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The State Hygienic Laboratory

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WATER QUALITY MANAGEMENT

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WATER QUALITY SURVEY of the MAQUOKETA RIVER near MANCHESTER, IOWA

#74-4

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Submitted to the Iowa Water Pollution Control Commission
by the
State Hygienic Laboratory on 30 August 1973

INTRODUCTION

The South Fork of the Maquoketa River originates west of Strawberry Point, Iowa in southern Fayette County and flows in a southeasterly direction approximately 100 river miles to its confluence with the North Fork of the Maquoketa River at Maquoketa, Iowa. Of primary interest to this report is the section of the South Fork from its origin to Manchester, Iowa, a stretch of nearly 30 river miles with a drainage area of 305 square miles. This reach of the river is designated for aquatic life use as a warm water area and is subject to the Iowa Water Quality Criteria for such areas. Average discharge at the USGS gaging station south of Manchester over a 33-year period was 195 cfs, while the 7-day, 10-year low flow was 9.3 cfs; and the maximum daily flow recorded was 16,000 cfs.

At the request of the Iowa Water Pollution Control Commission, the Limnology Division of the State Hygienic Laboratory conducted a survey of the Maquoketa River in the Manchester area on 7 August 1973. The purpose of the study was to evaluate the potential detrimental effects of municipal and industrial discharges into the river on water quality and aquatic life. The study area and sampling locations are shown in Figure 1 (page 2). These stations extend from the dam in Manchester downstream to the headwaters of Lake Delhi, a distance of about five river miles, and they include two locations above the Manchester STP discharge (1 and 2), four locations below the discharge point (4, 5, 6 and 7), and a grab sample of the effluent itself (3). It was planned that samples of Lake Delhi itself would be collected; however, the motor on the boat was damaged on the upstream trip and prevented this. Furthermore, the lake was not revisited at a later date as the data from the stream samples indicated that a single day's sampling would not allow the effects of the STP discharge to be adequately evaluated. Such a study on a lake is complex and must be carried out over an extended period of time; however, if such information is felt to be essential, a study could be begun immediately.

Due to the lack of accesses to this reach of the river, the survey was performed with the use of a small boat and motor. This proved to be fortunate in that it allowed a close investigation and evaluation of the aquatic habitats and surrounding terrestrial environment.

The stream itself was quite meandering and possessed a bottom composed of sand and rocks, with little or no evidence of silt deposition, and the water was fairly clear. The banks were heavily lined with trees and other vegetation, and there was no evidence of closely adjacent

FIGURE I

ROUGH MAP OF MAQUOKETA RIVER STUDY AREA

Station 1: 100 yds downstream of railroad bridge in Manchester

Station 2: 50 yds upstream of Manchester sewage treatment plant discharge

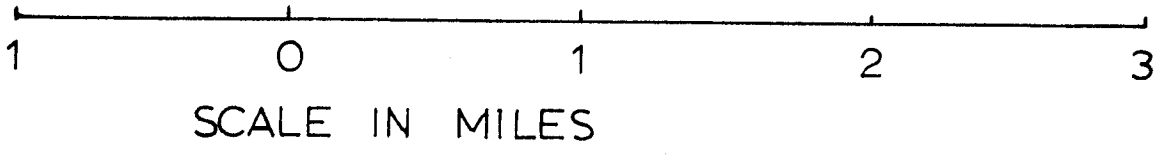
Station 3: Manchester sewage treatment plant discharge pipe

Station 4: 300 yds downstream of STP discharge

Station 5: 1 mile downstream of STP discharge

Station 6: 3 miles downstream of STP discharge

Station 7: Pin Oak Park, Maquoketa River Access



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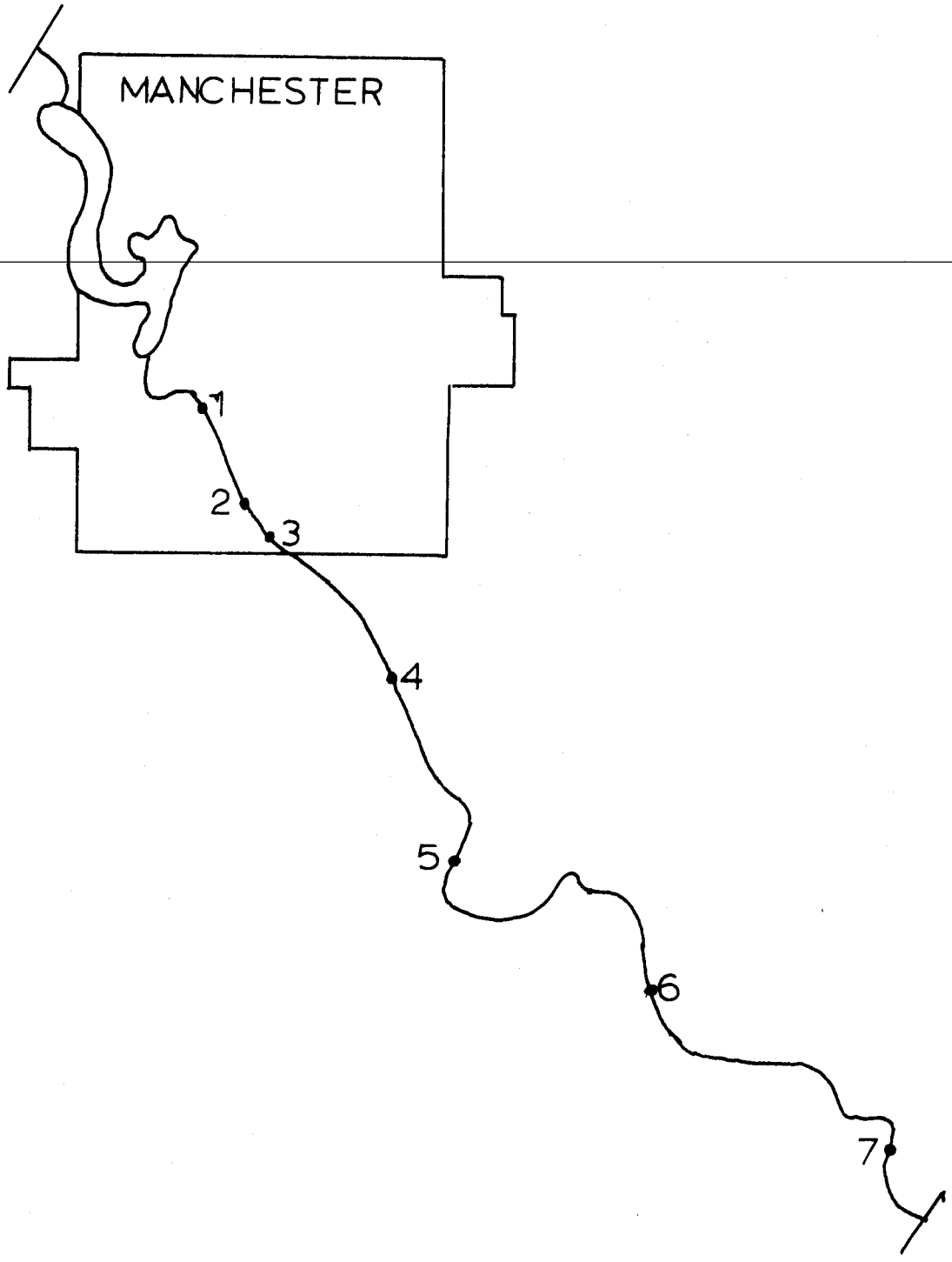

cultivation. Riffles and rapids were frequent as the stream in general was quite shallow; although there were several pools with depths of five to six feet. These conditions provide a diversity of habitats which should support a diverse and stable aquatic community. In general, it is a picturesque area with limited access that should provide valuable recreation in terms of fishing and canoeing.

RESULTS

Chemical and Bacteriological

The raw data generated from the chemical and bacteriological analyses conducted on samples collected in the August 7th survey are contained in the Appendix to this report.

Stations 1 and 2 were selected to represent a control area on the stream, above the Manchester STP, and a consideration of the data gathered there will establish ambient river conditions during the sampling period. Water quality at both stations was quite good. Dissolved oxygen concentrations were 7.7 and 7.9 mg/l, both near saturation for the 24°C water temperature. The pH of 8.0 was somewhat low, and indicated little or no algal activity in spite of the bright sunshine. All indicators of organic and nutrient load were quite low, i.e. BODs were 2 mg/l, CODs were near 10 mg/l, organic nitrogen was about 0.50 mg/l, and total phosphorous was less than 0.10 mg/l. Consistent with these results were the low fecal coliform values of 420 and 540 org/100 ml at stations 1 and 2 respectively. In addition, the water was quite clear as is shown in the low turbidities and suspended solids for both stations.

Station 3 was a grab sample of the Manchester STP effluent at the point of discharge, and the results show that effluent quality was not very good for a secondary treatment plant. The dissolved oxygen of 1.4 mg/l was quite low while the solids' content (total solids at 5,234 mg/l) was extremely high. This solids' value is not surprising as the effluent appeared to be of low quality. Furthermore, the effluent exhibited elevated levels of nutrient compounds as the ammonia-nitrogen content was 37 mg/l and the total phosphorous was 13 mg/l. Finally a fecal coliform content of 900,000 org/100 ml, although acceptable, is still very high.

Station 4 was located downstream at a distance below the discharge point so that the results gathered there would allow an evaluation of the effects of mixing and dilution as well as the short-term effects of the waste. In general, the chemical and bacteriological data showed little degradation of stream quality as values were quite similar to stations 1 and 2. Dissolved oxygen, ammonia-nitrogen, total phosphorous, solids, and BOD were little changed from upstream levels. Only the COD (40 mg/l) and fecal coliform (1,000/100 ml) levels showed moderate elevations from upstream conditions.

The results from station 5 located further downstream do exhibit some apparent anomalies when compared to those of station 4. The DO was higher at 8.7 mg/1, but so was nearly everything else. Ammonia-nitrogen increased to 0.28 mg/1; nitrate-nitrogen to 2.8 mg/1; total phosphorous to 0.17 mg/1; and fecal coliforms jumped to 11,000 org/100 ml. Although it is difficult to say exactly what caused such a reversal in trend; it could be the result of sampling a slug of stronger waste which had not mixed well, or an effect of road and bridge construction taking place between stations 4 and 5, or a combination of both.

The results from both stations 6 and 7 show that water quality is similar to that found upstream, and that recovery was nearly complete. Only the ammonia-nitrogen (0.24 and 0.16 mg/1) and the total phosphorous (0.14 mg/1) concentrations remain somewhat elevated over ambient levels.

The heavy metals were all low with the only significant one being zinc which was highest at the downstream stations, reaching a peak of 0.34 mg/1.

Mercury levels were all less than 1 µg/1 and lead less than 10 parts per billion.

These metal concentrations are quite typical of the normal Iowa environmental situation, and individually are mere fractions of the water quality standards set by the federal and state pollution control agencies.

The aggregate heavy metal concentrations are well below the 1.5 mg/1 level being proposed by the Iowa Water Quality Commission.

This metals' information provides background levels for assessment of future municipal and industrial discharge effects as well as agricultural run-off.

The monthly estimated BODs show the following values for the Manchester sewage treatment plant:

4/23/73	75
6/6/73	>150
7/10/73	< 25
8/6/73	>150

The BODs show great variation but the June and August values correspond well with the BOD of the plant effluent at the time of this survey. Since the actual analytical technique is quite precise and accurate, this amount of deviation tends to indicate either significant operational variation, plant performance changes, fluctuating loads, sampling deficiencies or some combination of these factors.

Unless engineering or operational factors to explain this fluctuaion are known, it suggests the need for an on-site visit to delineate the problem. This visit should certainly cover a discussion of sampling techniques for the monthly BODs as they specifically apply to this particular situation, especially with reference to time of procurement of the "grab sample" or a necessitated composite.

Biological

To complete the survey,collections of aquatic invertebrates were made at each station. Data on the biological community allow a more complete evaluation of water quality conditions in a river reach. Most of the organisms are fairly non-motile and as such, are exposed constantly to changing water quality conditions. An evaluation of the composition of this community is thus a good indicator of the chronic effects of subtle changes in water quality as many of the organisms have very specific habitat requirements.

It was intended that the invertebrates would be sampled in two ways; grab samples of bottom sediment, and hand collection from natural substrates. Since the sand bottom which was encountered is not suitable for colonization by soft bodied organisms, all biological collections were from rocks, limbs, and other natural substrates. These data which are presented in Table 1 are totally qualitative. Efforts were made to evaluate the diversity at each station as well as the relative abundance of each genus, but the numbers are not indicative of total production nor total abundance at each station.

The collections made at stations 1 and 2 showed the community to be fairly diverse and composed of insect larvae which were either quite ubiquitous or usually associated with good water quality. The caddis fly larvae, Hydropsyche and Cheumatopsyche, and the mayfly nymphs, Stenonema and Isonychia, which were abundant, are common in most Iowa streams. The large stonefly nymph, Pteronarcys, which appeared on most of the substrates examined at the two upstream stations is usually restricted to areas of high water quality. The blackfly larva, Simulium, and the larva of the midge, Chironomus, both of which are common in polluted areas, were quite rare in the control area.

The composition of the biological community at station 4 below the STP discharge was found to be quite different. Stoneflies were absent, and mayflies and caddis flies were much less common. The dominant organism by far was the larva of the blackfly Simulium. This organism flourishes in aerated water of high organic content. They are often a nuisance in sewage treatment plants as they grow very well in trickling filter beds.

The situation at station 5 was somewhat similar as stoneflies, mayflies, and caddis flies were either absent or uncommon. However, the midge larva Chironomus had replaced Simulium as the dominant organism. This

TABLE I

SUMMARY TABLE OF AQUATIC INVERTEBRATES

Maquoketa River at Manchester
7 August 1973

TAXA	Sampling Stations 1	2	4	5	6	7
Insecta						
Plecoptera						
Pteronarcidae						
Pteronarcys sp.	2	4	-	-	-	-
Ephemeroptera						
Heptageniidae						
Stenonema sp.	12	9	5	3	9	11
Baetidae						
Isonychia sp.	5	-	-	-	9	10
Ephemerella sp.	3	2	-	-	1	3
Trichoptera						
Hydropsychidae						
Hydropsyche sp.	15	18	6	10	14	16
Cheumatopsyche sp.	23	11	3	5	3	6
Diptera						
Simuliidae						
Simulium sp.	1	1	40	-	-	-
Chironomidae						
Chironomus sp.	1	1	2	103	-	-
Coleoptera	2	4	-	-	1	3
Total Organisms	63	50	56	121	37	49

organism grows well in organically enriched waters and can reach very high numbers even under very low DO conditions.

Stations 6 and 7 supported a community nearly identical to that of the upstream control area. Dipterans were rare, and mayflies and caddis flies again predominated even though no stonefly nymphs were collected.

DISCUSSION

The high water quality encountered on the Maquoketa River in the upstream control area can at least partially be attributed to an interaction of several factors. First, the small impoundment located just upstream would serve to remove most of any sediment load carried by the stream. Secondly, no recent rainfall had occurred upstream or in the study area, and runoff potential would be somewhat reduced due to the heavy vegetative growth along the river banks. Finally, the stream to this point had received very little organic load as shown by the chemical data, and the apparent lack of phytoplankton activity in spite of favorable physical conditions such as temperature, solar input and clarity.

The situation downstream of the Manchester STP discharge was not drastically different chemically and bacteriologically even at stations 4 and 5. At the time of sampling, the volume of flow in the river was sufficient to adequately dilute the wastewater and prevent any serious changes in water quality in terms of violations of standards. Appreciable increases in some parameters, especially fecal coliform bacteria, were observed at station 5; however, the cause for this was not completely clear. It could be related to the road and bridge construction upstream of station 5, or to the sampling of a slug of strong waste discharged earlier which had not completely mixed with the river water.

In spite of the lack of significant changes in chemical quality found at the time of sampling, the biological data show a profound effect of the wastewater discharge. The quality of the invertebrate community was much reduced in a 1.5 to 2-mile reach below the point of discharge. Clean water organisms such as stonefly, mayfly, and caddis fly larvae were nearly absent, while pollution tolerant dipteran larvae were abundant. Such changes in the biological community give evidence to water quality conditions over a long period of time. It is apparent that water quality at stations 4 and 5 may at times be very low and is probably of fairly low quality much of the time. The adversely affected reach of the river is rather short; however, as the invertebrate community found at stations 6 and 7 was similar to that found upstream.

CONCLUSIONS

Within the context of stream flow present at the time of the survey, all indicators of water quality show that the condition of the Maquoketa River upstream of the Manchester sewage treatment plant discharge was very good.

The quality of the effluent from the Manchester Sewage Treatment Plant was found to be poor at the time of sampling, but it did not cause a violation of water quality standards, although water quality was somewhat reduced for a distance of less than two miles.

The wastewater effluent was shown to be responsible for a reduction in the quality of the biological community over a 1 to 2-mile stretch below the point of discharge. Clean water organisms important as fish forage were nearly absent, while nuisance-causing, pollution-tolerant forms were abundant.

RECOMMENDATIONS

Since the five-mile reach of the Maquoketa River below Manchester is an important fishing stream ultimately discharging into Lake Delhi which is being considered for recreational development, and our stream and plant discharge data indicates less than acceptable secondary treatment plant performance, it is suggested that a comprehensive plant engineering review at the Manchester sewage treatment facility would be logical.

Dennis M Geary

Dennis M Geary, MS
Limnologist

R L Morris

Robert L Morris, PhD
Associate Director & Principal Chemist

jm

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A P P E N D I X

WATER QUALITY REPORT

STATE HYGIENIC LABORATORY, Des Moines Branch
The University of Iowa
E 7th & Court, Rm 405, Des Moines, Iowa 50309

Town	Manchester	Manchester	Manchester
Source	Maquoketa River	Maquoketa River	STP Discharge
Specific Location	Below RR Bridge	50 yds above STP discharge	Effluent point
Date Collected	7 August 1973	7 August 1973	7 August 1973
Date Received	8 August 1973	8 August 1973	8 August 1973
Lab. Number	1690	1691	1692
	FIELD DATA		
Collection Time	12:00	12:45	13:00
pH			
Temperature	24°C	24°C	24°C
Dissolved Oxygen	7.7	7.9	1.4
	BACTERIOLOGICAL EXAMINATION		
Fecal Coliform/100 ml	420	540	900,000
	CHEMICAL ANALYSIS (as mg/l unless designated otherwise)		
Conductance (micromhos)			
MBAS (as LAS)			
pH (units)	7.6	7.8	7.1
Alkalinity: P	None	None	None
T	194	190	398
NITROGEN: Organic N	0.64	0.52	13
Ammonia N	0.05	< 0.01	37
Nitrite N	0.037	0.035	0.016
Nitrate N	3.2	3.1	0.3
Nitrate as NO_3			
RESIDUE: Total	324	317	5234
Fixed	167	152	4834
Volatile	157	165	400
Filtrable Residue T	282	313	4936
F	129	150	4696
V	153	163	240
Nonfiltrable Residue T	42	4	298
F	38	2	138
V	4	2	160
Settleable Matter (ml/l)			
PHOSPHATE: Filtrable P	0.03	0.02	12
Total P	0.09	0.08	13
Dissolved Oxygen			
BOD	2	2	240
COD	12	10	346
Grease or Oil			
Turbidity (JTU)	18	12	39
Total Hardness (as $CaCO_3$)			
Calcium (Ca^{++})			
Magnesium (Mg^{++})			
Chloride (Cl^-)			
Sulfate (SO_4^{--})			

REMARKS:

COLLECTOR REPORT TO: Geary & Boyes
Limnology Division
State Hygienic Laboratory
Des Moines, Iowa

R. L. Morris, Ph.D.
Associate Director & Principal Chemist

1341

15 August 1973 jb

WATER QUALITY REPORT

STATE HYGIENIC LABORATORY, Des Moines Branch
The University of Iowa
E 7th & Court, Rm 405, Des Moines, Iowa 50319

Town	Manchester	Manchester	Manchester
Source	Maquoketa River	Maquoketa River	Maquoketa River
Specific Location	300 yds below STP outfall above bridge const. area	1/2 mile down stream of new bridge	2 miles downstream of STP
Date Collected	7 August 1973	7 August 1973	7 August 1973
Date Received	8 August 1973	8 August 1973	8 August 1973
Lab Number	1693	1694	1695
	FIELD DATA		
Collection Time	13:15	13:45	14:25
pH			
Temperature	24° C	24° C	24° C
Dissolved Oxygen	7.6	8.7	7.7
	BACTERIOLOGICAL EXAMINATION		
Fecal Coliform/100 ml	1,000	11,000	<100
	CHEMICAL ANALYSIS (as mg/l unless designated otherwise)		
Conductance (micromhos)			
MBAS (as LAS)			
pH (units)	8.0	8.0	7.9
Alkalinity: P	None	None	None
T	192	194	192
NITROGEN: Organic N	0.44	0.56	0.57
Ammonia N	0.03	0.28	0.24
Nitrite N	0.038	0.044	0.044
Nitrate N	2.8	2.7	2.8
Nitrate as NO_3			
RESIDUE: Total	310	365	352
Fixed	157	197	206
Volatile	153	168	146
Filtrable Residue T	286	334	325
F	140	175	180
V	146	159	145
Nonfiltrable Residue T	24	31	27
F	17	22	26
V	7	9	1
Settleable Matter (ml/l)			
PHOSPHATE: Filtrable P	0.03	0.11	0.10
Total P	0.10	0.17	0.14
Dissolved Oxygen			
BOD	3	5	3
COD	40	10	54
Grease or Oil			
Turbidity (JTU)	12	11	11
Total Hardness (as $CaCO_3$)			
Calcium (Ca^{++})			
Magnesium (Mg^{++})			
Chloride (Cl^-)			
Sulfate (SO_4^{--})			

REMARKS:

COLLECTOR REPORT TO: Geary & Boyes
Limnology Division
State Hygienic Laboratory
Des Moines, Iowa

1341

R. L. Morris, Ph.D
Associate Director & Principal Chemist

15 August 1973 jb

WATER QUALITY REPORT

The University of Iowa
E 7th & Court, Rm 405, Des Moines, Iowa 50309

Town	Manchester		
Source	Maquoketa River		
Specific Location	Pin Oak Park, Maquoketa River access		
Date Collected	7 August 1973		
Date Received	8 August 1973		
Lab Number	1696		
		FIELD DATA	
Collection Time	15:00		
pH			
Temperature	24° C		
Dissolved Oxygen	8.0		
	BACTERIOLOGICAL EXAMINATION		
Fecal Coliform/100 ml	1,400		
	CHEMICAL ANALYSIS (as mg/l unless designated otherwise)		
Conductance (micromhos)			
MBAS (as LAS)			
pH (units)	8.0		
Alkalinity: P	None		
T	194		
NITROGEN: Organic N	0.55		
Ammonia N	0.16		
Nitrite N	0.045		
Nitrate N	2.9		
Nitrate as NO_3			
RESIDUE: Total	351		
Fixed	207		
Volatile	144		
Filtrable Residue T	339		
F	197		
V	142		
Nonfiltrable Residue T	12		
F	10		
V	2		
Settleable Matter (ml/l)			
PHOSPHATE: Filtrable P	0.08		
Total P	0.14		
Dissolved Oxygen			
BOD	3		
COD	10		
Grease or Oil			
Turbidity (JTU)	9		
Total Hardness (as $CaCO_3$)			
Calcium (Ca^{++})			
Magnesium (Mg^{++})			
Chloride (Cl^-)			
Sulfate (SO_4^{--})			

REMARKS:

COLLECTOR REPORT TO
Geary & Boyes
Limnology Division
State Hygienic Laboratory
Des Moines, Iowa

R. L. Morris, Ph.D.
Associate Director & Principal Chemist

1341

15 August 1973 jb

METALS ANALYSIS

Town:	Manchester	Manchester	Manchester	Manchester
Source:	Maquoketa River	Maquoketa River	STP Discharge	Maquoketa River
Specific Location:	Below RR Bridge	50 yds above STP discharge	Effluent point	300 yds below ST outfall above br const. area
Date Collected:	7 August 1973	7 August 1973	7 August 1973	7 August 1973
Date Received:	8 August 1973	8 August 1973	8 August 1973	8 August 1973
Collected by:	Geary & Boyes	Geary & Boyes	Geary & Boyes	Geary & Boyes
Report to:	Limnology Division State Hygienic Lab Des Moines, Iowa	Limnology Division State Hygienic Lab Des Moines, Iowa	Limnology DIvision State Hygienic Lab Des Moines, Iowa	Limnology Divisi State Hygienic L Des Moines, Iowa
Lab Number	1690	1691	1692	1693
Aluminum				
Antimony				
Arsenic				
Barium	0.1	< 0.1	0.1	0.1
Boron				
Cadmium	< 0.01	< 0.01	< 0.01	< 0.01
Chromium	< 0.01	< 0.01	< 0.01	< 0.01
Cobalt				
Copper	< 0.01	< 0.01	0.03	< 0.01
Iron				
Lead	< 0.01	< 0.01	< 0.01	< 0.01
Magnesium				
Manganese				
Mercury	< 1 µg/l	< 1 µg/l	< 1 µg/l	< 1 µg/l
Nickel	< 0.1	< 0.1	< 0.1	< 0.1
Selenium				
Silver	< 0.01	< 0.01	< 0.01	< 0.01
Strontium				
Tin				
Zinc	0.05	0.04	0.18	0.08

Determinations reported as milligrams per liter (mg/l) unless otherwise stated.

cc: Dr. Morris

15 August 1973
jb

METALS ANALYSIS

Town:	Manchester	Manchester	Manchester
Source:	Maquoketa River	Maquoketa River	Maquoketa River
Specific Location:	1/2 mile downstream of new bridge	2 miles downstream of STP	Pin Oak Park, Maquoketa River access
Date Collected:	7 August 1973	7 August 1973	7 August 1973
Date Received:	8 August 1973	8 August 1973	8 August 1973
Collected by:	Geary & Boyes	Geary & Boyes	Geary & Boyes
Report to:	Limnology DIvision State Hygienic Lab Des Moines, Iowa	Limnology Division State Hygienic Lab Des Moines, Iowa	Limnology DIvision State Hygienic Lab Des Moines, Iowa
Lab Number	1694	1695	1696
Aluminum			
Antimony			
Arsenic			
Barium	0.1	< 0.1	< 0.1
Boron			
Cadmium	< 0.01	< 0.01	< 0.01
Chromium	< 0.01	< 0.01	< 0.01
Cobalt			
Copper	< 0.01	< 0.01	< 0.01
Iron			
Lead	< 0.01	< 0.01	< 0.01
Magnesium			
Manganese			
Mercury	< 1 µg/1	< 1 µg/1	< 1 µg/1
Nickel	< 0.1	< 0.1	< 0.1
Selenium			
Silver	< 0.01	< 0.01	< 0.01
Strontium			
Tin			
Zinc	0.27	0.33	0.34

Determinations reported as milligrams per liter (mg/l) unless otherwise stated.

cc: Dr. Morris

15 August 1973
jb