Protecting Our Water Environment

Metropolitan Water Reclamation District of Greater Chicago

RESEARCH AND DEVELOPMENT DEPARTMENT

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COMPARISON OF FECAL COLIFORM CONCENTRATIONS AND TRENDS IN TWO URBAN RIVERS: THE CHICAGO SANITARY AND SHIP CANAL AND THE DES PLAINES RIVER

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DISCLAIMER

Mention of proprietary equipment and chemicals in this report does not constitute endorsement by the Metropolitan Water Reclamation District of Greater Chicago.

SUMMARY AND CONCLUSIONS

The Metropolitan Water Reclamation District of Greater Chicago (District) developed a cooperative relationship with the Illinois Environmental Protection Agency (IEPA) in early 2002 to provide information on the potential recreational use classification of the Lower Des Plaines River (LDPR). It was apparently assumed that the District water reclamation plants (WRPs) were the dominant sources of fecal coliform (FC) reaching the LDPR. The District recognized that a thorough understanding of the trends and variation of FC concentrations both in the Des Plaines River (DPR) and the Chicago Sanitary and Ship Canal (CSSC) at Lockport are required before sound recommendations regarding recreational potential of the LDPR can be made.

This study was undertaken to explore the physical and chemical factors that help account for FC variations in the two waterways. The main purpose of this study was to compare the FC concentrations at the DPR upstream of Lockport (District monitoring location 91) and at the CSSC at Lockport (District monitoring location 92) for the 2000 - 2001 period. Existing water quality monitoring data [FC, total suspended solids (TSS), temperature, and turbidity] as well as river flow and rainfall data for the 2000 through 2001 period were put into a single database.

Statistical analysis was conducted to determine the seasonal effects and the relationship to weather conditions (wet and dry) and seasonal disinfection (May through October - disinfection and November through April - no disinfection) on FC concentrations. Multiple regression analysis was performed to study the relationship of FC concentrations at locations 91 (DPR) and 92 (CSSC) with river flow, rainfall, TSS, turbidity, and water temperature. Regression models were developed to predict FC concentrations at the two waterway locations.

The specific conclusions drawn from this study are enumerated below.

1. The 30-day period geometric mean (GM) measurements of FC concentrations at both locations 91 (DPR) and 92 (CSSC), were often above the Illinois General Use water quality standard of less than or equal to 200 CFU/100 mL. Location 91 (DPR) had a larger percentage (70 percent) of GMs exceeding the General Use standard than location 92 (CSSC) which exceeded the standard 55 percent of the 30-day periods.

2. The two-year cumulative GM concentration of FC bacteria at location 91 (DPR) was 330 CFU/100 mL, and at location 92 (CSSC) it was 274 CFU/100 mL. Based on the results of analysis of variance (ANOVA), it is concluded that the GM concentrations of FC bacteria at location 91 (DPR) and at location 92 (CSSC) were not significantly different over the two-year period.

3. The ANOVA results related to the comparison of the seasonal disinfection period [P1 (May - October)] versus the no disinfection period [P2 (November - April)] relative to FC indicated the following:

   a. There is a statistically significant difference in the FC concentrations measured at location 91 (DPR) in the P1 (GM=228 CFU/100 mL) versus the P2 (GM=467 CFU/100 mL) period ($p = 0.0094$). The FC concentrations were higher in P2.

   b. There is a statistically significant difference in the FC concentrations measured at location 92 (CSSC) in the P1 (GM=381 CFU/100 mL) versus the P2 (GM=179 CFU/100 mL) period ($p = 0.0078$). The FC concentrations were higher in P1.

c. There is no statistically significant difference in the FC concentrations measured at location 91 (GM=228 CFU/100 mL) and location 92 (GM=381 CFU/100 mL) in P1.

d. There is a statistically significant difference in the FC concentrations measured at location 91 (GM=467 CFU/100 mL) and location 92 (GM=179 CFU/100 mL) in P2 ($p = 0.0001$).

4. The results of the simple regression model developed in this study to predict FC concentration at locations 91 (DPR) and 92 (CSSC) indicated the following:

   a. The simple regression equations are:

      Location 91 (DPR):

      $$\ln(FC)=0.88647*\ln(Flow), R^2 = 0.95$$

      Location 92 (CSSC):

      $$\ln(FC)=0.71086*\ln(Flow), R^2 = 0.95$$

   b. Statistical analysis indicated that the slope of the regression equation for location 91 (DPR) is significantly higher ($p = <0.05$) than the slope of the regression equation for location 92 (CSSC). This confirms the probability of higher FC concentrations at location 91 (DPR) with an increase in river flow rate when compared to location 92 (CSSC).

5. The microbial quality of the CSSC at location 92 which is classified as a Secondary Contact water was comparable to the microbial quality of the Des Plaines River at location 91 which is classified as a General Use water. This finding indicates that the unchlorinated effluents from District WRPs discharging into the CSSC upstream of Lockport are not adversely affecting the microbial quality of the LDPR downstream of Lockport.

6. The microbiological water quality standards for freshwater recreational use in the LDPR should be reevaluated with a focus on nonpoint sources and point sources of pollution downstream of location 91 and 92 when determining water quality standards and the microbiological assessments of the LDPR.

INTRODUCTION

Description of the Des Plaines River and the Chicago Sanitary and Ship Canal

The DPR is a 130 mile long waterway originating in Kenosha County, Wisconsin (Terrio, 1995). It runs through four counties in Illinois to its confluence with the Kankakee River at Channahon, where the two form the Illinois River. Along the way its character changes from a rural creek draining agricultural areas, to a suburban stream, to a large urbanized river, to a major industrial waterway (Figure 1). The DPR forms one of the headwater streams of the Illinois River, a large tributary of the Mississippi River. The river corridor through most of Cook, DuPage, and Lake Counties in Illinois is in county Forest Preserve Districts.

The DPR is one of the most utilized water resources in Illinois. The northern DPR watershed is mostly rural with areas of urban development in progress. The southern part of the DPR is highly urbanized. Near Lyons, Illinois, the DPR flows southwest parallel to the CSSC. The CSSC is a man-made conveyance of the treated wastewater from the Metropolitan Chicago area. The Chicago River, Calumet-Sag Channel, Calumet, and Little Calumet Rivers drain into the CSSC (Figures 1 and 2). The CSSC joins with the DPR below the Lockport Lock and

FIGURE 1

DES PLAINES RIVER WATERSHED

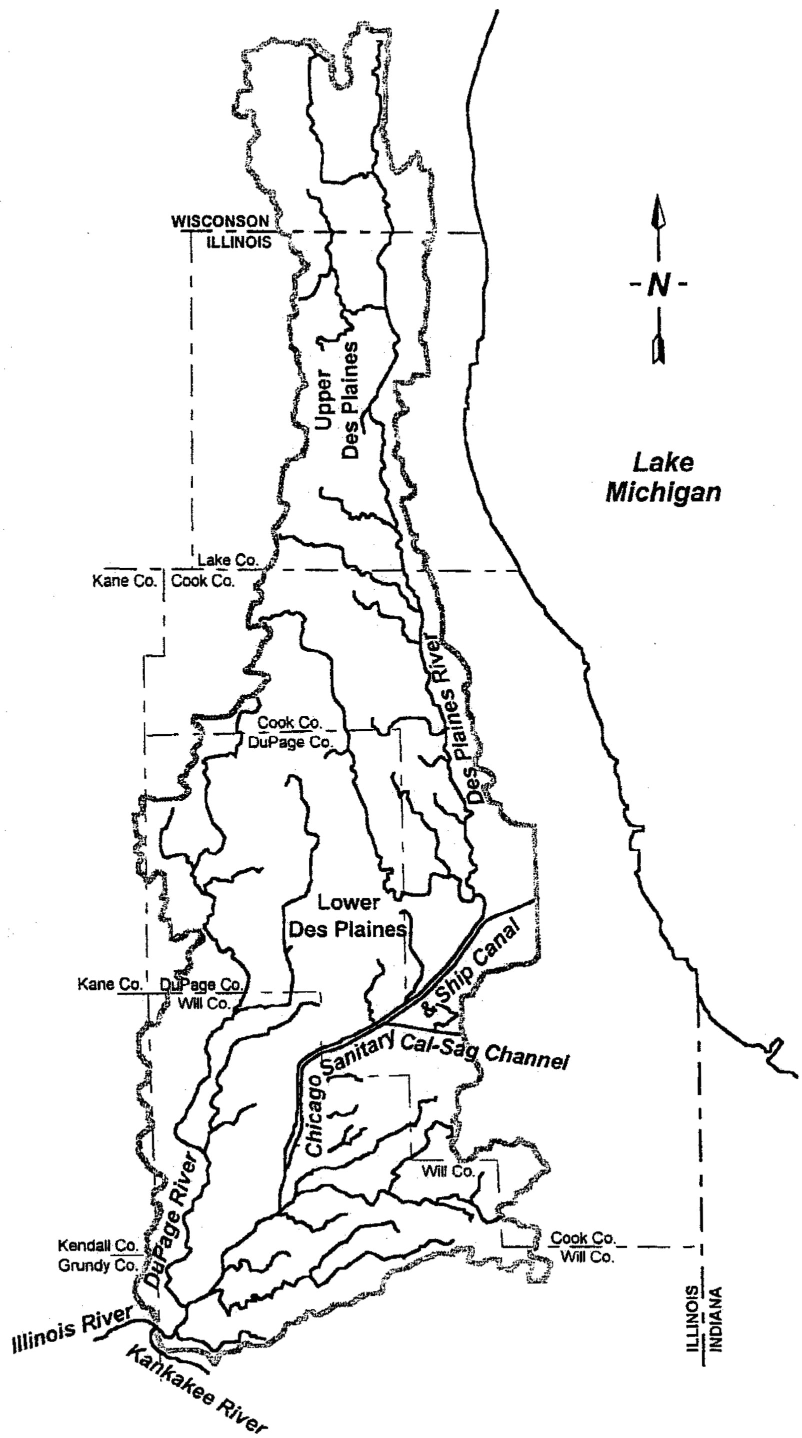
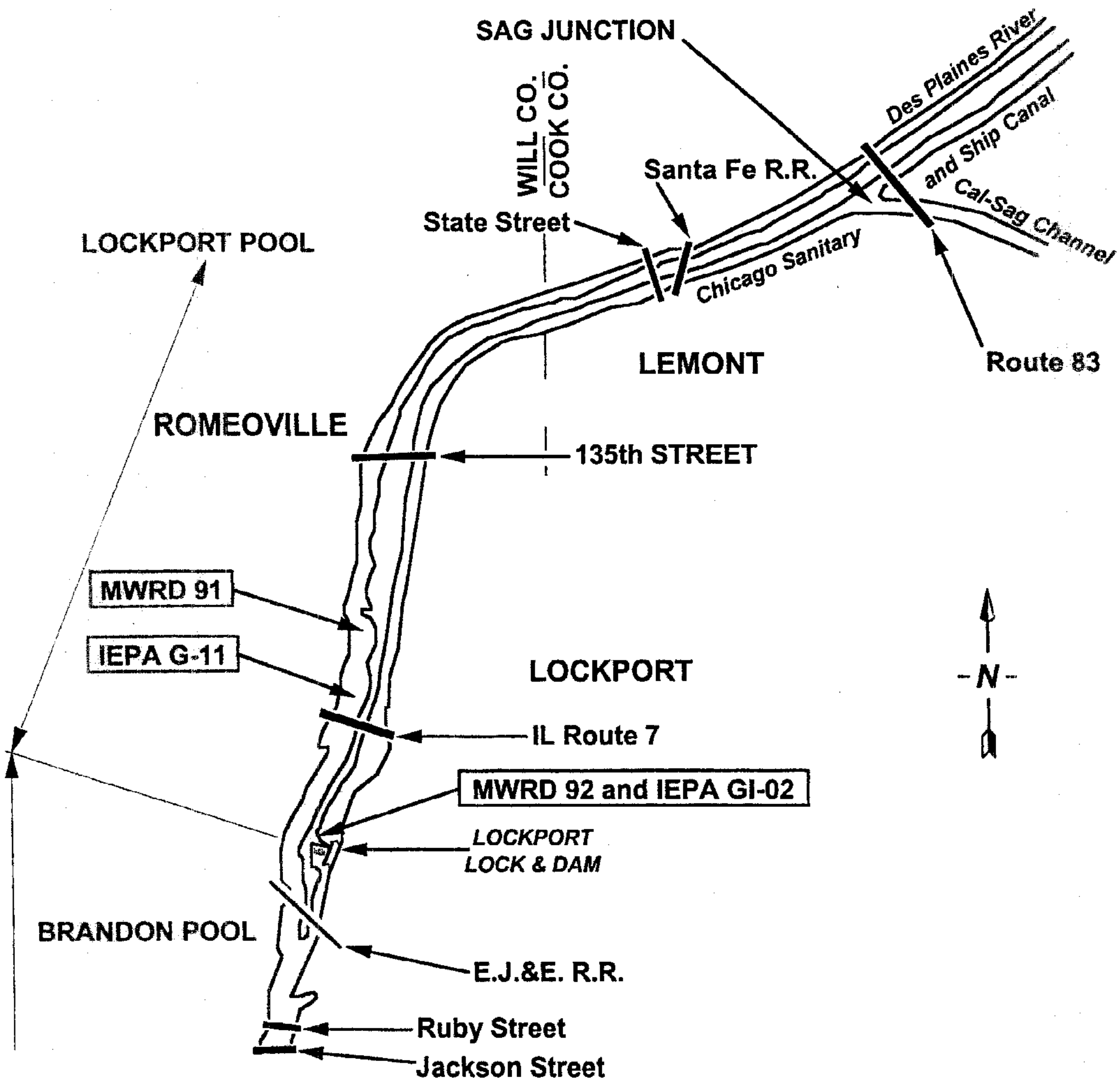


FIGURE 2

ENLARGED MAP OF SAMPLING LOCATIONS (91 AND 92) ON THE DES PLAINES RIVER AND THE CHICAGO SANITARY AND SHIP CANAL



Dam (Figure 3). The DPR from the junction with the CSSC to the Illinois River is referred to as the LDPR. The LDPR is 18 miles in length and covers the Brandon Road and Dresden Island navigation pools. The LDPR is on the IEPA's 303(d) list of impaired waters.

Current Illinois General Use and Secondary Contact Microbial Water Quality Standard

Water quality indicators are chosen based on the type of land use evident in a watershed. The IEPA has established water quality classifications for waterways in Illinois. The DPR is classified as General Use. According to the IEPA, water designated as General Use must meet the following microbial water quality limits during the months May through October (IEPA, 1972):

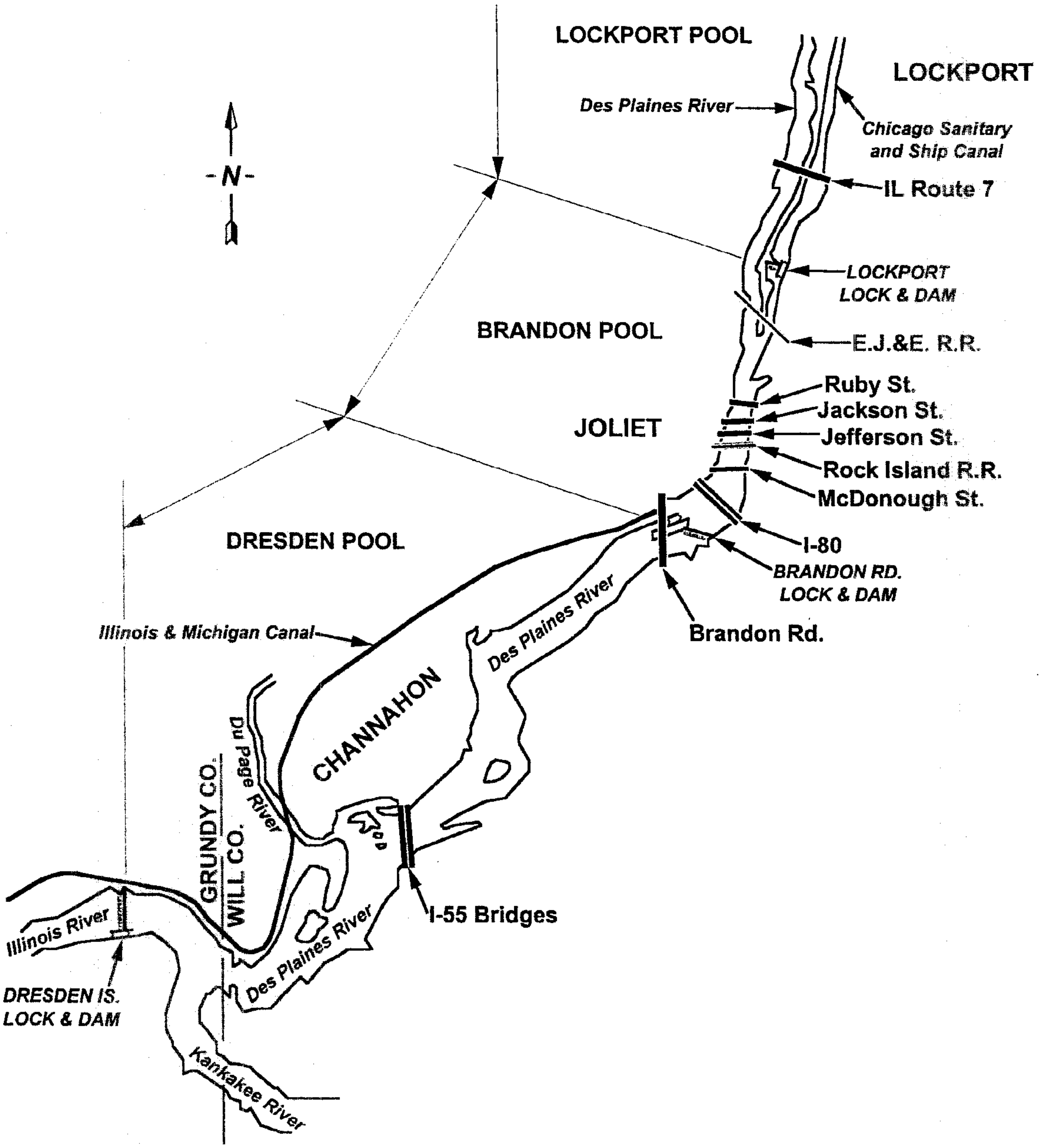
a. Based on minimum of five samples taken over not more than a 30-day period, FC shall not exceed a geometric mean (GM) of 200/100 mL;

b. nor shall more than 10 percent of the samples during any 30-day period exceed 400/100 mL.

The CSSC is a man-made waterway excavated in rock with vertical walls to handle WRP effluent, combined sewer overflows, and urban nonpoint run-off water. The CSSC is an effluent dominated water body, therefore, it is not suited for

FIGURE 3

MAP OF THE LOWER DES PLAINES RIVER (LDPR)



General Use activities and is classified as Secondary Contact by the IEPA. The navigable depths created by the Lockport Dam allow the CSSC to be used for secondary contact activities, mainly commercial navigation and recreational boating.

During the early 1970's the CSSC was classified as Restricted Use water (IEPA, 1972). This indicated that certain uses were not protected. The restricted use standard for bacteria was:

a. Based on a minimum of five samples taken over not more than a 30-day period, FC shall not exceed a GM of 1000/100 mL,

b. nor shall more than 10 percent of samples during any 30-day period exceed 2000/100 mL.

In 1982 this standard was repealed and currently no standards for bacterial pollution is in force for Secondary Contact water (the entire CSSC).

Use Attainability Analysis (UAA)

The IEPA has started introducing regulatory requirements for designated and existing water uses; the role of water quality standards; and the need for UAAs. The UAA is defined as a structured scientific assessment of the factors affecting the attainment of the use, which may include physical, chemical, biological, and economic factors. The UAA is required for water bodies where designated uses are lower than the statutory fish and aquatic life protection and propagation, and primary contact recreation. The UAA being performed on the LDPR will determine whether the current lower use classification could be upgraded.

Historically the LDPR has had poor water quality. This was mainly due to various wastewater effluent discharges and channel modifications. The LDPR has been classified as Secondary Contact water. An argument can be made for upgrading the designated use of the LDPR below its confluence with the CSSC. Significant progress has been made since the 1970s in improving the quality of the effluent from the North Side WRP, which is discharged to the CSSC via the North Shore Channel and the North and South Branches of the Chicago River; the effluent from the Stickney WRP, which is discharged directly into the CSSC; and the effluent from the Calumet WRP, which flows into the CSSC via the Calumet-Sag Channel. The District's Tunnel and Reservoir Plan (TARP) has significantly reduced the number of combined sewer overflows (CSOs) discharged into the CSSC and into the DPR system. As of 2001, TARP cumulatively captured 565 billion gallons of CSO that would otherwise have flowed into area receiving waters (USEPA, 2001). It is hoped that the eventual construction of the TARP reservoirs, now scheduled for completion by 2014, will virtually eliminate CSOs.

A meeting of the UAA Stakeholders Group, the IEPA, and the IEPA consultant was held on May 16, 2002, to discuss the designated use goals for the waterways. The IEPA consultant assumed that the treated effluents from the Stickney and Calumet WRPs are the dominant sources of bacteria reaching the LDPR. The IEPA consultant suggested the possibility of final effluent disinfection at these two District WRPs to meet some possible future standard for bacteria in the LDPR.

In determining the need for disinfection at the two WRPs, the District wanted to explore the FC bacteria distribution in the DPR and the CSSC during 2000 - 2001. Some of the FC bacteria issues of concern were:

1. What are the general water quality characteristics at two locations, in terms of flow, temperature, TSS, turbidity, and rainfall?
2. What are the factors that contribute to the density of indicator bacteria?
3. What are the concentrations and loads of FC bacteria?

4. Are there any statistical differences in FC concentrations?

5. How do the distributions and concentrations of FC bacteria change over time?

6. Can a model be developed to predict FC concentrations?

7. What are the sources of FC bacteria in these two waterways?

At this time there is limited understanding of the environmental factors that lead to seasonal variations in concentration of FC bacteria. An analysis of FC bacteria concentrations in these waterways may help determine if a proposed FC bacteria standard could be statistically attainable and if there is a need of resumption of disinfection practices to prevent pollution of the LDPR.

OBJECTIVES

The overall objective of this study was to conduct statistical analyses of the FC bacteria data collected by the District for the DPR near Lockport (location 91) and the CSSC at the Lockport Powerhouse (location 92) for the 2000 through 2001 period, in order to assess the impacts from these two waterways on the bacterial quality of the LDPR. The following statistical analyses were performed:

1. The arithmetic mean and range of water quality parameters such as river flow, turbidity, TSS, and temperature.
2. The 30-day period GM concentrations of FC bacteria.
3. The statistical differences between FC concentrations at both locations during rainy and dry periods in the Chicago area.
4. The statistical differences between FC concentrations under seasonal disinfection months.
5. The feasibility of statistical regression models as a tool for forecasting FC bacteria concentrations at the two locations.

MATERIALS AND METHODS

Data Used in Analysis

Data for this study were obtained from the following agencies:

1. Weekly FC data were obtained from the District Analytical Microbiology Laboratory for the period January 2000 to December 2001. The District's Analytical Microbiological Laboratory is certified by the Illinois Department of Public Health (IDPH), Registry Number 17508.
2. The TSS, temperature, and turbidity data for water samples taken from the two locations were obtained from the District's Analytical Laboratory which has been accredited by the IEPA, under National Environmental Laboratory Accreditation (NELAC), for the inorganic analysis of wastewater since 2001.
3. Daily mean stream flow values in cubic feet per second for the CSSC at Romeoville and the DPR at Riverside were obtained from the United States Geological Survey (USGS) NWISWeb internet based retrieval system using the "File of Site Numbers"

search criteria. Romeoville and Riverside are the locations closest to locations 92 and 91, respectively, where flow data have been collected. Flow data at locations 91 and 92 are not available.

4. Rainfall data in inches were collected by the District as part of normal operations. Average rainfall readings in inches were taken at 12:00 midnight from Glenview, North Side WRP, North Branch Pumping Station, Wilmette, Stickney West Side Plant, Springfield Ave., Racine Ave., 100 E. Erie, E. Melvina Ave., 87th and Western, Calumet WRP, 95th St. Pumping Station, and Lockport.
5. Storm data were collected by the District as part of normal operations.

Description of the Sampling Locations

For this investigation, the data collected from two sampling locations upstream of the Lockport Dam were chosen (Figures 2 and 3). The DPR upstream of Lockport sampling point is located directly above the IEPA station G-11. This sampling point is designated as location 91. Data collected at location 91 were used to assess the ambient water quality in the

General Use portion of the DPR. The CSSC sampling point is located at the Lockport Power House. This sampling point is designated as location 92 and is a Secondary Contact water. Location 92 is approximately 25 miles downstream from the Stickney WRP and 30.5 miles downstream from the Calumet WRP.

The DPR and CSSC merge just below Lockport to form the LDPR which is classified as a Secondary Contact water (Figure 3).

Number of Observations

During the two-year investigation (2000 through 2001), a total of 202 FC bacterial samples were collected and analyzed (Table 1). In 2000, a total of 50 water samples were analyzed for FC at each of the two locations 91 (DPR) and 92 (CSSC). In 2001, a total of 52 water samples were analyzed for FC at location 92 (CSSC) and 50 samples at location 91 (DPR).

All the data were compiled in a single database within the framework of wet/dry weather conditions and seasonal disinfection periods (P1 and P2).

Wet and Dry Weather Conditions

Rainfall varies as to intensity, duration, and volume. For this study rainfall that resulted in greater than 0.1 inches of rain within 24 hours was defined as a wet weather

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TABLE 1

NUMBER OF OBSERVATIONS AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Year/Condition	Number of Observations	
	Location 91 (DPR)	Location 92 (CSSC)
Total 2000	50	50
Total 2001	50	52
2000 through 2001		
Dry Weather Conditions	75	77
Wet Weather Conditions	25	25
Disinfection Period P1, (May - October)	52	52[1]
No Disinfection Period P2, (November - April)	48	50

[1]No Seasonal Disinfection (Stickney, Calumet, and North Side WRPs discharge undisinfected effluent year round).

event. For the statistical calculations, a wet event was determined from the weekly mean values of rainfall data in the Chicago area.

Seasonal Disinfection Period

The DPR upstream of Lockport receives discharges from urban run-off and treated municipal and industrial sewage effluents from several sewage treatment plants (STPs). Effluent from these STPs is discharged into the DPR at an average of 153.70 cubic feet per second (Hey and Associates, Inc., Draft Report, April 2002). All of these treatment plants disinfect final effluent between May and October. The effluent is not disinfected from November through April.

The CSSC, however, is an effluent dominated water body. It receives treated effluents from the Stickney, North Side, and Calumet WRPs. Effluent from these WRPs is discharged into the CSSC at an average of 1666.8 cubic feet per second (Hey and Associates, Inc., Draft Report, April 2002). The effluents from the Stickney, North Side, and Calumet WRPs are not disinfected.

For the purpose of this study the FC data were grouped in two seasonal periods, P1 and P2. The period one (P1) was classified as months when DPR (location 91) receives disinfected effluents. The P1 period included FC concentration data obtained from May through October. The period two (P2) is when undisinfected effluents are discharged into the DPR. The P2 period included FC concentration data obtained from November through April.

Statistical Methods

For the period of 2000 - 2001, arithmetic mean and range values of TSS, turbidity, and temperature were calculated for each waterway. Graphs were used to summarize and display data characteristics of river flow, rainfall, and FC concentrations.

The GM of the FC density at each location was calculated from five FC measurements made in a 30-day period to assess compliance with the General Use standard. In this study, a 30-day period was defined as any 30-day period at each location that had five FC samples. Due to this interpretation, the data were not grouped by month, but after every five samples. Twenty 30-day GMs were calculated for each location.

Multiple linear regression to predict FC concentrations at locations 91 (DPR) and 92 (CSSC) was performed using untransformed and transformed data as presented in the following equation (Rao, 2002; Walpole and Myers, 1989):

$$FC = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + + \beta_5 x_5$$

Where α = the y-axis intercept
x_1 = temperature (°C)
x_2 = turbidity (NTU)
x_3 = TSS (mg/L)
x_4 = rainfall (inches)
x_5 = flow (cubic feet per second)
and β_1 through β_5 = coefficients assigned to x_1 through x_5 and x_1 through x_5 represent the explanatory variables for inclusion in the multiple linear regression model.

The best model of all possible models was chosen on the basis of R^2 values and Mallow's CP statistics (Walpole and Myers, 1989).

Time series models were developed using the *ln* (FC) from the three previous *ln* (FC) measurements with flow as an explanatory variable (Box and Jenkins, 1970). These models are referred to as auto regressive models.

Akaike Information Criterion (AIC) were calculated to determine whether the linear regression model or the auto regressive model was better for each location (Khattree and Naik, 1999).

The Kolmogorov-Smirnov (K-S) test was used to test the collected data (transformed and untransformed) for normality (Gibbons and Chakraborti, 1992). Bartlett's test or the F test for homogeneity of variance (Walpole and Meyers, 1989;

Dyer and Keating, 1980) was performed on *ln* (FC) and *ln* (flow) data for which there was no reason to question the assumption of normality. Standard parametric ANOVA was used to test the equalities of GMs of FC concentrations at locations 91 (DPR) and 92 (CSSC) (SAS Institute, 2000; Khattree and Dayanand, 1999). Parametric analysis of covariance (ANCOVA) was performed to assess the relationship between FC concentrations and flow (Khatree and Naik, 1999; Rao, 2002).

RESULTS AND DISCUSSION

The results of this study provide a comparative assessment of FC concentrations at two waterway locations, 91 (DPR) and 92 (CSSC) for the two-year period (2000 - 2001). The following sections provide descriptive information on the waterways water quality characteristics such as river flow, rainfall, turbidity, TSS, and temperature during 2000 - 2001. These descriptions are followed by a series of statistical analyses of the FC concentrations at two locations during wet/dry weather and seasonal disinfection periods.

Fecal coliform, river flow, and rainfall data used for the statistical analyses are presented in Table AI-1. Total suspended solids, temperature, and turbidity data are presented in Table AI-2. The complete set of rainfall data for 2000 and 2001 are presented in Tables AI-3 and AI-4, respectively. The storm data for 2000 and 2001 are presented in Table AI-5. The calculated 30-day period, GM concentrations of FC bacteria are presented in Table AI-6. Predicted FC concentrations by time series and regression models are provided in Tables AII-1 (location 91) and AII-2 (location 92).

River Flow

The flow data for 2000 and 2001 are shown in Figures 4 and 5. The flow measurements were not obtained directly from the study locations 91 (DPR) and 92 (CSSC). The flow rates at the DPR Riverside and the CSSC Romeoville determined the estimated flow rates at locations 91 (DPR) and 92 (CSSC), respectively. These flow measurements are provided by the U.S. Geological Survey and are the closest locations to the study area.

The river flow rate measured at the DPR Riverside location ranged from 178 cubic feet per second to a high of 4,380 cubic feet per second. The average flow rate at this location was 854.6 cubic feet per second. The river flow rate measured at CSSC at Romeoville ranged from a low of 1,192 cubic feet per second to a high of 11,563 cubic feet per second. The average flow rate at this location was 2,289 cubic feet per second, three times higher than the average flow at DPR Riverside location during the 24-month period.

Rainfall

A bar graph characterizing monthly precipitation data in the Chicago area during the two-year period 2000 and 2001 is

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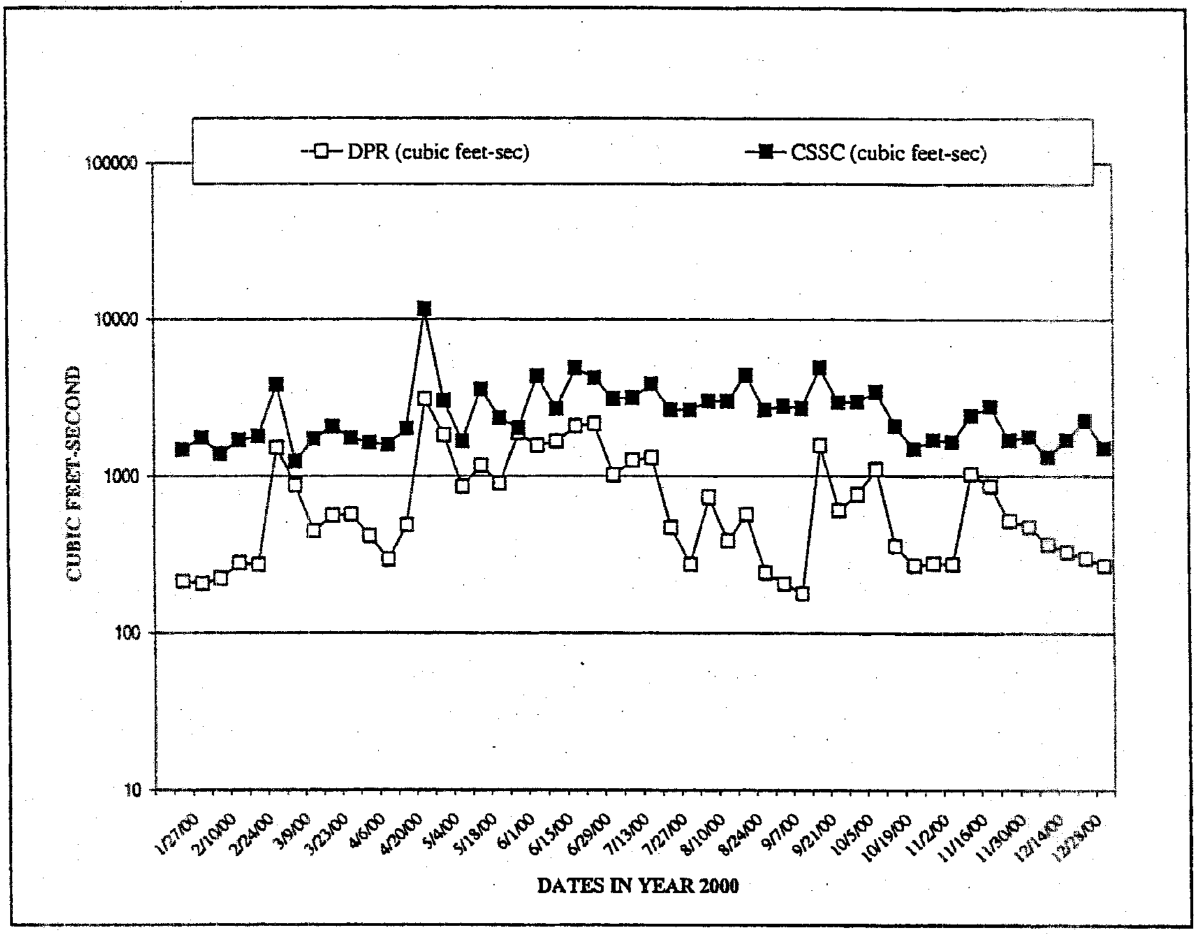
FIGURE 4

FLOW DATA FOR THE YEAR 2000



Source: http://waterdata.usgs.gov/nwis/measurements

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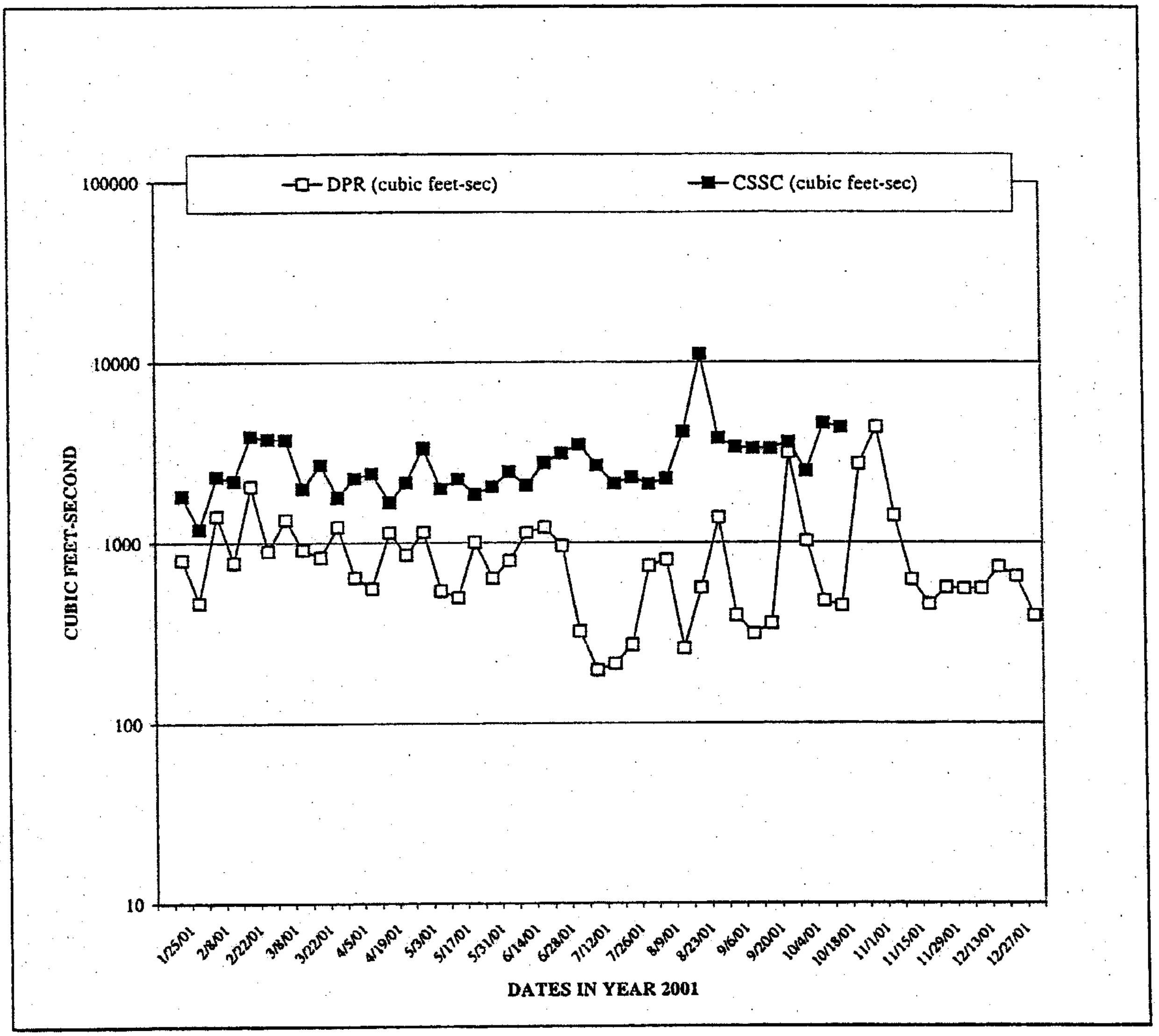
FIGURE 5

FLOW DATA FOR THE YEAR 2001



Source: http://waterdata.usgs.gov/nwis/measurements shown in Figure 6. The total annual precipitation was 28.5 inches in 2000 and 34.5 inches in 2001, (Table AI-1). The total precipitation was greater than 2.0 inches per month from April through September of 2000. In 2001, the total precipitation was greater than 2.0 inches per month from April through October. The total annual precipitation was greater in 2001 than 2000.

In 2001, there were five major rainstorm events, three in the month of August and two in October. The largest rainstorm on August 2, 2001, lasted more than 8 hours, and an overall average of 2.61 inches of rainfall was recorded (Table AI-5). There were no major rainstorm events in 2000.

Turbidity and Total Suspended Solids

Turbidity and TSS data at location 91 (DPR) and 92 (CSSC) for 2000 - 2001 are shown in Table 2. At location 91 (DPR), the turbidity ranged from 6-57 NTU and the arithmetic mean was 25 NTU. At location 92 (CSSC), the turbidity ranged from 5 to 35 NTU and the arithmetic mean was 11.5 NTU. It is clear that the means and maxima turbidity at location 92 (CSSC) were below the corresponding values obtained for the location 91 (DPR) samples.

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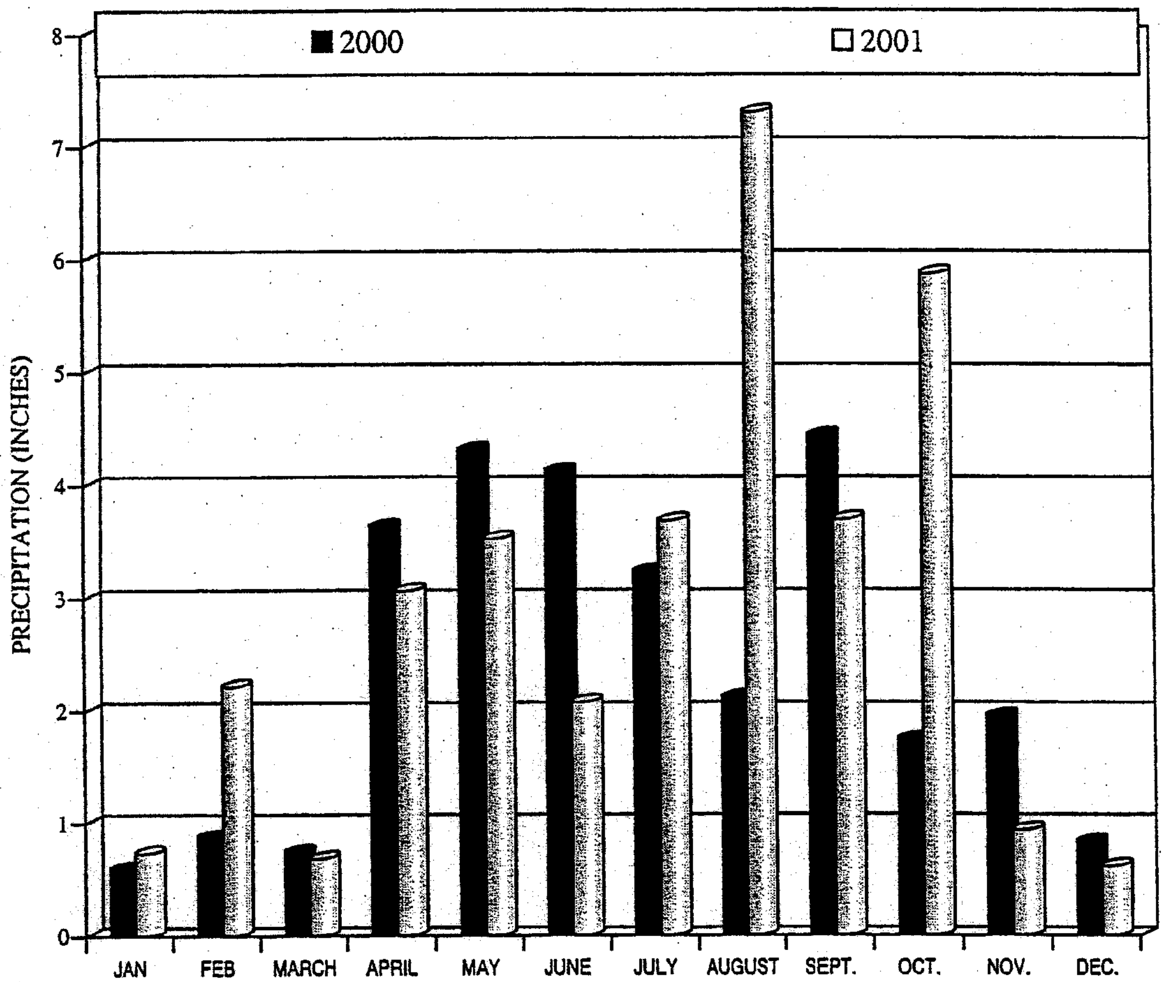
FIGURE 6

MONTHLY PRECIPITATION DATA FOR THE YEARS 2000 AND 2001



Source: MWRDGC Normal Operations Rainfall Data (rainfall readings in inches were taken at 12:00 midnight from Glenview, North Side WRP, North Branch Pumping Station, Wilmette, Stickney West Side Plant, Springfield Ave., Racine Ave., 100 E. Erie, E Melvina Ave., 87th and Western, Calumet WRP, 95th St. Pumping Station, and Lockport).

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TABLE 2

TOTAL SUSPENDED SOLIDS AND TURBIDITY DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Location/ Year	Turbidity (NTU)		Total Suspended Solids (mg/L)	
	Range	Average	Range	Average
91 (DPR)				
2000	6-51	25	4-76	39
2001	7-57	25	2-120	45
92 (CSSC)				
2000	6-35	12	3-59	16
2001	5-31	11	5-39	16

Turbidity is an indicator of the amount of sediment and related solid particulate matter transported by a river. Turbidity and river flow are related because flow can affect the suspension of soil constituents in a water column.

The TSS measurement represents suspended material in the water sample. Measured TSS values at location 91 (DPR) ranged from 2-120 mg/L and the arithmetic mean was 42 mg/L. Measured TSS values at location 92 (CSSC) ranged from 3-59 and the arithmetic mean was 16 mg/L. The mean TSS at location 91 (DPR) exceeded the mean TSS at location 92 (CSSC).

Temperature

Water temperature readings at two sampling locations, 91 (DPR) and 92 (CSSC) varied with seasonal months in 2000 and 2001 (Table AI-2). Water temperature readings during cold weather months (January through the third week of June; October through December of 2000 and 2001) at location 91 (DPR) and 92 (CSSC) ranged from 0.3-30°C, and the arithmetic mean was 13°C (Table 3). Water temperature readings during warm weather months (last week of June through September of 2000 and 2001) at location 91 (DPR) and 92 (CSSC) ranged from 17-36°C, and the arithmetic mean was 26°C.

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TABLE 3

WATER TEMPERATURES AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Location/Year/Month	Temperature (°C)	
	Range	Average
91 (DPR) and 92 (CSSC) 2000 - 2001		
(January - Third Week of June; October - December)	0.3 - 30	13
(Last Week of June - September)	17 - 36	26
91 (DPR)		
2000	0 - 32	15.5
2001	1 - 33	
92 (CSSC)		
2000	5 - 31	18.5
2001	4 - 36	

Water temperatures at location 91 (DPR) ranged from 0-33°C, and the arithmetic mean was 15.5°C. Water temperatures at location 92 (CSSC) ranged from 4-36°C, and the arithmetic mean was 18.5°C.

Geometric Mean FC Concentrations at Locations 91 (DPR) and 92 (CSSC)

Statistical summaries for FC bacteria together with GM densities in water samples collected at locations 91 (DPR) and 92 (CSSC) are given in Table 4.

In 2000, FC concentrations ranged from 10-15,000 CFU/100 mL at location 91 (DPR); the geometric mean was 295 CFU/100 mL. At location 92 (CSSC), FC concentrations ranged from 10-21,000 CFU/100 mL; the geometric mean was 256 CFU/100 mL.

In 2001, FC concentrations ranged from 20-10,000 CFU/100 mL at location 91 (DPR); the geometric mean was 351 CFU/100 mL. At location 92 (CSSC), FC concentrations ranged from 10-50,000 CFU/100 mL; the geometric mean was 271 CFU/100 mL.

Fifty percent of the FC concentration values at both locations, 91 (DPR) and 92 (CSSC), were greater than 200 CFU/100 mL in 2000. In 2001, fifty percent of the FC concentration values at location 91 (DPR) were greater than 200 CFU/100 mL, while at location 92 (CSSC) the fifty percentile value was

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TABLE 4

FC CONCENTRATIONS (CFU/100 mL) AT LOCATIONS
91 (DPR) AND 92 (CSSC)

YEAR/ LOCATION	GM FC[1]	MIN[2]	MAX[3]	PERCENTILE[4]				
				10	25	50	75	90
2000								
91 (DPR)	295	10	15,000	45	150	305	710	1450
92 (CSSC)	256	10	21,000	55	90	260	570	915
2001								
91 (DPR)	351	20	10,000	75	140	285	1000	2050
92 (CSSC)	271	10	50,000	40	95	190	715	1500

[1]Geometric mean FC concentrations in CFU/100 mL.
[2]Minimum FC concentrations in CFU/100 mL.
[3]Maximum FC concentrations in CFU/100 mL.
[4]Percentage of FC concentration data less than or equal to the value indicated.

190 CFU/100 mL. Some of the highest FC concentrations were found in water samples collected in 2001.

FC Bacteria Concentration in Comparison to GM Standard

The GM FC standard of the water designated for General Use requires that five samples be collected in a 30-day period. Figure 7 summarizes the 30-day period GM concentration of FC bacteria at locations 91 (DPR) and 92 (CSSC) for 2000 and 2001. For these two sites, there were twenty 30-day periods for which GMs were calculated. At location 91 (DPR), the GM FC concentration was greater than 200 CFU/100 mL for 14 of twenty 30-day periods, (70 percent). At location 92 (CSSC), the GM FC concentration was greater than 200 CFU/100 mL for 11 of twenty 30-day periods, (55 percent).

Thus, location 91 (DPR) had a larger percentage of GMs exceeding the General Use standard than location 92 (CSSC) even though location 91 (DPR) has a higher use classification than location 92 (CSSC).

FC Bacteria Concentration in Comparison to the General Use Never to Exceed Standard

The General Use never to exceed FC bacteria standard of no more than 10 percent of the samples during any 30-day period to exceed 400 CFU/100 mL applies to all grab samples

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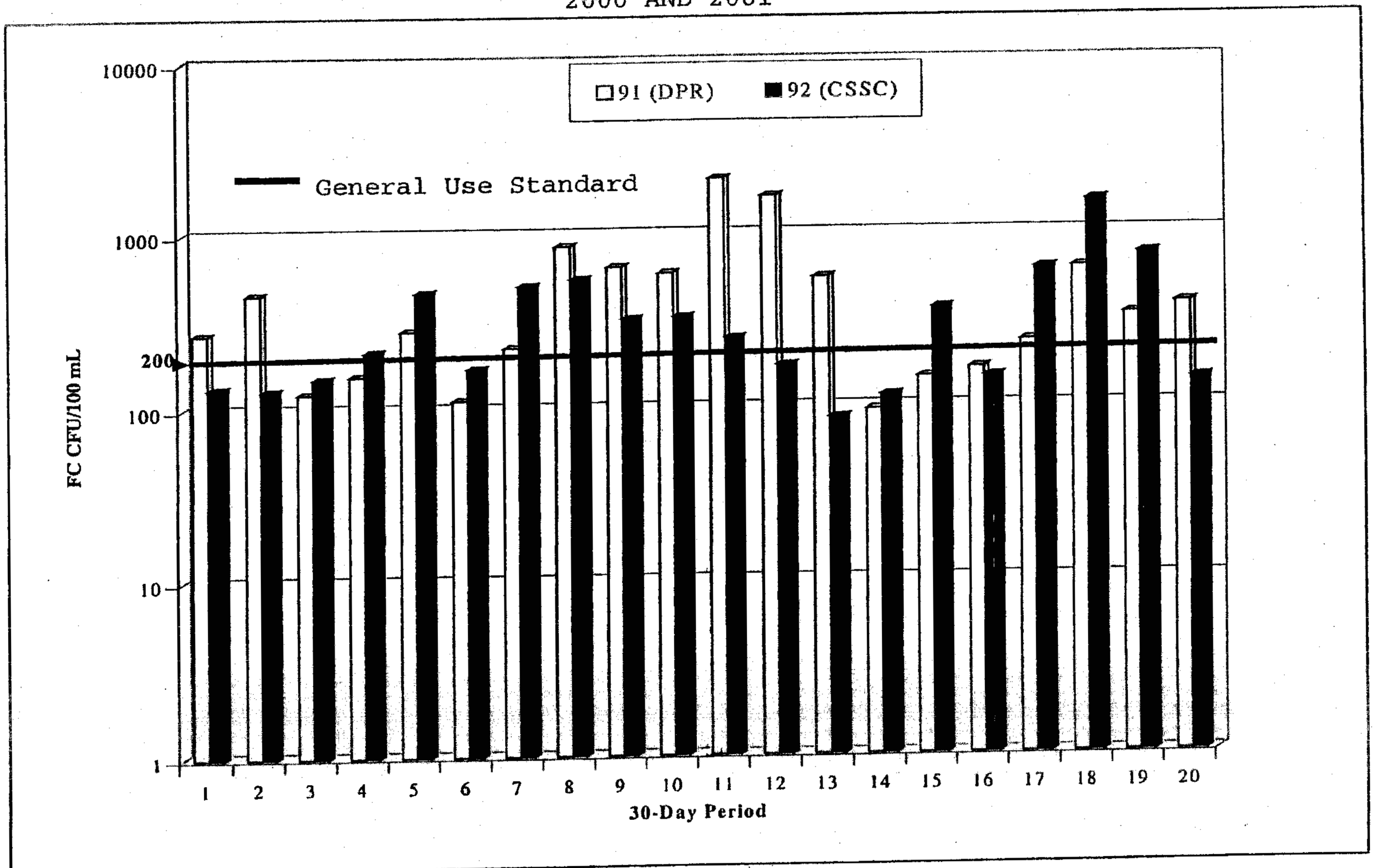
FIGURE 7

30-DAY PERIOD GM CONCENTRATIONS OF FC BACTERIA AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001



collected during the sampling period. According to this standard, out of twenty 30-day periods, nineteen periods (95 percent) exceed the single grab sample limit of 400 CFU/100 mL at location 91 (DPR). At location 92 (CSSC), seventeen sampling periods out of twenty (85 percent) exceed the 10 percent criteria FC concentrations of 400 CFU/100 mL.

This indicates that location 91 (DPR) has a higher percentage of FC concentrations that exceed the single-sample advisory limit of 400 CFU/100 mL than location 92 (CSSC).

Comparison of the FC Concentrations Between Locations 91 (DPR) and 92 (CSSC)

Results of ANOVA shown in Table 5 indicate that there is no significant difference in the GM FC concentrations between locations 91 (DPR) and 92 (CSSC) when the entire two-year data set is compared. However, when ANOVA was performed with flow as a covariate (ANCOVA analysis), which in effect standardizes the flow, the results indicate that the flow-specific FC concentrations at location 91 (DPR) are higher than those at location 92 (CSSC).

FC Concentrations During Wet and Dry Weather Conditions

The results of the comparison of the FC concentrations at two locations during wet and dry weather conditions, as

TABLE 5

COMPARISON OF THE FC CONCENTRATIONS BETWEEN LOCATIONS 91 (DPR) and 92 (CSSC)

Analysis	Covariate	Significance Probability of Equal Means (*ln* FC)	Conclusion
ANOVA	None	0.32	There is no significant difference in FC concentration between locations, 91 (DPR) & 92 (CSSC).
ANCOVA	River flow	0.0001	There is significant difference in FC concentration between locations, 91 (DPR) & 92 (CSSC) if the flows are standardized.

reflected by rainfall in the Chicago area, is summarized in Table 6.

Results of the K-S test for normality show that data came from normal populations at the 5 percent level of significance. Results of the F test show that variances of locations 91 (DPR) and 92 (CSSC) are equal in both wet and dry seasons. As log transformed FC came from normal populations, FC concentration follow log normal distribution.

At location 91 (DPR), under dry weather conditions, the GM FC concentration was 317 CFU/100 mL versus 337 CFU/100 mL during wet weather conditions. At location 92 (CSSC), under dry weather conditions, the GM FC concentration was 226 CFU/100 mL versus 424 CFU/100 mL during wet weather conditions.

The weather related results of ANOVA showed no significant difference in the FC concentrations between locations 91 (DPR) and 92 (CSSC). The results of ANOVA performed with flow as a covariate (ANCOVA) showed significant difference in the FC concentrations between locations 91 (DPR) and 92 (CSSC) during both dry and wet weather. The results of ANCOVA, which in effect standardized the flow at the two locations, indicated that the flow-specific FC concentrations at location

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TABLE 6

COMPARISON OF THE FC CONCENTRATIONS AT LOCATIONS 91 (DPR) AND 92 (CSSC) UNDER DRY AND WET WEATHER CONDITIONS

Location/ Condition	Obs[1]	GM FC[2]	Significance Probability of Normality[3] (*ln* FC)	Results of the F Test (*ln* FC)	Significance Probability of Equal Means[4] (*ln* FC)
91 (DPR)					
DRY	75	317	0.880[a]	0.132[b]	0.245[c]
WET	25	337	0.124[a]		
92 (CSSC)					
DRY	77	226	0.072[a]	0.066[b]	0.245[d]
WET	25	424	0.082[a]		

[1]Number of observations.
[2]Geometric Mean FC concentrations in CFU/100 mL.
[3]Results of K-S Test.
[4]Results of ANOVA.
[a]Data are from a normal population.
[b]Variances are equal.
[c]There is no significant difference in FC concentrations at location 91 (DPR) during dry and wet weather conditions.
[d]There is no significant difference in FC concentrations at location 92 (CSSC) during dry and wet weather conditions.

91 (DPR) are significantly higher than the flow-specific FC concentrations at location 92 (CSSC) during both dry and wet weather conditions. These results are shown in Table 7.

It is difficult to interpret the true significance of the wet weather/dry weather comparisons, as the effects of rainfall in the Chicago area on microbial water quality downstream can be confounded by the operation of the TARP system as well as variable time of travel as water flows downstream.

FC Concentrations During Seasonal Disinfection and No Disinfection Periods

The basic statistical results on the comparisons of FC concentrations during two periods, P1 (disinfection) and P2 (no disinfection) within locations 91 (DPR) and 92 (CSSC) are summarized in Table 8.

The results of ANOVA show that there is a significant statistical difference ($p = 0.009$) in GM FC concentration at location 91 (DPR) during the two periods tested, disinfection months (P1) and no disinfection months (P2). The calculated GM FC concentration at location 91 (DPR) during P2 (no disinfection months) was 467 CFU/100 mL which was higher compared to 228 CFU/100 mL during P1 (disinfection months).

TABLE 7

COMPARISON OF THE FC CONCENTRATIONS BETWEEN LOCATIONS 91 (DPR) AND 92 (CSSC) DURING DRY AND WET WEATHER CONDITIONS

Analysis/ Covariate	Weather Condition	Significance Probability of Equal Means (*ln* FC)	Conclusion
ANOVA/ None	Dry	0.1169	There is no significant difference in FC concentration between locations 91 (DPR) and 92 (CSSC).
	Wet	0.6140	There is no significant difference in FC concentration between locations 91 (DPR) and 92 (CSSC).
ANCOVA/ Flow	Dry	0.0001	Flow-specific FC concentrations are higher at location 91 (DPR) than at 92 (CSSC) in dry weather.
	Wet	0.0031	Flow-specific FC concentrations are higher at location 91 (DPR) than at 92 (CSSC) in wet weather.

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TABLE 8

COMPARISON OF THE FC CONCENTRATIONS OF THE DISINFECTION (P1) AND NO DISINFECTION (P2) PERIOD AT LOCATIONS 91 (DPR) AND 92 (CSSC)

Analysis/ Location	P[1]	Obs[2]	GM FC[3]	Significance Probability of Normality[4] (*ln* FC)	Results of the F Test (*ln* FC)	Significance Probability of Equal Means[5] (*ln* FC)
ANOVA						
91 (DPR)	P1	52	228	0.1853[a]	0.2956[b]	0.0094[c]
	P2	48	467	0.7652[a]		
92 (CSSC)	P1	52	381	0.1744[a]	0.0772[b]	0.0078[d]
	P2	50	179	0.0956[a]		

[1]Period, P1: May - October; P2: November - April.
[2]Number of Observations.
[3]Geometric Mean FC concentrations in CFU/100 mL.
[4]Results of K-S Test.
[5]Results of ANOVA.
[a]Data are from a normal population.
[b]Variances are equal.
[c]There is a significant difference between the GMs FC at location 91 in the disinfection and no disinfection period.
[d]There is a significant difference between the GMs FC at location 92 in the disinfection and no disinfection period.

As mentioned earlier, the CSSC receives undisinfected effluent throughout periods P1 and P2. However, results observed at location 92 (CSSC) during the two periods were interesting. The calculated GM FC concentrations during P1 (May - October) was 381 CFU/100 mL, which is significantly higher than the FC mean concentration of 179 CFU/100 mL during P2 (November - April) ($p = 0.008$).

The ANOVA was also performed to compare the concentration of FC bacteria between the two locations during the two periods tested. The results are shown in Table 9. The GM FC density in P1 was 228 CFU/100 mL at location 91 (DPR) and 381 CFU/100 mL at location 92 (CSSC). There is no significant difference in these values during the disinfection months at the two locations. However, there is a significant difference in the GM FC concentrations between the two locations in P2 (no disinfection months). The GM FC concentration at location 91 (DPR) is significantly higher (467 CFU/100 mL) than the GM FC concentrations (179 CFU/100 mL) at location 92 (CSSC) during no disinfection months ($p = 0.0001$).

These results are consistent with the earlier comparison of the 30-day period GM data. The results in Table 10 show six out of ten 30-day periods (60 percent) during P1 and eight

TABLE 9

COMPARISON OF THE FC CONCENTRATIONS OF THE DISINFECTION (P1) AND NO DISINFECTION (P2) PERIOD BETWEEN LOCATIONS 91 (DPR) AND 92 (CSSC)

Analysis/ Period[1]	Location	Obs[2]	GM FC[3]	Significance Probability Normality[4] (*ln* FC)	Results of the F Test *ln* FC)	Significance Probability of Equal Means[5] (*ln* FC)
ANOVA						
P1	91	52	228	0.1853[a]		
	92	52	381	0.1744[a]	0.3211[b]	0.094[c]
P2						
	91	48	467	0.7652[a]	0.3378[b]	0.0001[d]
	92	50	179	0.0956[a]		

[1]P1: May - October; P2: November - April.
[2]Number of Observations.
[3]Geometric Mean concentrations of FC bacteria in CFU/100 mL.
[4]Results of K-S Test.
[5]Results of ANOVA.
[a]Data came from normal population.
[b]Variances are equal.
[c]There is no significant difference between the GMs FC at locations 91 (DPR) and 92 (CSSC) in the disinfection period.
[d]There is a significant difference between GMs FC at locations 91 (DPR) and 92 (CSSC) in the no disinfection period.

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TABLE 10

30-DAY PERIOD GM CONCENTRATION OF FC BACTERIA AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Periods/Five Samples 30-day Period Dates	FC(CFU/100 mL)[1] at Location 91	FC (CFU/100 mL)[1] at Location 92
P1 (May - October)		
5/4/00 through 6/1/00	153.493	210.875[a]
6/8/00 through 7/6/00	278.092[a]	462.068[a]
7/13/00 through 8/10/00	111.439	168.203
8/17/00 through 9/14/00	221.867[a]	501.261[a]
9/21/00 through 10/19/00	845.044[a]	547.999[a]
5/24/01 through 6/21/01	145.917	365.826[a]
6/28/01 through 7/26/01	163.806	146.724
8/2/01 through 8/30/01	235.202[a]	614.302[a]
9/6/01 through 10/4/01	621.857[a]	1524.439[a]
10/11/01 through 11/8/01	331.766[a]	744.414[a]
P2 (November - April)		
1/20/00 through 2/17/00	268.674[a]	132.279
2/24/00 through 3/23/00	455.070[a]	127.935
3/30/00 through 4/27/00	122.545	148.929
10/26/00 through 11/21/00	638.286[a]	322.377[a]
11/30/00 through 12/28/00	587.764[a]	329.771[a]
1/4/01 through 2/1/01[2]	2084.328[a]	249.295[a]
2/8/01 through 3/8/01	1635.450[a]	172.689
3/15/01 through 4/12/01	552.125[a]	86.588
4/19/01 through 5/17/01	95.513	115.542
11/15/01 through 12/13/01	382.338[a]	140.213

[1]GM calculated from five samples during 30-day period from locations 91 and 92.
[2]GM calculated from three samples during 30-day period from location 91 and five samples from location 92.
[a]Value exceeds the General Use FC standard.

out of ten 30-day periods during P2 (80 percent) exceed the General Use standard for FC bacteria (≤200 CFU/100 mL) at location 91 (DPR). At location 92 (CSSC), the percentage of General Use standard FC exceedances is higher during P1 (80 percent) and lower during P2 (30 percent). The results described above suggest that effluent disinfection is reducing the FC burden at location 91 (DPR). However, the effect of weather and the difference in the physical structure of the DPR must also be considered. The DPR is wide and shallow. The man-made CSSC is about 15-feet deep and is protected by concrete or sheet pile vertical embankments. The fate and survival of FC bacteria in the DPR at location 91 may be more influenced by environmental factors when compared to the deeper CSSC. For example, the disinfection months (May through October) are usually warmer with increased frequency of rainfall than the no disinfection months (November through April). Rainfalls greater than 2 inches (Figure 6) and the water temperatures greater than 15°C (Table AI-2) were observed during disinfection months (May through October).

A USGS report by Terrio (1994) concluded that discontinuing chlorination increased FC concentrations downstream of the Stickney WRP outfall. The results from the present study, however, reveal that by the time any FC contained in the Stickney WRP effluent reach location 92 (CSSC), even without chlorination, the resulting FC concentration at that point is similar to the FC concentration at location 91 (DPR), a General Use water. This observation is supported by the work of Hass et al. (1988) and Sedita et al. (1987) who concluded that resumption of chlorination at the District's Stickney and Calumet WRPs would not result in a statistically significant reduction in the concentrations of FC downstream of Lockport.

Derivation of Models to Predict FC Concentration at Locations 91 (DPR) and 92 (CSSC)

Locations 91 (DPR) and 92 (CSSC) represent two separate waterways and the water quality of these are affected by many variables such as rainfall, temperature, turbidity, TSS, and river flow. The possibility of all these variables affecting the FC concentration were considered in the development of models to predict FC concentrations. The TSS, temperature, and turbidity correlated with the *ln* flow at both locations 91 (DPR) and 92 (CSSC). However, flow was the only parameter that was found to contribute significantly to the models. Figures 8 and 9, suggest that FC concentrations were correlated with flow during the study period.

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FIGURE 8

RELATIVE CONCENTRATION OF THE FC BACTERIA AND RIVER FLOW IN 2000

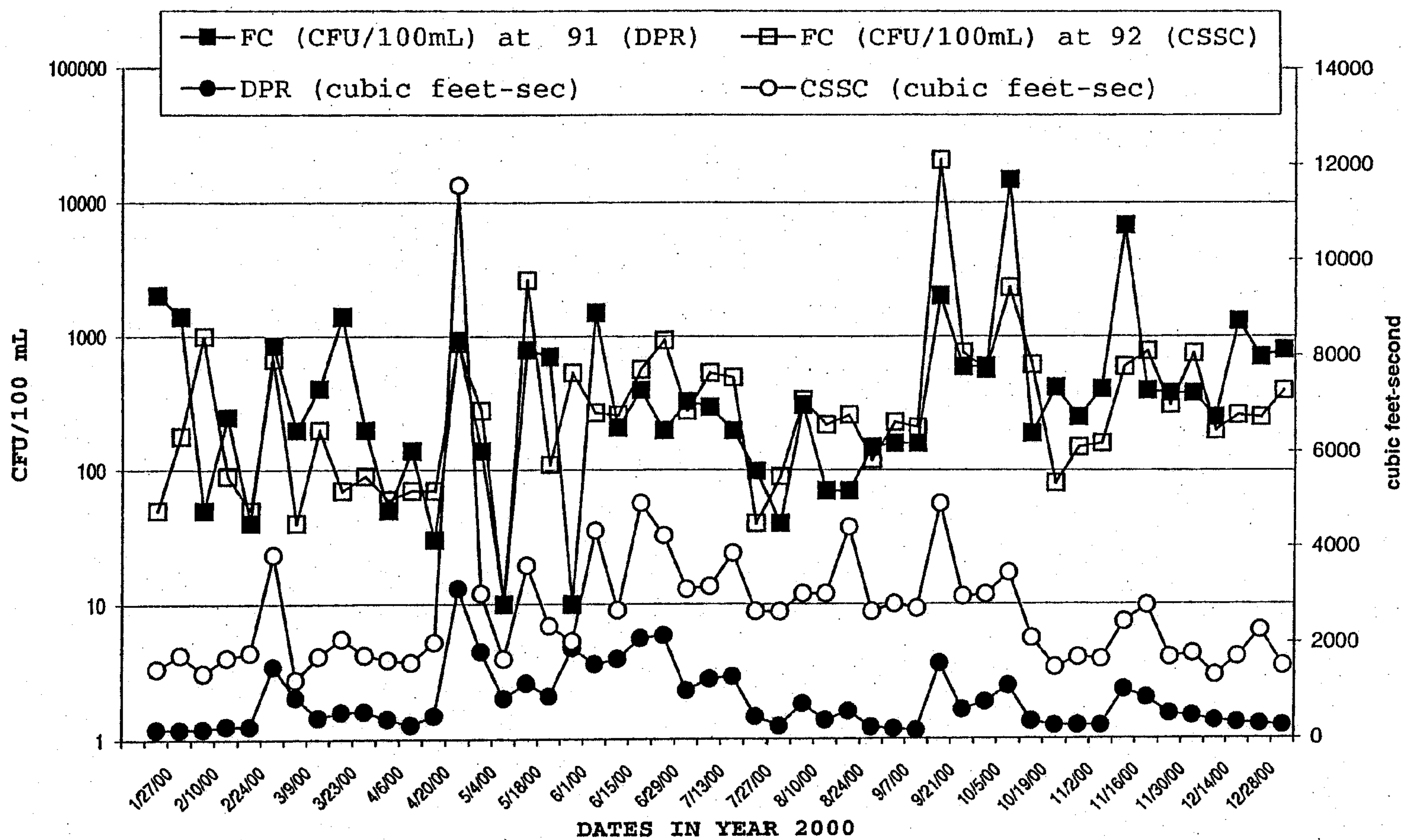

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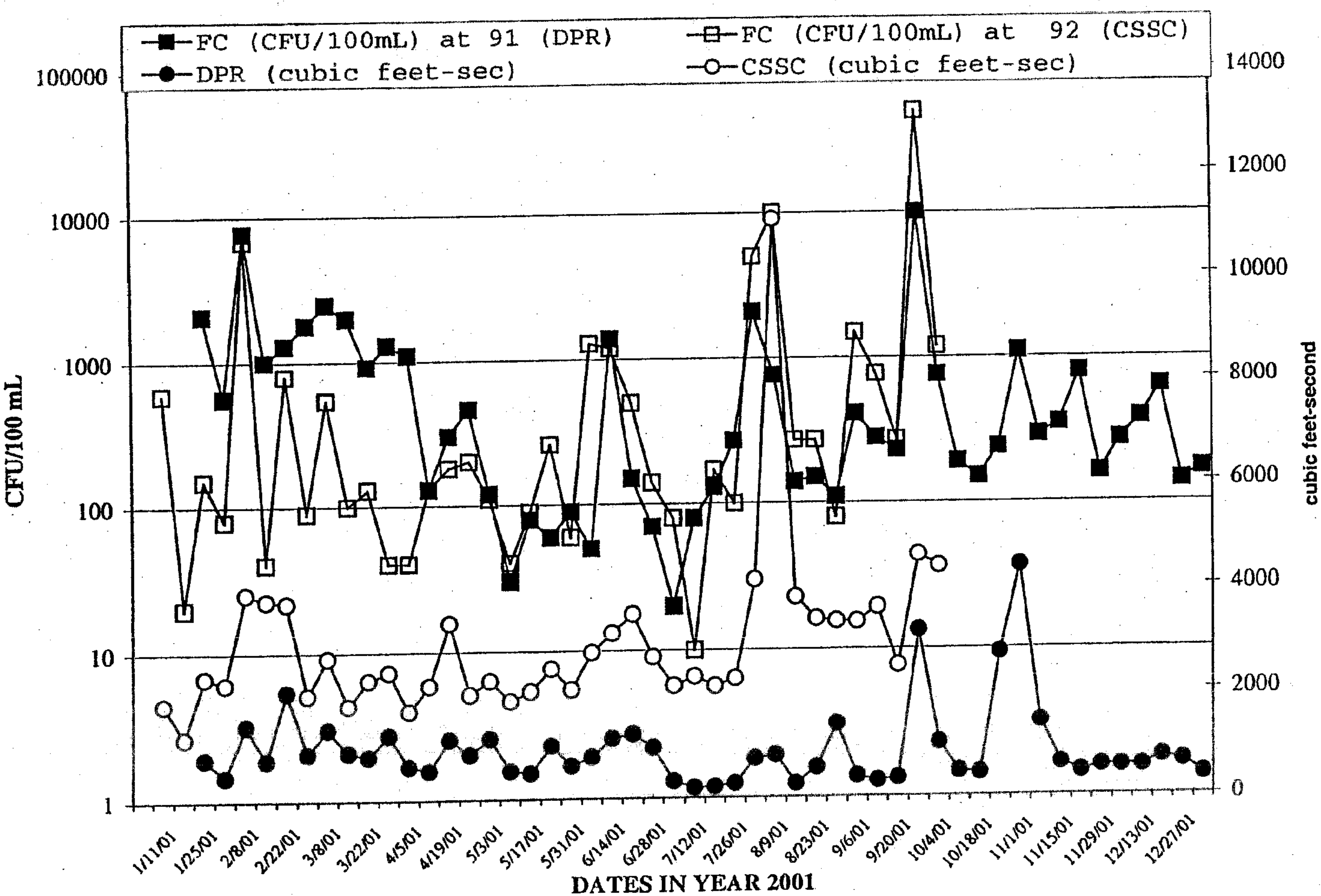
FIGURE 9

RELATIVE CONCENTRATION OF THE FC BACTERIA AND RIVER FLOW IN 2001



Forecast values of FC concentrations by the time series model and auto regression model at two locations 91 (DPR) and 92 (CSSC) are shown in Tables AII-1 and AII-2. At location 91 (DPR), the AIC value of the regression model is 343.7 and that of auto regressive model is 323.3. This implies that auto regressive model is slightly better than regression model. At location 92 (CSSC), the AIC value of regression model is 306.6 and that of auto regressive model is 308.8. This implies that regression model is slightly better than auto regressive model.

When the two models were tested to predict FC concentration at each location, the results revealed that forecast values are almost identical at each point. Therefore, for the purpose of simplicity, the regression model was selected as the best candidate model and the equation is summarized below:

Location 91 (DPR): $ln(FC) = 0.88647*ln(Flow), R^2 = 0.95$ (1)

Location 92 (CSSC): $ln(FC) = 0.71086*ln(Flow), R^2 = 0.95$ (2)

Where FC is the concentration of FC bacteria in CFU/100 mL, flow is the average river flow measured in cubic feet per second.

The intercept and slope were calculated by the least square method. The high R^2 value of 0.95 at each location indicates that each regression equation is very good in the sense that the regression model can explain 95 percent of the variability of FC concentration. The plotted graph of the predictive models at locations 91 (DPR) and 92 (CSSC) is shown in Figure 10.

Results of the t-test indicated that the slope of the regression equation for location 91 (DPR) was significantly higher than the slope at the regression equation for location 92 (CSSC) ($p = <0.05$). It is clear from Figure 10 that the probability of higher FC concentrations at location 91 (DPR) is predicted with an increase in river flow rate when compared to location 92 (CSSC).

Evaluation of Bacteriological Standard for Recreational Uses of LDPR

The USEPA published ambient water quality criteria for bacteria in 1986 (EPA 440/5-84-002, January 1986). The federal bacteriological criteria for freshwater specify the use of fecal indicator bacteria suggested by Cabelli (1983) and Dufour (1984). These bacteriological criteria are based on the assumption that the class of fecal bacteria including FC, *E.coli*, and enterococci are found only in feces or sewage, and that when these fecal indicator bacteria are found in environmental waters (streams, lakes, rivers) designated

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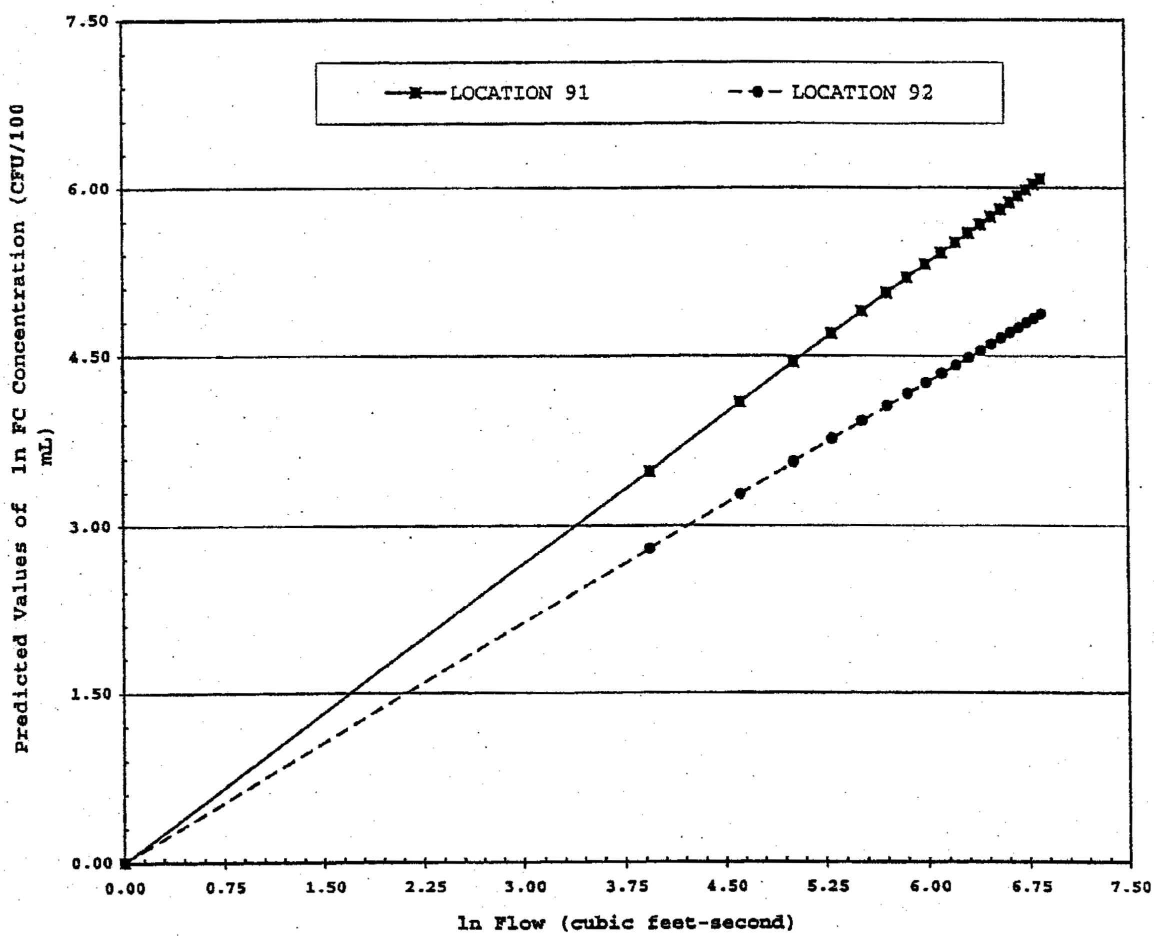
FIGURE 10

PREDICTION OF FECAL COLIFORM CONCENTRATIONS AT LOCATIONS
91 (DPR) AND 92 (CSSC)



for recreational use (swimming, wading), that water is considered contaminated with feces and represents a health risk to humans (USEPA, 1986).

The results of this study clearly indicate that the FC concentrations at the DPR upstream of Lockport (location 91) are often above the Illinois General Use water quality standard of 200 CFU/100 mL. Moreover, higher concentrations of FC bacteria were recorded at location 91 (DPR) than at location 92 (CSSC), an effluent dominated stream classified as Secondary Contact water. The GM concentrations of the FC bacteria observed in this study are consistent with USGS report data of FC densities in the DPR at Riverside and at the CSSC at Romeoville (Terrio, 1995). The USGS report indicates that the percentage of samples exceeding the Illinois General Use FC standard was substantially less in the CSSC than in the DPR basin. These measurements were made before TARP was built. After the construction of the TARP the number of CSOs discharged into the CSSC and into the DPR system has been significantly reduced. The IEPA consultant's draft report on the LDPR UAA study has acknowledged the beneficial impact of the TARP project on reduction of FC densities in the LDPR (Hey and Associates, Inc., Draft Report, April 2002).

The results presented here indicate that by using the FC bacteria criteria, the water of the DPR upstream of Lockport designated for recreational use does not meet the General Use bacteriological standards, but at the same time it cannot be concluded or assumed that point sources are solely responsible for the FC burden in the LDPR. It should be noted that the mere presence of high levels of FC in river or streams is not always an indicative of contamination by point source of pollution (Solo-Gabriele et al. 2000; Roll and Fujioka, 1997). Toronzos (1997) indicated that the FC bacteria are found in ambient waters in the absence of point source pollution and survive longer period when high levels of nutrients are available.

FC bacteria in any river system can originate from any of the following possible sources (USEPA, 2001):

1. Treated wastewater discharge from WRPs.
2. Combined Sewer Overflows (CSO).
3. Wastewater discharge from
    a. slaughterhouses
    b. meat processing facilities
    c. poultry processing facilities
    d. animal feedlots.
4. Leaking sewer lines.
5. Storm drains.

6. Failing septic systems.

7. Marinas and pump out facilities.

8. Illicit sewage connections.

9. Urban run-off.

10. Domestic pets fecal droppings.

11. Birds fecal droppings.

12. Wildlife.

13. Land application of manure.

14. Land application of biosolids.

15. Landfills.

Of these listed possible sources of pollution, most significantly, many researchers have reported hundreds or thousands of birds roosting on the surface water, which would have an adverse effect on the microbiological quality of the freshwaters (McLellan, 2001; Alderisio, K.A. and N. DeLuca, 1999; Benoit et al. 1993; Standridge et al. 1979). The recently issued, "State of the Waters 2002 Region 5" provide information about the causes of water body impairments for rivers and streams. This report designates nonpoint source pollution the leading cause of impairments to Illinois waters (USEPA, 2002).

The microbial water quality based on FC densities at location 92 (CSSC) which is classified as Secondary Contact is comparable to location 91 (DPR) which is classified as General

Use. It is appropriate to say that the primary sources of FC bacteria in the LDPR system (below the confluence of DPR and CSSC) are treated effluent from District WRPs, treated effluent from other sewage treatment plants, CSOs, and various environmental/nonpoint sources (storm drains, bird and animal feces, and soil run-off). There are currently no monitoring or analytical methods available that can distinguish between FC indicator bacteria originating from point sources from those originating from nonpoint sources. The identification and characterization of these nonpoint source(s) of the fecal pollution can provide a better understanding of the LDPR water resources and suggest ways to improve water quality. Effort should also be focused on exploring the microbial quality of treated effluents from other municipal sewage treatment plants that discharge directly into the LDPR.

The LDPR UAA study by IEPA is still in progress. The extent to which all sources of FC are affecting the water quality needs to be considered when determining the recreational use classification of the LDPR.

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APPENDIX AI

WATER QUALITY DATA FOR 2000 - 2001

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1

FECAL COLIFORM, RIVER FLOW, AND RAINFALL DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location Code	FC (CFU/100 mL)	Flow (cubic feet-sec)	Rainfall (inches)
10/20/00	91	2000	213	0.00
01/27/00	91	1400	207	0.00
02/03/00	91	50	222	0.00
02/10/00	91	250	279	0.00
02/17/00	91	40	272	0.00
02/24/00	91	850	1520	1.25
03/02/00	91	200	875	0.00
03/09/00	91	410	450	0.01
03/16/00	91	1400	566	0.59
03/23/00	91	200	575	0.00
03/30/00	91	50	419	0.00
04/06/00	91	140	294	0.55
04/13/00	91	30	490	0.00
04/20/00	91	940	3120	0.32
04/27/00	91	140	1830	0.00
05/04/00	91	10	855	0.00
05/11/00	91	800	1170	0.26
05/18/00	91	710	895	0.00
05/25/00	91	10	1890	0.12
06/01/00	91	1500	1560	0.00
06/08/00	91	210	1670	0.00
06/15/00	91	400	2100	0.00
06/22/00	91	200	2160	0.00
06/29/00	91	330	1020	0.00
07/06/00	91	300	1260	0.00
07/13/00	91	200	1310	0.00
07/20/00	91	99	473	0.00
07/27/00	91	40	273	0.00
08/03/00	91	310	738	0.00
08/10/00	91	70	389	0.00
08/17/00	91	70	574	0.00
08/24/00	91	150	242	0.33
08/31/00	91	160	206	0.44
09/07/00	91	160	178	0.66
09/14/00	91	2000	1570	0.01
09/21/00	91	600	610	0.00
09/28/00	91	600	771	0.00
10/05/00	91	15000	1110	0.57
10/12/00	91	190	359	1.34
10/19/00	91	420	270	0.00

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

FECAL COLIFORM, RIVER FLOW, AND RAINFALL DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location Code	FC (CFU/100 mL)	Flow (cubic feet-sec)	Rainfall (inches)
10/26/00	91	250	278	0.00
11/02/00	91	410	275	0.02
11/08/00	91	6800	1030	0.00
11/16/00	91	400	860	0.00
11/21/00	91	380	524	0.00
11/30/00	91	380	477	ND
12/07/00	91	250	370	ND
12/14/00	91	1300	330	ND
12/21/00	91	710	300	ND
12/28/00	91	800	270	0.00
01/18/01	91	2100	802	0.01
01/25/01	91	560	462	0.00
02/01/01	91	7700	1420	0.00
02/08/01	91	1000	773	0.88
02/15/01	91	1300	2060	0.00
02/22/01	91	1800	897	0.02
03/01/01	91	2500	1350	0.00
03/08/01	91	2000	910	0.00
03/15/01	91	920	826	0.21
03/22/01	91	1300	1230	0.00
03/29/01	91	1100	640	0.02
04/05/01	91	130	555	0.28
04/12/01	91	300	1140	0.00
04/19/01	91	460	854	0.00
04/26/01	91	120	1150	0.00
05/03/01	91	30	539	0.00
05/10/01	91	80	494	0.01
05/17/01	91	60	1010	0.02
05/24/01	91	90	634	0.41
05/31/01	91	50	794	0.35
06/07/01	91	1400	1140	0.00
06/14/01	91	150	1220	0.08
06/21/01	91	70	962	0.44
06/28/01	91	20	320	0.00
07/05/01	91	80	196	0.00
07/12/01	91	130	212	0.00
07/19/01	91	270	270	0.00
07/26/01	91	2100	742	0.00
08/02/01	91	760	802	1.80
08/09/01	91	140	257	0.24
08/16/01	91	150	559	0.00
08/23/01	91	110	1380	0.00

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

FECAL COLIFORM, RIVER FLOW, AND RAINFALL DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location Code	FC (CFU/100 mL)	Flow (cubic feet-sec)	Rainfall (inches)
08/30/01	91	410	392	0.14
09/06/01	91	280	311	0.21
09/13/01	91	230	354	0.00
09/20/01	91	10000	3160	0.13
09/27/01	91	760	1020	0.00
10/04/01	91	190	473	1.03
10/11/01	91	150	443	0.05
10/18/01	91	240	2730	0.00
10/25/01	91	1100	4380	0.00
11/01/01	91	290	1410	0.00
11/08/01	91	350	620	0.00
11/15/01	91	790	452	0.10
11/20/01	91	160	558	0.19
11/29/01	91	270	550	ND
12/06/01	91	380	551	ND
12/13/01	91	630	728	ND
12/20/01	91	140	646	ND
12/27/01	91	170	390	0.00
01/20/00	92	50	1477	0.00
01/27/00	92	180	1757	0.00
02/03/00	92	1000	1385	0.00
02/10/00	92	90	1702	0.00
02/17/00	92	50	1802	0.00
02/24/00	92	680	3823	1.25
03/02/00	92	40	1239	0.00
03/09/00	92	200	1727	0.01
03/16/00	92	70	2083	0.59
03/23/00	92	90	1749	0.00
03/30/00	92	60	1647	0.00
04/06/00	92	70	1597	0.55
04/13/00	92	70	2019	0.00
04/20/00	92	890	11563	0.32
04/27/00	92	280	3027	0.00
05/04/00	92	10	1671	0.00
05/11/00	92	2600	3599	0.26
05/18/00	92	110	2353	0.00
05/25/00	92	540	2040	0.12
06/01/00	92	270	4331	0.00
06/08/00	92	260	2683	0.00
06/15/00	92	570	4909	0.00
06/22/00	92	940	4230	0.00

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

FECAL COLIFORM, RIVER FLOW, AND RAINFALL DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location Code	FC (CFU/100 mL)	Flow (cubic feet-sec)	Rainfall (inches)
06/29/00	92	280	3116	0.00
07/06/00	92	540	3172	0.00
07/13/00	92	500	3863	0.00
07/20/00	92	40	2611	0.00
07/27/00	92	90	2649	0.00
08/03/00	92	340	3017	0.00
08/10/00	92	220	3019	0.00
08/17/00	92	260	4407	0.00
08/24/00	92	120	2652	0.33
08/31/00	92	230	2806	0.44
09/07/00	92	210	2714	0.66
09/14/00	92	21000	4908	0.01
09/21/00	92	760	2963	0.00
09/28/00	92	570	3000	0.00
10/05/00	92	2300	3450	0.57
10/12/00	92	620	2100	1.34
10/19/00	92	80	1492	0.00
10/26/00	92	150	1705	0.00
11/02/00	92	160	1663	0.02
11/08/00	92	600	2437	0.00
11/16/00	92	780	2776	0.00
11/21/00	92	310	1704	0.00
11/30/00	92	750	1776	ND
12/07/00	92	200	1330	ND
12/14/00	92	260	1716	ND
12/21/00	92	250	2259	ND
12/28/00	92	400	1516	0.00
01/04/01	92	590	1829	0.00
01/11/01	92	20	1192	0.00
01/18/01	92	150	2330	0.01
01/25/01	92	80	2209	0.00
02/01/01	92	6800	3920	0.00
02/08/01	92	40	3793	0.88
02/15/01	92	790	3747	0.00
02/22/01	92	90	1997	0.02
03/01/01	92	540	2703	0.00
03/08/01	92	100	1794	0.00
03/15/01	92	130	2270	0.21
03/22/01	92	40	2426	0.00
03/29/01	92	40	1685	0.02
04/05/01	92	130	2160	0.28

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-1 (Continued)

FECAL COLIFORM, RIVER FLOW, AND RAINFALL DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location Code	FC (CFU/100 mL)	Flow (cubic feet-sec)	Rainfall (inches)
04/12/01	92	180	3356	0.00
04/19/01	92	200	1992	0.00
04/26/01	92	110	2250	0.00
05/03/01	92	40	1862	0.00
05/10/01	92	90	2041	0.01
05/17/01	92	260	2472	0.02
05/24/01	92	60	2076	0.41
05/31/01	92	1300	2774	0.35
06/07/01	92	1200	3145	0.00
06/14/01	92	500	3500	0.08
06/21/01	92	140	2684	0.44
06/28/01	92	80	2132	0.00
07/05/01	92	10	2301	0.00
07/12/01	92	170	2122	0.00
07/19/01	92	100	2260	0.00
07/26/01	92	5000	4130	0.00
08/02/01	92	10000	11087	1.80
08/09/01	92	270	3794	0.24
08/16/01	92	270	3386	0.00
08/23/01	92	80	3343	0.00
08/30/01	92	1500	3330	0.14
09/06/01	92	770	3602	0.21
09/13/01	92	270	2484	0.00
09/20/01	92	50000	4596	0.13
09/27/01	92	1200	4369	0.00
10/04/01	92	660	ND	1.03
10/11/01	92	980	ND	0.05
10/18/01	92	2100	ND	0.00
10/25/01	92	990	ND	0.00
11/01/01	92	660	ND	0.00
11/08/01	92	170	ND	0.00
11/15/01	92	230	ND	0.10
11/20/01	92	90	ND	0.19
11/29/01	92	140	ND	ND
12/06/01	92	110	ND	ND
12/13/01	92	170	ND	ND
12/20/01	92	230	ND	ND
12/27/01	92	220	ND	0.00

ND = No Data

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2

WATER QUALITY DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location	Total Suspended Solids (mg/L)	Temperature (^{0}C)	Turbidity (NTU)
01/20/00	91	28	9.8	14
01/27/00	91	14	9.8	8
02/03/00	91	7	3.2	7
02/10/00	91	10	2.5	9
02/17/00	91	17	2.3	8
02/24/00	91	35	10	15
03/02/00	91	35	8.1	19
03/09/00	91	38	11.6	25
03/16/00	91	29	7.5	18
03/23/00	91	43	12.2	29
03/30/00	91	47	11.2	20
04/06/00	91	60	11.7	35
04/13/00	91	44	9.9	28
04/20/00	91	76	12.9	51
04/27/00	91	41	17.3	30
05/04/00	91	58	21.4	32
05/11/00	91	30	17.6	35
05/18/00	91	58	18.6	33
05/25/00	91	59	19.9	40
06/01/00	91	69	19	42
06/08/00	91	41	ND	28
06/15/00	91	48	20.5	28
06/22/00	91	31	23.7	22
06/29/00	91	47	22.3	27
07/06/00	91	42	24.7	27
07/13/00	91	41	31.9	22
07/20/00	91	60	22	34
07/27/00	91	51	26.5	34
08/03/00	91	59	22.5	30
08/10/00	91	55	26.8	35
08/17/00	91	50	23.4	32
08/24/00	91	54	27.3	34
08/31/00	91	54	28.4	32
09/07/00	91	42	24.7	27
09/14/00	91	53	20	32

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

WATER QUALITY DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location	Total Suspended Solids (mg/L)	Temperature (^{0}C)	Turbidity (NTU)
09/21/00	91	47	17.2	30
09/28/00	91	47	17.4	30
10/05/00	91	60	16.1	38
10/12/00	91	26	12.3	19
10/19/00	91	28	16.1	21
10/26/00	91	30	18.2	20
11/02/00	91	25	15.7	19
11/08/00	91	54	11.5	33
11/16/00	91	15	5.6	14
11/21/00	91	11	0.8	10
11/30/00	91	24	5.5	14
12/07/00	91	21	0.3	13
12/14/00	91	11	0.5	9
12/21/00	91	4	ND	8
12/28/00	91	6	7.8	6
01/18/01	91	19	1.9	13
01/25/01	91	2	0.7	8
02/01/01	91	50	3	21
02/08/01	91	12	4.3	9
02/15/01	91	19	8.2	18
02/22/01	91	17	7	14
03/01/01	91	25	2	22
03/08/01	91	12	2.6	12
03/15/01	91	16	6.6	12
03/22/01	91	34	11.1	17
03/29/01	91	11	7	7
04/05/01	91	17	15	10
04/12/01	91	49	13	27
04/19/01	91	39	10.1	21
04/26/01	91	59	15.3	17
05/03/01	91	58	20.2	26.6
05/10/01	91	85	21	36.9
05/17/01	91	80	22.2	31.4
05/24/01	91	62	17.8	27.8

TABLE AI-2 (Continued)

WATER QUALITY DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location	Total Suspended Solids (mg/L)	Temperature (^{0}C)	Turbidity (NTU)
05/31/01	91	59	15.6	30.2
06/07/01	91	50	19	29.4
06/14/01	91	44	28.8	20.5
06/21/01	91	24	25.2	24.9
06/28/01	91	82	28.2	30.8
07/05/01	91	56	25.4	28.6
07/12/01	91	109	26.1	55.7
07/19/01	91	120	30.1	56.5
07/26/01	91	84	29.1	35.6
08/02/01	91	66	28	33.7
08/09/01	91	63	33.4	41.7
08/16/01	91	63	23.7	38.8
08/23/01	91	71	28.8	40.6
08/30/01	91	60	28.2	31.1
09/04/01	91	70	29.6	38.4
09/06/01	91	58	24.8	35.4
09/13/01	91	65	23.1	35.8
09/20/01	91	111	19.6	53.1
09/27/01	91	40	17	23.4
10/04/01	91	47	21.8	29
10/11/01	91	44	15.4	26.3
10/18/01	91	19	14.1	15.3
10/25/01	91	48	11.2	20.2
11/01/01	91	33	11.8	23.8
11/05/01	91	30	12.6	18.1
11/08/01	91	37	11	23.5
11/15/01	91	28	20.7	17.4
11/20/01	91	26	9.2	18.3
11/29/01	91	13	8.7	10.2
12/06/01	91	26	10.9	16.4
12/13/01	91	9	8.8	08.5
12/20/01	91	11	10.6	10.6
12/27/01	91	12	1	11.2
01/20/00	92	22	8.8	6

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

WATER QUALITY DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location	Total Suspended Solids (mg/L)	Temperature (^{0}C)	Turbidity (NTU)
01/27/00	92	10	8.6	7
02/03/00	92	3	9.4	8
02/10/00	92	21	7.4	14
02/17/00	92	12	13.8	8
02/24/00	92	24	12	10
03/02/00	92	15	14.3	12
03/09/00	92	7	16.1	8
03/16/00	92	13	12.1	11
03/23/00	92	18	19	9
03/30/00	92	11	19.8	7
04/06/00	92	12	17.8	15
04/13/00	92	11	14.8	14
04/20/00	92	59	15.3	35
04/27/00	92	6	18.8	11
05/04/00	92	11	23.3	7
05/11/00	92	15	21	12
05/18/00	92	15	23.3	15
05/25/00	92	10	22.9	10
06/01/00	92	24	20.9	16
06/08/00	92	10	ND	9
06/15/00	92	27	22.8	22
06/22/00	92	19	25.4	13
06/29/00	92	17	25.1	13
07/06/00	92	15	27.8	10
07/13/00	92	16	31.1	11
07/20/00	92	15	27.3	11
07/27/00	92	10	29.6	9
08/03/00	92	18	25.5	10
08/10/00	92	11	29.3	9
08/17/00	92	23	26.9	17
08/24/00	92	10	29.1	9
08/31/00	92	12	29.7	10
09/07/00	92	9	29.6	10
09/14/00	92	15	22.9	15
09/21/00	92	23	21.9	11

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

WATER QUALITY DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location	Total Suspended Solids (mg/L)	Temperature (^0C)	Turbidity (NTU)
09/28/00	92	13	20	10
10/05/00	92	10	22	11
10/12/00	92	11	17.1	9
10/19/00	92	8	23.4	9
10/26/00	92	12	22.5	10
11/02/00	92	16	20.6	9
11/08/00	92	21	18	14
11/16/00	92	24	11.1	15
11/21/00	92	11	7	9
11/30/00	92	18	12.8	14
12/07/00	92	36	8.5	13
12/14/00	92	14	4.5	13
12/21/00	92	7	ND	7
12/28/00	92	8	7.8	8
01/04/01	92	5	7.4	5
01/11/01	92	5	7.8	7
01/18/01	92	11	7.5	8
01/25/01	92	10	7.7	9
02/01/01	92	21	6.2	13
02/08/01	92	20	10.3	10
02/15/01	92	38	4.2	26
02/22/01	92	12	7.5	11
03/01/01	92	39	7.9	31
03/08/01	92	11	8.4	9
03/15/01	92	14	11.9	13
03/22/01	92	19	14.2	11
03/29/01	92	11	10	7
04/05/01	92	11	14	9
04/12/01	92	17	16	12
04/19/01	92	17	13.2	10
04/26/01	92	11	18	9
05/3/01	92	9	21.2	8.1
05/10/01	92	17	21.7	9.9
05/17/01	92	15	24.1	9.3

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-2 (Continued)

WATER QUALITY DATA
AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Date	Location	Total Suspended Solids (mg/L)	Temperature (^{0}C)	Turbidity (NTU)
05/24/01	92	15	23.4	9.9
05/31/01	92	9	18	8.1
06/07/01	92	6	20.8	11.6
06/14/01	92	9	30.3	7.8
06/21/01	92	10	25.2	8.1
06/28/01	92	10	31.4	13.5
07/05/01	92	19	28	14.2
07/12/01	92	12	28.1	9.2
07/19/01	92	11	34.1	9.3
07/26/01	92	11	30.4	9.9
08/02/01	92	27	27.6	17.4
08/09/01	92	10	36	9.1
08/16/01	92	15	29.3	12.3
08/23/01	92	11	29	9.6
08/30/01	92	10	27.1	10
09/06/01	92	15	27	11.3
09/13/01	92	11	28.2	10.8
09/20/01	92	13	23	12.6
09/27/01	92	18	18.3	11.5
10/04/01	92	22	21.6	11.5
10/11/01	92	10	18.4	9.9
10/15/01	92	16	15.9	14.2
10/18/01	92	18	15.6	12.6
10/25/01	92	13	16.3	8.7
11/01/01	92	17	16.1	11.7
11/08/01	92	13	16	11.6
11/15/01	92	22	17.9	12.9
11/19/01	92	30	15.4	11.6
11/20/01	92	16	13.7	11.6
11/29/01	92	39	15.1	19.6
12/06/01	92	20	16.1	11.9
12/13/01	92	20	14.8	12.7
12/20/01	92	17	11.2	12.2
12/27/01	92	10	9.2	8.7

ND = No Data

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-3

MWRDGC RAINFALL DATA (INCHES) FOR 2000

Day	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.00	0.00	0.02	0.00	0.18	0.09	0.00	0.02	0.00	0.00	0.00	0.00
2	0.01	0.00	0.00	0.01	0.00	0.00	0.59	0.07	0.00	0.00	0.00	0.00
3	0.09	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.45	0.00	0.00
4	0.01	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.02	0.64	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.26	0.00	0.09	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.56	0.00
7	0.00	0.00	0.00	0.31	0.01	0.00	0.00	0.00	0.00	0.02	0.00	0.08
8	0.00	0.00	0.02	0.05	0.57	0.00	0.00	0.00	0.05	0.33	0.03	0.00
9	0.08	0.00	0.01	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.75	0.00
10	0.08	0.00	0.00	0.02	0.00	0.05	1.00	0.00	0.14	0.00	0.00	0.00
11	0.00	0.00	0.00	0.01	0.22	0.37	0.00	0.00	2.56	0.00	0.00	0.38
12	0.00	0.00	0.00	0.00	0.34	0.57	0.00	0.00	0.24	0.00	0.05	0.01
13	0.01	0.01	0.01	0.00	0.00	0.27	0.00	0.01	0.00	0.00	0.28	0.19
14	0.00	0.02	0.00	0.00	0.00	0.51	0.00	0.00	0.35	0.00	0.00	0.00
15	0.00	0.00	0.24	0.00	0.00	0.03	0.00	0.00	0.00	0.05	0.00	0.00
16	0.00	0.00	0.00	0.84	0.12	0.00	0.00	0.00	0.00	0.00	0.02	0.00
17	0.00	0.00	0.00	0.07	0.67	0.00	0.00	0.89	0.00	0.00	0.00	0.00
18	0.00	0.27	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
19	0.13	0.01	0.08	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
20	0.01	0.00	0.17	1.32	0.00	0.50	0.01	0.00	0.32	0.00	0.00	0.00
21	0.00	0.00	0.00	0.36	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
22	0.04	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.61	0.00	0.00	0.00
23	0.00	0.00	0.00	0.12	0.00	0.06	0.00	0.12	0.01	0.01	0.00	0.00
24	0.00	0.47	0.08	0.00	0.00	1.08	0.00	0.00	0.13	0.11	0.00	0.00
25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00
26	0.01	0.09	0.11	0.00	0.05	0.00	0.00	0.00	0.00	0.05	0.01	0.00
27	0.00	0.00	0.01	0.00	0.11	0.00	0.08	0.00	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.73	0.06	0.19	0.00	0.00	0.00	0.00	0.00
29	0.07		0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.07	0.08
30	0.05		0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.01	0.10
31	0.00		0.00		0.57		0.35	0.00		0.00		0.00
Month	0.59	0.87	0.74	3.63	4.31	4.12	3.23	2.11	4.43	1.74	1.95	0.83
Year	0.59	1.46	2.20	5.83	10.1	14.3	17.49	19.60	24.03	25.8	27.72	28.55

[1]Average Rainfall readings in inches taken at 12:00 midnight from Glenview, N. Side, N. Br. P.S., Wilmette, West Side, Springfield, Racine, 100 E. Erie, E. Melvina, 87th & Western, Calumet WRP, 95th St. PS, and Lockport.
Source: MWRDGC Normal Operations Rainfall Data.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-4

MWRDGC RAINFALL DATA (INCHES) FOR 2001

Day	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.00	0.00	0.00	0.00	0.00	0.12	0.06	0.00	0.00	0.00	0.00	0.01
2	0.00	0.00	0.00	0.00	0.00	0.01	0.00	2.61	0.00	0.00	0.01	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.00	0.02	0.00	0.05	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00
5	0.00	0.00	0.00	0.33	0.00	0.55	0.00	0.00	0.00	0.41	0.00	0.06
6	0.00	0.03	0.00	0.40	0.08	0.00	0.00	0.00	0.41	0.00	0.00	0.00
7	0.00	0.02	0.00	0.00	0.25	0.00	0.56	0.14	0.25	0.00	0.00	0.00
8	0.00	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.36	0.00	0.15	0.00	0.00	0.00	0.50	0.44	0.00	0.00	0.00
10	0.00	0.01	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.14	0.00	0.00
11	0.00	0.00	0.06	0.39	0.46	0.02	0.00	0.00	0.00	0.02	0.00	0.00
12	0.00	0.00	0.12	0.00	0.00	0.81	0.00	0.00	0.00	0.86	0.00	0.19
13	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.02	0.00	1.85	0.00	0.00
14	0.15	0.13	0.01	0.01	0.30	0.16	0.00	0.00	0.00	0.14	0.00	0.12
15	0.01	0.00	0.17	0.48	0.00	0.01	0.00	0.00	0.00	0.00	0.10	0.00
16	0.00	0.00	0.21	0.00	0.17	0.00	0.00	0.00	0.00	0.06	0.00	0.10
17	0.00	0.00	0.00	0.00	0.02	0.00	0.17	0.00	0.16	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.09	0.01	0.30	0.11	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	1.18	0.00	0.03	0.06
20	0.00	0.04	0.00	0.28	0.00	0.00	0.00	0.00	0.45	0.00	0.09	0.00
21	0.00	0.00	0.00	0.52	0.19	0.31	0.17	0.11	0.00	0.00	0.00	0.00
22	0.00	0.01	0.00	0.29	0.06	0.00	0.63	0.39	0.00	0.19	0.00	0.08
23	0.00	0.00	0.00	0.19	0.16	0.00	0.52	0.00	0.53	0.65	0.00	0.00
24	0.00	1.00	0.00	0.00	0.17	0.00	0.00	0.11	0.10	0.66	0.00	0.00
25	0.00	0.01	0.00	0.00	0.06	0.00	1.31	1.53	0.03	0.00	0.18	0.00
26	0.03	0.00	0.00	0.00	0.91	0.00	0.00	0.00	0.00	0.00	0.09	0.00
27	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.11	0.00	0.00	0.00	0.00
28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
29	0.45		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00
30	0.10		0.00	0.01	0.00	0.00	0.00	0.89	0.00	0.02	0.28	0.00
31	0.00		0.08		0.38		0.00	0.40		0.00		0.00
Month	0.73	2.21	0.68	3.06	3.52	2.07	3.68	7.30	3.69	5.87	0.93	0.61
Year	0.73	2.94	3.62	6.68	10.2	12.3	15.95	23.25	26.93	32.8	33.73	34.34

[1]Average Rainfall readings in inches taken at 12:00 midnight from Glenview, N. Side, N. Br. P.S., Wilmette, West Side, Springfield, Racine, 100 E. Erie, E. Melvina, 87th & Western, Calumet WRP, 95th St. PS, and Lockport.
Source: MWRDGC Normal Operations Rainfall Data.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-5

MWRDGC OFFICIAL RAINFALL[1] AND RECORD OF REVERSALS TO LAKE MICHIGAN

Date of Rainstorm and Reversal	Rainfall (inches)	Total Reversals (million gallons)
2000	No major rainstorm	0.0
2001		
7/25/01	1.31	No river reversals
8/2/01	2.61	973.1[a]
8/25/01	1.53	No river reversals
8/31/01	0.40	75.3[b]
10/13/01	1.85	90.7[b]

[1]Average Rainfall readings in inches taken at 12:00 midnight from Glenview, N. Side, N. Br. P.S., Wilmette, West Side, Springfield, Racine, 100 E. Erie, E. Melvina, 87th & Western, Calumet WRP, 95th St. PS, and Lockport.
[a]River reversals at Chicago River Controlling Works (CRCW) and at Wilmette Pumping Station.
[b]River reversal at Wilmette Pumping Station.
Source: MWRDGC Normal Operations Rainfall Data.

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AI-6

30-DAY PERIOD GM CONCENTRATIONS OF FC BACTERIA AT LOCATIONS 91 (DPR) AND 92 (CSSC) FOR 2000 AND 2001

Five Samples 30-day Period Dates	FC(CFU/100 mL)[1] at Location 91	FC (CFU/100 mL)[1] at Location 92
1/20/00 through 2/17/00	268.674	132.279
2/24/00 through 3/23/00	455.070	127.935
3/30/00 through 4/27/00	122.545	148.929
5/4/00 through 6/1/00	153.493	210.875
6/8/00 through 7/6/00	278.092	462.068
7/13/00 through 8/10/00	111.439	168.203
8/17/00 through 9/14/00	221.867	501.261
9/21/00 through 10/19/00	845.044	547.999
10/26/00 through 11/21/00	638.286	322.377
11/30/00 through 12/28/00	587.764	329.771
1/4/01 through 2/1/01[2]	2084.328	249.295
2/8/01 through 3/8/01	1635.450	172.689
3/15/01 through 4/12/01	552.125	86.588
4/19/01 through 5/17/01	95.513	115.542
5/24/01 through 6/21/01	145.917	365.826
6/28/01 through 7/26/01	163.806	146.724
8/2/01 through 8/30/01	235.202	614.302
9/6/01 through 10/4/01	621.857	1524.439
10/11/01 through 11/8/01	331.766	744.414
11/15/01 through 12/13/01	382.338	140.213

[1]GM calculated from five samples during 30-day period from locations 91 and 92.

[2]GM calculated from three samples during 30-day period from location 91 and five samples from location 92.

APPENDIX AII

STATISTICAL PREDICTION OF FC CONCENTRATIONS

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-1

PREDICTION OF FC CONCENTRATION BY TIME SERIES MODEL AND REGRESSION MODEL AT LOCATION 91 (DPR)

ln (FLOW) cubic feet-sec	*ln* (FC) CONCENTRATION (CFU/100 mL) REGRESSION MODEL[1]	TIME SERIES MODEL[2]
5.3613	4.7526	4.8175
5.3327	4.7273	5.8942
5.4027	4.7893	6.2399
5.6312	4.9919	5.6446
5.6058	4.9694	5.5207
7.3265	6.4947	6.5387
6.7742	6.0051	6.1005
6.1092	5.4157	5.2971
6.3386	5.6190	5.7088
6.3544	5.6330	6.1119
6.0379	5.3524	5.5733
5.6836	5.0383	4.8152
6.1944	5.4911	5.3407
8.0456	7.1322	6.5376
7.5121	6.6592	6.2180
6.7511	5.9846	5.2724
7.0648	6.2627	4.8926
6.7968	6.0252	5.2788
7.5443	6.6878	6.3751
7.3524	6.5177	5.2149
7.4206	6.5781	5.9734
7.6497	6.7812	6.1018
7.6779	6.8062	6.1900
6.9276	6.1411	5.3725
7.1389	6.3284	5.7712
7.1778	6.3629	5.8648
6.1591	5.4598	4.8743
5.6095	4.9726	4.3871
6.6039	5.8542	5.1801
5.9636	5.2865	4.8350
6.3526	5.6314	5.0971
5.4889	4.8658	4.1772
5.3279	4.7230	4.3333
5.1818	4.5935	4.4441
7.3588	6.5234	6.5857
6.4135	5.6853	5.9975
6.6477	5.8930	6.2819
7.0121	6.2160	6.6023

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-1 (Continued)

PREDICTION OF FC CONCENTRATION BY TIME SERIES MODEL AND REGRESSION MODEL AT LOCATION 91 (DPR)

ln (FLOW) cubic feet-sec	*ln* (FC) CONCENTRATION (CFU/100 mL) REGRESSION MODEL[1]	TIME SERIES MODEL[2]
5.8833	5.2154	6.3187
5.5984	4.9628	5.6687
5.6276	4.9887	5.7143
5.6168	4.9791	5.5781
6.9373	6.1497	6.8136
6.7569	5.9898	7.0945
6.2615	5.5506	6.2485
6.1675	5.4673	6.0124
5.9135	5.2421	5.7104
5.7991	5.1407	5.5129
5.7038	5.0562	5.8130
5.5984	4.9628	5.8286
6.6871	5.9279	6.9306
6.1356	5.4390	6.5093
7.2584	6.4344	7.3549
6.6503	5.8953	7.1157
7.6305	6.7642	7.8094
6.7991	6.0272	6.7876
7.2079	6.3895	7.2551
6.8134	6.0399	6.9537
6.7166	5.9541	6.9334
7.1148	6.3070	7.1577
6.4615	5.7279	6.4838
6.3190	5.6016	6.4080
7.0388	6.2397	6.5772
6.7499	5.9836	6.0659
7.0475	6.2474	6.3498
6.2897	5.5756	5.2697
6.2025	5.4984	4.7613
6.9177	6.1323	5.4031
6.4520	5.7195	4.7476
6.6771	5.9190	5.0104
7.0388	6.2397	5.1727
7.1066	6.2998	5.8959
6.8690	6.0892	5.5150
5.7683	5.1134	4.2813
5.2781	4.6789	3.6202
5.3566	4.7484	4.0165

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-1 (Continued)

PREDICTION OF FC CONCENTRATION BY TIME SERIES MODEL AND REGRESSION MODEL AT LOCATION 91 (DPR)

ln (FLOW) cubic feet-sec	*ln* (FC) CONCENTRATION (CFU/100 mL) REGRESSION MODEL[1]	TIME SERIES MODEL[2]
5.5984	4.9628	4.5440
6.6093	5.8590	5.7778
6.6871	5.9279	6.3425
5.5491	4.9191	5.3546
6.3261	5.6079	5.9045
7.2298	6.4090	6.4634
5.9713	5.2933	4.8881
5.7398	5.0881	5.0232
5.8693	5.2029	5.3109
8.0583	7.1435	7.3059
6.9276	6.1411	6.7663
6.1591	5.4598	5.9783
6.0936	5.4018	5.6812
7.9121	7.0138	7.1205
8.3848	7.4329	7.1271
7.2513	6.4281	6.1250
6.4297	5.6997	5.3170
6.1137	5.4196	5.2248
6.3244	5.6063	5.8137
6.3099	5.5935	5.5976
6.3117	5.5952	5.6079
6.5903	5.8421	5.9502
6.4708	5.7362	5.9655
5.9661	5.2888	5.2339

[1]Model: $ln(FC)=0.88647*ln(Flow)$

[2]Model: $(ln(FC))_t=0.8823*(ln(FC))_{t-1}+0.8986*ln(Flow)-.6280*(error)_{t-1}$

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-2

PREDICTION OF FC CONCENTRATION BY TIME SERIES MODEL AND REGRESSION MODEL AT LOCATION 92 (CSSC)

ln (FLOW) cubic feet-sec	*ln* (FC) CONCENTRATION (CFU/100 mL) REGRESSION MODEL[1]	TIME SERIES MODEL[2]
5.3613	4.7526	4.8175
5.3327	4.7273	5.8942
5.4027	4.7893	6.2399
5.6312	4.9919	5.6446
5.6058	4.9694	5.5207
7.3265	6.4947	6.5387
6.7742	6.0051	6.1005
6.1092	5.4157	5.2971
6.3386	5.6190	5.7088
6.3544	5.6330	6.1119
6.0379	5.3524	5.5733
5.6836	5.0383	4.8152
6.1944	5.4911	5.3407
8.0456	7.1322	6.5376
7.5121	6.6592	6.2180
6.7511	5.9846	5.2724
7.0648	6.2627	4.8926
6.7968	6.0252	5.2788
7.5443	6.6878	6.3751
7.3524	6.5177	5.2149
7.4206	6.5781	5.9734
7.6497	6.7812	6.1018
7.6779	6.8062	6.1900
6.9276	6.1411	5.3725
7.1389	6.3284	5.7712
7.1778	6.3629	5.8648
6.1591	5.4598	4.8743
5.6095	4.9726	4.3871
6.6039	5.8542	5.1801
5.9636	5.2865	4.8350
6.3526	5.6314	5.0971
5.4889	4.8658	4.1772
5.3279	4.7230	4.3333
5.1818	4.5935	4.4441
7.3588	6.5234	6.5857
6.4135	5.6853	5.9975
6.6477	5.8930	6.2819
7.0121	6.2160	6.6023

TABLE AII-2 (Continued)

PREDICTION OF FC CONCENTRATION BY TIME SERIES MODEL AND REGRESSION MODEL AT LOCATION 92 (CSSC)

ln (FLOW) cubic feet-sec	*ln* (FC) CONCENTRATION (CFU/100 mL) REGRESSION MODEL[1]	TIME SERIES MODEL[2]
2.3026	5.2754	5.2754
4.7005	5.5187	5.5187
5.5984	5.9524	5.9524
5.5607	5.6120	5.6120
6.3456	6.0415	6.0415
6.8459	5.9357	5.9357
5.6348	5.7184	5.7184
6.2916	5.7311	5.7310
6.2146	5.8712	5.8711
3.6889	5.5927	5.5927
4.4998	5.6030	5.6030
5.8289	5.6954	5.6954
5.3936	5.6959	5.6959
5.5607	5.9648	5.9648
9.9523	6.0414	6.0413
6.6333	5.6826	5.6826
6.3456	5.6914	5.6914
4.3820	5.1949	5.1949
5.0106	5.2898	5.2897
3.6889	5.3524	5.3524
4.4998	5.4176	5.4176
5.5607	5.5538	5.5538
7.0901	5.7250	5.7250
6.2146	5.8010	5.8010
4.3820	5.4486	5.4486
2.3026	5.5029	5.5028
5.1358	5.4453	5.4453
4.6052	5.4901	5.4901
8.5172	5.9187	5.9186
5.5984	5.7775	5.7774
4.3820	5.7684	5.7684
5.5984	5.5573	5.5572
7.0901	5.9587	5.9586
3.9120	5.1877	5.1877
5.1930	5.3111	5.3111
6.9078	5.1420	5.1420
4.4998	5.2885	5.2885
3.9120	5.3291	5.3291
3.6889	5.0628	5.0628
5.2983	5.2989	5.2989
4.4998	5.3079	5.3078

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-2 (Continued)

PREDICTION OF FC CONCENTRATION BY TIME SERIES MODEL AND REGRESSION MODEL AT LOCATION 92 (CSSC)

ln (FLOW) cubic feet-sec	*ln* (FC) CONCENTRATION (CFU/100 mL) REGRESSION MODEL[1]	TIME SERIES MODEL[2]
4.0943	5.2652	5.2651
4.2485	5.4099	5.4099
5.6348	5.6978	5.6978
5.0752	5.2720	5.2720
6.3969	5.5437	5.5437
6.6593	5.6363	5.6362
5.7366	5.2893	5.2893
6.6201	5.3188	5.3187
5.2983	5.1132	5.1132
5.5607	5.2943	5.2943
5.5215	5.4898	5.4897
5.9915	5.2062	5.2062
6.3801	5.3397	5.3396
2.9957	5.0353	5.0353
5.0106	5.5118	5.5117
4.3820	5.4739	5.4738
8.8247	5.8816	5.8815
6.6720	5.8495	5.8495
4.4998	5.4021	5.4021
6.2916	5.6173	5.6173
4.6052	5.3259	5.3259
3.6889	5.5405	5.5404
3.6889	5.2814	5.2813
5.1930	5.7711	5.7711
5.2983	5.4003	5.4003
4.7005	5.4869	5.4869
7.8633	5.8208	5.8208
6.2916	5.4173	5.4173
4.7875	5.6038	5.6038
5.4381	5.6439	5.6439
5.3471	5.6202	5.6202
7.7407	5.7908	5.7908
6.4297	5.4379	5.4379
4.0943	5.4297	5.4297
7.1701	5.6358	5.6357
4.9416	5.6123	5.6123
9.2103	6.6206	6.6206
5.5984	5.8583	5.8583
7.3132	5.7656	5.7656
6.6464	5.8214	5.8214
10.8198	5.9947	5.9946

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

TABLE AII-2 (Continued)

PREDICTION OF FC CONCENTRATION BY TIME SERIES MODEL AND REGRESSION MODEL AT LOCATION 92 (CSSC)

ln (FLOW) cubic feet-sec	*ln* (FC) CONCENTRATION (CFU/100 mL)	
	REGRESSION MODEL[1]	TIME SERIES MODEL[2]
6.5221	5.8638	5.8637
4.2485	5.4321	5.4321
4.2485	5.2432	5.2432
6.7912	6.6505	6.6505
3.6889	5.8582	5.8581
4.8675	5.4932	5.4932
4.8675	5.4579	5.4579

[1]Model: $ln(FC)=0.7109 * ln(Flow)$.

[2]Model: $(ln(FC))_t=0.83148 * (ln(FC))_{t-1} +0.7187 * ln(Flow)-0.7419 * (error)_{t-1}$.