TD
225
.C43
I8
1931

INVESTIGATION OF POLLUTION
OF THE
CEDAR RIVER

1926 - 1931

I O W A
C R A F T
PROJECT
Des Moines, Iowa
Works Progress
Administration

A H Wieters

REPORT

On The

PROPERTY OF
STATE DEPARTMENT OF HEALTH
Division of Sanitary Engineering
DES MOINES, - - IOWA

INVESTIGATION OF POLLUTION

OF THE

CEDAR RIVER

From Waverly to Columbus Junction

1930 - 1931

By The

BUREAU OF PUBLIC HEALTH ENGINEERING

STATE DEPARTMENT OF HEALTH

Des Moines, Iowa

Sept. 1931

REPORT

On The

INVESTIGATION OF POLLUTION

OF THE

CEDAR RIVER

From Waverly to Columbus Junction

1926 - 1931

By The

BUREAU OF PUBLIC HEALTH ENGINEERING

STATE DEPARTMENT OF HEALTH

Des Moines, Iowa

Sept. 1931

INDEX

TABLE INDEX

D. C. STEELSMITH, M. D.
COMMISSIONER

Iowa
State Department of Health
Division of Public Health
Engineering
Des Moines

A. H. WIETERS
DIRECTOR

September 5th, 1931.

D. C. Steelsmith, M.D.,
Commissioner,
State Department of Health,
Des Moines, Iowa.

Dear Dr. Steelsmith:-

I am transmitting herewith the report of your Bureau of Public Health Engineering covering the investigations of the pollution of the Cedar River from a point above Waverly, Iowa, to Columbus Junction, Iowa.

These investigations were instituted in 1926 at the direction of Dr. Henry Albert, former Health Commissioner, and were continued at your direction during 1930-1931, as provided for under Sections 2198 to 2209, Code of Iowa, 1927.

Respectfully submitted,

A. H. Wieters
A. H. Wieters,
Director.

AHW:M

GENERAL SUMMARY

In May, 1927, the Public Health Engineering Bureau of the Iowa State Department of Health began a study of the alleged pollution of the Cedar River and studies have been intermittently carried on from that time to the present. The portion of the stream which is covered in this report is from a point above Waverly to the junction of the Cedar River with the Iowa River at Columbus Junction, Iowa.

The study was instituted at the direction of Dr. Henry Albert, former Commissioner of Health, as provided for under Sections 2198 to 2208 of the Code of Iowa of 1927.

The scope of the work included observations of the physical conditions of the stream; collecting samples and making chemical and bacteriological examinations of both the stream water and the wastes discharged into the stream; collecting and compiling pertinent data on the stream flows, character and quantities of wastes discharged into the stream; compiling and interpreting the data from which the following conclusions are drawn. The body of the report contains in detail the data on tests and observations above referred to, together with the interpretation of these data.

CONCLUSIONS

In the portion of the Cedar River studied in these investigations two zones of acute pollution are noted; namely below the city of Waterloo and below the city of Cedar Rapids. A third zone of pollution, with conditions less acute, is noted below Cedar Falls.

The average B. coli content of the water below Waterloo and Cedar Rapids was 138,600 and 127,000 respectively during the 1930-31 period and the average B. coli content exceeded the standard set by the United States Public Health Service (10,000 per 100 ml.) as the maximum B. coli content for raw water, which after the best type of treatment known will yield consistently safe and palatable water. The 1927-28 B. coli findings showed the stream in little better condition at that time.

The river water is therefore unfit as a potential source of water supply, and is unfit for bathing and other recreational purposes requiring contact with the water throughout most of the portion of the stream included in this study.

Average bacterial counts are abnormally high during low stages throughout the portion of the stream included in this study, indicating gross pollution.

Clinical records are available indicating hundreds of cases of eye, ear and skin infections and several cases of typhoid fever were traceable to the polluted waters of the Cedar River during the past few years.

Oxygen determinations invariably indicate a negative oxygen balance below Waterloo and Cedar Rapids at the low stream stages and even at normal flows a serious lowering of the oxygen content was frequently noted.

Observations of physical conditions of the stream indicate heavy pollution below Waterloo and Cedar Rapids at normal dry weather flows, in the form of sludge banks in the stream bed, floating solids, sewage odors, septic areas and occasional destruction of aquatic life. The same conditions were noted below Cedar Falls but to a somewhat less degree. These conditions so detract from the attractiveness of an otherwise beautiful stream as to render such portion of the stream absolutely unfit for all recreational purposes.

Fish life has been destroyed below Waterloo, and evidence points to the fact that both below Waterloo and Cedar Rapids, game fish are driven from the zones of heavy pollution during long periods of time.

The free use of the stream for stock watering purposes is interferred with by the pollution. Aside from the probability that heavily polluted water is injurious to live stock, access to such water by dairy cows, constitutes a public health menace of the first magnitude unless milk from such herds is adequately pasteurized.

Stream flow records indicate that the lowest recorded flow (620 c.f.s.) in 1930-31 was almost 50% greater than the lowest flow on record (410 c.f.s. in 1912), and that during the past twenty-six years flows almost as low as the 1930-31 minimums have occurred with great frequency. The average of the minimum annual flows for the twenty-six year period is only 720 c.f.s.

PURPOSE OF INVESTIGATION

In 1924 the General Assembly passed a stream pollution law charging the State Department of Health with the duty of investigating the alleged pollution of streams. This law further provides for the calling of hearings and the issuing of orders by the department requiring the offenders to "desist in the practice found to be the cause of said pollutions", if the condition warranted such orders. In 1925 the General Assembly added some minor amendments. A complete copy of the stream pollution law will be found in Appendix I of this report.

In 1924 the Department of Health sent notices to the cities of Waverly, Cedar Falls, Waterloo, LaPorte City, Cedar Rapids, and to several industries located in these cities citing them to appear for a hearing on the matter of the pollution of the Cedar River to be held in Des Moines on July 23, 1924. At that time the department had made no chemical and bacteriological examinations of the stream waters as is now required by an amendment to the original stream pollution law.

The hearing was informal and subsequent action of the department was based upon complaints concerning the pollution of the river, and upon the testimony presented by citizens present at the hearing.

As an outcome of the hearing, the department issued orders requiring each city and industry discharging untreated wastes into the Cedar River "to proceed with the preparation of plans and specifications for sewage treatment plants, such that will be adequate to properly treat all sewage disposed of by each of the parties named". A definite time for the completion of such plans was not set in this order. To date, the department has received no plans for works contemplating the abatement of the pollution of the Cedar River by any of the cities or industries involved.

The city of Cedar Rapids has, however, constructed intercepting sewers on both sides of the river and has let a contract for a river crossing which, when completed, will bring all of the sewage to the site of a proposed sewage treatment plant. The Rath Packing Company in Waterloo has installed a series of catch basins and has extended the outfall sewer to a point in mid-stream, which has improved the physical appearance of the stream. Likewise, the Sinclair Packing Company at Cedar Rapids has installed a fine screen and a series of catch basins, which has resulted in keeping out of the stream an appreciable amount of coarse suspended material which formerly went directly into the stream. With these exceptions, nothing has been done toward the abatement of the pollution of the stream.

With the limited personnel and funds available to the Division of Public Health Engineering for carrying out the stream pollution investigations contemplated under the law, it has been possible to conduct only one major investigation at a time. With these limitations, the Division has conducted an investigation of the Cedar River intermittently from 1926 to 1931.

The purpose of the investigation, in compliance with the stream pollution law, was to collect data on the bacteriological, chemical and physical condition of the stream itself, to determine as exactly as possible the extent of pollution, and also to determine the quantity and character of sewage and industrial wastes which were being discharged into the river.

Obviously in work of this type, data collected during periods of abnormal high flows do not truly represent the condition of the stream. Likewise data collected during abnormally low flows, which may occur very infrequently and over brief periods of time, do not fairly represent the true condition. It was the purpose, therefore, in the investigation to obtain sufficient data under conditions of different stream flows and weather conditions so that a fair picture of the average and the worst conditions of the stream could be drawn.

ORGANIZATION OF THE WORK

The investigations herein reported were conducted by the Bureau of Public Health Engineering of the State Department of Health. The portion of the original survey in the Waterloo vicinity in 1926 was carried out by Assistant Engineers M. J. Lonergan and H. J. Peters under the direction of Mr. H. V. Pedersen, who at that time was Director of the Division. All of the remaining work from December, 1926 to date was carried out under the direction of A. H. Wieters, Director of the Bureau of Public Health Engineering. Due to the numerous changes in personnel in the division, the field work was conducted by several of the assistant engineers, principally M. J. Lonergan, W. W. Towne and R. B. McAllister. Assistant Engineers R. B. McAllister, P. J. Houser and E. G. Fiala assisted in compiling the data for the report.

Bacteriological analyses and sanitary chemical analyses for the latter part of the work were all made in the State Hygienic Laboratories at Iowa City, under the direction of Jack J. Hinman, Jr.

ACKNOWLEDGMENTS

Grateful acknowledgment is hereby made as follows: To the City of Cedar Rapids for the use of space in the water works laboratory and for their cooperation in furnishing data on sewage flows; to Black Hawk County for the use of laboratory space in the Highway Department building; to Professor C. O. Bates, City Chemist, Cedar Rapids, for the phenol determinations; to the U. S. Geological Survey; Professor Floyd A. Nagler, University of Iowa, and the Iowa Railway and Light Company for stream flow measurements.

SCOPE OF THE REPORT

Due to the great distances involved, it has been necessary to divide the Cedar River studies into several sections. With the limited personnel and with the lack of laboratory facilities at various points along the river, it was a physical impossibility to carry on a complete study of the river from its mouth to its source, including studies of the tributaries, simultaneously. Such a study would of course be very desirable but would require a staff four or five times as big as the staff available, and would also require greatly enlarged laboratory facilities with branch laboratories located at several points along the stream. Since this was impossible the stream has been divided into sections and a study of each section of the stream represents more or less a complete study in itself.

In the Cedar River, as in other rivers in the state, there are points of greatest pollution so widely separated that the stream has almost completely recovered from one heavy pollutional load by the time it reaches the next point of heavy pollution farther down stream. It was therefore possible to divide this stream into sections choosing for each study a portion of the stream which included one or two of the principal sources of pollution.

Studies on the Cedar River system have been divided as follows:

1st. A study of Lime Creek and the Shellrock River from a point above Mason City to Clarksville on the Shellrock River. These studies have been carried on intermittently from 1925 to 1931 inclusive. Data havebeen collected in each of the years of this period, most of the data being collected during the late fall and early winter months when conditions have been most acute due to the operation of a beet sugar factory at Mason City and due to the fact that the sewage load from a packing house at Mason City has been heaviest during this period. However, from the middle of 1930 to the present, this study has been carried on more or less continuously.

2nd. A study of the Cedar River from the Minnesota line to Nashua, Iowa. This study was begun in October, 1929, and continued until June, 1931. There were lapses of one or two months when no samples were taken during this period. This study is being made in cooperation with the Minnesota State Board of Health who have at the same time carried on a similar study of that portion of the Cedar River in Minnesota. The principal source of pollution in this portion of the stream is the Hormel Meat Packing Plant at Austin, Minnesota.

3rd. A study of the Cedar River from a point above Waverly, Iowa, to a point below LaPorte City, Iowa. The original study of this portion of the stream was conducted during the period from April, 1926 to February, 1927.

4th. A study of the lower Cedar River from LaPorte City, Iowa, to Columbus Junction. The original study of this part of the stream was carried out from April, 1927, to February, 1928.

5th. A second study of the Cedar River from a point above Waverly to Columbus Junction. This study includes a resurvey of the portions of the stream covered in studies three and four, and extended from October, 1930, to August, 1931.

Since the source of pollution of Lime Creek - Shellrock River is so far above the mouth of the Shellrock River and the studies of this stream show almost complete recovery by the time the Shellrock River discharges into the Cedar River, that portion of the Cedar River covered by this report is not effected insofar as pollution is concerned by the discharge of the Shellrock River into the Cedar proper.

In the study of the Upper Cedar River the principal source of pollution is Austin, Minnesota, and here again the studies show almost complete recovery from the pollution discharged at Austin at a point considerably above Waverly, Iowa. Consequently, in the lower river the pollution entering at Austin, Minnesota, is not a factor.

Both the Lime Creek - Shellrock pollution and the Upper Cedar River pollution have been reported separately and action has been taken independently of that portion of the river covered in this report. In this report, therefore, only that portion of the Cedar River proper between Waverly and Columbus Junction is considered.

This report includes detailed data and discussion principally on the second study of the Cedar River from Waverly to Columbus Junction, together with a summary of the two original studies of the Cedar River from Waverly to LaPorte City and from LaPorte City to Columbus Junction respectively. The reports of these two studies have previously been made and copies of these reports have been placed in the hands of the principal offending municipalities and industries. Consequently it is not deemed necessary to include the complete detailed data of the earlier studies in this report. However, in view of the fact that the stream flow conditions and the weather conditions were so entirely different during the period of these original studies, it is deemed advisable to include in this report summaries of the data of the previous reports for the purpose of comparing such data with the data obtained from the second studies of the stream just completed.

The discussion of the data will therefore be divided into three parts--first, results of the study of the river from Waverly to Columbus Junction for the 1930-31 period; second, results of the study of the river from Waverly to LaPorte City for the 1926-1927 period; and third, the results of the studies of the river from LaPorte City to Columbus Junction for the 1927-1928 period. The 1930-1931 study did not include any analyses of sewage or industrial wastes discharged into the stream, nor does it include any detailed observations of these sources of pollution. Since the conditions at the sources of pollution have not been changed materially since the original investigation in 1926 to 1928, the data collected at that timeare sufficiently accurate and reliable for the evaluation of present pollution entering the stream.

SCOPE OF THE TESTS

The chemical and bacteriological tests made during the investigation were carefully chosen with the view of obtaining the information which would present a true picture of the condition of the stream and at the same time which would be practical under the conditions under which the investigation had to be made.

The only central laboratory facilities available were those at Iowa City at the State Hygienic Laboratory. A field laboratory was set up in the county highway storage building at Waterloo for the first part of the survey, in the water works laboratory at Cedar Rapids for the second part of the survey, and in the temporary laboratory of the Department at Des Moines for the third part of the survey. These temporary field laboratories were not equipped for carrying on all of the tests in the field nor was the technical personnel available for this work. Consequently those tests which could be made in the field laboratory were carried out in the field and all other tests were made in the State Hygienic Laboratories at Iowa City, the samples being taken to the laboratory by the collector when possible and in other cases being shipped by express to the laboratory.

Since the stream pollution work of the Division was just being organized when the first study of the Cedar River in the Waterloo vicinity was made, the data collected are not as complete as for the later studies. For the most part, these tests were largely the oxygen and biochemical oxygen demand determinations. These tests will give more information as to the condition of a stream as far as organic content is concerned than any other single test. Likewise these tests will give more reliable information on the comparative strength or polluting qualities of sewage or industrial waste than any other test. Consequently with the limited personnel and laboratory facilities available, the first part of the survey included for the most part only these tests. All of these tests were carried out in the field or in the field laboratory.

In the two latter studies, a more elaborate program was possible and additional tests were included. In the 1927-1928 studies in the vicinity of Cedar Rapids, bacteriological determinations were made on all samples collected. This included total counts on litmus lactose agar at thirty-seven degrees for a twenty-four hour incubation period, total counts on nutrient agar for forty-eight hours with an incubation temperature of twenty degrees centigrade, and quantitative determinations of the organisms of the coli-aerogenes group, with complete confirmation of these organisms. These bacteriological tests were carried out by the field men in the field laboratory located in the water works laboratory at Cedar Rapids.

In addition to these tests, total solids, nitrate and nitrite determinations were likewise made in the Cedar Rapids Laboratory. Voluminous data on the bacterial content of the river water at Cedar Rapids and results of phenol analyses of samples of the river water collected at the Cedar Rapids Waterworks intake were available from the records of the Cedar Rapids Water Works Laboratory. This latter information was included in the original reports and therefore is not repeated in this report.

On the resurvey of 1930-1931, oxygen tests as usual were begun in the field and completed in the laboratory at Des Moines. Samples were collected and shipped to the State Hygienic Laboratories at Iowa City for all other determinations, which included bacterial counts at thirty-seven degrees for twenty-four hours, bacterial counts at twenty degrees for forty-eight hours, quantitative B. coli and B. aerogenes analyses, determinations for ammonia, albuminoid nitrogen, nitrites, nitrates, chlorides and alkalinities.

All tests, both in the field laboratories and in the State Hygienic Laboratory at Iowa City were carried out in accordance with the procedure set forth in the Standard Methods of Water Analysis of the American Public Health Association.

All samples for the oxygen determinations were collected in a special sampling can, which is a modification of the type of can used by the United States Public Health Service in their stream pollution work. The oxygen determinations were carried out in accordance with the Rideal Stewart modification of the Winkler method as described in the Standard Methods of Water Analysis of the American Public Health Association.

DEFINITIONS

For a better understanding of the tables of data and the charts of this report, following are the definitions of the terms used.

Dissolved oxygen represents the free uncombined oxygen present in the sample at the time of collection. This does not include and must not be confused with the combined oxygen which, with hydrogen, makes up the water molecule.

The biochemical oxygen demand of the sewage, industrial wastes or polluted water is the oxygen in parts per million required during stabilization of the organic matter by aerobic bacterial action. The oxygen demand is computed by determining the oxygen present in the original sewage or polluted water, and subtracting from this the oxygen remaining in another sample of the same waste or water which has been incubated for a definite period of time at twenty degrees centigrade. For convenience a five day incubation period has become standard practice in practically all laboratories. The complete demand is usually satisfied in twenty days at twenty degrees centigrade. Ninety per cent of the demand is satisfied in ten days at twenty degrees centigrade, and sixty-eight per cent of the demand is satisfied in five days incubation at twenty degrees centigrade. It is possible therefore to compute and express results in terms of five, ten or twenty day demand, regardless of the number of days of incubation. Unless otherwise specifically mentioned in this report, biochemical oxygen demand represents the five day demand at twenty degrees centigrade. In some parts of the survey, the ten day demand of sewage and industrial waste was determined in the laboratory, but in the compilation in this report these ten day demands have been reduced by computation to terms of five day B.O.D.

Bacterial counts per milliliter incubated twenty-four hours at thirty-seven degrees centigrade indicate the total number of bacteria which will grow when litmus lactose agar is inoculated with one milliliter of water and incubated for twenty-four hours at 37 degrees centigrade. Figures for bacterial counts at twenty degrees centigrade, forty-eight hours, represents the total number of bacteria which will grow when nutrient agar is inoculated with one milliliter of water and incubated for forty-eight hours at twenty degrees centigrade.

Bacterium coli are those bacteria which ferment lactose broth and which will grow on eosin-methylene blue agar with a characteristic growth peculiar to this organism. Their normal habitat is the intestinal tract of warm-blooded animals, and their presence in water indicates contamination from human or animal sources. Bacterium aerogenes is an organism related to Bacterium coli and the test is similar to that for B. coli except that on eosin-methylene blue agar, a different type of growth is noted. One strain normally inhabits the intestinal tract of warm-blooded animals. Another strain, however, will persist in soil and consequently the mere presence of B. aerogenes in a water does not as definitely indicate human or animal pollution as does B. coli.

Albuminoid nitrogen represents the complex unstable organic nitrogen compounds of fresh organic material and is not represented by a definite chemical formula. Ammonia, which has a definite chemical formula (NH_3) represents the nitrogenous organic material in its first stage of stabilization. Both albuminoid nitrogen and ammonia nitrogen indicate organic pollution of recent origin and both materials are very unstable and susceptible to rapid change.

Nitrite nitrogen (NO_2) represents nitrogen in an intermediate stage of oxidization. In this stage it is also somewhat unstable and it can readily be oxidized to form nitrates (NO_3), which represents the final stage in oxidization of nitrogenous material. In this form the material is entirely stable and undergoes no further change.

pH represents the hydrogen-ion concentration, or in simpler terms, the acidity of waste or sewage.

Chloride is the anion of a chlorine salt in solution in the water and may be derived from mineral deposite in the soil, or may come from polluting material, such as sewage or industrial waste.

Methyl orange alkalinity represents the half-bound carbon dioxide in the water, which is present as a result of the dissolving of limestone by water containing carbon dioxide.

For convenience the following abbreviations were used in the report:

D. O.	Dissolved oxygen
B.O.D.	5 day biochemical oxygen demand
NO_2	Nitrite Nitrogen
NO_3	Nitrate Nitrogen
NH_3	Ammonia nitrogen
c.f.s.	Cubic feet per second
B. coli	Bacterium coli
B. aero.	Bacterium aerogenes
p.p.m.	Parts per million
p.p.b.	Parts per billion
ml.	Milliliter
cc.	Cubic centimeter

PHYSIOGRAPHY OF THE CEDAR RIVER

/ The Cedar River rises in the marshy depressions of the glacial drift near Hayfield in Dodge County, Minnesota, and flows in a general southeasterly direction across the State of Iowa, joining the Iowa River at Columbus Junction about thirty miles above the point where the Iowa joins the Mississippi River. The Cedar River with its tributaries drains a total area of 7,780 square miles. The fall of the river is 740 feet, flowing a distance of 300 miles, which represents a fall of almost two and one-half feet per mile. The drainage area is approximately sixty miles wide along the entire length of the stream.

The most important tributary of the Cedar River is the Shellrock River, which joins the Cedar River about five miles north of Cedar

Falls, Iowa. The Shellrock River rises in the lakes and swamps among among the moraines in Freeborn County, Minnesota. It flows from Albert Lea Lake, a distance of 102 miles, to its junction with the Cedar River, and in this distance falls 350 feet or on the average of about three and one-half feet per mile.

The Shellrock, in turn, has two main tributaries, the West Fork which enters only a mile above the junction of the Shellrock and the Cedar River. The West Fork has a drainage area of about 360 square miles. Below Rockford, Iowa, 248 miles above Columbus Junction and 49 miles above the junction of the Shellrock with the Cedar River, the Shellrock is joined by another important tributary, namely, Lime Creek, or the Winnebago River as it has more recently been named. Above the junction of the two streams Lime Creek has a drainage area of 705 square miles as against 550 square miles of the Shellrock River proper, above the junction. Lime Creek rises in the southwestern portion of Freeborn County, Minnesota, and flows in a general southeasterly direction following a circuitous path 78 miles long to its junction with the Shellrock. The average fall of Lime Creek is between three and four feet per mile.

The Cedar River valley is for the most part three or four miles wide and is level and sandy. There are many indications that nearly every part of the valley proper has been traversed at some time or other by the river. There is, however, a decided restriction in the valley at Waterloo. Except for short distances below dams at Cedar Falls and Waterloo, the bed of the stream is of uncolsolidated material. Indurated rocks outcrop in but few places along its bank, and even the high bluffs at Cedar Falls and Waterloo are mostly drift materials. Above Waterloo these bluffs are chiefly on the southwest and slope off to level or rolling prairie with very few deep gullies which are usually with very high bluffs.

Lime Creek, after it leaves the marshes in northern Iowa has cut a channel through limestone which lies near the surface and the stream, particularly through Cerro Gordo County, has a more restricted valley than the other branches of the river.

The Cedar River watershed is for the most part fertile prairie soil from the Wisconsin, Iowan and Kansan drift. It is underlain at various depths by rocks of the Devonian, Mississippian and Pennsylvanian series. These series outcrop frequently in the deep valleys cut in the drift by the water courses. Almost the entire drainage area is under intensive cultivation.

Several fair size cities with considerable industrial development lie in the Cedar valley. The banks of the stream are heavily wooded with a variety of timber common to this latitude. These timbered areas are, however, confined for the most part to narrow areas immediately adjacent to the stream, and the broad valley as well as the table land above the bluffs is for the most part open prairie.

While the Cedar River probably carries somewhat more silt than does the Mississippi River above the junction with the Cedar, yet the Cedar River is clear as compared with the Des Moines, Skunk, Iowa, and other Iowa rivers. Only at high stages does it carry any considerable amount of silt. There are few records available of actual silt measurements. However, the Cedar Rapids Water Works has a considerable amount of data on turbidities of the Cedar River, and the turbidities here recorded are uniformly low.

The total water yield of the Cedar River is larger per square mile of drainage area than most of the streams in Iowa, and likewise the river has a much better low water yield than the Iowa, Skunk and Des Moines Rivers. It is true, like all other streams in Iowa, there is a big seasonal fluctuation in stream flow, yet the sustained dry weather flows are comparatively high. Generally speaking, the high dry weather flows coupled with the freedom from silt makes the Cedar River one of the finest rivers in the middle west for water supply purposes, for recreational purposes and for fish culture.

The matter of dry weather flows will be further discussed in the section of this report on stream flows.

THE GENERAL SIGNIFICANCE OF STREAM POLLUTION

The pollution of streams with sewage or industrial wastes is objectionable for the following reasons: First, sewage and industrial wastes contain millions of bacteria, many of which, particularly in domestic sewage, may be pathogenic or disease producing; second, all sewage and most industrial wastes contain unstable organic material which is being converted to harmless stable material robs the stream water of oxygen; third, sewage and industrial wastes contain solids which render an otherwise clear water turbid, which are objectionable to the aesthetic senses when they are floating downstream and which settle to the bottom of the stream bed causing objectionable deposits of solids known as sewage sludge. These deposite on the bottom of the stream undergo putrefaction accompanied by vile odors and contain objectionable bacteria, many of which may be disease producing, and furthermore, they rob the water of oxygen which is so necessary for the support of aquatic life; fourth, some industrial wastes contain material which is toxic to fish, live stock and humans.

For a better understanding of the data presented in this report a brief discussion of the significance of stream pollution is deemed advisable.

BACTERIA

All domestic sewage contains bacteria in exceedingly high numbers; many of these bacteria are harmless. However, the sewage also contains the pathogenic or disease producing bacteria which are present in the bodily excretions of people having diseases. While the so-called water-borne intestinal diseases, typhoid, paratyphoid, dysentery, etc., are most likely to be spread through the medium of polluted waters, skin infection, eye, ear, nose and throat infections, and even respiratory infections may be spread by contact with polluted waters containing the specific organisms of these diseases.

It is possible in the laboratory to measure the comparative bacterial pollution of a stream by actually making counts of the bacteria present in the stream water. The total bacterial counts of the stream water simply represent the number of bacteria present in a measured quantity of water which will grow under certain laboratory conditions on a certain media. Of the total number of bacteria which are represented by the plate counts, no doubt most of the bacteria are harmless. However, with them are associated the pathogenic or disease producing bacteria. It is reasonable to assume that disease producing bacteria will be present in a polluted water proportionately to the total counts. Thus if the total bacterial count of a polluted water is one hundred times the count of a relatively unpolluted water, the chances are that the disease producing bacteria will be present in the same proportions.

In the laboratory there is also a definite procedure by which certain of the intestinal bacteria can be quantitatively determined. These bacteria are known as bacterium coli and their normal habitat is the intestinal tract of warm blooded animals, including humans. Consequently, when these organisms are present in water it can be definitely stated that the water is polluted with intestinal discharges from humans or warm blooded animals, and organisms of this group have a decided sanitary significance as with these organisms may be associated the specific organisms causing typhoid fever, dysentery and other intestinal disturbances. If a drinking water contains any organisms of this group in 50 milliliters, it is not considered satisfactory for drinking purposes. Likewise, if a stream water contains these organisms in large numbers, the stream must be considered unsafe for bathing and other recreational purposes which require contact with the stream water. Specific disease producing bacteria are likely to be present in direct proportion to the number of these intestinal bacteria which are present.

DISSOLVED OXYGEN AND BIOCHEMICAL OXYGEN DEMAND

All unpolluted stream water contains free oxygen in a dissolved form. This oxygen is absolutely necessary for the support of fish life and without dissolved oxygen in the water fish will literally drown since the respiratory system is so constituted that it cannot utilize the combined oxygen in water any more than a mammal can.

Quantitative determinations of dissolved oxygen in a stream water can readily be made.

Dissolved oxygen in a water serves another useful purpose, namely, it is available to bacteria which oxidize or burn up organic material present in pollution entering the stream. These bacteria are absolutely dependent upon the presence of dissolved oxygen. If there is a sufficient quantity of oxygen present in the water this so-called aerobic bacterial action will result in the complete oxidation or burning up of the organic material present in the pollution without creating any objectionable odor nuisance or destruction of aquatic life. If on the other hand, there is not a sufficient amount of oxygen present in the water another type of bacteria termed as anaerobes gain the ascendency. With anaerobic bacterial action the organic material present in the wastes undergoes putrefaction with the accompanying foul odors, ebulition of gas and the black, inky appearance of water which is so familiar in a polluted stream.

It is possible in the laboratory by means of B.O.D. determinations to evaluate or to measure the organic content in the sewage in terms of its requirement of oxygen so that this orderly oxidizing or burning process can take place. If the organic material requires more oxygen than is present in the stream water, then the familiar black appearance of the water, the familiar odors and the destruction of the fish life will follow. In other words, to support aquatic life and to prevent nuisances there must always be in stream water a sufficiency of dissolved oxygen. Most authorities agree that if fish life is to be properly maintained there must always be from three to four parts per million of oxygen in the water. The exact amount of oxygen required for fish to thrive normally is not definitely known, but it is believed to be greater than this figure. Some authorities state that for satisfactory fish culture, the dissolved oxygen should always be between 60 and 70% of the saturation figure. In these studies there has been some evidence that some of the soft fish are more tolerant to lower oxygen content and can exist in water which contains less oxygen than that above mentioned.

Sewage and many types of industrial wastes, particularly wastes like those from meat packing establishments, canneries, creameries, etc. contain solids which are objectionable. These solids below a sewer outlet tend to make the water turbid; they are of course very unsightly, but the principal objection to them lies in the fact that the bacterial content is enormous and that they are composed almost wholly of organic material which will undergo decomposition or putrefaction. The solids, either floating or after they have settled in a stream bed, contain so many bacteria that they add very appreciably to the disease producing hazard due to their bacterial content.

In an area of a stream above a riffle or an artificial dam where the water velocity has been greatly reduced there is a tendency on the part of the heavier solids to settle forming banks of so-called sludge. The sludge in the stream bed then undergoes bacterial putrefaction with accompanying foul odors. Frequently, large masses of sludge will rise to the surface of the water due to the buoyancy of the entrained gases, thus rendering the entire overlying water black in color and odoriferous. This decomposition also exerts a great demand on the oxygen in the overlying stream water and thus in water above the sludge accumulations the oxygen content is likely to be depleted.

Sludge deposite also interfere seriously with the propagation of fish, in that the normal nesting places may be covered with sludge and even the eggs themselves may be covered with sludge, thus preventing their hatching. Sludge deposits also are very destructive to clams and other bottom forms of life.

The accumulation of sludge is, of course, most serious during extended periods of low stream flow. During such periods the velocity of the stream is greatly reduced and there is a better opportunity for the formation of sludge banks. Furthermore, during extended dry periods, any increased velocity due to a rise in the stream which would tend to flush out the settled solids, is absent, and thus it is possible to have an accumulation of sludge extending over a long period of time. If there is a considerable accumulation of sludge in the stream bed, a sudden rise in the stream will stir up these deposits carrying them in suspension with the result that the oxygen of the stream water is depleted and all aquatic life in the stream is destroyed. This very thing has occurred in the Cedar River, as well as in four other streams in the State during the summer of 1931, with the result that millions of fish were killed.

There is no evidence that fresh domestic sewage contains material which is toxic to fish or animals. There is evidence, however, to the effect that after undergoing anaerobic decomposition products are formed which are toxic to fish and to live stock. While there is little definite information available on the subject, this appears to be a factor in the destruction of fish and in rendering heavily polluted waters unfit for stock watering purposes.

Many industrial wastes, such as packing house wastes, cannery wastes and creamery wastes, are in themselves not toxic when fresh, but after undergoing putrefaction the same thing applies to these wastes as to domestic wastes.

Certain industrial wastes may, however, contain material which is toxic to fish and animals. For example, gas plant wastes contain phenols which are definitely toxic to fish if present in sufficient quantities. Phenol wastes, furthermore, are definitely objectionable in streams due to the fact that in very minute quantities they impart an objectionable taste to the water which renders the water unsatisfactory for drinking or domestic purposes, and also, if present in water in insufficient concentrations to kill fish, they still impart to the fish objectionable tastes which make the fish unfit to eat.

There are numerous other industrial wastes which contain toxic materials. However, there are no such industries located on the Cedar River and consequently we are not concerned with such industrial wastes in this report.

SELF-PURIFICATION OF STREAM WATERS

While it is not within the scope of this report to enter into a complete discussion of self-purification of streams, the important factors governing self-purification should be mentioned. The statement so often made, that a stream will purify itself flowing a certain distance, is a fallacy. On the other hand, were it not for the self-purification effected in streams, conditions would long since have become intolerant.

Aeration of stream water, thus keeping the oxygen content of the stream near the saturation point, is the greatest factor in self-purification. Probably the greatest source of oxygen in stream water is the atmospheric oxygen which is absorbed by the water surface which comes in contact with the air.

As previously stated, the actual purification is the result principally of biological action. However, since this biological life is absolutely dependent upon oxygen in the water for its very existence oxygen may well be considered the important factor in the self-purification of streams.

In addition to the direct absorption of oxygen from the atmosphere, the chlorophyll-bearing plant life in the stream is a source of abundant oxygen. Most of the algae and diatoms are prolific oxygen producers and if present in a polluted stream, they exert a beneficial influence. Unfortunately, however, sunlight, proper food and proper temperature conditions are necessary for the algal growth. Thus at night and on cloudy days or in turbid waters the algae do not produce oxygen. Furthermore, the activity of the great majority of species is confined to the summer months, when the water is warm. During cold weather these plants are normally not present. Bearing these factors in mind, the algae cannot be depended upon as a source of oxygen to take care of pollution dumped in the stream. It thus can be seen that the capacity of a stream for satisfactorily taking care of sewage by dilution would be decidedly variable for different streams and under different climatic conditions.

Generally speaking, the oxygen conditions in a stream which is comparatively shallow, which has a comparatively swift flow, thus exposing large surfaces of the water to the atmospheric oxygen, will usually be better than in a sluggish, slow moving stream. Since algae will not grow in turbid water, a stream having clear water will receive more benefit from oxygen produced by algae than will a turbid stream. The biological action in a stream is also dependent upon temperatures, the higher water temperatures producing the greater biological activity.

The oxygen demand of the organic material in the sewage will be exerted in a shorter time therefore at high temperatures than at low temperatures. Consequently, for a given amount of sewage, conditions immediately below the outlet will usually be worse during hot weather than during cool weather. On the other hand, when temperatures become so low that the surface of the stream is covered with ice for long reaches, thus eliminating opportunity for atmospheric reaeration, conditions at the same flow will usually be worse in winter than in summer in spite of the retarded biological activity, but such points of acute conditions will be farther down stream than at higher temperatures.

Sedimentation is also an important factor in the self-purification of streams. In quiescent water much of the suspended material will settle carrying with it many bacteria, thus relieving the stream farther down of much of the suspended organic load. On the other hand, these accumulations of suspended solids in comparatively small areas, will render conditions more acute in such areas than if this sludge were spread over larger areas of the stream bed.

Unfortunately, since there are so many factors governing reaeration and since there are so many different conditions, even in the same stream, it is impossible to definitely evaluate the reaeration of a stream and to definitely predict that a certain flow of water will take care of a certain quantity of waste as a general principle.

SOURCES OF POLLUTION

In the portions of the stream studied in this survey, the following cities and towns are discharging untreated sewage into the Cedar River: Waverly, Cedar Falls, Cedar Heights, Waterloo, LaPorte City, Vinton and Cedar Rapids. The cities of Marion and Mount Vernon discharge partially treated sewage into small creeks near the point of discharge of these creeks into the Cedar River.

The major industries discharging wastes into the Cedar River are the Sinclair Packing Company, Ltd., Cedar Rapids, Iowa, which is a meat packing establishment discharging directly into the river; Penick and Ford, Ltd., operate a corn products factory at Cedar Rapids. The discharge from this plant is into the Cedar River through a city storm sewer. The Rath Packing Company of Waterloo operate a meat packing establishment at Waterloo, and wastes are discharged directly into the river.

Smaller industries discharging into the river are as follows: Marshall Canning Company, operating a corn canning factory at Cedar Falls, wastes from which discharge into a bayou of the Cedar River; and the Iowa Canning Company operating a corn packing plant at LaPorte City, which discharges into a small creek a short distance above its junction with the Cedar River. The same company operates two plants at Vinton, Iowa, one of which discharges its wastes into the city's sewer and the other directly to the river. The Waterloo Canning Factory located in Waterloo discharges its wastes to the city sewers.

Gas plants located at Waterloo, Vinton, Cedar Falls and Cedar Rapids discharge wastes into the stream.

Of the municipalities, the cities of Cedar Falls, Waterloo and Cedar Rapids are the principal offenders, and of the industries the Rath Packing Company at Waterloo, the Sinclair Packing Company and the Penick and Ford Company, Ltd. of Cedar Rapids are the principal offenders.

During the first surveys in 1926 to 1928, a large number of samples were collected from the various sewer outlets in both the cities and towns, as well as from the industrial plants, and accurate data was obtained as to the relative concentration of the various wastes. Except for minor changes in two or three of the industrial establishments, nothing has been done to correct the pollution of the stream, and for that reason no effort was made to secure additional data on the character of the wastes from the various sources of pollution. It is reasonable to assume that with the growth of the municipalities in question and with the expansion of at least some of the industries, conditions as far as polluting material entering the streams are, if anything, worse today than they were four years ago. Consequently any conclusions based upon these data of four years ago must be conservative and will represent a condition, if anything, less serious than the actual conditions as they exist today

The average analyses of the sewage of municipalities and industries in the Waterloo area (1926-1927 survey) are shown in Table 1.

TABLE I

AVERAGE OXYGEN DATA ON SPECIAL SAMPLING STATIONS
Cedar River
Waverly to LaPorte City

Station Description	Station No.	No. of Samples	Average B.O.D. 5 Day	Average B.O.D. Each contributor 5 Day	Gallons of waste per 24 hours	Oxygen required lbs. per day*	Percent of total Oxygen Required
Waverly Sewer	A	23	270	362	200,000	890	2.5
" "	B	25	539				
" "	C	21	285				
" "	E	19	357				
Cedar Falls Sewer	F	25	425	425	700,000	3,640	10.2
Cedar Heights Sewer	G	23	371	371	100,000	450	1.3
Waterloo Sewer	S	19	388	425	1,000,000	18,765	52.7
" "	T	26	374		1,596,720		
" "	U	23	512		92,160		
" "	V	25	504		69,120		
" "	W	25	353		82,080		
" "	X	16	335		84,960		
" "	Y	28	583		85,392		
" "	Z	25	349		1,021,023		
LaPorte City Sewer	L	17	517	517	30,000	190	0.5

*Based on 20 day Oxygen Demand

TABLE I

(Continued)

AVERAGE OXYGEN DATA ON SPECIAL SAMPLING STATIONS

Description	Station No.	No. of Samples	Average B.O.D. 5 Day	Average B.O.D. Each contributor 5 Day	Gallons of waste per 24 hrs.	Oxygen Required lbs. per day*	Percent of total Oxygen Required
Rath Hair Wash Water	K-1	27	1150				
Rath Influent to Settling tank	K-2	26	1935				
Rath Effluent from Settling tank	K-3	27	1461				
Rath Outfall Sewer	K	48	892	892	1,000,000	10,920	30.7
Waverly Corn Canning Factory	C-1	10	997	997	19,300	235	0.7
Cedar Falls Corn Canning Factory	C-2	13	1442	1442	12,220	215	0.6
Waterloo Corn Canning Factory	C-3	35	1044	1044	18,700	240	0.7
LaPorte City Corn Canning Factory	C-4	6	605	605	10,300	75	0.2
Total						35,620	

*Based on 20 day Oxygen Demand

In Table 3 is shown the average analyses of sewage from the Cedar Rapids area, and Table 4 gives the average oxygen data for this area.

The city of Waverly has a population of 3,652 and discharges a normal domestic sewage into the stream, except that a corn canning factory is situated here which adds appreciably to the city sewage load during the period of operation. The operation period, however, is short, averaging not more than five or six weeks each year. Consequently for a major portion of the time the canning factory is not a factor in the pollution of the stream.

The average analyses of the Waverly city sewage indicate the sewage to be considerably stronger than average. However, the quantity is less than average for a city of this size, which probably accounts for the comparatively strong sewage. The wastes from the canning factory at Waverly represents a normal canning factory waste, both in quantity and in character.

All analyses of the sewage from the city of Cedar Falls, population 7,362, also indicate a strong sewage with a flow somewhat less than normal. The same thing applies to Cedar Heights, population 493.

Sewage from Waterloo indicates a very strong sewage and likewise a quantity which is somewhat greater than the average for cities of this size. The exact reason for this is unaccountable as Waterloo, population 46,191, does not have a large number of small industries which might appreciably add to the sewage load.

LaPorte City with a population of 1,470 contributes a sewage very strong but, on the other hand, in a quantity smaller than average. Taking into consideration the small quantity of sewage the amount of polluting material is probably somewhat less than would ordinarily be expected in a town of this size.

Vinton, with a population of 3,373, discharges a sewage somewhat stronger than average but in quantities less than average.

Cedar Rapids, population 56,097, discharges sewage slightly stronger than average and in quantities slightly less than expected from a city of this size.

The canning factories listed contribute a sewage of normal strength for industries of this type, but in quantities, on the whole, less than is ordinarily expected from industries of this type. The quantities designated are based upon estimates of the cannery officials and are probably low. Table 2 shows the average results of the analyses of the corn canning factory wastes.

The Rath Packing Company at Waterloo discharges a sewage considerably less concentrated than most meat packing plants which have been studied. However, the quantity of waste is far in excess of other plants that have been studied and consequently the waste coming from the plant is more diluted than the average. The amount of organic material discharged

TABLE 2

Corn Canning Factories
in
Cedar River Pollution Survey

Location	Gals. Water used daily	No. of cans in season	Means of waste Disposal
Marshall Canning Co. Factory #4, Waverly Start Aug. 25th	19,300 (city water)	7,000,000	Series of 3 settling tanks - 5'x 5'x 5', with screen at final outlet to city sewer, to Cedar River.
Cedar Falls Canning Co. at Cedar Rapids Start Aug. 16th	12,220 (city water)	1,000,000	Concrete settling tank 6'x 6'x 8', not in use. 6" sewer outlet to dry run to Cedar River.
Waterloo Canning Co. At Waterloo Start Aug. 28th	18,700 (city water)	3,600,000	Direct to city sewer (our Sta. W.) and also to separate sewer outlet direct to Cedar River.
Iowa Canning Co. At LaPorte City Start Aug. 29th	10,300 (city water) also private supply	3,000,000	Concrete settling tank - 10' deep 8' diameter, is cleaned out 2 or 3 times a week. 6" sewer to Big Creek to Cedar River.

TABLE 3

Averages of Results of Analyses of Sewage and Wastes Discharged into the Cedar River from LaPorte City to Columbus Jct.

April 1, 1927 to Feb. 2, 1928

SAMPLING STATION	D.O.	B.O.D.	Alk.	CHLOR-IDES	pH	SETTLEABLE SOLIDS	TOTAL SOLIDS	NO. OF SAMPLES TAKEN
A-Vinton Sanitary Sewer	6.3	411	462	157	7.8	.15%		11
C-20th Ave. Sewer Cedar Rapids	7.1	280	283	70	7.5	.3		21
D-21st Ave. Sewer Cedar Rapids	7.0	239	249	46	7.8	.5	1198	23
E-22nd Ave. Sewer Cedar Rapids	7.1	547	531	88	8.0	.13	3034	30
F-Large 2nd Ave. Sewer Cedar Rapids	6.3	299	287	99	7.8	.8½	1393	28
G-Sinclair Co. lower outlet	7.6	420	262	154	8.2	.9	1500	28
H-Sinclair-small sewer into "J"	7.3	308	290	181	7.9	.7½	1322	23
J-Sinclair Main sewer outlet	7.2	1212	392	692	8.1		3323	42
K-Penick & Ford Starch Works	7.6	128	164	21	7.9	.3	1231	45
L-Influent-Marion Treatment Plant	7.2	287	297	39	7.7			5
M-Effluent-Marion Treatment Plant	7.0	92	257	34	7.6	.2	700	6
N-Influent-Kenwood North Treat. Plant	7.7	596	221	35	7.6	.2	728	3
P-Influent-Kenwood South Treat. Plant	7.3	245	242	52	7.5	.2	904	6
R-Effluent-Kenwood South Treat. Plant	7.4	334	223	42	7.4	.5	713	6
S-Influent-Mt. Vernon Treatment Plant	6.8	271	336	61	7.5			5
T-Effluent-Mt. Vernon Treatment Plant	7.6	26	255	40	7.3		651	5
X-Cedar Rapids 8th Ave. Sewer to Sta. C.	5.8	247	373	7.0	7.7			3
W-City Storm Sewer used by Penick & Ford	9.0	112	142	22	7.7	.8		3
								303

by this plant after compensating for the strength is fairly representative of a normal packing house waste. Since the survey was made the Rath Packing Company has made some improvements in the way of screening devices, added settling tanks, and have extended their outlet to the middle of the stream, which has resulted in improving the physical appearance of the stream along the shoreline. On the other hand, since the first survey the plant has been enlarged, the daily kill has been increased, and consequently the figures as represented in Table 1 are probably considerably low for this plant. The population equivalent figures given in Table 5 probably more truly represent the polluting material discharged by the Rath Packing Company at the present time.

The Sinclair Packing Company at Cedar Rapids has likewise made a number of improvements since the original survey. The coarse suspended material which was being discharged into the stream at the time of the original survey has been eliminated by the installation of fine screens and a series of catch basins and settling tanks. So much of the organic material in a packing house waste, however, consists of material in solution and very finely divided or colloidal material in suspension that such treatment does not greatly reduce the oxygen consuming load placed upon the stream. This plant, like the one at Waterloo, has increased the kill and as a result the figures shown in Table 4 are probably too low, and the population equivalents shown in Table 5 are probably more representative.

Penick and Ford contribute a large quantity of waste to the stream, most of which is unpolluted condenser water. The waste water from this plant, while enormous in quantity, is very weak compared to most industrial wastes. A great reduction in polluting material has been accomplished by bottling up and reuse of all process water. Since the original survey was made added refinement and improvements have been made to their process which no doubt has resulted in a further decrease of the organic load going into the stream. Unfortunately an exact measure of this improvement is not available.

The quantities of wastes as designated in Table 5 for the cities are based upon water consumptions and on estimates based on population, with the exception of Cedar Rapids. In Cedar Rapids, flow measurements were made of all the sewage by the city engineer of Cedar Rapids in cooperation with this Department and the figures of quantity in Cedar Rapids represent accurately the dry weather flow in 1928. Quantities of waste from all of the industrial concerns are based upon estimates by officials of the companies.

The city of Waterloo has a combined sewer system with outlets at nine points on both sides of the river. Nothing to date has been done towards the construction of intercepting sewers nor towards the separation of storm water and sanitary sewage. In view of the fact that the sewers are combined and that intercepting sewers will be necessary, the cost of the treatment of sewage in Waterloo will be considerably greater than in some other cities of similar size.

All of the sewers in Cedar Rapids are separate sanitary sewers. Since the first survey, two intercepting sewers have been constructed, one on either side of the Cedar River, and a river crossing is under contract which will bring all of the sewage of Cedar Rapids at or near the proposed disposal plant site.

The city of Waverly has a combined sewer system with five major outlets into the stream. Nothing has been done here towards a sewage treatment plant.

The city of Cedar Falls has a system of sanitary sewers outletting at one point in the stream. The same is true for Cedar Heights, LaPorte City and Vinton. No effort has been made to treat sewage from those cities, except at LaPorte City, which has an obsolete septic tank, which effects practically no purification.

Table 1 lists the contributors of pollution to the portion of the Cedar River extending from Waverly to LaPorte City giving the oxygen in pounds which would be required in twenty days to oxidize these wastes based on average B.O.D. and quantity of waste. Particular attention is called to the last column in this table which indicates in percentages the relative amount of pollution contributed by the various municipalities and industries. The amount of oxygen available in the stream at Waterloo during the period of the lowest flow during the survey was 32,000 pounds, which will be noted is less than the amount of oxygen required to completely oxidize the wastes being discharged at that time. All the figures in this table are as of 1927.

The detailed data on results of analyses of the sewage and wastes from the various municipalities and industries listed in this table was included in the earlier reports of the Cedar River Studies. On account of the large volume of this material, those data will not be repeated in this report. The B.O.D. figures in this report represent averages of all the tests.

Table 3 shows the average results of the analyses of the sewage and industrial wastes discharged into the river from LaPorte City to Columbus Junction.

Following is a table showing the total figures for the wastes from the municipalities and industries located on the lower portion of the river with the percentage of the total oxygen required by each of the offenders.

Table 4

Average Oxygen Data on Special Sampling Stations
1927-1928

	Quantity of sewage Gal/day	Average 5 day B.O.D.	Lbs. of Oxygen required per day on basis of 20 day B.O.D.	% of total oxygen required
Vinton	200,000	411	1,000	2.1
Cedar Rapids	4,800,000	337	19,800	42.6
Sinclair Packing Company, Cedar Rapids	1,800,000	816	18,000	38.6
Penick & Ford, Cedar Rapids	5,000,000	128	7,800	16.7
			46,600	

19,845 pounds of oxygen available at minimum flows on record (410 c.f.s.,1912) assuming saturation summer temperatures.

34,500 pounds of oxygen available at average minimum flows for past twenty years assuming saturation at summer temperatures.

It is probable that there has been little change in the quantity or character of the municipal wastes since 1928 other than the increase due to the increase in population. The wastes from the canning factories are likewise probably about the same now as they were at that time. The wastes from the packing plants have probably increased materially since that time and an estimate of the packing house wastes on the basis of population equivalent based upon present kills would be a more reliable index as to the polluting quality of these wastes.

Voluminous data are available as to the quantity and strength of waste produced in slaughtering one animal. Consequently on the basis of total number of animals slaughtered per day in a packing house, a reliable estimate can be obtained as to the equivalent of this waste as compared to domestic wastes. Such equivalent is ordinarily expressed as a population equivalent and the term population equivalent of an industrial waste means that the wastes from the industry are equivalent in polluting qualities to wastes from the number of people designated as population equivalent.

Table 5 gives the population equivalent of the sewage from the various municipalities and industries discharging into the Cedar River. The population of the municipalities is from the census of 1930. The population equivalent of the canning factories and of the Penick and Ford factory at Cedar Rapids are computed from the 1927-28 data on quantity and character of wastes as measured at that time. The population equivalent of the wastes from the packing plants at Cedar Rapids and Waterloo are based upon the number of animals slaughtered during the year 1929-30.

TABLE 5

Population Equivalent
Cedar River

Contributor	Population 1930	Pop. Equiv. Aver. kill or pack	Total*	Pop. Equiv. Max. kill	Total**
City of Waverly	3,652				
Marshall Canning Co. Waverly		1,070			
Total for Waverly			4722		
City of Cedar Falls	7,362				
Marshall Canning Co. Cedar Falls		975			
Total for Cedar Falls			8337		
City of Waterloo	46,191				
Waterloo Canning Co. Waterloo		1,090			
Rath Packing Co. Waterloo		31,200		52,000	
Total for Waterloo			78,481		99,281
LaPorte City	1,470				
Iowa Canning Co. LaPorte City		340			
Total for LaPorte City			1,810		
City of Vinton	3,372		3,372		
City of Cedar Rapids	56,097				
Penick & Ford Co. Cedar Rapids		35,450			
Sinclair Packing Co. Cedar Rapids		33,200		55,200	
Total for Cedar Rapids			124,747		146,747
Grand Totals	118,144	103,325		107,200	

Total population equivalent at average kill and pack - 221,469.
Total population equivalent at maximum kill and average pack - 264,269.

*City population plus equivalent for average kill or pack.
**City population plus equivalent for maximum kill and average pack.

LIST OF STATIONS

The following is a list of sampling stations on the Cedar River. These stations were used during the entire survey made between May, 1926, and September, 1931.

Station No. 1. Located about five miles up river from Waverly and on a three span county road bridge.

Station No. 2. Located on a county road bridge just north of Waverly.

Station No. 3. Located on the two span steel bridge on U. S. Highway No. 218 at Janesville.

Station No. 4. Located on a 450 foot concrete bridge on U. S. Highway No. 218, at Cedar Falls.

Station No. 5. Located on an 800 foot concrete bridge on Mullen Ave. in Waterloo.

Station No. 6. Located on a 640 foot steel bridge on 11th St. in Waterloo.

Station No. 7. Located on a concrete interurban bridge at Elk Run.

Station No. 8. Located on a 1050 foot steel road bridge at Gilbertville.

Station No. 9. Located on a single span steel road bridge on the county road between LaPorte City and Brandon.

Station No. 10. Located on a four span steel road bridge on the county road between Brandon and Mt. Auburn.

Station No. 20. Located on a four span steel road bridge on Iowa Highway No. 101 just north of Vinton.

Station No. 30. Located on a five span steel road bridge on the county road between Urbana and Shellsburg.

Station No. 40. Located on a three span steel road bridge on a county road southeast of Palo.

Station No. 50. Located on a five span steel railroad bridge owned by the Northwestern R.R. This bridge is located near the Quaker Oats Co., Cedar Rapids.

List of Stations (Continued)

Station No. 60. Located on the Northwestern R.R. bridge about four miles below station No. 50.

Station No. 70. Located on a six span steel road bridge on Iowa Highway 261 between Mt. Vernon and Iowa City.

Station No. 80. Located on a steel road bridge at Cedar Bluffs on a county road between Solon and Tipton.

Station No. 90. Located on a steel road bridge on Iowa Highway No. 1 between Tipton and Iowa City.

Station No.100. Located on a steel road bridge on U.S. Highway No. 32 between Wilton Junction and West Liberty.

Station No.110. Located on a steel road bridge on a county road between Nichols and Muscatine.

Station No.120. Located on a steel road bridge on a county road near Myrtle.

Station No.130. Located on a steel highway bridge on Iowa Highway No. 2 near Columbus Junction.

PHYSICAL CONDITIONS

On each trip the investigator made notes as to the physical condition of the river at each station. Usually he found the conditions very much the same at each station on all of the trips. During the cold months it is hard to tell just what the physical conditions are because of the ice sheet which covers the river, so most of the data in this section was collected during the months when the river was open. Following is a compilation of that data.

The first four stations (1, 2, 3 and 4) show very little or no evidence of pollution. The water is clear, but contains some algae.

Station 5 located on Mullen Avenue in Waterloo usually shows a light oil scum, probably caused by Cedar Falls sewage and oil from motor boats.

Station 6 on 11th Street in Waterloo is below part of the sewer outlets in Waterloo and the river at this point has the appearance and odor of sewage. In addition to this, there is an area where septic action is taking place.

Station 7 at Elk Run shows the river in very bad condition. Floating solids may be found here at any time in addition to large numbers of algae.

Station 8 at Gilbertville shows a great improvement in the river, largely due to the aeration received just above this point. From the appearance of the riffle there was once a dam at this point.

Stations 9, 10, 20, 30, 40 and 50 appear to be in fair condition. Floating solids are not visible at any of these stations, although there is frequently a thin scum at Station 50 which is probably caused by the still water. At all of these stations, however, there are algae growths.

Station 60 is below the Cedar Rapids sewer outlet and has the appearance and odor of sewage. The stream flow is fairly swift at this point and there are no septic areas.

Station 70, about 11.5 miles below Station 60 shows the river to be physically bad, floating solids and heavy algae growths being a common sight.

Stations 80, 90, 100, 110, and 130 do not appear to be in bad condition except for the algae. At these stations the water has a green color caused by the density of these minute plants.

On June 24, 1931, Governor Turner received a telegram telling of dead fish in the Cedar River at LaPorte City and an investigator was sent out from the Bureau of Public Health Engineering to find, if possible, the reason for this wholesale killing of fish. The investigator arrived in LaPorte City at about 3:30 P. M. June 25. Dead fish lined the banks of the stream at that time and the temperature of the water had reached 31°C. It is known that this temperature will not kill the fish, but it will make them less resistant to pollution. The oxygen content at this point was 13.3 parts per million, which is a supersaturated condition.

The next day, June 26, the investigator made a trip up river from Waterloo and found no dead fish or anyone who had seen any. The oxygen determination was run on samples collected at the regular sampling stations from Janesville to Waterloo and it was found that there was sufficient oxygen at these points to maintain fish life, although it had not reached the point of supersaturation. At the first station below the Waterloo sewer outlets there was still enough for fish, but at the second station below Waterloo the oxygen content of 1.1 parts per million was lower than the amount required to support fish life. From this point on to Vinton there was more dissolved oxygen.

The investigator heard a rumor that the gates of the power dam at Waterloo had been opened. Upon further investigation it was found that the city officials of Waterloo had asked the power company to open the gates so that the rush of water would clean out the river bed. The power company agreed and opened the gates on June 23. The opening of the dam cleaned out the bed of the river, but in doing this the settleable solids that had collected on the river bed were riled up and during the process of decomposition used most of the oxygen out of the water. This, the investigator believes, was the cause of the death of the fish.

Following are the results of the dissolved oxygen determinations made during this investigation:

Station	D.O.	Temp. °C.	Date
9	13.3	34	June 25
3	5.4	27	June 26
4	6.2	29	" "
5	7.0	30	" "
6	5.7	30	" "
7	1.1	29	" "
8	4.4	30	" "
9	8.5	31	" "
20	12.1	32	" "

INTERPRETATION OF DATA

Bacterial Counts

Table 6 shows the bacterial counts for the survey of 1927-1928 for the stream from LaPorte City to Columbus Junction. Both the counts on nutrient agar incubated for twenty-four hours at thirty-seven degrees centigrade and the counts on litmus lactose agar incubated for forty-eight hours at twenty degrees were made. In table 7, columns five and six, are given the average bacterial counts for this period. The average 20°counts are shown in Chart 18, Appendix II. In the table of thirty-seven degree counts it will be noted that at station 10 the total count is 15,400. There is a slight decrease to station 50, and a decided increase at station 60 to 77,400 per milliliter, showing the effect of the Cedar Rapids sewage. At station 70 there is a tremendous decrease, 16,200, and from this point the counts do not vary greatly until station 130 is reached. The total counts at twenty degrees are of comparable magnitude except that they are slightly lower for the unpolluted sections of the stream and at station 60 below Cedar Rapids, are considerably higher --117,100, than the 37°counts. These results indicate that even with the comparatively high stream flows there is a tremendous increase in the bacterial content below the point of greatest pollution, namely Cedar Rapids.

TABLE 6

BACTERIAL COUNT - - THOUSAND PER M L.
(24 Hours at 37°C.)
LaPorte City to Columbus Junction
Cedar River

DILUTION	STATION 10			STATION 20			STATION 30		
DATE	0.1	.01	.001	0.1	.01	.001	0.1	.01	.001
1927									
6-24	6.7		30.0	20.2	25.0	18.7	8.8	32.0	30.0
6-27	15.3	20.0	31.0	30.4	24.0	57.5	11.0	34.0	30.0
7-1	25.0		44.0	8.2	55.0	51.0	11.2	19.0	14.0
7-8	3.3	8.0	2.0	44.8	2.7	8.0	11.2	1.4	3.0
7-11	28.0		36.0	56.0	16.0		3.1	13.0	12.0
7-15	4.8	17.0	25.0	7.6	5.8	10.0	2.7	4.9	9.0
7-18	22.4		32.0	14.1	15.0	13.0	2.9	1.6	1.0
7-25				4.5	6.0	7.0	30.0	55.0	13.0
8-1	9.8	12.0	14.0	5.6			1.8	1.9	5.0
8-26	10.0	13.0	12.0	4.8	7.0	6.0	27.0	33.0	17.0
9-15	5.4	21.0	27.0	14.4	20.0	5.0	30.0	33.0	22.0
9-22	9.0	10.0	25.0	15.4	17.0	7.0	27.0	31.0	21.0
11-2	9.0	1.0		1.4	1.1	4.0	4.1		
12-5	1.5	2.0	5.0	1.0	2.0	7.0		3.0	2.0
12-12	0.4	0.4		0.1	0.4		2.9	3.1	
12-27	0.1	0.2	3.0	0.6	4.0		0.4		
12-30	1.5	3.0	6.0	1.4	2.5	4.0	4.1	8.0	
1-11-28	0.4	1.0	4.0	1.2	1.2			5.0	6.0
1-16	12.6				12.0	10.0	9.0		
1-24	0.5	0.9	6.0	0.7	1.8	7.0	0.7	2.9	9.0
2-5	1.1	4.3	3.0	3.5	5.2	4.0	1.1	0.7	2.0
Averages	8.5	19.7	18.0	11.7	10.8	13.7	9.9	15.6	12.2
Grand Average		15.4			12.0			12.8	

1927	STATION 40			STATION 50			STATION 60		
6-24	8.8	21.2	10.0	2.0	6.0	17.5	22.5	32.0	16.2
6-27	12.4	46.0	15.0	7.4	14.2		145.2	76.0	55.0
7-1	58.8	62.0	27.0	14.4	22.0		140.0		182.0
7-8	2.0	1.3	1.0	4.7	12.0	6.0	95.2	115.0	78.0
7-11	3.9	7.0	11.0		9.0	4.0	77.0	420.0	510.0
7-15	5.5	8.8	12.0	8.4	7.5	7.0	14.4	32.5	500.0
7-18	4.2	1.4		5.6	8.0	5.0			
7-25	10.8	32.0	16.0	3.6	5.4	2.0	35.4	22.0	8.0
8-1	10.4	8.0	9.0	1.9	1.0	3.0	72.0	130.0	170.0
8-26	10.5	9.0	7.0	20.0	13.0	6.0	87.0	107.0	66.0
9-15	5.5	7.0	6.0	10.8	15.0	14.0	31.0	53.0	37.0
9-22	15.6	15.0	14.0	11.4	10.0	9.0	66.6	72.0	88.0
11-2	1.6							14.0	20.0
12-5	1.5			2.0			5.0	4.3	
12-12	.7	0.7	2.0		5.8		7.2		
12-27	0.1	2.2	2.1	0.1	4.8		9.8	9.0	
12-30	1.8		4.0	3.1	2.4	4.0		14.0	22.0
1-11-28	0.4	0.2	3.0	0.1		1.0		36.0	15.0
1-16	23.0	33.0	54.0		28.0				
1-24	11.2	1.2	3.0				14.3	20.2	42.0
2-5	2.6	1.7	1.0	1.3	0.8	2.0		28.0	25.0
Averages	9.0	14.3	10.9	6.0	9.6	6.1	54.8	69.7	107.8
Grand Average		11.4			7.2			77.4	

TABLE 6,
Cont'd

DILUTION	STATION 70			STATION 80			STATION 90		
DATE	0.1	.01	.001	0.1	.01	.001	0.1	.01	.001
5-17-27	10.5	3.4		2.4	11.2		1.5	1.5	
6-29	12.0	3.2	2.0	12.7	35.0	8.0	14.1	31.0	9.0
7-6	18.2	21.0	35.0	11.0	10.0	10.0		4.0	3.0
7-13	27.8	34.0	17.0	8.1	4.5	4.0	140.0	20.0	8.0
7-20		51.0			16.0	39.0	7.2	30.0	14.0
7-28							12.0	40.0	20.0
8-4				18.0	17.0	30.0		17.0	3.0
8-11	7.2	18.0	9.0	14.2	9.3	11.0	10.8	22.0	13.0
8-23	30.0	18.0	17.0	18.0	16.0	3.0	13.0	14.0	7.0
8-30	40.0	32.0	17.0	21.0	20.4	16.0	12.0	13.5	6.0
9-13	12.2	36.0	17.0	14.4	20.0	10.0	8.4	7.0	6.0
9-20	35.0	26.0	23.0	65.8	73.0	81.0	39.0	43.0	34.0
11-22	9.0	2.0	90.0	4.0	18.0	9.0	32.0	14.0	70.0
12-1	3.0		8.0						
12-7							0.8	2.4	3.0
1-8-28		5.7	15.0				3.2	30.0	
1-19									34.0
2-2	6.4	3.0					2.7	3.3	4.0
Average	18.4	19.4	20.9	17.2	20.8	20.0	27.1	18.2	14.9
Grand Average		16.2			19.3			20.1	

	STATION 100			STATION 110			STATION 120		
5-17-27	2.7	6.8		12.1	26.0	3.0	4.2	9.0	5.0
6-29	16.9	31.0	6.0	23.4	32.0		47.6	21.0	6.0
7-6	5.6	3.2	5.0	12.0	7.0	5.0	43.0	5.8	5.0
7-13	6.5	17.0	7.0	18.2	8.4	2.0	11.2	18.0	8.0
7-20	16.7	46.0	61.0						2.7
7-28	13.2	13.0	9.0	12.0	10.2	15.0	5.5	1.0	6.0
8-4	12.0	13.0	6.0	36.0	31.0	27.0	11.4	16.0	3.0
8-11	6.2	5.8	7.0	13.0	10.4	12.0			
8-23	19.0	7.0	7.0	9.0	7.5	3.0	6.5	6.0	6.0
8-30	27.0	16.0	16.0	10.8	8.0	9.0	12.4	18.0	16.0
9-13	9.4	13.0	3.0	20.0	23.0		10.6	30.0	17.0
9-20	28.0	28.0				50.0			7.0
11-22	20.0	13.0					1.4	8.0	7.0
12-1				.3	1.5		.3	.3	
12-7	.2	0.2			10.7	30.0		11.8	
1-8-28		3.0	15.0	12.4	25.0		1.2		
1-19		5.1	19.0	0.3	0.3	1.0	21.0	27.0	20.0
2-2	4.2	.2							
Average	11.9	12.9	13.4	13.7	14.3	14.7	13.4	20.9	8.0
Grand Average		12.7			14.2			14.1	

Table 6 Cont'd

BACTERIAL COUNT - - THOUSAND PER M. L.
(48 hours at 20°C.)

Cedar River

DILUTION	STATION 10			STATION 20			STATION 30		
DATE	0.1	.01	.001	0.1	.01	.001	0.1	.01	.001
1927									
6-24	10.8		20.	16.8	32.			11.5	
6-27	16.8	24.		14.4	18.		19.2		
7-1	24.		35.	35.		37.			22.
7-8	5.2		8.	28.	28.		6.2	.6	
7-11	29.4			6.1	9.	19.	6.	6.	4.
7-15	18.6	22.		17.	15.	4.	4.1	9.	7.
7-18		14.	15.	6.	12.	4.	1.2	.9	3.
7-25				7.2	3.3	2.	12.		21.
8-1	2.5	3.	2.	5.2	2.	5.	1.8	2.	4.
8-26	9.	12.5	11.	6.0	6.5	5.	13.	19.	4.
9-15	22.4	31.	3.	17.6	18.	9.			19.
9-22	18.6	21.	11.	16.	23.	9.			36.
11-25	1.0	.4		1.4	.6		.8	.1	
11-29	9.5	9.	6.	1.3	2.1	2.0	2.	1.8	2.0
12-5	5.	7.2	7.	2.8	1.5	6.	.4	.3	.7
12-12	1.6	2.	2.	1.2	.5	3.	9.4	12.	11.
12-27	.8	.6	4.		1.2	8.	4.5	8.	8.
12-30	4.		6.	1.2	2.1	2.	3.	2.5	2.
1-11-28	3.9	2.3	6.	5.4	4.		5.6	11.	4.2
1-16	12.8	16.		3.8	22.	20.	11.	9.4	10.
1-24	1.	.8	1.	.9	.7	1.	.5	.6	4.
2-3	4.	4.6	11.	9.3	8.3	13.	2.9	3.2	2.
Average	10.0	10.6	6.2	17.5	9.9	6.8	12.2	9.3	9.1
Grand Average		8.9			11.4			10.2	

1927	STATION 40			STATION 50			STATION 60		
6-24		22.	25.	3.1			23.5	80.	15.
6-27	16.	16.		6.	11.		19.2	48.	110.
7-1		28.		18.2		22.	112.	560.	500.
7-8	4.1	1.1	3.0			27.	155.		340.
7-11	7.4	3.2	5.		7.		202.	378.	760.
7-15	6.4	10.2	18.	5.8	10.	4.	378.	660.	710.
7-18	2.2	.5	1.	2.2	3.5	2.0	840.		
7-25	14.4		26.	13.	6.	3.	27.6	22.	8.
8-1	4.	5.	3.	2.3	2.5	8.	66.	92.	130.
8-26	7.8	8.5	7.	17.5	15.	7.	90.	81.	51.
9-15	17.4	21.	6.	11.6	12.8	17.	63.	78.	60.
9-22	19.4	20.	6.	13.6	14.	11.	110.	93.	70.
11-25	.8	.1		.2	.2		3.	3.	4.
11-29	1.5	1.6	6.	2.	2.6	2.	14.5	15.	21.
12-5	1.2	1.3	1.		7.2	7.	13.		64.
12-12	3.6	2.5	4.	5.1	1.		12.	11.4	
12-27	1.7	3.3	4.	.5			15.	14.	16.
12-30	1.5	1.6	5.	3.4	2.6	3.0	15.	20.	19.
1-11-28	1.5	2.2	2.	.3			16.9	39.	
1-16	4.7			10.	8.8	37.			
1-24	.7	11.	4.				12.9	22.	33.
2-3	2.8	3.4		1.4	11.	9.			
Average	5.9	8.1	7.4	6.4	8.5	11.2	108.6	130.3	112.4
Grand Average		7.1			8.7			117.1	

Table 6 Cont'd

DILUTION	STATION 70			STATION 80			STATION 90		
DATE	0.1	.01	.001	0.1	.01	.001	0.1	.01	.001
5-17-27	5.	9.6	8.7	30.	9.	38.	9.	38.	
6-29		15.	13.	19.2	30.	19.	18.9	31.	12.
7-6	16.		6.4	30.8	40.	34.	5.	21.	9.
7-13	37.8		34.	25.2		14.	22.4	18.	6.
7-20	28.	51.	38.	16.8	41.	36.	14.		21.
7-28							22.	17.5	4.
8-4				10.	18.	20.	19.2	9.	6.
8-11	8.4	15.	11.	10.8	10.	12.	13.2	16.6	27.
8-23	57.	41.	18.6	19.	19.	12.	16.8	15.5	10.
8-30	32.	30.	21.	7.	6.5	8.	17.	13.	4.
9-13	28.8	27.2		13.2	13.	14.	23.6	12.2	24.
9-20	27.	21.	20.						13.
9-22		40.	90.	26.	32.	38.	17.	22.	30.
12-1	8.	9.	12.	2.8	10.			4.	
12-7							4.2	2.2	
1-8-28	2.8	2.7	2.3				2.7	5.4	
1-19-28							2.3	16.	32.
2-2	11.	8.5						8.	12.
Average	21.9	22.5	20.2	18.4	20.7	21.0	14.5	15.5	15.0
Grand Average		21.5			20.0			15.0	

1927	STATION 100			STATION 110			STATION 120		
5-17	8.	11.2							
6-29	14.9		8.	18.		31.		19.	22.
7-6	3.6	3.4	6.				26.6	16.	11.
7-13	12.7	13.	18.		18.	31.		34.	
7-20	36.4		7.6	7.	20.	10.	28.	27.	21.
7-28	12.	10.6	7.				19.4	20.	31.
8-4	15.6	10.4	12.	5.4	4.3		6.	4.	4.
8-11	7.6	8.0	8.	32.		21.	7.	10.4	4.
8-23	36.	16.	9.	18.5	12.	11.			
8-30	31.5	20.	19.	7.5	12.	4.	4.6	5.5	5.
9-13	6.	18.	7.	13.3	21.2	7.			35.
9-20	36.4	33.	18.	27.4		18.	12.4	17.5	19.
9-22	16.	21.	12.	17.	29.	22.	7.	23.	21.
12-1	.9	2.1	3.	3.	11.	12.	1.9	21.	26.
12-7	2.3	1.	16.	4.3	4.	1.	2.8	3.	1.
1-8-28	2.5	11.	13.	3.7	18.	14.	7.5	3.	
1-19	3.9	8.4		13.2		20.	.6	23.	11.
2-2	2.3	7.8	6.	1.0	2.	3.	.8	4.1	2.
Average	13.7	12.1	14.8	12.2	13.7	14.6	9.5	15.3	15.0
Grand Average		13.5			13.5			13.2	

Table 6 Cont'd

BACTERIAL COUNT - - THOUSAND PER M L.

Cedar River

DILUTION	48 Hours at 20°C. STATION 130			24 Hours at 37°C. STATION 130		
DATE	0.1	.01	.001	0.1	.01	.001
5-17-27	5.6	5.6				
6-29	19.6	19.6		27.6		
6-6	37.8	8.1	35.0	12.6	14.	12.
7-13	24.5	22.4	2.0	25.	42.	
7-20	30.0	35.0	21.0	3.6	26.	1.
7-28	4.1	8.0	7.0	10.5		33.
8-4				5.5	5.	7.
8-11	32.0	21.5	17.0			
8-23	10.5	15.2	7.0	19.	15.4	14.
8-30			21.0	9.	7.5	9.
9-13	17.0		42.0	12.	16.	15.
9-20	2.4	2.0		21.	22.	20.
11-22	1.8	12.0	15.0	26.	9.	
12-1	.3	.7	1.0	1.8	6.	40.
12-7		6.1		2.	1.6	1.
1-8-28		38.0	30.0	3.6	4.7	6.
1-19	1.3	2.3	5.0	2.6	6.5	32.
2-2				.4	7.7	7.
Averages	14.3	14.0	14.4	11.3	13.1	15.1
Grand Av.		14.3			13.1	

TABLE 7

Average Laboratory Results
Over Period April, 1927 to February, 1928
LaPorte City to Columbus Junction
Cedar River

Sta. No.	D.O. p.p.m.	B.O.D. p.p.m.	Oxygen Balance p.p.m.	Total Bacterial Counts per ml. 48 hr. at 20°C.	24 hr. at 37°C.	% positive tests for coli-aerogenes in 0.1 ml.	.01 ml.	.001 ml.	Avg. coli-aerogenes per 100 ml. Phelps' Index	Reed's Index
10	9.7	7.3	+2.4	8,900	15,400	100	40	15	22,400	51,700
20	9.6	7.2	+2.4	11,400	12,000	91	53	9	18,500	42,700
30	9.7	7.5	+2.2	10,200	12,800	91	14	7	21,000	49,300
40	9.1	6.6	+2.5	7,100	11,400	91	24	4	3,300	7,700
50	9.1	6.3	+2.8	8,700	7,200	93	38	0	13,000	30,000
60	7.7	12.3	-4.6	117,100	77,400	100	100	100	70,900	163,800
70	7.3	8.6	-1.3	21,500	16,200	100	81	33	58,100	134,300
80	8.6	8.6	0.0	20,000	19,300	100	83	24	31,000	71,600
90	7.8	7.6	+0.2	15,000	20,100	100	65	11	27,500	63,500
100	7.6	7.3	+0.3	13,500	12,700	100	59	0	16,000	38,000
110	8.3	7.0	+1.3	13,500	14,200	82	50	0	14,800	34,100
120	8.0	6.7	+1.3	13,200	14,100	74	26	0	2,900	6,700
130	8.6	6.4	+2.2	13,100	14,300	82	44	0	5,400	12,500

Table 8 lists the total number of bacteria both at thirty-seven degrees and at twenty degrees for the stream between Waverly and Columbus Junction for the 1930-31 period. On the last page of table 9 are given the average bacterial counts for the period. The average counts are expressed graphically in chart 29 of the Appendix II. It will be noted in the thirty-seven degree counts that at station 1 the total number is 18,400. At station 2 the count increases to 40,000, and at stations 3 and 4 there are again decided decreases. At station 6 immediately below Waterloo, the total count increases to 66,900 and from this point to station 50 above Cedar Rapids there is a gradual decrease, reaching a low figure at station 40 of 3,900. Below Cedar Rapids there is again a tremendous increase to 55,400 and at station 80 a sudden decrease to 14,700, which shows remarkable bacterial purification in such a short section of the stream. From this point there is a gradual improvement to station 130. The average twenty degree counts follow the same trend except that these counts are, as would be expected, for the most part considerably higher than the thirty-seven degree counts. In the portion of the stream relatively unpolluted, the twenty degree counts are also higher than were the thirty-seven degree counts. The highest point reached in the stream was below Waterloo, 104,800.

In comparing these results with the 1926-1927 results, it will be noted that there is not a significant difference in bacterial counts at points in the river below the major sources of pollution in spite of the differences in stream flow. There is, however, a significant difference in the portions of the stream above the major sources of pollution, in that the bacterial content in the 1930-1931 period is much greater than for the 1927-1928 period. On the whole, the counts for the 1930-1931 period are abnormally high for clean water and the only conclusion can be that in no portion of the river from Waverly to Cedar Falls has the stream recovered from the bacterial pollution. The results above Cedar Falls indicate that the stream water shows the effect of pollution discharged above.

The total number of bacteria in a stream water does not, of course, have the same significance as does the presence of organisms of the B. coli group. Most of the organisms as represented by total counts are harmless. Many of these bacteria will multiply under the proper environment in stream water if the temperature is high enough, and if the proper material of an organic nature upon which bacteria feed is present, multiplication is to be expected. During the 1930-1931 period the stream water was so rich in organic material that many of these bacteria could multiply. Consequently bacteria in large numbers would persist for great distances below the sources of pollution, and no doubt these factors are responsible for the high bacterial content of the stream water throughout its entire course.

Bacterium Coli and Aerogenes

In table 10 are recorded the B. coli and aerogenes content of the stream water between LaPorte City and Columbus Junction for the 1927-1928 period. The results are expressed quantitatively. Quantitative determinations were made by the successive dilution method and numerical results are expressed in the table according to the Phelps method, using the reciprocal of the smallest dilution in which organisms of the coli-aerogenes group were found. To obtain an accurate index it is necessary

Table 8
Cedar River
Bacteriological and Chemical Analysis
October 29, 1930
From Waverly to Columbus Junction

Sta.	Bact. per ml. 37°C. L.L.	20°C. N.A.	Acid Col.	B. Coli	Nitrogen as Ammonia N.	Album. N.	Nitrite N.	Nitrate N.	Alk. to Methyl Orange	Cl.
1	100	500	0	0	0.060	0.100	0.004	0.5	101	28
2	100	6,000	0	10	0.060	0.100	0.002	0.7	101	26
3										
4	100	300	0	0	0.060	0.100	0.002	0.7	101	18
5	200	1,000	0	0	0.140	0.056	0.004	0.7	100	16
6	30,000	28,000	1,000	100	0.500	0.100	0.004	0.5	103	22
7	1,000	20,000	0	10	0.500	0.160	0.004	0.5	101	22
8	100	15,000	0	10	0.280	0.100	0.001	0	105	42
9	100	400	0	100	0.060	0.100	0.002	0	101	50
10	100	1,500	0	10	0.060	0.120	0.002	0	101	14
20	100	7,000	0	0	0.060	0.160	0.001	0	99	28
30	100	4,000	0	0	0.060	0.120	0.001	0	99	22
40	100	300	0	0	0.060	0.100	0.004	0.5	95	16
50	100	1,400	0	0	0.140	0.120	0.004	0.5	97	20
60	100	1,300	0	100	0.280	0.100	0.004	0.3	100	26
70	100	80,000	0	10	0.280	0.240	0.004	0.7	97	30
80	200	400	0	0	0.060	0.180	0.007	0.5	101	22

Table 8 (Continued)
Cedar River
Bacteriological and Chemical Analysis
November 20, 1930

Sta.	Bact. per ml. 37°C. L.L.	20 C. N.A.	Acid Col.	B. Coli	Nitrogen as Ammonia N.	Album. N.	Nitrite N.	Nitrate N.	Alk. to Methyl Orange	Cl.
1	9,000	12,000	0	0						
2										
3										
4	290	9,000	0	1	0.070	0.090	0.001	0.1	182	19
5	2,500	3,000	0	1	0.070	0.090	0.001	0.3	182	18
6	3,000	15,000	20	100	0.250	0.120	0.001	0.3	178	22
7										
8	1,000	3,600	300	1	0.250	0.140	0.004	0.1	184	22
9	460	9,000	0	10	0.170	0.120	0.004	0.1	180	21
10										
20	3,300	12,000	0	10	0.170	0.300	0.000	0.1	152	19
30	330	3,000	0	0	0.030	0.140	0.001	0.1	168	18
40	540	15,000	0	0	0.030	0.140	0.001	0.1	170	19
50	440	12,000	0	0	0.070	0.140	0.000	0.1	170	17
60										
70	900	9,000	50	10	0.250	0.200	0.000	0	174	25
80	420	3,000	0	10	0.070	0.300	0.000	0.1	178	22
90	1,070	9,000	0	1	0.070	0.300	0.000	0	184	21
100	400	9,000	0	10	0.070	0.200	0.000	0	170	20
110	640	9,000	0	1	0.070	0.120	0.000	0.1	164	20
130	540	9,000	0	1	0.070	0.140	0.000	0	156	14

Table 8 (continued)
Cedar River
Bacteriological and Chemical Analysis
January 9, 1931

Sta.	Bact. per ml. 37°C. L.L.	20°C. N. A.	Acid Col.	B. Coli	Nitrogen as Ammonia N.	Album. N.	Nitrite N.	Nitrate N.	Alk. to Methyl Orange	Cl.
1	200	78,000	*100	0	0.300	0.060	0.002	0.7	244	23
2										
3	100	120,000	*100	100	0.400	0.050	0.001	0.7	226	30
4	500	42,000	*100	10	0.300	0.050	0.001	0.7	218	18
5	400	30,000	*100	10	0.250	0.050	0.001	0.5	232	20
6	120,000	C.P.	C.P.	1000	0.600	0.090	0.001	0.5	238	28
7	10,000	120,000	*100	1000	0.600	0.120	0.002	0.5	232	26
8	10,000	180,000	300	1000	0.600	0.300	0.004	0.5	232	32
9	100	60,000	*100	10	0.300	0.090	0.002	0.5	220	20
10	100	60,000	*100	100	0.450	0.090	0.004	0.5	228	26
20	100	20,000	*100	0	0.450	0.060	0.004	0.5	224	22
30	300	7,000	*100	10	0.400	0.080	0.002	0.5	228	20
40	100	13,000	*100	0	0.450	0.080	0.002	0.7	224	22
50					0.450	0.060	0.002	0.7	228	18
60										
70	2,600	90,000	100	100	1.000	0.120	0.004	0.5	232	28
80	1,400	48,000	*100	10	0.700	0.120	0.004	0.5	232	30
90	500	78,000	*100	1000	0.600	0.090	0.002	0.5	236	19
100	100	78,000	*100	100	0.700	0.120	0.002	0.5	236	23
110	200	30,000	*100	0	0.600	0.080	0.004	0.5	230	20
130	300	5,400	*100	10	0.250	0.080	0.004	0.5	216	9

*Less than
C.P. - Crowded Plate

Table 8 (Continued)
Cedar River
Bacteriological and Chemical Analysis
January 28, 1931

Sta.	Bact. per ml. 37°C. L.L.	20°C. N.A.	Acid Col.	B. Coli	Nitrogen as Ammonia N.	Album. N.	Nitrite N.	Nitrate N.	Alk. to Methyl Orange	Cl.
1	*100	30,000	0	0	0.300	0.050	0.007	1.0	238	26
2										
3	100	2,300	0	10	0.400	0.050	0.010	1.0	240	28
4	500	4,000	0	0	0.170	0.050	0.010	0.7	220	20
5	300	15,000	0	0	0.250	0.050	0.010	0.7	218	18
6	500	25,000	0	100	1.500	0.120	0.020	0.7	222	24
7	200	10,000	0	0	0.450	0.090	0.020	0.7	216	22
8	100	8,000	0	100	1.000	0.060	0.040	0.5	218	32
9	100	2,000	0	10	0.300	0.090	0.030	0.7	200	23
10	300	50,000	0	0	0.700	0.060	0.030	0.7	198	8
20										
30										
40	*100	20,000	0	0	0.600	0.090	0.030	0.7	202	35
50										
60										
70										
80										
90										
110										
130										

*Less than

Table 8 (Continued)
Cedar River
Bacteriological and Chemical Analysis
July 9, 1931

Sta.	Bact. per ml. 37°C. L.L.	20°C. N.A.	Acid Col.	B. Coli	Nitrogen as Ammonia N.	Album. N.	Nitrite N.	Nitrate N.	Alk. to Methyl Orange	Cl.
1	6,000	4,200	*10	0	0.030	0.120	0.007	0	160	15
2	9,000	9,000	*10	10	0.030	0.200	0.004	0	140	24
3	30,000	12,000	20	100	0.030	0.140	0.004	0	148	14
4	9,000	15,000	*10	1	0.030	0.140	0.004	0	148	14
5	6,000	12,000	100	0	0.030	0.120	0.004	0.1	142	28
6	3,600	C.P.	100	100	0.400	0.140	0.010	0	164	23
7	30,000	C.P.	10	10	0.300	0.250	0.007	0.1	164	21
8	6,000	18,000	*10	10	0.450	0.120	0.050	0	162	26
9	9,000	C.P.	100	100	0.070	0.250	0.050	0	158	23
10										
20	C.P.	24,000	*10	100	0.170	0.250	0.004	0.1	130	18
30	6,000	9,000	*10	10	0.070	0.200	0.007	0	136	25
40	7,200	12,000	*10	10	0.070	0.120	0.004	0	136	20
50	4,800	6,000	*10	1	0.070	0.250	0.004	0	120	22
60										
70	C.P.	C.P.	*10	100	0.400	0.140	0.050	0	150	39
80	4,800	4,800	30	100	0.070	0.140	0.050	0	148	40
90	1,000	1,000	*10	1	0.070	0.250	0.004	0	152	32
100	1,000	450	*10	1	0.070	0.140	0.007	0	156	38
110	1,500	1,000	10	0	0.070	0.120	0.004	0	148	36
130	3,000	15,000	*10	0	0.070	0.120	0.007	0	140	30

*Less than

C.P. - Crowded Plate

Table 8 (Continued)
Cedar River
Bacteriological and Chemical Analysis
July 23, 1931.

Sta.	Bact. per ml. 37°C. L.L.	20°C. N.A.	Acid Col.	B. Coli	Ammonia N.	Nitrogen as Album. N.	Nitrite N.	Nitrate N.	Alk. to Methyl Orange	Cl.
1	C.P.	C.P.	*10		0.100	0.120	0.004	0	156	20
2	6,000	24,600	10		0.070	0.120	0.002	0	144	15
3	7,800	C.P.	10		0.030	0.090	0.004	0	162	16
4	5,200	10,800	50		0.070	0.250	0.002	0	158	15
5	12,000	C.P.	110		0.100	0.120	0.002	0	150	12
6	C.P.	C.P.	C.P.		0.450	0.250	0.004	0	154	17
7	C.P.	C.P.	C.P.		1.000	0.300	0.002	0	172	34
8	C.P.	C.P.	70		0.070	0.100	0.007	0	158	22
9	18,000	14,400	10		0.600	0.200	0.010	0	162	32
10	6,000	C.P.	*10		0.070	0.140	0.010	0	162	26
20	3,500	C.P.	*10		0.070	0.140	0.002	0	152	32
30	5,400	16,800	*10		0.070	0.140	0.002	0	124	25
40	11,000	25,200	*10		0.070	0.140	0.002	0	118	22
50	13,000	27,000	130		0.100	0.250	0.002	0	126	22
60										
70	C.P.	C.P.	70		0.600	0.120	0.030	0	138	29
80	C.P.	C.P.	10		0.200	0.200	0.040	0	142	38
90	18,000	48,000	*10		0.070	0.200	0.002	0	142	35
100	C.P.	C.P.	30		0.100	0.250	0.002	0	142	36
110	26,000	16,200	30		0.100	0.200	0.002	0	132	30
130	C.P.	C.P.	20		0.070	0.200	0.002	0	114	26

*Less than
C.P. - Crowded Plate

Table 8 (Continued)
Cedar River
Bacteriological and Chemical Analysis
August 7, 1931

Sta.	Bact. per ml. 37°C. L.L.	20°C. N.A.	Acid Col.	B. Coli	Nitrogen as Ammonia N.	Album. N.	Nitrite N.	Nitrate N.	Alk. to Methyl Orange	Cl.
1	42,000	138,000	*100	0	0.100	0.120	0.004	0	168	24
2	120,000	234,000	*100	0	0.070	0.100	0.002	0	146	19
3	C.P.	C.P.	*100	0	0.070	0.120	0.002	0.1	166	18
4	20,000	13,000	*100	0	0.070	0.120	0.002	0	140	11
5	90,000	330,000	*100	0	0.100	0.140	0.002	0	134	11
6	120,000	414,000	*100	1,000	0.300	0.200	0.002	0	142	11
7	C.P.	114,000	*100	1,000	0.500	0.140	0.002	0	150	21
8	C.P.	114,000	*100	100	0.700	0.200	0.025	0	146	16
9	15,000	23,000	*100	0	0.200	0.200	0.020	0.1	144	21
10										
20	1,000	Broken plate	*100	0	0.100	0.140	0.002	0	104	24
30	1,400	5,700	*100	0	0.100	0.200	0.002	0	96	24
40	1,700	10,000	*100	0	0.100	0.160	0.002	0	100	23
50	7,000	8,500	300	0	0.150	0.180	0.002	0	108	15
60										
70	34,000	32,000	*100	1,000	0.700	0.140	0.007	0	134	32
80	18,000	27,000	*100	0	0.100	0.200	0.007	0	142	34
90	6,000	19,000	100	0	0.070	0.140	0.002	0	146	32
100	5,000	10,000	*100	0	0.100	0.200	0.002	0	148	37
110	6,000	13,000	*100	10	0.070	0.180	0.002	0	144	34
130	3,000	7,000	*100	0	0.070	0.160	0.002	0	138	29

*Less than

C.P. - Crowded Plate

Table 8 (Continued)
Cedar River
Bacteriological and Chemical Analysis
August 20, 1931

Sta.	Bact. per ml. 37°C. L.L.	Bact. per ml. 20°C. N.A.	Bact. per ml. Acid Col.	B. Coli	Nitrogen as Ammonia N.	Nitrogen as Album. N.	Nitrogen as Nitrite N.	Nitrogen as Nitrate N.	Alk. to Methyl Orange	Cl.
1	53,000	95,000	*100	100	0.100	0.090	0.004	0	174	33
2	27,000	18,000	*100	0	0.070	0.180	0.004	0	160	23
3	55,000	120,000	300	0	0.100	0.120	0.004	0.1	172	22
4	50,000	65,000	*100	0	0.070	0.180	0.004	0	168	15
5	40,000	78,000	*100	0	0.100	0.140	0.002	0.1	150	11
6	240,000	C.P.	1900	1000	1.250	0.300	0.004	0	170	38
7	138,000	C.P.	2600	1000	0.350	0.200	0.004	0	160	14
8	37,000	90,000	*100	100	1.250	0.250	0.050	0	150	24
9	20,000	35,000	*100	0	0.400	0.140	0.040	0	148	29
10	19,000	32,000	*100	0	0.070	0.120	0.040	0.1	152	21
20	5,000	22,000	*100	0	0.070	0.220	0.004	0	130	28
30	12,000	26,000	*100	0	0.070	0.140	0.002	0	118	20
40	3,400	6,000	*100	0	0.090	0.140	0.004	0	128	20
50	21,000	29,000	*100	0	0.090	0.120	0.002	0.1	130	22
60	C.P.	C.P.		1000	0.400	0.200	0.002	0	140	35
70	180,000	270,000	500	1000	0.500	0.140	0.004	0	146	35
80	20,000	72,000	*100	0	0.090	0.140	0.004	0	148	30
90	1,100	18,000	*100	0	0.100	0.160	0.004	0.1	152	33
100	1,400	15,000	*100	0	0.090	0.180	0.004	0	142	27
110	44,000	84,000	*100	0	0.100	0.180	0.004	0.1	140	25
130	1,400	24,000	*100	0	0.080	0.140	0.002	0.1	148	27

* Less than

C.P. Crowded Plate

Table 9
Total Counts
B. Coli and Coli-Aerogenes Group per Milliliter
Waverly to Columbus Junction
Cedar River

Sta.	Sept. 24, 1930 B. Coli	Sept. 24, 1930 Coli-Aero. Group	Oct. 29, 1930 B. Coli	Oct. 29, 1930 Coli-Aero. Group	Nov. 20, 1930 B. Coli	Nov. 20, 1930 Coli-Aero. Group	Jan. 9, 1931 B. Coli	Jan. 9, 1931 Coli-Aero. Group	Jan. 28, 1931 B. Coli	Jan. 28, 1931 Coli-Aero. Group
1			0	0	0	0	0	0	0	0
2			10	10						
3							100	100	10	10
4	0	0	0	0	1	1	10	10	0	0
5	100	100	0	0	1	1	10	10	0	0
6	1000	1000	1000	1000	100	100	1000	1000	100	100
7	1000	1000	100	100			1000	1000	0	10
8	1000	1000	10	100	1	10	1000	1000	100	100
9	10	10	1000	1000	10	10	10	10	10	10
10	0	10	10	10			100	100	0	0
20	0	0	0	10	10	10	0	0		
30	0	0	0	10	0	1	10	10		
40	0	0	0	0	0	10	0	0	0	0
50			0	0	0	0				
60			100	100						
70			10	1000	100	100	100	100		
80			0	10	10	10	10	100		
90					1	10	1000	1000		
100					10	10	100	100		
110					1	10	0	100		
130					1	1	10	10		

Table 9, Cont'd.
Total Counts
B. Coli and Coli-Aerogenes Group per Milliliter
Waverly to Columbus Junction
Cedar River

Sta.	July 9, 1931 B. Coli	July 9, 1931 Coli-Aero. Group	July 23, 1931 B. Coli	July 23, 1931 Coli-Aero. Group	Aug. 7, 1931 B. Coli	Aug. 7, 1931 Coli-Aero. Group	Aug. 20, 1931 B. coli	Aug. 20, 1931 Coli-Aero. Group	Averages B. coli	Averages Coli-Aero. Group
1	0	0	0	10	0	100	100	100	12.5	26.3
2	10	10	0	100	0	100	0	100	4.	64.0
3	100	100	1	10	0	100	0	1000	35.2	220.
4	1	1	0	10	0	100	0	10	1.3	14.7
5	0	0	0	100	0	1000	0	10	12.3	135.7
6	100	100	100	100	1000	1000	1000	1000	600.	600.
7	10	10	100	100	1000	1000	1000	1000	526.3	527.5
8	10	10	100	100	100	1000	100	100	269.0	380.
9	100	100	0	10	0	100	0	0	126.7	138.9
10			0	10			0	10	18.3	23.3
20	100	100	0	1	0	100	0	0	13.8	27.6
30	10	10	0	1	0	10	0	10	2.5	6.5
40	10	10	0	1	0	10	0	10	1.1	4.6
50	1	10	0	100	0	1000	0	0	.2	185.
60							1000	1000	550.	550.
70	100	100		100	1000	1000	1000	1000	385.	485.7
80	100	100		100	0	10	0	10	20.	48.6
90	1	1		10	0	1000	0	0	200.4	336.8
100	1	1		100	0	100	0	0	22.2	51.8
110	0	0		100	10	100	0	10	2.2	53.3
130	0	0		100	0	1000	0	10	2.2	186.8

Table 9, Cont'd.
Total Counts
B. coli and Coli-Aerogenes Group per Milliliter
Waverly to Columbus Junction
Cedar River

Sta.	B. coli/100 ml. Phelps' Index	B. coli/100 ml. Reed's Index	Bacteria per ml. 37°C. L.L.	Bacteria per ml. 20°C. N.A.	Acid Colonies
1	1,250	2,900	18,400	51,100	0
2	400	924	40,500	58,300	2
3	3,520	8,100	18,600	94,100	55
4	130	300	9,700	19,300	13
5	1,230	2,800	17,000	61,500	42
6	60,000	138,600	66,900	104,800	604
7	52,750	121,900	49,900	82,800	652
8	38,000	87,800	22,300	60,200	136
9	13,890	32,100	12,300	30,000	55
10	1,830	4,200	6,300	31,500	0
20	1,380	3,200	4,000	14,100	0
30	250	577	4,100	9,600	0
40	110	254	3,900	12,300	0
50	20	46	9,200	14,000	108
60	55,000	127,000			
70	38,500	88,900	55,400	96,200	144
80	2,000	4,620	14,700	25,900	10
90	20,040	46,300	6,300	28,800	50
100	2,220	5,100	1,600	22,500	15
110	220	508	13,100	25,500	13
130	220	508	1,600	9,700	10

Table 10

ORGANISMS OF COLI-AEROGENES GROUP PER 100 ML.
CEDAR RIVER
LA PORTE CITY TO COLUMBUS JUNCTION
APRIL 1927 TO FEB. 1928

Numbers computed using Phelps method

DATE	STATIONS					
	10	20	30	40	50	60
4-13			10,000	10,000	10,000	10,000
6-24	100,000	10,000	1,000	10,000	1,000	100,000
7-1	100,000	100,000	100,000	1,000	0	10,000
7-8	100,000	100,000	100,000	1,000	100,000	100,000
7-11	100,000	1,000	1,000	0	1,000	100,000
7-15	1,000	1,000	1,000	1,000	10,000	100,000
7-18	0	0	0	0	10,000	100,000
7-25		10,000	10,000	10,000	10,000	10,000
8-1	0	10,000	1,000	1,000	10,000	100,000
8-26	1,000	1,000	10,000	10,000	10,000	100,000
9-15	1,000	1,000	10,000	1,000	1,000	100,000
9-22	1,000	1,000	1,000	10,000	10,000	100,000
11-25	0	10,000	1,000	1,000	1,000	10,000
11-29	1,000	100,000	1,000	1,000	0	100,000
12-5	1,000	1,000	1,000	1,000	0	100,000
12-12	10,000	10,000	1,000	10,000	0	100,000
12-27	1,000	1,000	100,000	1,000	1,000	100,000
12-30	10,000	10,000	100,000	1,000	10,000	100,000
1-11	10,000	10,000	1,000	1,000	0	10,000
1-16	1,000	1,000	10,000	1,000	100,000	
1-24	0	0	0	0	0	10,000
2-3	10,000	10,000	10,000	1,000	1,000	100,000
Av.	22,400	18,476	21,363	3,317	13,000	70,900
Reed's Index	51,700	42,700	49,300	7,700	30,000	163,800

Table 10 (Continued)

Cedar River Coli-Aerogenes Con'd from prev. page.

DATE	STATIONS						
	70	80	90	100	110	120	130
4-13	1,000	10,000	10,000	10,000	10,000		
6-29	-	-	100,000	10,000	10,000	10,000	10,000
7-6	100,000	1,000	1,000	1,000	1,000	1,000	1,000
7-13	100,000	100,000	10,000	1,000	0	0	10,000
7-20	1,000	10,000	10,000	10,000	0	1,000	1,000
7-28			10,000	10,000	1,000	1,000	1,000
8-4		10,000	10,000	10,000	100,000	1,000	10,000
8-11	100,000	100,000	100,000	100,000	10,000	10,000	-
8-23	100,000	10,000	1,000	10,000	1,000	1,000	
8-30	100,000	10,000	1,000	1,000	10,000	10,000	10,000
9-13	100,000	100,000	100,000	10,000	10,000	10,000	10,000
9-20	10,000	10,000	10,000	1,000	1,000	0	1,000
11-22	100,000	10,000	10,000	10,000	100,000	0	1,000
12-1	1,000	1,000	1,000	100,000	0	0	1,000
12-7	-	-	100,000	0	0	1,000	10,000
1-8	1,000		1,000	10,000	1,000	1,000	-
1-19	-	-	10,000	1,000	1,000	1,000	10,000
2-2	100,000		10,000	1,000	10,000	1,000	0
Av.	58,142	31,000	27,500	16,444	14,777	2,882	5,428
	134,300	71,600	63,500	38,000	34,100	6,700	12,500

that the smallest dilution inoculated give a negative result. It is not always possible in the laboratory to predict what dilutions are necessary so that a negative result will be obtained. Consequently in some of the results the lowest dilution which is inoculated indicates the presence of organisms of the B. coli group, and in this respect the results are not absolutely reliable. Actually, the coli-aerogenes content is greater than indicated on the table since without doubt, in some instances where the smallest dilution indicated the presence of organisms of this group, a still smaller dilution would also have indicated the presence of these organisms.

Confirmation tests were made on all gas-formers. However, in the 1927-1928 work no attempt was made to differentiate between B. coli and B. aerogenes. Where no organisms of this group are indicated, it must be remembered that the greatest inoculations made were never greater than one milliliter, whereas in many instances the greatest inoculation was .1 milliliter of water. No doubt greater quantities of water would invariably have shown the presence of organisms of this group.

In table 7 are given the average figures for the coli-aerogenes group per 100 milliliters. In the first column the numbers are computed from the Phelps index, simply using the reciprocal of the lowest dilution in which the result was positive. The second column indicates the results according to Reed's index, which is based upon the results of numerous determinations indicating that the most probably number or organisms of this group is 2.31 times the reciprocal of the lowest dilution in which the organism was found. In the Reed index, therefore, the results would be 2.31 times the result obtained by using the Phelps index. The average coli-aerogenes content is shown in Chart 17, Appendix II.

As was the case with the total bacterial count, the coli-aerogenes content at station 10 is high, namely 51,700. This no doubt is due to the effect of the Waterloo sewage discharged some distance upstream. There is a slight improvement at station 20, 42,500, and a slight increase at station 30, 49,400. At station 40 there is a decided improvement and at station 50 there is a decided increase, which no doubt is due to the accumulation of sludge in the stream at the location of this sampling point. At station 60 the coli-aerogenes content is 171,600, showing a tremendous increase. From this station to station 130 there is a gradual but decided improvement, reaching a low figure of 7,800 at station 120.

On the first and second pages of table 9 are given the figures for quantitative B. coli and B. aerogenes determinations for the stream from Waverly to Columbus Junction for the 1930-1931 period. The procedure was the same in this series of tests as in the 1927-1928 series, except that differentiation has been made between B. coli and B. aerogenes. On Page 2 of the same table are given the average results of the B. coli determinations based both on the Phelps index and Reed's index. B. aerogenes are not included in these average compilations. These results are expressed graphically in Chart 28. The B. coli content at station 1 is relatively low, namely 2,900 per 100 milliliters. While there is some variation, this content remains relatively low until station 6 is reached, where an average of 138,600 B. coli per 100 milliliters is reached. At station 7 the average content is 121,900, at station 8 87,800, and from this point to station 50 there is a gradual and decided increase until at station 50 the B. coli content is only 46 per 100 milliliters. At station 60 the content again jumps to 127,000 and remains high until station 100, and from this point to station 130 there is a sharp decrease, the content at station 130 being only 508 per 100 milliliters.

Due to the fact that in the 1927-1928 results differentiation was not made between B. coli and aerogenes, direct comparison of the results of the two surveys cannot be made. In both instances, however, a tremendous increase occurred below Cedar Rapids and in 1930-1931 a similar tremendous increase was noted below Waterloo.

B. coli, unlike any of the soil bacteria, does not readily multiply in water and it is significant to note the tremendous reduction in B. coli content some distance below the sources of pollution.

The United States Public Health Service has made a study of numerous water filter plants and concludes that with the best type of water treatment known, 10,000 B. coli per 100 milliliters is the maximum load which can be placed upon such water treatment plant if the final effluent is to be consistently safe and potable. It will be noted from the average results that this figure of 10,000 is very greatly exceeded below the major sources of pollution, and is exceeded at more than one-half the sampling stations along the entire course of the stream. Thus the Cedar River is unfit as a potential source of water supply throughout a great portion of the stream studied in this survey even though a most modern type of purification plant were installed. Cedar Rapids is the only city included in this survey which uses Cedar River water. The average B. coli results during the 1930-1931 survey indicate that the water was in such condition during this period when it reached Cedar Rapids that it could safely be used after treatment in the existing elaborate plant. The previous period of 1927-1928, however, indicated a higher B. coli content at this point of the stream in spite of the fact that greater dilution was available.

This apparent discrepancy in the results can very easily be accounted for by the fact that at the higher stages in 1927-1928 the velocity of the stream was greater and the B. coli from Waterloo sewage would be carried down the stream much faster and many of the organisms would reach Cedar Rapids before being destroyed. At the low stages, with the decreased velocity, the time of passage from Waterloo to Cedar Rapids would be greatly increased and thus far greater numbers of the organisms would be destroyed before they reached Cedar Rapids. Thus, insofar as B.coli content is concerned, the conditions at some distance below the points of heavy pollution are more acute at normal stream stages than at the extremely low stages. Cedar Rapids has had considerable difficulty with obnoxious tastes and odors in the water supply during the past year in spite of the very elaborate treatment. No doubt much of this taste is due to the pollution of the stream above Cedar Rapids and to the algae content of the stream,which in turn depends upon the pollution largely for food.

A further conclusion is that there is great danger of the spread of disease through the medium of dairy animals having access to a stream as heavily polluted with sewage bacteria as the Cedar River is. Dairy cows having access to such polluted water are likely to pick up disease-producing bacteria on their udders and underside of the body. These bacteria in turn may be transferred mechanically to the milk during the milking process. Since milk is an excellent medium for the propagation of many of the disease-producing bacteria, unless all milk from dairy herds having access to a stream like the Cedar River is pasteurized, the use of such milk constitutes a serious public health hazard.

A further conclusion must be that the stream, through most of its course, is absolutely unfit for bathing purposes and for other recreational purposes where contact with the water is required, due to the high bacterial content. Clinical evidence bears this out, in that hundreds of cases of eye, ear, nose, throat and skin infections have been reported by physicians along the Cedar River, and these physicians have stated that the source of infection was the Cedar River water. This has particularly been true among the bathers who frequent the bathing beach at Waterloo, which is below the Cedar Falls sewer outlet. There have been a number of cases of typhoid fever reported from below Waterloo following a flood of the Cedar River, and the source of infection has been reported by the physicians as the Cedar River water. With the laboratory findings coupled with the clinical evidence, there can be no doubt but that a serious health hazard is present in the Cedar River due to the heavy pollution.

Oxygen Findings

The dissolved oxygen and biochemical oxygen demand findings for the three periods are recorded in tables 11, 12 and 13. Since the surveys were not continuous, the interpretation of the oxygen findings will be considered in three parts.

In the 1926-27 survey from Waverly to LaPorte City, the oxygen conditions of the stream were for the most part good. See table 11. However, below Waterloo a moderately heavily polluted stream was indicated. At no time during this period was the oxygen low enough to destroy fish life and at most of the sampling points there was a positive oxygen balance at all times. The lowest dissolved oxygen recorded for the period was 3.3 parts per million, which occurred below Waterloo on May 27, 1926. The highest biochemical oxygen demand was 12 parts per million, which occurred on August 4, 1926, at the same station. The lowest oxygen resources in terms of percentage of saturation occurred on January 31, 1927, when the water at the station immediately below Waterloo contained only 25 per cent of the saturation figure for dissolved oxygen.

Attention is called to table 17 showing the stream discharges at Waterloo during August and September, 1926. Figures throughout the period on stream discharges are not available. However, these figures are representative for the flows during the period of sampling. It will be noted that the discharges are uniformly high compared with the minimum flows which have been recorded in times past, and which have occurred since that time. These rather high discharges during the period of survey are no doubt responsible for the rather favorable oxygen conditions in this portion of the stream.

TABLE 11

Results of Oxygen and Biochemical Oxygen Demand Determinations
Waverly to LaPorte City
1926 - 1927
Cedar River

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	%Saturation	B.O.D.
	May 27, 1926				June 1, 1926			
1	21	7.3	81.3	3.1	20	10.1	110.1	6.3
2	21	3.3	36.8	1.2	20	6.3	69.4	6.2
3	21	5.3	59.2	3.4	20	4.4	48.0	1.0
4	21	6.9	76.7	5.0	20	4.7	51.2	3.1
5	21	5.8	64.5	4.7	20	4.5	49.1	2.3
	May 28, 1926				June 3, 1926			
6	20	6.9	75.2	5.1	19	8.2	87.7	6.1
7	20	6.0	65.4	5.0	19	5.3	56.7	4.2
8	20	5.6	61.1	4.6	19	3.9	41.7	3.4
9	20	6.4	69.8	5.6	19	7.2	77.0	6.4
	June 7, 1926				June 14, 1926			
1	18.5	9.1	96.3	1.9	20	8.2	89.5	2.3
2	18.5	8.8	93.2	3.6	20	6.5	70.8	3.5
3	18.5	10.1	107.0	4.6	20	5.5	61.0	1.8
4	18.5	9.0	95.3	4.8	20	6.3	68.7	2.0
5	18.5	7.4	78.4	2.2	20	5.5	60.0	2.2
	June 9, 1926				June 16, 1926			
6	21.5	11.5	129.1	8.3	19.5	6.6	71.3	3.2
7	21.5	14.2	159.4	11.4	19.5	6.6	71.3	3.6
8	21.5	11.7	131.3	10.7	19.5	6.3	68.1	3.4
9	21.5	11.4	127.9	9.8	19.5	7.2	77.8	3.6

Table 11 (Continued)
Cedar River

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
	June 21, 1926				June 28, 1926			
1	19.5	9.7	104.9	2.8	20.5	6.0	74.2	1.2
2	19.5	9.4	101.6	5.1	20.5	5.5	60.5	4.6
3	19.5	10.5	113.5	4.7	20.5	5.4	58.5	2.2
4	19.5	7.6	82.2	4.6	20.5	6.5	71.6	2.2
5	19.5	7.7	83.2	4.0	20.5	7.6	83.7	3.4
	June 23, 1931				June 30, 1926			
6	21.5	9.5	106.6	7.5	21.5	5.1	57.2	5.7
7	21.5	7.0	78.6	6.4	21.5	5.0	56.1	5.7
8	21.5	8.2	92.0	7.0	21.5	5.8	65.1	5.4
9	21.5	10.8	121.2	8.9	21.5	9.8	110.0	9.0
	July 7, 1926				July 12, 1931			
1	26.5	5.0	61.4	2.8	24.5	7.4	78.3	1.4
2	26.5	5.5	67.6	3.4	24.5	10.7	126.6	7.1
3	26.5	8.6	105.7	6.3	24.5	9.5	112.4	4.8
4	26.5	5.9	72.5	2.4	24.5	8.6	101.8	3.3
5	26.5	4.0	49.1	1.9	24.5	8.4	99.4	2.2
	July 8, 1926				July 14, 1931			
6	24	4.1	48.1	3.3	27.5	5.7	71.2	4.4
7	24	3.6	42.2	3.4	27.5	6.3	78.7	6.5
8	24	3.5	41.0	3.2	27.5	6.6	82.5	6.9
9	24	5.3	62.1	2.7	27.5	5.6	70.0	9.6

Table 11 (Continued)
Cedar River

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
	July 19, 1926				July 26, 1926			
1	25.5	7.5	80.5	2.4	23	8.6	99.2	2.4
2	25.5	3.7	39.7	3.6	23	7.2	82.9	5.8
3	25.5	4.3	48.2	1.2	23	7.8	89.9	3.8
4	25.5	8.2	98.8	5.9	23	6.9	79.5	5.1
5	25.5	6.1	73.5	5.5	23	6.4	73.7	5.5
	July 21, 1926				July 28, 1926			
6	22	6.0	67.9	6.5	27	6.0	74.3	8.1-
7	22	5.7	64.5	6.5-	27	5.9	73.1	6.0-
8	22	7.5	84.9	8.7-	27	9.3	115.2	9.2
9	22	8.4	95.1	8.1	27	11.0	136.3	8.8
	Aug. 2, 1926				Aug. 9, 1926			
1	23.5	7.6	88.3	2.5	21	8.1	90.0	2.6
2	23.5	9.0	104.7	4.7	21	4.8	53.4	2.5
3	23.5	8.6	100	3.0	21	7.8	87.4	3.9
4	23.5	9.3	108.1	4.2	21	13.0	144.6	8.4
5	23.5	7.8	90.7	3.0	21	9.9	110.1	6.6
	Aug. 4, 1926				Aug. 11, 1926			
6	24.5	9.0	106.5	9.0	26.5	7.6	93.4	9.6
7	24.5	9.8	116.0	11.1-	26.5	7.8	95.8	7.0
8	24.5	9.4	111.2	9.6-	26.5	8.6	105.6	8.4
9	24.5	12.4	146.7	12.0	26.5	8.8	108.1	7.0

Table11 (Continued)
Cedar River

	August 16, 1926				August 23, 1926			
Sta.	Temp.	D.O.	% Sat-uration	B.O.D.	Temp.	D.O.	% Sat-uration	B.O.D.
1	24.5	7.9	93.4	1.6	24.5	4.3	50.8	
2	24.5	8.2	96.9	5.6	24.5	5.9	69.7	4.8
3	24.5	6.2	73.8	2.3	24.5	7.0	77.8	4.3
4	24.5	7.0	82.8	3.1	24.5	6.3	74.6	4.5
5	24.5	9.4	111.2	6.6	24.5	7.0	82.8	3.6
	August 18, 1926				August 25, 1926			
6	23	7.4	85.2	5.5	24	4.4	51.6	6.8
7	23	9.8	112.9	7.9	24	12.0	140.7	10.4
8	23	9.8	112.9	6.9	24	7.8	91.4	8.7
9	23	12.4	142.8	9.9	24	11.0	129.0	8.7
	August 30, 1926							
1	24	7.8	91.5	1.9				
2	24	8.2	96.1	5.5				
3	24	7.4	87.4	2.8				
4	24	9.9	116.1	6.9				
5	24	10.3	120.7	6.3				
	September 1, 1926				September 8, 1926			
6	23.5	9.4	109.3	9.5	24	5.6	65.6	4.1
7	23.5	11.8	137.2	11.2	24	7.2	84.4	7.1
8	23.5	9.7	112.8	8.3	24	6.3	73.9	4.5
9	23.5	7.4	86.0	7.4	24	6.6	77.4	3.3

Table 11 (Continued)
Cedar River

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
	September 13, 1926				September 20, 1926			
1	15	10.8	106.4	5.1	20	9.0	98.2	3.9
2	15	8.3	81.7	4.4	20	8.6	93.8	5.3
3	15	10.6	104.4	6.4	20	8.6	93.8	6.0
4	15	12.6	124.1	8.2	20	10.0	109.0	6.4
5	15	10.7	105.4	5.4	20	6.3	68.7	6.1
	September 15, 1926				September 22, 1926			
6	21	9.4	104.6	10.3	20	8.3	90.5	4.3
7	21	11.8	131.3	9.3	20	4.8	52.3	2.0
8	21	9.1	101.2	8.0	20	7.5	81.8	4.6
9	21	9.2	102.3	7.1	20	7.0	76.3	3.0
	January 31, 1927				February 3, 1927			
1	1	6.2	43.6	2.7	2	9.6	69.4	9.6
2	1	10.8	75.9	7.6	2	11.9	86.0	10.1
3	1	10.8	75.9	7.4	2	10.5	75.9	10.5
4	1	3.5	24.6	1.4	2	12.7	91.8	11.9
5	1	11.5	80.8	5.7	2	16.5	119.2	14.7
	February 1, 1927				February 2, 1927			
6	0	12.4	84.8	9.8	0	9.8	67.0	6.2
7	0	8.8	60.2	4.6	0	11.3	77.3	10.3
8	0	8.6	58.8	7.7	0	8.8	60.2	9.0
9	0	8.8	60.2	6.3	0	9.4	64.3	8.4
10					0	7.9	54.0	5.0

TABLE 12

Cedar River

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	%Saturation	B.O.D.
	June 24, 1927				June 27, 1927			
10	20	6.8	75	4.0	23	7.5	86	5.8
20		6.7	73	3.2		6.5	75	4.6
30		6.6	72	3.3		6.3	72	3.9
40		6.5	71	3.3		7.3	84	4.9
50		5.8	64	1.1		7.4	85	3.8
60		7.0	77			7.0	81	
					June 29, 1927			
70					24	2.8	33	6.4
80						8.7	102	7.0
90						7.9	93	5.1
100						7.7	90	4.8
110						6.8	80	4.0
120						6.5	76	3.4
130						6.2	73	3.0
	July 1, 1927				July 8, 1927			
10	23	7.5	86	5.5	24	0.4	4	9.4
20		7.8	90	6.4		9.6	113	8.8
30		8.6	99	7.3		9.9	116	9.3
40		7.8	90	6.6		9.7	114	8.9
50		8.7	100	7.9		11.2	130	10.9
60		9.0	104	9.0		9.3	109	9.4
70								
80								
90								
100								
110								
120								
130								

TABLE 12 (Continued)

Cedar River

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
	July 11, 1927				July 15, 1927			
10	27	10.7	132	9.9	25	10.0	120	10.9
20		10.1	125	9.2		8.2	98	7.7
30		11.5	142	11.2		10.8	129	10.1
40		10.7	132	10.5		9.8	118	9.5
50		7.1	88	6.8		7.2	86	7.1
60		7.6	94			5.5	66	13.2
	July 13, 1927							
70	25	8.7	104	8.6				
80		9.5	113	9.4				
90		9.8	117	9.7				
100		8.3	99	8.2				
110		7.4	88	7.2				
120		6.0	71	5.1				
130		6.3	75	5.9				
	July 18, 1927				July 25, 1927			
10	25	10.3	123	10.2	24			
20		11.1	132	10.1		6.5	76	6.3
30		11.7	139	10.4		8.6	101	8.5
40		10.1	120	10.0		7.4	87	7.1
50		8.2	98	7.5		10.3	121	10.1
60		6.5	78	16.0		5.5	64	
	July 20, 1927				July 28, 1927			
70	24	8.0	94	8.4	24	7.5	88	13.2
80		8.1	95	8.0		8.0	94	9.2
90		7.6	89	12.4		7.8	91	8.8
100		7.5	88			6.5	76	10.0
110		9.0	106			7.7	90	9.2
120		9.0	106	9.2		9.2	84	9.6
130		9.1	107			10.0	117	

TABLE 12 (Continued)

Cedar River

Sta.	Temp.	D.O.	% Sat-uration	B.O.D.	Temp.	D.O.	% Sat-uration	B.O.D.
	August 1, 1927				August 15, 1927			
10	24	10.5	123	9.5	24	12.7	149	9.9
20		10.0	117	9.0		11.2	131	9.7
30		10.1	118	9.1		11.2	131	9.6
40		10.1	118	9.6		10.4	122	9.4
50		8.1	95	7.4		7.5	88	7.2
60		6.4	75			4.5	53	
	August 4, 1927				August 11, 1927			
70					24	6.0	70	6.8
80	24	7.8	91	13.2		6.5	76	8.0
90		7.5	88	8.0		6.5	76	10.0
100		7.9	93	12.4		6.5	76	8.4
110		9.6	110	9.2		6.4	75	9.8
120		9.6	110	10.0		6.0	70	7.2
130		7.5	88	8.0		6.1	71	-
	August 26, 1927							
10	24	10.0	117	9.5				
20		10.0	117	8.8				
30		10.8	127	10.6				
40		10.2	118	10.2				
50		11.3	132	9.1				
60		9.2	108	9.0				
	August 23, 1927				August 30, 1927			
70	25	10.4	125	7.6	24	9.4	110	10.8
80		10.2	123	9.2		9.2	108	14.8
90		9.1	108	6.0		8.0	94	12.0
100		7.7	92	10.0		7.4	87	8.8
110		11.1	134	10.0		9.8	115	12.8
120						9.6	112	10.8
130		9.2	108			8.1	95	

TABLE 12 (Continued)

Cedar River

Sta.	Temp.	D.O.	%Saturation	B.O.D.	Temp.	D.O.	%Saturation	B.O.D.
	Sept. 5, 1927				Sept. 15, 1927			
10		12.4		11.3		9.0		9.1
20		10.6		10.4		8.8		8.5
30		9.5		9.1		9.5		9.3
40		5.9		5.6		8.3		8.2
50		5.1		5.1		7.1		6.9
60		5.1				5.9		8.9
	Sept. 13, 1927							
70		5.2						
80		5.5		6.4				
90		5.0						
100		5.3		7.4				
110		4.7		9.0				
120		5.1		6.4				
130		5.4		6.8				
	Sept. 20, 1927				Nov. 25, 1927			
10					3	12.7	94	3.3
20		11.4		11.0		12.0	89	4.0
30		11.4		10.3		12.8	95	4.5
40		11.9		10.7		9.8	72	2.6
50		11.8		11.4		13.6	101	3.8
60		11.5		10.4		9.0	66	9.0
	Sept. 20, 1927				Nov. 22, 1927			
70		6.0		8.5	13	10.7	101	
80		7.9		7.8		11.2	105	4.2
90		7.8		7.6		11.7	110	3.3
100		8.4		8.3		12.3	117	4.9
110		7.2		7.7		13.3	125	7.4
120		7.2		7.0		12.5	118	5.0
130		8.5		8.4		12.0	114	5.7

TABLE 12 (Continued)

Cedar River

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	%Saturation	B.O.D.
	November 29, 1927				December 5, 1927			
10	6	12.4	99	2.5	1			7.4
20		13.1	105	3.9				8.3
30		13.2	106	5.4				6.1
40		12.8	102	2.8				7.0
50		13.1	105	3.8				6.2
60		13.8	111			11.2	80	16.5
	December 1, 1927				December 7, 1927			
70	2			8.8	1			
80		10.4	75	6.1				
90				6.1				10.3
100				5.8				8.1
110		11.3	81	2.3		7.0	49	
120		4.5	29			6.8	48	
130		10.2	74	4.5				8.3
	December 12, 1927				December 19, 1927			
10	0			7.4	0			7.5
20		14.0	96	5.6		13.8	94	6.7
30		13.5	92	9.9				
40		14.0	96	7.1		11.7	80	6.5
50		14.6	100	6.2		14.6	100	6.3
60				20.2				18.3
70								
80								
90								
100								
110								
120								
130								

TABLE 12 (Continued)

Cedar River

Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
	December 27, 1927				December 30, 1927			
10	0.5	7.1	49	3.9	0	13.5	92	9.0
20		12.6	87	8.4		10.9	74	8.0
30		8.8	61	6.1		6.9	47	
40		10.4	72	6.6		9.8	44	6.5
50		8.6	59	5.5				
60		7.1	49	13.4		13.1	89	19.6
					January 8, 1928			
70					0.5	8.1	56	6.6
80								
90						7.5	52	6.2
100						7.0	48	5.8
110						4.0	28	2.9
120						9.4	65	8.1
130						9.4	65	8.2
	January 11, 1928				January 16, 1928			
10	0.5	10.6	72	9.5	0.5	6.0	42	4.7
20		10.6	73	8.5		8.7	60	7.5
30		9.2	64	7.4		8.5	59	5.7
40		6.6	46	4.3		6.0	42	1.3
50		4.5	31	2.6				
60		4.5	31	7.6		6.2	43	
					January 19, 1928			
70								
80								
90					1	9.8	69	6.2
100						10.0	70	5.5
110						9.5	67	3.9
120						9.2	65	5.2
						11.0	77	6.6

TABLE 12 (Continued)

Cedar River

	January 24, 1928				February 3, 1928			
Sta.	Temp.	D.O.	% Sat-uration	B.O.D.	Temp.	D.O.	% Sat-uration	B.O.D.
10	1	6.0	42	2.1	0	7.0	48	4.7
20		7.0	49	2.5		5.0	34	1.9
30		6.3	44	1.4		6.6	45	3.5
40		5.9	41	4.0		4.3	29	1.6
50						4.9	33	2.2
60		7.0	49			5.3	36	9.0
					February 2, 1928			
70					0	4.5	31	
80								
90						3.7	25	2.1
100						4.1	28	1.1
110						6.5	44	3.0
120						6.6	45	5.6
130						10.3	70	5.3

TABLE 13

Cedar River

	September 25, 1930				November 20, 1930			
Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
1					13	10.3	97.2	3.3
2								
3								
4	24	9.2	107.8	5.5	13	10.2	96.2	2.4
5	23	9.5	109.4	6.1	11	11.8	106.5	2.2
6	23	9.1	104.8	8.9	12	11.0	101.6	6.4
7	20	5.7	62.2	5.3				
8	20	9.4	102.5	7.4	12	9.5	87.7	5.7
9	20	13.4	146.1	7.0	12	11.2	103.4	6.0
10	20	13.6	148.3	7.1				
20	21	10.6	117.9	7.7	13	9.2	86.8	6.3
30	21	10.3	114.6	7.1	14	14.6	140.8	5.3
40	21	8.8	97.9	6.5	13	13.5	127.4	5.5
50					13	12.4	117.0	4.3
60								
70					8	8.6	72.4	8.3
80					7	11.2	92.0	7.2
90					7	11.3	92.8	7.6
100					7	13.0	106.8	8.2
110					7	12.3	101.1	7.6
120					7	13.4	110.1	7.4
130					8	13.2	111.2	7.0

Table 13 (Continued)
Cedar River

	January 9, 1931				January 28, 1931			
Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
1	0	11.3	77.3	3.3	0	12.2	83.4	3.0
2								
3	0	12.8	87.5	3.6	0	12.1	82.8	3.6
4	0	13.5	92.3	4.4	0	12.5	85.5	3.4
5	0	13.4	91.6	4.7	0	12.0	82.1	3.3
6	2	12.5	90.3	18.6	3	12.0	89.0	20.7
7	0	10.4	71.1	6.6	0	9.6	65.7	7.5
8	0	9.2	62.9	13.2	0	8.4	67.4	15.0
9	0	12.1	82.8	5.9	0	12.8	87.5	8.3
10	0	9.4	64.3	5.8				
20	0	9.8	67.0	3.4		8.8		3.1
30	0	9.8	67.0	3.6				
40	0	10.0	68.4	4.4		9.3		3.3
50	0	10.3	70.4	3.4				
	January 8, 1931							
70	0	7.7	52.7	14.8				
80	0	7.1	48.6	6.4				
90	0	8.0	54.7	7.2				
100	0	7.7	52.7	4.4				
110	0	10.0	68.4	2.7				
120								
130	0	12.6	86.2	4.9				

Table13 (Continued)
Cedar River

	July 9, 1931				July 23, 1931			
Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
1	18	8.6	90.1	5.8	21	8.4	93.4	5.6
2	21	9.0	100.1	7.4	25	9.9	118.1	7.8
3	21	10.6	117.9	8.6	25	8.6	102.6	5.2
4	21	8.0	89.0	7.4	26	6.9	83.9	5.7
5	24	9.0	105.5	11.1	28	6.4	80.8	9.5
6	25	4.8	57.3	9.3	28	5.4	68.2	7.5
7	24	8.2	96.1	14.1	26.5	2.8	34.4	13.0
8	24	8.4	98.5	7.9	27	4.4	54.5	7.5
9	25	14.0	167.1	14.0+	29	7.6	97.8	6.3
10					29	10.8	139.0	8.7
20	24	8.4	98.5	7.9	30	16.0	209.7	13.6
30	25	13.4	159.9	11.9	31	17.0	227.6	14.7
40	24	10.2	119.6	9.2	30	7.4	97.0	7.4
50	24	5.0	58.6	5.0 +	30	3.5	45.9	3.5 +
	July 10, 1931				July 24, 1931			
70	22	4.0	45.3	12.6	25	2.8	33.4	8.5
80	24	11.6	136.0	11.2	26	9.6	116.8	9.5
90	24	12.6	53.9	11.3	30	15.0	196.6	13.2
100	25	12.8	152.7	10.1	29	13.0	167.3	11.8
110	26	11.4	138.7	10.0	31	11.6	155.3	10.8
120								
130	27	11.2	138.8	10.0	31	11.2	149.9	11.2 +

Table13 (Continued)
Cedar River

	August 7, 1931				August 20, 1931			
Sta.	Temp.	D.O.	% Saturation	B.O.D.	Temp.	D.O.	% Saturation	B.O.D.
1	24	6.2	72.7	4.6	20	7.4	80.7	4.2
2	28	6.0	75.8	3.7	23	11.6	133.6	6.4
3	27	6.9	85.5	2.9	23	7.8	89.9	3.8
4	29	7.5	96.5	6.1	25	8.0	95.5	4.4
5	29	4.0	51.5	6.8	26	9.5	115.6	6.5
6	29	5.0	64.3	20.5	27	7.9	97.9	14.5
7	28	3.2	40.4	21.5	26	4.2	51.1	19.5
8	29	4.0	51.5	7.7	25	4.5	53.7	6.5
9	30	6.3	82.6	5.6	28	12.4	156.6	7.8
10					27	12.8	158.6	6.8
20	30	12.6	165.1	6.4	27	16.0	198.3	11.2
30	31	10.5	140.6	4.8	27	15.0	185.9	10.6
40	30	4.5	59.0	9.4	27	12.2	151.2	8.6
50	30	3.5	45.9	6.0	26	9.8	119.2	7.4
	August 8, 1931				August 21, 1931			
60					23	2.1	24.2	14.5
70	28	2.7	34.1	18.0	22	4.4	49.8	17.0
80	28	7.4	93.4	12.0	22	11.8	133.6	12.3
90	29	13.2	169.9	11.9	23	11.6	133.6	7.1
100	29	12.1	155.7	9.9	23	12.2	140.6	8.1
110	30	7.6	100.0	7.6 +	24	11.2	131.3	7.8
120								
130	30	10.9	142.9	10.0	25	10.8	128.9	8.5

In Chart 2, Appendix II, is recorded the average dissolved oxygen and biochemical oxygen demand results for the period. As a general rule average figures for oxygen and dissolved oxygen are not reliable indices of pollution due to great deviation of individual results from the average, depending upon weather conditions and stream flow conditions. There can readily be a one hundred per cent deviation from the mean in twenty-four hours time and for this reason too much significance should not be placed on average figures. However, during the period of study, stream flow and weather conditions were rather uniform and the individual results were quite uniform and did not deviate as much from the means as is ordinarily the case. Consequently it was not thought worthwhile to draw up individual charts showing the dissolved oxygens and biochemical oxygen demands as represented by the individual samples and as is done with the results of analyses on samples from the lower part of the river. . . .

Table 12 gives the results of the dissolved oxygen and B.O.D. for the river between LaPorte City and Columbus Junction for the period 1927-1928. During this period the oxygen results were fairly good except below Cedar Rapids. The oxygen data are represented graph ically for each individual sample on Charts 3 to 15, Appendix II.

It will be noted from these charts that at the first station below Cedar Rapids there was a negative oxygen balance on twelve of the eighteen sampling dates. The lowest oxygen content was 3.7 parts per million at this sampling point on February 2, 1928.

Expressed in terms of per cent saturation, the lowest oxygen content was noted on this same date. The per cent saturation was 25%. The highest biochemical oxygen demand noted during the period was 20.2 parts per million, which occurred at this same station on December 12, 1927. Table 14 gives the results of the average dissolved oxygen and biochemical oxygen demand for the period of this survey and it will be noted that the average results for the period indicate a negative oxygen balance below Cedar Rapids. Chart 16, Appendix II, shows these average oxygen determinations graphically.

Attention is called to tables 18 and 19 showing the river discharges for the period 1927-1928. Here again the average and minimum discharges for the period of the survey at Cedar Rapids were considerably in excess of the past minimum recorded flows, and much higher than minimum flows which have been recorded since that time. Consequently it is to be expected that the oxygen conditions would be fairly good during this period.

The 1930-1931 results from Waverly to Columbus Junction are indicated in table 13, where conditions are quite different from the previous surveys. On Charts 19 to 26, inclusive, are shown the dissolved oxygen and B.O.D. for each sampling station on each individual date of sampling. During this period of time, at the first station below Waterloo, there was a positive oxygen balance on only two of the eight sampling dates. For the entire period the average negative oxygen balance was 8.1 parts per million. The lowest individual oxygen content occurred on July 23rd when 2.8 parts per million of oxygen was present at this sampling point. The highest biochemical oxygen demand was 21.5 parts per million on August 7th.

TABLE 14

Average Oxygen Data
Cedar River

Sta.	D.O.	B.O.D.	Oxygen Balance
	1926 - 1927 Waverly to LaPorte City		
1	7.9	2.8	+5.1
2	7.1	4.5	+2.6
3	7.6	3.9	+3.7
4	8.2	4.6	+3.6
5	7.0	4.2	+2.8
6	7.0	5.8	+1.2
7	7.9	6.8	+1.1
8	7.6	6.7	+0.9
9	9.0	7.3	+1.7
	1927 - 1928 LaPorte City to Columbus Junction		
10	9.7	7.3	+2.4
20	9.6	7.2	+2.4
30	9.7	7.5	+2.2
40	9.1	6.6	+2.5
50	9.1	6.3	+2.8
60	7.7	12.3	-4.6
70	7.3	8.6	-1.3
80	8.6	8.6	0.0
90	7.8	7.6	+0.2
100	7.6	7.3	+0.3
110	8.3	7.0	+1.3
120	8.0	6.7	+1.3
130	8.6	6.4	+2.2

TABLE 14 (Cont'd)

Average Oxygen Data
Cedar River

Sta.	D.O.	B.O.D.	Oxygen Balance
		1930 - 1931	
		Waverly to Columbus Junction	
1	9.2	4.3	+4.9
2	9.1	6.3	+2.8
3	9.8	4.6	+5.2
4	10.7	4.9	+5.8
5	9.4	6.3	+3.1
6	8.5	12.5	-4.0
7	5.3	13.4	-8.1
8	8.1	9.0	-0.9
9	11.2	8.1	+3.1
10	11.6	7.1	+4.5
20	11.4	7.5	+3.9
30	12.9	8.3	+4.6
40	9.5	6.8	+2.7
50	7.4	4.9	+2.5
60	2.1	14.5	-12.4
70	5.0	13.2	-8.2
80	9.8	9.8	0.0
90	11.9	9.7	+2.2
100	11.8	8.7	+3.1
110	10.9	7.7	+3.2
130	11.6	8.6	+3.0

Below Cedar Rapids the oxygen findings indicate still heavier pollution. At the first sampling station below Cedar Rapids, on only one occasion was there a positive oxygen balance and at this time there was only one-fourth part per million dissolved oxygen in excess of the biochemical oxygen demand. The lowest oxygen content at this sampling station for an individual sample was 2.1 parts per million, which occurred on August 20, 1931. The highest biochemical oxygen demand was recorded at this station on August 7, 1931, and was 18 parts per million. The average oxygen resources for the period, below Cedar Rapids, was minus 12.4 parts per million.

Chart 27, Appendix II, represents the oxygen results in the river for the period 1930-1931 based on the average dissolved oxygen and biochemical oxygen demand findings. The oxygen results are indicated in parts per million plus or minus and are computed by subtracting the average figures for the biochemical oxygen demand for the period from the average dissolved oxygen content for the period. It will be noted that the oxygen balance is negative throughout a great portion of the stream.

During this period of survey, no doubt the average stream flows were well below normal. Attention, however, is called to table 19 giving the river discharges for the period and, while the average discharges and the maximum discharges recorded during the period are very much below normal, it will be noted that the minimum flow recorded during the entire period was approximately 50% greater than the minimum flow previously recorded on the stream --see table 20. The minimum flow during the 1930-1931 period at Cedar Rapids was 620 c.f.s. whereas the minimum flow of 410 c.f.s. had previously been recorded at this point, and the average minimum flows for a period of twenty-six years was only 720 c.f.s., which is only slightly in excess of the minimum recorded during 1930-1931.

The tables and charts indicate a slight but perceptible change in oxygen conditions immediately below Cedar Falls. However, from a standpoint of oxygen, the condition below Cedar Falls has not approached an acute stage. Below Waverly, Cedar Heights, LaPorte City and Vinton there is no perceptible reduction in the oxygen content of the stream. This is to be expected in view of the small quantity of waste being discharged by these municipalities and the large dilution factor available. Below Waterloo and Cedar Rapids, however, these results indicate that an acute condition, insofar as oxygen is concerned, is reached during low flows. During most of the period there was sufficient oxygen to support fish life but the oxygen content on several occasions was so low that no doubt game fish migrated to cleaner waters to escape suffocation. The oxygen condition was always such that a slight change either in the pollution load on the stream or a further reduction in the flow of the stream would prove disastrous. This was evidenced by the fact that on June 23, 1931, the power dam gates at Waterloo were opened, thus permitting a sudden increase in the discharge of the stream. This increaseddischarge increased the velocity sufficiently so that solids, which had previously settled to the bottom of the stream, were stirred up and those solids in suspension so greatly increased the oxygen consuming load that fish were killed by the millions below Waterloo. At the higher river stages the oxygen findings indicate that the conditions are dangerously near an acute stage, as is evidenced by the 1927-1928 results.

It is further significant to note that oxygen conditions in the stream are not directly proportional to the discharge. It has been found in studies on other streams that the most acute conditions do not necessarily occur at times of absolute minimum stream flows, and it is obvious from a study of the oxygen records in this report that the dissolved oxygen content of the stream water was almost as low with stream discharges of 1,200 c.f.s. as it was when the discharge was only 620 c.f.s.

There are several reasons why this is true. When the stream is at an extremely low stage the water is spread in a thin sheet over the stream bed, and particularly where the stream bed is rocky a greater surface of the water is exposed to the atmosphere than during higher flows. Thus the opportunity for reaeration is better at extremely low flows.

A second factor is that during low flows the velocity above riffles is decreased, thus increasing the tendency for the solids to settle out within a short distance below the point of discharge of sewage. With more of the solids settled out, one would thus expect the stream to be in a worse condition immediately below the point of discharge but in a better condition farther downstream than would be the case where the solids were evenly distributed over the stream bed for some miles downstream. The results of the three surveys indicate this to be true.

A third important factor is the reaeration of the water by living plants. During the extremely low flows the water is shallower, is clearer and it is more heavily mineralized than during the higher flows. All three of these factors are necessary for the growth of algae and consequently at the extreme low flows a more profuse algae growth occurs than at higher stages. During the period of the 1931 survey, very profuse algae growths were noted on the Cedar River and there is no doubt but that the algae growths were a decided factor in preventing worse conditions from the standpoint of oxygen content than actually occurred. It is unusual to find during summer temperatures B.O.D's as high as 20 parts per million and still have dissolved oxygen in the water, yet during the summer of 1931 there were instances of high B.O.D. and at the same time the oxygen exceeded the saturation point. The only explanation can be that the algae are giving off the oxygen as fast, or almost as fast, as it is being consumed in the oxidation of the organic material. Algae of course are not present during the winter time and consequently if the low flows continue and if the river freezes over in long stretches, a complete depletion of oxygen in the stream below Cedar Rapids and Waterloo is almost a foregone conclusion.

A few results obtained during the winter of 1930-1931 cannot be considered representative conditions in this climate because the winter of 1930-31 was an extremely mild winter and at no time was the river completely frozen over for long stretches, thus cutting off the atmospheric oxygen supply. It is therefore predicted with confidence that if the stream flows remain low and if the weather is cold during the coming winter, the condition below both Waterloo and Cedar Rapids will become very acute from a standpoint of odor nuisances due to anerobic putrefaction and also from a standpoint of fish life in the stream.

OTHER CHEMICAL FINDINGS

Table 8 gives the results of analyses of the river water for ammonia nitrogen, albuminoid nitrogen, nitrite nitrogen, nitrate nitrogen, methyl orange alkalinity and chlorides.

Table 15 gives the average for the nitrogen determinations for each station during the period of the survey. It will be noted that below Waterloo there is an appreciable increase in the ammonia content with a gradual decrease to station 50 above Cedar Rapids. At station 70 below Cedar Rapids there is again a perceptible increase in ammonia nitrogen, with a decided improvement at station 80 and then a gradual improvement to station 130. These results simply augment the oxygen findings and are indicative of a rather heavy concentration of fresh organic pollution. While the ammonia nitrogen content is not especially high below the principal sources of pollution, yet the increase, which is approximately fourfold, is significant. The same thing, in a general way, is true of the albuminoid nitrogen content. However, the increases are not as great. Albuminoid nitrogen likewise indicates fresh organic pollution.

The nitrite nitrogen shows a perceptible increase at station 8 some miles below Waterloo, which is to be expected in a portion of the stream recovering from pollution. Since the nitrite content denotes the partially oxidized ammonia and albuminoid nitrogen, these figures indicate that excellent self-purification is taking place below Waterloo, The same is true below Cedar Rapids, and it is even more marked in that nitrification is apparently taking place within a shorter distance from the source of pollution.

The nitrate nitrogen content does not indicate any significant increases throughout the course of the stream. The nitrate content is uniformly quite low and would indicate that the purification has not reached the nitrate stage at any part of the stream.

The methyl orange alkalinity test indicated whether or not excessive acid wastes were being discharged into the stream, or wastes which had acid producing tendencies. The results, (see table 8) , however, do not indicate any significant changes in alkalinity throughout the course of the stream which might indicate material detrimental to fish life.

The chloride content (see table 8) indicates slight increases in the chloride content immediately below Waterloo and Cedar Rapids. However, the increases are not particularly great at these points. Since sewage and industrial wastes contain more chlorine as chloride than the normal stream water, these increases are simply additonal indicators of sewage pollution.

Phenol determinations. No specific samples were sent to the State Hygienic Laboratory for phenol determinations. However, there has been considerable complaint at Cedar Rapids relative to phenol tastes in the city water. This situation seemed to be worse when the city of Cedar Rapids was using the old water purification plant and before they began using the more elaborate type of treatment now used. Mr. C. O. Bates, the chemist at the city waterworks at Cedar Rapids, undertook a

TABLE 15

Results of Chemical Analyses
Average Nitrogen Content
Waverly to Columbus Junction
1930 - 1931
Cedar River

Sta.	Ammonia Nitrogen	Albuminoid Nitrogen	Nitrite Nitrogen	Nitrate Nitrogen
1	0.141	0.094	.0046	.314
2	0.060	0.140	.0028	.140
3	0.171	0.095	.0042	.316
4	0.105	0.122	.0032	.275
5	0.130	0.096	.0032	.300
6	0.656	0.165	.0058	.250
7	0.570	0.180	.0059	.257
8	0.575	0.160	.0226	.138
9	0.262	0.150	.0198	.175
10	0.270	0.106	.0172	.216
20	0.156	0.181	.0024	.100
30	0.114	0.143	.0024	.088
40	0.184	0.121	.0061	.250
50	0.153	0.140	.0023	.200
60				
70	0.533	0.157	.0141	.171
80	0.184	0.183	.0156	.157
90	0.163	0.190	.0023	.100
100	0.188	0.182	.0028	.083
110	0.170	0.147	.0027	.116
130	0.102	0.140	.0028	.100

long series of phenol determinations of the raw river water at the waterworks intake. In table 16 are recorded some of the results of the phenol determinations made by Mr. Bates. It will be noted that on the dates indicated, phenol was almost invariably present in the river water and on one date was present to the extent of eighty parts per billion, which is far above the maximum permissible phenol content if tastes are to be absent from chlorinated water which is used for drinking purposes.

There has also been considerable comp int that the fish taken from the Cedar River, particularly below Waterloo, are unfit to eat because of the taste, which is described by the complainants as " a gas house taste". There are gas plants at Waterloo, at Cedar Rapids and at Vinton, discharging small quantities of wastes into the stream. While accurate information as to the analyses of these wastes and as to the quantity discharged are not available, data from similar gas plants indicate that with the type of treatment employed at these gas plants it is easily possible that enough phenol will be discharged into the stream to impart objectionable tastes and odors to the water. In the three gas plants in question every possible effort is being made to eliminate tar and oil from the gas plant wastes, and their efforts have been quite satisfactory from this standpoint. However, the phenols are in solution and consequently any ordinary processes of settling or centrifuging are not effective in removing phenols. With the small quantities of phenols that are being discharged from these plants it is the opinion of the writer that, mixed with city sewage, these wastes could be successfully treated in an ordinary sewage treatment plant.

STREAM FLOW RECORDS

Unfortunately stream flow records for the Cedar River are very incomplete and not many data are available for the period of critically low flows during 1930-1931. Prior to 1927 the United States Geological Survey had stream gauging stations at Janesville and Cedar Rapids. Unfortunately these stations were discontinued. During a brief period of two months during the survey, Mr. K. Jetter, Engineer of the U. S. Geological Survey, set up a temporary station at Waterloo for the purpose of securing discharge measurements for these studies. Since 1927 there are no records available for the Janesville station. However, the Iowa Railway and Light Company have maintained the station at Cedar Rapids continually since that time.

In table 19 are tabulated the river discharges at Cedar Rapids for the period 1928 to the present time. These records were available through the courtesy of Prof. Floyd A. Nagler of the University of Iowa. Table 17 gives the stream discharges for August and September, 1926, at Waterloo and Cedar Rapids. Table 18 shows the stream discharges at Cedar Rapids(October, November and December, 1927), and table 20 gives the annual maximum and minimum discharges at the Cedar Rapids station for the past 26 years.

While these records are very incomplete, a study of them reveals several interesting factors in connection with these studies. The most significant fact is that the 1930-1931 low discharges (620 c.f.s.) were almost 50% greater than the lowest discharge previously recorded (410 c.f.s.). It is further significant to note that during the twenty-six years of record at Cedar Rapids, minimum discharges almost as low

TABLE 16

PHENOL DETERMINATIONS
in
parts per billion
At Cedar Rapids Waterworks Intake
Cedar River

Results by Prof. C. O. Bates

Date	River raw water	Date	River raw water
12-15-27	18.	12-16-27	3.
12-21-27	3.	12-22-27	2.
12-23-27	3.	12-24-27	0.
12-27-27	15.	12-28-27	10.
12-29-27	60.	12-31-27	13.
1-3-28	13.	1-4-28	7.
1-5-28	7.	1-6-28	4.
1-7-28	4.	1-9-28	0
1-10-28	9.	1-11-28	4.
1-12-28	3.	1-13-28	5.
1-14-28	7.	1-16-28	8.
1-17-28	6.	1-19-28	2.
1-20-28	3.	1-21-28	4.
1-23-28	4.	1-24-28	5.
1-25-28	5.	1-26-28	3.
1-27-28	5.	1-28-28	4.
2-1-28	4.	2-2-28	4.
2-3-28	3.	2-4-28	80.

have been recorded in a great majority of the years of record. In fact, taking an average of the minimum annual discharges over the twenty-six year period, we find that this average 720 c.f.s. is only about 15% greater than the minimum discharge in 1930-31.

It is true that the mean discharge for 1930-1931 is far below the average for the past twenty-six years. Likewise, the maximum flows recorded during 1930-1931 are very much lower than the maximum for other years of the period.

Since the low flows represent the critical periods in the stream pollution studies, the fact that the 1930-1931 minimums are above previous recorded minimums and not much less than the minimums of normal years, the stream discharge conditions during the period through which we are passing cannot be considered as abnormal from the standpoint of stream pollution, as might appear at first glance. It is true that during the past eighteen months there have been no periods of heavy discharge which would tend to flush out the accumulated material in the stream bed and thus be beneficial.

The records show that the Cedar River is unique for Iowa conditions in the uniformity of the minimum flows. There is perhaps no other stream in the state that has such uniform sustained dry weather flows as has the Cedar River. From these records it would appear that in estimating the carrying capacity of the stream, the data collected during this summer would serve as a very reliable index for future consideration, since these data were collected during a time of minimum flows which are comparable with the minimum flows that had occurred so uniformly in the past. It must therefore be concluded that the conditions as represented by the 1930-1931 studies will recur quite frequently with the recurrence of low water stages.

It is regretable that records for Waterloo are not available. However, a study of the records at Janesville would indicate that the flows at Waterloo are proportional to the flows at Cedar Rapids, although of course considerably less in quantity. Consequently the same conclusion must be made for the condition at Waterloo in the future.

TABLE 17

1926

Discharge in cubic feet per second of Cedar River at Waterloo & Cedar Rapids
(From original report)

	August			September			
	Waterloo		Cedar Rapids	Waterloo		Cedar Rapids	
	Gage	discharge	Discharge	Gage	discharge	Discharge	
				1.17	800	990	1
				1.16	790	990	2
				1.28	880	1120	3
				1.25	860	1120	4
				1.22	840	1410	5
				1.16	790	1490	6
7		760	1120	1.09	740	1410	7
				1.28	880	2740	8
				1.37	960	3150	9
				1.50	1070	2260	10
				1.68	1210	2050	11
12		870	1410			2150	12
				1.40	985	2150	13
				1.42	1000	1950	14
			1410	1.35	940	2050	15
			1260	1.31	910	2150	16
17	1.14	775	1120	1.30	900	2050	17
18	1.16	790	1340	1.30	900	1950	18
19	1.12	760	1190			5600	19
20	1.93	1410	1060	3.29	2620	8710	20
21	1.37	1800	990	2.63	2040	9720	21
22	1.73	1250	1570	2.60	2010	8050	22
23	1.68	1210	2260			6900	23
24	1.32	920	2150			5810	24
25	1.30	900	1850			6120	25
26	1.28	880	1490			5400	26
27	1.17	800	1260	2.20	1650	4590	27
28	1.18	810	1260			4290	28
29	1.12	760	1190			4000	29
30	1.10	745	1060			3570	30
31	1.10	745	990				31

Cedar Rapids Station approximately 70 miles downstream from Waterloo.
Power plant regulation affects flow at Cedar Rapids.

K. Jetter
Assistant Engr. U. S. G. S.

TABLE 18

Gauge Heights and Discharge for Cedar River
October 1927 to December 1927

Date	October Disch.	November Disch.	December Disch.
1	2160	1410	1260
2	3140	"	1260
3	3140	"	760
4	4570	"	870
5	5820	"	"
6	5820	1120	"
7	4870	"	1750
8	4208	"	1570
9	3710	"	"
10	3420	1260	980
11	3420	1120	1260
12	3140	"	1950
13	3140	1260	1120
14	2620	"	1260
15	2380	1570	1120
16	2380	1950	1570
17	2160	1750	1750
18	"	"	"
19	1950	1570	1350
20	"	1260	1570
21	"	"	1120
22	"	"	1260
23	"	"	1120
24	1750	"	"
25	1575	"	980
26	1400	"	1260
27	"	1410	980
28	"	1260	1950
29	"	1570	3720
30	"	1260	"
31	"		4000
Total	83,182	36,960	47,690
Mean	2,682	1,368	1,538

TABLE 19

Daily Discharges
Cedar River at Cedar Rapids
6,570 Sq. mi.

Used: Rating curve dated 11-7-27,
Curves - 1917, 1919 and 1924
Measurements
Extremes (1913-1914)

1928

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	2080	1370	1220	3310	1880	4450	2780	2780	1530	1880	1530	14800
2	3040	1370	1220	2300	1530	4750	2780	2530	1530	1880	1530	11100
3	3040	1370	720	2080	1080	5650	2530	2300	1370	1880	1700	9780
4	3040	1370	830	2530	1220	5350	2530	2300	1370	2080	2080	9780
5	4450	1370	830	2080	1080	5960	2530	2080	1370	2300	4450	9200
6	5650	1080	830	1700	1080	4450	2780	2080	830	2080	4750	7800
7	5650	1080	1700	1700	5350	3870	3870	2080	1370	2080	5350	6270
8	4750	1080	1530	1370	5350	3310	3870	2080	1370	2080	6270	5650
9	4160	1080	1530	1220	5350	4750	3870	2080	1700	2780	6580	5050
10	3590	1220	950	1080	5650	4750	4160	2300	1530	2780	6270	4750
11	3310	1080	1220	1080	5960	5960	3870	2080	1530	1880	4750	8470
12	3310	1080	1880	1220	12300	5960	3590	2080	950	1880	3870	6270
13	3040	1220	1080	1220	13000	8470	3310	1880	1530	3040	3310	5650
14	3040	1220	1220	1220	10100	8470	3310	1880	950	1880	3040	5350
15	2530	1530	1080	1530	8790	9200	3590	1880	1080	1530	2530	[illegible]
16	2300	1880	1530	1700	8790	8790	3870	1880	1080	1530	2530	5650
17	2300	1700	1700	1700	8470	9200	4160	1880	1220	1530	2530	5960
18	2080	1700	1700	1700	8470	5960	4160	2300	1530	1530	3040	6580
19	2080	1530	2080	1700	6890	5050	4160	4750	1700	2300	2300	6580
20	1880	1220	1530	2080	4450	4160	4450	4160	2080	3870	2080	6270
21	1880	1220	1080	2080	3590	3590	4450	2530	3040	4160	3870	5050
22	1880	1220	1220	1700	2530	3310	4750	2530	3040	2780	3590	4450
23	1880	1220	1080	1530	2530	3310	5350	2300	3310	2300	3310	3870
24	1880	1220	1080	1370	3590	3310	5350	2300	3870	2080	4450	3590
25	1700	1220	950	2530	3870	3040	4750	2300	3870	1530	4160	3040
26	1530	1220	1220	2300	3590	3040	4450	2080	3310	1530	5960	3040
27	1370	1370	950	2080	3040	3310	4160	1880	2780	1530	13700	2780
28	1370	1220	1880	1700	3590	3040	3310	1880	2300	1530	14400	2780
29	1370	1530	3590	1700	3590	2780	3310	1700	2300	1530	27800	2780
30	1370	1220	3590	1530	---	2780	3310	1700	2300	1530	25800	2530
31	1370	---	3870	1700	---	2780	---	1530	---	1530	18900	---
Mean	2670	1308	1510	1770	5050	4930	3780	2260	1920	2090	6340	6000

TABLE 19 (Continued)

Daily Discharges
Cedar River at Cedar Rapids
6,570 sq. mi.

1929

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	2530	4450	4750	4160	8470	3310	7200	19300	4150	2780	1700	1080
2	2300	4750	4750	5050	7800	3590	7200	15200	4450	2300	2780	1080
3	2300	7200	5050	3310	8150	3870	6880	11500	4750	2080	3050	1080
4	2300	8150	5350	3590	7510	3870	7520	9100	4450	2080	2300	1080
5	2530	8790	4750	3040	6890	3870	8100	7840	4150	1880	2530	1220
6	2530	8470	4450	3310	6270	3870	7840	6570	3870	1880	2530	1220
7	2300	7510	4750	3590	5650	6580	9400	5950	3600	2300	2530	1080
8	2300	6570	3040	3870	5650	5350	12200	5050	3300	2080	2530	950
9	2300	6890	4450	3870	6890	6270	15200	4750	3050	1880	2300	950
10	2080	6890	3590	4160	7510	7800	14400	4750	2780	2080	2080	950
11	2080	7200	3310	4750	6270	5350	14100	4750	2780	1880	1880	1220
12	2080	7800	3870	4450	6270	7510	11500	5050	2780	1880	1880	1220
13	2780	7200	4450	4450	5650	12600	10100	5950	3050	1700	1880	1220
14	2530	6890	6270	5650	5650	19700	9400	6260	2780	1880	1360	1360
15	2300	6580	6580	7200	4750	28700	10500	7840	2780	2530	1360	1360
16	2300	5960	7510	7200	4450	30700	11100	7520	2530	3600	1360	1360
17	2300	6270	8200	7510	4450	33300	10500	6570	2530	3300	1360	1360
18	4750	9450	8200	8150	4750	58400	8400	5950	2530	3300	1360	1360
19	4750	9200	7510	8790	4750	61700	7840	5650	2530	2780	1360	1360
20	6580	9200	6890	11800	5350	50600	7520	5350	2300	2530	1520	1360
21	7510	8790	5050	10100	4450	39100	7200	4750	2080	2300	1520	1220
22	8790	8150	4160	11500	4160	30000	6570	4450	2080	2080	1520	1080
23	8790	7200	4750	9450	3590	25300	5950	4150	2080	1880	1520	1080
24	7800	6580	3590	9450	3040	21300	5650	4150	2080	1700	1520	1080
25	6890	5650	3310	9780	3040	14400	5950	3870	2080	1700	1080	1080
26	5350	5650	3870	10100	3040	12300	6260	3870	1700	2080	1220	1080
27	4450	5050	4450	9450	3310	10800	6570	3600	2080	1880	1080	1080
28	4750	4750	5050	9780	3310	9450	7840	3600	1700	1700	1080	1080
29	4450	4450	5350	9780	- -	8470	11500	3600	1880	1520	1080	1080
30	4160	4750	5650	9450	- -	8150	19700	3870	1700	1520	1220	1360
31	4450	- -	5050	8790	- -	7200	- -	4150	- -	1520	1220	- -
Mean	3980	6850	5100	6950	5400	17500	9340	6290	2820	2150	1730	1170

TABLE 19 (Continued)

Daily Discharges
Cedar River at Cedar Rapids
6570 sq. mi.

1930

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.
1	1360	1080	840	950	1220	4150	1520	2080	1520	2530	1520	950
2	1360	1080	950	950	1080	3050	1700	2080	1520	2300	1360	840
3	1220	1080	950	1080	1080	2300	1520	2080	1520	2300	1360	950
4	1220	1360	950	950	1220	2300	1520	1700	1360	2300	1220	840
5	1220	1360	1360	1080	1220	1880	1520	1700	2080	2080	1220	840
6	1080	1360	1360	950	1220	3300	1520	2080	1880	2780	1360	840
7	1220	1360	1220	950	1080	2300	1360	2300	2080	3300	1360	950
8	1220	1220	1220	950	1220	2080	1360	2300	2300	3300	1520	840
9	1360	1220	1220	950	1220	2300	1700	2780	2530	3050	1360	840
10	1360	1080	1080	1080	1360	2080	1700	3600	2530	3050	1080	840
11	1080	1360	1080	1080	1520	1880	1520	3300	2300	2780	1080	950
12	1080	1360	1080	1080	1360	1880	1220	3300	2300	2780	1080	950
13	1220	1360	1080	1220	1220	1880	1080	3600	2300	2780	1080	840
14	1220	1220	1080	1080	1220	1880	1220	4450	2300	2780	1080	840
15	1360	1520	1080	1080	1220	1700	1360	3870	5050	2530	1080	840
16	1360	1700	1080	1220	1220	1700	1360	3600	6570	2300	1080	840
17	1360	1520	840	1080	1220	1700	1520	3300	6880	2300	1080	840
18	1360	1520	620	1080	1220	1700	1520	3300	6880	2080	1080	950
19	1360	1220	700	1080	1880	1880	1520	3050	6880	1880	1080	950
20	1080	1520	700	1080	3600	1880	2300	2780	6570	1700	1080	950
21	1080	1080	700	1080	3870	1880	2780	2530	6570	1700	1080	950
22	1080	1080	840	1080	8800	2080	2780	2530	5350	1700	1080	950
23	1220	1220	840	1080	10500	1880	3300	3870	5350	1520	1080	840
24	1080	1080	840	1080	11800	1880	3300	3050	4450	1520	1080	840
25	1080	1080	950	1080	11500	1880	3050	2780	4450	1520	950	840
26	1080	1220	1080	1080	8800	1700	2780	2530	3870	1520	950	840
27	1080	1360	950	1220	6570	1700	2530	2300	3300	1520	950	1220
28	950	1360	950	1080	4750	1700	2300	2080	3050	1700	1080	1220
29	950	1080	950	1220	---	1700	2080	2080	3050	1880	950	1360
30	1080	1080	1080	1220	---	1700	2080	1880	2530	1700	950	950
31	1220	---	950	1220	---	1880	---	1880	---	1700	950	950
Mean	1190	1270	988	1080	3360	2060	1900	2730	3640	2220	1140	923

TABLE 19 (Cont'd)

Daily Discharges of
Cedar River at Cedar Rapids
6,570 sq. mi.

1931

	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.
1	950	840	950	950	1700	1080	1080	1080	950	840		
2	950	840	950	840	1520	1080	1080	1080	950	840		
3	700	950	840	840	1520	1080	1080	1080	950	840		
4	840	840	840	700	2530	1080	1080	1080	840	840		
5	840	950	950	840	1520	1080	1700	1080	840	840		
6	840	840	950	840	1520	1080	1700	1080	950	700		
7	950	950	950	950	1520	1080	1700	1080	1080	700		
8	1220	950	950	950	1700	950	1700	1080	700	700		
9	1220	840	950	840	1360	1080	1700	1080	950	700		
10	950	840	950	840	1700	1080	1700	1080	840	700		
11	950	840	950	700	950	1080	1520	1080	840	700		
12	1080	840	1080	700	1080	950	1360	1080	700	840		
13	1080	840	950	1700	1080	1080	1080	1080	950	2080		
14	1080	840	1080	1700	1220	950	1080	1080	840	1520		
15	1080	950	840	840	840	950	1080	1080	840	840		
16	1220	1080	620	700	1080	950	1700	1080	700	840		
17	1220	1080	840	620	950	950	1700	1080	700	700		
18	1080	950	700	620	1080	1080	1700	950	700	700		
19	1080	950	700	620	1080	1080	1700	1080	700	620		
20	1080	1360	700	700	1080	840	1700	1080	700	840		
21	950	1220	840	700	1080	950	1700	950	700	700		
22	950	1360	840	840	1080	950	1700	950	700	620		
23	950	1700	840	700	1080	950	1700	950	700	620		
24	840	1220	840	700	1080	950	1700	950	700	620		
25	950	1080	840	700	1080	950	1700	950	700	620		
26	950	1080	840	1080	1080	950	1700	950	1220	620		
27	950	840	840	840	1080	950	1520	950	1080	620		
28	950	840	950	840	1080	700	1700	950	950	620		
29	950	700	1080	1080	---	950	1700	950	950	620		
30	950	840	840	1080	---	1700	1520	950	950	620		
31	950	---	840	1080	---	1080	---	950	---	620		
Mean	992	982	882	875	1270	1020	1530	1030	846	761		

TABLE 19 (Cont'd)

SUMMARY

	Maximum	Minimum	Mean	Inches of Run-off
1931				
October	1220	700	992	.17
November	1700	700	982	.17
December	1080	620	882	.15
January	1700	620	875	.15
February	2530	840	1270	.20
March	1700	700	1020	.18
April	1700	1080	1530	.26
May	1080	950	1030	.18
June	1220	700	846	.14
July				
August				
September				
The year	2530	620	1047	1.42

TABLE 19 (Cont'd)

Cedar River at Cedar Rapids
6,570 sq. mi.

SUMMARY

	Maximum	Minimum	Mean	Inches of run-off
1928				
October	5650	1370	2670	.47
November	1880	1080	1308	.22
December	3870	720	1510	.26
January	3310	1080	1770	.31
February	13000	1080	5050	.83
March	9200	2780	4930	.87
April	5350	2530	3780	.64
May	4750	1530	2260	.40
June	3870	830	1920	.33
July	4160	1530	2090	.37
August	27800	1530	6340	1.11
September	14800	2530	6000	1.02
The year	27800	720	3302	6.83
1929				
October	8790	2080	3980	.70
November	9200	4450	6850	1.16
December	8200	3040	5100	.89
January	11800	3040	6950	1.22
February	8470	3040	5400	.86
March	61700	3310	17500	3.07
April	19700	5650	9340	1.59
May	19300	3600	6290	1.10
June	4750	1700	2820	.48
July	3600	1520	2150	.38
August	3050	1080	1730	.30
September	1360	950	1170	.20
The year	61700	950	5773	11.95
1930				
October	1360	950	1190	.21
November	1700	1080	1270	.22
December	1360	620	988	.17
January	1220	950	1080	.19
February	11800	1080	3360	.53
March	4150	1700	2060	.36
April	3300	1080	1900	.32
May	4450	1700	2730	.48
June	6880	1360	3640	.62
July	3300	1520	2220	.39
August	1520	950	1140	.20
September	1360	840	923	.16
The year	11800	620	1875	3.85

U. S. Engineer Office
Rock Island, Illinois

TABLE 20

Discharge in Second Feet at Cedar Rapids
Cedar River

Year	Maximum	Minimum
1904	8835	
1905	22810	600
1906	50500	965
1907	19400	660
1908	20400	1100
1909	21000	840
1910	23700	810
1911	13100	
1912	54100	410
1913	21400	580
1914	16600	490
1915	32400	1100
1916	25300	800
1917	52600	740
1918	26200	565
1919	29700	775
1920	14400	550
1921	16300	788
1922		
1923	15700	554
1924	24500	600
1925	12200	730
1926		
1927	11500	
1928	27800	720
1929	61700	950
1930	11800	620
1931	2530	620
Average since 1904	24480	720

APPENDIX I

POLLUTION OF STREAMS - LAW

2198. Investigation of pollution of water. The department may upon its own initiative investigate the alleged pollution or corruption of any stream or body of water which is rendering the same unwholesome or unfit for domestic use, or as a public water supply, or which is rendering it deleterious to fish life, and the department shall make such investigation upon the written petition of:

1. The council of any city or town.
2. Any local board of health.
3. The trustees of any township.
4. Twenty-five residents of the state.

The power vested by this section in the department shall not apply, however, to the lower five thousand feet of any stream flowing into a river at a place where such river forms a part of the boundary line of the state.

2199. Time and place of hearing. After a full and complete investigation including bacteriological and chemical analysis of the water and location of the source of contamination, the department shall make an order fixing the time and place for a hearing which shall not be less than ten days thereafter. Such hearing shall be public and shall be carried on as far as possible in the same manner as a court hearing and every alleged offender shall have the right to appear by counsel, present testimony, and examine witnesses.

2200. Notice. Notice of the time and place of hearing shall be served upon each alleged offender at least ten days before said hearing in the manner required for the service of notice of the commencement of an ordinary action in a court record.

2201. Order. After such hearing the department may, if it believes the alleged offender is guilty of the charges, enter an order directing such person to desist in the practice found to be the cause of such pollution or corruption, or it may order a change in the method of passing waste materials into the water so that the same will be rendered innocuous and harmless. No order shall be issued under the provisions of this section that will require the expenditure of more than five thousand dollars (5000.00) without the written approval of a majority of the members of the state executive council.

2202. Reasonable time for compliance. If any such change is ordered, unless such practice is rendering such water dangerous to the public health, a reasonable time shall be granted to the offender in which to put in use the method ordered.

2203. Record. The department shall keep a complete record of such proceedings, including all the evidence taken, and such record shall be open to public inspection.

2204. Appeal. An appeal may be taken by the aggrieved party from any order entered in such proceeding to the district court of the county in which the alleged offense was committed. Such appeal shall be perfected by serving a written notice on the commissioner of public health within thirty days of the entry of such order.

2205. Transcript. Within thirty days after an application for appeal is filed with the commissioner, he shall make, certify, and file in the office of the clerk of the court to which the appeal is taken, a full and complete transcript of all documents and papers relating to the case.

2206. Trial term -- precedence. The first term after the appeal is taken shall be the trial term, and if the appeal is taken during a pending term, it shall be triable during such term at any time after ten days from the date that the transcript is filed by the commissioner. The hearing on appeal shall be tried as a suit in equity and shall be de novo.

2207. Violation of order -- contempt. Failure to obey any order made by the department with reference to matters pertaining to the pollution of streams shall constitute contempt. In such event the department may certify to the district court of the county in which such disobedience shall occur, or to the district court of Polk county, the fact of such failure. The district court shall then proceed to hear and determine the matter and to punish for contempt to the same extent as though such failure were in connection with an order made by the district court which is made punishable by contempt.

2208. Penalty. Any party found guilty of contempt under the preceding section shall be fined not to exceed one thousand dollars or be imprisoned for failure to pay such fine. The penalties provided in this section shall be considered as additional to any penalty which may be imposed under the law relative to nuisances or any other statute relating to the pollution of streams and a conviction under the preceding section shall not be a bar to prosecution under any other penal statute.

APPENDIX II

Chart Index

BUCHANAN
BREMER
BLACK HAWK
BENTON
Cedar
STA. 1
STA. 2
WAVERLY
JANESVILLE
STA. 3
STA. 4
River
CEDAR FALLS
WATERLOO
STA. 7
STA. 6
STA. 5
GILBERTVILLE
STA. 8
MT. AUBURN
LA PORTE CITY
STA. 9
BRANDON
URBANA
STA. 30
River
PALO
SHELLSBURG
STA. 10
Cedar
VINTON
STA. 20


BREMER
BUCHANAN
BLACK HAWK
BENTON
Cedar
River
STA. 1
STA. 2
STA. 3
STA. 4
STA. 5
STA. 6
STA. 7
STA. 8
STA. 9
STA. 10
STA. 20
STA. 30
WAVERLY
JANESVILLE
CEDAR FALLS
WATERLOO
GILBERTVILLE
LA PORTE CITY
MT. AUBURN
BRANDON
URBANA
SHELLSBURG
VINTON
PALO


CHART NO. 1
BUCHANAN
LINN
CEDAR
TIPTON
WILTON JCT.
ROCHESTER
STA. 90
MOSCOW
STA. 100
MT. VERNON
CEDAR BLUFFS
Cedar
STA. 80
MUSCATINE
STA. 70
STA. 30
URBANA
River
CEDAR RAPIDS
SOLON
WEST LIBERTY
MUSCATINE
BRANDON
HAWK
STA. 60
STA. 50
PALO
STA. 40
STA. 110
BERTVILLE
STA. 8
STA. 10
SHELLSBURG
Cedar
MT. AUBURN
NICHOLS
LA PORTE CITY
STA. 9
VINTON
STA. 20
IOWA CITY
MYRTLE
STA. 120
STA. 7
STA. 6
STA. 5
River
JOHNSON
STA. 130
BENTON
Iowa
River
COLUMBUS JCT.
LOUISA
MAP SHOWING
SAMPLING STATIONS
ON THE
CEDAR RIVER

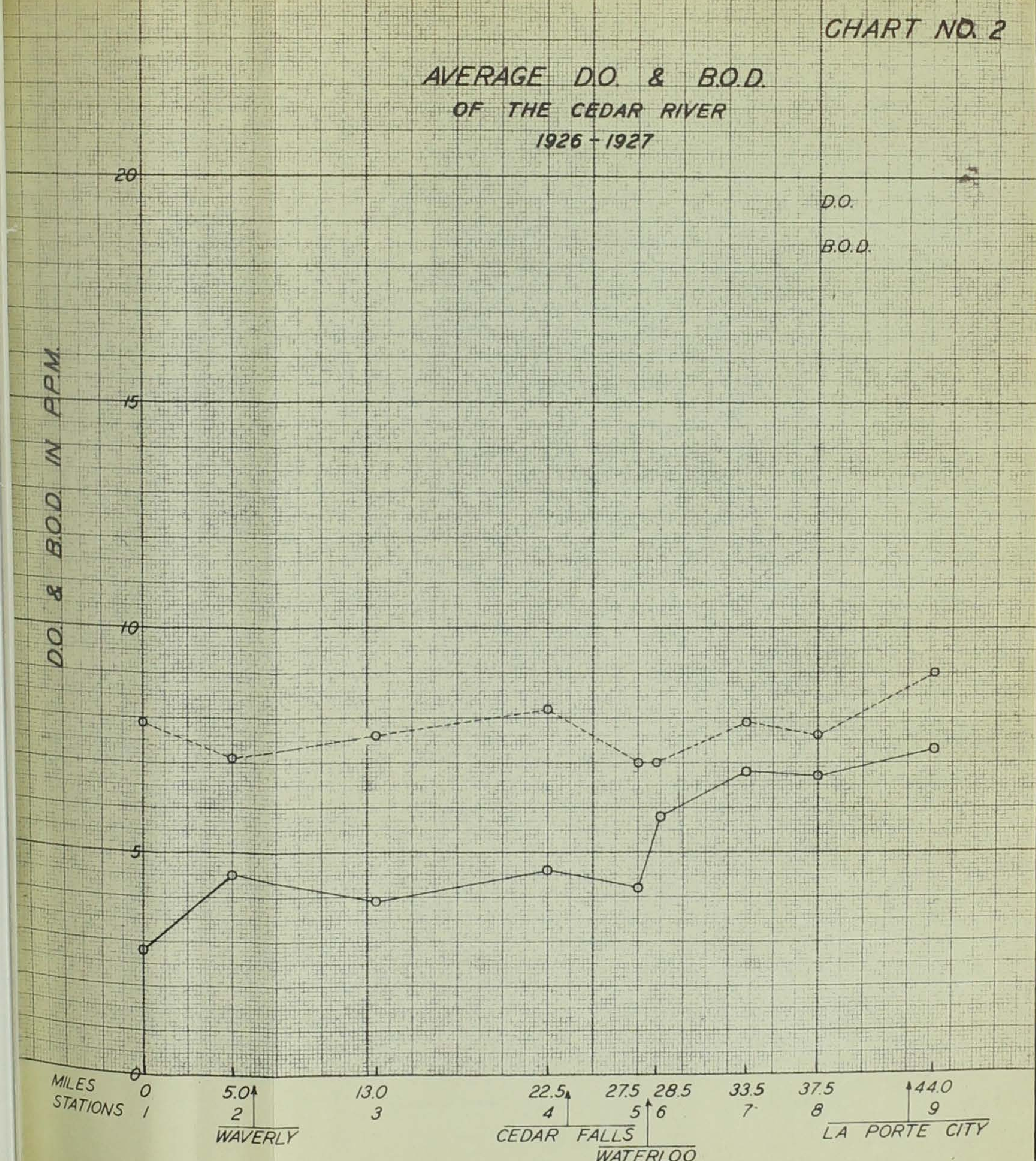


CHART NO. 2
AVERAGE D.O. & B.O.D.
OF THE CEDAR RIVER
1926 - 1927
D.O. & B.O.D. IN P.P.M.
20
15
10
5
0
D.O.
B.O.D.
MILES 0 5.0 13.0 22.5 27.5 28.5 33.5 37.5 44.0
STATIONS 1 2 3 4 5 6 7 8 9
WAVERLY
CEDAR FALLS
WATERLOO
LA PORTE CITY


CHART NO. 3
CEDAR RIVER
D.O. And B.O.D. CURVES For STATION -10- 49 Miles Above CEDAR RAPIDS
D.O. ——
B.O.D. - - - -
13
12
11
10
9
8
7
6
5
4
3
2
1
24 27 1 8 11 15 18 25 1 15 26 5 15 25 29 5 12 19 27 30 11 16 24 3
JUNE
JULY
AUG.
SEPT.
NOV.
DEC.
1927-1928
JAN.
FEB.
DATE
STANDARD PROFILE PLATE A. 4 X 20
KEUFFEL & ESSER CO. NEW YORK
MADE IN U.S.A.
TOWNE MAR '28
STANDARD
KEUFFEL


CEDAR RIVER
STATION - 20
37 Miles Above CEDAR RAPIDS
D.O. And B.O.D. CURVES
D.O.
B.O.D.
CHART NO. 4
14
13
12
11
10
9
8
7
6
5
4
3
2
1
JUNE
JULY
AUG.
SEPT.
NOV.
DEC.
1927
1928
JAN.
FEB.

CHART NO. 5

MADE IN U.S.A.
STANDARD PROFILE PLATE A. 4 X 20
KEUFFEL & ESSER CO. - NEW YORK
TOWNE MAR '28

CHART NO. 6
CEDAR RIVER
STATION-40
11 MILES ABOVE CEDAR RAPIDS
D.O. AND B.O.D. CURVES
D.O.
B.O.D.
PARTS PER MILLION
14
13
12
11
10
9
8
7
6
5
4
3
2
1
24 27 1 8 11 15 18 25 1 15 26 5 15 20 25 29 5 12 19 27 30 11 16 24 3
JUNE
JULY
AUG.
SEPT.
NOV.
DEC.
1927-1928
JAN.
FEB.
DATE

CHART NO. 7

MADE IN U.S.A.
STANDARD PROFILE PLATE A. 4 X 20
KEUFFEL & ESSER CO. NEW YORK
MADE IN U.S.A.
TOWNE MAR '28

CHART NO. 8
CEDAR RIVER
STATION - 60
3 MILES BELOW
CEDAR RAPIDS
D.O. AND B.O.D. CURVES
D.O.
B.O.D.
PARTS PER MILLION
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
27 27 1 8 11 15 18 25 1 15 26 5 15 20 25 28 5 12 19 27 30 11 16 24 3
JUNE
JULY
AUG.
SEPT.
NOV.
DEC.
1927-1928
JAN.
FEB.

CHART NO. 9

STANDARD PROFILE PLATE A. 4"X 20
KEUFFEL & ESSER CO. - NEW YORK.
MADE IN U.S.A.
STANDARD PROFI
KEUFFEL & ES


CHART NO. 10
CEDAR RIVER
STATION - 80
30 MILES BELOW CEDAR RAPIDS
D.O. AND B.O.D. CURVES
D.O.
B.O.D.
PARTS PER MILLION
14
13
12
11
10
9
8
7
6
5
4
3
2
1
JUNE
JULY
AUG.
SEPT.
NOV.
DEC.
1927-1928
JAN.
FEB.

CHART NO. 11

CEDAR RIVER
STATION - 90
41 MILES BELOW CEDAR RAPIDS
D.O. AND B.O.D. CURVES
D.O. ———
B.O.D. - - - -
PARTS PER MILLION
14
13
12
11
10
9
8
7
6
5
4
3
2
1
29
13
20
28
4
11
23
30
13
20
22
1
7
8
19
2
JUNE
JULY
AUG.
SEPT.
NOV.
DEC.
1927-1928
JAN.
FEB.
DATE
MADE IN U.S.A.
STANDARD PROFILE PLATE A. 4 X 20
KEUFFEL & ESSER CO. - NEW YORK.

CHART NO. 12

CEDAR RIVER
STATION 100
100 MILES BELOW CEDAR RAPIDS
D.O. AND B.O.D. CURVES
D.O.
B.O.D.
PARTS PER MILLION
14
13
12
11
10
9
8
7
6
5
4
3
2
1
29
13
20
28
4
11
23
30
13
20
22
1
7
8
19
2
JUNE
JULY
AUG.
SEPT.
NOV.
DEC.
1927-1928
JAN.
FEB.
DATE

CHART NO. 13
CEDAR RIVER
STATION-110
65 MILES BELOW CEDAR RAPIDS
D.O. AND B.O.D. CURVES
D.O.
B.O.D.
14
13
12
11
10
9
8
7
6
5
4
3
2
1
29
13
20
28
4
11
23
30
13
20
22
1
7
8
19
2
JULY
AUG.
SEPT.
NOV.
DEC.
1927-1928
JAN.
FEB.
DATE
MADE IN U.S.A.
STANDARD PROFILE PLATE A. 4 X 20
KEUFFEL & ESSER CO. - NEW YORK.
MADE IN U.S.A.

CHART NO. 14


CEDAR RIVER
STATION 120
72 MILES BELOW CEDAR RAPIDS
D.O. AND B.O.D. CURVES
D.O.
B.O.D.
29
13
20
28
4
11
23
30
13
20
22
1
7
8
19
2
JULY
AUG.
SEPT.
NOV.
DEC.
1927 - 1928
JAN.
FEB.
DATE


CHART NO. 15
IOWA RIVER
AND
CEDAR RIVER
STATION - 130
81 MILES BELOW CEDAR RAPIDS
D.O. AND B.O.D. CURVES
D.O.
B.O.D.
PARTS PER MILLION
14
13
12
11
10
9
8
7
6
5
4
3
2
1
29
13
20
28
4
11
23
30
13
20
22
1
7
8
19
2
JUNE
JULY
AUG.
SEPT.
NOV.
DEC.
1927 - 1928
JAN
FEB.
DATE
STANDARD PROFILE PLATE A. 4 X 20
KEUFFEL & ESSER CO. - NEW YORK.
MADE IN U.S.A.

CHART NO. 16

AVERAGE D.O. & B.O.D.
OF THE CEDAR RIVER
1927-1928
D.O.
B.O.D.
D.O. & B.O.D. IN P.P.M.
20
15
10
5
0
MILES
STATIONS
0
10
6.5
20
16.0
30
30.0
40
38.5
50
42.5
60
CEDAR RAPIDS
54.0
70
66.5
80
77.0
90
87.0
100
99.5
110
105.5
120
114.0
130

CHART NO. 17


AVERAGE B. COLI CONTENT
IN THE CEDAR RIVER
1927-1928
BASED ON REED'S INDEX
B. COLI PER 100 ML. IN 1,000'S
200
150
100
50
0
MILES
STATIONS
0
10
6.5
20
16.0
30
30.0
40
38.5
50
42.5
60
CEDAR RAPIDS
54.0
70
66.5
80
77.0
90
87.0
100
99.5
110
105.0
120
114.0
130


CHART NO. 18
AVERAGE NO. BACTERIA PER ML.
LA PORTE CITY TO COLUMBUS JUNCTION
1927 - 1928
20° C
BACTERIA PER ML. IN 1,000'S
100
75
50
25
0
MILES 0 6.5 16.0 30.0 38.5 42.5 54.0 66.5 77.0 87.0 99.5 105.5 114.0
STATIONS 10 20 30 40 50 60 70 80 90 100 110 120 130
CEDAR RAPIDS

CHART NO. 19

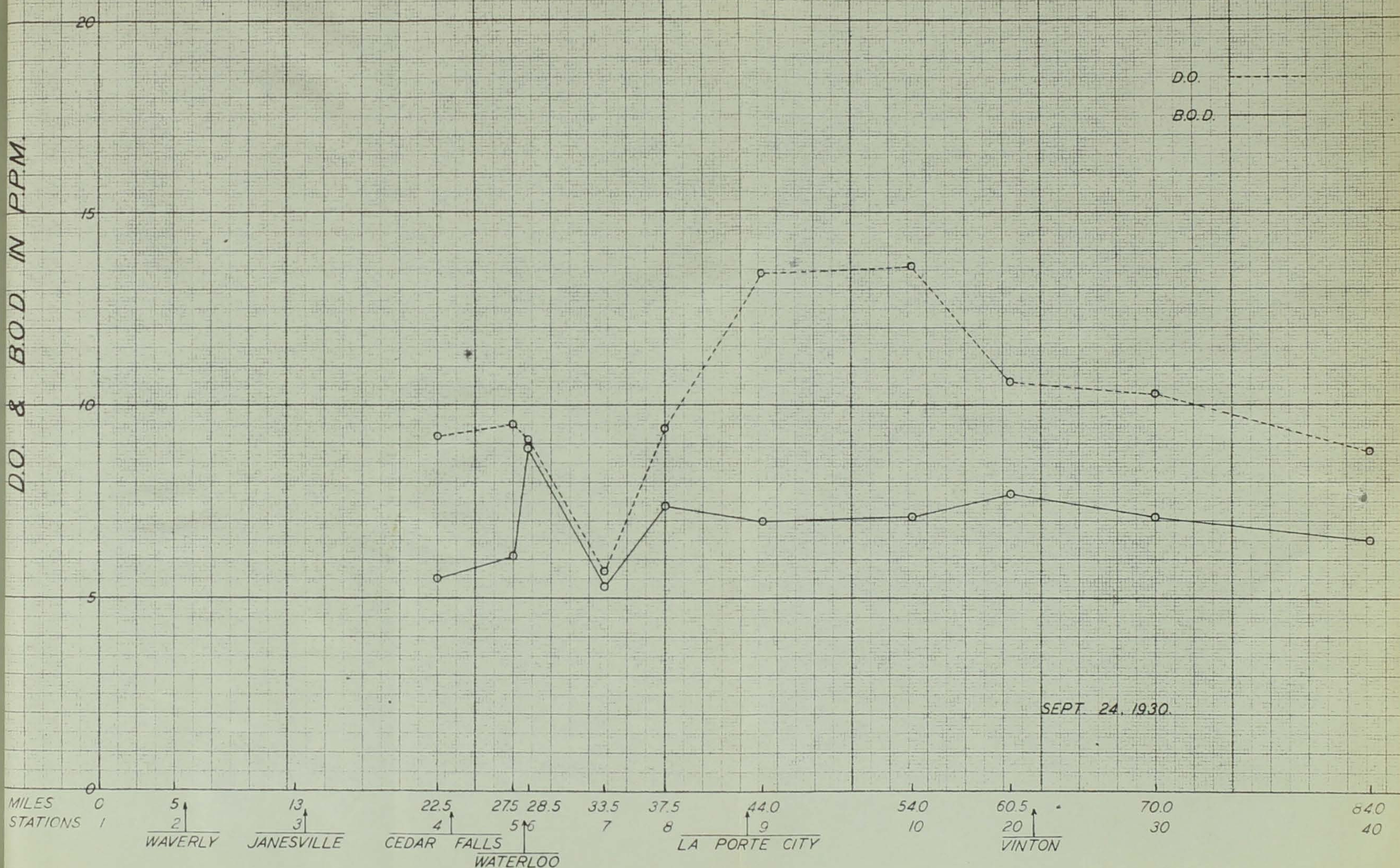
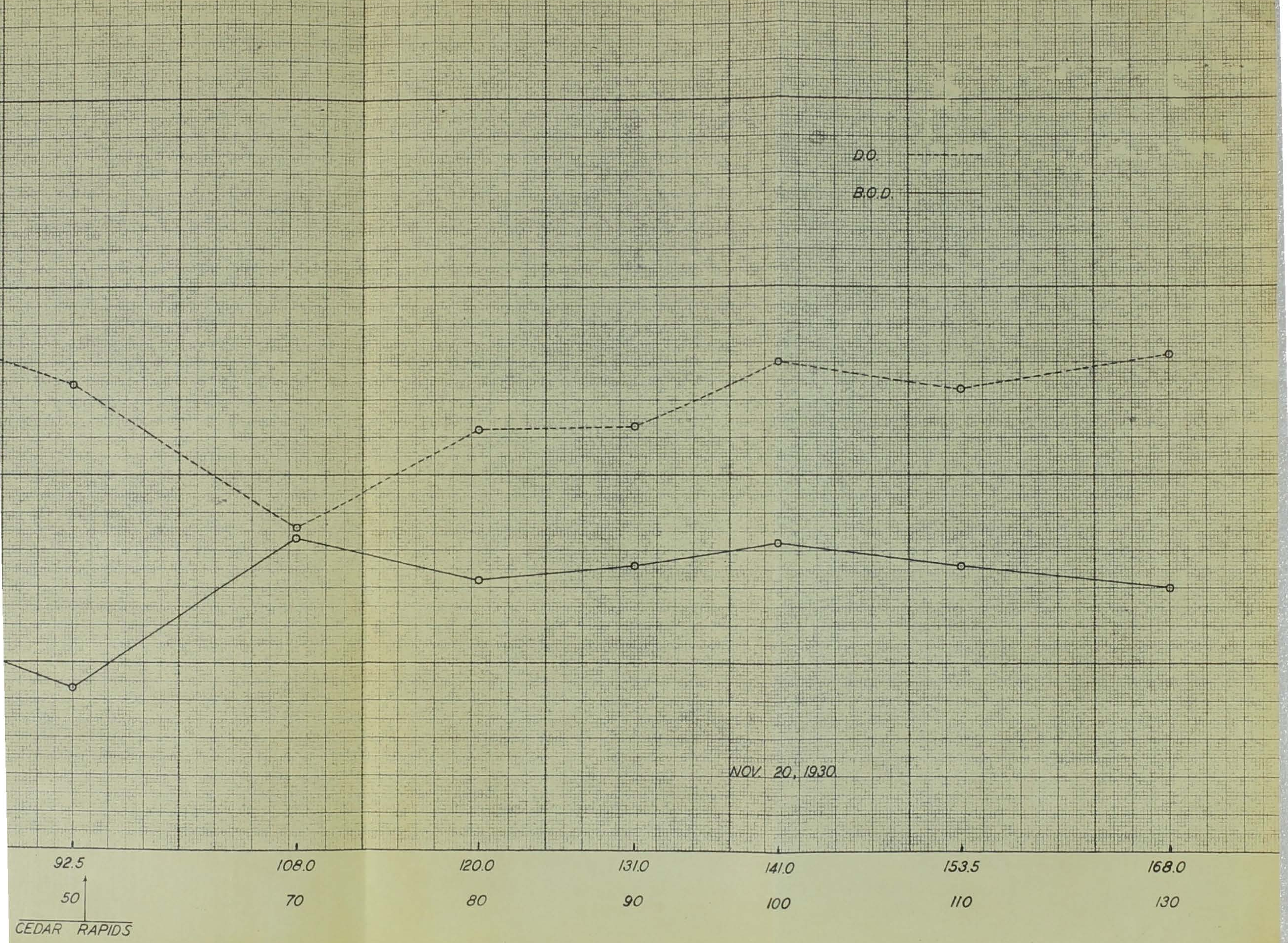

D.O.
B.O.D.
D.O. & B.O.D. IN P.P.M.
20
15
10
5
0
MILES 0 5 13 22.5 27.5 28.5 33.5 37.5 44.0 54.0 60.5 70.0 84.0
STATIONS 1 2 3 4 5 6 7 8 9 10 20 30 40
WAVERLY
JANESVILLE
CEDAR FALLS
WATERLOO
LA PORTE CITY
VINTON
SEPT. 24, 1930.

CHART NO. 20



D.O.
B.O.D.
NOV. 20, 1930.
92.5
108.0
120.0
131.0
141.0
153.5
168.0
50
70
80
90
100
110
130
CEDAR RAPIDS


D.O. & B.O.D. IN P.P.M.
20
15
10
5
0
MILES
STATIONS
0 1
5 2 WAVERLY
13 3 JANESVILLE
22.5 4 CEDAR FALLS
27.5 28.5 5 6 WATERLOO
33.5 7
37.5 8
44.0 9 LA PORTE CITY
54.0 10
60.5 20 VINTON
70.0 30
84.0 40
92.5 50 CEDAR RAPIDS
108.0 70

CHART NO. 21

D.O.
B.O.D.
JAN. 9, 1931.
60.5
20
VINTON
70.0
30
84.0
40
92.5
50
CEDAR RAPIDS
108.0
70
120.5
80
131.0
90
141.0
100
153.5
110
168.0
130

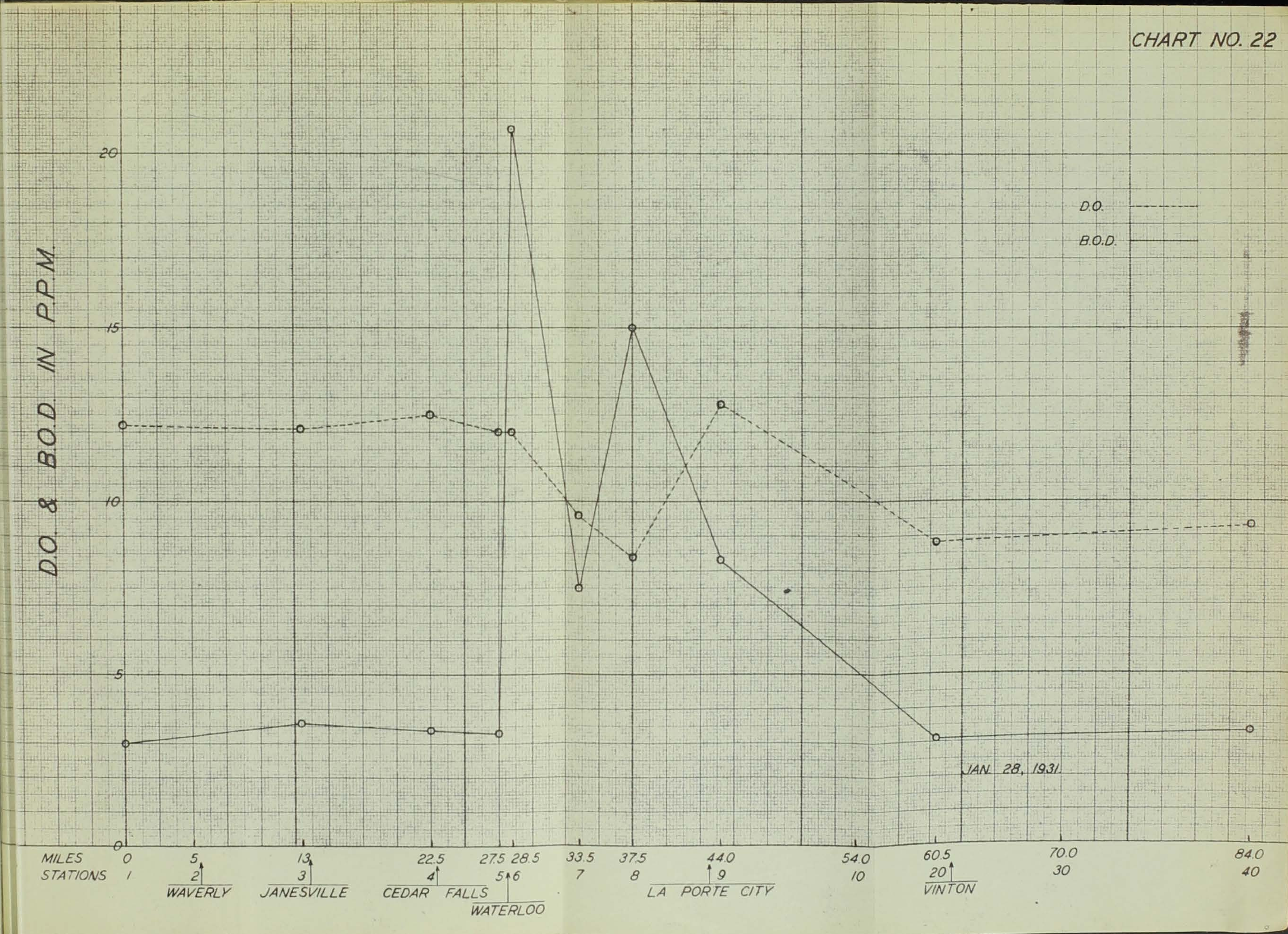


CHART NO. 22
D.O. & B.O.D. IN P.P.M.
D.O.
B.O.D.
20
15
10
5
0
JAN. 28, 1931
MILES
0
5
13
22.5
27.5
28.5
33.5
37.5
44.0
54.0
60.5
70.0
84.0
STATIONS
1
2
3
4
5
6
7
8
9
10
20
30
40
WAVERLY
JANESVILLE
CEDAR FALLS
WATERLOO
LA PORTE CITY
VINTON


D.O. & B.O.D. IN P.P.M.
20
15
10
5
LES
IONS
0
1
5
2
WAVERLY
13
3
JANESVILLE
22.5
4
CEDAR FALLS
27.5
5
28.5
6
WATERLOO
33.5
7
37.5
8
44.0
9
LA PORTE CITY
54.0
10
60.5
20
VINTON
70.0
30
84.0
40
92.5
50
CEDAR RAPIDS
108.0
70
80

CHART NO. 23


D.O.
B.O.D.
JULY 9 1931
5
TON
70.0
30
84.0
40
92.5
50
CEDAR RAPIDS
108.0
70
120.5
80
131.0
90
141.0
100
153.5
110
168.0
130


D.O. & B.O.D. IN P.P.M.
20
15
10
5
0
MILES 0 5 13 22.5 27.5 28.5 33.5 37.5 44.0 54.0 60.5 70.0 84.0 92.5 108.0
STATIONS 1 2 3 4 5 6 7 8 9 10 20 30 40 50 70
WAVERLY
JANESVILLE
CEDAR FALLS
WATERLOO
LA PORTE CITY
VINTON
CEDAR RAPIDS

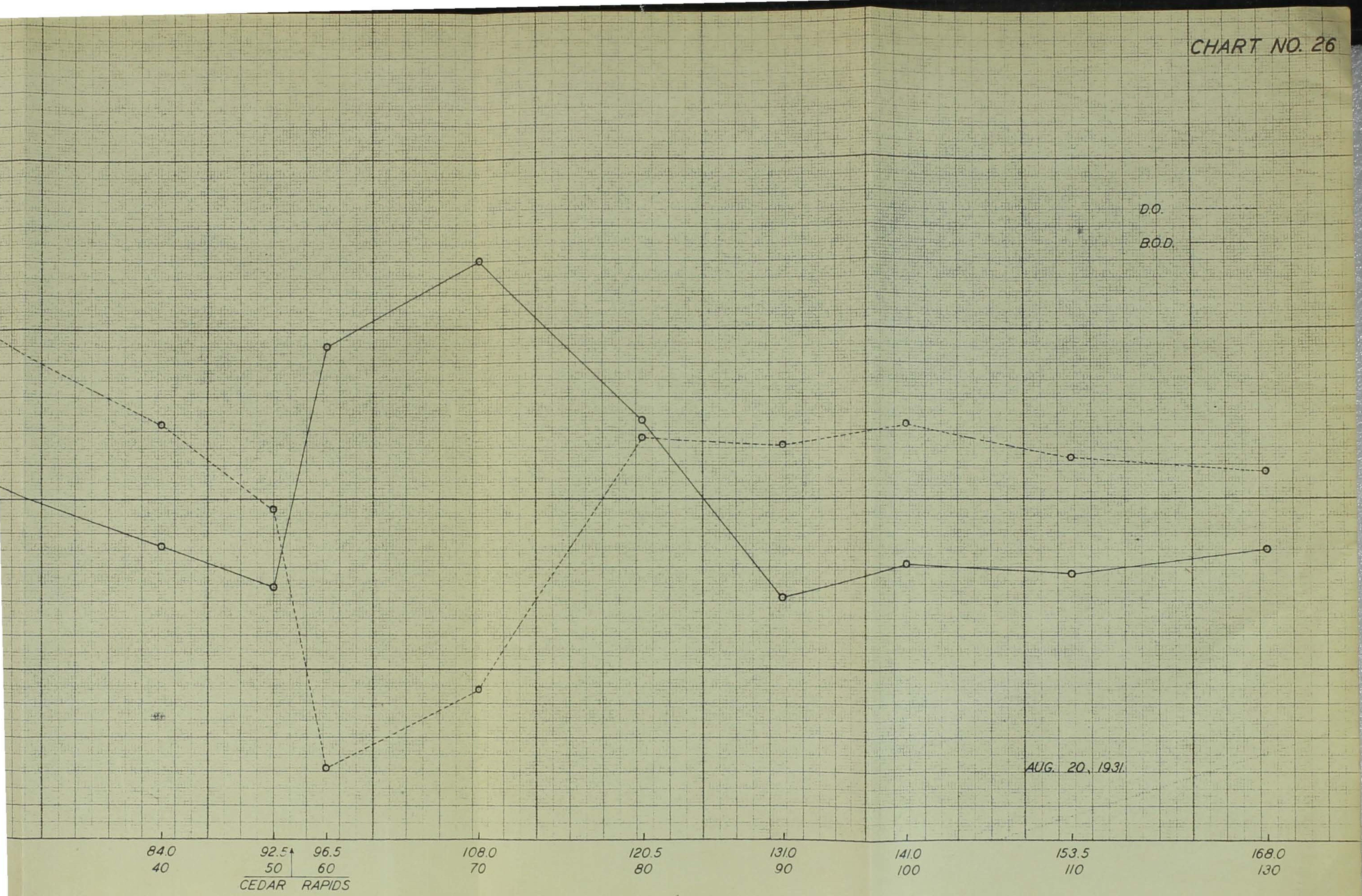
CHART NO. 24
D.O.
B.O.D.
JULY 23, 1931
54.0
10
60.5
20
VINTON
70.0
30
84.0
40
92.5
50
CEDAR RAPIDS
108.0
70
120.5
80
131.0
90
141.0
100
153.5
110
168.0
130

D.O. & B.O.D. IN P.P.M.
20
15
10
5
MILES 0 5 13 22.5 27.5 28.5 33.5 37.5 44.0 54.0 60.5 70.0 84.0 92.5 108.0
STATIONS 1 2 3 4 5 6 7 8 9 10 20 30 40 50 70
WAVERLY
JANESVILLE
CEDAR FALLS
WATERLOO
LA PORTE CITY
VINTON
CEDAR RAPIDS

CHART NO. 25
D.O.
B.O.D.
AUG. 7, 1931.
54.0
10
60.5
20
VINTON
70.0
30
84.0
40
92.5
50
CEDAR RAPIDS
108.0
70
120.5
80
131.0
90
141.0
100
153.5
110
168.0
130
ITY


D.O. & B.O.D. IN P.P.M.
20
15
10
5
0
MILES 0 5 13 22.5 27.5 28.5 33.5 37.5 44.0 54.0 60.5 70.0 84.0 92.5 96.5
STATIONS 1 2 3 4 5 6 7 8 9 10 20 30
WAVERLY
JANESVILLE
CEDAR FALLS
LA PORTE CITY

CHART NO. 26



D.O.
B.O.D.
AUG. 20, 1931.
84.0
40
92.5
50
96.5
60
CEDAR RAPIDS
108.0
70
120.5
80
131.0
90
141.0
100
153.5
110
168.0
130

OXYGEN RESOURCES
CEDAR RIVER
SEPT. 24, 1930 TO AUG. 20, 1931
OBTAINED BY SUBTRACTING AVERAGE B.O.D. FROM AVE
OXYGEN BALANCE IN P.P.M.
+5
0
-5
-10
-15
MILES
STATIONS
0
1
5
2
WAVERLY
13
3
JANESVILLE
22.5
4
CEDAR FALLS
27.5
5
28.5
6
WATERLOO
33.5
7
37.5
8
44.0
9
LA PORTE CITY
54.0
10
60.5
20
VINTON
70.0
30
84.0
40
92.5
50
96.5
60
CEDAR RAPIDS
108.0
70


CHART NO. 27
OXYGEN RESOURCES
CEDAR RIVER
SEPT. 24, 1930 TO AUG. 20, 1931
OBTAINED BY SUBTRACTING AVERAGE B.O.D. FROM AVERAGE D.O.
CITY
54.0
10
60.5
20
VINTON
70.0
30
84.0
40
92.5
50
96.5
60
CEDAR RAPIDS
108.0
70
120.5
80
131.0
90
141.0
100
153.0
110
168.0
130

AVERAGE B. COLI CONTENT
IN THE CEDAR RIVER
1930-31
MOST PROBABLE B. COLI CONTENT IS
BASED ON REED'S INDEX.
200
150
100
50
0
0
1
5
2
WAVERLY
13
3
JANESVILLE
22.5
4
CEDAR FALLS
27.5 28.5
5 6
WATERLOO
33.5
7
37.5
8
44.0
9
LA PORTE CITY
54.0
10
60.5
20
VINTON
70.0
30
84.0
40
92.5 96.5
50 60
CEDAR RAPIDS
108.0
70
120.5
80


CHART NO. 28
AVERAGE B. COLI CONTENT
IN THE CEDAR RIVER
1930-31
MOST PROBABLE B. COLI CONTENT IS
BASED ON REED'S INDEX.
54.0
10
60.5
20
VINTON
70.0
30
84.0
40
92.5
50
96.5
60
CEDAR RAPIDS
108.0
70
120.5
80
131.0
90
141.0
100
153.0
110
168.0
130


AVERAGE NUMBER BACTERIA PER ML.
CEDAR RIVER
1930-31
5 2 WAVERLY
13 3 JANESVILLE
22.5 4 CEDAR FALLS
27.5 5
28.5 6 WATERLOO
33.5 7
37.5 8
44.0 9 LA PORTE CITY
54.0 10
60.5 20 VINTON
70.0 30
84.0 40
92.5 50 CEDAR RAPIDS
108.0 70
120.5 80

CHART 29

AVERAGE NUMBER BACTERIA PER ML.
CEDAR RIVER
1930-31
37°C. L.L.
20°C. N.A.
54.0
10
60.5
20
VINTON
70.0
30
84.0
40
92.5
50
CEDAR RAPIDS
108.0
70
120.5
80
131.0
90
141.0
100
153.5
110
168.0
130

STATE LIBRARY OF IOWA
3 1723 02121 6338