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CSO Impact Assessment for Banklick Creek

Lindell E. Ormsbee
University of Kentucky College of Engineering, lindell.ormsbee@uky.edu

A. Reddy
University of Kentucky

S. Gruzesky
University of Kentucky

A. Jain
University of Kentucky

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by

L. Ormsbee, Associate Professor
Department of Civil Engineering
University of Kentucky , Lexington, Kentucky 40506-0281

and

A. Reddy, S. Gruzesky, A. Jain, Graduate Students
Department of Civil Engineering, University of Kentucky

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EXECUTIVE SUMMARY

This report contains the results of a combined sewer overflow (CSO) impact assessment study for Banklick Creek, which flows into the Licking River just south of Covington, Kentucky in Kenton County, Kentucky. This study is a component of a larger study that was conducted to determine the general impact of CSOs in the Northern Kentucky region. The study was conducted through the Kentucky Water Resources Research Institute of the University of Kentucky and was funded by the Kentucky Natural Resources and Environmental Protection Cabinet through a grant from the United States Environmental Protection Agency.

The original objective of this study was to quantify the impact of combined sewer overflows on Banklick Creek. This was accomplished by instrumenting and sampling two combined-sewer discharge pipes along with seven, separate stream locations. The two combined-sewer discharge pipes were located between KY16 and KY177, while the stream samples were collected at various points between I275 and the mouth of Banklick Creek. Initial baseline sampling of the creek indicated the probable occurrence of additional overflows at the Lakeview Pump Station creek crossing. Because of sampling difficulties, this site was not instrumented, although stream samples were taken upstream and downstream of the site in an attempt to assess its possible impact.

This report contains the results of the sampling effort for the period 7/1/93-11/1/93. During this time period, water quality samples were collected for 5 baseline events, 4 short-term (6 hours) events, 2 intermediate (2 day) events and 3 long-term (3-5 days) events. A total of 220 separate stream samples and 44 separate CSO samples were collected. Each sample was analyzed for the following parameters: 1) Dissolved Oxygen, 2) Conductivity, 3) Temperature, 4) PH, 5) Fecal Coliform, 6) Fecal Strep, 7) BOD, 8) TSS, 9) VSS. In addition to these samples and analyses, 3 separate samples were analyzed for the full spectrum of priority pollutants.

The results of this study indicate that pollutant loadings on the creek always increased following a storm event - the BOD loadings were lower than expected while the fecal loadings were much higher than expected. No strong relationship was established between the observed dissolved oxygen levels and the associated BOD concentrations. It is possible that this relationship may be affected by the presence of other chemicals within the stream. In addition, significant eutrophication was observed within certain reaches of the creek during the months of July and August.

The upper reach of Banklick Creek consists of a series of pools. The Lakeview Pump Station creek crossing overflow was observed to discharge into a frequently stagnant stream pool, which resulted in especially high fecal and low DO readings. Occasionally, baseline samples at the site were very high indicating the possible occurrence of dry weather overflows. Following significant storm events, it appears that the pollutants from this pool may be displaced and move down the creek as pollutant plugs or cells.

Flow and water quality dynamics of the lower reach of Banklick Creek appear to be very complex. Travel times between KY16 and KY177 were highly variable and seem to be dependent upon both storm magnitude (flow) and the initial river stage. Both the flow and water quality dynamics appear to be significantly influenced by the backwater effect from the Licking River and the storage effect from off- channel storage along the north side of the creek. In some cases, flows in the lower reach were observed to be stopped or even moving upstream. In such instances, the lower reach effectively became a stagnant pool.

In general the Lakeview Pump Station SSO appeared to have a greater impact on the water quality of Banklick Creek than the two monitored CSOs. However, both CSOs were observed to have a measured impact. In addition, both CSOs were observed to overflow in response to rainfall events as small as 0.05 inches. Based on the constituent concentrations observed in the CSO discharges it would appear that part of the loadings may in fact be attributable to inputs from the stormwater runoff. If this hypothesis is in fact correct, then it may be possible to decrease part of the final stream loadings through various on-site management practices.

I. INTRODUCTION

1.1. Background

The Federal Clean Water Act of 1972 established the National Pollutant Discharge Elimination System (NPDES) for use in limiting pollutant discharges to the nation's waterways. In the past, the primary application of this legislation has been on controlling pollutant discharges from wastewater treatment facilities (WWTF). In recent years, EPA has extended the enforcement of this legislation to include discharges from combined sewer overflows (CSOs). Combined sewers are sewers that collect and convey both stormwater and domestic sewage. During dry periods the sewers are used to convey domestic sewage to wastewater treatment facilities. However, during storm events, the capacity of the collection systems are frequently exceeded so that the excess flows are diverted untreated to receiving waters through various overflow points along the collection system.

As of July 1995, Kentucky contained approximately 354 CSOs associated with 16 separate wastewater systems. The majority of the CSOs are located in cities located along the Ohio River. In 1990, the Kentucky Division of Water (DOW) prepared and submitted to EPA the Kentucky Combined Sewer Overflow Control Strategy, which established a uniform, statewide approach to developing and issuing KPDES permits for Combined Sewer Overflows (CSOs). Since that time, the program has been implemented as each municipality and sanitation district renews their old KPDES permits. The purpose of the permit program is to 1) insure that any CSO is a result of wet weather flow only, 2) bring all wet weather CSO into compliance with technology-based requirements and applicable water quality standards, and 3) minimize water quality, aquatic biota and human health impacts due to wet weather overflows.

The CSO permit program involves two separate phases. The first phase of the program requires each municipality or sanitation district to 1) identify the receiving water for each overflow, 2) update the existing sewer use ordinance to prohibit the construction of any new combined sewers and minimize any new flows into existing combined sewers, and 3) develop a comprehensive Combined Sewer Operational Plan (CSOP) for the system. The first phase of the program is to be completed within 15 months of the issuance of the permit. The second phase of the program involves the implementation of a CSOP to reduce the total loading of pollutants entering receiving streams from the combined sewer system.

To develop a relevant set of CSO permit requirements associated with each KPDES permit, some understanding of the basic characteristics and impacts of CSOs is needed. To obtain a basic understanding of these impacts, at least in Kentucky, the Kentucky Natural Resources and Environmental Protection Cabinet secured a grant from the United States Environmental Protection Agency to investigate and characterize these impacts. The resulting grant was used to study two separate areas within the state that had been identified as having significant CSO impacts. These two areas included the Jefferson County region, and the Northern Kentucky region, which includes Boone County, Campbell County, and Kenton County.

The CSO study for Jefferson county was conducted for the Louisville and Jefferson County Metropolitan Sewer District by Tenney Pavoni Associates, Inc. The results of this investigation have been report elsewhere (Tenney Pavoni, 1994). The CSO study for the Northern Kentucky region was conducted by the Kentucky Water Resources Research Institute of the University of Kentucky. Partial results of this study are contained in this report.

1.2. Purpose

The objective of this report is to provide a summary of the methodology and results associated with a water-quality sampling effort for Banklick Creek. As early as the 1950s, residents along the banks of Banklick Creek, described the creek as "smelly" and complained about debris left behind receding waters (Cincinnati Enquirer 1988). A 1952 attempt to lessen the creek's odors by building up the banks and containing the creek failed to alleviate the problem. Such problems have continued up to the present as evidenced by the high levels of bacteria that have been measured in the creek in recent years. One of the most likely sources of such contamination is from combined sewer overflows that exist along the banks of the creek. As a result, this study was initiated in an attempt to identify potential pollutant sources and to measure their associated impact. As discussed previously, this effort was one component of a larger effort to determine the impact of CSO discharges on the Northern Kentucky region.

1.3. Overview

This report has been divided into six chapters. Chapter 1 provides an introduction and background with regard to the associated study. Chapter 2 provides a description of the study area along with an identification of the sampling sites. Chapter 3 provides a discussion of the sampling protocol along with a discussion of the specific water quality constituents that were analyzed. Chapter 4 presents the results of the sampling effort, while the fifth section provides a discussion of the observed results. The final chapter contains a summary of the results along with conclusions and recommendations for future studies. Logs and figures of the collected data are provided in the report Appendices.

II. STUDY AREA

2.1. Northern Kentucky Region

The purpose of this project is to shed light on the impact of CSOs on various water quality problems that have been observed in the Northern Kentucky region. The Northern Kentucky region is located within the Greater Cincinnati, Ohio area and includes Kenton, Campbell and Boone counties (see Figure 2.1). Information from the 1990 census shows that the population of this area is approximately 300,000.

The climate of the region is temperate and humid. Average monthly temperatures range from a low of 23 degrees F (January) to a high of 87 degrees F (July). Precipitation is fairly well distributed throughout the year. The average annual rainfall is approximately 40 in. The average monthly rainfall for the data collection period of June 1993-November 1993 is shown in Figure 2.2. As can be seen from the figure, rainfall in July was significantly below normal while the rainfall in August was significantly above normal.

Presently, 90 separate CSOs have been identified in the Northern Kentucky region. These 90 CSOs are distributed among the nine cites shown in Table 2.1. Currently, the sewage from each of these cities is collected within the boundaries of the individual cities and then conveyed by a secondary truck sewer to a wastewater treatment plant that is owned and operated by the Sanitation District #1 of Campbell and Kenton counties. Although the Sanitation District collects the sewage from the individual cities through its own truck main, it does not currently own the sewers within the individual cities nor is it responsible for the associated CSOs.

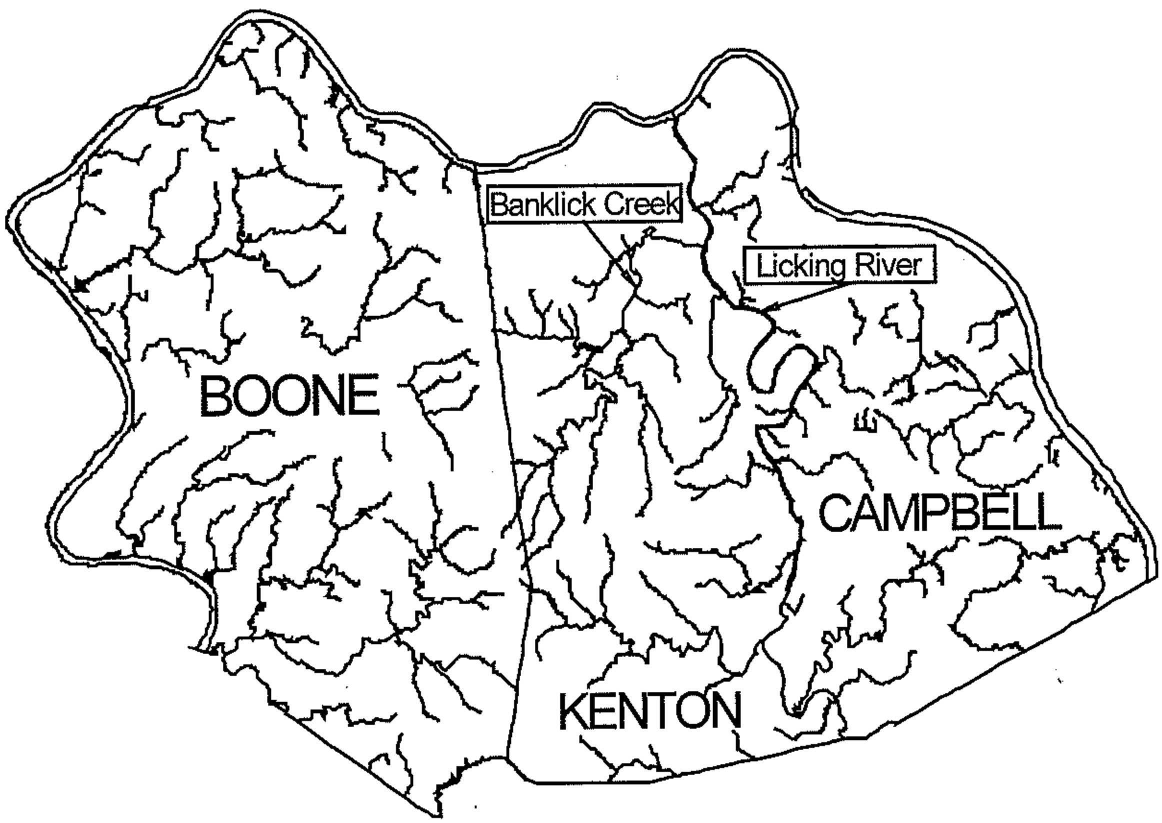

Figure 2.1. Map of Northern Kentucky Area

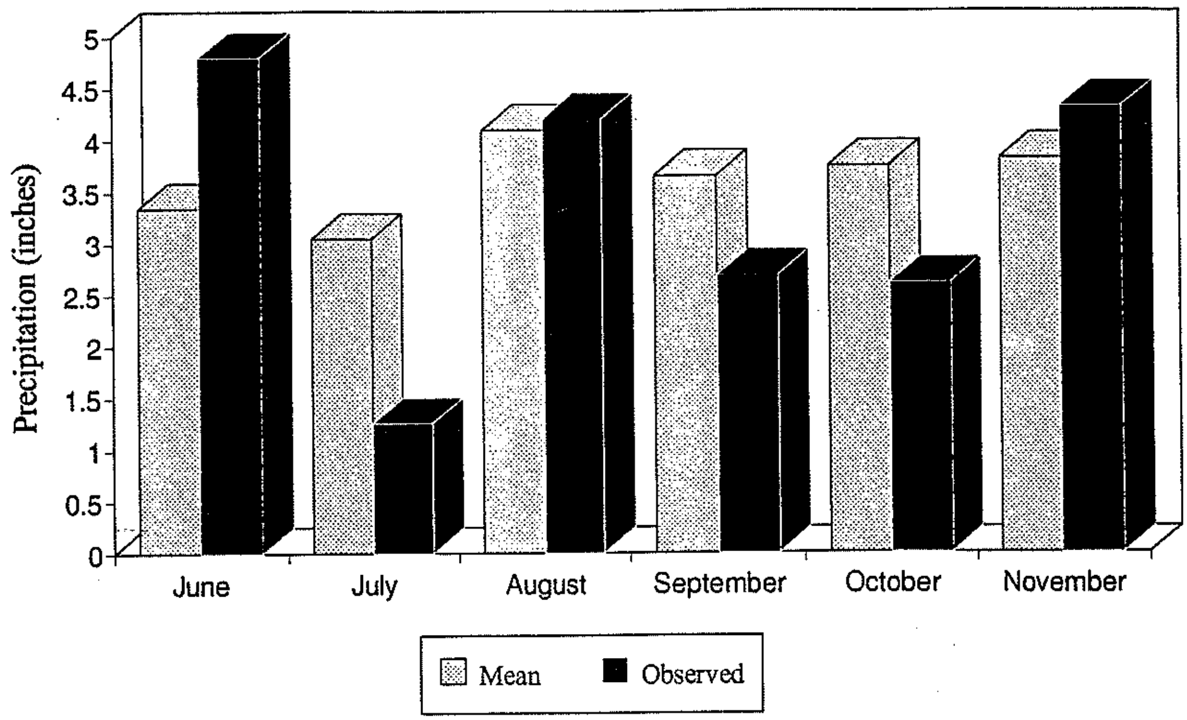

Figure 2.2. Average Monthly Rainfall During Study Period

Table 2.1. Table of Northern Kentucky Cities

City	KPDES Number	Number of CSOs
Bellevue	KY0098337	15
Bromley	KY0098428	2
Covington	KY0098272	63
Dayton	KY0098299	2
Ft. Wright	KY0098311	2
Ludlow	KY0098281	6
Newport	KY0098264	16
Park Hills	KY0098256	8
Taylor Mill	KY0098302	1

Recently, legislation was passed that permits the individual cities to turn control of their collection systems over to the Sanitation District. Such an arrangement will provide a more comprehensive framework for managing the various CSOs and for funding of the necessary improvements to the various sub-systems.

2.2. Banklick Creek

Banklick Creek originates in Boone County and flows north and then east to the Licking River. The Banklick Creek watershed has a total area of 58.3 sqmi and is characterized by gently sloping to sloping soils that are moderately well drained. The major subsoils in the watershed include both clays and loams. Land use in the study area is primarily urban with some light industry. Agricultural lands are more common upstream of the study area.

To obtain an initial understanding of the impacts of CSOs in the Northern Kentucky region, a short (5 mile) section of Banklick Creek was chosen for evaluation (see Figure 2.3). This section was chosen for both logistical reasons (the presence of two separate bridges permitting relatively easy upstream and downstream stream sampling) and for water quality reasons (this section has had a history of water quality problems).

The CSO impact assessment analysis of Banklick Creek was accomplished by instrumenting and sampling two combined-sewer discharge pipes along with seven separate stream locations. The two combined-sewer discharge pipes were located between KY16 and KY177 while the stream samples were collected at various points between I275 and the mouth of Banklick Creek. The exact location of each site is shown in Figure 2.3.

2.3. Lakeview Pump Station

Initial baseline sampling of the creek indicated the probable occurrence of additional overflows at the Lakeview pump station creek crossing (see Figure 2.3). Because of technical restrictions, this site was not instrumented, although stream samples were taken upstream and downstream of the site (i.e. S1, S2 and S3) in an attempt to assess its possible impact.

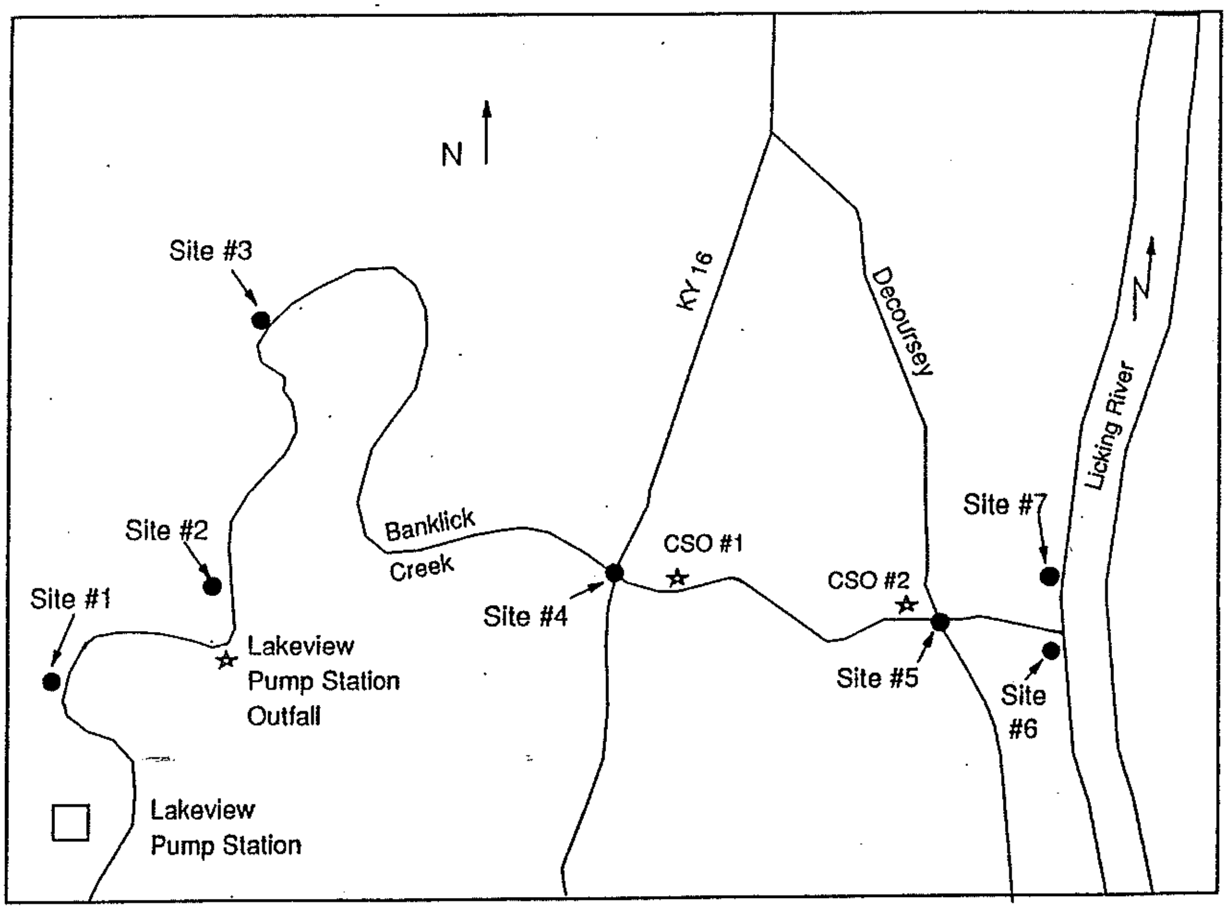

Figure 2.3. Map of Study Area

III. SAMPLING PROTOCOL

3.1. Location of CSO Sample Sites

To determine a set of CSO sampling sites, all CSOs were first identified on available sewer maps and then verified in the field. Final selection of the sites was based on a number of factors including: size of the outfall, physical access, safety and security, and requirements for associated streamflow sampling. The two CSOs that were finally selected were observed to discharge into Banklick Creek between KY 16 (CSO 1) and KY 177 (CSO 2) (see Figure 2.3.). The KY16 CSO (C1), consists of a 5-feet diameter pipe and drains an area of approximately 154 acres. The KY177 CSO (C2) consists of a 21-inches diameter pipe and drains an area of approximately 15 acres.

3.2. Location of Stream Sampling Sites

Once the CSO sites were established, the associated stream sampling sites were then determined. Initially, two stream sampling sites were identified, one upstream of the CSOs and one downstream of the CSOs. The upstream site was at the KY 16 bridge, while the downstream site was at the KY 177 bridge (i.e., S4 and S5). In addition to these two sites, two additional sites where chosen one upstream of the confluence of Banklick Creek and the Linking River and one downstream of the confluence (i.e., S6 and S7). These sites were selected for use in assessing the impact of Banklick Creek on the Licking River. Initial preliminary sampling at these sites identified a significant pollution source upstream of the KY 16 sampling site. The most likely source of the pollutants was identified to be an SSO at the Lakeview pumping station river crossing. As a result, three additional stream sampling sites were added to the sampling protocol (i.e., S1, S2, S3) to try to assess the impact of the SSO on the associated stream quality. As a result, a total of seven separate stream sites were included in the sampling protocol.

3.3. CSO Sampling Equipment

At each CSO sampling site, an ISCO Model 3230 Flow Meter and an ISCO Model 3700 Portable Sampler were inserted in upstream manholes for use in determining the sewer stage (for use in determining discharge) and for collecting samples of detected overflow events. Each unit was powered by a 6-volt battery that had a continued-use life of approximately 3 days. Prior to each storm event both instruments were turned on and the sampler was packed with ice to preserve samples. The flow meter triggered the program of the automatic sampler at the start of an overflow event. The sampler was configured to collected 850 ml of sample every 15 minutes for the first 4 hours of an overflow. The samples collected during each hour were combined into a single composite sample for subsequent laboratory analyses.

3.4. Stream Sampling Equipment

Each stream sample was collected directly from the stream or river banks (i.e. S1, S2, S3, S6, S7) or from a bridge using a horizontal grab sampler (i.e. S4, S5). Samples were collected as close to mid-stream as possible and all within 1 ft of the water's surface because Banklick Creek is both shallow and narrow--characteristics that allow mixing and limit stratification.

3.5. Sampling Duration

Prior to the occurrence of any overflow event, a series of baseline stream samples was taken at each stream sampling site. Subsequent stream and CSO sampling were performed using two separate protocols depending upon the magnitude of the following rainfall event. During a significant rainfall event, stream samples were taken concurrently with the CSO samples. During a slight or moderate overflow event, stream samples were taken on a daily basis over a three-day period. This latter protocol provided an opportunity to assess the migration effects of pollutants from the Lakeview Pumping Station SSO as the pollutants moved down the creek over the first few days following an storm event.

3.6. Analysis of Samples

Generally, temperature (C), conductivity (ms/cm), pH, and DO (mg/l) were recorded for each sample at the time of collection using a Hydrolab H20 transmitter. Laboratory analyses usually included fecal coliform, fecal streptococcus, biochemical oxygen demand, total suspended solids, and volatile suspended solids. These parameters were selected to best depict the influence of CSOs on the water quality of receiving streams. Scans for priority pollutants were conducted on a single sample collected from each CSO and from the stream site downstream of the SSO at the Lakeview pumping station. All fecal coliform and fecal streptococcus samples were analyzed by Dr. David Lye of Northern Kentucky University, while both BOD and solids samples were analyzed in the water quality laboratory at the University of Kentucky. Each priority pollutant analysis was performed by Commonwealth Technology Inc., of Lexington, Kentucky.

VI. SAMPLING RESULTS

4.1. Summary

A total of 9 storm events (4 short term, 2 intermediate, and 3 long term) and 5 additional baseline events were sampled from the period between June 21, 1993 and November 16, 1993. A summary of the various events is provided in Table 4.1. Results of the associated water quality analyses are provided in Appendices A-D. A detailed discussion of each of the storm events is provided in the following sections.

Table 4.1 Summary of CSO and Stream Sampling

Beginning Date	Sampling Duration	Rainfall (inches)	CSO Samples	Stream Samples
06/21/93	1 day	None	0	4
07/14/93	2 days	0.05 in	3	8
07/19/93	1 day	None	0	4
07/28/93	1 day	None	0	6
08/03/93	4 days	0.08 in	2	28
08/12/93	1 day	2.23 in	8	21
08/19/93	1 day	None	0	7
08/23/93	5 days	0.47 in	4	28
08/31/93	1 day	None	0	7
09/02/93	2 days	0.80 in	3	9
09/13/93	5 days	0.50 in	3	28
09/24/93	2 days	0.50 in	6	14
10/19/93	2 days	0.50 in	2	12
11/16/93	2 days	1.15 in	20	24

4.2. Short Term Events

Short-term events consisted of those events when the CSO samples and the stream samples were taken concurrently. Stream sampling was restricted to those sites directly above and below the two CSO sites (i.e S4 and S5). A discussion of the four short-term events is provided in the following sections.

4.2.1 August 12, 1993

The first short-term event that was monitored occurred between 8:00am and 9:00pm on August 12, 1993. During that time period, approximately 2.32 inches of rainfall occurred. Because of the timing of the storm, no baseline water quality samples were collected. Four overflow samples were collected from both CSO #1 and CSO #2. Each CSO sample was analyzed for the full range of water quality constituents. The rainfall and CSO discharge hydrographs for this event are shown in Figure A.3, while graphical histograms of the water quality analyses are shown in Figures B.17-B.30. The complete set of results is presented in tabular form in Tables C12-C14. A summary of the average results is provided in Table 4.2.

As can be seen from Table 4.2, the average constituent values all increased following the storm event (with the exception of DO, which decreased) indicating the impact of the storm event in decreasing the water quality associated with Banklick Creek. Following the storm event, all of the biological parameter values increased downstream of the two CSOs, while the solids loads decreased. The first observation would appear to demonstrate the impact of the CSO loadings, while the decrease in solid loadings may be attributable to the decrease in stream velocity associated with the lower reach of Banklick Creek.

Table 4.2. Average Constituent Values for August 12 Event

Site	BOD	DO	FC	FS	TSS	VSS
Site 4	8	6.40	4,800	--	18	3
Site 5	7	6.16	5,400	80	35	4
CSO1	97	6.46	3.7×10^6	5.6×10^4	79	36
CSO2	77	5.51	4.3×10^6	2.7×10^5	68	23
Site 4	20	5.51	1.0×10^6	3.7×10^4	4357	280
Site 5	49	5.23	1.1×10^6	5.1×10^4	1271	124

Note: BOD = Biochemical Oxygen Demand (mg/l), DO = dissolved oxygen (mg/l), FC = Fecal Coliform (count per 100 ml), FS = Fecal Streptococcus (count per 100 ml), TSS = Total Suspended Solids (mg/l), VSS = Volatile Suspended Solids (mg/l), first set of site values are before storm event while second set of values are after the storm event.

4.2.2. September 25, 1993

The second short-term event occurred on September 25, 1994. Approximately 0.5 inch of rainfall occurred on this date between 9:30 am and 3:30 pm. During the storm the automatic sampler collected overflow samples for four and two consecutive hours at CSOs 1 and 2, respectively. Stream samples were collected from sites S4 and S5 each hour for 3 hours during the storm. The rainfall and CSO discharge hydrographs for this event are shown in Figure A.7. The laboratory analyses for these samples are presented in Figures B.58-B.66 and Tables C.31-C.32. A summary of the average results are provided in Table 4.3.

As can be seen from Table 4.3, the initial conditions at site S5 were extremely poor, indicating a significant pollution problem. It is hypothesized that the elevated loadings are attributable to previous CSO or SSO loadings that have migrated down the stream where they have then collected as a result of the backwater effect from the Licking River. Despite the extremely poor initial conditions, the majority of the average constituent values increased following the storm event (including the DO) indicating the impact of the storm event in decreasing the water quality associated with Banklick Creek. Following the storm event, all of the biological parameter values increased downstream of the two CSOs, while the solids loads decreased. As in the previous case, the first observation would appear to demonstrate the impact of the CSO loadings, while the decrease in solid loadings may be attributable to the decrease in stream velocity associated with the lower reach of Banklick Creek.

Table 4.3. Average Constituent Values for September 25 Event

Site	BOD	DO	FC	FS	TSS	VSS
Site 4	5	4.06	8000	380	7	1
Site 5	2	2.21	2.4×10^7	1.1×10^5	10	--
CSO1	200	4.01	9.9×10^6	---	130	87
CSO2	103	7.08	1.7×10^6	---	143	84
Site 4	6	4.33	7.8×10^4	---	54	7
Site 5	37	3.27	1.1×10^6	---	10	5

Note: BOD = Biochemical Oxygen Demand (mg/l), DO = dissolved oxygen (mg/l), FC = Fecal Coliform (count per 100 ml), FS = Fecal Streptococcus (count per 100 ml), TSS = Total Suspended Solids (mg/l), VSS = Volatile Suspended Solids (mg/l), first set of site values are before storm event while second set of values are after the storm event.

4.2.3. October 20, 1993

The third short-term event occurred on October 20, 1993. Approximately 0.5 inch of rain was received between 4:00pm on October 19 and 6:00pm on October 20th. Overflow samples were collected every 15 minutes following the beginning of the storm event. Heavier rain fell after 4:00am , which caused on overflow that continued until 10:00am. Three separate stream samples were collected from stream sites S4 and S5. The rainfall and CSO discharge hydrographs for this event are shown in Figure A.9. The results of the laboratory analyses for these samples is provided in Figures B.67-B.79 and Tables C.33-C.35. A summary of the results is provided in Table 4.4.

As can be seen from Table 4.4, the average constituent values all increased following the storm event (with the exception of DO, which decreased) indicating the impact of the storm event in decreasing the water quality associated with Banklick Creek. Following the storm event, the fecal coliform counts increased, the fecal strep counts decreased and the BOD, TSS, and VSS all basically stayed the same downstream of the two CSOs. As a result, it would appear that the impact of the CSO on BOD, TSS, and VSS loadings was minimal although the fecal coliform loadings did increase by a factor of ten.

Table 4.4. Average Constituent Values for October 20 Event

Site	BOD	DO	FC	FS	TSS	VSS
Site 4	4	6.0	2400	1120	301	10
Site 5	3	6.8	8000	100	15	1
CSO1	452	0.9	1.8×10^8	4.0×10^6	738	602
CSO2	305	---	1.6×10^7	6.6×10^5	455	291
Site 4	12	3.9	6.2×10^5	1.2×10^4	61	8
Site 5	11	5.8	1.1×10^6	9.5×10^3	59	7

Note: BOD = Biochemical Oxygen Demand (mg/l), DO = dissolved oxygen (mg/l), FC = Fecal Coliform (count per 100 ml), FS = Fecal Streptococcus (count per 100 ml), TSS = Total Suspended Solids (mg/l), VSS = Volatile Suspended Solids (mg/l), first set of site values are before storm event while second set of values are after the storm event.

4.2.4. November 17, 1993

The fourth short-term event occurred on November 17, 1993. A total of approximately 0.5 inches of rainfall was received on this date between the hours of 1:00 am and 2:00 pm. Baseline stream-samples were previously collected on November 16, 1993. This storm caused an overflow event to begin at approximately midnight on November 26 and continue through the afternoon. Overflow-samples were collected from both CSO #1 and #2 from between midnight to 4:00am and then again from between 10:15 and 2:00pm from CSO 1 only. During this event, 4 stream samples were collected from both stream sites S4 and S5. The rainfall and CSO discharge hydrographs for this event are shown in Figure A.10. The laboratory results from the analyses of these samples are provided in Figures B80-B91 and Tables C.36-C.39. A summary of the results are provided in Table 4.5.

Table 4.5. Average Constituent Values for November 17 Event

Site	BOD	DO	FC	FS	TSS	VSS
Site 4	15	17	31,000	8,000	60	11
Site 5	12	10	41,000	6,200	46	4
CSO1	223	8	$2.6x10^7$	$2.4x10^5$	62	36
CSO2	126	10	$9.9x10^6$	$1.5x10^5$	97	38
Site 4	14	10	$3.3x10^5$	$3.1x10^4$	294	34
Site 5	16	9	$1.4x10^5$	$2.5x10^4$	279	49

Note: BOD = Biochemical Oxygen Demand (mg/l), DO = dissolved oxygen (mg/l), FC = Fecal Coliform (count per 100 ml), FS = Fecal Streptococcus (count per 100 ml), TSS = Total Suspended Solids (mg/l), VSS = Volatile Suspended Solids (mg/l), first set of site values are before storm event while second set of values are after the storm event.

As can be seen from Table 4.5, the average constituent values all increased following the storm event (with the exception of DO, which decreased) indicating the impact of the storm event in decreasing the water quality associated with Banklick Creek. However, in this case, both fecal coliform and fecal strep counts were lower at Site 5 following the storm than at Site 4 but higher than the baseline events. As a result, the impact of the CSOs is masked as a result of increased loadings at Site 4. That is to say, it is unclear whether the increase in pollutant loadings at Site 5 are directly attributable to the CSO loadings or from other sources upstream of Site 4 that may have migrated down to Site 5 during the storm event.

4.4. Intermediate Events

Intermediate events consists of those events when the CSO overflow event occurred late at night or early in the morning and in which stream samples were taken the day before and the morning or afternoon following the overflow event. In general, the intermediate events were restricted to sampling at stream sites S4 and S5. A discussion of the two intermediate events is provided in the following sections.

4.4.1. July 14, 1993

The first intermediate event that was monitored occurred between 5:30pm and 8:00pm on July 14, 1993. During that time period, approximately 0.50 inch of rainfall occurred. Prior to the storm event, baseline water quality samples were collected at sites S4-S7. Two overflow samples were collected from CSO #1 (downstream from KY16), while one overflow sample was collected from CSO #2 (upstream from KY 177). The rainfall hyetograph and CSO discharge hydrographs for this event are shown in Figure A.1, while graphical histograms of the water quality analyses are shown in Figures B.1-B.8. The complete set of results is presented in tabular form in Tables C.2-C.4. A summary of the results is provided in Table 4.6.

Table 4.6. Average Constituent Values for July 14 Event

Site	BOD	DO	FC	FS	TSS	VSS
Site 4	9	4.1	40	---	18	11
Site 5	7	7.1	$4.9x10^4$	---	3	2
CSO1	13	---	---	---	80	45
CSO2	19	---	---	---	381	143
Site 4	20	2.9	$3.2x10^6$	$7.0x10^3$	333	205
Site 5	7	2.8	$7.5x10^6$	$1.0x10^4$	15	5

Note: BOD = Biochemical Oxygen Demand (mg/l), DO = dissolved oxygen (mg/l), FC = Fecal Coliform (count per 100 ml), FS = Fecal Streptococcus (count per 100 ml), TSS = Total Suspended Solids (mg/l), VSS = Volatile Suspended Solids (mg/l), first set of site values are before storm event while second set of values are after the storm event.

As can be seen from Table 4.6, the average constituent values all increased following the storm event (with the exception of DO, which decreased) indicating the impact of the storm event in decreasing the water quality associated with Banklick Creek. Following the storm event, both the fecal coliform counts and fecal strep counts increased downstream of the CSOs indicated their probable impact. Of particular note were the extremely low dissolved oxygen readings that were obtained after the storm event. Also of interest is the high level of fecal counts at Site 5 prior to the storm event. It is again hypothesized that these high levels may be due to prior loadings that have collected in the lower reach as a result of the backwater effects of the Licking River. However, these readings due not seem to correlate well with either the observed oxygen levels or the BOD levels.

4.4.2. September 3, 1993

The second intermediate event that was monitored occurred between 1:00am and 3:00am on September 3, 1993. During that time period, approximately 0.8 inch of rainfall occurred. Three overflow samples were collected from CSO #1, while no samples were collected from CSO #2 due to equipment problems. Each CSO sample was analyzed for the full range of water quality constituents. The rainfall and CSO discharge hydrographs for this event are shown in Table A.5, while graphical histograms of the water quality analyses are shown in Figures B.41-B.49. The complete set of results is presented in tabular form in Tables C.22-C.24. A summary of the results of this event are provided in Table 4.7

Table 4.7. Average Constituent Values for September 3 Event

Site	BOD	DO	FC	FS	TSS	VSS
Site 4	25	4.6	900	200	42	10
Site 5	22	5.6	$1.8x10^4$	---	43	5
CSO1	86	5.9	$2.4x10^7$	$1.3x10^5$	89	32
CSO2	---	---	---	---	---	---
Site 4	23	5.5	$4.6x10^5$	$2.4x10^4$	165	12
Site 5	32	6.2	$5.0x10^3$	$1.1x10^4$	221	17

Note: BOD = Biochemical Oxygen Demand (mg/l), DO = dissolved oxygen (mg/l), FC = Fecal Coliform (count per 100 ml), FS = Fecal Streptococcus (count per 100 ml), TSS = Total Suspended Solids (mg/l), VSS = Volatile Suspended Solids (mg/l), first set of site values are before storm event while second set of values are after the storm event.

The results from this storm event are very similar to the results of July 14, 1993 in that the baseline data reveal low fecal counts at stream Site 4 with very high counts at Site 5. Other than showing a general increase in the total pollutant loadings following the storm, the results from this storm fail to reveal any specific trends.

4.5. Long-Term Events

Long-term events consisted of those storm events when the stream samples were taken one day before and several days after a particular storm event. For each long-term event, stream samples were taken at all seven stream sampling sites (i.e. S1-S7). The long-term sampling protocol provided an opportunity to assess the impacts of both CSO #1 and CSO #2 as well as the migration effects of pollutants from the Lakeview Pumping Station SSO as the pollutants moved down the creek over the first few days following an storm event. During the sampling period, three different long-term events were monitored. Each of these events is discussed in the following sections.

4.5.1. August 4, 1993

Baseline samples were collected at all streamflow sites on August 3, 1993. On August 4, 1993 a 0.08 inch rainfall event occurred that caused a 0.5 hour overflow event to occur early in the morning. Within a couple of hours of the overflow event, stream samples were collected from all 7 sites. Additional post-storm samples were collected on August 5th and 6th. The rainfall hyetograph and CSO discharge hydrographs for this event are shown in Figures A.2. The results of the laboratory analysis of these samples are illustrated in Figures B.9-B.16 and Tables C.7-C11.

An examination of the various water quality parameters revealed three interesting observations. First, the baseline fecal coliform and fecal strep values were already well above acceptable levels. Second, the two small CSO overflows did not appear to significantly impact the pollutant loadings on Banklick Creek. For most cases, the pollutants loadings at stream site S5 were actually lower than at site S4. Third, the primary source of pollutants associated with the baseline data and the subsequent post overflow data would appear to be the SSO associated with the Lakeview Pump Station. This hypothesis is supported by the high BOC, FC, and FS levels and the extremely low DO levels at stream site S2. It should be noted that these conditions were already present in the baseline values for these constituents indicating the probable occurrence of a dry weather overflow event sometime prior to the actual storm event. It would also appear that there was an additional SSO overflow event associated with the storm event as evidenced by the increase in all pollutant loadings at site S2 on August 4. Based on an examination of the Figures B9-B16, it would appear that the storm of August 4 primarily created an overflow at the SSO along with the associated storm runoff displaced pollutants from the SSO pool, which then migrated down Banklick Creek over the next several days. This hypothesis is supported by the shift in pollutant loadings from site S2 to the downstream sites and by the general degradation of dissolved oxygen over the next several days.

Compared to baseline samples that were collected on August 3, 1993, fecal coliform counts increased at stream sites S4 and S5 for the first day after the rain. Fecal coliform remained relatively unchanged at the Lakeview stream sites (i.e. S1-S3) throughout the sampling period. Although 100,000,000 and 11,200,000 colonies per 100 ml were detected in samples collected from CSO 1 and 2, respectively, the associated stream data did not clearly identify the source of the pollutants.

The light rainfall and associated overflows on the 4th of August did not appear to greatly influence DO levels in Banklick Creek. DO levels remained around 5 mg/l at the Lakeview upstream site (i.e., S1) and around 1 mg/l at the Lakeview downstream site (i.e., S2). DO levels also remained above 5 mg/l at both stream sites S4, and S5 following the overflow event. The most noticeable decline was at site S4 which dropped from 12.3 mg/l (baseline) to 6.86 mg/l the day after the rain.

The BOD concentrations for individual sites were similar over the sampling period, although the BOD of the stream site downstream of Lakeview (i.e. S2) was markedly greater than the BOD of the other stream sites during the first 2 days of the sampling period. The results suggested little impact from the BOD of the overflows detected from CSOs 1 (94 mg/l) and 2 (73 mg/l).

Total and volatile suspended solids increased from 19 to 202 mg/l and from 7 to 42 mg/l, respectively, from the day before to the day after the storm for the stream site downstream of the Lakeview CSO. TSS and VSS remained essentially unchanged for other stream sites over the sampling period.

4.5.2. August 24, 1993

Approximately 0.5 inch of rainfall was received on the night of August 24th, which triggered an overflow of a 2 hour duration. Overflow samples were collected between 8:30am and 9:30pm. The first set of samples were collected after the rainfall from 10:30am to 1:30pm on August 25. Addition samples were collected from all 7 sites on August 26 and 27. The laboratory results of these samples are presented in Figures B.31-B.40 and Tables C.16-C.20.

Similar to the event of August 4, 1994, the baseline values would appear to indicate the prior occurrence of a dry weather overflow event at the Lakeview Pump Station SSO. This hypothesis is supported by the high pollutants loadings and associated low dissolved oxygen readings at site S2. As with the previous event, it would appear that the storm event caused an additional SSO overflow event to occur downstream of the Lakeview Pump Station which then migrated downstream to the other sites. As with the previous storm, this had the impact of significantly decreasing the dissolved oxygen values at the downstream sites although some recovery was observed by August 6th.

The impacts of the two CSOs on the lower reach of Banklick Creek are somewhat inconclusive although the pollutant loadings at Site S5 generally show an increase with regard to Site S4. It should be noted, however, that both sites show significant increases together, indicating a significant pollutant source upstream of site S4. Currently, this is thought to be attributable to the Lakeview Pump Station SSO although there may be some additional secondary sources that may be influencing the loadings at site S4.

Fecal coliform concentrations of samples collected on August 25 from sites S4 and S5 were markedly greater than those of baseline samples collected from these locations on 23 August. The increase in fecal coliform counts reflected the impact of overflows that contained fecal coliform concentrations as high as 25,000,000 colonies per 100 ml. As seen from the figures, fecal coliform levels remained elevated over the 3-day sampling period.

Fecal streptococci results implied a trend similar to that of fecal coliform. Following the storm event, the number of streptococci colonies increased at both sites S4 and S5 as well as unexpectedly upstream of the Lakeview SSO (Site S1). In contrast, the baseline streptococci count at the stream site downstream of the Lakeview SSO exceeded that of post-storm samples collected there. Over the 3-day period, generally streptococci levels fell at stream sites. A comparison of the streptococci levels detected at site S4 and S5 did not indicate that discharge from the sampled SSO had a significant additive impact on stream levels of streptococci.

DO levels decreased following the storm at the 3 most downstream sites and DO remained below 1 mg/l downstream of the Lakeview SSO at site S2. It appears that DO began to increase by August 27, 3 days after the storm. BOD increased the day after the storm at stream sites S2-S5. BOD in overflow samples reached 140 mg/l but did not appear to greatly impact BOD levels at site S5.

TSS and VSS followed similar trends. Results for both parameters indicated that solids increased following the storm and in general decreased over the 3-day sampling period. The concentration of solids was greater in the overflow samples collected during the first hour than during the those collected in the second hour. The consistently higher solid values at site S4 as compared to site S5 indicated that solids discharged between the two sites did not noticeably increase their concentration in the stream.

4.5.3. September 15, 1993

On the morning of September 15, 1993, approximately 0.5 inch of rain was received. A combined sewer overflow event subsequently occurred in CSO #1 at approximately 4:00 am. This event triggered the automatic sampler (CSO #1 only), which collected samples for 3 nonconsecutive hours. The rainfall hyetograph and CSO discharge hydrographs for this event are shown in Figure A.6. The laboratory results of the samples collected from this event are illustrated in Figures B.50-B.57 and Tables C.25-C.29.

As with the previous two events, the baseline values would appear to indicate the prior occurrence of a dry weather overflow event at the Lakeview Pump Station SSO. This hypothesis is again supported by the high pollutants loadings and associated low dissolved oxygen readings at site S2. Unlike the previous two events, it does not appear that the storm event caused an additional SSO overflow event to occur downstream of the Lakeview Pump Station, although it may have flushed out some of the pollutants in the pool downstream of the site, which may then have migrated downstream to the other sites. This hypothesis is supported by two observations. First, unlike the previous two storms, the associated dissolved oxygen values were only marginally affected by the pollutant loadings. Second, the majority of pollutants loadings downstream of site S2 actually decreased following the storm event (the dissolved oxygen values actually increased). However, while the pollutant loadings at site S2 appeared to decrease following the storm event, the pollutant loadings at site S1 actually increased. The most likely source of this increase in pollutant loadings would be from an overflow event at the Lakeview Pump Station itself, which is located further upstream from site S1. Thus while it would appear that an overflow event did not occur at the Lakeview Pump

Station SSO, it does appear probable that a pollutant discharge did occur from the pump station itself.

As with the previous storm, the impacts of the two CSOs on the lower reach of Banklick Creek are somewhat inconclusive although the pollutant loadings at Site S5 generally show an increase with regard to Site S4, especially the fecal coliform loadings. It should be noted, however, that both sites show significant increases together, indicating a significant pollutant source upstream of site S4. As with the previous cases, this is thought to be attributable to the Lakeview Pump Station SSO, although there may be some additional secondary sources that may be influencing the loadings at site S4.

The concentration of fecal coliform in the samples collected on September 15th was greater than that in baseline samples collected on September 13th for sites S3-S5, while the fecal coliform counts decreased just downstream of the Lakeview SSO at site S2. Fecal coliform in overflow samples collected from CSO 1 exceeded 200,000,000 colonies in 100 ml of sample, which appeared to lead to an increase in the concentration of fecal coliforms in the stream as evidenced by the higher concentration of coliform at both sites S4 and S5 for all sampling days. Fecal coliform concentrations appeared to decrease by September 17.

Compared to baseline samples fecal streptococci was greater at all stream sites on September 15. The most notable difference was at site S5, which increased from 20 to 16,800 colonies per 100 ml, again suggestive of the impact of the upstream CSOs. The streptococci in samples collected on subsequent days decreased for most sites.

Compared to the baseline readings, the dissolved oxygen (DO) decreased, albeit slightly, at sites S3-S5 and increased just downstream of the Lakeview CSO at site S2. Otherwise DO did not vary significantly during the sampling period. The high level of BOD from all of the 3 overflow samples (all from CSO1), ranging from 273 to 484 mg/l, did not correlate with the relatively low BOD readings (11 mg/l) from the sample readings associated with site S5. Interestingly, results from samples collected at the stream site downstream of the Lakeview SSO indicated a decrease in BOD at this location following the storm event.

TSS and VSS did not noticeably increase following the storm event at sites S3-S5, despite the high solid concentrations detected in overflow samples. In contrast, solid concentrations of the samples collected from the 2 stream sites that bracketed the Lakeview SSO (i.e S1 and S2) did increase for the day after the storm only.

4.6. Baseline Events

In addition to the data associated with the observed storm events, several data were taken in anticipation of a storm event that never occurred. The results of the water quality analyses associated with these events are provided in Appendix C.

4.7. Priority Pollutant Events

Three separate priority pollutant samples were collected during the study. Analyzed parameters included 1) total cyanide, 2) ammonia nitrogen, 3) phenols, 4) total phosphorus, 5) metals, 6) organic pesticide/ herbicides, 7) organic pesticides/pcbs, 8) organic semivolatiles, 9) and organic volatiles. The results of each of the three samples are discussed in the following sections.

4.7.1 July 16, 1993

The first sample was taken from CSO #2 on July 16, 1993. All parameters values that were measured above detectable limits are shown in Table 4.8. The complete set of results of the analysis are provided in Appendix D.

4.7.2 August 26, 1993

The second sample was taken at stream site S2 just downstream from the Lakeview Pump Station SSO. All parameter values that were measured above detectable limits are shown in Table 4.9. The complete results are provided in Appendix D.

Table 4.8 Priority Loadings for Site S2 on August 26, 1993

Parameter	Results (mg/l)
Cyanide	0.005
Nitrogen Ammonia	7.900
Oil & Grease	7.000
Phenols	0.019
Total Phosphorus	1.600
Total Cadmium	0.010
Total Chromium	0.012
Total Copper	0.018
Total Lead	0.008
Total Zinc	0.030
Toluene	0.098

Table 4.9 Priority Pollutant Loadings for CSO#1 on July 16, 1993

Parameter	Results (mg/l)
Cyanide	0.006
Nitrogen Ammonia	1.600
Oil & Grease	19.00
Phenols	0.021
Total Phosphorus	1.300
Total Chromium	0.010
Total Copper	0.0420
Total Lead	0.010
Total Silver	0.0025
Total Thallium	0.009
Total Zinc	0.007

4.7.3 December 10, 1993

The third sample was take at CSO#1. All parameter values that were measured above detectable limits are shown in Table 4.10. The complete set of results of the analysis is provided in Appendix D.

Table 4.10 Priority Loadings for CSO#1 on December 10, 1993

Parameter	Results (mg/l)
Cyanide	0.005
Nitrogen Ammonia	4.900
Oil & Grease	9.000
Phenols	0.034
Total Phosphorus	2.100
Total Copper	0.018
Total Silver	0.0013
Total Zinc	0.040
Chloroform	0.007

V. WATER QUALITY MODEL PARAMETERS

5.1. General Parameters

There are numerous physical, chemical, and biological parameters that can be monitored in a stream system. These parameters can provide clues as to the source of pollution entering the system. They are also useful tools for characterizing the overall health of a surface water and predicting its response to pollutant loads. The parameters monitored in the Northern Kentucky Combined Sewer Overflow (CSO) Study for Banklick Creek consisted of:

1) Physical Parameters:	Temperature
	Flow
2) Chemical Parameters:	Dissolved Oxygen (DO)
	pH
	Conductivity
	Five Day BOD
	Total Suspended Solids (TSS)
	Volatile Suspended Solids (VSS)
	Priority Pollutants (at select locations)
3) Biological Parameters:	Fecal Coliform (FC)
	Fecal Streptococcus (FS)

Although suspended solids are often considered a physical parameter, they will be classified in this report as a chemical parameter. This is done because the relationship between TSS and VSS is indicative of the chemical composition of the suspended solid.

Following is a brief summary of the significance of each parameter as well at the type of information that may be obtained by studying them. In addition a brief discussion of the expected parameter correlations is provided.

5.2. Flow

The CSO study estimated the flow in Banklick Creek and directly measured the flow of selected CSO discharges. Flow is a crucial variable because pollutant loading and transport is entirely dependent upon it. Flow also effects how sensitive the water system is to pollutant stress. Also, when receiving water flow rate is estimated, the location of critical (or minimum) dissolved oxygen content can be predicted.

5.3. Temperature

Temperature is a very important parameter because of its effects on the ability of various chemical reactions to occur, as well as corresponding reaction rates. The dissolved oxygen content of water varies with temperature, as does biological activity.

5.4. Dissolved Oxygen

Dissolved Oxygen (DO) is one of the most useful indicators of the health of a water system. DO is required for the respiration of aerobic microorganisms that consume organic pollutants in water, as well as all other aerobic life forms. It also represents the receiving water's ability to recover from organic pollutant loadings, such as CSO discharges. Kentucky's water quality criteria for DO is > 5 mg/l.

5.5. pH

Like temperature, pH has important effects on the survival and growth rate of microorganisms. The optimum pH for growth is 6.5-7.5.1. Measured pH values less than 4 and greater than 9 are harmful to aquatic life. The pH also effects the formation of various chemical complexes. The forming of complexes can place toxic constituents into a form that is not bioavailable and therefore no longer toxic.

5.6 Conductivity

The conductivity of water indicates the amount of free ions in solution. Water that is free of dissolved mineral salts has little capacity for carrying electric current, making its conductivity low.

5.7 BOD5

Five-day BOD is the most widely used measure of organic pollution. It determines the quantity of oxygen that will be required to biologically stabilize the organic matter present. This parameter is valuable for predicting the oxygen depletion that the water system will experience.

5.8 Total Suspended Solids:

Total Suspended Solids (TSS) is the solid matter in water that will not settle out and cannot be removed by filtration. The material is removed by biological oxidation. Because of this, when there is an increase in TSS, there will generally be a decrease in DO. High TSS will also effect water color, and reduce plant photosynthesis. In contrast though, high TSS can reduce the toxicity of metals. Dissolved metals tend to adsorb onto particles of suspended matter, making them nontoxic to aquatic life.

5.9 Volatile Suspended Solids

Volatile Suspended Solids (VSS) is a portion of TSS. It represents the organic content (versus the mineral content) of TSS. High VSS indicates that the pollution source is organic in nature, such as domestic sewage. The biological oxidation associated with high VSS loading will reduce the DO concentration.

5.10 Fecal Coliform

Fecal Coliform (FC) is an indicator organism that lives in the intestinal tract of humans and other animals. Its presence in water indicates that other pathogens (such as salmonella) may also be present. Due to its origin, increased FC counts indicate increased organic pollutant loading. The water quality standard for water contact is 200 counts/100 ml.

5.11 Fecal Streptococcus

Fecal Streptococcus (FS), like FC is an indicator organism that lives in the intestinal tract of humans and animals. The difference between FC and FS is that FS is more indicative of animal waste. This is because the quantity of fecal coliforms and fecal streptococci that are discharged by humans are significantly different from the quantities discharged by animals. The ratio of FC/FS can indicate if the source of pollution tends to be from animal or human waste.

5.12 Priority Pollutants

Priority Pollutants include those pollutants that are suspected to be a carcinogen, mutagen, geratogen, or have a high acute toxicity. The presence of a high concentration of a priority pollutant can provide clues regarding the source of pollution. It could also indicate appropriate locations to focus pollutant elimination/minimization efforts. A complete Priority Pollutant scan was conducted at three locations on Banklick Creek. One was conducted at a stream sampling site, while the other two were collected from CSO discharges. The results of three scans indicate that significant concentrations of Priority Pollutants are not present in Banklick Creek.

5.13 Discussion:

Correlation analysis can provide an indication of the interdependence between two parameters. A strong correlation between parameters may imply similar sources or other related factors that deserve further examination. However, if a weak correlation, or no correlation is found where a strong one is expected, this requires investigation as well. It could mean that some previously ignored variable has significant impact on the water system, and must be taken into consideration.

5.13.1 Flow/Pollutant Correlations - Often, flow can be expected to exert the main influence on pollutant concentrations, although many other factors also have an influence. Flow is highly variable, which can make it difficult to determine the relationship between flow and concentration. Generally, flow exhibits an inverse relationship with concentration.

The flow/concentration relationship is more difficult to determine in faster flowing waters. It is easier to evaluate standing water, because the longer residence time gives the pollutants a chance to react, allowing their effects to be evaluated.

The study of Banklick Creek revealed that its response to pollutant loading was highly dependent on flow. During low flow conditions, even a relatively small rain storm could result in an extremely adverse response and slow recovery. Pollutants accumulated in the system, causing high BOD and bacterial counts, and low DO. Large rain storms produced greater CSO discharges, but also significantly increased the stream flow. The result was that the pollutants were flushed out and the stream recovered quickly.

5.11.2 Flow/DO Relationships - In contrast to the flow/pollutant concentration relationship is the flow/DO concentration relationship. The flow/DO relationship is a direct proportion (up to a maximum limit for DO concentration). This is because high flow has turbulent mixing which entrains air. Also, the increased residence time that organic pollutants have in a low-flow scenario allows for more bioactivity. The bioactivity depletes the quantity of oxygen available. This relationship was quite noticeable on Banklick Creek. During high-flow conditions, DO concentrations did not drop below Kentucky's water quality standard of 5 mg/l. O < 5 mg/l was common during periods of low-flow.

5.11.3. Temperature/DO Relationship - Oxygen gas is more soluble at lower temperatures, which allows DO concentrations to increase as temperature decreases. Another factor that contributes to this relationship is that bioactivity increases with increasing temperatures, therefore microorganisms consume more DO at higher temperatures. This relationship was noticeable on Banklick Creek. The DO range in the late summer tended to vary between 3 mg/l-7 mg/l and in the late fall between 6 mg/l-10 mg/l.

5.11.4. pH/Conductivity Relationship - pH reflects the carbon dioxide content of water. Water with high pH generally has higher levels of carbonates and associated salts, which would produce a higher conductivity. In contrast, higher pH also allows the formation of organic and inorganic complexes, which would reduce the conductivity. This is a difficult relationship to characterize because these two factors act in opposite directions. The Banklick Creek results do not indicate a relationship between these two parameters.

5.11.5. pH/Bioactivity Relationship: pH has an important effect on the survival and growth rate of bacteria. Acidic waters tend to have lower nutrient contents and less abundant aquatic life. The optimum pH for growth is between 6.5-7.5. The pH of Banklick Creek facilitates optimum growth, with pH values normally between 7.0-8.0. Algal growths that were observed in the creek throughout the summer are evidence of this relationship.

5.11.6 BOD/DO Relationship - Since BOD is an indication of the oxygen depletion potential of a water sample, an inverse relationship would be expected to exist between the two parameters. This relationship was not readily observed on Banklick Creek. This could be due to several factors. Oxygen can be introduced to the water through turbulent mixing, increasing the DO content. The amount of time that has passed since the pollutant was introduced and the sample was taken will also have a strong influence. If only a short time has passed, both BOD and DO could be elevated because little bioactivity has occurred yet. If the pollutant has existed in the system for some time, both the organic matter and oxygen content would be reduced. Therefore, this relationship will only occur when the BOD load exceeds the water's oxygen content, and if a significant period of time has passed that allows bioactivity to occur.

5.11.7. BOD/Fecal Coliform Relationship - Since BOD is an indication of organic pollution and FC is an indication of human or animal waste, a direct relationship would be expected between these two parameters. This was not a consistent relationship on Banklick Creek. Fecal Coliform counts tended to remain elevated more so than did BOD concentrations. This inconsistency could be due to the pollutants' residence time in the receiving water, if BOD has a faster decay rate than FC.

5.11.8. TSS/VSS Relationship - VSS represents the organic portion of TSS. Throughout the Banklick Creek study the proportion of VSS to TSS remained consistent, with the majority of TSS being organic in nature. This indicates that the pollution has a consistent composition that is primarily organic. Domestic sewage discharges would fit this description.

5.11.9. TSS/Toxic Metals Relationship - As TSS increases, the toxicity of metals in water decreases. This is because the adsorption of metals onto particulates increases as the solids concentration increases. In this form, metals are not bioavailable, and therefore not toxic. This relationship was not investigated on Banklick Creek because the priority pollutants scans indicate that significant concentrations of metals are not present.

5.11.10. FC/FS Relationship - The FC/FS relationship is a useful one to study because the ratio of FC to FS is a good indicator of whether the pollutant source is from human or animal waste . A FC:FS ratio greater than four indicates that the source of bacteria is from human waste, while a FC:FS ratio less than one indicates that the origin is from animal waste. This was not a consistent relationship on Banklick Creek, although normally FC was much greater than FS. This inconsistency may be due to different decay rates between FC and FS. Because of this and other limitations, the FC:FS ratio may be useful as a broad indicator of pollutant source, but should not be relied on solely. This ratio, as applied to Banklick Creek, indicates that the pollutant source is from human waste.

5.12. Data Interpretation

The correlations listed above can assist in data interpretation and predictions of water system response. Care must be taken however when evaluating data because failure to consider all variables involved can lead to incorrect conclusions. Such variables include masking effects of one parameter on another and differential flow within the system.

Masking can be described as one parameter acting on another in such a manner that false conclusion can be drawn from the data. Examples of masking are:

- Various chemical constituents may inhibit microorganism growth. This will yield a low five day BOD test result, compared to the result if the chemical constituents were not present.

- Photosynthesis of aquatic plants can produce elevated DO levels which would indicate a healthy water system. At night those DO levels could drop significantly and cause fish kills.

- High suspended solids concentrations can inhibit plant growth by preventing the penetration of sunlight. This could mask the presence of high nutrient concentrations.

Differential flow within the stream has a strong influence on pollutant transport and residence time. Predictions of system response can be completely wrong if a bad assumption regarding flow in the system is employed. Banklick Creek, for example, has variable flow characteristics. They range from ponding water, to meandering flow, to steady flow, to backflow, at different locations in the creek. These vary significantly with runoff.

5.13. Conclusion

To correctly characterize the health of a water system, all variables acting on the system should be studied. Placing disproportionate weight on one parameter or another can lead to incorrect conclusions. There are numerous interrelationships that can occur at any point in time. Because of this, it is important to become very familiar with the water system over time. This is the only means of identifying trends and characterizing the system's health.

VI. SUMMARY AND CONCLUSIONS

The objective of this study was to quantify the impact of combined sewer overflows on Banklick Creek. This was accomplished by instrumenting and sampling two combined-sewer discharge pipes along with seven, separate stream locations. The two combined-sewer discharge pipes were located between KY16 and KY177, while the stream samples were collected at various points between I275 and the mouth of Banklick Creek. Initial baseline sampling of the creek indicated the probable occurrence of additional overflows at the Lakeview Pump Station creek crossing. Because of technical restrictions, this site was not instrumented, although stream samples were taken upstream and downstream of the site in an attempt to assess its possible impact.

The results of this study indicate that pollutant loadings on the creek always increased following a storm event - the BOD loadings were lower than expected, while the fecal loadings were much higher than expected. Of particular interest was the fact that the two monitored CSOs located between KY16 and KY177 were observed to overflow in response to rainfall events as small as 0.05 inches. In general, many of the CSO pollutants loadings exhibited a first flush phenomenon, indicating either the influence of stormwater pollutants on the resulting loadings or the scouring of biological loadings that may have already been present in the sewer. Many of the pollutant loadings associated with the higher intensity storms were higher than originally anticipated, indicating the possible significant impact of stormwater pollutants on the CSO discharges.

In general, the ratio of VSS to TSS in the CSO discharges was consistent with the expectation that the primary source would be due to organic loadings. As expected, the observed ratio in the stream samples was much lower, which would be expected in the presence of more inorganic loadings. The ratio of FS to FC in the CSO discharges was again generally consistent with ratios indicative of human fecal loadings, while the ratios in the stream were again less, which would be expected as a result of the influence of non-human wastes that find their way into the stream.

No strong relationship was established between the observed dissolved oxygen levels and the associated BOD concentrations. It is possible that this relationship may be affected by the presence of other chemicals within the stream. In addition, significant eutrophication was observed within certain reaches of the creek during the months of July and August.

The various baseline samples would appear to indicate the possible occurrence of dry weather overflows associated with the SSO downstream of the Lakeview Pump Station. Stream samples on the upper reaches of Banklick Creek also would appear to indicate the occurrence of wet weather overflows associated with both the Lakeview Pump Station SSO and the Lakeview Pump Station itself.

The upper reach of Banklick Creek consists of a series of pools. The Lakeview Pump Station SSO was observed to discharge into a frequently stagnant stream pool that resulted in especially high fecal and low DO readings. Following significant storm events, it appears that the pollutants from this pool are displaced and move down the creek as pollutant plugs or cells. In general, it would appear that the loadings from these sites had a much greater impact on the subsequent stream water quality than the observed CSO discharges.

In summary, it would appear that the primary source of water quality problems on Banklick Creek are from both dry and wet weather overflows associated with the Lakeview Pump Station. The impact of the two CSOs on the stream quality was observable in many storm events although it was somewhat unclear in others. This variability may be somewhat attributable to the magnitude of the storm event and the resulting CSO discharge, the water quality dynamics of the creek, and the masking effect of pollutants that appear to migrate down from the Lakeview Pump Station site. Both the flow and water quality dynamics appear to be significantly influenced by the backwater effect from the Licking River and the storage effect from off- channel storage along the north side of the creek. Travel times between KY16 and KY177 are highly variable and seem to be dependent upon both storm magnitude (flow) and the initial river stage. In some cases, flows in the lower reach were observed to be stopped or even moving upstream. In such instances the lower reach effectively became a stagnant pool.

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7. U. S. Department of Agriculture soil Conservation Service, Water Quality Indicators Guide, 1986.

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APPENDIX A

Table A.1 Stream Water Quality Parameters on May 05, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1234	7.56	400	21.4	.32	7.70
2	1225	7.90	2800	21.8	.32	7.70
3	1219	8.80	6000	22.4	.33	7.90
4	1217	8.66	7000	22.0	.33	7.94
5	1215	8.38	8000	21.7	.33	7.88
6	1102	7.11	5200	21.2	.34	7.64
7	1052	7.03	6900	21.3	.35	7.62
8	1045	7.15	5700	21.3	.35	7.67

Table A.2 Stream Water Quality Parameters on May 21, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	---	---	170	---	---	---
2	1155	8.90	100	19.4	0.38	7.73
3	1135	8.80	1700	19.2	0.39	7.70
4	1122	8.70	1800	19.0	0.40	7.91
5	1112	8.54	2300	19.0	0.40	8.27
6	1102	7.78	2700	18.9	0.38	8.03
7	1055	7.73	17000	19.1	0.74	8.23
8	1040	8.70	3900	19.5	0.36	7.70

Table A.3 Stream Water Quality Parameters on May 25, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1045	9.14	30	19.9	0.28	---
2	1035	9.20	40	19.9	0.28	---
3	1025	8.75	600	19.2	0.29	---
4	1022	8.92	500	19.2	0.29	---
5	1017	8.80	400	19.2	0.29	---
6	1005	8.73	1200	19.1	0.29	---
7	955	8.85	1400	18.8	0.30	---
8	940	9.08	1600	19.7	0.31	---

Table A.4 Stream Water Quality Parameters on May 27, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1125	8.65	10	20.9	0.30	7.50
2	1107	8.36	20	20.9	0.30	7.53
3	1100	8.55	40	20.7	0.29	---
4	1050	8.18	60	20.6	0.29	7.44
5	1045	8.28	90	20.6	0.29	7.56
6	1032	8.27	3200	20.9	0.29	7.30
7	1024	8.55	1200	20.8	0.29	7.44
8	1020	8.95	1300	20.5	0.32	7.56

Table A.5 Stream Water Quality Parameters on June 10, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1137	7.20	600	19.0	---	7.40
2	1111	7.40	2000	19.3	0.20	7.28
3	1104	7.50	2400	19.3	0.20	7.10
4	1059	7.35	900	19.3	0.20	7.26
5	1050	7.37	1000	19.2	0.19	7.22
6	1034	7.15	900	19.5	0.19	7.29
7	1024	7.08	3400	19.8	0.19	7.24
8	1013	7.43	2500	19.7	0.19	8.05

Table A.6 Stream Water Quality Parameters on June 16, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1227	5.70	25000	20.5	---	7.40
2	1203	5.60	19000	20.5	---	7.25
3	1155	---	16600	---	---	7.20
4	1153	5.90	16600	20.5	---	7.27
5	1108	5.60	3300	21.0	---	7.46
6	1054	5.60	9600	20.5	---	7.48
7	1042	5.50	30000	20.5	---	7.51
8	1035	5.50	7300	21.0	---	7.67

Table A.7 Stream Water Quality Parameters on June 24, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1013	7.43	2500	19.7	0.19	8.05
2	1034	7.15	900	19.5	0.19	7.29
3	1050	7.37	1000	19.2	0.19	7.22
4	1059	7.35	900	19.3	0.20	7.26
5	1104	7.50	2400	19.3	0.20	7.10
6	1111	7.40	2000	19.3	0.20	7.28
7	1120	5.10	105000	21.8	0.58	7.50
8	1137	7.20	600	19.0	---	7.40

Table A.8 Stream Water Quality Parameters on June 28, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1110	6.91	---	27.6	0.28	7.70
2	1056	6.88	310	27.6	0.28	7.75
3	1052	6.72	1000	27.0	0.28	7.60
4	1044	6.70	800	27.1	0.28	7.61
5	1045	6.36	530	26.8	0.28	7.58
6	1025	5.72	1700	26.6	0.29	7.45
7	1010	5.60	4400	26.4	0.29	7.47
8	1002	7.00	3800	26.8	0.43	7.54

Table A.9 Stream Water Quality Parameters on June 30, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1050	6.80	---	24.8	---	7.90
2	1031	6.53	700	25.6	0.29	7.83
3	1025	6.70	1200	25.7	0.29	7.90
4	1024	6.90	32000	25.7	0.29	7.87
5	1018	6.90	500	25.7	0.29	7.91
6	952	7.15	6000	26.5	0.30	8.04
7	947	---	10400	26.5	0.30	7.97
8	942	7.25	18400	26.5	0.30	8.02

Table A.10 Stream Water Quality Parameters on July 08, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1125	6.90	190	30.1	0.34	7.80
2	1105	6.68	700	30.1	0.34	7.78
3	1059	6.55	1800	29.7	0.34	7.70
4	1055	6.01	1300	30.0	0.34	7.69
5	1050	6.50	1800	29.5	0.34	7.75
6	1032	6.06	9200	29.8	0.31	7.68
7	1025	5.85	10200	29.4	0.32	7.69
8	1020	5.79	40000	29.4	0.32	7.66

Table A.11 Stream Water Quality Parameters on July 23, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1100	5.40	20	28.8	0.28	7.60
2	1043	5.85	20	28.6	0.29	7.73
3	1036	5.76	120	28.3	0.30	7.70
4	1034	5.80	130	28.3	0.29	7.64
5	1030	5.80	50	27.9	0.30	7.62
6	1015	4.49	6000	25.1	0.30	7.51
7	1000	3.58	2400	27.9	0.31	7.40
8	957	7.30	14000	29.0	0.41	7.65

Table A.12 Stream Water Quality Parameters on July 27, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1140	5.00	29	19.9	0.32	7.50
2	1120	5.13	30	29.8	0.31	7.50
3	1123	5.78	70	29.6	0.32	7.50
4	1107	6.90	190	30.4	0.30	7.76
5	1051	5.47	500	29.6	0.31	7.48
6	1028	4.49	3400	29.4	0.30	7.27
7	1020	8.10	4700	29.9	0.46	7.85
8	1010	9.00	10000	30.2	0.47	8.04

Table A.13 Stream Water Quality Parameters on July 29, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1140	5.00	520	29.2	0.32	7.50
2	1126	6.90	70	30.0	0.32	7.79
3	1123	5.78	270	29.6	0.32	7.50
4	1120	5.50	160	29.7	0.31	7.50
5	1115	5.22	940	29.6	0.31	7.38
6	1106	4.26	5100	30.0	0.34	7.37
7	1102	5.76	300	28.0	0.42	7.47
8	1100	7.20	400	30.1	0.46	7.45

Table A.14 Stream Water Quality Parameters on August 20, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1040	7.00	2200	---	---	---
2	1032	7.00	2000	---	---	---
3	1029	6.90	600	---	---	---
4	1026	7.00	1500	---	---	---
5	1021	6.90	1100	---	---	---
6	1012	6.70	4300	---	---	---
7	1006	6.70	7600	---	---	---
8	1003	7.10	6100	---	---	---

Table A.15 Stream Water Quality Parameters on August 23, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1140	7.38	60	23.3	0.20	---
2	1127	7.50	140	23.9	0.20	---
3	1122	7.54	150	23.5	0.20	---
4	1120	7.50	100	23.5	0.21	---
5	1115	7.60	140	23.8	0.21	---
6	1107	7.67	1100	24.0	0.21	---
7	1057	7.30	500	28.1	0.48	---
8	1050	7.56	280	28.6	0.50	---

Table A.16 Stream Water Quality Parameters on August 26, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1123	8.80	10	27.3	0.21	8.40
2	1102	8.80	7000	27.0	0.22	8.36
3	1058	9.19	13900	27.1	0.22	8.40
4	1055	9.05	13000	26.7	0.22	8.44
5	1045	10.70	13700	26.7	0.22	8.78
6	1030	8.10	3900	29.1	0.49	8.40
7	1028	7.10	4400	29.2	0.49	7.90
8	1025	7.00	3300	29.5	0.50	7.87

Table A.17 Stream Water Quality Parameters on August 31, 1993

ID	TIME	Diss Oxy	Fecal Coliform	Temp	Cond	pH
1	1045	8.30	90	28.5	0.24	8.30
2	1020	8.10	90	28.4	0.24	8.28
3	1016	8.80	260	28.4	0.24	8.40
4	1015	9.13	290	28.4	0.24	8.47
5	1010	9.42	2800	28.5	0.23	8.59
6	1008	7.43	6300	29.6	0.47	7.99
7	1005	7.00	2200	29.7	0.52	7.89
8	1000	7.63	1600	30.1	0.54	8.00

APPENDIX B

Figure B.1 Dissolved Oxygen May 05, 1993

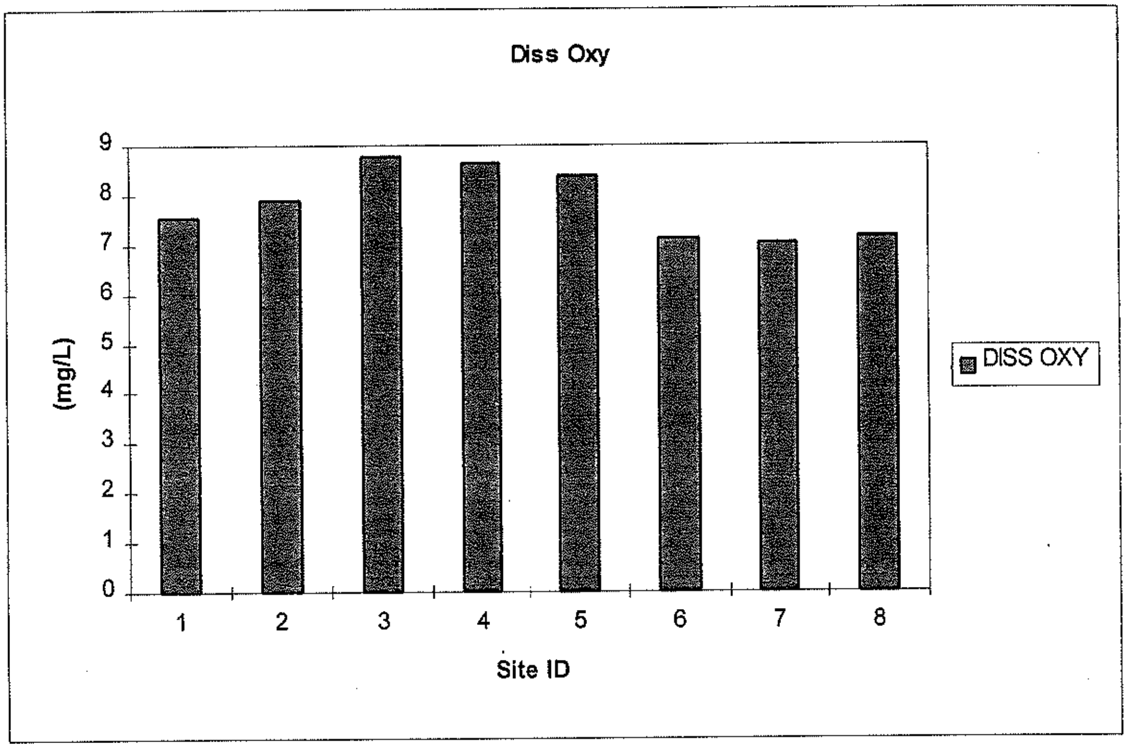


Figure B.2 Fecal Coliform May 05, 1993

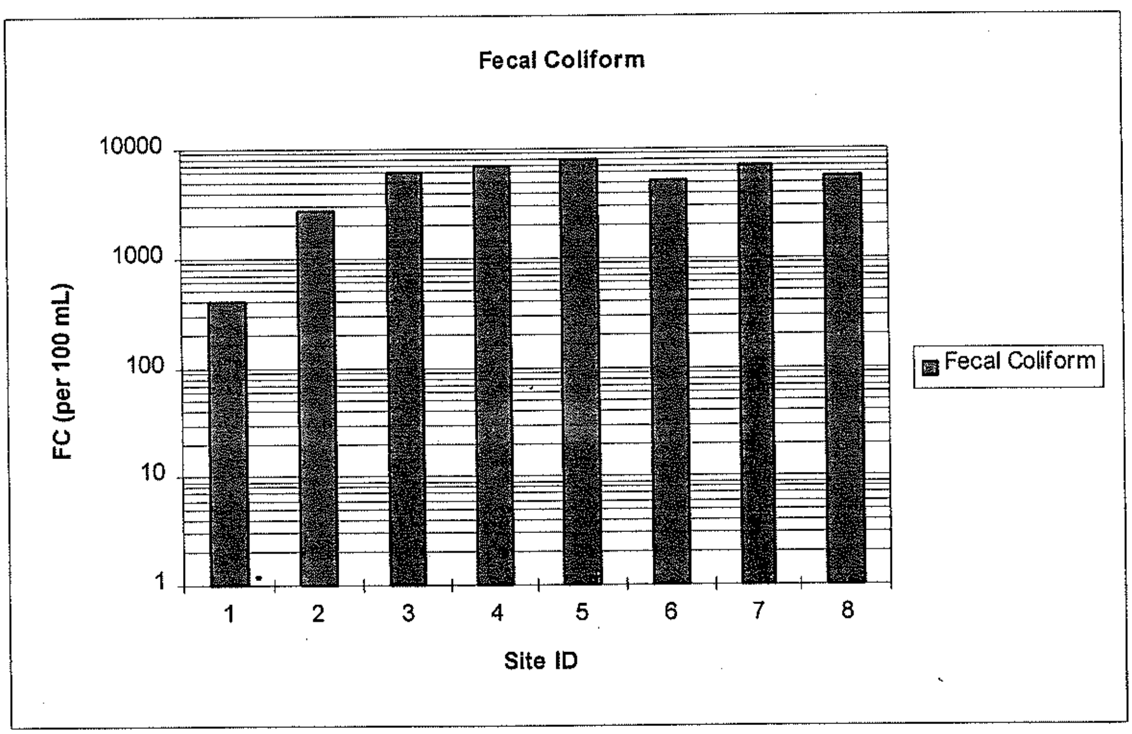


Figure B.3 Dissolved Oxygen May 21, 1993

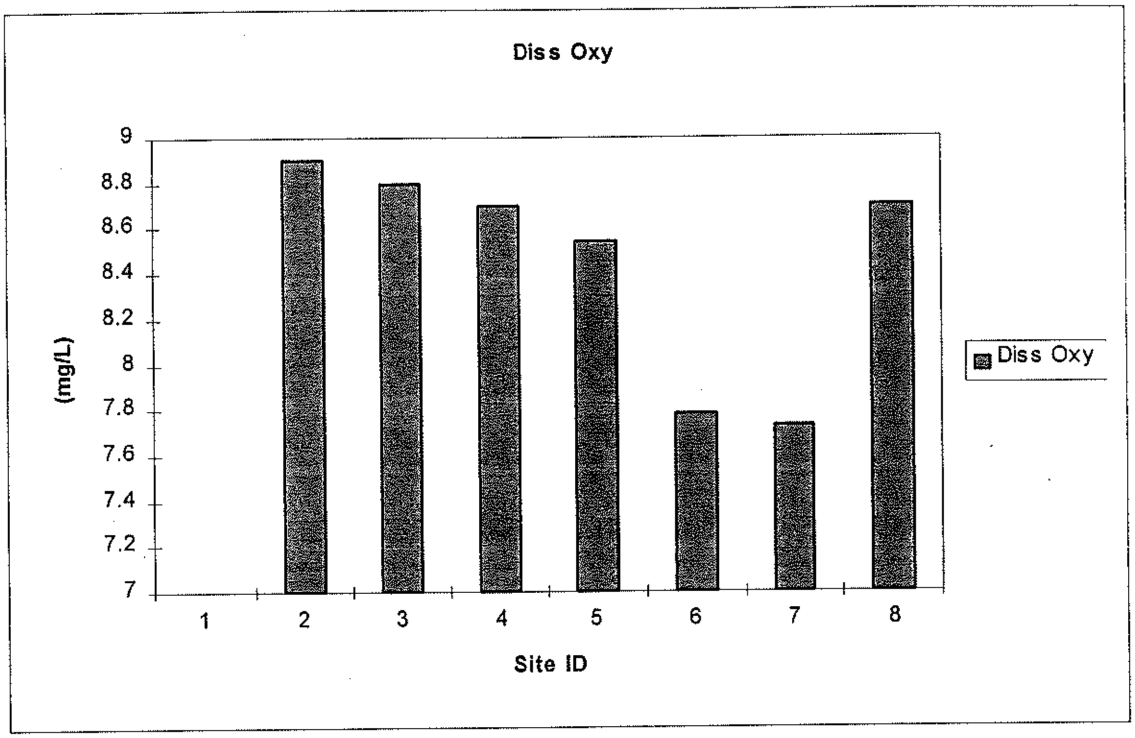


Figure B.4 Fecal Coliform May 21, 1993

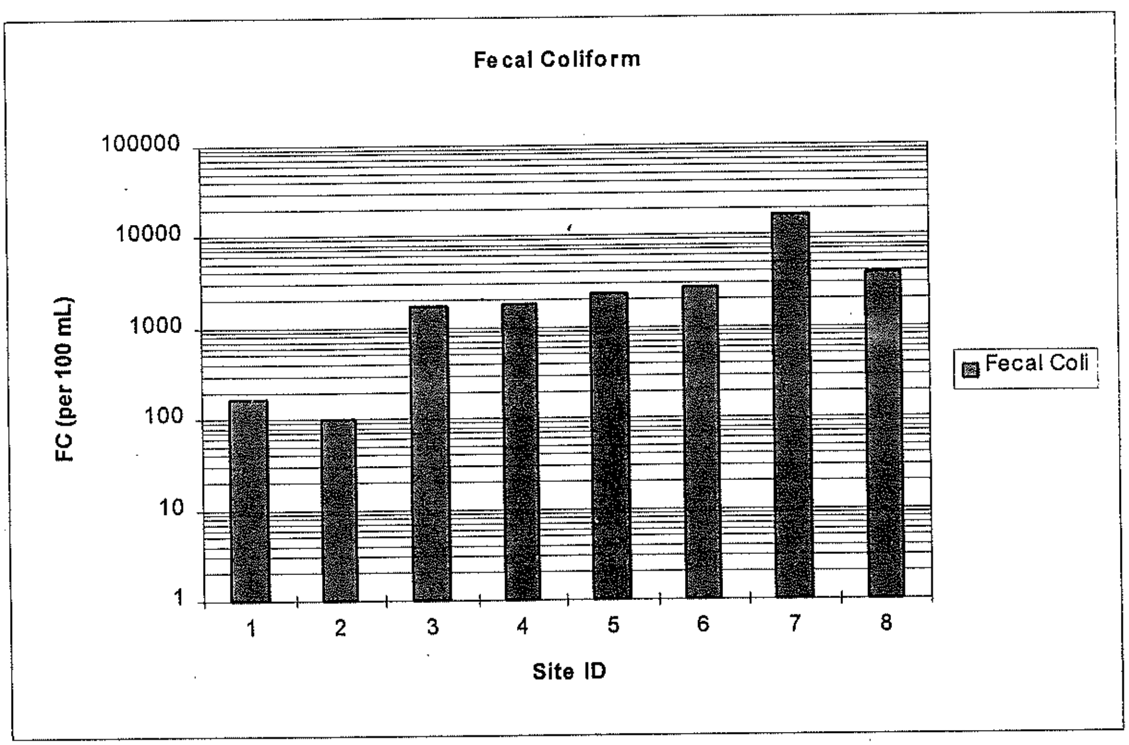


Figure B.5 Dissolved Oxygen May 25, 1993

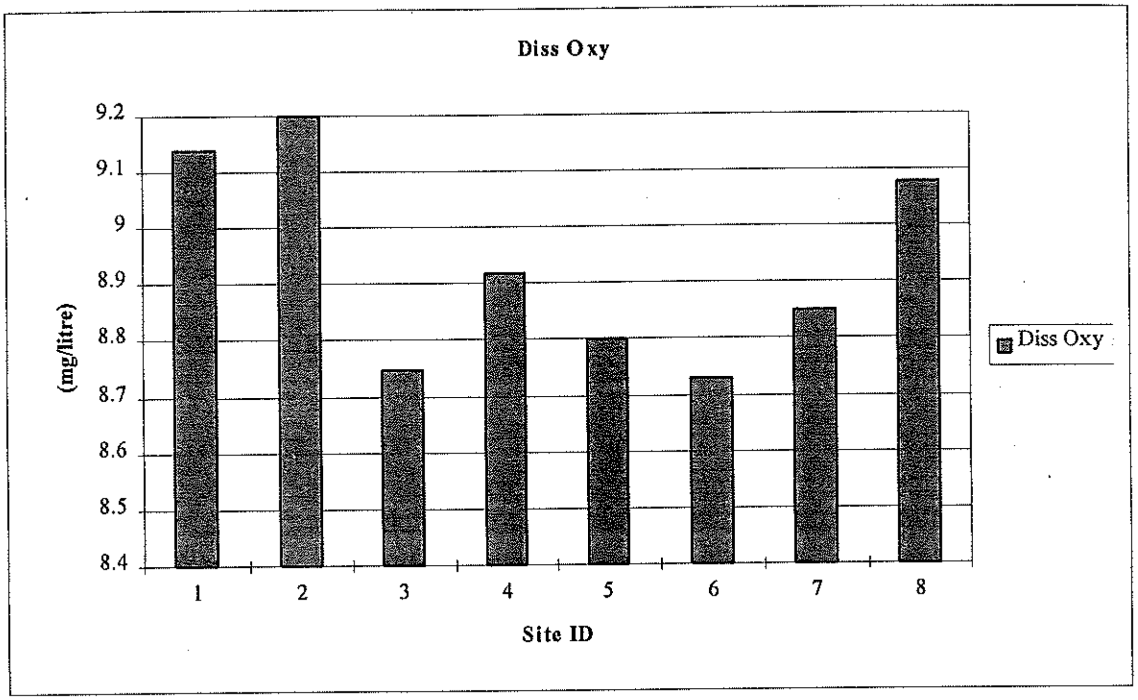


Figure B.6 Fecal Coliform May 25, 1993

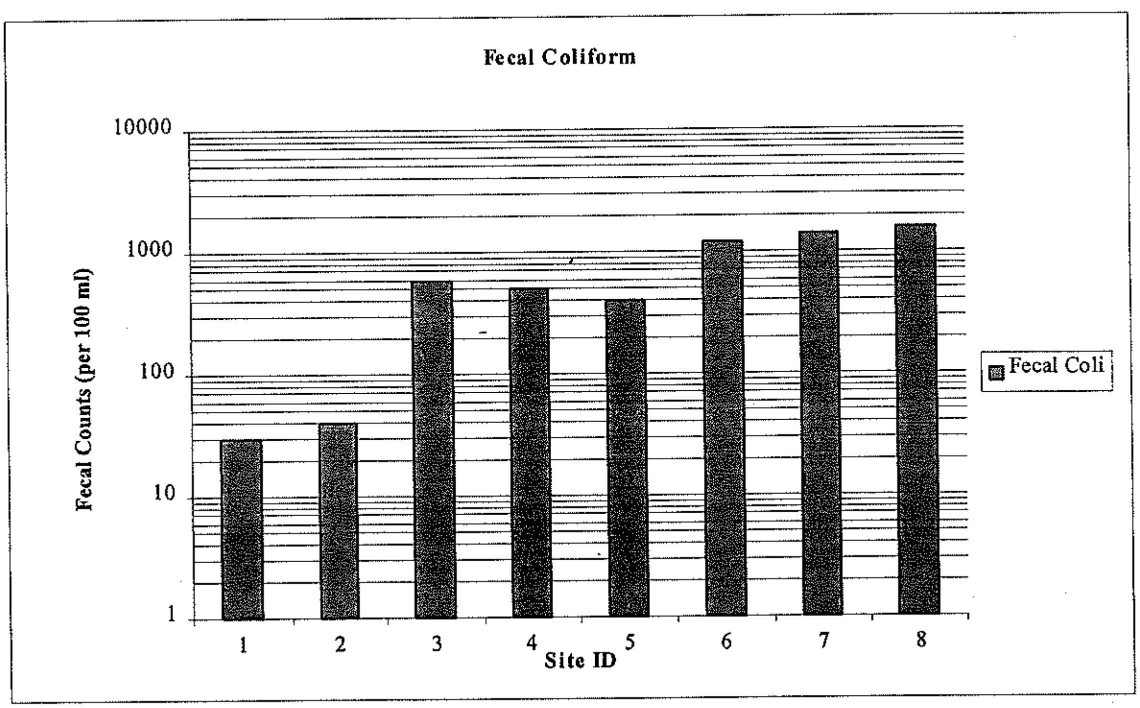


Figure B.7 Dissolved Oxygen May 27, 1993

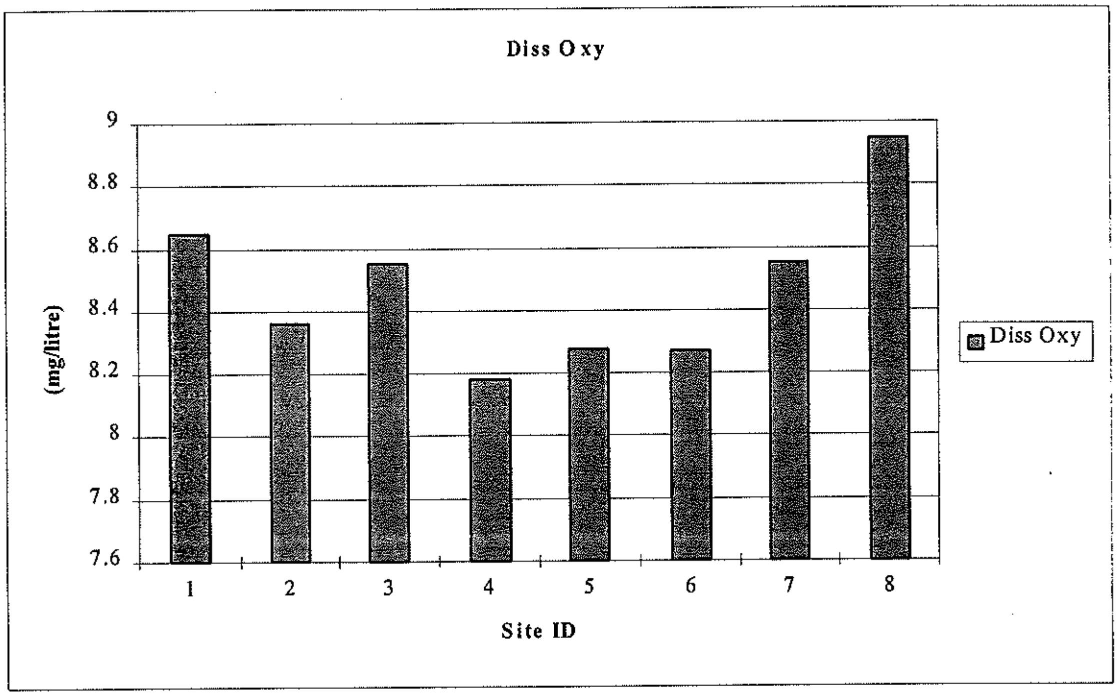


Figure B.8 Fecal Coliform May 27, 1993

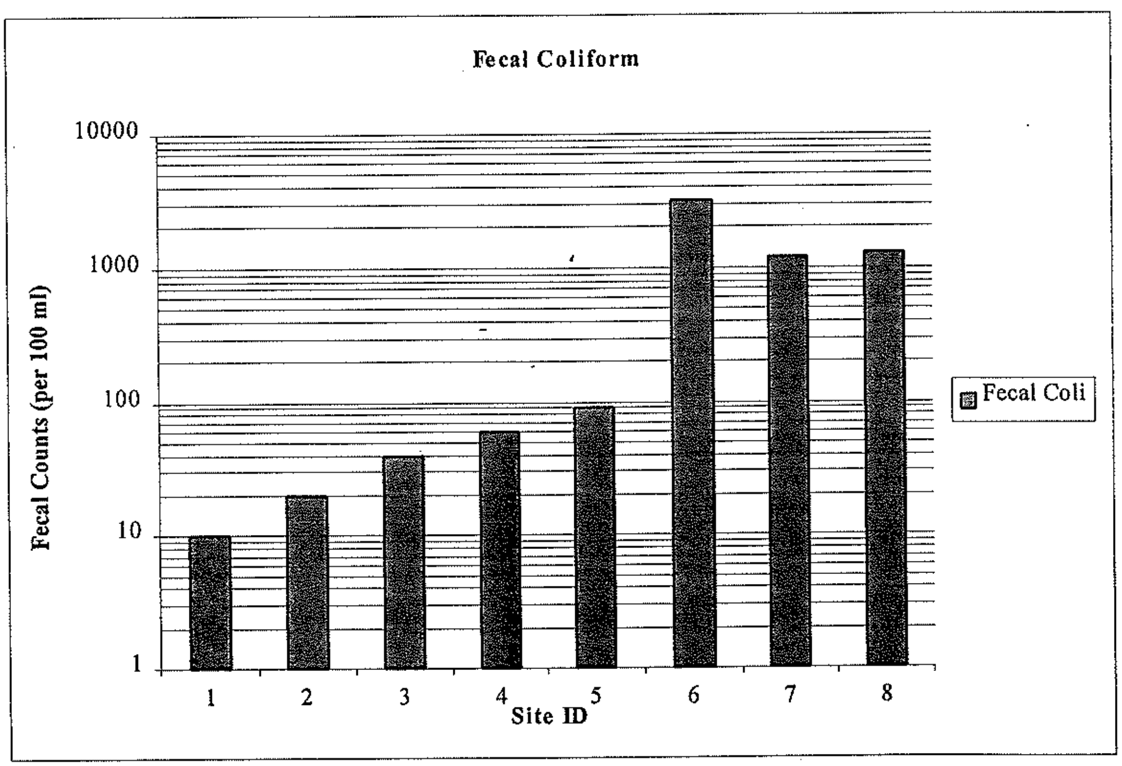


Figure B.9 Dissolved Oxygen June 10, 1993

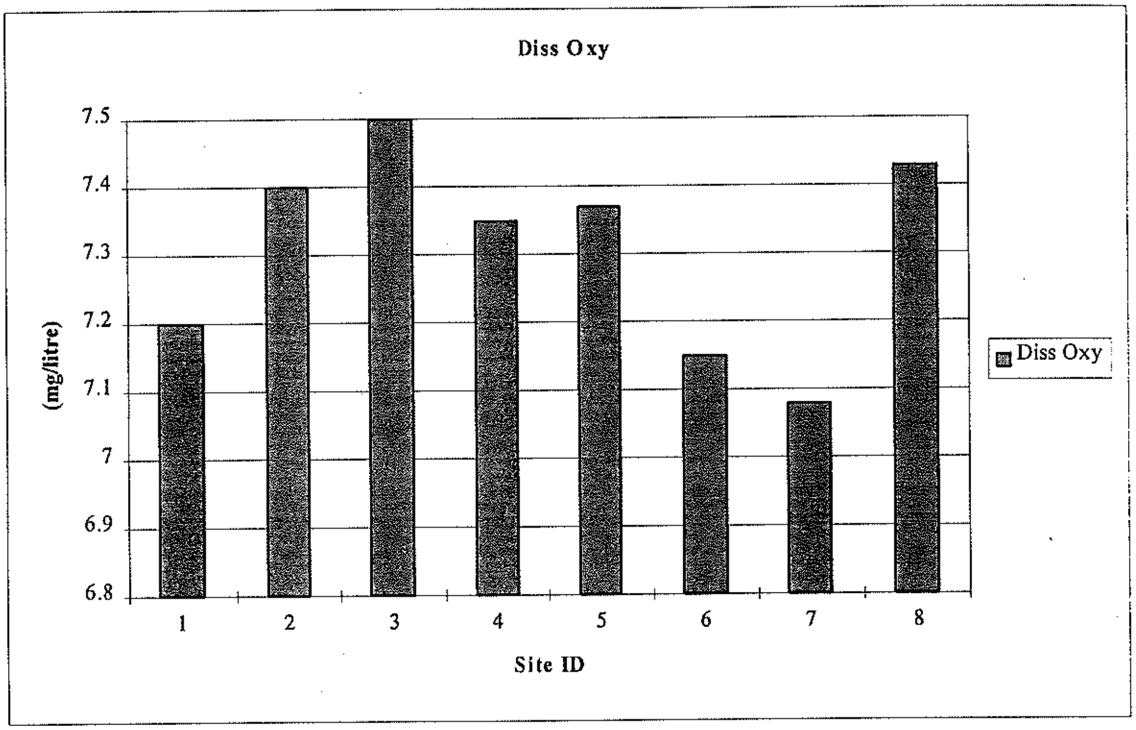


Figure B.10 Fecal Coliform June 10, 1993

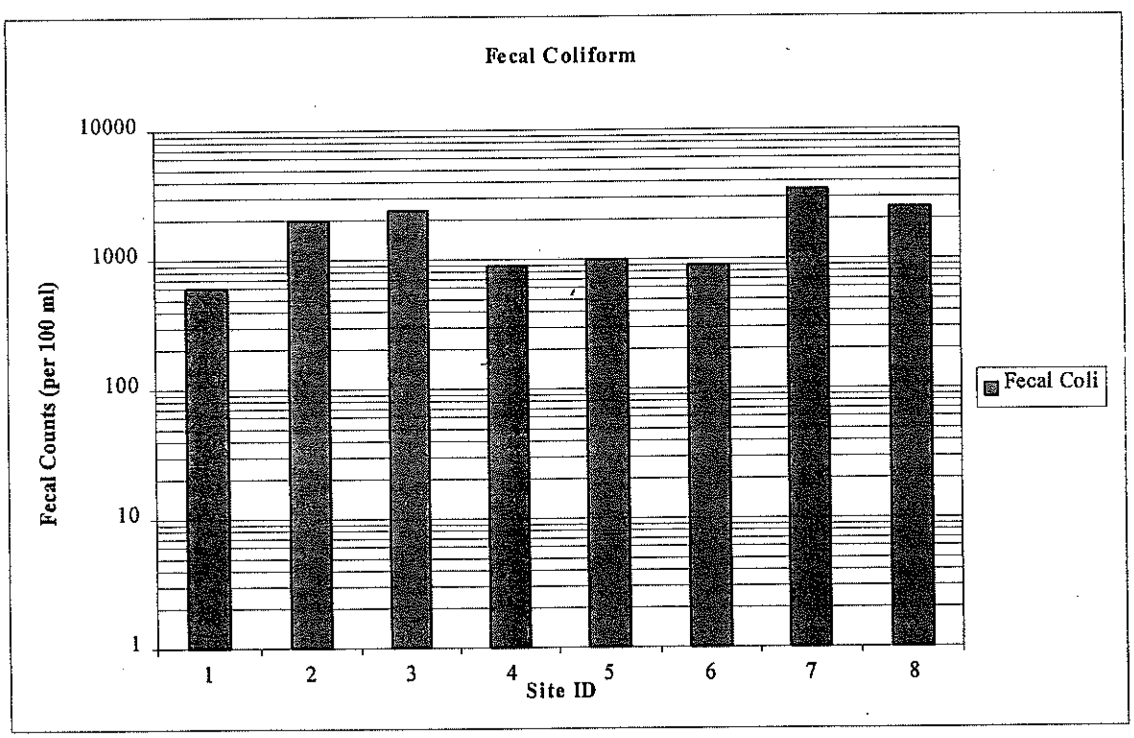


Figure B.11 Dissolved Oxygen June 16, 1993

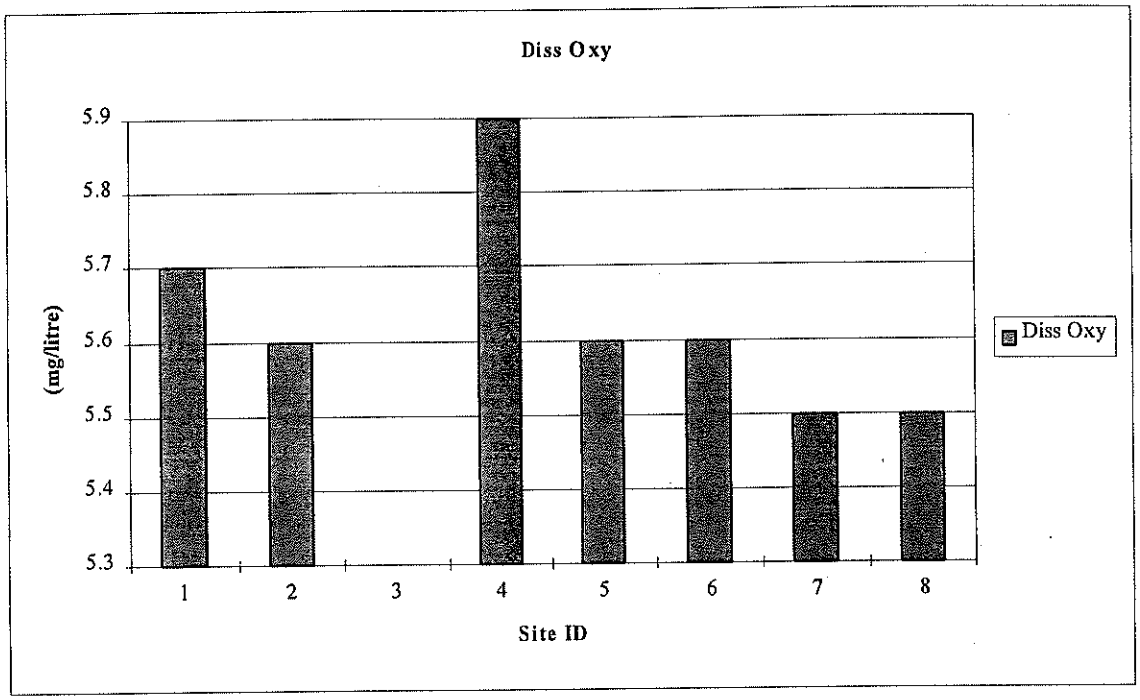


Figure B.12 Fecal Coliform June 16, 1993

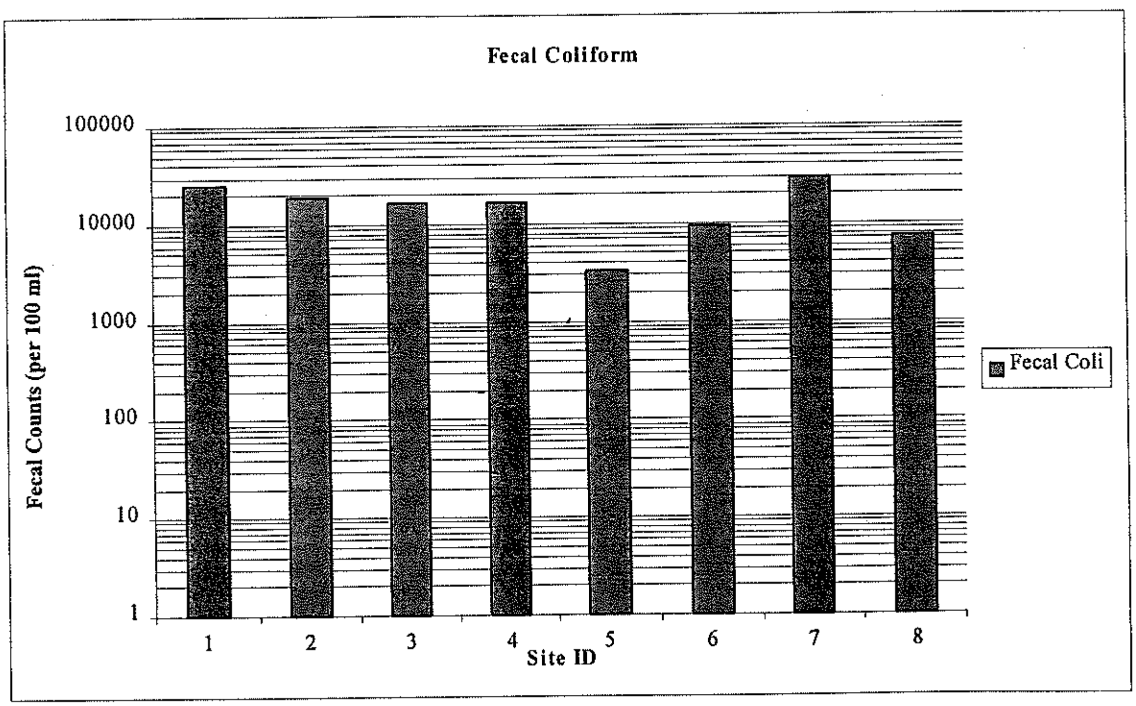


Figure B.13 Dissolved Oxygen June 24, 1993

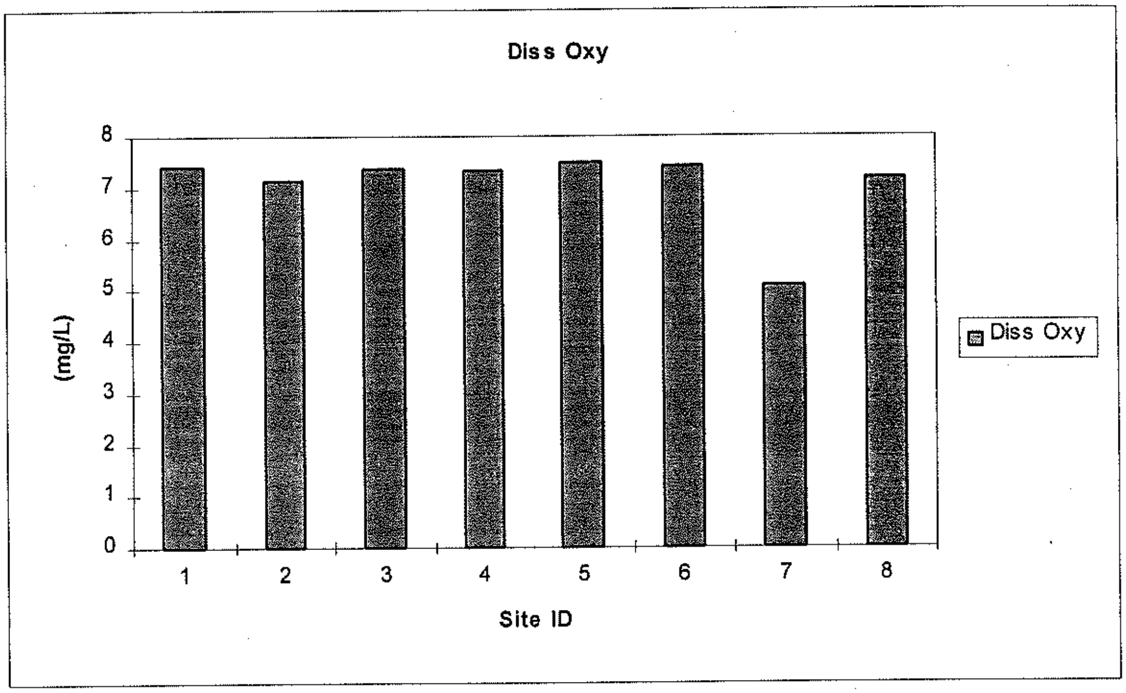


Figure B.14 Fecal Coliform June 24, 1993

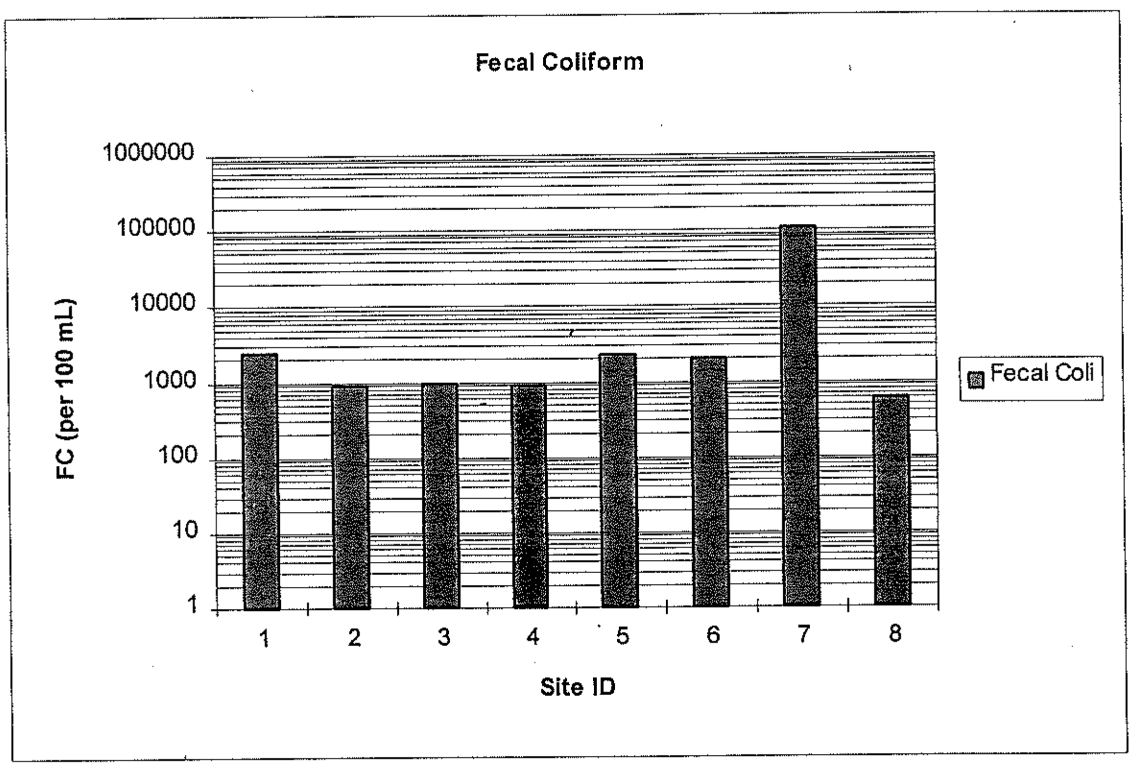


Figure B.15 Dissolved Oxygen June 28, 1993

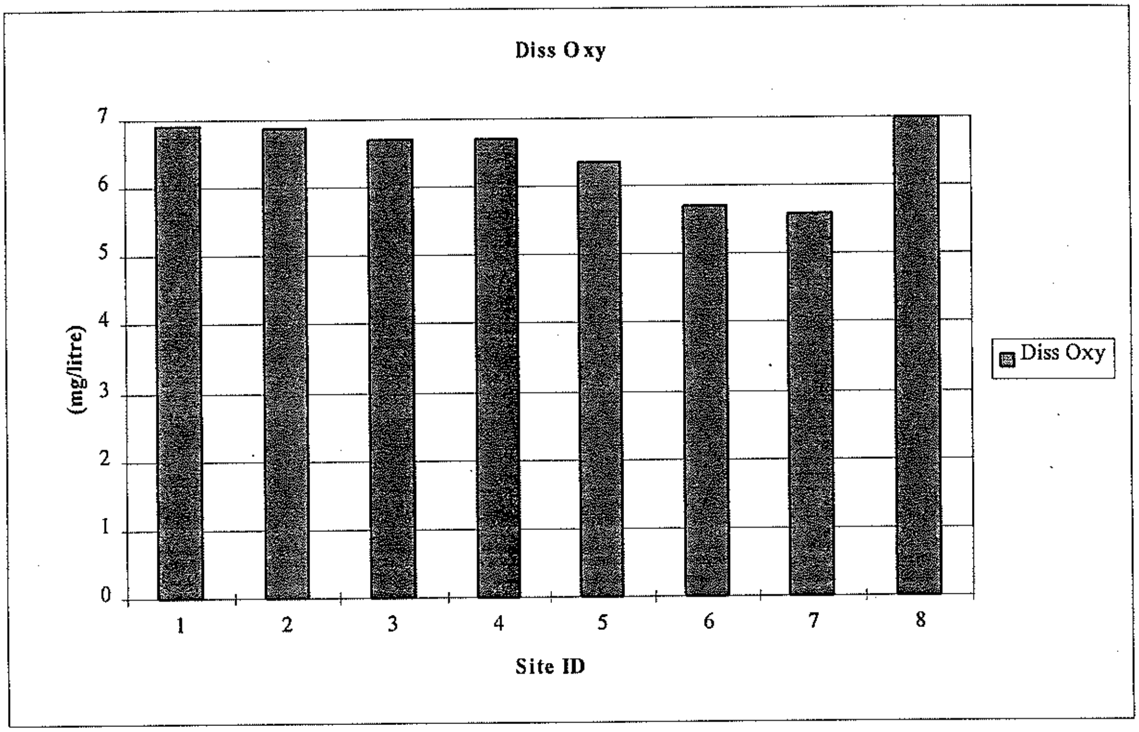


Figure B.16 Fecal Coliform June 28, 1993

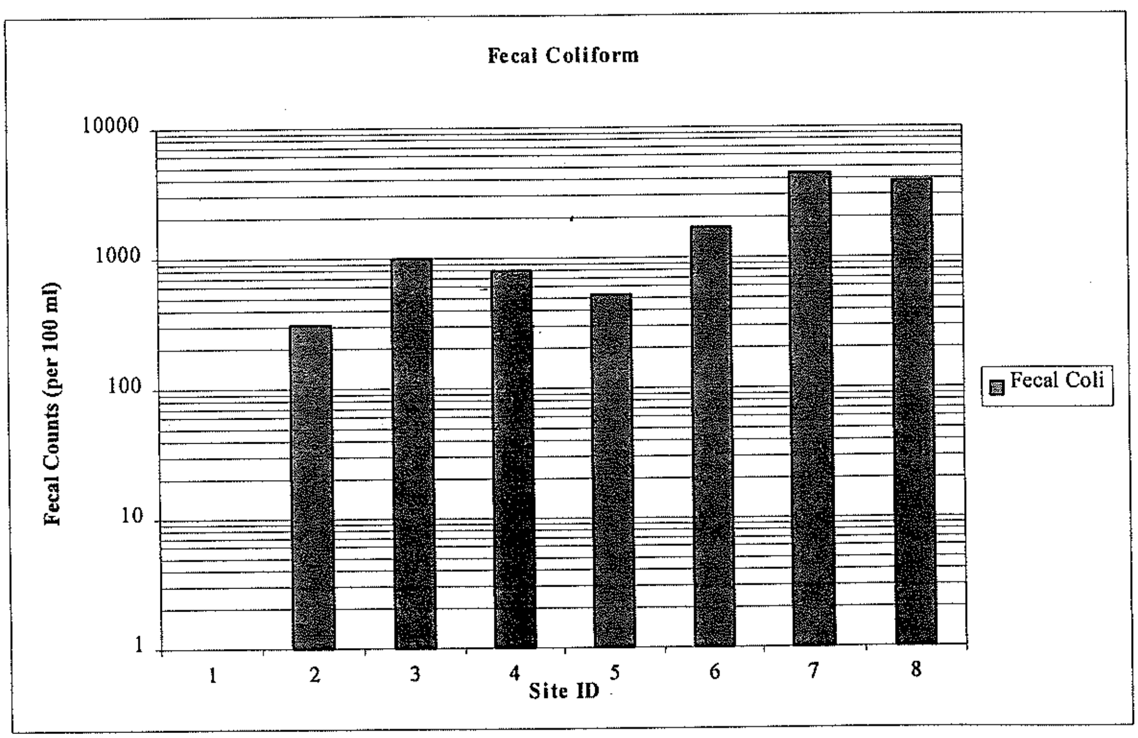


Figure B.17 Dissolved Oxygen June 30, 1993

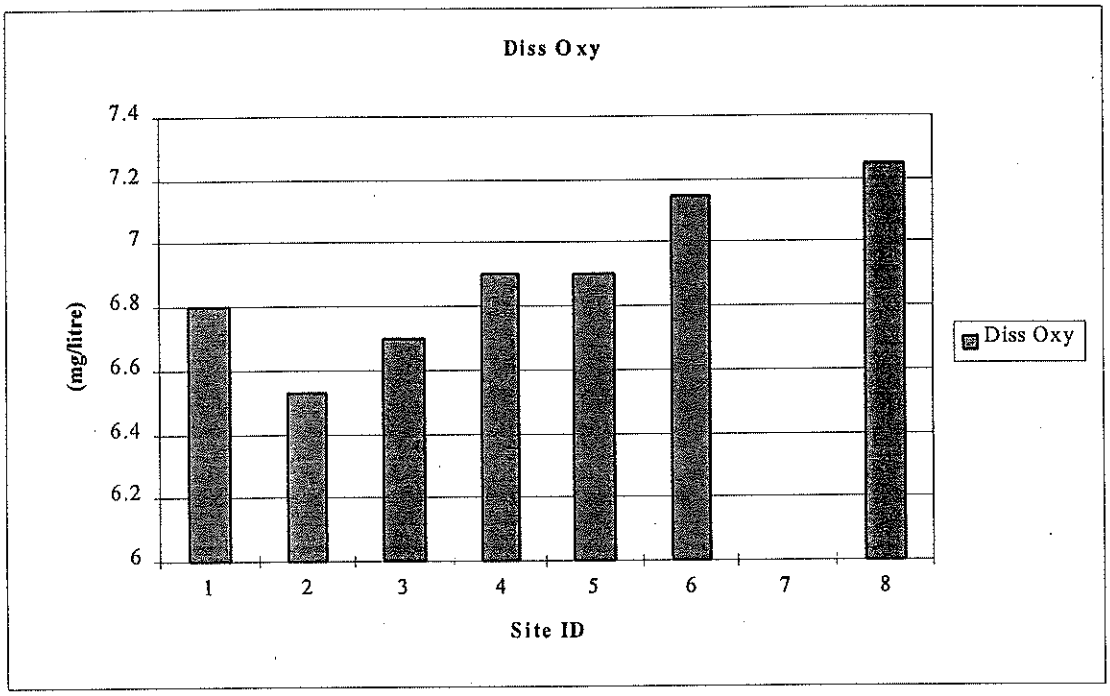


Figure B.18 Fecal Coliform June 30, 1993

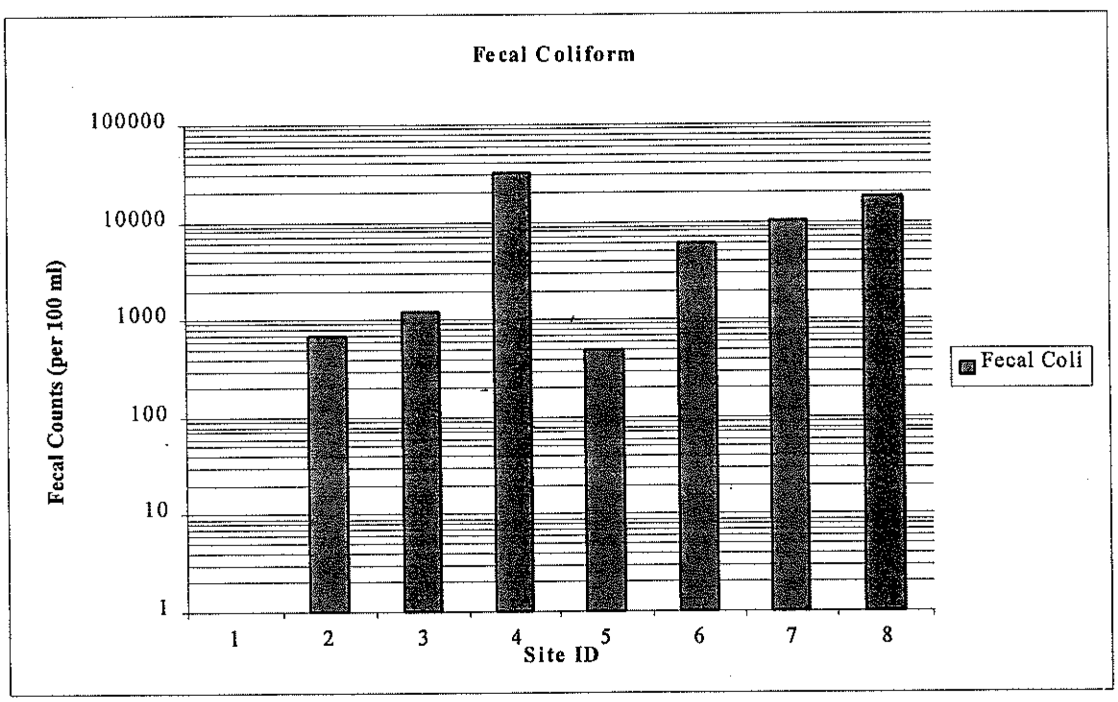


Figure B.19 Dissolved Oxygen July 08, 1993

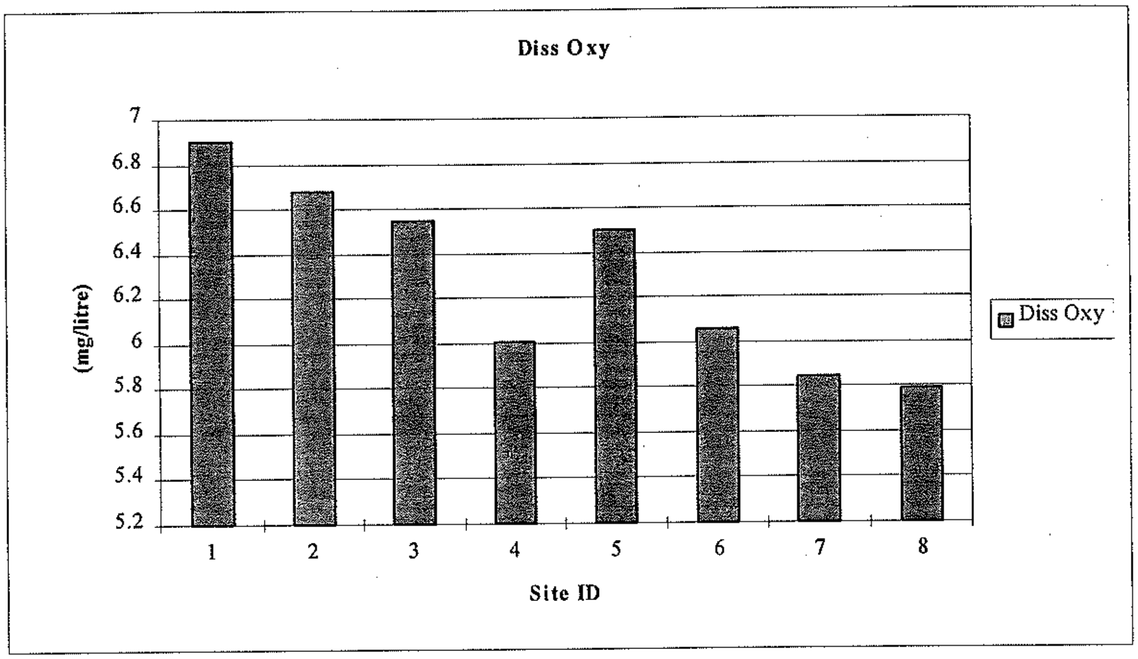


Figure B.20 Fecal Coliform July 08, 1993

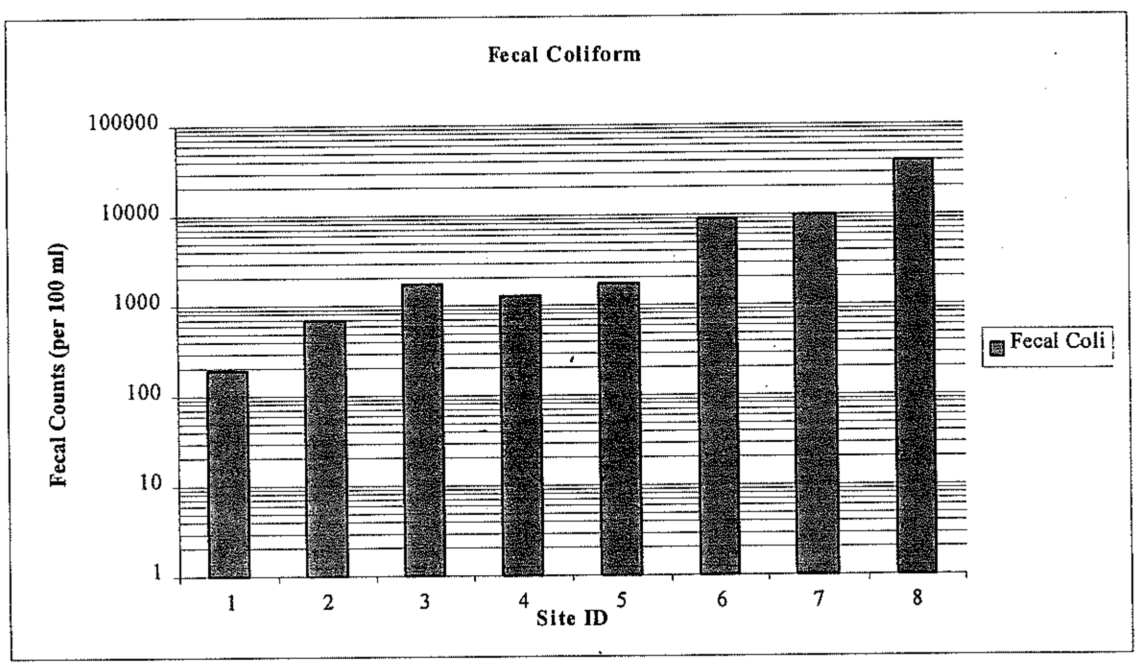


Figure B.21 Dissolved Oxygen July 23, 1993

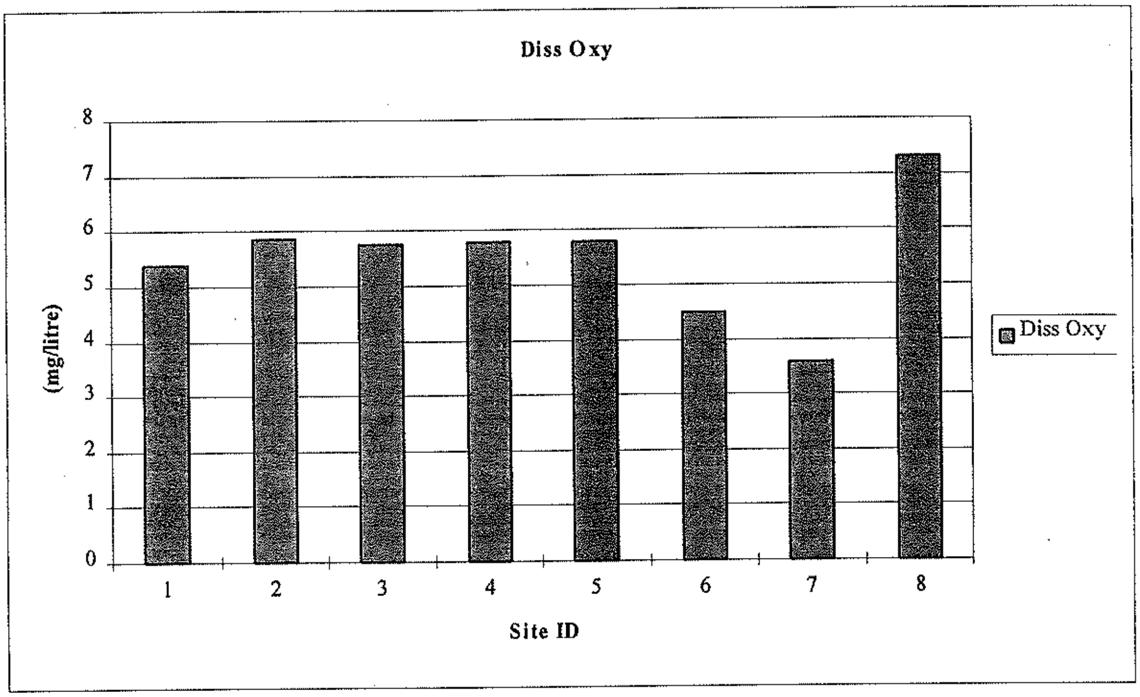


Figure B.22 Fecal Coliform July 23, 1993

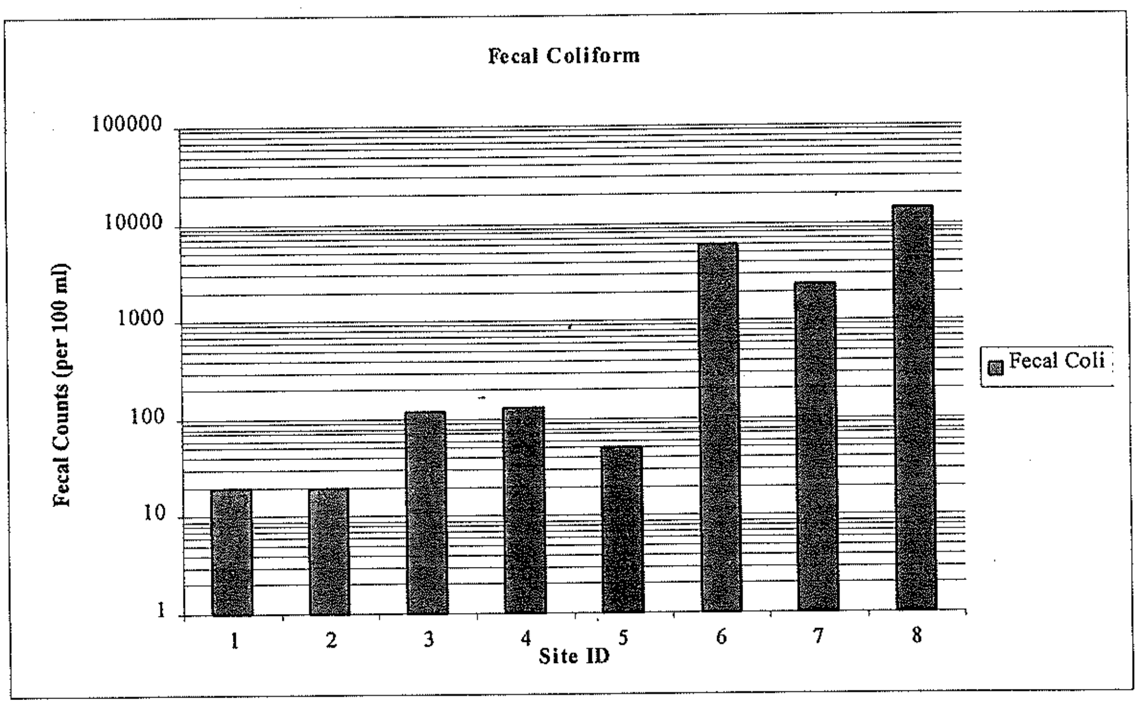


Figure B.23 Dissolved Oxygen July 27, 1993

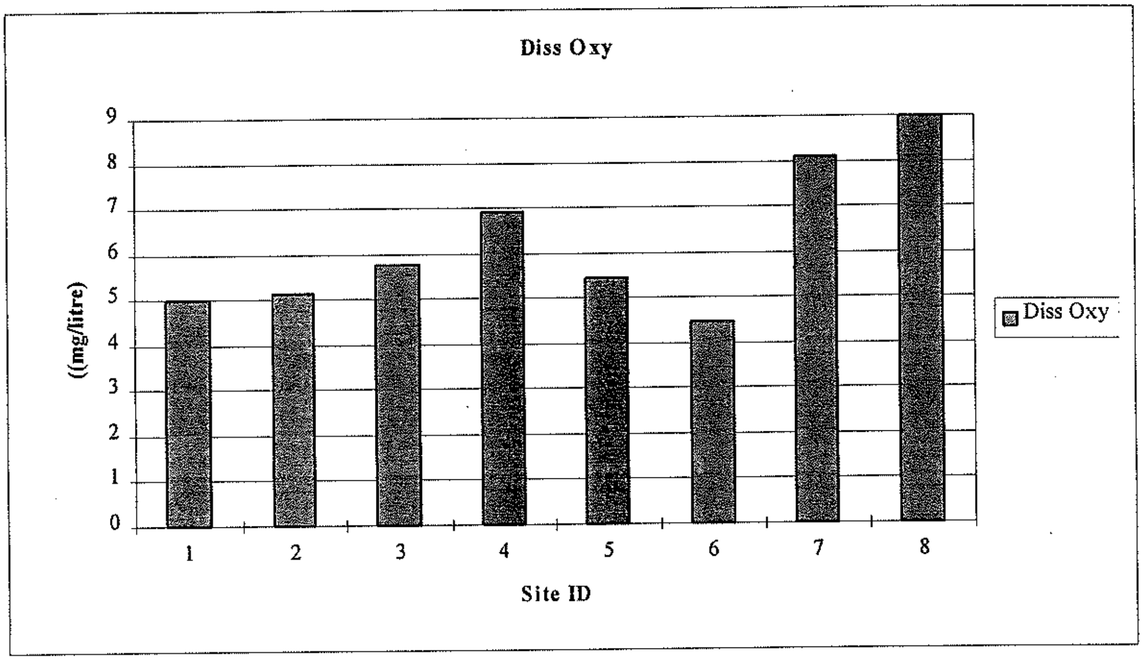


Figure B.24 Fecal Coliform July 27, 1993

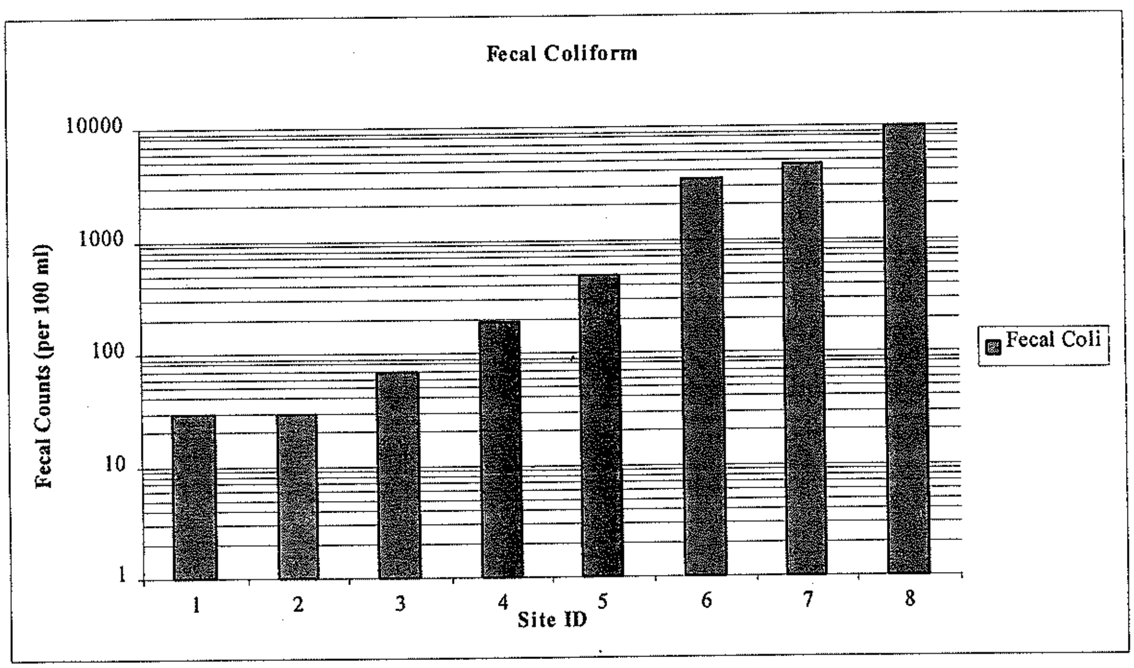


Figure B.25 Dissolved Oxygen July 29, 1993

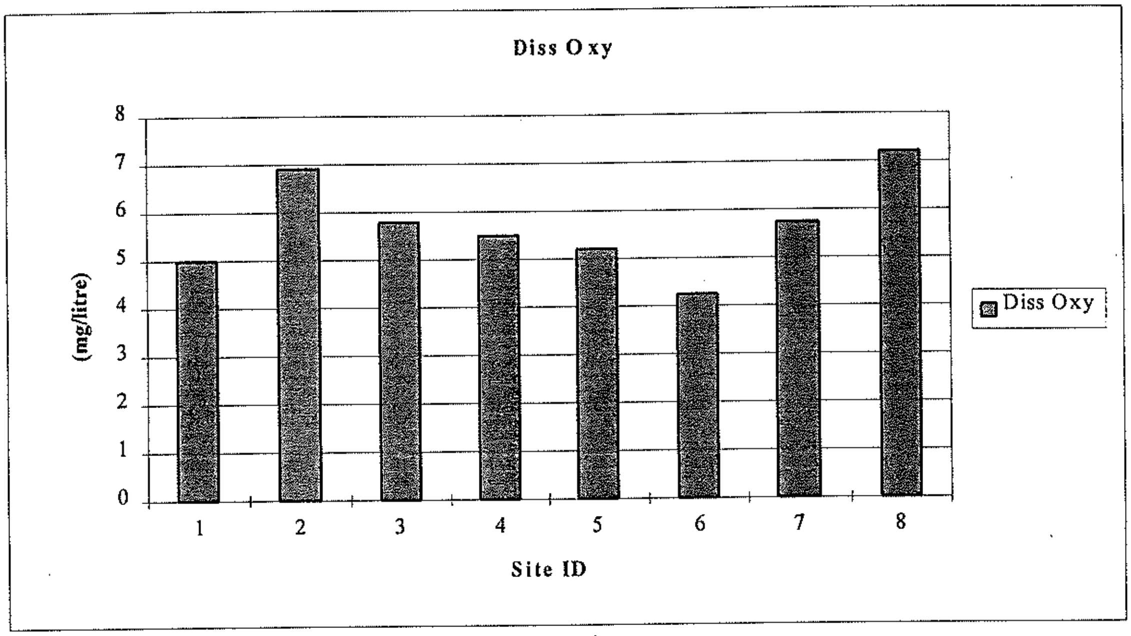


Figure B.26 Fecal Coliform July 29, 1993

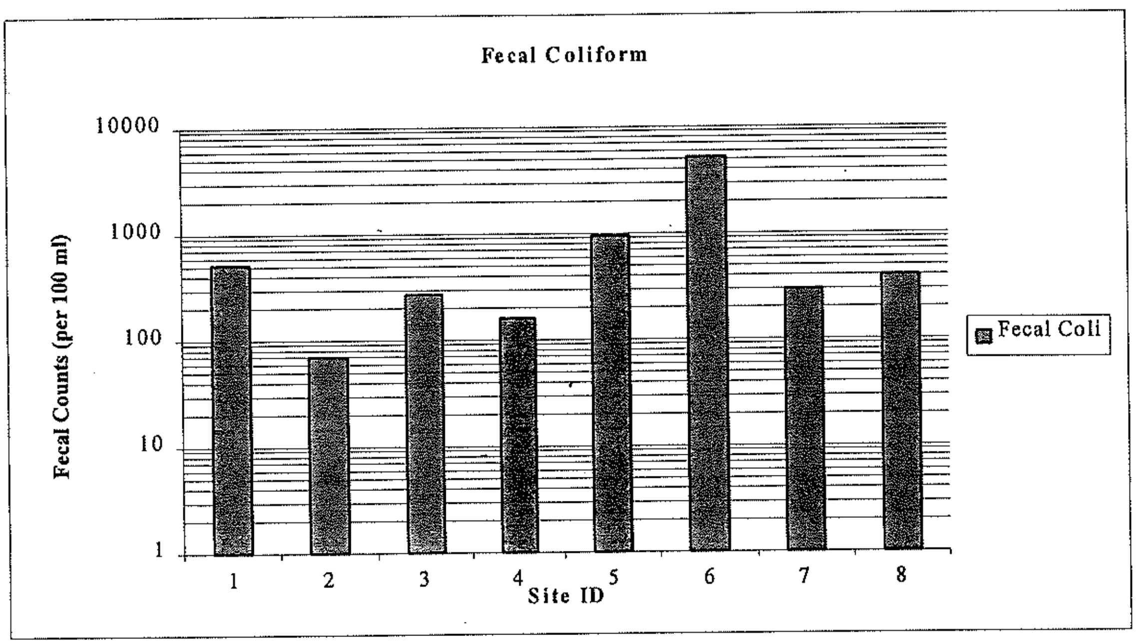


Figure B.27 Dissolved Oxygen August 20, 1993

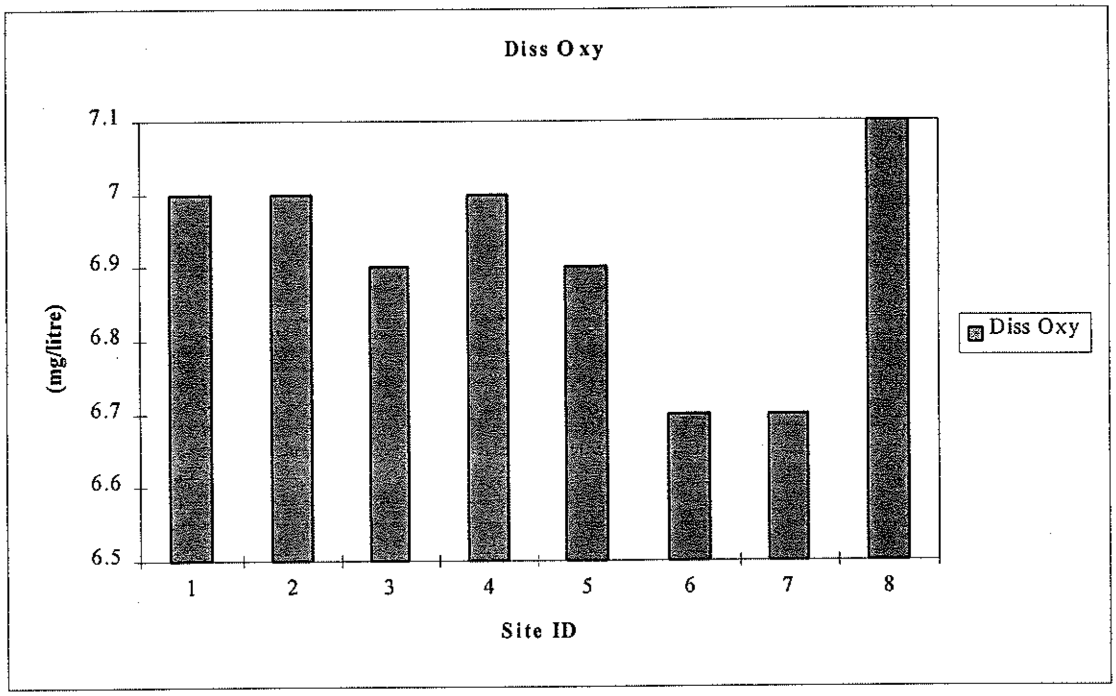


Figure B.28 Fecal Coliform August 20, 1993

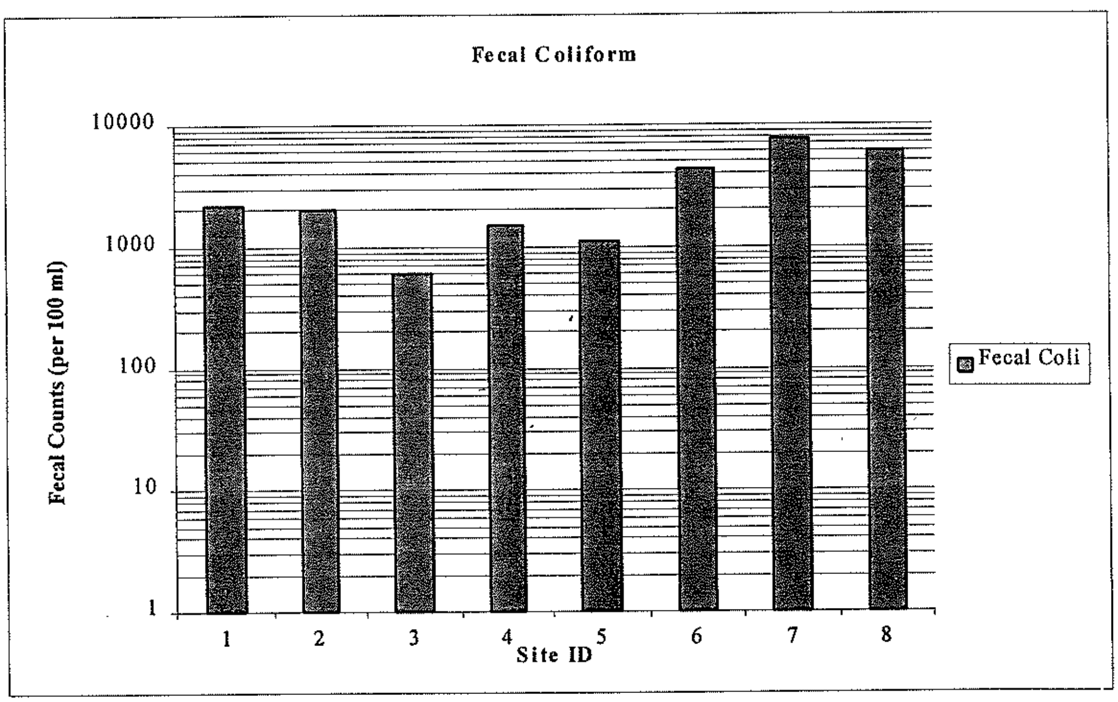


Figure B.29 Dissolved Oxygen August 23, 1993

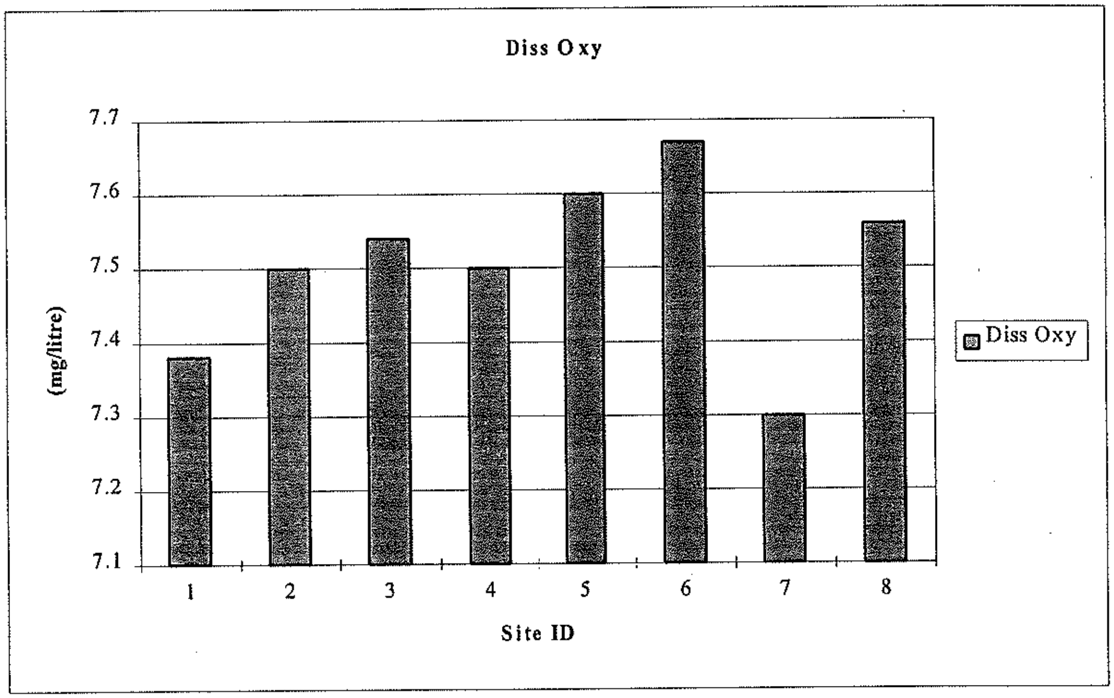


Figure B.30 Fecal Coliform August 23, 1993

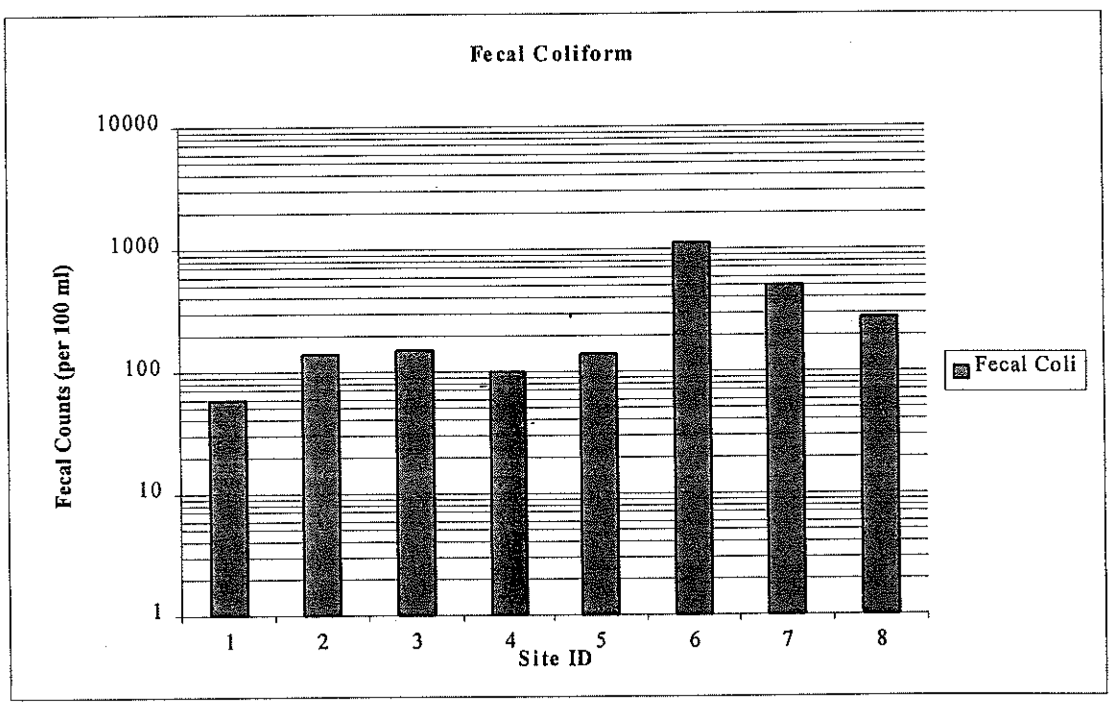


Figure B.31 Dissolved Oxygen August 26, 1993

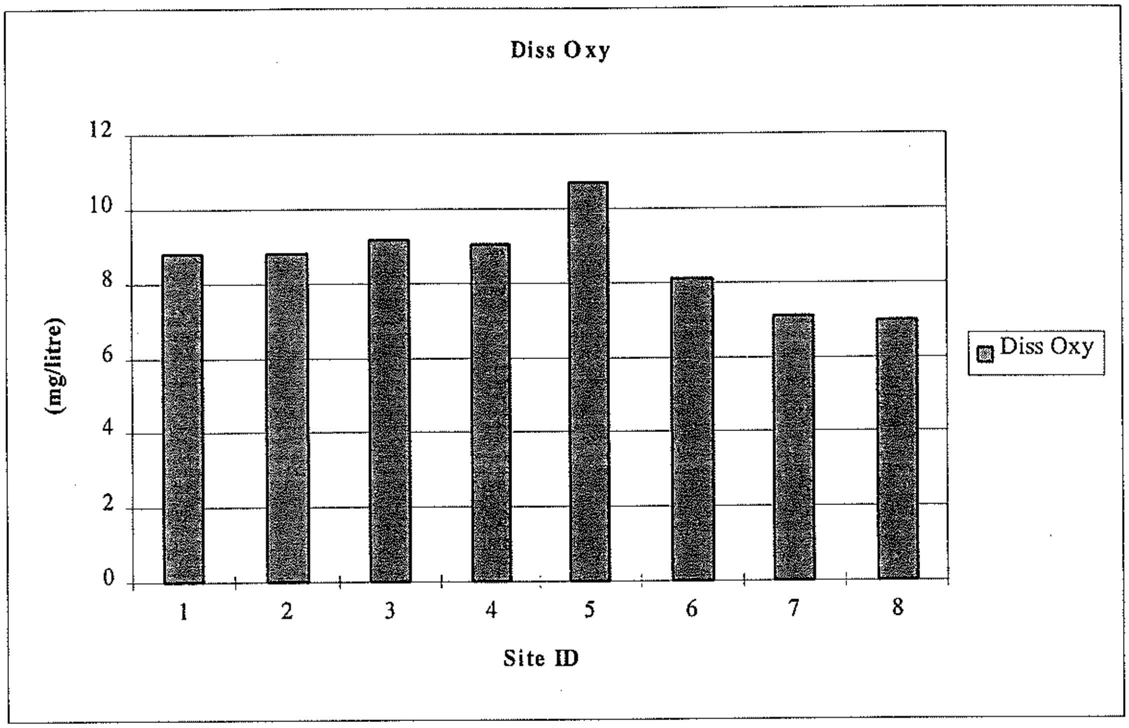


Figure B.32 Fecal Coliform August 26, 1993

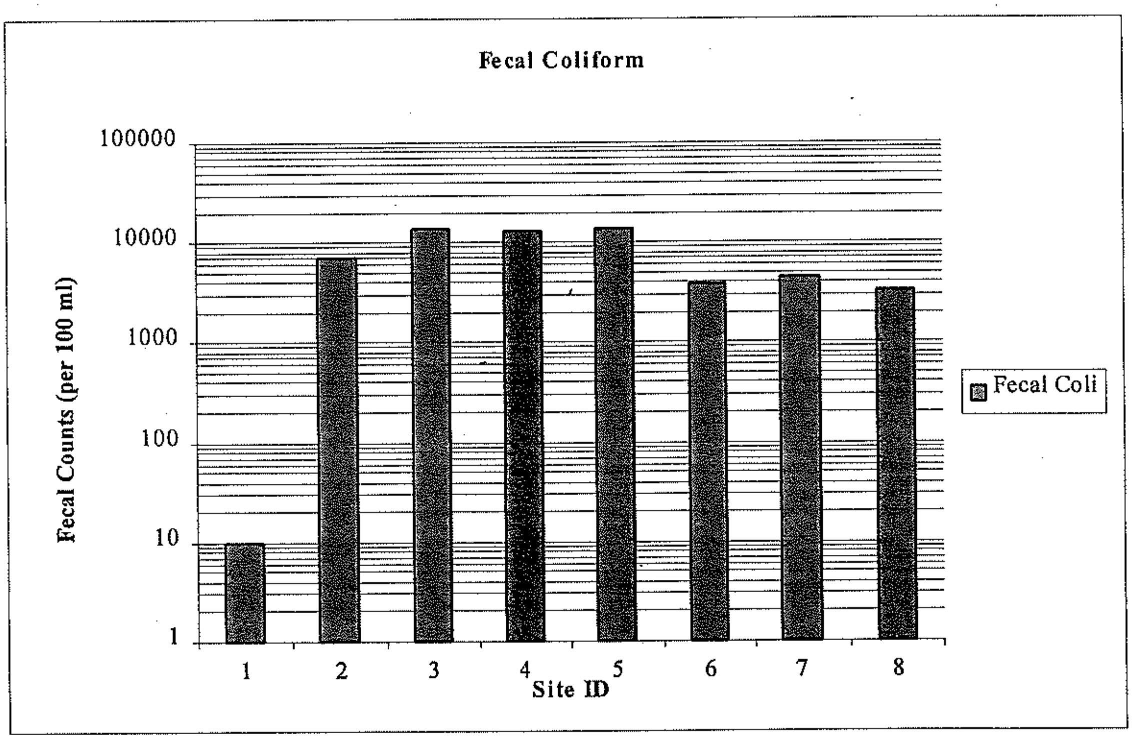


Figure B.33 Dissolved Oxygen August 31, 1993

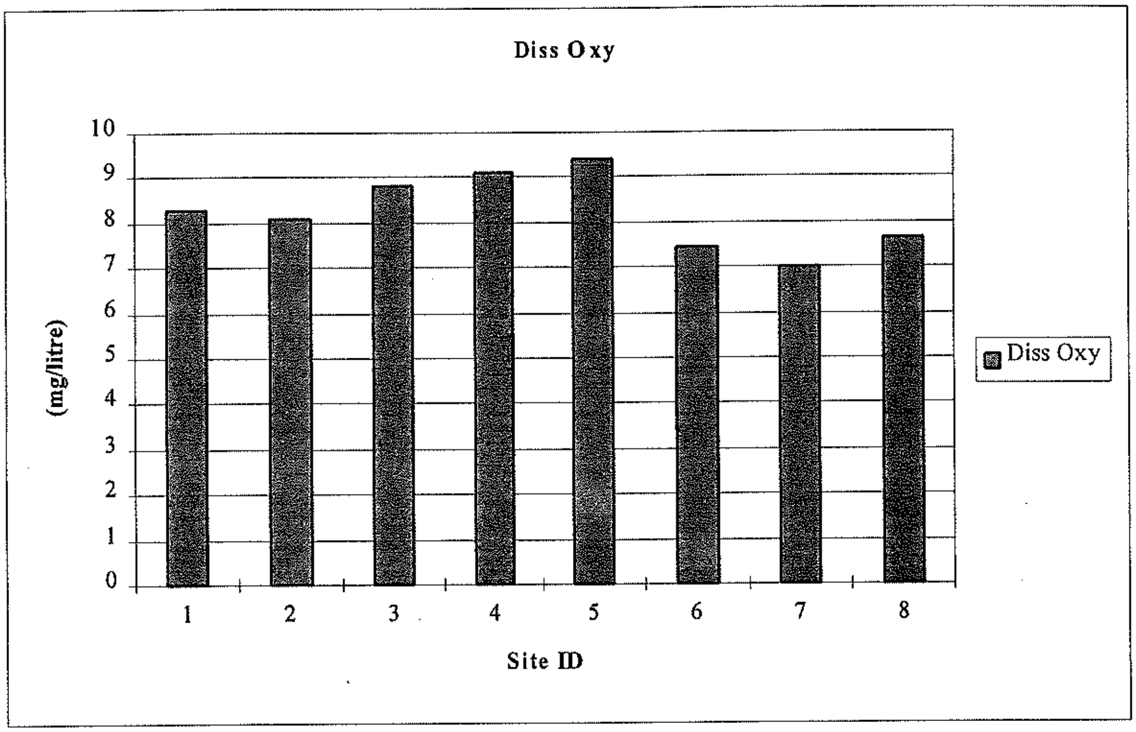
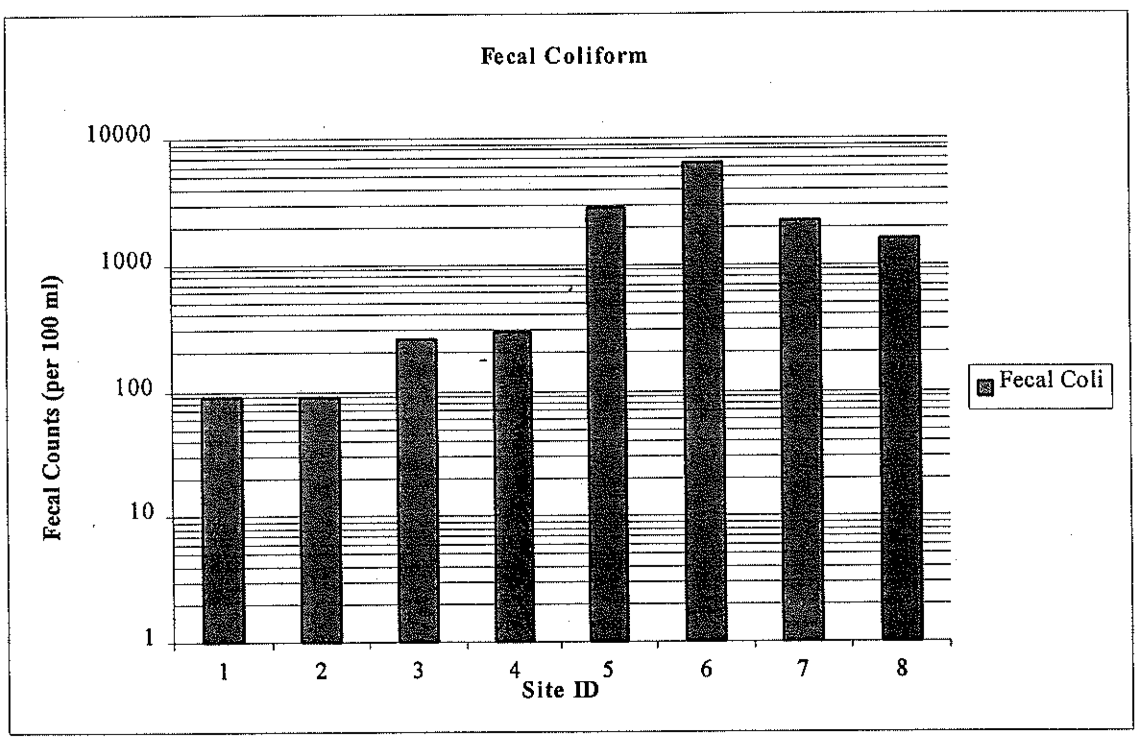


Figure B.34 Fecal Coliform August 31, 1993



APPENDIX C

Table C.1 Stream Water Quality Parameters on June 07, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	12.30	1	20	60	---	---	26	301
2	12.10	1	560	540	---	---	25	301
3	13.00	---	8600	240	---	---	25	305
4	13.40	1	1600	520	---	---	24	304
5	15.50	3	1400	1200	---	---	24	290
6	14.70	1	---	---	---	---	24	286
7	15.10	6	480	400	---	---	24	287
8	14.10	3	3000	1360	---	---	24	288

Table C.2 Stream Water Quality Parameters on June 09, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	---	1	0	4	11	3	---	----
2	---	1	60	10	16	3	---	---
3	---	1	0	4	13	5	---	---
4	---	2	0	0	7	3	---	---
5	---	2	2000	24	12	2	---	---
6	---	2	---	---	18	4	---	---
7	---	2	0	48	14	39	---	---
8	---	2	4000	100	17	5	---	---

Table C.3 Stream Water Quality Parameters on June 14, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	8.24	1	48	4	---	---	27	358
2	8.47	1	100	8	---	---	26	352
3	---	---	180	44	---	---	---	---
4	8.60	2	200	46	---	---	26	365
5	8.13	1	3000	60	---	---	26	363
6	8.14	1	800	96	---	---	26	360
7	8.08	2	460	24	---	---	27	359
8	8.49	1	380	12	---	---	26	357

Table C.4 Stream Water Quality Parameters on June 16, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	8.06	---	36	46	---	---	27	347
2	8.11	---	40	32	---	---	27	346
3	---	---	100	920	---	---	---	---
4	8.29	---	400	180	---	---	27	349
5	6.88	---	140	74	---	---	27	363
6	6.73	---	80	58	---	---	27	365
7	6.70	---	160	70	---	---	26	365
8	6.64	---	480	92	---	---	26	367

Table C.5 Stream Water Quality Parameters on June 21, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	6.16	1	32	28	2	0	31	350
2	5.80	1	20	8	12	0	31	352
3	---	---	34	46	---	---	---	---
4	6.15	1	120	12	14	0	31	353
5	7.12	2	1220	240	4	1	30	353
6	8.36	3	900	200	4	3	30	353
7	7.80	5	3600	960	1	0	30	352
8	7.88	3	940	560	2	5	29	352

Table C.6 Stream Water Quality Parameters on June 27, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	5.49	---	200	1600	---	---	26	355
2	5.37	4	240	1680	41	16	26	356
3	6.34	4	7000	13200	97	9	25	369
4	6.16	4	4800	9600	81	8	24	369
5	3.72	3	18000	5600	53	5	26	353
6	3.60	4	22000	5200	43	15	26	354
7	3.66	5	26000	5000	48	5	26	351
8	3.45	---	10400	6400	36	22	26	353

Table C.7 Stream Water Quality Parameters on July 02, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	9.79	---	40	100	11	7	27	342
2	9.30	---	2400	800	19	6	27	348
3	8.64	---	3600	620	22	6	27	361
4	8.50	---	920	620	22	7	27	362
5	5.80	---	400	100	16	5	27	383
6	5.96	---	1200	140	21	5	27	393
7	5.58	---	1800	120	16	5	27	394
8	7.84	---	200	2200	19	11	27	422

Table C.8 Stream Water Quality Parameters on July 06, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	9.43	2	150	162	16	7	29	356
2	10.40	3	20	2	3	0	30	358
3	11.30	2	400	200	11	5	30	361
4	11.60	3	40	8	19	7	30	363
5	10.20	4	620	320	14	5	30	373
6	11.20	2	1000	120	20	6	30	394
7	11.20	3	1200	100	13	6	30	395
8	12.00	5	900	60	16	5	30	414

Table C.9 Stream Water Quality Parameters on July 14, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	7.98	3	240	840	23	7	27	359
2	8.31	4	280	360	27	6	28	356
3	7.60	2	1760	1240	8	5	29	356
4	8.05	4	1360	1200	20	6	29	356
5	11.70	3	5600	620	8	5	29	400
6	10.60	3	1420	100	10	4	29	410
7	10.70	3	80	120	1	0	29	411
8	10.40	2	1360	1880	---	---	29	416

Table C.10 Stream Water Quality Parameters on July 28, 1994

ID	Diss Oxy	BOD	Fecal Coliform	Fecal Strep	TSS	VSS	TMP	COND
1	6.77	1	8	52	26	3	26	238
2	6.80	1	6	42	26	3	26	240
3	6.50	2	30	44	28	3	26	246
4	6.40	2	6	27	33	4	26	247
5	6.12	1	10	400	44	5	25	260
6	6.25	1	40	200	38	4	25	262
7	6.06	2	420	320	45	4	25	261
8	7.11	3	80	560	47	5	26	310

APPENDIX D

Figure D.1 BOD and Dissolved Oxygen June 07, 1994

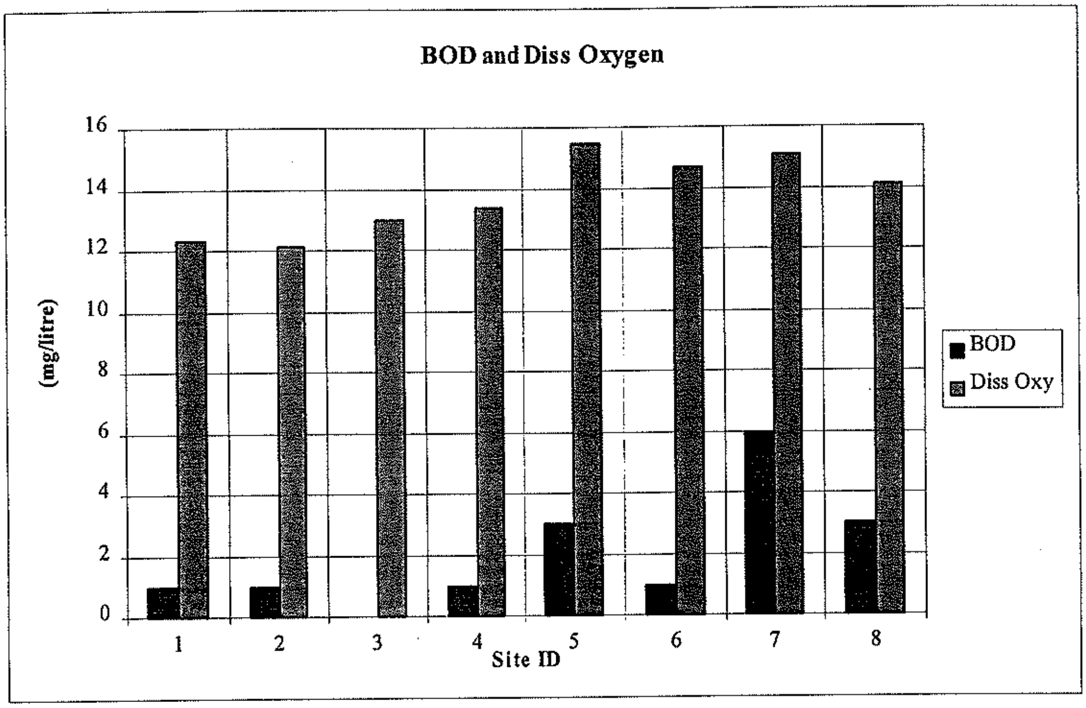


Figure D.2 Fecal Coliform and Fecal Strep June 07, 1994

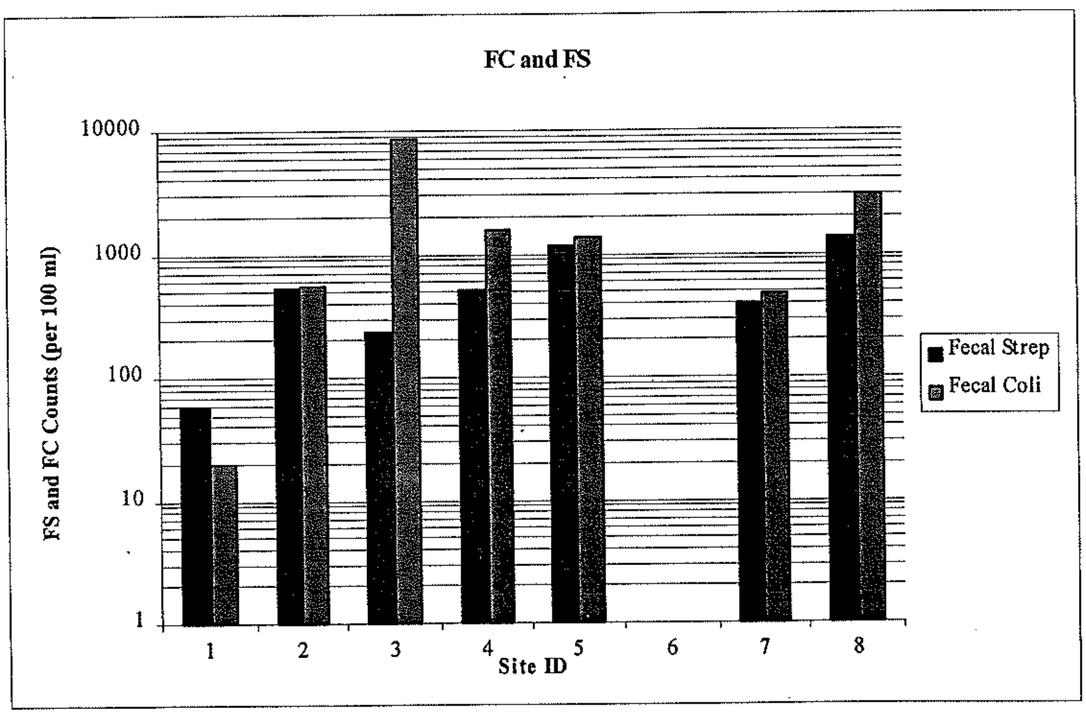


Figure D.3 BOD June 09, 1994

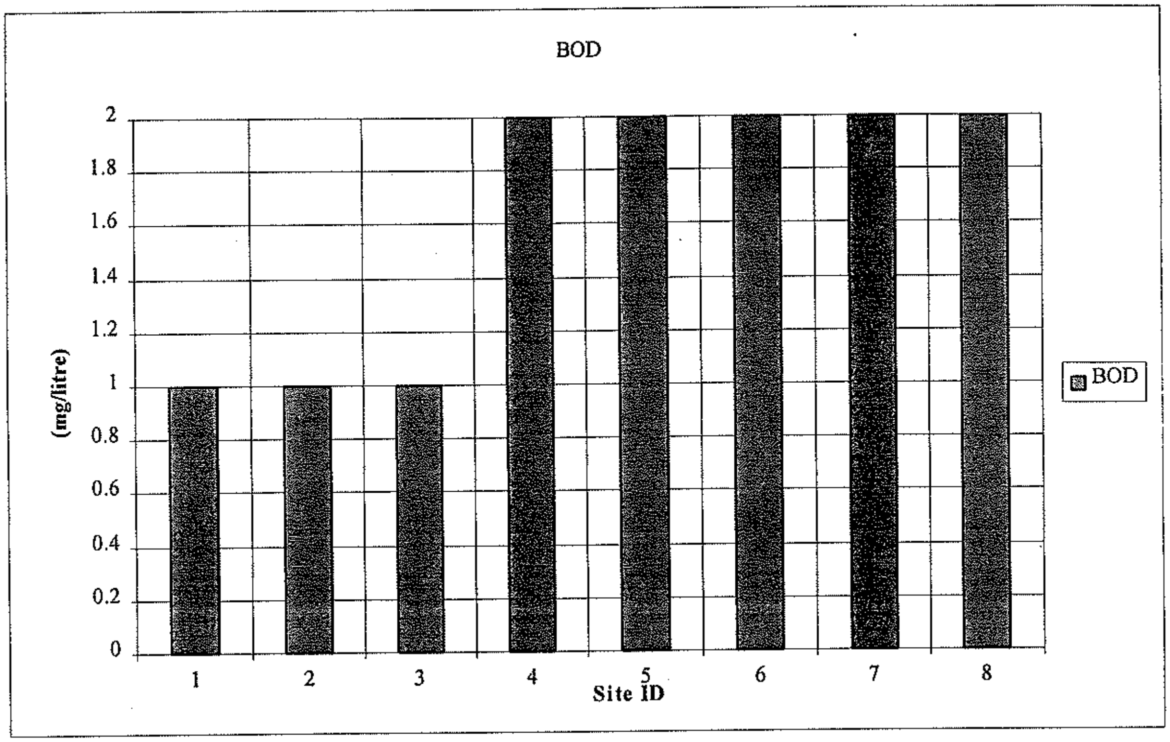


Figure D.4 Fecal Coliform and Fecal Strep June 09, 1994

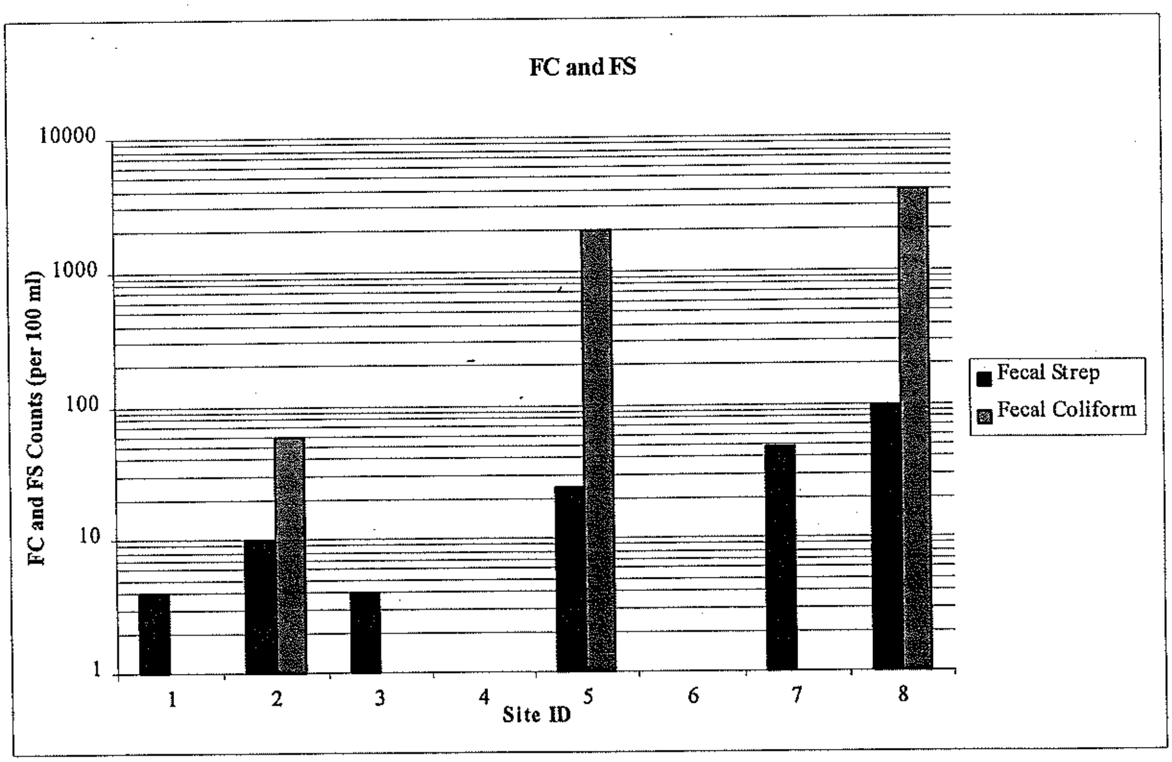


Figure D.5 Total and Volatile Suspended Solids June 09, 1994

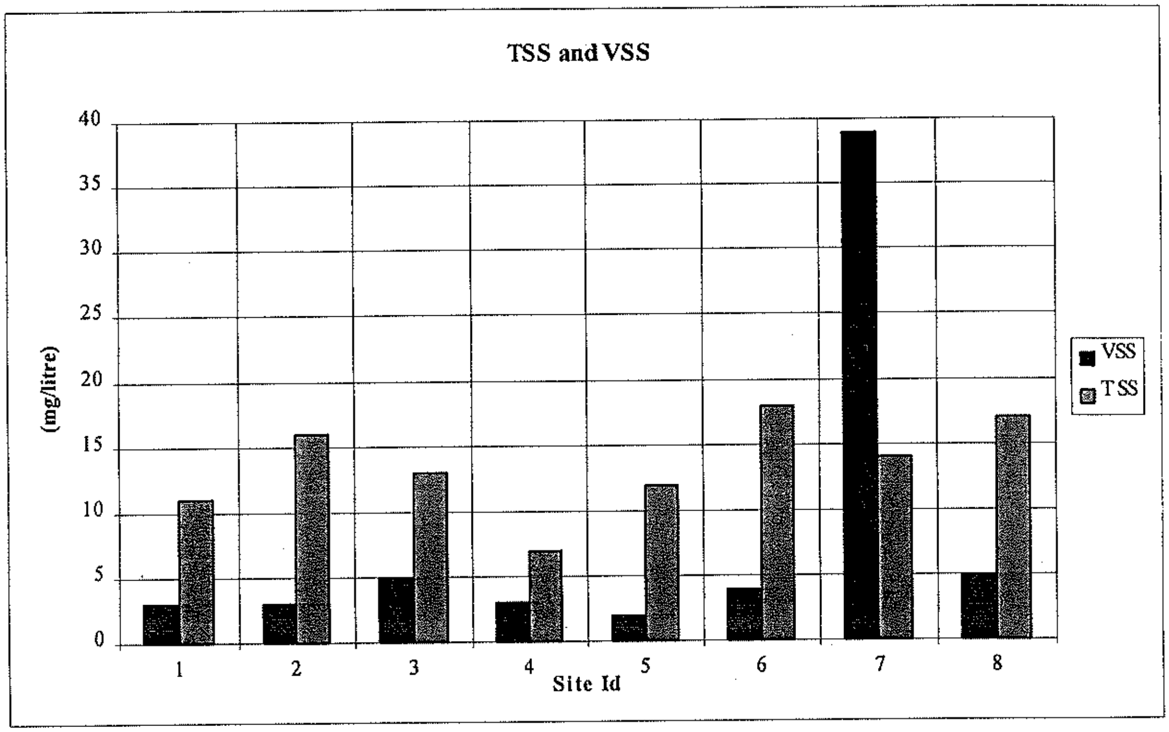


Figure D.6 BOD and Dissolved Oxygen June 14, 1995

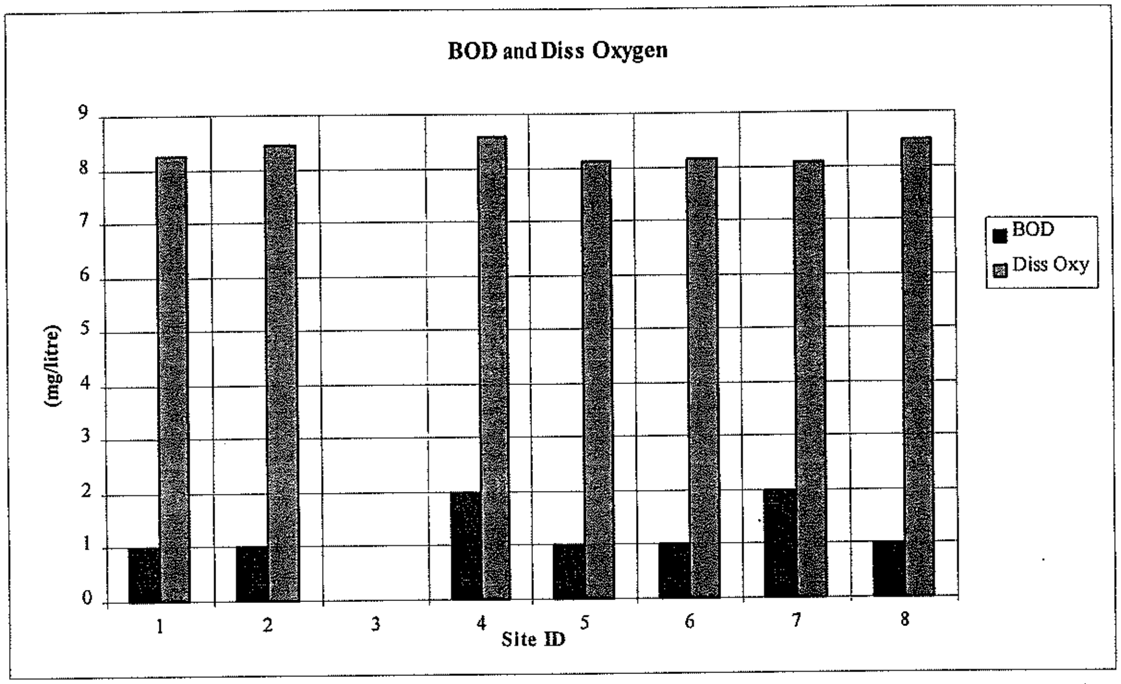


Figure D.7 Fecal Coliform and Fecal Strep June 14, 1995

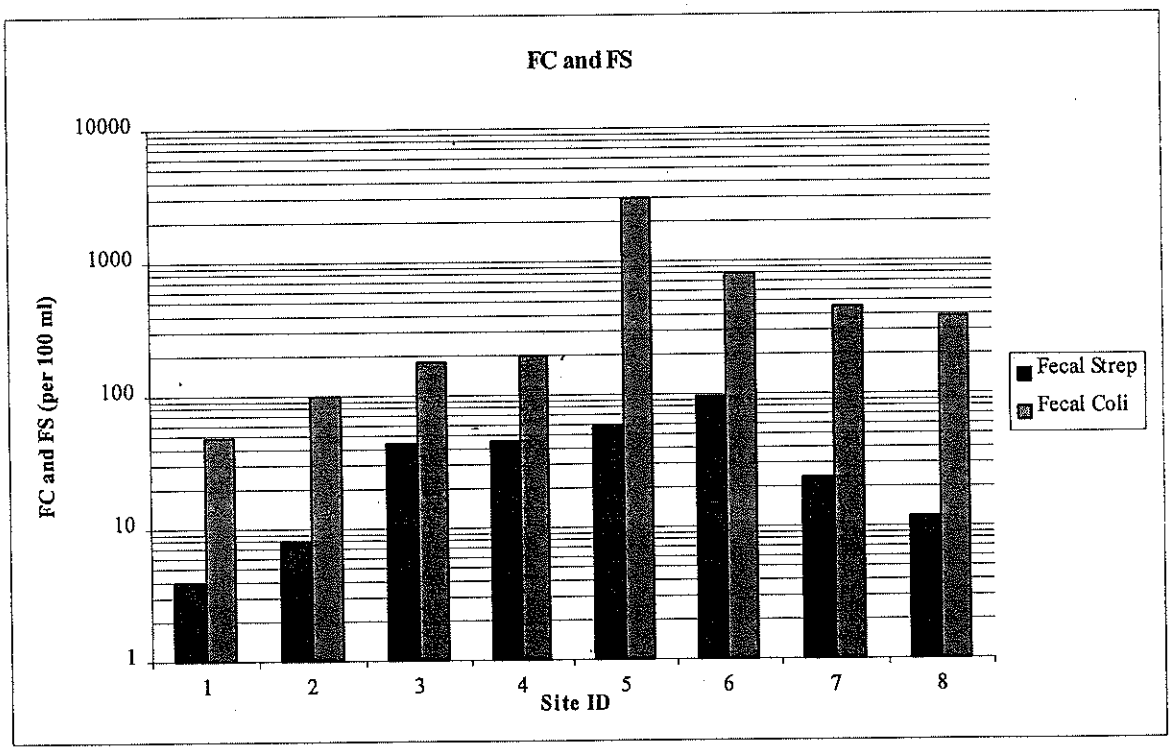


Figure D.8 Dissolved Oxygen June 16, 1994

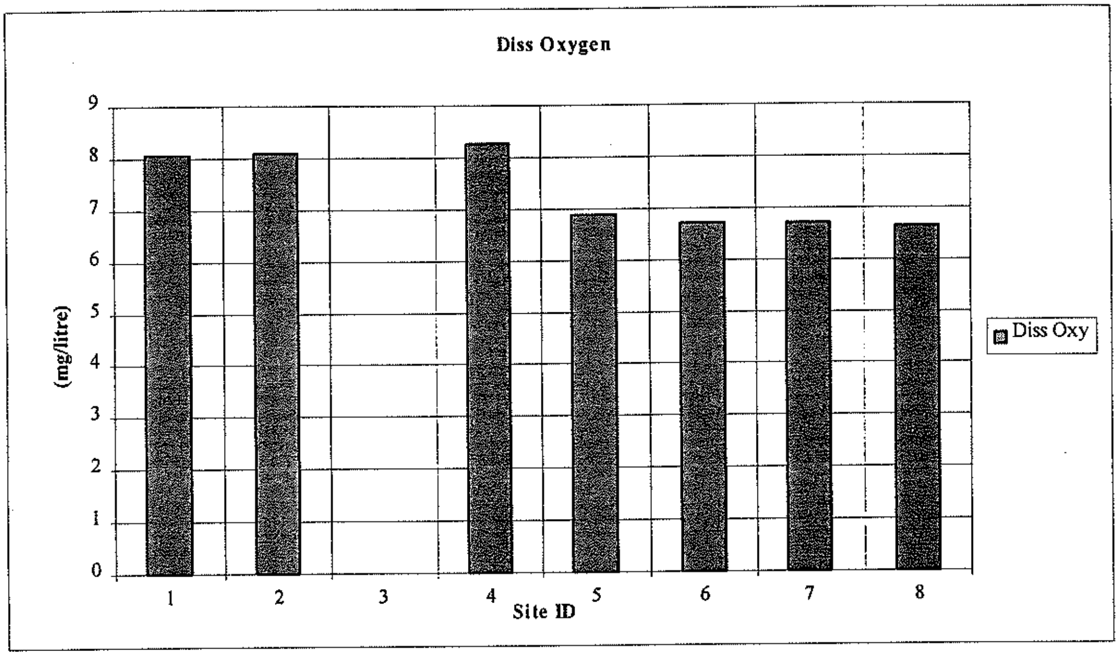


Figure D.9 Fecal Coliform and Fecal Strep June 16, 1994

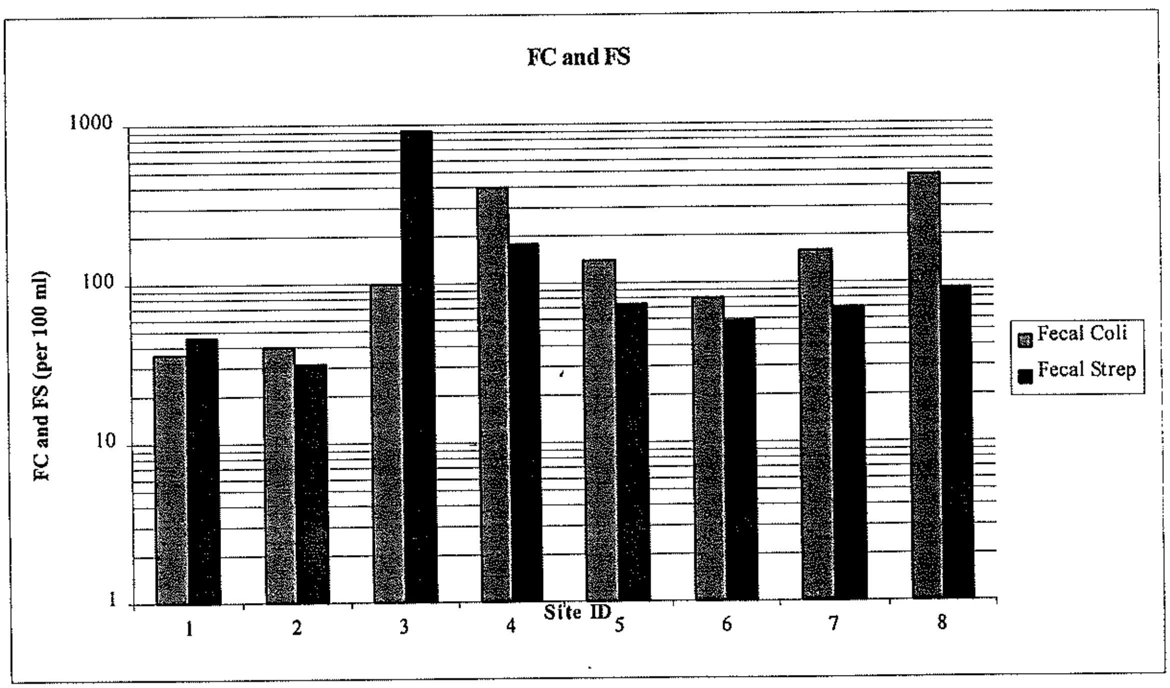


Figure D.10 BOD and Dissolved Oxygen June 21, 1994

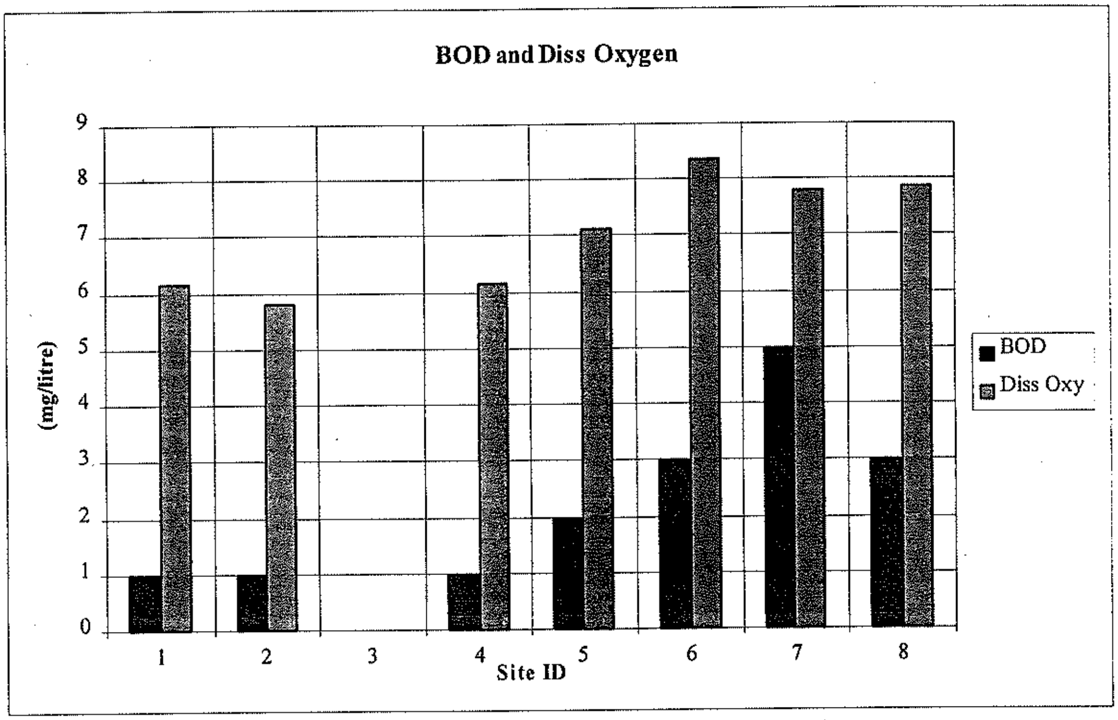


Figure D.11 Fecal Coliform and Fecal Strep June 21, 1994

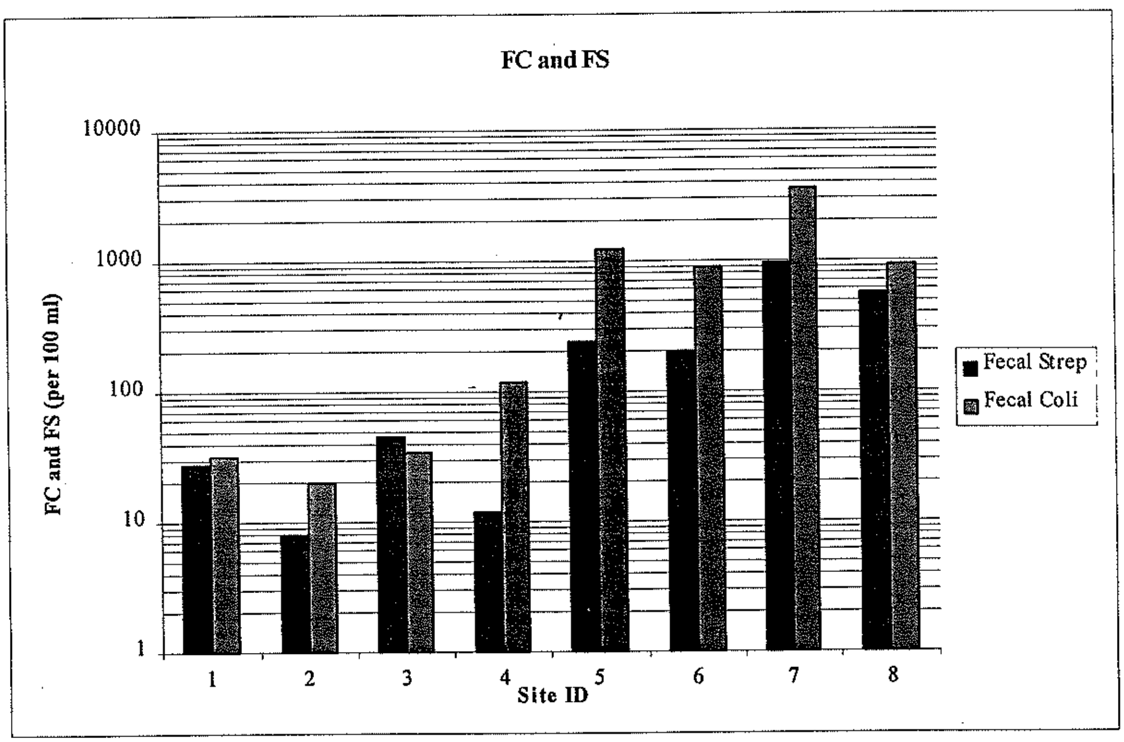


Figure D.12 Total and Volatile Suspended Solids June 21, 1994

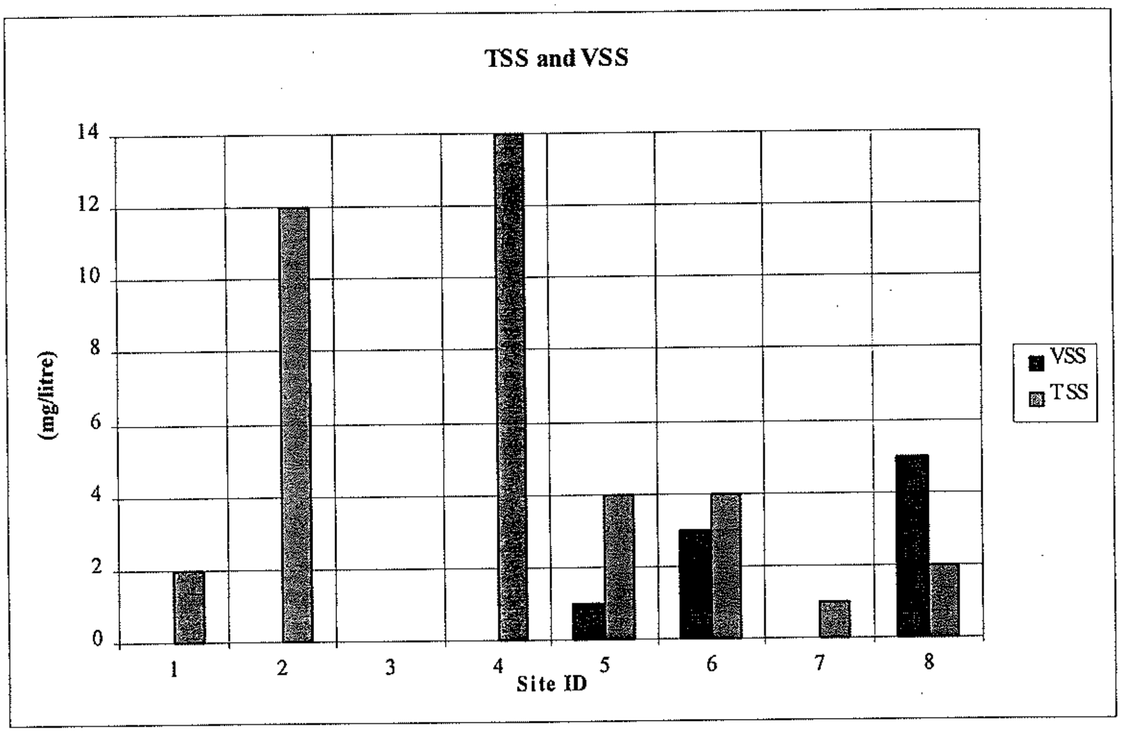


Figure D.13 BOD and Dissolved Oxygen June 27, 1994

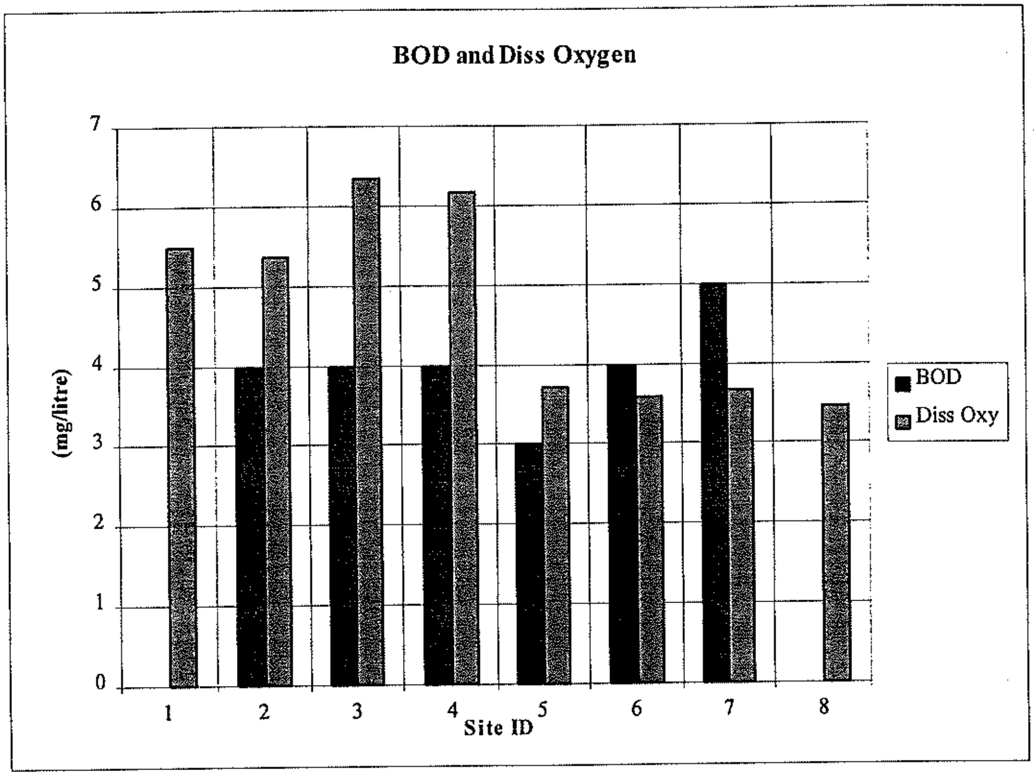


Figure D.14 Fecal Coliform and Fecal Strep June 27, 1994

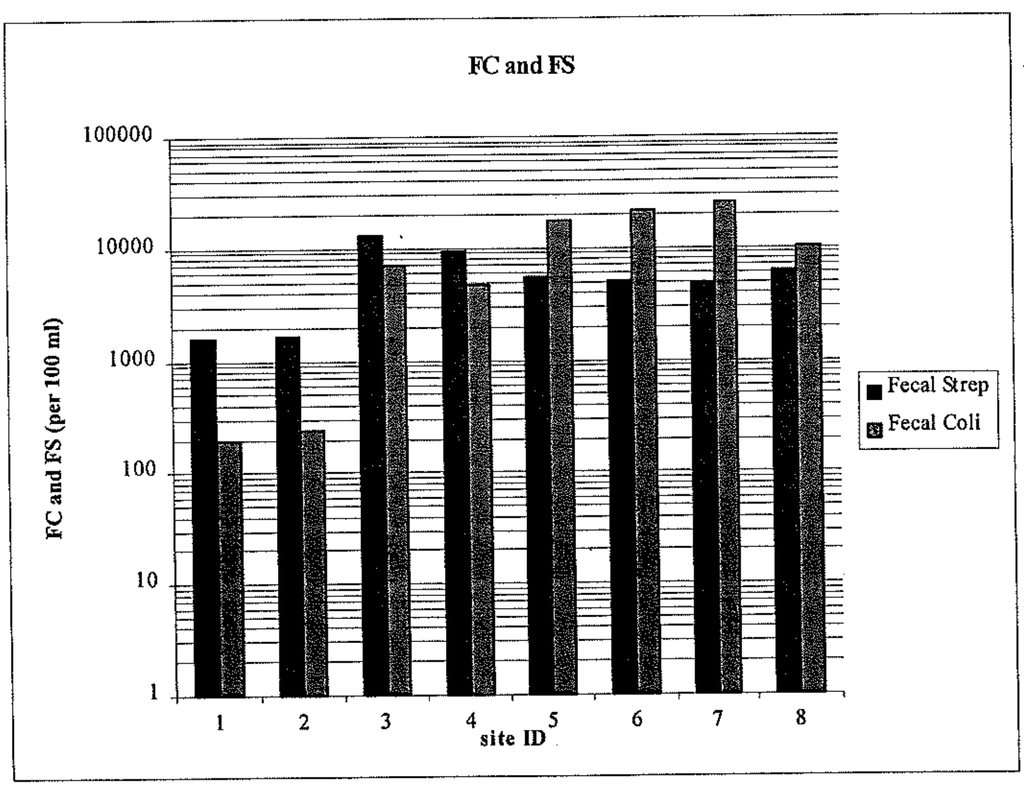


Figure D.15 Total and Volatile Suspended Solids June 27, 1994

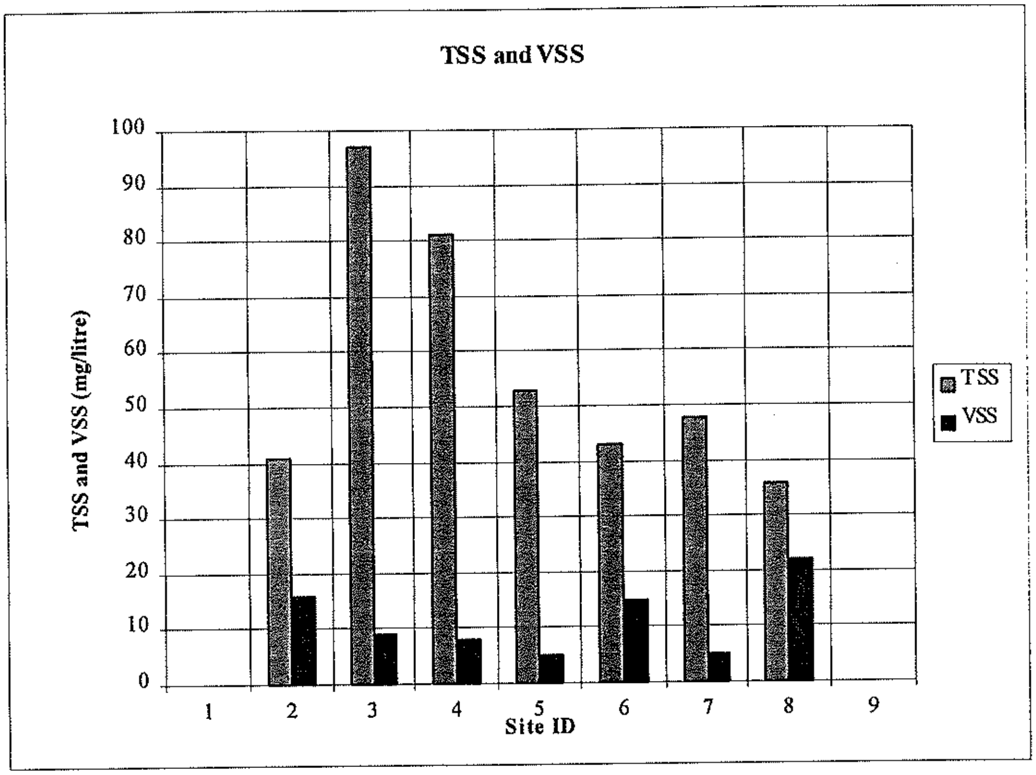


Figure D.16 Dissolved Oxygen July 02, 1994

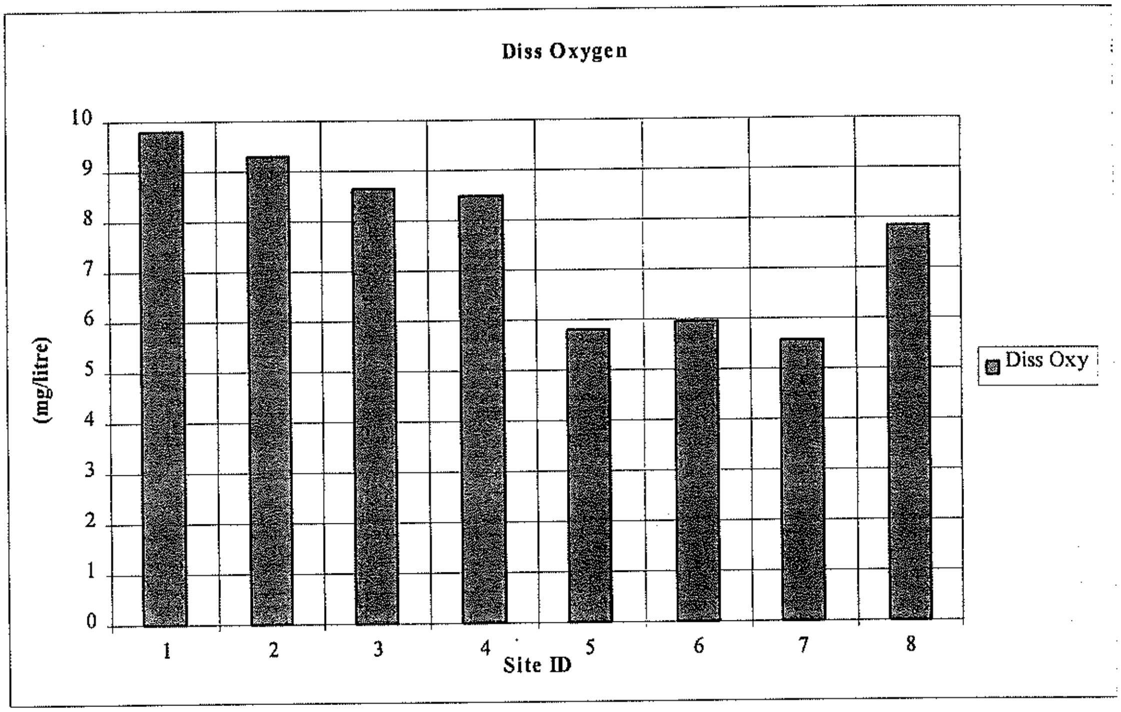


Figure D.17 Fecal Coliform and Fecal Strep July 02, 1994

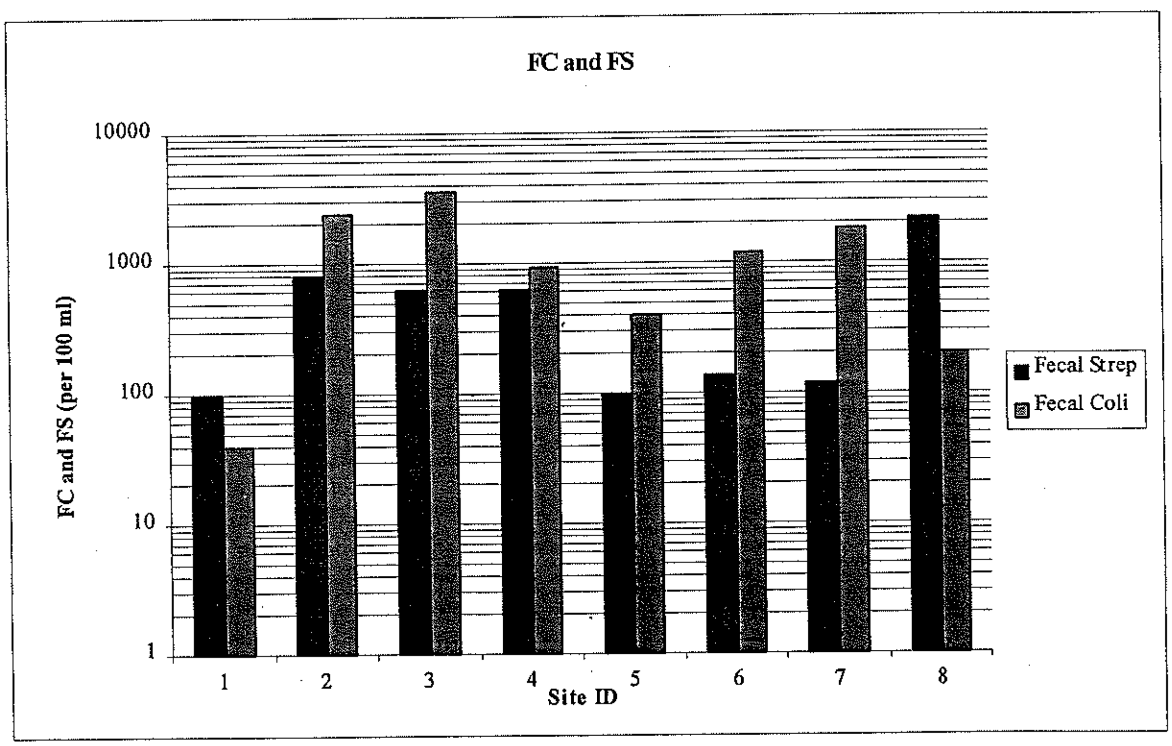


Figure D.18 Total and Volatile Suspended Solids July 02, 1994

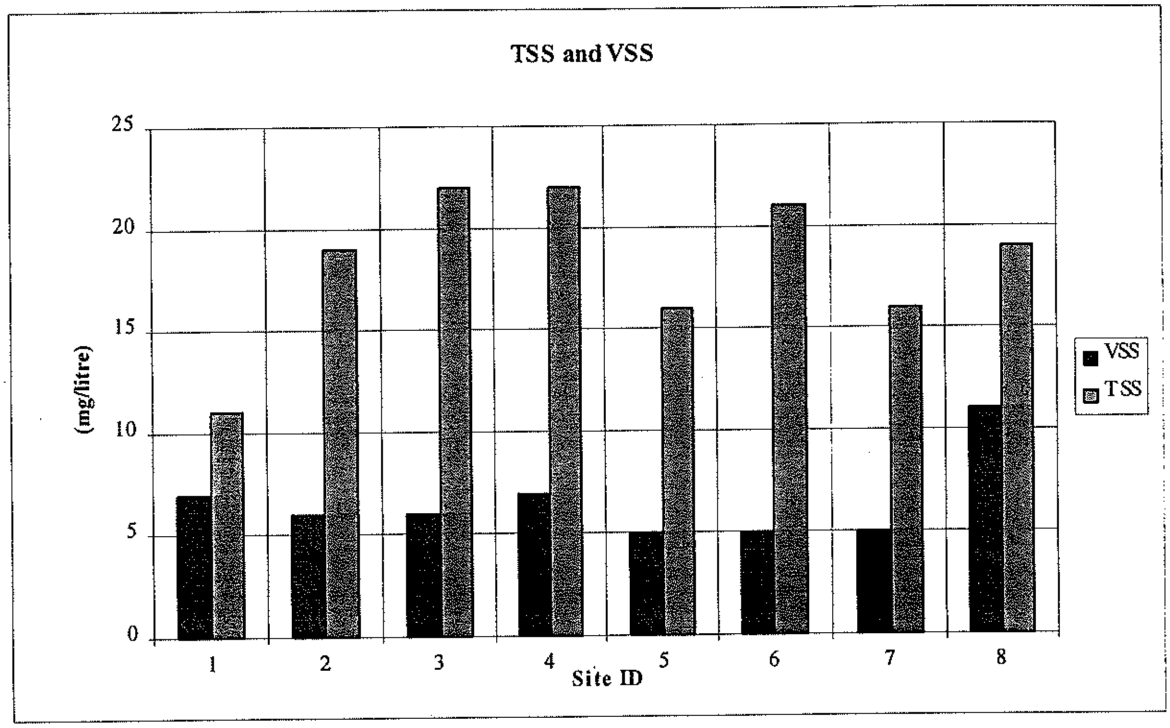


Figure D.19 BOD and Dissolved Oxygen July 06, 1994

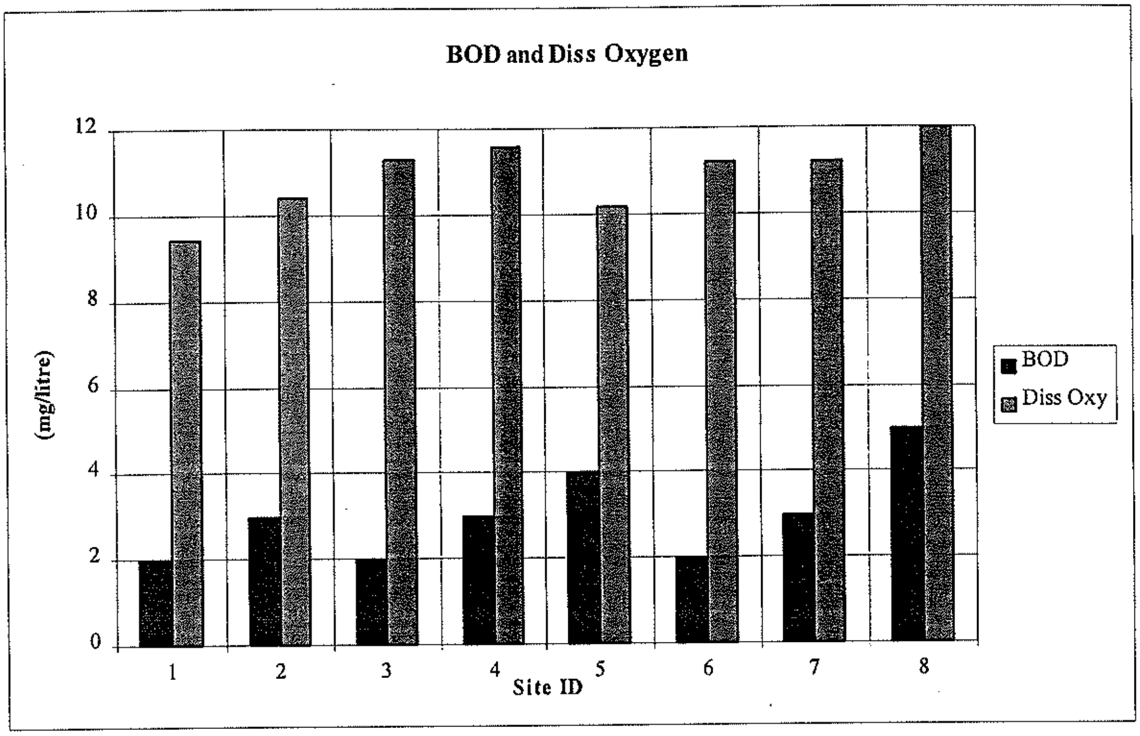


Figure D.20 Fecal Coliform and Fecal Strep July 06, 1994

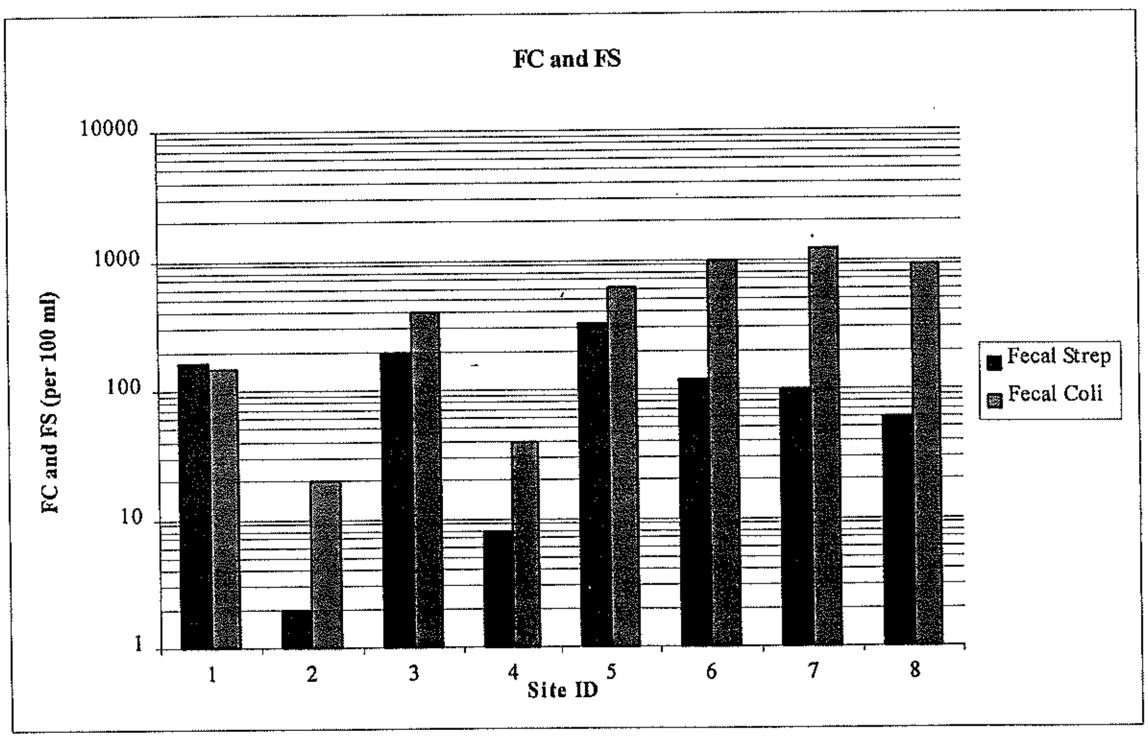


Figure D.21 Total and Volatile Suspended Solids July 06, 1994

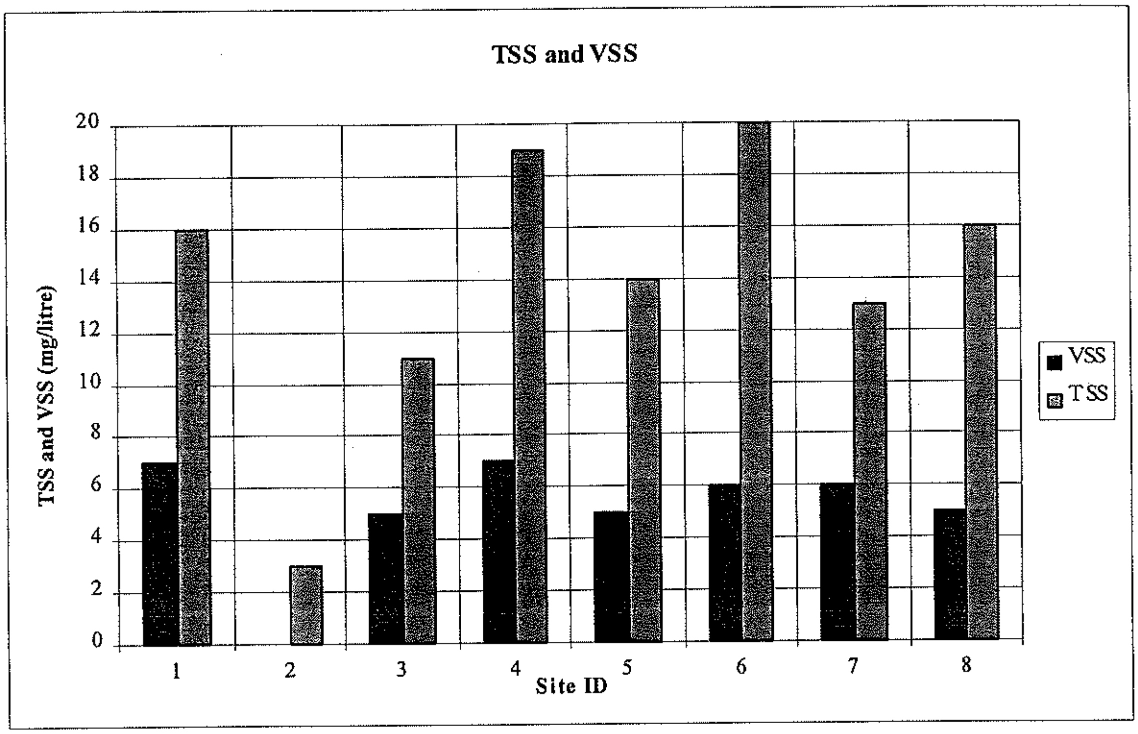


Figure D.22 BOD and Dissolved Oxygen July 14, 1994

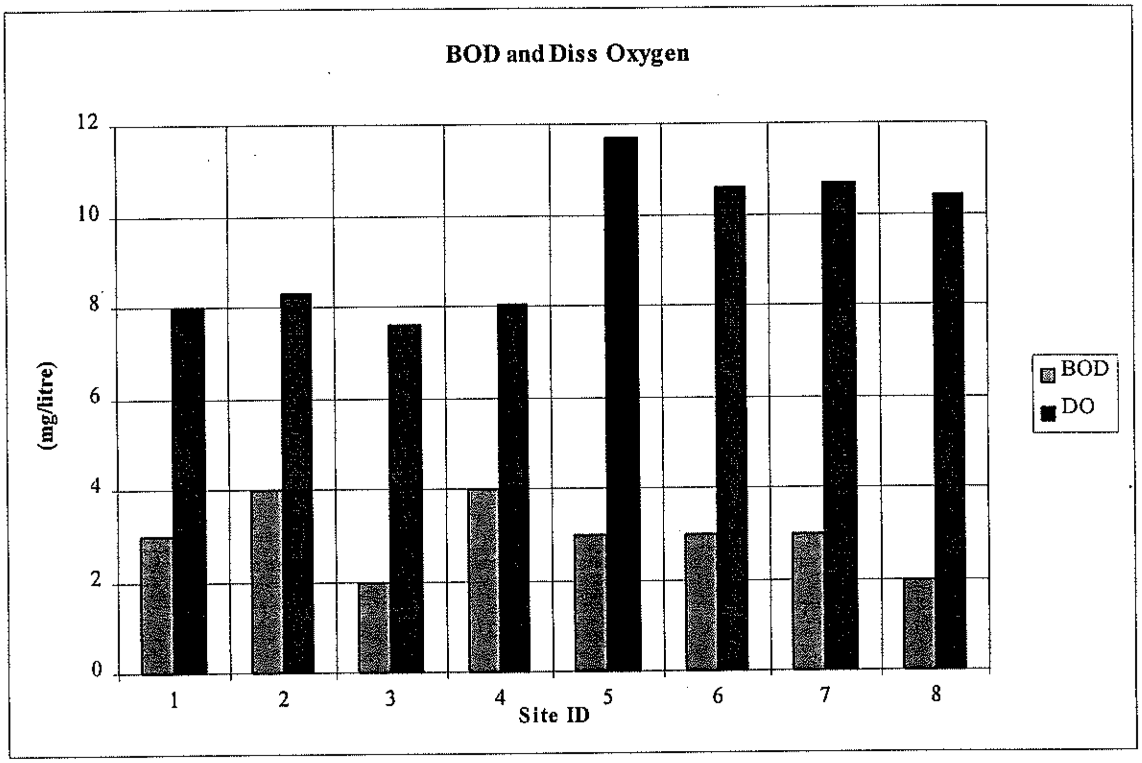


Figure D.23 Fecal Coliform and Fecal Strep July 14, 1994

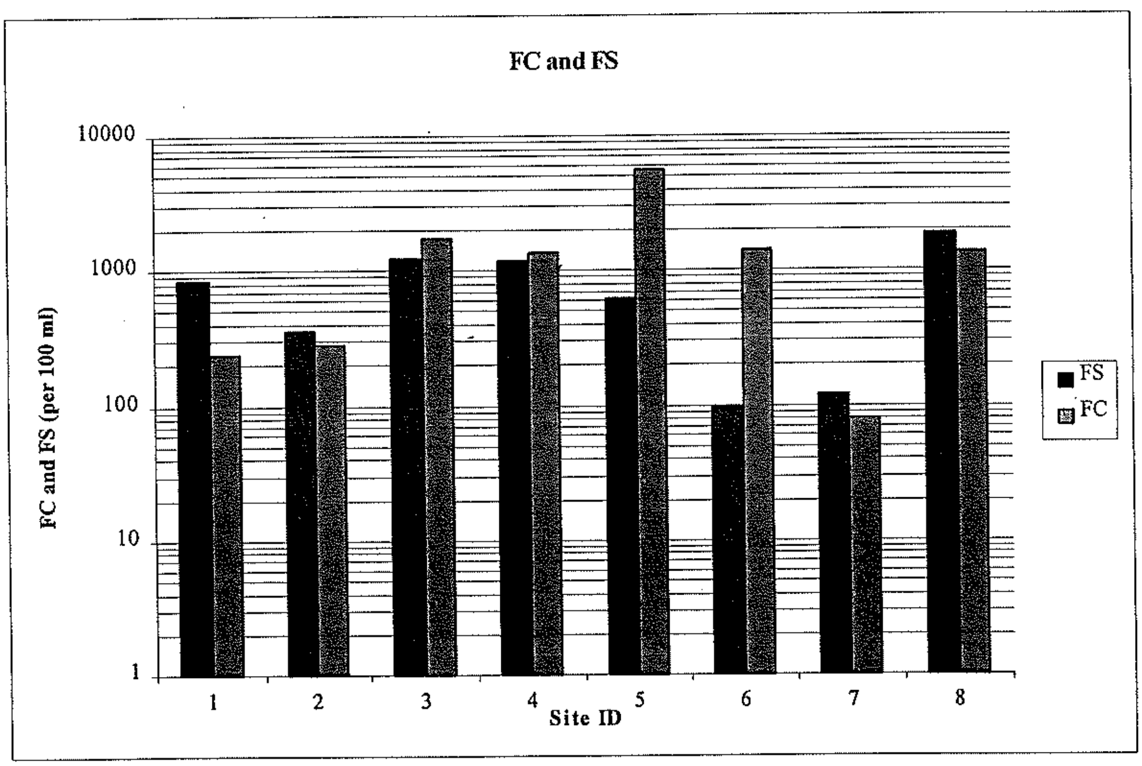


Figure D.24 Total and Volatile Suspended Solids July 14, 1994

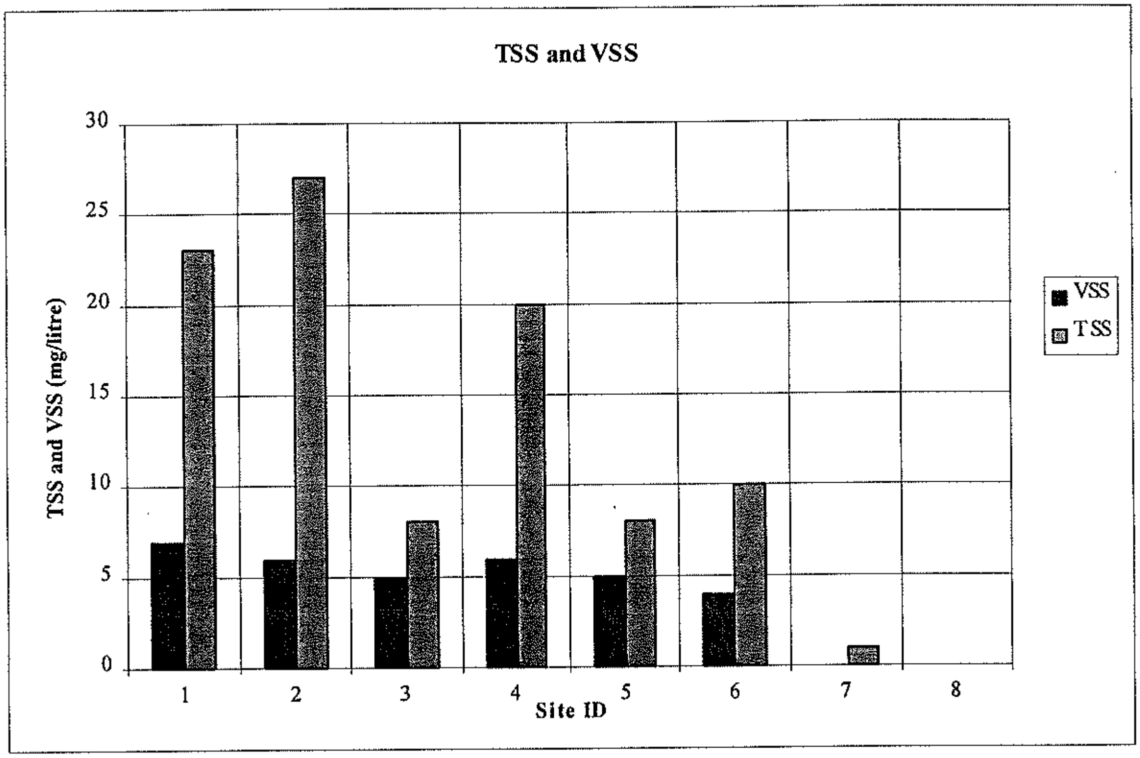


Figure D.25 BOD and Dissolved Oxygen July 28, 1994

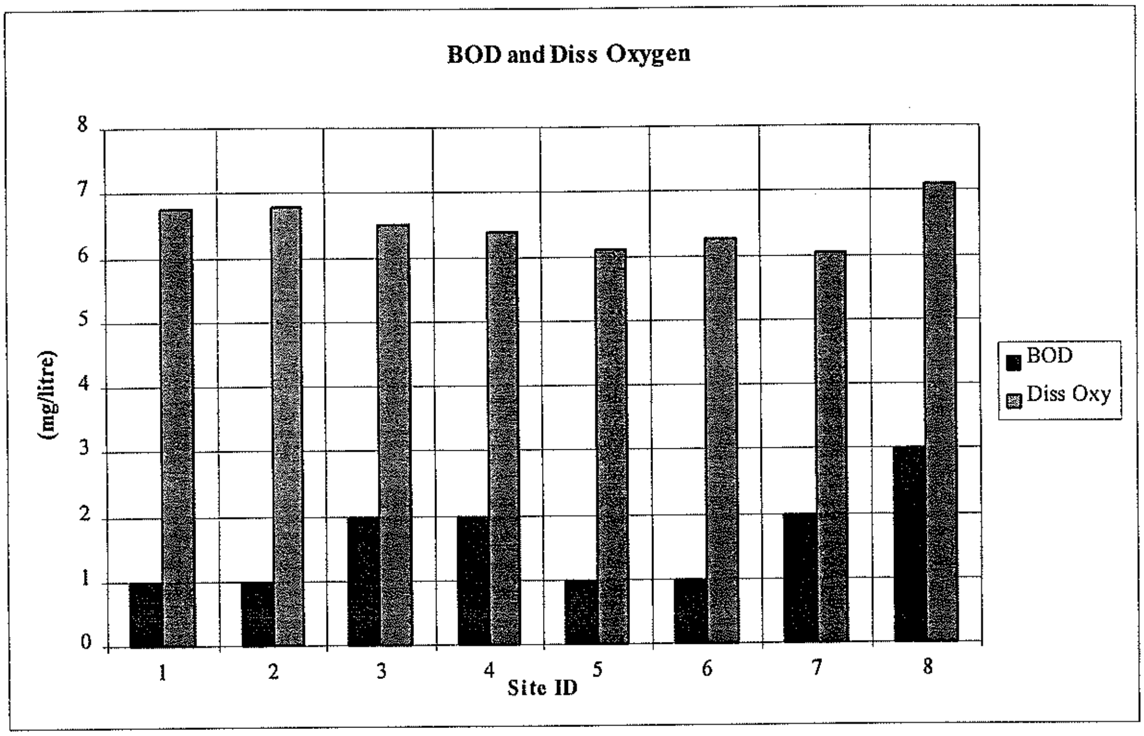


Figure D.26 Fecal Coliform and Fecal Strep July 28, 1994

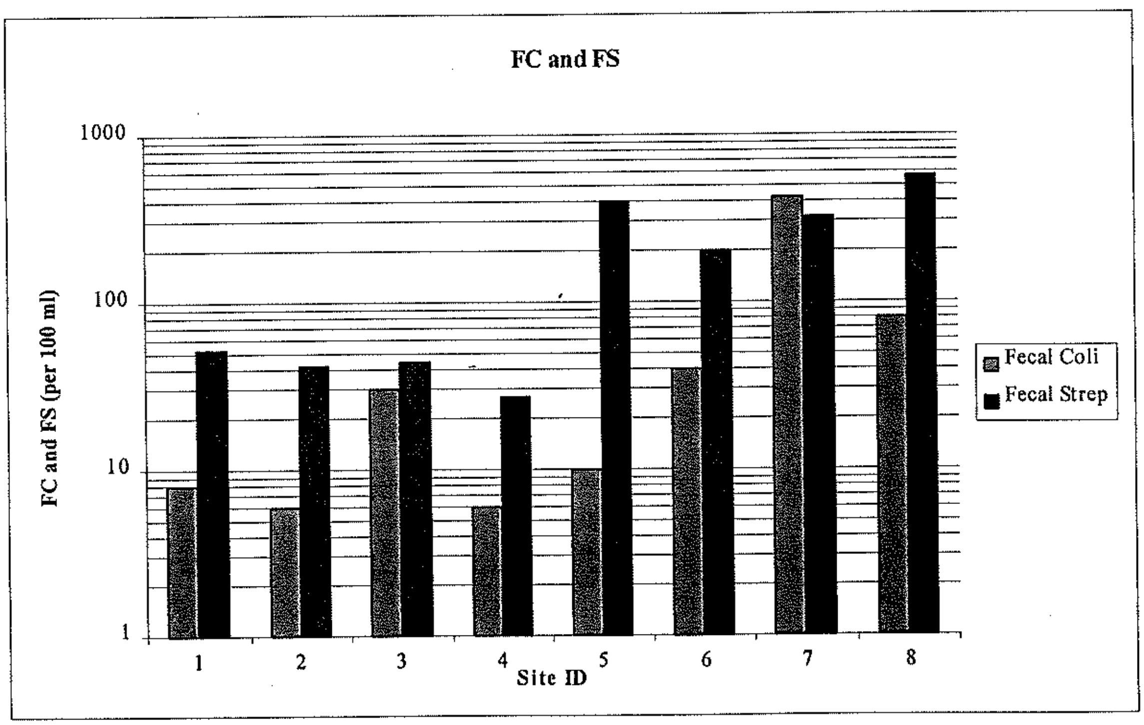
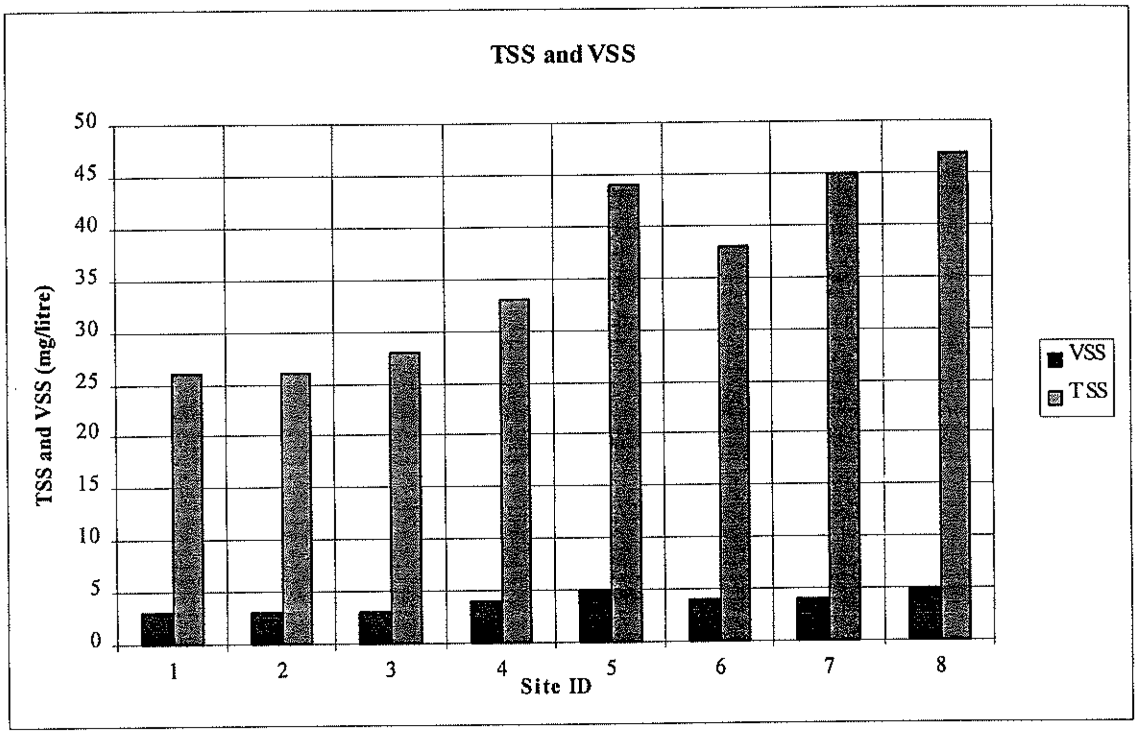


Figure D.27 Total and Volatile Suspended Solids July 28, 1994



APPENDIX E

Table E.1 Stream Water Quality Parameters on August 19, 1994

ID	TIME	DO	BOD	FC	FS	TSS	VSS	TMP	COND
1	1828	15.00	7	180	80	1	5	27	311
2	1823	15.00	8	20	20	12	5	27	311
3	1816	12.80	5	140	74	6	5	27	336
4	1812	11.80	5	72	42	12	4	27	341
5	1803	9.73	2	0	70	16	4	27	402
6	1758	9.96	7	20	66	15	3	27	404
7	1754	9.10	5	0	64	16	1	27	404
8	1751	9.33	3	0	80	14	3	27	405

Table E.2 Stream Water Quality Parameters on August 20, 1994

ID	TIME	DO	BOD	FC	FS	TSS	VSS	TMP	COND
1	1635	13.50	9	40	120	21	6	26	316
2	1640	12.50	6	0	60	22	2	26	317
3	1645	12.00	5	0	200	11	0	27	358
4	1648	10.70	5	0	160	15	2	27	369
5	1652	9.18	3	100	100	20	1	27	400
6	1700	9.30	8	80	80	18	2	27	399
7	1702	9.16	5	0	172	11	1	27	399
8	1707	8.72	2	0	80	14	1	27	396

Table E.3 Stream Water Quality Parameters on August 21, 1994 - 2:00 pm

ID	TIME	DO	BOD	FC	FS	TSS	VSS	TMP	COND
1	1325	10.60	5	64	18	9	4	25	308
2	1330	9.60	4	2	48	13	4	25	308
3	1335	9.99	4	8	20	13	6	26	321
4	1339	9.44	6	160	42	15	5	26	322
5	1347	8.10	5	1120	240	18	5	26	387
6	1351	8.40	4	106	400	20	5	26	389
7	1354	8.00	4	60	520	14	4	26	390
8	1357	7.80	3	1480	680	13	3	26	394

Table E.4 Stream Water Quality Parameters on August 21, 1994 - 6:00 pm

ID	TIME	DO	BOD	FC	FS	TSS	VSS	TMP	COND
1	1757	11.80	5	0	52	13	5	26	298
2	1754	12.10	5	0	80	13	5	26	297
3	1747	11.50	5	0	30	16	4	26	316
4	1744	11.20	5	0	86	14	4	26	318
5	1737	10.10	5	60	66	17	4	27	379
6	1733	9.55	3	2	60	8	5	26	385
7	1727	9.63	5	18	84	14	4	27	387
8	1724	10.50	5	166	40	13	4	27	389

APPENDIX F

Figure F.1 Dissolved Oxygen

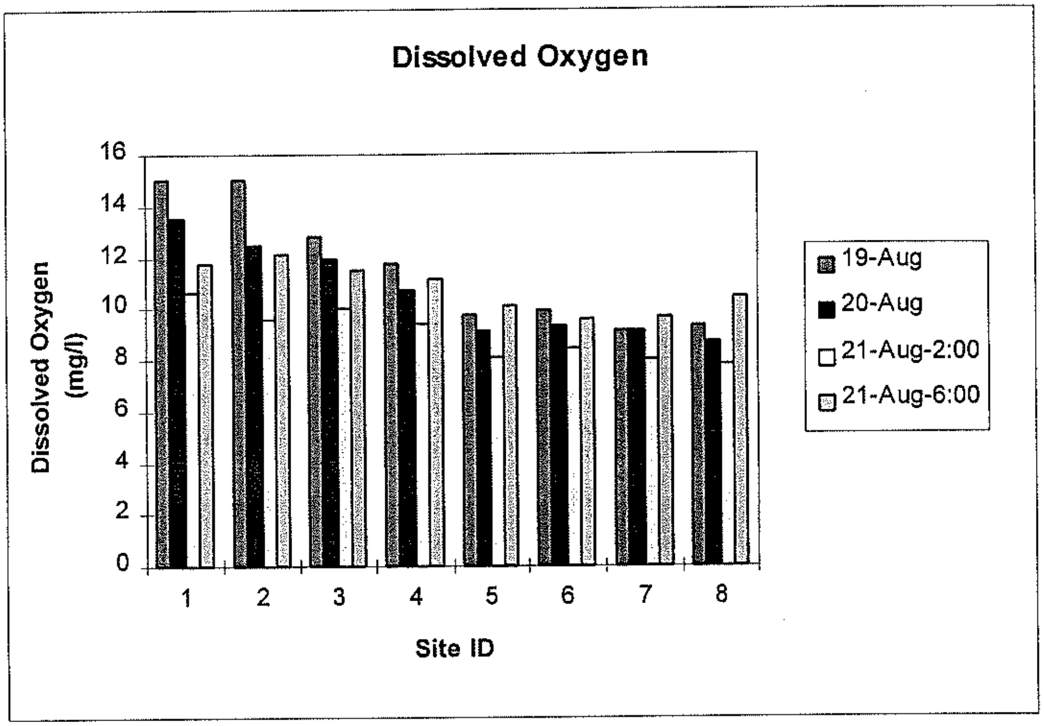


Figure F.2 Biochemical Oxygen Demand

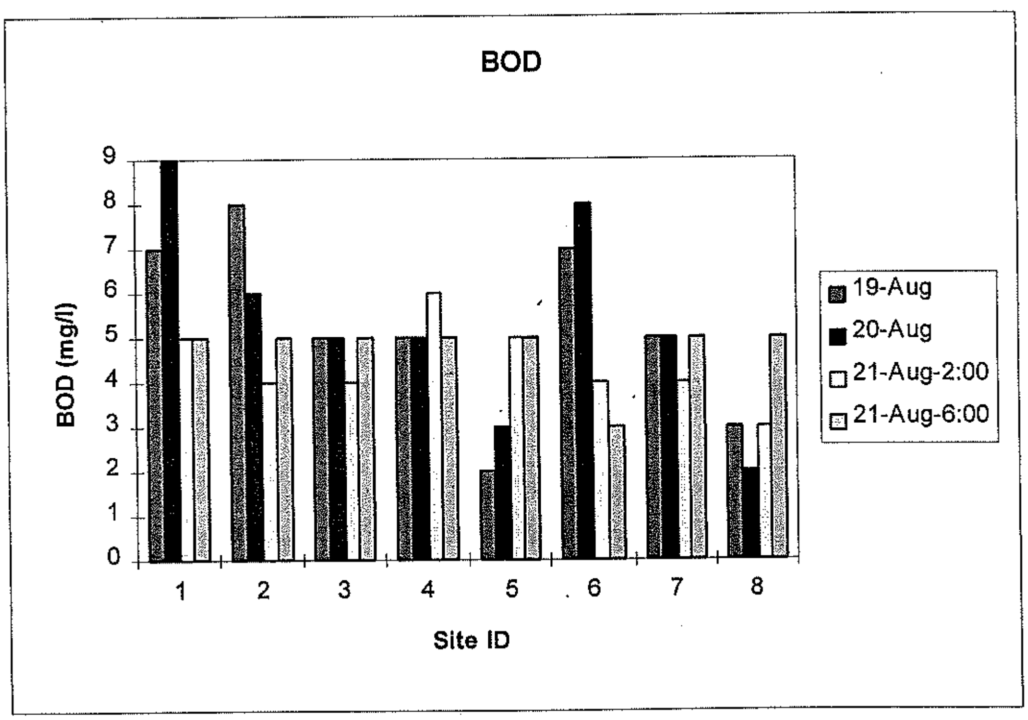


Figure F.5 Volatile Suspended Solids

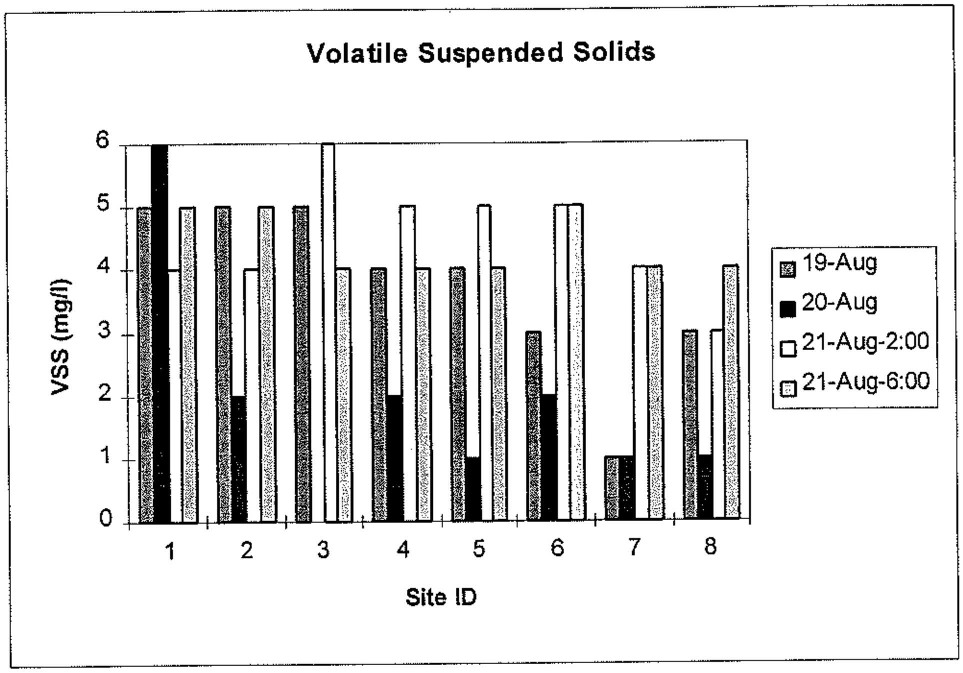


Figure F.6 Total Suspended Solids

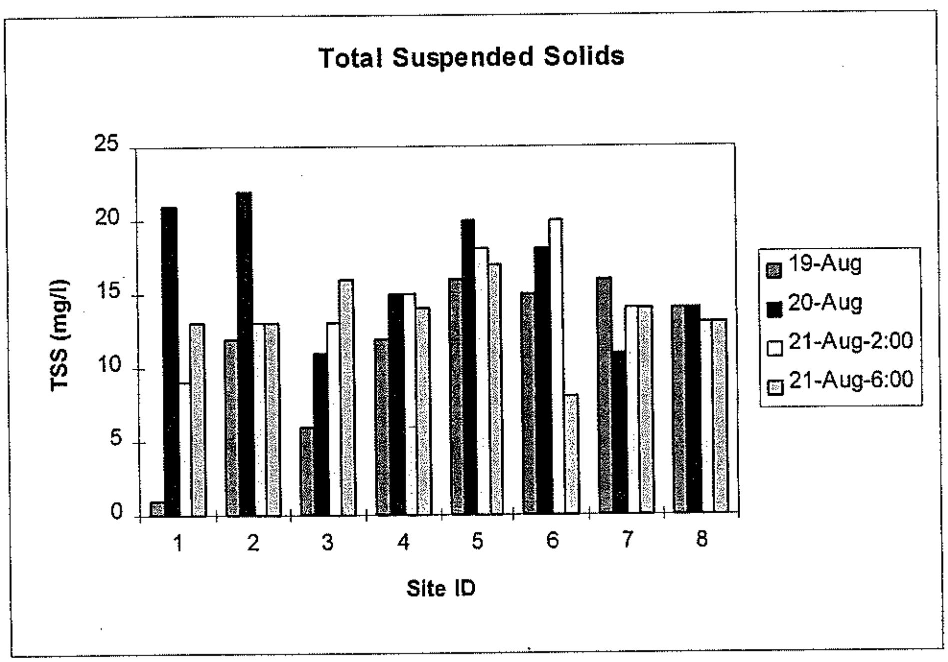


Figure F.3 Fecal Coliform

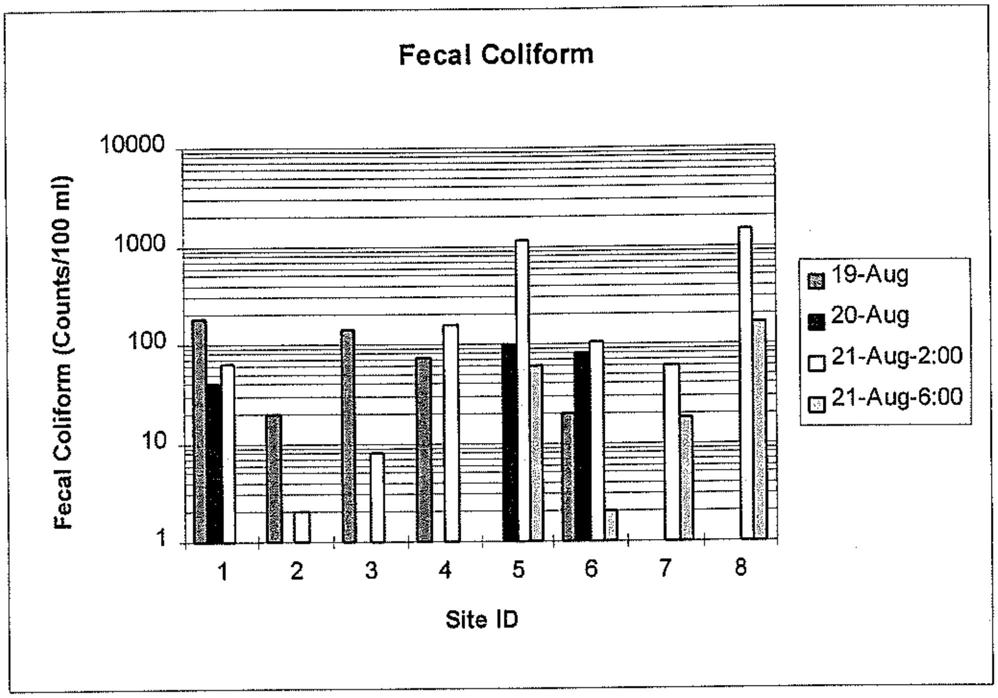
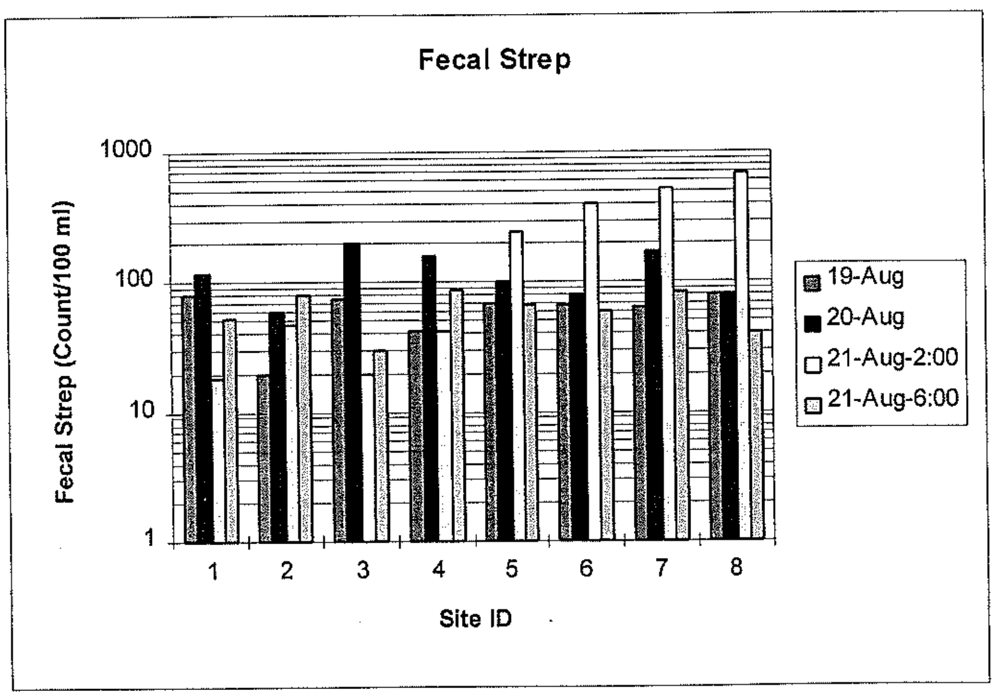


Figure F.4 Fecal Strep



APPENDIX G

COMMONWEALTH TECHNOLOGY, INC.

Laboratory Results

ACCT#: CUNICE

CTI LAB NO: 93111400

ATTN: Dr. Lindell Ormsbee
TO: University of Kentucky-CE
Dept. of Civil Engineering
242 Anderson Hall
Lexington KY 40506

DATE: June 29, 1993

P. O. NO: 675573

SAMPLE ID: Combined Sewer Overflow
SOURCE OF SAMPLE: -
SAMPLE MATRIX: Wastewater

DATE OF COLLECTION: 06/09/93
COLLECTION TIME: 12:30P
COLLECTED BY: Client
DATE RECEIVED: 06/09/93

NOTE: Chain Of Custody Record Attached/ * Best Detection Limit Possible Due To Sample Matrix Interferences./** Surrogate Did Not Meet EPA Requirements Due To Sample Matrix Interferences.

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	ANALYSIS BY
93111400								
GENERAL PARAMETERS								
Cyanide, Total		0.004	mg/L	0.002	Grab	EPA335.3	06/16/93	MLC
Nitrogen, Ammonia		1.5	mg/L	0.04	Grab	EPA350.1	06/15/93	CMB
Oil & Grease, Total/GRAV		15	mg/L	7	Grab	EPA413.1	06/24/93	MLC
Phenols		0.007	mg/L	0.006	Grab	EPA420.2	06/15/93	MLC
Phosphorus, Total		1.1	mg/L as P	0.01	Grab	EPA365.4	06/16/93	SCL
METALS								
Total Antimony (Furnace)	<	0.005	mg/L	0.005	Grab	EPA204.2/4.1.3	06/21/93	MEC
Total Arsenic (Furnace)	<	0.005	mg/L	0.005	Grab	EPA206.2/4.1.3	06/18/93	RTV
Total Beryllium (Furnace)	<	0.0005	mg/L	0.0005	Grab	EPA210.2	06/24/93	RTV
Total Cadmium (Furnace)	<	0.002	mg/L	0.002	Grab	EPA213.2/4.1.3	06/17/93	MEC
Total Chromium (Furnace)	<	0.002	mg/L	0.002	Grab	EPA218.2/4.1.3	06/18/93	VDA
Total Copper (Furnace)		0.022	mg/L	0.002	Grab	EPA220.2/4.1.3	06/18/93	VDA
Total Lead (Furnace)		0.039	mg/L	0.005	Grab	EPA239.2/4.1.3	06/22/93	MEC
Total Mercury (Cold Vapor)	<	0.0005	mg/L	0.0005	Grab	EPA245.1	06/15/93	VDA/RTV
Total Nickel (ICP)	<	0.02	mg/L	0.02	Grab	EPA200.7/9.3	06/15/93	MEC
Total Selenium (Furnace)	<	0.005	mg/L	0.005	Grab	EPA270.2/4.1.3	06/16/93	VDA
Total Silver (Furnace)		0.0133	mg/L	0.0002	Grab	EPA272.2/4.1.3	06/14/93	VDA
Total Thallium (Furnace)	<	0.005	mg/L	0.005	Grab	EPA279.2/4.1.3	06/17/93	RTV
Total Zinc (ICP)		0.13	mg/L	0.02	Grab	EPA200.7/9.3	06/15/93	VDA
ORGANIC - PESTICIDES/HERBICIDES								
Herbicides Sample Preparation		N/A	N/A	N/A	Grab	SW8150	06/10/93	DLJ
Herbicide, 2,4,5-TP Silvex*	<	0.005	mg/L	0.005	Grab	SW8150	06/24/93	LMO
Herbicide, 2,4,5-T*	<	0.005	mg/L	0.005	Grab	SW8150	06/24/93	LMO
Herbicide, 2,4-D*	<	0.005	mg/L	0.005	Grab	SW8150	06/24/93	LMO
Herbicide, Dalapon*	<	0.015	mg/L	0.015	Grab	SW8150	06/24/93	LMO
Herbicide, Dicamba*	<	0.025	mg/L	0.025	Grab	SW8150	06/24/93	LMO
Herbicide, Dinoseb*	<	0.015	mg/L	0.015	Grab	SW8150	06/24/93	LMO
ORGANIC - PESTICIDES/PCB'S								

2520 Regency Road
Lexington, Kentucky 40503-2921

(606) 276-3506
Fax: (606) 278-5665

COMMONWEALTH TECHNOLOGY, INC.

Laboratory Results

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE METHOD	ANALYSIS DATE	BY
4,4-DDD	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
93111400							
ORGANIC - PESTICIDES/PCB'S							
4,4-DDE	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
4,4-DDT	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Aldrin	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Alpha-BHC	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Arochlor-1016	<	0.001	mg/L	0.001	Grab EPA608	06/17/93	KRH
Arochlor-1221	<	0.001	mg/L	0.001	Grab EPA608	06/17/93	KRH
Arochlor-1232	<	0.001	mg/L	0.001	Grab EPA608	06/17/93	KRH
Arochlor-1242	<	0.001	mg/L	0.001	Grab EPA608	06/17/93	KRH
Arochlor-1248	<	0.001	mg/L	0.001	Grab EPA608	06/17/93	KRH
Arochlor-1254	<	0.001	mg/L	0.001	Grab EPA608	06/17/93	KRH
Arochlor-1260	<	0.001	mg/L	0.001	Grab EPA608	06/17/93	KRH
Beta-BHC	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Chlordane	<	0.002	mg/L	0.002	Grab EPA608	06/24/93	LMO
Delta-BHC	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Dieldrin	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Endosulfan I	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Endosulfan II	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Endosulfan Sulfate	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Endrin	<	0.0005	mg/L	0.0005	Grab EPA608	06/24/93	LMO
Endrin Aldehyde	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Gamma-BHC	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Heptachlor	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Heptachlor Epoxide	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Methoxychlor	<	0.001	mg/L	0.001	Grab EPA608	06/24/93	LMO
Pesticides/PCBs Sample Preparation		N/A	N/A	N/A	Grab EPA608	06/16/93	TCR/KRH
Toxaphene	<	0.007	mg/L	0.007	Grab EPA608	06/24/93	LMO
ORGANIC - SEMIVOLATILES							
1,2,4-Trichlorobenzene	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
1,2-Dichlorobenzene	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
1,3-Dichlorobenzene	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
1,4-Dichlorobenzene	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
2,4,6-Trichlorophenol	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
2,4-Dichlorophenol	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
2,4-Dimethylphenol	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
2,4-Dinitrophenol	<	0.025	mg/L	0.025	Grab EPA625	06/14/93	MTM
2,4-Dinitrotoluene	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
2,6-Dinitrotoluene	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
2-Chloronaphthalene	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
2-Chlorophenol	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
2-Methyl-4,6-Dinitrophenol	<	0.025	mg/L	0.025	Grab EPA625	06/14/93	MTM
2-Nitrophenol	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
3,3'-Dichlorobenzidine	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
4-Bromophenyl-Phenylether	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
4-Chlorophenyl-Phenylether	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
4-Chloro-3-Methylphenol	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM
4-Nitrophenol	<	0.005	mg/L	0.005	Grab EPA625	06/14/93	MTM

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REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
93111400								
ORGANIC - SEMIVOLATILES								
Acenaphthene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Acenaphthylene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Anthracene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Benzo(a)Anthracene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Benzo(a)Pyrene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Benzo(b)Fluoranthene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Benzo(g,h,i)Perylene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Benzo(k)Fluoranthene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Bis(2-chloroethoxy)methane	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Bis(2-Chloroethyl)Ether	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Bis(2-Chloroisopropyl)Ether	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Bis(2-Ethylhexyl)Phthalate	<	0.020	mg/L	0.02	Grab	EPA625	06/14/93	MTM
Butylbenzylphthalate	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Chrysene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Dibenzo(a,h)Anthracene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Diethylphthalate	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Dimethylphthalate	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Di-n-Butylphthalate	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Di-n-Octylphthalate	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Fluoranthene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Fluorene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
GC/MS Method 625 Sample Preparation		N/A	N/A	N/A	Grab	EPA625	06/09/93	JLH
Hexachlorobenzene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Hexachlorobutadiene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Hexachloroethane	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Ideno(1,2,3-cd)Pyrene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Isophorone	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Naphthalene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Nitrobenzene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
N-Nitrosodiphenylamine	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
N-Nitroso-Di-n-Propylamine	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Pentachlorophenol	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Phenanthrene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Phenol	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
Pyrene	<	0.005	mg/L	0.005	Grab	EPA625	06/14/93	MTM
SURROGATE: 2,4,6-Tribromophenol		59	% Recovery	1	N/A	Limits: 10-123%	06/14/93	MTM
SURROGATE: 2-Fluorobiphenyl		55	% Recovery	1	N/A	Limits: 43-116%	06/14/93	MTM
SURROGATE: 2-Fluorophenol		22	% Recovery	1	N/A	Limits: 21-100%	06/14/93	MTM
SURROGATE: Nitrobenzene-d5**		32	% Recovery	1	N/A	Limits: 35-114%	06/14/93	MTM
SURROGATE: Phenol-d6		20	% Recovery	1	N/A	Limits: 10- 94%	06/14/93	MTM
SURROGATE: Terphenyl-d14		88	% Recovery	1	N/A	Limits: 33-141%	06/14/93	MTM
ORGANIC - VOLATILES								
1,1,1-Trichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
1,1,2,2-Tetrachloroethane	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
1,1,2-Trichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
1,1-Dichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
1,1-Dichloroethene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM

COMMONWEALTH TECHNOLOGY, INC.

Laboratory Results

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
93111400								
ORGANIC - VOLATILES								
1,2-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
1,2-Dichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
1,2-Dichloropropane	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
1,3-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
1,4-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
2-Chloroethyl vinyl ether	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Benzene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Bromodichloromethane	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Bromoform	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Bromomethane	<	0.020	mg/L	0.02	Grab	EPA624	06/15/93	DHM
Carbon Tetrachloride	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Chlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Chloroethane	<	0.020	mg/L	0.02	Grab	EPA624	06/15/93	DHM
Chloroform	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Chloromethane	<	0.010	mg/L	0.01	Grab	EPA624	06/15/93	DHM
cis-1,3-Dichloropropene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Dibromochloromethane	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Ethylbenzene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Methylene Chloride	<	0.010	mg/L	0.01	Grab	EPA624	06/15/93	DHM
Tetrachloroethene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Toluene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
trans-1,2-Dichlorethene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
trans-1,3-Dichloropropene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Trichloroethene	<	0.005	mg/L	0.005	Grab	EPA624	06/15/93	DHM
Trichlorofluoromethane	<	0.010	mg/L	0.01	Grab	EPA624	06/15/93	DHM
Vinyl Chloride	<	0.010	mg/L	0.01	Grab	EPA624	06/15/93	DHM
SURROGATE: 4-Bromofluorobenzene		96	% Recovery	1	N/A	EPA624	06/15/93	DHM
SURROGATE: d4-1,2-Dichloroethane		104	% Recovery	1	N/A	EPA624	06/15/93	DHM
SURROGATE: d8-Toluene		96	% Recovery	1	N/A	EPA624	06/15/93	DHM

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COMMONWEALTH TECHNOLOGY, INC.

ACCT#: CUNICE

CTI LAB NO: 94114460

ATTN: Dr. Lindell Ormsbee
TO: University of Kentucky-CE
Dept. of Civil Engineering
242 Anderson Hall
Lexington KY 40506

DATE: September 1, 1994

P. O. NO: N/A

SAMPLE ID: Eighth Street CSO
SOURCE OF SAMPLE: -
SAMPLE MATRIX: Wastewater

DATE OF COLLECTION: 07/08/94
COLLECTION TIME: 5:00P
COLLECTED BY: Client
DATE RECEIVED: 07/11/94

NOTE: Chain Of Custody Record Attached

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
94114460								
GENERAL PARAMETERS								
Cyanide, Total		0.004	mg/L	0.002	Grab	EPA335.3	07/22/94	JSG
Nitrogen, Ammonia		5.4	mg/L	0.02	Grab	EPA350.1	07/27/94	CMB
Oil & Grease, Total/GRAV		26	mg/L	5	Grab	EPA413.1	07/21/94	MJV
Phenols		0.008	mg/L	0.006	Grab	EPA420.2	07/13/94	JSG
Phosphorus, Total		2.6	mg/L as P	0.01	Grab	EPA365.2	07/13/94	SCL
METALS								
Total Antimony (Furnace)	<	0.005	mg/L	0.005	Grab	EPA204.2/4.1.3	07/21/94	MEC
Total Arsenic (Furnace)	<	0.005	mg/L	0.005	Grab	EPA206.2/4.1.3	07/14/94	GLM
Total Beryllium (Furnace)	<	0.001	mg/L	0.001	Grab	EPA210.2	07/27/94	GLM
Total Cadmium (Furnace)		0.0026	mg/L	0.0002	Grab	EPA213.2/4.1.3	07/20/94	GLM
Total Chromium (Furnace)		0.015	mg/L	0.002	Grab	EPA218.2/4.1.3	07/22/94	MEC
Total Copper (Furnace)		0.13	mg/L	0.002	Grab	EPA220.2/4.1.3	07/22/94	MEC
Total Lead (Furnace)		0.11	mg/L	0.005	Grab	EPA239.2/4.1.3	07/15/94	SCL
Total Mercury (Cold Vapor)	<	0.0005	mg/L	0.0005	Grab	EPA245.1	07/20/94	MEC
Total Nickel (ICP)	<	0.02	mg/L	0.02	Grab	EPA200.7/9.3	07/13/94	DJM
Total Selenium (Furnace)	<	0.005	mg/L	0.005	Grab	EPA270.2/4.1.3	07/15/94	GLM
Total Silver (Furnace)		0.0040	mg/L	0.0002	Grab	EPA272.2/4.1.3	07/25/94	GLM
Total Thallium (Furnace)	<	0.005	mg/L	0.005	Grab	EPA279.2/4.1.3	07/21/94	MEC
Total Zinc (ICP)		0.22	mg/L	0.02	Grab	EPA200.7/9.3	07/13/94	DJM
ORGANIC - PESTICIDES/HERBICIDES								
Herbicides Sample Preparation		N/A	N/A	N/A	Grab	SW8150	07/14/94	SC
Herbicide, 2,4,5-T	<	0.001	mg/L	0.001	Grab	SW8150	08/14/94	XSQ
Herbicide, 2,4,5-TP Silvex	<	0.001	mg/L	0.001	Grab	SW8150	08/14/94	XSQ
Herbicide, 2,4-D	<	0.001	mg/L	0.001	Grab	SW8150	08/14/94	XSQ
Herbicide, Dalapon	<	0.005	mg/L	0.005	Grab	SW8150	08/14/94	XSQ
Herbicide, Dicamba	<	0.005	mg/L	0.005	Grab	SW8150	08/14/94	XSQ
Herbicide, Dinoseb	<	0.005	mg/L	0.005	Grab	SW8150	08/14/94	XSQ
ORGANIC - PESTICIDES/PCB'S								

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
4,4-DDD	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
94114460								
ORGANIC - PESTICIDES/PCB'S								
4,4-DDE	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
4,4-DDT	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Aldrin	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Alpha-BHC	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Arochlor-1016	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Arochlor-1221	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Arochlor-1232	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Arochlor-1242	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Arochlor-1248	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Arochlor-1254	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Arochlor-1260	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Beta-BHC	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Chlordane	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Delta-BHC	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Dieldrin	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Endosulfan I	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Endosulfan II	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Endosulfan Sulfate	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Endrin	<	0.0001	mg/L	0.0001	Grab	EPA608	07/15/94	XSQ
Endrin Aldehyde	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Gamma-BHC	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Heptachlor	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Heptachlor Epoxide	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Methoxychlor	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
Pesticides/PCBs Sample Preparation		N/A	N/A	N/A	Grab	EPA608	07/14/94	SC
Toxaphene	<	0.001	mg/L	0.001	Grab	EPA608	07/15/94	XSQ
ORGANIC - SEMIVOLATILES								
1,2,4-Trichlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
1,2-Dichlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
1,3-Dichlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
1,4-Dichlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,4,6-Trichlorophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,4-Dichlorophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,4-Dimethylphenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,4-Dinitrophenol	<	0.0025	mg/L	0.0025	Grab	EPA625	08/20/94	JG
2,4-Dinitrotoluene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,6-Dinitrotoluene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2-Chloronaphthalene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2-Chlorophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2-Methyl-4,6-Dinitrophenol	<	0.0025	mg/L	0.0025	Grab	EPA625	08/20/94	JG
2-Nitrophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
3,3'-Dichlorobenzidine	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
4-Bromophenyl-Phenylether	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
4-Chlorophenyl-Phenylether	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
4-Chloro-3-Methylphenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
4-Nitrophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG

2520 Regency Road
Lexington, Kentucky 40503-2921

(606) 276-3506
Fax: (606) 278-5665

COMMONWEALTH TECHNOLOGY, INC.

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
94114460								
ORGANIC - SEMIVOLATILES								
Acenaphthene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Acenaphthylene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Anthracene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(a)Anthracene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(a)Pyrene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(b)Fluoranthene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(g,h,i)Perylene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(k)Fluoranthene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Bis(2-chloroethoxy)methane	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Bis(2-Chloroethyl)Ether	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Bis(2-Chloroisopropyl)Ether	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Bis(2-Ethylhexyl)Phthalate		0.003	mg/L	0.002	Grab	EPA625	08/20/94	JG
Butylbenzylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Chrysene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Dibenzo(a,h)Anthracene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Diethylphthalate		0.0020	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Dimethylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Di-n-Butylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Di-n-Octylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Fluoranthene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Fluorene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
GC/MS Method 625 Sample Preparation		N/A	N/A	N/A	Grab	EPA625	07/13/94	SC
Hexachlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Hexachlorobutadiene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Hexachloroethane	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Ideno(1,2,3-cd)Pyrene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Isophorone	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Naphthalene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Nitrobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
N-Nitrosodiphenylamine	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
N-Nitroso-Di-n-Propylamine	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Pentachlorophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Phenanthrene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Phenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Pyrene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
SURROGATE: 2,4,6-Tribromophenol		110	% Recovery	1	N/A	Limits: 10-123%	08/20/94	JG
SURROGATE: 2-Fluorobiphenyl		58	% Recovery	1	N/A	Limits: 43-116%	08/20/94	JG
SURROGATE: 2-Fluorophenol		27	% Recovery	1	N/A	Limits: 21-100%	08/20/94	JG
SURROGATE: Nitrobenzene-d5		54	% Recovery	1	N/A	Limits: 35-114%	08/20/94	JG
SURROGATE: Phenol-d6		39	% Recovery	1	N/A	Limits: 10- 94%	08/20/94	JG
SURROGATE: Terphenyl-d14		50	% Recovery	1	N/A	Limits: 33-141%	08/20/94	JG
ORGANIC - VOLATILES								
1,1,1-Trichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
1,1,2,2-Tetrachloroethane	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
1,1,2-Trichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
1,1-Dichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
1,1-Dichloroethene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM

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REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
94114460								
ORGANIC - VOLATILES								
1,2-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
1,2-Dichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
1,2-Dichloropropane	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
1,3-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
1,4-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
2-Chloroethyl vinyl ether	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Benzene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Bromodichloromethane	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Bromoform	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Bromomethane	<	0.020	mg/L	0.02	Grab	EPA624	07/12/94	DHM
Carbon Tetrachloride	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Chlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Chloroethane	<	0.020	mg/L	0.02	Grab	EPA624	07/12/94	DHM
Chloroform	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Chloromethane	<	0.010	mg/L	0.01	Grab	EPA624	07/12/94	DHM
cis-1,3-Dichloropropene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Dibromochloromethane	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Ethylbenzene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Methylene Chloride	<	0.010	mg/L	0.01	Grab	EPA624	07/12/94	DHM
Tetrachloroethene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Toluene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
trans-1,2-Dichlorethene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
trans-1,3-Dichloropropene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Trichloroethene	<	0.005	mg/L	0.005	Grab	EPA624	07/12/94	DHM
Trichlorofluoromethane	<	0.010	mg/L	0.01	Grab	EPA624	07/12/94	DHM
Vinyl Chloride	<	0.010	mg/L	0.01	Grab	EPA624	07/12/94	DHM
SURROGATE: 4-Bromofluorobenzene		108	% Recovery	1	N/A	EPA624	07/12/94	DHM
SURROGATE: d4-1,2-Dichloroethane		90	% Recovery	1	N/A	EPA624	07/12/94	DHM
SURROGATE: d8-Toluene		96	% Recovery	1	N/A	EPA624	07/12/94	DHM

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(606) 276-3506
Fax: (606) 278-5665

ACCT#: CUNICE

CTI LAB NO: 94118191

ATTN: Dr. Lindell Ormsbee
TO: University of Kentucky-CE
Dept. of Civil Engineering
242 Anderson Hall
Lexington KY 40506

DATE: September 2, 1994

P. O. NO: N/A

SAMPLE ID: Stream Sample
SOURCE OF SAMPLE: -
SAMPLE MATRIX: Wastewater

DATE OF COLLECTION: 08/05/94
COLLECTION TIME: 2:30P
COLLECTED BY: Client
DATE RECEIVED: 08/05/94

NOTE: Chain Of Custody Record Attached

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	ANALYSIS BY
94118191								
GENERAL PARAMETERS								
Cyanide, Total	<	0.002	mg/L	0.002	Grab	EPA335.3	08/16/94	MJV
Nitrogen, Ammonia	<	0.02	mg/L	0.02	Grab	EPA350.1	08/09/94	KAH
Oil & Grease, Total/IR		3.4	mg/L	0.3	Grab	EPA413.2	08/24/94	WLS
Phenols	<	0.006	mg/L	0.006	Grab	EPA420.2	08/15/94	MJV
Phosphorus, Total		0.17	mg/L as P	0.01	Grab	EPA365.2	08/30/94	SCL
METALS								
Total Antimony (ICP)	<	0.1	mg/L	0.1	Grab	EPA200.7/9.3	08/09/94	GLM
Total Arsenic (Furnace)	<	0.005	mg/L	0.005	Grab	EPA206.2/4.1.3	08/14/94	MEC
Total Beryllium (ICP)	<	0.005	mg/L	0.005	Grab	EPA200.7/9.3	08/09/94	GLM
Total Cadmium (ICP)	<	0.005	mg/L	0.005	Grab	EPA200.7/9.3	08/09/94	GLM
Total Chromium (ICP)	<	0.01	mg/L	0.01	Grab	EPA200.7/9.3	08/09/94	GLM
Total Copper (ICP)	<	0.01	mg/L	0.01	Grab	EPA200.7/9.3	08/09/94	GLM
Total Lead (ICP * Furnace)	<	0.005	mg/L	0.005	Grab	EPA200.7/239.2	08/19/94	DJM/MEC
Total Mercury (Cold Vapor)	<	0.0005	mg/L	0.0005	Grab	EPA245.1	08/21/94	MEC
Total Nickel (ICP)	<	0.02	mg/L	0.02	Grab	EPA200.7/9.3	08/09/94	GLM
Total Selenium (Furnace)	<	0.005	mg/L	0.005	Grab	EPA270.2/4.1.3	08/10/94	GLM
Total Silver (ICP)	<	0.01	mg/L	0.01	Grab	EPA200.7/9.3	08/09/94	GLM
Total Thallium (ICP)	<	0.5	mg/L	0.5	Grab	EPA200.7/9.3	08/09/94	GLM
Total Zinc (ICP)	<	0.02	mg/L	0.02	Grab	EPA200.7/9.3	08/09/94	GLM
ORGANIC - PESTICIDES/HERBICIDES								
Herbicides Sample Preparation		N/A	N/A	N/A	Grab	SW8150	08/08/94	SC/JZ
Herbicide, 2,4,5-TP Silvex	<	0.001	mg/L	0.001	Grab	SW8150	08/14/94	XSQ
Herbicide, 2,4-D	<	0.001	mg/L	0.001	Grab	SW8150	08/14/94	XSQ
ORGANIC - PESTICIDES/PCB'S								
4,4-DDD	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
4,4-DDE	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
4,4-DDT	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Aldrin	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ

COMMONWEALTH TECHNOLOGY, INC.

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
94118191								
ORGANIC - PESTICIDES/PCB'S								
Alpha-BHC	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Aroclor-1016	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Aroclor-1221	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Aroclor-1232	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Aroclor-1242	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Aroclor-1248	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Aroclor-1254	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Aroclor-1260	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Beta-BHC	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Chlordane	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Delta-BHC	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Dieldrin	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Endosulfan I	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Endosulfan II	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Endosulfan Sulfate	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Endrin	<	0.0001	mg/L	0.0001	Grab	EPA608	08/18/94	XSQ
Endrin Aldehyde	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Gamma-BHC	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Heptachlor	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Heptachlor Epoxide	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Methoxychlor	<	0.001	mg/L	0.001	Grab	EPA608	08/18/94	XSQ
Pesticides/PCBs Sample Preparation		N/A	N/A	N/A	Grab	EPA608	08/10/94	SC/JZ
Toxaphene	<	0.003	mg/L	0.003	Grab	EPA608	08/18/94	XSQ
ORGANIC - SEMIVOLATILES								
1,2,4-Trichlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
1,2-Dichlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
1,3-Dichlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
1,4-Dichlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,4,6-Trichlorophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,4-Dichlorophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,4-Dimethylphenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,4-Dinitrophenol	<	0.0025	mg/L	0.0025	Grab	EPA625	08/20/94	JG
2,4-Dinitrotoluene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2,6-Dinitrotoluene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2-Chloronaphthalene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2-Chlorophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
2-Methyl-4,6-Dinitrophenol	<	0.0025	mg/L	0.0025	Grab	EPA625	08/20/94	JG
2-Nitrophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
3,3'-Dichlorobenzidine	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
4-Bromophenyl-Phenylether	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
4-Chlorophenyl-Phenylether	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
4-Chloro-3-Methylphenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
4-Nitrophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Acenaphthene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Acenaphthylene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Anthracene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(a)Anthracene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG

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REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
94118191								
ORGANIC - SEMIVOLATILES								
Benzo(a)Pyrene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(b)Fluoranthene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(g,h,i)Perylene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Benzo(k)Fluoranthene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Bis(2-chloroethoxy)methane	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Bis(2-Chloroethyl)Ether	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Bis(2-Chloroisopropyl)Ether	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Bis(2-Ethylhexyl)Phthalate	<	0.002	mg/L	0.002	Grab	EPA625	08/20/94	JG
Butylbenzylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Chrysene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Dibenzo(a,h)Anthracene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Diethylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Dimethylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Di-n-Butylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Di-n-Octylphthalate	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Fluoranthene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Fluorene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
GC/MS Method 625 Sample Preparation		N/A	N/A	N/A	Grab	EPA625	08/11/94	SC/JZ
Hexachlorobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Hexachlorobutadiene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Hexachloroethane	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Ideno(1,2,3-cd)Pyrene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Isophorone	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Naphthalene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Nitrobenzene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
N-Nitrosodiphenylamine	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
N-Nitroso-Di-n-Propylamine	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Pentachlorophenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Phenanthrene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Phenol	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
Pyrene	<	0.0005	mg/L	0.0005	Grab	EPA625	08/20/94	JG
SURROGATE: 2,4,6-Tribromophenol		14	% Recovery	1	N/A	Limits: 10-123%	08/20/94	JG
SURROGATE: 2-Fluorobiphenyl		60	% Recovery	1	N/A	Limits: 43-116%	08/20/94	JG
SURROGATE: 2-Fluorophenol		137	% Recovery	1	N/A	Limits: 21-100%	08/20/94	JG
SURROGATE: Nitrobenzene-d5		98	% Recovery	1	N/A	Limits: 35-114%	08/20/94	JG
SURROGATE: Phenol-d6		155	% Recovery	1	N/A	Limits: 10- 94%	08/20/94	JG
SURROGATE: Terphenyl-d14		75	% Recovery	1	N/A	Limits: 33-141%	08/20/94	JG
ORGANIC - VOLATILES								
1,1,1-Trichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
1,1,2,2-Tetrachloroethane	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
1,1,2-Trichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
1,1-Dichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
1,1-Dichloroethene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
1,2-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
1,2-Dichloroethane	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
1,2-Dichloropropane	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
1,3-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM

COMMONWEALTH TECHNOLOGY, INC.

REPORT OF ANALYTICAL RESULTS

CTI LAB NO./ ANALYTICAL TEST		RESULTS	UNITS	DETECT LIMIT	SAMP TYPE	METHOD	ANALYSIS DATE	BY
94118191								
ORGANIC - VOLATILES								
1,4-Dichlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
2-Chloroethyl vinyl ether	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Benzene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Bromodichloromethane	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Bromoform	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Bromomethane	<	0.020	mg/L	0.02	Grab	EPA624	08/10/94	DHM
Carbon Tetrachloride	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Chlorobenzene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Chloroethane	<	0.020	mg/L	0.02	Grab	EPA624	08/10/94	DHM
Chloroform	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Chloromethane	<	0.010	mg/L	0.01	Grab	EPA624	08/10/94	DHM
cis-1,3-Dichloropropene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Dibromochloromethane	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Ethylbenzene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Methylene Chloride	<	0.010	mg/L	0.01	Grab	EPA624	08/10/94	DHM
Tetrachloroethene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Toluene		0.006	mg/L	0.005	Grab	EPA624	08/10/94	DHM
trans-1,2-Dichlorethene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
trans-1,3-Dichloropropene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Trichloroethene	<	0.005	mg/L	0.005	Grab	EPA624	08/10/94	DHM
Trichlorofluoromethane	<	0.010	mg/L	0.01	Grab	EPA624	08/10/94	DHM
Vinyl Chloride	<	0.010	mg/L	0.01	Grab	EPA624	08/10/94	DHM
SURROGATE: 4-Bromofluorobenzene		98	% Recovery	1	N/A	EPA624	08/10/94	DHM
SURROGATE: d4-1,2-Dichloroethane		104	% Recovery	1	N/A	EPA624	08/10/94	DHM
SURROGATE: d8-Toluene		100	% Recovery	1	N/A	EPA624	08/10/94	DHM