1		
05/17/89	0.10	1.44	1		
05/23/89	0.30	3.61	9		
05/24/89	0.30	3.68	9		
05/29/89	0.30	4.74	12		
05/31/89	0.50	3.54	15	0.40	7
06/05/89	0.30	5.80	15		
06/07/89	0.50	6.05	25		
06/12/89	0.30	3.95	10		
06/14/89	0.40	4.53	15		
06/19/89	0.10	2.93	2		
06/21/89	0.40	3.12	10		
06/27/89	1.40	1.43	17		
06/28/89	1.30	1.19	13	0.59	13
07/04/89	7.60	1.02	65		
07/05/89	6.50	1.00	54		
07/10/89	2.50	1.85	39		
07/12/89	3.10	2.91	75		
07/17/89	0.80	3.52	23		
07/20/89	0.40	4.98	17		
07/24/89	1.30	6.95	75		
07/26/89	5.30	6.56	290		
07/31/89	14.30	3.45	411	4.64	117
08/02/89	13.30	3.91	434		
08/07/89	3.80	4.21	133		
08/09/89	2.60	2.48	54		
08/14/89	0.40	2.85	10		
08/16/89	0.20	4.61	8		
08/21/89	0.40	1.03	3		
08/23/89	0.70	1.90	11		
08/28/89	0.70	5.59	33		
08/30/89	0.60	6.07	30	2.52	80
09/04/89	0.70	6.82	40		
09/06/89	0.60	1.96	10		
09/11/89	0.50	3.85	16		
09/13/89	0.30	4.21	11		
09/18/89	0.20	4.58	8		
09/20/89	0.30	1.42	4		
09/25/89	0.30	2.69	7		
09/27/89	0.90	1.51	11	0.48	13
10/02/89	0.40	2.84	9		
10/04/89	0.30	2.78	7		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR 8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
10/09/89	0.10	3.10	3		
10/11/89	0.70	2.98	17		
10/16/89	1.40	1.54	18		
10/18/89	0.80	2.91	19		
10/23/89	1.60	4.69	63		
10/26/89	3.40	3.17	90		
10/30/89	0.60	3.37	17	1.03	27
11/01/89	1.40	3.87	45		
11/06/89	2.80	3.57	83		
11/08/89	1.50	3.12	39		
11/13/89	0.30	1.90	5		
11/15/89	0.30	2.33	6		
11/20/89	0.20	4.65	8		
11/21/89	0.20	4.08	7		
11/27/89	0.30	4.47	11		
11/29/89	0.30	5.43	14	0.81	24
12/04/89	0.20	2.40	4		
12/06/89	0.30	3.15	8		
12/11/89	0.10	2.32	2		
12/13/89	0.10	3.05	3		
12/18/89	0.20	2.97	5		
12/20/89	0.20	3.58	6		
12/25/89	3.00	4.02	101		
12/27/89	2.40	3.25	65	0.81	24
01/01/90	1.60	1.61	21		
01/03/90	0.90	4.85	36		
01/08/90	0.30	3.78	9		
01/10/90	0.50	5.12	21		
01/15/90	0.50	2.25	9		
01/17/90	0.40	2.60	9		
01/22/90	0.60	5.85	29		
01/24/90	0.90	3.39	25		
01/29/90	0.20	4.79	8		
01/31/90	0.60	4.51	23	0.65	19
02/05/90	3.00	5.84	146		
02/07/90	5.70	6.48	308		
02/12/90	1.60	1.56	21		
02/14/90	1.00	6.02	50		
02/19/90	0.10	5.67	5		
02/21/90	0.10	1.87	2		
02/26/90	0.10	7.77	6		
02/28/90	0.10	4.92	4	1.46	68
03/05/90	0.10	7.02	6		
03/07/90	0.10	5.79	5		
03/12/90	0.20	7.10	12		
03/14/90	0.20	7.20	12		
03/19/90	2.60	6.61	143		
03/21/90	0.10	5.22	4		
03/26/90	4.60	3.59	138		
03/28/90	2.00	4.91	82	1.24	50
04/02/90	4.00	5.23	174		
04/04/90	0.20	5.76	10		
04/09/90	0.20	1.86	3		
04/11/90	0.20	4.17	7		
04/16/90	0.10	5.67	5		
04/18/90	0.10	3.48	3		
04/23/90	0.10	4.75	4		
04/25/90	0.10	1.50	1		
04/30/90	0.30	5.81	15	0.59	25
05/02/90	0.20	2.99	5		
05/07/90	0.10	3.28	3		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR
8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
05/09/90	0.30	5.68	14		
05/14/90	0.20	8.16	14		
05/16/90	0.20	7.50	13		
05/21/90	0.20	5.11	9		
05/23/90	0.30	6.83	17		
05/28/90	0.20	5.47	9		
05/30/90	0.20	2.84	5	0.21	10
06/04/90	1.60	3.63	48		
06/06/90	1.30	2.50	27		
06/11/90	0.60	2.11	11		
06/13/90	0.50	3.40	14		
06/18/90	0.60	4.60	23		
06/20/90	0.60	3.12	16		
06/25/90	0.80	2.44	16		
06/27/90	0.30	3.07	8	0.79	20
07/02/90	0.60	4.21	21		
07/05/90	0.40	3.34	11		
07/09/90	0.60	2.16	11		
07/11/90	0.60	2.83	14		
07/12/90	0.50	4.08	17		
07/16/90	0.30	3.52	9		
07/18/90	0.10	4.67	4		
07/19/90	0.60	4.67	23		
07/23/90	0.20	5.21	9		
07/25/90	0.10	8.28	7		
07/30/90	0.50	4.45	19	0.41	13
08/01/90	0.60	1.76	9		
08/06/90	0.50	3.26	14		
08/08/90	0.20	3.16	5		
08/13/90	1.60	3.03	40		
08/15/90	5.70	2.18	104		
08/20/90	2.50	4.86	101		
08/22/90	1.90	4.86	77		
08/27/90	2.90	4.02	97		
08/29/90	0.90	3.83	29	1.87	53
09/03/90	0.70	2.49	15		
09/05/90	0.50	2.72	11		
09/10/90	0.10	2.78	2		
09/12/90	0.10	2.93	2		
09/17/90	0.20	2.92	5		
09/19/90	0.20	3.01	5		
09/24/90	0.10	3.02	3		
09/26/90	0.10	2.00	2	0.25	6
10/01/90	0.10	3.34	3		
10/03/90	0.30	2.87	7		
10/08/90	0.30	3.47	9		
10/10/90	0.40	4.81	16		
10/15/90	0.90	6.23	47		
10/17/90	1.10	3.37	31		
10/22/90	0.50	4.35	18		
10/24/90	1.20	3.11	31		
10/29/90	0.10	3.57	3		
10/31/90	0.10	3.06	3	0.58	17
11/05/90	0.20	4.82	8		
11/07/90	0.70	6.06	35		
11/12/90	0.20	4.48	7		
11/14/90	0.20	4.49	7		
11/19/90	0.20	2.45	4		
11/20/90	0.20	1.92	3		
11/26/90	0.10	4.88	4		
11/28/90	0.20	5.75	10	0.25	10

PLANT EFFLUENT AMMONIA

POUNDS FACTOR
8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
12/03/90	0.80	7.09	47		
12/06/90	0.40	7.14	24		
12/10/90	0.20	4.72	8		
12/12/90	0.40	3.93	13		
12/17/90	0.20	3.86	6		
12/19/90	0.20	3.29	5		
12/25/90	6.70	3.46	193		
12/26/90	11.60	3.46	335	2.56	79
01/01/91	2.60	3.63	79		
01/03/91	1.80	4.69	70		
01/08/91	0.20	4.09	7		
01/09/91	0.20	4.34	7		
01/14/91	0.10	4.93	4		
01/16/91	1.60	4.00	53		
01/21/91	0.30	4.66	12		
01/23/91	0.30	4.54	11		
01/28/91	1.10	4.22	39		
01/30/91	0.40	3.67	12	0.86	29
02/04/91	0.70	3.60	21		
02/06/91	0.40	5.61	19		
02/11/91	0.10	4.77	4		
02/13/91	0.20	4.04	7		
02/18/91	0.10	3.76	3		
02/20/91	0.10	4.06	3		
02/25/91	0.10	3.37	3		
02/27/91	0.30	3.16	8	0.25	8
03/04/91	0.10	3.53	3		
03/06/91	0.10	3.38	3		
03/11/91	0.10	4.26	4		
03/13/91	0.10	4.05	3		
03/18/91	0.10	4.17	3		
03/20/91	0.10	8.22	7		
03/25/91	0.30	5.06	13		
03/27/91	0.20	4.67	8	0.14	5
04/01/91	0.30	3.91	10		
04/03/91	0.10	4.23	4		
04/08/91	0.20	3.59	6		
04/10/91	0.40	9.26	31		
04/15/91	0.20	6.42	11		
04/17/91	0.10	6.72	6		
04/22/91	0.60	6.28	31		
04/24/91	0.70	5.07	30		
04/29/91	0.50	3.50	15	0.34	16
05/01/91	0.80	3.50	23		
05/06/91	2.50	4.33	90		
05/08/91	1.40	5.18	60		
05/13/91	0.80	3.34	22		
05/15/91	0.20	4.50	8		
05/20/91	0.30	3.50	9		
05/22/91	0.10	3.90	3		
05/27/91	0.40	5.54	18		
05/29/91	0.30	6.44	16	0.76	28
06/03/91	1.20	3.08	31		
06/05/91	14.60	2.59	315		
06/10/91	16.10	1.95	262		
06/12/91	6.60	4.16	229		
06/17/91	0.40	4.37	15		
06/19/91	0.30	4.07	10		
06/24/91	1.60	3.01	40		
06/26/91	0.20	3.50	6	5.13	113
07/01/91	0.10	3.27	3		

POUNDS FACTOR 8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
07/02/91	0.40	2.44	8		
07/08/91	0.40	3.86	13		
07/10/91	0.40	3.55	12		
07/15/91	9.60	3.14	251		
07/17/91	21.90	3.61	659		
07/22/91	19.20	3.65	584		
07/24/91	10.30	3.37	289		
07/29/91	2.80	3.42	80		
07/31/91	2.30	1.54	30	6.74	193
08/05/91	10.60	3.21	284		
08/07/91	20.80	4.29	744		
08/12/91	5.70	4.23	201		
08/14/91	2.20	4.14	76		
08/19/91	0.70	4.06	24		
08/21/91	0.30	3.69	9		
08/26/91	0.20	3.42	6		
08/28/91	0.10	2.42	2	5.08	168
09/02/91	0.50	2.39	10		
09/04/91	0.50	3.05	13		
09/05/91	0.70	2.61	15		
09/09/91	0.40	2.57	9		
09/11/91	0.40	2.59	9		
09/16/91	0.50	3.98	17		
09/18/91	0.30	2.81	7		
09/23/91	0.10	3.43	3		
09/25/91	0.10	2.66	2		
09/30/91	0.40	2.76	9	0.63	17
10/02/91	0.80	2.53	17		
10/07/91	0.20	5.09	8		
10/10/91	3.50	3.88	113		
10/14/91	0.40	3.53	12		
10/16/91	3.20	3.45	92		
10/21/91	3.20	2.56	68		
10/23/91	19.30	2.71	436		
10/28/91	3.80	7.47	237		
10/30/91	1.30	5.66	61	3.97	116
11/04/91	10.80	3.65	329		
11/06/91	15.60	3.49	454		
11/11/91	5.20	5.30	230		
11/13/91	2.60	4.06	88		
11/18/91	0.70	5.98	35		
11/20/91	0.40	5.97	20		
11/25/91	1.40	4.64	54		
11/26/91	2.40	3.81	76	4.89	161
12/02/91	0.70	5.42	32		
12/04/91	0.30	5.28	13		
12/09/91	0.10	4.54	4		
12/11/91	0.20	4.18	7		
12/16/91	0.10	3.78	3		
12/18/91	0.10	4.09	3		
12/23/91	2.10	2.13	37		
12/25/91	3.50	3.42	100		
12/30/91	1.20	3.74	37	0.92	26
01/01/92	1.10	2.40	22		
01/06/92	0.40	3.69	12		
01/08/92	0.20	1.92	3		
01/13/92	0.20	4.05	7		
01/15/92	0.30	4.19	10		
01/20/92	0.80	4.11	27		
01/22/92	0.70	3.55	21		
01/27/92	0.30	4.03	10		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR 8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
01/29/92	0.20	3.75	6	0.47	13
02/03/92	0.60	3.43	17		
02/05/92	0.50	3.78	16		
02/10/92	0.60	3.40	17		
02/12/92	0.40	4.27	14		
02/17/92	0.30	3.89	10		
02/19/92	1.70	4.80	68		
02/25/92	0.40	5.31	18		
02/26/92	0.30	4.51	11	0.60	21
03/02/92	0.10	3.55	3		
03/04/92	0.10	4.17	3		
03/09/92	0.20	3.96	7		
03/11/92	0.20	5.43	9		
03/16/92	0.40	4.09	14		
03/18/92	0.40	3.76	13		
03/23/92	0.20	4.03	7		
03/25/92	0.20	4.09	7		
03/30/92	0.70	4.46	26	0.28	10
04/01/92	0.40	5.15	17		
04/06/92	0.12	3.87	4		
04/08/92	0.45	3.70	14		
04/13/92	0.72	2.99	18		
04/15/92	0.48	4.18	17		
04/20/92	0.48	5.26	21		
04/22/92	0.25	5.38	11		
04/27/92	0.20	3.81	6		
04/29/92	0.30	3.04	8	0.38	13
05/04/92	0.30	3.03	8		
05/06/92	0.20	3.38	6		
05/11/92	0.20	3.54	6		
05/13/92	0.20	2.95	5		
05/18/92	0.20	2.49	4		
05/20/92	0.10	1.71	1		
05/25/92	0.60	3.30	17		
05/27/92	0.50	3.43	14	0.29	8
06/01/92	0.10	3.83	3		
06/03/92	0.10	3.41	3		
06/08/92	0.10	4.09	3		
06/10/92	0.20	3.39	6		
06/15/92	0.30	1.59	4		
06/17/92	0.20	2.11	4		
06/22/92	0.40	3.92	13		
06/24/92	0.20	1.50	3		
06/29/92	0.20	3.56	6	0.20	5
07/01/92	0.10	2.76	2		
07/05/92	0.30	2.19	5		
07/08/92	0.30	3.82	10		
07/13/92	0.20	3.55	6		
07/15/92	0.50	4.23	18		
07/20/92	0.20	4.91	8		
07/22/92	0.20	4.28	7		
07/27/92	0.10	1.97	2		
07/29/92	4.60	2.70	104		
07/30/92	9.40	4.55	357	1.59	52
08/03/92	10.70	3.78	337		
08/05/92	3.10	3.87	100		
08/10/92	0.40	3.64	12		
08/12/92	0.30	2.93	7		
08/17/92	0.30	1.55	4		
08/19/92	0.40	3.51	12		
08/24/92	0.30	2.54	6		

PLANT EFFLUENT AMMONIA

POUNDS FACTOR 8.34

	PE NH3 ,mg/l	PE FLOW ,mgd	PE NH3 ,pounds/day	MONTHLY AVERAGE NH3 ,mg/l	MONTHLY AVG NH3 LOAD ,pounds/day
08/26/92	0.20	3.75	6		
08/31/92	0.20	4.22	7	1.77	55
09/02/92	0.20	5.13	9		
09/07/92	0.10	3.26	3		
09/09/92	0.20	3.68	6		
09/14/92	0.10	5.56	5		
09/16/92	0.10	3.33	3		
09/21/92	0.20	2.84	5		
09/23/92	0.30	2.74	7		
09/28/92	0.60	3.11	16	0.23	6
1/85–9/92					
MINIMUM	0.10	0.35	0	0.13	3
MAXIMUM	78.00	9.26	2252	57.25	1121
AVERAGE	5.99	3.65	151	6.11	154
1/87–9/92					
MINIMUM	0.10	0.36	1	0.14	4
MAXIMUM	29.00	9.26	760	23.63	600
AVERAGE	2.94	3.84	83	3.07	87
1/89–9/92					
MINIMUM	0.10	0.36	1	0.14	5
MAXIMUM	26.00	9.26	744	10.03	259
AVERAGE	1.75	3.84	49	1.79	50

/a AVERAGE MONTHLY FLOWRATE USED
DAILY FLOWRATE NOT AVAILABLE

CHAPTER 4

APPENDICES

ESTIMATED MEAN FAUNAL DENSITIES
FOR SAMPLE SITES ON CHICAGO SANITARY AND SHIP CANAL

SAMPLE ID	NO. OF DROPS	AREA OF DREDGE ,sq. meters	TOTAL AREA SAMPLED (no. drops x area dredge) ,sq. m	TOTAL NO. SPECIMENS	#SPEC./sq. m
U-1	3	0.0522575	0.156773	34	217
U-2	1	0.0522575	0.052258	232	4440
U-3	2	0.0522575	0.104515	561	5368
U-4	2	0.0522575	0.104515	121	1158
U-5	2	0.0522575	0.104515	82	785
U-6	1	0.0522575	0.052258	51	976
D-1	3	0.0522575	0.156773	178	1135
D-2	3	0.0522575	0.156773	71	453
D-3	3	0.0522575	0.156773	157	1001
D-4	4	0.0522575	0.209030	105	502
D-5	1	0.0522575	0.052258	78	1493
D-6	2	0.0522575	0.104515	107	1024
D-7	3	0.0522575	0.156773	132	842
D-8	2	0.0522575	0.104515	58	555

SIZE OF DREDGE= 9" X 9" = 0.75' X 0.75'
AREA OF DREDGE= 81 sq. in. = 0.5625 sq. ft.
CONVERSION FACTOR: 1 sq. ft. = 0.0929023 sq. m.

AREA OF DREDGE= 0.0522575 sq. m.