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EIA - Water Quality

A WATER QUALITY SURVEY
RED RIVER AND RIO GRANDE
NEW MEXICO

Prepared by
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
In Cooperation with
NEW MEXICO DEPARTMENT OF GAME AND FISH
and
NEW MEXICO ENVIRONMENTAL IMPROVEMENT AGENCY

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

Region VI
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Ada Facility
Ada, Oklahoma

November 1971

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I. INTRODUCTION

Authority

In a letter dated December 17, 1969, the New Mexico Department of Game and Fish requested that the Environmental Protection Agency (EPA) perform a stream survey on the Red River of the Rio Grande to determine the present quality of the stream.

This study was made under the provisions of the Federal Water Pollution Control Act, as amended (33 U.S.C. 466 et seq.).

Background, Purpose, and Scope

Prior to operation of the Molybdenum Corporation of America's (MCA) mine and mill between Questa and Red River, New Mexico, the New Mexico Department of Public Health, anticipating possible future stream degradation, requested that a water quality study be made of the Red River. Chemical, bacteriological, and biological studies were made in November 1965 by EPA's predecessor agency, the Federal Water Pollution Control Administration (1), in cooperation with the State of New Mexico agencies. Follow-up biological studies were made on the Rio Grande and Red River in October 1966 in that stretch of the river immediately above and below the mouth of the Red River (2).

The results of the 1970 stream survey were to serve primarily as comparison data for the purpose of determining the extent of any water quality degradation that might have come as a result of increased activity along the watershed of the Red River since the study in 1965. These operations, along with the increased number of people employed by the construction contractors and mining company, have the potential to incur a significant pollution problem to the water resources of the basin.

At the present time, the most significant water users are the molybdenum mine and mill, a State fish hatchery, and a small amount of irrigation (some 800 acres).

Acknowledgments

The cooperation of many people and several agencies was necessary in this study. The efforts of the following are especially appreciated: New Mexico Department of Public Health and New Mexico Department of Game and Fish.

II. SUMMARY AND CONCLUSIONS

Summary

The New Mexico Department of Game and Fish requested the EPA to conduct a water quality study on the Red River near Questa, New Mexico.

In accordance with this request, personnel fr the EPA Surveillance and Analysis Division, Ada Facility, assisted by State personnel, investigated seven major sampling stations along the main stem of the Red River from above the town of Red River to below the State fish hatchery near Questa and collected additional biological samples at four stations on the Rio Grande.

The facilities of the New Mexico State Public Health Laboratory in Albuquerque were used during the study where some 55 water samples were analyzed, including seven bacteriological samples.

The biological samples taken during the sampling period were analyzed at the EPA facility, Ada, Oklahoma. Biological samples were taken at the seven chemical sampling stations and two additional stations (T and 2A) along the Red River and four stations on the Rio Grande.

Basic water quality measurements were made at each sampling station on 2-hour intervals for three, 8-hour sample days and one, 24-hour sample day. Measurements were made using portable instruments.

The river flow was gauged near each of the seven main stem stations by State and Federal field personnel during the period of the investigation.

Conclusions

1. The chemical quality of the Red River water remains very good. The water is suitable for a wide range of beneficial uses such as domestic, industrial, and recreation, including the propagation of trout.

2. Microbiological quality of the river is good, as indicated by the data.

3. Biological conditions in the river are good. A biotic index of 10 or greater is indicated at all stations. A clean stream is described as a stream with a biotic index of 10 or greater at all stations.

4. The slurry from the MCA mine and mill is currently being pumped through a pipeline along the Red River [illegible] a tailings pond located just west of Questa. Occasional breaks in the line are causing some degradation in stream quality and biota. Some of the settleable material coats the stream bed which damages the stream's biological elements.

5. The effluent from the MCA tailings pond exerts a fertilizing effect on the Red River by the addition of minerals.

6. The State fish hatchery, located on the Red River some three or four stream miles above its mouth, is contributing to degradation of that portion of the stream and, consequently, to the Rio Grande. This degradation is increased when fish ponds are drained and cleaned for restocking. This discharge contains organics and solids and also has a fertilizing effect by the addition of nutrients.

7. The town of Red River, mobile homes, and tourist camps located along the river are contributing to degradation of the river, primarily due to septic tank drainage and other untreated waste making its way into the stream. An oxidation pond was being constructed at the time of the study to provide waste treatment for the town of Red River.

III. DESCRIPTION OF THE PROJECT

Location

The project study area is located near Questa in North Central New Mexico, including 20 miles of the Red River from the State fish hatchery near Questa to above the town of Red River. (See location map designated Figure 1 in back of this report.)

Seven major stream stations along the Red River, designated Stations 2 through 8, received intensive investigation. Six grab samples were taken from the MCA tailings pond seepage and discharge for metals analyses.

Since the primary purpose of the study was one of comparison, the same sampling stations were used as during the study made in 1965.

Characteristics of the Drainage Area

The drainage area of the Red River is mountainous and ranges in elevation from 13,151 feet at Wheeler Peak to 6,500 feet at the confluence with the Rio Grande. Most of the area is forested except for that part above timberline and the area on both sides of State Highway 3 north of the river. Part of the area on each side of State Highway 3 is irrigated for crops and pasture. The forested and rocky nature of most of the drainage basin produces fine material which contributes to the silt load of the stream. Landslides or construction activities may, however, contribute large quantities of silt from small areas.

4. Iron - Standard Methods, Thirteenth Edition, Phenanthroline Method, Part 124A.

5. Zinc - Standard Methods, Thirteenth Edition, atomic absorption, direct determination, Part 129A.

6. Chlorine - Standard Methods, Thirteenth Edition, Mercuric Nitrate Method, Part 112B.

7. Nitrate Nitrogen - Standard Methods, Thirteenth Edition, Phenoldisulfonic Acid Method, Part 133A.

8. Conductance - Standard Methods, Thirteenth Edition, Specific Conductance corrected to 25°C, Part 154.

9. Turbidity - Standard Methods, Thirteenth Edition, Nephelometric Method, Part 163A.

10. Hardness - Standard Methods, Thirteenth Edition, EDTA Titrimetric Method, Part 122B.

11. pH - Standard Methods, Thirteenth Edition, Glass Electrode Method, Part 144.

12. Dissolved Residue - Standard Methods, Thirteenth Edition, Filterable Residue 103-105°C, Part 148B.

13. Suspended Residue - By difference of total and fiterable solids.

14. Total Residue - Standard Methods, Thirteenth Edition, Total Residue 103-105°C, Part 148A.

15. Alkalinity - Standard Methods, Thirtheenth Edition, Potentiometric Titration, Part 102.

16. Lead - Standard Methods - Thirteenth Edition, Dithizone Method, Part 125A.

pH - Measurements were made with either an Instrumentation Laboratories meter, Model 175, or an Analytical Measurements meter, Model 100. The instruments were calibrated with buffers of pH four and seven prior to each sample run. Adjustments for temperature compensation were manually controlled.

Bacteriological Methods

Water samples for bacteriological analyses were collected in sterile, widemouthed, ground glass-stoppered bottles. The samples were transported from Red River to Albuquerque under ice and were examined within 24 hours after collection. The sample analyses were performed by personnel at the New Mexico State Health Department laboratory at Albuquerque.

The procedures outlined in Standard Methods for the Examination of Water and Wastewater, Thirteenth Edition, were used for the bacteriological analyses of the samples collected during this survey. The methods used are described as follows:

1. Total Coliform - Standard Methods, Thirteenth Edition, Membrane Filter Method, Part 408A.
2. Fecal Coliform - Standard Methods, Thirtheenth Edition, Membrane Filter Method, Part 408B.
3. Fecal Streptococci - Standard Methods, Thirteenth Edition, Membrane Filter Method, Part 409B.

V. PRESENTATION OF DATA

Chemical Quality

A chemical analysis of the water from all survey stations in the Red River Basin indicates that the water is of a very good quality and has undergone very little change since the stream study in 1965, except for the mineralization effect of the tailings pond discharge.

Table 2 is a water quality summary sheet which lists the project averages for each station for comparison. Tables 3 through 9 list the complete chemical analyses of all stations sampled during the survey. Figures 3 through 14 are data comparison graphs which show the level of change in some of the more important chemical parameters from the 1965 study to the 1970 study.

Figure 3 (the flow data comparison graph) shows a change in the stream flow pattern due to water usage by the molybdenum mine and mill located between Stations 5 and 6. The molybdenum mill diverts a portion of the Red River water for use in the milling operation. The mill also uses groundwater. The MCA tailings pond effluent then discharges into the Red River between Stations 2 and 3 which accounts for a large portion of the flow increase between Stations 2 and 3. Spring water used by the fish hatchery also contributes to the flow increase between Stations 2 and 3.

Dissolved Oxygen - The dissolved oxygen readings in November 1970 were slightly higher than the readings in November 1965. This increase in dissolved oxygen level is probably due to the lower water waters. When concentrated to high levels by the plants, certain illnesses can be transmitted to livestock.

All other metals found were in insignificant concentrations.

Biological Quality

Red River

Since all samples constitute the same amount of area sampled, stations can be compared. Figure 15 depicts the number of organisms per sample and the number of kinds (Genera) per sample. From this illustration, a general trend of depression can be seen. Station 8 is considered a control station; and, in comparison with other stations, it shows a decrease in both the number of organisms and number of kinds, with the exception of Stations 2A and 2. This decrease is most evident in the 1970 study as shown by the number of organisms per sample.

Benthic organisms are known to be a reliable monitor of water quality (9, 10, 12, 13, 19, 23); thus, any significant change in the environment will be reflected in the biota. This has also been demonstrated even when subtle or mild changes occur (11, 16, 17, 20, 24). The cause for the decrease in water quality, demonstrated during these studies, appears to be somewhat complex due to the nature of this recreational area, the aforementioned tailings pipeline breaks, the presence of a town (Red River) without adequate sewage treatment facilities at the time of the study, and the natural order of change in a river from headwaters to mouth.

Figure 17 is a graphic illustration of the Biotic Index for all studies on the Red River. All stations are considered clean--a numerical index of 10 or more classifies a station as clean. The fertilization effect of the tailings effluent and the fish hatchery effluent is clearly seen. The depression effect previously mentioned is also illustrated in Table 13.

Rio Grande

As in the Red River study, all samples constitute the same amount of area sampled and thus can be compared.

Figure 18 depicts the number of organisms per sample (3 ft^2) and the number of kinds (Genera) per sample. These data illustrate a fertilizing effect from the Red River on the Rio Grande. In 1966, the effect appears to have been longer lasting as it progressed downstream and diminished between river mile 1600 and 1630. Comparison of the number of organisms at Stations 2 and 5 shows almost the same number, but the number of kinds dropped slightly at Stations 2 and 3. In the 1970 study, the number of kinds increased greatly at the stations below Red River only. Stations 2 and 3 were comparable to the control station, 5. The number of organisms per sample did not reflect the fertilizing effect as greatly; however, there was an increase. Figure 19 depicts the same fertilization effect as illustrated by the Biotic Index. Station 5 was noted in an earlier study to be somewhat affected by silting, and this was reflected by a decrease in the benthic animal population. A silt covering on the aquatic plant growth was

Some water quality degradation was occurring to the Red River due to inadequate sewage treatment facilities for the town of Red River at the time of the study. This pollution increases with an increase in recreational activity in and around the town of Red River.

TABLE 2
WATER QUALITY SUMMARY SHEET

1970

	STATION #8	STATION #7	STATION #6	STATION #5	STATION #4	STATION #3	STATION #2
CHEMICAL ANALYSES							
TEMPERATURE, °C	2.0	3.5	2.6	2.0	2.6	3.8	9.1
CONDUCTIVITY, micromhos	198	232	253	220	255	267	435
pH	7.1	7.0	6.9	7.0	6.8	6.8	6.8
DISSOLVED OXYGEN, ppm	11.2	10.8	11.6	11.8	11.0	10.6	9.4
PERCENT OXYGEN SATURATION	112	112	114	116	105	100	102
TURBIDITY, turbidity units	22.7	25.9	7.7	8.6	16.9	47.1	3.5
C.O.D., mg/l	19.2	14.3	11.7	6.5	9.2	9.8	14.0
TOTAL DISSOLVED SOLIDS, mg/l	159.8	184	188	162	160	186.2	248
SUSPENDED SOLIDS, mg/l	3.2	3.0	16	1.6	2.7	2.8	12
TOTAL SOLIDS, mg/l	163	186	204	164	163	189	260
ALKALINITY as $CaCO_3$, mg/l	84.5	69	59	65	54	57.2	74.2
[illegible]	2.17	0.17	0.5	0.16	0.7	1.5	5.6
[illegible]	10.1	41.2	62.5	44.4	66.5	69.3	118.3
[illegible]	31	34	35.3	34	35.7	36	47
[illegible]	3.1	5.1	18.5	5.3	6.9	7.1	10.8
[illegible], mg/l	0.23	0.25	0.14	0.15	0.09	0.12	0.11
[illegible], mg/l	0.02	0.02	0.02	0.02	0.01	0.01	0.02
As, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zn, mg/l	<0.01	0.01	<0.01	0.01	0.01	<0.01	<0.01
HARDNESS as $CaCO_3$, mg/l	90	105	119	106	118	127	162

TABLE 4
CHEMICAL QUALITY - STATION NO. 3*

Date :	11-2-70	11-2-70	11-4-70	11-5-70	11-5-70	11-5-70
Run No.:	1	2	3	4-a	4-b	4-c
FIELD ANALYSES						
TEMPERATURE, °C	5.2	4.4	4.1	0.6	4.4	4.4
CONDUCTIVITY, micromhos	275	275	270	240	270	270
pH	6.5	6.8	7.0	7.0	6.7	6.8
DISSOLVED OXYGEN, ppm	10.9	11.1	10.8	10.6	10.5	9.8
PERCENT OXYGEN SATURATION	112	112	107	74	96	99
LABORATORY ANALYSES						
CONDUCTIVITY, micromhos	270	260	275	265	270	265
pH	7.2	7.2	7.2	6.9	7.1	7.3
TURBIDITY, turbidity units	130	5.5	130.0	6.0	4.5	6.5
C.O.D., mg/l	5.0	6.0	7.0	10.0	15.0	16.0
TOTAL DISSOLVED SOLIDS, mg/l	198	205	193	173	190	158
SUSPENDED SOLIDS, mg/l	9	0	3	0	0	5
TOTAL SOLIDS, mg/l	207	205	196	173	190	163
ALKALINITY as $CaCO_3$, mg/l	56	56	62	58	56	55
Cl^-, mg/l	5.0	2.0	1.0	0.0	0.0	1.0
SO_4^{--}, mg/l	60.0	68.0	76.0	64.0	64.0	84.0
Ca^{++}, mg/l	34.0	34.0	38.0	36.0	38.0	36.0
Mg^{++}, mg/l	7.3	8.5	8.5	7.3	6.1	4.9
Fe^{--}, mg/l	0.12	0.12	0.12	0.12	0.12	0.12
NO_3^-, mg/l	0.01	0.01	0.01	0.01	0.01	0.01
As, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zn, mg/l	0.01	0.01	<0.01	<0.01	<0.01	0.02
HARDNESS as $CaCO_3$, mg/l	115	120	130	120	165	110

*Located below town of Questa - Elevation 7,300'

TABLE 6

CHEMICAL QUALITY - STATION NO. 5*

Date :	11-2-70	11-3-70	11-4-70	11-5-70	11-5-70	11-5-70
Run No.:	1	2	3	4-a	4-b	4-c
FIELD ANALYSES						
TEMPERATURE, °C	3.9	1.1	2.0	1.0	1.7	2.2
CONDUCTIVITY, micromhos	220	220	200	215	220	225
pH	7.4	7.1	6.6	7.0	6.8	6.9
DISSOLVED OXYGEN, ppm	11.9	13.5	12.2	10.9	11.3	11.2
PERCENT OXYGEN SATURATION	121	131	119	104	109	111
LABORATORY ANALYSES						
CONDUCTIVITY, micromhos	220	220	235	235	225	220
pH	7.6	7.4	7.3	7.3	7.4	7.4
TURBIDITY, turbidity units	7.5	4.0	20.0	8.0	4.0	8.0
C.O.D., mg/l	5.0	4.0	<1.0	5.0	15.0	10.0
TOTAL DISSOLVED SOLIDS, mg/l	165	168	185	158	160	135
SUSPENDED SOLIDS, mg/l	1	0	1	-	0	6
TOTAL SOLIDS, mg/l	166	168	186	-	160	141
ALKALINITY as $CaCO_3$, mg/l	68	64	67	67	62	64
Cl^-, mg/l	0.0	0.0	1.0	0.0	0.0	0.0
SO_4^{--}, mg/l	49.0	42.3	45.0	47.5	40.0	42.8
Ca^{++}, mg/l	34.0	34.0	36.0	34.0	32.0	32.0
Mg^{++}, mg/l	6.1	3.7	4.9	7.3	4.9	4.9
Fe^{+++}, mg/l	0.20	0.20	0.12	0.16	0.12	0.12
NO_3^-, mg/l	0.01	0.02	0.03	0.01	0.02	0.02
As, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zn, mg/l	0.01	0.01	<0.01	<0.01	0.01	0.01
HARDNESS as $CaCO_3$, mg/l	110	100	110	115	100	100

*Located below molybdenum mill - Elevation 8,000'

TABLE 8

CHEMICAL QUALITY - STATION NO. 7*

Date :	11-2-70	11-3-70	11-4-70	11-5-70	11-5-70	11-5-70
Run No.:	1	2	3	4-a	4-b	4-c
FIELD ANALYSES						
TEMPERATURE, °C	5.0	3.9	3.9	1.1	4.4	2.8
CONDUCTIVITY, micromhos	225	240	230	235	245	220
pH	7.4	7.1	6.6	7.0	6.9	6.9
DISSOLVED OXYGEN, ppm	11.4	10.2	11.6	10.2	10.2	10.9
PERCENT OXYGEN SATURATION	122	112	120	99	108	109
LABORATORY ANALYSES						
CONDUCTIVITY, micromhos	230	240	235	240	235	225
pH	7.6	7.1	7.2	7.2	7.4	7.3
TURBIDITY, turbidity units	3.0	130.0	3.0	2.5	8.0	9.0
C.O.D., mg/l	5.0	28.0	<1.0	10.0	38.0	5.0
TOTAL DISSOLVED SOLIDS, mg/l	160	253	200	153	175	160
SUSPENDED SOLIDS, mg/l	0.0	2	0	0	12	4
TOTAL SOLIDS, mg/l	160	255	200	153	187	164
ALKALINITY as $CaCO_3$, mg/l	69	68	67	68	73	70
Cl^-, mg/l	0.0	1.0	0.0	0.0	1.0	0..0
SO_4^{--}, mg/l	38.0	45.0	45.0	40.0	39.0	40.0
Ca^{++}, mg/l	32.0	34.0	34.0	34.0	34.0	34.0
Mg^{++}, mg/l	6.1	6.1	4.9	4.9	3.7	4.9
Fe, mg/l	0.20	0.52	0.24	0.20	0.20	0.16
NO_3^-, mg/l	0.02	0.03	0.01	0.02	0.01	0.01
As, mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pb, mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Zn, mg/l	<0.01	<0.01	0.04	<0.02	0.02	0.01
HARDNESS as $CaCO_3$, mg/l	105	110	105	105	100	105

*Located below town of Red River - Elevation 8,680'

TABLE 10
MCA TAILINGS
POND DISCHARGE

PARAMETER	Date: 11-2-70 Run No: 1	11-3-70 2	11-4-70 3
Zn, μg/l	18.0	16.4	11.6
Cd, "	<1.5	<1.8	1.3
Fe, "	90.0	50.0	288.0
Mo, "	3500.0	3050.0	2924.0
Sn, "	5.5	<6.1	6.4
Mn, "	46.5	47.5	45.1
Cu, "	26.0	30.5	21.9
Ag, "	<5.0	<6.1	<4.3
Ni, "	22.0	23.1	81.7
Pb, "	<5.0	<6.0	<4.3
Cr^{+6} "	<1.5	<1.8	<1.3
As, "	-	-	-
Sb, "	-	-	-
Se, "	<15.0	<18.0	<13.0
Tl, "	-	-	-
CN, "	0.04	<0.04	<0.04
Hg, "	<0.5	<0.5	<0.5

TABLE 12
BACTERIOLOGICAL RESULTS
(MEMBRANE FILTER)

DATE AND ANALYSIS	STATION #8	STATION #7	STATION #6	STATION #5	STATION #4	STATION #3	STATION #2
11-4-65:							
TOTAL COLIFORM/100 ml.	6	410	280	240	121	170	760
TOTAL COLIFORM/100 ml.	3	2500	360	280	129	170	900
11-6-65:							
TOTAL COLIFORM/100 ml.	4	4000	290	680	270	270	800
11-7-65:							
TOTAL COLIFORM/100 ml.	2	290	30	10	5	95	650
FECAL COLIFORM/100 ml.	<1	50	<2	2	4	24	4
FECAL STREPTOCOCCI/100 ml.	1	<2	<2	2	2	30	74
11-5-70:							
TOTAL COLIFORM/100 ml.	<10	20	40	50	20	<10	200
FECAL COLIFORM/100 ml.	<10	10	70*	10	90*	<10	<10
FECAL STREPTOCOCCI/100 ml.	10	20	10	50	90	60	60

*Unreliable Data

TABLE 14

Summary of Raw Data of Biological Conditions at the Sampling Stations in the Rio Grande of New Mexico

November 1970

Sampling Station	Amount of Sample	Percent of Genera Clean	Percent of Genera Facultative	Percent of Genera Tolerant	Biotic Index	No. of Genera	No. of Organisms
2	3 $ft.^2$	63	25	12	12	8	188
3	"	87	13	0	15	8	388
4	"	69	25	6	26	16	403
5	"	80	20	0	9	5	48

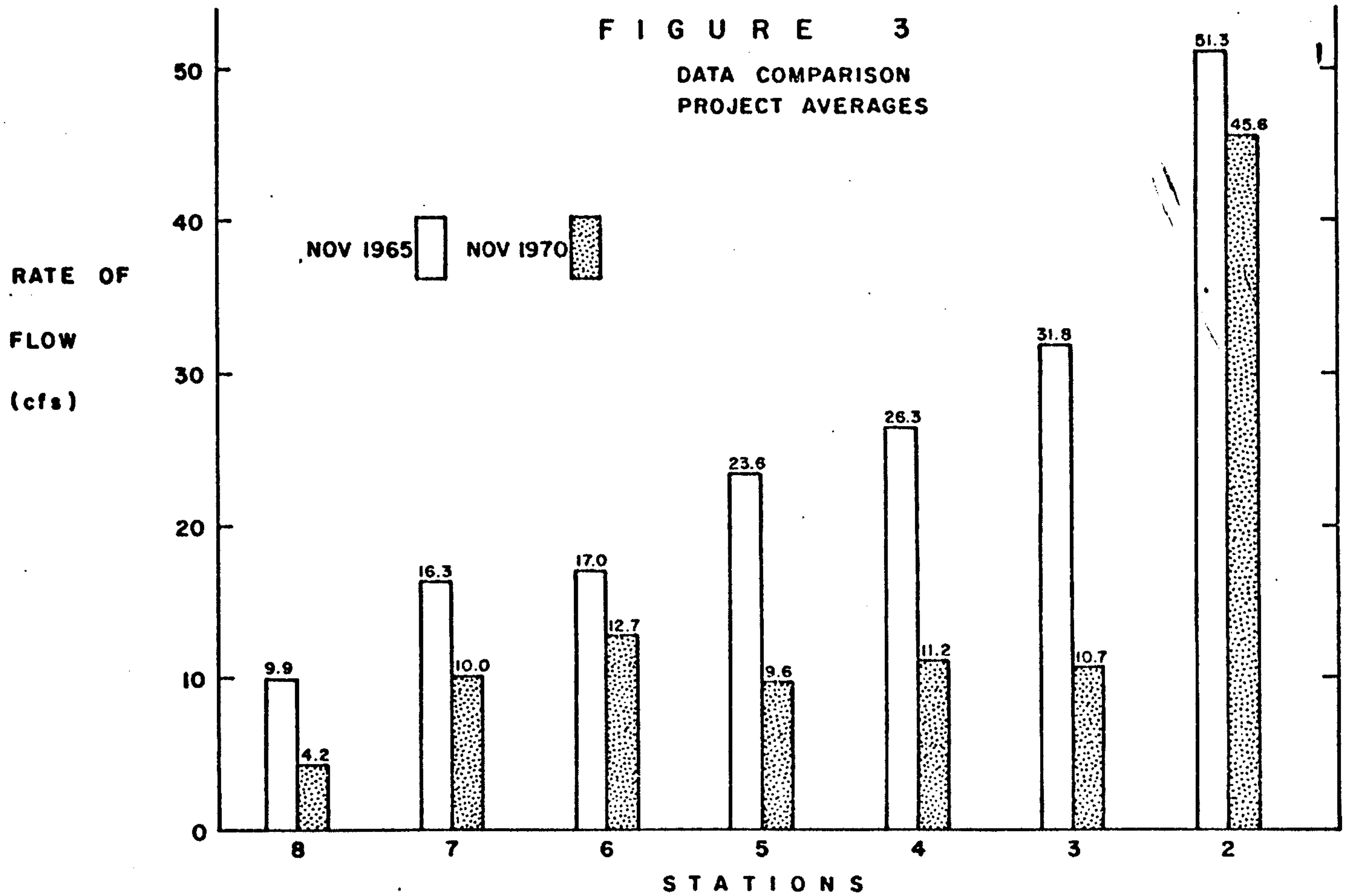


FIGURE 3
DATA COMPARISON
PROJECT AVERAGES

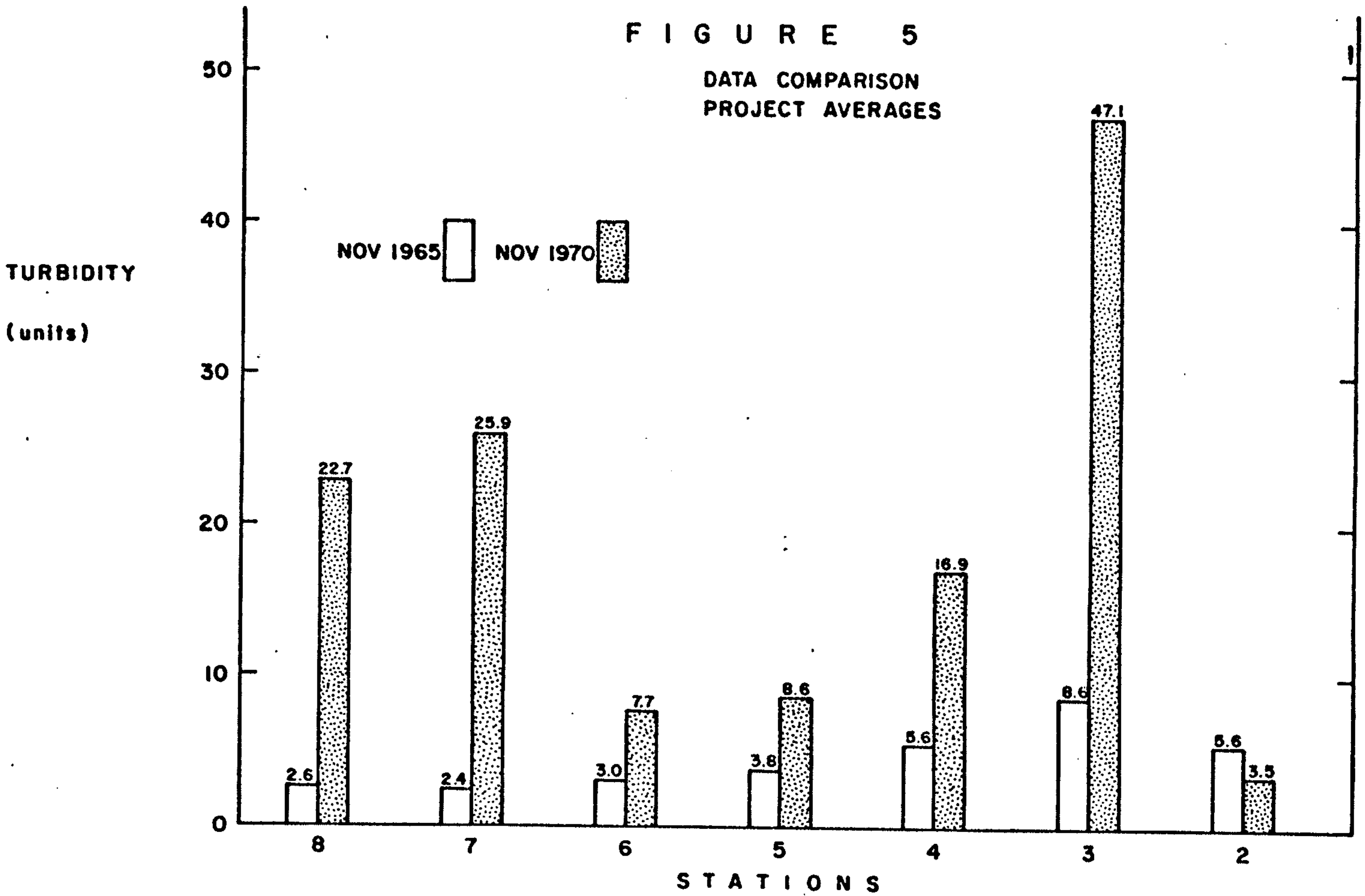


FIGURE 5
DATA COMPARISON
PROJECT AVERAGES

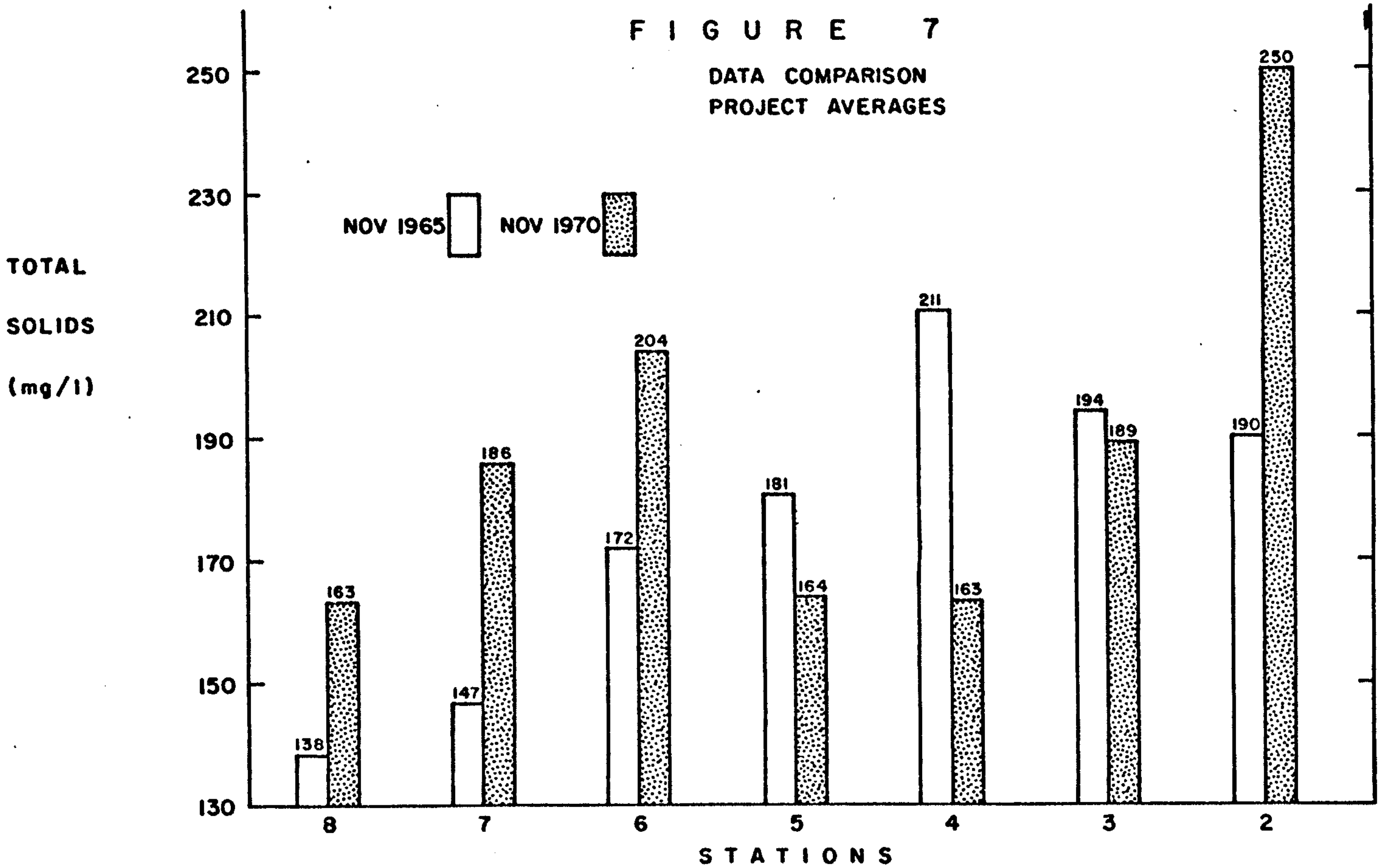


FIGURE 7

DATA COMPARISON
PROJECT AVERAGES

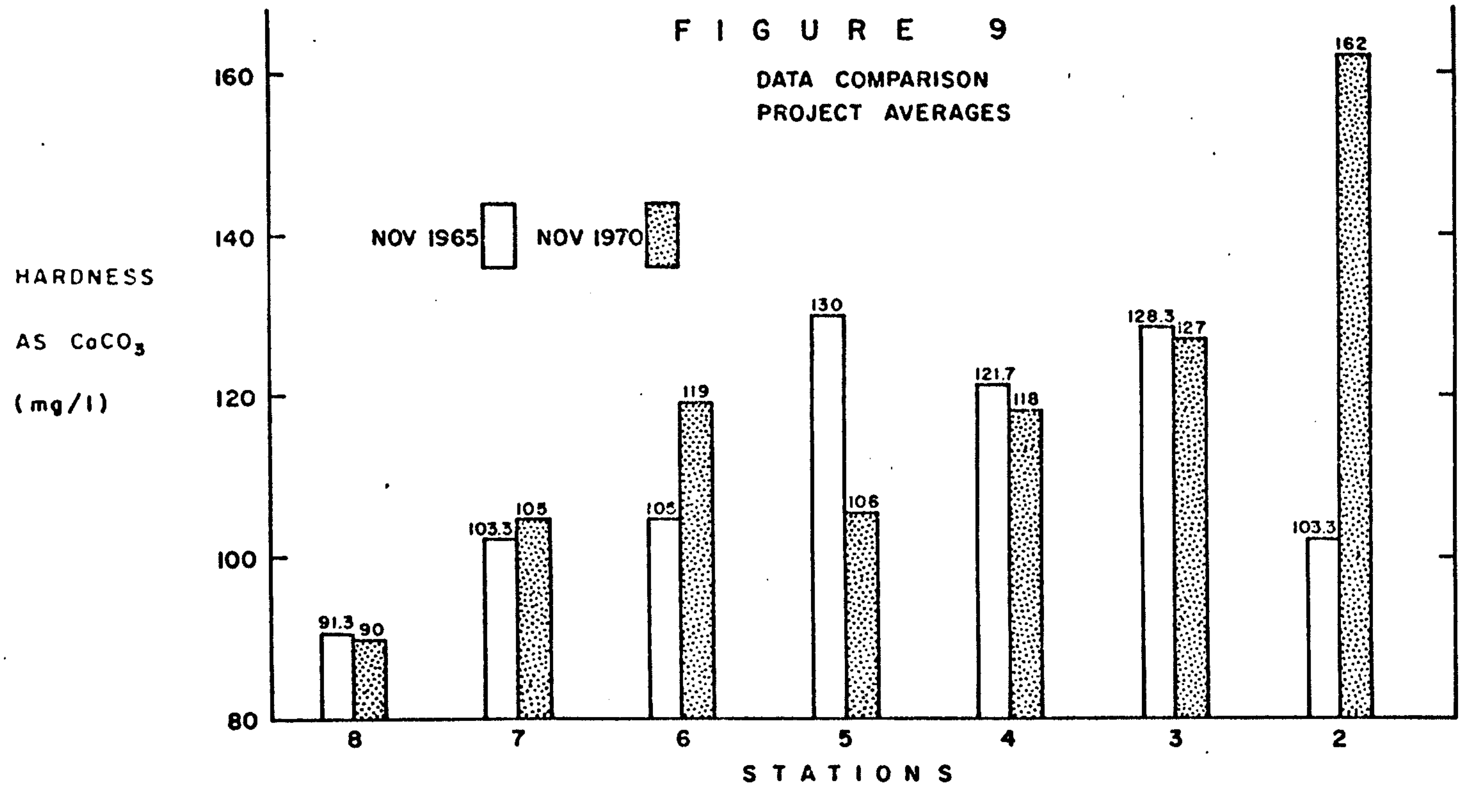


FIGURE 9

DATA COMPARISON
PROJECT AVERAGES

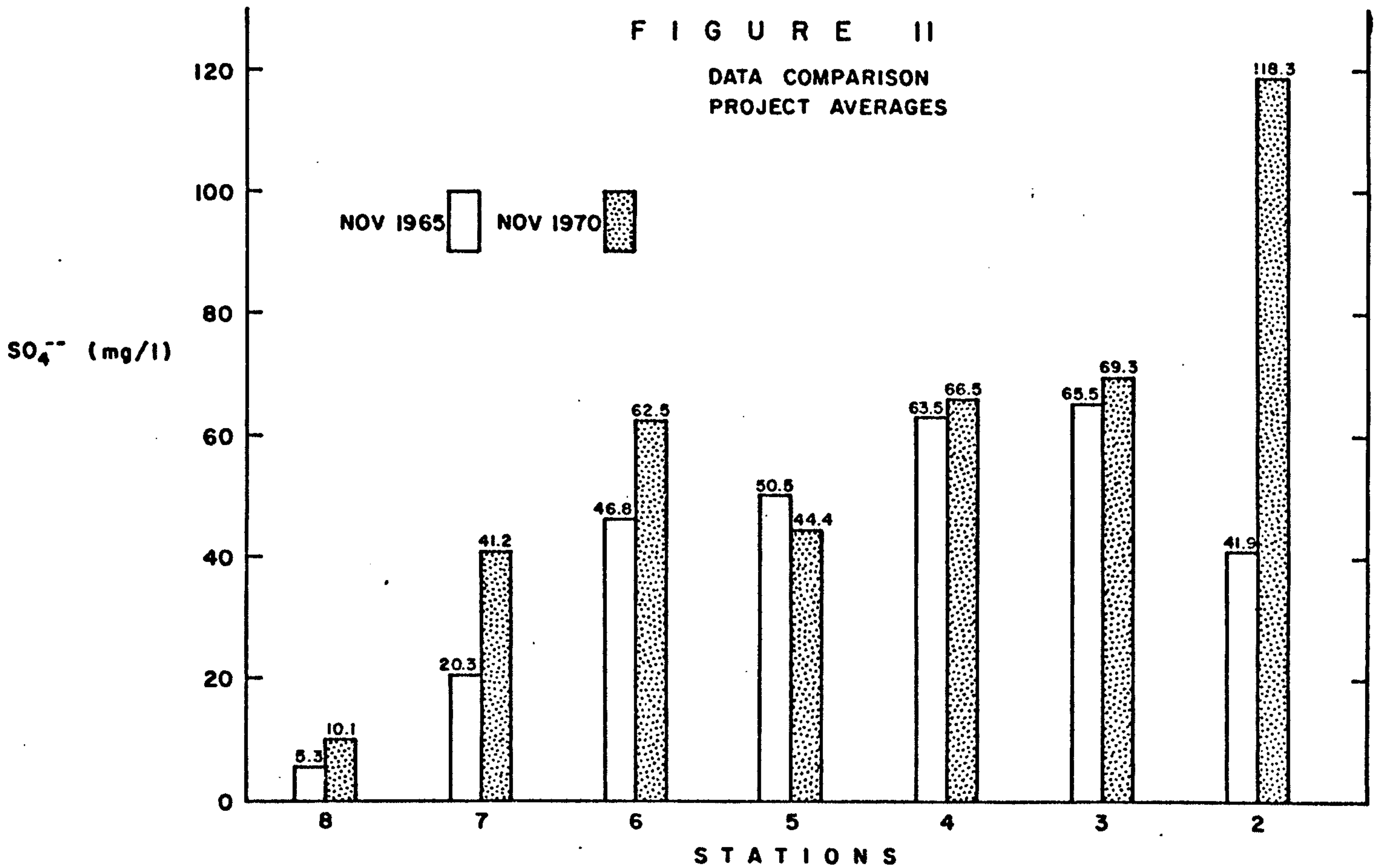


FIGURE 11
DATA COMPARISON
PROJECT AVERAGES

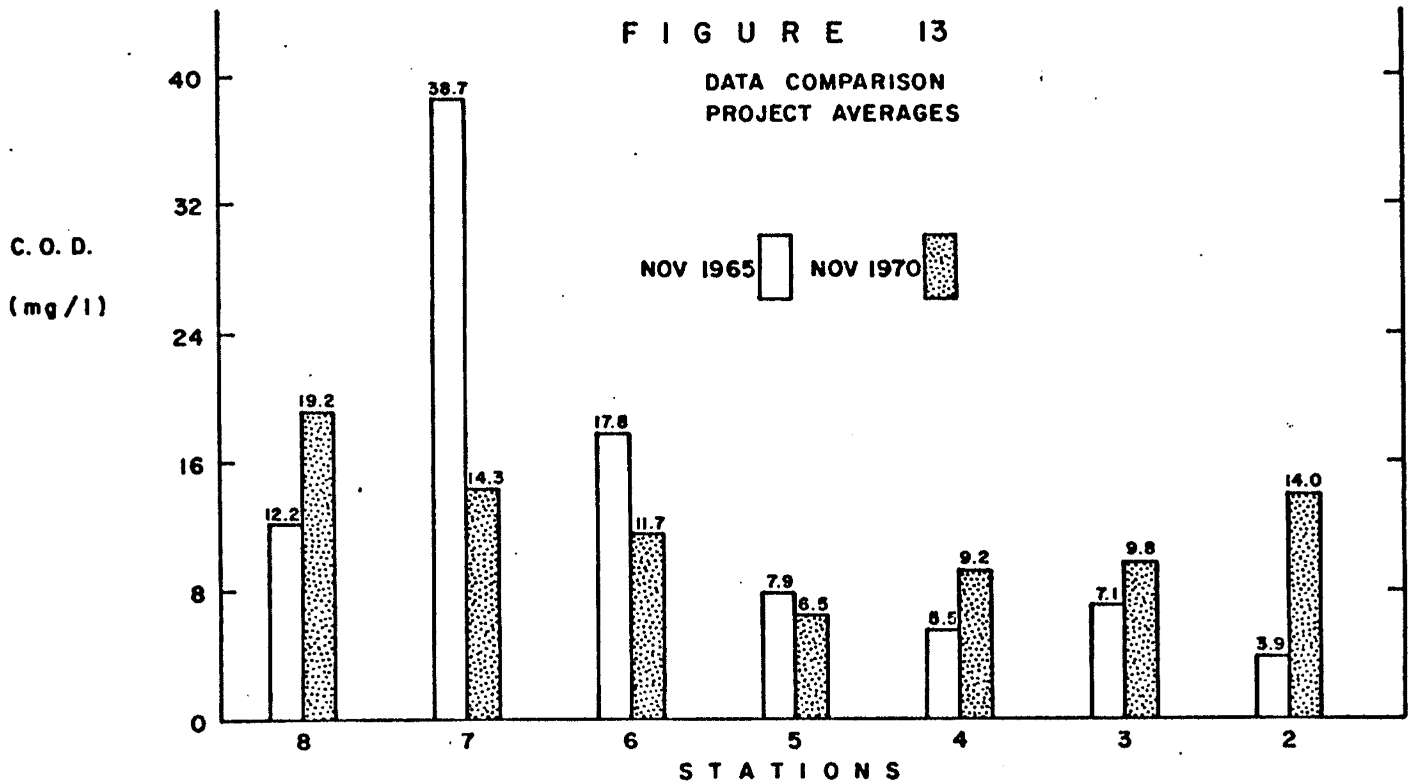


FIGURE 13
DATA COMPARISON
PROJECT AVERAGES
C. O. D.
(mg/l)
NOV 1965
NOV 1970
40
32
24
16
8
0
38.7
19.2
17.8
14.3
12.2
11.7
7.9
6.5
5.5
9.2
7.1
9.8
3.9
14.0
8
7
6
5
4
3
2
STATIONS

FIGURE 15

RED RIVER OF NEW MEXICO

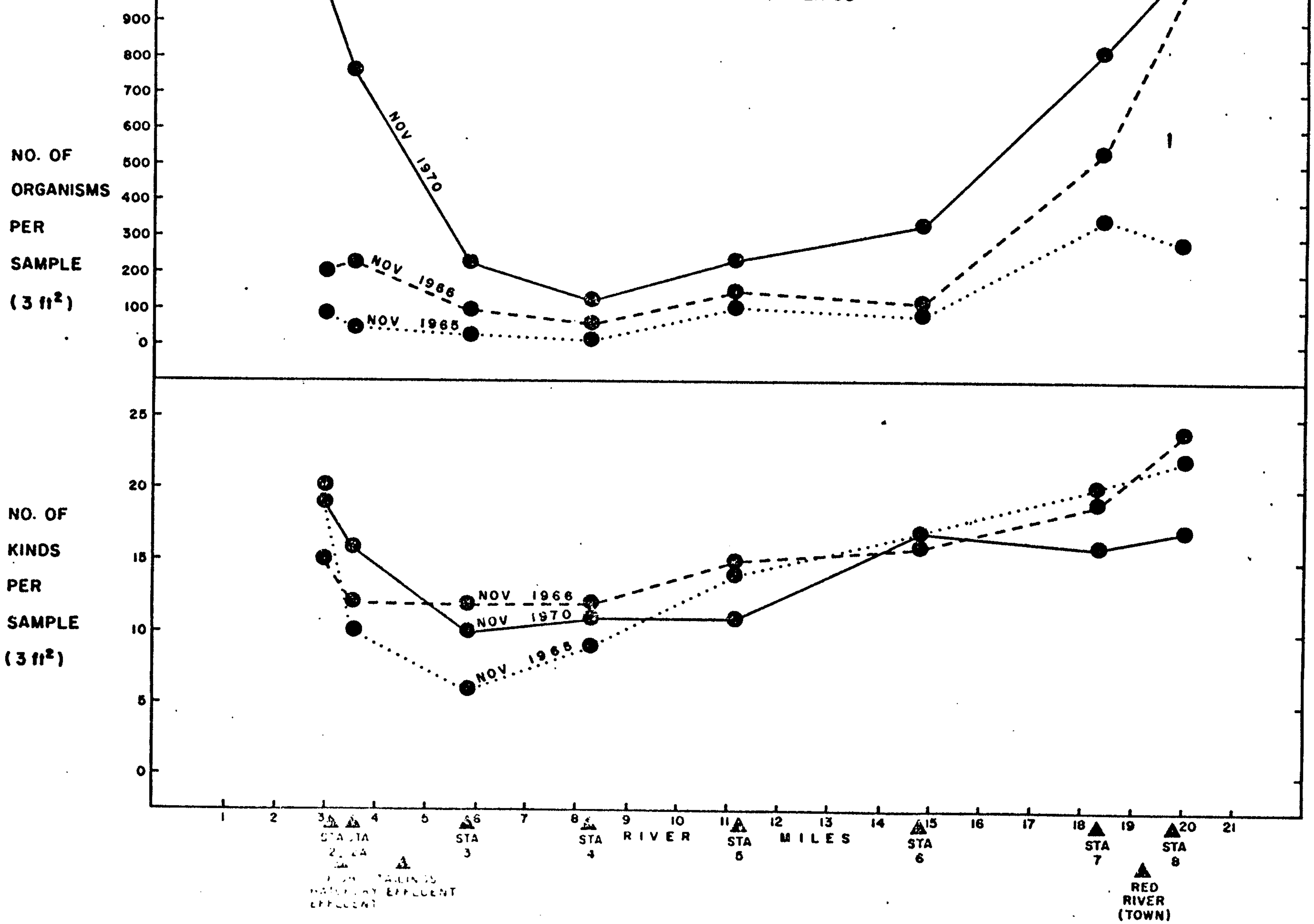


FIGURE 17

BIOTIC INDEX

RED RIVER OF NEW MEXICO

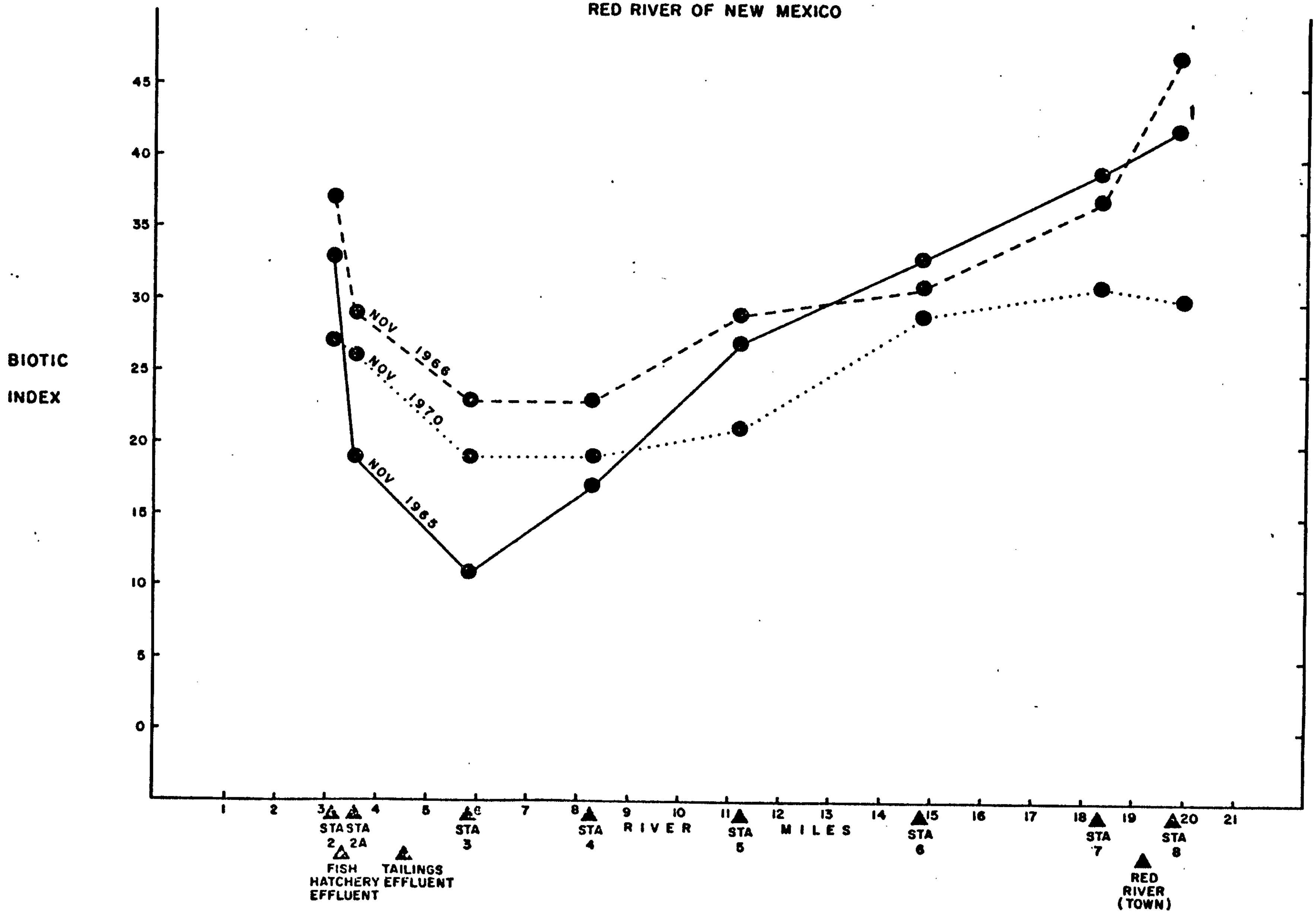
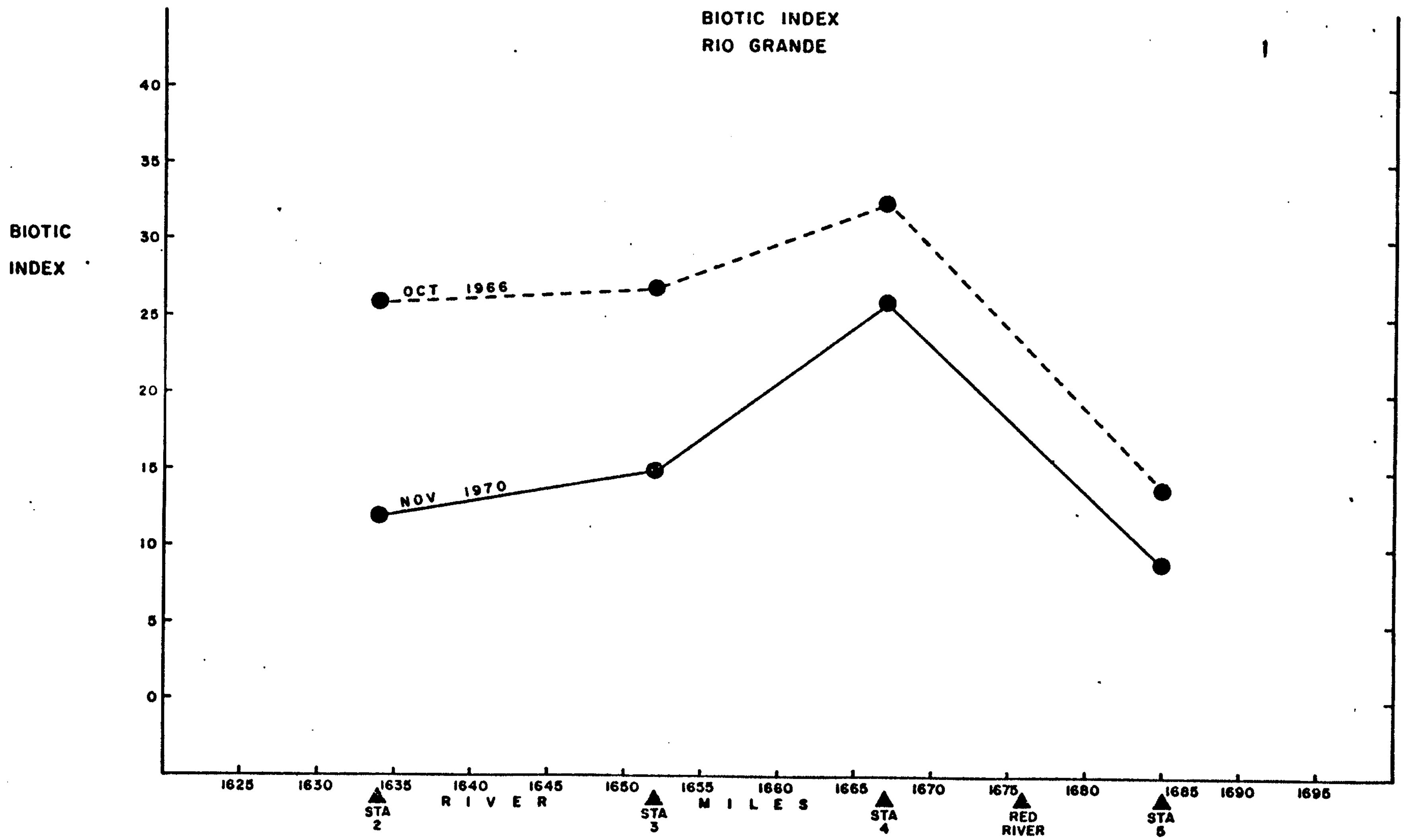


FIGURE 19

BIOTIC INDEX
RIO GRANDE



(14) Gaufin, A. R., and Tarzwell, C. M., 1952, "Aquatic Invertebrates as Indicators of Stream Pollution," Public Health Reports, 67 (1): pp 57-64.

(15) Gaufin, A. R., and Tarzwell, C. M., 1955, "Environmental Changes in a Polluted Stream During Winter," American Midland Naturalist, 54 (1): pp 78-88.

(16) Gaufin, A. R., and Tarzwell, C. M., 1956, "Aquatic Macro-Invertebrate Communities as Indicators of Organic Pollution in Lytle Creek," Sewage and Industrial Wastes, 28 (7): pp 906-924.

(17) Hynes, H. B. N., 1962, "The Significance of Macro-Invertebrates in the Study of Mild River Pollution," Third Seminar, Biological Problems in Water Pollution, C. M. Tarzwell, Editor, U. S. Department of Health, Education, and Welfare, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

(18) Keup, L. E., and Stewart, K., 1966, "Effects of Pollution on Biota of the Pigeon River," North Carolina and Tennessee, FWPCA, T. A. & I., Technical Services Program, Cincinnati, Ohio, pp 35.

(19) Paine, G. H., Jr., and Gaufin, A. R., 1956, "Aquatic Diptera as Indicators of Pollution in a Midwestern Stream," Ohio Journal of Science, 56 (5): pp 291-304.

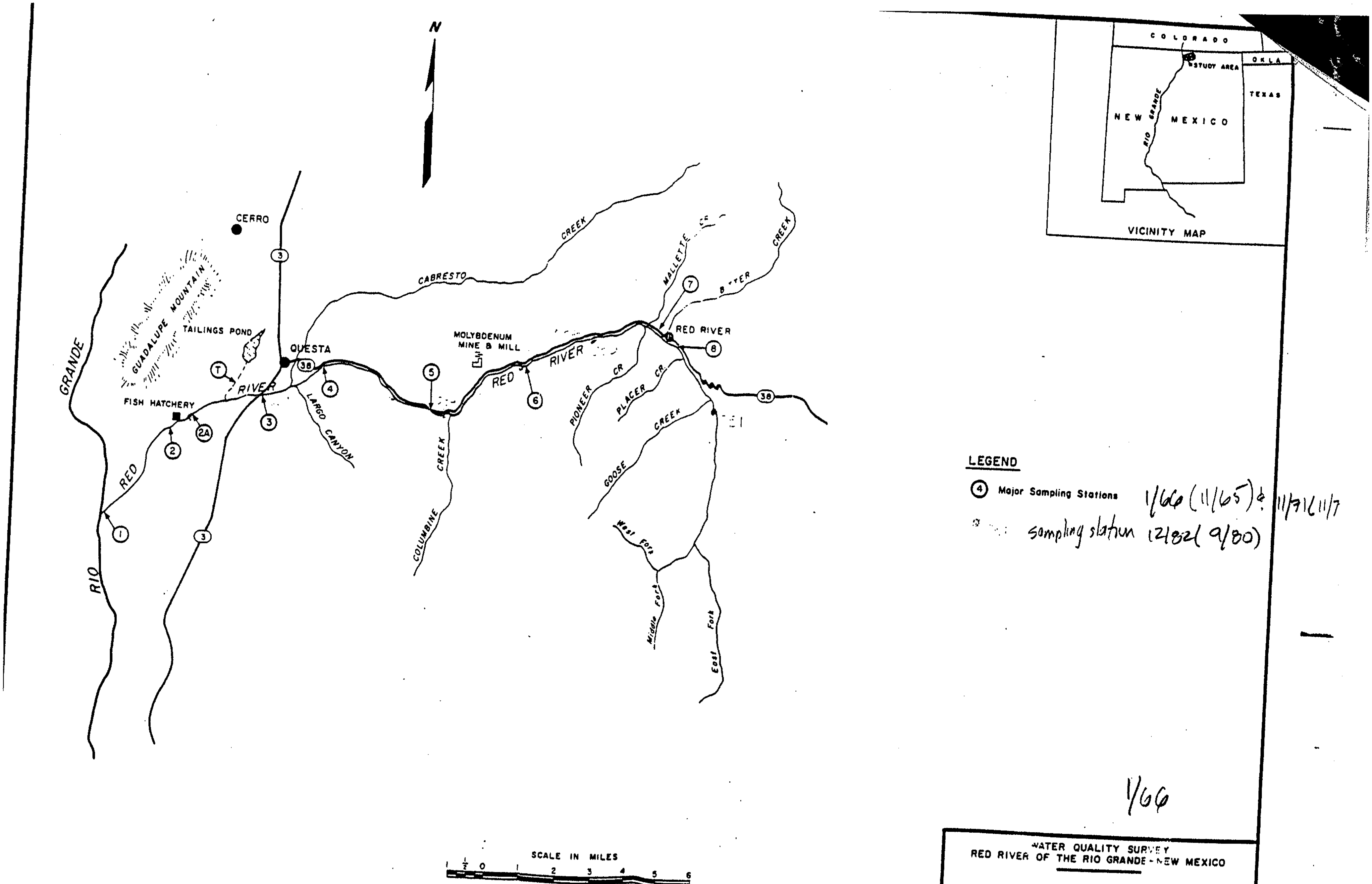
(20) Richardson, R. E., 1928, "The Bottom Fauna of the Middle Illinois River, 1913-1925: Its Distribution, Abundance, Variation and Index Value in the Study of Stream Pollution," Illinois Natural History Survey Bulletin, Chicago, pp 387-475.

(21) Rogers, W. A., 1962, "A Study of Two Streams Receiving Domestic Sewage," Proceedings of the 16th Annual Conference, Southeastern Association, Game and Fish Commission, October 14-17, 1962, pp 449-463.

(22) U. S. Department of the Interior, 1967, Effects of Pollution on Aquatic Life Resources of the South Platte River Basin in Colorado, Vol. I & II, FWPCA, South Platte River Basin Project, Denver, Colorado, and T. A. & I., Cincinnati, Ohio.

(23) Hawkes, H. A., 1963, "Effects of Domestic and Industrial Discharges on the Ecology of Riffles in Midland Streams," International Journal of Air and Water Pollution, 7 (6/7): pp 565-586.

(24) Woodwiss, F. S., 1964, "The Biological System of Stream Classification Used by the Trent River Board," Chemistry and Industry, pp 443-447, (Water Pollution Abstract) 39 (7): pp 218, No. 1026.



LEGEND

④ Major Sampling Stations 1/66 (11/65) & 11/71 (11/7

sampling station 12/82 (9/80)

1/66

WATER QUALITY SURVEY
RED RIVER OF THE RIO GRANDE - NEW MEXICO

LOCATION MAP

U.S. DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
Federal Water Pollution Control Administration
ROBERT S. KERR WATER RESEARCH CENTER — ADA, OKLAHOMA