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# United States Supreme Court

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STATE OF MISSOURI

vs.

STATE OF ILLINOIS AND  
THE SANITARY DISTRICT OF CHICAGO

---

TESTIMONY OF

**JOHN W. ALVORD**

Sanitary and Hydraulic Engineer of Chicago, Ill.

TAKEN BEFORE

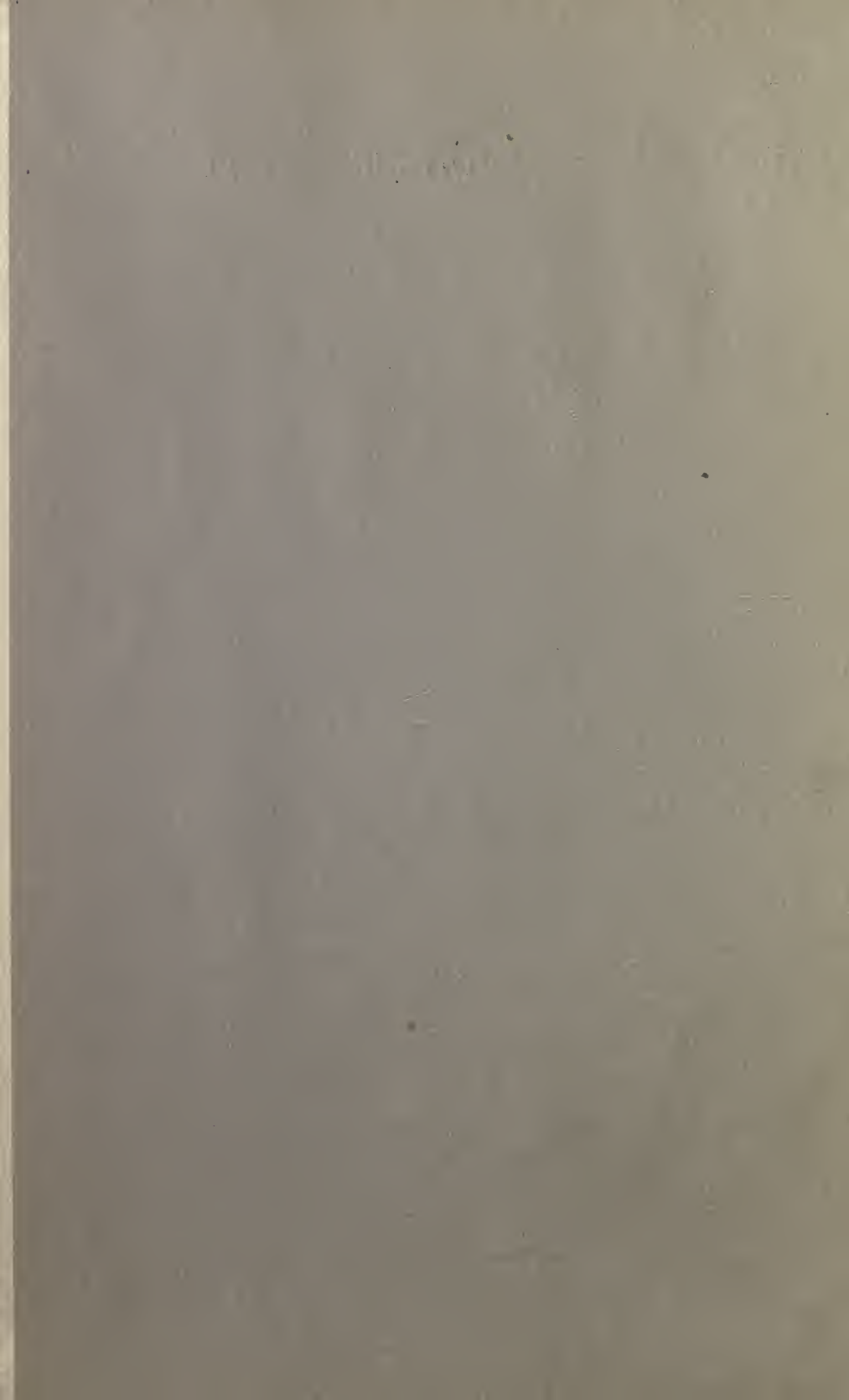
**HON. F. S. BRIGHT**

Commissioner

AT THE SOUTHERN HOTEL, ST. LOUIS, MAY 25th AND 26th  
1904



TRIBUNE PTG. CO., JEFFERSON CITY



# United States Supreme Court

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STATE OF MISSOURI, *complaint*

vs.

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THE SANITARY DISTRICT OF CHICAGO

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JOHN W. <sup>*also,*</sup> ALVORD *1861*

Sanitary and Hydraulic Engineer of Chicago, Ill.

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TRIBUNE PTG. CO., JEFFERSON CITY



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JOHN W. ALVORD,

a witness called on behalf of the complainant, being duly sworn by the Commissioner, was examined in chief by Mr. Jeffries, and testified as follows:

Q. Please state your full name and address?

A. John W. Alvord.

Q. Also your occupation?

A. Sanitary and Hydraulic Engineer, Chicago, Illinois.

Q. How long have you been engaged in the practice of your profession as a hydraulic and sanitary engineer?

A. About twenty-four years.

Q. Where?

A. With Chicago as a center, in and about Chicago and the middle west.

Q. Mr. Alvord, give an outline in a general way of your educational training?

A. I was ready for entrance to the Sheffield Scientific School of Yale College in 1877, but was unable to take the course owing to poor health. My engineering education has therefore been confined to study and travel, coupled with practical experience. The first engineering work in which I was engaged was in 1879 in Chicago in connection with the construction of the Hyde Park Pumping Station of the Chicago water works and the Inlet tunnel to such station under Lake Michigan.

Later, I was in charge of the operation of the Lake View Station of the Chicago water works, and was for four years City Engineer of Lake View, then a separate municipality from the city of Chicago, since annexed.

After the annexation of Lake View I engaged in general practice in sanitary work in the suburbs of Chicago and adjacent cities.

I visited Europe in 1888 and 1894 and examined the question of water purification and sewage disposal particularly. From 1890 to 1893 I had charge of a department in the construction of the World's Columbian Exposition at Chicago and in 1894 resumed private practice, since which time I have been engaged in various capacities with

about thirty-five different city water works plants and about forty-five municipal sewer systems, including the purification of water supplies and the disposal of sewage. I was engaged in 1898 in making a report to the city of Columbus, Ohio, on the extension of its sewer system and the disposal of its sewage, which report was published.

From 1898 to 1902 I was consulting engineer to the Illinois State Canal Commission, advising as to the works of the sanitary district channel in and through Joliet and in the litigation as to the removal of dams and locks at Joliet.

I have been engaged recently in the development of water power at Petosky, Michigan, and Big River, Missouri, and Des Moines, Iowa. I have been engaged in the design of some twelve water works plants which have been constructed and in which the question of river pollution bore an active part.

I have had some limited experience in typhoid epidemics, having studied them at Hurley, Wisconsin; Ironwood 12836 Michigan, and Culver Academy, Indiana in 1894, and the typhoid epidemic of Chicago in 1892 and 1893, the Duluth epidemic of 1896, the typhoid epidemic at Grand Forks, North Dakota, in 1894, and was engaged to investigate the causes of the epidemic at Wequetonsing, Michigan, and Petosky, Michigan, in 1903.

Q. State whether or not the epidemics that you have referred to were caused by water in any case?

A. So far as I have studied them they were all caused by polluted water supplies.

Q. Are you familiar with the Chicago river, the drainage canal, the Desplaines and the Illinois river?

A. I am. In 1888 I was engaged in conducting the litigation in behalf of the State of Illinois with the Sanitary District, in the course of which the hydraulics of the upper portion of the Desplaines river were thoroughly reviewed. I have studied in general the progress of the construction of the drainage channel and the related questions, and was engaged in working for the special commission which reported upon its com- 12837 pletion.

I have observed the Illinois river at Morris, Ill., where I designed the system of sewers; at Ottawa, where I was engaged in water power litigation; at Marseilles, where I advised as



to the enlargement of the water power, and have also observed the general characteristics of the river at Seneca, La Salle, Peru, Hennepin, Peoria, Pekin and Havana, at which latter two places I have designed sewerage systems.

I am also familiar with the Mississippi river from St. Louis to Alton, to some extent.

Q. State whether or not you are familiar with the ordinary minimum flow of the Illinois river before and since the opening of the drainage canal?

A. I have had occasion to observe at different times before the opening of the drainage channel the flow of the Illinois and the lower Desplaines river, and have also observed it since the opening of the drainage channel.

Q. Mr. Alvord, state whether or not you have given the subject of bacteriology any attention in connection with your 12838 profession?

A. I have to a limited extent. I have tried to keep myself posted upon bacteriology in a general way ever since it has come into use among engineers.

Q. Now state whether or not you have familiarized yourself with the subject of chemistry as applied to your profession?

A. Also to a limited extent. I took a partial course in chemistry at the University of Chicago in 1894. In 1900 I studied bacterial quantitative analysis under the advice of Professor Novy of Ann Arbor, Michigan. I have endeavored to keep informed on the subject in everything which would be of interest to my work as a sanitary engineer.

Q. State whether or not you were ever engaged with the water investigations of the city of St. Louis? -

A. I was employed in 1902 by the special commission that investigated the extension of the water supply of the city of St. Louis, and my part of the work was to study the financial history of the present works, their physical cost and the cost of their operation. In the course of this work I became familiar 12839 with the characteristics of these works and have visited the Chain of Rocks stations and sedimentation basins, also the old station at Bissel's Point, and have studied the physical features of the sedimentation plant.

Q. State whether or not you have made any special study

of the typhoid condition on the water shed of the river above St. Louis?

A. To some extent.

Q. Where did you obtain the data which you have in regard to the typhoid deaths and the population of these water sheds?

A. From the records in this case.

Q. From evidence introduced by the respondents?

A. Yes sir.

Q. And complainants?

A. Yes sir.

Q. State whether or not you have prepared a diagram showing the relations of typhoid fever deaths in St. Louis with typhoid deaths on the water sheds?

A. I have.

Q. Will you submit this diagram?

A. I will.

12841 MR. JEFFRIES: Q. I will ask you, Mr. Alvord, whether or not this diagram is based upon the typhoid fever deaths upon the water sheds of the Mississippi, the Illinois and the Missouri rivers respectively, as shown by a tabulated sheet of the evidence upon that subject, introduced in this case?

A. It is.

MR. JEFFRIES: I now, Mr. Commissioner, offer this diagram in evidence.

The diagram is as follows:

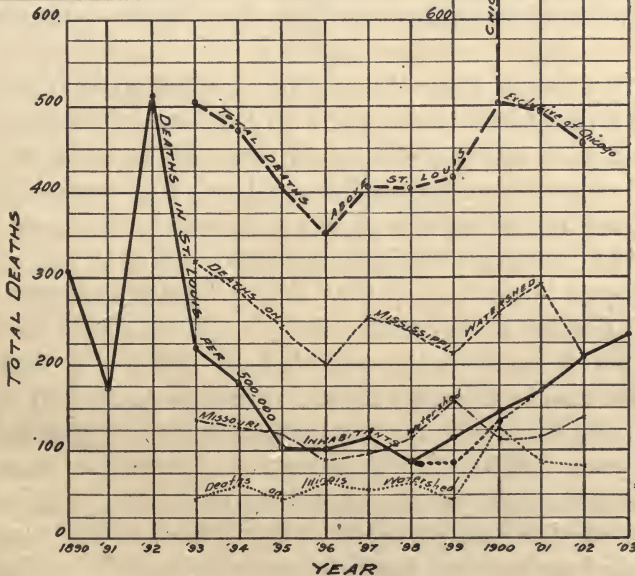
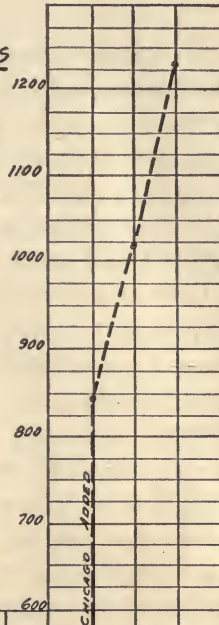
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Complainant's Rebuttal Chart No. 1.

Diagram Showing  
RELATION OF TYPHOID DEATHS IN ST. LOUIS  
TO TYPHOID DEATHS ON WATERSHED

JOHN W. ALVORD, Hydraulic & Sanitary Engineer  
 CHICAGO

YEAR	Deaths in St. Louis	Pop'n in St. Lo's	Deaths St. L. per 500,000	Deaths on Water Shed	Deaths in Chicago	Deaths Water Sh. Chicago Included
1890	277	451,770	307			
91	160	465,000	174			
92	488	477,000	522			
93	215	489,000	220	505		505
94	178	500,000	178	474		474
95	106	522,000	103	408		408
96	106	524,000	101	354		354
97	125	538,000	116	410		410
98	95	550,000	96	411		411
99	130	561,000	116	420		420
1900	168	572,238	147	503	339	842
01	198	585,000	169	494	509	1003
02	222	600,000	185	431	801	1232
03	288	612,000	235			



Note dotted line leaving St. Louis clouds in 1898 and rejoining same in 1901 give reduction in figures for local typhoid epidemic

THE COMMISSIONER: This diagram is known in evidence as complainant's rebuttal chart number 1.

MR. JEFFRIES: Q. Please explain this chart or diagram?

A. The data from which the diagram is plotted are shown in a table of seven columns, in the upper left hand corner. The first column which gives the year in which the deaths occurred, the second column showing the total typhoid deaths in St. Louis for each given year, the third column showing the population of St. Louis for each given year, taken from the Federal Census for the years 1890 and 1900, and the Federal estimated census for the years 1901 and 1902, and estimated complete for the remaining years, such estimate being made at the proportional rate of increase to the figures of the Federal census and the Federal estimates.

12844 The fourth column gives the typhoid death rate in St. Louis per 500,000 population, being reduced to that standard population for the years as given.

The fifth column gives the typhoid deaths on all of the water sheds above St. Louis, taken from the records in this case above referred to and excluding the sanitary district of Chicago.

The sixth column gives the typhoid deaths in the city of Chicago for the years 1900, 1901 and 1902, as taken from the record in this case above referred to, and the seventh column gives the deaths from typhoid for all of the water sheds above St. Louis, including the Sanitary District of Chicago, as taken from the records in this case above referred to.

The diagram is plotted so that the ordinates represent the total typhoid deaths, the abscissa the years from 1890 to 1902, inclusive, in which such deaths occurred. The lower dotted line of the diagram marked deaths on the Illinois water shed shows the deaths on the Illinois water shed, excluding the drainage district for the years 1893 to 1900, inclusive. Above this line will

12845 be found a light dash and dotted line marked Missouri water shed, which gives the total typhoid deaths on the Missouri water shed for the years 1895 to 1902, inclusive.

Above this line again will be found a light dash line marked deaths on the Mississippi water shed which gives the typhoid

deaths on the Mississippi river above St. Louis for the years 1893 to 1902, inclusive.

Above this line again will be found a heavy dash line marked total deaths above St. Louis, exclusive of Chicago, which gives the total typhoid deaths on the three combined rivers above St. Louis for the years 1893 to 1902, inclusive, excluding the Sanitary District of Chicago.

In January, 1900, the drainage channel was opened, adding the discharge of the sanitary district of Chicago to the last described line. This is shown on the diagram by a line extending vertically upward from the last described line to the year 1900 and plotted of such a length so that it shows the total deaths from typhoid in that year in the sanitary district of Chicago which is added to the total typhoid deaths on all the water sheds.

This heavy dashed line, marked on the diagram "Chicago 12846 added," extends diagonally upward from the year 1900 through the years 1901 and 1902, being in each case plotted so that the total typhoid deaths in the sanitary district of Chicago are added to the total deaths on the line marked total deaths above St. Louis, exclusive of Chicago, and shows the total deaths on all water sheds including the sanitary district of Chicago. The heavy line on the diagram marked "Deaths in St. Louis per 500,000 inhabitants," shows the typhoid deaths in St. Louis taken from the records in this case above referred to for the years 1890 to 1903, inclusive, the dotted line leaving this heavy black line in the year 1898 and rejoining it again in the year 1901 shows a correction made by deducting certain deaths due to a localized milk epidemic described by Professor Sedgwick and Mr. Lochridge.

MR. JEFFRIES: Q. Mr. Alvord, state what conclusions you draw from this diagram?

A. It has been the endeavor in this diagram to disclose the causes for the increase in typhoid deaths in St. Louis during the last few years. In order to intelligently determine such causes, the typhoid deaths along the different rivers have been separated from each other and plotted separately so as to determine the source of the most marked pollution. It will be seen that the deaths from typhoid on the Illinois water shed, exclusive of the sanitary district of Chicago, are fairly uniform up to the year 1899, but show a rise in the year 1900, the year in

which the drainage canal was opened. Otherwise they seem to be fairly uniform for the years preceding and following the commencement in the rise in the number of typhoid deaths in St. Louis.

The deaths on the Missouri river water shed appear also to be reasonably uniform for the period under consideration, and the typhoid deaths on the Mississippi river water shed, while fluctuating somewhat more than the first two described, are nevertheless generally uniform before and near the rise in the typhoid deaths in St. Louis.

In summing up the total typhoid deaths on the water shed above St. Louis, as given in the record, it would appear 12848 that while there is some fluctuations and a low period about the year 1896 that at no time since the rise in typhoid deaths in St. Louis they have materially exceeded a fair average rate and have in fact fallen off since the year 1900.

It will be observed, however, that the addition of the deaths from the sanitary district almost doubles the total typhoid deaths, influencing the pollution of the St. Louis water supply and that such addition is materially increased during the years 1901 and 1902, so that in 1902 the total typhoid deaths are nearly two and one-half times the deaths on the water shed above St. Louis, exclusive of the sanitary district of Chicago.

A local epidemic in St. Louis typhoid deaths in 1892 is clearly shown by the diagram and is attributable to the contamination of the water supply at the old station at Bissell, by Ginras Creek, and neighboring sewers.

Upon the removal of the source of supply from Bissell's Point to the chain of rocks in the years 1894 to 1895 there is shown a marked improvement in the total number of deaths from typhoid for the latter year.

MR. JEFFRIES: Q. What cities were considered by you on the three water sheds in the plotting of this diagram?

A. Only those referred to in the records of this case.

Q. I will ask you to state briefly, if you know, what changes have taken place in the conditions of the water in the Mississippi river at St. Louis since the removal of the intake from Bissell's Point to the chain of rocks in 1895?

A. The sanitary district of Chicago opened their channel on or about the 17th of January, 1900, introducing into the water

shed above St. Louis a large additional amount of water and sewage.

MR. JEFFRIES: Q. State whether or not you are acquainted with the physical conditions, drainage area and the population upon the water sheds of the Illinois, the Mississippi above Grafton and the Missouri river.

A. In a general way I am.

Q. Taking into consideration the evidence introduced in this case upon the typhoid death statistics upon the water sheds of these rivers, and all evidence in connection therewith, I will ask you to state to what do you attribute the increase in typhoid in the city of St. Louis, during the years 1900 to 1903, inclusive?

Q. Question read.

A. I should consider, after a study of the data that in all human probability the rise in typhoid deaths in the city of St. Louis in the last few years has been caused by the added typhoid contamination from the sanitary district of Chicago.

MR. JEFFRIES: Q. In what way, Mr. Alvord, is the longevity and vitality of typhoid organisms of special interest to you in your profession as a sanitary engineer?

A. In advising municipalities as to the purity and safety of their sources of water supply.

Q. State whether or not you are familiar with and have acquainted yourself with the literature upon this subject?

A. I have endeavored to do so for the past fifteen or eighteen years.

Q. What was your object in doing so?

A. In order that my advice to municipalities might be conservative.

Q. What do you consider in your practice and in the recommendations which you make in your profession as a fair statement of the longevity of typhoid organisms which would lead you to give what you consider conservative advice upon this subject?

A. I have for some years past considered the life of the typhoid bacilli would be from sixty to ninety days under favorable environments, and while large masses of such bacilli might be removed from any given source of supply in a comparatively short time under unfavorable environments, it would not be safe to assume that a water once thus polluted would be safe to rec-

commend for public use under the time given, unless the contamination were eliminated by a carefully designed and properly operated system of purification.

MR. JEFFRIES: Q. Are you familiar with the results of the experiments found in the reports of the Massachusetts Board of Health in which Hiram T. Mills presents data on the longevity of typhoid bacilli in the waters of the Merrimack river which results were obtained by him upon analysis and experiments conducted by him?

A. I am.

12853 Q. Where, if any, do you find other similar experiments or determinations?

A. There will be found in the proceedings of the Sanitary Institute of 1899, some experiments made by Dr. Horrocks which appear to be similar to those carried out by Mr. Mills. These experiments are also quoted in Mr. Samuel Rideal's book on sewage, on page 70.

MR. TODD: Q. Are the experiments that you are quoting the experiments of Mills?

A. No sir, Horrocks.

MR. JEFFRIES: Q. Are you familiar with the sewerage system of Chicago?

A. I am. A portion of it has been constructed under  
12854 my design and supervision.

Q. Under what conditions in your opinion are typhoid bacilli carried away from Chicago so as to approximate conditions which Mr. Hiram F. Mills and Dr. Horrocks used in their experimental work?

A. The sewerage system of Chicago has very flat gradients and requires frequent artificial flushing. It has been the history of heavy rainfalls in that city that the entire content of the sewers are at such times disgorged into the river bringing into it a mass of pollution which has been accumulating for months together. Before the opening of the drainage channel such periods were extremely dangerous to the water supply of the city, as was shown in the increase in typhoid deaths following the period of such contamination. Such heavy flushings of rainfall occur  
12855 ordinarily in the early spring or after the breaking up of the winter and at times when the temperature is most favorable to the longevity of the typhoid germ and greatly



increases for the time being the rate of pollution in the drainage canal and Desplaines and Illinois rivers.

In my opinion the action of such a flushing of the Chicago sewer system into the Chicago river with its present large proportion of pure water and low temperature furnishes conditions which parallel or indeed form more favorable conditions to the longevity of pathogenic bacteria than those under which the experimental work above noted were taken. The discharge of this various amount of pollution at times of flood waters appears also to furnish the necessary velocity for rapid conveyance through the drainage canal down the Desplaines and Illinois rivers to the intake of the St. Louis water supply; the increment of tributary streams also increases the dilution and decreases the chance for toxic destruction of the total number of typhoid germs present. Such conditions are prevalent in greater or less degree during many times of each spring.

MR. JEFFRIES: Q. In what you have said of the spring flood, do you have reference to the ordinary spring floods or to the exceptional floods which sometimes occur in this region?

A. My answer refers entirely to ordinary conditions such as occur perhaps eight or ten times or more in the spring of each year and often at other times in the year, rather than to exceptional floods such as that of 1888 or 1892 and one or two other heavy floods in which extreme high water marks were reached. Such floods would naturally conduct the danger from typhoid pollution to greater distances from the source or origin.

MR. JEFFRIES: Q. Are there any other evidences from the testimony introduced in this case and which you have observed which would increase the flow above that mentioned by you?

A. Yes sir, in the case of heavy rainfall on the watershed of the Chicago river, it is often necessary in order to prevent outflow into Lake Michigan through the main river, to lower the Bear Trap Dam at Lockport so as to produce greater velocity at all stations down the channel at such times. This undoubtedly aids in the rapidity with which pollution is conveyed away from Chicago down the channel of the Desplaines and Illinois rivers.

Q. What are the conditions of stream flow in the Desplaines river?

A. Below the outlet of the drainage canal at Lockport, the Desplaines river flows very rapidly to a pool formed by what is known as dam number one at Joliet. This descent over ordinary and normal flow produces rapid velocity and 12858 a slight rise, from rainfall will develop velocity in the channel of from 40 to 60 miles per day.

MR. JEFFRIES: Q. What are the conditions of flow in the Desplaines and Illinois river as far down as the Marseilles dam?

A. Below dam number one and at Joliet the flow again becomes very rapid at times of moderate rises. This flow is slightly checked through Lake Joliet, but there is a further rapidity incurred on its outlet all the way down to the mouth of the Kankakee river. Below this point the Marseilles dam slightly checks the current.

Q. What are the conditions of flow in the Illinois river immediately below the Marseilles dam, below Marseilles at Peru?

A. Another rapid flow takes place below the Marseilles dam as far down as to Peru, where the influence of the Henry dam is felt.

Q. State whether or not that is especially true in time of 12859 spring floods or rises?

A. In the time of spring rises the velocity in these reaches is very materially increased, running, as I have said, up to as high as forty to sixty miles a day.

Q. Are you familiar with the testimony of Mr. Randolph in this case?

A. I have read Mr. Randolph's testimony.

Q. Taking into consideration the testimony of Mr. Randolph and the testimony of all other witnesses affecting the subject of hydraulics and sanitary engineering, I will ask you to state, Mr. Alvord, what effect, if any, has the discharge of 250,000 cubic feet of water per minute through the Chicago Drainage Canal upon the dangerous and deleterious substances contained in the sewage discharged into the Chicago river and the drainage canal?

A. The effect is to materially increase the current of the

Desplaines and Illinois river and to carry dangerous pollution to greater distances and with more rapidity.

MR. JEFFRIES: Q. Are you familiar with the flow measurements of the Chicago river, the main drainage canal, the Desplaines river and the Illinois river as described by Mr. Randolph in his testimony?

A. I have studied them.

Q. Do you know the discharge of the river at the time these observations were made under Mr. Randolph's directions?

A. I am unable to find anything in Mr. Randolph's testimony which gives any clue to the amount of discharge in the Desplaines and Illinois river either at Joliet or Peoria and therefore am unable to determine what stage the river was in at the time of his float measurements. The times of these experiments were in July, 1903, as appears by the record and such time is not covered by the table of discharge given in his testimony at Lockport, nor are any guage readings given at 12861 Peoria where the testimony includes a rating table. I

only find the statement that the floats passed over this distance in fifteen days, which is raised to eighteen and one-half days by dividing by eight-tenths.

Q. What distance do you refer to in your last answer?

A. The distance from the Chicago river to the chain of rocks in the Mississippi above St. Louis.

Q. As a hydraulic engineer state whether or not the time limit as ascertained by the floats should be raised in the manner indicated by Mr. Randolph in his testimony, by dividing by .8?

A. I fail to see the pertinency of his conclusion that a correction should be made, tending to reduce the maximum surface velocity to the mean velocity of flow. The use of the .8 correction, in the manner described in Mr. Randolph's testimony is a very rough approximation, used by hydraulic engineers when surface floats are run in the most rapid part of the channel of a river to determine the average flow for the whole cross section of the channel in order to get at the 12862 quantity passing a given point per second. In the case under consideration, we are not endeavoring to determine the quantity of water passing any given cross section per second, but the problem presented is what length of time will

any given pollution, flowing in mid channel, pass over the necessary distance from the Chicago river to the chain of rocks. This only requires, in my opinion, a determination of the mean velocity of the bore or central section of the stream.

Q. Do you as a hydraulic engineer consider the floats described by Mr. Randolph and Mr. Crane as surface floats?

A. I should not consider them so. As described in the testimony they appear to be partially submerged and I believe they give the mean velocity of the central portion of the stream with a fair degree of accuracy.

Q. Assuming, Mr. Alvord, that these determinations as made by Mr. Randolph give the mean velocity of the central portion of the stream, state whether or not in your opinion corrections of the character named and described by Mr. 12863 Randolph are necessary?

A. I believe that they are not necessary.

Q. What, then, would you consider the length of time that it would take pollution to pass over the described distance as the results of these experiments so conducted by Mr. Randolph at the time such experiments were made?

A. I should judge that fifteen days actual time would fairly represent the ability of the water of the Illinois and Desplaines rivers to carry pollution to the Chain of Rocks at the stage when the experiments were made.

Q. State whether or not in your opinion the mean flow of the stream should be considered as the time element in the passage of sewage and pollution from a given point to a point below on that stream?

A. I think it should not. Pollution is carried much faster on a given stream than would be indicated by a mean average flow. It may not be carried as fast as the very fastest thread of the stream, but it is certainly carried as fast as the average velocity of the central or fastest part.

12864 Q. Have you examined the evidence of the experiments conducted by Professor Van Ornum, described in the records of this case?

A. I have.

Q. Taking into consideration the testimony of Mr. Randolph in the experiment which he conducted with the floats in obtaining the velocity of the water in the Illinois river, in July,

1903, I will ask you to state what conclusions you draw from a comparison of the respective velocities obtained by Mr. Randolph and Professor Van Ornum, and taking into consideration the evidence as to the guage readings that existed for a period prior to these experiments and subsequent thereto, as introduced in evidence by Mr. Randolph and Crane, in what way do these experiments represent the minimum or maximum velocity of the water in the Illinois river?

A. I should judge, in answer to the first part of your question, that the float experiments of Mr. Randolph in July 1903, were undertaken at a very much lower stage of the river than were those of Professor Van Ornum in March, 1903, as Professor Van Ornum finds materially greater velocity than does Mr. Randolph.

I also observe that Professor Van Ornum commenced his float experiments in a low stage point, between two March rises, in the river. There were flowing over the Bear Trap dam at the time he commenced his operations, as taken from the figures in the tables in the evidence, 289,000 cubic feet per minute, which gives a rather low velocity in the drainage channel. About 394,000 cubic feet per minute was passing over dam number one at Joliet at the same time.

Eight days prior to this, and on the 8th and 9th of March, 707,000 and 718,000 cubic feet per minute, respectively, passed over the dam at Joliet.

12866 Five days after Professor Van Ornum commenced his experiments, or on the 21st and 22nd of March, 764,000 and 711,000 cubic feet per minute passed over dam number one, or nearly double the amount of flow, both earlier and later, was in existence than occurred when his experiments were commenced.

It would seem, therefore, that Professor Van Ornum's experiments were undertaken at a very comparatively high stage but not by any means the highest stage so far as the drainage channel and the upper portion of the Desplaines river are concerned.

In passing Peoria, Professor Van Ornum observes the stage of water upon the gauge, which I find, by referring to the table of flow submitted by Mr. Jacob A. Harmon, in this case, gives a

flow of about 50,000 cubic feet per second. This flow would correspond to a stage of the river which is somewhat overflowing the banks in the lower courses.

As Professor Ornum used submerged floats, I feel that the actual time traveled by the velocity floats represents fairly the mean velocity of the pollution vehicle, and I take the total time as represented by these floats as representing the total 12867 time which it requires to travel the total distance under consideration, with the exception that I believe that there are times when the velocity in the drainage channel in that portion of the river immediately below the Bear Trap Dam is greater than those which he found.

In 1898 I was engaged as consulting engineer for the State Board of Canal Commissioners in litigation with the sanitary district of Chicago over certain water powers and these channels below the Bear Trap Dam, and had occasion to very carefully study the velocities and stages and various stages in this vicinity. I have, therefore, verified Professor Van Ornum's float experiments in this vicinity, recognizing them to correspond with what I know to be the facts in the spring rises in the upper portion of the course under consideration. Below Lake Joliet I have accepted Professor Van Ornum's experiments to the chain of rocks as being properly indicative of what might happen in ordinary spring floods.

From Bridgeport to the chain of rocks I find that 9.8 days is consumed, using mean velocity to Joliet, and Professor Van Ornum's float experiments from there to the chain of 12868 rocks. I do not consider that this is the shortest time in which pollution would travel this distance, but believe that the maximum flood such as occurred in 1892 would reduce this time to at least eight days and possibly slightly less. The 9.8 days represents to my mind a stage which could be counted upon as occurring a number of times in each year.

MR. JEFFRIES: Q. State whether or not you have had occasion to examine and study the velocity and stages of the rivers in question, in the course of your professional career?

A. I have.

Q. From what you have said of your observations of the testimony introduced in this case and of the testimony of Mr. Randolph, from his float experiments, state whether or not in

your opinion the float experiments of Mr. Randolph represent a minimum velocity of the water in the Illinois river from Chicago to St. Louis at all times of the year?

A. Not having been able to ascertain the specific stage at the time of Mr. Randolph's experiments, I should be unable to state positively that his experiment was made at the minimum stage of the river, but speaking generally it is my impression that it was and represents the average of the minimum velocity in the ordinary dry seasons of the year between the Chicago river and the chain of rocks.

MR. JEFFRIES: Q. I will ask you if you have examined the chart referred to by Mr. Rudolph Hering, 12870 who testified for respondents in this case, in which it is referred to by Mr. Hering in his evidence as follows, the chart with the caption "Sanitary District of Chicago, schematic representation of the self-purification of the waters of the Missouri, Mississippi and Illinois rivers between the points indicated based upon the longevity of the life of the typhoid bacillus as fixed by the experiments made under the direction of Hiram F. Mills, the results of which are given in the paper entitled 'Typhoid fever in its relation to water supply?'"

A. I have.

Q. State what to you, then, it represents, as observed by you as a hydraulic sanitary engineer?

A. It represents an attempt to derive the possible amount of contamination in the water at the chain of rocks from the sanitary district of Chicago, by assuming that the original pollution is proportional to the population, and that the longevity of a typhoid bacillus is, as found by the experiments of Hiram F. Mills in the paper referred to. The chart also makes the same deductions for the Mississippi and Missouri rivers and gives the rate of fall of the three watersheds. In the case of the Illinois river the length of time of flow from the Chicago river to the chain of rocks is taken at 18½ days, as stated by Mr. Randolph from his experiments, after adding to the original experiments an additional time for the correction to the mean velocity. It would seem to me in the first place that Mr. Hering has not given due weight to the relative effectiveness of different populations in the production of typhoid pollution. The sanitary district of Chicago has been

afflicted for years with an abnormal number of typhoid deaths. Other cities on the Illinois watershed, deriving their water supply from artesian wells, have extremely low death rates from the same cause. It would appear, therefore, to me, that to make the diagram more exact some method should be introduced by which the disparity in typhoid data could be allowed for in its effect upon the St. Louis water supply.

Again, I should judge that the diagram as compiled under Mr. Hering's direction gives the time of travel of the pollution vehicle at low stages of the river and therefore does not fairly indicate the greater danger of pollution to the St. Louis supply at medium or high stages of the river. It would seem that the diagram should be so constructed that these modifications might be clearly apparent.

Q. Have you prepared a diagram which, according to the methods suggested by Mr. Hering, based upon the experiments of Mr. Hiram F. Mills, which would also include the two modifications just described by you?

A. I have.

Q. Will you submit this diagram?

A. I will.

MR. JEFFRIES: Now, Mr. Commissioner, I offer this chart to be read in evidence and be made a part of the testimony of this witness.

THE COMMISSIONER: The chart is marked complainant's rebuttal chart number two (2), and is as follows:



12873

Complaints Rebuttal Chart No. 2.

Schematic Representation

of the Reduction of Typhoid Bacterial Pollution in Illinois Rivers

Using the Data and Methods proposed by Rudolf Hering C.E. in his diagram Submitted in this case.

But with Suggestions for Corrections as follows.

- 1st by using Prof Van Ornum's float experiments
- 2nd by valuing the effect of contributory population on the basis of a standard typhoid death rate of 20 per 100,000 living.
- 3rd by using velocity of pollution vehicle rather than average of full cross section of River.

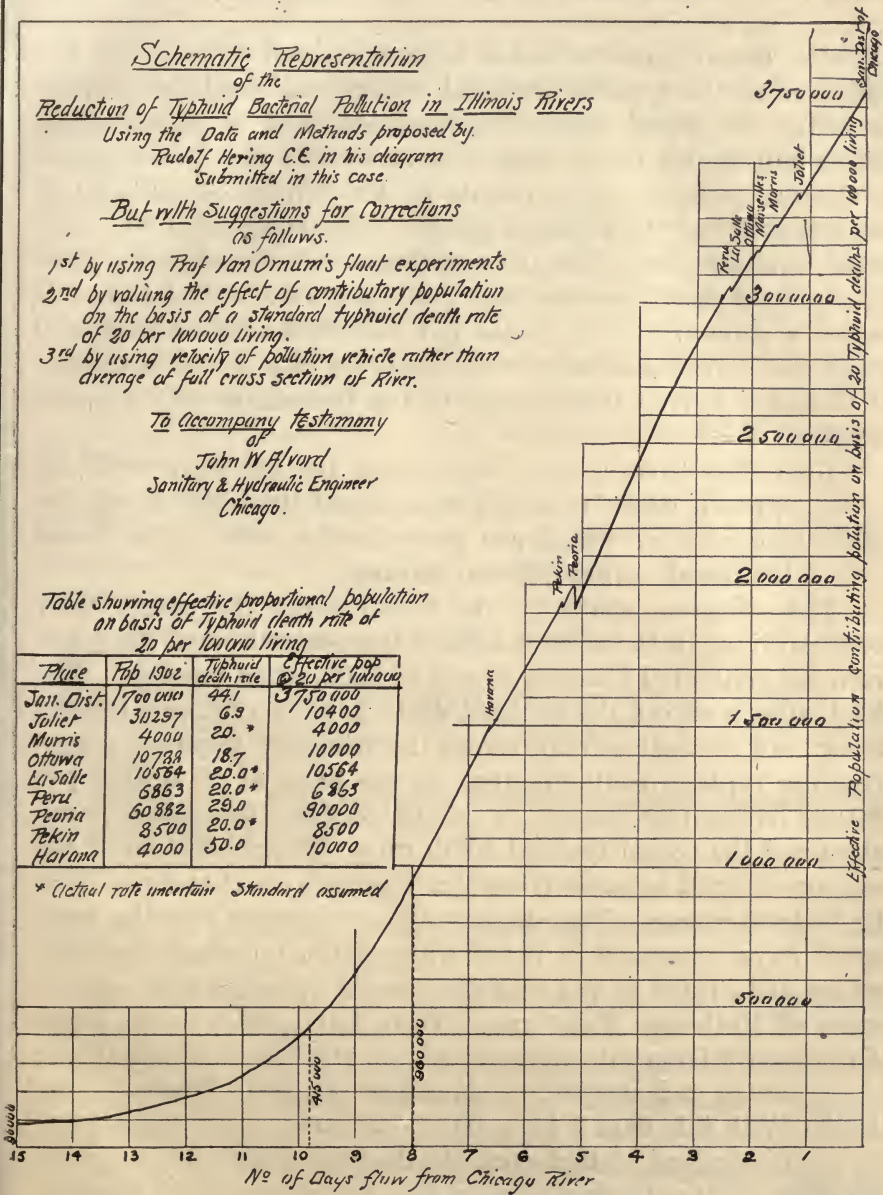
To Accompany testimony

John W Alford  
Sanitary & Hydraulic Engineer  
Chicago.

Table showing effective proportional population on basis of Typhoid death rate of 20 per 100,000 living

Place	Pop 1902	Typhoid death rate	Effective pop @ 20 per 100,000
Jan. Dist.	1700000	44.1	3750000
Joliet	30297	6.3	10400
Morris	4000	20.*	4000
Ottawa	10733	18.7	10000
La Salle	10564	20.0*	10564
Peru	6863	20.0*	6863
Peoria	60882	29.0	90000
Peekin	8500	20.0*	8500
Harana	4000	50.0	10000

\* Actual rate uncertain Standard assumed



Effective Population contributing pollution on basis of 20 Typhoid deaths per 100,000 living

12874 MR. JEFFRIES: Q. Will you please explain this diagram or chart?

A. The diagram which I have submitted covers only the reduction of the typhoid bacterial pollution in the Illinois river as being the object under consideration, and is prepared as nearly as possible in the manner described by Mr. Crane in his testimony, using the experiments of Mr. Hiram F. Mills as to the longevity of the typhoid germ. The ordinates in the diagram represent the tributary population calculated in its relative typhoid death production. As a basis for this I have assumed a standard of 20 deaths per 100,000 living as being the death rate of an ordinary well regulated city in the situation of Chicago, having due regard to the protection of its water supply.

Upon this basis I have determined for the year 1902 the typhoid death rate of Chicago and the cities along the Illinois river which are given in the table in the lower left hand corner of the diagram.

This diagram shows in the first column the place under consideration; in the second column the population of the place from the estimated Federal census of 1902; when possible. The third column shows the typhoid death rate in 1902 per 100,000 living, and the last column shows the tributary population contributing typhoid contamination on the basis of 20 deaths per 100,000 living, per annum, as calculated from the actual population and the actual typhoid death rate. The population of the sanitary district is taken from Mr. Hering's chart and not from the Federal census. The abscisse of the diagram give the number of days consumed in the flowing of the pollution from the sewers of Chicago to the 15th day, based upon the float experiments of Professor Van Ornum, from Lake Joliet to the chain of rocks, and from my estimates of the velocity in the drainage canal, and Desplaines river down to Lake Peoria.

12876 With this data I have plotted a curve in a similar manner to that plotted upon the diagram prepared under the direction of Mr. Hering, giving due consideration to the percentage of reduction in the typhoid contamination from the population center through the proper increments of time to agree with the experiments of Hiram F. Mills.

MR. JEFFRIES: Q. State what the curve in this chart indicates?

A. The curve plotted upon the diagram indicates the relative typhoid bacterial pollution, so far as the same can be predicated upon the population, by using the bacterial reduction found in the experiments of Hiram F. Mills and substantiated by Dr. Horrocks.

MR. JEFFRIES: Q. State whether or not as a general proposition the number of deaths from typhoid fever in any community represent the total amount of pollution from typhoid bacteria?

A. They do not; if they are confined to deaths only they do not represent the whole number of cases.

MR. JEFFRIES: Q. What else should be taken into consideration?

A. There are always a very large number of cases of typhoid fever which recover and which nevertheless are active producers of typhoid infection in addition to the infection produced by cases when deaths have occurred.

Adjourned until May 26, 1904, 10:00 a. m.

12878 Room 232, Southern Hotel, St. Louis, Mo. 10:00 a. m.,  
Thursday, May 26, 1904. Continuation pursuant to adjournment.

Present, the Commissioner and same counsel representing the respective parties.

#### JOHN W. ALVORD

resumed the stand for further direct examination, by Mr. Jeffries, and testified as follows:

Q. State whether or not this diagram, as constructed, represents pollution from fatal cases alone or from all cases which actually existed in the communities under consideration, special reference being here made to complainant's rebuttal chart number two (2).

A. It represents the comparative pollution contributed by the fatal cases alone. Furthermore it should be remembered that fatal cases cease to contribute infection to the stream on and after the date of the death, while unfatal cases do and may continue to contribute infecting material to the stream for days, weeks and even months.

The diagram as constructed fails to take account of this extra and added pollution and is therefore conservative.

MR. JEFFRIES: Q. How do the corrections which you have applied to Mr. Hering's chart affect the final results and especially the estimate of the typhoid contributing pollution at the chain of rocks?

A. Assuming active typhoid contamination is proportional to the population, and assuming diminution in the number of typhoid germs day by day to be as shown in the experiments of Mr. Hiram F. Mills, the modifications which I have introduced in the diagram would considerably increase the 12880 amount of typhoid pollution entering the intake at St. Louis.

I find that whereas Mr. Hering's diagram shows that the typhoid pollution entering the intake at the chain of rocks is equivalent at the end of a low river flow of 18½ days to an infection from a tributary population immediately above the intake of a city of 13,000 people, the conclusions of the diagram would seem to indicate that the normal flow of fifteen days would be equivalent to an infection from a tributary population with a death rate of 20 per 100,000 living of a city located immediately above the intake, with a population of about 90,000 people, while on the basis of ordinary spring floods, such as were gauged by Professor Van Ornum the infection arising at the chain of rocks would be equivalent to the population of a city of 415,000 population, situated immediately above the intake tower, and with a typhoid death rate of 20 per 100,000.

With a maximum flood such as occurs only once in every several years, it would appear that the comparative 12881 pollution reaching the intake of the St. Louis water-works would be equivalent to a population of 960,000 with a typhoid fever death rate of 20 per 100,000 living, this latter assumption being based upon the movement of the pollution vehicle from the Chicago river to the chain of rocks in eight days.

12882 MR. JEFFRIES: Q. Why do you employ 20 deaths from typhoid fever per 100,000 population in your last answer?

A. Because there are a very considerable number of cities which have so exercised care and discretion in the protection

of their water supplies that they have reduced the typhoid death rate to a point below this rate. Some of the smaller cities upon the Illinois river have typhoid death rates as low as 6.9 per 100,000 living. It would therefore seem to be a fairly reasonable standard to assume that all cities having reasonable regard to the purity of their water supplies should be able in the light of present science to reduce their typhoid death rate at least to the basis assumed, if not materially lower.

MR. JEFFRIES: Q. In the chart which you have introduced in evidence in comparison with the chart or diagram introduced in evidence by Mr. Hering, based upon the experiment of Hiram F. Mills, what weight do you attach to these 12883 experiments?

A. I believe they are what might be termed incomplete investigations, that is to say, they are valuable, but neither sufficiently comprehensive nor numerous. The results show that typhoid germs do live under the conditions of the experiments the length of time given, but they do not show that typhoid germs may not live much longer. The difficulty of isolating typhoid bacteria from waters of known pollution would seem to substantiate this view.

12884 MR. JEFFRIES: Q. Are you familiar with the testimony of Professor Kinnicutt in this case?

A. I have read it over.

Q. State whether or not you are familiar with the principles of practice of modern sewage purification?

A. I am.

Q. State whether or not you have given attention to the development of processes of sewage purification by means of septic tanks?

A. I have given particular attention to the development of septic tanks and have designed some ten or fifteen plants for municipalities in which a septic tank has been employed on my recommendations. Of these plants eight septic tanks have been constructed under my immediate supervision for different municipalities and have been in operation for periods ranging from one to four years. Two of these plants have been under my immediate supervision ever since construction and I have watched the operation of others.

Q. What is septic action and how long should sewage

12885 remain in a septic tank in order to obtain practical results from a sanitary standpoint?

A. Septic action is the process of breaking down the organic matters in sewage by micro-organisms or their products in the absence of oxygen. This process is continuously brought about by allowing the sewage to come nearly or quite to a state of rest in deep tanks and allowing it to remain so until the dissolved oxygen present, if any, is exhausted and until the solid particles of the sewage have been attacked and broken up more or less in soluble compounds. It is desirable in order to provide favorable conditions for this process that the temperature remain as constant as possible and very high, and it is preferable that light and air should be excluded, although this is not absolutely essential. The proper period of rest necessary to get the best results will vary with the composition of the sewage, its temperature and character. It has been found desirable to adjust the rest period so that the temperature and other variables can be controlled and the period of rest adapted to the concentration of the sewage and its relative flow, proportioned to the tank in which it is confined.

MR. JEFFRIES: Q. State whether or not flowing sewage ordinarily undergoes the process of septic action?

A. It does not ordinarily.

Q. State whether or not diluted sewage flowing in open channels simulate septic tank conditions?

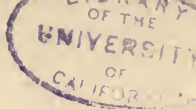
A. It would not. The flow of liquids through open channels tend to bring all portions of the liquid from time to time to the surface where it may receive oxidizing influences tending to retard septic action.

Q. Are you acquainted with the present physical condition of the Chicago Drainage Canal?

A. I am.

Q. Please compare the conditions existing in the Chicago Drainage Canal with those of a true septic tank?

12887 A. In the Chicago Drainage Canal we have a large volume of diluted sewage flowing at the rate of one to three feet per second, giving ample opportunity for renewing its dissolved oxygen. And we have this action further increased by the opportunity of the wind to stir the surface of the stream and still further oxygenate it.



We have also an opportunity for exposure to low temperatures, light, etc., which are detrimental to the septic action.

Q. State whether or not septic action to any considerable extent takes place in the sewage of Chicago during its passage through the drainage canal?

A. It does not.

Q. Are you acquainted with the chemical data that has been introduced in evidence by the defendants?

A. I am to some extent.

Q. State whether or not in your opinion the chemical data introduced by the defendants with reference to the character of the contents of the Chicago drainage canal, indicate any septic action has taken place?

12888 A. My opinion is that they do not. The amount of improvement in the sewage in its travel of the drainage canal found by Professor Kinnicutt in his testimony in this case would seem to me to be largely due to aerobic action. Possibly there is anaerobic action to a very limited extent, but not enough in my opinion to influence the results perceptibly.

Q. State whether or not the extensive dilution of the sewage of the city of Chicago by the richly oxygenated water of Lake Michigan is a useful preliminary to septic action?

A. It is not. On the contrary it is distinctly opposed to the inception of septic action. In good practice, in the designing of septic tanks it is the endeavor always to bring the sewage into the tank as quietly as possible, undiluted with surface or underground waters containing dissolved oxygen.

Q. State whether or not you were familiar with the South branch of the Chicago river prior to the opening of the drainage canal?

A. I am.

Q. What was the condition of that part of the river at that time?

A. It presented all the characteristics of septic action to a marked degree.

12889 Q. What were those characteristics?

A. The absence of marked current, and the presence in certain places of foul products and considerable surface scum, the absence of undissolved oxygen as shown by chemical examinations and the visible production of gases bubbling up

from the depths below such as characterize the septic tank when in active reduction of its organic matter.

MR. JEFFRIES: Q. State whether or not in your opinion typhoid germs are now more able to survive longer under the present condition of sewage dilution in the drainage canal than they could formerly have survived in the South Branch of the Chicago River or in the Illinois and Michigan Canal?

A. I believe that typhoid germs could survive materially longer under the present conditions than was the case formerly in the Illinois and Michigan Canal and the South Branch of the Chicago River.

Mr. Jeffries: Q. Taking into consideration your knowledge of septic operation, and all that you know upon the subject of sanitary science and sanitary hydraulic engineering and taking into consideration the physical condition of the Illinois River the drainage canal and the Desplaines River, and the chart or diagram introduced in evidence by Mr. Hering, and the diagram introduced in evidence by you in connection therewith, state whether or not in your opinion the presence of sewage from the sanitary district of Chicago in the waters of the Mississippi River at the chain of rocks makes it more costly to provide suitable water for domestic purposes for the citizens of St. Louis?

A. In my opinion it does make it more costly.

Mr. Jeffries: Q. In what respects is the water supply of St. Louis made more costly or difficult by virtue of the opening of the drainage canal?

A. The design and construction of a purification plant dealing with a seriously polluted water, especially of one of known high typhoid pollution should be more complete and delicately adjusted to its work than when dealing only with water of rare infection and presenting less dangerous difficulties such as turbidity and color.

Mr. Jeffries: Q. What form should this added protection take?

A. It should take the form either of double filtration or have complete sedimentation in more than one stage followed by most careful filtration.



Mr. Jeffries: Q. State whether or not you know of any case where double filtration is being used or resorted to?

A. It has been resorted to in several places in Germany 12893 and has been recommended at Springfield, Massachusetts, by Messrs. George W. Fuller and Samuel M. Gray, and is now being introduced into the new filtration plant of Philadelphia by Mr. John W. Hill, in which case they are proposing to pass water of known typhoid pollution through what are called preliminary filters as a first stage and then through slow sand filters as a second stage.

Mr. Jeffries: Q. Would such methods be more expensive than single filtration?

A. They would. It is my opinion that they would very greatly increase the cost of filtration, both in its first construction and in operation.

Mr. Jeffries: Q. State whether or not single sand filtration as practiced in the United States is always a protection from the danger of typhoid infection?

A. It is not.

Mr. Jeffries: Q. Why is it not?

A. Sand filtration of either type is practically able to remove pathogenic bacteria from domestic water supply, but we find that in practice filtration works are a most delicate mechanism, which have to be very carefully operated in order to produce at all times and under all conditions the results anticipated by their designers. In cases where the danger of infection hovers over the filtration plant year in and year out it is obvious that the slightest relaxation may result in the most serious consequences.

Mr. Jeffries: Q. State whether or not you know from your own observations and study of the cases in which single sand filtration or filter plants of either type have failed to 12895 protect the water supplies from typhoid infection?

A. I do. There have come under my observation, typhoid epidemics in water supplies protected by filtration in the following places:

Rock Island, Illinois,  
Ashland, Wisconsin,  
Berlin, Germany,

Lawrence, Massachusetts,  
 Lake Forest, Illinois,  
 Butler, Pennsylvania,  
 Waterloo, Iowa,  
 Beaver Falls, Pennsylvania, and  
 Augusta, Maine.

MR. JEFFRIES Q. Mr. Alvord, are you a member of any engineering societies or associations?

A. Yes, sir; I am a member of the American Society 12896 of Civil Engineers since 1893. I am a member and trustee of the Western Society of Civil Engineers. I am president of the Illinois Society of Civil Engineers and Surveyors. I am a member of the American Waterworks Association and of the New England Waterworks Association. I am also a member of the American Public Health Association, and am serving this year upon its committee of water and sewage purification. I am a member of the American Society of Municipal Improvements, the American Academy of Social and Political Science, and of the Engineers' Club of Chicago.

Q. Mr. Hering, who testified for the defendants on March 10th last, was asked by counsel for the defendants the following question "From what you know of the question of disposal of sewage and from the knowledge which you have in regard to the drainage canal, the manner in which it is operated, and taking into consideration the experience you have had since you made your preliminary report, what changes would you recommend for the sewage disposal of the city of Chicago if the same problem was submitted to you now which was submitted to you in 1886, as a sanitary and hydraulic engineer?" An- 12897 swering this question Mr. Hering said that in considering the several ways of disposing of the sewage of Chicago, from personal knowledge and experience, my recommendation would be that the sewage of Chicago should be disposed of by dilution through the channel substantially as that which has been constructed with the subsequent discharge into the Desplaines and Illinois rivers." Thereupon the following further question was asked him: "In the study of this problem have you discovered anything that would change the view expressed by you in your preliminary report at that time?" In answer to

which question Mr. Hering said: "I have not." I will ask you, Mr. Alvord, to state whether or not there are in your opinion any practical modifications of the existing system of sewage disposal of the city of Chicago by which the drainage canal could still be employed for keeping the Chicago river in an inoffensive condition and yet avoid the pouring of unpurified sewage into and through the canal over the Bear Trap Dam at Lockport and into the Desplaines and Illinois rivers?

A. I am of the opinion that it is entirely practicable to retain the drainage channel so that it can be still employed for keeping the Chicago River in condition and yet avoid pouring unpurified sewage into and through the canal and into the Desplaines and Illinois Rivers, and I would suggest as the proper remedy the construction of suitable intercepting sewers along the Chicago River and its branches, by means of which the sewage flow of the city may be kept out of the Chicago River and led along its banks to the upper end of the drainage channel beyond Bridgeport and then raised by a suitable pumping station preferably operated with water power derived from the drainage canal to and into a suitable purification plant constructed in accordance with the latest bacteriological 12899 principles and effectually remove from such sewage all or practically all of its organic wastes and pathogenic bacteria and emptying the effluent from such sewage plant into the drainage channel near Bridgeport to be conveyed through the same and through the Desplaines and the Illinois Rivers in a harmless and purified state.

Mr. Jeffries: Q. State whether or not you have considered the relative expense of such a plant as you have described in your last answer?

A. I have considered the expense in a general way and am of the opinion that such intercepting sewers and purification plant could be constructed at an expense no greater than that necessary to widen the South Branch of the Chicago River in order to increase its flow of dilution water to the requirements of dilution.

And I am further of the opinion that the operating ex-  
12900 pense of such a plant would be no greater than the operating expense of the present system of pumping sewage

and the necessary dilution water through the same for the northerly and southerly portions of the sanitary district and the dilution water for the proposed additions to such sanitary district.

CROSS-EXAMINATION, by Mr. Todd:

Q. In figuring out such a purification plant as you have referred to in your last answer and the building of intercepting sewers and the operation of pumps and the installation of pumping machinery, what estimate in dollars and cents do you place that such a plant would cost, according to your estimates?

A. Between twelve and fifteen millions of dollars.

Q. Does that contemplate the purification of the entire sewage of the sanitary district?

A. It does.

Q. From Calumet on the south and Lake View on the 12901 north and the building of intercepting sewers on each side of the Chicago River and on each side of the north branch which receives the sewage from its adjacent neighborhoods as well as the sewage from Twelfth Street south and the west side?

A. I should not think it necessary to build intercepting sewers on each side of the river. One main sewer connecting across the river by tunnels would probably result in economy of expenditure over a double intercepting sewer along each bank.

Q. How would you intercept the sewers that empty into the Chicago River from its left bank?

A. I should carry an intercepting sewer along either one or the other banks of the river, along the most economical location, connecting it with the mouths of the sewers on each side of the river, either by short branch tunnels, grouping several sewers together on the opposite side or in the case of the large sewers by direct tunnel connections in each case.

Q. What would be the cost that you would figure for the pumps necessary to pump the entire sewage of Chicago from its sewers and the intercepting sewers to this purification plant?

A. I would not be able to give you those detail figures at

this time as I do not have them by me. The estimates were made some years ago.

12902 Q. How many acres of land would be necessary for the plant located in the neighborhood of Bridgeport, sufficient to dispose of the entire sewage of the city of Chicago and the sanitary district?

A. That would depend entirely upon which of several available systems of bacterial purification might be adopted.

Q. Taking the one that you had in mind when you gave your testimony?

A. I do not think I had any particular one in mind.

Q. How were you able to make an estimate if you did not have a particular system in mind upon which to base an estimate?

A. By estimating the cost of the one which would in all probability be the most expensive.

Q. Taking the one that would probably be the most expensive, how many acres of land in the neighborhood of Bridgeport would it require to establish such a purification plant?

A. Possibly 1,000 acres.

Q. Do you know what the value of real estate in the neighborhood of Bridgeport is?

12903 A. I have general ideas.

Q. What are your ideas on the value of 1,000 acres of land in the neighborhood of Bridgeport where you contemplated the establishment of such a plant, per acre?

A. Possibly a half a million of dollars. It would be desirable perhaps to place the plant at the point where the maximum of land could be obtained at the minimum price, not confining ourselves to any exact location in the vicinity or below Bridgeport.

Q. Have you any spot in mind where such an amount of land could be had near Bridgeport at \$500.00 per acre?

A. The sanitary district of Chicago has a large amount of land in that vicinity and without having given the subject particular attention I should judge that it might be possible that they had land enough without having to purchase any additional.

Q. Do you assert that as a fact or as a surmise that the sanitary district owns 1,000 acres of land within a distance of three or four miles of Bridgeport, available for such use?

A. I would not limit myself to three or four miles. It is not necessary in the location of such a plant to limit  
12904 yourself. The plant could be eight or ten miles away.

Q. If the sanitary district of Chicago owns 400 feet on each side of the channel from its mouth at Robey Street to Summit, with the exception of a few places where it goes back as far as 700 or 800 feet, would you consider the plant such as you have contemplated could be utilized on a long stretch of that kind?

A. It might be done or some other mode of purification which occupied less land than that, which I have estimated might be put in. There are several different kinds of bacteriological purification which demand different and varying amounts of land. We find at times we are limited in land and we recommend often that kind of purification which can be placed upon the minimum of land. If we find that land of a suitable character exists in abundance it varies our ideas as to what form of purification we would recommend.

Q. In bringing the sewage from the different sections of the city what estimate did you place upon the cost of the construction of additional sewers in order to bring the sewage to the plant?

12905 A. About five million dollars.

Q. Where would those sewers be located?

A. Following as closely as possible the north and south branches of the Chicago river and endeavoring to strike with the shortest possible length the greatest number of present sewer outlets emptying into the river.

Q. Have you figured out the cost of such a system as you have in mind in making your estimate?

A. I have figured it far enough to see that it is practicable and reasonably economical.

Q. Will you give in detail briefly the plan which you have in mind for the disposal of Chicago sewage?

A. Well, I have quite a number of plans in mind. I have not limited myself to any one plan.

Q. Well, give me the plan as it pertains to the delivery of sewage to the plant which you had in mind?

A. Well, in order to utilize as far as possible construction already commenced, I would begin by saying that the intercepting sewers now under way would form possibly a basis for conducting the sewage of the outlying portions of the city 12906 from the north end and from the south districts so far as they go. These I should supplement with additional intercepting sewers conveying their contents and the outflow of the sewers now emptying into the different branches of the river to the vicinity of the drainage channel beyond Bridgeport, necessarily finding that in doing so I had consumed some gradient or fall which must be recovered by pumping not only to raise the sewage to the level of the drainage channel, but to raise it an additional height necessary to pass it through that system of purification that might be selected. Different systems of purification also vary in that they require different amounts of head necessary to properly purify the sewage which passes through them.

Q. How would you bring the sewage from the north branch of the city to Bridgeport?

A. The north side of the city has already under construction a system of intercepting sewers along the lake shore now completed, and a branch across at Lawrence Avenue to the north branch of the Chicago river where it is proposed to erect a pumping station to elevate that sewage into the north branch. This collects all of the sewage of the north portion of the city, 12907 which formerly emptied into the lake. I would, therefore begin at the point where this sewage is to be lifted into the north branch and continue a new intercepting sewer from that point along the north branch of the Chicago River on the side which might be found by detailed study to be the most convenient, thence to the junction of the north branch with the south branch of the Chicago River and along the south branch of the Chicago River to Bridgeport, in such location that it would receive the discharge of all of the sewers on the north side of the city not connected with the intercepting sewer system now under construction, it would be further necessary in order to collect the sewage of the north side of the city

to extend a short branch of the intercepting sewer easterly from the junction of the north and south branches of the Chicago River to intercept those sewers emptying into the main river from the north side.

Q. How would you bring the Calumet District to Bridgeport?

A. The Calumet district within the limits of the sanitary district is now proposed to be brought to the east fork of the south branch by a system of intercepting sewers now nearly completed. This intercepting system contemplates a pumping station in the vicinity of Seventy-third Street, I think, 12908 proposals for which have just recently been advertised.

This pumping station will lift the sewage of the extreme southern portion of the district into the intercepting sewer already finished or nearly so which runs northerly along Stoney Island Avenue and the right of way of the Illinois Central Railroad to Thirty-ninth Street, where a very large pumping station is now being erected to pump dilution water into a conduit which will take such dilution water and sewage from the intercepting sewer and carry it westerly to what is known as the Stock Yards Slip at Halstead Street.

Q. How would you take the sewage from South Chicago by the method you have described as the method adopted for the Calumet District?

A. The sewage of South Chicago is proposed by the present plans of the sanitary district of Chicago to be carried to the main channel by way of Blue Island and the Sag Valley. I would say that in making my estimate of \$5,000,000.00 for intercepting sewers I covered the territory of the original sanitary district and not the district as enlarged by the act of the Legislature in 1903. Such outlying territories as have since been added could be brought to Bridgeport in any event by 12909 methods and at an expense which would be equal in either case with the methods and within the costs now proposed by the sanitary trustees, but the preference, if any, in favor of the system which I have outlined in that no dilution water would have to be pumped in addition to the sewage.

Q. What estimate do you place for the widening and deep-



ening of the Chicago River to a width of 200 feet and to a depth of 26 feet, as is contemplated to be done at present?

A. The best of my knowledge and belief the estimates for widening of the Chicago River to the uniform width of 200 feet so far as I have seen them published range from eleven to fourteen million of dollars. I believe it would be fair to say that the cost can not be accurately estimated in advance as large portions of valuable land will have to be acquired by condemnation.

Q. Are you aware of the amount of land that has already been acquired by condemnation?

A. I am aware that condemnation is constantly going on.

Q. Are you aware that over seven-tenths of the land has already been acquired?

A. I have no information other than that that I have stated.

Q. And this is in detail the method of the sewage disposal systems that you have proposed to construct, the amount of land that it would be necessary to acquire under this 12910 estimate is in the neighborhood of twelve million dollars?

A. The total cost of the whole project would be twelve to fourteen millions of dollars.

Q. At the time that Mr. Hering made the preliminary report when the question of sewage disposal for Chicago was under consideration was the question of bacteriology then recognized as a science?

A. Not generally.

Q. Was the question of the purification of sewage in the manner that you have described it then known?

A. The purification of sewage was then known and extensively practiced, but the systems which I now have in mind were not developed, and speaking generally the systems then in use while efficient, were expensive.

Q. What experiments have you conducted upon the longevity of the typhoid germ as a bacteriologist?

A. None whatever.

Q. Have you ever separated the typhoid germ in the laboratory from the excreta of typhoid patients?

A. I have not.

12911 Q. Are you sufficient of a bacteriologist to do so?

A. I am not.

Q. Have you ever made any experiments of your own upon the longevity of the typhoid germ in sewage?

A. I have not.

Q. Have you made any experiments of your own upon the longevity of the typhoid fever germs in sterilized water in lake water, in the water of the drainage canal or the waters of the Illinois River?

A. I have not.

Q. Have you examined and read the experiments introduced in evidence in this case and made by Professors Jordan, Zeit and Russell?

A. I have.

Q. Have you read the entire testimony in regard to those experiments or has it been told to you?

A. I can not say that I have read it all. My time has been too limited to read all that has been introduced on the subject. I have read portions of it and am familiar with parts of it.

12912 Q. Have you read the experiments of Professors Jordan, Zeit and Russell as carefully as you read the experiments of Hiram F. Mills?

A. Yes sir.

Q. In reading the experiment of Hiram F. Mills, have you read the technique of the manner in which the experiment was conducted and the method employed in the detection of the typhoid germ?

A. Yes sir.

Q. How do the methods employed by Hiram F. Mills compare with the methods employed by Jordan, Zeit and Russell in the detection of the typhoid germ?

A. I should not consider myself competent to criticize the technique of either Mr. Hiram F. Mills or Messrs. Jordan, Zeit and Russell.

Q. Have you read the experiments made and introduced in evidence in this case in the testimony of John W. Hill of Philadelphia, who is in charge of the filtration bureau?

12913 A. I have read as much of it as was possible in the time at my disposal.

Q. I mean the testimony on the experiment of the typhoid germ in the water of the Schuylkill River?

A. I do not think I have read that. I do not remember to have seen that.

Q. In the chart which you have introduced in evidence, in which you testified that since the opening of the drainage canal the typhoid rate in the cities on the watershed of the Illinois River has gone up since 1899 to 1900, exclusive of Chicago, I believe you called special attention to that feature of the chart in your direct testimony did you not?

A. It seemed to me a variation in the general result worth noticing.

Q. How do you account for that rise as evidenced on that chart from 1899 to 1900?

12914 A. I have not attempted to account for it particularly. I think I observed that the line was fairly uniform and that the only marked departure from the uniformity was that rise which I considered not of large amount.

Q. For the years 1900, 1901 to 1902 there is a fall in the typhoid along the Illinois River, exclusive of Chicago, is there not, as evidenced by this chart?

A. There is a slight fall.

Q. How do you account for that?

A. I have not attempted to account for it.

Q. Upon the Mississippi River from 1899 to 1901 there is a rise in the typhoid rate as evidenced by the chart. How do you account for that?

A. I have not attempted to account for that, or for any of the minor fluctuations except on the theory that there are always fluctuations in any such death rate, and that in order to be of interest they should be somewhat marked.

Q. There was a rise in St. Louis from 1898 to 1899 to 1900 — was that not evidenced by this chart?

A. That was on the face of the returns from the typhoid deaths.

12915 Q. From the face of the returns in each instance is it not?

A. In each instance with the exception noted in the lower

right hand corner of the chart which refers to a dotted line leaving the deaths in St. Louis at the year 1898 and rejoining that again in the year 1901. In this case the face of the returns are plotted in the usual line in which all of the St. Louis deaths are situated, and the possible deduction due to localized epidemics is shown by this dotted line above referred to. With that exception the diagram is constructed wholly from the deaths agreed upon in this case.

Q. Is there anything on this chart that shows that the rise of typhoid fever in the city of St. Louis is due to the typhoid condition in the city of Chicago?

A. I think there is.

Q. Will you point out on this chart where such a fact appears?

A. The diagram shows that the deaths on each of the three water sheds contributing to St. Louis are fairly and reasonably uniform, barring the minor fluctuations which always occur in such death rates from various slight causes, but the diagram further shows that at and from the year 1900 a very large number of deaths were added to the normal deaths upon the combined water shed by the opening of the drainage canal. In two years after the opening of the drainage canal the total number of deaths attributable to the water supply of St. Louis had been more than doubled, in marked contrast to the fairly uniform conditions which prevailed on each water shed, excluding the sanitary district of Chicago.

Q. And is that evidenced by the chart which you have referred to?

A. I think it is.

Q. Have you seen the charts prepared by Professor Mason, comparing the typhoid conditions in Chicago with the typhoid fever conditions in St. Louis by the month?

A. I have not. They do not seem to me to be among the records which I have examined in this case.

Mr. Jeffries: I want to state in this connection that the charts offered in evidence by Professor Mason and about which this evidence concerns were placed in the hands of the

12917 Commissioner at once and the complainant since that time has not been in condition to examine them or have witnesses examine them.

Mr. Todd: Q. Have you compared the typhoid condition in the city of Chicago by the months with the typhoid condition in the city of St. Louis by the months?

A. I have not.

Q. Would such a comparison, allowing thirty days interval between Chicago and St. Louis to intervene, shed any light upon the question as to whether Chicago has any effect upon the typhoid conditions in St. Louis in your opinion?

A. I should be afraid that it would induce too many fluctuations and variables to be of the greatest value, I should prefer to take the averages for the year, showing in a more marked manner any main distinguishing characteristics.

Q. Might not an increase in the typhoid fever in the city of St. Charles be expressed in the typhoid conditions in the city of St. Louis?

A. Possibly.

Q. Might not an increase of typhoid fever in Kansas City be expressed in the increase in typhoid fever in the city of 12918 St. Louis, taking into consideration that sixty-seven per cent. of the water consumed in St. Louis is Missouri River water?

A. It might possibly but so far as I have been able to observe it does not.

Q. Can you tell whether the infection that afflicted St. Louis comes from St. Paul, Minneapolis and the cities on the Mississippi River, the cities on the Missouri river or the cities on the Illinois River?

A. I think when conditions are marked and data fairly adequate that it is possible to tell.

Q. Do you consider that any of the typhoid fevers cases in the city of St. Louis is due to Missouri River water?

A. There is always that possibility.

Q. What is your opinion as to whether any of the typhoid fever in St. Louis is due to Missouri River water?

A. My opinion would be that a percentage of the normal typhoid deaths in St. Louis prior to 1900 would very probably

be due to the contamination from waters of the Missouri River.

Q. What cities on the Missouri River would you attribute the infection to?

12919 A. I should want to make a more detailed study of the case before venturing an opinion. My endeavor has been to study the problem by water sheds rather than cities, except in the case where I have added the sanitary district of Chicago.

Q. Would you regard the conditions at St. Charles as contributing as much typhoid as the city of Kansas City, to the city of St. Louis?

A. It is probable that it may have an equal effect upon the normal typhoid deaths in St. Louis.

Q. How far would you consider the city of St. Charles by water in point of time from the St. Louis intake?

A. I am not exactly informed as to that.

Q. The distance has been estimated by the river at approximately forty miles. Are you acquainted with the hydraulic conditions of the Missouri River?

A. To some extent.

Q. If one typhoid fever patient could create the epidemic at Plymouth, Massachusetts, what effect in your opinion would the number of cases of typhoid deaths in the city of St. Charles as evidenced by the statistics which you have studied, have upon the water supply of St. Louis?

A. There are always possibilities of contamination from 12920 unexpected sources.

Q. Would you say that beyond all reasonable doubt the typhoid fever as you know it to exist in the city of St. Charles is not responsible for the great proportion of the typhoid fever in the city of St. Louis, bearing in mind what you know about the epidemic at Plymouth, Pennsylvania, and of other epidemics that you have studied and introduced in this case?

A. I should be inclined to think from my diagram that the typhoid deaths in St. Charles might have influenced the normal typhoid deaths in St. Louis prior to 1900 to some unknown percentage.

Q. Since 1900?

A. I should be disinclined to think that since 1900 the

typhoid in St. Charles could have been responsible for so marked a change in the number of deaths in St. Louis from typhoid.

Q. Does the number of people afflicted with typhoid fever in a given city depend upon the number of people that have typhoid fever above on the water shed?

A. It does to some extent when you are considering averages over long periods.

12921 Q. How do you account for the Plymouth epidemic that was due to one typhoid fever case?

A. There are always exceptional occurrences of that kind.

Q. Might not such an exceptional occurrence happen between St. Charles and the city of St. Louis?

A. It is within the range of possibility.

Q. Being in the range of possibility, can you assert that the greater proportion of typhoid fever in the city of St. Louis can not be attributed to such a possibility beyond all reasonable doubts and to a moral certainty?

A. In the absence of direct proof that the typhoid deaths in St. Charles have been responsible for the rise in deaths in St. Louis, we are obliged to proceed on the theory of probability, and the theory of probability would indicate that the preponderating number of deaths, wherever they may be found, are the responsible cause, therefore I would be disinclined to attribute (in the absence of direct proof) the rise in the typhoid deaths in St. Louis to the typhoid deaths in St. Charles.

Q. Do you employ the theory of probabilities in drawing your conclusions that the typhoid increase in St. Louis 12922 is due to Chicago?

A. Whenever we deal with a problem of the magnitude of this problem and its complications, we are obliged as one of the contributing data to proceed on such theory.

Q. And that theory has been employed by you in giving your opinions on the effect of the opening of the canal upon the typhoid condition in St. Louis?

A. As one the data from which I draw my conclusions.

Q. What importance do you attach to the typhoid conditions on the water shed of the Missouri River?

A. The importance that is shown by the plotting of their

deaths upon this diagram in its relation to the deaths from other sources.

Q. Anybody could plot those deaths on a diagram could they not?

A. Well, they might not always be able to accomplish that in such a way that they would bring clearly out the facts.

Q. But my question is, what importance do you attach regardless of the diagram to the number of cases of typhoid fever on the water shed of the Missouri River as affecting the 12923 sanitary quality of that river?

A. I should attach this importance, that I observe that the typhoid deaths on the Missouri water shed, all things considered, have been fairly uniform for the whole period shown, and therefore whatever percentage of contributory infection the Missouri water shed may have produced prior to 1900, I should be inclined to attribute in equal degree to the period since 1900.

Q. Do you regard the water of the Missouri River in its raw state as a safe drinking water for drinking and domestic purposes?

A. I do not.

Q. As treated by the settling basins of St. Louis, do you regard it as a safe drinking water for drinking and domestic purposes?

A. I should say that it has in all probability been greatly improved in its general character.

Q. Is it not a fact that the water of the Missouri River has been deteriorating as a safe drinking water for the last twenty-five years, and each year more so?

A. I think that may be safely assumed and the same is probably true perhaps of all our western rivers.

12924 Q. Do you regard the Mississippi River above Grafton as a safe drinking water?

A. I do not.

Q. Do you regard the water of the Illinois, Mississippi and Missouri Rivers, assuming that the sanitary district of Chicago was eliminated, and treated as it is treated in the settling basins at St. Louis, as a safe drinking water to be used by a city of 800,000 inhabitants, such as St. Louis is, as it is at present used?

A. I do not regard it entirely so.



Q. If you were selected as a sanitary engineer or a hydraulic engineer to pass upon the quality of the water of the Mississippi River, a mixture of Missouri, Mississippi and Illinois River water, excluding the sanitary district of Chicago, treated as it is now treated, would you recommend it as a safe drinking water, free from typhoid infection?

A. I should not like to so recommend it.

Q. What were the discharges of the Illinois River at the time that Randolph made his float experiments?

A. I was not able to discover. I believe Mr. Randolph 12925 gave some gaugings at Peru and gauge readings at La Salle, but as I have no data for these cross sections, I am unable to determine what the stage was in terms of the discharge.

Q. Was it at high, low, average, mean or below mean flow of the Illinois River?

A. If I were obliged to determine from such evidence as I am able to derive from his testimony, knowing that the time when the floats were run, was in the month of July, and knowing that the total time of transit in comparison with Professor Van Ornum was as 10 is to 15, I should be inclined to judge that the stage at which Mr. Randolph's experiments were taken were the average low waters of mid summer.

Q. If you do not know the stages of the river and its flow, how are you able to give that opinion?

A. I do not think that that opinion is as valuable as it would be if I did know the exact stages of the flow.

Q. It is more in the nature of a guess than an opinion based upon scientific knowledge?

A. It is an intelligent guess.

Q. Did you ever measure the current from the Bear Trap 12926 dam to Lake Joliet with floats yourself?

A. I believe not personally.

Q. Do you know what the fall is from the Bear Trap dam to Lake Joliet?

A. Yes sir.

Q. Knowing the fall and the volume of water, can you figure the velocity of flow?

A. Yes sir.

Q. Can that be accurately ascertained by that method?

A. Not as accurately as it could by the floats.

Q. Did you have it done?

A. No sir.

Q. With floats?

A. No sir.

Q. When you corrected Professor Van Ornum's time, what method did you employ in doing it?

A. I calculated the mean velocity by the cross-section and fall and deducted the surface velocity by dividing by .8.

Q. Is there a better method than floats such as Professor Van Ornum used?

A. There would not be if the same stages were considered, 12927 but it is impossible to predicate the surface velocity at another stage from the float experiments of Professor Van Ornum, with any very great exactness. I might say however that I used the speeds found by Professor Van Ornum for the lower stage as a check upon the calculations which I made for the slightly higher stage which I got.

Q. In figuring out the average time between Chicago and St. Louis, what conclusions did you come to?

A. That at most stages of the river uninfluenced by flood of any kind, the time of passage of the pollution vehicle would be in the neighborhood of the float experiments, as determined by Mr. Randolph or thereabouts, but not reduced to mean velocity, and that in times of slight or medium rises, the time of passage of the pollution vehicle would be apparently in accordance with the experiment of Professor Van Ornum, and that in time of very great floods, such as occurred in 1902, and I believe in 1888, and at one or two other times in my recollection, the time of passage might be reduced to eight days or less.

Q. In the times of flood there would be greater dilution would there not?

12928 A. Yes sir.

Q. And dilution minimizes danger from infection, does it not?

A. Not altogether; it increases the longevity of the typhoid germ.

Q. But it disseminates them in a greater body of water

thereby diminishing on the theory of probability, the danger from infection does it not?

A. I should think that would be a fair statement, yes sir.

Q. In figuring on Mr. Hering's chart that is introduced in evidence, did that chart show a population of 13,000 people above the intake tower?

A. I have not seen the original chart that Mr. Hering produced but a zinc etching which has been reduced in size, so that it is difficult to determine what the actual figures might be from the scale. I have, however, relied upon the statement of Mr. Crane, who prepared the chart, with reference to those figures.

Q. By the method that you employed on the Illinois end of this chart, applying that same method to the Missouri and Mississippi Rivers, will you state what the results show?

12929 A. I have not undertaken to reduce the Missouri and Mississippi Rivers to terms of typhoid pollution at St. Louis in the manner shown by Mr. Hering.

Q. Why?

A. Because I did not deem them pertinent to this inquiry.

Q. The chart which Mr. Hering introduced in evidence showed a comparison between the conditions that obtained on the Illinois, Mississippi and Missouri Rivers, based upon Mill's experiment, did it not?

Mr. Jeffries: Object to the question for the reason that this inquiry is not to determine the extent of the pollution and the infection of the Mississippi River above Grafton and the Missouri River, but that the inquiry is directed solely to the effect that the sewage discharged from the city of Chicago has upon the waters of the Illinois River and consequently upon the waters of the Mississippi River below Grafton.

A. Yes sir.

Mr. Todd: Q. If you had carried out the comparison contemplated in the chart introduced by Mr. Hering, would the pollution from the Illinois River be as great as the pollution  
12930 from the Mississippi and the Missouri Rivers, figured in the same manner that you have figured the chart which you introduced?

A. I am not able to say, not having worked out the data.

Q. In order to make a comparison between your method of calculation and the method employed by Mr. Hering, do you not think it would have been more accurate to have carried out your charts for the three rivers instead of one?

Mr. Jeffries: I object to the question for the reason that it is not competent evidence in this case to make comparison between the relative pollutions of the three rivers, the question involved in this case being as to the effect of the sewage discharges from the city of Chicago upon the Illinois River and Mississippi River below Grafton, and for the further reason that the chart introduced in evidence by this witness based upon the chart of Mr. Hering, which was prepared by Mr. Crane, was not introduced for the purpose of showing a comparison between the pollutions of the three rivers, but for the purpose of showing the effects of the sewage of Chicago upon the waters of the Mississippi River below Grafton.

Mr. Todd: In reply will state that the chart speaks for itself and shows the opposite of what the counsel con-12931 tends.

Q. Question read.

A. I do not see how it could.

Mr. Todd: Q. In the chart which you introduced, computed upon the method which you adopted, I believe you stated that at a maximum flow in the Illinois River, the pollution at the intake tower of the chain of rocks was equal to an infection from a population of 960,000 people. Is that correct?

A. I think I stated that the method of Mr. Hering, worked out with the corrections which I have suggested, would indicate that.

Q. Did you not understand Mr. Hering's chart to be for the purpose of showing the relative pollutions of the three rivers with a ratio of 13 to 97 and 106, whether expressed in people or otherwise?

A. I understood that that was one of the facts which he endeavored to bring out, but I also understood from the study of his chart that he was endeavoring to bring out as well the probable amount of pollution which would reach the intake at the chain of rocks from the sanitary district of Chicago, based upon the experiments of Hiram F. Mills and the float experi-

ments of Mr. Isham Randolph.

12932 Q. You did not understand his testimony and the chart to mean that there was a city of 13,000 people dumping sewage into the Mississippi River at the intake?

A. I took it that that was the practical effect of his reasoning.

Q. And under your interpretation of the chart, supplemented by your method of calculation, there would be, at maximum time, a population of 96,000 people?

A. There would be.

Q. In the testimony that you have given when filter plants have been in operation, and the cities using such filter plants have been the victims of a typhoid fever epidemic through the mismanagement or other cause of the plants, are any of those plants to which you refer owned and operated by the municipality itself or by private water companies?

A. They are about equally divided between the two.

Q. How many of these epidemics were due to shutting down of the filters and turning in the raw water to the water supply of the people?

A. I think two.

Q. Which ones?

12933 A. Butler, Pa., and Beaver Falls, Pa.

Q. That was not the cause then of the filter plant as much as the carelessness of the water company?

A. Well, it was the fault of the filter plant to adequately protect the water supply through the carelessness of the employe connected with it.

Q. In the matter of the Butler Company do you know whether it was a question of the employes or the question of the management that took that filter plant out of operation and turned the raw water in?

A. I think it was, in that case, the question of the management.

Q. Are you familiar with the causes that led to the epidemic at Butler?

A. Somewhat.

Q. In the case at Beaver Falls the same thing is true is it not?

A. I should say that it was.

Q. What is the cause of greatest expense in constructing a filter, matters in suspension or infection?

A. That will depend very much upon the kind of water and its amount of pollution that is to be dealt with.

12934 In a turbid water free from typhoid pollution, the turbidity will undoubtedly be the cause of the greatest expense, but in a water comparatively clear, or clear most of the time, but subjected to typhoid infection, the infection will undoubtedly be the greatest cause of expense.

Q. Which would it cost the most to filter, the Missouri, Mississippi or the Illinois River water?

A. Based on turbidity the Missouri River water. Based on typhoid infection the Illinois River below the sanitary district of Chicago.

Q. I mean at Grafton?

A. I should say at Grafton the typhoid infection would be at least equal in cost to the turbidity.

Q. The Mississippi?

A. For the Mississippi River I should think the cost would be about equal for both turbidity and typhoid infection.

Q. Would the cost of the Mississippi be greater or less than that of the Illinois?

A. It would be greater for turbidity and less for typhoid infection.

Q. In the general cost of filtering the two rivers taking 12935 everything into consideration for an equal sized plant, would it cost any more to filter the Illinois River at Grafton than it would the Mississippi at Grafton?

Mr. Jeffries: I object to the question for the reason that the question assumes that the turbidity of the two rivers is the same and that while increased turbidity might to some extent increase the cost of the construction as well as the operation, but inasmuch as the cost of the construction and operation of a given plant for a given river is determined upon the question of turbidity and the well known and probable existence of infectious material, that by reason of the introduction of the additional in-

fectous material from the Illinois River, the cost might or might not be greater, and therein lies the impropriety of the question, and for that reason the question is misleading and does not contain sufficient facts upon which to base an intelligent and reasonable answer.

Q. Question read.

A. I should say that it would for the reason that in filtering the Illinois River at Grafton we are obliged at first to provide for the cost of removing the turbidity which, while 12936 it is less than the turbidity of the Mississippi is nevertheless very great at certain seasons of the year, and in addition to this question to provide for the cost of protection against typhoid pollution which in my opinion would be greater than in the case of the Mississippi River.

Mr. Todd: Q. You would recommend filtration for the water supply of the city of St. Louis would you not?

A. In any event.

Q. If the sanitary district of Chicago should be eliminated, you would still recommend a filtration system for the water of the city of St. Louis would you not?

A. I would.

Q. When in the employment of men to supervise and attend a filter plant of that kind you would get the highest skill, would you not?

A. Yes sir, reasonably so.

Q. If the sanitary district of Chicago should turn its sewage in, you would still recommend the filtration system would you not?

12937 A. Yes sir, but I should recommend at least a double filtration system, preceded by successive stages of sedimentation or some additional form of protection to that which I would suggest for waters from the water shed, excluding the sanitary district of Chicago.

Q. Would you employ any less competent men to operate the filter plant with the sewage of Chicago eliminated, than you would with it present?

A. I am inclined to think I should want a very high grade of intelligence at the head of such a plant, if it were going to provide against typhoid contamination as against perhaps less

expensive treating if it were going to deal with turbid waters or waters of very rare pollution.

Q. Where would you get the men from to operate such a plant that had experience in a filter system the size that would be needed in the city of St. Louis?

A. Albany, Berlin, London, or men in this country who had given those large filters close study and attention.

Q. Would you put men in charge of a filter plant with less capability and experience if the sewage of Chicago was 12938 eliminated than you would if it were present?

A. Not to any very marked degree. I should think I would be a little more cautious and would recommend a little greater expense, but I do not think that the difference in the cost of filtration would be very much affected by that particular item.

Q. In the construction of the filtration plant at Philadelphia—which is the largest in the United States is it not?

A. Yes sir.

Q. Do you know whether there is any element of cost entered into in that plant in order to guard against infection?

A. Yes, I think the final filters can be properly so considered.

Q. If John W. Hill who was constructing that plant should testify that infection was no element of cost in the operation and installation of that plant, would his opinion have any weight with you?

A. I think I should be disinclined to agree with him.

Q. Have you constructed any filter plant wherein you have made additional cost to guard against infection?

12939 A. I do not think I have personally, with this exception that I have provided for the filtration of sewage as well as the purification of water in a city deriving its water supply from the same source into which it emptied the sewage.

Q. Have you designed any filter plant where the question of infection was eliminated, in the purification of water?

A. I think I have not designed any plant where it was wholly eliminated. In some of the places it was a very minor consideration?

Q. Mr. Alvord, Mr. Hering, in his testimony, was asked



this question: "In the construction of a filtration plant, is it not a fact that sanitary engineers take into consideration the extent of the infecting material discharged into a stream above in determining the character of the plant to be recommended," and in answer thereto said, "We do take that fact into consideration." The further question was asked, "In considering the construction of a filtration plant for the filtering of a water supply for a city which is taken from a running stream, sanitary scientists would recommend the use of a larger quantity of sand, if it be that character of a plant, per 100,000 population than if such water be subjected to the sewerage of a city of 1,000 population would they not," and in answer thereto, Mr. 12945 Hering said: "The population would cut no figure in my mind. We would under peculiar conditions possibly recommend one system of filtration for a highly polluted water, while we would be satisfied with another system of filtration in a very slightly polluted water." I will ask you if in the construction and operation of a filtration plant, sanitary engineers do not take into consideration the fact that when water is highly polluted with infected material that more complex construction must be obtained and that complex construction or plant more perfectly marked and that by reason of such superior construction and cautious maintenance a municipality would be required to employ more efficient men and be more cautious and observant as to the operation of the plant, and that this fact is well recognized by sanitary engineers and by the officers of the municipalities where filtration plants are being constructed.

Mr. Todd: Object to the question as not re-direct examination, and as leading. It is not rebuttal and therefore incompetent, irrelevant and immaterial.

A. I think this is a fact well recognized.

12946 Mr. Jeffries: Q. Is it not a fact that as the infection material is increased in a running stream that is being filtered that it is recognized by all sanitary engineers that the construction must be more perfect, of a higher grade, and that the equipment, the maintenance and the character of the employes more efficient?

Mr. Todd: Object to the question as to the previous question.

A. I think that it is.

Mr. Todd: Move to strike out the answer for the reasons heretofore given.

Mr. Jeffries: Q. In the filtration of a given water when the filtration plant has been constructed, assume that subsequent to the construction of this filtration plant the sewage disposal of a large and populous city be so disposed as to find its way, or the deleterious substances that are found therein, into the waters of that river above the filtration plant, state whether or not in your opinion more precaution and greater care should afterwards be maintained in the operation of that 12947 plant?

Mr. Todd: Object to the question for the same reason as heretofore stated.

A. In my opinion they should.

Mr. Todd: Q. If you were going to construct a filtration plant for the city of St. Louis would you construct it less stable and durable and with infected material to filter in order to filter the water of the Mississippi River with the sewage of the drainage canal eliminated than you would if that sewage was in it?

A. I do not think that the stability or permanency would enter into the question. I think it would be simply a question of the number of stages into which the purification would be divided, and the resulting complexity of the plant as a whole.

Q. But in answer to one of Mr. Jeffries' questions you stated that it would not require the same high skill in the putting up of the plant under the one condition as the other. As a matter of fact building a filter plant to filter the amount of water necessary for the city of St. Louis, you would employ the very best material and the highest skill obtainable in 12948 such a plant under either condition would you not?

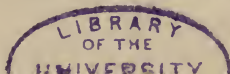
A. So far as the actual construction was concerned, yes. But in so far as the complex arrangement of the plant is concerned, no.

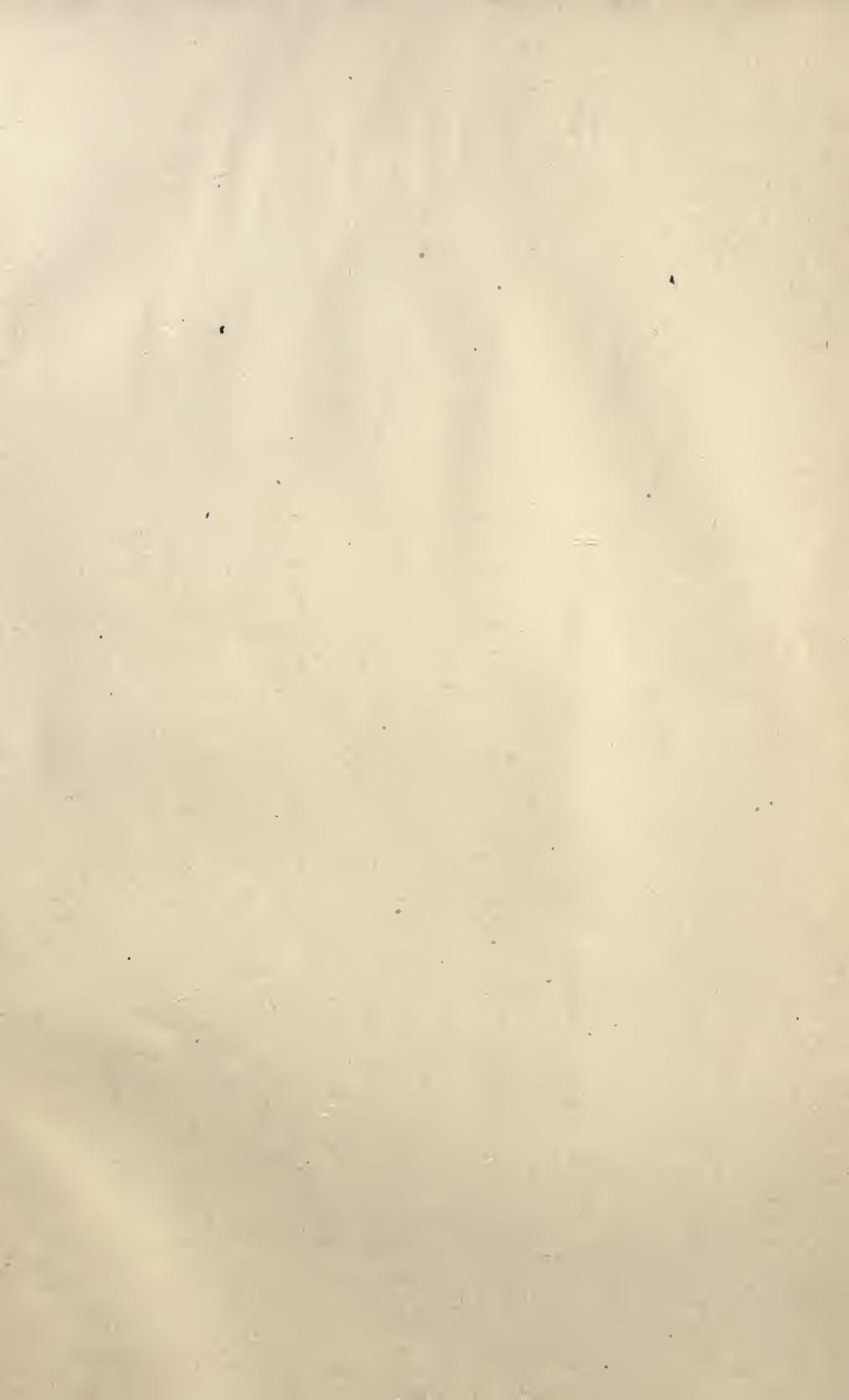
Q. In the employment of the men to handle the filter that would be a matter that would be left to the municipality would it not?

A. I presume it would.

JOHN W. ALVORD.

ADJOURNED until 2:30 P. M., May 26, 1904.









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