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AN EFFICIENCY SURVEY OF THE DAVENPORT SEWAGE TREATMENT PLANT AND ITS EFFECTS UPON COTTONWOOD CREEK

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EFFICIENCY SURVEY OF THE DAVENPORT SEWAGE TREATMENT PLANT AND ITS EFFECTS UPON COTTONWOOD CREEK

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ABSTRACT

A three day survey was conducted during the summer low flow at the Davenport STP. Water quality and biological sampling was done to test the efficiency of the sewage treatment plant (STP) and its effects upon Cottonwood Creek, its receiving waters. It was found that the high concentration of nutrients and chlorine had a degrading effect upon Cottonwood Creek. It was recommended that the STP should be upgraded to remove the residual chlorine entering the stream.

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ACKNOWLEDGEMENTS

Roger Stanley of the DOE Water and Wastewater Monitoring Section identified and counted the periphyton diatoms and calculated the diversity indexes.

The survey was aided by the cooperation of Phil Williams of the Eastern Region, DOE and Dave Tyze, the Davenport STP operator.

INTRODUCTION

The survey of the Davenport Sewage Treatment Plant (STP) and its impact, both chemically and biologically, upon Cottonwood Creek was done at the request of the Eastern Regional Office, Department of Ecology (DOE), Spokane, Washington.

The STP is approximately 26 years old and is presently at its maximum design capacity for this Lincoln County seat's population of 1,450 (Figure 1, page 2). The STP is a secondary plant with two clarifiers, a trickling filter, a digester and two polishing ponds. Chlorine is applied in gaseous form in the pipe which connects the two polishing ponds (Figure 2, page 3).

Its receiving water, Cottonwood Creek, starts its perennial flow within the east side of Davenport and flows through town to the northwest corner, about 3/16 of a mile, where it receives the effluent from the STP. The creek flows another six miles where it becomes Hawk Creek and flows another 14 miles before it meets Franklin D. Roosevelt Lake of the Columbia River. Although there are no official water rights permits, the creek system supplies water for livestock.

MATERIALS AND METHODS

STP Survey

Manning S-4000 automatic sequential samplers were installed at the headworks and at the outfall (Station B, Figure 2, page 3). A 500 ml sample was taken automatically every two hours. At the end of 24 hours the

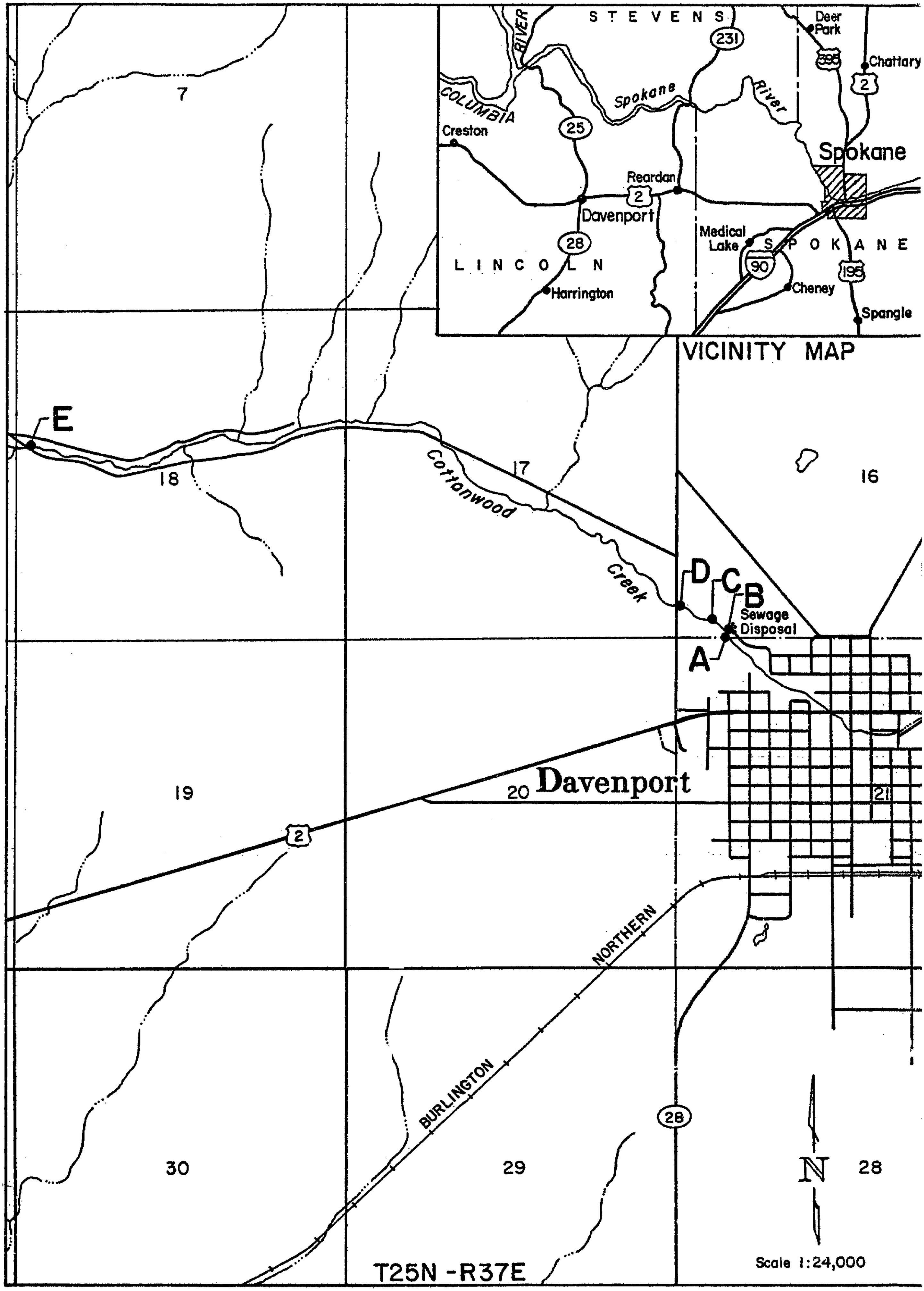

Figure 1. COTTONWOOD CREEK SAMPLING POINTS

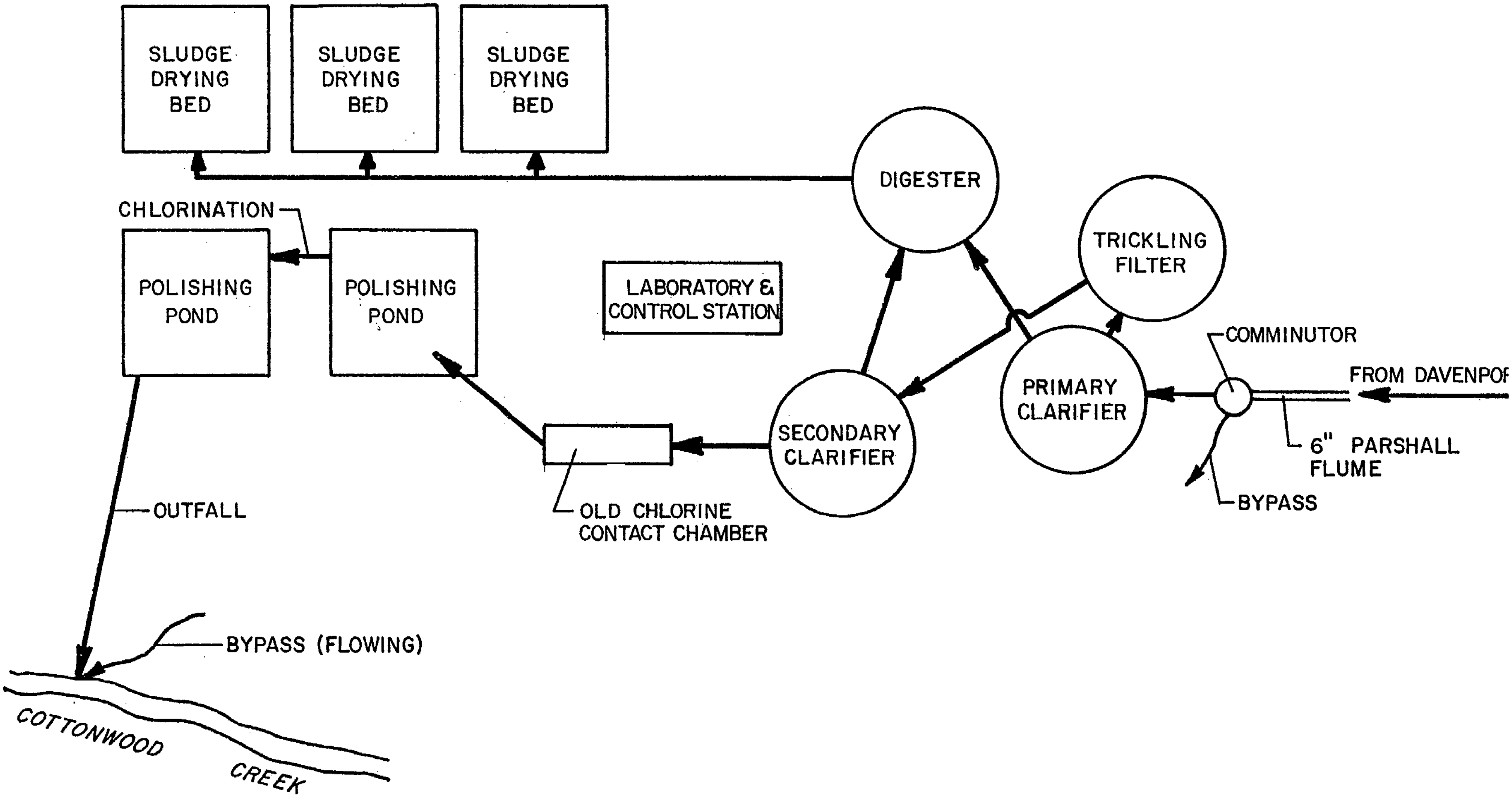

Figure 2. DAVENPORT SEWAGE TREATMENT PLANT.

samples were composited and shipped by bus to the DOE lab at Olympia for analysis. A Manning Dipper Flowmeter was installed at the 6 inch Parshall flume of the headworks because the STP does not have an adequate flowmeter. A check of the dipper's accuracy was made using a Marsh-McBirney flowmeter. The two methods were within 2% of each other.

Stream Survey

Cottonwood Creek was sampled at four points (A, C, D, E, see Figure 1, page 2) starting just above the STP outfall to a point about two miles downstream. At each station, samples were taken for laboratory analysis of nutrients and total and fecal coliforms. Field parameters taken at each point were pH, conductivity, temperature, dissolved oxygen (Winkler-azide method), and residual chlorine using the DPD method. At each of these four sampling points, scrapings were taken from rocks to determine diversity of attached diatoms. These samples were preserved in formalin and then shipped to Olympia where they were prepared for analysis.

RESULTS

STP Efficiency Survey

The TSS (Total Suspended Solids) in the STP effluent averaged a reduction of 94% and the BOD (Biochemical Oxygen Demand) averaged a reduction of 91%. The required reduction is 85% or better. However, ammonia (NH_3-N) concentrations in the effluent averaged 16.3 mg/l. The expected ammonia concentration from a trickling filter should be much lower - averaging around 4 to 5 mg/l. The ammonia will tend to combine with the chlorine forming chloramines which results in a less efficient disinfection. The rest of the parameters look fairly normal for this type of STP. Table 1, page 15, lists the three day average of these parameters. The 24 hour flow starting at 1040 was 162,877 gallons for August 23-24 and 131,445 gallons for August 24-25, 1977. Normally the STP flows would have been more uniform, averaging slightly less than the August 24-25 flow. However, thunderstorms affected both STP and stream flow. Precipitation for August 23 was .47 inches, August 24 was .12 inches and August 25 was .19 inches (U.S. Soil Conservation Service, Davenport).

Cottonwood Creek Survey

The STP discharge during the morning maximum flow ranged from 30% on the 24th to 55% on the 25th of the total stream flow. The 55% figure is probably more typical of the normal dry summer condition. This 1:1 dilution is much less than the DOE accepted dilution of 20:1. Figures 3, 4, 5 and 6 (pages 7, 8, 10, and 11), show the influence of the STP discharge chemically and biologically. Stations A, C, D and E (Figure 1, page 2) are the stream stations. The effluent enters between stations A and C.

The top four graphs on Figure 3, page 7, show the effects of high concentrations of ammonia entering the stream from the STP. As the ammonia enters the stream it is oxidized by biochemical action according to the simplified equation.

$$\underset{\text{(ammonia)}}{NH_3} \xrightarrow[O_2 \text{ (oxygen)}]{\text{Biochemical Action}} \underset{\text{(nitrite)}}{NO_2^-} \xrightarrow[O_2]{\text{Biochemical Action}} \underset{\text{(nitrate)}}{NO_3^-}$$

This reaction explains the delayed rise in nitrite and nitrate levels. The nitrite and nitrate levels start dropping off after station D due to biological assimilation and possibly dilution.

Total Kjeldahl is the organic nitrogen plus ammonia. Most of the Total Kjeldahl is probably ammonia which explains why it is nearlv identical to the ammonia curve.

Ortho-phosphorous ($O-PO_4$, Figure 3, page 7) and total phosphorous (Total Phos-P, Figure 4, page 8) are initially high from the STP and show biological assimilation and possible dilution downstream.

Conductivity (Figure 4, page 8) rises steeply due to the STP and gradually tails off, perhaps due to dilution from groundwater entering downstream.

Dissolved oxygen (D.O., Figure 4, page 8) values averaged 4.29 mg/l or 45% saturation above the outfall. This low value may be due to either oxygen consuming wastes entering the stream or an initially low D.O. content of the ground water entering the stream in that area. The STP discharge depressed the D.O. to 3.66 mg or 39% saturation at station C. However, at station D the D.O. increased to 6.03 mg/l or 62% saturation and to 10.30 mg/l or 106% saturation at station E. The increase is due to the oxygen demanding material being 'satisfied' and aeration and algal production regenerating the D.O.

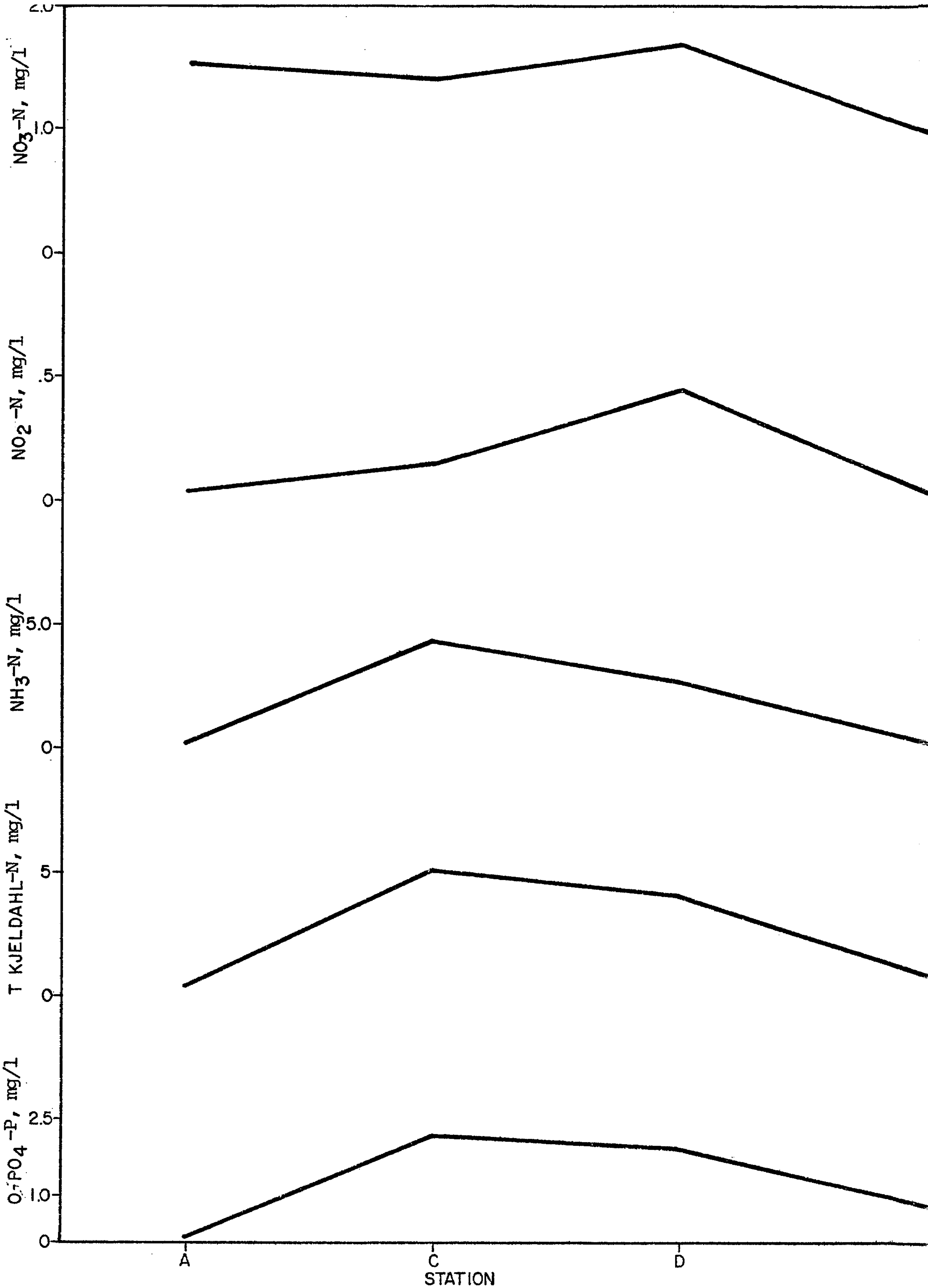

Figure 3. COTTONWOOD CREEK - NO_3, NO_2, NH_3, T KJELDAHL, & $O\text{-}PO_4$.

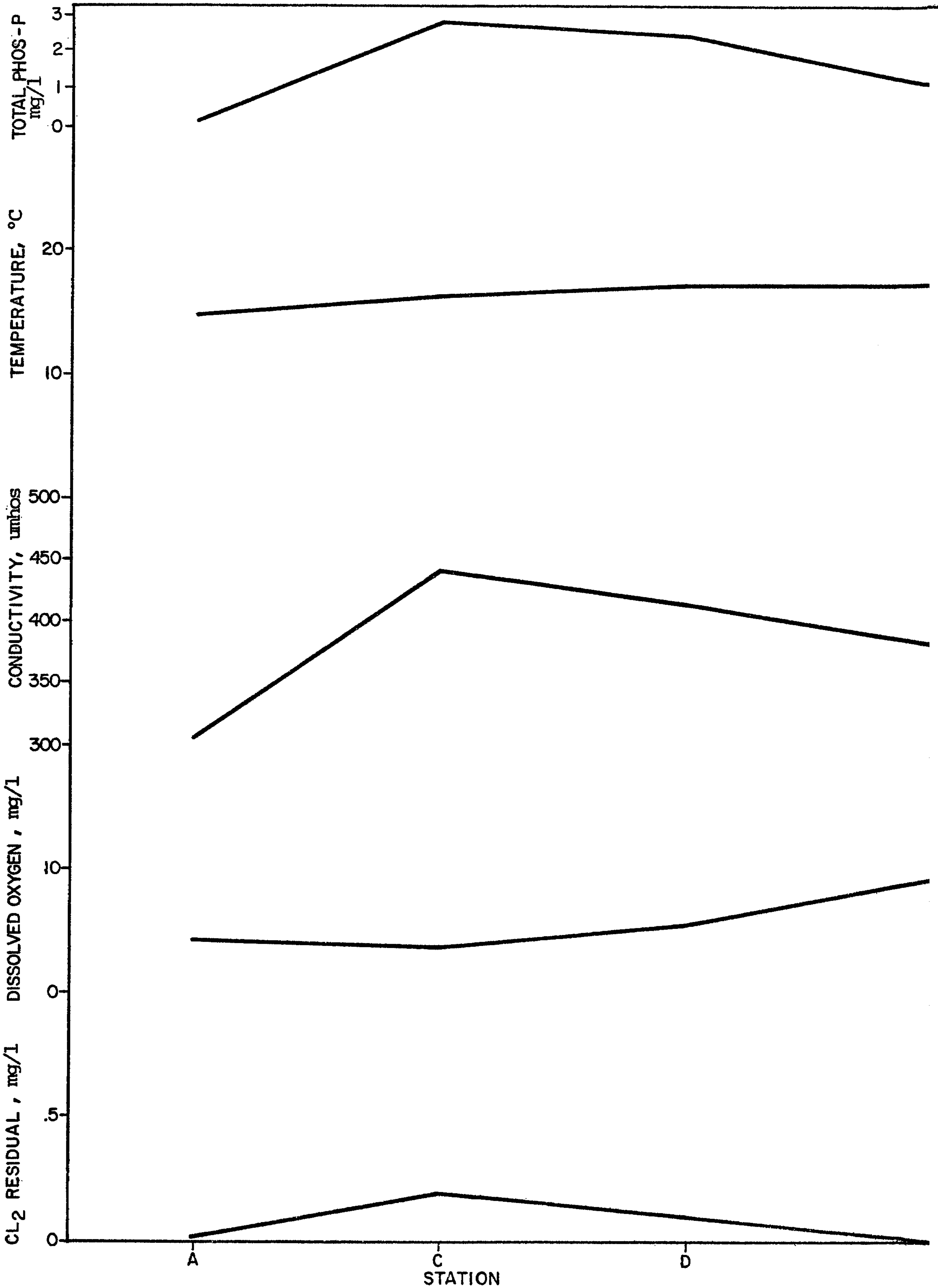

Figure 4. COTTONWOOD CREEK - TOT. PHOS-P, TEMP., COND., DISSOL. OXY., & CL_2 RESID

Residual chlorine to trace amounts was found as far as two miles downstream at station E (Figure 4, page 8). The effluent concentration of 1.8 mg/l was quickly reduced to .2 at station C, .1 at station D and trace at station E.

Total and fecal coliform counts (Figure 5, page 10) were also highly influenced by the STP. Like the rest of the parameters except D.O., the counts declined rapidly in a downstream direction.

However, the majority of the coliform counts appeared to be coming from a small discharge (labeled bypass [flowing], Figure 2, page 3) at the base of the polishing pond dike. The STP fecal coliform count was 66 while the small discharge fecal coliform count was 320,000. An application of dye showed that this small discharge, which appears to be partially treated sewage, originates with either the headworks bypass, or more likely, a leak at the standpipe in the old chlorination chamber.

Attached diatoms taken from rock scrapings (Figure 6, page 11) showed a significant reduction in the diversity index. The computed Margalef Natural Log declined from 2.656 at station A to .660 at station C. At station C the two most abundant species <u>Nitzschia palea</u> and <u>Gomphonema augustatum</u> indicate stressed waters when they become the predominate species. The diversity improved downstream with 2.466 at station D and 3.283 at station E. The diatom count sheets are presented in the appendix.

The pH showed a slight dip due to the effluent and then a recovery downstream.

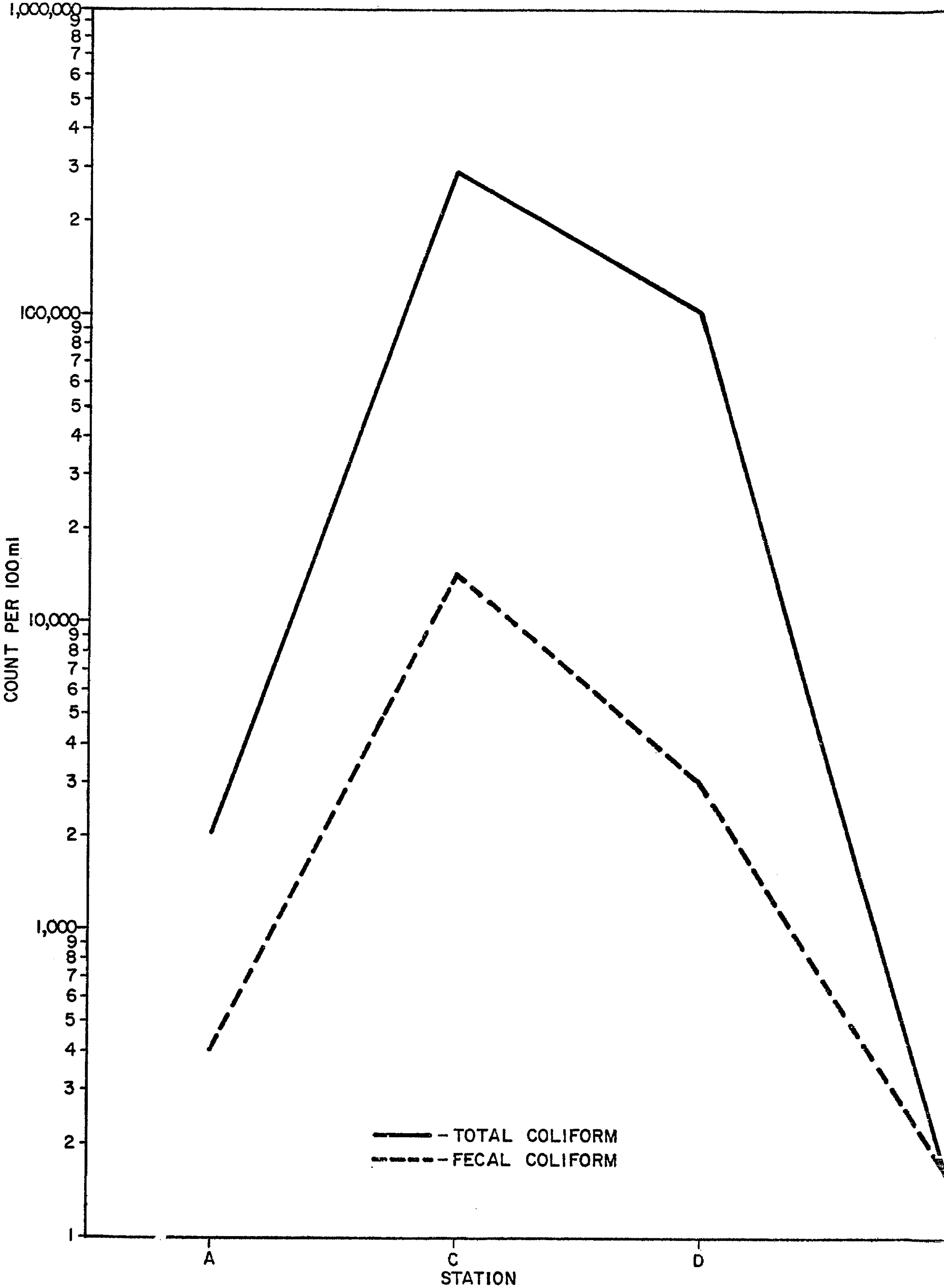

Figure 5. COTTONWOOD CREEK-TOTAL AND FECAL COLIFORM.

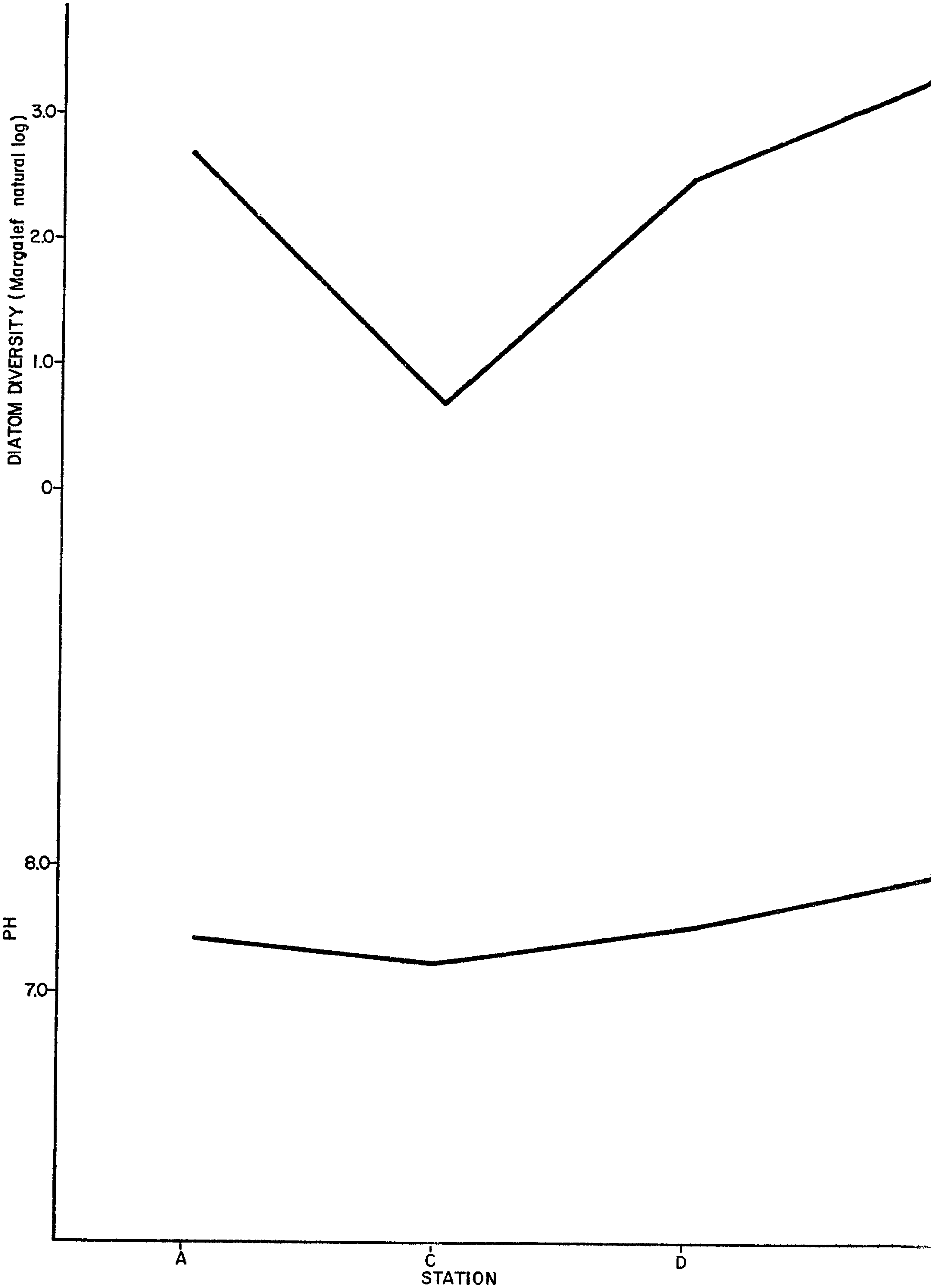

Figure 6. COTTONWOOD CREEK - DIATOM DIVERSITY & PH.

CONCLUSIONS

The Davenport STP exerted a significant degrading influence upon Cottonwood Creek. This has been clearly documented by the proceeding graphs. Every chemical parameter tested showed the STP's effects. The presence of chlorine downstream was most important because concentrations as little as .01 mg/l can be lethal to the resident Rainbow trout (Becker). The ammonia concentration of 2.7 mg/l is much higher than the toxic level of .3 mg/l (Becker). Ammonia and chlorine combine with each other to produce toxic chloramines.

The degrading effects of the STP were apparent biologically with the diatom diversity index as the indicator. The high nutrients, low D.O, high chlorine residual and high coliform counts probably all put a stress upon the diatom community.

Another problem is the high total and fecal coliform counts immediately below the outfall. This sudden increase must be coming from a small flow marked Bypass (flowing) on Figure 2, page 3). This fecal coliform source would virtually eliminate this water source for domestic water supply.

RECOMMENDATIONS

Improvements must be done with the Davenport STP in order to eliminate the toxic levels of ammonia and chlorine.

The flow in the small ditch with its very high coliform counts which was labeled Bypass (flowing) in Figure 2 must be eliminated.

The cyclone fencing presently encompasses all of the STP except for the polishing ponds and the sludge drying beds. The fencing should be expanded to enclose the whole facility. This would remove a health and safety hazard to the children who occasionally play in the area.

BIBLIOGRAPHY

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Becker, C. D. and T. O. Thatcher. *Toxicity of Power Plant Chemicals to Aquatic Life.* Compiled for United States Atomic Energy Commission by Battelle Pacific Northwest Laboratories. Richland, Washington. June 1973.

APPENDIX

Table 1

DAVENPORT SEWAGE TREATMENT PLANT
AVERAGE CONCENTRATION FOR THREE DAYS
August 23, 24, 25, 1977

	Influent	Effluent (Station B)	% Reduction
pH*		7.4	
Temperature, °C		20.1	
Dissolved Oxygen, mg/l		6.25	
Conductivity, umhos		727	
Chlorine Residual, mg/l		1.8	
NO_3-N, mg/l		.7	
NO_2-N, mg/l		<.05	
NH_3-N, mg/l		16.4	
T. Kjeldahl-N, mg/l		16.3	
O-PO_4-P, mg/l		8.4	
Total Phos.-P, mg/l		9.2	
COD, mg/l	380	98	74
BOD, mg/l	138	13	91
Total Solids, mg/l	555	426	
Total Non-Volatile Solids, mg/l	295	309	
Total Suspended Solids, mg/l	199	12	94
Total Suspended Non-Volatile Solids, mg/l	34	3	91
Total Coliforms, * colonies/100 ml		10,976	
Fecal Coliforms,* colonies/100 ml		66	

* Geometric Mean

Table 2

COTTONWOOD CREEK
AVERAGE CONCENTRATIONS FOR THREE DAYS
August 23, 24 and 25, 1977

	Stations			
	A	C	D	E
Total Colif. *Col./100 ml	2132	234,459	81,271	1651
Fecal Colif. *Col./100 ml	400	16,406	6,376	800
pH*	7.4	7.2	7.5	7.9
Temperature °C	14.7	16.1	17.1	17.3
Conductivity umhos	303	442	413	382
Dissolved oxygen mg/l	4.29	3.66	5.53	9.45
Chlorine residual mg/l	0.0	.2	.1	Trace
NO_3-N mg/l	1.5	1.4	1.7	.98
NO_2-N mg/l	.04	.15	.46	.04
NH_3-N mg/l	.02	4.4	2.7	.03
T-Kjeldahl mg/l	.35	5.1	4.1	.95
O-PO_4-P mg/l	.10	2.3	1.9	.78
Total Phos-P mg/l	.15	2.9	2.5	1.1

* Geometric mean

Table 3

DIATOM PROPORTIONAL COUNT

Sample No. A . Notebook No. ______ . Page No. ______ .

Major or Sub-Major Basin ______ . Minor Basin ______ .

Water and Location Cottonwood creek near Davenport .

Community Diatom . Substrate cobble scrape composite .

Date Aug 24 · 77 . Collector/Agency Allen Moore / DOE . Project ______ .

TAXON	COORDINATES (NIKON SKE)	NUMBER	PERCENT RELATIVE ABUNDANCE
Amphora perpusila		123	29.78
Rhoicosphenia curvata		58	14.04
Nitzschia dissipata		47	11.38
Nitzschia epiphytica		25	6.05
Nitzschia palea		24	5.81
Navicula tripunctata		22	5.33
Achnanthes lanceolata		20	4.84
Achnanthes minutissima		19	4.60
Nitzschia fonticola		16	3.87
Achnanthes linearis		13	3.15
Navicula viridula		10	2.42
Gomphonema angustatum		10	2.42
Cyclotella meneghiniana		8	1.94
Navicula secreta		7	1.69
Cocconeis placentula		5	1.21
Cymbella minuta		3	.73
Fragilaria pinnata		3	.73
Nitzschia linearis		T	
Nitzschia acicularis		T	
Nitzschia kutzingiana		T	
Navicula cryptocephala		T	
Navicula cuspidata		T	
Amphora ovalis		T	
Gomphonema truncatum		T	
Clyclotella glomerata		T	
Synedra ulna		T	
Diatoma vulgare		T	
Meridion circulare		T	
Fragilaria construens		T	

	COORDINATES (NIKON SKE)		RELATIVE ABUNDANCE
Synedra rumpens		T	
Surirella ovata		T	
Synedra acus		T	
fragilaria capucina		T	

Total Taxa 33. Taxa Counted (m) 17. Cells Counted (N) 413.
Diversity: Margalef Natural Log (d) 2.656; Other ______.

Notes and Sketches: $\frac{17-1}{6.02345}$

Table 4

DIATOM PROPORTIONAL COUNT

Sample No. C. Notebook No. ______. Page No. ______.

Major or Sub-Major Basin ______. Minor Basin ______.

Water and Location COTTONWOOD CREEK NEAR DAVENPORT.

Community DIATOM. Substrate ______.

Date Aug 24/77. Collector/Agency Allen Moore / DOE. Project ______.

TAXON	COORDINATES (NIKON SKE)	NUMBER	PERCENT RELATIVE ABUNDANCE
Nitzschia palea		168	39.25
Gomphonema angustatum		220	51.40
Cyclotella meneghiniana		23	5.37
Achnanthes linearis		14	3.27
Nitzschia dissipata		3	.70
Gomphonema truncatum		T	
Synedra ulna		T	
Surirella ovata		T	
Surirella angustata		T	
Cocconeis placentula		T	
Cymatopleura solea		T	
Cymbella minuta		T	
Melosira varians		T	
Navicula viridula		T	
Navicula tripunctata		T	
Diatoma vulgare		T	
Amphora ovalis		T	
Cymbella tumida		T	
Rhoicosphenia curvata		T	
Navicula cryptocephala		T	
Fragilaria construens		T	
Meridion circulare		T	
Nitzschia epiphytica		T	
Nitzschia linearis		T	
Achnanthes minutissima		T	
Nitzschia sp.		T	
Cyclotella sp		T	

TAXON	COORDINATES (NIKON SKE)	NUMBER	PERCENT RELATIVE ABUNDANCE

Total Taxa 27. Taxa Counted (m) 5. Cells Counted (N) 428.

Diversity: Margalef Natural Log (d) .660; Other ______.

Notes and ~~Sketches~~:

$$\frac{5-1}{6.05912}$$

Nitzschia palea and *Gomphonema angustatum* are both indicative of some sort of environmental stress

Table 5

DIATOM PROPORTIONAL COUNT

Sample No. D. Notebook No. ________. Page No. ________.

Major or Sub-Major Basin ________. Minor Basin ________.

Water and Location Cottonwood Creek near Davenport.

Community Diatom. Substrate Cobble scrape composite.

Date August 24/77. Collector/Agency Allen Moore / DUE. Project ________.

TAXON	COORDINATES (NIKON SKE)	NUMBER	PERCENT RELATIVE ABUNDANCE
Gomphonema angustatum		129	29.45
Nitzschia palea		81	18.49
Achnanthes linearis		74	16.89
Cyclotella meneghiniana		51	11.64
Navicula sp.		40	9.13
Achnanthes lanceolata		16	3.65
Nitzschia amphibia		8	1.83
Navicula cryptocephala		6	1.37
Nitzschia sublinearis		6	1.37
Cymbella minuta		5	1.14
Navicula viridula		5	1.14
Nitzschia epiphytica		5	1.14
Rhoicosphenia curvata		3	.68
Nitzschia dissipata		3	.68
Fragilaria construens		3	.68
Achnanthes minutissima		3	.68
Cocconeis placentula		T	
Surirella ovata		T	
Synedra ulna		T	
Navicula radiosa		T	
Navicula tripunctata		T	
Amphora ovalis		T	
Synedra acus		T	
Navicula cuspidata		T	
Diatoma vulgare		T	
Gomphonema truncatum		T	
Navicula secreta		T	
Surirella angustata		T	
Cyclotella glomerata		T	

TAXON	COORDINATES (NIKON SKE)	NUMBER	PERCENT RELATIVE ABUNDANCE
Meridion circulare		T	
Nitzschia kutzingiana		T	
Nitzschia fonticola		T	

Total Taxa 32. Taxa Counted (m) 16. Cells Counted (N) 438.

Diversity: Margalef Natural Log (d) 2.466; Other ____.

Notes and Sketches: 16-1 / 6.08222

Diatom community in recovery phase though some stress still evident

Table 6

DIATOM PROPORTIONAL COUNT

Sample No. E. Notebook No. ______. Page No. ______.

Major or Sub-Major Basin ______. Minor Basin ______.

Water and Location Cottonwood Creek near Davenport.

Community Diatom. Substrate cobble scrape composite.

Date Aug 24/77. Collector/Agency Allen Moore | DOE. Project ______.

TAXON	COORDINATES (NIKON SKE)	NUMBER	PERCENT RELATIVE ABUNDANCE
Navicula tripunctata		106	23.98
Nitzschia amphibia		54	12.22
Cyclotella meneghiniana		46	10.41
Nitzschia palea		41	9.28
Cocconeis placentula		40	9.05
Navicula cryptocephala		26	5.88
Nitzschia fonticola		26	5.88
Nitzschia dissapata		17	3.85
Rhoicosphenia curvata		12	2.71
Gomphonema angustatum		11	2.49
Achnanthes lanceolata		9	2.04
Navicula viridula		9	2.04
Navicula sp		8	1.81
Nitzschia sublinearis		7	1.58
Achnanthes linearis		6	1.36
Nitzschia epiphytica		6	1.36
Melosira varians		5	1.13
Synedra ulna		4	.90
Fragilaria construens		3	.68
Surirella ovata		3	.68
Nitzschia sp		3	.68
Navicula secreta		T	
Navicula cuspidata		T	
Amphora ovalis		T	
Gomphonema truncatum		T	
Hantzschia amphioxys		T	
Achnanthes minutissima		T	
Synedra rumpens		T	
Gomphonema intricatum		T	

TAXON	COORDINATES (NIKON SKE)	NUMBER	PERCENT RELATIVE ABUNDANCE
Cyclotella glomerata		T	
Nitzschia gracilis		T	
Epithemia turgida		T	
Nitzschia acicularis		T	
Cymbella minuta		T	
Nitzschia frustulum		T	
Synedra minuscula		T	
Frustulia sp		T	

Total Taxa 37. Taxa Counted (m) 21. Cells Counted (N) 442.

Diversity: Margalef Natural Log (d) 3.283; Other ______.

Notes and Sketches:

$$\frac{21-1}{6.09131}$$