R. J. Schliekelman

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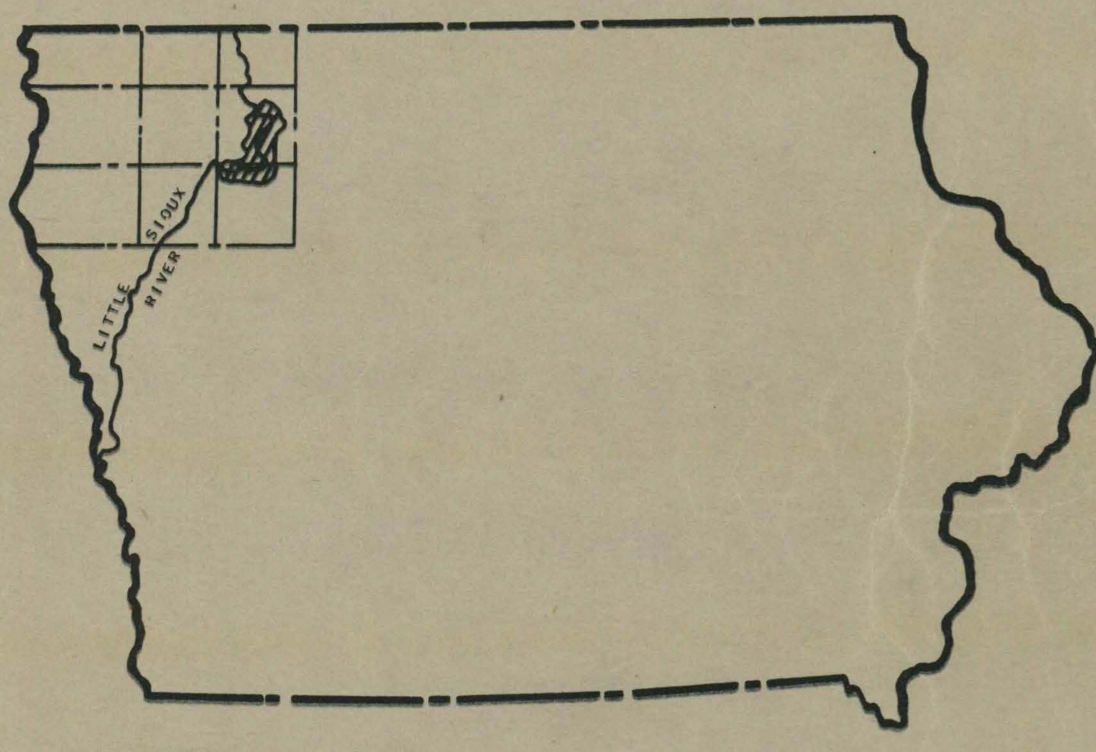
Little Sioux R

LITTLE SIOUX RIVER
WATER POLLUTION INVESTIGATION

FROM
SPENCER TO PETERSON, IOWA



Hearing

DIVISION OF PUBLIC HEALTH ENGINEERING
IOWA STATE DEPARTMENT OF HEALTH
DES MOINES, IOWA
MARCH 1951

REPORT

On The

INVESTIGATION OF POLLUTION

Of The

LITTLE SIOUX RIVER

From Spencer to Peterson

1950 -1951

By The

DIVISION OF PUBLIC HEALTH ENGINEERING

STATE DEPARTMENT OF HEALTH

Des Moines, Iowa

March, 1951

WALTER L. BIERRING, M. D.
COMMISSIONER

State of Iowa
Department of Health
Des Moines 19

DIVISION OF
PUBLIC HEALTH ENGINEERING
PAUL J. HOUSER, DIRECTOR

PLEASE ADDRESS ALL CORRESPONDENCE TO THE
DIVISION OF PUBLIC HEALTH ENGINEERING

April 2, 1951

Walter L. Bierring, M. D.
Commissioner
State Department of Health
Des Moines, Iowa

Dear Dr. Bierring:

I am transmitting herewith a report of your Division of Public Health Engineering covering the investigation of pollution of the Little Sioux River from a point above Spencer, Iowa to below Peterson, Iowa.

These investigations were instituted during February 1950, in accordance with Sections 135.18 to 135.29 of the Iowa Stream and Lake Pollution Law.

Very truly yours,

P. J. Houser, Director
Division of Public Health Engineering

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POLLUTION OF LITTLE SIOUX RIVER

Spencer to Peterson

February 16, 1950
January 16, 1951

I. INTRODUCTION:

The present investigation was initiated in February, 1950 upon the request of the State Conservation Commission which had been notified of fish loss in the Little Sioux River near Linn Grove. A check of the stream at this point by the Conservation Commission revealed a low oxygen condition apparently due to the sewage and pollutional load upstream.

During the early thirties the State Department of Health devoted its principal effort to securing abatement of pollution of the streams in Iowa below the larger cities since the pollution of streams was most acute at these points. Under a cooperative arrangement with the State Planning Board it was possible to expand this work in 1934 and investigations were made of the pollution of some of the smaller towns in the state including the Little Sioux River into which Spencer, Sioux Rapids, Linn Grove and Peterson discharge their wastes. While no orders under the Stream Pollution Law were issued following this investigation the City of Spencer and Town of Peterson completed the installation of sewage treatment plants in 1940. Plans for a proposed sewage treatment plant at Sioux Rapids were approved by this Department in 1942 but because of priorities on materials, the plant was not constructed.

The construction of the treatment plants at Spencer and Peterson eliminated the pollution of the Little Sioux River below these municipalities. However, greatly increased population and the construction of a meat packing plant and other food processing industries has overtaxed the capacity of the Spencer sewage treatment plant and contributed to the renewed pollution of the river to some degree. Mechanical difficulties at the sewage treatment plant have also reduced the efficiency of treatment and contributed to the pollution of the river at this point. Serious pollution of the Little Sioux River has continued by raw sewage and industrial wastes from the towns of Sioux Rapids and Linn Grove and by the wastes from a number of small industries. Construction of the sewage treatment plant at Peterson has eliminated the pollution from this source and with efficient operation the plant should continue to provide a satisfactory effluent.

In addition to the fish loss which occurred during January of 1950, fish in distress due to lack of oxygen were also observed during January of 1951 and fish loss will again occur. The pollution of the Little Sioux River below Sioux Rapids has been noted by the United Counties Chapter of the Izaak Walton League at Storm Lake which has asked in a letter dated January 27, 1951 to this Department, that the condition be investigated and corrected.

During 1950 meetings were held with the town councils of Sioux Rapids and Linn Grove for the purpose of discussing the necessity of providing sewage treatment for these communities to eliminate the pollutional load contributed to the Little Sioux River. No further action has been taken by these communities. Meetings have also been held with the Spencer city officials at which time their attention was directed to the need for improvements to the existing treatment plant so as to reduce the pollutional load. Although a planning program has been initiated to improve conditions, no specific date has been set for completion of the needed improvements.

In accordance with provisions of the Iowa Stream and Lake Pollution Law, Section 135.26, Code of Iowa 1950, a permit was issued on September 12, 1950 to the City of Spencer for the installation of sanitary sewer extensions. The permit was issued subject to the following stipulation: "Since these sewer extensions and the reopening of the meat packing plant will add to the pollution load reaching the receiving stream, planning toward the expansion of the present treatment plant will continue and construction started at an early date."

II. SCOPE OF INVESTIGATION:

The present investigation includes the collection of river samples from selected points on the Little Sioux River from a point above Spencer to a point below Peterson. The investigation was begun on February 16th, 1950 and continued to January 16th, 1951. An average of seven samples were collected from these sampling stations during this period. In addition the results of an investigation of oxygen conditions above Linn Grove conducted in January, 1950 by the Conservation Commission are also reported.

During February and March, 1950, a study was made of the Spencer sewage treatment plant at the request of the City Engineer in order to determine the adequacy of the treatment facilities and make recommendations toward improvement of the degree of treatment. In connection with this plant study a limited number of stream samples were collected below the plant to determine the effect of the treatment plant. The results of the plant studies and recommendations for enlarging the plant were forwarded to the city officials and will not be repeated in this report.

III. SCOPE OF TESTS:

Field determinations made immediately following collection of the samples included temperature readings, pH determinations, and dissolved oxygen determinations. Notes relative to the physical condition of the stream at the time of sampling were made. Samples for biochemical oxygen demand determinations were iced in the field and taken to the laboratory in Des Moines where these determinations were completed. Samples for bacteriological analysis were iced and shipped to the State Hygienic Laboratory of Iowa City where these determinations were made. Samples for chemical analyses were preserved, iced and forwarded to the laboratory in Iowa City for analysis. The chemical determinations consisted of organic nitrogen, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen.

All tests in the field and in the laboratories were carried out in accordance with the procedures set forth in the ninth edition of "Standard

Methods for the Examination of Water and Sewage" of the American Public Health Association. All field work including sampling and field laboratory determinations was done by members of the staff of the Division of Public Health Engineering.

IV. ACKNOWLEDGEMENTS:

Grateful acknowledgement is made to E. B. Speaker, Superintendent of Biology, State Conservation Commission, for information pertaining to fish life; to Earl T. Rose, Fisheries Biologist, State Conservation Commission, for information with special reference to fish potentialities of the Little Sioux River; and to V. R. Bennion, District Engineer, Geological Survey, for preliminary data on stream flows.

V. SIGNIFICANCE AND DEFINITIONS OF THE VARIOUS PHYSICAL, CHEMICAL AND BACTERIOLOGICAL TESTS USED IN THE SURVEY:

Temperature: The temperature values are of the stream water at the point of sampling and are reported in degrees Fahrenheit. Temperature governs the solubility of oxygen in the stream and influences the rate of purification.

pH: Hydrogen-ion concentration or pH indicates the relative acidity or alkalinity of a water. A value of 7 is considered neutral, those values above 7 are alkaline and those below are acid.

Dissolved Oxygen: Oxygen in dissolved form is essential to the natural purification of streams and the maintenance of aquatic life. This oxygen is drawn upon to support biochemical oxidation of organic waste and is replaced by absorption from the atmosphere and the photosynthetic action of some water plants including algae. A deficiency in dissolved oxygen, below the saturation level indicates the presence of polluting organic substances which are absorbing oxygen from the stream water. The degree of this deficiency is a measure of the deoxygenating effect of the polluting matter and hence an index of the degree of pollution in a particular stream zone. If there is a sufficient quantity of oxygen present in the water the organic material will be oxidized without creating any objectionable odor nuisance or destruction of aquatic life. However, if there is not a sufficient amount of oxygen present, anaerobic decomposition takes place and the organic material present in the water undergoes putrefaction with the accompanying foul odor and the black, inky appearance of water which is familiar in a polluted stream.

Five-day Biochemical Oxygen Demand at 20°C. (BOD): This determination indicates the amount of dissolved oxygen which may be expected to be absorbed in 5 days at 20°C. (68°F) to support the biochemical oxidation of the organic pollution carried by the stream at the point of sampling.

Coliform Bacteria (MPN): Expressed as the most probable number per 100 ml. of sample. This test is the most delicate and specific test for pollution by sewage as it shows the approximate density of a group of bacteria which are always present in large numbers in sewage and are relatively few in number in other stream pollutants. Coliform bacteria are normal inhabitants of the intestines of warm-blooded animals and are discharged in large numbers in human feces, which constitute the principal source of these bacteria in sewage.

VI. SIGNIFICANCE OF STREAM POLLUTION:

The pollution of a stream with raw or improperly treated sewage or industrial wastes is objectionable for the following reasons:

1. Sewage and industrial wastes contain millions of bacteria, many of which may be pathogenic or disease producing.

2. All sewage and most industrial wastes contain unstable organic material which in being converted to harmless stable material robs the stream water of oxygen.

3. Sewage and industrial wastes contain solids which are objectionable when they are floating downstream and which settle to the bottom of the stream bed causing objectionable sludge deposits when undergoing decomposition.

4. Some industrial wastes contain materials which are toxic to fish, livestock and human beings.

Pollution of a stream is a serious public health problem because of the very high numbers of bacteria found in domestic sewage and some industrial wastes. Many of these bacteria are harmless but disease producing bacteria may be present in the bodily wastes of people having disease or carriers of disease. The water-borne intestinal diseases, typhoid, dysentery or diarrhea are likely to be spread through the medium of polluted water. The possibility of the transmission of poliomyelitis by polluted water also exists since the virus of poliomyelitis has been isolated from sewage. Other infections reported spread by bathing in polluted water are a variety of inflammatory skin diseases as well as eye, ear, nose and throat infections. Any type of recreation which requires contact with heavily polluted water is dangerous and may result in infections of this type.

Sludge banks in the region of greatest pollution may contain material which is infected with disease producing bacteria. Contact with this material will be dangerous and flies may carry disease organisms from such deposits.

Dairy animals having access to polluted stream water present another public health hazard. Cattle wading in polluted water may pick up disease-producing bacteria on their udders and bodies which may be transferred mechanically to the milk.

Little is known of the exact effect of heavily polluted water on livestock. There are a few diseases which are common to both humans and livestock and there is a possibility that such disease may be transmitted to livestock through sewage. There is the further possibility that wastes, such as packing plant wastes which may contain material from diseased animals that are killed, might easily contaminate the water to a degree that livestock drinking the water would become infected.

In order to support aquatic life and prevent nuisances, there must always be present in the water a sufficiency of dissolved oxygen. It is generally agreed that if fish life is to be normally maintained, there must always be from three to five parts per million (ppm) of oxygen in the water at all times. Some fish require less than 3 ppm dissolved oxygen and many can survive for limited periods at much lower concentrations, especially at low temperatures, but it appears that a minimum of about 4 ppm dissolved oxygen may be required for prolonged survival of some fish at summer temperatures and a minimum of 5 ppm is desirable. In addition to the direct effect on fish of pollution, there is evidence that fish will leave areas of deficient oxygen if they can find means of escape.

Submerged vegetation promotes the propagation of fish life by furnishing shelter and nourishment to many forms of life which are necessary in the diet of the common game fish. These organisms and plants are all dependent upon oxygen and sunlight for existence and cannot grow under water made turbid and depleted of oxygen by sewage or wastes. Thus a low oxygen content not only kills or excludes the fish life at the time the deficiency occurs but also kills a major portion of the food organisms. In general it is the worst conditions of pollution which occur occasionally, rather than the average conditions, which determine whether fish can be successfully propagated in certain streams.

In an area of the stream above a riffle or artificial dam where the water velocity has been reduced, there is a tendency on the part of the heavier solids to settle, forming banks of so called sludge. These areas are often low or completely depleted of dissolved oxygen and bacterial putrefaction with accompanying foul odors and large masses of sludge rise to the surface rendering the water black in color and odorous. These sludge deposits interfere seriously with propagation of fish life. The accumulation of sludge is most serious during the extended periods of low stream flow and if there is a considerable accumulation of sludge in the stream, a sudden rise in the stream will stir up these deposits carrying them in suspension with the result that the oxygen of the stream waters is depleted and aquatic life in the stream is destroyed.

VII. RIVER DESCRIPTION:

The Little Sioux River rises in Jackson County in southwestern Minnesota. From its headwaters the river flows in a general southwesterly direction through northwestern Iowa, to its confluence with the Missouri River near the Town of River Sioux, Iowa. The river basin has an area of 4,550 square miles with 1030 square miles drainage area above Spencer and approximately 1590 square miles above Linn Grove. Above Cherokee County the Little Sioux River basin is characteristic of the original glacial drift plain; however, a definite drainage pattern has developed. Irregular mounds and ridges with small lakes and marshes distinguish the glacial plains. Gullies, steep hillsides, and ridges along the larger streams, due to erosion of the loessal soils, define the middle portion of the basin. The streams flow through valleys with narrow flat bottom lands.

The runoff from the Little Sioux River Basin is small during the winter season when streams are frozen. There are also long periods of low flows during the summer and fall. The Little Sioux River is a heavy silt carrier because of the pronounced erosion over much of the basin. However, erosion in the upper part of the basin is much less pronounced than in the lower reaches of the stream.

Information from various sources indicates that the reach of the Little Sioux River from Linn Grove to a point below Cherokee is one of the best fishing streams in the state. The State Conservation Commission reports a heavy population of channel catfish and occasionally a good population of walleyes. Conservation officers also report that fishing in the Little Sioux River from the Dickinson County line north of Spencer to just above Spencer is generally very good for catfish and often good for walleyes.

Fish catches in the reach from above Linn Grove to Spencer are reported to be less than in the reach south of Linn Grove. In this reach above Linn Grove, there is a record of fish mortality due to pollution during the past two winters and the amount of sewage and industrial waste discharged in the stream, undoubtedly has an adverse effect on fish life during all periods of low flow.

VIII. SAMPLING STATIONS:

The sampling stations on the charts and in the tables of this report are usually referred to by number. A map indicating the geographical locations of the various sampling stations is shown on the following page of this report. Table I following this map, is a description of the various sampling stations.

IX. SOURCES OF POLLUTION:

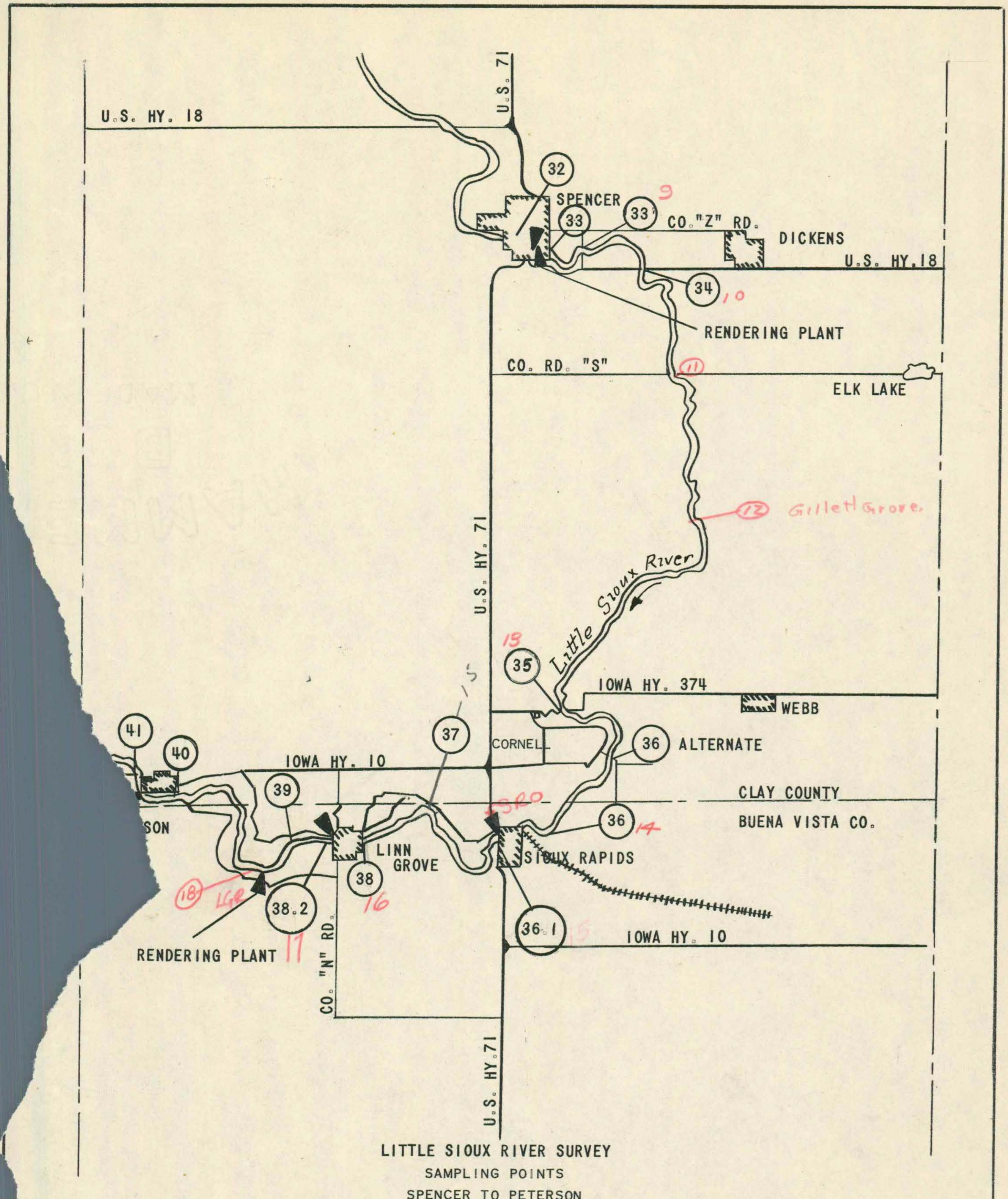
The following sources of pollution are listed in order downstream from Spencer to Peterson and are also indicated on the map.

1. Spencer Sewage Treatment Plant:

This plant has become overloaded in recent years due to the great increase in population and industrial activity and no longer provides the degree of treatment necessary for the protection of the stream. This plant overload is both organic and hydraulic. Operational difficulties at the plant have at time increased the organic load to the stream. The meat packing plant at Spencer was closed during the early part of the survey due to a change in management and did not reopen until the late fall of 1950.

2. Spencer Rendering Plant:

The outlets from this two cooker plant enter the river approximately 500 feet below the city treatment plant outlet. This plant contributes process wastes from the rendering operations and also raw sewage from the sanitary facilities. Floating grease and sewage solids are found at most times below these outlets.

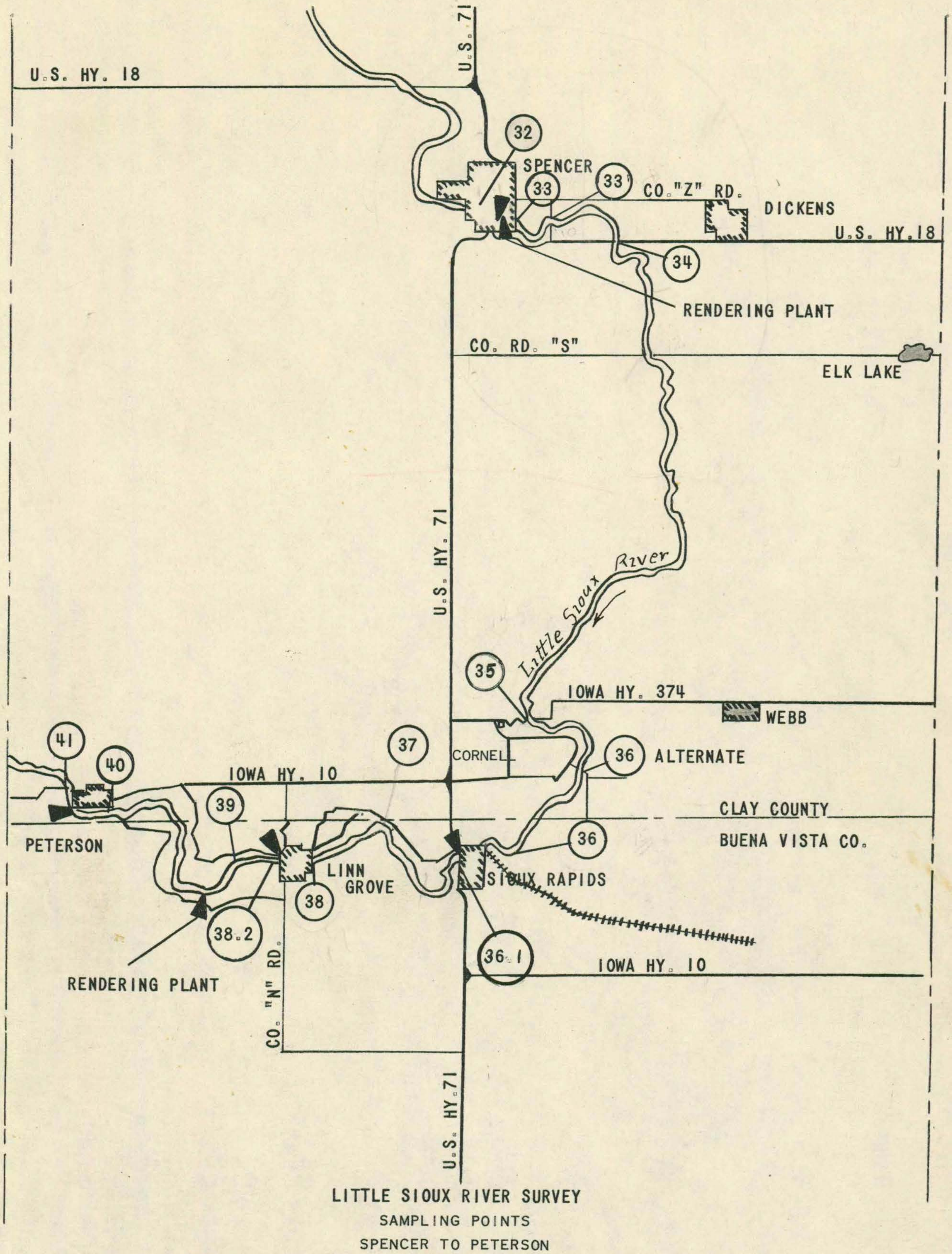


LITTLE SIOUX RIVER SURVEY
SAMPLING POINTS
SPENCER TO PETERSON

○ REFERS TO SAMPLING STATION

▲ SOURCES OF POLLUTION

SCALE: 1" = 4 MILES



LITTLE SIOUX RIVER SURVEY
SAMPLING POINTS
SPENCER TO PETERSON

○ REFERS TO SAMPLING STATION

▲ SOURCES OF POLLUTION

SCALE: 1" = 4 MILES

STREAM POLLUTION SURVEY
LITTLE SIOUX RIVER
Spencer to Peterson
LOCATION OF SAMPLING STATIONS

TABLE I

32 - 500' above Highway 71 bridge in Spencer.

33 - Below city and rendering plant outlets at the southeast edge of Spencer.

33' - County road bridge 1 mile east of Spencer on 18 and 1/4 mile north.

34 - Highway 18 bridge 2.3 miles east of Spencer.

35 - Bridge on Highway 374, 1 mile east of Cornell.

36 - Northeast edge of Sioux Rapids above all outlets.

36.1 - Below Highway 10 bridge in Sioux Rapids.

STP →

37 - 2 miles west and 1 mile north of station 36.1. This station is at a point where the river bends near the road.

38 - Above dam in Linn Grove.

38.2 - Below dam at Linn Grove.

39 - One mile west of Linn Grove where river bend nears road.

40 - Bridge in Wanata State Park at Peterson.

41 - Bridge on highway 10, 1/4 mile west of Peterson.

42 - Bridge on highway 10 approximately 4 miles west of Peterson.

3. Sioux Rapids Outlets:

All sewage and industrial waste from this community of approximately 1100 persons is directed to the river untreated. Sewage solids, gray color and strong odors may be noticed in the stream below the main outlet at all times. Some waste from a locker plant is reported to be present in a storm water line 1000 feet upstream from the main city outlet. This line also carries some oil waste possibly from the city water pumping station. 1007

4. Linn Grove Outlet:

The sewage from this community of approximately ~~400~~ 320 people is directed to the river untreated. This outlet is located approximately one-half mile below the dam in Linn Grove. Sewage and sewage solids are present in the stream below this outlet. 320

5. Linn Grove Rendering Plant:

The plant is located approximately two miles below Linn Grove. Condensate from the cookers and wastes from the floor washing and truck washing operations are directed through septic tanks and then to the river.

6. Municipal Sewage Treatment Plant at Peterson:

The sewage from this community receives primary settling and treatment on a trickling rock filter. No final settling is provided. This plant with competent operation and supervision should, for the present, provide adequate treatment.

X. PHYSICAL CONDITION OF STREAM:

At the time of sampling the physical condition of the stream at the individual sampling points was noted. The sampling period covered in this report was initiated in the winter of early 1950, extended through the summer months of 1950 and into the early winter of 1951.

Station 32 is located approximately 500 feet above the Highway 71 bridge in Spencer and is ordinarily above all sources of pollution from Spencer. The exception to being above all pollution occurs when the high flow by-pass at the ~~lift station~~ by-pass manhole approximately 1000 feet above the bridge is being used. This occurs only when a heavy wet weather flow is received at the lift station. Conditions at this station were very good at all times of sampling. The water was clear and the bottom clean.

Station 33 is below the city and rendering plant outlets at the southeast edge of Spencer. Conditions at this point were very poor with strong odors, floating solids and grease being apparent. On occasions gas formation indicating digestion of sludge in the stream was observed.

Station 33' is located approximately 1 1/2 miles below the city outlet. At the time of winter sampling the stream at this point was highly colored, contained many fine solids and had a strong odor. Summer sampling revealed sludge deposits, some odor and heavy algae growth.

Station 34 is located at the Highway 18 bridge east of Spencer. In general this station revealed the same conditions as those found at station 33' with solids, odor and color being found in the winter and odor and profuse algae and bottom growths in the summer.

Station 36 is above all pollution from Sioux Rapids and the stream at this point, from a visual standpoint, did not contain excessive sewage solids, color or odor.

Station 36.1 is located approximately 200 feet below the lower Sioux Rapids outlet. Sewage solids and strong odor were very apparent at this station. On occasions oil was issuing from the upper outlet and an oil film was present near the left bank of the stream.

At Station 38 which is above the dam at Linn Grove some odor was noticeable with sphaerotilus natans growth in evidence at the upstream dam face. Sphaerotilus natans is a fungus growth associated with sewage pollution. Some color due to algae growths was also noted.

Sewage solids were observed in the stream immediately below the Linn Grove outlet with some odor apparent. From this point to below Peterson the stream appeared to make a rapid recovery from the effects of the pollution and appeared to be in normal condition, except below the rendering plant outlet. The stream immediately below the outlet of the rendering plant showed sludge deposition and fungus growths on the bottom with odors and floating solids observed some distance downstream.

XI. INTERPRETATION OF CHEMICAL AND BACTERIOLOGICAL DATA:

The Little Sioux River was sampled under both winter and summer conditions in order to determine the effect of low flows, ice cover, water temperature and other factors which influence the recovery rate of the stream. Charts I, II, III, and IV and Table II accompanying this report are graphical and tabular presentations of oxygen and bacteriological data of the individual surveys. Two sampling surveys were made under summer conditions and six surveys were made under winter conditions.

In general the samples collected during the winter revealed the most critical stream conditions. However, negative oxygen balances were found below both Spencer and Sioux Rapids on each summer survey. When a negative oxygen balance exists the BOD value at that particular point exceeds the dissolved oxygen value. In the summer surveys and in all other surveys the critical point in the stream from the point of dissolved oxygen was found to be upstream from the dam in Linn Grove. The sample collected upstream from the dam on September 7 revealed a dissolved oxygen of 5.5 ppm and on September 12 a dissolved oxygen value of 2.4 ppm was found at this point. This latter value indicates a condition unsatisfactory to fish life, particularly under high summer temperatures. Apparently this condition is caused by the progressive utilization of the oxygen in the stream water by

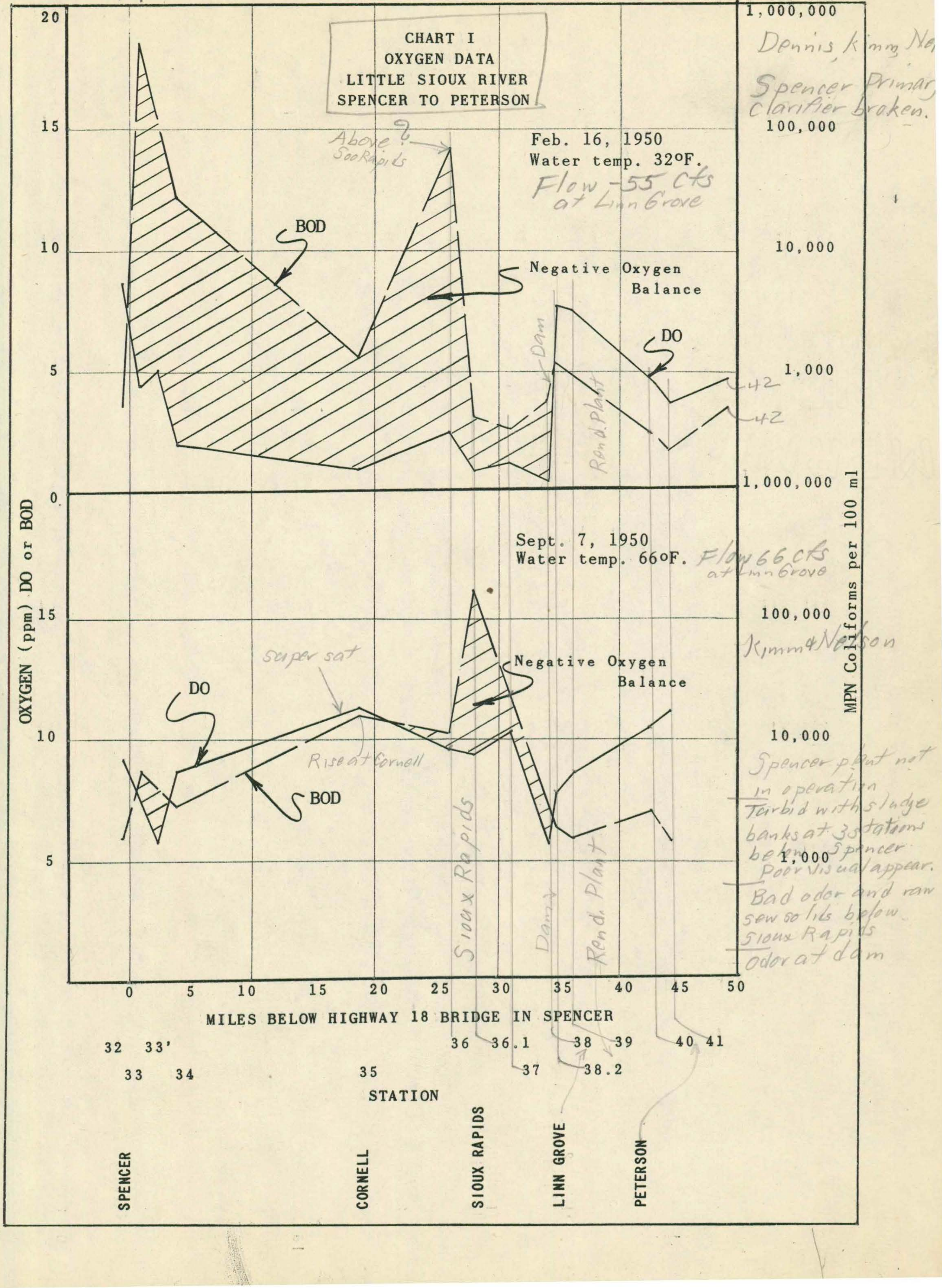


CHART I
OXYGEN DATA
LITTLE SIOUX RIVER
SPENCER TO PETERSON
Feb. 16, 1950
Water temp. 32oF.
Flow -55 cfs at Linn Grove
Above ? Soo Rapids
BOD
Negative Oxygen Balance
DO
Dam
Rend. Plant
42
42
Dennis, Kimm, Nelson
Spencer Primary clarifier broken.
Sept. 7, 1950
Water temp. 66oF.
Flow 66 cfs at Linn Grove
Kimm & Nelson
super sat
Negative Oxygen Balance
DO
Rise at Cornell
BOD
Sioux Rapids
Dam
Rend. Plant
Spencer plant not in operation
Turbid with sludge banks at 35 stations below Spencer
Poor visual appear.
Bad odor and raw sew solids below Sioux Rapids
odor at dam
OXYGEN (ppm) DO or BOD
20
15
10
5
0
15
10
5
MPN Coliforms per 100 ml
1,000,000
100,000
10,000
1,000
1,000,000
100,000
10,000
1,000
0
5
10
15
20
25
30
35
40
45
50
MILES BELOW HIGHWAY 18 BRIDGE IN SPENCER
32
33'
33
34
35
36
36.1
37
38
38.2
39
40
41
STATION
SPENCER
CORNELL
SIOUX RAPIDS
LINN GROVE
PETERSON

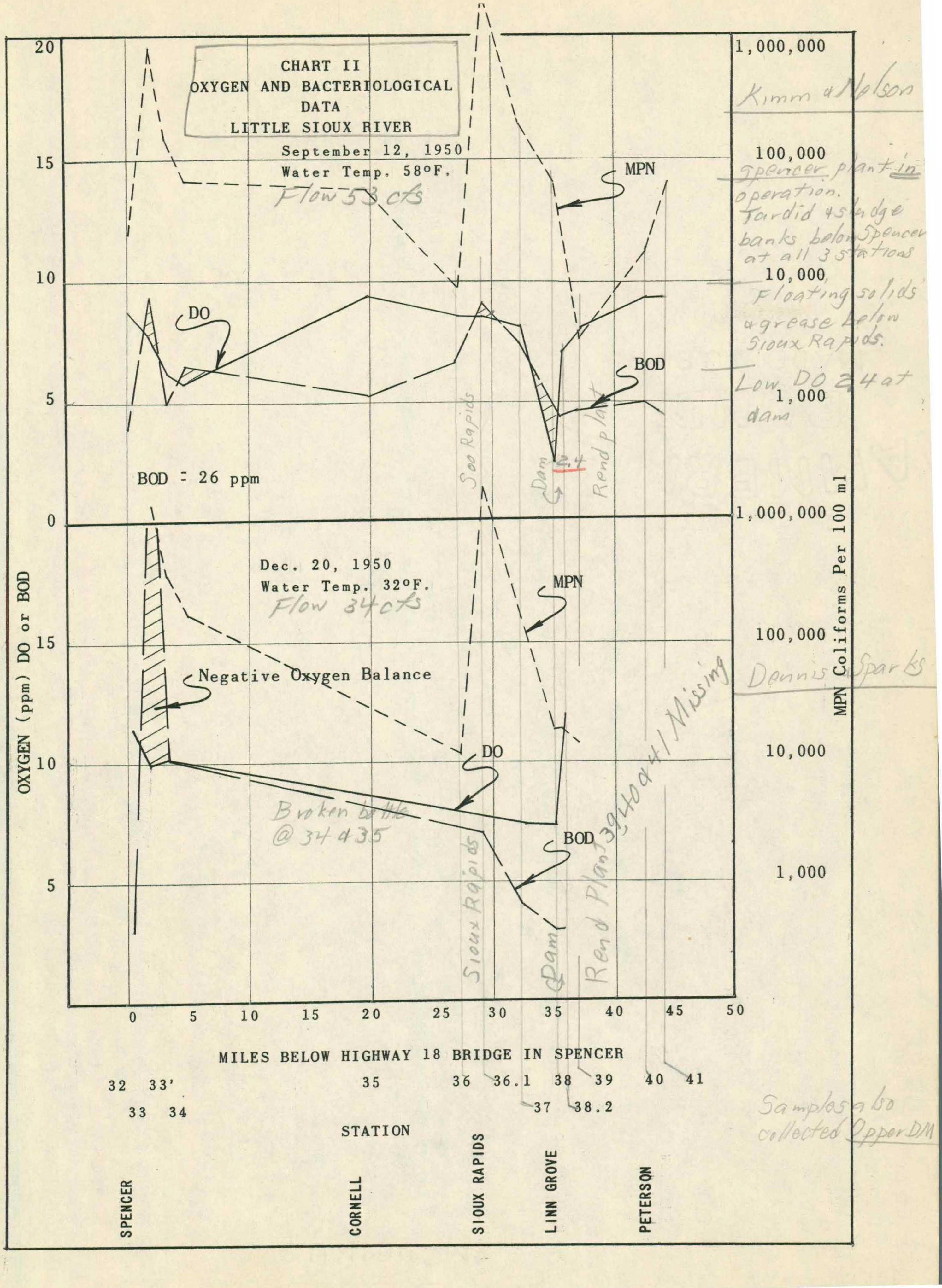


CHART II
OXYGEN AND BACTERIOLOGICAL DATA
LITTLE SIOUX RIVER
September 12, 1950
Water Temp. 58°F.
Flow 53 cfs
MPN
DO
BOD
BOD = 26 ppm
Soo Rapids
Dam
2.4
Rend plant
Dec. 20, 1950
Water Temp. 32°F.
Flow 34 cfs
MPN
Negative Oxygen Balance
DO
BOD
Broken bottle @ 34 & 35
Sioux Rapids
Dam
Rend Plant 39, 40 & 41 Missing
OXYGEN (ppm) DO or BOD
MPN Coliforms Per 100 ml
20
15
10
5
0
1,000,000
100,000
10,000
1,000
0 5 10 15 20 25 30 35 40 45 50
MILES BELOW HIGHWAY 18 BRIDGE IN SPENCER
32 33' 35 36 36.1 38 39 40 41
33 34 37 38.2
STATION
SPENCER
CORNELL
SIOUX RAPIDS
LINN GROVE
PETERSON
Kimm & Nelson
Spencer plant in operation. Tar did & sludge banks below Spencer at all 3 stations
Floating solids & grease below Sioux Rapids.
Low DO 2.4 at dam
Dennis & Sparks
Samples also collected Upper DM

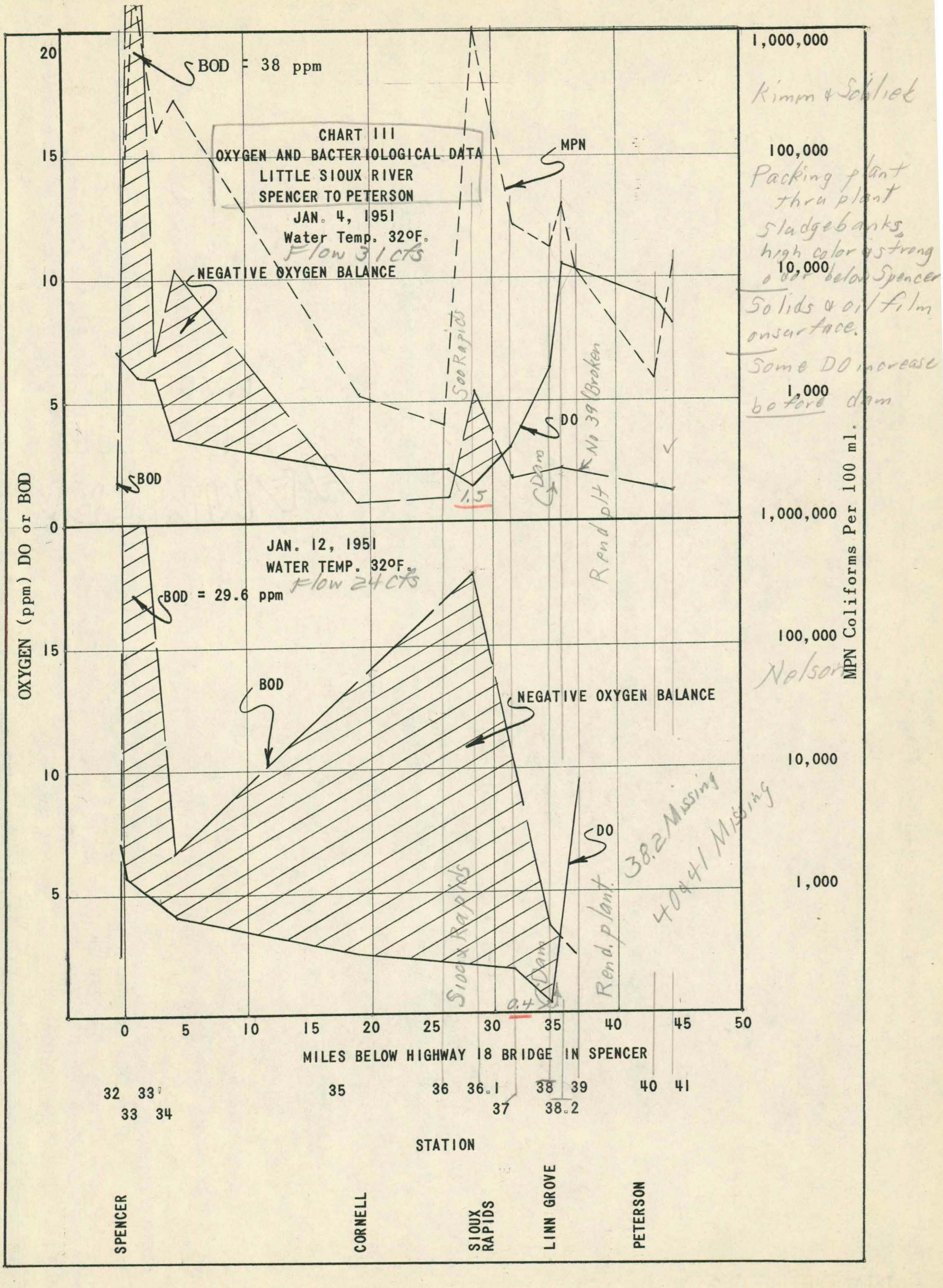


CHART III
OXYGEN AND BACTERIOLOGICAL DATA
LITTLE SIOUX RIVER
SPENCER TO PETERSON
JAN. 4, 1951
Water Temp. 32°F.
Flow 31 cfs
BOD = 38 ppm
MPN
NEGATIVE OXYGEN BALANCE
BOD
DO
1.5
Soo Rapids
Dam
No 39 Broken
Rend plt
JAN. 12, 1951
WATER TEMP. 32°F.
Flow 24 cfs
BOD = 29.6 ppm
BOD
NEGATIVE OXYGEN BALANCE
DO
0.4
Sioux Rapids
Dam
Rend. plant
38.2 Missing
40 & 41 Missing
OXYGEN (ppm) DO or BOD
20
15
10
5
0
MPN Coliforms Per 100 ml.
1,000,000
100,000
10,000
1,000
MILES BELOW HIGHWAY 18 BRIDGE IN SPENCER
0
5
10
15
20
25
30
35
40
45
50
STATION
32
33
33
34
35
36
36.1
37
38
38.2
39
40
41
SPENCER
CORNELL
SIOUX RAPIDS
LINN GROVE
PETERSON
Kimm & Schliek
Packing plant thru plant
Sludgebanks, high color & strong odor below Spencer
Solids & oil film on surface.
Some DO increase before dam
Nelson

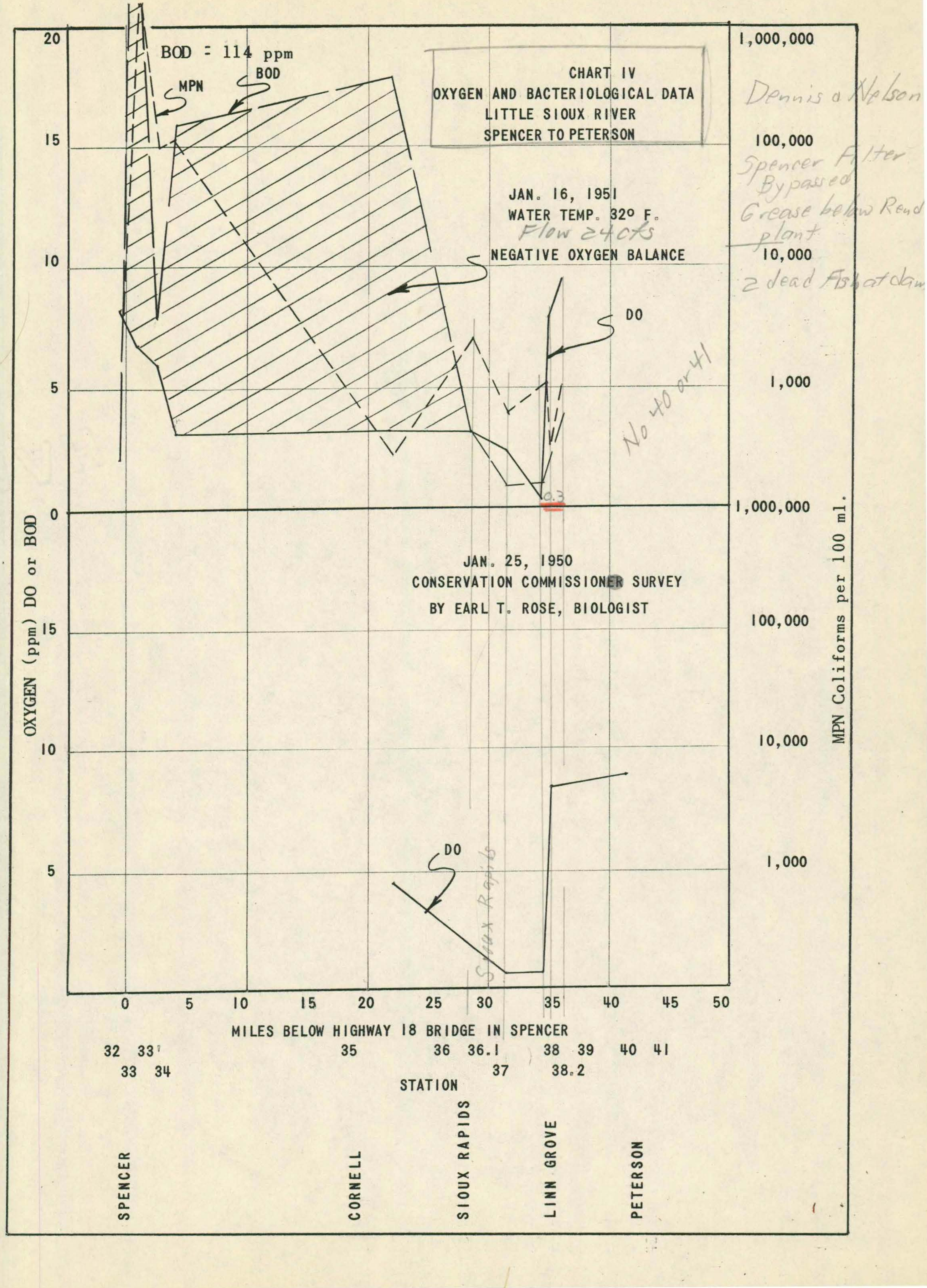


CHART IV
OXYGEN AND BACTERIOLOGICAL DATA
LITTLE SIOUX RIVER
SPENCER TO PETERSON
BOD = 114 ppm
MPN
BOD
JAN. 16, 1951
WATER TEMP. 32° F.
Flow 24 cfs
NEGATIVE OXYGEN BALANCE
DO
No 40 or 41
0.3
JAN. 25, 1950
CONSERVATION COMMISSIONER SURVEY
BY EARL T. ROSE, BIOLOGIST
DO
Sioux Rapids
OXYGEN (ppm) DO or BOD
20
15
10
5
0
15
10
5
1,000,000
100,000
10,000
1,000
1,000,000
100,000
10,000
1,000
MPN Coliforms per 100 ml.
0 5 10 15 20 25 30 35 40 45 50
MILES BELOW HIGHWAY 18 BRIDGE IN SPENCER
32 33 35 36 36.1 38 39 40 41
33 34 37 38.2
STATION
SPENCER
CORNELL
SIOUX RAPIDS
LINN GROVE
PETERSON
Dennis a Nelson
Spencer Filter Bypassed
Grease below Rend plant
2 dead Fish at dam

Stream Pollution Survey
LITTLE SIOUX RIVER
Spencer to Peterson
February 16, 1950 to January 16, 1951
CHEMICAL AND BACTERIOLOGICAL DATA

TABLE II

Sta.	Temp. °F	pH	Dissolved Oxygen ppm	Saturation per cent	BOD ppm	Oxygen Balance	MPN per 100 ml	River Flow cfs (1)
February 16, 1950								
32	32	7.6	8.7	60	3.6	5.1		55
33	34	7.5	4.4	30	18.7	-14.3		
33'	32	7.5	5.1	35	16.0	-10.9		
34	32	7.3	1.9	13	12.2	-10.3		
35	32	7.1	0.9	6	5.5	-4.6		
36	32	7.3	2.4	16	14.2	-12.8		
36.1	32	7.3	0.8	5	3.0	-2.2		
37	32	7.1	1.1	7	2.5	-1.4		
38	32	7.3	0.3	2	3.7	-3.4		
38.2	32	7.3	7.6	52	5.3	2.3		
39	32	7.3	7.4	51	4.8	2.6		
40	32	7.3	4.5	31	2.3	2.2		
41	32	7.3	3.5	24	1.5	2.0		
42	32	7.3	4.5	31	3.3	2.2		
September 7, 1950								
32	60	7.9	9.1	92	5.9	3.2		66
33	62	7.9	7.3	75	8.6	-1.3		
33'	62	7.7	5.5	56	8.1	-2.6		
34	64	7.7	8.6	90	7.2	-1.4		
35	62	8.1	11.2	115	10.8	0.4		
36	64	8.0	9.4	99	10.2	-0.8		
36.1	65	8.0	9.1	97	15.9	-6.8		
37	68	8.0	10.2	111	12.0	-1.8		
38	66	7.7	5.5	59	7.0	-1.5		
38.2	69	7.9	7.6	84	6.2	1.4		
39	70	7.9	8.4	93	5.7	2.7		
40	72	8.1	10.3	117	6.8	3.5		
41	68	8.1	10.9	119	5.6	5.3		

(1) Estimated flow at Linn Grove.

TABLE II (CONTINUED)

Sta.	Temp. °F	pH	Dissolved Oxygen ppm	Saturation per cent	BOD ppm	Oxygen Balance	MPN per 100 ml.	River Flow cfs*
				September 12, 1950				
32	54	7.7	8.7	80	3.9	4.8	35,000	53
33	56	7.8	7.7	74	9.4	-1.7	920,000	
33'	55	7.7	6.1	58	4.8	1.3	140,000	
34	56	7.7	5.7	54	6.4	-0.7	79,000	
35	56	8.1	9.3	89	5.2	4.1	70,000	
36	57	8.0	8.5	82	6.5	2.0	9,300	
36.1	58	7.9	8.5	83	9.0	-0.5	3,500,000	
37	58	7.9	8.1	79	7.5	0.6	240,000	
38	62	7.9	2.4	25	4.5	-2.1	79,000	
38.2	63	7.7	6.9	72	4.2	2.7	23,000	
39	62	7.7	7.8	80	4.5	3.3	4,500	
40	60	7.9	9.2	92	4.9	4.3	11,000	
41	60	7.9	9.2	92	4.4	4.8	79,000	
				December 19-20, 1950				
32	32	7.6	11.4	78	3	8.4	*	34
33	36	7.8	9.8	71	26	-16.2	1,600,000	
33'	32	7.7	10.1	69	10	0.1	540,000	
34	32	7.7	*	-	*	--	180,000	
35	32	7.8	*	-	*	--	13,000	
36.1	32	7.9	7.7	53	7	0.7	2,400,000	
37	32	7.7	7.4	51	4	3.4	130,000	
38	32	7.7	7.3	50	3	4.3	24,000	
38.2	32	7.7	11.8	81	3	8.8	24,000	
39	32	7.8	*	--	*	--	11,000	
				January 4-5, 1951				
32	32	7.4	7.1	49	1.5	5.6	790	31
33	32	7.3	6.0	41	38	-32	3,500,000	
33'	32	7.5	5.9	40	6.8	-0.9	230,000	
34	32	7.5	3.5	24	10.5	-7.0	540,000	
35	32	7.4	2.2	15	1.0	1.2	1,700	
36	32	7.3	2.2	15	1.1	1.1	780	
36.1	32	7.4	1.5	10	5.5	-4.0	1,100,000	
37	32	7.3	3.2	22	1.9	1.3	49,000	
38	32	7.3	6.5	44	2.1	4.4	31,000	
38.2	32	7.5	10.7	73	2.2	8.5	70,000	
39	32	7.5	10.5	72	--	--	11,000	
40	32	7.5	9.2	63	1.5	7.5	2,600	
41	32	7.5	8.2	56	1.3	6.9	11,000	

*Bottles broken due to freezing.

TABLE II (CONTINUED)

Sta.	Temp. °F	pH	Dissolved Oxygen ppm	Saturation per cent	BOD ppm	Oxygen Balance	MPN per 100 ml	River Flow cfs
January 12, 1951 *Nelson*								
32	32	7.3	7.6	52	2.5	5.1		24
33	37	7.3	5.7	42	29.6	-22		
33'								
34	32	7.4	4.0	27	6.7	-2.7		
35	32	7.1	2.5	17	--	--		
Soo R → 36								
36.1	32	7.3	2.0	14	17.9	-15.9		
37	32	7.3	1.8	12	--	--		
38	32	7.3	0.4	3	3.5	-3.1		
Linn Gr → 38.2								
39	32	7.3	9.5	65	2.5	7.0		

Sta.	Temp. °F	pH	Dissolved Oxygen ppm	Saturation per cent	BOD ppm	Oxygen Balance	MPN per 100 ml	River Flow cfs
January 16, 1951								
32	32	7.3	8.3	57	2	6.3	490	24
33	39	7.6	6.7	46	114	-107	3,500,000	
33'	32	7.3	6.0	41	8	-2.0	110,000	*Dennis & Nelson*
34	32	7.3	3.1	21	16	-12.9	170,000	
35.5	32	7.3	3.2	22	18	-14.8	450	
Soo R → 36.1	32	7.3	3.2	22	3	0.2	54,000	
37	32	7.3	2.3	16	1	1.3	7,800	
38	32	7.3	0.3	2	1	-0.7	13,000	
Linn Grove → 38.2	32	7.3	8.2	56	2	6.2	4,900	
39	32	7.3	9.7	66	4	5.7	13,000	

Sta.	Temp. °F	pH	Dissolved Oxygen ppm	Saturation per cent	BOD ppm	Oxygen Balance	MPN per 100 ml	River Flow cfs
January 23, 1950 (Earl T. Rose Data)								
Soo R → 35		7.4	4.4					
37		7.2	0.6					
38		7.2	0.6					
Linn Gr → 38.2		7.4	8.4					
41		7.6	8.8					

the organic material added to the stream at Sioux Rapids and Spencer. Also the stilling effect of the dam allows any remaining organic material to accumulate behind the dam and exert an additional oxygen demand while at the same time lessening the opportunity for reaeration. After the stream was reaerated by passing over the dam the dissolved oxygen value increased in all surveys. Apparently the opportunity for reaeration afforded by the open water of the warmer months and the action of the chlorophyll bearing algae in producing oxygen through photosynthesis allows the stream under summer conditions, to maintain, except below Spencer and Sioux Rapids, a satisfactory oxygen balance.

In all surveys high BOD values were found in the stream below Spencer and Sioux Rapids. In two of the surveys a BOD rise was noticed below Linn Grove.

Under winter sampling the stream was found to be in very poor condition. In the surveys of February 16, 1950 and January 12, 1951, a negative oxygen balance existed from immediately below Spencer down to the dam at Linn Grove a distance of approximately 35 miles. In the surveys of January 4, 1951 and January 16, 1951, conditions were found to be essentially the same. In all of these surveys and also the one made by Mr. Earl T. Rose, fisheries biologist of the State Conservation Commission on January 25, 1950, extremely critical oxygen conditions were found at the sampling station above the dam at Linn Grove. In four of the winter surveys the dissolved oxygen was found to be less than 1 ppm at this sampling station. This oxygen deficiency has led to the destruction of fish during both winters of the survey.

Most probable numbers (MPN) of coliform bacteria per 100 ml. of sample are tabulated in Table II and plotted on the charts showing the dissolved oxygen and BOD data for the various surveys. The MPN, on each survey, shows a very great increase below Spencer, Sioux Rapids and Linn Grove. The extremely high numbers of coliform bacteria greatly exceed any suggested standards of water purity. One tentative interpretation of coliform densities has been suggested as follows: "Waters showing a coliform index between 100 and 500 per ml. are considered to be normal for inland streams free from detrimental pollution."

The nitrogen data from the determinations made on samples collected February 16, 1950, are shown in Table III. The high total nitrogen values below Spencer, Sioux Rapids, and Linn Grove are apparent. The total nitrogen value may be taken as proportional to the total organic material present.

XII. RIVER DISCHARGE:

Flow data at Correctionville, Linn Grove and Spencer for each date on which samples were collected during the survey are shown in Table IV. The discharge at Linn Grove and Spencer was computed using a discharge-drainage area relationship from preliminary flow data for the Little Sioux River at Correctionville. The Spencer gaging station was in operation from 1936 to 1942.

-9 4/05

Stream Pollution Survey
LITTLE SIOUX RIVER
Spencer to Peterson
NITROGEN DATA

TABLE III

February 16, 1950

Station	34	35	36.1	38	39	40	41
Organic Nitrogen	5.9	2.2	4.0	1.6	1.8	1.0	2.1
Ammonia Nitrogen	2.47	2.21	2.34	2.39	2.47	2.39	2.53
Nitrite Nitrogen	0.059	0.049	0.025	0.008	0.010	0.005	0.006
Nitrate Nitrogen	0.8	0.3	0.3	0.3	0.3	0.3	0.5
Total Nitrogen	9.229	4,759	6.665	4.298	4.580	3.695	5.136

Station:

34 Below Spencer
35 East of Cornell
36.1 Below Sioux Rapids
38 Above dam in Linn Grove
39 Below Linn Grove
40 Wanata State Park at Peterson
41 West of Peterson

Stream Pollution Survey
LITTLE SIOUX RIVER
Spencer to Peterson.
February 16, 1950 to January 16, 1951
STREAM FLOW DATA

TABLE IV

Flow in Cubic Feet per Second

at

Date	Correctionville	Linn Grove*	Spencer*
Feb 16, 1950	85	55	36
Sep 7, 1950	101	66	42
Sep 12, 1950	82	53	35
Dec 19, 1950	52	34	22
Jan 5, 1951	47	31	20
Jan 12, 1951	37	24	16
Jan 16, 1951	37	24	16
	2x Spencer	½ x spencer	

*The above flow data for Correctionville is provisional data from the United States Geological Survey. Data for Linn Grove and Spencer were computed from the Correctionville data using a drainage area relationship.

Drainage area at Spencer	- 1030 square miles
Drainage area at Linn Grove	- 1590 square miles (Approx.)
Drainage area at Correctionville	- 2450 square miles
" " " Kennebec	- 2730 square miles

PERIODS OF SUSTAINED LOW FLOW

TABLE V

Date	Station	Flow	Time in Days
Feb 1-16, 1937	Spencer	5 cfs or less	16
Jan 1 - Mar 1, 1937	Spencer	10 cfs or less	60
Jan 14 - Feb 2, 1937	Correctionville	13 cfs or less	21
Dec 31, Feb 2, 1937	Correctionville	30 cfs or less	50

The Little Sioux River does not have a good sustained flow for part of the year. In evaluating the effect of sewage or industrial waste on a stream, it is the extended periods of low flow rather than individual days that govern. A study of flow records for Spencer and Correctionville in Table V indicate that long periods of consecutive minimum discharge have occurred. Discharges of less than five cubic feet per second (cfs) occurred at Spencer for 16 consecutive days during February 1937. Discharges of 10 cfs and less occurred for 60 consecutive days during the same period. Stream flows at Correctionville were correspondingly low during the same period of record with discharges of 13 cfs or less for a period of 21 days and less than 50 cfs for a period of 60 days during early 1937.

XIII. INFLUENCE OF RIVER DISCHARGE ON POLLUTION EFFECT:

A study of Table II and Charts I, II, III and IV indicates that critical oxygen levels and a zone of near oxygen depletion are reached under winter conditions with flows as high as 85 cfs at Correctionville as indicated by results at the time of the February 16, 1950 survey. Flows of 13 cfs. or less have occurred at Correctionville for a period of 21 consecutive days. Critical oxygen conditions also occurred under summer conditions with flows as high as 82 cfs as indicated by results of the September 12, 1950 survey. These results and the past record of stream flow would indicate that critical oxygen conditions may occur quite frequently. Low flows occur with the greatest frequency during early fall or during extremely cold winter weather.

A study of Charts I, II, III, and IV showing the oxygen sag curve indicates that the pool formed by the dam at Linn Grove is the point of greatest oxygen deficiency with critical oxygen conditons occurring under both winter and summer conditions. Undoubtedly, much of the solid material from the treated or raw sewage and industrial wastes from the municipalities of Spencer and Sioux Rapids settles out before reaching the dam. However, it appears that the fine solids are settling to form sludge banks in the pool formed by the dam and this oxygen demand combined with the lessened opportunity for reaeration in the quiescent pool creates the most serious oxygen deficiency under all conditions.

XIV. CONCLUSIONS:

1. The Little Sioux River from Spencer to Linn Grove was found to be grossly polluted due to the discharge of partially treated wastes from the City of Spencer and the discharge of raw sewage from the towns of Sioux Rapids and Linn Grove. Lesser sources of pollution are the industrial wastes contributed by the rendering plants at Spencer and Linn Grove.

2. The investigation revealed that critical oxygen conditions existed in the reach of the river above the dam at Linn Grove during six of the eight surveys conducted.

3. Destruction of fish life occurred during the two winters of the survey. This fish destruction was caused by the depletion of dissolved oxygen by the organic wastes being added to the stream.

4. In addition to the considerable oxygen demand exerted by the wastes of the rendering plants, the solids and dissolved gases in these wastes may impart a bad taste to the fish and render them undesirable for eating.

5. A hazard exists, from a public health standpoint, to persons bathing or wading in the river or otherwise coming in intimate contact with the river water in the section of the river covered by this survey. The bacterial load carried by the stream is generally many times greater than any suggested standards of purity for recreational usage. Any type of recreation which requires contact with heavily polluted water is hazardous and may lead to infection.

6. Milk from dairy animals having access to the polluted stream also presents a public health hazard. Dairy cows wading in polluted waters may easily pick up disease-producing bacteria on their udders or bodies and such bacteria may be transferred mechanically to the milk by the milking process. Heavy pollution also interferes with the free use of the river water for livestock watering purposes.

XV. RECOMMENDATIONS:

1. It is recommended that the treatment facilities at Spencer be enlarged so as to provide adequate treatment of all sewage and industrial wastes before being discharged to the Little Sioux River.

2. It is recommended that treatment facilities be installed at Sioux Rapids and Linn Grove in order to provide adequate treatment of the sewage and industrial wastes orginating from their communities.

3. It is recommended that the two rendering plants provide adequate treatment of their wastes either by discharge to the municipal sewerage system in the case of the Spencer plant or by construction of treatment facilities of their own.

Pollution of Little Sioux River
Spencer to Peterson

February 16, 1950
January 16, 1951

POLLUTION DISCHARGED IN POPULATION EQUIVALENT

TABLE A

Spencer Plant tests - ISDH	Plant BOD	Population Equivalent	Percent Removal
Feb. 21-22, 1950	533 lb.	3200 persons	65
Mar. 2-3, 1950	312 lb.	1900 persons	80
Mar. 13-14, 1950	639 lb.	3800 persons	72
	494 lb. Ave.		

Spencer Rendering Plant
Max. production 14,000 lb.
Pop. equivalent 14 x 5.5 lb.* = 77 lb. BOD = 420 persons

Sioux Rapids
Population to stream = (Assumed 80-85% connected) 850 persons
BOD = 850 x.167 = 142 lbs.
Locker Service Load (Daily kill)
Hog 10 x 2.5 lb.* = 25.0 lb.
Beef 2 x 6.75lb.* = 13.5 lb.
38.5 lb. = 230 persons
Total population equivalent 1080 persons

Linn Grove
Population to stream (Assumed 80-85% connected) 270 persons
BOD = 270 x .167 = 45 lb. BOD

Linn Grove Rendering Plant
Maximum Production 15,000 lb.
Population Equivalent 15 x 5.5 lb.* = 82 lb. BOD = 495 population

Population Equivalent to Stream

	BOD lbs.	Population Equivalent to Stream
Spencer	494	2960 persons
Spencer Rendering Plant	77	420 persons
Sioux Rapids and Locker	180	1080 persons
Linn Grove	45	270 persons
Linn Grove Rendering Plant	82	495 persons

* Waste BOD equivalents.