IMPROVEMENT OF THE MISSISSIPPI RIVER.

HEARING BEFORE COMMITTEE ON RIVERS AND HARBORS, HOUSE OF REPRESENTATIVES.

WASHINGTON, D. C., *Tuesday, February 2, 1904.*

The committee met at 10.30 o'clock a. m., Hon. Theodore E. Burton in the chair.

The CHAIRMAN. Mr. Parker, how much time is required by you?

Mr. PARKER. I should say that we have six speakers, and they will take not exceeding fifteen minutes apiece.

Mr. PATRICK HENRY. Mr Chairman, there was a great levee convention held in New Orleans in October, which was attended by over 1,000 registered delegates from 166 cities and municipalities of this country, from 22 States. They passed a resoution which this delegation has been appointed to present to this committee, and I will introduce to you, Mr. Chairman, and to the committee, Mr. John M. Parker, the chairman of the committee, who is probably now the largest cotton commission merchant in the world, young as he is.

STATEMENT OF MR. JOHN M. PARKER.

Mr. PARKER. Mr. Chairman and gentlemen of the committee: In October of last year, in New Orleans, we had one of the largest non-political conventions ever held in the United States; to which were appointed over 3,000 delegates, representing every branch of industry in this country. Of this number we had probably a thousand who were actually present, representing over 166 of the largest cities of the United States and comprising 27 different States.

The proceedings of that convention have been communicated in detail to each and every member of the committee, so that any further details from me on that matter would be useless. Speaking from a business man's standpoint, I do not think there is any subject in the United States that is of greater importance than the rivers and harbors which are directly and closely affiliated with our levees down there.

Few gentlemen who have not been down there and seen our levees and the conditions behind them can appreciate the conditions and possibilities of that country. To-day you find that England and France and Russia are spending millions of dollars in order that they may be able to raise cotton in competition with the American product. There is probably no place on the face of the globe that naturally offers the facilities that Mississippi does. Twenty-five per cent of the land available there is now in cultivation, and with protection to that area down there we could probably put in 15,000,000 acres addi-

tional. That to-day is largely typical swamp land, representing the fertility and deposits of silt of centuries upon centuries. One of the great reasons now that every acre of that land is not put in cultivation is that, with the vagaries and changes in the Mississippi River, people are afraid to come there and put their money into it and develop it. That is one reason why this convention came together down there and appealed to the United States. That, Mr. Chairman, was one of the strong reasons why the people of that region appealed to the United States to come down and give them protection, either by taking absolute control of the country or making such appropriations as will enable us to continue the work that we have undertaken, and guaranteeing safety.

We are not unaware that this committee has done a great deal, and the highest tribute that can be paid to the efficiency of their aid and the ability of the men who have conducted that work is the statement that no levee that has ever been erected under the auspices of the United States Government has ever failed to serve its purpose and to continue to do so. There are strong reasons why that statement is a fact. Our old levees—many of them are levees that have been built a little at a time and from time to time, whereas the Government levees have been erected by the United States engineers with plenty of means to see that the levees are thoroughly and solidly built and properly constructed and are properly protected after they are built.

We do not come here exactly in the line of being supppliants, because we have put up two dollars for every dollar that has been paid out by the United States Government for this purpose, but there are thousands of acres in that Delta that are not worth over $2 an acre, which, if put into cultivation, as they certainly would be the moment that it was known that the United States Government was going to protect these levees, would rise in value to $50 an acre. Many of those people own their lands, and are not men who are actuated in the slightest degree by personal interests. We occupy down there a unique position, inasmuch as we sell everything we raise. We furnish the largest exports to maintain the balance of trade of the world for the United States, and in return we buy nearly every dollar's worth that we use. We are the largest customers for the farmers of Ohio and Tennessee and Kentucky for their stock; we keep the mills of Pittsburg running to furnish us with cotton ties and coal; we are the largest consumers of machinery in the Southern States; we buy everything that we use; and, over and beyond that, that river that flows by our doors has more importance and means more to the farmers of the West than anything else, because it furnishes parity of transportation rates and forces them to give us reasonable rates.

I do not know whether you have noticed the enormous strides that in recent years New Orleans has made commercially. This has been largely due to the fact that we had a few years ago no railroads at all through that Delta, and now we have five trunk lines—lines whose stocks and bonds are owned all over the United States. As a practical cotton planter, who has been in that business for twenty years, I would say that we think that this year the Mississippi Delta alone will make 16,000,000 bales of cotton. I think, sir, that with protection from the United States Government—simply the assurance of this committee that you gentlemen believe that the requests we make

are fair, and you believe that you are better able to take charge of those levees than the separate States or than the separate levee boards which have under former methods of work undertaken it—I believe, if the commission of the United States Government makes the announcement to the world, the Delta will rapidly populate and be one of the most prosperous parts of the United States.

STATEMENT OF MR. M. F. SMITH.

Mr. SMITH. Mr. Chairman and gentlemen, I will read the resolutions adopted by the Interstate Mississippi River Improvement and Levee Convention:

Resolutions adopted by the Interstate Mississippi River Improvement and Levee Convention held at New Orleans, La., October 27, 1903.

The committee on resolutions begs leave to submit the following report:

First. After years of actual observation and experience, and supported by the opinions of all engineers, whether from the Engineer Corps of the Army or from civil life, who have been directly connected with the work of levee construction, we desire to affirm that we have the most absolute confidence in the sufficiency of levees, when built according to correct standards, to protect the Mississippi Valley from overflow.

In support of this declaration we beg leave to submit the following facts, which have been fully established: An elaborate and careful investigation, made under the direction of the Mississippi River Commission, wholly disproves the notion, which still prevails to a considerable extent, that the immediate effect of levee construction is to cause the bed of the Mississippi River to rise. If this were true it would necessarily follow that the levees would need to be continuously strengthened and elevated, and thus all hope of protection would have to be abandoned.

In the years 1881, 1882, and 1883 an elaborate survey was made of the river bed from Cairo to the Passes, a distance of 1,063 miles. Four cross sections to the mile were made, and 75 soundings were made to each line. The result of this survey was carefully plotted, recorded, and preserved.

In the years 1894, 1895, and 1896, after the lapse of a period of thirteen years, a still more elaborate survey was made of that part of the river bed between the Arkansas River and Donaldsonville, La., a distance of 472 miles.

While local changes in the river bed are necessarily constantly happening by reason of the gradual movement downstream of the bends, and accompanying bars and pools, they of themselves signify nothing. Yet a comparison such as that which has been drawn from the result of the two extensive surveys mentioned would necessarily furnish proof that the bed of the river was rising if such were the truth. So far from the comparison indicating such result from levee construction, it was discovered that there is a general tendency to the establishment of a more uniform channel in depth and width and with greater capacity.

The comparison also brought to light the fact that the crests of the low-water bars, as well as those of the high-water bars, have been lowered.

If we turn to the evidence afforded by the records of the numerous gauges established along the river, which have also been carefully recorded and preserved, we find that the low waters now are several feet lower than they were in the years preceding active levee construction, accompanied by an equal volume of water and an equal depth of channel. This unquestionably shows that the effect of levee construction has been to bring about a gradual depression of the river bed. This effect has been produced within the past few years, for prior to that time there was no such restraint of the flood waters as could leave any impress whatever, one way or the other, upon the river bed.

The notion that the bed of the river is rising has been somewhat revived since the flood of 1903, because of the fact that at certain points the gauge reading showed not only unusually great elevation of the flood height, but irregular elevation. From this it has been deduced by some that at those places where the gauge readings were the highest there had been, as the result of levee construction, an unusual deposit of silt, thus raising the bed of the river. A simple explanation will destroy this theory:

In 1880, when the levees were by no means continuous and were altogether insufficient to affect the flood plane in any degree, the first thoughtful and scientific observation of the river began. This was because of the fact that the Mississippi River Commission then entered upon the discharge of its duties. It was noted that the rise and fall of the river was very different at different points. It was observed that the greater annual oscillations, which were of about forty-five feet, were to be found at or near the mouths of the tributaries, such as the Ohio, the St. Francis, the Arkansas, and the Red rivers. It was also observed that the lesser annual oscillations, which were of about thirty-five feet, were to be found at intermediate points along the fronts of the great basins drained by these tributaries—as, for example, at Fulton, Memphis, Greenville, Lake Providence, and St. Joseph.

A careful platting of the gange readings at that time exhibited a smooth and regular high-water slope, but an exceedingly irregular low-water slope. This was caused by considerable depression of the river bed at or near the junction with the tributaries of the river, and a considerable elevation of the bed along the fronts of the great basins between them. For this reason it was noted that the rise in high water was much greater where the bed of the river was depressed at or near the points of junction with its tributaries.

It was observed that the discharge at high water at these points, because of these depressions, was something like 1,500,000 cubic feet per second, while along the intervening basin fronts the discharge was several hundred thousand feet less. This difference in discharge, ranging from a quarter to a half-million feet, was because of the escape of water over the river banks along these basin fronts. This escape of water undoubtedly caused the elevation of the bed along these fronts, which was noted, and we feel justified in affirming that when this escape shall have been permanently prevented by the construction of suitable levees, these elevated portions of the river bed will be gradually lowered to conform to the bed at the points of junction with tributaries, thus making a regular low-water slope. When this shall have been accomplished, undoubtedly the lowering of the river bed will steadily go on.

It has also been noted that during the flood of 1903 the heights attained by the flood in excess of those hitherto recorded were greatest at the points along these basin fronts, as, for instance, at Memphis, where the rise was 3 feet greater than any ever known.

The excess of flood height at the points of depression referred to was nothing like so extreme.

We therefore declare that, in our judgment, there is no warrant whatever for the assertion that the effect of levee construction has been or will be to raise the bed of the river, but, on the contrary, it is our definite conviction that the effect will be to cause a general and considerable lowering of the bed.

EFFICIENCY OF LEVEES.

Second. We also desire to express our firm opposition to all schemes for reducing flood heights of the lower river by the construction of reservoirs or so-called outlets. We refer to and indorse fully all that is said upon this subject by the very careful and able report submitted in 1898 by the Commerce Committee of the United States Senate, which is so complete and elaborate as to exhaust the consideration of the question. We will add that all schemes which have ever been proposed for the relief of the river in times of flood by outlets or reservoirs would either prove wholly inefficient or would cost such vast sums and require such constant care and expenditures as to entitle them to no consideration.

Third. While the flood of 1903 was very nearly as great as that of 1897, and while the flood plane was greatly in excess of that of 1897, the protection afforded in 1903 over that of 1897 is so great as to satisfy the minds of all impartial investigators that so far as the test has gone the principle of protection by levee construction has been amply vindicated. In 1903 there were but 6 crevasses as against 43 in 1897. With each recurring flood since levee construction began in earnest the number of crevasses has grown smaller and smaller, and the protection afforded has grown greater and greater. As a result, investments of capital in the Mississippi Valley have increased until they are almost fabulous. The low-lying back lands, which prior to that date were regarded as valueless, are fast being occupied and converted into homes for the benefit of our people. Towns and cities have sprung up in every direction. Railroads now traverse the valley so that nearly every part of it is now reached

by them. All of this affords eveidence of the strongest possible conviction on the part of the people that the time is sure to come when they will have absolute protection from the floods of the river.

Theorists may argue against the efficiency of levees, but they do so in vain. The strong common sense of the people responds by rejecting their theories. The work must go on. It can not now stop. Too much money has been invested in levees to suffer them to be destroyed, and unless they are prosecuted to completion they will be destroyed. The enormous investments made because of them, and in reliance upon their completion, can not in good faith be abandoned now to the devastation of the floods. We presume that no man can be found at this stage of the work to suggest that the plan of protection by levees should be abandoned, at least until a full and complete test has shown them to be impracticable.

MISSISSIPPI RIVER COMMISSION.

Fourth. The following abstract of the report of the Mississippi River Commission, just made, and hardly yet published, gives the very latest opinion of the Commission upon the levee question, and is so comprehensive and pertinent that we give it at length, to wit:

"The past flood established, more clearly than has any previous one, both the importance and the practicability of a complete and sufficient levee system. In its present condition, incomplete both as regards extension and dimensions, it gave substantial protection to three-quarters of the alluvial valley and its interests, which under equal flood conditions without levees would have been a lake from 20 to 80 miles wide from Cairo to the Gulf. The improvement made during the past six years has reduced the number of crevasses between Cairo and New Orleans from 38 to 6. Of the area overflowed this year, five-eighths was the direct result of back water from the lower ends of the basins and overflow through unbuilt parts of projected lines, and only three-eighths from breaks in the levees, notwithstanding their unfinished condition as regards both grade and section.

"Under these circumstances the importance of the earliest practicable completion of the work is apparent. If the flood damages of 1903 may be approximately estimated at $5,000,000, the previous expenditure of that sum in permanent work would have largely if not entirely prevented them. Every year's delay in completion incurs the risk of similar loss. When the system shall have been completed the cost will have been increased by many millions of dollars, and the development of the valley delayed by many years of anxiety and disaster, which could have been saved by continuous work on a scale commensurate with the importance and magnitude of the improvement. The State levee districts realize this. Most of them have anticipated their revenues as far as practicable, and several have now under consideration plans for such increase of resources applicable to the work as will shorten the time of completion. The Commission is so impressed with this view of the subject that it considers it for the best interest of the work to now make contracts for levee construction to the extent of $2,000,000, as provided for in the river and harbor act of June 30, 1905, and June 30, 1906. Furthermore, it suggests that if Congress should think proper to make additional provisions for levee construction during the fiscal years ending June 30, 1905, and June 30, 1906, the sum of $2,000,000 in addition to the amounts already provided can be judiciously and advantageously expended during each year."

CONSERVATION OF COMMERCE.

Fifth. In addition to the protection of the lands of the Mississippi Valley from the floods, it is a matter of supreme importance that the mind of the nation should be kept constantly advised of the commercial importance of the Mississippi River as a highway of commerce. The marvelous growth of railroad building within the last quarter of a century has so diverted the attention of the public from the Mississippi River as a means of transportation that it has been to some extent lost sight of. It has remained, however, a constant safeguard against undue rates of transportation and promises in the near future to become once more as active a factor in interstate commerce as it ever has been in the past. This is owing, first, to the almost unparalleled increase in industrial activity throughout the valley, and, second, to the demonstration which has been made in recent years that by means of hydraulic dredges a sufficient chan-

nel for low-water navigation can be secured and maintained. We earnestly express the hope that the work of the Mississippi River Commission in this direction be pressed as rapidly as can be properly done, with a view to opening up the great river once more, so that the people may fully enjoy the extraordinary facilities which it is capable of supplying for the cheap and steady exchange of their commodities. Levee construction is undoubtedly essential, even if all thought of reclaiming the fertile lands of the valley should be abandoned, for without levees all river commerce during periods of overflow would necessarily cease.

A GRIEVOUS BURDEN.

Sixth. The work of levee construction has been carried on by the cooperation of the United States Government through the agency of the Mississippi River Commission with the levee organizations of the several riparian States. Of the amount expended in this work, the Government has contributed, in round figures, about one-third. The people have subjected themselves to such heavy taxation in furnishing their contributions until they have already overburdened their resources in this regard. It is the opinion of the residents of the great valley that the difficulties and magnitude of the work and the vast benefits to result from it are such that in common justice the burden should be placed upon the strong shoulders of the Federal Government, and that the work should be urged to speedy completion. By suitable annual appropriations this can be accomplished, thus securing not only safety, but great economy. Therefore:

DUTY OF THE GOVERNMENT.

Resolved, That in the judgment of this convention the protection of the Mississippi Valley from floods is of such national importance as not only to justify but to make it the duty of the General Government to undertake it and press it to the speediest possible completion. If, for any reason, the exercise of sole jurisdiction at this time by the General Government should not be deemed advisable then this convention urges most earnestly that Congress make, at its approaching session, such appropriations as are recommended by the Mississippi River Commission in its recent report.

THE COMPREHENSIVE PLAN.

Resolved further, That the system of river improvements in the Valley of the Mississippi from its headwaters to the Gulf and in the Valley of the Ohio and other tributaries, now provided for and those which may hereafter be provided for by Congress, under the supervision of the United States engineers, meets our hearty commendation and should be prosecuted to completion without unnecessary delay.

Resolved, That the attention of Congress is invited to the serious disasters which have befallen those residing at or near St. Louis, Kansas City, and other localities by reason of the recent great floods, and the Secretary of War is respectfully requested to cause an inquiry to be made with a view to the preparation of suitable plans for the prevention of a recurrence of such injuries.

Be it resolved, That the convention of delegates representing the States of the great Mississippi Valley from Duluth to the Gulf of Mexico gives its unqualified approval to the movement for the construction of a waterway connecting the Great Lakes at the north with the Mississippi River and the Gulf of Mexico at the south.

We recognize the expenditure of $35,000,000 by the sanitary district of Chicago as a practical demonstration in the furtherance of this project. We express the hope that the Senators and Representatives in Congress from the various States represented in this convention will give their encouragement and assistance to Congressional legislation in favor of the completion of the deep waterway, to which the Mississippi Valley States have already given their approval, and to which the State of Illinois and the sanitary district of Chicago are committed as a matter of policy and by great financial expenditures already made.

Resolved, That it is the sense of this convention that the work of the Interstate Mississippi River Improvement and Levee Association, under the wise and able guidance of its president, Charles Scott, has been of great and lasting value, and its continuance is a matter of vital importance, and that this organization, as it exists, with Charles Scott as its president and J. W. Bryant and W. A. Ever-

man as its secretaries, be continued, and that Charles Scott be authorized to appoint three members from each State as members of the executive committee of said association.

Mr. HENRY. You will next be addressed, Mr. Chairman and gentlemen, by Mr. Charles S. Fairchild, of New York.

STATEMENT OF MR. CHARLES S. FAIRCHILD, OF NEW YORK.

Mr. FAIRCHILD. Mr. Chairman, in the last few years I have had occasion to go to the South and to New Orleans on business and pleasure a number of times. I have been in New Orleans at the time of this great convention in October, which is spoken of, and from all that I learned there, all that I heard, and from my own reflections, I have been profoundly impressed with the importance of this subject, and led to the belief that it was the supreme interest of the people of our whole country to take care that the best was done along the Mississippi River for the protection of its adjoining lands and for the improvement of its waterway that could be done under the teachings of science and experience.

This crop, this great cotton crop which they raise in that country, and the extension of which is possible beyond anything that we know now, is of vast importance to every part of this country. A failure of the cotton crop, or a permanent diminution of the amount produced, would make it necessary for the people of this country to readjust its whole financial relations with the world. It is, as the chairman of this committee which appears before you, Mr. Parker, has said, the thing that more than anything else maintains our balance of trade. It is the one crop in which the United States has practically the monopoly of the world. It is the one thing by extending which we can command the business of the world. We have rivals in everything else that we produce. In cotton our rivals are but few, and those poor and feeble. Therefore it behooves us to nurse and care for this unique thing which gives the United States so commanding a position in the world.

Then see all of our people who are more immediately interested in it. Think of the effect in every mill town in New England of the amount of the cotton crop; think of the effect, the possible effect, upon them now of a partial failure of cotton crops during the last few years; think of the thousands and thousands of people all over our northern country who are so immediately affected in their daily lives by this; and then, logically, with all else that we have done and are doing we should above all things promote the welfare of this Mississippi Valley. Think of what we have done in the past; think of the great sums of money for which the United States obligated itself to build railways across the continent; think of the vast empires of land which we gave away to build those railways; think of all that we are doing and proposing to do for irrigation in the great West, very properly and wisely, because it has been demonstrated that that must go beyond State lines. Think of all that we are doing to improve our harbors on our eastern coast. Why? Why, for the benefit of the wheat fields of the great West, the dairies of our East and Middle West, in order that they may have a ready and easy access to the ocean.

Think of the great enterprise upon which we are entering in building a canal; to build a canal to connect the Atlantic and the Pacific. Think of what we are doing in the far East, in China, in extending our treaty relations, in taking up a position where we will have a greater influence and a greater access than ever before. Why? For what? To do what with them? To sell things to those people. What things? Why, the main thing we are to sell them is cotton—cotton goods. That is why we are willing to almost strain our relations with some of the nations of the world, that we may keep open markets. What we wish to sell in those markets is cotton goods. Now, if we do not take care of the production of the raw material of the cotton goods, all that we are doing in that respect is almost waste time, because we will cease to be a great cotton manufacturing country.

Now, all of these considerations lead me to the conclusion that logically, consistently with all that we are doing in these directions of which I have spoken, we should go on to do that which science and experience tells us will be most beneficent and most speedy for the extension of the production of this great staple. I am sure that there is no one in the North who, when he fairly considers the subject, when he considers the relations which it bears to all of our interests, when he considers the vast market which it affords for all of our Northern products in the South, giving a great interstate trade, when he considers the importance of it to our own interests, in connection not only with our own consumption, but with that of the world, will begrudge any expenditure this committee may consider it necessary to make to speedily and efficiently do that work that should be done along that Mississippi River. Further than that, by cheapening the means of transportation, by still further increasing this enormous commerce which now goes out from that Mississippi River, you will be conferring a benefit upon the remotest parts of our Middle West.

Therefore, gentlemen, it is with great pleasure and satisfaction that I have come here at the invitation of these gentlemen to say my few words and to urge you to do all that you possibly can to speedily complete this work, because every year that it is delayed is an enormous loss to the West.

Mr. PARKER. I will introduce to you next, Mr. Chairman, Mr. A. M. Caldwell, of Memphis.

STATEMENT OF MR. A. N. CALDWELL.

Mr. CALDWELL. Mr. Chairman and gentlemen, I want to say that I am not a public speaker and I want to save just as much of your time as possible because I know that it is valuable, and in order to save hesitation and repetition I have made a written outline of the few things which I have to say to you, and I assure you that they are not very many.

In supporting the resolutions of the great convention which was recently held in New Orleans, I wish to give you the viewpoint of a business man, of one who, in 1882, left Indiana and cast his lot with the people of the great Mississippi Delta. While I live in the city of Memphis my separate business interests are in the delta itself.

This territory, which we are asking you now and which you know we have been asking you for many years to assist in protecting, has, I believe, about 19,000,000 acres of land; and I think there is less

than one-third of that area that is in actual cultivation, and that third I know is very sparsely settled, and very poorly improved, because of frequent overflows. Now, in these times, when all the great nations of the world are striving after enlarged territorial possessions and hesitating at the expenditure of no amount of money in their purchase nor human lives in their conquest, is not this territory of itself, irrespective of the navigation of the Mississippi River, worthy of the attention of Congress, not only because of the increased population which will come and the increased commerce which Mr. Fairchild has so ably spoken to you about, and the increased wealth, but in order to maintain the supremacy of this country in the production of cotton?

Just now both Germany and England are giving a good deal of attention to the development of cotton fields in their colonies and in their various spheres of influence, and they are expending vast sums of money in this work. It is within the year that an agent of the German Government called upon me in the city of Memphis and told me that he had been representing for quite a long time the German Government in German East Africa in developing that country, and he wanted to pump me about cotton growing in the United States, and he wanted to get as much information as he could. He wanted to buy cotton seed and he wanted me to recommend to him white men who understood cotton culture and were open to employment by the German Government and who were willing to go way out there and open up that new country for cotton growing. Well, I told him all I knew, and I have no doubt that those fields as well as others will be greatly increased; although I believe with Mr. Fairchild that if the proper thing is done in this country we need never fear competition in cotton culture.

But the most important matter for the consideration of our people is the present condition of the cotton trade. On the basis of prices which have been obtained for that part of the present cotton crop which has been up to the present time marketed, and taking the present value of cotton as a basis for estimating that which is to be marketed from now until the end of the year, and taking the Government's estimate of the size of the crop, say 12,000,000 bales, as another basis, this present crop of cotton and seed will produce $750,000,000. Now, not all of that will have been received by the Southern planters, but nearly all of it will have been received by citizens of the United States. A little bit of it has gotten away to our friends of England, who bought cotton early. But not a great deal.

Now, it seems to me that a serious question, and one that I have not heard brought up before this committee, or in this convention, is the fact that all of the people of the United States who consume cotton—cotton goods—and that is practically nearly all of them, and especially the wage-earning class, the poorer classes of our country, have got to pay and have paid the enhanced prices of cotton by virtue of this short crop; and that may seem to you, without study, to be a small thing, but if you knew the advance in the price of cotton goods, based on the present value of the raw material, you could see that it is a very serious thing, and that many people at present prices will not be able to get as many cotton goods as they would under what I call normal conditions—that is, when cotton is about 8 or 9 cents a pound.

Now, gentlemen, would it not be infinitely better for us to get that $750,000,000 out of a crop of 15,000,000 bales at 8 cents per pound—and that is about what 15,000,000 bales produces—rather than to get that large sum of money out of 10,000,000 bales of cotton at that very large price?

Is that not a matter absolutely of interest to every single person in the United States, irrespective of where he lives or what he does? But you must not stop at the contemplation of a crop of 15,000,000 bales, because the steady increase in the annual consumption of cotton makes it quite sure that it will be only a few years before 15,000,000 bales will be as short a crop in that day as 10,000,000 bales is to-day.

I think it is generally conceded that the consumption of cotton at moderate prices has now overtaken production, and that the largest cotton crop we ever raised, that of a few years ago, about 11,250,000 bales, would, if produced this next season, sell for at least 12 cents a pound; and if the conditions of the world remain normal, many people believe that an 11,250,000-bale crop would sell for more than 12 cents. So that in the last very few years—I think it is only three or four—what was the largest crop of cotton that was ever made, and which was talked about as a tremendous crop, has in that very short time down to the present time that I am talking to you, almost become a short crop. So that if we are to think about the material welfare of the citizens of this whole country, and what they are to pay for an article of clothing that probably they use more than any other article of clothing, we must prepare in this country, unless we voluntarily give it to other nations in the world, larger cotton crops.

Perhaps you may think that 18-cent cotton is the result of speculation. That is what I believe July cotton sold for yesterday, and by July cotton I do not mean speculative cotton, I mean cotton to be actually delivered in July from plantations or from interior points, wherever it may be now, to the particular market where that price was made. You may think that that high price of cotton is the result of speculation, but, gentlemen, you would be wrong. That is not the case. It is directly the result of too little cotton. As a business man who has had a great many years' experience with cotton and really ample opportunity to judge and observe, I should say it is the steady annual increase of consumption in the larger annual ratio than production. I can not help but be impressed with the gravity of the situation, and I do not believe that I am sounding a false alarm when I say I think it is well worthy of the attention of Congress and of this committee which has it so largely in its power to prevent the people of this country from carrying the present burden, and possibly relieve them of a heavier burden in the future.

To me the question does not seem to be one of soliciting you gentlemen for one million dollars or two million dollars or three million dollars this year or next year or the year after, nor does it occur to me at all as a question in which you should put the relative position of the great Mississippi River with the other rivers and harbors of the country. I know that there are other rivers and harbors just as much entitled to the support and help of the Government as the Mississippi River, but to my mind this is a great deal bigger problem than a river problem.

If Germany and England are willing to spend large sums of money in the development of cotton fields in their colonies, is it not worthy

of your attention? And is there a surer way of bringing the price of cotton down to what it was a few years ago, down to a comparatively small price, than by the increase of the acreage planted in cotton? Some years the seasons may be favorable, or the negroes may work a little better that year, and we may arrange the acreage planted so as to make a somewhat larger crop than the year before. But larger cotton crops, as a rule, very much larger cotton crops, gentlemen, are only going to be obtained by increasing the area planted in cotton. I have no doubt that there are many places in the United States and in the Southern States, I should say, where there are still some lands available for cotton, but I know of no State that has a territory to compare with this great territory in the Delta of the Mississippi, none in which the area is anywhere near as large, and none where the land is anywhere near as fertile.

If this is worth doing, gentlemen, do you not think that it is worth doing just as soon as possible? As I am not here to urge your appropriation of one or two million dollars for the next year, or any other sum, I am not here either to ask you to appropriate the whole $15,000,000 that are necessary right now; but is it not worthy of carrying in your minds and making up your minds that it shall be done just as soon as possible, to be done in the most economical way, to be mapped out in advance as a continuous work, so that there shall be no waste of money by its not being able to go on after the thing is once begun?

There might be some reason for putting this off to the future, for putting off what you yourselves think were well done now, if we were poverty stricken; but, gentlemen, you know that that is not the case, for our present prosperity is the talk of all the peoples of the world, and it is actually the political slogan of more than one-half of the people of the United States.

Now, there is a little enterprise in which our Government was engaged a short time ago that has always struck me on my humorous side when it was brought up in connection with the expenditure of Government funds for such great public works as this, and that was the expenditure of considerably over $300,000,000, I believe, and nearly 3,000 lives of our fellow-citizens, in wresting Cuba from Spain and presenting it as a free gift to people who are alien to us in blood and custom, and who love us just about the same as the average man loves a man to whom he is under financial obligations. There may have been some benefit to us, gentlemen, in having the Cubans rule Cuba rather than the Spaniards, but for my part it has not been at all clear. The sentimental part of that transaction was understood, and the taking from Spain was almost unanimously approved, but I am not quite sure that the present to these ungrateful Cubans would be as heartily approved just now. Cuba, with all is islands, embraces a territory of about 29,000,000 as against the 19,000,000 acres in the delta of the Mississippi, and a far larger proportion of Cuba's total acreage is and always will be totally unproductive.

Now, if the Government could afford to be so lavishly generous in making a present to these kind friends of ours in Cuba of so large an amount of money, gentlemen, is it asking very much, or is it a very strange thing, that we should ask the expenditure of a paltry $15,000,000 to develop a Cuba lying in your very midst? Just think of this magnificent province. It is as large as Vermont, New Hamp-

shire, Massachusetts, and Rhode Island. The undeveloped part of it is as large as Vermont, Massachusetts, and Rhode Island. That undeveloped part is of just about the size of New Jersey, Delaware, and Maryland. Now, suppose that those three last-named States were entirely undeveloped on account of overflows from the ocean, and that the $15,000,000 would open them up to settlement, open up their lands to the various productive crops that those States can raise; gentlemen, would there be any hesitation on the part of the United States Government about expending that amount to save and develop a province like New Jersey, Delaware, and Maryland? And yet we come to you and point out that here is a province a little farther toward the West, at present made unfit for population and cultivation, and for the production which I have suggested is to the benefit of the whole country, by overflows, not from the ocean whose waters can not be increased or diminished; an area which can not be increased or diminished as cultivated area is increased all over the country outside of this area I am speaking of, but a country which is affected by overflows of waters that pour down upon it from a little over two-fifths of all the other parts of the United States.

Now, I have heard it said in connection with these matters that the Mississippi River Commission, as it came down my way on more than one occasion, has said that God helps those who help themselves. If that is the case, gentlemen, certainly the nation, which is our earthly god, ought to stretch out a helping hand to this country down there, for they have been doing year after year everything in their power imposing upon themselves a burden, to keep from drowning in waters that come from the north, the east, and the west. You have been told about the difference between the amount expended by the Government in levees and by this country down there which is to be protected. I believe from the first levees constructed the Government has expended $17,000,000, and the people of that country have expended something over $40,000,000. Of course there was a time during this late unpleasantness when a good many of these levees were broken and destroyed; but even after the work was taken up again, after the civil war, the people down there spent a great deal more than the Government in that work. And it has been demonstrated to be effective.

I do not believe there is anyone on this committee, in view of all the reports of Government engineers and the Mississippi River Commission, who will doubt the efficacy of the levees, if they were completed, or the efficacy of the levee system even as far as it has gone; and if that is true, should not the Government down there, after the expenditure of $15,000,000—even if all these others things do not make any impression upon you—put in the other $15,000,000 to complete this work? If it is true that half begun is well done, I say that half done, if you are to stop there, certainly was not well begun.

Now, I am the owner of several plantations in that delta, and I have owned a good many. Before coming up here I had the tax receipts of the places that I now own, and some others that I owned only a few years ago, brought to me, and, gentlemen, the taxation down there varies from 2 per cent to 4 per cent on the cost of these plantations to me, the variation being according to the levee district in which the plantation happens to be situated. Now, that is a taxation solely for levee purposes, not for anything else. It is solely for the purpose of maintaining the levees. Does not that suggest a pretty heavy burden

of taxation? Does it not suggest that the people down there are doing all in their power to bring about a result which should be for the good of the whole country?

But you can not impose a heavier burden than that upon them. The property will not stand it. But if the levee system were completed, if it were entirely done, I have not any doubt, from the increased area in cultivation, and the increased value of the property, and the increased production, that the people of that country would be able to take care of and protect this levee system without any further assistance from the Government.

But the last thing I wish to speak to you about, and to my mind it is a very strong reason why the Government should do this work, and do it as quickly as possible, is this: We have with us in the delta a large number of the wards of the nation—the negroes. It is the natural home of the negro. There is the maximum yield of cotton for the minimum amount of work, and that always suits the negro. [Laughter.]

Among Southern negro farmers the drift has for many years been toward the delta, and still is, but interrupted by the frequent overflows. With the complete protection of this country, the negro will find his greatest opportunity, and he will not do harm to other States, because in those States the land will be taken up by the whites. The white man will not become a tiller of the soil in the South alongside of the negro, and as the negro gets out of the country the white settlers come in, and like the cultivators of the wheat and corn lands of the North they will become actual tillers of the soil. Now, I believe that in this very delta lies the solution of the so-called "negro question." We have him with us always, and he is on the minds of many of us. I have done a great deal of thinking about it, and I have tried an experiment.

I believed that the negro would become an industrious citizen and a fairly good citizen if he owned his farm; that not education but land ownership was the thing to elevate the negro, if you choose to call it that, but at any rate to better his condition and make him—what is to the interest of the whole country—a good citizen. I am not in the real-estate business, gentlemen, but I subdivided some of my own lands, and was instrumental in having some other land owned by some of my own friends subdivided into small farms, 40, 60, 80, and 160 acres, and these farms I sold to negroes without any cash payment, on long time and easy payments and at a rate of interest low in that section—6 per cent.

In nearly every instance I built a cabin, a little frame house, for the negro to live in. In many instances I bought and furnished him a mule with which to make the crop, and in some instances I even went the length, after furnishing him the house and the mule, of furnishing him the money with which to live for the first year. In all I disposed of a little over 23,000 acres in this way, and less than one-fourth of it has come back on my hands, and while in the instance of the other three-fourths the money has not all been paid, sufficient of it has been paid to guarantee that of those transactions the remaining three-fourths will turn out well. And in every instance the negro who has bought land has become a good citizen and an industrious citizen, and ambitious to further better his condition. And this has been my observation also of other negro land owners. I know that

there are some exceptions; I do not mean to say that there are not; but I believe that the rule will hold generally good, and I have not the slightest hesitancy in telling you gentlemen that the negro farmer is a better citizen and a more successful man than the negro preacher, the negro doctor, the negro artisan, and the negro lawyer. I am not alone in this belief, for Judge Robert S. Taylor, has said:

> In considerable and ever-increasing numbers they are buying land and becoming independent cultivators. Those who do so are steadily advancing in thrift, intelligence, and the qualities of good citizenship. Nowhere else in the South are as favorable opportunities offered to the black man as in the reclaimed Mississippi lowlands, and nowhere else is he doing as much for his own uplifting.

That is the observation of a man who does not live there, but who comes there a great deal.

I am sincere in bringing this negro question before you. It has not been done to make an additional argument, but it is done because I am fully convinced that there is a great deal in it, and that the opening up of that 13,000,000 or 14,000,000 acres of land in the Delta will do more than anything else to quiet a question that is not as loud in the South as it is in the North, but a question that is a serious one, the providing in some way for this great mass of black population that has got to do something .

Now, a great many people in the United States feel that the nation owes the negro something, and to them I would say, here is a practical way of paying that debt without giving him what the negro thought he ought to have at the end of the war—40 acres and a mule—and what he certainly is not going to get from Uncle Sam, and that is Government rations.

STATEMENT OF MR. LEROY PERCY.

Mr. PERCY. Mr. Chairman and gentlemen of the committee: My conception of the duty of this committee in coming here before you was to tell the Committee on Rivers and Harbors here the character of conventions that passed these resolutions, the diverse interests represented by them, and to vouch in person for the earnestness of purpose and the dire need which prompted the demands or requests upon the National Government.

I had not thought and do not think it advisable to attempt before this board of experts, as you may say, on this subject, to go into any academic or scientific discussion in regard to the Mississippi River, how the work shall be done, whether it can be done or not. At the same time, there are a few suggestions which appear to me to be pertinent, and if the committee will pardon me for the unprepared manner in which they are submitted, I would like to submit to the committee that there are three questions upon the affirmative answers to which depends whether this convention and its needs have any standing before this committee or any right to expect aid from the National Government. These questions are: Is this work of reclaiming the Delta from the overflow waters of the Mississippi River worth doing? Second, can this work be done? And third, by whom must this work be done if at all? Unless those questions can be answered in the affirmative, then, indeed, is our errand here a futile one. If answered in the affirmative, then the necesasry aid must necessarily and will

follow. The sole thing left for consideration is the time and the manner in which the work shall be done.

First, is the work of reclaiming this Delta one worth doing? Thirty thousand square miles of territory—alluvial land—is to be protected by the complete reveting of the Mississippi River. Twenty million acres of territory, of which there is possibly 6,000,000 acres in cultivation now. There are probably 4,000,000 acres that could not be put in cultivation, owing to the necessary overflow out and back water, no matter what system of levees you have; but there is at least 10,000,000 acres of it that is susceptible of the highest degree of cultivation. Upon this 10,000,000 acres of land, on the most conservative estimates, in addition to the diverse crops—sugar cane and corn and other agricultural products that can be grown—2,000,000 bales of cotton can and almost certainly will be grown.

Is the growing of it a matter of national importance? The answer to that question has already been made in the eloquent and broad-minded and patriotic speech of Mr. Fairchild. He has told what that means to this nation; he has told how by our cotton crop we have been elevated almost, you may say, to the most commanding position among the nations, and he has told you how we have pried open the strong boxes of every nation on the globe. The cotton crop constitutes 28 per cent of the exports of the United States, 41 per cent of the value of all agricultural exports. To attempt to improve upon what Mr. Fairchild has said would be indeed to attempt to paint the lily; but the answer is not only found in plain English, such as he has spoken, but it is found in diverse tongues from all quarters of the globe.

The five greatest consumers of the cotton exported by the United States are England, Germany, France, Russia, and Belgium. They are to-day exhausting every effort, regardless of cost of the enterprise, going into the waste places of the earth, going among the barbarous uncivilized tribes of the world, in the effort to escape this tribute which we have inexorably demanded at their hands, and I hazard this statement, Mr. Chairman, that no civilized nation to-day is so depleted in treasure as to hesitate one moment to make an investment of the kind required here, $20,000,000 at the outside, on an almost indefinitely small chance of realizing such a return as is promised here. Shall the United States, the richest and most progressive of all nations, flinch from such an investment when the return is not a venture but a certainty?

Mr. Caldwell has eloquently brought before you the fact that the cost of these cotton goods is one that affects every citizen of the United States. If this amount of cotton can be grown by means of this aid extended by the National Government or by reason of this work being done, then the question has been answered that the work is worthy of doing; that this income, which turns the balance of trade in our favor, which amounts to $500,000,000 a year, and will increase from now on, is something worth struggling for; the investment is worth making.

Can it be done? Can the 1,140 miles of levee necessary to protect the Mississippi delta be maintained? Is the project a possible one? About that in the past there has raised much discussion; about that in the future there can be no dispute and no question. The question

has been answered with mathematical certainty that it can be done, and in dollars and cents you are told for what price it can be done. The Mississippi River Commission appointed in 1879 by the Government for the purpose of taking control of this river answers the question not by any a priori reasoning. Composed of some of the most eminent engineers in the United States, selected on account of their competency and attainments, they have not trusted simply to the voice of science, but after spending twenty years and more investigating the question they say that the result of the high water of 1903, with the disaster that it brought, brought also the assurance that the end was in sight; that the problem had been solved; that it could be definitely stated what it would cost to complete the work now under way.

That overflow was the greatest that we have had on record. In the 1,140 miles of levee the river made six breaks, counting breaks above New Orleans such as overflowed any area of country at all. In the entire line of levees there were six crevasses. Altogether there were 2.4 miles of levee swept away by the flood, but more than nine-tenths of the levee district remained protected, notwithstanding the size of the flood, and the crevasses that did occur, did not occur in the incipient stages of the high water, so that the argument oft made and oft the flood, and the crevasses that did occur did not occur in the incipi- it was in before the crevasses occurred, when the water was within twenty-four hours of reaching the point where the break occurred, failed in this instance, when, if there had been no break, there would have been no appreciable increase in the height of the water, demonstrating that the levees as made were almost sufficient to carry off this water, and showing exactly what kind of levee was needed to guard against the recurring waters of the future.

When you look back to 1882, when the entire district of Louisiana, Arkansas, Mississippi, Tennessee, and Missouri would have been submerged by this water, the question is answered as to whether these levees are a success, when you find that with such a flood only one-tenth of the ground protected was overflowed; and the Commission says that by the expenditure of $18,000,000 you can complete and protect this system so that there is an assurance of safety behind these earthen walls.

The work, then, can be done. The next question is, Who must do it? That work must be done by the National Government. It can be done in no other way; and it will be done by the National Government, and for these reasons. In the first place, we are leveeing a national stream. It has been described as the nation's great sewer, draining 41 per cent, exclusive of Louisiana, of the entire area of the United States, draining of States and parts of States 32 in number. It is the water that the nation has gathered up and hurls down upon the denizens of the lower valley. Even in common law, and more so in courts of equity, the rule is well recognized the world over that no man shall use his own to the hurt of another.

It is a maxim, Mr. Chairman, that will not be disregarded by a great nation in dealing with its own citizens. From the cleared forests of the West and the Northwest in all these States comes all this mighty avalanche of water, and upon these people, a mere fringe of humanity that stretches along between the river banks and the hills, has devolved the duty of battling with these waters. It is the nation's duty, and therefore the nation will respond to it; and that it

has not done so sooner has been because that sense of duty has not been awakened in it. It is a national work, Mr. Chairman, because this same commission reports to the Government that appointed it that without a perfected system of levees the navigation of that stream can never be brought to any condition of perfection. This is a channel that the Government owns, and the tribunal in charge of it tells you that these crevasses and breaks and overflows create shoals up and down the river which interfere with navigation and must necessarily do so.

The question as to the raising of the bed of the river has been answered by the report of the Commission. The experiments made by them, conducted through a number of years, have removed that apprehension from the minds of all people who have followed their investigations; so that I say, Mr. Chairman, in the interests of comdoing that the Government will do it, because the Government alone can do it. It is of a magnitude beyond the reach of any local organization or board.

That, Mr. Chairman, is perfectly demonstrable, and in this connection I submit to this committee that, as Mr. Caldwell has said, these people have helped themselves. Through the long years, for years without, and since 1882 with, Government aid, these people have struggled with this problem as best they could, by taxation imposed in a hundred ways so as to make it tolerable, they have sought to protect themselves. They have spent since 1882 more than $20,000,000 where the Government has spent $17,000,000. They have spent since and prior to the time of the Government commencing to aid them, $40,000,000. Is there any other class of citizens which comes before this committee appealing for Government aid, whether they come from the great cities, with their countless millions of wealth, or wherever they may come from, that can make the showing that these little bands of straggling agriculturalists, hampered by State lines, State laws, and State constitutions, can make?

We have borne the burden through the darkest hours of adversity, and it is not to escape that burden that we now come before the committee, but we come here for the purpose of showing that the work is beyond our feeble efforts—beyond all we can do; and if the committee will excuse me for a moment for dwelling upon local matters, I can best illustrate that by giving you the outlook in the district where I live, not as singular at all, but as illustrative of the difficulty of doing anything by local organization. That district is known as the Yazoo delta from the Tennessee hills to Vicksburg, embracing 325 miles of levee, 200 miles of which are within the district where I reside, the lower Mississippi district. We had, up to 1882, spent $10,000,000.

The flood of 1882 devastated the entire country. I remember well the convention which assembled for the purpose of deciding the question of whether any more money should be expended on levees, not that the levee question was a failure, but that it was recognized that the work was beyond our means to cope with. At that time we had two banks in that district where to-day we have thirty; we had two oil mills where to-day we have twenty-eight; we had not and never could have had, without levees, a single mile of railroad, where to-day we have one thousand.

And it was decided to go on, and we went on under a tax imposed, to give you some idea of how this money was raised, of 5 cents per acre on all land, 5 mills ad valorem on all property, real and personal, $1 per bale on all cotton raised within the district; and through these taxes we collected in those days about $250,000 a year, and with that increasing as the development made the amount of tax collected greater, and since 1882 assisted by the Government, we have advanced to the condition of being probably the most prosperous part of the Yazoo delta. The entire country is threaded with railroads; about 50 per cent of the land in that portion of the delta is cleared up, and to-day, with that prosperity, and with the increased returns coming from taxation, we are perfectly aghast and helpless at the outlay that confronts us.

The last engineer's report, made by the engineer of our local board, not for the purpose of parading our ills before the world, but because it contains information addressed to the board for the information of the District, showed that by the caving of those banks we would have to spend in the next few years $1,200,000 in building new levees, and $2,000,000 in raising our levees above the last water. and the lowest, most scant margin consistent with any degree of safety would take $3,700,000; and all that we had with which to do this work was this revenue from taxation of $350,000 a year, a large part of which is devoted to acquiring rights of way and keeping up the levees already constructed.

But we have not shrunk with the protection of the Government—with the aid that the Government has given us. We have not held back with the idea that our own efforts might be charged against us by the Government when it came to the consideration of the question of assisting us. In the legislature of Mississippi there is pending a measure by which we propose to tax ourselves for $1,000,000 more in bonds in that single district, and yet with all that, Mr. Chairman, unless the Government should aid the district, we are as helpless to-day as when we built the first yard of levee, because $3,200,000 in two years is a sum beyond any possibility of raising by any system of taxation that can be devised by man; and so it is throughout these other districts. The labor is one beyond the power of the local boards. It is one easily within the reach of the Government.

When we say we expended, Mr. Chairman, $12,000,000 in two districts, the amount of the expenditure must not be taken as a criterion of what it is necessary for the Government to expend in order to give us protection. That $12,000,000 is money that has been expended year by year in driblets, as it could be raised from the people by taxation, and a large part of the work done with that money has been swept away by floods within the year, and that work has had to be built over and over again where we had built before. That does not represent the amount of money that would have to be spent if as much as was needed was available all at once and it was spent intelligently, so that the floods would not carry away one year what had been placed in position the year before—spent by the one spending having means to do it at the proper times, and to see that what was done was properly protected and that the work done was not imperiled.

That is the reason I say, Mr. Chairman, that the work will be done by the Government, and I say again that we do not come here, onerous as this tax is, to escape from our burden; we are not driven here, and

these conventions are not called together, for the purpose of escaping this taxation. Few who attend the conventions bear the burden of that taxation. We have borne it in the past, and with the aid of the Government we are willing to bear it in the future, but what we want is to have the Government say, "We are willing to add that to your efforts which will give you safety;" to say to the capitalists of the world, "Behind these levees you can place your money, knowing that it is protected by the Government;" and we want to be able to hold out to the laborers of the world an invitation—for here in this part of the world there is a greater demand and return for their labor than at any other place on the top of the globe—and we want to be able to say to them, "Here you can labor and rest in safety, because this Government guarantees that this work will be maintained."

So, as I say, it is not to escape the burden that we have borne that we are here. And as to what should be given by the Government, that rests within the discretion of the committee and of the Congress. But there is this to be considered, that if it is well to do it, you want to do it now; you want to do it just as rapidly as the money can be expended. If you know that you are going to do this work, do it so that you know you are not going to have to spend dollar for dollar in repairing work that has been swept away. Every high water through which the work is postponed menaces your entire work. Millions of dollars that you have invested will be swept away by a single flood; and not only that, but the local boards are your partners, Mr. Chairman, in this labor. They have been your partners, contributing three dollars to your one, ever since you have gone into this, and they are willing to be your partners in the future. You do not want by your delay to hazard the bankruptcy of your partners.

The flood of 1893 cost over $5,000,000 in loss of life and agricultural products. The flood of 1906, if the levees are not placed in condition, may make that loss of $5,000,000 seem a paltry thing. You want to do that work so that your completed system is left to the districts to maintain, if you see fit to leave it to them, and not as it is now—a system which every engineer along the line of the Mississippi knows is simply dependent upon the caprice of the flood, and which may be swept away by the next spring's rain. You can finish that, put it in its completed shape, for $15,000,000. I mean to say that the Government can do it for that. If you give us under this appropriation $1,000,000 a year for this 1,140 miles of levees, that is barely enough to maintain it if you had it completed. Give us $4,000,000 for four years, and complete the work which you have entered upon.

It is no answer to this, Mr. Chairman, to say that there are meritorious demands from other sections. Test it. Is the work worth doing anywhere? Is it the duty of the Government to do it? Can anyone else but the Government do it? And where these questions are answered in the affirmative, then make the expenditure, and it is a wise expenditure and a good expenditure of the Government's money.

The CHAIRMAN. Let me ask you just two or three questions. What share of the total appropriations, of the expenditures for rivers and harbors, do you think should be given for the Mississippi River?

Mr. PERCY. I do not know that the matter should be decided in that way. The question is, What does the Mississippi River need? I could not answer that, as to what share of the total should be given to the Mississippi River.

The CHAIRMAN. We have the same argument from at least a hundred other sources all the time. They say the question is as to what they need. We have to equalize them.

Mr. PERCY. Then you have to look to the national character of the work, Mr. Chairman, and the magnitude of it, and see what is necessary.

Just one other thing: The most of the work that this committee is doing in the appropriations for various harbors and cities, all of which are wise and right, that work is frequently permanent. We might be satisfied with what you are giving us with the million dollars a year you are giving us, we might be willing to struggle on with this conflict at that rate, but you are imperiling every year your own investment. It is not like building a house, where you can stop if driven to it because of lack of funds, and later you can go back and find the house there as you left it.

The CHAIRMAN. The argument is very strong with regard to the levees, but it is not exceptional, for in many other cases the work has to be finished before it can be used, and it is liable to destruction if it is left.

Mr. PERCY. So it is, in some instances.

The CHAIRMAN. As, for instance, in the case of breakwaters. How many crevasses were there in this district?

Mr. PERCY. Only one.

The CHAIRMAN. What is the present condition of the levees to resist ordinary floods? Suppose that we have only an ordinary flood in 1905?

Mr. PERCY. The ordinary high water we would be protected from by the existing levees. It is the high waters that come every three or four years, or four or five years, that do the damage.

The CHAIRMAN. Why must this levee be raised four or five feet?

Mr. PERCY. Because the high water in this district was in some places more than a foot higher than the levee for 4 miles. I saw the levee raised more than 1 foot with the water lapping over it with every wave. That was raised by sacks, mere temporary work, which was done at a cost at that particular place of about $40,000. That work was purely temporary, and had to be put up to prevent the water running over the top of the levee and submerging the whole country. A raise of 2 feet simply puts it about 12 inches over the last high water.

The CHAIRMAN. I believe the last flood was more severe than its predecessor, in 1897?

Mr. PERCY. Yes, sir.

The CHAIRMAN. And more severe than others?

Mr. PERCY. Yes, sir.

The CHAIRMAN. In how many places would you say that the levees were threatened in your own district?

Mr. PERCY. They were threatened along the entire 200 miles.

The CHAIRMAN. That is, the crevasses would be likely at any point?

Mr. PERCY. Yes, sir.

The CHAIRMAN. You think it difficult to select the weak places?

Mr. PERCY. Yes, sir; at some places there are only a few miles where we have been able to reach Government grade—that is, the grade that the Government engineers say would give safety. Those places are safe, but the works need raising and also enlargement.

The CHAIRMAN. What would you say with reference to the construction of levees. Are they threatened with undermining by the river?

Mr. PERCY. No, sir; not except where the river has caved up rapidly to within a short distance.

The CHAIRMAN. That is where revetment is needed?

Mr. PERCY. Yes, sir; the Longwood leevee in our district, one of the largest in the district and one of the worst threatened points always in previous years, because of the poor foundation for it, and because of the exposed position to water wash, that levee was built up to grade and built up to the river bank. It has never been a source of anxiety since. But an examination within the last three months showed that it has caved up to within 300 feet of the face of that levee, and that it was still caving in at the rate of more than half the distance in a year. That means that that levee has to be relocated within two years.

The Government engineers have made an estimate of the cost. and it appears that that levee has to be put back for two miles or more. The cost of the entire work, including any damages and effects of water, and so forth, is $500,000, and nine miles of a trunk-line railroad will have to be removed—moved back, and the entire traffic on that road will have to be interrupted during that work.

The CHAIRMAN. If the levee system is to be completed, what will be the principal source of expenditure, for revetments to prevent caving, or for the construction of levees proper?

Mr. PERCY. The principal source of cost would be where it would become necessary to relocate a levee on the ground and the moving. Where you locate the levee back you are bound to take the chance of some extraordinary caving reaching it within the next ten years.

The CHAIRMAN. What would you say as to the general policy of the Government, as to what we should recommend in this committee, in regard to the protection of all lands abutting on rivers from flood or from the ocean? Now, I notice in the resolutions presented here that there is a recommendation as to St. Louis and Kansas City. What would you say as to the policy that we should pursue there?

Mr. PERCY. That was simply that the Government engineers should investigate and report if anything could be done by the Government to prevent the recurring floods there. What I should say was the proper way would be to handle these questions as they are presented to you and in the order of magnitude and merit as these claims seem to warrant. You can not at one sesion of Congress, or you can not now, map out what will be the limits of the river and harbor expenditures, but you can say "here is a work we have got to do," and you can say that here is a work that is worthy of care, and this is a work the magnitude of which is known.

The CHAIRMAN. Of course we do not blame you for your earnestness, but there are many other things which are presented to us with equal earnestness. How about the Mississisppi River above Cairo?

Mr. PERCY. The people up there are much better able to present their claims to you than I am. (Laughter.)

The CHAIRMAN. How about the Missouri River. That is another question?

Mr. PERCY. Yes, sir; that is a matter that worries the Missouri man.

The CHAIRMAN. That, of course, is a very serious question for the committee, as to what should be the general policy in regard to it. I think it is only due to the committee and to you to say that we have before us $500,000,000 of estimates, and our bill does not carry more than $25,000,000 a year. Now, doing the best we can to take care of the estimates, it is a difficult matter. Anything you do to stimulate and educate the public sentiment in these matters will help us, of course.

Mr. PERCY. There is one thing certain, you must get away from that limit of $25,000,000.

Mr. FAIRCHILD. Mr. Chairman, as you have been talking, it has seemed to me that questions of this nature we make a great mistake in not treating as a whole; we make a mistake in treating them as merely annual affairs.

Now, you are going to build this canal, and you are going to issue bonds to provide for the whole enterprise. Here is a thing which is not like others that you have suggested, but which will last for all time in its importance. It is not like the question of keeping a harbor clear, of dredging the annual accretion of deposits in a harbor, but it is doing something such as the building of a canal, such as we are doing in the State of New York in making the barge canal through that State, which is for all time, as that is there.

Now, it seems to me that wise statesmanship would take that in view, and if need be, issue bonds—do that which does the work most effectively and economically and expeditiously. It seems to me that the time has come when these great questions, and particularly a question like this which is of such vast importance to us and of such a permanent nature, ought to be considered in some such way, and not made to fit into the annual revenue of the Government.

The CHAIRMAN. Then, do I understand you that you would advocate the issue of bonds for this purpose?

Mr. FAIRCHILD. I would.

The CHAIRMAN. For river and harbor improvements?

Mr. FAIRCHILD. I would, where they are of this permanent nature, like the building of a canal, like the doing of that sort of thing. I think that economy and wise finance would treat the subject in that way and provide for the funds as they can be wisely expended, irrespective of annual revenue. That is the way I would do it if I was an individual doing it, and if I was the United States and had these things on hand I would do it in that way.

Mr. BISHOP. I would like to ask one question. You have had a great deal of experience in public affairs. The committee is largely up against this proposition and must assume some policy in its own defense in reference to it. Setting aside the Mississippi River, to which the Government is already pledged in a measure, would you advocate the policy of the Government caring for the banks of a river to prevent the erosion of private property?

The CHAIRMAN. The banks of rivers?

Mr. BISHOP. Yes, sir, the banks of rivers.

The CHAIRMAN. That, of course, must apply to all property and all characters of projects.

Mr. FAIRCHILD. I think that, as a rule, I should.

Mr. BISHOP. That is, without reference to navigation.

Mr. FAIRCHILD. Not in reference to navigation. Where it is a matter that you can see is of importance extending beyond the locality, where it affects the country as a whole in its interests in any way, I should say that the United States should take whatever they determined should be its share of that.

The CHAIRMAN. Now, is it not true that the protection of all lands is of interest to the country at large, that is, the protection of agricultural or other lands bordering upon rivers?

Mr. FAIRCHILD. That is quite true. Of course the thing has got to be treated in a practical, sensible way, but there are some cases where you would fear to say that the interests of the country as a whole was not enough in it; there are others that will be doubtful cases, and there are others where it is manifestly so.

The CHAIRMAN. That is a question of great importance to us, Mr. Fairchild, because if we undertake that protection of land against floods and erosions, almost immediately the amount which must be appropriated for that purpose will be well in excess of the annual amounts we are now expending for all the affairs included in our rivers and harbors bill, and everything. And this is true, and this has been one strong argument used in favor of the appropriations for levees of the Mississippi River, that it is a fact that the abutting property has paid half and more than half of the expense of the improvements down there. In that way this matter has been distinguished from the rest. Originally the argument, of course, was that it was in the interest of navigation, and to an extent certainly very plausible arguments can be made that it benefits our navigation now.

Mr. FAIRCHILD. It does benefit navigation; there is no doubt about it, and on that ground alone it is, of course, very important. But it is a very much broader question than that. We would not hesitate to spend any amount of money in acquiring a property which we can acquire in this way if it was an original proposition somewhere of acquiring it some place in the world, and we would not hesitate to issue bonds for that purpose. Now, this thing is of a great deal more importance than your isthmian canal.

The CHAIRMAN. That has not been the general sentiment of Congress.

Mr. FAIRCHILD. It is, and justifies that sort of thing—treating it on a large scale, with bond issues if necessary, I say. If that sort of thing is to be done it should be done on the same principle on which you build your isthmian canal.

The CHAIRMAN. Here is another question relating to this. Some years ago we could not pass a bill in the House but what the Senate would put on amendments appropriating very large sums for purposes of irrigation. Now if we adopt the general principle that money should be appropriated where the value of the land will be increased, and arable areas extended, do we not adopt the other principle, that money must be expended for a great variety of subjects, not only making lands available by irrigation, but giving them protection against natural calamities? Do we not do that?

Mr. FAIRCHILD. Very likely.

The CHAIRMAN. Do we not logically come to that conclusion?

Mr. FAIRCHILD. Very likely. But I think we must remember that in many directions the United States Government has entered upon

that sort of work. It has entered upon it and it is going to do it. There is no use closing our eyes to the fact that we are not going back to the way that we used to do things. The United States Government is going on to do this kind of thing. We might as well make up our minds to that, and that being the case I do not see why we should not proceed, in view of that state of things, and do it comprehensively and systematically and in the most economical and effective way. It may be that we started entirely on a wrong basis in doing these things by the National Government at all, but we are doing them and we are going on to do them.

The CHAIRMAN. There is one point, of course, in this connection, that is pertinent to the work of this committee. Strictly speaking, our work should be limited to these appropriations which have to do with navigation.

Mr. FAIRCHILD. Yes, I know.

The CHAIRMAN. The deepening and improvement of rivers would improve the harbors as well. This question is before us because at the beginning it was argued that these levees were for the sake of navigation. We have continued them, and they are carried on our bill, partly as a matter of custom.

Mr. FAIRCHILD. But after all, the Congress and the country has ratified your action. They know that a large amount of your expenditure has been outside, really beyond, the subject of navigation, and it has become an established thing, it seems to me, that this committee does take these larger interests into consideration.

The CHAIRMAN. I hardly know an exception outside of this. The tendency has been to restrict expenditures to matters pertaining to rivers and harbors. This is true, that we all recognize the magnitude of the problem down there, and that it has been the settled policy of the Government for twenty years to recognize the great importance of developing those plans. It has, however, seemed to us that the benefit to the abutting property was such that that property should carry its share of the burden.

Mr. FAIRCHILD. I think that is true.

The CHAIRMAN. Here are lands worth only $2 or $3 an acre that may be made worth $50 or $60 an acre.

Mr. FAIRCHILD. Yes.

The CHAIRMAN. Now, is it quite right that that land owned by private parties, not an acre of it by the Government, or transferred to the States, should be so increased in value at the exclusive cost of the National Government?

Mr. FAIRCHILD. No; of course, when you put it that way, that is not correct. That is not correct, but even that applies to all kinds of things that you do; that unearned increment which was Henry George's favorite runs everywhere. In some countries they do those things a little better than we do. For instance, I noticed the system of street opening in Birmingham, England. Here in New York, for instance, if we want to open a street we take just the amount of land necessary for the opening of that street, and we assess the adjoining owners for the benefits and the city pays a portion. In Birmingham they take a great deal more land than is actually necessary for the opening of the street, pay everybody for it when they take it, sell it on long leases—the land that is improved—and it does not cost the city or anybody anything. That is not our system, but everything we

do gives that unearned increment to somebody—almost everything you are doing.

The CHAIRMAN. The question is this, does the general improvement of a river or a harbor confer any such benefit on the adjacent property as does this improvement by the construction of levees? Of course every bill we pass, every improvement of a harbor increases the value of the property.

Mr. FAIRCHILD. Of course.

The CHAIRMAN. For instance, take the harbor of your own city—New York Harbor; the appropriations for that harbor increase the value of the property in the city, but do they increase that value in any such percentage as does this improvement?

Mr. FAIRCHILD. Why, Mr. Chairman, I suppose if you did not keep continually improving and taking care of that harbor property in New York would become almost valueless; and where are you going to draw the line as to where it comes?

The CHAIRMAN. But is it not a question of the proposition in which it benefits the adjacent property? This benefits this land to the extent of increasing its value ten to twenty times over. Is the property in New York benefited, increased in value, ten to twenty times by what we do in the harbor?

Mr. FAIRCHILD. You mean, suppose we had a harbor all stopped up so that ships could not get up beyond Sandy Hook, and you should come and dig it out and make a way across to that city, what would be the effect on property?

The CHAIRMAN. Certainly; that is not similar to this question, because it is a comparatively small expense in proportion to the result of this thing, while this is a very much larger expense.

Mr. FAIRCHILD. No, that would be fully as large an expense in proportion to the result obtained then. But of course if you go into that question, I think you have got to revise your whole system and go into an ascertainment of exactly how much benefit is coming to the localities and how much of the expense they shall bear, and then you have laid out a task of investigation which has almost no end.

Now it would appear that those people down there have put a burden upon themselves of all that they can bear with their present resources. You go and add some millions of dollars to what you give to help them, and you improve resources down there very much, indeed.

Now, unless you can devise some system by which the United States is going to take possession of those lands, improve the river, and then sell the lands and get the profit of it, which would be a business thing to do, you have got to take the chances of some people making more than their share out of the improvement, just as it is everywhere else.

The CHAIRMAN. But is this the real point? I tried to make this clear before; is not the added value here altogether out of proportion to what it is in the ordinary river and harbor? Here it is a conceded fact that these lands are worth only three or four dollars an acre, and that they will come to have a value of ten or twenty times as great after the improvement of these levees. Suppose you take the improvement of the Ohio River, for which a considerable amount is sought. Does the money expended there increase the value of property along the river in any such proportion as here?

Mr. FAIRCHILD. No; probably not. But I do not think it is any argument against making the appropriation that this is a far greater benefit and will increase the national wealth a great deal more. When you come to think that there is no other way of doing it, that the present property has been taxed to the utmost extent that it can be, then to produce the other result this other money has got to come. If people are benefited by that in a greater degree in some localities than in others, owing to the conditions, I do not see that you can gauge it.

The CHAIRMAN. There still remains the fact that we must take those facts into consideration. It may not be different in kind, but we have to notice differences in degree.

Mr. FAIRCHILD. Well, I do not think that makes any difference as to the appropriation. If you can devise any way to get that back out of the future benefits, well and good; but if you can not, that is no reason why you should not devise some way by which this improvement could be made.

The CHAIRMAN. I think the committee is fully of the opinion that certain appropriations should be made.

Mr. CALDWELL. I think you have an entirely erroneous opinion of the land prices down there, Mr. Chairman. I can not conceive how anyone would make a statement here that the building of these levees would increase the value of these lands ten or twenty times over.

Now let me state the facts as they exist down there now. Cultivated land is worth so much per acre according to its location in relation to railroad or transportation facilities, in accordance with its freshness, and in accordance with its improvement. Unimproved lands, woodlands, are worth about so much per acre to-day in accordance with their location with reference to transportation, density of population, natural lay of the land as to drainage and levee protection. Now there is a great deal of land down in that country, unimproved land, that by many people is considered fully protected, but the people who consider it so are not so farsighted, because with the system not completed we can not say that any of it is protected. But, granted, here is a tract of woodland that is considered fully protected.

Now, that tract of woodland, irrespective of the value of the timber thereon, which is an entirely different proposition—and we are taking it for agricultural purposes only—is worth $5 an acre, whereas in some other portion of the Delta another tract of land not rendered valuable by timber, but in the minds of the people fully protected from overflow, is worth $2 per acre. What gives value to those lands? They are not increased in value ten or twenty times by putting up levees and completing the levee system. They never have been. Lands which before the completing of the levee system were worth $2 an acre never jumped up to $20 or $40 after the levees were built. But the lands become valuable as the timber is taken off, as ditches are made, as houses are put upon the lands, as the plow goes into the ground, and as people come there and live upon it. That is what makes that valuable, and not the mere fact of the building of the levees.

Now, for us to get the people there, to get the houses and the ditches there, to get the plow in the ground, we must have the levees, and I think you are making a great mistake if you think that the increase in value by this is anything like so great as that; and if I had been

asked the question as to the increase in value of the property in the city of New York by river and harbor improvement as against these improvements in the Delta, I would have said that the increase in the Delta is but a drop in the bucket as compared to the increase in value of the lands of New York.

The CHAIRMAN. Of course that was more by way of illustration. I have been reading with a great deal of interest the pamphlets giving an account of the proceedings in New Orleans, and this estimate that I have spoken of is made in these addresses and pamphelts. So it does not originate entirely with me.

Mr. CALDWELL. People do all the time confuse those two ideas, as to the productive area of land and the increased value per acre.

STATEMENT OF MR. CHARLES F. HUHLIEN.

Mr. HUHLIEN. Mr. Chairman and gentlemen of the committee, you can no doubt realize my embarrassment at being asked to speak after those who have preceded me. I might say that Kentucky has, as you all know, an immense mileage of navigable streams, both within and along its borders. It has a comparatively small levee district, and I will not attempt to refer to any phase of that question. But if you will pardon me, I would like to indulge in a little personal shop talk. I am a manufacturer at Louisville, and since the 1st of January it has been my duty to contract for many hundreds of tons of pig iron for our own business which we have bought in the Birmingham district. We have bought many hundred tons of bar iron from the Ohio and Indiana mills, and it is my intention in a day or two to return home by way of the Pittsburg district and to contract there for several hundred thousand tons of steel for our business.

I take the liberty of referring to that simply because I believe that we are typical of many hundreds, if not thousands, of industries all over the country. That is the interest that the manufacturing industries of this country have in the trade of the great delta, because we, along with hundreds, if not thousands, of other manufacturers, find our market largely, if not entirely, in this great delta of the Mississippi. Those people, as has been stated, buy everything they consume, they manufacture nothing and will hardly manufacture anything, and they sell all that they produce as raw material to keep the mills of our country busy. We believe that this great delta which would be reclaimed by these proposed improvements is one of paramount importance to this country, if you please, and we believe that it is well established that these levees simply expedite the current of the Mississippi River thereby causing it to scour a deeper channel and more readily confine itself within its banks, and we believe as manufacturers that the transportation interests of the Mississippi River are facilitated by these levees.

We believe that the property all along the Mississippi Valley would be greater, the internal commerce of that whole section, the interstate commerce of the whole section, would be facilitated by these improvements; and as Kentuckians, and as patrons of the iron and steel interests and many other interests of the other parts of the country, we would be very glad if your committee would recognize what we believe to be the vastness of this great project. We believe that the best is none too good for any part of this great country, and we believe

that a project as great and meritorious as this is merits the most generous and most liberal consideration at your hands.

STATEMENT OF MR. ALEX. G. COCHRAN, REPRESENTING THE MISSOURI PACIFIC RAILWAY SYSTEM.

Mr. COCHRAN. Just before the holding of the levee convention at New Orleans, invitations were extended to many persons throughout the country to attend, and among others to Mr. Gould, president of that vast system of railroads known as the Gould system, and I will read to the committee the brief reply which he made:

I regard your convention to be held in New Orleans on the 27th as a very important event for the entire Mississippi Valley and all the great and diversified interests therein, and I hope the views and plans for levee protection that will be formulated will be so desirable to all interests, and including those of your great city, that they will commend themselves to the public at large and to the Congress of the United States, where it is hoped liberal appropriations will be provided.

The railroad interests I am connected with have under way and partially completed a low-grade line from East St. Louis, Ill., to New Orleans, crossing the Mississippi River on a great bridge at Thebes, Ill. When this line is completed it will be a water-grade line, parallelling the Mississippi and opening up virgin forests upon its west bank, and in addition it will make accessible great areas of farming lands susceptible of a high degree of cultivation if made safe from inundation. We are also, at great expense, rebuilding the railroad between Little Rock, Ark., and Coffeyville, Kans., and are constructing a new low-grade line of railroad in the White River Valley to connect our Kansas City lines with the main line of the Iron Mountain road. All of this, with necessary expenditures for equipment and other railroad appurtenances will amount to from $40,000,000 to $50,000,000, and the work has been under way for two or three years with the belief on our part that this great investment, the bulk of which will be in the Mississippi Valley, will be protected from damage by floods and inundation. The completion of our plans hereinabove outlined will inure greatly to the benefit of the city of New Orleans and largely add to her maritime trade.

Mr. Gould very much regretted that imperative engagements in New York made it imposible for him to appear in person before the committee, and he has requested me to speak in his stead.

I am interested in this question from a railroad point of view, because I am a citizen of the great metropolis of the Mississippi Valley, St. Louis, and because seven or eight of the best years of my professional life, prior to becoming connected with railroad enterprises, were spent with that great engineer of the Mississippi, Capt. James B. Eads, whose counsel I was up to the time of his death. The Mississippi River has, therefore, always been a most interesting problem to me, and its phenomena a matter of careful study and thought.

Now, of course, it is apparent to every gentleman of the committee that the question of railroad development in this vast alluvial delta is one dependent absolutely upon the proposition whether the lands through which the railroads are expected to run shall or shall not be protected from inundation. It is idle to suppose that great capitalists, who have at heart, of course, the interests of the country through which they run—as being identical with their own interests—will expend the vast sums of money necessary to construct and equip railroads through this valley, unless they have some assurance that, when completed, their investment will not be swept away and destroyed, or unless they can have some further assurance that it will not cost more

than the total amount of revenue earned for replacement or repairs because of injuries done by the floods. I can speak not only for our system of roads, which amounts to between 15,000 and 16,000 miles, but I am sure that every other railroad system which has lines extending through this Mississippi Valley is deeply in sympathy with this movement to reclaim those lands and protect them by levees, so that railroad construction, which has been greatly impeded, or absolutely prevented, in the past, by reason of periodical overflows, may be completed and protected. Of course no argument is necessary before this committee that railroads are indispensable to the development of that vast territory. They will certainly be there if they can be protected from overflow. They will as certainly not be there if they can not be so protected, because it is idle to suppose that they will be constructed unless they can be guaranteed substantial protection from periodical inroads of the river which would ruin the property.

There are certain propositions in connection with this problem which I suppose we may consider as practically conceded. First, it has been setled by Congress that it is proper to make appropriations for levee improvement, irrespective of the consideration whether that improvement conduces to navigation of the river or not, and, as all the members of the committee are aware, there has been for some years past set apart from the appropriations for the Mississippi River Commission a certain amount per annum which has been devoted to the building up and strengthening of the levees. With that precedent approved by years of experience, it seems to be idle to go into a discussion——

The CHAIRMAN. We all concede that, Mr. Cochran. The million dollars a year is set aside, and it has been discussed frequently on the floor of the House and also in this committee. However, we have usually coupled with that the statement that the localities gave as much or more than the General Government.

Mr. COCHRAN. Of course there can be no complaint as to what the localities have done, because the records show that these good people who live down in that valley have taxed themselves to the utmost, have borne burdens heroically and with patience, for the building up of this great line of fortifications to protect themselves against that great on-rushing enemy. We have, as boys, all read of the dragon that lived in the mountains and came down at stated intervals and demanded his victims, devouring the people who lived in the valleys below. My hair has stood on end many a time, as a boy, reading that tale. It makes me think of the great flood of the Mississippi. Those people do not produce it, and their country does not produce it; it is produced by thirty-two States above them, and it comes rushing down through this channel, and swells to a mighty flood which spreads abroad, carrying havoc everywhere.

The CHAIRMAN. It is not one dragon only which is raised up before us.

Mr. COCHRAN. Well, we will have to kill them one at a time, and we will begin with this Mississippi dragon. [Great laughter.]

Down comes this great flood, pouring away from ten States, and probably twenty-two others, and here are these people with this rich land, undeveloped as yet, capable of supporting many times the number of its present inhabitants, capable of producing the enormous crops of cotton of which Mr. Fairchild has so forcibly spoken (every

word of what he said I cordially endorse, as well as every word that has been said on that same line by other speakers)—here are these people to be protected. Now, is that an ordinary case? Are you going to look at that as you would at the question of whether a portion of the bank of the Ohio River, upon which I used to live, for instance, shall be revetted? Are you going to look at it as you would at the question whether there shall be a wing dam thrown out here or there, or whether this or that work shall be done here and there, as is ordinarily done for the protection of banks on these streams tributary to the Mississippi? If so, you are going to take hold of this question from the view point of the low valley and not from the hilltop.

This is a question that must be viewed from the mountain top and not from the low ground of the valley. Here is a vast region which, without the protection of these levees, will be destroyed or rendered practically worthless without that protection. Not only so, but there is this justification which the committee has for regarding this improvement as materially different from others, in that the Government of the Unied States has already invested more than $17,000,000 in this improvement, and it becomes essential for the protection of this large amount of Government money already invested that more shall be put in to save it. Consider for a moment. Is not that a good answer to those who would say, "We are technically just as much entitled to protection as those who live at the mouth of the river?" You see, gentlemen, our Government has invested this enormous amount of money in these levees. True it is that in the same time we were expending this $17,000,000 the people living along the banks of this river expended $40,000,000, or rather, from the year 1882, when the appropriations commenced, the people expended $28,000,000. Now, in view of the $28,000,000 that these people have put in here in good faith, and in view of the $17,500,000, say, that the Government has put in, we have a vast investment to be protected. We are facing a condition and not a theory, and for the protection of that investment we should complete this work.

Gentlemen of the committee, this is no small question. It is a question which you must look at from the broadest point of view, and I do verily believe, if the good people of the United States could read those well-considered arguments that were made before the great levee convention at New Orleans in October last, that there is hardly a man in the United States who would not vote aye, and stand up, if necessary, in favor of this proposition. It is a great, broad, expanded theme, that needs great, broad and expanded treatment. We are bound to look at it from the broadest and the highest standpoint. These people need our help; they must have it. There is no use in doling it out to them in small amounts of money year by year. They have reached the maximum of their results in the way of raising money by taxing themselves. Now we must meet the situation upon that basis. A small amount of money spent in the next two or three or four years may be of some benefit, but along comes one of these tremendous floods, like the flood of 1903, and in a few hours the work which has been done has been swept away by that mighty and almost resistless tide.

Now, there is the proposition that confronts you, gentlemen. I know the difficulties of this committee; I know how every part of

the country is demanding help; I know that in a technical sense the Chairman is right when he says: "Why, so and so asks us for this and that. Now, on principle, are we not forced to divide it up and give a little here and a little there?" I say you are bound to do that to a degree, but conditions must control you in this matter. The investment that I have spoken of, the demonstrated willingness of all these people to put their hands in their pockets and to help along to the utmost of their resources, which you do not find in many cases, and the grand results to flow from this, must be considered. As to the improvement of any of these tributaries of the Mississippi, certainly in the upper regions where the farms are, and where there are agricultural communities, there is no vast overflow, but more correctly speaking a washing of the banks, and no one will pretend to say that there are any such conditions there as prevail down at the mouth of the river.

Now, there is this further consideration which, if you will pardon me, I will advert to, because you, Mr. Chairman, have referred to it, and I think you touched fairly upon every point in your questions. Mr. Chairman, there is this further to be said, and that is that the building of the levees promotes navigation and is a part of the scheme for the improvement of navigation. When Captain Eads first undertook to improve the South Pass of the Mississippi by the jetties, the little steam launch in which he and some of his engineers went about grounded in less than six feet of water. Now the commerce of the world passes through there unimpeded, through a channel not less than 200 feet in width and 30 feet in depth. Captain Eads was always an advocate of and a believer in the levees as instrumentalities for the improvement of navigation, and one can see for himself, without much study of the technical questions, how manifestly this is true. The capacity of a sediment-bearing stream to carry the material with which those waters are charged is dependent upon two factors—one, the volume of water, and the other the velocity with which that water moves.

Now, if you will look at this map of the Mississippi River you will see what I mean. If you allow the Mississippi River to scatter over a vast area of country, you are decreasing its volume, and just in proportion as you decrease its volume you decrease the carrying power of the current, you increase the friction upon the bottom, and the result is that instead of this volume of water passing down and carrying its load of detritus to the Gulf, where it is distributed over a vast area of deep water, it drops this load and decreases its own velocity. If you take a glass of Mississippi River water, it is as dark as coffee. Set it aside for a time and you will find that there is an inch of detritus at the bottom of it, and the remainder of the water is clear. What does this mean? The movement of the water has been stopped, and with the stoppage of this movement you have stopped its ability to carry this sediment. Now, it is the same in this matter of the cutting. The Mississippi River Commission has reported against the plan of these cut-offs for the purpose of overflow to let out the surplus water of the river to the one side or the other, holding, first, that to do so would build up a bar, and gradually, by building up above the curves, would raise instead of lower the flood line of the river, and furthermore, the Mississippi River Commission, after care-

ful investigation and due consideration, has reported to Congress that the levee system adopted and approved by it on lines satisfactory to it is a system in aid of the navigation of the river.

Certainly the foregoing may be legitimately said in favor of a system of levees as an aid to navigation, but if people say, "We want you to reclaim our land," and it should turn out to be a mere matter of reclamation of land, pure and simple, without any benefit whatever to the general plan of improving the river, there you at once see that the two matters differ materially. But whatever way you look at it, and from whatever point you view it, the more you study it the more you must be convinced that this is a great exigency which the committee should meet in a great and broad-minded way.

STATEMENT OF MR. O. M. KILLOUGH.

Mr. KILLOUGH. Mr. Chairman and gentlemen, I shall detain you a very few moments. I have been allotted by the chairman of our delegation ten minutes in which to tell this committee all about the benefits that the great valley has derived from levees, and what the needs of the levees are. I might very readily in that time give you all phases of the canal question, or settle the tariff question or the free silver question, but I feel totally inadequate to settle this question in that length of time. So I shall confine myself to one suggestion.

I come from a levee district in my State, and I must state things from our own personal experience, for I have no varied experience. This district is one of the youngest in length of maintenance along the river; some 230 miles in length and 20 to 50 miles in width. Until the levee system was begun in 1893 that country was a howling wilderness. We had a Mississippi River 50 miles wide every year, nearly. That river deposited flotsam and jetsam of all descriptions that it gathered up in its onward rush to the sea, and that deposit consisted of human as well as other waste, and some other things detrimental to agricultural interests. We had a country infested with a migratory class of people, who for a number of years immediately after the war and down until within a recent time reflected no great credit upon the great State of Arkansas. We flattered ourselves, and always contended, and do yet, that we were not responsible for the presence of these gentlemen, but had them because the sheriff of the county they came from was a crippled man, or they were more fleet than he was, and escaped, because they do not grow on Arkansas soil, and we do not sprout that sort of people.

Now, we feel safe in the hands of the Mississippi River Commission. We feel that, if their plans are followed out and they are allowed full and free control, the levee interests will be in no bad hands. I have not seen this suggested, and I wish to make the suggestion, and it will be all that I have to say to the committee. The Commission, in alloting the $2,000,000 a year that has been allotted to the Mississippi River, proposed at the last meeting of the Commission that the sum of $2,000,000 be allotted to the district at once, rather than to follow the agreement made at the prior meeting of the Commission.

The CHAIRMAN. Two million dollars for levees?

Mr. KILLOUGH. Yes, sir.

The CHAIRMAN. The ensuing year?

Mr. KILLOUGH. Yes, sir; instead of the $1,000,000 for each year. That allotment of the Commission failed to meet the approval of the Secretary of War, and the money was denied to us. Immediately following a great overflow it is clearly apparent to those familiar with the levees and the river itself that a small sum of money is much more advantageous and can be handled to greater advantage to the people of the district than a considerable sum spread out over a length of time. You take your canal, and when you have dug a mile you can go away and leave it and go back again with a surety of finding the hole there, and you can continue your canal; but when you build 1 mile of levee and do not follow that up or build it sufficiently strong, and you go away and leave it and come back, you will find a canal instead of a levee, and the last vestige of the levee is gone and it is usually a vast ditch. If we should have the $2,000,000 allotted by the Commission, I should feel that our district, which is the worst district along the river, would be greatly benefited.

It has now a bonded debt of $1,500,000. It is settling rapidly, and it is fertile land; and if we had that money, or, in other words, if the recommendation of the Mississippi River Commission were carried out, I should feel that our trip has not been in vain.

The CHAIRMAN. Mr. Parker, is there a pamphlet of the proceedings of your levee commission in New Orleans?

Mr. PARKER. Yes, sir; a copy was sent to every member of the committee.

The CHAIRMAN. I would like to have that.

Mr. PARKER. I will see that copies are sent you, Mr. Chairman. Before adjourning, Mr. Chairman, I desire to thank you, sir, and the entire committee, for our delegation, for the courtesy and consideration with which you have listened to us, and I earnestly hope that we can report results when we get back.

Thereupon the committee adjourned.

[Hearings before the Committee on Commerce, United States Senate, in relation to the improvement of the Mississippi River, May 12, 1890.]

STATEMENT OF GENERAL CYRUS B. COMSTOCK.

General CYRUS B. COMSTOCK, president of the Mississippi River Commission, appeared before the committee.

The CHAIRMAN. Are you chairman of the Mississippi River Commission?

General COMSTOCK. Yes, sir.

The CHAIRMAN. How long have you been connected with the Mississippi River Commission?

General COMSTOCK. Since its organization, in 1879.

The CHAIRMAN. Have you ever given personal attention to the work?

General COMSTOCK. Prior to that I was a member of the board on the improvement of the Mississippi River, which reported on the improvement of the river prior to the organization of the Mississippi River Commission.

The CHAIRMAN. Are you familiar with the Lake Borgne outlet improvement?

General COMSTOCK. In some degree.

Senator GIBSON. I suggest that General Comstock make a statement of the plan that the Commission has adopted, the work done, and the results achieved.

The CHAIRMAN. I want to ask one or two more preliminary questions, and then I will start him off.

Have you examined with any attention the recent inundations of the Mississippi?

General COMSTOCK. So far as the data has been worked up I have.

The CHAIRMAN. The committee is desirous of getting, so that all money that Congress may appropriate for the Mississippi River shall not be wasted, as much information as you are able to give them in relation to the Mississippi River, its improvements, the method of improvements, etc., of course including the proposed outlet at Lake Borgne; and if you will go on and make your statement in your own way it will be agreeable to the committee.

General COMSTOCK. The Mississippi River has widths of a mile and a half and possibly two miles in some places. In the worst places the Commission has begun narrowing the river, or attempting to do so, down to a width of 3,500 feet in expectation of improving the low-water channel. They have tried it at one place, Plum Point. They have built, where they attempted to narrow the river, dikes out into the river and have put brush-work aprons on those dikes to keep the water from flowing through and make the water still, or partially still, behind them.

That is to produce contraction. Contraction has been produced and large deposits have been obtained behind the dikes built in that way. Under contraction on one side of the river, the river may cave very rapidly, and it may be necessary to protect the opposite bank to keep the river from running away from you. Where there is a caving bend you want to hold that beind in order to prevent the river changing its form and carrying away the other works. These caving banks are held by putting on them brush aprons and covering them with stone. That is the general method the Commission has used.

At Plum Point the water sometimes before the work began went down to 4½ or 5 feet. In the last six or eight years the lowest it has been has been about 8½ feet, and a very decided improvement in the river has been made.

The CHAIRMAN. What is the length of that?

General COMSTOCK. Thirty-four miles. The work of the Commission has been confined to some 15 or 16 miles.

The CHAIRMAN. There the result has been satisfactory to the Commission?

General COMSTOCK. Yes, sir.

At the Lake Providence reach, 60 or 70 miles above Vicksburg, the same method was undertaken; pile dikes were built in that way and enormous deposits were obtained. There was revetment of banks at certain places, especially at Pilcher's Point, Louisiana Bend. Those revetments became damaged. The appropriation for them for one year was not made, and in the following year Congress prohibited us from building revetments. The consequence was that we lost that work, something like 2 miles of it. That also interfered with our doing anything below; that is, the absence of money in the first year and the prohibition the second year, covering a period of three years altogether.

The same thing affected us down at the tow-head below at Myersville, and there also we lost a mile and a half or two miles of revetment.

The dike work has essentially produced the results it was built to obtain. So far for works in the bed of the river.

The Commission has also expected to improve the river by building levees on its bank. It has spent in building those levees something like three millions.

Those two methods combine the work done by the Commission.

In reference to the outlet question, I made a report some time ago on the specific outlet proposition of Captain Cowden at Lake Borgne, and I do not know that I can do better than to read it.

Senator GIBSON. I did not understand you to say, General, what the results achieved at Lake Providence were, whether the channel responded, what the behavior of the river was, after you completed or partially completed your work.

General COMSTOCK. The channel has been better there since the work has been carried on so far as it has been done.

Senator GIBSON. How much have you spent on the levees?

General COMSTOCK. Something over $3,000,000.

Senator GIBSON. What proportion of the levees erected by you has given way in this flood?

General COMSTOCK. I am not able to answer that.

Senator GIBSON. Some of your subordinates can, probably.

General COMSTOCK. Yes, sir.

Senator WASHBURN. What depth of channel was there before you commenced?

General COMSTOCK. Five or 6 feet; 5 feet probably.

Senator WASHBURN. And you have nearly doubled it?

General COMSTOCK. We have increased it about one-half.

In regard to the Lake Borgne outlet I would say, a canal a mile in width leading from the Mississippi into Lake Borgne, its bottom being everywhere 10 feet below low water, as proposed by the bill, would, by an approximate computation, which is the only one practicable in such a case, divert from the Mississippi about 400,000 cubic feet per second, when the stage of the river near Lake Borgne is about 7 feet above Gulf level, and 500,000 cubic feet when the stage there is about 9 feet. The corresponding stages at Carrollton would be about 10 and 12 feet (since the slope would at last be the present high-water slope), the maximum stage there being 15.6 above mean Gulf. An outlet diverting 400,000 cubic feet per second would lower the highest flood at Carrollton by about 6 feet.

These computations are based on the discharge curve at Carrollton of 1883. If more water is forced past Carrollton hereafter by maintaining levees above, these figures will need modification. Judging from the effect of local changes of flood height elsewhere on the river, this lowering of flood height at Carrollton would die out in something like 200 miles in ascending the river. Since for this distance the slopes would be steepened, it follows that velocities would be increased, with their destructive effects on the banks of the river and on levees. The outlet would do no good to navigation, but rather the reverse. The first effect of taking 400,000 cubic feet per second out of the Mississippi would be a large lowering of the flood surface near the outlet. The flow through Lake Borgne would itself be a river of large size. Both theory and experience show that when, at all stages, a reduction in the size of a river flowing in alluvial soil is made, or the river is split in two, the smaller rivers gradually take greater slopes than the main river had. Hence both the main river and the new river would gradually increase their slopes to suit the new conditions. Since the slope begins at the Gulf, it can not become greater on the main stream below Lake Borgne, which is now nearly straight, without increasing flood heights at Lake Borgne. After some years, then, if both routes to the sea remain large rivers, the flood level above the outlet would be higher than it is now unless (as indeed is not improbable) the large amount of sediment which would be dropped into Lake Borgne (where the flood velocities would at first be but one-sixth of those in the Mississippi) should close this outlet, thus repairing the injury done to the main river. A large diversion of flow from the Mississippi to Lake Borgne would also seriously diminish the depth at the present mouths of the river.

For the following reasons, then, no important outlet at Lake Borgne should be either undertaken or permitted.

(1) It would for some years lower the floods at the outlet, accelerate velocities above it and increase caving and the consequent destruction of levees.

(2) It would cause shoaling at the present mouths of the river.

(3) If both the new outlet and the main river below it remained important streams—that is, if neither of them closed itself under the action of natural causes—the flood heights at Lake Borgne and New Orleans would after some years be greater than they are now.

It may be noted that if the United States desired such an outlet, its construction should be open to public competition instead of being a monopoly.

That relates only to forming an outlet which shall be a permanent stream. I think the water can be spared from the Mississippi River without injury to navigation under certain circumstances.

The CHAIRMAN. Do you think that would be desirable?

General COMSTOCK. I think that is desirable. At the Atchafalaya I think it is desirable to take five hundred or six hundred thousand cubic feet per second out of the river. In the same connection I have some memorandum as to outlets other than this outlet, if you wish to hear it.

The CHAIRMAN. Yes, sir.

Senator WASHBURN. Before you proceed let me ask you what would be the effect immediately on the main stream if you were to make a low-water outlet?

General COMSTOCK. I think it would shoal up immediately below, but not enough to injure navigation.

Senator WASHBURN. Taking as much water out as you say you would, it would shoal at the jetties?

General COMSTOCK. Yes, sir; and for 10 miles above there.

Senator WASHBURN. And still be an enormous amount of water?

General COMSTOCK. Yes, sir; still about one-half or two-thirds of the river, unless in making this outlet the whole river saw fit to go this way [indicating], which I do not think is probable. It will do no good to navigation and it would be of doubtful ultimate benefit to the levees.

Senator WASHBURN. What has been the ultimate effect of opening Bonnet Carré?

General COMSTOCK. Its effect in what way?

Senator WASHBURN. Below where it discharges; leads from the Mississippi into Lake Pontchartrain. Is that still open?

General COMSTOCK. It has been closed several years.

Senator WASHBURN. What was the effect when it was open?

General COMSTOCK. I think probably it shoaled the river somewhat below, but not enough to interfere with navigation.

Outlets have often been proposed as a method of reducing flood heights on the Mississippi. The immediate results of flood heights are so evident and so beneficial when a large crevasse is formed, the good results of an opening far larger than ever occurs naturally, seem so immediate and apparent, that it is not strange that many persons look on them as the true remedy for great floods.

In a letter of February 1, 1890, to the Chief of Engineers, I considered the effects of making an outlet a mile wide and to a depth of 10 feet below low water from the Mississippi River into Lake Borgne, and need not repeat the discussion here. In it I assumed what is well known to all persons familiar with hydraulics, namely, that a sedimentary river flowing in its own alluvion only acquires a stable regimen, when it has taken a slope suitable to its varying discharges and to the material through which it flows: and as a rule that these slopes diminish as the size of the river increases and increase as the size of the river decreases. It may be well to give some examples of this general fact.

The South Pass carried in 1875 about one-fourth of the water that the Southwest Pass did. Its slope from the Head of the Passes to its original bar was about one-third greater than that of the Southwest Pass.

The observed discharges of the Atchafalaya in 1882 were from one-seventh to one-tenth of those of the Mississippi. Its average slope to the Gulf is double that of the Mississippi.

The Sulina Pass in the delta of the Danube carries two twenty-sevenths of the total river flow, while the St. George Pass carries eight twenty-sevenths. The slope of the Sulina is one-half greater than that of the St. George Pass.

These examples are sufficient to illustrate the general rule already stated, that sedimentary rivers flowing in their own alluvion take larger slopes the smaller they are. Hence, if at Lake Borgne or elsewhere in its Delta the Mississippi were divided into two rivers, since each would be smaller than the present river, the two new rivers would go to work to obtain the new and steeper slopes suited to dimensions smaller than those of the original river, and hence would build up their beds. This process would only cease when the steeper slopes needed by each were obtained. Since both rivers would then have one end at the Gulf, and have steeper slopes up to their point of divergence than the main river now has, the flood surface of the rivers at that point would be higher than now.

There have been cases where the experiment of dividing a river in two has been tried by nature or by man. About A. D. 1438 the Adige broke its levees and poured its waters south into the Castagnoro and Canale Bianco, which then formed a drainage stream parallel to the Po. In 1545 the break had so increased that two-thirds of the low-water flow of the Adige and three-fourths of the high-water flow went through it. A low dam was built across the Castagnoro to check the flow into it, and both rivers raised their beds. In 1678 a new dam was built, as the old one was then buried in the deposit. The bed still rose. In 1791 a masonry dam 39 feet high, with many archways through it to allow floods to pass, was built across the Castagnoro. The bed continued to rise, and the floods on the Adige were so high that in 1838 the Castagnoro was permanently closed. In the six years following the closure the floods in the Adige fell, and the more markedly the nearer the point considered was to the Castagnoro.

Thus far only outlets have been considered which are permanent rivers. For such outlets the effect in finally raising the flood surface of the main river will be the greater as the flow of the outlet is more nearly equal to the remaining flow in the main river. If the outlet is small, its effect on the main river will be small.

Places where there is no escape except at high stages are sometimes called

outlets. For many years prior to the recent closing of levee gaps along the Mississippi below Red River, and of the gaps which permitted water to escape from the vicinity of Turnbulls Island into the Atchafalaya Basin, the maximum flood flow past New Orleans was but about 1,100,000 cubic feet per second. This flow is ample for all navigation purposes, and no practical gain to navigation will result from increasing it. In 1882 it was estimated that about 2,200,000 cubic feet per second passed the latitude of Red River mouth. It has been proposed to allow only 200,000 cubic feet per second to go down the Atchafalaya, leaving 1,900,000 or 2,000,000 cubic feet per second to go down the main river.

In my judgment, until the heights of levees below Red River are largely increased, there should be left a free opportunity for the escape overland of 400,000 cubic feet per second from the vicinity of Turnbulls Island into the Atchafalaya Basin, in such floods as those of 1882, in addition to the 200,000 cubic feet per second which is to go down the Atchafalaya. If such an escape, existing only at high water, be called an outlet, then I think it necessary, at least for the present. It will do no harm to navigation, which was good enough for many years before the escape into the Atchafalaya Basin was reduced. On the other hand, to try to force in a great flood, 1,900,000 cubic feet per second past New Orleans, with levees at present heights, is sure to renew the disasters to levees at or below Red River which have occurred this year. The injury resulting from many breaks below Red River is so much greater than that resulting from the escape into the Atchafalaya Basin from the vicinity of Turnbull's Island that the lesser interest should yield to the greater until it is possible to protect both.

It may be concluded, then, that the reduction, by any large amount, of the flow of the Mississippi at Lake Borgne below what it has been for many years will be ultimately followed by a rise in the flood heights at that place and a shoaling of the river below and at its mouth.

Also that until levees below Red River are much higher than they are now, about 600,000 feet per second in the greatest floods should be allowed to go into the Atchafalaya Basin, thus relieving the river below.

The opinion that the head of the Atchafalaya Basin should not be closed by levees was urged by me in the annual report of the Mississippi River Commission for 1884.

There is one other question, and that is that leveed rivers raise their beds higher and higher as the levees are raised. That is a very essential question in levees as long as are those on the Mississippi, and I have some memoranda as to them which I can read to the committee.

The CHAIRMAN. The statement has been made that the bed of the Mississippi River has risen some seven or eight feet.

General COMSTOCK. I have heard that. I have examined that question also. I have prepared a statement as to that question.

The statement is often made that leveed rivers raise their beds higher and higher as levees are raised, and hence that levees will give no permanent relief against overflow. These statements are usually made from theoretical opinions and without a thorough knowledge of the theoretical side of the subject, and probably without any knowledge of the facts of experience, which alone can lead to conclusions entirely safe. The river Po has long been leveed, and it is often stated that its bed has risen largely in consequece of levees. The following data will show how unfounded is the statement that the bed has risen by amounts that are of much importance:

At the revival of civilization the levees on the Po were complete and continuous from Cremona to the mouth of the Oglio, 49 kilometers, or 58.4 miles. About A. D. 1300 they were carried farther down the river, and in the succeeding centuries to near its mouth. In the present century levees have been systematized as to height. Four hundred kilometers, or 248½ miles, were below the flood of 1872. At the end of 1877 it was expected to reduce this to about 30 kilometers, or 18 miles. (Cenni monografici sull' idraulica fluviale in Italia. *Roma*, 1878.)

Zendrini, in 1720, observed an extreme low water at Ponte Lagoscuro, only .36 foot less than that of 1817; and at the dam of Governolo, near the mouth of the Mincio, the river was 1.3 feet lower than a stage of water of 1609, declared by Bardazzoli to be marvelous (Lombardini, Notizii).

The Cenni Monografici gives the following:

Pontelagoscuro.

Years.	Mean lowest water.	Mean highest water.	Maximum high water.	Minimum low water.
	M. Ft.	*M. Ft.*	*M. Ft.*	*M. Ft.*
1807–1825	3.28=10.4	7.42=24.3	8.62=28.3	0.38=1.3
1826–1850	3.26=10.3	7.38=24.2	8.96=29.4	0.72=2.3
1851–1875	3.19=10.1	7.39=24.2	9.32=30.5	0.62=2.0

The above gauge readings, which have been only kept since 1807, show that there has been no important rise of the bed of the river (since that could not rise without raising the low-water surface) at Pontelagoscuro in the sixty-eight years covered; and in connection with Zendrini's observations, show that there has been no probable rise of any importance since 1720, although the raising of levees has been going on during this period. Lombardini (Dei Congiamenti del Po, 1852, p. 17) examines this question for points above Pontelagoscuro, which itself is 92 kilometers (57 miles) from the mouth of the Po. He concludes that at Ostiglia, which is 183 kilometers (114 miles) above the mouth, the bed appears to have risen a few decimeters (decimeter=3.9 inches) in a century, while at Governolo, 15 kilometers (9⅓ miles) above, it appears to have been stationary for four centuries.

In *Il grande estuario Adriatico*, 1868, *Appendix D*, he gives the following table of heights of low waters above the lowest water known, which was in May, 1817:

Means of observed low waters, in meters.

Years.	Ostiglia.	Sermide.	Quatrelle.	Pontelagoscuro.
	M.	*M.*	*M.*	*M.*
1817–1850	0.55	0.54	0.47	0.49
1851–1867	0.44	0.77	0.84	0.55

Comparing the means from 1817 to 1850 with those from 1851 to 1867, it will be seen that a small rise in low-water heights is indicated, but the observations at several stations in the first period were few, and hence the results are uncertain.

The flood heights have, however, steadily risen. The following greatest floods are recorded:

	M. Ft.	
1837–1877	3.22=10.6	in the year 1872
1757–1796	2.15= 7.1	in the year 1777
1797–1836	2.68= 8.8	in the year 1833
1837–1877	3.22=10.6	in the year 1872

From this table it appears that the highest floods have increased in height since 1705 by 1.4 meters (4.6 feet). The rise in flood heights on the Po has not been confined to the single point Pontelagoscuro, but has extended far above.

Gallizia (Giornale del genio civile, February, 1878) examines this question and gives the following results. The miles given are reckoned from the mouth of the river.

"At Becca (394 kilometers, or 245 miles), within the century, there is a progressive rise of 1.53 meters (5 ft.) from 1801 to 1857; at Corossa (337 kilometers, or 209 miles), the flood of 1801 read 6.35 meters, and their heights rose gradually to 7.95 meters in 1872, or to 7.45 meters if allowance is made for a change of bed at this place. At Casal Maggivre (233 kilometers, or 145 miles), from 5.60 meters in 1801, the floods rose gradually to 6.07 meters in 1868, a rise of 0.47 meters or 1.5 feet. At Ostiglia (149 kilometers, or 93 miles), from 6.80 meters in 1801, and 7.50 meters in 1812 to 8.56 meters, although the river was not entirely confined. At Pontelagoscuro (92 kilometers, or 57 miles), from 2.19 meters *sopra guardia*, in 1801, to 3.32 meters in 1872; the river not being entirely confined in this last year—a rise of 1.13 meters (3.7 feet); so that on the average there has certainly been a rise of more than a meter (3.28 feet) in the last seventy-five years along the whole course of the leveed river, excluding the Parma Cremona front, where the levees are far apart, and the rise is about one-half as much."

Cenni Monografiri sûll'idranlica, p. 59, attributes the increased heights of the great flood of 1839 to "the more perfect leveeing of the Po and its tributaries, preventing the lateral escape of the waters, and sending in a canal to the sea that which previously flowed over the country."

Lombardini (Ilgrande estuario Adriatico, p. 96) says the increased floods "arise in part from levees which hinder their spreading out, and also from the deforesting of mountain slopes."

Gallizia (loc. cit.) attributes increase of floods to deforesting, to the interest each one has to get rid of injurious water, without consideration for those below him, to the leveeing of upper parts of rivers and their tributaries, and to the extension of the river mouth into the sea.

To sum up in reference to the Po, it may be said that during the present century the levees on the Po have been systematized and raised to follow an increase in flood height that in seventy-five years amounted to about three feet along the leveed portion of the river: and that there is some evidence of a small rise in the extreme low-water surface of the river, which may be caused by a rise of the bed. It should be noticed, however, that the rise in the bed (if it really exists) amounts to only two-hundredths of a foot a year, and that the annual cost of raising levees to keep up with it would be but a small part of the annual cost of a complete system of levees.

As to the rise in the flood level as the waters are more and more thoroughly confined, it may be said that this was a necessary result of confinement: that the same thing occurs on the Mississippi, and that it will cease when the levees have been built high enough to contain the greatest floods.

On the Po thus far during the last seventy-five years the effect of the confinement of waters in raising the flood level has far exceeded any tendency that confinement may have had to reduce flood heights by scouring the bed.

Senator WASHBURN. Are the conditions the same in the valley of the Po as in the Mississippi Valley?

General COMSTOCK. Yes, sir; essentially the same; an alluvial stream.

Senator CULLOM. So that your conclusion is that the bed of the river has not risen?

General COMSTOCK. Not to any considerable amount; not to exceed 6 or 8 inches.

Senator CULLOM. For how long a period?

General COMSTOCK. From seventy-five to one hundred years.

Senator CULLOM. Oh, that is the Po. What is the fact with reference to the Mississippi River?

General COMSTOCK. Our records of low water run back only twenty-five or thirty years. Our records do not go back far enough to draw an intelligent conclusion. You want a period of from seventy-five to one hundred years to say positively whether any changes have occurred.

The Rhine is also a river which, below Düsseldorf, has long been leveed, and if levees raise the bed of a river, here they should have produced their full effects, as they are rarely broken.

The following table from Fijnje (Beschonwingen over eenige rivieren, erste gedeelte, bijlage A, p. 185) gives (in meters) the height of the lowest water which occurred in each ten years from 1772 to 1880, above the Amsterdam zero, for Cologne and Emmerich:

Years.	Cologne.	Emmerich.	Years.	Cologne.	Emmerich.
1772–1780	36.82	11.29	1831–1840	36.30	10.88
1781–1790	36.14	11.26	1841–1850	36.35	10.81
1791–1800	36.36	11.24	1851–1860	36.06	10.16
1801–1810	36.56	11.11	1861–1870	36,03	9.92
1811–1820	36.30	11.03	1871–1880	36.28	10.21
1821–1830	36.30	10.64			

It will be seen that the low-water surface appears to have fallen in the last hundred years at Emmerich, and possibly at Cologne.

Hagen (Wasserstände in den Preussischen Strömen, p. 12) carefully examines the gauge readings at Cologne, from 1846 to 1879, and at Düsseldorf from 1800 to 1879, to detect changes in high and low water heights. Treating the gauge reading by the method of least squares, he found the most probable annual change in the water heights. At Düsseldorf he found that, with great probability, there was an annual sinking of the maximum high water in each year

amounting to 0.3 inch; that the mean stage did not change, and that the annual lowest waters showed, with some probability, an annual rise of one-twelfth of an inch.

For Cologne he found that, with great probability, the high waters had sunk, and the lowest waters had risen by about the same amounts as at Düsseldorf. A rise of one-twelfth of an inch a year, or 8 inches in a hundred years, is so small as not to be an important matter in a system of levees; and if the hundred years of the table above are taken, this rise disappears.

It has often been asserted that the bed of the Hoang Ho, or Yellow River of China, has risen above the surrounding country, where it is leveed. The error, originally due to Abbé Huc, has been repeated by English writers on China. The following extract from a letter to me by Gen. J. H. Wilson (a very competent authority) gives reliable information on the subject:

WILMINGTON, DEL., *May 6, 1890.*

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In reply I hasten to say that I crossed the Yellow River on the 7th of January, 1866, near the city of Kai-fong-fu, in the province of Honan, and visited the site of the great break of 1853, about 30 miles below Kai-fong-fu; also traversed its embankments or levees on both banks of the river, visiting and measuring them at various points between Kai-fong-fu and Chinan-fu in the province of Shan-Toong, taking observations, notes, and measurements, and having specially in view the repair and maintenance of the embankments, their present condition, and the effects produced by them. I had no instruments, however, except a hand level, sextant, and tape line, and could therefore make no accurate levels across embankments, bed of the stream, fore shores, and adjacent plains, but the conclusion I came to in regard to the influence of the levees upon the bed of the river was that they had nowhere filled it to a higher level than the adjacent country. I had heard of Father Huc's narrative on that point, and I visited the plain at which the river had left its old channel in 1853, leading to the sea south of the peninsula of Shan-Toong, and made itself an absolutely new one to the Gulf of Pe Chi Li, north of that peninsula. Between this place—known on the maps of Asia (Kirke Johnson's is the best) as Lung mum Ku—and Kai-fong-fu, the embankment was very large, but it was near the latter place that the great break occurred two years ago. This was closed after incredible efforts and great expense, and this river forced to resume its old channel, where it is now emptying itself, according to my advices of a few months ago, and where it will most probably continue to empty itself till it can find a shorter line and steeper declivity to tide level.

By referring to my little book on China (Appleton & Co.), you will get other details.

In conclusion I do not hesitate to say that I can not believe that Abbé Huc was entirely mistaken in regard to the silting up of the channel, and that an exhaustive survey would prove beyond a doubt that no such silting as to raise any part of the bed above the adjacent country has ever taken place.

Yours, very truly,

JAMES H. WILSON.

The question of the rise of bed of the Mississippi will now be considered. Unfortunately it has not been studied as thoroughly as the Rhine and Po, and its gauge records go back but a few decades.

Levee building has gone on most rapidly since 1880, and as the river was very low in December and January, 1887–88, and again in October and November, 1889, if there has been any important rise in the river bed resulting therefrom it should show itself in a corresponding rise in the extreme low-water surface.

Several places will be considered, selecting those where our gauge records cover as many years as possible.

(1) *Cairo.*—The lowest water record extends back to 1859, with breaks, but is continuous since 1871. January 1, 1888, the gauge read 1.8 feet, and October 22, 1889, it read 2.7 feet. From November 10, 1859, to these dates the record gives but three years when the water was as low as in 1888 and 1889. These years were:

	Feet.
December 26, 1871; Cairo gauge	—1.0
December 6, 1872; Cairo gauge	1.0
January 1, 1877; Cairo gauge	1.0

These gauge readings are lower that those of 1888 and 1889, but the period since 1880 is entirely too short to conclude that in it there was a year in which

the discharge reached its lowest value, thus giving extreme low water. The greater low-water heights in 1888 and 1889 may be simply due to there being more water flowing in the river at those times than in 1871. If in seventeen years following 1888 there are no gauge readings as low as those of 1871, 1872, and 1877, it will in some degree indicate but not prove that the bed has risen. At present the data do not extend over a period long enough to draw any reliable conclusions.

(2) *Memphis.*—This gauge read:

	Feet.
November 20, 1887	1.20
January 4, 1888	0.80
October 26, 1889	1.90

The records of low water before these dates extend back to 1848 and are continuous back to 1871. The records back to 1848 give but three dates when the water was lower than on January 4, 1888, namely 0.80 feet. These dates are:

December 29, 1871	—0.92
December 25, 1872	—0.95
January 2, 1877	+0.75

Here again the extremely low waters of 1871 and 1872 show themselves, and they are lower than any since 1880. But, as was said in reference to Cairo, the period since 1880 is entirely too short to enable us to assume that in it there has been a year of minimum flow, or, what amounts to the same thing, that there will not in a few years occur a stage as low as that of December 29, 1871.

(3) *Helena.*—The low-water record is continuous, excepting 1878 and 1879, back to 1871. The gauge read:

	Feet.
December 29, 1871	1.15
December 26, 1872	0.00

The record afterwards gives no waters as low as these till 1887. The gauge read:

	Feet.
November 20, 1887	1.20
January 4, 1888	0.80

Comparison of the two periods gives a difference too small to establish a rise of low-water level.

(4) *Lake Providence.*—The low-water record extends back to 1872 and the lowest waters are:

	Feet.
December 29, 1872	—3.85
October 16, 1879	0.55

Since 1880 the two lowest waters are:

	Feet.
November 22, 1887	1.52
October 31, 1889	2.80

There seems to have been a great depression of low water in this part of the river about 1872. The Terrapin Neck cut-off, shortening the river about 16 miles, occurred in 1866 and may have been a partial cause. The gauge readings given indicate a rise in the water surface and probably of the bed at Lake Providence since 1872.

(5) *Vicksburg.*—Excepting 1878 and 1879, the low-water record is continuous back to 1872. The gauge read:

	Feet.
December 30, 1872	—1.30

From this date to 1886 the lowest record is:

	Feet.
January 6, 1887	2.25

Since 1880 we have:

	Feet.
November 16, 1886	0.00
November 24, 1887	3.91
January 7, 1888	1.32
October 29, 1889	0.80

Here the gauge records indicate a fall in the low-water surface and perhaps a fall in the bed. The question is complicated by the Terrapin Neck cut-off of 1866, the Vicksburg cut-off of 1876, and the Davis Island cut-off of 1867.

From 1872 to 1881 the low-water fall in the surface of the river between Lake Providence and Vicksburg varied between 21.0 feet and 22.9 feet; in 1883 it was 24.9; in 1886, 26.2; in 1887, 29.0; in 1888, 26.7, and in 1889, 27.2 feet. The change of fall from 22.6 feet in 1887 to 29.0 feet in 1887, amounting to 6.4 feet, is very great. About two-thirds appear to be due to a sinking of the low-water plane at Vicksburg, and the rest to a rise in the low-water plane at Lake Providence. The low-water slope from Lake Providence to Vicksburg was in 1884 still much greater than just above or below. Its great value was probably due to the cut-offs. In 1884 the distance from Lake Providence to Vicksburg was 57 miles; the sum of the two cut-offs was 18 miles. If we suppose that before these two cut-offs the river was two-thirds of this 18 miles longer than now, or the distance from Lake Providence to Vicksburg to have been 69 miles, the slope would have been but fifty-seven sixty-ninths of its present value. The result of the cut-offs would be to increase the velocity of the river above and near them. This increase of velocity would tend to scour the bed and banks, perhaps making a deposit in the river below the Davis cut-off, and temporarily raising the bed there; and it may be that it is now returning to its normal low-water position by removing the deposits below.

(6) *Red River Landing.*—The low-water record is continuous back to 1872, which was the year of the lowest known low water, the gauge reading 0.0. In 1879 it fell as low as 0.55, and in 1887 to 0.47. The difference in low-water heights of 1872 and 1887 is too small to be evidence of a rise in the bed of the river.

Thus far only low waters of the Mississippi have been considered. The high-water records cover longer periods, but as an increased high water may result from confining the floods between lines, as well as from a rise of the bed of the river, it can not be concluded from a rise of flood height in the river that the bed has also risen. At Cairo—

	Feet.
June 21, 1858, the gauge read	49.6
May 2, 1862	50.8
March 21, 1867	51.0

The river did not again reach these heights till—

February 26, 1882	51.87
February 27, 1883	52.17

This increase in the later heights is not supposed to indicate any rise of bed, but can be accounted for solely by a greater flood discharge.

At Memphis the record goes back to 1828. In 1862 the river reached a flood height of 34.45, the record then showing no greater one. In 1882 the greatest height was 35.15; in 1887, 35.30; and in 1890, 35.60. This rise of 1.1 feet since 1862 may be accounted for by a greater discharge, by the construction of levees below Memphis, and, perhaps by the influence of railroads across the St. Francis bottom, without the supposition of a rise of bed.

At Vicksburg the record goes back to 1828. The highest known water was 51.1 feet, in 1862. The next highest was 49.1, March 15, 1890. Here there is no indication of a rise of bed.

At Natchez the record goes back to 1802. The highest water was 49.9, in 1862. In 1890 the highest water was 48.6 on March 22. In 1815 the highest water was 48.5. There is no indication of a rise of bed.

From an examination of the Po and Rhine, it may be concluded that if their beds rise in the leveed portions (which is not entirely certain from the data), it is at so slow a rate as not to be an important factor in the maintenance of a levee system. With levees 10 feet high, if the bed rose at the rate of 1 foot in a hundred years, the cost of raising a line of levees having the length of the present Mississippi system—about 1,300 miles—by this 1 foot, would be but about $4,000,000, distributed over the country, or $40,000 per annum, which is a small part of the annual cost of the system.

On the Mississippi, the records, while not extending over a period long enough to give final results, do not, so far as they go, indicate that the bed has risen.

The opinion so often held, that levees cause a river bed to rise, is probably due to the fact that the bed of a river does sometimes rise, although leveed, and hence it is concluded that the levees cause the rise. Any sedimentary stream, having a definite succession of stages and discharges, and flowing in its own

alluvion, finally takes such a slope as will give a velocity sufficient to enable it to carry its sediment, whether derived from above or from it own banks and bed farther down stream, without, on the whole, scouring or filling its bed. An average velocity less than this will give rise to deposits in its bed, or if it is crooked, it will become straight, thus in either case increasing its slope and velocity toward their normal values. An average velocity greater than this will scour its bed or cause caving in its convex bends, thus increasing its length and diminishing its slope and velocity to such values as its bed can bear without, on the whole, scouring or filling. When, therefore, the slope of a sedimentary stream suddenly diminishes from that which it needs for a stable regimen, its velocity also diminishes; it drops a part of its alluvion, and its bed rises. Thus, when the Mississippi enters the Gulf of Mexico, its slope suddenly diminishes, its velocity diminishes, and it builds up bars out in deep water. So Bayou Lafourche, when its waters fall to the level of swamps but a few feet above Gulf level, builds up its bed, necessitating high levees. So, too, the Adige, where it reaches the low plains of the Po, needs for permanence a steeper slope than the country has, and raises its bed above it. In all these cases the bed would rise without levees.

There is one more cause for the rise of bed of a sedimentary river, which, however, acts at a very slow rate. The Mississippi pushes its mouths out into the Gulf at the rate of about 4 miles in a century, and this increases in length requires a corresponding increase in fall of water surface to make the waters flow out. An increase of 4 miles in length would, with existing slopes, raise the high-water surface at New Orleans about 0.7 foot. The cost of raising levees to correspond with this rise per century in the water surface would, as has already been seen, be a small part of the annual cost of the system.

It has often been asserted that the bed of the Hoang Ho, or Yellow River, of China, has risen above the surrounding country where it is leveed, and is causing trouble. I wrote to General Wilson in reference to that, and he told me some time ago about it, and he assures me that he examined that river with reference to levees at a number of points: that the test he made was by using a hand level, tape lines, and sextant, and in his opinion at no place is the bed of the Hoang Ho River as high as the surrounding country.

Senator WASHBURN. He thinks that the bed has not risen since the levees have been built.

General COMSTOCK. The levees have been there for hundreds of years, but the bed of the river has at no place risen to a higher level than the surrounding country.

The CHAIRMAN. The levees on that river are very high.

General COMSTOCK. Yes, sir.

The CHAIRMAN. The Chinese minister wrote to some gentleman the other day that they were as high as the dwellings.

General COMSTOCK. Yes, sir. He speaks of the break that happened a few years ago, and he says it was of an enormous extent. Now, with reference to the Mississippi River at Cairo, it was minus 1 foot in 1871, which was the lowest ever known. In January, 1888, it went down 1.8 feet, so that in 1871 it was about 2.8 feet lower than it was in 1888. That may indicate some slight rise in the bed of the river, there, but it is equally possible that it was due to the fact that in 1888 the river was larger than it was in 1881—that is, the river flow was larger.

Of course the height of this low-water surface depends upon the volume of water that runs through it. Sometimes the river builds bars across itself which makes the water rise higher. I do not think we have any evidence to show that the river has risen at Cairo, but if you find that the lowest water in 1888 is 2.8 feet higher than it was in 1871, which covers a period of seventeen years, then if in seventeen years more it does not fall as low as in 1871, there will be some evidence that the river bed has risen.

At Memphis that same year the low water produced a somewhat similar result. In January, 1888, the river was eight-tenths of a foot on the guage. In 1871 it was minus ninety-two hundredths; that is the difference of 1.7 feet. These same remarks might be applied as well to the other. So far as figures go it indicates a slight rise there. From Cairo down to Memphis there have been no levees.

At Vicksburg—the lowest water in 1872—the guage was minus 1.3 feet. November 24, 1887, it was minus 3.91 feet—that is to say, the lowest water there was 2.6 lower at Vicksburg in 1882 than it was in 1871. It is due to the cut-offs which occurred there in 1876, 1866, and 1867.

Senator CULLOM. If it meant anything more than local causes it would reduce the bed of the river below, and there you have levees.

General COMSTOCK. Yes, sir; and it has got down 2.6 feet.

At Red River the low-water record is continuous back to 1872. In 1872 it fell to zero and in 1887 to forty-seven hundredths, so that the river in 1887 was only four-tenths higher than it was in 1872. So that it can be safely said, so far as our records go, and that is the most reliable information existing, there is no certain rise in the bed of the Mississippi at any point, even at Cairo. I am not sure but that that may be due to difference of discharge. The river has not been completely leveed there.

Senator CULLOM. Would leveeing below have any effect upon the river at Cairo?

General COMSTOCK. Nothing to speak of. It is only continuous when you get down to Arkansas City, which is 438 miles below Cairo.

The CHAIRMAN. It is stated in some of these papers that the Eads jetties for narrowing the river there have reduced the stream and have raised the bottom of the river above it. What have you to say as to that?

General COMSTOCK. I would attach no value whatever to such a statement as that, unless the figures were given to me, and I should not believe it even then.

Senator CULLOM. Do you mean the figures of the cause?

General COMSTOCK. I mean the figures—that is to say, if you put any obstruction in the river you would raise the water above it in some small degree. I do not suppose it is possible that these jetties have raised the river at New Orleans by 2 inches.

Senator WASHBURN. We had Captain Leathers before the committee the other day, and I asked him this question:

"As I understand the theory of the Mississippi River Commission, the theory upon which appropriations have been made, it has been that of contracting the river, contracting the current so as to wash out and lower the bed of the river, and in consequence give a greater depth of navigable water?

" Senator GIBSON. The theory, Senator, is this: Not to contract it beyond its natural limits, but to keep it within its natural banks.

" Senator WASHBURN. From your experience is that the effect it has had, to lower the bed of the river, or has the bed of the river been raised?

" Mr. LEATHERS. As you have contracted you have filled the bottom, and you have elevated the surface. I think that the work which has been done by the Commission has been a disastrous thing to the people in the valley. I have seen no improvement there whatever towards that. We have got for navigable purposes three or four feet more water going to sea than we ever had, but it has been at the expense of the planters in the valley, putting five or six feet of water on them."

Now, the statement, as the chairman has just remarked, has been made here repeatedly that the result of these levees had been to raise the bottom of the river from 6 to 7 feet. You state that that is not the fact, do you?

General COMSTOCK. It is not the fact.

Senator WASHBURN. As a matter of fact it has not been raised at all?

General COMSTOCK. I do think it has. I have not formed any certain conclusion that it has been raised at all. As to the rise in high-water surface I have no doubt that the perfecting of the levees has raised the water.

The CHAIRMAN. To what expense have you gone to in building the levees?

General COMSTOCK. About three millions of dollars.

The CHAIRMAN. With reference to navigation alone?

General COMSTOCK. That is the way the Commission has construed the law. The law provides that it shall not be spent on levees except as a part of the plan to improve navigation, etc.

The CHAIRMAN. What would be the effect of leveeing the Mississippi River from top to bottom?

General COMSTOCK. In what respect?

The CHAIRMAN. As to navigation.

General COMSTOCK. I do not think it would improve it sufficiently to make that in any degree an economical method of improving the river.

The CHAIRMAN. You resort to other methods.

General COMSTOCK. I would resort to the other method.

Senator CULLOM. Which other method?

General COMSTOCK. Works in the bed of the river—spurs, dikes, and revetments.

The CHAIRMAN. Then you would have to build levees?

General COMSTOCK. Not necessarily.

The CHAIRMAN. You would not build levees?

General COMSTOCK. Under the law, as it is now I should not build levees, according to my idea of the effects of levees. Of course, I am a minority of the Commission. The majority of the Commission think the river can be improved by building levees. My own individual opinion is that levees are too expensive a way of improving the river to justify it under the law, and I am not sure that they would improve it at all.

Senator WASHBURN. In some places the only improvement would be in levees. For instance, at Plum Point and Lake Providence Reach.

General COMSTOCK. Our improvements are at Lake Providence Reach, but the main works are in the river and are not levees.

Senator CULLOM. You do not believe in the levee system, as a matter of fact?

General COMSTOCK. I believe in it implicitly. I think it is necessary to build them in order to take care of the country. I do not think the United States should put them there at their own expense, for navigation purposes.

Senator CULLOM. But for the general good of the country, its development, etc., you believe in levees?

General COMSTOCK. Of course I do. It always seemed to me that the Italian way was a fair one. On the important rivers they have adopted the principle that the people interested should pay the bills, and so the State assumes the cost to the extent of one-half and the Province assumes the cost of one-quarter, by taxation. Besides that they have associations of men called Consorzii, and these Consorzii pay the other one-fourth. So that the State pays one-half of the whole amount. On the Mississippi River, as the thing actually works, the State and local authorities have been paying two-thirds since 1880 and the United States one-third. There have been $10,000,000 spent on the river since 1880, and of that amount the United States paid one-third.

Senator WASHBURN. Suppose the Government should appropriate the money to build levees the entire length of the river beyond Cairo, of a width, I think you agreed on 3,600 feet. That is the general width to which you would contract the river.

General COMSTOCK. In my judgment the farther apart the levees the better.

Senator WASHBURN. In many places the width is 3,600 feet.

General COMSTOCK. That is low water.

Senator WASHBURN. Assuming that that was done, are not there periods of time in the year when that length would not be sufficient to hold the water within the banks of the river?

General COMSTOCK. It depends upon how high you build the levees.

Senator WASHBURN. At any reasonable height?

General COMSTOCK. I think they are building them from 10 to 13 feet.

Senator WASHBURN. What was the occasion of the breaks this spring below Red River?

General COMSTOCK. This flood in the upper river, at Helena, for instance, appears to have been somewhat less than the flood of 1882. At Red River, from the information that Captain Kingman gives me this morning, it would seem to be nearly equal to the flood of 1882. In 1882 about 600,000 cubic feet a second went from the Red River into the head of the Atchafalaya basin and escaped into the Mississippi. Levees were built across the head of that basin subsequently, and if they stood of course they were going to force this 600,000 feet, less what was allowed to go down the Atchafalaya proper, down past New Orleans. The effect of keeping those levees intact is to throw a greater strain on the levees directly below Red River.

I have not the definite data now at hand, and of course my opinion is not final, but I think these levees on the Atchafalaya broke sooner than on the Mississippi below Red River. I believe the levees at the head of Atchafalaya should let 600,000 cubic feet of water escape down there. In addition to that, I would raise the levees below Red River.

Senator WASHBURN. Your answer to my question, then, would be that the river, if it were levied the whole distance, would not carry the entire volume of water.

General COMSTOCK. Oh, yes.

Senator WASHBURN. But you would relieve it by opening up the Atchafalaya?

General COMSTOCK. That would be the way.

The CHAIRMAN. If there were money enough there would be no difficulty in putting them at a height that would raise the river?

General COMSTOCK. I think not.

The CHAIRMAN. Have you compared the overflows on the Mississippi River during the last fifteen or twenty years with this last one?

General COMSTOCK. Our data of the overflows are very meager, except with reference to the flood of 1882, which was a great one. All the data are not in. I have not received them as yet in reference to this present flood. As I said before, at Helena the maximum flow appears to two hundred or three hundred thousand cubic feet a second less than in 1882. At Red River it was about equal to that of 1882. Both of these were great flood years.

The CHAIRMAN. Do you know how the country inundated appeared in 1882 as compared with that country this year?

General COMSTOCK. There was no comparison whatever. At that time the levees were broken from Cairo down to Bonnet Carre. The country was overflowed from Cairo to the Gulf, and the damage was greatly less in 1890 than it was in 1882.

Senator CULLOM. Now, for navigation purposes, have you any idea what amount of money would be necessary to be spent to make that river as good as it can be made?

General COMSTOCK. I have estimated it in the neighborhood of $75.000.000.

Senator CULLOM. For navigation purposes purely?

General COMSTOCK. Yes, sir.

Senator CULLOM. Without reference to river interests?

General COMSTOCK. Yes, sir.

Senator CULLOM. How much would it cost to levee it?

General COMSTOCK. There has been no estimate made of that at all.

The CHAIRMAN. Suppose you built the levees at the same time, what would it cost?

General COMSTOCK. So far as getting ten feet of water, it might take off $10,000,000.

The CHAIRMAN. It would take off $10,000,000.

General COMSTOCK. The works on the bed of the river might cost $10,000,000 less if you made a perfect system of levees.

The CHAIRMAN. How much does the perfect system of levees add?

General COMSTOCK. There has been no estimate made of it. The Commission made an estimate in 1884 and 1885, I think, of levees at a certain height, at $11,000,000. I think that is too small for a perfect system of levees.

Senator WASHBURN. You say to build levees would diminish the amount already mentioned in improving the level of the river.

General COMSTOCK. As I said before, I do not know whether levees would improve navigation. I said that the building of levees might make the navigation improvement cost ten million dollars less, or sixty-five millions of dollars, but I have no certainty that it would.

Senator CULLOM. Have you gone over the system that you would adopt if you had your own way with reference to the improvement of the river for navigation purposes?

General COMSTOCK. Yes, sir

Senator WASHBURN. That is by making improvements in the bed of the river and not by building levees?

General COMSTOCK. Yes, sir.

Senator WASHBURN. The building of the levees the entire distance would not obviate the necessity of making these improvements in the bed of the river that you are now doing?

General COMSTOCK. I think not.

Senator WASHBURN. Now, the effect of relieving the river at the Atchafalaya has been good, as I understand you.

General COMSTOCK. The effect of what?

Senator WASHBURN. The effect on the Atchafalaya outlet by relieving the Mississippi of, say, one-fourth of the discharge, the result has been good, has it not?

General COMSTOCK. No, I can hardly say that the result has been good, because the levees broke in 1882. When that was entirely open the levees broke.

Senator WASHBURN. You would relieve the river of so much water?

General COMSTOCK. Yes, sir; but the amount that should be raised would be small in comparison with what would be necessary to bring the water down the main river.

Senator WASHBURN. Would you recommend the closing entirely of the Atchafalaya outlet, assuming that you had money enough to build the levees high enough below?

General COMSTOCK. No, I do not think it would. It depends upon the country back there.

Senator GIBSON. As I understand it, the Atchafalaya is not, strictly speaking, an outlet of the Mississippi. It is both an outlet and an inlet. At certain times when the Tensas Valley basin is full of water, and the Red River is full, it is an inlet into the Mississippi River; it empties into it. I suppose it is doing that now, and during the flood season it has been a tributary of the Mississippi River—I mean the Red River has. But the function that the Atchafalaya performs is to take off water that otherwise would go into the river.

General COMSTOCK. Yes, sir.

Senator GIBSON. From the Tensas Basin and from the Red River.

General COMSTOCK. All of that would become part of the Mississippi River below it.

Senator GIBSON. Assuming that that is the case, why would not the opening of the Lake Borgne outlet have the same effect by relieving the river by discharge?

General COMSTOCK. If you were to make an opening of the same size, the first question would be how low down you would have that opening.

Senator GIBSON. No; what you would call a high-water opening?

General COMSTOCK. That is about the level of the banks. For that purpose it would give some relief. But at Lake Borgne the rise and fall of the river is only something like 12 feet perhaps, so that if you stop your sills at 9 or 10 feet above low water it would require one a good many miles long, which would require expensive work.

Senator GIBSON. How deep an outlet could you have there without interfering with the river below; not to shoal up the river and affect the navigation below?

General COMSTOCK. It is possible you might take 100,000 feet a second. The flow has been about 1,100,000 feet a second. This year it has been more. You might take 100,000 without injuring the South Pass. I do not think you would gain enough by that experiment to balance the danger you run.

Senator GIBSON. How far is it from the point on the Mississippi River where it is proposed to make the Lake Borgne outlet to deep water?

General COMSTOCK. I do not recollect the distance exactly. I think it is something like 60 or 70 miles. From Lake Borgne to the Mississippi Sound the water is from 10 or 12 feet to 20 feet deep, while the main river at Lake Borgne down to the head of the pass is probably 100 feet deep.

Senator GIBSON. How far is it from Lake Borgne to deep water?

General COMSTOCK. About 100 miles to the jetties.

Senator GIBSON. What would be the damage likely to be inflicted upon the city of New Orleans and upon the people in that vicinity by making an outlet into Lake Borgne?

General COMSTOCK. It would raise the water there by a number of feet.

Senator GIBSON. Would not that necessitate the leveeing in of the whole rear of the city of New Orleans?

General COMSTOCK. I think so. The dams would be overflowed and raise the water in Lake Borgne.

Senator GIBSON. You have spoken of the River Rhine and the River Po. Is not there a great deal of gravel in the River Rhine, and more gravel in the River Rhnie than in the Mississippi River in proportion to size and the volume of water?

General COMSTOCK. When you get down towards the boundary of Holland I think there is not much besides sand. As you go up it is possible that there is a little gravel there, as there is in the Mississippi River down as far as Profit Island.

Senator GIBSON. Have they not taken in vast tracts of country on the Rhine by sharpening the river?

General COMSTOCK. There has been a good deal of cut-off work done above the region of levees on the Baden frontier.

Senator GIBSON. If you were to construct this outlet at Lake Borgne, how far would you think it necessary to levee that outlet to prevent it from overflowing the whole country?

General COMSTOCK. You would have to levee it all around; I think all the way around Lake Borgne.

Senator GIBSON. How would you levee it through Lake Borgne?

General COMSTOCK. I consider that so foolish that I have not given it a thought.

Senator GIBSON. Would not the secondary effect of this outlet be to fill up that basin with sediment?

General COMSTOCK. The velocity in Lake Borgne would at first be one-sixth of that which it is in the main river, and of course a large portion of the Mississippi sediment would drop into Lake Borgne.

Senator GIBSON. You have been down to the forts there, have you not?

General COMSTOCK. Yes, sir.

Senator GIBSON. Do you know a place called Cubitt's Gap?

General COMSTOCK. Yes, sir.

Senator GIBSON. Was not that originally an outlet to the deep water of the Gulf, right above the Gulf, on the right-hand side?

General COMSTOCK. Yes, sir; on the left bank.

Senator GIBSON. It is on the right-hand side going down the river.

General COMSTOCK. That is the Jump.

Senator GIBSON. What has been the effect of building these outlets?

General COMSTOCK. The effect has been to build a bar.

Senator GIBSON. Has not the river really closed them up?

General COMSTOCK. I think they are very much closed up. I have not seen a survey of them for many years.

Senator WASHBURN. What is the distance from the Lake Borgne outlet where you would start off from the Mississippi River to the deep water of the Gulf; what would be the distance across there?

General COMSTOCK. My recollection is it is sometihng like 60 or 70 miles.

Senator WASHBURN. What is the distance from that same point to an outlet at the jetties?

General COMSTOCK. About 110 miles.

Senator WASHBURN. Then the current would be very much more rapid through the Lake Borgne outlet than it is in the Mississippi?

General COMSTOCK. No, sir.

Senator WASHBURN. The fall would be much greater.

General COMSTOCK. The fall would be greater in the ratio of sixty to one hundred, but the velocity would not depend upon the fall alone. It depends just as much on the depth. You would nearly double the slope of the river, but the depth would be only one-tenth as much. The main river is 100 feet deep, and you would have to dig it out nearly to that depth to get as high velocity all the way to the sound as in the Mississippi.

Senator WASHBURN. The result would be in the first instance to fill up Lake Borgne and to cut a main channel in there, so that the objections raised by the citizens of Louisiana would not come about.

General COMSTOCK. I think that would be the result ultimately. Lake Borgne now is a very wide body of water.

Senator WASHBURN. Not very deep.

General COMSTOCK. No, but still its cross section is larger than that of the Mississippi, so that the velocity of the water flowing through it would be very much less than the Mississippi River. The process would be to shoal it up and form channels through it, and the velocity would be less.

Senator WASHBURN. There would ultimately be a distinct channel through it?

General COMSTOCK. Yes, sir.

Senator GIBSON. You said a while ago that it would cost about $75,000,000 to complete the works on the Mississippi River. Have you ever made any estimate of what the cost would be of completing the works on the Atlantic sea-board, the improvement of the rivers and harbors?

General COMSTOCK. No, sir

Senator GIBSON. Or on the lakes?

General COMSTOCK. No, sir

Senator GIBSON. You said, also, that it would cost $10,000,000 less than $75,000,000 if we applied the levee system in conjunction with the jetty system.

General COMSTOCK. I mentioned that as possible to my mind. I really do not know.

Senator GIBSON. What benefit would it confer upon the people living on the banks of the river to have it leveed?

General COMSTOCK. The benefit would be enormous.

Senator GIBSON. What area of territory would it bring into habitation?

General COMSTOCK. Some 30,000 square miles, if the whole of it were cultivated.

Senator GIBSON. What effect would it have on the common carriers, the railroad systems?

General COMSTOCK. A very large effect. The effect of the levees on the Yazoo River has been very large during the last few years, both in the way of river transportation and railroads.

Senator CULLOM. You say there are levees now above the level of the valley along the river?

General COMSTOCK. They are not very much more than 3 or 4 feet high in some places.

Senator CULLOM. How much of that country would be so endangered as to drive the people away and destroy the crops, stock, etc.?

General COMSTOCK. That would depend very much upon whether the levee broke and discharged the water over it. Take the Yazoo district. There is a number of drainage streams running through it into which the water flows from the Mississippi, and they have built up ridges along their banks just as the Mississippi has, and when the flood comes the water is guided by those ridges and flows into the bottom. It is almost impossible to tell what damage is going to be done in a given place by a given break, except by one thoroughly familiar with the local topography.

Senator CULLOM. Can not people, property, stock, etc., be gotten onto high spots around there, so that they can secure themselves from danger?

General COMSTOCK. Very often the levees are the only high spots.

Senator WASHBURN. Is the topography of the country such that there is any point above the Atchafalaya where an outlet could be made and the water reach the Gulf?

General COMSTOCK. I think not of any value at all. Mr. Cowdon has proposed an outlet into Bayou Bartholomew from the Arkansas River, which scheme I think is not good.

Senator WASHBURN. Why so?

General COMSTOCK. It is rather a small narrow stream there. Suppose you take 100,000 feet of water out of the Arkansas River, I doubt if you could get it to run through that stream. I am not sure you could make a canal from the Arkansas River through to Bartholomew to carry even that amount except at enormous expense.

Senator WASHBURN. During the past two or three years the levees have been closed. How has the low-water navigation been affected?

General COMSTOCK. Affected by State works or by the works of the Commission?

Senator WASHBURN. It has been affected by levees and not by jetty works, I understand; but where the river has been leveed, has the low-water navigation been improved by those levees?

General COMSTOCK. That is a question which is something like asking about the rise in the bed of the river. You want a good many years to settle that question. The results to be effected would be the disappearance of the bars having less than 10 feet. I looked at that question some time ago with reference to the low waters of 1887, 1888, and 1889, which were quite low-water years, and nearly as low as 1871 and 1872. There were a good many bars that showed themselves in those years. Our record is not definite and precise enough to say that the bars have diminished. I do not know that except by the disappearance of the bars or by resurvey of the whole river. It can be shown that levees have improved the bars which give trouble to navigation.

With reference to the rise in the river bed, Colonel Ernst has given me some averages for a period of years. There are a number of points, taking the mean low water, that indicate that the low water has not risen.

Mr. COWDON. It has been stated that the Jump showed itself up to 4 feet at its intersection with the Mississippi River, and that was given as evidence why the Lake Borgne outlet was closed. I want some gentleman to look at this chart and see if that is correct. Some Senator get up and look at this map.

General COMSTOCK. I doubt if I gave that testimony as to being only 4 feet. I will say speaking from recollection, that while the jetties were being built I went in there one day and was told it was filling up rapidly, and that there was great difficulty in getting a steamboat about in there.

Senator WASHBURN. How late in edition is this map?

Mr. COWDON. The first date was in 1872, and it was revised in 1884 and 1885.

General COMSTOCK. I would say that it is difficult to tell on that map when the survey was made.

Mr. COWDON. The map was made two years after the survey was made.

General COMSTOCK. It was made in 1887, but the survey may have been made ten years before. It is a Government map.

Mr. COWDON. That report was made in 1880. I went there and got the proofs. I measured it and found 56 feet of water.

General COMSTOCK. How far did you go down?

Mr. COWDON. I went down about three-quarters of a mile.

STATEMENT OF LIEUT. COL. CHARLES R. SUTER.

Lieut. Col. CHARLES R. SUTER, U. S. A., a member of the Mississippi River Commission, appeared before the committee.

The CHAIRMAN. How long have you been connected with the Mississippi River?

Lieutenant-Colonel SUTER. About twenty-four years.

Senator CULLOM. Are you a civilian?

Lieutenant-Colonel SUTER. No, sir; I am an officer of the Engineer Corps, U. S. Army.

The CHAIRMAN. Just make a general statement as General Comstock did in relation to the Mississippi River, its improvement, etc.

Lieutenant-Colonel SUTER. I presume you refer more particularly to the work of the Mississippi River Commission.

The CHAIRMAN. Yes, sir.

Lieutenant-Colonel SUTER. The Commission was organized in 1879. The first report that the Commission submitted in accordance with the law organizing it considered various plans that had been presented at various times for improving the Mississippi River. They were defined in the bill as the outlet plan, the levee plan, and what was called the jetty plan. The Commission reported upon all three plans and then made their recommendation as to what they proposed.

The so-called outlet plan was condemned *in toto*. The plan of improving the navigation by levees alone was not adopted by the Commission.

Of course, as a protection against overflow they were unanimously favored by the Commission. The closure of the then existing gaps was recommended, as it was considered that the levee system would form an important auxiliary in channel improvement when taken in connection with the other work which was recommended. The Commission were of the opinion that an approximately uniform regimen of the river should be aimed at, and that the control over the river should extend through all its stages, including high water, which of course brings in the levees as a factor in the channel improvement. I will state that when I speak of a uniform regimen of the river I mean that the object is to introduce as nearly as possible similar conditions throughout, so that there will be no abrupt changes in its main features.

The river in its present state varies from 2,000 feet to over 10,000 feet in width, with corresponding variations in velocity and everything connected with it. The idea was to bring it into something like uniformity. Of course, it was not considered advisable that the minimum width should be taken as the standard. The minimum width I think is 2,000 feet. It is not considered necessary to go that far, but the Commission found on investigation, from such surveys as were available, that a width at low water of about 3,000 feet would give sufficient depth for all navigable purposes, and the plan formulated was to reduce the river to this width at low water by proper contraction works. The kind of contraction works proposed were what may be denominated silt-catching works. They consist of systems or combinations of dikes made of piles and carrying brush screens, so designed as to check the current over certain selected portions of the river bed and induce there deposits of silt, so that ultimately the river may rectify itself by reclaiming those portions of the bed which are not needed for the navigable channel and building up new banks. Eventually these shoals become the training dikes just as ordinary dikes do on rivers of the usual character. It is a system of improvement only possible on a sediment-bearing stream.

The second feature of the proposed plan was the revetment of banks where exposed to erosion, the idea of course being to make the current act on the bottom instead of the banks, in order to deepen the channel.

These two constitute the main elements of the channel improvement in the bed of the river; that is, permeable dikes to induce deposits, and revetments to hold the banks and keep the river in place. The maintenance of levees on the top of the banks was thought by the Commission to subserve two purposes. In some places there is very little question that the navigation of the river

has been serously deteriorated by the existence of breaks in the levee. That, of course, is especially manifest in those portions of the river that have been leveed for a long time; that is, where the system of levees has been kept up for a great many years.

It has been found by measurement that below extensive gaps in levees there is a very decided deterioration in the channel, and the Commission were of the opinion that this deterioration is due to the existence of these gaps; hence their inference was that if those gaps in the levees were closed the deposits formed under the influence of the crevasses would be swept away and the channel of the river correspondingly improved and deepened. Furthermore, levees were deemed essential, both for the safety of the works in the bed of the river, and to maintain the regiment at those places where it was already good. The only way to obtain uniformity of regimen, or to keep it when obtained, is to control the entire discharge of the river, which of course means the control of the floods as well as low stages. At the period of flood discharge you have an enormous volume of water, capable of almost any amount of mischief; at that period the cut-offs are formed and all sorts of accidents of that kind occur, all of which tend to upset the uniform regimen you are endeavoring to get.

From this point of view the function of the levee system may be considered as conservative: its other function confers a direct benefit. The plan of the Commission contemplated both of these functions and these three factors; that is, the channel contraction works, the revetment of the banks, and the levees on the top of the banks constitute the plan on which the Commission has worked from that day to this.

The CHAIRMAN. If you were regarding the navigation of the Mississippi River alone, and forgetting for the time being the landowners up and down the Mississippi River, would you adopt the levee system in conjunction with the system which you did adopt at certain reaches there in order to make the river navigable?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. Would you take both of them?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. Then you differ from General Comstock in that respect?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. What have you to say in relation to the assertion that the bottom of the river has been rising?

Lieutenant-Colonel SUTER. I do not think there is the slightest evidence of it.

Senator GIBSON. You have stated the plan adopted by the Commission? Will you now state the results achieved by the execution of that plan?

The CHAIRMAN. General Comstock has stated that fully.

Senator GIBSON. General Comstock has been practically in charge of it?

Lieutenant-Colonel SUTER. Yes, sir.

Senator WASHBURN. Have the plans you have carried out fully met your expectation?

Lieutenant-Colonel SUTER. They have; they have certainly met mine.

The CHAIRMAN. Your judgment is now that you would continue the same process you have been going through with since you have been on the Commission, in order to improve the navigation of the river?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. Captain Leathers has been on the Mississippi River since 1836, and he says that the navigation of the river is not so easy to-day as it was in 1836, when he first went on.

Lieutenant-Colonel SUTER. I do not know anything about 1836. That is rather before my time.

The CHAIRMAN. Has there been any improvement in the navigation of the Mississippi since you have been on it?

Lieutenant-Colonel SUTER. There certainly has been where the Commission has been at work. That is the only thing upon which I can give you any definite evidence. I know that at Plum Point and Lake Providence, which are the only places where the Commission has done work of any consequence, the low-water depth has been more than doubled.

The CHAIRMAN. Those two reaches?

Lieutenant-Colonel SUTER. Yes, sir; over those portions of them where the work has been carried on.

The CHAIRMAN. What is your opinion of this Lake Borgne outlet?

Lieutenant-Colonel SUTER. I have not changed my opinion about it at all since

the first report of the Commission was made. I think it is a perfect piece of foolishness.

The CHAIRMAN. Why?

Lieutenant-Colonel SUTER. Because, in the first place, it would do no good, and in the second place, I feel very confident that it would do a great deal of harm. In the third place, I do not think it could be maintained even if it was once opened.

Senator WASHBURN. You said it would do no good. If you relieve the river of a large amount of water it would do good at very high water, would it not?

Lieutenant-Colonel SUTER. No, sir; I do not think so. I have very great doubts about it. When it was first opened it might, but in a very few years this relief would disappear entirely. I think the flood heights above the outlet would ultimately increase.

Senator SAWYER. If you were to build a dam there when it got up to that surplus water it would not only relieve the water, but the country.

Lieutenant-Colonel SUTER. Wherever you divide the channel you must have an increased head to carry the water through the two branches. That is, the smaller river has the higher slope.

Senator SAWYER. You would not interfere with the water in the ordinary stage?

Lieutenant-Colonel SUTER. You would at high water.

Senator SAWYER. Use it as a waste way to get rid of that surplus water.

Lieutenant-Colonel SUTER. I think at that stage I would raise the levee beyond what the water would have been if the waste had not been there.

Senator SAWYER. Of course, if you did not have it so that it would wash out; if you did not get it down to solid foundation to back out the water, I do not think it would overflow when the river got to a certain size.

Senator WASHBURN. If you give a capacity of discharge of 100,000 cubic feet of water a second additional to the present capacity, I do not see how you would raise the water below.

Lieutenant-Colonel SUTER. I did not say "below;" I said "above." It has been known, ever since hydraulic laws have been formulated, that if you have a stream of a given capacity and divide it, you must have a steeper slope to carry the water off than you had when it was one stream. That can only be done by raising the water surface above the point of division.

Senator GIBSON. That is, the velocity is checked above?

Lieutenant-Colonel SUTER. The velocity is checked by the increased resistance in the two branches, and you must have an increased head to force the water through.

Senator DOLPH. The Mississippi carries a great deal of sediment?

Lieutenant-Colonel SUTER. Yes, sir.

Senator DOLPH. I understood you to say that the process adopted for the improvement of the river is to narrow the river at its widest places by constructing dikes which will cause the shallow parts of the river on each side to fill up and narrow the channel.

Lieutenant-Colonel SUTER. Yes, sir.

Senator DOLPH. Is it possible to carry all the sediment down the whole length of the river and deposit it?

Lieutenant-Colonel SUTER. Yes, sir; I do not think it would make any difference. At present the Mississippi has to carry not only the sediment brought in from other streams, such as the Missouri, but also that from its own banks. This latter supply would be cut off if the banks were protected as contemplated in the plans of the Commission.

Senator DOLPH. Under the natural state of the river those widest places afford easy places for sediment where the velocity of the current is somewhat impeded?

Lieutenant-Colonel SUTER. At some places it deposits, and it scours out at others. I do not think there is much permanent deposition.

Senator CULLOM. Along the line of the river?

Lieutenant-Colonel SUTER. Yes, sir.

Senator DOLPH. Is there much sediment carried out when there are breaks?

Lieutenant-Colonel SUTER. Very little. You see the heavy sediment is near the bottom.

Senator GIBSON. What is the depth of the sedimentary stream near the bottom of the river?

Lieutenant-Colonel SUTER. I do not know. I only know that the sediment increases as you go down. There is no way in which it can possibly be ascer-

tained how deep down the movement of sediment actually goes on. There is, however, very good reason for believing that a considerable portion of the bed of the river is in motion all the time.

Senator DOLPH. If your plan is successful in narrowing the river and raising its banks, it will remove the sediment and cause it to go through the river into the Gulf?

Lieutenant-Colonel SUTER. Yes, sir.

Senator DOLPH. If it is not sufficient to carry the sediment to the Gulf, it must be deposited then into the channel of the river and have a tendency to fill up the bed of the river?

Lieutenant-Colonel SUTER. If the current were not sufficiently strong to carry it forward I think it would, but this is not likely to be the case.

Senator WASHBURN. According to your theory it would be desirable to close the Atchafalaya outlet, would it not?

Lieutenant-Colonel SUTER. As an outlet, yes. That is to prevent the Mississippi from going into it.

Senator WASHBURN. That would raise the water above it.

Lieutenant-Colonel SUTER. I do not think it would do so permanently, although that would probably be the first effect.

Senator WASHBURN. I understood General Comstock to state that he thought it was well to maintain the Atchafalaya outlet.

Lieutenant-Colonel SUTER. That is his opinion, not mine.

The CHAIRMAN. You take a cross-section of the river 1,000 feet wide and 15 feet deep: have you any opinion what the weight of that cross-section would be a foot wide?

Lieutenant-Colonel SUTER. I do not think I understand your question.

The CHAIRMAN. Suppose the whole weight of water is so much a square inch or a square foot, and the whole weight of that water is pressing down over the whole cross-section——

Lieutenant-Colonel SUTER. The depth of water of course will determine the pressure.

The CHAIRMAN. It must be enormous in a river a mile wide and 20 feet deep.

Lieutenant-Colonel SUTER. The pressure at any point varies according to the depth of the water. If the water is 15 feet deep there will be about 900 pounds pressure on each square foot of the bottom.

The CHAIRMAN. Of course the weight is downward?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. With that enormous pressure downward on the bottom of this river, and the current going a mile an hour, which is acting on the bottom all the time, it will act as a scraper and take the sediment along with it?

Lieutenant-Colonel SUTER. The movement of the bottom depends entirely on the velocity of the current.

The CHAIRMAN. A slow current would move it just as a swift one; not so rapidly, but to the same depth?

Lieutenant-Colonel SUTER. That depends upon the weight of the material on the bottom. Very light material will be moved by a current of small velocity. If you have coarse sand or gravel it takes a very much stronger current to move it.

Senator GIBSON. You made observations on the river some time ago, I think, to ascertain the velocity of the current when the river was at its highest stages and yet held within its banks. You determined that the flood, when held in the banks of the river, would take just ten days to go from Cairo to New Orleans.

Lieutenant-Colonel SUTER. Some such figure as that. I do not remember exactly. The general idea was that where crevasses took place the velocity was checked and the movement of the flood wave was retarded.

Senator GIBSON. You determined from your observation that it took just ten days for a flood contained within the river to go from Cairo to the Gulf, and that when it passed over the banks of the river it took a hundred days.

Lieutenant-Colonel SUTER. It took a very much longer period that when inside its banks.

Senator GIBSON. Does not that involve the whole question of the Mississippi River?

Lieutenant-Colonel SUTER. Very largely.

Senator GIBSON. With regard to the question of passing flood waters off, if those breaks in the levees had not occurred there is every reason to suppose that the velocity would have been obtained and the whole water would have passed off at a much lower level.

Lieutenant-Colonel SUTER. This retardation of velocity has a tendency to increase the flood height. The water behind keeps piling up on that in front until you get 4 or 5 feet of abnormal elevation.

Senator GIBSON. Have you ever looked at the tables showing the discharge of water at Columbus and Carrollton and possibly at some other points furnished by Humphreys and Abbot?

Lieutenant-Colonel SUTER. I have seen them.

Senator GIBSON. They report that when the river is at a depth of 86 feet at Carrollton and it should rise only 6 feet more, which would make it $92\frac{6}{10}$ feet, that the volume of discharge of the river is doubled.

Lieutenant-Colonel SUTER. I think our observations show fully that much if not more.

Senator GIBSON. Now, then, by confining the water to the channel of the river by levees so that at that point only 6 feet of water should be contained in the levees—the levees should be built so as to hold this amount of water in the river—this amount of water in the river would be the equivalent to making another Mississippi River on the top of the river when it is 86 feet deep.

Lieutenant-Colonel SUTER. Something like that.

Senator GIBSON. Eighty-six and six-tenths feet deep.

Lieutenant-Colonel SUTER. That would be the case at New Orleans.

Senator GIBSON. That shows, therefore, that it is a question of velocity.

Lieutenant-Colonel SUTER. I think it is entirely a question of velocity. If you can make that water run faster you can safely pass off the largest flood that ever came into the river. Anything that tends to retard velocity tends to increase the height of the water surface.

Senator GIBSON. If that is the law of the river, you take the flood when it reaches Cairo, and instead of being confined in the river and passing on to the Gulf at the rapid rate of ten days, therefore diminishing the surface of the river, it fills the St. Francis Basin, does it not?

Lieutenant-Colonel SUTER. Yes, sir.

Senator GIBSON. There is a vast accumulation of water stored there, the velocity is interrupted, retarded, the height increases by this retardation of the river itself; then with the accumulated force of this vast amount of water accumulated in the basin of the St. Francis, that accumulation is precipitated on the river below, is it not?

Lieutenant-Colonel SUTER. Yes, sir; it comes out and returns to the Mississippi while it is still high.

Senator GIBSON. That is a flood on top of a flood caused by this retardation, because the law of velocity has been suspended. It is like accumulating a great body of troops to make an assault. It increases the height of the river at the point of attack on the levees below. Now, is not that the reason why the levees gave away on the upper line of the Mississippi, in the State of Mississippi, and on the lower line of the Arkansas, this concentration which was furnished by the St. Francis Basin?

Lieutenant-Colonel SUTER. I have not yet had an opportunity to sufficiently study the records of this flood; we have not got them yet and I do not feel able to discuss the subject intelligently. There are gentlemen present who are more familiar with the facts who can doubtless answer that question.

Senator GIBSON. I am not asking you with reference to the facts, but with reference to the theory.

Lieutenant-Colonel SUTER. I was going to say that according to my notion—I may be mistaken—I think that the great heights that were obtained in the lower part of the river were due to the southern tributaries. They had most unusual floods. What you were saying, however, is undoubtedly true. I think there is very little question that the great flood heights obtained at Helena are higher than they would have been if the water had all passed down the main channel. I think the water that is drawn off into the St. Francis Basin and then returned at Helena will give a greater height at Helena than if that water were to pass down the main channel. The same phenomenon occurs at Vicksburg and possibly other places.

Senator GIBSON. The same at Red River at the foot of Tensas Basin?

Lieutenant-Colonel SUTER. Exactly.

Senator CULLOM. I believe you and General Comstock are not entirely agreed on all matters pertaining to the conduct of the work of the Mississippi River, as I understand you. Does that disagreement involve you in any way in carrying on the work with the execution of which you have been charged?

Lieutenant-Colonel SUTER. No, sir.

Senator CULLOM. You are acting under the statute without reference to what you believe?

Senator GIBSON. You all agree on the plan?

Lieutenant-Colonel SUTER. The Commission does.

Senator CULLOM. You mean a majority of the Commission?

Senator GIBSON. I understand that General Comstock approved the plans, but he did not do so for the same purpose.

The CHAIRMAN. Not for navigation purposes? He does not approve the plans for navigation purposes?

Senator GIBSON. He said that it would cost $10,000,000 less to use the levees in connection with the improvement of the river for navigation purposes than it would cost without them.

The CHAIRMAN. He thought it might cost $10,000,000 less.

At 12 o'clock m. the committee took a recess until 2 o'clock p. m.

At the expiration of the recess the committee resumed its session.

STATEMENT OF LIEUT. COL. CHARLES R. SUTER—Continued.

The CHAIRMAN. Captain Condon has handed me some questions which he desires should be propounded to you. Would you levee, dyke, spur-dam, etc., the upper end of a sediment-bearing stream before you would improve the lower end of such stream?

Lieutenant-Colonel SUTER. I do not know what is meant by "improve" in that question. There are different ways of improvement.

The CHAIRMAN. Well, what do you say in answer to his question?

Lieutenant-Colonel SUTER. Unless I understand it better than I now do, I can hardly answer it.

The CHAIRMAN. Then take it the other way. Would you improve the upper end of a sediment-bearing stream before you did the lower?

Lieutenant-Colonel SUTER. If it needed it more; yes.

The CHAIRMAN. Will water flow down an angle or incline of two inches to the mile faster than it will flow down an incline of one inch to the mile?

Lieutenant-Colonel SUTER. That depends on the depth.

The CHAIRMAN. Is the fall greater per mile at Cairo than at New Orleans?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. Is the current greater at Cairo than at New Orleans?

Lieutenant-Colonel SUTER. I think the difference is very slight. I do not remember the exact figures.

The CHAIRMAN. Does not the greater current above bring the mud down faster than the slower current at the lower end can discharge it?

Lieutenant-Colonel SUTER. I do not think there is a slower current at the lower end.

The CHAIRMAN. Suppose the current was faster above.

Lieutenant-Colonel SUTER. Then it would, undoubtedly; but I do not think such is the case.

The CHAIRMAN. If you build levees higher at the lower end than at the upper end, does that increase or decrease the angle of fall?

Lieutenant-Colonel SUTER. It most likely would have nothing to do with it.

The CHAIRMAN. It is claimed that the inflow of water is 2,100,000 cubic feet per second and that the overflow of water at the mouths of the Mississippi is 1,100,000 cubic feet per second; and if this be true, will you explain how you would prevent overflows?

Lieutenant-Colonel SUTER. By raising the levees sufficiently.

The CHAIRMAN. Is the South Pass in any sense an outlet of the Mississippi?

Lieutenant-Colonel SUTER. It is one of the mouths. Any outlet can be considered as a mouth. I suppose the mouth could be considered an outlet.

The CHAIRMAN. Are the mouths of the Mississippi in any sense outlets?

Lieutenant-Colonel SUTER. I think they are.

The CHAIRMAN. If you wanted to get the flood water of the Mississippi into the Gulf of Mexico quicker than it would now flow through the present mouths, would you close up all of the present mouths or would you open more outlets?

Lieutenant-Colonel SUTER. I certainly should not open more. Whether I would close the others or not is a question I have never particularly considered. Our jurisdiction stops at the Head of the Passes, so that I have not considered it.

The CHAIRMAN. If it were possible to make the Lake Borgne outlet wide enough and deep enough to lower the flood line of the Mississippi River at that place down to Gulf level, would that enormous outflow of flood water increase or decrease the current of the Mississippi River?

Lieutenant-Colonel SUTER. What do you mean, decrease it where; above or below?

The CHAIRMAN. The question does not state which.

Lieutenant-Colonel SUTER. That is a very important question.

The CHAIRMAN. Take it both ways.

Lieutenant-Colonel SUTER. It would certainly decrease it below.

The CHAIRMAN. What would be the effect above?

Lieutenant-Colonel SUTER. First a great increase; eventually I do not think there would be any.

The CHAIRMAN. Have you stated what your opinion is of what is called the outlet system?

Lieutenant-Colonel SUTER. Yes, sir; I believe I have.

Senator GIBSON. Have you stated the result of the improvement at Plum Point and Lake Providence Reach in relation to navigation?

Lieutenant-Colonel SUTER. I think not.

Senator GIBSON. What have been the results?

Lieutenant-Colonel SUTER. The low-water depths have been about doubled.

Senator GIBSON. Do you know what effect the levees have had on the navigation anywhere?

Lieutenant-Colonel SUTER. Yes, sir; I think they have had a very decided effect at Lake Providence, and also to a certain extent at Plum Point. At Plum Point the levees have been constructed by the Commission purely and entirely to improve navigation. They are local levees, on both banks of the river, and the effects have been very marked.

Senator GIBSON. You stated a moment ago in reply to a question by the chairman that if you were improving the Mississippi River, even if it were running through a wilderness, if the country through which it ran was not peopled, you would still build levees on the banks.

Lieutenant-Colonel SUTER. Yes, sir.

Senator GIBSON. Why do you hold that opinion?

Lieutenant-Colonel SUTER. Because I consider that the improvement of the stream for navigable purposes; without it is impossible.

The CHAIRMAN. Why?

Lieutenant-Colonel SUTER. I think you have got to retain control over the whole volume of water. The discharge which passes within the banks is less than half of the flood discharge of the river, and the low-water discharge is only about one-tenth of that which passes within the banks, about one-twentieth of the total discharge, and any works that you can put in to control the low-water flow on a stream like the Mississippi are liable to be utterly destroyed and rendered nugatory by this vastly larger volume of water which passes down the river during flood stages. At this season of the year the cut-offs occur, which will upset any plan of improvement, because they change entirely the regimen of the river, its course, its slopes, and everything about it.

Again, the water being over the works and everything else, has a chance to develop new channels precisely where you do not want them to occur. A still further effect is produced where the levees are down; the water that goes over the banks keeps going out and coming back again. Whenever it makes its appearance in the river it acts like a tributary. It produces entirely new phases, just as any tributary will. Sometimes it entirely reverses the conditions of flow. The influence that levees exert under these heads I believe I have stated as conservative. They prevent the river from doing damage to the works we put in to improve the low-water discharge of the stream.

The CHAIRMAN. If there was no question about protecting the land, and you were simply improving the Mississippi River for navigation, would you have built the levees that are now built?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. You say you would?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. So that, regardless of the question of the landowners, you say that this Commission has done none too much toward levee building?

Lieutenant-Colonel SUTER. That is my opinion.

The CHAIRMAN. Do you not think the people whose lands are preserved by these levees should pay a part of the expense of constructing them?

Lieutenant-Colonel SUTER. That is hardly an engineering question. I think, however, the same question might be asked with regard to other improvements. For instance, one of the most important features of the work of the Commission is the protection of the banks from caving. In doing that we do it entirely in the

interest of navigation, but it does at the same time prevent many a man's plantation from caving into the river.

The CHAIRMAN. In other words, you think the levee is a part of your system as well as the jetties?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. You mean to say that these dikes and levees are necessary to preserve the channel of the river itself?

Lieutenant-Colonel SUTER. Yes, sir.

The CHAIRMAN. The permanency of the channel?

Lieutenant-Colonel SUTER. Yes, sir; that is my view.

The CHAIRMAN. How long did you say you had been on the river?

Lieutenant-Colonel SUTER. Since 1866.

STATEMENT OF CAPT. SMITH S. LEACH.

Capt. SMITH S. LEACH, United States Engineers, in charge of first and second districts of the Mississippi River, appeared before the committee.

The CHAIRMAN. How long an acquaintance have you had with the Mississippi River?

Captain LEACH. Since 1878.

The CHAIRMAN. Are you a member of the Commission?

Captain LEACH. Yes, sir; I am a subordinate officer of the Commission.

The CHAIRMAN. Where are you located?

Captain LEACH. At Memphis.

The CHAIRMAN. State what your experience with the river has been.

Captain LEACH. In the summer of 1878 the board of engineers was organized which was referred to here by General Comstock and others. I was then second lieutenant of engineers and was assigned to duty as recorder of that board. That board undertook extensive surveys, examinations, hydrometric measurements, etc. The field work of a large part and the computations of all of these were placed in my immediate charge. I began from that time to study this question from the original data and measurements made upon the stream itself, and I have done nothing else professionally from that day to this.

The CHAIRMAN. Have you observed the overflows of the river?

Captain LEACH. Repeatedly. I have been over the river in its whole length and at almost every stage of water.

The CHAIRMAN. State to the committee as briefly as you can your idea of the improvement of the Mississippi River for navigation.

Captain LEACH. To start with what should not be done, I would mention the project of taking off any portion of the water of the natural discharge of the river at any stage whatever or for any purpose, or at any point. The salient point in connection with that topic is, first, the question of the effect upon the channel of the river above and below resulting from taking off such water under such circumstances. I have here a complete map of the Delta of the Mississippi showing its approaches to the Gulf. I may state a fact, which I do not think will be denied by any one, that this single-trunk channel as it approaches the Head of the Passes is one of the finest navigable flowing streams on the face of the earth. It is of reasonable width, very deep, and has at all times a regular and moderate current. At a point here [indicating on map] it is divided into three principal branches. Each one of those branches is narrower and shallower and more irregular in its regimen than is the main stream. This is the Head of the Passes [indicating on map].

At this point where this main stream is divided into three branches the phenomenon is presented of a large and deep and good channel being transformed into three narrow and shallow and poor channels. A great deal of talk has been heard about the difficulty that Captain Eads had in removing the bar at the mouth of South Pass bar. If he were here to-day he would confess a much more serious difficulty in dealing with the shoal water at the head of that pass. This is the bar that gave him the real difficulty [indicating on map]. This is the bar at the Head of the Passes at the point of diffusion, at this point division of the main stream. It was to get a greater depth over this bar at the head of South Pass that he laid a sill over the other two passes, and constructed the funnel-shaped prolongations of the natural banks of this pass in order to augment the flow of water through there.

We have these three passes, each having a bar at each end, and each being 30 feet average depth between the bars in its original and natural condition

as against 125 or 130 feet depth of the main stream. Here is the South Pass [indicating on map]. This is the one that has the great depth. This is the one that carries from 26 to 30 feet. This Southwest Pass carries less than that, perhaps 16 feet.

Now, the point I make is this: This phenomenon occurs here [indicating on map]. It occurs at the corresponding point on every known alluvial sedimentary stream on the face of the earth that branches into a delta formation.

Now, if the degradation of these subsidiary channels occurs here when the stream divides into three parts, why will it not occur at Lake Borgne if you there divide it into two? The fact can be explained on no other hypothesis than that in division there is weakness, a proverb more familiar in the inverse terms "In union there is strength." I never heard any other advanced for it, and its converse, which the outlet theory demands for its support, is not only absurd on its face, but contradicts every fact of the river's life which has come to my knowledge. Anything further on the subject of outlets is only an elaboration of that general statement. To substatiate that, if proof should be necessary, there are frequent observations in the bed of the river itself. These consist of a large number of exact measurements, as precise and accurate for that purpose as would be any measurement that could be made of the length of this Capitol building. We have not guessed at this thing; we have measured it, and we had no theory to establish when we made the measurement, but we made the measurement for the purpose of finding out the theory.

The measurements have shown conclusively in repeated instances that when a crevasse occurs the channel for a few miles immediately below becomes distinctly smaller. When that crevasse is closed, measurements made before and after the closure have shown that this loss in the area of the channel is recovered. When a crevasse is closed and immediately after that closure—let me change the form of that statement—when a crevasse opens and immediately after that opening by exact measurement there is found to be a deterioration of the channel of about 12 per cent of its area, and again when this same crevasse is closed after the next succeeding flood there is found to be a recovery of this 12 per cent lost, I do not think any other hypothesis will explain it.

Second in importance will be the deterioration of the navigable depth in this channel, which is now an extraordinarily good one, and which can be maintained there, as the experience of the last ten years has shown, at a very trifling expense. If that channel were injured and deteriorated by the natural and inevitable result of taking off a large portion of the flood discharge at a point higher up the river, you would then, instead of having little or no expense to keep it open, have an enormous annual expense, and even then the condition of the channel would be so precarious that the effect on commerce would be very detrimental. Ships will go to a port where they know they will find 26 feet of water, without doubt, more readily than they would go to a port where they were promised 30 feet and might find but 20 feet. A reliable 26-foot channel is better than a precarious 30-foot channel.

The CHAIRMAN. You are familiar with the methods of the Mississippi Commission as to improvements?

Captain LEACH. Will you bear with me a little further on this topic?

The CHAIRMAN. Yes, sir.

Captain LEACH. The question has been discussed over and over again as regards the elevation of the bed of the river as the result of the construction of levees, and also as to the deterioration of the channel below the outlet. I know of no engineering authority that can be quoted in support of this view, except by garbling, and as you have had a little garbling already before you I would like to read some full and complete extracts. I have before me the report of Colonel Ellet. I would like to read a few extracts from it; it will take but a moment. I will read the introduction pretty much *in extenso*.

The CHAIRMAN. When was that report made?

Captain LEACH. Eighteen hundred and fifty. It is a report and the only one I know of where an engineer of any standing has deliberately and definitely proposed to make a certain definite outlet.

"In this paper the causes of the more frequent and more extensive overflows of the Delta of the Mississippi in recent than in former times are considered, and plans suggested for the mitigation of the evil.

"The greater frequency and more alarming character of the floods are attributed—

"Primarily, to the extension of cultivation throughout the Mississippi Valley, by which the evaporation is thought to be in the aggregate diminished, the

drainage obviously increased, and the floods hurried forward more rapidly into the country below.

"Secondly, to the extension of the levees along the borders of the Mississippi, and of its tributaries and outlets, by means of which the water that was formerly allowed to spread over many thousand square miles of lowlands is becoming more and more confined to the immediate channel of the river, and is, therefore, compelled to rise higher and flow faster, until, under the increased power of the current, it may have time to excavate a wider and deeper trench to give vent to the increased volume which it conveys.

"Thirdly, to cut-offs, natural and artificial, by which the distance traversed by the stream is shortened, its slope and velocity increased, and the water consequently brought down more rapidly from the country above, and precipitated more rapidly upon the country below.

"Fourthly, to the gradual progress of the Delta into the sea, by which the course of the river at its embouchure is lengthened, the slope and velocity there are diminished and the water consequently thrown back upon the lands above.

"It is shown that each of these causes is likely to be progressive, and that the future floods throughout the length and breadth of the Delta and along the great streams tributary to the Mississippi are destined to rise higher and higher as society spreads over the upper States, as population adjacent the river increases, and the inundated lowlands appreciate in value.

"For the prevention of the increasing dangers growing out of these several cooperative causes six distinct plans are discussed and advocated:

"First. Better, higher, and stronger levees in lower Louisiana, and more efficient surveillance—a local measure, but one requiring State legislation and official execution and discipline.

"Second. The prevention of additional cut-offs; a restraint which may call for national legislation, or possibly judicial interference to prohibit the States and individuals above from deluging the country below.

"Third. The formation of an outlet of the greatest attainable capacity from the Mississippi to the head of Lake Borgne, with a view, if possible, to convert it ultimately into the main channel of the river.

"Fourth. The enlargement of the Bayou Plaquemine, for the purpose of giving relief to that part of the coast which now suffers most from the floods, viz, to the borders of the Mississippi from above Baton Rouge to New Orleans.

"Fifth. The enlargement of the channel of the Atchafalaya for the purpose of extending relief higher up the coast, and conveying to the sea, by an independent passage, the discharge from Red River and the Washita.

"Sixth. The creation of great artificial reservoirs, and the increase of the capacity of the lakes on the distant tributaries, by placing dams across their outlets with apertures sufficient for their uniform discharge, so as to retain a portion of the water above until the floods have subsided below. It is proposed by this process to compensate, in some degree, for the loss of those natural reservoirs which have been and are yet to be destroyed by the levees, and, at the same time and by the same expedient, improve the navigation of all the great tributaries of the Mississippi, while affording relief to the suffering and injured population of the Delta."

Now I read again from part 2 of Prolongation of the Delta:

"It is a popular belief that the bed of the Mississippi is gradually *rising*, and to that assumed cause is not unfrequently attributed the constantly increasing height required for the protecting levees. But his belief can be traced to no better evidence than the fact that certain points which formerly exhibited deep soundings have subsequently become shallower, a circumstance which is attributable altogether to the shifting nature of the shore and bottom of the river. As consequences of the changing and movable character of the soil through which the Mississippi flows, shores which are at one period curved subsequently become salient; banks that at one time wash and cave in, at a later date fill up; places which during one period are gradually growing deeper, at another become less deep and to the sounding line indicate an elevation of the bottom. There is, in fact, no evidence of any change in the general level of the river's bed beyond what may be inferred from the evident prolongation of the Delta, the lengthening out of the course of the stream, and the consequent diminution of the plane of descent. But this elevation of the bed is not indicated by any increased depth of the stream, though it must of necessity occasion a corresponding elevation of the surface. Any increase in the height of the floods, produced by a given body of water discharged in a given time, beyond what may be justly

attributed to this extension of the Delta, must, therefore, be sought in other adequate causes.

"The idea which has acquired a certain hold upon public opinion that an appreciable elevation of the bed of the Mississippi has been produced and is still going forward in consequence of the extension of the levees, has no foundation in experience or philosophic deduction. The extension of the levees, it will be hereafter shown, exercises great influence upon the height of the floods, but not, as is supposed, by raising the bed of the river. It is true that by the increased transporting power which the levees give to the river and by their prevention of lateral deposits the Mississippi is enabled to convey greater deposits into the Gulf, and thus, in some slight degree, accelerate the formation of land opposite its mouths. To this amount and no further the extension of the levees may promote the elevation of the river's bed, but this is not an appreciable quantity.

"It is customary to point to the Po in evidence of the effect of embanking the coasts of streams in producing an elevation of the bed of the river. And it is assumed that because the bottom of the Po and of all rivers that empty into the Adriatic is to be found in the great quantity of earthy matter which they transport to the sea, and the shallowness of the gulf into which this material is conveyed, this deposit in the course of twenty centuries has produced a prolongation of the delta of the Po estimated at about 25 miles, and has converted cities which at the commencement of the Christian era were respectable seaports into inland towns, at this day 20 miles from the seashore."

Senator GIBSON. You mean to say that more modern investigations have shown that the Po did not rise?

Captain LEACH. At the time that Colonel Ellet was writing in the United States, Lombardini had written in Italy a complete refutation of De Prouy's conclusions as to the bed of the Po rising. Lombardini's researches were probably not known to Colonel Ellet, who, feeling himself obliged to accept the current belief that the bed of the Po had risen, is so confident that levees had and could have nothing to do with it that he takes pains to bring forward another explanation.

Cut-offs are mentioned in this outlet scheme as being in the dim future desirable to be done.

"Among the causes of inundations that have recently produced so much loss and distress on the lower Mississippi, in the opinion of the writer, must be enumerated the cut-offs which have been made at and below the mouth of Red River. It is true that men of science have denied, and do still contest, this point. But the opinion here entertained rests on what are deemed to be the natural laws of the flow of the river, and, moreover, on indisputable results. The theory which is entertained by many intelligent persons, that by shortening the channel and cutting off the bends of the river the velocity of the current will be increased, the channel scoured out wider and deeper, the floods conveyed more rapidly to the sea, and the surface therefore reduced, is all perfectly true, excepting the practical conclusion."

The following extract is read to show that Colonel Ellet's mind dwelt especially upon an outlet as a means of taking off water that could not be controlled in any other way:

"But there is another ground for the practical conclusion that extensive outlets may be opened without a shadow of fear for the preservation of the channel below. The Mississippi and its natural outlets are now greatly overburdened in times of extreme high water and are unable to vent the volume which is poured into them by the distant tributaries as fast as it is brought down. This excess of water finds new outlets by overflowing the natural banks or through crevasses in the artificial levees. Outlets, then, acting only as high-water vents, through which this surplus may be let off, can not possibly diminish the actual area of the river's section below, for such outlets will discharge water which does not pass through the channel at all.

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"Again, it has been seen that the volume discharged by the floods of the lower Mississippi is annually increasing, in consequence of the extension of levees above. In opening outlets below Red River sufficient to give passage to this increased supply, as it comes, we can not possibly impair the efficiency of the present channel, for this increased discharge has had no part in the creation or maintenance of the present channel."

That passage bears on the same point.

"A word may be added in allusion to the fear often expressed that the new outlets, which it is proposed to open at points where the route which the waters

will follow to the sea will be shortened, may ultimately become so enlarged as to absorb the Mississippi itself, and thus leave the city of New Orleans on some secondary bayou.

"The reply to this apprehension is the fact already stated, that the water passing through such vents is never known to cut out or deepen its channels without assistance. The bayous which still lead from the river into the adjoining lakes and swamps have been in activity during thousands of years, and do not seem to have gained the least on the Mississippi, while the whole Delta shows evidence of ancient outlets which have been filled up by deposits and now no longer act in relieving the discharge of the river.

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"Indeed, the writer is not in possession of any fact which goes to show that any outlet can be made from the Mississippi above New Orleans, which, left to itself, will become larger and ultimately excavate a new channel into the Gulf. If we could calculate with confidence on such a result, the problem of protecting the country below Red River would be relieved of all its difficulties at once, for we might then open an outlet into Lake Borgne, and, turning the Mississippi into that arm of the Gulf, transfer its embouchure to the deep water south of Ship Island, and thus promptly reduce its high-water surface some 6 feet at New Orleans. But, unfortunately, the water can not open the way without assistance, and the new channel will not be produced without other aid."

Senator WASHBURN. You infer that he favors that if it could be done?

Captain LEACH. His conclusion appears very plain. He is in favor of a limited high-water outlet.

He goes on to say:

"These objections to the use of outlets, to a limited extent, are not tenable. It is, therefore, proposed to resort to high-water vents so far as is necessary to obtain prompt though limited relief from pressing distress and impending calamity, but not to rely on this expedient exclusively, or even to look to it for full protection or permanent security.

"The object of this examination is not considered to be merely the protection of the country below Red River from the difficulties against which the population there is now struggling, but to embrace the whole area of the Delta, and to do the work by some plan that will not be incompatible with the intention of Congress, as it is manifested in recent legislation, to reclaim all the lands in that vast area which are subject to inundation. These great purposes will be aided but not accomplished by outlets which, therefore, are now only recommended for local relief and limited application."

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After describing outlets in full he says:

"But, in addition to all this, the protection of lower Louisiana will require other expedients. For this State, indeed, there is no alternative. She can not wait for Congress to discuss, doubt, survey, and appropriate. She can not wait for the slow machinery of legislation. She must build levees without hesitation or delay, or see her fields annually swept by the floods.

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"But, while recommending these prompt and vigorous measures, it is the duty of the writer to express his conviction that, after all these means of relief, carried as far as prudence and proper regard to economy and the interests upon which this excess of water will be turned, have been exhausted, they will be found insufficient to secure even the State of Louisiana against the floods which, at no distant day, will be poured down the Mississippi, while the great area subject to inundation in the States of Arkansas and Mississippi can receive no sensible relief from any of these expedients but that of levees. To secure the whole Delta it will be necessary to commence promptly and press vigorously the great work of retaining the waters in the mountains."

This is the reservoir idea. There are more of these extracts than I thought there were. I think I have read all that are really important, and I hope enough to give you the opinion that the idea, the tenor of this report, as previously put before you, is erroneous. I hope it was unintentionally done, but I can scarcely believe it.

Now, if this report is read, the impression is obtained that Colonel Ellet was in apprehension of a perfectly appalling increase of floods in the Mississippi. He goes so far as to say that he thinks in no long period of time the increase of floods due to the progress of deforesting and the extension of cultivation and drainage, together with the building of levees, will cause an increase in the height of the floods of 18 feet at Red River. Since that time deforesting has

gone on for forty years, and I believe now is about at a maximum. I think that tree planting is keeping pace with deforesting. Cultivation and drainage have gone on in the Mississippi Valley, and have gotten nearly as far as they are going, and we have had no such elevation floods. We have as yet had no floods that could not be restrained with levees of moderate heights.

Such floods as Colonel Ellet anticipated have never been realized; never will be; never can be. The whole tenor of his report shows very plainly that he was forced to accept the outlet theory against his deeper conviction, simply because he thought that no levees which could possibly be built would restrain the floods which he expected in the future.

His idea was that the extension of the levees would hurry forward the discharge from above. The elevation of the flood line would begin at Cairo and increase until it reached this figure, 18 feet at Red River

Subsequent experience has shown that these apprehensions were entirely unfounded. We get a good illustration of that from the Po at Ferrara, which occupies a position on the Po about the same as that of Vicksburg or Natchez on the Mississippi. The super-elevation of the flood surface within the history of the Po for several hundred years, due to the extension of levees and other causes, is about 3 feet. It is reasonable to suppose that the super-elevation caused by the hastening forward of the discharge of the floods will bear some relation to the slope of the river and its size. In slope the Po leaves off at the sea about where the Mississippi begins at Cairo. If the hastening forward of the flood on the Po, with a slope of from 30 inches per mile at its headwaters to 5 at the sea, results in an increased height of 3 feet at Ferrara, we may reasonably expect that the super-elevation of floods due to the same cause on the Mississippi will be less in amount—less than 3 feet, since the greatest slope of the latter stream is but little in excess of the least slope of the former.

The CHAIRMAN. In how long a period?

Captain LEACH. Forever; the causes of increase must culminate at some time.

The CHAIRMAN. Captain Leathers says the bottom of the river has risen 7 or 8 feet now.

Captain LEACH. I know he does.

The CHAIRMAN. What do you say about that?

Captain LEACH. The gauge records show that the absolute elevation of the low-water surface is about, as nearly as can be figured, where it always has been at various points. Captain Lethers runs his boat through low water, at about 7 feet depth, and if the bottom has risen 7 feet, the surface remaining stationary, he would have no water to run his boat through. He would have to run it on wheels. The low-water surface has not risen. We have unquestionable evidence as to that. We have measurements just as good as any man can make. We have records that have been made at various places by a great many different people, so that there could be no collusion about it, no mistake about it. They agree perfectly; they are consistent with each other. Their reports are that the low-water surface is exactly where it was for about the same volume of discharge. The records at Natchez go back to the beginning of this century.

The CHAIRMAN. Captain Leathers says the bottom of the river has risen at Memphis.

Captain LEACH. I do not know what Captain Leathers has stated. The records at Memphis show nothing of the kind.

The CHAIRMAN. Now, captain, the committee will be glad to have you give your views as to the plan the Commission have adopted to improve the river.

Captain LEACH. As to the improvement of the river, I do not know that I have anything new to add over and above what has been stated. The plan of the Commission has been outlined. The degree of success that has been attained has been stated. In all those points I can do no better than to say that I fully concur.

The CHAIRMAN. General Comstock says that in his opinion levees are not necessary to improve the navigation of the Mississippi River, while Major Suter says that in his opinion the levees are essential. What is your opinion about that?

Captain LEACH. My opinion is that they are absolutely essential; that there are certain well-defined possibilities to the improvement of the Mississippi River. There are certain natural conditions present which by proper scientific treatment can be made to produce a stream of a certain degree of navigability. It has its ultimate possibilities. With levees, that possibility can be attained; without levees it can not. Without levees a stream can be improved; with

levees it can be improved much more. That is my idea of the river with and without the levees.

The CHAIRMAN. General Comstock, what is your view—is it best in making an appropriation of two or three millions for the improvement of the Mississippi River to direct the expenditure of money at partcular points?

General COMSTOCK. If the money is intended to be spent in protecting towns and cities and villages along the river, that object will be attained by that process, but probably there will be very little left for the improvement of the river generally.

The CHAIRMAN. Has not the Commission, so far as navigation and its interests are concerned, been very much crippled by the action of Congress in thus disposing of its appropriations?

General COMSTOCK. I think so in some degree, because I think Congress would have given us probably a larger amount for the general improvement of the river if they had not made specific appropriations. For instance, in the last bill there was an appropriation of fifty or sixty thousand dollars for Columbus, some for Greenville, and so on down. Those were all places where money would come out of what we otherwise would have had to use for the general improvement of the river.

The CHAIRMAN. Major Suter, I want to ask you the same question.

Major SUTER. My opinion is about the same as General Comstock's.

Captain LEACH. That is a question rather higher in the horizon than I have ever been called upon to consider. I am only a subordinate. I have tried to execute the plans of the Commission and to carry out the will of Congress expressed in the law, and in regard to probable or possible improvement in the method of making appropriations I do not know that I have any opinion to express.

Senator WASHBURN. I would like to ask a question. Suppose Congress should appropriate two and a half or three million dollars for the improvement of the lower Mississippi without restriction, how would it be expended by the Mississippi River Commission?

General COMSTOCK. I can answer that. I do not think it would be an unjust distribution to make the distribution we have made heretofore, two-thirds for the improvement of the river and one-third for levees.

Senator GIBSON. Captain Leach, you are not a member of the Mississippi River Commission?

Captain LEACH. No, sir.

Senator GIBSON. I suppose shortly after you graduated from West Point you were assigned to the Mississippi River Commission?

Captain LEACH. I graduated in 1875, and in 1879 I was assigned as secretary of the Commission.

Senator GIBSON. Did you have any preconceived notions as to how the river should be treated?

Captain LEACH. Not at all.

Senator GIBSON. Your opinion is based upon your experience and observation on the river?

Captain LEACH. Entirely so.

Senator GIBSON. Are you a native or a resident of the Valley of the Mississippi?

Captain LEACH. No, sir; I am a native of Indiana.

Senator WASHBURN. You do not agree with Colonel Ellet in the opinion that these outlets, what you call high-water outlets, are desirable?

Captain LEACH. No, sir.

Senator WASHBURN. Under no condition of things?

Captain LEACH. No, sir; because the conditions under which Colonel Ellet arrived at the conclusion he did were predictions for the future. We are now in a good part of that future. We see that those predictions will not be realized.

Senator WASHBURN. Why should not the same principle apply? We have had very high water this year, perhaps not as high as he contemplated, but certainly very high. Why should not the same principle apply in the very high water we have had this year as he contemplated?

Captain LEACH. The best method of controlling a flood is by levees. There are physical limits to the building of levees, and if a flood went so high as to exceed those limits, then it would be necessary to obtain relief. It was under such apprehension, in my opinion, that Colonel Ellet proposed an outlet.

Senator WASHBURN. Major Suter takes the position that the river with these outlets would not discharge the water as rapidly as though it were held in one channel.

Captain LEACH. I think it is fully agreed that there would be an immediate relief. The great destruction will come on the second or third generations hence, and of course if a man is under water he will get out, regardless of what is going to happen to his descendants.

Senator WASHBURN. You think that by making these outlets, take the Atchafalaya, we would afford immediate relief from the great floods?

Captain LEACH. It would afford slight local relief from the pending flood, undoubtedly.

Senator WASHBURN. In other words, it would discharge the water more rapidly than though you attempted to maintain it in one channel?

Captain LEACH. I do not know.

Senator WASHBURN. You would get rid of it?

Captain LEACH. Yes, sir; it would reduce the level slightly. Two years ago I thought myself, and stated before a committee of this Senate that I thought it possible to reduce the surface 10 feet by opening the Lake Borgne outlet. I should be compelled to divide that by 2 now—5 feet, by any possible outlet.

Senator WASHBURN. And you hold still further that the degree of elevation would decrease as the years went by?

Captain LEACH. Very much. The scope of the river to the mouth of the passes would be increased. Now, if you want to increase the inclination of a line one end of which is fixed, it can only be done by raising the other end. The Mississippi River from the Gulf to New Orleans is such a line. Its lower end is fixed at Gulf level, and if it is compelled by division to take a steeper slope, it can only do it by raising its level at New Orleans. The divided channels must inevitably take a higher slope, and in doing so the point of their divergence must be elevated absolutely.

Senator GIBSON. And that would make a bar.

Captain LEACH. Unquestionably, and it will raise the flood line also. Nothing else you can do will elevate the flood plane so certainly. In fact, that is the one solitary thing that must give New Orleans bigger floods than ever before.

The CHAIRMAN. Captain Cowden wants me to ask you certain questions. Would you levee-dike, spur-dam, etc., the upper end of a sediment-bearing stream before you would improve the lower end of such a stream?

Captain LEACH. That would depend entirely upon the conditions. If the lower end demanded improvement in the interest of navigation and the upper end did not, I would sacrifice my theories and improve the lower end first, provided I held such theory, and on the converse if the upper end demanded improvement and the lower end did not, I would improve the upper end. I would improve the end which first demanded it.

The CHAIRMAN. Will water flow down an angle or incline of 2 inches to the mile faster than it will flow down an incline of 1 inch to the mile?

Captain LEACH. Not necessarily. It may flow very much faster down the lower inclination.

The CHAIRMAN. The same volume and the same width?

Captain LEACH. No restrictions with regard to volume were made. I was only asked one question with regard to velocity and slope. The velocity depends, as nearly as it can be stated in brief terms, on the square root of the angle of the fall and the square root of the mean depth. To increase the mean depth will increase the velocity just as much as an equal increase of slope. The average mean velocity of high water from Cairo to New Orleans does not differ very much from 6 feet in a second; that regardless of considerable changes in slope. Repeated observations, hundreds of them, are available to show that there is a remarkable uniformity in the mean flood velocity from Cairo to the Gulf.

The CHAIRMAN. Is the fall greater at Cairo than at New Orleans?

Captain LEACH. It is.

The CHAIRMAN. Is the current greater at Cairo than at New Orleans?

Captain LEACH. A little greater at low water, but at high water it is almost the same.

The CHAIRMAN. Then does not the greater current above bring the mud down faster than the slower current at the lower end can discharge it?

Captain LEACH. There is no greater current above.

The CHAIRMAN. If you build levees higher at the lower end than at the upper end, does that increase or decrease the angle of fall?

Captain LEACH. I do not think it has any effect at all.

The CHAIRMAN. It is claimed that the inflow of water is 2,100,000 cubic feet per second, and that the outflow of water at the mouths of the Mississippi is

1,100,000 cubic feet per second, and, if this be true, how would you prevent overflows?

Captain LEACH. By one of the best-known principles of river physics, that is, that there is a very appreciable reservoir effect in the volume of the channel itself. If the water is flowing in at Cairo faster than it is flowing out at New Orleans and I am asked where the surplus goes, I am able to reply that it goes to raising the surface of that water. There are thousands of square miles of water to be raised and it rises sometimes in places as high as 2 or 3 feet a day.

The CHAIRMAN. Is the South Pass in any sense an outlet of the Mississippi?

Captain LEACH. Yes, sir.

The CHAIRMAN. Are the mouths of the Mississippi in any sense outlets?

Captain LEACH. In every sense.

The CHAIRMAN. If you wanted to get the flood water of the Mississippi into the Gulf of Mexico quicker than it would now flow through the present mouths, would you close up all of the present mouths or would you open more outlets?

Captain LEACH. I certainly should not close up all the mouths of any stream under any circumstances. I admit that I would leave at least one open.

The CHAIRMAN. Would you open any more outlets?

Captain LEACH. No, sir.

The CHAIRMAN. If it were possible to make the Lake Borgne outlet wide enough and deep enough to lower the flood line of the Mississippi River at that place down to the Gulf level, would that enormous outflow of flood water increase or decrease the current of the Mississippi River?

Captain LEACH. It would increase the current for a short distance above enormously and it would decrease the current below. In fact, if the hypothesis stated were realized, there would not be any current at all below except a little ebb and flow of the tide, and of course it would increase the current enormously above, it would aggravate the destruction of the banks, and in that way would not only make the maintenance of a levee system along there very precarious, but it would make the work of regulation of the stream very difficult.

The CHAIRMAN. How does this year's floods compare with floods of previous years?

Captain LEACH. The data are not in yet. There are some peculiar developments that would require study before expressing a definite opinion. I would say as the result of what I have seen that I believe the flood at Memphis was about 5 per cent less than in 1882, the greatest in volume we have ever had, taking the whole length of the river. At Helena it approached closely to the 1882 flood, and below Helena it was the greatest flood of record in every respect except one—duration. In every other respect it was the greatest flood on record.

The CHAIRMAN. How does the land actually overflowed compare with that of 1882?

Captain LEACH. About 20 per cent as much.

Senator WASHBURN. Twenty per cent less than in 1882?

Captain LEACH. Only 20 per cent of what was overflowed in 1882.

The CHAIRMAN. What do you charge that to?

Captain LEACH. The levees. The overflow was made possible by the breaks in the levees. There were breaks of less than 2 miles, perhaps, in 1,300 miles. I may say, generally speaking, in regard to the possibility of maintaining a levee system for restraining floods, we have this year with the greatest flood on record approached more nearly the complete restraint of the flood than ever before.

The CHAIRMAN. Suppose the levees had not broken, would the overflow not have occurred?

Captain LEACH. The river was almost at its height before the breaks began, and from information which will be placed before the committee later it will be seen that the taking out of a very large quantity of water, at one place 400,000 cubic feet per second, had a very slight, unexpectedly slight, effect in reducing the height of the river. It is perfectly reasonable to suppose that an addition of 400,000 cubic feet per second would have had no greater effect in raising the river than the outlet had in depressing it. I think there is a great deal of evidence to show that with grades in some parts 2 feet higher than we now have, and in other parts no higher than now, and with levees thoroughly policed and controlled from the beginning of the flood, there would be few or no breaks.

The CHAIRMAN. What was the difficulty?

Captain LEACH. Defective foundations.

The CHAIRMAN. Whose fault is that?

Captain LEACH. I do not know exactly where to put it.

The CHAIRMAN. Were they built by the United States engineers?

Captain LEACH. Some of them, and some not; but the foundation was simply what nature left, not prepared foundations. I think, however, that we have underestimated the necessity of thoroughly exploring the foundations of the levee. I think all the engineers connected with the levee work are agreed upon that now.

The CHAIRMAN. Do the levees cave into the river?

Captain LEACH. Occasionally. The Commission within the last two or three years has distinctly committed itself to the policy of preferring, in the order of progress in bank protection by revetment, localities where the caving will involve large levees. I may say, generally, with regard to the history of the levee system, that over three-fourths, probably, of the entire sum of money expended by the States in the last ten or fifteen years in the construction of levees would have been saved if the United States had prevented the banks from caving.

Senator GIBSON. You said that this recent flood was the greatest flood of which you have any record?

Captain LEACH. Yes, sir.

Senator GIBSON. You mean in its height, or in its volume?

Captain LEACH. In its volume.

Senator GIBSON. You were speaking of the volume?

Captain LEACH. Yes, sir; but at some places it was greater in height.

Senator GIBSON. More water has passed down the Mississippi this winter in its flood stages than ever before.

Captain LEACH. I believe so; that is, below the mouth of the White River. The very top of this flood was caused by the discharge of a phenomenal volume of water out of the White and Arkansas rivers upon the fairly large flood which was passing Memphis.

Senator GIBSON. Have you any knowledge, from tradition or data, of the flood of 1828?

Captain LEACH. There is some data on that subject, but I am not familiar with it now. I have not looked at it for a long time.

Senator GIBSON. Have you heard from old people living in the valley anything about the flood of 1828?

Captain LEACH. No, I have not. The only thing I know about it is that there is a paragraph about it in the Humphreys and Abbott report, and what data there is is collated there.

Senator GIBSON. You ascribe these breaks in the levees to the enormous body of water that pressed against them?

Captain LEACH. To the water against them, so long and with greater head than was ever known before in their history. By greater head I do not mean greater actual height of water in the river, but you know very well that if levees break extensively and back water rises behind them of course there is little or no head against them. In the flood of 1882 the levees, to be sure, were exposed to water perhaps 50 or 60 per cent longer than this year, but this year they were mostly dry behind.

Senator GIBSON. What are the facts, first, as to the number of miles that gave away this year in comparison with the floods of 1882 or 1884 and so on, and, secondly, the number of breaks?

Captain LEACH. I have here the report of a number of engineers made to the recent Vicksburg convention. It is signed by about fourteen or fifteen engineers. This number comprises the United States engineers in charge of the district where the principal overflow occurred this year, two members of the Mississippi River Commission, and all the civil engineers engaged under all State organizations in the guarding and maintenance of levees during this flood. If anybody in the world has information about this thing these men have, and if any statement could be relied upon these gentlemen's statements certainly can.

"The disasters from the recent flood have been exaggerated and magnified beyond their true proportions by the sensational treatment, and which has tended to shake confidence in the efficiency of the levee system. In confirmation of this, attention is called to the following:

"In 1882 the total number of crevasses in the levees was 284, aggregating 589 miles in width.

"In 1883 the number of crevasses was 224, with an aggregate width of 341.1 miles.

"In 1884 the crevasses numbered 204, aggregating 106.04 miles in width.

"The result of the crevasses enumerated during these three years were the general overflow of the Mississippi delta.

"In the present flood, the dangers of which are nearly passed, the crevasses which have occurred number 23, aggregating about 4¼ miles in width in a total length of 1,100 miles of levee—one-half of 1 per cent of the total line of levees, notwithstanding that the present flood has exceeded those of the three years cited in the height attained and all points below, and has not exceeded in duration."

Senator GIBSON. I wish you would state what levees constructed by the Mississippi River Commission, or in accordance with their plans, by the Army engineers, have given away.

Captain LEACH. I really have no information on that point whatever.

Senator GIBSON. Has a single one given away?

Captain LEACH. I do not know. None of these levees are in my district.

Senator GIBSON. Yours is the Memphis district.

Captain LEACH. The first and second. This year we had but a single break, one at Austin, less than 300 feet wide.

Senator GIBSON. Built by the United States?

Captain LEACH. By the State.

Senator GIBSON. Has any of the work in your district built by the United States engineers given away?

Captain LEACH. No, sir.

Senator GIBSON. Are there any there?

Captain LEACH. Yes, sir; I have about 30 miles on one side and 15 on another, 45 miles in all, at Plum Point reach, and about 15½ from Helena down. Half of this was built by the United States and all the Plum Point levees.

While I am on the subject of the Plum Point levees I would like to make a little statement.

The Commission in carrying out the work in the early years at Plum Point had not provided for any levees. In a debate in the Senate on one of the river and harbor bills the point was made by a Senator that the Commission was professing to make an experimental application of their system at Plum Point reach and a part of their plan was a levee. That year an allotment was made and a levee built on the Tennessee side of the reach. The next year an allotment was made for levees on the Arkansas side and those levees were built. A party was engaged all the time in making surveys. The surveys made after the construction of the second line of levees and before the first flood and again after the first flood showed that the high bars in the regulated or deepened channel of about 3,500 feet width had had their tops scalped off 8 feet uniformly. Nothing of the kind had ever occurred before, and in the two crossings under control and under improvement the maximum depths had increased in one case 1 foot and in another case 2 feet, and they have remained to this time.

The CHAIRMAN. Since the levees were built?

Captain LEACH. Yes, sir.

The CHAIRMAN. Have you any idea what it would cost to repair these levees?

Captain LEACH. That would depend entirely upon the scheme adopted. My belief is now that we can strike with much more certainty than ever before. This flood, with all its disasters, has convinced me, and others, I think, of what we before believed, but could not prove—that is, that we can with reasonable levees confine any flood we are likely to have, and it seems to me that instead of working as we have heretofore we ought to change the plan altogether and give a little more money and reduce the risk. I think it is perfectly safe now—a year ago I would not have dared to say so—to have a scheme of levees that will be almost impregnable, and to do that I suppose will cost in the neighborhood of $10,000,000 at prevailing prices.

The CHAIRMAN. Ten millions for repairs alone?

Captain LEACH. To repair and enlarge and levee the St. Francis basin. To repair the present breaks alone, I think $100,000 will do at present rates. The breaks are not very large and do not occur where the levees are very high. No very high levees have broken. The massive levees are all intact.

Senator WASHBURN. Let us understand what you propose to do with the $10,000,000.

Captain LEACH. Ten millions will put up a line of levees 4 feet above the highest known water, with strong profile on the west bank from Cairo to the mouth of the St. Francis. That is the first thing. It will also increase the work at Plum Point to that standard. It will build up the White River front from Helena to and including Laconia to the same grade and profile. It will enlarge the Arkansas levees from the high land at Ames Ridge down past Arkansas City and on past the State line down to Red River. It will enlarge the lower district

of the Yazoo front, and make some enlargements from point to point as may be necessary in the upper district. It will increase and strengthen the levees on both sides of the river where ever they now exist.

Senator WASHBURN. Would it build all the levees that are required?

Captain LEACH. Yes, sir.

Senator WASHBURN. What is going to become of the other $65,000,000 which have been estimated for?

Captain LEACH. That sum will be required for the caving banks and for any other work that may be necessary in closing high-water chutes, and in case of local obstructions of navigation, taking such means as may be necessary to remove them. I mean that the sixty-five millions will control the whole river.

Senator WASHBURN. How will the seventy-five millions be expended? You propose to expend ten millions for levees; how would the other sixty-five millions be expended?

Captain LEACH. In the first place I may say that sixty-five millions is the maximum estimate of any engineer connected with the work. My own estimate would be less than half of it, and I do not think my estimate is the lowest possible. Some of the money would have to be expended to protect the banks of the river from caving.

Senator WASHBURN. How do you get at that?

Captain LEACH. By a system of revetment, mattresses of brush ballasted with stone.

The CHAIRMAN. Have not some of these mattresses caved in?

Captain LEACH. Not recently. Not since we found out how to build them. We have not lost any since we found out how to build them.

The CHAIRMAN. Then, in your opinion, the amount of money that it required to build a canal from Manchester, England, to deep water will protect the Mississippi River from top to bottom?

Captain LEACH. Fifty millions will do it handsomely.

Senator WASHBURN. Do you agree with General Comstock that so far as the improvement of navigation is concerned, that is to be accomplished more by improvements in the bottom of the river than by levees?

Captain LEACH. No; I do not agree with him in that respect. I have stated my position as definitely as I can. I believe that the improvement is progressive, that a little improvement is better than none, and that complete improvement is best of all, and is what the people need and demand. Partial improvement may be effected by partial control. Channel works will protect the river and control it so long as it is in its natural banks. Complete improvement is possible only with complete control. That is only possible by levees.

With regard to the specific way in which levees are made useful, I may illustrate by the practice in sewer constructions. Where the river makes a sharp bend at high water when it is well out of the banks, the fall across the point is equivalent to the fall around the bend. Therefore the rate of the fall is very much greater across the point. The result is that a greater or less amount leaves the channel at right angles and flows across the point. If you try to make a junction of a branch sewer with the main at right angles you will have considerable trouble. They do it effectually by bringing the joint in at an acute angle. If water flowing squarely into a sewer will obstruct it, why would it not do the same thing in a river? There is only one way to keep it from flowing in and out of the river, and that is to build a levee. The water does harm when it comes out, and it does harm when it goes in.

The CHAIRMAN. I suppose the most important place is the middle of the levee where the water goes out, and returns in the same place.

Captain LEACH. Yes, sir. I think the levee should be made to follow the convolutions of the river as closely as the nature of the ground will permit. If they could be built at a uniform distance, a mile apart the whole length of the river, the conditions would be the most perfect that could be hoped for. If that is impossible, then the next best thing is to build them as nearly at a uniform distance apart as can be done.

STATEMENT OF CAPT. DAN C. KINGMAN.

Capt. DAN C. KINGMAN, Corps of Engineers, U. S. Army, in charge of the fourth district of the Mississippi River, appeared before the committee.

The CHAIRMAN. How long have you been in charge of the fourth district?

Captain KINGMAN. About three years and a half.

The CHAIRMAN. Please state your knowledge of the Mississippi River and its overflows, in regard to navigation.

Captain KINGMAN. The present discussion in regard to the Mississippi River has been relative to the effect of outlets on flood heights, and I have here a hydrograph which shows what outlets actually do to the river by showing what the crevasses which have taken place during this last flood have done to the flood heights. I have here gauges at some six or seven points in my district [indicating on map]. This black line represents the gauge heights at Carrollton. This [indicating] at Bayou Sara; this [indicating] represents that at Red River Landing; this [indicating] is Natchez; this [indicating] is St. Joseph. The next gauge would be at Vicksburg, which is above my district.

These little squares here [indicating] represents a half day. This [indicating] represents one-tenth of a foot. Starting in here on the 1st of March and taking this gauge-reading at the next half day, I indicate the rise or the fall, and in this way the shape of flood wave is shown graphically by the curve that results from the union of all of [indicating] these points. It is the line that would be marked by a pointer which moved over two of these squares each day and also moved up or down one of these little squares for each tenth of a foot that the river rose or fell.

The river was at high stage on the 1st of March; about 14¾ feet at New Orleans, and at a corresponding height at the points above, and it continued to discharge at a very rapid rate the water that came down from above. The discharge amounted to 1,280,000 cubic feet per second at New Orleans on the 11th and 12th of March.

Up to that time no breaks had occurred. At that time a break occurred a little above College Point, at a plantation called Nita. This break was due to a rice flume, a cut made through the levee to admit water to the fields for the purpose of irrigation; this box or sluice had gates in it, by means of which the water could be admitted to or excluded from the fields. It was a timber affair and the pressure of the water forced the water around and under it and the box was "blown out," thus creating an opening which soon became a crevasse.

The CHAIRMAN. Do the people up and down these levees have a right to put in chutes and all that sort of thing?

Captain KINGMAN. Yes, sir; except in levees constructed by the United States, or unless there is a local parish law to the contrary. When they put them in they have to get authority from what would correspond to authorities of the county up here—the police jury, as it is called down there.

Senator WASHBURN. Are they in the habit of doing that to a great extent?

Captain KINGMAN. Yes, sir; hundreds of them. It is only in the rice-producing districts, however.

The Nita crevasse enlarged very rapidly. After it had been running for eight or ten days we measured the discharge and it was 90,000 cubic feet per second, the crevasse being about 600 feet wide, with an average depth of 15 feet. The water flowed out with great velocity in a fan-shaped body and inundated a great area of country. The crevasse increased in width in spite of all efforts to restrain it by driving piles and putting down a mattress. Now it is 3,000 feet wide and 15 feet deep, discharging 400,000 cubic feet a second, or about one-half as much water as is now passing by New Orleans. Fine brick houses have been swept away and obliterated by this crevasse. So large an outlet as this ought to have produced a very marked effect on the river. If any outlet could do any good surely this one, discharging 400,000 cubic feet per second, ought to produce great relief.

Senator WASHBURN. What becomes of the water?

Captain KINGMAN. It flows out across the country downward and eastward until it strikes the old Bonnet Carré Channel and there the ridge formed by that crevasse prevents it from flowing down any farther. It goes across the country to Lake Pontchartrain, and the stream is 20 miles wide there. The track of the Illinois Central Railroad is under water for many miles, and that road can not now send trains to New Orleans. The water then flows through Lake Pontchartrain and passes out through the Chef Menteur, the Rigolets, and through the other outlets of the lake, and you can see the yellow water going out through the Rigolets far into Lake Borgne. Clear out into Mississippi Sound can be seen Mississippi water instead of the green salt water which is ordinarily seen there.

On the College Point gauge there was a fall up to the time the general fall set in of about a foot and a half. That is all the relief that place got in the way of a direct fall. At New Orleans there has been a fall from the highest point, until the final fall set in, of about a foot. The extreme height was 16 feet

on the Carrollton gauge, and a foot was the extreme oscillation. The discharge through this crevasse has been shown to be nearly equal to one-half the volume of water now passing New Orleans. If we take out one-third of the water, we ought, if the conditions remained the same, to reduce the gauge height one-third. Therefore the Carrollton gauge ought to have gone down to about 10½ feet, but it actually went down to about 15 feet.

Senator GIBSON. From 16 feet?

Captain KINGMAN. Yes, sir; until the final fall set in, due to some other causes. Therefore the relief from this was very slight. When we go up to Plaquemine, which is 50 miles above the crevasse, and compare the hydrograph with all the stations above, we see that there has been no effect from that crevassé.

The hydrograph at Bayou Sara and Red River correspond exactly. They preserve their own shape up to the 21st of April, when the crevasse occurred up there. We had there the Preston, Taylor, the Fannie Riche, the old Morganza and the new Morganza breaks, the Raccourci, and two or three others. These crevasses occurred by the water overtopping the levee. For 25 or 30 miles the levees had been raised. We fought the rising water until the levees had been raised 2 or 3 feet above the crown, and the water kept pace with us. Then a severe storm came and the waves swept volumes of water over the levees, so that men were driven away from their work. Then the sand bags and planks which had been put on it yielded and broke and were carried away. None of the levees in those places broke from any other cause than simply by being overwhelmed by the water.

Senator GIBSON. You stated that at Plaquemine, which is only 50 miles above the Nita Crevasse, there was no change?

Captain KINGMAN. No, sir; no change at all due to this crevasse; though the several crevasses I have just mentioned, and with an aggregate discharge two or three days after they broke of about 237,000 cubic feet a second, being above Plaquemine, did produce some effect. They were all in there together within 10 or 12 miles, and the fall at Bayou Sara was about a foot in less than a day. They caused at the mouth of Red River the first day a fall of 2 or 3 inches, and in three or four days it amounted to about a foot. After that the fall was just simply that which was due to the fall of the river above. These several crevasses between Bayou Sara and the mouth of the Red River gave a discharge of 237,000 feet per second. They gave more than that finally because they got larger, but I give this discharge so as to compare it with the effect that was produced at that time. Between Red River landing and Natchez there were two small crevasses, the discharge of which I have not got yet. I had them measured, but have not received the measurements yet. As near as I can tell, their discharge must have been about 20,000 cubic feet a second. There was rather an abrupt fall at Natchez of about 4 or 5 inches, evidently due to that crevasse, and also due to another crevasse which occurred almost opposite Natchez, in Lake Concordia, which must have given a greater discharge. These crevasses caused an abrupt fall of 4 or 5 inches at Natchez. At St. Joe, a comparatively short distance above Natchez, there is absolutely no abnormal change in the hydrograph, and no fall due to crevasses occurred there at all. The river there takes its fall naturally, due to the natural fall coming down the river from above.

Senator GIBSON. How many miles up is St. Joe?

Captain KINGMAN. I do not know (referring to map). Here is Natchez and here is St. Joe. I should say about 50 miles; about the same as Plaquemine was above the Nita. Down below the city there were a good many small crevasses, probably twelve or fourteen in all. They have all been closed but one, and in the aggregate their discharge might have amounted to 20,000 or 30,000 feet a second; but as they only stood open two or three days, and the people began to close them right away, and as they have since been closed, their effect is insignificant, and can not be traced on the hydrograph at all.

Now, to show what produced this remarkably high water below the mouth of the Red River, for it was remarkably high water: The Morganza levee had been built a foot and a half above high water of 1882, and the water of this year would have gone over the top of that levee from 6 to 18 inches in depth if it had not been for the work we built on the crown. So that at Morganza, right at that particular bend, the extreme high water must have been from 2 to 2½ feet above the high water of 1882. We have got the high-water marks of this year, but when I was up there the 1882 marks were so far under water that we could not find them. At New Texas we had better luck. We found them 19

inches below the high water of this year. At Baton Rouge the river was 5 inches above 1882, if I remember right. I talked with a good many of the inhabitants of the valley—the oldest inhabitants probably—and they all admitted that they had never seen any water that approached the present water in height. They pointed to some of their old marks—trees, old levees, etc.—then submerged, which they said they had never known to be under water before. It was certainly the highest water below Red River that has been there within historic times.

On the 1st of March, before the levees had broken in Arkansas, north Louisiana, and Mississippi, the Atchafalaya at its head was about 6 or 8 inches lower than the Mississippi River at Red River Landing, and a good current was flowing from the Mississippi out into the Atchafalaya—not a very large discharge, but quite a considerable amount of water—and doubtless the Atchafalaya was affording some relief to the Mississippi. This continued until about the middle of March. Then the advance of the crevasse water that found its way down the Tensas began to appear below the mouth of Red River. It filled up the Atchafalaya and in a few days brought it above the level of the Mississippi, and the water began to return to this river. The inlet extended all the way from the Bougere Swamp down to the mouth of Red River. It was practically impossible to measure the amount of water coming out that way, because it flowed through the woods for miles and miles, and you could see the nearly clear crevasse water extending out 800 or 900 feet from the bank and pushing the Mississippi water towards the other side of the river. The effect seemed to retard rather than accelerate the current of the river. That is what caused the high water there.

The Atchafalaya has been carrying off an immense amount of water. The last discharge that we had measured was taken there on about the 1st of May. The Atchafalaya was then carrying nearly 5,000 cubic feet a second over the dams that we put in. It was not required when we put the dams in that they should permit the passage of over 200,000 cubic feet a second; and they would do this with a velocity of 4 feet a second. Now there is a velocity over the dam of about 9. The velocity is so great that steamboats can hardly stem it. In fact, some good steamboats have been forced to make two or three attempts before they could pass through that portion of the channel. A great many of the levees down below have given way, and the Atchafalaya is spread out right and left, and covers the country down below Simmsport. There is no Red River water passing down the Atchafalaya at its head now. The Red River begins to show itself in the river near Simmsport, 6 miles from the head.

Senator GIBSON. Does the Red River go on the north side of Turnbulls Island now?

Captain KINGMAN. There has been a channel there always—a clear and well-defined channel—but not quite as deep a channel as on the south side.

Senator GIBSON. It was thought that the sills would turn it around.

Captain KINGMAN. No, sir. They were placed about 6 miles down the Atchafalaya, and had no effect upon the water of the Red River. A sill was built last fall to connect Turnbulls Island to the main line, between the old mouth of Red River and the head of the Atchafalaya. A dam is to be placed upon this sill, and when the dam is put in there it will doubtless cause the river in low stages to pass around the north side of the island.

Senator GIBSON. Now, while there were 500,000 cubic feet per second going out the Atchafalaya, how much was going down the Mississippi? That was all Mississippi water?

Captain KINGMAN. Pretty much. It did not come directly out of the Mississippi, but it was all crevasse water. There was about 1,450,000 cubic feet a second going down the Mississippi below Red River Landing at this time—that is, in round numbers.

The CHAIRMAN. What is your conclusion about the outlet system at Lake Borgne?

Captain KINGMAN. It would be a disappointment. It would not afford the relief which is counted on; it would be an entire failure as a means of relief from overflow. If it did any good at all, temporarily, it might do good from the outlet down to the mouth of the river, where there is no land of any particular value. A narrow strip of land runs along the river from Lake Borgne to the forts, which is about as liable to overflow from the back water as it is from the front water, and this danger would be increased rather than diminished by the discharge of the Mississippi through the outlet above it. Finally, I do not see why there should be any more relief at New Orleans from this Lake Borgne

outlet than there was at Plaquemine from the Nita Crevasse. I think that we have an absolute demonstration of what an outlet will do. Here is a crevasse which is now flowing, and this is what is has done. Below the crevasse it has afforded a little relief, but nothing like commensurate with the amount of water taken out, and above the crevasse it has afforded no relief at all.

Senator WASHBURN. Do you not think the Atchafalaya has given relief?

Captain KINGMAN. I think it has, yes, sir; but I think it has done so because the condition of the Mississippi River near the mouth of Red River is an abnormal one. The Atchafalaya has been there so long that the river has adapted itself to that condition. Now, the Mississippi River flows in a channel of its own formation, and if you were to compare a map of the river of fifty years ago with the map of the present day you would find that the channel of the Mississippi is entirely different. If it occupies the same channel now that it did then it would most likely be because it had gone away and come back again, except at the lower end of the river, where the changes in the channel are less rapid. This channel has a certain size. It is of a size sufficient to carry its average flood discharge. Whenever it has to carry a discharge which is greater than the average discharge it is overtaxed. If it had only to carry half the water it does now it would have only half its present capacity of channel.

The CHAIRMAN. Was not the channel of the Atchafalaya dry in 1840?

Captain KINGMAN. It can not be said to have been dry; it had a very much less capacity of discharge then than it has now. I think in 1836 the State removed, or partially removed, the raft in the Atchafalaya, which was situated from 12 to 20 miles below its head. This was a mass of trees, logs, and drift. It was partially floating and the water ran under and through it, but while it greatly diminished it did not absolutely stop the discharge down the Atchafalaya. Old people living on the Atchafalaya have told me that at the head of the river they crossed in low water on a single fence rail at a place where it is now 1,000 feet wide and 100 feet deep.

The CHAIRMAN. It has been making an outlet of itself?

Captain KINGMAN. Yes, sir; it is a case different from any other of the outlets on the Mississippi. My own idea is that the Atchafalaya is not a natural outlet of the Mississippi. It is not a part of the delta proper. I think there were originally three independent rivers flowing into the Gulf, namely, the Red River, which reached the Gulf through the Teche; the Black River, which flowed through the Atchafalaya, and the Mississippi River. Those three rivers flowed in their own separate channels. In the course of time the Red River obstructed its own channel near the head of what is now the Teche; its water was forced north of the Avoyelles prairie till it found its way into the open channel of the Black River. The Red River thus became a tributary of the Black River. The Red River continued to be a raft maker, and in time it obstructed the channel of the Black, or what is now called the Atchafalaya. At this time the Mississippi River caved in to the Black River at a point below its junction with the Red, and both of the rivers became tributaries of the Mississippi, and would have remained so if new conditions had not been set up by the removal of the Atchafalaya raft.

The CHAIRMAN. These rivers are tributaries to the Mississippi, but at a certain stage of water the Mississippi becomes tributary to them?

Captain KINGMAN. Yes, sir. The Red River flows now, since the raft has been removed out of the Atchafalaya, down the Atchafalaya to the Gulf. The Mississippi occupies its own channel. They are connected by Old River like the Siamese twins. If the water in the two rivers is of the same height there is no circulation. If one is higher than the other the current is from the higher to the lower. If the Red is the higher, then its water divides and part goes down the Atchafalaya and the rest goes out to the Mississippi. If the other condition prevails, then all the Red River goes down the Atchafalaya and a part of the Mississippi goes over until it raises up the Atchafalaya enough to establish a condition of equilibrium, and so the water flows. That is the reason that the Atchafalaya does not close up, because it always has the Red River to act upon it. Sometimes it has the Mississippi.

Senator GIBSON. It is both an outlet and an inlet?

Captain KINGMAN. It is not exactly an inlet. The Atchafalaya does not flow into the Mississippi.

The CHAIRMAN. Did it never flow into the Mississippi?

Captain KINGMAN. No, sir; it never was a tributary to the Mississippi. I think it was the lower half of Black River. It was not a part of the delta of the Mississippi. Its banks are a black, clayey deposit, and upon that is found

a red deposit, and upon that it is sandy. It looks like the work of the Black River and then of the Red and Black combined, but it is clearly an independent river by itself, with this accidental connection between it and another river. It always has the Red River to flow down, and it is no more likely to deteriorate than if the Mississippi was not there. That is the reason it does not fill up like the other outlets.

The CHAIRMAN. Are you familiar with the methods of the Mississippi River Commission in improving the Mississippi River for navigation?

Captain KINGMAN. No, sir; not very familiar. My district only goes up as far as Vicksburg. There have been no channel improvements in my district, so that what I know of the channel works has been only what I saw in passing over the river, or what I read about them in the annual reports. All the work I have done has been local, such as at the mouth of the Red River, New Orleans Harbor, and the construction and maintenance of levees.

The CHAIRMAN. In your district, as between levees and the outlet system, you have no doubt?

Captain KINGMAN. I have not a particle of doubt.

The CHAIRMAN. Suppose you drop all considerations of overflows and regard navigation alone, how then?

Captain KINGMAN. I should consider that the levee is a very important means of improving navigation, and I can give an instance. The Morganza crevasse was caused by a break that occurred in 1874. It remained open as a crevasse practically until closed in the winter of 1886 and 1887, a period of about twelve years. It has a deep bend there and plenty of water, and there had been no trouble with the navigation until after the crevasse was formed. After the crevasse occurred the navigation became worse and worse, and steamboat men told me they hated to run that bend at night, particularly in low water, not when the water was running out. When the water was running out there would seem to be danger of being drawn into the crevasse. The steamboat men dreaded it at low water because the sand-bar, or tongue of land opposite this bend, had extended so far over into the bend that there was hardly room enough for two large steamboats to pass there. The crevasse was closed, jointly by the Commission and by the State, in the winter of 1886 and 1887. Since then the navigation has steadily improved until now it is as good as it ever was. The current is quite regular. There is ample room now, and steamboat men have spoken to me repeatedly this year about the great improvement which has taken place in Morganza Bend since the crevasse has been closed. There is an actual case where the building of a levee made bad navigation good.

Of course, at Bonnet Carre there was a crevasse open for a long time, but the river was so deep at that place, there being no abrupt bend, that the navigation did not get bad. It certainly got worse than it was, but to reduce a channel from 60 feet down to 40 feet, when the boats draw but 10 or 12 feet, does not make any difference, so that a sounding line would be required to show that the channel depth had deteriorated and afterwards been restored. Of course, there was not enough change there for steamboat men to notice. This Morganza case is a good one in point.

The CHAIRMAN. Where does the Morganza water go?

Captain KINGMAN. It passes down through what is known as the Choctaw Swamp, until it comes down nearly back of the town of Plaquemine, and there it finds its way through an intricate system of channels into Grand Lake, and ultimately goes out in Lower Atchafalaya Bay.

Senator GIBSON. How many breaks or crevasses did you have in your district during the whole season?

Captain KINGMAN. About 32.

Senator GIBSON. How many did you close?

Captain KINGMAN. Out of this number we closed about a dozen.

Senator GIBSON. That would leave about 20?

Captain KINGMAN. Yes, sir.

Senator GIBSON. How many miles?

Captain KINGMAN. A little less than 2 miles would be the total length of them.

Senator GIBSON. How many of those crevasses occurred in works built by the United States engineers?

Captain KINGMAN. If I recollect aright, there was but one; that was the Morganza. That broke in the manner I have described; the break was right in the center of the new Morganza.

Senator GIBSON. How much money would it take to put up these levees and raise them to flood heights—that is, to the heights at which you raise them?

Captain KINGMAN. I have not made an estimate of what it would cost, but I think most of the breaks can be closed right in the throats of the crevasses. Where a break is 500 or 250 feet long, to build that short distance and to raise it 2 or 3 feet above the general height of the levee would hardly be logical. To restore the levees to the condition they were in before the breaks occurred would cost $100,000. That is a liberal estimate, and I do not think it would cost more than that.

Captain LEACH. I think the whole system can be restored to the condition in which it was before this flood occurred by the expenditure of in the neighborhood of $100,000.

Captain KINGMAN. It would cost in the neighborhood of $5,000,000 to make them perfect in my district—that is, to put them up 5 feet higher than they now are from Vicksburg to the mouth of Red River, 4 feet from there to New Orleans, and 3 feet from there to the Forts; and to give them, at the same time, the proper slopes.

Senator GIBSON. Your district would have to be levied on both sides?

Captain KINGMAN. Yes, sir; from Baton Rouge down. That is more than half the distance.

Senator GIBSON. Have you ever been to Holland?

Captain KINGMAN. No, sir.

Senator GIBSON. On the River Rhine or the Danube?

Captain KINGMAN. No, sir.

"THE LEVEE THEORY ON THE MISSISSIPPI RIVER," AN INFORMAL DISCUSSION AT THE ANNUAL CONVENTION, AMERICAN SOCIETY OF CIVIL ENGINEERS, JUNE 10, 1903.

B. M. HARROD, Past President American Society of Civil Engineers. The question whether a theory is justified by experience is hardly fair, when its application is quite incomplete, as is the case on the lower Mississippi River, where the levees have as yet neither the grade, section, nor extension considered necessary, and the present contents in cubic yards are not more than two-thirds of the quantity required by the adopted standard.

The discussion of the subject, however, is opportune, as a recent flood of magnitude has excited interest and afforded much information.

The justification of the "Levee Theory" is involved in such changes in the bed of the river, as a flood channel, as result either from natural causes or from an increase of the discharge by levees during more than bank-full stages. If the bed is rising, or the capacity is otherwise reduced by natural and continuing conditions, the completion of a levee system will be prolonged, if not made interminable. If the bed is not rising and the waterway is maintained or improved, either by deepening or widening by the discharge of a larger volume at higher velocity, then the problem, though large, is simple and certain.

The Mississippi River Commission, therefore, has given careful investigation to such changes since its appointment. Local and seasonal movements are constantly going on. At certain stages bars build up and pools scour. At others this process is reversed. Besides this, there is a general downstream and snake-like movement of the sinuosities of the stream. The current binds against the upper and is slack against the lower side of points. Therefore the points, with their opposite concavities, move slowly downward from erosion on the upper and accretion on the lower side. The location of the pools and bars has a definite relation to the curvature of the bends, the former lying in the concavities, alternately on the right and left banks, and the bars at the nodes or revison points between the pools. Hence, as the bends move downstream the bars and pools move with them. Again, as a result of caving on one and accretion on the opposite bank, the river shifts sideways. Instances are not wanting where this movement has amounted to its entire width in fifteen or twenty years.

It is evident that with these unstable conditions but little can be learned from isolated on scattered surroundings. A cross-section line over a bar may, in a few years, lie through a pool, or the river may have slipped to one side, leaving it on dry ground.

In the years 1881, 1882, and 1883 the Commission made an exact and detailed survey of the river from Cairo to the Head of the Passes, a distance of 1,063 miles, with cross sections averaging about four to the mile, and seventy-five soundings to the line. There was no better way of investigating this difficult and important question than by repeating the survey. This was done in 1894, 1895, and 1896, after an interval of thirteen years, over that part of the river where the levee system had been most improved during the interval, from the mouth of White River to Donaldsonville, La., a distance of 472 miles. This second survey was made in greater detail, in order that it might better serve for future comparisons.

There is a limit to the value of the results obtainable even by this exhaustive process, of which the Commission was aware, but no better method seemed available. A comparison between the two surveys would be conclusive in proportion to the similarity of the stage conditions preceding them and prevailing while the parties were in the field. Each survey was of such magnitude and detail as to require several months, and it was improbable that there would be a close repetition of the conditions of the first during the second.

Both surveys and the analysis of their elements were made under the charge of J. A. Ockerson, member American Society of Civil Engineers, and his detailed report on them is found in the reports of the Mississippi River Commission for 1896 and 1897, published, respectively, in the sixth and fifth parts of the reports of the Chief of Engineers for those years.

The following conclusions from his study of the conditions are well founded:

The differences found in these two surveys do not necessarily represent all the changes or the resultant of all the changes that may have taken place between them. During this time the conditions of the river bed may have varied in both directions from those found in either survey. They should, however, indicate any trend, or persistent and progressive change that has taken place. This general tendency seems to be toward a channel more uniform in depth and of greater capacity.

Table No. 1 gives the results from the Arkansas River to Vicksburg, 200 miles.

TABLE No. 1.—*Relation of elements in 1894 to those in 1881–82.*

	Low water.	Medium stage.	Bank-full.
	Per cent.	*Per cent.*	*Per cent.*
Width	+3.6	+8.3	−0.08
Mean depth	−6	−6	+4.5
Area	−3.6	+2.7	+3.1
Hydraulic radius			+3.25

A composite comparative diagram of the sections in this part of the survey is shown in fig. 1.

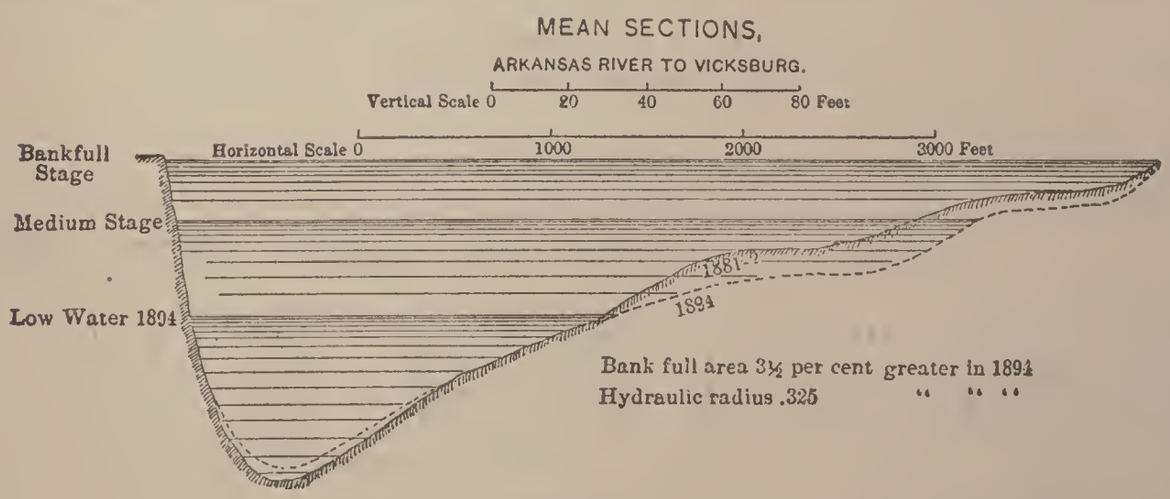

FIG. 1.

The mean of the results from Vicksburg to Donaldsonville, La., 272 miles, is given in Table No. 2.

TABLE No. 2.—*Relation of elements in survey of 1895–96 to those in 1882–83.*

	Low water.	Medium stage.	Bank-full.
	Per cent.	*Per cent.*	*Per cent.*
Width	+3.6	+3.8	+7.5
Mean depth	−5.9	−8.1	−8.9
Area	−3.8	−0.8	+1.4

The conditions under which the two surveys from Vicksburg to Donaldsonville were made were so different as to give abnormal results. The first (1882) was after the greatest recorded flood and on the rise of the succeeding one, which was of considerable magnitude, while the last (1895–96) was preceded by two seasons of extreme low water, and a very moderate intermediate flood, during which sediment transported from above would be deposited in the lower part of the river, particularly below Red River, where a relatively large low-water section, flat slopes, and correspondingly small velocities are found.

A duplication of the survey of 1881 is now being made over that part of the river from Cairo to the mouth of the Arkansas, along which the levee system has been much extended since 1895. In the future, at proper intervals of time, similar resurveys will be made over the entire river, until they yield indications of a persistent and progressive change.

It may be assumed that the low-water plane conforms to the shape of the river bed, and that any elevation or depression of the latter, as the result either of natural causes or of levee building, will be recorded in the low-water gauge readings. The improvement of levees during the past twenty years, and their effect in increasing the height of floods, has been most marked in the 500 miles of river in which are included the gauge stations of Fulton, Memphis, Greenville, and Lake Providence. There has, as yet, been no levee building which has affected the flood stage at Cairo. The effect on the bed of the river, therefore, may be observed by comparing the low-water stages at the points where levee improvement has been greatest with those at Cairo where no influence of the kind has been felt.

Prior to 1882 the United States had built no levees, and the insufficient and incomplete State levees existing at the time were badly wrecked by the flood of that year, which left them in quite an unserviceable condition.

If the average of the low waters at the points mentioned above, which have been selected as fairly representative, for the five years following this disaster of 1882 (1883 to 1887) and that of the last five years (1898 to 1902) be compared with the averages of the low waters at Cairo during the same two periods, as a standard, there will be observed, during the latter period an average relative depression of the low-water surface of 0.74 foot at Fulton, 0.68 foot at Memphis, 1.60 feet at Greenville, and 1.89 feet at Lake Providence.

These reductions of the low-water plane are indicative of a depression of the bed, and are proportionate to the duration and degree of levee maintenance and improvement in the vicinity of the gauge stations mentioned.

Table No. 3 will make this statement clearer.

TABLE No. 3.

Average low water.	Cairo.	Fulton.	Memphis.	Greenville.	Lake Providence.
1883–1887	5.21	4.50	2.57	5.56	4.04
1898–1902	5.35	3.90	2.03	4.10	2.29
Difference in averages	+0.14	−0.60	−0.54	−1.46	−1.75
Reduction below Cairo, 1898–1902	.....	0.74	0.68	1.60	1.89

It was observed, in the great flood of 1897, that:

"The first gauge below Red River to exceed its previous record was the lowest one on the river, at Fort Jackson. The next was the Carrollton gauge, and so on up to Red River, where the gauge did not exceed its previous record until sixteen days after the Carrollton gauge had done so. When the Carroll-

ton gauge had reached its previous maximum, that at Red River still lacked 1.6 feet of the height which had produced that maximum."

The same prematurity of rise at the lower-gauge stations occurred during the present year. In a discussion of this phenomenon by Major Derby, member American Society of Civil Engineers, in the Report of the Mississippi River Commission for 1900, it was considered as due to one of only three causes: (1) A raising of the bed of the river below Carrollton; (2) the effect of crevasses and their closure, or (3) an increase of the carrying capacity of the channel between Red River and Carrollton by which the resistance to discharge and the slope over that 200 miles of river was reduced. His analysis of flood waves ranging in height, at Red River, from 19.3 to 45.2 feet between the years 1872 and 1899, discredited the first two causes and led to the conclusion that the discharge capacity of this part of the river had been increased during the period under consideration.

Besides these extended comparative observations, others of a more local character have been made in connection with crevasses or temporary outlets, as at Malone's, Riverton, Bolivar, Mound Place, Morganza, Bonnet Carré, and Cubitt's Gap. Whenever the resurvey was made after the occurrence of an outlet it showed a reduction of the cross-sectional area below. When made after closure, an enlargement has been observed.

When, in 1880, the river was first subjected to continuous observation, the levee system was in its infancy; some basins were entirely unleveed, and such crude levees as existed were breached at many places by every high water. It was then noticed that the rise and fall was very different at different places. When classified, the greater annual oscillations, amounting generally to about 45 feet, were found at or near the mouths of the tributaries—the Ohio, St. Francis, Arkansas, Yazoo, and Red rivers—while the lesser ones, averaging only about 35 feet, were observed at intermediate points along the fronts of the great basins drained by these tributaries, as at Fulton, Memphis, Greenville, Lake Providence, and St. Joseph.

The gauge readings, when plotted, showed a smooth and regular high-water slope, while that of the low-water slope was quite irregular, being depressed about the junctions of the tributaries, and raised between them or along the basin fronts. A diagram of the high water of 1882 and the low water of 1883, fig. 2, shows that these differences in annual oscillation were caused not by the rise but by the excess of fall at the tributaries over that on the bars of the elevated bed of the river between them.

It was further indicated by the discharge observations taken at high waters at the places near the tributaries and at the others along the basin fronts that the discharges at the former were about 1,500,000 cubic feet per second, and exceeded those at the latter, or intermediate points along the basin fronts, by several hundred thousand feet.

This difference, from a quarter to a half million feet at times, had escaped from the river bed over the banks into the basins, and was returned to the main river below through the tributaries, which are the outfalls for their normal and overflow drainage. Where the river discharged between banks the entire flood volume, the bed was deepened; and where it discharged only two-thirds of that volume the bed was shallowed. The depletion of a thousand floods by overflow had impressed this shape upon the bed.

A part of the "Levee Theory" is that the escape of flood water from the river along the fronts into the adjacent basins caused the elevation of bed that existed, as evidenced by the low-water slope; and that, when this is prevented by levees and the discharge confined, a primary effect will be the reproduction, in the high-water slope, of those elevations which have been observed and described in the low. This has already been brought about by the extension and improvement of levees, and is measured by the excessive height of recent floods at points situated along the middle of basin fronts, as Memphis or Lake Providence. It will be observed that an equal increase of heights has not occurred at the mouths of the tributaries.

Another part of the "levee theory" is that a reversal, or removal, of the conditions which have contracted one part of the waterway and relatively enlarged another, of the same river, will remove these differentiations, and that with a uniform discharge for each stage, from Cairo to the sea, affected only by increments from the normal drainage of the basins, through an erosible bed which the river has molded to its needs, these irregularities of slope, velocity, and section will disappear, and that there will result a regular and substantially

parallel slope curve flattened a little by each increment of volume from a tributary, until Red River is reached, and from thence down the slopes at all stages will converge to sea level.

If the flow is as great along the basin fronts as at the tributaries, why should

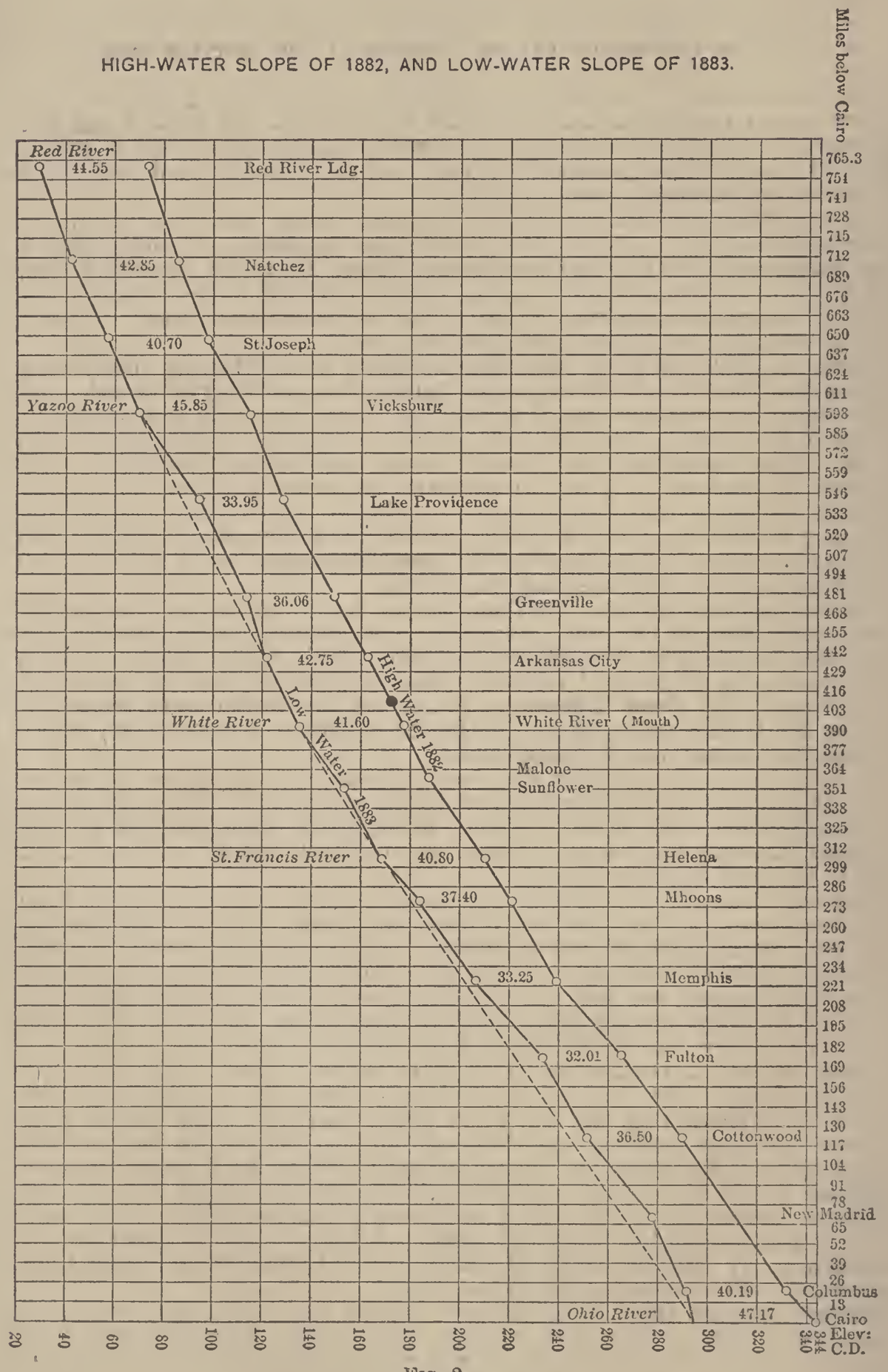

FIG. 2.

not the channel capacity of this strictly sedimentary stream be as great at one place as at another?

The condition in which the Commission found the river, and of which a description has been attempted, is the result of many centuries of alternation of

channel depletion and enlargement at every flood stage. It is not to be expected that an accumulation of deposit, almost geological in its age and its mass, will be removed by five or ten years of levee improvement, or by a few great floods occurring at intervals of five or six years. But, with the force and time we have on hand, the result is not in doubt. The evidence of a start in this direction is given in a previous part of this discussion.

The result of all observations seems to show a general tendency to an enlargement of the stream, that its capacity for flood discharge has been more than maintained, and that the apprehension of its deterioration, from natural causes, or from levee building, may be dismissed as, at least, unproved, if not disproved.

Consideration must also be given to the floods of the future, which will seek an outfall through the channel below Cairo. Will they be of greater volume than those of the past? They come from four sources, the upper Mississippi, the Ohio and the Missouri watersheds, and from the tributaries of the main trunk below Cairo. It may generally be stated that, when the first three form a combination which causes a dangerous stage on the lower Mississippi, about two-thirds of the discharge, or 1,000,000 cubic feet per second, is contributed by the Ohio. This is the controlling factor in great floods.

While the relation between deforesting and precipitation is assumed rather than established, there is no doubt that the processes of clearing, draining, and cultivating may materially affect the distribution of the run-off, delivering to the streams of outfall a larger share in a shorter time, and tending to higher high waters and lower waters. Under certain topographic conditions, these results may be limited and even reversed. It is, therefore, an important part of this discussion to consider the bearing which the conditions of the four sources of supply have had, and will have, upon the high waters of the lower Mississippi.

It seems probable that the future changes in the flood conditions in the upper Mississippi Basin will be slight. The forests, or those having commercial value, have been very largely cut down, cultivation under improved methods is already greatly extended, the reservoir system may be increased, and while the projected discharge of the Chicago Canal, constituting about one-tenth of the low-water discharge of the river below Cairo may be appreciably beneficial to low-water navigation, its contribution of about one-half of 1 per cent to the flood volume is too small for consideration.

It is unfortunate that the records do not extend far enough back to give a life history of these tributary rivers, the gauges having generally been established within the last thirty years. Fortunately, since it bears on the most important flood factor, Cincinnati is an exception, having a continuous record of forty-five years. An examination of this shows that, if this period is divided in halves, the average of flood heights on the Ohio in the first half is 48.80, and in the second 52.37 feet. If, however, it is divided into thirds, they give the following relation of averages for the three periods: 48.51, 52.57, and 50.69 feet. For low water the average result for half periods is 3.80 and 3.86 feet, and for thirds is 3.83, 3.60, and 4.06 feet. It does not appear, therefore, that on the Ohio River, for the last forty-five years, there has been a progressive change to higher high waters to lower low waters (although the processes to which such a result is usually attributed have presumably continued), but rather that some conservative or restorative influence has been in operation.

The high and low waters at Cincinnati for the period under consideration are shown in fig. 3.

The physical conditions in the basin of the Missouri are materially different from those in the Ohio. Except about the headwaters, it is a region of gentler slopes, largely without forests. Its progressive occupation and cultivation will be accompanied by plowing and planting surfaces which are now smooth and barren, and probably by a great development of reservoir building for irrigation. The tendency of these processes should be to check the rapidity with which its floods are discharged, and render less likely their coincidence with those of the Ohio, which generally culminate in February or March.

The tributaries below Cairo may be grouped together for consideration. While some of them head in arid regions similar to those drained by the Missouri, they generally flow through flat alluvial lands, where drainage is and always will be slow, and where the prevailing forests will be gradually replaced by a cultivation which will not materially hasten the run-off. With overflow excluded from the basins, there is no reason apparent why the natural discharge of these drainage systems should be materially increased in the future.

If not levees, what then? Reservoirs, or outlets?

The tendency of any extension of a reservoir system on the upper Mississippi or Missouri would be to abate floods on the lower Mississippi, but probably to a degree hardly appreciable. Such a system on the Ohio, if practicable, might produce more important results. But the late Milnor Roberts, past president American Society of Civil Engineers, closed this part of the subject forever in his most able report of 1870.

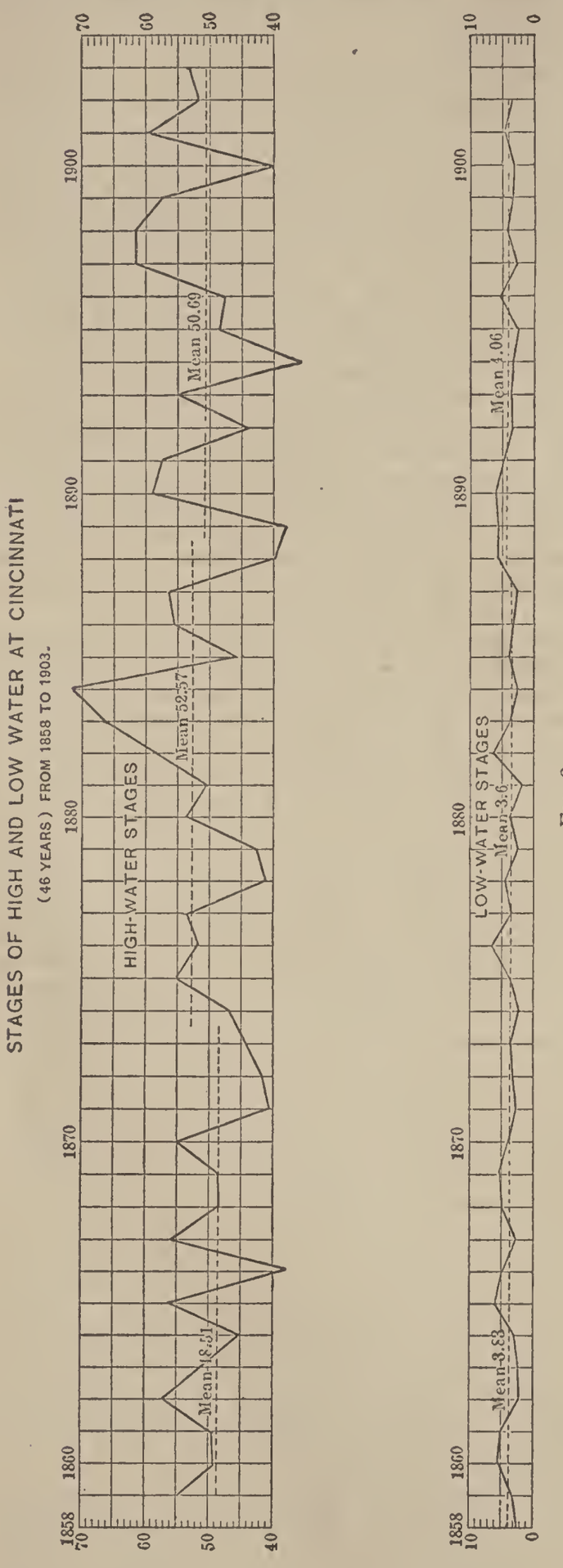

FIG. 3.

Outlets have received theoretic support in the report of Humphreys and Abbot, and of the United States Commission of Engineers of 1875 for the reclamation of the alluvial basin from overflow, but, after a detailed examination, they are unanimously:

"Forced unwillingly to the conclusion that no assistance in reclaiming the alluvial region from overflow can judiciously be anticipated from artificial outlets. They are correct in theory, but no advantageous sites for their construction exist."

The views on which these theoretical conclusions in favor of outlets were based, viz, that the bed of the stream was in a material so inerosible, and that changes in volume and velocity bore so little relation to scour or deposit, that its shape and dimensions would not respond to these changes, have not been upheld by more recent and exhaustive observations. These show that the bed is in a material which is being moved by the current from day to day and from bar to bar, and that its shape and dimensions are the resultants of this force.

The experience in levee building is that the limit to which the use of the material and methods of their construction can be safely extended has not yet been approached. The larger levees, which reach, in sloughs or other depressions, a height of 30 to 40 feet, and even more, are generally considered as among the safest.

Many substitutes and reenforcements for the earthen embankment, of various materials and construction, wood, stone, steel, concrete, etc., have been proposed. But when all things are considered, including ease of construction, economy, and endurance, the outlook at present is that a carefully constructed earthen levee system, with sufficient grade and section, when properly cared for, presents advantages with which competition will always be extremely difficult.

There are two natural conditions prevailing on the Mississippi below Cairo

which add materially to the practicability and efficiency of the "levee system." One is the general presence of Bermuda grass, which grows with closely interwoven stems, attached to the ground by root tufts at close intervals, and forms a dense sod, presenting great protection against wave wash. The other is the high charge of sediment carried by the river at its higher stages. As the water seeps into and through the levees, it is filtered, the particles being deposited in the interstices of the soil of which it is built. The clear water percolates through to the land slope, while its charge of sediment remains and gradually diminishes the leakage.

The experience concerning the cost of making good the losses sustained by the existing levees, from caving banks and breaks from other causes, has been collated for the past eight years. It amounts annually, during that period, to a little less than 1½ per cent. The losses by the flood of this season and by certain important works of renewal now in sight will probably temporarily increase this annual cost in the near future. Also, as the levees approach the grade and section which it is considered necessary to give them, and their contents per linear foot are thus increased, the work of closing any gap that may occur will be proportionately greater. On the other hand, the better locations, construction, and care which are already made possible, to a certain degree, and which can in the future be practiced to a still greater extent, from the more liberal and regular supply of funds, should tend to a reduction of the annual losses from caving banks and the occasional losses from extreme high waters.

This increase of resources can be expected both from a fuller realization by the General Government of the importance of the work which it has undertaken, the reclamation from overflow, and the agricultural and commercial development of 20,000,000 acres of the most fertile soil, and from the increasing number and wealth of the communities now occupying and improving these lands.

The amount applied to the extension and improvement of the levee system of the lower Mississippi in the year 1900 was about $2,961,000. Of this, about $1,000,000 was allotted from the appropriation by Congress for the river below Cairo, and the remainder was supplied by the levee organizations of the riparian States. This is substantially the division of cost which has prevailed since the Government has shared in the construction of a levee system. Several of these local organizations now feel justified, by their experience with the "levee theory," to seek legislative authority for an increase of their contribution by additional taxation and bond issues.

When the levee system of the lower Mississippi shall have been completed, it will still be but an engineering structure, subject to the vicissitudes of time and accident. It will need constant care, and occasional renewal of parts. Crevasses will occur as long as trains are derailed, or collide, as ships are wrecked, or fireproof buildings are destroyed. A crevasse in the levee of the future will be a more serious disaster than in one of the present time, in proportion to its greater depth and discharge, and the greater improvements which have developed under its protection. But this is the case with all of our work, whose progress has not been deterred by the greater risks which are necessarily assumed in meeting the demands of modern civilization.

This discussion, already too long, will be closed with a short comparison of the floods of 1897 and 1903 and their results.

The computations of the discharge measurements of the last flood are not yet complete, but it is apparent that the maximum discharge of 1897 was slightly more than that of 1903. Greater heights were generally reached this year, mainly along the fronts of the basins where levees have made the greatest reduction in the overflow, but not at the mouths of the tributaries. This increased height was due both to the extension of levees along hitherto unleveed fronts, and to the improvement made in the existing lines since 1897, which enabled them to exert more resistance and control.

The greatest increase of flood height this year was about 3 feet at Memphis, where levees have been but recently extended. Nevertheless, there were, in 1897, between Cairo and New Orleans, a distance of 960 miles, forty-three crevasses, while during the past flood, so great had been the improvement of levees in the meantime, there were but six. While the limit of the overflowed area has not yet been completely ascertained, it is known to be reduced largely, if not quite in proportion to the lesser number of breaks.

Table No. 4 gives certain high-water records. In the third column is given a standard, adopted provisionally, as the heights which great floods might be

expected to reach when controlled by levees. The other columns are explained sufficiently by their headings.

The experience of 1903 makes advisable a revision of the provisional standard in the vicinity of some of the gauge stations.

TABLE No. 4.—*High-water records.*

Gauges.	Miles below Cairo.	Standard high water.	Highest before 1903.	Highest in 1903.	1903 compared with previous highest.	1903 compared with standard.
	Miles.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Cairo	----------	54.17	52.17	50.60	−1.57	−3.57
Columbus	21.3	48.10	45.58	44.40	−1.18	−3.70
New Madrid	70.3	42.90	41.50	39.50	−2.00	−3.40
Cottonwood Point	122.5	42.20	39.35	40.00	+0.65	−2.20
Fulton	175.4	40.40	38.30	40.10	+1.80	−0.30
Memphis	230.0	41.60	37.66	40.60	+3.00	−1.00
Mhoon	276.3	46.20	41.60	41.80	+0.20	−4.40
Helena	306.5	54.10	51.75	51.00	−0.75	−3.10
Sunflower	352.7	50.20	47.17	48.00	+0.83	−2.20
White River	393.2	56.40	52.42	53.70	+1.28	−2.70
Arkansas City	438.3	56.30	51.90	53.00	+1.10	−3.30
Greenville	478.3	50.50	46.75	49.10	+2.35	−1.40
Lake Providence	542.3	48.00	44.54	46.40	+1.86	−1.60
Vicksburg	599.3	55.00	52.48	51.80	−0.68	−3.20
St. Joseph	648.3	50.80	47.85	48.00	+0.15	−2.80
Natchez	700.3	54.00	49.82	50.40	+0.58	−3.60
Red River Landing	765.3	52.50	50.20	50.00	−0.20	−2.50
Bayou Sara	799.8	45.70	43.70	43.45	−0.30	−2.30
Baton Rouge	833.3	43.20	40.65	40.00	−0.65	−3.20
Plaquemine	854.1	38.70	36.25	36.10	−0.15	−2.60
Donaldsonville	885.4	34.95	32.75	32.10	−0.55	−2.75
College Point	904.5	29.80	27.95	27.80	−0.15	−2.00
Carrollton	957.0	20.35	19.17	19.40	+0.23	−0.95
Fort Jackson	1,039.0	8.00	7.20	8.00	+0.80	−0.00

It will be observed that no high water has yet reached the predicted standard.

The engineers engaged in the reclamation of the valley of the Mississippi River from overflow know more about levee building than they have yet had the opportunity of putting in practice. They are quite aware of many and much-needed improvements, both in their construction and in their care and preservation. Up to the present time the compelling need has been, and for several years will be, continuity of line, higher grades, and standard sections. Those used provisionally are everywhere below those considered safe for great floods, and the present contents of levees are not more than 60 per cent of what is considered necessary for satisfactory protection.

Yet behind this partial shelter population has increased, values have risen, wealth has accumulated, comfort and culture have developed, and great railroad systems have extended at such a rate that it can be said that the reclamation of this region is one of the most successful and beneficent public works now in progress.

J. A. OCKERSON, member American Society of Civil Engineers (by letter). In early days, prior to the advent of the levee system, the steamboat man and the passenger going down the Mississippi River saw a narrow strip of cultivated land along the immediate banks of the river. They did not realize that for 40 to 60 miles beyond that strip the alluvial basin was practically uninhabited and its rich soil untilled.

They saw the fields covered with water during flood times, to a depth of perhaps 3 or 4 feet, and very limited areas in certain localities, developed by radical changes in the regimen of the river, were known to be above water except during extraordinary floods. They did not appreciate the fact that perhaps 5 miles farther back the water was 10 feet or more in depth, that without levees to control the floods these great interior basins could not be inhabited or cultivated.

In the meantime systematic levee work began, and year by year the levees are gradually being brought up to such height as will finally effectually carry the greatest floods safely to the sea. These same men notice that the flood water on the battures and the lands between the levees gradually becomes deeper and the levees grow higher, and they conclude that if the levees can ever be made to control the floods at all they will ultimately "reach the tree tops

in height." They are fully convinced and most positive in their opinion that the increase in flood height is due to the raising of the river bed.

To the engineer it is no surprise that there should be an increase in the height of a flood confined between levees from 1 to 5 miles apart over that of a flood confined only by the hills that limit the basins with a width of 40 to 60 miles. More than that, the engineer, in the beginning of the work, computed the heights which the maximum confined flood would ultimatly reach, and the results have shown that his calculations are very near the mark.

Everyone familiar, even to a slight degree, with the physical characteristics of the river, has noticed the extraordinary local changes that occur in brief intervals of time. Very few, however, realize the fact that tangible changes in the general regimen of the river require long periods of time.

The belief among laymen that there is a general progressive elevation of the bed of the stream going on, which is augmented by levees, is widespread. Statements have been made, by those who ought to know better, that the bed of the river at New Orleans is higher than the adjacent land, while the fact is that the bed is some 200 feet below the land.

A former Secretary of War, in discussing this question with the writer, stated that he proposed to settle the vexing question himself by "measuring the river in several places." Just what he intended to compare the measurements with, or how he proposed to eliminate the effect of purely local changes, does not appear.

The statement that the Mississippi River Commission had already made many thousands of such measurements, covering some 425 miles of river, may have had something to do with the abandonment of his project.

Without any preconceived theory to prove, and with a view of simply ascertaining the facts in the case, the writer prepared in 1894 a project for a resurvey of the river from the mouth of the Arkansas River to Donaldsonville—a distance of 425 miles—and this project was approved by the Mississippi River Commission.

The first general survey had been made, much of it under the personal supervision of the writer, some twelve to fifteen years prior to that time. This first survey comprised accurate lines of levels, with established bench marks at intervals of 3 miles. Each line of soundings across the river (at frequent intervals) had its water-surface elevation determined by levels, hence an accurate cross section of the bed could be plotted. Surveys made at the later date, referred to the same bench marks and the same datum, gave reliable data from which to determine the difference in conditions at the two epochs.

A careful comparison of the two would, of course, disclose any general changes of considerable magnitude in the elevation or capacity of the bed.

The thousands of cross sections of the two surveys were carefully plotted, their respective areas measured, and their mean and maximum depths determined. Then comparisons were made between individual sections and between corresponding groups of sections comprising successive pools and crossings. All this entailed an enormous amount of painstaking work, and the conclusions are as follows:

The crests of the low-water bars, as well as the high-water bars, were found to be lower. About half of the total length resurveyed showed a depression of the thalweg, and about an equal amount showed a slight elevation, confined chiefly to the pools.

The results reached by this investigation are not as specific as might be desired, but it does not seem possible that such great elevations of bed as would be required to account for increased flood heights could escape detection.

Embracing, as it did, a comparison of 2,768 cross sections of the river, together with something like 150,000 elevations, it seems to prove beyond a reasonable doubt, if any such proof be really needed, that the elevation of a confined flood in the Mississippi is not due to the elevation of the bed of the river.

There is a still more simple proof which should be satisfactory to all, even if highly prejudiced against a levee system.

Gauges are established at intervals along the river, and are connected with several permanent bench marks in the immediate vicinity. Frequent inspections keep the gauge zeros at the same height from year to year. The readings are taken by reliable observers, both morning and evening, and a continuous record is thus maintained throughout both high and low waters.

These records show in the most positive way that the low waters of recent years are several feet lower than those of earlier years, with equal volume of flow and with equal channel depths.

Only one explanation of this condition is possible. It points unerringly to a depression of the bed of the stream, and should effectually set at rest any fears that there is such a thing as a tangible progressive elevation of the river bed.

During the height of the flood of 1903 the Mississippi River Commission viewed the river from St. Louis to the Gulf of Mexico. Anyone who could have seen, as they did, hundreds of miles of levee intact, the farmers behind them busy plowing and planting, the fruit trees in bloom, the stock fattening on the green herbage, would surely have been impressed with the efficacy, the necessity, of levees.

Add to this the knowledge that the levee system had served to fill with thrifty settlers the fertile basin where life without levees would be impossible, and it becomes incomprehensible how anyone can oppose the completion of the levee system, unless it be on the score of ignorance as to the facts in the case.

Contrast the peaceful condition of things where levee protection exists with the suffering and misery during a flood along the unleveed portions of the river, as revealed by a trip along the river during any flood, and no argument is needed to demonstrate the wisdom of a perfected levee system.

That occasional breaks should occur in levees, partially completed as to both height and section, is by no means surprising. They are to be expected, and they may occur under great stress on rare occasions even in a completed system. But the area flooded and the damage done on such occasions will be trivial as compared to that of the general flooding of the entire basins under the "no levee" system.

The argument that the floods should be permitted to fill the basins in order that the sediment might build them up, so as to reach ultimately a height above overflow, has no substantial facts to justify it. If it were practicable to deposit on the land all the sediment carried by the stream, it would still take a very great number of years to raise the general elevation of the 30,000 square miles of basins to any tangible extent. Then, too, the deposit could never reach the height of the rare, exceptional floods, and if the doctrine is true that the bed of the river is rising, the relative height of bed, banks, and flood would remain the same, and overflows would always continue.

There can be no reasonable doubt as to the possibility of constructing an effective levee system. Far more elements of uncertainty are involved in many engineering problems that have been carried to successful completion.

The engineers of this progressive age will not falter in their conviction that the floods of even the mighty Mississippi can be effectually controlled, and it is not likely that a nation with such great resources as ours, which has undertaken to make the deserts blossom, will hesitate to contribute generously to a project which has for its object the conversion of the vast alluvial basins into fertile fields tilled by a prosperous people, happy and contented in homes of plenty.

ENGINEER OFFICE, U. S. ARMY,
St. Louis, Mo., February 12, 1904.

HON. JOS. E. RANSDELL:

MY DEAR SIR: I have just received your letter of the 9th instant requesting my views regarding the much disputed question of levees and elevation of the river bed. In answer, I beg leave to state my conviction that the levees do not permanently raise the bed of the stream. It is of course obvious that, if waters, which at flood spread out under natural conditions over a width of 10 miles, are confined between levees separated by not more than 4 or 5 miles, there is bound to be an increase of flood height of the water, a fact which is becoming well known; but, at the same time, it must be remembered that this raising of the flood surface increases the velocity of the current and gives it greater scouring power and greater capacity to carry sediment. So it will be found that the total amount of sediment carried to the sea will not be less but rather more than if the floods could spread out over wide areas with more sluggish current. In fact, I believe that levees increase the flood heights, but actually decrease the low-water plane, or, in other words, depress the bed of the stream. The River Po, in Italy, is often quoted as an instance of levees raising the bed of the stream, and in actually crossing the Po, as I did in 1883, it seemed to me that the stream was really artificially elevated above the surrounding country, held in by its earthen walls, but the true condition was not what it seemed to be. The river was at flood, and of course the flood surface

was far above where it would have been under natural conditions, but measurements made about that time, I am told, showed that the bottom of the stream was below its original level.

Hoping that my views are presented clearly, and that my reasons therefor may be understood by yourself and the committee, believe me,

Very sincerely, yours,

THOS. L. CASEY,
Major, Corps of Engineers, Member Mississippi River Commission.

MISSISSIPPI RIVER COMMISSION,
Chicago, Ill., February 12, 1904.

Hon. JOSEPH E. RANSDELL,
House of Representatives, Washington, D. C.

DEAR SIR: I have to acknowledge the receipt of your favor of the 9th instant, in which you request me to state my views and my reasons for entertaining them upon the question, "Do levees cause the bed of the Mississippi to rise?"

Persons not familiar with the Mississippi may perhaps wonder why there should be any doubt upon this subject—why the facts should not be so well known that there can be no room for discussion. The explanation lies in the unstable character of the river bed. The bed is composed of an alternating succession of bars and pools, all in motion downstream. At one stage the bars build up and the pools scour; at another this process is reversed, and there is a leveling action. The river also has a motion sideways, due to erosion on one side and accretion on the other. Evidently any general law, such as the raising or lowering of the river bed, if there be such a law, can be detected only after prolonged observations and intelligent study.

The Mississippi River Commission has given much attention to these observations. In 1894, 1895, and 1896, a complete resurvey of the river where most completely leveed was made from the mouth of the White to Donaldsonville, La., a distance of 472 miles, and careful comparisons were made with the previous survey of 1881, 1882, and 1883. Nearly 3,000 cross-sections of the river, with about 150,000 elevations, were compared, involving an enormous amount of labor. The result was to show no evidence whatever of a rising of the bed.

On the other hand, the gauge records give some evidence that the bed has been lowered by the levees. A careful comparison of the low-water readings of ten gauges between Cairo, Ill., and Carrollton, La., was made by Major Harrod, for the periods 1872 to 1887, and 1887 to 1902, using the average for the sixteen years of each period. As a general rule, the low-water surface was at a lower level during the second period than during the first. That there was no great difference in the quantity of water flowing is shown by the fact that the reading of the Cairo gauge was essentially the same during the two periods.

Theoretically, I should expect the levees to have a tendency to lower the bed in some small degree, but that the amount would be so small as to be of no practical importance. That they should have the effect of raising it, I can not conceive. The result of all the observations on the river so far is that there has been but little change, and that that little has been in the direction of lowering the bed.

Yours, very respectfully,

O. H. ERNST,
Colonel, Corps of Engineers,
President, Miss. River Com.

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124 EAST TWENTY-SEVENTH STREET,
New York City, February 15, 1904.

DEAR SIR: Your favor of the 12th is received. My opinion that levees have not caused a rise in the bed of the Mississippi is unchanged.

Very truly, yours,

C. B. COMSTOCK.

Mr. PATRICK HENRY,
Interstate Mississippi River Improvement.

WAR DEPARTMENT,
OFFICE OF THE CHIEF OF STAFF,
Washington, February 16, 1904.

MY DEAR MR. RANSDELL: I beg to acknowledge the receipt of your kind letter of February 15 asking my opinion as to whether the construction of levees upon the Mississippi River has a tendency to elevate the bed of the river.

This subject was treated very exhaustively in 1890 by General Comstock, then president of the Mississippi River Commission. The particular subject of your inquiry is referred to in General Comstock's paper, and will be found on page 3098 of the Annual Report of the Mississippi River Commission, 1890. I concur in the opinion therein expressed, which I have held from the beginning of my familiarity with the Mississippi River.

I do not think it can be doubted that the effect of levees has been to increase flood heights; the result at your own home, Lake Providence, exemplifies this in a marked degree. It does not necessarily follow that there has been any elevation of the bed of the river at low stage. I do not believe that there has been, nor do I believe there has been a progressive and continuous elevation of the bed for any long stretch of the river at any point in its course from Memphis through the levee district.

If you are not familiar with General Comstock's paper I advise you to consult it, because he includes in his examination not only the Mississippi River, but the Po, Hoang-ho, and the Yellow River, the most prominent examples of sediment-bearing streams.

Very respectfully, your obedient servant,

G. S. GILLISPIE,
Major-General, General Staff.

Hon. J. E. RANSDELL,
House of Representatives.

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