51ST CONGRESS, 2d Session. } HOUSE OF REPRESENTATIVES. { REPORT No. 3767.

CEDING THE ARID LANDS TO THE STATES AND TERRITORIES.

FEBRUARY 11, 1891.—Committed to the Committee of the Whole House on the state of the Union and ordered to be printed.

Mr. VANDEVER, from the Select Committee on Irrigation of Arid Lands in the United States, submitted the following

REPORT:

[To accompany H. R. 12210.]

The Select Committee on Irrigation of Arid Lands of the United States, to whom was referred the bill (H. R. 12210) to cede the arid lands to the States and Territories wherein they are situate, and to provide for irrigation and the protection of forest lands and pasture lands, and for other purposes, submit the following report, and recommend the passage of the bill with sundry amendments.

Mr. Herbert, of Alabama, and Mr. Lanham, of Texas, reserve the right to make a minority report favoring a general transfer of all the public lands undisposed of to the States within which they are situated, as indicated in H. R. 12709, introduced by Mr. Herbert.

It is estimated that two-thirds of the agriculture of the globe at the present day is dependent wholly, or in part, upon artifical irrigation for success. Irrigation is an ancient art, understood and practiced thousands of years ago, and quite as well understood then as it is to-day. It has been from the beginning the most effectual means by which man is enabled to fulfill his mission of subduing the earth.

Direct rainfall in many populous lands is found to be inadequate for the production of crops and the support of the people. Copious rains and melting snows at the sources of streams in high mountains often cause floods more destructive than beneficial to the cultivators of the land in the valleys where showers seldom fall. In such cases methods for the restraint, storage, and application of flood water for agricultural use as it may be needed, becomes a necessity of the highest importance for the restraint of floods as well as for the prevention of drought and famine.

Major Powell estimates that two-fifths of the total area of the United States, excluding Alaska, requires artificial irrigation to reclaim its soil to fertility and productiveness. This arid region, available chiefly for pasturage, lies mostly west of the one hundredth meridian of west longitude and embraces an area of 1,000,000,000 acres. The percentage of agricultural, of forest, and of pasture land in this region is computed by Joseph Nimmo, jr., a follows:

	Per cent.
Agricultural lands	18
Forest land	18
Pasturage land	64
Total	100

The agricultural lands of the arid region, those which may be most easily reclaimed by irrigation, amount possibly to 100,000,000 acres.

Most of the arid region is, properly speaking, pasture land. Notwithstanding the insufficiency of rain for agricultural purposes it is clothed with indigenous grasses, the buffalo, the gramma, and the bunch grass, which cure perfectly in their wild state, and are available summer and winter without cutting for grazing. Innumerable herds of buffalo formerly subsisted on these grasses, but now American cattle, sheep, and horses are fattened upon them in preparation for Eastern markets. Cattle kings and the cowboy succeed the buffalo and the Indian in the sovereignty of these plains. In the portion of the arid land capable of reclamation, if this bill should become a law, grazing will become associated with agriculture. Each of these interests will thrive and increase by associating with the other.

Three great transcontinental lines of railway cross these arid plains, uniting the East and the West by iron bands of dependent interest. Lateral branches from the main lines of these roads penetrate the intervening country. Mining enterprise, commerce, grazing, agriculture, and all the useful arts flourish; homes are established; cities and towns are built; education is encouraged; and new States are organized and admitted into the Union from this region. The interior of the continent can no longer be called the great American Desert, for now is fulfilled in it the saying of Holy Writ:

> The wilderness and the solitary place shall be glad for them.

The English common law of riparian rights requires that running water shall be permitted to flow in its natural channel and reach every riparian proprietor's land, unimpaired in quality and undiminished in quantity. In humid England, where frequent and abundant rains descend upon the fields, there is no occasion to divert water from the streams for the purpose of irrigation. But, in countries that suffer from deficiency of rainfall, the application of this rule is found to be a barrier to agricultural development. An older and more efficacious rule that has prevailed in all parts of the world from the earliest times where irrigation is essential to insure crops, is, that water may be diverted from its natural channels and distributed to lands more or less remote, for the purpose of irrigation, and owners of land on the banks of streams are protected in their right to use only so much water as they can apply to useful purposes. In California the conflict between the two rules has been sharp and virulent, but is at length happily settled in favor of the latter rule. The right to appropriate water for beneficial uses is recognized under the provisions of the Wright irrigation law of that State, and is sustained by the decisions of the courts.

Two and a half million acres have been reclaimed in California by irrigation works constructed at a cost many million of dollars by the people interested without a dollar of aid from the Government. Large areas of country remain to be reclaimed, owned by the Government and railroad corporations, and the question of what is necessary to be done to promote a general system of irrigation is becoming more and more pressing.

In Arizona, New Mexico, Colorado, Wyoming, Idaho, Utah, Montana, Nevada, Washington, the Dakotas, western Kansas and Nebraska, and in Texas, the people are deeply interested in the work of irrigation, and have made from their private means large expenditures to promote it. Without coöperation by the Government any general system for reclamation of the arid public domain will be found impracticable;

with encouragement by the Government it can become an accomplished fact and will prove a blessing to the present and to all future generations.

The average rainfall in the mountains of the arid region is estimated at from 50 to 75 inches, while in the plains it is from 5 to 15 inches. Twenty-eight inches of rainfall is necessary to insure crops in ordinary years. Forests will not grow where there is less than 25 inches of annual rainfall. The forests of the arid region grow at elevations of from 6,000 to 12,000 feet above sea level. It is contended that to denude the mountains of their timber will tend to lessen the rainfall upon them, and therefore the supplies of water for irrigation of the plains below will be seriously diminished. If this be so, and I see no ground for disputing it, then any plan to secure and retain mountain floods for irrigating the arid plains should include provisions for protecting the forests from needless waste.

The time has fully come when some adequate plan should be devised and enforced for the preservation of the forests from spoliation or waste. Proprietorship of the waters of the public domain should also be asserted by the General Government, and the control of them secured by a system that will secure a fair distribution to settlers upon lands reclaimable only by their use.

Public land should not be regarded by the Government as a source of revenue, but as a public trust to be transferred to the people in homestead tracts at the lowest possible cost.

The United States is reported to have expended for purchases and cessions of public lands	$88,157,390
Surveying and sale	46,663,302
Indian occupancy	187,328,904
Total	322,149,596
Received from sales	299,547,818
Excess	22,601,778

Most of the lands of the United States capable of producing crops without the aid of artificial irrigation have been disposed of. The whole area of the lands in the United States, excluding Alaska, may be classed under three general heads, namely, humid, subhumid, and arid.

The humid district lies for the most part east of the ninetieth meridian, and extends to the Atlantic shore, comprising within its limits probably four-fifths of the population and wealth of the country. Within this region the husbandman relies wholly upon the rains of heaven to irrigate his fields.

West of the ninetieth meridian, to the one hundredth of west longitude, the rainfall is only partially sufficient for the production of crops in ordinary seasons. This region is destitute of timber, except narrow belts near the streams that cross it, in their descent to the sea from mid-continent mountain ranges. It is a sparsely populated district of country available chiefly as grazing ground for cattle and sheep.

West of the one hundredth meridian, extending to the Pacific Ocean, the land for the most part is classed as arid, though it is not wholly so. The rainfall throughout this region, except on the mountains, is light, uncertain, and insufficient for the production of crops without artificial aid. The precipitation upon the mountains is copious, both of rain and snow. On the plains an almost perpetual drought prevails, which is the cause of the arid character of the lands.

Though nominally arid this region is not irreclaimably so. Experience demonstrates that extensive portions of it may be reclaimed by the introduction of water from accessible sources, and that by a system of artificial irrigation at least 100 million acres can be rendered even more fertile and prolific than the soil of regions where direct rainfall is ordinarily sufficient for the production of crops.

Major Powell, Director of the Geological Survey, estimates the extent of the arid public domain, west of the one hundredth dominion, as equal to about two-fifths of the entire area of the United States, excluding Alaska. Without the artificial application of water but a small part of this vast region can be made available for agriculture.

From the mountainous parts of this arid region, at elevations that attract the clouds, there is shed forth floods of water, now running to waste that can be utilized through the agency of a reservoir and canal system, for the reclamation of extensive tracts stretching away from their base.

To provide for the collection and storage of the copious water supplies found adjacent to the arid plains and to reserve the waters for distribution over large areas of the public domain, incapable of cultivation without their use, the following provision was inserted in the sundry civil appropriation bill of the Fiftieth Congress, approved October 2.

For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation and the segregation of the irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and the prevention of floods and overflows and to make the necessary maps, including the pay of employés in field and in office, the cost of all instruments, apparatus, and materials, and all other necessary expenses connected therewith, the work to be performed by the Geological Survey under the direction of the Secretary of the Interior, the sum of one hundred thousand dollars, or so much thereof as may be necessary. And the Director of the Geological Survey, under the supervision of the Secretary of the Interior, shall make a report to Congress on the first Monday in December of each year, showing in detail how the said money has been expended, the amount used for actual survey and engineer work in the field in locating sites for reservoirs, and an itemized account of the expenditures under this appropriation. And all the lands which may hereafter be designated or selected by such United States surveys for sites for reservoirs, ditches, or canals for irrigating purposes, and all the lands made susceptible of irrigation by such reservoirs, ditches, or canals, are from this time henceforth hereby reserved from sale as the property of the United States and shall not be subject after the passage of this act to entry, settlement, or occupation until further provided by law: *Provided*, That the President, at any time in his discretion, by proclamation, may open any portion or all of the lands reserved by this provision to settlement under the homestead laws.

The sundry civil bill, approved March 2, 1889, appropriated the further sum of $250,000 to be expended for the same purpose.

The money thus appropriated was to be expended by the Director of the Geological Survey under the direction of the Secretary of the Interior.

Preliminary to these provisions of the sundry civil bill, Senator Teller, of Colorado, in the Fiftieth Congress, introduced from the Committee on Public Lands the following joint resolution:

JOINT RESOLUTION directing the Secretary of the Interior by means of the Director of the Geological Survey to investigate the practicability of constructing reservoirs for the storage of water in the arid region of the United States, and to report to Congress.

Whereas a large portion of the unoccupied lands of the United States is locatad within what is known as the arid region and now utilized only for grazing purposes, but much of which, by means of irrigation, may be rendered as fertile and productive as any land in the world, capable of supporting a large population, thereby adding to the national wealth and prosperity;

Whereas all the water flowing during the summer months in many of the streams of the Rocky Mountains, upon which the husbandman of the plains and mountain valleys chiefly depends for moisture for his crops, has been appropriated and is used for the irrigation of lands contiguous thereto, whereby a comparatively small area has been reclaimed; and

Whereas there are many natural depressions near the sources and along the courses of these streams which may be converted into reservoirs for the storage of the surplus water, which during the winter and spring seasons flows through the streams, from which reservoirs the water there stored can be drawn and conducted through properly-constructed canals, at the proper season, thus bringing large areas of land into cultivation and making desirable much of the public land for which there is now no demand: Therefore, be it

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior, by means of the Director of the Geological Survey, be, and he is hereby, directed to make an examination of that portion of the arid region of the United States where agriculture is carried on by means of irrigation, as to the natural advantages for the storage of water for irrigating purposes, with the practicability of constructing reservoirs, together with the capacity of the streams and the cost of construction and capacity of reservoirs, and such other facts as bear on the question of storage of water for irrigating purposes; and that he be further directed to report to Congress as soon as practicable the result of such investigation.

This resolution passed, and was approved March 20, 1888.

Immediately upon the passage of the act of October 2, 1888, authorizing irrigation surveys, active work was instituted by the Director of the Geological Survey, and, in compliance with the requirements of the law, the Secretary of the Interior issued his orders withdrawing from entry, occupation, and settlement all lands that might be affected by the act.

This withdrawal was found to interfere with the projects of a large number of persons and companies who had organized to seize upon the reservoir and canal sites in advance of the Government selections, and to acquire for speculation both the land and water designed by the act of October 2, 1888, to be reserved for actual settlers.

The irrigation clause of the act of 1888 was hailed as a beneficent provision designed to encourage the settlement of the arid region by guarantying to the settler, on easy terms, a supply of water for irrigation of whatever land he might desire to cultivate, free from the exactions of water or land monopolists.

No bona fide homesteader or settler on the public domain west of the hundredth meridian objected to the operation of the act of 1888, withdrawing or reserving from sale to speculators reservoir and canal sites and the land to be irrigated thereby.

Allow the water sources and reservoir sites in the arid region to pass under unrestricted control of monopolists, and the land to be reclaimed by irrigation might as well be granted to them at once, for the ownership of the water virtually gives them the land, and that is what they expect to achieve.

According to Major Powell, an average rainfall of 20 inches is required for the production of agricultural crops in ordinary seasons. By some it is placed as high as 28 inches.

If 20 inches of rainfall is the minimum at which agricultural crops can be produced, and 25 inches is required to make crops a certainty, and if, as is well known, the average annual rainfall upon the plains west of the one hundredth meridian, except in a few localities, is but a few inches, then the arid character of this vast region is accounted for, and the fact is made apparent, that without artificial irrigation it must forever remain uncultivated and barren except in the immediate vicinity of streams, where little labor is required to conduct water upon the land,

and where not much more than natural seepage is necessary for irrigation.

Twelve cubic inches of water artifically applied for irrigation is more than equal to 20 inches of natural rainfall, and renders the production of crops more certain from the fact that the irrigator fears no drought from lack of rain, but has water at his command in just such quantities as he requires and at the times when he most needs it.

It is therefore evident that the time has fully come when action should be taken by Congress and a permanent policy established, whereby the irrigable lands of the arid region west of the one hundredth meridian can be supplied with the necessary water for irrigation under Government control. If the enterprise is thought to be too great or beyond the proper province of the Government to undertake, or too expensive, then let the work be remitted to the States or Territories within whose boundaries the lands are situated.

About all of the serviceable agricultural lands at the disposal of the Government in the humid regions of the country have been disposed of, and the demand for more land is not abated. To appease or supply the demand for more land, millions are being expended in the extinguishment of Indian titles, for opening of new regions to settlement, and for the organization of new Territories or incipient States. What remains of the public domain lies mostly west of the one hundredth meridian and is arid or desert on account of limited rainfall, but can be reclaimed by the introduction of water from accessible sources, and be made marvelously productive and fruitful. Why, then, should the Government longer delay in providing for the reclamation and settlement of the arid region? New fields of enterprise will be opened to the people; the resources of unexplored regions be developed; great accessions be made to national and individual wealth; a peaceful solution of the Indian question be found, and the general prosperity enhanced by the settlement and cultivation of a vast area of the arid public domain, the benefits of which can not now be more than suspected and scarcely conceived.

Inasmuch as the inauguration of a general system of irrigation in the arid region, by the General Government, would be a measure of doubtful utility, and would require the expenditure of vast sums from the public Treasury, it is deemed expedient by your committee to provide only for the necessary surveys and segregation of reservoir sites and irrigation districts at the public expense as a part of the survey of public lands in the arid region, and that the districts and reservoir sites, together with the land embraced therein, be granted to the States, upon condition that the States provide for the organization of irrigation districts and the construction of irrigation works, as provided in the bill herewith submitted, the passage of which is recommended, with amendments as follows:

After the word "irrigation" in line 8 of section 1, insert the words "including underflow and artesian water."

Strike out the word "ceded" where it occurs in line 2 of section 2, and insert in lieu thereof the words "and are hereby granted."

After the word "conditions" in line 4 of section 2, insert the words "and provisions."

After the word "irrigation" in line 34 of section 2, insert the following:

Provided, however, That when the boundaries of an irrigation district, surveyed and platted in pursuance of the provisions of this act, shall be found to extend into adjoining States and Territories, the grant of arid lands for irrigation and other useful

purposes as provided in this act shall not become operative therein until the said adjoining States and Territories have respectively assented by law to the formation of irrigation districts lying partially within the jurisdiction of each, and shall have provided for the organization of the same. And not until it shall be made to appear to the satisfaction of the President of the United States that such laws have been passed by the respective States or Territories within the boundary of which irrigation districts are partially located, shall he authorize the issue of patents for land in districts thus situated.

The bill as amended will read as follows:

A BILL to cede the arid lands to the States and Territories wherein they are situate, and to provide for irrigation and the protection of forest lands and pasturage lands, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior shall cause the arid lands of the United States, where irrigation is necessary for successful agriculture, to be surveyed and platted into irrigation districts in such a manner that each district shall consist of a basin for the collection, storage, and distribution of water to be used in irrigation, including underflow and artesian water, together with the catchment area and the sites for reservoirs and all the irrigable lands on which the waters of such irrigation district can be used for irrigation.

SEC. 2. That the lands embraced in irrigation districts as herein provided shall be, and are hereby, granted to the several States and Territories in which they are situate, for the purpose of reclamation and settlement, upon the following conditions and provisions, to wit:

First. It shall be incumbent upon the State or Territory to provide that the qualified voters of each irrigation district may organize as a body corporate and politic for the purpose of controlling water for irrigation and for other beneficial purposes, and for the construction of irrigation works by any of the methods, to wit: First, by the sale of the irrigable lands; second, by the co-operation of the people interested therein; third, by taxes levied on the lands irrigated; fourth, by the issuance of irrigation district bonds, the interest and principal to be paid by taxes levied on the lands irrigated; fifth, by granting to persons and corporations the right, and imposing on them the duty, of supplying water for irrigation and other beneficial purposes through the agency of irrigation works for a term of twenty-seven years, and by further providing that at the expiration of such term of twenty-seven years from the beginning of the first service of water the rights and duties of such persons or corporations shall terminate, and all such irrigating works shall thereupon become and be the property of the respective irrigation districts to which they pertain; then in such case the people of each irrigation district, in their corporate capacity, may use and control the reservoir sites for the storage of water for agricultural and other beneficial purposes.

Second. It shall be incumbent upon the State or Territory to select the suitable irrigable lands to be disposed of by the State or Territory, as hereinafter provided, and the residue of lands in the irrigation district shall be declared timber lands and pasturage lands, to remain the inalienable property of the State or Territory as catchment areas for the water to be used in irrigation: *Provided, however,* That when the boundaries of an irrigation district, surveyed and platted in pursuance of the provisions of this act, shall be found to extend into adjoining States or Territories, the grant of arid lands for irrigation and other useful purposes, as provided in this act, shall not become operative therein until the said adjoining States and Territories have respectively assented by law to the formation of irrigation districts lying partially within the jurisdiction of each, and shall have provided for the organization of the same. And not until it shall be made to appear to the satisfaction of the President of the United States that such laws have been passed by the respective States or Territories within the boundary of which irrigation districts are partially located, shall he authorize the issue of patents for land in districts thus situated.

SEC. 3. That any State or Territory in which are situate any of the irrigation districts provided for in this act shall have authority to dispose of the irrigable lands by sale to actual settlers in tracts not greater than ——— acres, the proceeds of such sale to be used in the construction of the irrigating works necessary for their reclamation.

SEC. 4. That any State or Territory in which are situate any of the irrigation districts provided for in this act shall have authority to provide by statute for the use and protection of the forests of the timber lands and the use and protection of the grazing on the pasturage lands by the citizens of the irrigation districts.

SEC. 5. That this act shall not be construed to convey to the States or Territories any mining lands or coal lands included in the timber lands and pasturage lands, but

such mining lands and coal lands shall be subject to acquirement under the statutes of the United States providing for the disposal of such mining lands and coal lands.

SEC. 6. That whenever the governor of any State or Territory wherein are situate any of the irrigation districts provided for in this act shall have certified to the President of the United States that the provisions of this act have been complied with by such State or Territory, and shall have properly exemplified the same, and if the President shall find that such provisions have been properly complied with, he is hereby authorized to issue his proclamation setting forth the facts and declaring that such State or Territory and the people of such irrigation districts are entitled to the benefits of this act, and thereupon this act shall have full force and effect.

APPENDIX A.

As an indication of the wonderful transformation that has been wrought in Southern California under the operation of the Wright irrigation district law, the following extracts are made from a report recently submitted by Hon. L. M. Holt to the State board of irrigation:

The public, and perhaps many members of the legislature, are not aware of the immense interests at stake to-day in this State by virtue of the Wright irrigation district law. I, therefore, present herewith a few figures, showing the extent of that interest, giving a list of irrigation districts in the State, their acreage, bonds voted, bonds sold, amount of bonds per acre, etc.

Here we have twenty-eight irrigation districts in the State, five of which are in the Sacramento Valley, eight are in the San Joaquin Valley, and fifteen in Southern California. Twenty-five of these districts have voted bonds to the extent of $11,092,000, and thirteen of the districts have sold bonds in whole or in part to the extent of $3,975,000. In this list I include the Alessandro district, which will vote its bonds in a few days and have them already contracted to be sold. I have no data at hand to show the assessed valuation of the districts, but a careful estimate will give the figures as follows:

Sacramento Valley districts	$10,141,500
San Joaquin Valley districts	21,003,240
Southern California districts	14,935,575
Total	46,080,315

These figures are made on the basis of values before irrigation works are constructed, and it is believed by those best competent to judge that these valuations will be doubled and even quadrupled in most cases within the next five years, if the irrigation works are constructed without great delays.

The districts which have voted bonds contain 1,382,090 acres, and the average amount of bonds per acre throughout the State amounts to $8.02.

In the Sacramento Valley the average amount of bonds to the acre is $4.85.

In the San Joaquin Valley the average amount of bonds to the acre is $5.55.

In the Antelope Valley, composed of cheap lands, the average amount of bonds to the acre is $7.02.

While in the districts of Southern California proper the average amount of bonds to the acre is $32.58.

I give these facts that the public may judge of the extent of the irrigation interests at stake.

It is well in this connection to call attention to the rapid increase in wealth in the State occasioned by irrigation enterprises.

Wealth and increase of population go hand in hand. According to the Federal census this State has increased in population during the decade just closed 39½ per cent.

While the State has been jogging along at a moderate rate, somewhat faster than that enjoyed by the country at large, what have the irrigated sections of the State been doing? In San Diego County the increase has been during the past ten years 295 per cent.; in Los Angeles and Orange Counties, 244 per cent.; San Bernardino County, 227 per cent.; Fresno County, 228 per cent.; and Tulare County, something less than 200 per cent. Take out the rapid growth of these six irrigated counties, and the growth of the State would have been less than that of the nation at large, and the glorious State of which we all feel so proud would have practically come to a standstill.

The assessment rolls show a much larger increase of valuation in the irrigated counties of the State than the census returns do in the increase of population.

The six irrigated counties mentioned in 1880 had an assessed valuation of $41,121,782, while in 1890 they had an assessed valuation of $182,157,655, an increase of $141,006,573, an increase of 343 per cent., while some of the counties showed an increase of nearly 500 per cent.

While these six counties were increasing in wealth to the extent of $141,000,000, all the other counties of the State outside of San Francisco only increased in wealth $205,000,000.

It is true that irrigation alone is not responsible for all the increase in wealth in the six counties named, and it is also true that some of the other counties have used irrigation in a limited way, yet it is plain to be seen that a rapid development has followed the active extending of irrigation enterprises, and slow progress has been the rule elsewhere.

It is also plain that if the irrigation enterprises of the State were to-day wiped out of existence millions of property would be destroyed, our train loads of exports would cease to roll away over the mountains, the banks would lose their deposits, our people would lose their prosperity, and desolation would follow the thrift which to-day everywhere abounds in irrigated sections.

As an illustration of rapid development, attention is called to the Alessandro Irrigation district of 25,340 acres. Six months ago the land in that district could not be sold for $10 an acre, and, without irrigation, actual settlers could not afford to take it as a gift. As soon as it was decided to establish a district and irrigate the land, sales commenced, and up to date 8,400 acres have been sold for $560,000, in ten and twenty acre tracts, mostly to actual settlers, and the land is selling readily to-day for $120 an acre. If this increased valuation in that one district could all appear on the assessment roll it would show an increase in that one district alone of $2,787,400, and a State tax levy of 50 cents on the hundred dollars would give the State an increased income of $13,937 a year, which is more than the irrigation districts ask the State to contribute to the temporary support of a State board of irrigation that will be of great service in placing the irrigation districts on a solid footing, enabling them to further place their bonds and construct their works. Assuming that other districts in the State will show a similar increase of valuation, it is easy to see that the work of the irrigation districts will not only add increased wealth and population to the State, but they will give the State a largely increased revenue, and will be, two years hence, fully able to care for the State board of irrigation and their important work.

Last September a State irrigation convention was held at Tulare, which was attended by representatives from nearly all the irrigation districts of the State. At that convention the State Association of Irrigation Districts was organized. The second meeting of that association has just adjourned in this city. At the Tulare meeting a legislative committee was appointed, consisting of Hon. C. C. Wright, of Modesto; Will S. Green, of Colusa; E. H. Tucker, of Selma; J. W. Nance, of San Diego County, and L. M. Holt, of San Bernardino. This committee has been holding a joint meeting with the State association. They have perfected two bills to present to the legislature, one for the formation of the State Association of Irrigation Districts and the creation of a State board of irrigation, and the other proposes a few amendments to the Wright irrigation district act. The amendments proposed are few in number and make no radical changes in the law. No amendments have been recommended except such as have had the unanimous approval of all members of the association and committee. The members of the association and committee have had practical experience in the workings of the law, and they know what is needed to perfect the law and benefit the districts.

As evidence of the progress being made, it might be stated that at the Tulare meeting the report was published that the districts had sold their bonds to the extent of $1,672,000, while at this date—four months later—bonds are reported sold to the extent of $3,975,000, and much of this work has been the result of coöperation among the districts.

The supreme court has decided the Wright law constitutional by a unanimous decision given in banc, and all its decisions since the enactment of that law have been favorable to the districts; however, no radical changes should be made in the law.

APPENDIX B.

IRRIGATION IN THE UNITED STATES.

COMMITTEE ON IRRIGATION,
Thursday, February 6, 1890.

The committee, having under consideration House Bill No. 3924, this day met (Mr. Vandever in the chair) for the purpose of hearing statements in regard to the same.

Mr. LANHAM. It will be remembered by the gentlemen of the committee who were present at the first meeting after our organization that I brought to the attention of the committee a bill introduced by myself (H. R. 3924) relating to the "Irrigation of arid lands in the valley of the Rio Grande River, the construction of a dam across said river at or near El Paso, Tex., for the storage of its waste waters, and for other purposes." It was determined by the committee that we would endeavor to secure the presence of Major Mills, of the United States Army, who had been detailed at that point at the instance, I believe, of the Director of the Geological Survey to take observations with reference to the practicability and feasibility of the construction of this dam. Major Powell himself has been there and beheld for himself the situation. Major Mills has been acting under his directions, I believe, and I should like very much, as Major Mills is now present—and so is Major Powell—that we should have these gentlemen to give us what light they can upon this question this morning.

Major Mills is temporarily here; he has been detailed by the War Department to report and give his testimony touching this measure. Major Powell is with us at all times, and I think their concurrent testimony upon the question is important. If the committee would allow it, I would be glad to hear this question discussed this morning by these gentlemen in such order as may be desired by Major Powell. I would move, if it be in order, that we hear these gentlemen upon the question this morning.

Mr. HERBERT. In considering the statement of my friend from Texas, there are good reasons for hearing Major Mills now upon that topic, because he is here temporarily. I submit, after we do that, that it will be perhaps better to go on logically with the general subject. The stenographer will take down the testimony of Major Mills. Major Powell, who is present to hear that testimony, could now make any statement necessary to bring out the evidence needed from Major Mills. I would therefore submit that Mr. Lanham should modify his motion so that we take up Major Mills and examine him, in order to avail ourselves of his temporary presence, and then we can take up the other testimony more logically and go into the whole question, because I understand that this particular bill is simply a branch of the general subject upon which we want to get information.

Mr. LANHAM. It is a rather independent measure, I would state to the gentleman from Alabama, and I would like to have the statement and observations of Major Powell, which will not take very long, upon this particular plan in connection with the statement that Major Mills may make.

The CHAIRMAN. What do I understand the proposition to be now?

Mr. LANHAM. That we hear those gentlemen upon House bill No. 3924.

The CHAIRMAN. Is that the pleasure of the committee?

Major POWELL. Mr. Chairman, I think if I should be heard in this matter fully it would take a good deal of time, but I think in five or ten minutes I can outline the subject so that Major Mills's explanation of specific facts of that region will be a little more readily understood, and at another meeting I could take up the whole subject in discussing the Rio Grande.

The CHAIRMAN. We will hear Major Powell, if it is the pleasure of the committee.

STATEMENT OF MAJ. J. W. POWELL, DIRECTOR OF THE GEOLOGICAL SURVEY.

Major POWELL addressed the committee as follows:

Mr. Chairman and gentlemen of the committee, the valley of the Rio Grande which you see marked here [illustrating on map], is a great north and south valley, and irrigation has been practised in that valley for two hundred years by the Spanish people coming from the old country and Mexico. Of late years the development of the country has caused the subject of irrigation to receive a great deal of attention, and the waters which were formerly used in the lower part of the valley by the Spanish people—Pueblos—of that country, are gradually being taken away from them.

The Rio Grande heads in Colorado. Until of late years there has been practically no protection in that principal portion of the Rio Grande, and the people of Colorado have by the construction of canals irrigated about 3,000,000 acres in the State of Colorado. The Rio Grande heads in that State, and a very large portion of its water supply comes from the great mountains of Colorado. Then as we come down, the people of New Mexico, in the region of the tributaries of the Rio Grande are beginning to take out the waters of the tributaries of the Rio Grande. Then the people living below, at Albuquerque, Los Cruses, etc., are also beginning to take out canals, utilizing the waters of the Rio Grande. Now, the point is this—that the taking out of the waters for irrigation in the regions above so diminishes the supply of water in the Rio Grande below as to cut off irrigation during the critical season of irrigation, and especially during seasons of excessive drought, as the last two years have chanced to be in that region of country. Now the real point is that the waters which head in the mountains far to the north, and west, and east, fall above the waters which flow to the Rio Grande below and are distributed in the vast sand plains, so that, to irrigate 200,000 or 300,000 acres in the lower valleys of the Rio Grande, it would be necessary to protect those people, and that under the present conditions, without storage reservoirs, etc., it would be necessary to cut off some 4,000,000 or 5,000,000 acres above of waters which flow from the mountains and are lost in the sands. A river like the Rio Grande is like the Nile. Where the great

tributaries of the Nile unite, there is five or seven times as much water flowing into that river as there is at the mouth, because of the water lost in the sands and evaporated to the heavens.

The Rio Grande is a stream which illustrates that fact to a still greater degree. In ordinary seasons the waters above are from ten, twenty, fifty, one thousand times as much water up high in the river as down below in the river, because that evaporates on the way and is lost in the sands. Now, in late years, the cutting off of that water above for irrigating of vast areas comparatively has cut off the water they were using in the Messila Valley above El Paso and the El Paso Valley, and during the past year the supply has been cut off in two ways. It has been a dry season, and in a dry season the irrigation above has cut off waters from three to four hundred miles, and the river has been dry for—how long is it, Major?

Major MILLS. One hundred and thirty-seven days.

Major POWELL. The effect of that has been to cause the farming below El Paso, both on our side and on the side of the Republic of Mexico, to be destroyed. The winds are drifting sands here and there, and the farms, orchards, and vineyards are perishing. That has come to be a matter of international importance, so much so as to be looked into. That is the subject-matter of Mr. Mills's remarks to you.

Mr. LANHAM. I want to ask you a question. You were at El Paso in September?

Major POWELL. Yes, sir.

Mr. LANHAM. Did you examine the site of this proposed dam while there?

Major POWELL. I did.

Mr. LANHAM. What do you believe with reference to the feasibility and practicability of that plan?

Major POWELL. There is nothing difficult about it at all. It is perfectly feasible, and the chief difficulty will come—it is a pretty long story, but the chief difficulty is the vested rights. There are two railroads running through the valleys that have vested rights to the land which is to be flooded by this dam.

Mr. LANHAM. Did you have the testimony of Mexican people at Juarez, which is just across the river?

Major POWELL. No, sir; the committee did not take testimony in that direct way. They only took statements touching it.

Mr. LANHAM. Did not the committee take statements of Mexican officials?

Major POWELL. The Senatorial committee went across the line to look over the ground, and heard their speeches and statements in regard to the matter, but I believe they did not incorporate any portion of it in their testimony.

A MEMBER. Excuse me; there were several Mexicans before the committee from on our side.

Mr. LANHAM. These Mexican people, I have understood, have been deprived of water in consequence of these canals and ditches being taken out in the United States. That is the trouble with them.

Major POWELL. That is the state of facts.

Mr. LANHAM. You can give us full evidence upon this question hereafter?

Major POWELL. Yes, sir. It is quite a long and complicated question, which would take, perhaps, a session of the committee to give in full.

Mr. LANHAM. I trust the committee will now hear from Major Mills.

STATEMENT OF MAJ. ANSON MILLS.

Maj. ANSON MILLS, Tenth United States Cavalry, temporarily stationed at Fort Bliss, next addressed the committee. He said:

Mr. Chairman and gentlemen of the committee, my first acquaintance with the country on the Rio Grande, which Major Powell has described, was in 1858, when I went there in the interest of the Memphis, El Paso and Pacific Railroad, which was to cross at that point. I then got into the occupation of surveying lands, and surveyed almost all the Texas lands from the New Mexican boundary down to 100 miles below fronting on that river, and in that way I became very well acquainted with its characteristics. I lived there four years prior to the war. Since the war I have served in that locality and have been acquainted with the river ever since. About two years ago, while on leave of absence at El Paso, I was requested by some of my friends to project a remedy for the then decreasing water in the river, and the perishing of a great many farms, trees, orchards, and vineyards by the drought. I had explained previously to them about a natural basin for a lake above the pass.

El Paso is named after the pass in the mountains through which the river runs. Above that pass is the natural basin for a lake, and it is very easy to build a dam at that point and impound the water to almost any extent. You can make a lake there 50 miles long by building a dam high enough, and impound as much water in that way as the Rio Grande would furnish. I came on to Washington——

Mr. HERBERT. I would like to ask you a question there. What is the altitude of that proposed lake?

Major MILLS. The height of the lake?

Mr. HERBERT. No; the altitude from the sea.

Major MILLS. It is about 3,700 feet.

Mr. HERBERT. Would not the water evaporate more rapidly at that altitude?

Major MILLS. Yes, sir; I will give you my observations on that subsequently.

Mr. HERBERT. Then you will also speak of the bed of the lake and the material of which it is composed?

Major MILLS. Yes, sir; I have made a report and have it here with me. It is a pretty extended report and contains maps, etc.

Mr. HERBERT. I have not seen that.

Major MILLS. I came to Washington, and had an interview with Major Powell, and he took quite an interest in the subject. He had had the subject of water storage on his mind for some time before, and he recommended me to pursue investigations as far as practicable, and as it was an international question, he advised me to see the Secretary of State. I went to the Secretary of State and had a verbal interview with him, when he asked me to reduce my views to writing, and he afterwards printed it in a Government publication. Later on Major Powell induced the Secretary of War to detail me to duty at El Paso under his instructions to make the necessary investigations to determine whether such a scheme was practicable. One of my principal instructions in regard to my duty there was to cultivate friendly investigations in the matter between the people of this side and the people of Mexico, so in case a dam should prove practicable, I could find out whether the Mexican population would assent to it and would cooperate in it.

Mr. LANHAM. It will be observed by the committee—if you will allow the interruption—that this dam is proposed to rest one end on Mexican soil and the other on United States soil.

Major MILLS. Yes, sir. I think I had probably better go back and begin at a different point. At El Paso the river becomes the boundary line between the two nations, the Republic of Mexico and the United States. About 2 miles above El Paso, and below to the Gulf, of course, each country is supposed to have a joint interest in the waters of the river. These people, as stated by Major Powell, have had ditches for over two hundred years on both sides of the river in Texas and in Mexico, but they have been clamorous of late years for their vested rights in the water as against the people in Colorado and New Mexico, and that has now raised an international question. Texas has also raised a question between the State of Texas and the Territory of Colorado about these waters. I am now investigating a question of this kind in the Messila Valley above El Paso, extending 60 miles to Fort Seldon. In that valley they have had ditches for one hundred years in operation under the ancient Mexican method. Lately Americans have come in there and proposed to take out ditches on a grander scale, and consequently more economically, and yet in consequence of the scarcity of water the holders of the old ditches claiming prior rights have protested against this. This is a question that has been before both the Secretary of War and the Secretary of the Interior, and the hearings, I believe, are to be had to-day before them, the Secretary of War having given a revokable license to the company at Las Cruces to take out a large ditch, and he did that, as he informed me, on *ex parte* representations. Now he has suspended the license and is hearing the question as to whether it shall be restored.

I mention this to show the controversies existing there. In the mean time, the people of the El Paso Valley have protested to the Secretary against the regranting of that license and allowing a new ditch to be built. I believe this statement will give the gentlemen of the committee an understanding of some of the questions involved there.

The CHAIRMAN. In the construction of this dam at El Paso and bringing the water back into the Messila Valley, how much land now cultivated would be flooded?

Major MILLS. Very little land in the lake part. There would probably be about 1,000 acres in cultivation of the 26,000 to be flooded by the lake. There has been perhaps 2,000, but mostly by Mexicans who live in jacals, and it is not of any great value.

Now, the middle third of the Rio Grande, from a point about Albuquerque to the Presidio del Norte, has no confluents that throw water into it to maintain its flow. The flow comes from Colorado, and the head waters in the high mountains, from the drifted snow on the mountains melted by rains in the spring. The river has confluents above and below these points which are living streams and furnish the flow, but have none intermediate.

Mr. LANHAM. This dry portion extends down the Presidio del Norte about 200 miles, and the river is absolutely dry?

Major MILLS. Yes, sir; in 1888 the river was dry for sixty days during a portion of August, September, and part of October. Last year the river ceased to flow entirely about the 5th day of August, and did not commence its flow until December 20, one hundred and twenty-seven days.

Mr. LANHAM. How far did that extend above El Paso?

Major MILLS. To near Albuquerque.

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Mr. LANHAM. How far in distance?

Major MILLS. About 200 miles.

Mr. LANHAM. It became dry for 200 miles above and how much below?

Major MILLS. Two hundred miles.

Mr. LANHAM. General Stanley estimates in his report to the War Department that there is about 500 miles in all.

Major MILLS. That would depend upon whether he takes the meandering line of the river, or whether he takes a straight line?

The CHAIRMAN. After this long period of drought, during which the river ceases to flow, and there comes a flood, does the river remain in the same channel as it did before the drought commenced?

Major MILLS. I will come to that. The prime object in this project is to correct the boundary line between the United States and Mexico. I have maps here, and I will show you how this river changes. Within two months this river shifts its channel 4 to 5 miles, flooding the country so as to render the best bottom lands wholly valueless for cultivation, and it mixes up the boundary question between the United States and Mexico. There are tracts of thousands of acres now over which it is not positive which country has jurisdiction. This condition renders it very feasible to smuggle and to carry on thefts of horses from one country to the other, for a refuge for murderers and other criminals, who are a constant menace to the peace and good order of the people on both sides. It is a matter that must be remedied. There are two great troubles there; one is when the spring floods come, which begin about the first to the middle of April and last about three months. I have seen the Rio Grande when it appeared to be as large a stream as the Mississippi and to cover as much area. I have seen it flooding all over the whole country. This water, by the way, comes from the mountains in Colorado and from a part of New Mexico at seasons when they do not need irrigation. On account of the early frosts they are unable to plant there at that time, and these waters come unobstructed. Another difficulty is the dry season when the people lose their crops. We have had two such seasons, and the indications are that this year will be dry.

Mr. HERBERT. What is the population from El Paso to Presidio del Norte on both sides?

Major MILLS. It is about fifty thousand equally divided.

Mr. HERBERT. Is it not a very rich, productive valley?

Major MILLS. It is one of the richest and most productive valleys I have ever seen. I am pretty well acquainted with southern California, and I believe they can raise everything there except oranges that they can in southern California and abundantly, provided they had the water, but these floods and droughts prevent it, because the floods destroy the value of about one-third of all the land in both valleys, the Messila and El Paso. There is of land that could be cultivated in the valley of the Messila about 100,000 acres, and on the Mexican side in El Paso valley 100,000 acres and on the Texas side 100,000 acres which could be cultivated if they had the water. When a dry season comes like last year, most of the young vines and fruit trees perish, and if there should be a like drought the next year a greater proportion still, including the older ones would perish.

Mr. PICKLER. This drought of last year was excessive.

Major MILLS. The heavy drought of last year is probably to be attributed to a great extent to the slight fall of snow during the winter and the light rains. In my investigations I procured the report of the chief

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engineer of Colorado of the year before last, and he claims that three hundred and thirty-one ditches have been taken out of the Rio Grande and its tributaries in Colorado alone, and we understand they are still on the increase. Everywhere they are taking them out without any assurances that they are going to have water for them.

Mr. LANHAM. Have you any idea how many were taken out in New Mexico?

Major MILLS. Not nearly so many, because there are few tributaries in New Mexico that carry living waters. They are principally taken from the Rio Grande in New Mexico, but in Colorado a large portion are taken out from the tributaries. There are many ditches taken out there and many projected; one grand one of 40 feet width above Albuquerque, now in course of construction; and this one I am reporting on, in the Las Cruces Valley, is also about 40 feet wide, and it is proposed to take the water during August, September, and October to irrigate; and this is objected to by the people of the valleys below who claim prior vested rights.

Mr. HERBERT. Let me ask you a question on that point: You were in that country before the civil war?

Major MILLS. Yes, sir.

Mr. HERBERT. Was there any scarcity of water then?

Major MILLS. Yes, sir; about once in seven years there was a dry season, but not so excessive as lately. I never knew of two dry seasons coming together before.

Mr. HERBERT. Did the river ever go dry above El Paso before the war?

Major MILLS. Yes, sir; about once in seven years.

Mr. HERBERT. During the other six years how was it?

Major MILLS. There was abundance of water.

Mr. HERBERT. For all purposes of irrigation?

Major MILLS. In fact there was too much.

Mr. HERBERT. How much land was there in cultivation at that time?

Major MILLS. There was probably three times as much land in cultivation as there is at the present time. Perhaps on the Mexican side of the river in the El Paso Valley there was between 40,000 and 50,000 acres. On the American side there was between 20,000 and 25,000 acres. In the Messila Valley there was perhaps 45,000 acres.

Mr. HERBERT. Did I understand you to say there are fifty thousand on each side?

Major MILLS. Fifty thousand on each side.

The CHAIRMAN. Give us some idea of the Messila Valley.

Major MILLS. It is that valley of the river above the pass at El Paso and below Fort Seldon, which is 68 miles above El Paso.

The CHAIRMAN. That portion of the Rio Grande Valley between El Paso and Fort Seldon is called the Messila Valley?

Major MILLS. Yes, sir.

The CHAIRMAN. It goes down to Las Cruces?

Major MILLS. Yes, sir, and below to the Pass.

Mr. HERBERT. Thirty or forty years ago, was there any dry weather between El Paso and Presidio del Norte?

Major MILLS. I think the drought came all along, and that the river ran dry about Messila in former years on down to Presidio del Norte.

Mr. HERBERT. When it goes dry now, it is over the same region?

Major MILLS. No; it is dry now to Albuquerque.

Mr. HERBRT. Haw far is Albuquerque to Messila?

Major MILLS. It is about 200 miles.

Mr. HERBERT. So before the war it only became dry when there was a drought from El Paso down to Presidio del Norte, but now it goes dry from Albuquerque to 200 miles above Messila?

Major MILLS. Yes, sir. Now as to the remedy. As I stated before, when I went to El Paso in the interest of the Memphis, El Paso and Pacific Railroad, I was looking for a crossing of the railroad over that river. It was considered a more difficult task to bridge a river in those days than now. In this pass I at once saw an opportunity to build a dam and create a great lake, not only for the purpose of irrigating, but to control the great flood that destroyed everything in its course down. I had often spoken to the people about it there, and as I have indicated, I was ordered to make observations under directions of Major Powell. There were various steps to be taken and investigations to be made. One special one was the silt carried by the water, which was feared to be absolutely prohibitory, some intelligent people contending that the water contained such a large amount of silt that the lake would soon fill with solid matter and become useless. My investigations during the seasons of flow in the river for the past nine months have shown that that is a matter unworthy of consideration; that there is less than one-third of 1 per cent. of solid matter in the average at all stages of the river and at all stages of silt; that it would take the flow of the river about a year to fill the lake after it was dammed, and that it would take perhaps three hundred years to fill the lake with silt. Not counting the moving sand at the bottom or the detritus from the sides of the lake by storm floods, at all events it would take two hundred years to fill, and as we have no engagements beyond that time, I assume that it is not worthy of consideration.

Another thing was the evaporation. That is the greatest obstacle in the way. The evaporation will be between 6 and 7 feet off the surface.

The CHAIRMAN. Annual evaporation?

Major MILLS. The annual evaporation. There is a question, though, how far that will be of the whole surface of the lake. Our observations were taken in a narrow channel of the river, and after it went dry they were taken in pools, and I think that would be excessive compared with the evaporation from a large body of water like a lake would be. In other words, the dry air passing over a lake would become in the first few hundred yards so saturated with water that it would take up a less amount in passing over the remaining distance of the lake.

Mr. PICKLER. Is there much wind there?

Major MILLS. There is a little more than here, but not much more. There is wind in the spring when the evaporation is very slight. The evaporation now is about one-tenth of an inch per day, and the evaporation last August, September, and October was about half an inch a day. We gauged the flow of the river as far as we were able to, and we estimated that it would take about a year to fill that lake with water by the average annual flow of the river.

There are two locations that we found practical for building a dam. One is about 4 miles above the town at the head of the pass, and the other, which is the most feasible, is about 2 miles from the town. The lower one would have one end on the soil of the Republic of Mexico and the other would be in Texas. The upper one would have one end resting in Texas and the other end in New Mexico. The gentlemen of the committee will see that it would be more desirable, it being an international project, to have it where Mexico would have dominion over

one end of it. At the time I went to El Paso I found a Mexican federal engineer by the name of Garfias. He asked permission from his Government and received orders to co-operate with me in all my investigations, which he did. We concluded, after our investigations, that the project was feasible and necessary. I furnished him a copy of all the plans, specifications, and estimates, which he carried to the City of Mexico, and he reported to me on his return that he had had an interview with the President and the minister of public works, and minister of foreign relations, and had fully explained the matter; that they had expressed to him the opinion that the project ought to be carried out, and that they would forward these papers to our Government with such a recommendation; but that it would be necessary to refer the matter to a lawyer (they have no attorney-general) for investigation and report on the legal aspects. He has kept them in his hands, however, for nearly three months. They are very slow people there; they do everything to-morrow, and there is no telling when they will get through. There is no doubt, however, that they will approve the project. They propose to bear one half the expense of constructing the dam, but they claim that inasmuch as we have been depriving them of their vested rights in the water we should move the railroads and condemn the land.

Mr. HANSBROUGH. They would not receive one-half the benefit of irrigation?

Major MILLS. Yes, sir; and also the other benefits in the rectification of the boundary, and in the water-power created.

Mr. HANSBROUGH. I understand the dam is above the line?

The CHAIRMAN. He says an end will rest on each side.

Major MILLS. The site above the line would have the right bank about 500 or 600 yards above the line between New Mexico and old Mexico. The lower site, which is a more feasible one, would have one end in Mexico, and the other in Texas.

Mr. HANSBROUGH (referring to map). This is United States soil here?

Major MILLS. Yes, sir.

Mr. HANSBROUGH. Here is where the foundation of this would be?

Major MILLS (illustrating on map). No, sir; that is the line.

Mr. HANSBROUGH. This is Mexico and the dam would be here, or a little above here; therefore they would not have to take the water from the United States through here [illustrating].

Major MILLS. This is a map of the proposed lake, and the lower dam-site has one end in Mexico and the other end in Texas. The upper dam-site has one end in New Mexico and the other end in Texas, and would necessitate the carrying of water for Mexican irrigation through a quarter of a mile of American soil. I think there will be no question that the lower site would be chosen in preference.

The CHAIRMAN. Have you got an estimate of the volume of water to be in this lake and the cost of the construction of this dam?

Major MILLS. Yes, sir. The lake is about 15 miles long and from 3 to 3½ miles wide. It would submerge 26,000 acres of land. It would contain, when filled to the full line, 500,000 acre-feet of water. I did not know what an acre-foot of water was until Major Powell told me, and probably you gentlemen do not. He tells me an acre-foot is water enough to cover 1 acre 1 foot deep. There would be about 500,000 acre-feet of water in that lake, but it is proposed to have the reservoir consist of only 10 feet on top the lake; that is, the water would be taken out of the reservoir 50 feet above the level of the river. This 10 feet on top would embrace almost half the contents of the lake, being much longer and broader, and would contain 200,000 acre-feet of water.

The CHAIRMAN. Did I understand you to say a while ago that this volume of water would only flood about 1,000 acres of land that is now under cultivation? What proportion of land which is now under cultivation would be flooded by holding this water?

Major MILLS. On the Mexican side of the river now——

The CHAIRMAN. On the American side.

Major MILLS. There is perhaps 10,000 or 15,000 feet.

Mr. LANHAM. I do not think you understand the Chairman's question. He wishes to know what proportion of the land now under cultivation would be flooded by this water.

Major MILLS. It is less than 1,000 acres. We were some three months in making the survey. The first thing we did was to make a survey of the contour of the lake, the flow-line of the lake, which is shown here.

Mr. HERBERT. How wide is the Rio Grande where the dam is proposed to be built?

Major MILLS. The lower side is 500 feet.

Mr. HERBERT. And the depth there?

Major MILLS. From the surface of the water to the bed-rock?

Mr. HERBERT. Yes, sir.

Major MILLS. From the surface of the water to the bed-rock would be 22 feet at the deepest place.

Mr. HERBERT. With the river at what stage?

Major MILLS. At the stage of the water at which we made the survey, which was very low.

Mr. HERBERT. The water itself is 22 feet deep.

Major MILLS. No, sir; there was no running water in the river when we made the soundings for bed-rock.

Mr. HERBERT. Then you mean it will be 22 feet from the bed-rock up to the height you raise the water. I want to know how high the dam will be?

Major MILLS. The dam will be 65 feet above the level of the water at the time we made the survey.

Mr. LANHAM. How high are the mountains on either side of the pass?

Major MILLS. At the upper side 115 feet near the river.

Mr. HERBERT. If you raise that dam 65 feet, would it not endanger the town of El Paso below it; that is, in case of a rupture of the dam, would it be disastrous?

Major MILLS. Yes; in case of a rupture there would not be much left I suppose. It would utterly destroy the city and the valley below.

Mr. HERBERT. The whole town of El Paso is below the level to which you propose to raise this dam?

Major MILLS. No, sir; not the whole town. I live in a house above the level of the lake. That was jokingly referred to by some individuals, as evidence that I was afraid of my project. I am asked the question whether, if the dam should break, it would destroy the town and drown the people. I say it would, but there is not the slightest danger of the dam breaking if it is properly built.

Mr. HERBERT. What is the population of El Paso?

Mr. LANHAM. It is about 11,000 by the last estimate.

Major MILLS. I believe that is right. The flow line of this dam will be only 60 feet above the level of the water of the river. The dam is to be built 65 feet, so as to guard against a possible flow or cataclism or a tremendous rush of waters in the lake. The waste-weir or "by-wash," as it is called, will be over a little granite mountain where the fall would be gradual. It would be 200 feet wide, and there is no doubt it will

carry all the waters ever coming into the lake before it would rise 5 feet over the crest of the dam.

Mr. HERBERT. Does it carry it around the town of El Paso?

Major MILLS. No, sir; to the channel below, so as to avoid the danger of the dropping of water from the crest of the dam. It would endanger any dam for a great and heavy fall of water to drop 65 feet, as it would create a tremor in the walls of the dam.

Mr. HERBERT. Is there any opposition to the project among the people of the town of El Paso?

Major MILLS. No, sir; none at all, on either side of the river that I have heard of.

Mr. PICKLER. Who owns the lands of the Messila Valley?

Major MILLS. To be submerged in New Mexico there are two Spanish grants. No one has the title to any land that will be submerged in New Mexico. There is about one-third in New Mexico and two-thirds on the Texas side, which latter is owned by perhaps twenty or thirty parties. The upper portion of the land is held under an old Spanish grant confirmed and patented by Texas by a few individuals, which embrace several thousand acres, but there is none under cultivation. In framing a bill to carry out this work great care should be taken to provide for condemnation, for people want to get all they can, and I have no doubt some men would ask $100 an acre for land that is not worth 100 cents.

Mr. LANHAM. What is the value of land there at this time?

Major MILLS. It averages about $2.50 an acre. I have had 100 acres for about thirty years which I got for surveying this large tract, and it is the best land in the valley. I have offered it repeatedly for $3, and I could not get it, and still have to pay the taxes on it. I am willing to take that for mine, and I think $2.50 is a fair price, on an average.

Mr. LANHAM. I wish you would state to the committee what effect the proposed dam will have in reference to the correction of this boundary line?

Major MILLS. I was informed by Major Powell that he had no money to expend below El Paso, so I asked the county surveyor to make a survey of the meanderings of the river from Fort Hancock, which is 54 miles below El Paso. He took the records in the county surveyor's office of the meanderings of the river as it runs now, as it was in 1858, and as it was in 1849, and these lines represent the river as it ran at those different dates [exhibiting same on table before the committee]. This is a photograph from the map in which the scale was 2,000 feet to the inch, and of course being a photograph, I could not give the scale exactly. This is El Paso [illustrating]. This is the line between Mexico and New Mexico. Here is where the lake will be.

I want to state something on this question. It was urged by the people of El Paso that the Mexicans were violating the treaty of Guadalupe Hidalgo, and here is a report made by Major Ernst in regard to the investigation he made, showing how changeful the river is. When Major Ernst made his survey in 1855, the river ran here. This is where it runs now; the red line shows it. In 1827 the river ran here and it has been moving to this point [illustrating]. I simply show you this to let you understand it. You see here that this moving of the river has destroyed the best portion of the city of Juarez.

Mr. PICKLER. What is the name of that city?

Major MILLS. Juarez. It used to be called El Paso, but since we have named our town El Paso, they changed it.

The CHAIRMAN. What document is that?

Major MILLS. It is a Senate document of last session.

Mr. HERBERT. Is that on the same scale as this [referring to another map]?

Major MILLS. That is much smaller.

Mr. HERBERT. How much has it moved?

Major MILLS. It has moved from half a mile to a mile at different points. By taking up this map, you will see that this is the line of the river when I made my surveys in 1858. I can show you better on this, [taking another map]. In 1858, when I made the survey—this is my meandering line where the river ran at that date. Since that date the river has changed to this position [illustrating]. The next high flood in the river it will come here [illustrating]. The river floods and raises the banks by deposits, so that eventually that side of the valley becomes higher than the opposite, and the next unusual flood moves the channel to the other side of the valley. Sometimes the change takes place by erosion and deposit and sometimes by avulsion or cut-offs. I believe the treaty which fixes the boundary line between the United States and Mexico is generally understood to mean that when a change takes place under the water the boundary line moves with the river, but when by avulsion or a cut-off the boundary remains unchanged.

The CHAIRMAN. What is the boundary line of the treaty?

Major MILLS. I have the treaty here. Some people give it one construction and some another. Mexicans hold that the river should remain all the time where it was at time of the treaty. I do not feel competent to give it a construction other than I have mentioned; that is, the general theory, that the line moves with the river when an erosion or deposit takes place under water, but when an avulsion takes place then the line remains in the old channel. Here are some tracts of land marked B B. There is one 4 miles long and 2 miles wide, containing something like 5,000 acres. Five years ago the river ran here. This is Mexico on that side. It changed from here and ran where this dim line is. It was in red ink, and it did not take well in the photograph. The people live on the Mexican side of the river now, but in the United States. Formerly the Mexicans down here at San Ygnacio had a ditch right from the Rio Grande to irrigate their lands, and now they have to go 3 miles through Texas soil to take out a ditch from the river in Texas, and they have to bring that water 3 miles through Texan lands to irrigate this land, owing to the shifting of the channel of the river. All this is proposed to be remedied by the construction of this dam and reservoir. In the spring, before the floods come, the 10 feet of the reservoir will have been depleted of its waters by irrigation and maintaining a current in the channel of the river during the dry season, then when the floods from Colorado come from the melting of the snow, the reservoir will catch the flood waters and it will be feasible by gauge to allow just so much water to pass through to the river below every month in the year, and thus avoid any suffering from the drought, or any destruction to the banks by any overflowing and changing boundary line in the lower lands.

Mr. LANHAM. Do you think it possible to make a uniform flow of the river?

Major MILLS. There is no question about it if we can build this dam and reservoir.

Mr. PICKLER. What is the proposed length of the dam?

Major MILLS. The lake is a little under 15 miles long from the upper

dam site; it is 14⅔ miles long—you mean the dam. The dam at the upper site is 400 feet long, and at the lower 500 feet long.

The CHAIRMAN. What would be the abutments of the dam?

Major MILLS. The abutments at the lower site on the right bank, on the Mexican side, would be granite. There is a granite mound about 110 feet high on the Mexican side, and on the American side it is a conglomerate, principally of limestone, which is almost as hard as the granite.

The CHAIRMAN. What is the depth of the sand?

Major MILLS. At the upper site the maximum depth of the sand is 50 feet; at the lower site it is 22 feet.

The CHAIRMAN. Still you have not got the bed-rock when you get the water. How deep is it to bed-rock?

Major MILLS. Twenty-two feet is the deepest place at the lower site and 50 feet at the upper site.

The CHAIRMAN. There is an underflow at all times when the channel is dry?

Major MILLS. Yes, sir.

Mr. HERBERT. Have you made a calculation as to how many cubic feet of water passing out of these gates every day during the dry season would be required to maintain the water at a uniform volume?

Major MILLS. Yes, sir. From our investigations we have estimated that the mean annual flow would be 1,200 cubic feet per second, and that 400 feet (one-third) should pass the dam constantly to maintain a flow in the channel.

Mr. HERBERT. Have you put that in any report?

Major MILLS. Yes, sir. The flow in order to irrigate would depend entirely upon the number of acres to be irrigated on either side, and it is estimated that an acre foot of water would irrigate an acre of land.

Mr. LANHAM. You made a report to Major Powell?

Major MILLS. Yes, sir; I made a full report to Major Powell.

The CHAIRMAN. Give us an idea of the cost.

Major MILLS. The cost of the dam proper would be from $200,000 to $300,000, depending upon the site chosen, the upper one $300,000, the lower $200,000. The cost of the land would be about $75,000 to $100,000. The cost of the removal of the railroads is the largest item.

Mr. LANHAM. You have not explained that to the committee.

Major MILLS. No, I have not. If the gentlemen care for me to make a full explanation, it would be better to have it in another session, if you are willing to hear me, as it would take some time.

The CHAIRMAN. It seems to me this is a very important subject, and it is hardly worth while to let it go in the present state. I leave it to the pleasure of the committee.

The matter was here debated by the committee, and finally Mr. Lanham made the following motion:

I move we adjourn, to meet on Saturday next at 10.30 a. m., in continuation of the matter now under consideration, with the understanding that Major Powell and Major Mills are to be here at that time and give us additional facts upon this proposition.

The motion was agreed to, and thereupon the committee adjourned, to meet at 10.30 o'clock, Saturday, February 8, 1890.

COMMITTEE ON IRRIGATION,
Saturday, February 8, 1890.

The committee met pursuant to adjournment, Mr. Vandever in the chair.

STATEMENT OF MAJ. J. W. POWELL.

Maj. J. W. POWELL, Director of the Geological Survey, then addressed the committee as follows:

Mr. Chairman and gentlemen of the committee, since the last meeting I have prepared a map of the valley of the Rio Grande, from its headwaters to El Paso, the point where it becomes the boundary line between the Republic of Mexico and the United States, for the purpose of placing before you the general problems of that valley, especially those which bear upon the matter which was before you at the last meeting, relating to the utilization of the waters at El Paso. You will see the boundary line between Colorado and New Mexico here [illustrating]. I have divided the valley of the Rio Grande into subdistricts. In each district there are different problems, and yet to some extent they are interdependent, and all affect the problem of the use of the water in the Rio Grande at El Paso. In Colorado I have mapped out two districts. The Saguache district is drained by a stream which ordinarily does not flow into the Rio Grande. It is on rare occasions that the water of the Saguache flows into the Rio Grande. The waters are used and will be used in the immediate valleys. In Colorado we have the head of the Rio Grande as you see on the map. That portion of the river [illustrating] runs through the San Luis Valley, and it is claimed by an engineer to be sufficient to irrigate 3,000,000 acres of land.

Mr. HERBERT. Is that the State engineer of Colorado?

Major POWELL. No, sir; the most of that work is in the hands of an insurance company. An insurance company is investing its funds in the construction of canals and the purchase of lands, and is in part proprietor of the lands, but in the main is now proprietor of the irrigating works. Their engineer, Mr. Graves, tells me that they have already canals constructed and projected to irrigate 3,000,000 acres of land. If this is completed, it may be expected that all the waters falling north of this line will be utilized.

Mr. HERBERT. Do they impound any waters?

Major POWELL. Not yet.

Mr. HERBERT. Do they contemplate impounding waters under that system?

Major POWELL. Yes, sir; I understand they do.

Mr. HERBERT. So you think they will take up all the waters by this construction of canals?

Major POWELL. Yes, sir; if they complete their system they will do it. They have spent several million dollars, I understand, in that valley.

Mr. HANSBROUGH. Where will they impound that?

Major POWELL. At various places along the stream tributary to the Rio Grande.

Mr. HERBERT. Who did the surveying?

Major POWELL. Their own engineer, Mr. Graves, so far as it has been done at all.

Mr. HERBERT. Did he utilize to any extent the surveys made hereto fore by the Geological Survey?

Major POWELL. None have been made.

Mr. HERBERT. Colorado was surveyed by——

Major POWELL. By Hayden.

Mr. HERBERT. Did they not utilize Hayden's survey to some extent?

Major POWELL. They had a general map. Hayden's surveys did not take into account the hydrographical conditions.

Mr. HERBERT. They marked it off—what do you call that system of surveys—it escapes me at the moment—by which you get levels?

Major POWELL. Contours.

Mr. HERBERT. Have you made contour maps?

Major POWELL. In the Hayden survey the contours were 200 feet apart, and were not available for this purpose. Near the State line the Rio Grande enters a cañon, and there is no irrigable land on either side, that is, not to amount to anything, after reaching the point here.

Mr. HERBERT. If it will not interrupt you, before leaving Colorado here—it was stated yesterday by Major Mills that there had been three hundred and thirty-one ditches or canals made in Colorado.

Major POWELL. These are scattered in this system I am speaking of. This company has taken up the canals, and consolidated them, and has taken old Spanish grants and bought titles to some of the land and has taken options on other lands. This is the system which is prevailing very largely in the West.

Mr. HERBERT. Does any railroad run through that?

Major POWELL. Yes, sir; here is the Taos district, which lies in here, and is drained by the Taos River, which ultimately will have all its waters used. Here we anticipate that no water will be fed to the Rio Grande ultimately.

The CHAIRMAN. You know the Taos district has been a rich agricultural district for many years. I know in early times all our supply of flour came from the Taos Mills, carried over the Urus Mountains by bullock teams.

Major POWELL. The Chama River comes next. There is a good deal of irrigation by the Chama, but it is difficult to store and manage its water; but it is anticipated that all the waters of the Chama will be utilized in its valley, so that ultimately all its water will be kept from the Rio Grande. I am going to show what waters will be left for these people of the lower Rio Grande.

The CHAIRMAN. In that connection allow me to make this statement. There are two great pueblos, village settlements, originally the pioneers of this system of irrigation in a rude way, and from whom we have gotten a good many ideas about it.

Major POWELL. These people probably irrigated a thousand years ago; that is, the Indian inhabitants.

Mr. HERBERT. Are the remains of their ditches perfectly apparent?

Major POWELL. Not always; but they are sometimes. They are all irrigated in a small way.

The CHAIRMAN. Many of the descendants are still living there?

Major POWELL. Many of them are living there. There are twenty-nine of those pueblos within the territory of the United States. The next is the Española or San Il Defonso Valley, which is mostly irrigated from small streams that come from the great mountains on the east—a great system of mountains—and there are ten or a dozen Indian villages in the valley supported by irrigation. There are also a number of Mexican settlements dependent on irrigation. The valley is a large

and beautiful one, and a great area can be utilized by taking the waters which fall on the mountains and come down through Embudo Cañon to be spread upon this valley. So up to this point at the foot of Española Valley all the waters of the Rio Grande will be cut off ultimately. Going from this point down to that point [illustrating], about 50 miles by the windings of the cañon, there is a deep gorge varying from 600 to to 1,000 feet in depth. There is no land along the streams that come from very high mountains, on either side, streams which furnish a large body of water that can be taken out above Bernalillo at the mouth of White Cañon.

Here is Santo Fé Creek. We have completed a survey of the Santa Fé Creek. Already there is a great deal of irrigation along it. All the civilization along the Santa Fé Creek depends upon that stream, and it will be taken up. Here is the Tewan Plateau, drained by the Jemez, which is a little stream. I have brought the map of the Jemez as an illustration of this district, showing how the waters of the Jemez district will be cut off, so that it will not contribute anything to the Rio Grande. The irrigation survey has extended over only three regions in the Rio Grande; so what I say is from general information and a study of the subject in that region of country, in which I have traveled a good deal in the last twenty years; but the Santa Fé Creek and the Jemez River districts have been surveyed, so what I say about them is from actual survey. What I say about the rest of the country is from general information.

Here is the creek which you see on the map heading in the Tewan Mountains. The Tewan Mountains are volcanic. The mountains rise from 9,000 to nearly 12,000 feet above the level of the sea, and hence there is a great condensation of water, the rain-fall is great. High up in these mountains are many beautiful meadows. Its valleys are timbered in part, and there are many beautiful meadows and a great many beautiful streams of water, small creeks—rivers they call some of them—that all unite and form the Jemez River. The Jemez, after it emerges from these mountains, has to pass over a sand plain of about 26 miles in width, and it loses its water largely; and although it is always a large river above it sometimes gets dry near its mouth, and it never discharges into the Rio Grande more than a small part of the water coming from the mountains. In order to utilize the Jemez it has to be taken out above, and it must be managed in this way. I have surveyed seven reservoir sites in the stream above, and I have made plans not yet complete, but which for the purposes of this exposition are sufficient. The waters can be taken out at this point with a diverting dam here [illustrating].

On these plains, on the mesa back of Bernalillo and Albuquerque, are the lands on which the water can be used. At present that river —I am speaking from memory—is able to serve about 1,600 acres of land. It is estimated that by storing the water and taking it out at the foot of the mountain before it enters the sands, about 150,000 acres can be irrigated by the storage of the water and the construction of canals. It is manifestly to the interests of the people that this should be done, rather than by some process it should be declared that the waters must flow into the Rio Grande in order that they may be used below; for if used below they will irrigate but hundreds of acres, while if used above they will irrigate thousands. It is an important question of public policy whether to establish water-rights to irrigate thousands of acres in the lower regions or to establish right to irrigate millions of acres above. That is the problem confronting us everywhere in the valley of the Rio Grande. In all the regions I have mentioned should

it be declared by the courts that the waters of the upper region must flow to the lower region, it would cut off millions of acres that can be irrigated above to supply a few thousand acres below. So it is necessary for the ultimate development of that country that the people of Colorado be allowed to use the waters of that State, and that the people of the upper tributaries and upper valleys of New Mexico be permitted to use the waters there as they have been doing. But that means that the waters must be cut off from below; yet they have rights which cannot be ignored. The established but comparatively small industries below ought not to be ruthlessly destroyed that great industries may be developed in the future.

The CHAIRMAN. Do you know the proposition is to dam the river below and catch the surplus of water that flows in it during the flush season of the year?

Major POWELL. I will bring that point out, Mr. Chairman, before I get through. The Jemez and the Santa Fé will all be taken out and utilized above, so no water will be contributed in flood time. Now, understand, I am not speaking of what it is now, but what it will be ultimately. They will store the waters and cut off the floods and the waters which run down during the season of irrigation, and we must look ahead a little. It will be but a little time until they cut off all the flood waters above White Rock Cañon, and there will be no waters to store for the lower region. From the mountains on either side a large body of water will always flow through this White Rock Cañon, and at its mouth the waters can be taken out. The present flow of the river during the season of irrigation is already utilized by the Mexican and American settlements from this point down to Fort Selden. The waters in the dry season are taken up now by the settlers, and the increase of the area of irrigation has to depend upon the utilization of the flood waters. All the increase has to depend upon the utilization of the flood waters.

Now, the proposition is to collect these flood waters at El Paso, far below. That is the proposition laid before you the other day. There may be a lake made at El Paso to contain 27 square miles of water, which will store 500,000 acre-feet of water. By an acre-foot of water, I mean an acre of water 1 foot deep, and it is a very convenient unit, because an acre-foot of water will irrigate under good management about 1 acre of land. It is proposed to store at El Paso 500,000 acre-feet and annually use 300,000 acre-feet, enough to irrigate 200,000 acres of land. Now, the question is, where will this water come from? If we catch the flood waters above and turn them upon the lands in Colorado, on the Chama Valley, on the Taos Valley, on the Española Valley, on the Jemez Valley, on the Santa Fé Valley, and below White Rock Cañon, on the Albuquerque Valley, where will the water come from to supply the El Paso reservoir? There are two or three small creeks below there. There is one and here is one [shows on the map]. These small creeks come in, but the people on these creeks are taking out the water on their lands just as they are above. Now, the survey has not proceeded far enough to show that the storm waters of that region and the waters which can be cut off below the big White Cañon, I have mentioned, will be sufficient to preserve the rights of the people who are settled in the Albuquerque Valley and in the Messila Valley—to preserve all their rights—so as not to destroy the irrigation already practiced and get a sufficient flow to fill the reservoir at El Paso. I believe it is sufficient, but it is not right to accept that belief for more than it is worth. It is

not based upon a hydrographic survey, so as to have the facts absolutely.

There is one other point about the El Paso plan. The construction of the dam is a feasible thing, and the ground on which the dam is to be built is an admirable situation for that purpose, and a dam could be constructed there which no streams can affect. It is an admirable site upon which to construct the dam. The theory and principles upon which they build these dams now are very well known. Men have been experimenting for thousands of years, and they have been built all over the world. We know a dam can be constructed and such a reservoir be made as was presented to you the other day, and there is no difficulty in making it sufficiently safe for all purposes. The real point is, when it is done, will there be water enough to fill it? There is water sufficient now, as shown by the work of the survey, and it is estimated that that reservoir will be filled with water in one year's flow. I think it will be filled with a great deal less than one year's flow. That is my judgment, but I am not sure of that, not having the surveys of the regions above completed. There is one other point: Is it the best place to store these waters?

There are three complications about putting it where it is now planned; The Southern Pacific Railroad passes through the valley and it would have to be moved up on to high ground. The Atchison, Topeka and Santa Fé road runs through the same valley across this reservoir site, and would also have to be moved out, and there is a little irrigation in there that would have to be stopped. There are three vested rights in the valley which would have to be condemned by some process or other, and that complicates the question very much. I do not know it positively, but I believe it is at present the best site. The survey of the upper region has not been extended so far and thoroughly that I could say that we can store it at that point better than any other point.

Mr. LANHAM. This bill does not propose to fix absolutely the site.

Major POWELL. I think the bill is very wise in that respect. I think an inquiry ought to be made and the survey extended further to show if this is the most practicable point; first, to see if there will be water sufficient to fill it if the water is cut off above and whether the rights of the people in the valley above can be protected in the lands already irrigated, and whether these waters which flow can be divided between these districts so that a sufficient amount of water will be left to fill the lake.

It will be seen that there are several interstate problems involved. There is the interest of Colorado. Then there is the interest of New Mexico and the interest of Texas to be considered; and then there is an international problem between the United States and the Republic of Mexico. So there are two interstate problems and one international problem involved in the proposition. It must be understood all the time that there is more land everywhere all along that valley than there is water, and hence the values do not inhere in the land, but the principal values are always in the water rights. When we speak of land being $50 and $100 an acre, it must be considered that the value of an acre of land is governed by the value of the water right, and the real value inheres in the water. At present there is no law arising from legislative or judicial action to control the division of waters. Some system must be devised for this purpose; and I think while on this ground I will proceed a little further. The English law of riparian rights, which relates to the use of streams and which we have inherited and extended through the courts of this country, recognized two classes

of uses; one, the use of waterwhich is to be returned to the channel and the other the consumption of water. For example, the water used as a power can be returned to the stream; the water used for domestic purposes is consumed.

Now, the analogies of water used for irrigation are of both characters; a part of the water is consumed and a part is returned to the channel, and on reading the decisions of the courts you will find that sometimes the decisions have been made on the theory of the laws which govern the consumption of water, while sometimes on the other hand the decisions are made on the theory that the water is to be returned. So we have no body of consistent judicial decisions especially adapted to this new condition which has sprung up in the United States and which is recognized in the Spanish law, and in the Italian law, and laws of countries where irrigation is practiced. Here there is no legislative or judicial law deciding what are the rights of the people. The decisions seem to be contradictory.

I did not bring the papers which would explain the proposition of this dam as I supposed Major Mills would be here, and I presume I had better leave that to Major Mills himself. What I want to make clear about it is that at the present stage of affairs, it seems to me, perhaps I am going too far in speaking about it, but at the present stage of affairs it seems to me that the inquiry should be first made as to where the dam should be constructed, and whether we can have water sufficient to fill it.

Mr. LANHAM. This bill does not propose to fix a site for the construction of this dam.

Major POWELL. I know it does not. The bill is just right.

Mr. LANHAM. Now, I want to ask you a question, Major Powell. During what is known as the torrential flow of the Rio Grande, which is about three months, from the middle of April say up to July, is not there a vast amount of water ordinarily flowing down the stream?

Major POWELL. Yes, sir.

Mr. LANHAM. I wish you to give the committee some idea of the practicability of storing the waters during the torrential flow by the building of this dam or storage reservoir, as indicated in the measure under consideration.

Major POWELL. There is no difficulty whatever in storing that water at El Paso. There is no difficulty by this means of correcting and fixing the boundary line between Mexico and the United States. The only point about it is, will there be flow sufficient to fill the dam when the people up there use the water for irrigation purposes?

Mr. LANHAM. You think it is feasible under the present conditions?

Major POWELL. Under present conditions it is possible to accomplish it.

Mr. LANHAM. I wish you would speak in regard to the boundary line below in case this reservoir is constructed.

Major POWELL. The river below El Paso for a long reach flows over a low flood plain, like the valley of the Mississippi, on to which the river may turn out at any flood time. When the flood season comes on it fills the existing banks which are forever choked in low-water time by sands which have drifted more or less. During the flood season the river turns out of the natural channel and pours over this flood plain, and cuts for itself new channels. The conditions for that cutting are exceedingly favorable, because it is a flood plain of sand, largely of drifting sand, so when it goes out in the flood season, you never know where it will be established at the end of the season, whether it will return to the old

channel or flow in a great curve somewhere else. As long as the center of the flow in the channel is the boundary between the two countries it makes a shifting, variable boundary line. By cutting off that flood, which is entirely practicable—there is no difficulty in doing it at all—by a reasonable expenditure, that flood can be prevented, so that there will be a regular flow of water which comes down. The channel will sometimes be dry, and sometimes in the flood season will carry water, but it will carry a very much smaller amount of water, and the danger of avulsions of tracts of land can be avoided by the building of this dam.

Mr. LANHAM. During this flood season or torrential flow in the Rio Grande does not a vast amount of this water flow down before it is needed for irrigation, early in April, up in Colorado and New Mexico?

Major POWELL. The water for irrigation is used in Colorado for about fifty-five days. As you go down the river you go southward, and you are constantly reaching a warmer climate, and the season for irrigation is longer. You may get in the lower part of the Rio Grande two crops. Sometimes the season may be three or four months long below. So the season for irrigation is variable from north to south, and if you are only to utilize the water which flows during the season of irrigation above, then there is no difficulty in filling this lake below; but I am going on the supposition that the people are going to store these waters above and use them themselves, and that process is beginning. Then the point is, how much water will ultimately—not now, but, say, fifteen or twenty years from now—be permitted to flow down? I was hardly believed when I wrote, fifteen years ago, that this generation would have this water-right question sprung upon it. It has come ten years earlier than I estimated when I wrote my first book. Then I did not dream that these communities would be protecting their rights with shotguns, in the courts, and in all manner of ways. Mr. Vandever knows of this in his own district. This history should be a lesson, so that if provision is made to store waters now running to waste further provisions should be made to divide the waters and protect the storage properties.

The CHAIRMAN. Have you made an estimate of the percentage of wastage by the evaporation in this proposed lake?

Mr. LANHAM. Major Mills said it was about 6 feet, I believe.

The CHAIRMAN. I want an estimate of the ordinary evaporation of this lake as compared with other lakes.

Major POWELL. The conditions of waste by evaporation are somewhat multiform and complex, as they depend upon the relative humidity of the atmosphere. If there is a great deal of rain-fall in a region of country, there is less evaporation. There is greater evaporation from north to south; the further south you go the warmer the winds are, and consequently the greater the evaporation. The four chief factors which affect evaporation are the distance from the equator, distance from the level of the sea, relative humidity, and the prevailing winds. To store these waters here is to store where there is 6 to 7 feet of evaporation annually. To store the waters here [illustrating], is to store it where there would be 30, or at most 40, inches of evaporation. This is on one of the tributaries——

Mr. HERBERT. The altitude is how much?

Major POWELL. The reservoirs will be 11,000 feet above the level of the sea.

Mr. HERBERT. And the distance from El Paso will be how much?

Major POWELL. About 320 miles.

Mr. HERBERT. Nearly due north.

Major POWELL. Yes; nearly due north, but a much lower altitude.

The CHAIRMAN. What is the altitude of El Paso?

Major POWELL. I will have to look at the map.

Mr. HERBERT. Major Mills said it was 3,000 feet.

Major POWELL. I have so many figures constantly before me that I can not remember all the altitudes.

Mr. LANHAM. You were at El Paso last summer?

Major POWELL. Yes, sir.

Mr. LANHAM. You made an examination of the Rio Grande Valley above and below El Paso?

Major POWELL. Yes, sir.

Mr. LANHAM. The river at that time was absolutely dry.

Maj. POWELL. Yes, sir.

Mr. LANHAM. Did you talk with the Mexican people on the other side of the river with reference to the trouble in this respect?

Major POWELL. I did, and I went over their lands.

Mr. LANHAM. Do you know for how many miles the river was dry at that time?

Major POWELL. I should think about 300 miles.

Mr. LANHAM. Do you attribute that dearth of water in the Ric Grande to the fact of these irrigating ditches and canals having been taken out above?

Major POWELL. Yes, sir, and no, sir. It needs explanation. The primary cause was that it was a very dry season, but although the season was dry had there not been irrigation above the water would have flowed through for perhaps two months longer time. There would have been a constant flow of water in the Rio Grande for perhaps 200 miles farther down if the waters had not been cut off above.

Mr. LANHAM. What was substantially the complaint on the part of the Mexican people in relation to this matter?

Major POWELL. That they had been irrigating for a century, or perhaps two centuries, and that they had never before had their water entirely cut off. There would be sometimes dry seasons in the last part of the irrigating season when they would not have sufficient water, but now for the first time the water was cut off early in the season of irrigation, so as to utterly destroy their crops.

Mr. WALLACE. What is the area of the flood plain below El Paso?

Major POWELL. I do not know that; Major Mills knows it. From that point I have never seen it except near El Paso. It has not been surveyed.

Mr. HANSBROUGH. Irrigation extends below El Paso how far down?

Major POWELL. Nearly to the Gulf of Mexico.

Mr. HANSBROUGH. The creation of this lake would interfere, would it not, with those interests?

Major POWELL. Not much.

Mr. LANHAM. Not much, for the reason that below El Paso, as you go down, they have confluents—the Pecos, which is a fine stream, and other streams.

The CHAIRMAN. Where is the Pecos Valley?

Major POWELL. It is 200 miles below.

The CHAIRMAN. Below what?

Major POWELL. Below El Paso.

The CHAIRMAN. What is the extent of the streams on the Mexican side?

Major POWELL. They are of considerable size.

The CHAIRMAN. Do they contribute considerable to the flow of the stream?

Major POWELL. Oh, yes.

The CHAIRMAN. When you get into that portion of the Rio Grande that runs dry, you do not have to sink very far in the sand until you come to water where there is an underflow.

Major POWELL. Yes, sir.

Mr. HERBERT. This proposed site of the reservoir at El Paso was once a lake, was it not?

Major POWELL. No; I do not think it was a lake. I think it is a flood-plain deposit. At the same time it may have been overflowed.

Mr. HERBERT. Major Mills suggested it was once a lake, but you do not so understand it.

Major POWELL. No; I understand it to be a flood-plain deposit like the valley of the Mississippi.

Mr. HERBERT. What is it composed of—clay; sand?

Major POWELL. Clay, sand, and gravel.

Mr. HERBERT. Would it retain the water well or not? Is there enough clay to insure the holding of water?

Major POWELL. Oh, yes. There is a curious state of affairs. Here is a river coming down, and standing right athwart it is a granite and limestone ledge. There is solid rock upon which this dam can be built. As the valley goes up it widens out into a great flood plain.

Mr. HERBERT. You say the soil is of such a character as to hold water.

Major POWELL. To hold water; yes, sir.

Mr. HERBERT. You say the waters are used for irrigation in Colorado for about fifty-five days in the year?

Major POWELL. Yes, sir.

Mr. HERBERT. During what season is that?

Major POWELL. That will commence about the 1st of May and end near the last of June.

Mr. HERBERT. Is that the season in which there is drought now below?

Major POWELL. Only in part.

Mr. HERBERT. The dry season below is when they catch the water above?

Major POWELL. In part, and in part later.

Mr. HERBERT. Are there many catch-basins in which water is stored now in the upper regions on the tributaries?

Major POWELL. The waters are not now stored. There are some small exceptions, as at Santa Fé.

Mr. HERBERT. The season of drought below is not the season during which they are utilizing the waters above. Then the irrigation above does not affect the river below at the time when the waters would be used for irrigating purposes there, the climate being different?

Major POWELL. You have spoken of an extreme case. As you go down the valleys the season is longer and longer; when you get to El Paso, it is practically coincident with the season in the valley immediately above.

Mr. HERBERT. It becomes gradually more and more coincident as you go down?

Major POWELL. Yes, sir; the waters from the upper region permeate the sands, and are practically stored to some extent in the sands and find their way slowly down. From the Albuquerque Valley, from this point to that point [illustrating], it is a sand plain such as I have described. It is only a sand plain from that point to this [illustrating on map.]

Mr. HERBERT. The bottom of the river is also sand?

Major POWELL. Yes, sir; the water rolls down in this sand and is largely evaporated. There may be coming through that cañon a great river, but it would not reach here [illustrating]. There is a fine river coming out of that cañon, but it spreads in the sands here.

Mr. HERBERT. Take the two sections of the country now, from the southern boundary of Colorado up to the source of these streams, and that other section from Santa Fé up to the lower boundary of Colorado; can you tell how much land is now irrigated in each of those sections?

Major POWELL. In the first a rough estimate would be 150,000 acres, and in the second from 35,000 to 40,000 acres.

Mr. LANHAM. Did you make any observations in regard to the agriculture and vineyards and so on below El Paso in the valley of the Rio Grande?

Major POWELL. No, sir.

Mr. LANHAM. And of the number of farms, etc.?

Major POWELL. No, sir.

Mr. LANHAM. I want to ask you this question in order to bring it prominently to the attention of the committee. That river being dry above and below El Paso for two or three hundred miles, no water in it, and that being a valuable tract of country below El Paso on either side, both belonging to the Mexican people and our people, what remedy do you suggest?

Major POWELL. The remedy is to store the surplus water of the floods.

Mr. LANHAM. And that is proposed by this dam?

Major POWELL. That is the proposition which is made. The only thing I spoke about was whether there would be sufficient water to fill so great a lake as we have talked about. At present there would be.

Mr. LANHAM. The rain-fall in that region is not an important factor so far as the growth of crops and cultivation of the soil is concerned, is it?

Major POWELL. No, sir; not at all. It is totally inadequate.

Mr. LANHAM. They depend almost absolutely and wholly upon irrigation?

Major POWELL. Yes, sir.

Mr. LANHAM. Then unless some sort of remedy like this contemplated can be effected, the people in the lower valley at this point, in the valley between Presidio del Norte and El Paso, would have to abandon it?

Major POWELL. Yes, sir; the point simply is, how are the waters to be divided, and how will it be possible to protect the rights of the people of Mexico and Texas, and permit that irrigation above.

Mr. LANHAM. Do you believe under present conditions that if that dam were constructed, and you think it can be——

Major POWELL. There is no doubt about it.

Mr. LANHAM. You believe if that dam were constructed under present conditions, that that lake or reservoir could be filled with water?

Major POWELL. Under present conditions it could be.

Mr. LANHAM. And it may be years and years before the complete absorption of the water above would occur?

Major POWELL. I think within a decade or two it would begin to occur.

Mr. LANHAM. During this flood flow, when the water is not used above in Colorado and New Mexico for the purpose of irrigation, it would flow on to this point near El Paso into the proposed lake?

Major POWELL. It would if the people above were prohibited from storing any water, and only permitted to use the water at the season of irrigation. Then the dam at El Paso could always be filled.

Mr. HERBERT. But if the people above shall store all the water necessary to irrigate all the irrigable lands above Albuquerque, then there would be no water.

Major POWELL. That goes a little further than I should say. I believe there will be enough to accomplish this general purpose; but I shall not know whether it will be enough until the survey is complete.

Mr. HERBERT. How much rain-fall is there annually, and during what months, from Albuquerque to El Paso?

Major POWELL. It is about 10 inches. It varies from 8 to 12, but 10 inches is about a fair mean.

Mr. HERBERT. And above that the rain-fall up in the mountains is very much greater?

Major POWELL. Oh, yes; at the mountains of course we get 20, 30, 40, and in some places even 50 inches in the high mountains.

Mr. LANHAM. Have you ever been at or near the Rio Grande when there was a flood season from the melting of snows in the mountains?

Major POWELL. Yes, sir.

Mr. LANHAM. Is it not an immense stream then?

Major POWELL. It is a fine stream. It is a very wide, but very shallow stream.

Mr. HERBERT. The flood plain you have described, as I understand you to say, is made of silt just like the alluvial plains of the Mississippi Valley, except that it is not so rich.

Major POWELL. It is just as rich, but there is not sufficient rain-fall to cover it with vegetation.

Mr. HERBERT. You encounter the same difficulty of keeping the stream within the banks?

Major POWELL. The difficulty on the Rio Grande is much greater than on the Mississippi.

Mr. HERBERT. Because there are no roots of trees and no vegetation to support the banks?

Major POWELL. Yes, sir; and the winds drift the sands and pile them across the channel of the streams and make a great sand-drift across it.

Mr. HERBERT. When did you first see the Rio Grande?

Major POWELL. It was on the Rio Grande at Albuquerque in 1870.

Mr. HERBERT. Was it dry then?

Major POWELL. No, sir.

Mr. HERBERT. How far below?

Major POWELL. I can not tell you.

Mr. HERBERT. Have you ever made a study of the question how often the river was dry thirty years ago, before this irrigation began in Colorado?

Major POWELL. No, sir; except by the traditions of the people. I have no absolute facts, but the traditions of the people are that it occurs about once in seven years.

Mr. HERBERT. You have no other means of ascertaining?

Major POWELL. No, sir.

Mr. HERBERT. You agree with Major Mills that it occurs about once in seven years?

Major POWELL. Yes, sir; I should think so.

The CHAIRMAN. You said that the general elevation here is from 6,000 to 8,000 feet, and that the time of irrigation is approximately

fifty-five days in the year, confined to the months of May and June. When you get below here——

Major POWELL. It commences earlier and runs later.

The CHAIRMAN. What is the time of flood in the Rio Grande usually?

Major POWELL. I should say it commences in May.

The CHAIRMAN. I have seen a flood in the Rio Grande from Albuquerque for 100 miles or more in July.

Major POWELL. It varies from year to year, and sometimes the flood lasts one or two months. It comes in part from the melting of the snows as well as from rains.

Mr. LANHAM. Have you examined this bill, the subject-matter of which we are now considering?

Major POWELL. I read it some two or three weeks ago.

Mr. LANHAM. You perceive that its object is to have an inquiry and investigation into this question?

Major POWELL. Yes, sir.

Mr. LANHAM. From your knowledge of the situation, having been at this point, what do you think about the proposed measure?

Major POWELL. I always shrink from expressing opinions on matters of legislation, but I have no objection to saying as——

Mr. LANHAM. You may say what is the object and scope of it.

Major POWELL. I think the interests of the ancient settlers, as well as the interests of the later settlers, the old Spanish settlements and the American settlements alike demand some adjustment of the water rights in that region of country, and unless that is done all these lower settlements will be wiped out. I have no doubt that unless something is done to protect the water rights the lower settlements in the Messilla Valley and El Paso Valley will all be wiped out. There can be no doubt about that at all. It will only take ten years to drive all the farming out of that country if the development of irrigation goes on as it has done in the last ten years.

Mr. HERBERT. I see that you have located these catch-basins on the Jemez and its tributaries.

Major POWELL. Yes, sir.

Mr. HERBERT. Will you give the approximate cost of location of these catch-basins?

Major POWELL. That has been published in an investigation of two committees, and I can only give it from memory. This has all been published. I think $450,000 for six reservoir-dams.

Mr. HERBERT. In all cases where I ask for figures if you do not remember exactly, you can afterwards insert them, as it is impossible for a man to remember everything. You can put definite answers when you come to revise your evidence as taken by the stenographer.

Major POWELL. Do you want me to give an estimate now?

Mr. HERBERT. Yes, sir,

Major POWELL. You see there are six dams. This one here is the Valle Grande; that reservoir will hold 69,000 acre feet of water. This one here will hold about 23,000 acre feet of water; it is the Valle San Antonio. The Rio Cebolla Reservoir will hold 16,000 acre feet of water. This one (Wilson's Ranch) will hold 28,000 acre feet of water. This one will hold 9,000, and this one nearly 10,000 acre feet of water. Making in all about 155,000 acre feet. The cost of that will be about $450,000 for the construction of these dams, less than $3 per acre foot. But in addition to that there is to be a diverting-dam below and a canal to be constructed. These reservoirs will not hold all the water. The survey is yet incomplete, as our men were driven away on account

of small-pox breaking out in the settlement. Thirty or forty more reservoir sites are known. There is no difficulty in storing all the water, and the country lies in such a manner that the dams can be built at a small cost.

Mr. HERBERT. If a sufficient number of catch-basins were constructed to store all the water, would it irrigate all the irrigable lands on the Jemez and all the tributaries down to the Rio Grande? Could it all be used profitably on the lands before you get to the mouth of the Jemez?

Major POWELL. Yes, sir; the lands immediately along the lower Jemez are sands. The waters can not be used immediately along the Jemez to advantage, because they are lost in the sands. The chief body of land that would be irrigated is the mesa which lies 100 feet or more above Bernalillo and Albuquerque, all down here [illustrating on map].

Mr. HERBERT. How wide is that mesa?

Major POWELL. It is from 5 to 20 miles in width in different places.

Mr. HERBERT. Could all the waters be used?

Major POWELL. They can all be used there. These are townships. I have selected them all along here. There is the Rio Grande. Here is Albuquerque. Bernalillo is here. On this mesa all these townships can be irrigated. There is a great deal more land than there is water to serve.

Mr. HERBERT. Is that the case with all the other tributaries of the Rio Grande above there?

Major POWELL. Yes, sir; it is the same thing.

Mr. HERBERT. That there is more land than there is water to serve it if the water was all cut off and scientifically and judiciously stored?

Major POWELL. Yes, sir.

Mr. HERBERT. Still there would be irrigation as far as Albuquerque.

Major POWELL. Yes, sir.

Mr. HERBERT. So the problem is to secure an equal and equitable distribution of water?

Major POWELL. Yes, sir.

Mr. HERBERT. Among the inhabitants here and below?

Major POWELL. Yes, sir.

Mr. HERBERT. I do not know whether I have asked you, but if not, I will ask you to put in your answers an estimate of the percentage of water that is evaporated as the water flows from Albuquerque down to El Paso both by evaporation and absorption in the soil.

Major POWELL. That amounts to the same thing.

Mr. HERBERT. It is, of course, the same thing, as it is lost. It is both lost by evaporation from the surface and evaporation from the soil.

Major POWELL. That is a very complex question, and one in which myself and two or three men in the survey have been at work for several years. In over one-half of the area of the arid region all the waters are evaporated. In over one-half of the area of the arid region there is no water that runs to the sea. There are many streams outside of the great basins which flow down, like the Box Elder, that have at their heads an abundance of water, but which flow down and are lost in the sands by being all evaporated.

The CHAIRMAN. Is it not owing in a great measure to the absorption in the sand?

Major POWELL. That means it is ultimately evaporated.

The CHAIRMAN. The term "evaporation" includes the other.

Major POWELL. Yes, sir; it goes into the sands and permeates and saturates the sands, and the sands themselves are agencies for evaporation greater than the water surface. If you keep the sand at the surface saturated with water you subdivide that surface into millions of minute facets, for every grain of sand there is a surface for evaporation, and the heat striking that surface evaporates the water much faster than from the surface of a lake; so the evaporation from the sands is greater than the evaporation from a water surface. It is a difficult question, and I am glad you brought the point out; it is a very important point. There was a narrow lake along the course of the stream with a rock bottom. If there is sand valley below several miles in width which is overflowed all this water will be evaporated and lost.

The CHAIRMAN. You have been in the Colorado River desert?

Major POWELL. Yes, sir.

The CHAIRMAN. You know there are points in the Colorado River desert where the elevation is below the sea-level?

Major POWELL. Yes, sir.

The CHAIRMAN. How far do you have to sink at those points until you get to water?

Major POWELL. I do not know.

The CHAIRMAN. I have seen it along the railroad, where they did not have to go more than a dozen feet at the stations until they got to water. You strike water within a dozen feet of the surface.

Major POWELL. The great desert of America is in southern Colorado.

The CHAIRMAN. There is a flood of water within 12 feet of the surface where the surface is below the sea level.

Mr. HERBERT. Do you remember the length of the canal you have surveyed from that point where it debouches from the river?

Major POWELL. About 25 miles.

Mr. HERBERT. What is the size of the canal and the width?

Major POWELL. I have not planned it?

Mr. HERBERT. Have you examined the soil there sufficiently to be able to say it is good soil for a canal?

Major POWELL. It is rather difficult soil.

Mr. HERBERT. Would it be necessary to line it at all to keep the water from sinking?

Major POWELL. My opinion is there will be a short distance over a salt basin for a mile or two where it will be necessary to——

Mr. HERBERT. To pave——

Major POWELL. Iron perhaps would be better. The canal part is not yet planned. It would have been but for the small-pox, which prevented our men from finishing the work.

Mr. HERBERT. So you can not make a definite estimate of the cost until you make a more definite survey?

Major POWELL. No, sir.

I suppose you would prefer now to have Major Mills go on?

The CHAIRMAN. We are very much obliged to you, Major Powell.

Mr. LANHAM. I will be glad for Major Mills to finish his statement which he began the other day if Major Powell is through.

STATEMENT OF MAJOR ANSON MILLS—Continued.

Mr. Chairman and gentlemen of the committee: I will resume where I left off the other day, which I believe was on the subject of the railroads.

Mr. LANHAM. Here is a map which has been made showing these railroads—the Atchison, Topeka and Santa Fé, and the Southern Pacific.

Major MILLS. They do not show as plainly as they do on this. The Atchison, Topeka and Santa Fé road will have to be removed the whole length of the lake.

Mr. HERBERT. How many miles?

Major MILLS. It will be about 18 miles (including the approach from El Paso). Its bed now lies below the proposed surface of the water, and there comes the greatest difficulty of construction. The estimates for this change are about $400,000. There is no question but what this road will have in the near future to leave its present bed, because the river is now changing to the left bank, and will carry it away in a few years if there are any high floods.

Mr. HERBERT. You do not mention the Southern Pacific?

Major MILLS. I will proceed to do that. I want first to explain the difficulties of the Atchison, Topeka and Santa Fé, which do not apply to the other road. The Atchison, Topeka and Santa Fé has a maximum grade of one-half of 1 per cent., which is 26 feet per mile. It would be rather arbitrary to force them to change their grade. The difficulty is in getting the elevation over the water in the lake from the depot in the city to the lower dam-site. The lower dam-site is in every other respect much the best, and it would probably cost only two-thirds or perhaps one-half of the estimate for the upper site, the upper site being estimated at $300,000. The lower site would probably cost $150,000 to $200,000; but the railroad engineer preferred to make his estimates on the upper site, because he saw no serious difficulty in getting the Atchison, Topeka and Santa Fé road to that elevation. There are many advantages in the lower site, one being that one end is in Mexico; another it is nearer the fields to be irrigated, and the expensive part of the canals, etc., to irrigate the land would be much shorter—about 2 miles shorter. In my report I have suggested a method of overcoming this difficulty by running up a ravine near the river about a mile, and thus get the road above the waters before it reaches the lake. I think that is perfectly feasible, and I have consulted with railroad engineers in regard to it. An engineer of the Atchison, Topeka and Santa Fé road pronounced it perfectly practicable.

Mr. LANHAM. Here is your report if you have occasion to use it.

Major MILLS. Thank you, sir. I think a railroad requires a distance of about half a mile of comparatively level grade to depart from their depot, so that we could not force them to take a maximum grade to start from the depot. To the lower site they have got about a mile and a half to gain 50 feet, because the depot is above the level of the water. If that is practicable the lower dam-site will no doubt be preferred. I believe I stated the estimate approximately; I can give you the exact figures.

Mr. LANHAM. That is all given in your report there.

Major MILLS. It will cost $385,299 for moving the Santa Fé road.

Mr. HERBERT. Does that include the grading and locating them upon any route?

Major MILLS. It includes every cost that will be encountered in making the change, using new iron because it was concluded it would cost more to change the old without interrupting traffic than to put down the new iron.

Mr. HERBERT. Has the engineer or have any of the authorities concurred in that estimate as being correct?

Major MILLS. No, sir; we have not felt authorized to submit the matter to them. But Mr. Follett is an engineer who has been doing work for the Atchison, Topeka, and Santa Fé road for many years, and he pronounces the grade as practicable. The Southern Pacific road, which crosses the Rio Grande just below the upper site, it will be necessary to move a distance of about 5 miles; but there is no difficulty about the grade because their maximum is just twice that of the Santa Fé, or 52 feet to the mile, which allows them readily to get over the lake. The estimate for moving that road is $204,591. This is the plan for the location of the upper dam-site [exhibiting same]. It gives the soundings for the bed-rock and the contour lines with elevations, etc. The members of the committee can look at it if they desire to do so. This map represents a cross-section of the river at the soundings for bed-rock and the level of the water at the time the soundings were taken. These iron pipes on either side represent six 48-inch cast-iron pipes which will be placed through the dam a little above the level of the water as it now stands for relief in case of floods or any obstruction that might come in the waste-ways. These 48-inch pipes would carry with the pressure above in case the lake was full, all the water the river would carry below without disturbing the boundary lines. This map represents a cross-section of the proposed masonry dam proposed to be constructed on the most approved scientific principles and supposed to be perfectly safe. This [illustrating] is a plan of the river at the lower site.

Mr. HERBERT. Who is the author of that plan of dam, yourself?

Major MILLS. No, sir; it is taken from this book on masonry dams, by Mr. Wedgeman. In this book there are eight or ten different profiles of types of dams by different engineers.

Mr. HERBERT. It is from some gentleman who is an authority?

Major MILLS. Yes, sir; this gentleman is considered the best authority on the subject of masonry of dams. There are many theoretical profiles here, and Mr. Follett selected that of Mr. Alphonso Ftoley as the one he thought best adapted to this particular dam. Now, in regard to safety, Mr. Herbert asked me the other day what effect the breaking of this dam would have upon the city of El Paso. There is no question but what it would utterly destroy it. But I wish to call attention here to the history of some of the most important dams in the world. Here is one they call the Almanza dam in Spain. It is 65 feet high, which happens to be just the height of the one we propose. It has been standing three hundred years. The masonry of that dam was built three hundred years ago.

Mr. HERBERT. Was it constructed by the Moors?

Major MILLS. I do not know. It was constructed in 1579 to 1594.

Mr. HERBERT. That is immaterial and it does not matter.

Major MILLS. Here is the Alicante dam, which has also been in existence three hundred years. It has a height of 135 feet, which is twice the height of ours. This is considered a high authority; I brought it here for the use of any members of the committee who choose to refer to it. It is considered, I believe, the very highest authority in the world

now. It gives the dimensions of a proposed dam 270 feet high, called the Quaker Bridge dam in the Croton Valley, New York.

Mr. HERBERT. What kind of foundation have you there?

Major MILLS. We have sounded there as thoroughly as possible and we find a solid rock foundation. We have had the best sounding rods possible, and we have found what is almost positive indications of solid rock, granite and limestone.

Mr. LATHAM. How long have you lived in that country? I wish you would tell the committee what you know in reference to the history of of that river, Major.

Major MILLS. I went to El Paso in 1858 with the parties projecting the Memphis, El Paso and Pacific Railroad; made the first survey of the town of El Paso that was ever made; I was occupied until the breaking out of the war; principally these years in surveying lands in these valleys of Messila and El Paso.

Mr. LANHAM. I wish you would tell what you know of the conditions of the river there during that period and its present condition, so that the committee may have a general understanding of it.

Major MILLS. It is almost incredible the size that river attains in seasons of high flood. I have seen the river when it appeared to carry as much water as the Mississippi. Of course it could not be so. I was in El Paso in July, 1884, and the river was then a raging torrent and carried away its banks and shifted its bed in some places three miles laterally and ten or fifteen miles longitudinally—lengthwise.

Mr. LANHAM. It destroyed a portion of the railroads below there—the Texas Pacific and the Southern Pacific, did it not?

Major MILLS. It carried away 15 miles of the Galveston, Houston and San Antonio Railroad, and they never found some of the iron. One tract of land embracing over 5,000 acres was left on the Mexican side of the river, yet according to the treaties it is claimed to be in Texas. I can not conceive it possible—of course all things are possible—there is a limit to everything; but I think they will have to build a great many reservoirs on the headwaters of the Rio Grande if it carries as much water as it did in 1884 to prevent getting a great supply for the lake after the first filling, because while it will take a year to fill the lake on the first building of the dam the greater portion of that will be held there permanently; for the reservoir on top being but 10 feet deep contains but 200,000 acre-feet of water out of 500,000 acre-feet capacity of the lake. So we will only have to replace after the first filling 200,000 acre-feet at most annually in the 10 feet top of the lake. Of course it is possible, if they build these vast dams and reservoirs above, to deplete it entirely, and more probably in dry seasons, such seasons as last year was; but this 200,000 acre-feet of reservoir would probably supply four or five times as much water as will be used annually in the next five or ten years in that valley.

Mr. LANHAM. How much valuable land would you say in the Rio Grande Valley below El Paso would be affected by these dry conditions?

Major MILLS. That would otherwise be cultivated?

Mr. LANHAM. Yes, sir.

Major MILLS. I think there is on the Mexican side about 40,000 acres that would be cultivated if there was water. On the Texas side there are about 25,000 acres that would be cultivated if there was sufficient water; yet if this dam was built and it was filled there could be 100,000 acres cultivated on either side by high line ditches taken from a 50-foot altitude in the lake.

The CHAIRMAN. I understand you to say the capacity of the dam would be 500,000 acre-feet and 200,000 would be ordinarily sufficient for what purposes? For irrigation?

Major MILLS. No, sir. Understand me, the proposition is to take the main ditches from the lake at a height of 50 feet above the present level of the river; there will be no water taken out below that level as a rule for irrigation, and the reservoir will consist of only 10 feet on top.

The CHAIRMAN. The reservoir portion will be above 200,000 acre-feet and there will be this reserve of 300,000 feet that could be utilized for increasing the volume of the river below.

Major MILLS. Yes, sir; and that is one object in putting in 48-inch pipes, so that the water would be available at a lower level than at the top of the dam if a dry season should come. It will be available for the land that lies below that level, but the higher lands could not be irrigated from that lower part of the reservoir.

Mr. HERBERT. Do I understand you to say there will be only about 200,000 acre-feet which you expect to utilize in irrigation?

Major MILLS. That is the plan; but in case of dry seasons so the lake would not be filled, then we have pipes at the bottom by which we can drain the lake lower if necessary.

Mr. HERBERT. I understood the pipes on the bottom would not carry water on the same lands; they would be of a different altitude.

Major MILLS. Yes, sir; but they will be 20 feet above any ditches now in existence at El Paso.

Mr. HERBERT. If this plan be carried out, do you propose to take all the water from this lake by iron pipes and convey it directly to the fields you would irrigate, or do you propose to let it run off into the bed of the river below and waste as it goes down?

Major MILLS. We have developed no particular plan.

Mr. HERBERT. What would you say in regard to that?

Major MILLS. I have a theory of carrying all to be used for irrigation by high land canals, because there would be less absorption than in the sands. As you get on high land the soil is better calculated to prevent percolation.

Mr. HERBERT. Suppose you had that lake constructed, had it full of water and turned it off to fill this river-bed below in a dry season, how far would it run, and how long would it run—would it run all the way down and irrigate all the lands on each side by the ditches that have been heretofore used down as far as Presidio?

Major MILLS. No, sir. Ninety miles below El Paso the gorge commences again, and there are no lands below 90 miles that could be irrigated.

Mr. HERBERT. Would it be sufficient to irrigate the land on both sides of the river that has been heretofore cultivated?

Major MILLS. It may be utilized that way, but it would not be economical. Naturally both sides would seek to use the water in the high line canals, which would be less expensive, and there would be no more ditches taken from the bed of the river, and the water in the river would only be used for stock and domestic purposes.

Mr. HERBERT. Do you think it would be wise to let the water run from this reservoir to fill the channel of that stream for 90 miles?

Major MILLS. No, sir; not to fill the channel; only to maintain a flow.

Mr. HERBERT. Then your scheme really contemplates a system of ditches and iron pipes conveying the water directly from the lake that

you propose to construct to the land on either side, on the Mexican side and the Texas side?

Major MILLS. Yes, sir; in ditches. I never contemplated iron pipes.

Mr. HERBERT. You would only leave water in the stream which the stock could drink?

Major MILLS. Yes, sir; a sight flow would probably be maintained from seepage and overflow in extended irrigation.

Mr. HERBERT. That is the proposition?

Major MILLS. Yes, sir.

Mr. HERBERT. In the event that this scheme is carried out there would be no Rio Grande River at all; it would be simply these pipes?

Major MILLS. Yes, sir; I think it would be better to let it run off in these canals, as far as practicable, should water become very scarce, but a small constant stream in the channel would neither overflow or waste much water in this 90 miles.

Mr. HERBERT. That is what the scheme really means?

Major MILLS. The primary object of this scheme was to correct the boundary line.

Mr. HERBERT. There would be no river and boundary, because the water is conveyed in these canals and the channel of the river may stand as a definite line as fixed by marking the boundaries?

Major MILLS. Yes, sir; either entirely dry or with a small current.

The CHAIRMAN. In this limit of 90 miles below El Paso down to the gorge what arroyos come into the river from either side?

Major MILLS. None whatever that carry water except such as come from heavy rains, when the water from the cañons flows into the river, which generally ceases within forty-eight hours after the rain.

The CHAIRMAN. There are no arroyos?

Major MILLS. No, sir; no water runs in, except sometimes in hard rains, when there is something in the nature of a so-called cloud-burst.

Mr. HERBERT. When is the rainy season?

Major MILLS. About El Paso the rainy season is in July and August.

Mr. HERBERT. Too late for the crops?

Major MILLS. Corn would dry up in twenty days after the heaviest rain, the evaporation is so great.

Mr. HERBERT. Any rains at any time except in July and August?

Major MILLS. There are slight rains in the winter.

The CHAIRMAN. Do you understand that they distinguish between the Sonora rains?

Mr. HERBERT. These are the Sonora rains.

The CHAIRMAN. In all Arizona, New Mexico, and Colorado they have this rain. It is especially so on the Pacific coast. Did you ever make any estimate of the amount of land that would be irrigated by the 200,000 acre-feet of water?

Major MILLS. No, sir. I am not very well acquainted with the amount of water required to irrigate an acre of land, but I consider that 12 inches is sufficient.

The CHAIRMAN. Major Powell said this morning that 1 acre-foot of water would irrigate 1 acre of land.

Mr. HERBERT. That means, of course, without any evaporation.

Major MILLS. Yes, sir; that would be so. I believe I spoke of the evaporation of the surface of the lake.

Mr. HERBERT. That is a point I want——

Major MILLS. Major Powell has a much better idea of the evaporation, as I have not been in the business so long. I discovered the evaporation last year would be about 6 or 7 feet from the surface of the water

in the pools in which we took observations after the river was dry and the narrow channel when it flowed. What it would be in a lake like that is something I do not know about; I have not been able to find anything in books about it. Whether the evaporation would be the same in the middle of the lake as at its borders, where the hot, dry air strikes it, is something of which I am unable to give an opinion.

Mr. HERBERT. Will you make a calculation, if you have not already made it, and append it to your answers when you shall correct them, showing what would be the size of the best iron pipes necessary to convey this water from this lake so as to irrigate for 90 miles below; the probable cost of buying and laying that pipe and constructing the necessary conduits to the land?

Major MILLS. We have estimated about the size of the pipes to convey a certain amount of water through the dam, but I do not think it would be necessary or even practicable to go to the expense of putting iron pipes——

Mr. HERBERT. I understood you to say you thought that would be best.

Major MILLS. Then I misunderstood your question. We put these iron pipes through the dam——

Mr. HERBERT. I understood from Major Powell that the land below here was very sandy and the water was evaporated very rapidly, and would be absorbed from near El Paso down below.

Major MILLS. That is very true in the great overflows.

Mr. HERBERT. I understood you to say that if the water was turned into the bed of the river the greater portion of it would sink and you could could not irrigate these lands for 90 miles below.

Major MILLS. No, but I said the altitude of the outlets in the dam was 50 feet above the level of the city, with a fall of 10 feet between the dam and city, which would make them 60 feet above the valley, which would throw the canal back on the higher mesas, or what you might call the hard-pan land.

Mr. HERBERT. Are they clay?

Major MILLS. They are what we call "adobe dirt." It is not sand, but it is solid and becomes almost impervious to water.

Mr. HERBERT. And you think it would not be necessary to use iron pipes?

Major MILLS. No, sir; the great expense would make it impracticable to do so, in my opinion.

Mr. HERBERT. The evaporation, then, would be principally evaporation through the air?

Major MILLS. Yes, sir.

Mr. HERBERT. And not evaporation through the soil?

Major MILLS. No, sir.

Mr. HERBERT. Can you find that same land all the way down?

Major MILLS. We will have aroyas where there is sand, where I presume it will be cheaper to have a flume of wood than to go to the expense of large iron pipes.

Mr. HERBERT. Are there a good many aroyas?

Major MILLS. Yes, sir.

Mr. HERBERT. What proportion of the distance would it occupy?

Major MILLS. Probably one-twentieth for the first 5 miles down and after that it would be a less proportion. You understand that the average fall of that river in the valley of El Paso is 4 feet to the mile. If these canals are built large and reasonably straight, they need not have more than 1 foot fall for every mile, so that in going down 90 miles they

will be three times 90 feet above the bed of the river, plus 50 feet the height taken, or 320 feet above the river at the lower end of the valley.

Mr. HERBERT. Is the configuration of the soil there such as to enable you to always get the altitude you want without cost?

Major MILLS. There will be cost, of course, but not extraordinary.

Mr. HERBERT. I wish to get at, by some calculation as near as you can make it, what would be the net cost of conveying the water along in these canals below so as to irrigate from that lake the lands down to Presidio. Of course it would depend entirely upon the system you adopt, but I would like to get some idea of it.

Mr. LANHAM. Is it proposed to take all the water that would be used through these ditches? My understanding has been that it would be used also for the purpose of still maintaining the flow in the stream below.

Major MILLS. That question was brought out by a question of Mr. Herbert's, and I agree with him in his ideas. It never occurred to me before. For a distance of 90 miles below the dam it would be much better to become perfectly dry should there ever be any great scarcity of water, but ordinarily I don't think these ditches would carry the mean annual flow.

Mr. LANHAM. It may be flooded——

Major MILLS. But the floods never come to any great extent except in the spring, from April to the last of July; then by irrigation or otherwise this reservoir of 10 feet would be depleted, and at the highest flood it would take a month or six weeks to fill that reservoir, and seeing a large flood coming down we could fill these ditches and allow a small current in the channel to carry it off so as to be prepared for the coming of another flood.

The CHAIRMAN. What do you call the valley of El Paso?

Major MILLS. The valley 90 miles below El Paso [illustrating].

The CHAIRMAN. Does it include this part here [illustrating]?

Major MILLS. No, sir.

The CHAIRMAN. What is this?

Major MILLS. The Messila Valley.

Mr. HERBERT. I understood that the object of this dam was to keep a steady flow in the bed of the river below.

Mr. LANHAM. To make the boundary line.

Major MILLS. If they have an abundant flow of water in the river it could not be carried very readily outside the river's bed.

Mr. HERBERT. By iron pipes?

Major MILLS. The river would cut no figure in it at all then, when there should be great scarcity of water, and all should be carried in canals, but I don't think that would be often the case.

Mr. LANHAM. If you maintain the water in the river channel, that channel could be controlled to such an extent it could be made a permanent boundary line, could it not?

Major MILLS. There is no question about that. It might be as Mr. Herbert said that during an overflow when there is a great surplus we could let it run into the river. There is no doubt if this dam is built with this reservoir we could control the floods so there can not be any change in the river at all. It must be remembered that this water instead of having silt in suspension would be perfectly clear, and it is said by those who have given a good deal of study to the question that this silt in suspension is what causes change in rivers by depositing the silt on one bank and cutting it from another. So when the river enters the head of the lake it may have silt in suspension, but after

half a mile in comparatively still water it would be precipitated and make the water perfectly clear.

Mr. HERBERT. What is the percentage of silt?

Major MILLS. It runs from 2 per cent. to a quarter of 1 per cent. It is higher when the river is low, the flood waters contain less. When these little streams in New Mexico become flooded of course it increases it.

The CHAIRMAN. It is said that at the mouth of the Mississippi River the proportion of solid matter at low water is greater than it is at high water.

Mr. HERBERT. To an unscientific man that appears to be a peculiar proposition.

Major MILLS. It may not be true for all rivers, but it was so with the Rio Grande for the last year.

Mr. LANHAM. Do you know anything of the extent of the farming operations on both sides of the river below El Paso?

Major MILLS. I do not know whether I made that statement in my former appearance here or not. This is approximate, but it will give you a tolerably good idea of the acreage. The land in cultivation now on this side of the river—that is not Mexico—in the El Paso Valley, is about 15,000 acres.

Mr. LANHAM. You said that awhile ago. What is the character of the products there?

Major MILLS. The products are various—fruits of nearly all kinds. The production of grapes is large. They produce peaches, apricots, pears, and apples; all sorts of vegetables; and they raise wheat, barley, oats, corn, and onions, all in great abundance.

Mr. LANHAM. Alfalfa?

Major MILLS. They raise three to four crops of alfalfa in the same season. The season is very long, beginning early and ending late.

Mr. LANHAM. Do they count on the rain-fall as an element or factor in the cultivation of their crops?

Major MILLS. Not any further than when the rain comes it does away with immediate irrigation, but without irrigation it would be utterly useless to plant anything.

Mr. LANHAM. If this dry condition should continue I want to know what would be the fate of this country?

Major MILLS. I do not see any hope for them. There are in the El Paso Valley some fifty thousand people. In the Messila Valley there are probably eight or ten thousand, and for these sixty thousand people I do not see any other result than to abandon everything in the line of agriculture unless some remedy is provided for this depletion of the river.

Mr. HERBERT. Do these eight or ten thousand people in the Messila Valley occupy the site of the proposed lake?

Major MILLS. No, sir; not a hundred of them.

Mr. LANHAM. He stated the other day there was about a thousand acres in cultivation that would be submerged by this proposed lake.

Mr. HANSBROUGH. There are only a few people there.

Major MILLS. Only a few.

Mr. HANSBROUGH. The sixty thousand people are not wholly dependent upon agriculture?

Major MILLS. No, sir; but the greater portion of them are. Those who are not dependent upon agriculture will be dependent upon the support of the agriculturist to a great extent—those who are engaged in merchandise and other pursuits. You understand as well as I that

if the pursuit of agriculture is stopped it will also stop a great portion of other pursuits by loss of the patronage of the agriculturist.

Mr. LANHAM. Does any member of the committee desire to ask Major Mills any further question? He has been examining this question for a long while and is very conversant with it.

The CHAIRMAN. You stated awhile ago that about sixty thousand people were residents of El Paso Valley?

Major MILLS. No, sir; fifty thousand.

The CHAIRMAN. And how many in the Messila Valley?

Major MILLS. Ten thousand. In the El Paso Valley they are equally divided between Mexicans and Americans.

The CHAIRMAN. How far below this point here does this contraction at Fort Quitman continue [illustrating]?

Major MILLS. It continues down to the Concho, a confluent from Mexico. Then there is a small valley right here at Presidio del Norte [illustrating].

The CHAIRMAN. Where does the Pecos come in?

Major MILLS. Below that point there. Then Devil's River is here. Both the Devil's River and the Pecos. This makes quite a fine stream below.

The CHAIRMAN. They have no trouble in the river after the Pecos comes in?

Major MILLS. No, sir.

Mr. HANSBROUGH. The rain-fall is heavier near the sea.

Major MILLS. This confluent here, the Concho, arises in the high mountains of Mexico, similar to the Rio Grande in Colorado, and it is a living stream.

Major POWELL. I would like to say just one word here. The plans for construction, I would say, are all of them submitted by competent engineers of the Geological Survey, and then I have a board of revision, and when we may recommend anything to Congress this board of revision takes it all up and rediscusses it before the time for publication, so what I have now presented is only preliminary and not final.

Mr. HERBERT. This report made by Major Mills not having been published, of course we would like to include it in the testimony.

Major POWELL. This report of Major Mills I shall publish as part of my report.

Thereupon the committee adjourned.

SELECT COMMITTEE ON IRRIGATION,
Thursday, March 6, 1890.

The committee met pursuant to adjournment, Mr. Vandever in the chair.

The committee having under consideration H. R. 7504, "Providing within certain limits for the promotion and regulation of irrigation and matters subsidiary and accessory thereto, creating and empowering commissions, and for other purposes," this day heard statements in regard to same.

STATEMENT OF J. W. GREGORY, OF GARDEN CITY, KANS.

Mr. GREGORY addressed the committee as follows:

Mr. Chairman and gentlemen of the committee, I will read to you two or three sections which I consider the most important part of the bill. The title, I presume, you have observed.

A BILL providing within certain limits for the promotion and regulation of irrigation and matters subsidiary and accessory thereto, creating and empowering commissions and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That in all that portion of the United States lying west of the ninety-seventh meridian of longitude west from Greenwich, England, all the waters, whether standing or running, whether derived from storm torrential, or subterranean sources, shall be devoted primarily to purposes of irrigation in aid of agriculture, subject, however, to ordinary domestic uses, and may be diverted from natural beds and channels for such purposes.

I will state that my idea in the first place was that about the ninety-ninth meridian should be the eastern boundary, but other parties interested desire the ninety-seventh meridian made the eastern limit because that includes territory in States necessary to be included in the territory devoted to practical irrigation. So far as we are concerned about the ninety-ninth or even the one hundredth meridian would be far enough east, but there is a strip of country which would be great deal benefited by irrigation at times, and of course there is no objection to extending it farther east.

Provided, That rights acquired and vested prior to the passage of this act shall not be disturbed, except in the manner hereinafter provided; nor shall anything in this act be so construed as to interfere with the use of such waters for purposes of navigation, mining, manufacturing, or any other purpose, whenever such uses shall not actually interfere with the use of said waters for irrigation.

Now, I would like to call your attention to this one thing: There is one right that needs to be protected and guarded in the matter of controlling the use of the water, and that is the right of the user only. The

right of prior appropriation, as applied or exercised by corporations, is only a derivative right. It is important because it is necessary to protect the settlers and users. It is impossible for individuals or farmers to provide their own means of irrigation. There must be co-operation to a certain extent, and corporations are necessary so that there may be capital obtained, and so that the work may be done in a systematic and economical way; and inasmuch as that is the case, it is absolutely necessary that the priority of appropriation of corporations shall be recognized and protected, not because they have any right in the water, but because it is necessary to protect the farmers and individuals who move into a new country and risk their time, and their means, and their labor to acquire vested rights. It is the only way they can be protected.

Mr. HERBERT. You mean to say private and natural rights?

Mr. GREGORY. Yes, sir; and this protection is necessary to protect the rights of farmers.

SEC. 2. That the privilege to use such waters for purposes of irrigation shall inhere in all the actual appropriators thereof, without regard to State, Territorial, or other civil boundaries, according to the order of appropriation of the actual and continued use thereof, in point of time, a bona fide attempt to secure and use a supply of water for irrigation being considered an actual appropriation thereof to the extent of the bona fide and continued effort to so appropriate it.

SEC. 3. That the right of prior appropriation of water for irrigation shall be an appurtenance to the irrigation works by and through which it shall have been acquired and exercised and may be sold and transferred for a valuable consideration, as any other property; and each separate parcel of land shall have precedent right to such amount of water as shall have been assigned to and used thereupon from year to year, subject only to the right of any other such parcel of land as shall have acquired an earlier right by actual and continual use of water from or through such irrigation works: *Provided, however,* That nothing in this act shall be so construed as to entitle any such parcel of land to a precedent water right, except upon the payment of the agreed or allotted annual or other cost thereof, and that no tract of land shall acquire the right to any amount of water in excess of what is actually needful for the irrigation of such tract.

SEC. 4. That all that portion of the territory described in section one of this act lying east of the crest of the Snowy Range of the Rocky Mountains shall be known as the eastern irrigation division, and all that portion lying west thereof shall be known as the western irrigation division, the exact boundary line between said two divisions to be precisely determined in the manner hereinafter set forth.

SEC. 5. That the President of the United States shall, by and with the advice and consent of the Senate, appoint nine commissioners of irrigation for each said division. At least one-third of the number of persons thus appointed shall be learned in the law, at least one-third shall be practical civil engineers, and at least one-third shall be persons of practical knowledge and experience in irrigation, and all shall be residents of the territory described in section one of this act, or persons who have resided therein for at least five years. The President shall designate one of said commissioners in each division as chief of council of such division, and one of these two as president, and the other as vice-president of the general council. All official sessions of this irrigation commission shall be public, under such restrictions as usually govern courts of law, and all the records provided for herein shall be public records.

SEC. 6. That the commissioners for both irrigation divisions shall constitute the general council. They shall meet as such general council as soon as practicable after the creation of this irrigation commission, at some place and time to be designated by the president thereof, and adopt such general regulations governing its official actions as shall be necessary and proper to carry out the provisions of this act; fix the boundary between the two divisions hereinbefore provided, and may afterward alter the same; adopt and provide for a seal with which its official actions shall be authenticated; fix upon a place for holding the sessions of said body and the times when such sessions shall be held, which shall be at no greater interval than once in two years, a regular session to be held each even-numbered year, and adopt a systematic method of designating the different irrigation areas and systems, and the component parts thereof, and all the different timber reserves and other reservations by names or numbers, or both, so as to avoid confusion and furnish the means of identification and record. The concurrence of twelve commissioners shall be necessary in the decision of all matters coming before the general council.

Mr. HERBERT. I thought you had not less than nine commissioners.

Mr. GREGORY. That is for each division. This now is called the general council of both divisions. This bill divides the irrigation territory into two parts.

The president of the general council shall appoint a clerk, who shall perform the duties usually devolving upon the clerk of a court of record, and said president of the general council shall also appoint an official reporter and other necessary employés, and reports of the proceedings of said general council shall be printed and distributed after each session thereof, in such number and under such regulations as said general council may order.

SEC. 7. That the president and vice-president of the general council shall, at each regular session of the same, assign each member thereof to the division in which he shall serve until the next regular session of said body; and the general council shall designate the times when and places where the council for each division shall be held, which shall not be at a greater interval of time than one session thereof each year.

I have read more than I intended to read, but I wanted to read so much as would bring out the general plan, and I believe we have that in what I have read here. First setting apart the waters of that part of the United States west of the ninety-seventh meridian as devoted to irrigation, and at the same time dividing that region into two parts, the eastern and the western, and providing each with an irrigation council of nine members, and making the general council to meet in session at least once in two years, so that the commissioners may have an opportunity to confer and decide upon questions that affect the whole irrigation area. Then you will find in looking further through the bill, it will be the duty of these councils to subdivide each irrigation division into districts; each district will consist of all lands that are irrigated from common sources, streams, and systems, like the Arkansas Valley, for instance, and the Platte Valley, and the Yellowstone Valley; that is, it treats of entire or independent areas, without regard to civil boundaries, without regard to State or Territorial lines at all.

Mr. HERBERT. Were you here when Major Powell explained his theory of this division?

Mr. GREGORY. No, sir, I was not.

Mr. HERBERT. He proposed to divide the Arkansas Valley into several districts according to convenience, one of them above, and one on each tributary, and wherever it was convenient to have them to do so. Do you propose to have the whole Arkansas Valley——

Mr. GREGORY. These districts would be subdivided into sections. If an irrigation district should be small enough, it would not be subdivided; and, for convenience' sake, if they were very small, a few such districts might be thrown together. For the purpose of holding the commissioners' courts, the districts would be subdivided into sections not more than 150 miles square and not containing more than 10,000,000 acres. This is for the purpose of holding commissioners' courts, these courts to each consist of three of the nine commissioners. It is further provided that, at each general council for each division, different commissioners shall be assigned to different places for holding at least one term of court every year in each section, at such places as shall be designated.

Mr. PICKLER. What is the object of the general council?

Mr. GREGORY. There are a great many matters which are general in their nature, and affect the whole arid region. Another reason is that they can come together and have consultations, so that all may have the benefit of the experience and ideas of all the rest, and they may be informed on all points as far as possible, and may have the benefit of

learning from the experience of all the others. Beside, there will be a great many questions that could only be properly settled by a body of that kind—either settled by a body of that kind, or else come to Congress.

The CHAIRMAN. Does this bill provide that any department of the Government shall have supervision—shall be the supervising head?

Mr. GREGORY. Yes, sir; it is to be under the direction of the Agricultural Department. It is to be under the supervision and control of the Secretary of Agriculture, as an irrigation division in the Agricultural Department.

Now I would say as far as any provision of the bill is concerned that it is largely tentative. The idea is to present a frame-work upon which you can build something that will answer the purposes of this entire arid region.

Mr. HERBERT. How do you propose that money is to be appropriated to carry on this system of irrigation?

Mr. GREGORY. Among the provisions of the bill is one providing for a forestry, and a forester for each division, and as many assistants as necessary; he shall have charge of caring for and the extension of forests, and it is provided that hereafter the proceeds of the sales of all timber that may be sold from the natural accumulations of such forests shall be part of the irrigating fund; that all moneys received from and after the passage of this act from Government land, aside from necessary expenses of local officers, shall be part of this fund, and so on.

Mr. HERBERT. Government lands throughout the whole United States?

Mr. GREGORY. No, west of the ninety-seventh meridian. The provisions of this bill are specifically limited to the region described in section 1. There is a clause in this bill which undertakes to appropriate $800,000 to be placed to the credit of the irrigation fund as a starting point. The means to carry on the work will be derived from direct appropriations, from income derived from public lands, from the sale of timber, and from rentals of pasture lands, that is lands which are found to be absolutely beyond the reach of irrigation, classed as non-irrigable land and which, perhaps, for that reason, would not pass out of the ownership of the Government very readily. The bill provides that such lands may be rented as pasture lands under certain limitations. Any fines for infractions of the act, or anything of that kind, shall be turned in and become part of the irrigation fund.

Mr. HERBERT. How are the dams necessary for the storage basins to be constructed, by Government instrumentality or not?

Mr. GREGORY. There is no provision of that kind, but there is a provision for an engineering corps that shall have supervision and control—not control but supervision—and inspection of all works whether public or private; that no corporation or individual, or any one, shall have the right to go ahead with the construction of any irrigation work contrary to the orders of the engineering corps. It is to be under the supervision of the irrigation commission, but the idea is simply to provide the means of inspection, to prevent such disasters as those at South Fork and Walnut Grove dams, and matters of that kind; and also to have means at hand to which anybody may have access, who desires, for obtaining proper estimates and plans and information of all kinds with reference to all engineering matters pertaining to irrigation.

Mr. HERBERT. Private corporations are to be allowed to construct storage basins under the superintendence and protection of this commission?

Mr. GREGORY. Yes, sir; the idea is that it would be impracticable to obtain the help from the Government that would be necessary to bring about this development within a reasonable time. It would take very long and the people now upon these lands would be starved out or lose their property before anything could be done, but if means are provided by which private capital may come into that country and bring about that development with safety, and it is under such limitations and restrictions that it would not become oppressive to the people, we are convinced that there will be an abundance of private capital that will come to our aid; that it will be done, and done quickly and thoroughly. The people need protection against corporate combinations of various kinds, but at the same time the corporations themselves, as well as the people, need protection against the undue multiplication of such concerns, and you all know how it is in the case of railroads and other such companies, that it is necessary they should have certain rights protected in order that the investment of capital may be safe.

Mr. HERBERT. Does your bill divide the public land into districts; are they embraced in the functions of the commission?

Mr. GREGORY. The only reference to public lands in the bill is this: that the irrigation commission shall have management and oversight and control of all public parks and all public reservations in that area, and also provides that any person or any corporation may have the right of way across Government lands for the construction of irrigation works. The section which makes that provision is adopted from Senator Teller's right-of-way bill.

Mr. HERBERT. There are some railroads which have large bodies of land, and my question is whether this provision in your bill would give the power to this commission to take control over the irrigation upon these lands that had passed to individuals or corporations in the same way, to exercise the same control?

Mr. GREGORY. Do you mean to speak of the right of way or of development?

Mr. HERBERT. As to the control. For instance, it provides in the bill that no person shall construct any dam, I believe, except under the superintendence and direction of this commission. Is control given by this bill, or is there an inhibition by the provisions of the bill from erecting storage basins upon Government land?

Mr. GREGORY. No, sir.

Mr. HERBERT. The bill does not apply to that?

Mr. GREGORY. It applies to this extent, that any person or corporation undertaking to construct a storage basin or build a dam or anything of that kind would first have to obtain right of way therefor and would be subject to the inspection of the engineer corps under this bill. That is, it would be seen to that the works that were erected would be so strong and substantial that they would be safe. This is one of the things that it undertakes to do.

Mr. HERBERT. They would not be prohibited from erecting a dam and storing the water?

Mr. GREGORY. No, sir; the idea is to encourage everything of that kind to the greatest extent possible; to encourage the construction of storage basins and to preserve the forests now growing, and to extend them.

Mr. HERBERT. Now, take some tributary of the Arkansas. If some private person owned a grant of 10,000 acres in the upper part of that drainage basin, suppose they erected a storage basin there that would

store all the waters of all kinds and prevent the flow of water as before to persons below, would this bill inhibit them from doing it?

Mr. GREGORY. If it interferes with vested rights, yes.

Mr. HERBERT. Then your bill applies alike to public and private lands?

Mr. GREGORY. It applies to this extent, that no vested right can be disturbed except where it is found necessary to condemn such vested rights, and buy them out; where it is found necessary for the public good to do so. It makes provision that a vested right may be condemned, where public interest requires it, but that no vested right can be disturbed under any other circumstances.

Mr. HERBERT. It applies in its terms to all lands, public and private alike.

Mr. GREGORY. Yes, sir, it does; it provides that every person shall have right of way across any land, whether public or private, for ditches or storage basins, upon the proper condemnation proceedings being had.

Mr. PICKLER. Does your bill apply to artesian wells?

Mr. GREGORY. It applies to all kinds of water supply.

Mr. PICKLER. It says subterranean waters.

Mr. GREGORY. Yes, whether it is storm, torrential, or subterranean, standing or running. The idea in draughting this bill was, as I stated before, to provide a frame-work or beginning of something that would fit the entire arid region. Because there is such an interdependence of interests, and I am satisfied the more you study it the more you will find there is absolutely almost no independent area. There may be small spots and valleys in the mountains that stand absolutely alone, and I do not know but what the Pacific coast may be independent, but you may take almost any irrigation area you please, and by the time you follow it out as to all matters of storage and economy of water, and all that, you will find that it affects some other irrigation area and there is such an interdependence that they can not be wholly separated.

Mr. HERBERT. It suggests itself to me: suppose a stream arises in the northern portion of Kansas and it flows down through the State, and upon the headwaters of that stream in the State some one undertakes to erect a dam for storage purposes that will deprive of its usual flow of water some other citizen of Kansas who lives below that on the same stream. Suppose the question is entirely between these citizens of Kansas. Your bill there would give the jurisdiction of this court over that question between citizens of the State of Kansas. Do you think you can do that under the Constitution?

Mr. GREGORY. I do not believe Congress has the right to do that, if it could be shown that it was absolutely between the citizens of Kansas alone.

Mr. HERBERT. Now, for instance, there are some streams that sink; that rise in the State of Kansas and sink in the State of Kansas. Now, the question of citizens living on the banks of that stream seems to me to be cognizant solely under the laws of the court of Kansas. I do not see how you could give jurisdiction; your bill would give jurisdiction to this general commission in cases of that kind.

Mr. GREGORY. There would be two ways out of that difficulty: either limit the application of the bill so it plainly should not apply to matters of that kind, or else undertake to secure the co-operation of the different States and Territories so interested in such cases, that consent could be obtained to this kind of legislation. You know one bill has been

already introduced, I think, perhaps, in the House as well as in the Senate, which has that method in view—of Congress providing certain legislation to which the assent of the States will be asked.

Mr. LANHAM. In all the States where the practice of irrigation is carried on, do they not have statutes bearing upon these questions?

Mr. GREGORY. Yes, sir; in all of them, I think. But the difficulty is, as I have stated, that the irrigation areas are nearly all in some way interstate and interdependent one with another. Those that are not so interdependent are so few that they are almost insignificant, excepting the Pacific coast.

Mr. HERBERT. The difficulty of the plan would be to formulate a bill covering cases of that kind, and it seems to me impractical, because the Constitution of the United States could not be amended by three, four, or five States.

Mr. GREGORY. There are seventeen in which these conditions arise.

Mr. HERBERT. The jurisdiction conferred upon Federal authorities will only be in seventeen States out of forty-two, and it does not seem to me practical. It just suggested itself to me that in that respect it would be thoroughly unconstitutional.

Mr. PICKLER. This generation would not get through with a proposition to try to get the States to attend to that.

Mr. GREGORY. It would take a long time, it is true, and after all I think that proposition, as this gentleman suggests, even if the States ratified it——

Mr. HERBERT. Seventeen States of course could not amend the Constitution of the United States.

Mr. GREGORY. It would take a constitutional amendment to make it legal. The areas in those States, which are purely local, are small and insignificant, but after all I suppose it is not judicious to neglect anything of that kind, because such things, when neglected, become great.

Mr. HERBERT. If the whole provisions of your bill except one should be constitutional and one provision was not constitutional, the Supreme Court would strike out all.

Mr. GREGORY. That is true; but the question as to the right of Congress to handle this matter at all has been a question which I do not think is logical. I think the question has arisen merely from a hasty view of the situation. It seems to be the impression that Congress can not have anything to do with it at all. It is that feature I desire to speak to particularly, but I do not feel like undertaking to do it to-day, as I am not feeling at all well.

Mr. HERBERT. I would like to hear you upon that subject.

Mr. GREGORY. I would like very much to have that privilege.

Thereupon the committee adjourned to meet on the usual day, Thursday next.

STATEMENT OF J. W. GREGORY.

Mr. J. W. GREGORY, of Garden City, Kans., addressed the committee as follows. He said:

Mr. Chairman and gentlemen of the committee, What I wish to present for your consideration deals first with the general question of irrigation and then more particularly with the bill (H. R. No. 7504) introduced by Mr. Peters, of Kansas, and now before your committee. I have prepared in written form what I wish to say, because I can present it so much more clearly, fully, and rapidly than if I should undertake to speak without manuscript. I have endeavored to make my remarks as brief and pointed as may be, and shall consume but little of your time, though I shall of necessity speak rapidly, in order to cover all the ground I wish to cover in the time occupied. If any questions should occur to you which you would like to ask, if you will kindly reserve them until I have finished this paper, it will probably save time, as some of the questions which will probably occur to you you will find are answered further on.

I take it that it is not necessary to more than refer, by way of beginning, to the importance of the subject of irrigation for the West, because at least a majority of your committee have examined into the matter sufficiently, no doubt, to be not only impressed but oppressed by the magnitude of the interests and complexity of the questions involved. While I have been waiting my turn for this hearing a part of the ground I wished to cover has been much more ably covered by what has been brought to your attention by the Director of the Geological Survey, but I shall by your permission glance hurriedly over the whole field, including what I have already touched upon at previous hearings before a part of your committee.

To go at once to the core of the subject, I will say that this bill is based upon the idea that the only serious problems of irrigation are national problems, as distinguished from State or Territorial, and must be considered as such in searching for a means of solution. This is the gist, the starting point and the end of the whole matter, and I wish that all concerned might understand and realize, once for all, that it is a national matter and can not by any manner of means become or be made anything else.

There are two great factors which enter into the irrigation problem and make it a national problem. They are: (1) The insufficiency of the water supply for general irrigation, and (2) the non-coincidence, or interference, of civil boundaries with the outlines and effects of natural irrigation systems. In the first place, if there were water enough for all desired irrigation, there would be no material clashings of interests, no serious questions to be settled—only such minor local details as rights of way for canals, methods of construction and management, and other things of such sorts—no more serious than where and how to locate a road or build a bridge. In the second place, if every natural irrigation basin lay wholly within some one State or Territory and had no connection with, or bearing upon, any other, in another State or Territory, then, however serious might be the complications and questions to be settled in the development and application of irrigation, they would be local questions only and could be settled in no other way than by the individual States and Territories concerned.

But, unfortunately, as has already been shown you, there is great scarcity of water, considered with reference to the entire area of land

needing irrigation, hence, clashings of interests which bid fair to become—in fact most certainly will become—violent, and not only dangerous, but destructive to the peace and prosperity of many communities, unless prompt, vigorous, and efficient measures shall be speedily taken by some authority to prevent. This may sound like an extravagant statement, but, as a matter of fact, it is conservative. Irrigation questions are such as affect not only interests of individuals, but the entire interests of whole communities, and difficulties growing out of an irrigation controversy are such as quickly lead to broils and bloodshed. This is factor number one.

Then, these clashings of interests are not confined to citizens of the same State; but, in a multitude of instances, arise between the inhabitants of two or more different States or Territories. You have had these facts impressively presented to your notice, and are aware how continually interstate questions arise; how the waters of the Arkansas River must be divided among the inhabitants of two States, and how the conflicting interests are already seriously jarring, and will continue to do so, in a vastly greater degree henceforward. And so it is with the Platte and in the broad region covered by the great Missouri and its tributaries; these difficulties are or will be repeated over and over, and you find them in the basin of the Truckee and in notable complexity in the basins of the Bear and Snake Rivers; and other streams repeat the same situations again and again and again. This is fact or number two, and you have the problem made up. Well, then, if the great and vexing questions of irrigation are interstate question, they are, for that reason, national questions. That is a sort of question which must be settled by national means, and has no other means of settlement, as I shall endeavor to show you.

But, for the purpose of obtaining a view of this question from all stand-points, let us go a step backward and begin with the undisputable proposition that the questions to be settled must be either national or state, one or the other, since these two classifications cover the whole range of political, legal, economic, and all other general public questions which can arise in this country. Then let us suppose that States shall undertake among themselves to settle these outlapping, intertwining, irrigation questions. You have seen how, in many instances, not less than three States and Territories are concerned in the solution of some single irrigation question. You will find, upon closer examination, that this number may, in some instances, be increased to at least four. In such case, in what form shall they meet for discussion at the outstart?

It may be said that joint state commissions might be appointed for purposes of conference and agreement. About how long would it take, with even but two States concerned, as such things go, to bring about concert of action and secure the appointment and empowering of such commissions, arrange their conferences, conclude their deliberations, and have their conclusions finally ratified by the different legislatures concerned. You all know that, practically, it would take several years' time to bring such a matter to a successful issue with but two parties concerned, both desirous of a settlement. Introduce a third factor, and the complexity is trebled. Make a fourth party at interest and the difficulties would be almost endless. Let one party to such a settlement be desirous only of delay and inaction, and there would be absolutely no means of bringing matters to an equitable conclusion. Upon a stubborn disagreement, there would be no power lodged anywhere to decide a matter at issue, so that years of negotiation might

end in the accomplishment of nothing whatever. This is a brief view of what a single problem might involve, while the State of Colorado, for example, would have need to treat with not less than four States, and possibly more than six, upon separate and distinct problems.

Wyoming would be interconcerned with at least four others, and so would Idaho, Nevada, and Utah; Montana two or three; California the same; and so on, the questions mixed and intertwined in the most complex manner, so that a question in process of settlement would barely reach some sort of adjustment before the appearance of some new factor would necessitate an undoing and doing over of the tedious work on a new basis. Then, as there are absolutely two, and practically four, of the seventeen States and Territories concerned which have, from a narrow and selfish stand-point, nothing to gain, with possibly much to lose, by any concession to another State in irrigation matters, or any conference thereon, and as they are interconnected in a more or less intricate manner with all the remaining thirteen, you know, as practical men, that settlement of these matters by State negotiations is out of the question. If a final amicable outcome were possible it would take five years to get the process under way, and by that time it would be useless even to close the stable door, because horse, provender, manger, and stalls will have been stolen. If such negotiations could be begun and ended in good time there would still be no court to decide the thousand and one questions of detail and individual rights having interstate bearings unless the State commissions were made permanent interstate courts; and even then they would have no laws that could enforce their findings, because no State law can be by any means made to extend or apply beyond its State limits.

But, all these matters aside, such a method of settling such questions would be counter to the provisions of the Constitution of the United States—the fundamental and paramount law of the land—hence unlawful and inoperative.

It has been brought to your attention that in the world's history of irrigation there have been two general methods of regulating it, the national and the municipal, and it has been stated with a great deal of force and reason that the former has tended to give rise to the massing of interests in the hands of a few, while the municipal method has tended to keep power and rights divided into small holdings in many hands. While such may have been the tendency in other lands under laws and conditions dissimilar to our own, the strictly municipal policy as a general policy is impossible in this country under our laws and conditions, and a national policy, probably modified, is the only one possible, and, furthermore, the only policy under which the rights of the people individually and as a whole may be either ascertained or surely and fully protected.

Why? For a number of reasons.

The basis of the municipal method is this, that each irrigation basin should be an economic entity, separate and distinct from all others, and governed by such regulations as may be adopted by the inhabitants thereof, so far as irrigation is concerned. One method of solving the irrigation problem has been proposed in this form, that each natural drainage basin shall become an irrigation municipality, and this area be turned over wholly to the inhabitants without reserve, and left to their will to develop or ruin it, to husband, economize, and increase its resources, or recklessly waste them, as they may see fit, on the ground that the inhabitants of such an area are the only parties concerned, and if they see fit to cut down and destroy the timber, let fires

rage and waste through their pasture lands, and in these and other ways dry up the fountains of their streams and lay waste their territory, the loss will be upon them alone and nobody ought interfere.

To this plan I would enter a respectful but most earnest and emphatic protest. There is no considerable drainage basin but exerts and may exert a potent influence upon all surrounding areas physically, and the true policy is not to turn over what may be made a treasure-house of riches suddenly to any unorganized, inexperienced or reckless control, to be, perhaps, laid waste in a year or two to such an extent that decades of expensive care and waiting would be required to restore it. The control of a great many such municipalities could be easily obtained by single powerful corporations, as witness the Kern River basin in California, and Major Powell showed you a week ago how a wealthy ompancy, not being able to get control of a certain valley in Arizona in any other way, had bought out the landed interests of an entire district. It is no difficult matter for a single well-organized, shrewdly-managed interest to practically control and manipulate all the machinery affecting vastly greater, but unorganized, interests. You see examples of this throughout the entire country; in fact the world over. It might easily happen that, in some instances, those into whose power certain areas should fall would be tempted to wastefully exhaust great resources for present temporary advantage instead of conserving them for vastly greater and permanent future development. Then as a large majority of these irrigation areas extend into two or more States, either they must be furnished with a means of government of irrigation questions from and through the General Government, or they must, as has been suggested, be allowed to make their own laws and execute them in their own way. The power to erect this sort of municipality does not exist in the United States at this time. In effect it would be the creation of a lot of new States, so far as matters of irrigation are concerned, with legislative, executive and judicial powers—States overlying other States created for other purposes—two sorts of governments occupying the same territory at the same time with independent powers which would inevitably clash and interfere in numberless ways. The General Government can not create such municipalities, neither can the States themselves. They are an impossibility without a new constitution or extensive amendment of the present one; and if they could be created, we should not then be rid of the interstate questions, because these areas are not clear-cut and distinct, projected like silhouettes upon the maps, but their borders overlap and diffuse in such a manner, in so many places, that some sort of tribunal or commission to decide inter-area questions would still be necessary month after month and year after year. This complex interdependence simply can not be disregarded nor got rid of. It inheres in the nature of the things concerned and simply must be taken into consideration because it can not be eliminated.

In all candor, it seems to me that there is too much disposition to make this matter more difficult of solution than need be—a disposition to resort to that which will be complicated and dilatory, barren of results, and enormously costly, while there are simple, legal, economical, and direct methods in reach.

Hon. George P. Marsh, who was for some sixteen years United States minister to Turkey and Italy, who studied deeply the whole subject of irrigation in all its bearings, and who wrote the first report upon the subject, so far as I have noted, published in this country (published

in 1875), says, on the question of the control and supervision of irrigation:

> There are, no doubt, serious objections to the assumption of such burdens and such responsibilities by republican governments; but there are also graver and, as I think, insuperable objections to any other system.

This is the opinion of a man of learning, experience, and statesmanlike acquirements and capacity, who, having examined into the history of irrigation in all lands, seemed apprehensive as to its introduction into our industrial economy at all, while conceding that it was both inevitable and necessary; who took great pains to dwell upon all the disadvantages and dangers of irrigation, who had weighed all methods carefully and decided, as a result of his investigations, that national control and management are necessary. I believe that upon a careful study of the matter you will be convinced that his view is the correct one; that the National Government, as things are in this country at the present time, ought to have complete control of the entire irrigation system, down to the smallest detail of application and management, because in that way the rights of the people can be most successfully guarded.

In these days so vast amounts of capital may be massed in the hands of individuals and single corporations as to be above the power of any governmental control short of national control. Instances illustrative of this fact have already been cited. Much more striking examples of the power of vast wealth in the hands of a few individuals may be found in multitudes throughout the country. Municipal authority is no safeguard with millions of money seeking such investments as irrigation offers. There is only one safeguard strong enough to protect the interests of the people, and that is the strong arm of the National Government. It is probably impossible, however, under our laws, for the General Government to take that complete control favored by Mr. Marsh, and which is easily possible under a completely centralized government like that of Great Britain, whose regulation of irrigation questions he seems to have taken as a model. In fact, he perceived and even magnified the legal obstacles in the way.

But, when we can not secure all that is right and altogether the best methods, we must go as far as we can in the right direction and finish out with expediency. One thing, at all events, may be clearly and indisputably established, and that is that to attempt any other method of settling the interstate questions which constitute nearly the whole of the irrigation problem than through national means, is to attempt to go directly counter to the Constitution. And, before I proceed to discuss the provisions of the Constitution on this point, I wish to call your attention impressively to one thing, and it is this, that the query as to national right and authority to control these matters does not come, except in a reflected and apprehensive form, from the people who are directly concerned.

There is but a small percentage of people of mature age residing west of the ninety-seventh meridian who were not citizens of the United States before they were citizens of the particular State or subdivision which they now inhabit. They believe in the nationality of the United States, and are proud and confident in their citizenship of the nation They have no fear of the bugbear of "paternalism," and are not afraid of "encroachments" on the part of the General Government. Their only fear is that, on account of some such imaginary difficulties, they may be cheated of the attention, the remedies, the assistance so urgently required, and required at once. They are not stickling over any fruitless ideality of some particular form of "local sef

government." They look at all these matters in the light of broad, enlightened common sense. Esteeming themselves a potent part of the Government, they have no dread of any mysterious, terrible, possible tyranny to grow out of themselves upon themselves. Their only question is: "Will Congress do its duty by us now, in our time of pressing need?" I had the honor to bear to you from the people of a portion of the Territory concerned a petition on this question, signed by some ten thousand anxious and sincere petitioners, residents of two States, who indicated in no uncertain terms their opinions in this regard; and from my knowledge of that region and its people I am sure that ten times as many more would have been glad of an opportunity to join in its prayer.

Of course, if it is not both plainly within the power and also the plain duty of Congress to meet and provide for the exigencies of the present situation of affairs as regards irrigation in the West, then we can not be heard to complain if Congress shall do nothing. Fortunately, we need not be long in uncertainty both as regards the power and the duty of Congress in this particular.

Section 8 of Article I of the Constitution says that "Congress shall have power * * * to provide * * * for the general welfare of the United States." While this provision occurs in a section providing for the levy of taxes, duties, etc., it is none the less the broad and general provision that Congress shall have power to provide for the general welfare of the people, inasmuch as it would be a manifest absurdity to take the view that power is granted to raise the means for a certain purpose, yet that the power stops short of the ability to apply the means and in every way carry out the purpose itself. In fact, it certainly will not be denied that the whole purpose of the Constitution and of all bodies and powers and created under it is this thing itself, namely, to provide for the general welfare. And if the seven words, "Congress shall have power to regulate commerce" are capable of construction so varied, so elastic, and so comprehensive as have been put upon them, there need be no going out of the way to avoid so plain and logical an interpretation or construction as the one just enunciated.

The same section 8 of article I, provides that Congress "shall have power to constitute tribunals inferior to the Supreme Court." It therefore has power to constitute such tribunals as are provided in this bill.

The same section provides further that Congress—

> shall have power ——— to make all laws which shall be necessary and proper for carrying into execution the foregoing powers and all other powers vested by the Constitution in the Government of the United States, or in any department or officer thereof.

In express terms, then, Congress has power to pass all such laws as may be necessary to provide for the general welfare, and all such laws as may be necessary to carry into execution the powers which may be vested in such tribunals, inferior to the Supreme Court, as Congress may see fit to create in promotion of that general welfare.

But this is neither all the authority, nor the best authority, on this matter to be found in the Constitution, because it is general in its provisions, whereas there is authority which in effect is specific. Section 2 of Article III of the Constitution provides that—

> The judicial power [of the United States] shall extend to all cases in law and equity arising under the Constitution and the laws of the United States as to controversies between two or more States, between a State and the citizens of another State, and between the citizens of different States

I submit that this fits the great majority of irrigation questions as plainly, clearly, and specifically as if it had been framed for the express purpose. Congress may constitute tribunals inferior to the Supreme Court, shall enact laws to execute the powers of such tribunals, and such powers shall extend to the settlement of controversies between States, between a State and the citizens of another State, and between the citizens of different States. Not only so, but the power to reach and settle such questions does not exist anywhere else. The means and methods provided by the Constitution take the place of all others which might have been adopted or suggested. These provisions are plain, unmistakable, unequivocal, and can not be denied nor ignored. Then the duty of Congress to provide the means of settling these questions arising now between States and between citizens of different States is just as plain and unmistakable and the responsibility can not be avoided nor shifted onto other shoulders by any sort of experiments or expedients. They would not only prove cumbersome and wasteful of the people's rights and property and wholly futile in the end, as I have shown you, but positively unlawful as well. To undertake to turn over the settlement of such matters to States or State commissioners or courts, would be directly in conflict with the Constitution.

If we may take any other view; if States may among themselves, settle the interstate questions involved, what is to compel any two States to regard the rights of a third? Why may not Nevada and California, for example, agree to divide the waters of the Colorado between them, leaving Arizona out of consideration? Ought such action be permitted to the destruction of prior vested rights of citizens of Arizona? Why not Wyoming and Utah divide the waters of the Bear, leaving Idaho without her equitable portion? Would that be right or permissible under the Constitution? Yet they may do so if States may settle these matters. If so, why may not the principle be carried a step further and Colorado, or Wyoming, or Montana, or any other State conclude to impound and retain all the waters falling within its borders, whether needed for its own use or not, and allow it to run to the inhabitants of other States only upon the payment of any water rental it might see fit to demand? Should this be permitted to the impoverishment of the people living beyond a certain arbitrarily fixed limit, and to the benefit of late comers upon one side of an imaginary line to the destruction of hard-earned and dearly bought vested rights on the other side of that line? If there is nothing that Congress may do in these matters, as some seem to fear and others to desire, there is absolutely nothing to prevent any State which contains the source of a water supply appropriating, withholding, or unnaturally diverting all of it at any time—if the right to divert water for irrigation shall be recognized at all—without regard to losses which may be occasioned to those who have, by the expenditure of time, labor, and money, earned large vested rights lower down stream in other States.

There are persons who appear to hold the opinion that States may do this very thing. Let us see whether the Constitution contains anything directly applicable to this point. Section 2 of Article 4 of the Constitution says:

> The citizens of each State shall be entitled to all privileges and immunities of citizens in the several States.

I take it that this fully and completely covers the interstate application of vested rights in water for irrigation and the priority of appropriation of it. There can be no property in running water any more than in floating air. Man acquires in natural water only the privilege

of use. This fact has been recognized and established the world over and through all time. There have been different methods of permitting the exercise of that privilege of use, but nowhere and at no time has anything more than a privilege of the use of water been vested in any one. In the United States this fact has been recognized by every State and Territory yet legislating upon this subject. Where there is less water obtainable in any given basin than would be necessary to irrigate all the land susceptible of irrigation in that basin, the first appropriator is protected in his privilege of use; and this is right and in accordance with justice and sound public policy.

If a man find a valuable mine, it is his if he develop it; if he discovers some new application of physical law, or some new mechanical contrivance, he is entitled to protection by letters patent if he shall desire to profit by his discovery; if he evolve a new idea, or even clothe old ideas in new forms, he is entitled to protection by copyright in the enjoyment of the fruits of his mental labor, if he shall so elect. In line with and stronger than any of these, if any man, risking time, labor, and money, shall go into the desert, as it were, and by opening from source of water supply an irrigating canal, reclaim land, and build up a home, the means of subsistence of himself and his family, to the increase of the wealth and prosperity of his State and nation, the appropriation of water made by such means should be safe and fully protected against all subsequent comers who might seek to profit by his example, courage, and enterprise, and at his cost.

This is but right and equitable—the only just policy. To neglect the enforcement of this right is to make it always possible that any successful irrigator, living in a basin of inadequate supply, as nearly all the drainage areas are, will sooner or later be left without the means of irrigation and ruined by later comers exhausting his water supply further up stream; the harder his labor and the greater his resulting success, the greater the probability of his ultimate dispossession. And those who would thus rob him, being at the mercy of similar supplanters, the effect, as you have been shown, is to drive the agriculture of the irrigated regions into broken hill lands and into the regions of snow in the mountains to the destruction not only of the property of many individuals, but to the ultimate great loss of municipal wealth as well. Then if it is right and necessary to protect a man in his acquired privilege of the use of water, it matters not upon which side of a State or Territorial line he may reside or have made his appropriation, his right to the enjoyment of that privilege and to protection in that enjoyment are the same.

In this country we are supposed to be precisely equal before the law without regard to the accident or circumstance of location. No citizen of Colorado is born with or can acquire any privilege that does not belong to any citizen of Kansas, or Nebraska, or New Mexico. Justice and equity are the same in Idaho as in Utah or Wyoming. The paramount law of the United States says so in terms that can not be misunderstood. "The citizens of each State shall be entitled to all privileges and immunities of citizens of the several States"—entitled to the privilege of enjoying that which has been recognized as right in all the States and Territories—a privilege earned and acquired through genius, enterprise, labor, risk, expense, and immunity from loss through the operations or machinations of any person who would seek to take possession of or enjoy what has been so earned. These are the inalienable rights of citizenship in the United States, and the enjoyment of them is guarantied by the Constitution. No State line can ever be made an

intrenchment under cover of which that which is right or wrong as between citizens residing upon one side of that line may not be enforced or prevented as between citizens residing upon different sides of that line.

Congress having been created for the purpose of carrying out the provisions of the Constitution and endowed with the power necessary so to do, can neither neglect to observe nor fail to execute each and every provision of that Constitution. There can neither be exception nor any degree of observance short of completeness. In this particular, all provisions, whether affecting great or minor interests, are alike important. One question of right is always as great as every other; and if the smallest right of the meanest citizen of any Government may be trampled upon without redress, that Government contains within itself the elements of its own destruction; for a Government that will willfully or negligently permit injustice, has neither the right nor the power to continue in permanent existence.

Now I submit that the right, the authority, and the duty of Congress, under the Constitution, to act in the matters considered and provided for in this bill are clear and well established. As applied to irrigation matters which are in any part or bearing interstate there simply can be no shadow of doubt of it. As to such limited areas as have no interstate bearing whatever they could only come within the provisions of this bill, or of any other act of Congress, upon the ground of such jurisdiction being necessary to the general welfare. On a former hearing Mr. Herbert, of the committee, suggested that the bill should be clear upon this point so as to avoid any danger of unconstitutionality. Accordingly such change has been suggested as will leave no doubt of the proper and legal limitation of the authority and application of the bill. If such local irrigation areas can not be included with the rest of the surrounding territory, as it seems they ought to be, in a general economical system, then the General Government can never have that complete control of irrigation advocated by Mr. Marsh.

Leaving the Pacific slope alone out of consideration, such strictly local and independent areas will be found few and small indeed. But, whether great or small, if they can not properly be regarded and included under national control, they will have a sufficient, though separate, and probably variant means of regulation in the State governments. All these aside, it will be found that the matters pressing upon national attention are of vast extent and incalculable importance, and, if it is established that it is the duty of Congress to take cognizance of them, it only remains to consider what means ought to be adopted to discharge the duties and responsibilities imposed upon you in this regard by the Constitution.

While it must be conceded that some code or system of laws must be adopted by the national legislature regulating these matters, it has been suggested that the existing United States courts could and should dispose of all business arising out of irrigation questions.

I say it must be conceded that legislation is necessary because it certainly will not be held by any one that a plaintiff could plead or ask for the enforcement of Idaho laws in Utah or Wyoming, or of Kansas or Nebraska laws in Colorado, or the reverse. No State law can be applied to the settlement of an interstate question because powerless beyond its own state line. Hence, in any event, Congress owes it to the people of the West to at once provide some system, or at least the frame-work or groundwork of a system of laws under which the settlement of irrigation questions may at least begin. Then, when laws are

provided, shall the United States district and circuit courts, as at present constituted, be the courts in which such matters shall be heard?

To my mind there are two very serious objections to so disposing of the matter, either of which should be sufficient to prevent so doing. One is that those courts already have all the business they can attend to, there being considerable delay in reaching final adjudications as things are now, and the growth in volume of such business as already falls to those courts will doubtless fully keep pace with any probable extension of their facilities. If they should be called upon to decide the new questions arising out of the extension and development of irrigation, the number of courts would have to be so greatly increased at once that there would not only be no saving of expense, or the multiplication of legal machinery over the method provided in the bill under consideration, but, on the contrary, both would be much greater on account of the tedious, technical methods followed in such courts, and there would be tremendous loss to the people concerned in the decision of irrigation questions by reason of the delay suffered.

The second reason why those courts are not the sort of tribunals in which to secure the relief needed, is that it would be pouring in suddenly upon them for decision a flood of such questions as they were not created to settle and are not prepared to settle. I will discuss this more fully a little further on, glancing first at the general outline of the provisions of this bill to see whether it provides the right sort of laws or tribunals, or both, to most promptly, certainly, and economically attain the desired ends. You will note that it affirms certain fundamental rights and purposes, creates tribunals, defines terms, and provides methods. It first sets apart the waters west of the ninety-seventh meridian to purposes of irrigation, subject to ordinary domestic uses. This must be accepted as necessary and consistent with the public policy which should govern the arid region, because, to subserve the interests of that region, irrigation must be the paramount interest. I believe that all who understand the situation will agree that this provision is right and necessary.

On the question of boundary, the idea has long obtained that the one hundredth meridian marks the beginning of certain aridity; but the desire for, and the at least occasional need of, the benefits of irrigation have rendered it advisable, in the opinion of parties concerned, to make the ninety-seventh meridian the eastern boundry of the region of applied and systematic irrigation; though, as a matter of fact, much successful farming can be done, at times, without irrigation, over considerable areas west of the one hundredth meridian. It affirms and establishes the right of precedent use of water for irrigation, and its necessary accompaniment, the right of prior appropriation through irrigation works.

The justice and necessity of plainly and clearly recognizing and protecting this right of precedent use have already been touched upon. Though the right of prior appropriation is that which is generally, as a matter of collective convenience, recognized and affirmed by custom and statute; it is a derivative and expedient right only. Taken alone, as it is usually exercised and recognized most frequently by corporations, and apart from direct use upon the land, would be a monstrous injustice, and should not only not be recognized, but not even tolerated by law. It is only that it is the expedient, the means for protecting the vested right of the user of water, that it is a right at all, and to be protected; and this fact should neither be forgotten nor overlooked nor left in uncertainty, in the incipiency of legislation on irrigation. Other-

wise, color and encouragement may be given to the idea, which seems often to be possessed by a furnisher of water, that he has acquired some sort of *property* in water because of having expended time and means in diverting and appropriating it, and that he may turn it here or there, supply it to or withhold it from actual users at will or at caprice; or even let it wantonly run to waste, if he choose, while the people, in whom the only real right of use can vest, and who are dependent upon its supply, are left to starvation and ruin for want of it. To permit anything of this sort is to make the whole irrigated region, in a few decades, the property of a few princely aristocrats and the home of their dependents and servants, instead of making it the abode of millons of snugly lodged, comfortably clothed, well fed, happy, free, and independent families, as it ought to be and may be.

In a region requiring irrigation, yet having less water available than is necessary to irrigate all the land needing it, if the control of the water supply be given over to any person who may manipulate it at will, it need be but a question of time until he may own all the land as well, and reduce the inhabitants to the condition of dependents and serfs. It has been noted that every country yet made great and rich by means of irrigation has been the home of tyranny and oppression, where the wealth has been in the hands of a few, and for the one reason of the few controlling the water, which alone gives value to land under such conditions. It lies with you, gentlemen, to take counsel of the warnings of history, and take the initiative in making such results impossible in this free and enlightened country, under a Government which is for the people as a whole, and not for a favored few.

If, then, it may be conceded that these two things are established as necessary, (1) the setting apart of the waters for irrigation, and (2) the recognition and protection of the right of precedent use (and they must before any further genuine progress can be made toward the solution of the irrigation problem), then we can proceed to consider the best means of ascertaining rights and protecting individuals in the enjoyment of them. After laws shall have been provided for these purposes, then there must be tribunals having jurisdiction to try and determine legal questions which will constantly arise, and determine and enforce rights under those laws. I have already stated why the settlement of irrigation questions ought not to be left to the present U. S. courts, namely, that those courts already have all the business they can handle, and that their business will doubtless increase as rapidly as the courts will probably be multiplied.

The second reason, which I promised to refer to again later, is best elucidated by showing what sort of court is needed. The questions to be settled concerning irrigation will be very largely questions of the practical applications of hydraulic engineering and the practical applications of irrigation as to methods and customs. It is said that when Judge Gresham was to decide an important question as to an infringement of a telephone patent he took three or four years to study the whole range of the practical employment of electricity in mechanical appliances, and that when he rendered his decision it was a masterpiece of learning upon the points involved and of logical deduction from the whole range of electrical science which he had mastered for himself. He decided with confidence and his findings were unshakable, because based upon positive, intimate, personal knowledge.

No intelligent, sound, reliable decision upon any important question can be reached or rendered in any other way. Now this bill provides for a court which shall contain (1) a skilled lawyer, competent to direct and

manage all judicial proceedings according to those forms of law which are as necessary to a court as parliamentary rules are to a deliberative body; to judge of the competency of evidence and see that what is done shall be done in due and legal form and order; (2) a practical engineer, competent, fully informed, and ready to judge intelligently of all engineering questions coming before the court, and qualified to know when engineers and inspectors under the act are properly performing their duties; (3) a practical irrigator who has technical knowledge of what is in fact one of the most difficult and intricate sciences and which can be learned only in the school of experience and practice, namely, the practical workings of irrigation.

If for the settlement of these irrigation questions we were simply to have present United States courts multiplied, there would be no saving of expense, because there would have to be, as already shown, a sufficiently large number of courts to transact the business, or the people would necessarily suffer from delay on that account, and then we should have lawyers only to pass upon questions almost wholly outside the knowledge of lawyers, and either the people concerned must then wait until those lawyers could be educated as engineers and as practical irrigators, or there must be a vast deal of loose and bad deciding of difficult and important points by men ignorant of the things involved. As a matter of fact, there would be a great deal both of delay and bad decisions. The people can not afford either.

A court constituted as this bill provides would tend to become one in which all the members would eventually be competent lawyers for all the purposes of the court, good theoretical hydraulic engineers so far as such engineering applies to practical irrigation, and have a knowledge of irrigation itself in its practical workings, which would be so much the better, as a matter of course. But, not only so, it would be a court competent and thoroughly equipped from the first for prompt and intelligent and correct action, and that is what the arid region needs, for a host of the most important questions are pressing for answer now, and it is furthermore important that the early decisions, the beginning of a line of precedents, should be correct and sound.

As to the bill as a whole, it is largely given to matters of detail and intended to be suggestive and furnish a starting point, a basis of action. It has been suggested, for instance, that the offices of prefect and superintendent, as created in the bill, might be consolidated; that it might be wise also, at the present time, to leave whole branches, as treated of in the bill, out of present consideration, so that it may be simplified and rendered more easy and certain of consideration. Such might be done advantageously. Many matters of very great importance, which really need attention soon, were not be embraced in this draught at all, for the single reason that it seems to be impracticable to secure attention to so much of one subject at one time; and what is needed first is a correct basis, a proper frame-work upon which future operations and legislation may be safely and economically built. This is of prime importance. It should be broad, without mere surplusage, strong without being unwieldy, should possess symmetry, and, above all things else, be practical, effective, and soon made ready.

It is not supposed for a moment that what is here presented is above criticism and most extensive amendment. It would be strange, indeed, if a bill treating of new matters so extensive and of so great importance, hurriedly prepared in a short time, could not be very largely improved upon. Four sections of the entire bill are adapted from other sources, all the rest being evolved from the personal experience,

observation, and investigation of a single person, must necessarily be full of crudities and weak places. But there is one criticism, which is always the first, and against which I wish to most earnestly protest, and that is, that the bill is long and its consideration will require time. I must insist that the matters involved are worthy all the time that will be required for consideration, even though they were a dozen bills as long to be carefully scanned and dissected. Nearly half the United States is directly interested, and thousands of people and millions of present wealth and billions of the wealth of the future are most deeply concerned, and the necessity of action grows greater every day. Such a matter can not be dismissed in ten lines, nor twenty, nor in a few moments' cursory examination. Where so much is at stake, and necessities are so pressing, we, the people, certainly do hope that you, the representatives of the people, will give our vital interests all the time they require.

We have no objection to express to Congress taking a week to locate the next World's Fair, nor days at a time to settle contested-election cases, nor six weeks to consider appropriation bills, wherein the most time will be devoted to discussing the propriety of expending vast sums in pulling snags or removing bars from innumerable coves and creeks, because all these matters are public necessities and can not be avoided; but it is hoped you will not omit "the weightier matters of the law." Let it not be said "these ought ye to have done and not left the other undone."

The necessities of irrigation legislation present grand opportunities for the display of genuine statesmanship; and not only is this true, but besides the responsibility is upon you and can not be avoided. To neglect these great opportunities is, in large part, to lose them, because if this session of Congress shall remain inactive, before the next session can be held millions of the people's wealth will be totally lost to them, and difficulties involving millions more will have arisen which will not arise if the present Congress shall act promptly and wisely. Every month, and I might perhaps have said every week, or even every day, witnesses the birth of new complications the removal of which will, in the aggregate, cost enormously; and, like the rolling snow-ball, which grows so much more rapidly at every turn, these complications grow with an increasing rapidity that is both startling and appalling to those who study and understand the situation.

In the preparation of this bill the study has been to incorporate first what is essential in the beginning of legislation on the irrigation question. One basic idea was followed throughout, and that was, how to secure and establish the rights of the settler, the direct user of water. Primarily there is no other interest entitled to consideration. But cooperation and the investment of large amounts of capital are rendered necessary by the nature of the circumstances governing irrigation in this country. Whether the Government ought or ought not invest millions of money in building reservoirs and in other means of conserving and developing water supply in aid of agriculture in the arid regions, there is no gainsaying the fact that it will not do so in the immediate future. Hence, large amounts of private capital must be induced to supply the means of development, and for this reason this bill aims to insure to capital a safe and reasonably profitable investment and security against possible agrarian injustice. These things are necessary and capital ought not ask anything more—nor does it. Adventuring promoters and scheming speculators who wish to grow rich suddenly off the people may desire greater advantages than this bill

allows, but actual capital seeking investment does not. This is one of the most important features of the bill, if not the most important.

The time will come when the people of any and all irrigation districts must either own and control their irrigation water supply or else the water must be furnished at a very reasonable profit over and above actual cost of the construction and the necessary current expenses of the irrigation works employed. If, then, promoters and intermediaries are to be permitted to cover the whole arid region with works ostensibly representing many times their actual cost, and to extort, even temporarily, exorbitant charges for the water furnished, the result will be that the users of water will eventually rebel against the extortion; but the coming down to a proper basis will be at the expense of the water user or the genuine investor, or both, while the intermediary will have gotten off with his large, unjust, and unearned gains.

The provisions of this bill are such that the increase in values will accrue, as it ought, to the benefit of the people. Wild speculation will be prevented, and whether irrigation works shall be built by municipalities at public expense or by private corporations, the people will receive the benefit just the same. It gives to the individual land-owner and water-user protection against extortion and injustice and against the possible encroachments of organized speculation or too greedy capital. In other words, it renders it impossible for grasping avarice, in the guise of furnishers of water, to "squeeze out" or "freeze out" small land-owners and practically confiscate their property. It provides for the growth and preservation of timber, a matter of prime importance, and for the storage and economy of water so as to cause it to render the greatest service to the largest number of people at the least cost; provides for the most thorough, systematic, and authoritative inspection of all dams, reservoirs, and other irrigation works, with a view to preventing such horrors as the breaking of the South Fork dam, the Walnut Grove dam, and other things of the same kind, growing out of reckless carelessness and cupidity.

I would also call your attention to the fact that the storage and use in irrigation of the muddy waters of such rivers as the Missouri and the Arkansas would be a powerful factor in solving the Lower Mississippi problem. With those vast floods of mud-bearing water turned to the business of fertilizing the great plains, leaving the cleaner waters of such streams as the Ohio and the Cumberland to do the work of scouring out channels through the jetties and between banks, a large factor might be turned to doubly profitable use. As the day so rapidly approaches when the levee system, as applied to the Lower Mississippi, will stand incontrovertibly demonstrated a vast and expensive failure, this will be found worthy of careful attention. It might not be amiss, too, in passing, to call attention to the fact that the building of levees along the Mississippi can not, except by the aid of a vivid imagination, be considered a "regulation of commerce," and there is no valid reason for the Government doing such work which does not apply with at least equal force to the work of reclaiming the arid and semi-arid lands.

As to infractions of the act, it aims to prevent wrong-doing in the surest way, namely, by making detection and punishment most certain. It provides a court, as already shown, the most competent to immediately, judiciously, and actively take up the work necessary, and such a court as will, with lapse of time, become more and more proficient and well furnished, a court enjoying the greatest freedom from political or other extraneous and undue influences, from motives of demagogy, from dangers of frequent change, from the blunders of inexperience;

one in which the officers shall have the greatest incentives to make a record of honorable usefulness, be free from the apprehensions consequent upon a necessity of providing for personal needs, free from any excuse for temptation to corruption—yet, withal, hedged about by the most effective safeguards against corruption, incompetency, or tyranny in office.

It provides for such methods as will secure harmony and consistency with flexibility in the construction and administration of the laws; require the exercise of individual judgment, and give scope for the display of individual talent, yet secure the benefits of frequent counsel and conference. It treats the rain-making question as the broad, comprehensive, national question that it is, yet looks after every detail of the rights of the humblest settler, so that he may be secure in the enjoyment of that which is justly his. It seeks to avert the dangers as well as extend the benefits of irrigation—for there are many and imminent dangers to be guarded against. It provides local self-government in its truest sense, securing co-operation, and, while insuring even and exact justice to all concerned, seeks always to secure the greatest good to the greatest number. Under this bill the people of Nevada would be perfectly safe in expending all the money necessary to store water on California soil or anywhere else, and Idaho may have her drainage basins or reservoirs in any State or Territory where the "lay of the land" may require.

Each resident along the course of any stream will be secure in his acquired rights against every subsequent comer; or if public policy shall require that certain vested rights shall give way for a new arrangement and order of things, then it is provided that such obstructing rights may be condemned and paid for as may any other private property taken for public use. This is just and right. No man's property ought to be confiscated, neither should any individual whim or chance of location be allowed to stand in the way of the public good.

In matters of detail the bill must, in the very nature of things, run counter to the ideas of others, though not intentionally so. This matter being new to legislation, one of the greatest difficulties first to be met is the wide range of different individual ideas and opinions on the subject, and, before any progress can be made, there must be a coming together by means of mutual concessions. No one mind thinks all of truth, nor contains all wisdom. So far as the people of the Southwest are concerned, we should be glad to make any concession in reason, gladly sanction any plan, only so that the essentials of protection to just rights are retained and so that prompt action may be taken. One criticism which has been offered before your committee upon a part of the bill I wish to notice briefly. It was upon the provision for charter-license.

If any member of the committee has not examined that provision of the bill carefully, I hope he will do so. It is a provision of the utmost importance to all parties concerned in the genuine work of developing the means of irrigation and is intended to most effectually protect the interests of the people. It provides for granting charter-license, not to give any concern a chance thereby to acquire unjustly great and valuable franchises, but solely as a means of control so as to save both settlers and actual investors from the enormous losses now possible through the manipulations of irresponsible promoters and swindling speculators. This is neither saying nor intimating that all, or even a majority, or even a large part of the number of those engaged in promoting irrigation enterprises are irresponsible or engaged in nefarious practices.

Many promoters are engaged in legitimate and laudable business enterprises, calculated to be of great benefit to the regions concerned. But no such genuine enterprise will shrink from compliance with the regulations imposed in order to secure a charter-license.

If there is any loop-hole through which claims against the Government can be drawn out of this provision I fail to perceive it. The Government has expended millions of dollars in the past many years in building levees and in other means to control the waters of the Mississippi River and protect the adjacent country from inundations, but I do not understand that thereby the Government now becomes liable for damages caused by the floods now prevailing However, if there is a danger of that sort lurking in that provision the warning is timely and the defect can be remedied.

And now, in closing I wish to offer this apology. If I shall have seemed over-earnest or over-persistent on some points, you are asked to remember that I speak for a people and a region needing, above all things else, *promptness* of action. Almost any system of laws passed now by Congress, if it but contain the elements of right and justice, will do us great good. Every month of delay does us immense harm; while, if action be postponed two or three years, it might as well never take place, so far as a large proportion of our citizens are concerned. A faultless system of laws passed, then, while they would have great effect, no doubt, upon the development of resources in the middle Arkansas valley as a region, would reach and benefit a comparatively small percentage of the present population; because, scattered abroad by stress of circumstances brought about or heightened by delay of action in providing the legislation necessary, they could have no part or share in the greatest possible prosperity which might afterward be built up.

Urgent as is the need of the people of the middle Arkansas Valley, they are situated only as are the people of scores of other localities, and we all feel that the matter is one which may well engage the attention of Congress, since the situation is so grave, affects so many people, and can be relieved from no other source. The truth is, if Congress shall do nothing in this matter either now or hereafter, the wonderful resources of the arid region will some day find development, because the treasures are there and will be uncovered; but, at what tremendous waste of time, energy, and wealth; at what expense of trampled rights, and through what outrages of justice, can now be but faintly outlined.

We feel that, as a matter of right, we might urge large appropriations of money by the general Government to assist in the development of irrigation, because the arid region must have already paid into the United States Treasury for land over one hundred millions of money; but life is too short to wait upon the expectation of full justice being done us in this regard. It has been suggested that Congress might, with the most gratifying results, adopt, at least, a modification of Senator Stanford's recently published idea as to the Government loaning money upon land to the people, at a low rate of interest, and applying it to the construction of irrigation works.

It is a thing that is feasible, and would bring about results so wonderful as to be beyond the complete grasp of the human mind. As far as that is concerned, it would not be necessary for the Government even to furnish the money. Upon proper Governmental provision regulating the issue of the securities; payment of interest, and so on, a hundred millions of foreign capital could be had as low, probably, as 2 per cent. per annum, and the people reap the benefit of this low rate of in-

terest. It would be the beginning of a flood-tide of prosperity that would soon put the United States in the lead of all nations in wealth.

But of course nothing of this kind will be done immediately, if at all, though it will be proposed. The Government will certainly do something in the way of experimenting to ascertain and develop the sources of water supply, and this will be of very great value indeed; but there can be no possible excuse for failing to provide the legislation which will protect the people in the enjoyment of their rights, and enable that great region to begin to secure the investment of the private capital necessary to make up for what the Government will not do. Action at this juncture means certainty of results, system, economy, the wishes of the people gratified, their rights and property protected, and wealth created by millions in their hands. Inaction means chaos, the rights and opportunities of the people frittered away, their wishes disregarded, and the accumulation of wealth and power in the hands of a few at the expense of many. It is for you, gentlemen of the committee, to decide, first of all, which course shall be pursued, because upon your action hang the issues of the matter.

I have not gone more into the details of the bill for lack of time, and for the reason that it should first be decided whether or not the general plan of it is the desirable one. I would only say that each and every part attempts to cover some need taught by experience and observation, and which ought to be provided for. Each section is only a part of the machinery necessary to carry into execution the principles of the bill. Should you desire it, I will take pleasure at any time in going over it by sections and stating what point each is intended to cover, and why it is necessary so to do. There is, at least, one good reason for present action on each provision, and many reasons for some. But if the general plan is not approved, it would be a useless waste of time to discuss details. I am at your service to any extent and at any time.

I thank the committee for their courtesy.

Mr. PICKLER. That is certainly a very interesting paper.

Mr. LANHAN. I fully agree with you, Mr. Pickler.

Thereupon the committee adjourned.

COMMITTEE ON IRRIGATION,
February 27, 1890.

The committee met pursuant to adjournment.

STATEMENT OF MAJ. J. W. POWELL, DIRECTOR OF THE GEOLOGICAL SURVEY.

Major POWELL addressed the committee as follows:

Mr. Chairman and gentlemen of the committee, I have on the wall before you a map of the western portion of the United States, on which is exhibited an outline of the area in which irrigation is necessary. The eastern border of the region is marked by a red line, as you see, which runs across the country near the 100th meridian, but is irregular. The western boundary is still more irregular. The mountains are so formed and the currents of the Pacific are of such a nature that much moisture is drifted into this northern country and the boundary is pushed farther eastward. Within the lines on the map there is a total area of 1,340,000 square miles, but that does not include all the area where irrigation is or should be used, and where it must be practiced in the near future. There is a doubtful belt of 2 or 3 degrees in width on the east side of the line, which I have heretofore in my writings called the sub-humid region, where irrigation is practiced to some extent. In some years there is sufficient rain-fall to warrant the planting of crops and agriculture is successful, but from time to time seasons come in which there is no rain-fall, and crops are cut off and disaster comes to the people; so they are beginning now to resort to irrigation 100 or 200 miles beyond or east of this line.

The two lines include a region where, except little places on the mountains, agriculture is practically impossible year by year without irrigation. Then there is a sub-humid region on the west where agriculture is sustained without artificial means some seasons and other seasons not. If we include all the area where agriculture is dependent in whole or in part on irrigation one-half the area of the United States, exclusive of Alaska, would be embraced therein. The map further shows the extent to which irrigation has been practiced. Such areas are colored blue, and are scattered about the map, so that it will be seen that the question of irrigation is no longer one of uncertainty, it is no longer a theory; but large areas are irrigated, aggregating in all about 8,000,000 acres, scattered variously throughout the States and Territories embraced in these lines. The larger part of that irrigation is dependent upon the utilization of the small streams—creeks, and small rivers—and to some slight extent upon artesian waters, and to a very small extent upon pumps taking the water from wells which do not overflow and are not artesian wells in the proper sense; but in the main the agriculture is dependent upon the flowing waters, the exceptions being so trivial as scarcely to be worthy of mention. There are a few places where water is stored, as in California; but in the main

no attempt has yet been made to create reservoirs, and the waters from fifty to eighty days only are used for irrigation, while the remainder are allowed to run to waste.

Mr. HERBERT. If the waters in that area which you have marked off were all scientifically utilized, what portion of that area would be rendered productive—as much as one-tenth or one-twentieth?

Major POWELL. I have made a pretty careful estimate; three of us have been engaged on it for several years, from time to time, attacking the problem by different methods and coming substantially to the same conclusion, that we have about 100,000,000 acres of land which can be redeemed between those lines by the use of the streams.

Mr. HERBERT. How many million acres are between those lines?

Major POWELL. There are nearly 900,000,000 acres. I believe about 100,000,000 acres can be redeemed by the utilization of streams.

The CHAIRMAN. Storage and so on?

Major POWELL. Storage and so on. But there will be in addition to this three other sources which will increase the area to an extent of which we are not willing to make predictions; the investigations are not sufficient to warrant it. But I will indicate the three sources. The first is the utilization of the storm waters—waters which are not perennial. To a large extent the storm waters will be used in detail on small tracts of land, where they do not contribute to the flow of perennial streams. Where they do they are better used with the streams, and are included with them in my estimate. Then there are the "sand reservoirs," as I shall call them, where the water accumulates in valley sands and does not appear as artesian waters; and finally, there are the artesian waters. From these three sources considerable areas in addition to what I have estimated will ultimately be redeemed. Of the three additional sources the storm waters constitute the chief.

The CHAIRMAN. Do I understand you to say there are 100,000,000 of acres of land between these two lines which will be cultivable if they had water put on them?

Major POWELL. No, sir; one-half the area, if you had water, would be cultivable.

The CHAIRMAN. And of that half 100,000,000 acres would be cultivable?

Major POWELL. There are probably 500,000,000 acres of land which would be arable if there were sufficient water.

The CHAIRMAN. Then your idea is that of this, 100,000,000 acres of land are cultivable by the use of all the water?

Major POWELL. Yes; from perennial streams.

The CHAIRMAN. That is, that 100,000,000 acres of land could be cultivated including the estimate of storm waters?

Major POWELL. No, sir; that has to be added. The amount to be irrigated from the use of the three sources—storm waters, sand-reservoir waters, and artesian waters—is to be added to the 100,000,000 acres.

The CHAIRMAN. Then to give importance to that problem you must have some sort of an estimate of the amount of storm water?

Major POWELL. Yes, sir. In the regions where the streams are perennial the cutting off of the storm waters will, to a large extent, cut off the supply from permanent streams and reservoirs, and such cutting would be injurious, for it is better to handle them with the permanent streams. There are other regions where the storm waters can be used as such, and must be used as such if used at all, for they do not feed perennial streams. Let me make myself understood. All the waters are primarily storm waters. They all come from the heavens. Some

are gathered into perennial streams, and then I call them *stream* waters, and such waters constitute the chief body to be used in irrigation. A small amount of the waters coming from the storms sink into the rocks, and when they can be recovered by overflowing wells they are called *artesian* waters. Another small amount of original storm waters are accumulated in *sand* valleys, and are called sand-reservoir waters. They are to be recovered in part by pumps and in part by gravity—that is, by drawing them off onto lower lands. Now, there are regions of country where the rain does not gather into permanent streams, but where storm streams that soon go dry are abundant, and these we call storm waters.

The CHAIRMAN. If there is no other point just there, perhaps it might be desirous to get at some information on the different precipitations of the mountains and in the valleys.

Major POWELL. I shall come to that.

The CHAIRMAN. This whole region is traversed by mountains.

Major POWELL. The rain-fall of the arid region is very irregularly distributed, as it is concentrated on the mountains. In the great valleys and plains there is comparatively little. Now, the storm waters of the mountains feed the streams and become *stream* waters, and are used in irrigation in the valleys below, and it is through the use of these mountain-born streams that 100,000,000 acres of land can be redeemed. The rain that falls on the arid plains does not give rise to perennial streams; only storm-water streams are formed, and largely these waters coming down from the hills sink into the valley sands and are evaporated. Ultimately large tracts of land on the plains will be irrigated by catching these storm waters and holding them in tanks or ponds to be used in irrigation. This is the chief resource of water for the plains.

Mr. Chairman, I have prepared a table by States and Territories of the land irrigated. I will not read that table to the committee, as it is statistical, but I wish to incorporate it, if I may be permitted, in my remarks, to show how much land is irrigated in each State and Territory.

Irrigated areas—Totals.

	Acreage.		Percentage irrigated to total area of States.	Authority.
	Under ditches constructed or projected.	Irrigated (and under ditch).		
	Acres.	*Acres.*		
Arizona	455,600	175,000	.2	T. E. Farish.
California	6,000,000	3,000,000	3	
Colorado		2,000,000	3	
Idaho	740,000	400,000	.7	J. C. Straughn.
Montana		*348,000	.3	
Nevada		75,000	.1	
New Mexico	1,360,000	638,000	.8	T. B. Mills.
Oregon	191,000	119,000	.2	W. G. Steel.
Utah		802,000	1.5	F. H. Newell.
Wyoming	1,227,819	*500,000	.8	E. Mead.
Total		8,057,000		

NOTE.—The figures above are not comparable among themselves as they are derived from many sources and by various persons, each having different purposes and ideas as to what constitutes irrigation.

* Including large areas of hay lands; in Wyoming probably 9 per cent. is meadow.

ARIZONA.

The estimates for Arizona are based on the report of Mr. T. E. Farish, commissioner of irrigation, bearing date May 25, 1889. Following is a summary of his figures:

County.	Reclaimable.	Under ditch.	Cultivated.	Estimated under irrigation. (Newell.)
	Acres.	*Acres.*	*Acres.*	*Acres.*
Mohave	.....	.....	1,000	1,000
Yavapai	.....	.....	11,680	10,000
Apache	.....	.....	9,000	9,000
Graham	.....	47,000	.....	10,000
Gila	.....	.....	6,600	5,000
Pinal	.....	71,600	12,000	10,000
Maricopa	1,250,000	300,000	132,800	100,000
Yuma	.....	30,000	5,000	5,000
Pima	300,000	7,000	5,000	5,000
Cochise	100,000	.....	20,000	20 000
Total	1,650,000	455,600	203,080	175,000

COLORADO.

[Statement of Prof. L. G. Carpenter, State Agricultural College.]

Water division:	Under ditch.
I. South Platte division	1,125,395
II. Arkansas division	495,718
III. Rio Grande division	1,000,960
IV. San Juan division	86,400
V. Grand River division	134,400
VI. Bear and White division	70,400
Total	2,913,273

The amount actually irrigated can not be correctly given at present. Mr. E. S. Nettleton, supervising engineer U. S. Geological Survey, estimates the total as about 2,000,000 acres.

IDAHO.

[From the report of the governor 1889.]

Counties.	Approximate area.	Irrigated and in process as reported.	Irrigable as reported.	The irrigable land now irrigated.	Total area reclaimable.
	Sq. miles.	*Acres.*	*Acres.*	*Per cent.*	*Per cent.*
Ada	2,424	60,000	900,000	6.25	62
Alturas*	2,100	14,500	268,000	5.13	21
Bear Lake	†1,300	21,500	40,000	35.5	74
Bingham ‡	12,364	284,750	2,503,500	10.5	35.5
Boisé	3,024	83,500	262,000	24	18
Cassia	5,100	82,000	655,000	11.1	22.5
Custer	4,350	24,000	446,000	5.1	17
Elmore	2,700	10,000	230,000	4.2	14
Lemhi	4,300	10,000	600,000	1.64	22.2
Logan	5,200	50,000	1,250,000	2.6	39
Oneida	2,600	38,800	148,000	20.8	11.2
Owyhee	7,812	21,300	248,500	8	42
Washington	2,900	40,000	500,000	7.4	29
Total	56,174	§740,350	8,051,000	9.2	24

* Much on Lost River and lava bed.
† This area includes the lake.
‡ Much of this is "in process."
§ The land actually under ditch at present can not be much over one-half of this amount, evident from the amount of water known to be used in certain counties. (Capt. C. E. Dutton.) Estimated area now under ditch 400,000 acres.

MONTANA.

[Estimate by H. M. Wilson, engineer in charge Montana division, 1889.]

County.	Arable.	Irrigable.	Easily irrigable.	Cultivated.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Beaver Head	544,000	544,000	96,000	20,971
Cascade	960,000	640,000	44,800	2,020
Choteau	2,600,000	3,840,000	96,000	14,378
Crow Indian Reservation	640,000	640,000	32,000	----------
Custer	5,120,000	3,200,000	64,000	21,812
Dawson	7,680,000	3,840,000	64,000	109
Deer Lodge	608,000	576,000	96,000	49,875
Fergus	1,408,000	640,000	112,000	12,696
Gallatin	236,800	224,000	80,000	47,330
Jefferson	224,000	224,000	48,000	37,000
Lewis and Clarke	352,000	288,000	48,000	25,968
Madison	448,000	352,000	96,000	44,204
Meagher	960,000	640,000	128,000	32,300
Missoula	1,152,000	1,152,000	64,000	13,862
Park	384,000	320,000	64,000	6,759
Silver Bow	96,000	76,800	19,200	4,461
Yellowstone	960,000	960,000	54,400	7,357
Total	31,372,800	18,156,800	1,206,400	348,102

Under the head of *arable* is included land which will yield paying crops if water can be provided.

Under *irrigable* is included the arable land for which it is believed there is sufficient water available.

Easily irrigable comprises not only land now actually under cultivation but also numerous scattered areas which may be easily irrigated at small expense, and can be utilized without general scientific investigation by irrigation engineers.

Under the heading of *cultivated* is given the acreage returned by the assessors as being the total cultivated in 1888. Of this 209,000 acres is meadow land, which should be deducted from the total of 348,102, leaving 139,102 as small grains, vegetables, and farm produce. This should be borne in mind in making comparisons with other States and Territories.

As shown by the totals above one-third of the State is arable; of this arable land 58 per cent., or a little over one-half, can probably be supplied with water, and of this latter amount less than 7 per cent. can in all likelihood be brought under ditch by the farmers unaided. As to the remaining 93 per cent., or 17,000,000 acres, careful and extensive surveys should be made to secure the best results to future communities.

Assuming the total area of the State as 93,000,000 acres, and deducting from this 18,000,000 acres as irrigable, there is left 75,000,000 acres Of this fully 50,000,000 acres will be available for grazing when the water supply is fully utilized and a large portion of the remaining 25,000,000 acres will be of value as forest land.

NEW MEXICO.

Estimate of land under ditches.

[By T. B. Mills, June 24, 1889.]

County.	Under ditch.	County.	Under ditch.
	Acres.		*Acres.*
Bernalillo	12,421	Santa Fé	9,820
Colfax	133,400	Sierra	8,673
Doña Ana	37,621	San Juan	20,000
Grant	8,721	Socorro	73,464
Lincoln	100,279	Taos	88,763
Mora	51,279	Valencia	26,429
Rio Arriba	29,623		
San Miguel	38,241	Total	638,455

Projected ditches and ditches under construction will serve in addition 722,000 acres.

OREGON.

[Report of W. G. Steel, June 27, 1889.]

County.	Irrigated.	Irrigable (under ditches).	County.	Irrigated.	Irrigable (under ditches).
	Acres.	*Acres.*		*Acres.*	*Acres.*
Baker	5,000	10,000	Malheur	40,000	60,000
Crook	8,000	8,000	Morrow	6,000	18,500
Gilliam	3,000	5,000	Umatilla	5,000	7,000
Grant	10,000	10,000	Union	5,000	8,000
Harney	20,000	20,000	Wallowa	7,000	10,000
Klamath	5,000	30,000			
Lake	5,000	5,000	Total	119,000	191,500

UTAH.

[Church statistics.]

County.	Land under irrigation.	1889. Actually irrigated.	Dry farming.	Arable land not irrigated.
	Acres.	*Acres.*	*Acres.*	*Acres.*
Beaver	14,670	7,450	4	48,080
Box Elder	88,695	11,740	24,090	159,046
Cache	89,025	53,489	18,653	68,917
Davis	.....	.....	.....	.....
Emery	44,140	22,406	.....	298,680
Iron	9,107	6,937	100	56,200
Garfield	13,365	7,635	.....	33,046
Juab	9,000	5,300	400	33,000
Kane (Co. Surv.)	1,625	.....	.....	1,750
Millard	104,428	12,150	450	488,773
Morgan	8,804	6,687	624	2,823
Pi Ute	29,080	15,285	.....	22,260
Rich (Co. court)	40,811	.....	.....	44,749
Salt Lake (partial)	44,489	22,982	6,875	89,027
San Juan	770	500	.....	750,000
San Pete	45,506	24,014	1,350	68,605
Sevier	32,874	24,914	.....	30,150
Summit	24,115	20,825	800	14,950
Tooele	6,122	4,080	1,340	112,342
Uintah	33,750	18,818	.....	12,810
Utah	96,097	60,520	6,910	112,680
Wasatch	21,500	15,200	10	21,000
Washington	7,435	6,235	10	22,250
Weber	37,048	25,270	4,465	26,265
Total (except Davis county)	802,456	371,437	66,081	2,525,403

WYOMING.

[Statement of Prof. Elwood Mead, Territorial engineer, 1889.]

District number.	Total area of districts.	Total number of recorded ditches.	Total length as stated in miles.	Area reclaimed.
	Acres.			
1	9,123,840	643	1,322	482,434
2	5,446,656	389	699	418,329
3	4,854,988	457	576	451,424
4	5,289,984	75	174	64,280
5	13,999,104	502	996	440,540
6	3,796,992	124	197	58,162
7	4,405,248	322	518	108,976
8	4,737,945	182	212	35,395
9	340,992	49	92	42,460
Unorganized	9,738,547	7	12	4,180
Total	61,734,296	2,750	4,798	2,106,180

In addition to the above there are over 500 ditches unrecorded, making the total over 3,200.

Of the recorded ditches given above many of the statements are incomplete; 640 omit the acreage watered and 417 fail to record the length of ditch. No attempt has been made to supply these omissions and the acreage represents 2,080 out of 2,750 recorded ditches. Complete statistics would show fully 2,500,000 acres reclaimed, and this area could be more than doubled by the construction of ditches and without the aid of storage. Fully 10,000,000 acres can be reclaimed by irrigation if proper measures are taken for storing and distributing the water. This land is not only enormously productive but its agricultural value is enhanced by the contiguity of nearly 30,000,000 acres of valuable grazing land.

[Statement of May 9, 1889.] Actually irrigated, including hay lands, 500,000 acres; agricultural, 50,000 acres; duty of water, 1 second-foot to 80 acres.

It will be seen from the map before you that irrigation is widely distributed; so there is no great district of country where irrigation is possible that does not present examples of what has been accomplished. I think I should have stated further, while there are about 8,000,000 acres now actually under cultivation, there are probably 2,000,000 to 4,000,000 more under canals; the works are already constructed, and it is estimated that from 2,000,000 to 4,000,000 acres more will be cultivated. That is because a man often has only a portion of his farm irrigated, but will irrigate more in time from the works already constructed.

The map which I now place before you exhibits the distribution of the forests. The same lines indicating the borders of the arid lands are seen here, and within that area we have a map of the forests. Over almost all the region surveys have been carried on, so the forests are mapped with a fair degree of accuracy. They are of two characters. First, on the high mountains and plateaus we have forests of commercial value, forests of pine, fir, spruce, and sequoia. They are colored in dark green. The area covered by forests of this class is not one-tenth of the whole; it is about 125,000 square miles. But all of these forests are on high plateaus and mountains. Now, it must be understood that the forests of which I am speaking, although they cover a considerable area, are not dense. On this map here we have had to represent them in large bodies, and for that reason they are apparently exaggerated. There are

fine open prairies and glades intermingled among the forests; there are mountains covered here and there by forests, but having great spaces of naked rock, and there are other regions of country where the trees are far apart. It will be safe to say that all the forests of this 125,000 square miles of which I make mention could stand on one-fourth of the space.

In addition to these there are forests of some value covering a somewhat larger area than that of the heavy forests of commercial value. These consist of piñon or nut pine, cedars, and in some places dwarf oaks. They are available for fire-wood, fences, and for minor domestic purposes, but they are very scant—everywhere there is but a small amount of wood to the acre. Along the streams we find cottonwood trees that are of some value for fire-wood and fences, but it is not generally dense. The cottonwood forests, the cedar forests, the piñon forests, and the dwarf-oak forests are all colored in light green. The area covered in this manner is a little over 130,000 square miles, so that within the arid area the extent of forest is about one-fifth, and it is scattered.

The distribution of forests is otherwise shown by this table:

Approximate area in square miles of timbered lands in the arid region.

State.	Fire-wood.	Merchantable timber.
	Square miles.	*Square miles.*
Washington	1,050	1,080
Idaho	8,600	9,800
Montana	6,500	21,000
Oregon	3,500	8,700
Wyoming	7,300	15,700
South Dakota	2,400	400
North Dakota (river bottoms)	200	.....
California	20,300	11,000
Nevada	5,400	700
Arizona	26,510	11,700
New Mexico	21,540	14,490
Colorado	15,000	23,500
Utah	14,000	7,700
Totals	132,300	125,770
	125,770	
Grand total	258,070	

Total area of arid lands, 1,340,000 square miles.

Now, some important facts must be brought out, showing where these forests are, and their relation to agriculture and other industries of the country. Where the forests of commercial value grow, as a general thing, agriculture can not be practiced. They grow high on the mountains and plateaus.

The CHAIRMAN. Not over 5,000 feet elevation?

Major POWELL. It varies from north to south. The lower limit of the commercial forests varies from 4,500 feet above the level of the sea at the north to about 6,000 or 7,000 feet at the south, and from this lower limit the timber belt rises 4,000 feet into the region above. Where these forests of commercial value are situate great snows fall during the winter, and during the summer frosts may be expected; so that, by reason of climatic conditions in part, the region covered by commercial forests is not agricultural. There are still other reasons why in these high mountains agriculture would not be productive. In the rough mountains there will be no agriculture except in little spots—gardens where the people cultivate potatoes and such things about the mining camps. In

general it is not an agricultural region where forests of commercial value are found. The area colored in dark green is not an agricultural region. The area colored in light green is in part agricultural, and will in part fall within the irrigation districts which must ultimately be established in the country and which practically they are beginning to establish all over the land.

The forests are being rapidly destroyed, and it is of their protection that I wish to speak now, and to show their relation to the agriculture. The forests are utilized by the people who are engaged in agriculture in the valleys far away—5, 10, 20, 50, or 100 miles from the forests—and they are also utilized for mining purposes, and they are burned in the towns and cities as fire-wood.

Mr. HERBERT. And the railroad companies also use them largely for cross-ties.

Major POWELL. Yes, sir; but ordinarily that is not a very great use. The mining use is great, the domestic use is very great, and the use for railroad purposes is of little importance. It will be understood, then, that the man who cultivates a farm in this region of country usually has no timber on his tract of land. The timber with which he builds his house, with which he builds his fences, and which he uses for fire-wood grows many miles away. Hence they build roads into the cañons and bring the timber down, and they construct tramways to some extent, and slides down the mountain sides, and flumes taking it out on streams of water and floating it down; so that the timber industry is away in another region from the farming industry—it is segregated to itself. But the timber is being very rapidly destroyed by fire. That which men use is insignificant. Man himself, taking the grand aggregate, has made no impression on the forests of that country. They grow faster than man has heretofore cut them, and if they could be protected from devastation by fire the use made by man would never injure the forests, not until a vastly denser population is gathered. These forests are composed of coniferous trees that are rich in inflammable resinous substances, the bark of the trees is exceedingly inflammable, and the pine needles which fall upon the ground are inflammable, and all give rise to great fires, and vast areas of forest have thus been destroyed.

A little more than ten years ago I mapped the Territory of Utah, and in making that map I delineated not only the existing forests, but the burned forests, and found that at that time one-half of the forests of the Territory had been burned. I have seen one fire in Colorado destroy more timber than has been used by man from the migration to Pike's Peak up to the present time; and I have seen several such fires in Colorado. This past season, as an attaché to the Senatorial committee investigating the questions relating to the arid lands, I passed through South Dakota, North Dakota, Montana, Washington, Oregon, and Idaho by train. Among the valleys, with mountains on every side, during all that trip a mountain was never seen. This was because the fires in the mountains created such a smoke that the whole country was enveloped by it and hidden from view. That has been the experience for twenty-odd years, year by year, in this region. The geographical work of our Survey is cut off during the very dry months by the smoke; the men can not get lines of sight from height to height through that country because of the fires produced in the mountains and the smoke settling down over the land. In the last twenty years one-half of the timber has been burned. Where timber burns in this manner it springs up again; the lands as forest lands are

not destroyed by these fires, but the timber itself is destroyed, and it is of slow growth.

Mr. HERBERT. Can you suggest any method of preventing the fires?

Major POWELL. Yes, sir; I am just coming to that. In the first place, let me make it plain that the character of the forests themselves is such that it makes these fires exceedingly destructive. In lands where trees are not coniferous, but ordinary deciduous trees, the fires are not so destructive. The coniferous trees, pines, firs, hemlocks, spruces, and so on, are very easily burned. In an ordinary year fire is not destructive; fire in an ordinary year passes over the ground and burns the leaves and cones, etc., only. But there come critical years, five, ten, fifteen, or twenty years apart, critical seasons of great drought, when there is no rain for several months, and the fire starts and sweeps everything away. Now, the settlement of the country conduces to this. If the forests' grounds were perennially burned—burned every year, as by the Indians in the olden times—these great fires would not prevail. But protected from annual burning as they are now, the cones, leaves, and twigs accumulate for six, eight, ten, or twelve years, as the case may be, until there is a heavy mat of this inflammable material, and when a dry season comes and the fire starts it sweeps over the country in one big conflagration. The real protection is to come ultimately in two ways. It will come in part by pasturing the lands. The pasturing of the lands will destroy the younger growth and consume the grass, and stock will make trails and roads by which the fires will be cut off and not spread widely. Then, by annual burning, at times properly selected, when not too dry, the trees can be protected.

The points of importance in connection with matters relating to irrigation are, the people who are engaged in irrigation have their timber land far away. The timber lands that are far away are subject to fires. Now, how is the General Government to protect them from these fires? They are asking that the Government establish a forestry commission for this purpose. It will be noticed that the area drained by a river like the Platte, or the Arkansas, or the Rio Grande, has its source in the mountains, the timber lands. The people in the valleys who are cultivating the soil by irrigation are interested in the forests above, in the mountains, where the sources of water supply are found. They are interested in it in a double manner. They want the wood for their use below, and, further, they want to protect these forests which stand about the sources of their water supply; so the people have a double interest in the mountain lands. They need that timber and need to protect the sources of their water supply.

Mr. HERBERT. What will be the fuel of the future in that country; is there coal enough to supply the future population you anticipate?

Major POWELL. The geology of the arid region is not so fully known that we can state that all of the coal has been discovered. But, Mr. Chairman, I now place before you a map of the same region showing the distribution of the known coal-fields. In Dakota, as you see, we have a very large body of coal. While coal is probably found throughout the greater part of that area, in much of the region it lies so deep as to be unavailable for working economically. We have here in Utah and Colorado a very large area with which I am personally acquainted, as I have examined it myself. We have smaller ones lying around here, as you will see. There is one in Washington, and so on. There are two or three small places that have been found in Nevada, but the great body of the coal lies in the Rocky Mountains

and to the east of the Rocky Mountains. Altogether there are very great coal-fields. Compared with the coal-fields of the eastern portion of the United States they are far superior in area.

The CHAIRMAN. There is a coal-field down here [marking on the map].

Major POWELL. Yes, sir; in Texas.

Mr. LANHAM. There are coal-fields east of that line.

Major POWELL. There are coal-fields down in here [indicating]. I have only put in the coal-fields within these two lines. There are coal-fields west of the arid region and others east of it. But there are coal-fields between the two lines enough to supply all practical purposes. You will see little dots over the areas, red dots in the blue areas, representing places where they are mining considerable quantities. In the main the coal is very accessible. It has been so placed by geological agencies that it can be reached with comparatively little expense. It is not very ancient coal, not so ancient as that in the eastern portion of the United States. It is in part Cretaceous and in part Tertiary. It exists in large quantity, and the quality is good enough for all domestic purposes and for making steam, and the people are gradually learning to coke it. It was difficult to use in the metallurgical processes for a long time, but the difficulties are being surmounted as experimentation goes on. Now, the sources of fuel for the people are in part the forests represented on the map before you and in part the coal-fields represented on this map. There may be discovered ultimately other coal-fields than those already known.

Climatic temperature decreases from the level of the sea to the summit of the mountains, but it also grows colder from the equator to the poles. Now, the lowest lands of the arid country are farthest south. In Arizona and southern California the uninhabitable deserts of America are found; there are districts of country below the level of the sea and other stretches just above it. There are other stretches where billows of sand drift across the desert with the prevailing winds. Still other areas are covered with sand and stony fragments and strewn rocks, where vegetation gains little foot-hold. All these lands are worthless. In passing from the Mexican to the British line, where conditions of altitude are the same, the grasses steadly improve, and those of the northern half are comparatively rich. But even here there are waste places, for lava fields abound that are virtually desert. And there are "bad lands" that yield little vegetation—hills of clay and sand that are washed by the storms and baked by the sun. When the rains come the hill-sides are sloughs, and when the winds come the dried surfaces crack and crumble. Then there are cañon lands that are carved by many winding, branching gorges, and are thus rendered worthless. Then there are alcove lands where every rill of the rainy season heads in a precipitous, rocky gulch. These are also barren. Then buttes are scattered over the mesas and plateaus—fragments of formations left by the destroying storms for their future employment. Then there are cinder-cones, naked and desolate. Often lines of cliff stretch athwart the country—the margins of mesas and plateaus. These cliffs are worthy of further mention. When the winds drift the clouds along the lowlands, such a cliff, a few hundred or a few thousand feet in height, obstructs their way. So the clouds rise and discharge their moisture, and floods are speedily born. In regions of cliff a large portion of the precipitation is along these lines, and yet with this increased precipitation they are not favored with great vegetation, for the water glides away on the steep declivities, and a zone of low-lands near by receives it, and here the most valuable forests of

piñon and cedar are often found. Then the mountains are not all grassy slopes, for they are often interrupted with rocks and ledges and cliffs that are naked.

Though the grasses of the pasturage lands of the West are nutritious, they are not abundant as in the humid valleys of the East. Yet they have an important value. These grasses are easily destroyed by improvident pasturage, and they are then replaced by noxious weeds. To be utilized they must be carefully protected, and grazed only in proper seasons and within prescribed limits. But they can not be inclosed by fences in small fields. Ten, twenty, fifty, acres are necessary for the pasturage of a steer. So the grasses can be utilized only in large bodies, and be fenced only by townships or tens of townships. Yet they must have protection or be ruined, and they should be preserved as one great resource of food for the people. When the valleys below are irrigated, so that flocks and herds may be fed when the snows and frosts of winter come, the hills and mountains of the arid region will support great numbers of horses, cattle, and sheep.

The mountains of the far West are full of gold. Ores of this metal are found in fissures that seam the rock, and fill spaces between barren formations, and lie in bodies where lavas have cooled in hill-bound basins. Then the whole mountain region has been plowed with glaciers and swept by storms or buried by river floods, and in these glacial gravels and storm gravels and river gravels the gold has been carried, and here the placer mines are found. In other hills and mountains there are stores of silver and copper, while lead and iron abound. Then asphalt, oil, and gas are found, and the hills are often filled with coal. With slight exception all of these minerals are found in lands which can not be redeemed for agriculture. The coal lands are chiefly pasturage lands, and the gold and silver mines are under the forests. The coal and iron have been and can be discovered by science; but gold and silver are discovered by prospectors, and revealed only by the pick and shovel. These mines of gold and silver furnish the basis of our monetary system, and are the source of vast wealth. During the last calendar year $32,816,500 in gold, and $59,118,000 in silver were taken from these regions, and this supply is to be continued through an indefinite future.

Mr. Chairman, I have thus presented a general outline of the arid lands and certain facts connected with the agriculture of the country, the present distribution of irrigation, the forests, the distribution of coal, a description of the pasturage lands, and have made mention of the mineral lands.

I propose now to present an outline of some of the more important problems relating to irrigation, and in order to do this to the best advantage I have prepared a series of maps, each one representing some great river valley and all the areas drained by the river, within the arid region. I now place before you a map of the Arkansas basin, so much of it as is in the arid region. The Arkansas heads in central Colorado in high mountains, about 14,000 feet above the level of the sea, and it flows eastward across the Kansas line at this point. It has many important tributaries and they all head in the high mountains. You will see that I have divided the Arkansas drainage into districts, and each one represents a natural irrigation district—a region of country that must be considered as a unit. I shall first call attention to the headwaters of the Arkansas itself. You will see that west, north, and south from Cañon City there is a great mountain area. This is the catchment region of the waters of the upper Arkansas.

Below Cañon City you will see that the district connected with the

mountain catchment area narrows greatly down to Pueblo, and continues a comparatively narrow strip down the Arkansas many miles, and then leaves the Arkansas to the north and extends to the State line. This narrow district below is the farming region, which must depend for its waters upon the catchment district above. The mountains above furnish the water to the plains. This great fact is important, for it illustrates a general condition in all regions of agriculture by irrigation. The farming area below depends on a catchment area above, and this dependence is vital. Let us call the whole the upper Arkansas district, extending from Leadville to the Kansas line. The farming must chiefly be below Cañon City, and the water must chiefly come from above Cañon City, and Cañon City marks approximately the critical point in the valley. Above it most of the waters are to be stored, when storage is resorted to, though a part can be stored below, but those stored below should be diverted from the river near Cañon City. The surveys have progressed far enough for us to state that the waters of the Arkansas coming down to Cañon City can be taken out in that neighborhood and carried by high-line canals over the lands below lying within the district as outlined. A part of the waters can be taken out on the north side by high-line canals; another part of the waters can be taken out by a high-line canal starting a little below Cañon City and running on the south side of the river. The irrigable lands therefore lie chiefly below Cañon City on both sides of the river, and extend on the south side half way to the Colorado-Kansas line and on the north side entirely to the Kansas line. But not all the lands in the lower part of the district can be irrigated; the water is insufficient for that purpose. At the present time in critical years—and I mean by that in dry years—all of the waters of the Arkansas are used that flow during the season of irrigation. All additional development of agriculture along the region therefore depends upon the storage of water. In years of great precipitation much larger areas can be cultivated without storage, but in years of drought waste water must be used, and this demands storage.

Permanent, prosperous agriculture, therefore, if it is to be enlarged in this district, will have its enlargement depend upon storage. We already know of fine storage basins in the upper region, and others in the lower region, and know that the waters which now run to waste for ten months, can be stored. Now I wish to make it clear that the entire district of which I make mention is an interdependent district; that the interests of the people throughout the district are common interests, and that one man's interest can not be affected without at the same time affecting another man's interest; that there are certain great common problems in which all of the people of the district are involved and about which they must be all consulted and in the determination of which they should all have a voice.

First, then, is the catchment area above Cañon City, where the chief body of water falls. Now this water can not be divided among the farmers below until it reaches Cañon City; it must be divided there; and farther down a common body of water flows by from which every farmer must take his quota. If the water is to be stored above, the farmers below who are to store it must go in the upper districts, away from their homes one or two hundred miles, and construct reservoirs; when the waters of these reservoirs are needed they must be discharged into the natural channels to be taken out again by diverting dams; the people must also go away from their homes many miles to construct the diverting dams where the waters are taken out from the natural

channels and turned into canals. In like manner, the canals must be constructed on lands above them, 5, 10, 20, 50, 100, or 200 miles as the case may be. The last farmer near the Kansas line is as much interested in the storage reservoir at Twin Lakes, high in the mountain 300 miles away, as the man living at Pueblo below Cañon City.

This upper region is mountainous, and the mountains are largely covered with forests. But the forests themselves are being destroyed by fire. This destruction of the forests is exceedingly injurious to the reservoirs. Forests should be managed in the interest of agriculture, that the water supply of the people may have protection in the mountains where it is caught. All the people of the district, therefore, to the Kansas line are alike interested in the mountain slopes and the forests which they carry, and they are the only people directly interested in them, for they are the people who wish to use the timber which these forests will afford. Their homes are to be made, their farms are to be fenced, and their firewood is to be obtained from them; though their fuel will, perhaps, be derived in part from the coal which the region affords.

But not all of the land can be irrigated. The mountain region can not, but it is worth something for pasturage purposes; and the plains below can not all be irrigated. The non-irrigable portion, which is several times larger than the area which can be irrigated, has value for pasturage purposes. But this pasturage can be and is being rapidly destroyed by being overfed. It can not be fenced and used as pasturage grounds as in the eastern or humid lands, because the pasturage is scant and a large tract is needed to support a small herd—so large that fencing in small tracts is impossible. In the main the stock raised on this pasturage must be fed during the winter; the cattle, horses, and sheep, therefore, that feed on the summer pasturage of the district must winter on the farms of the district that are cultivated by irrigation, and the people who can utilize these lands best, who live in the district and engage in agriculture, should by some means have control of the pasturage. They must have control of the forest areas because their agriculture depends upon them, and the non-forest areas can better be controlled by them than by anybody else.

Here the people are to be scattered from Cañon City to the Kansas line in communities dependent upon irrigation. About them on every hand on the plains will be pasturage lands over which their cattle may roam, and far above on the river will be the forest lands which constitute the catchment basin for their agriculture. All of this land must by some means or other be placed under the control of these farmers, for its management is vital to their industries because of the water, timber, and pasturage which it affords. There must necessarily be small bodies of land actually cultivated and large bodies of land will forever remain uncultivated, and the management of the uncultivated lands is vital to success on the cultivated lands. If the water, the timber, and the grass are to be utilized and protected from destruction—and all of the values inhering in them are liable to destruction to a greater or less extent by mismanagement—then these people who are interested therein should have control and management of the unoccupied lands as a body-politic, and should be allowed to make their own rules and regulations for its protection and use.

There is another great fact to be brought out in the consideration of the upper Arkansas district. I spoke of Cañon City as being in the neighborhood of a critical point on the river. Above in the mountain region the rivers, all the streams, are clear water, and they run usually in deep, narrow cañons; but there are mountain valleys along water-

courses, in some places especially, where the waters are to be stored. But on leaving the mountains below Cañon City the waters speedily become turbid, as they are loaded with mud. The streams are no longer deep, swift, and clear, but they become broad, shallow, and muddy. Now the best place to take out these waters for irrigation is here near Cañon City, before they become loaded with mud. Experience shows that this mud is of no value to agriculture, but that it clogs and chokes the canals and water-ways, so that it is difficult to maintain irrigation works, and the sandy water injures the soil. The waters are taken out below after they have become more or less muddy, but always to a disadvantage. But, still more, the waters are now taken out from point to point along the valley from Cañon City nearly down to the Kansas line in a most wasteful and expensive manner. One or two high-line ditches on either side, with laterals running toward the river, should be constructed so as to control all the waters of the Arkansas, and this must ultimately be done for economy's sake. This economy appears in two ways: first, the works necessary to be made can be made much more cheaply by that plan; second, the waste of water is much less. But in order to carry out the water in this manner the rights already acquired by the water companies to carry water below for shorter distances and near to the river must be extinguished. The existing rights, therefore, are obstructive rights; they constitute an obstruction to the development of the entire region, and they constitute an obstruction to the cheapest method of supplying the country with water.

It is thus that obstructive rights are established—rights inhering, in water companies as distinct from the rights of the farmers cultivating the soil. If a river is taken out at numerous points along its course to irrigate a section of country close to the river, lands that lie in the flood-plain, the lands themselves can never be properly drained and only the poorest agriculture can be carried on. But if the waters are taken high up on lands that have natural drainage or that can be drained at little expense, the agriculture will be very greatly improved. Then a multiplicity of small dams along a stream involves the construction of many lines of canal, which are in the aggregate expensive, and water lost by them through evaporation and seepage is very great, and so all the water is not used. To take the water of the Arkansas out by great canals as I have indicated, would be to double or treble the area irrigated, and the lands cultivated would be better acre for acre, and the cost of irrigating the entire tract by the high-line canals would be no greater than, and perhaps not so great as, to irrigate the small tracts. But there is another condition of great importance in this connection. On the broad valley where these mountain streams enter the valleys and plains below and spread out over the sands, the waters permeate these sands for wide distances on either side and are by them re-evaporated to the heavens; so that a great flood of water may come from the mountains and pour onto the plains, but it will not be carried far down toward the Kansas line, for it steadily diminishes, being lost in the sands, which send it back to the air. The nearer the water can be taken out to the critical point which I have indicated the greater the amount of water which can be saved. So that there are four reasons why the water should be taken out at this critical point, each one substantial and important in itself and each one sufficient to control the matter, while all together they are so important that they can not be neglected. These four reasons are, first, high-line canals are least expensive; second, they save water which would be lost by absorption and evaporation in the numerous low-line canals; third, they carry the

water to better lands; fourth, they save the water from being evaporated in the sands of the lower basin.

We next come to a consideration of the Fountain district. Coming down from around Pike's Peak we have a beautiful stream of water, all of which can be used in its valley below before reaching the Arkansas itself, as indicated by the lines which I have drawn on the map. Now the people who live on these irrigable lands below are dependent upon the catchment areas above, and are interested in the preservation of the forests, alike for agricultural purposes and that they may use the timber; they are the only people directly and economically interested in them; and they are all interested in common in the same things—the water, the timber, and the pasturage. They also must construct storage reservoirs above them and must run canals on lands which they do not own. From the Fountain eastward to the Kansas line and from the divide between the Platte and the Arkansas on the north down to the boundary of the great upper Arkansas basin which I have described, you see there is a great district on the plains. The streams in that district head in the highlands at the north. They are Chico Creek, Horse Creek, Rush Creek, and Big Sandy River, with some minor streams. These streams, not heading in the mountains, are not perennial; they are only wet-weather streams. Often fine streams are running about their sources when no water is found in their lower courses nearer the Arkansas, the waters sinking away and being lost in the sands, where they are evaporated. I have thrown all of these into one great district. About the headwaters of the streams there are piñons and cedars, but very little forest growth valuable for commercial purposes. The region is ultimately to be one chiefly devoted to pasturage purposes. Still, much land may be cultivated by the storage of the storm-waters.

South of the Arkansas we have, first, the St. Charles River, not a very large stream, but its waters can all be stored and all used within its own valley before reaching the Arkansas, in the district which I have outlined as you see on the map. Passing eastward, we come to the Huerfano River, a fine mountain stream heading in high mountains and having abundant basins for the storage of its waters. Here, as on the St. Charles and on the upper Arkansas basin and elsewhere, the people are interested in the preservation of the forests, in order that their sources of water supply may be protected; and they are also interested in the preservation of the grasses. They have three great values which they must protect, in water, timber, and grass, and they should be allowed to protect them for themselves, for they are the only people who have a direct interest in them. Then come the Apishapa River and the Animas River, each constituting an independent district. In the Apishapa all the people are interested in the three great problems. The same is true with the people of the Las Animas Valley. You will see that I have cut off a district along the lower part of the Arkansas, a district which is in part in Colorado and should extend two or three degrees into Kansas. This district has its own drainage area, and will largely be dependent upon the storage of storm waters; but the waters which escape into the sand basin of the river itself can be utilized and be brought up to the surface by pumps or by gravity; that is, the upper portions of the sand basin may be drained onto the lower portions, and much irrigation may be developed thereby. There will often escape from the other districts more or less water, especially at flood times and seasons of great rain, all of which will flow down into this lower district, and can there be caught and used in irrigation. In the west-

ern half of the United States the total rain-fall, if evenly distributed throughout the country, would be pretty great.

Mr. PICKLER. In the western half?

Director POWELL. Yes, in the western half. In this region of country I am speaking of there is considerable rain-fall, but it is not evenly distributed from region to region. It varies from 3 inches to 60 or 70 inches annually.

The CHAIRMAN. The mean annual rain-fall?

Director POWELL. Yes, the mean annual rain-fall. This is dependent upon complex conditions. Generally the rain-fall increases from north to south, due to the configuration of the coast and the trend of the great oceanic currents. The rain-fall increases from the lowlands to the highlands also, so that taking it altogether the chief precipitation of rain is on the mountains. When the clouds gather about the mountains, drifting here and there, there are great storms, while the valleys below are quite clear; and this goes on month after month and year after year. So the waters are concentrated, in the main, in the mountains. In the mountains there may be 25, 40, or 60 inches of rain, while in the valleys below there may be only 3, 6, 10, or 15 inches, as the case may be.

Mr. HANSBROUGH. What is the average in the western region? I suppose that could not be ascertained accurately.

Major POWELL. No, sir; but I should say about 20 inches.

Mr. HANSBROUGH. That is sufficient for ordinary agriculture.

Major POWELL. Yes, if it is distributed through the year well.

The CHAIRMAN. A statement is made that in Portland it is about 20 inches, and at San Francisco it is about 25 inches, and when you get as far south as San Diego it is less than 10 inches; so there is a gradual diminution. I think the amount of rain-fall required for the production of crops, for an ordinary production, would be about from 20 to 25 inches.

Major POWELL. It depends upon when it falls; 9 inches of rain falling during the season of growing crops would be sufficient for the growing crops if it would come just at the right time, but that is not to be expected. There are some portions of Dakota where the greater part of the rain-fall comes during the season of growing crops, and there are other regions of the country, say in Texas, where the maximum rain-fall is in the winter time.

Thus, the waters fall on the mountains and roll down in rivers to the sea. About one-half the streams of the arid region have no outlet to the sea. They sink in the interior, in salt lakes, and in the sand. Only about one-half of the streams of the arid region are ultimately discharged into the sea. In these regions, where the rain-fall is not more than 10 or 12 inches, very little of the water gets to the sea; it is absorbed by the sand and discharged into salt lakes. On another map, which I once had before you, the region where the waters do not flow to the sea was delineated. All of this region along the plains in western Kansas and eastern Colorado is one without perennial streams, except as they come through from the mountains beyond. The people of this region would therefore have to depend largely upon the storage of storm waters. But, on the other hand, the rain-fall gradually increases as we go eastward, so that there are many seasons when irrigation is not necessary; and in those years when it is necessary a smaller supply of water need be furnished artificially.

The hour of 12 having arrived, the question was discussed by the

committee whether Major Powell should be further heard at this meeting.

Mr. HERBERT. I move that the meeting adjourn until Saturday, and it be understood that Major Powell commences talking at half-past 10 o'clock whether there is anybody to talk to except the chairman or not.

Thereupon the committee adjourned until half-past 10 o'clock Saturday morning, March 1.

COMMITTEE ON IRRIGATION,
Saturday, March 1, 1890.

The committee met pursuant to adjournment, Mr. Vandevér in the chair.

STATEMENT OF MAJOR J. W. POWELL—Continued.

Maj. J. W. Powell, Director of the Geological Survey, addressed the committee as follows:

Mr. Chairman and gentlemen of the committee, I place before you to day a map of the Rio Grande, including all the area drained by that stream north of the Texas line. There are some important facts relating to the utilization of the arid lands which can be well elucidated by considering that region of country, and I present the map again for that region. In talking to you at the last meeting about the irrigation problems presented in the valley of the Arkansas, I called your attention to the fact that that valley could be divided into districts, each one an independent unit. The whole arid region may be divided in like manner into natural districts or drainage basins, each one of which has its problems so interwoven that the entire district must be considered in planning its system of irrigation works, but which is practically independent of all other districts. These hydrographic basins, as I call them, are of three classes, viz, headwater districts, river-trunk districts, and lost-stream districts.

The headwater districts commence in the mountains and extend down the streams far enough to include catchment areas and farming areas. They are found not only on the main streams, but on all perennial laterals or tributaries. Usually each lateral or tributary forms a natural district by itself. But the great rivers flow on across the plains and down the great valleys, and their trunks must be divided into districts, each one of which presents an independent system of works. These I call river-trunk districts. Then in the arid lands there are many streams which do not flow into great rivers and ultimately to the sea, their waters being lost in the sands or emptying into salt lakes. These I call lost stream districts. All three classes of districts are illustrated in the Arkansas basin, as I presented the subject to you at the last meeting, and all of these classes are represented in the Rio Grande region, the map of which is before you.

In considering this subject and planning the work of the irrigation survey, it has been found that a natural district or hydrographic basin must be considered as a unit in which all the problems are interrelated. In order to report upon a district and recommend a plan of works, we must know for such district how much water will be supplied for irrigation, where the diverting-dam sites, reservoir sites, and canal sites are situated, and where the lands to be irrigated lie. And it has been found, after a careful examination and from the best data we have on

hand, that there will be about one hundred and fifty such districts in the arid region, and that if the survey is carried out it will need a separate report on each.

I have therefore found it necessary, for the administration of the survey, to consider these hydrographic basins, and have been studying them for some time, in fact for years before the survey was organized, for I early recognized that ultimately these natural features would present conditions which would control the engineering problems of irrigation and which would ultimately control the institutional or legal problems. The study which I have made in this direction can not of course be considered final. An actual survey on the ground is necessary to define the limits of each basin, and a very careful survey is especially necessary to define the limits of the trunk districts. The headwater districts, or those of the first class, and the lost stream districts, or those of the third class, are quite easily discovered; but the districts of the second class require very careful study for their determination. The meaning of this will more fully appear from the illustrations which I am able to present to you to-day in considering the Rio Grande Valley.

First, we have the Saguache River, a river with tributaries—a number of beautiful creeks. The river flows into a sink, and the drainage is lost in the sands. Now, the utilization of that water affects that valley only. It is independent of all the other regions of country.

The CHAIRMAN. Do you not think there is a possibility of its finding an outlet into the channel of the Rio Grande below at some distant point?

Major POWELL. Not to any amount. The region of country at the sink is one of sand and the water sinks in these sands and is evaporated. It is only on very rare occasions—many years apart—that there will be a great flood which will cause it to overflow and open a channel to the Rio Grande. In ordinary years all the water which is used must be in the valley here [indicating], hence it is an independent basin. This is what I call a district of the third class—a lost-river district. It will be noticed that in this district the people who engage in agriculture here can not possibly have any conflict about water rights with the people of any other district. They may use all of this element which they can catch and spread it upon their lands, and nothing will be cut off from any other district; nor can they obtain water from any other district to put upon their lands. And they are interested not only in the water, they are interested in the forests about the fountains whence their waters come, and they are the people who should be interested in the grasses which grow in the valleys and on the hills and mountain slopes.

The Saguache district, therefore, is clearly defined in nature. Its boundary is marked everywhere by the parting of the waters.

Passing over to the Rio Grande proper we have the San Luis district, which is also a headwater district. The San Luis Park is a beautiful tract of land, and high mountains stand around it and gather great quantities of water. This is a region lately redeemed for agriculture, but already all the flow of critical years with extreme dry seasons is used in agriculture, and the companies that are specially interested in these water rights are preparing to store and use all its waters which flow through other season. It may be possible that they can use all, and that the area of good land to be cultivated will be sufficient. We do not yet know the amount of water that flows in the streams, nor do we know the amount of good available land. Be that as it may, we are able to state that this great district is a unit, and that it must be considered as such in planning the proper system of irrigation works, and

that its people as a body will be interested in the management of its waters, its forests, and its pastures. And they are the only people to be interested, except to this extent, that if the waters are not used here they will flow into trunk districts below to be used there. If the people of the districts below, in New Mexico, could lay an embargo upon irrigation in the San Luis Valley, larger areas in New Mexico could be cultivated, but the loss of water on the way would be such that they would not equal in area the lands that could be irrigated in Colorado. It is therefore manifestly to the advantage of the agricultural interests of the country that the people of Colorado who live in the San Luis Valley should be permitted to develop their agriculture to the utmost and use all the waters that they can put upon good agricultural lands.

The Rio Grande, in crossing the line between Colorado and New Mexico, enters a cañon and flows for about 50 miles through the gorge, and its waters can not be taken out along this stretch. This cañon ends where Taos River, coming from the east, joins the Rio Grande. The Taos is a beautiful stream, and all of its waters can be used in its own valley—all that run during the season of irrigation, and all that can be stored, so that the waters of the Taos may ultimately be cut off from the Rio Grande.

The region of country on either side of the cañon of which I have made mention—Embudo Cañon—has lava fields and is not agricultural; but some fair timber grows there and much water comes down into the cañon, so that when the river emerges into the valley at the foot of Embudo Cañon it is a fine stream, and must always be so whatever water is taken out in Colorado above. Some 40 or 50 miles, below the river enters another cañon. Between these two cañons lies the valley of San Ildefonso, into which come some small creeks from the east, and the water of the Rio Grande can be taken out at the foot of Embudo Cañon and spread over the San Ildefonso Valley and make here a river, trunk district, or district of the second class. This is a district also well defined in nature. Its catchment area is lava fields above and mountains on every hand, and its irrigable or farming area is the low valley stretching back from the Rio Grande on either side.

Near the foot of San Ildefonso the Chama enters from the west. The Chama is a large river for that country, and its tributaries drain great mountains, and there are many beautiful valleys scattered about through the region. The lower portion of the Chama runs through a sand plain, and these sands are volcanic ashes which drift and blow into the river and fill it with sediment. The Rio Grande above the mouth of the Chama is a clear, beautiful river, but at the mouth of the Chama it is transformed by the mud of the Chama itself. It then becomes a river of mud and continues such to the Gulf, as it takes up sands along its way. The Chama basin is another natural basin, having timber lands, pasturage lands, and agricultural lands.

At the foot of San Ildefonso Valley the Rio Grande enters White Rock Cañon and continues its course through a deep gorge for 40 or 50 miles. Along this course its waters can not be used for irrigation. The cañon walls are hundreds of feet, and in some places more than a thousand feet, above the waters. But the high volcanic plateau on the east furnishes a notable amount of water to this stream, and on the west there is a group of great volcanoes from which many beautiful streams flow, so that if all the water should be cut off at the head of White Rock Cañon there would still come into the Rio Grande, through the course of this gorge, a large body of water to be used below—water which can not be used elsewhere, as none of the streams above on either

side of the cañon have agricultural lands along their courses. But they have great forests. Here some of the finest forests of New Mexico are found. This is the great catchment area for the valley below White Rock Cañon.

Some flood waters will always come down the Rio Grande from San Ildefonso Valley, however thoroughly the country may be utilized, and additional water will be caught in the cañon itself, and so the valley below will have a good supply. White Rock Cañon empties below into a valley which I shall call the Albuquerque Valley. In it lies Bernalillo, Albúquerque, Los Lunas, Socorro, and other towns. Now, all the water that comes out of White Rock Cañon can be used in the Albuquerque Valley, as it may be diverted below the White Rock Cañon and carried out and stored on the flanks of the valley. There is now much agriculture in this valley, and some of it is very ancient. Including the catchment area about White Rock Cañon and the hills and mountains on either side, and the valley where agriculture can be carried on, we have another natural district or hydrographic basin—a district of the second class, or stream-trunk district. Now, it will be seen that all the water to be used in this great valley comes from the mouth of White Rock Cañon. Whoever has control of that point—owns that dam site and has the right to take the water out of its natural channel and carry it into canals—has command of all the agriculture of that great district.

I wish to explain further that the people who have settled here have taken out the waters of the Rio Grande and utilized them during the season of irrigation, but they have not yet resorted to storage, and the waters which they use are used to very poor advantage. The flood plain or strip of country next to the river, which is sometimes overflowed, is broad and sandy; the river itself is shallow and is a river of mud, and it is very wide, so it flows into these sands and is evaporated to a very large extent and thus lost to agriculture. Then the people have constructed low-line ditches near to the Rio Grande, and take out the water by a system which is exceedingly wasteful and which is destroyed more or less with every flood. Ultimately they will find it to their advantage to take the water higher up, near the mouth of White Rock Cañon, and carry it out by high-line canals, and store the surplus in the lateral valleys. By this means the area of agriculture in the valley can be increased five or ten fold.

Mr. LANHAM. Suppose this dam is constructed that you speak of here——

Director POWELL. At the mouth of White Rock Cañon?

Mr. LANHAM. Yes, sir. What effect would that have upon the supply of water below that point of the stream?

Director POWELL. They could take out all the water for canals below by constructing a dam at White Rock Cañon. It is possible to take all the water of the Rio Grande there during the season of irrigation. It is also possible to take out all the water there during the non-irrigating season. If the water for the non-irrigating season is to be stored, you are compelled to take it out there. You can not take it out by the present ditches, for they do not lie on high enough ground; but if a canal is constructed from the mouth of White Rock Cañon, and a diverting dam built there, and lakes made—there are good places—all the water can be used in the valley. So, not only is it necessary to take the water out at that one point and utilize the entire flow during the season of irrigation, but it is also necessary to take it out at that point in order to store the water which now runs to waste. So that if the water is

taken out at this one point, all together, the area of irrigation will be multiplied ten times. But that can not be done without considering the rights of the people who now use some of the water by improvident and obstructive dams.

Mr. LANHAM. If you store the water above here by means of this dam you speak of, what is going to be the effect upon the flow of the stream say 100 or 150 miles below?

Director POWELL. I suppose that if the water was wholly taken out here at this point, the water which could be utilized at El Paso would be very small, provided no water is stored and only the water running during the irrigating season is used. If all the water should be taken out here and stored, it would cut off more than two-thirds of the flow at El Paso; but in doing that you would irrigate a million or two acres of land above here, and if you allowed it to flow down there it would irrigate 40,000 or 60,000 acres of land only, as it is wasted on the way down by evaporation in the sands.

Mr. HERBERT. If all the water was stored at that point you have indicated above here, and if utilized, would it be sufficient to irrigate all the lands that could be rendered arable along the Albuquerque Valley?

Director POWELL. No, sir.

Mr. HERBERT. Then there is no water supply here that can be used to irrigate the whole valley?

Director POWELL. No, sir; there is not water enough here, and I doubt if half the land can be irrigated.

Mr. HERBERT. This is a valley extending from Bernalillo down to or below Socorro.

Director POWELL. From White Rock Cañon past Albuquerque.

Mr. HERBERT. Then it would take all the water that would otherwise have been stored by this dam at El Paso?

Director POWELL. Not all the water, because there are some feeders down below.

Mr. HERBERT. If the water along all these feeders of the Rio Grande was used as soon as it could be utilized to advantage at points, it would really dry up the Rio Grande down to El Paso?

Director POWELL. For all practical purposes for irrigation. It is possible to cut off all of the water of the Rio Grande above El Paso which can be utilized for irrigation. It is possible to cut it all off at one place or another.

Mr. HERBERT. And use all to advantage above?

Director POWELL. And use all to advantage above.

The CHAIRMAN. Storm water and all?

Director POWELL. No, sir; only the stream flow of the Rio Grande.

Mr. LANHAM. What do you say about the torrential flow there?

Director POWELL. Let me explain that. Irrigation has a peculiar limit that must be always understood. The amount of water falling in the valley of the Rio Grande annually from year to year varies. One year it will be from 8 to 10 inches, taking the whole country, mountains and all. Another year in the valley of the Rio Grande it may amount to 20 inches. Years of smallest rain-fall limit the amount of agriculture, unless the water be stored there from one year to another, for if you develop irrigation beyond the minimum year and do not store for the critical year, you will have some years when the agriculture will be disastrous, while other years it will be successful. When the disaster comes it is absolute; the fields dry up. When the disasters are absolute, or when the people can not irrigate their lands for one or two entire seasons, that agricultural community is destroyed. They not only

lose all of the crops of that year, but they lose all of their vines and all of their fruit trees. One or two dry seasons coming together in this manner are so disastrous that the people can not live on their lands; they are compelled to go away. Hence the irrigation is limited by the dry seasons. If, then, all the water is used in one region above to its utmost capacity of the dry season, that destroys the region below, for in the dry season there is no storm water below.

Off to the east, here as you see on the map, is the Santa Fé Creek, on which the city of Santa Fé is situated. It also constitutes a distinct basin with irrigable lands, timber lands, and pasturage lands, and all its waters can be caught and used in the Santa Fé Valley, so that no considerable amount will ultimately flow from the Santa Fé Creek into the Rio Grande.

On the west we have the Jemez River, where another natural district of the first class is found. The Jemez River drains the Tewan Mountains and plateau. The catchment area is well wooded. Fine forests are found and great mountain meadows are seen, but the land above is cold and is not valuable for agriculture, except for pasturage, and perhaps a little hay may be cut with advantage. The many streams which head in the Tewan Mountains and plateau find their way into deep cañons. On leaving the mountains, near Jemez Pueblo, the whole body of the stream can be taken out and put on the mesa above Albuquerque or west of Albuquerque and Bernalillo. It is another natural hydrographic basin of the first class.

Below Albuquerque we have the Rio Puerco. All of its waters can be used in the upper portion of its valley, and there is much more land than the water will serve. Very little water ever runs into the Rio Grande from the Puerco, and that comes only at flood time. It is a hydrographic district of the third class, with irrigable, timber, and pasturage lands and with many fine sites for reservoirs.

Where the Albuquerque district should end and the next district, embracing the Messilla Valley and the El Paso Valley, should begin, I am not able to state, but from such information as I have been able to collect I believe that below Socorro a new natural division can be made.

Mr. HERBERT. Could I interrupt you to ask how much of that territory is private property—say from the source of the Rio Grande to its mouth?

Director POWELL. It is impossible for me to give an answer.

Mr. HERBERT. Well, above El Paso?

Director POWELL. The circumstances are peculiar in New Mexico. There are old Spanish claims of millions of acres. The claims that have been actually confirmed are few in number. The unconfirmed claims are very great in the aggregate. The amount which has been taken up by homestead and pre-emption act and other laws for disposing of the public domain is not very great.

Mr. HERBERT. Are there any railroad grants crossing the Rio Grande?

Director POWELL. There are grants along the Atlantic and Pacific, but I believe they have not been confirmed.

Mr. HERBERT. Has the Texas Pacific any grants crossing there?

Mr. LANHAM. That is lower down.

Mr. HERBERT. Has the Denver and Rio Grande any?

Director POWELL. I believe not. In the main the most of the land grants in all the southern half of the United States include but small amounts of irrigable land. The conditions for running the best railroad

lines controlled them, and they kept out of regions of country which are more broken and furnish water in abundance. That is true of the Texas and Pacific or Southern Pacific and the Atlantic and Pacific and of the Union Pacific and Central Pacific. They had little idea at the time that these irrigable lands would be valuable, and they left them to one side; but they embrace irrigable lands sometimes. I have the grants platted on a map at my office, and could bring the map to the committee if so desired.

Mr. HERBERT. We would be glad to have you append it to your testimony.

Director POWELL. Very well.

Let us go on to consider the region of the Rio Grande below, from Socorro to a point on the river 30 or 40 miles below El Paso. Here there are two valleys, Messilla Valley above El Paso and the valley below, a part of which is in the Republic of Mexico and a part in Texas. Now, it is possible to cut off from these two valleys all of the waters which flow during the season of irrigation in critical years and destroy all the agriculture therein unless the waters of the non-irrigation seasons are stored. During the non-irrigating season large bodies of water come into the Rio Grande from the mountains on either side. There are high mountains to the west and high mountains to the east, but there are few perennial streams, and they are only small creeks. The principal body of the water comes in as storm water. But the area is pretty large and its waters can be stored immediately above El Paso and at the head and along the flanks of the Messilla Valley. At the Point of Rocks, at the head of Messilla Valley, all of the waters of the Rio Grande can be captured again and be taken out into the Messilla Valley and used once more. The waters of the non-irrigating season can be stored on the flanks of the valley, and there is more land than all the waters will serve. Still there is a mountain catchment area on either side of the Messilla Valley the waters of which will flow through the valley at El Paso at flood times, and these waters can be stored to be used in the valley below in Texas and Old Mexico. But I do not think there is enough of these waters to support all the agriculture now developed if the waters of the Rio Grande are all taken out at the Point of Rocks.

To maintain the irrigation now developed in the El Paso and Messilla Valleys some division of the waters must be here made. The catch from Socorro down coming from the mountains on either side, and the surplus which may come down in great floods from the Rio Grande above, must be divided between the Messilla Valley and the El Paso Valley to maintain the agriculture already established and to give some development to the same. Just how this can be done to advantage is not known; the topographic survey has not proceeded far enough. We know where the waters can be stored for the El Paso Valley, and I have already explained that to the committee some days ago. We can create a great reservoir with reasonable economy immediately above El Paso; we can also create a reservoir or series of reservoirs in the Messilla Valley; but how much water can be caught and held in these reservoirs we do not know, and can not know until the topographic survey is completed, for on that we depend to determine the water supply. It is safe to say, however, that the reservoir at El Paso may be constructed, and I incline to think that the rights to the present irrigation in the Mesilla Valley may be maintained, and the rights in the El Paso Valley maintained, and that irrigation in both districts may be increased, but to what extent and to what size these reservoirs should be con-

structed is yet unknown. It will require another year's survey to determine these facts. This, however, is certain, that there can be no development of irrigation in these valleys through the use of the waters of the irrigating season only; in fact, the present agriculture can not be maintained unless the waters are stored.

The irrigation already developed in Colorado and the upper valleys of New Mexico is destroying the agriculture here. Two more years of development will cut it all off when dry seasons come. The only hope for these valleys is through storage, and how the entire problem is to be solved by storage is not yet known. Nor can it be done without some interference on the part of the United States. If the General Government does not step in and by definite legislation assign specific waters to El Paso and the Messila, the El Paso Valley will surely be destroyed, and the Messila Valley can be almost ruined by the people of the Albuquerque Valley. What is needed is the construction of storage reservoirs, and their protection by the assignment of specific catchment areas to those reservoirs. The Government must say that a certain catchment area can be used for the Messila Valley and that the remaining catchment area must be used for the Albuquerque Valley. A State, a Territory, and a foreign country are involved, and they can not settle the problem for themselves. There is only one way to protect this ancient irrigation in the El Paso and Messila valleys and their right to use the water of the irrigating season and to proceed as they have heretofore done without storage, and that is to destroy all irrigation in Colorado and all of the lately developed irrigation in the valley of the Rio Grande in New Mexico above, and to prohibit forever the use of the waters there; and this would mean that to maintain 75,000 to 100,000 acres of agriculture several million acres of development must be stopped. Of course, this can not be done; they must resort to storage, and somehow storage rights must be fixed and maintained.

Mr. LANHAM. What is your solution of the question? It seems to me a man who lives at the source of a river may be in good condition, although a comparatively new country, and the man who lives below him, although his ancestors may have lived there for a hundred years, is deprived of irrigation. What is the solution of that question?

Major POWELL. Senator Reagan has introduced a bill which, I think, is a solution of it.

Mr. LANHAM. Will you allow me to draw your attention for a moment to the lower Rio Grande? Here in the El Paso Valley are Mexicans and Americans. We have Mexican citizens on the American side of the river, also. These people have been practicing agriculture for about two centuries.

Major POWELL. Yes, sir.

Mr. LANHAM. These communities above are comparatively recent. Now, what is your idea, to allow the communities above to cut off and destroy all the supply of water to the exclusion of the people below?

Major POWELL. I think their rights must be maintained. There are two considerations of primary importance in the matter. The first is to protect the rights of the people who have the vested rights; second, to prevent new vested rights from becoming practically an impediment in the development of the country.

The CHAIRMAN. Let me suggest here that your system of damming and retaining waters at different points on these streams is not unlike the system adopted to improve navigation on the principle of slack-water navigation. It economizes water where it can be easily utilized.

Major POWELL. There is this difference in it, which is a radical difference. When water is taken out for the purpose of slack-water navigation or for powers, the water is returned to the channel, but in the case of irrigation it is largely used.

The CHAIRMAN. That is the same rule in regard to irrigation. They take it out and devote it to irrigation purposes and return it, so it is left in the channel.

Major POWELL. But the greater part is never returned.

The CHAIRMAN. It is evaporated.

Major POWELL. It is evaporated to the heavens. It would be manifestly bad policy if by some process, in order to protect 50,000 acres at Albuquerque, we had to stop the irrigation of several million acres of land above.

Mr. LANHAM. What right has anybody to take the entire water of a river and divert it from the people below? Suppose I live 10 miles above my neighbor on a river, would it be right to take the whole body of that stream from my neighbor?

Major POWELL. No, I think not. I think if rights have been established in that valley they must be maintained.

Mr. LANHAM. Is it not a fact that the rights of the people in the Rio Grande Valley, from Santa Fé down to the mouth of it, are older than any rights above?

Major POWELL. Altogether. But the new rights are in other States, and they have no remedy at present. If the people below are to be destroyed they ought to be bought out. But provision can be made for those below to secure the surplus of water which is not used now during the season of irrigation. It would be possible to secure the rights to 50,000 acres in El Paso Valley and destroy 4,000,000 acres above. All that can be avoided by the use of the water stored—the surplus of the storm waters.

The CHAIRMAN. Your idea is, then, that the Government of the United States can fairly and legally provide for catching the water from the water-sheds and making use of it—putting it in a way in which it can be economically used?

Major POWELL. I would like to go over the Rio Grande, because I believe I could make it clearer than to go all over the United States. I suppose I had better go over that after it is written out by the stenographer.

Mr. LANHAM. I wish you would go over, in your revision, this problem in reference to the people of the Rio Grande. I feel a very deep and profound interest in it. That valley would all be ruined under the conditions you name.

Major POWELL. Suppose, Mr. Chairman, not to weary you with an extended talk, that I be allowed to insert eight or ten pages about the water of the Rio Grande and how it can be used and all rights protected.

The CHAIRMAN. I wish you would do that.

Major POWELL. I can do that without an interminable talk to you, gentlemen. I am afraid that I have wearied you already.

Mr. HERBERT. You are not wearying me, for I feel a very great interest in it.

The MEMBERS OF THE COMMITTEE. And we are deeply interested in it.

Major POWELL. The area drained by the Rio Grande above El Paso is a little more than 23,500,000 acres, or about 37,000 square miles. But much of the region is mountainous. Even if there was water enough

it would not be possible to irrigate one-half of the land. Of the arable lands, only a portion is irrigable, from the fact that there is not water to supply them all. It may be that when all the waters of the Rio Grande are used in Colorado and New Mexico, and in the valley of El Paso, in Texas and the Republic of Mexico, from three to four million acres can be cultivated; but this can be done only by using all of the waters and storing all those that now run to waste. And then the irrigable lands must be properly selected, so that the waters can be used to the best advantage. That none may be wasted they must be stored where there is the least evaporation, and the lands must be selected near where they are stored, and the waters must not be permitted to run through sand valleys where they are evaporated. They must be taken out from the streams and stored to the best advantage and used without waste. Then it may be possible to irrigate from three to four million acres. Of course the estimate is rough, because the surveys have not been perfected, and it may be too great; I do not think it is too small. Now, the problem which you ask me to solve is this: How can these waters be used to the best advantage? How can they be divided among the best lands, and how can the rights of the present irrigators be maintained? I shall try to answer these questions, and certain collateral problems that are involved; and to do so, shall go over the ground again district by district.

Commencing, then, at the head of the Rio Grande Valley, we first meet with the Saguache. This river sinks in the sands; except in very great floods it discharges no water into the Rio Grande. Its valley, therefore, is an independent district, one of the third class; all that can be done in the Saguache district is to select the best irrigable lands and provide that the waters shall not be used where they will be largely wasted.

Then we have a district drained by the headwaters of the Rio Grande —a district of the first class. All or nearly all of its waters can be used within the district on good lands, but the lands must be selected or the waters will be wasted. The district lies wholly within the State of Colorado.

The next district below on the river is the San Ildefonso. This is a trunk district, and thus belongs to the second class. For 60 miles down below the Colorado line the river can not be taken out, as it runs in a cañon. The lands on either side are of little value and should be used only for pasturage and forest purposes. This upper portion of the San Ildefonso Valley is naturally the catchment area for the waters to be used in the valley below the mouth of Embudo Cañon. There are some creeks that come into this valley from the mountains on the east. This district, therefore, has a great catchment area which will supply a large quantity of water which should be dedicated to the use of the farmers of the valley below. But they should understand that they can not maintain rights to use water coming from the San Luis district; that they should develop their agriculture wholly from the supply of their own catchment area. The best lands lie on either side of the river in the valley below Embudo Cañon and along sections of the eastern tributaries. These lands should be selected in sufficient amount to use all the waters of the district, and all other lands should be deprived of the right to use water for irrigation; then there could be no controversy about water-rights in the district. Settlers could not go upon the non-irrigable lands and illegally take the water, farming could be developed in the valley to the greatest extent and on the best lands, and the farmers would be secure from depredations by

other farmers going above them and "pirating" the water—to use a term common in the western country.

Midway in this district and at the head of the irrigable lands the Taos joins the Grande. It is a fine stream, and its drainage basin constitutes a district of the first class. All the waters of the Taos can be used in its own valley, and it should be established that the people of that district have a right to use all of those waters and that the people in the San Ildefonso Valley below can never maintain the right to have those waters flow down to their valley; that the Taos Valley is not a part of the catchment area of the San Ildefonso Valley.

In the lower part of the San Ildefonso Valley the Chama joins the Rio Grande. The basin drained by this river constitutes a district of the first class. All its waters can be used at home, and it should be established that the people have a right to use them there and that no right can be maintained to the use of its waters outside the district.

At the foot of the San Ildefonso Valley the Rio Grande again traverses a deep cañon for a distance of 50 miles. Along this course it receives many important tributaries that drain high mountains, and on these irrigation can not be practiced to any advantage. It is a pasturage and timber region, and is a catchment area for a district below. The cañon is known as White Rock Cañon. At its mouth the waters can be taken out again and spread over a large valley. In this valley there are already a number of considerable towns. Albuquerque is the principal city, and we will call it the Albuquerque Valley, and the district including the valley and the catchment area above, the Albuquerque district. It is of course a trunk district, and hence belongs to the second class. Now, it should be established that the people of the Albuquerque district can not maintain rights to use water not caught within their district; that all of the volume of the Rio Grande in the San Ildefonso above belongs to the people of that valley; that the only waters which the Albuquerque farmers can use and permanently maintain rights to are those falling from the heavens over their district.

The irrigable lands of the Albuquerque district are in excess of the water supply. The nearer to the mouth of White Rock Cañon they can be used, the greater is the area that can be irrigated. Perhaps this district should terminate at Socorro. Perhaps it should go down to San Marcial. A careful topographic and hydrographic survey is necessary to determine this boundary. The district would at any rate be more than 150 miles in length, and it is a long sand basin. If the irrigable land should be selected in the southern end of the district, much of the water would be lost on its way; if selected in the northern end of the district, this water could be saved. The Rio Grande will irrigate two acres in the northern end of the valley for every acre that can be irrigated in the southern end of the valley. But there are lands already irrigated in the southern end of the valley, and their rights should be maintained—at least until they are justly extinguished. Doubtless this will ultimately be done. It is of prime importance that no more rights be established in the southern region of the district.

To the east of the White Rock Cañon lies Santa Fé Creek. It is a beautiful stream of water, and the region which it drains forms a district of the first class. Here the city of Santa Fé is situate, and the waters of the great creek are all used in irrigation during the summer months. An attempt has been made to store water, but it has proved a failure. The site of the reservoir was among hills that had been denuded of their forests and grasses, and the reservoir was destroyed by the

enormous and rapid accumulation of débris. Other and better reservoir sites can be found where the forests are not yet destroyed. The farmers of the district should have control of these forests, or they can not greatly increase the area of irrigation in the district. The lands to be irrigated lie on a plateau in the neighborhood of the city and are already of great value. The principal catchment area is in high mountains where there are extensive forest lands, and where there should be pasturage lands, but these are largely destroyed by overfeeding. The pasturage and timber lands greatly need protection in the interests of agriculture below.

Just above Bernalillo the Jemez joins the Rio Grande, and here we have another district of the first class. The Jemez now discharges a part of its waters into the sand, for there is a long stretch of dunes extending from Zia down to the Rio Grande. Still, the river has a volume sufficient to carry part of its waters over these sands and discharge them into the Rio Grande. The catchment area is the Tewan Mountains and the Tewan Plateau, a lofty region covered with beautiful forests and rich grass lands yet uninjured by fire or overfeeding. The mountain meadows are abundant and beautiful, and the forests are among the best in New Mexico. The lands to be cultivated by this river lie on the mesa west of Bernalillo and Albuquerque. The waters can be stored in the mountain meadows and elsewhere very cheaply, but it will be expensive to take the water across the sand-dunes onto the irrigable lands of the mesa. The mesa itself and the catchment area both should constitute one district. The waters of the mountains should be attached to the lands of the mesa, and the right to use the waters should permanently inhere there. The settlers in the valley of the Rio Grande should not be able to acquire rights to the waters, for in so doing they would be chiefly wasted. The catchment area is a volcanic district, and volcanic cinders and ashes abound; and these conditions make it necessary to carefully protect the lands, otherwise they will silt the streams and fill the reservoirs. The forest area is, therefore, chiefly valuable as a catchment area, and should never be denuded of its trees.

The next stream is the Puerco, which comes in below from the west It heads in the Nacimiento Mountains, the western slope of the Tewan group. Along this range of mountains there are several beautiful streams that flow into a distant valley into the dry channel of the Puerco for it here flows through sands, and passes only in extreme floods into the Rio Grande. Practically it is a district of the third class. Its waters have been used in irrigation in the settlements near the mountains, which are to some extent well situated for such purposes. But farming is chiefly carried on in the valley of the Puerco, and in that region can not be permanently maintained to advantage. The rights to irrigate so far from the mountains must be permanently extinguished if the Puerco is to be used to the best advantage. The catchment area is the slope of a great mountain range covered with fine forests, and there are many good reservoir sites. The pasturage is also extensive, but the pasturage and the forests must be protected to save the agriculture. The irrigable lands of the Puerco should be carefully selected, and no other lands should be cultivated. The reservoirs must be selected in the valleys and on the slopes of the mountains, where they will not be subject to destruction by silting if the forests and grasses are not carefully preserved.

From Socorro southward to El Paso is a distance of about 200 miles by the river. There is already irrigation in the Mesilla Valley above

El Paso, and there is also much farming below El Paso in Texas and the Republic of Mexico. Through much of the way from Socorro to the head of the Mesilla Valley the river cañons again, and there is a natural catchment area for the country below. This upper region should be declared the catchment area for the Mesilla Valley. At the mouth of this cañon there is a place called Point of Rocks, near Fort Selden. Now, it is possible to take out all the waters of the Rio Grande derived from the catchment area just described at this point, and there is land enough in the Mesilla Valley to use it. But this would cut off all the water from the El Paso Valley below. There is a short pass or gorge just above El Paso through which the Rio Grande runs. This divides El Paso Valley from Mesilla Valley. To maintain the rights of present irrigators in Mesilla Valley and El Paso Valley alike, it becomes necessary to unite these two valleys into one district and to divide the waters between them. There is water enough coming from the catchment area below Socorro to maintain all the agriculture yet developed and to increase it somewhat—how much we do not know, as the survey is unfinished. Nor do we know how to divide the waters. The El Paso Valley is partly in Texas and partly in the Republic of Mexico. The Mesilla Valley is in New Mexico. It is thus that the waters of the Rio Grande in this district must be divided between three peoples, and unless some authority steps in and makes this division the irrigators of the Mesilla Valley can take all the water from Texas and old Mexico and destroy all the farming below. The survey has developed the fact that we can store water with reasonable economy and in sufficient amount immediately above El Paso, at the gorge of which I have spoken, to supply the wants of all the farming in the valley below in both countries, and from the same reservoir an additional area can be served, but there is no wisdom in constructing this reservoir unless steps are taken to provide a catchment area for it and to protect that catchment area from spoliation.

It is thus that the El Paso problem can not be solved by the construction of a dam at El Paso and the establishment of a reservoir to hold water for the valley below. A catchment area must also be provided, and in providing this the rights in the Mesilla Valley must be maintained. It is true that if the dam is constructed at El Paso now, flood waters in sufficient quantities will come down to serve present wants, but these flood waters can be caught above, and ultimately will be, and it will be wise to pay heed to the ultimate conditions. How many years ere this will be I do not know; it will depend upon the rate of development, an uncertain factor. But schemes have been projected and begun in the Rio Grande Valley within the last eighteen months to take one-half of the ultimate supply of water. Most of these schemes have been projected without any proper consideration of the conditions to be met in order to utilize the greatest amount of land. If they are completed and rights finally established on the ground selected, then one-half of the value of the Rio Grande Valley is forever destroyed. The rights and interests thus established will be so wasteful of water that the Rio Grande will sustain only one-half of its possible population. This statement is very conservative. It may be and it is even probable that the water will be able to do only one-third of its duty. And the Rio Grande is a fair illustration of the facts and conditions pertaining to every great river in the arid lands.

This then is needed in the Rio Grande Valley, that its agriculture may develop normally and that all rights established may be maintained: First, it should be divided into irrigation districts, as I have described.

In each district the catchment area and the irrigable lands should be determined and defined. To define the irrigable lands, it is necessary to measure the waters, in order to discover how much land can be used. Then the irrigable lands should be declared such, and the law should prevent any other lands being irrigated. Then the catchment areas should be defined, and settlement on the catchment areas for agricultural purposes should be prohibited, and the people farming on the irrigable lands should have a right to control the catchment areas and to protect and use the forests and grasses. Then, in each district the storage basins should be segregated and reserved from sale and occupation, so that they may not fall into the hands of speculators whose rights would have to be purchased before the waters were stored; but the people who live in the district as a body politic and corporate should have a right to control these storage basins for the common use. The dam sites and the canal sites ought in like manner to be designated and preserved from sale to individuals and held for the common use of the people. By this plan the irrigable lands would be held in severalty by the people; the sites for reservoirs, canals, and dams, and the catchment areas would be held in common in each district. But in the El Paso district, in which the catchment area is in New Mexico, and a part of the irrigable lands in the Mesilla Valley of New Mexico and a part in the El Paso Valley of Texas and old Mexico, some means must be provided to divide the waters. It is an interstate and an international problem; but the rights of all of the people now cultivating the soil should be maintained.

To define the districts, a topographic survey is necessary; to define catchment areas, and irrigable areas, and to select the reservoir sites, canal sites, and dam sites, a topographic survey is necessary; to divide the waters, a hydrographic survey is necessary, and a hydrographic survey is based upon and can be most economically made through the agency of a topographic survey. In selecting the lands in headwater districts, they should be taken in regions low enough to have a good agricultural climate. In the trunk districts the land should be as near to the points where the waters are taken from the rivers by diverting dams as possible, that these lines may be the shortest and that the least water may be wasted. The reservoir sites, other things being equal, should be selected on the highest lands, where the evaporation is least. As far as possible, reservoirs should be selected away from the channels of the principal streams, where they can be maintained at the least cost and where the danger of destruction is least. The principal lines of canal should all be designated in advance, in order that impedimentary and obstructive rights may not be established. These obstructive rights are of two classes. First: Where a lateral stream joins a main stream, the waters of the lateral should be taken to lands sufficiently high up its course to be out of the way of the development of irrigation on the principal stream. The principal stream usually has a lower gradient, and its waters can not be taken to very high lands; and if the waters of the lateral stream occupy the low lands, the waters of the principal stream can not be used. This condition of affairs has arisen in many cases already in the development of irrigation in the West. The obstructions of the second class relate to low-line canals taken out along the course of a stream which runs in a sand plain. If the canals are taken out here, the whole length of line is extravagantly great, and the loss of water is correspondingly great. All canal lines should be made as high as possible.

Such are the most important conditions which relate to the utiliza-

tion of water for irrigation and to the development of agriculture in arid lands. They are all of great importance; no one can be neglected without doing serious injury to agricultural industries. If these things were done in advance of more dense settlement, and then the people permitted to control their affairs in their own way—divide the waters among themselves in each district as they please, protect and utilize the forests in obedience to their own judgment corrected by experience as time goes on, use the pasturage for their flocks and herds and protect it from destruction that they may thus use it—the arid lands would furnish homes to prosperous, peaceful, and happy people.

At another time I shall have something to say about water rights.

Let us now pass westward, across the great Rocky Mountain divide, and we come to the Gila River, which flows westward into the Colorado. I place before you a map of the Gila River and its tributaries, together with a portion of the Colorado River and this small river known as Bill Williams' Fork, which is a tributary to the Colorado. You will see that the Gila River heads in the Mogollon Range and the San Francisco Mountains, and runs westward to the Colorado. Then it has a tributary on the north known as Salt River, and an important tributary of the Salt River is the Verde.

The Gila, above the mouth of the Salt, constitutes a great hydrographic basin, with timber lands, pasturage lands, and irrigable lands, extending southward toward the Southern Pacific Railroad in this region [indicating on map], southward and westward from Florence. There are good sites for storage reservoirs in the upper regions of the Gila and elsewhere throughout the catchment area. And upon this catchment area above, and the reservoirs which must be constructed there, and the canals which must head above and connect the river and the reservoirs with the irrigable lands, the farmers of the agricultural region must depend. They are also interested in the protection of the forests and their utilization, and have a common interest in the grass lands of the region drained by the Gila.

The Salt River and the Verde head in a great line of cliffs which extend across Arizona from the Colorada River to the San Francisco Mountains. The line of cliffs cut off the lowlands on the south and west from a great table-land or plateau above, known as the Mogollon Mesa, or the Great Colorado plateau. On this plateau many high mountains or extinct volcanoes are found, and many small streams come down here to feed the Salt River and the Verde, and the two streams together constitute a great hydrographic basin, with timber lands, pasturage lands, and irrigable lands. The town of Phœnix is situated in the center of the irrigable district. The Upper Gila and the Salt River districts are of the first class, as they are headwater districts.

Below the junction of the two streams the Gila River gives rise to a trunk district. What water it has we do not yet know. A sufficient examination of the country has not yet been made to warrant predictions as to the possible extent of agriculture therein. On the north there are two streams which belong to the third class: The Agua Fria heads near Prescott and sinks before it reaches the Gila; but at flood tide a little water runs over. Then to the west we have the Hassayampa Creek, which also has a dry channel most of the year along its lower course. We have, for the present, thrown these streams into the Lower Gila, or trunk district, until we know more of their possibilities for agriculture.

North of this trunk district we have Bill Williams' Fork and its tributaries. Little is yet known about the quantity of water which it will

supply for irrigation. It is partly a mountainous region and partly a district of lowlands, and there are pasturage lands and timber lands.

The CHAIRMAN. You know the Indians, the Pimas and Maricopas, on their reservation to the south, and that they have a large area thoroughly ditched by their own labor?

Major POWELL. Yes; there is another irrigation district, and opportunities to store water. Southern Arizona does not appear on this map. We do not know how to divide it into districts, nor do we know how its waters are to be utilized. The streams are few and small. Artesian wells can be obtained in some places, but no great amount of agriculture can be developed thereby. The sand basins, from which waters must be pumped, are more extensive. In the main the people will have to depend upon the storage of stream waters.

Mr. LANHAM. I would like to hear you for a few moments on that proposition. I saw recently an account of a great destruction of life somewhere in Arizona.

Major POWELL. The construction of dams for all purposes, for power and for irrigation, is a very ancient art. If you go to the Book of Chronicles, you will find that they diverted rivers onto the lands. Dam construction is very old. In the provinces of India dams have been constructed by thousands and hundreds of thousands for irrigation purposes. Some have been destroyed and brought disaster, as at Johnstown in Pennsylvania last summer and at Hassayampa in Arizona a few days ago. In both of these cases a glance at the map will show why these dams were destroyed. In the case of the Hassayampa dam it was the simplest thing imaginable. Now let me make that clear. The Hassayampa dam was planned for a dry wash. It was for the storage of storm waters. The area drained was 320,000 square miles. The Hassayampa is surrounded by three great mountains, rising a little more than 7,000 feet above the level of the sea. On one side is Mount Tritle, rising 7,500 feet. The mountains are not clad with forests. A few scattered trees grow, but in the main the mountains are naked, solid rock. Now, it is possible that one storm in these mountains may bring a fall of rain to the amount of 2 inches, or even more. If that stream receives 2 inches of rain-fall, after a rain that has previously soaked the ground, almost the whole amount will be delivered into the wash below. I computed the matter a day or two ago, and I found that to protect that dam it was necessary to have a waste-weir which would discharge 6 acre-feet of water every second.

The CHAIRMAN. Equal to how many inches?

Major POWELL. I could not tell that without making a computation; but a great many inches. Now, a glance at the map reveals that condition. In constructing a dam for the storage of flood waters and storm waters, one of the fundamental propositions is that the degree of declivity must be known. That is to say, the dam must be related to the catchment area, and means must be provided by which all the water in the greatest possible storm can be controlled. Otherwise, when a great storm occurs, the works are liable to destruction. In the Hassayampa no provision was made for one of these great storms, and when it came it broke all before it.

Mr. HERBERT. But if it is stored ——

Major POWELL. Now here is this dry wash, and an ignorant engineer believes the dam is safe from all the water that comes from a storm, for he has never seen it at flood-time. It may be that once in ten or twenty years there comes a storm which becomes a vast flood, and then the dam goes. Of course, in planning these reservoirs we must provide

for all conditions. It is idle to say that we can not plan against them; we have simply to collect the facts and provide against all contingencies. In looking over India, where this matter of dam construction has been going on for a long time, I find there are dams which have been used for more than a thousand years. There are some that have been breeched and abandoned.

In planning reservoirs and all hydraulic works for irrigation, a hydrographic survey is necessary. It is a primary condition that we learn how much water is to be controlled at any and all times. A hydrographic survey is based on a topographic survey, by which the catchment area is measured and the declivities determined. Then, the rain fall being known, in a general way—that is, the mean annual rain-fall, the maximum annual rain-fall, and the maximum storm-fall—we are able to determine how much water is to be controlled. In getting at this we also have to gauge the typical streams. But I propose to explain this matter more fully to the committee when I lay before it the operations of the survey for the past year. Of course, works can be constructed after *guessing* at the amount of water to be controlled; but this is dangerous to life and property. If the estimates of water are too great, works are made too expensive; if they are too small, the works will be destroyed. Tound work can not be done without a hydrographic survey, and this must be based on a topographic survey.

SELECT COMMITTEE ON IRRIGATION,
March 13, 1890.

The committee met pursuant to adjournment, Mr. Vandever in the chair.

STATEMENT OF MAJOR J. W. POWELL—Continued.

Major POWELL said:

Mr. Chairman and gentlemen of the committee: I place before you this morning a map of the Colorado River and its tributaries, together with the entire area drained thereby. The river heads in the Wind River Mountains of Wyoming, and is there known as Green River. The Grand heads in the Middle Park of Colorado, and the name Colorado is attached to the river from the junction of the Grand and Green to the Gulf of California. A portion of Wyoming, a portion of Colorado, a portion of New Mexico, a portion of Utah, a portion of Nevada, a portion of California, and a portion of Arizona are all drained into the Colorado, and its waters are thus to be divided between seven States and Territories. The great valley of the Colorado is naturally divided into two very distinct parts. The lower and much the smaller part lies but little above the level of the sea, except that here and there volcanic mountains are found. The upper and larger part is an elevated region of plateaus and mountains. The step from the lower to the higher region is very abrupt, and is marked by a great line of cliffs which face the south.

The upper basin, which is divided by deep gorges or cañons into plateaus, lies from 5,000 to 7,000 feet above the level of the sea. About the rim of the basin there are high mountains, the Wasatch and the Uintahs on the west, the Wind River Mountains on the north, and the great Rocky Mountains on the east. To a large extent the rivers run

through deep cañons and can not be taken out on the lands. For this reason the irrigable lands are greatly limited. The Colorado itself cuts through the lower portion of the plateau region in a deep cañon from 5,000 to 6,000 feet below the general surface of the country. The Green and Grand are also in cañons for much of their courses, and all of the upper streams cañon more or less. In the main the irrigable lands lie at the foot of the mountains, and the entire country can be carved into irrigation districts very conveniently, but unfortunately some of these districts must be in two or more States. As the boundary lines of States are not natural lines, Wyoming and Utah are involved in some of the districts, Wyoming, Utah, and Colorado in one natural district, Colorado, New Mexico, and Utah in another, Colorado and Utah in a number of trunk districts, and Arizona and Utah in several headwater districts of lateral streams. In every district important forest and pasturage interests are involved; in fact, the whole of this upper region of the Colorado is largely pastoral. The mountains are lofty, and great elevated plateaus exist, and the forests are abundant. In general, there is more water, than there is land and only in a few places will it be necessary to store the waste in this upper region.

The Colorado heads in the north and runs to the south, and it is about 2,000 miles in length. The northern region is elevated, the southern depressed, coming down practically to the level of the sea. It is a great river. These changes of altitude and latitude involve great changes of climate, and permit of a great variety of agricultural productions. The valleys in Wyoming are very beautiful, but they are very high, and subject to deep snows with late and early frosts, and only a small variety of crops can be raised. Great meadows may be cultivated, and potatoes, rye, barley, and oats to some extent may be raised. Perhaps in the very lowest valleys of Wyoming a little wheat may be grown. I will call this upper region the potato region. Down the river farther, in southern Wyoming, Utah, and Colorado, wheat can be raised to advantage. These I call the wheat lands; and there are some very beautiful valleys to be irrigated by the Yampa, the White, the Grand, the Green, and the Uintah rivers. Here there will ultimately be some of the finest agricultural districts of the West, for the waters are abundant, coming from great mountain ranges, and the forests of the catchment areas are of the first order. Still farther down the Colorado there are a few cañon valleys where some agriculture may be carried on; but in the main, southern Utah, southwestern Colorado, and northern Arizona, will be a catchment area for the great valley of the Colorado below. However thoroughly the upper valleys may be developed, the Colorado will discharge from the mouth of the Grand Cañon into the valley below an enormous stream of water, sufficient to irrigate several million acres of land. There are some beautiful valleys just above the cliffs, far back from the river, where corn can be raised to good advantage and where vines and fruit-trees flourish. These are the corn lands. In the great valley below, vines, cotton, sugar-cane, oranges, lemons, date-palms, and all the products of sub-tropical climates can be raised to advantage. There is a great supply of water, and a great body of land; but we do not yet know how these waters can be taken out onto the land. Ultimately they are to be divided between California and Nevada on the one side, and Arizona on the other. The mouth of the river is in the territory of the Republic of Mexico, and in that lower region there are extensive tracts of available land. The utilization of the

Colorado, therefore, involves an international problem, and interstate problems also must be solved.

I shall not take up this vast region district by district, as time would fail me to enter into the subject to so great an extent; but I will dwell a few moments to point out the conditions which exist in two natural districts, which will be sufficient to illustrate the subject. I should be pleased to dwell on this part of the subject, for the great valley of the Colorado is one with which I am most familiar, having explored, traversed, and surveyed much of it myself. I will call your attention first to the Kanab district, which is really a district of the third class, as the Kanab sinks in the sands, though it re-appears many miles below, where it enters a deep cañon and obtains a new supply of water. The Kanab heads in Utah, in high plateaus, where there are great forests. Near its source there is a beautiful little valley, valuable for pasturage, and which can be cultivated to raise hay and potatoes, but it is too cold for general agriculture, and the waters of the Kanab should not be used thereon. Twenty-five or thirty miles farther down, the Kanab emerges from a deep cañon into a valley plain. Here all of its waters can be used in agriculture, and they are now used there so far as they can be without storage. But the irrigable lands lie along the Territorial line, a small part being in Utah, a greater part in Arizona. It is thus that the lands that depend upon the same reservoirs and upon the same canals must be divided between the two Territories. The principal farming lands should be in Arizona, the reservoirs must all be in Utah. The Kanab is only a small stream, and not a very large area can be cultivated; but the district is large and valuable for pasturage purposes. Unfortunately it is rapidly being destroyed. The forests of the catchment area are also disappearing, as they are being devastated by fire.

To the west lie the Rio Virgen and its tributaries. Here is another natural district; part of its catchment area is in Utah and a part in Nevada. The irrigable lands are also partly in Utah and partly in Nevada, and the pasturage lands are in like manner divided. The Rio Virgen is already supplied with several flourishing settlements; but the forests and grasses are disappearing. It is possible to cut off nearly all the water from Nevada and use it in Utah, and this is being done, and through this agency most of the settlements in Nevada have failed. At one time there were several flourishing towns and agricultural districts on the Virgen, in the latter State, but development of agriculture above has laid them waste. The position of the State line here is peculiarly unfortunate, as it divides the districts in a very bad way, as you see. But, more than that, here is a large area of Arizona, lying on the north side of the Grand Cañon, which can be crossed only at one point for five hundred miles. This gorge, separating the northern portion of Arizona from the main body of the Territory, and impassable except at one point, is from 2,000 to 6,000 feet in depth. The citizens of Arizona who live on the north side can not go to their capital or communicate with the people of the other side without going out of the Territory and traveling hundreds of miles. All that district should be attached to Utah.

Mr. HERBERT. The river forms the line between Arizona and California, I believe.

Major POWELL. Yes, sir; the river forms the line.

Mr. HATCH. Is that blue line the river? I can not see distinctly from here.

Major POWELL. Yes, sir; it is the Colorado River. The immediate

valley of the Colorado, in its lower course, is not very wide; still, it is probable that considerable areas can be irrigated on both sides of the river. Perhaps this can be done to good advantage by pumping. It may be that it will not pay to control so great a river to irrigate the bottom-lands. The settlers are already using pumps very successfully. Just to the west, here in southern California, there is a vast area of good land. How the waters are to be got there we yet do not know. There are also good lands in Mexico—this region, as you see [indicating]. Here, farther in the interior of California, is a great sink, which is a continuation of the the basin of the Gulf of California, and the region lies below the level of the sea.

Mr. HERBERT. Is that fertile land?

Major POWELL. It would be fertile if covered with water; but it can not be irrigated or cultivated from the fact that it can not be drained. If the land were irrigated it would soon be destroyed by alkaline salts; and as it is below the level of the sea, there is no possibility of drainage. The impossibility of drainage is a considerable difficulty.

I will next take up the map of Utah. As there is a great deal of country to go over I will only select salient points as we go along, lest I weary you.

The region represented on the map before you will illustrate some rather important facts in connection with the control of the waters for irrigation. The Sevier River heads just opposite the Kanab. It flows northward until it leaves the mountains, and runs out to the sand plain or desert on the west and enters the Sevier Lake, a salt lake, a sink. There is a development of agriculture originally along the plain of the lower river. It has been developed here to the extent of utilizing all the waters of the irrigating season, but no waters have been stored. Some of the country is being rapidly settled on the headwaters up in the mountains. The waters from the land originally irrigated are being taken away, so that some of the farmers are compelled to abandon part of the land which before was irrigated in this region of country. The places for storing are in these upper regions. The waters of the Sevier ought to be used in the two sections of the lower valley, where wheat and corn can be raised and a great variety of other crops; but in order to do it the waters must be stored in the mountain regions above, where the storage basins are. This upper region is well forested and contains a great body of pasturage land. The land below, where agriculture is to be practiced, is almost—not entirely, but almost—destitute of grass, but very valuable for agriculture, as it is a warm climate. If the region here is to be irrigated to the entire capacity of the Sevier River, then the water must be stored in the upper regions, and the people who irrigate these valleys must have control, by some process or other, of the waters of the upper region.

It is the same problem as is exhibited elsewhere; the people are interested in the protection of the forests about the sources of their water supply, and in the protection of the grasses, so as to feed their cattle in summer. This is the story over and over again wherever we may go, a peculiar fact being that in general the agriculture is dependent upon the land not owned by the agriculturists, or not occupied directly by the agriculturists—that is, the waters come from another region. The irrigating canals have to be constructed over other lands, the storage basins are not lands that are occupied for agriculture, and the catchment areas are in other districts, where they must be protected from destruction by waste of the forests, etc., so that wherever agriculture is to be developed by the utilization of the streams of the country, the

people themselves, the agriculturists, have an interest in some other country. That is the most important fact about the whole system of irrigation everywhere.

There are some other interesting problems on the Sevier, but I will pass on to Salt Lake Valley. The Salt Lake Valley is one where some evils growing out of improvident projection of canals and improvident utilization of waters are very clearly illustrated. The Jordan heads in the Wasatch Mountains and in the Uintah Mountains beyond. There are a number of small streams here [indicating on map]. These streams run into Utah Lake. The river is known as the Jordan from the point where it leaves Utah Lake to the point where it enters Salt Lake.

Mr. HERBERT. Is Utah Lake salt?

Major POWELL. It is not salt, it is fresh water. Salt Lake is salt. There is irrigation all along these streams, on the Provo, the Spanish Fork, and so on. A fine area around Utah Lake is already irrigated by streams which run from the mountains. A great many creeks run down from the Wasatch Mountains into Jordan River that are used for irrigation. On entering the country the people settled low down comparatively in the valley of the Jordan and took the water from these streams that run down into the Jordan and brought it on the plains or lowlands near the Jordan River. Then ultimately they wanted to use the Jordan itself. Utah Lake is itself a great storage reservoir, and it is utilized to some extent for that purpose now, and only a small expenditure is needed to make it a storage reservoir of vast resources; but the people there can not utilize it because they have entangled themselves with prior rights. They have taken out the waters of these streams onto the only land that can be reached by the Jordan, instead of taking them higher up in the lateral valleys. Now, in order to utilize the whole Jordan they must move this agriculture by the banks of the Jordan away to districts up the tributary streams. We are coming to that condition everywhere in the West. The tendency is first to utilize small streams on the lands that should be reserved for the large streams. Then when the larger stream is to be used it can not be, because of vested rights. They are adjusting these matters by Church authority in Utah, but we can not elsewhere in the country manage it that way.

Now, another problem is illustrated clearly in Utah. Utah Lake is a natural reservoir, and it would take only a small dam and the opening of canals to irrigate all this valley of the Jordan. But the people who settled on these plains settled along the margin of the lake; established their homes near the lake. If the water which goes into Utah Lake is to be stored and all of it saved by constructing a dam—which can be done very cheaply at the outlet of the lake—and make a reservoir for all the waters of the year, then all this agriculture has to be bought out, because the lands will be flooded. They have already irrigated from one to two hundred thousand acres of land by raising a dam two or three feet high at this point, but they did it without first consulting the people above. As soon as they stopped the waters here and dammed them upon the land, there resulted a contest between two counties, Salt Lake County and Utah County, and it was settled locally by Church arbitrators. One county paid one-third of the expense, the other paid one-third, and the Church paid one-third, so that the matter was settled. But a large area below, on the Jordan, could be irrigated if all these rights along the margin of the river were bought out.

Mr. HANSBROUGH. Is that area settled upon now?

Major POWELL. Yes, sir.

Mr. HANSBROUGH. That can be irrigated?

Major POWELL. Yes, sir; that area:

Mr. HANSBROUGH. This is wild land?

Major POWELL. Yes, sir; and that wild land can not be settled now, because it is blocked by the settlement above; and that is the condition we are coming to again and again all over the arid lands, blocking the utilization of the waters by establishing impedimentary rights elsewhere. If the canals projected and begun during the past years, since the passage of the act creating an Irrigation Survey, are actually constructed, and the various plans before Congress for granting rights of way are actually granted, and if the various plans for granting rights of way by States and Territories are actually given, and the canals constructed there which are now projected—if all the schemes on hand today and developed in the last eighteen months are carried out, it will be impossible to utilize all the waters of the country without buying out vested rights to the amount of several hundred million dollars. The process now is to block development in the manner in which I have spoken. That arises from the fact that the first irrigation goes into a country regardless of the future development of the country, and selects first the smaller streams that can be taken out the cheapest, and takes the water on the lowest land, when the water ought to be taken out near the source.

Mr. PICKLER. How do you account for the multiplicity of schemes in the last eighteen months?

Major POWELL. It is because of the large increment of value given to land by reason of irrigation. It is so enormous that there is no difficulty in obtaining hundreds of millions of dollars for the land's redemption. Hardly a week passes that some foreign or American investment company does not write to me asking for information. Capital is offering everywhere. You must appreciate what it means to take desert land that has little or no value and make it worth anywhere from $30 to $200 an acre, and after these lands have been increased thus in value, to obtain permanent right to water and make a permanent investment. The opportunities for investment and for making grand fortunes are so great that money pours into the country for the purpose.

Mr. HERBERT. You have estimated that it will take several hundred million dollars to buy out the rights that will be vested if existing plans are carried out. What is your estimate of the amount that would be required to buy out vested rights in order to carry out the provisions of the bill which is before us, the general bill?

Major POWELL. I think that less than one-fifth. That bill does not propose that the Government shall do it, but provides for condemnation of rights and that the people shall do it themselves. I think while I am on this point it is best to go to another in regard to these impedimentary or obstructive rights which are growing up in the country. I can illustrate it on the map here. Going back here to Phœnix—at first the irrigators take out a stream in a cheap way. They plant a sand dam or a brush dam or a bowlder dam, just enough to check the flow of water a little, so as to turn a part of the water into a canal. They run low-line canals over the land and irrigate a strip of lowland which at times of very high water will be overflowed by the river. Two or three miles below they take out another such canal, and still below another. Thus, along the course of a stream they will take out twenty or fifty little canals following the stream. Now, in order that the water shall flow into these canals it is necessary that a much larger volume than the canals themselves will carry shall go past them. If the two, three, ten,

or twenty canals were consolidated and a point selected upon the stream where the river closes in and has a rocky bottom, and a great dam were constructed and one great canal used to irrigate the country that can be supplied, two, four, or ten times the amount of land could be irrigated and the one great canal would cost less than the many canals originally established. But the canals originally established will not permit a high-line canal to be taken out, because those persons not only want the water which flows in their canals to go down, but they must have a sufficient volume of water to pass their canal mouths so that their canals may catch some. The dams are not sufficient to catch the whole body of the water, and only a little can be turned off by these canals, so they must have a great body of water flowing down the river in order to get a small body out in the canal. This is quite an important consideration.

Mr. HATCH. It results in a great waste of water.

Major POWELL. The result of which is a great waste of water. It is illustrated here in this region of country. They want to irrigate a large tract of land. A company is organized to do it. That company buys up all the land and takes out the water above. In order to buy these earlier men out they not only have to purchase the lands but they must also purchase the water rights.

It will thus be seen that there are two classes of impedimentary rights which are being established in the country. The first arises through the utilization of small streams on lands which should be reserved for the service of the large streams, and by this means rights and interests are established which prevent the proper utilization of the large streams. The second class relates to the construction of wasteful low-line canals that prevent the construction of high-line canals where the waters could be used much more economically in the aggregate, and where none would be wasted. Some of these rights are already established, and provision must be made by some authority for their gradual extinguishment; but the matter of most importance is to prevent their establishment in the future. The evil is already seen, and it should not be permitted to grow.

The CHAIRMAN. Is not the southern part of California under irrigation more than the north?

Major POWELL. There is much irrigation development there. A survey ought to be made there. When the committee reaches the place to question me in reference to the surveys I want to bring the matter out, Mr. Chairman, if you please.

The State of Nevada has but little water. The mountains of Nevada are low in the main and the waters mostly fall on the mountains. The principal bodies of water which fall in the mountains of Nevada are not used in that State. They must be used in another State. On the other hand, the principal streams which are to be used in Nevada head in another State. The State lines chance to run in that manner. Before you is a map of a portion of Nevada which illustrates it. Here is Truckee River. We have made a survey of the Truckee River, so I am able to give definite facts about it. It is part of last year's work. The waters of the Truckee River may be stored in part in Nevada, but in chief part in California. The upper waters of the Truckee River can be stored in five or six lakes and in some mountain valleys with great economy, but the lands to be irrigated thereby lie in the State of Nevada. The State of Nevada made an appropriation which proposed to give the income derived from the lands which are granted by the United States and some other sources to the development of irrigation.

They passed an appropriation last year, if I remember rightly, of $150,000 to be used in creating storage reservoirs.

Mr. HERBERT. In Colorado?

Major POWELL. No, sir; in the State of Nevada; and when we came to examine the condition of affairs, the physical condition, it was found that the work had to be done in California; so it was blocked. The timber above the water sources there must be preserved to protect these water rights. All this great farming district, and it is a rich farming district, requires for its protection authority to manage the forest above the reservoirs. The same statement applies to the Carson River and the Walker River. These three rivers, surveys of which have been made, can have all their waste waters stored in the State of California and in their own State, but in order to do it there must be some right in the farmers below to control the land above, and when storage basins are thus constructed, there must be established some way in which they can protect them.

I think I will not go on to explain the reservoir systems in this region. There are many other small streams through out Nevada which can be utilized, but the chief reservoirs are on these three streams which I have mentioned. The chief source of irrigation in Nevada is the storage of the storm waters, so that the great development of irrigation in that State depends upon conditions very much like those pertaining to the region along the 100th meridian, which I will afterwards explain. I am going over the ground very rapidly, not to weary you; if I have not explained this matter fully enough I shall be pleased to answer any questions.

This is a map of Southern California and of a portion of Nevada. I have divided this into irrigation districts, as ultimately it must be done. Somehow or other, by some authority or other, the people who live in these districts must as a body-politic control all the waters, all the timber, and all the pasturage within each. How it is to be accomplished I do not know, but it is a necessity for the country. I wish to call attention to the Kern River, which is now used largely for irrigation. On its headwaters there are some fine basins which can be used for storage of water. It is a very highly developed agricultural district, and it has been developed by a company obtaining land along the lower part of the river; this region of country here [illustrating on map]. Had that river chanced to be taken out from 50 to 75 miles farther up than where it was taken out, the ultimate area irrigated would have been more than twice the amount.

Mr. HERBERT. What river is that?

Major POWELL. The Kern.

The CHAIRMAN. I would call your attention to one fact about the irrigation of the Kern. That has been done mostly by Haggin and Carr. They control—I got this from themselves—about 400,000 acres of land. They have got water enough to irrigate 2,000,000 acres of land. I have a report from the registrar of the land office at Los Angeles, which states that in that district there are 13,000,000 acres of land in the Mohave and Colorado Desert subject to entry under the desert land act. Here is one company who control the water that will irrigate 2,000,000 acres of land, and they now control about 350,000 to 400,000 acres.

Mr. HERBERT. Is that company incorporated under the laws of California? Have they a charter to take out that water?

The CHAIRMAN. It is a partnership.

Mr. HERBERT. Have they any charter granted by the State of California?

The CHAIRMAN. Only under the old law of prior appropriation.

Mr. HERBERT. That is a law of the State.

The CHAIRMAN. Yes, sir.

Mr. PICKLER. That is the law of all these States, the law of prior appropriation.

Major POWELL. It is the law of all of them.

The CHAIRMAN. They have got one canal 3, 4, or 5 miles, 120 feet surface width, 80 feet in the bottom, and it is 6 feet deep, and that is made as a feeder to small canals.

Mr. HERBERT. What I was trying to ascertain was whether there were any statutes in the State of California upon this question of irrigation.

The CHAIRMAN. We have a good law now under which we are organizing irrigation districts; that is known as the Wrights Bill, and under that law they are authorized to issue bonds, and they are being issued, and are being taken with great rapidity, perhaps two millions of money having been invested in these irrigation bonds in California, and before it gets through it will run up to fifty millions.

Mr. HERBERT. What is the nature of that law; is it a general law by which any parties complying with certain conditions can incorporate themselves and acquire rights?

Major POWELL. The Wright bill of California will rapidly develop the irrigation of the country. The Wright bill of California will effect the establishment of conflicting rights in a very bad way, and it will ultimately result, as far as it is carried into effect (and it will be carried into effect very rapidly)—it will ultimately result in all the irrigation of that land falling into the hands of companies, and either the farming will be done by wholesale, or the farming will get into the hands of individuals and the companies own the waters. It has very good features. The difficulty with the Wright bill is this, that it does not provide for the organization of irrigation districts as natural hydrographic basins. Any tract of land or region of country may be organized into an irrigation district, and the people may issue bonds to raise the money for the construction of irrigation works. But these districts will soon be in conflict with one another, as there are no means yet provided for the division of the waters among them. If the law had provided for irrigation districts such as I have described to you, it would be a long step in the right direction. As it is, it will ultimately lead to the multiplication of controversies, and put neighborhood at war with neighborhood. In most of the States—if I remember rightly in all the other States which have been organized—the State constitutions declare that the waters are the property of the people, but at the same time rights are granted to companies and individuals to control the water as distinct from the land, so that the tendency, except in southern California, and also in Utah, is to put the lands and the waters in the hands of capitalists or corporations; and that is going on at a very rapid rate. In southern California, at Greeley and other places in Colorado, in the Mexican settlements, and in Utah, the tendency is to put the control in the hands of small owners. Outside of these, all the lands and all the waters are coming under the control of companies at a rapid rate, at the rate of millions of dollars annually.

The CHAIRMAN. As a general thing the water is rented out to the consumer.

Major POWELL. In that country?

The CHAIRMAN. Except Haggin and Carr, where they own practically the great bulk of land.

Major POWELL. This matter on the Kern River illustrates what is going on everywhere except in the particular regions I have mentioned.

The CHAIRMAN. This firm is now endeavoring to sell the land at reasonable rates—the land with the water attached, both go together.

Mr. HERBERT. You spoke of Utah and some other regions in which the tendency is for small owners to get control. Will you explain in your testimony and append if you please to your answers the local laws and regulations under which this is accomplished?

Major POWELL. Yes, sir. The settlements in southern California have been made by men who appreciate this question. The streams are not large. Irrigation depends on springs, small sources, and to some extent on artesian wells, and the use of the water on these streams in some cases has been in litigation. Now gradually the communities are buying up the rights. At Riverside they had a long litigation and resorted at one time to shotgun protection against the water company. But finally they compromised the matter and bought the companies out as a community; and in the main, communities are getting control of the water in southern California.

In all Spanish communities the world over, not only Mexico and California, but in Spain, the common law provides for that; the old law that has come down through centuries keeps the control of the water in municipalities. They seem to think they are doing the same in Colorado and in some of the States and Territories by providing in their constitutions that the water belongs to the people, but when they charter a company or an individual and give to him the right to take out the water, they convey that which should belong to the people, just as much as if the man should seize and possess without a charter—the effect is just the same. So while they think they accomplish this matter they have not done it, because in connection with the reservation which generally declares that the waters belong to the people, they further provide in the statutes that grants may be made to individuals and corporations to take out the water instead of leaving it in the hands of municipalities or bodies of people at large. You see how that defeats the general purpose of the statutes.

Mr. HERBERT. One difficulty, I understand, in the way is, in this country they are much more strict in upholding vested rights than they are in countries governed by the civil law. The Dartsmouth College case has gone a long way in the settlement of this question. The holding in that case affected the question very seriously.

Major POWELL. There are two methods of controlling irrigation and dealing with these questions. Throughout all lands, where agriculture depends upon irrigation anywhere, there are two diverse systems of administration. The Spanish and Italian people provide one system of administration; the French and English provide another. This, I think, is worthy of explanation. It will be understood, first, that agriculture where irrigation is practiced is practically under conditions with which we are unfamiliar in this country. We come from a humid land, where a man may make a farm for himself, because the clouds supply sufficient rain; but wherever agriculture is dependent upon irrigation the agriculturist is dependent upon the river and catchment area away from his land. The second fact is, that if that land is to be irrigated, irrigation works are to be constructed, perhaps costing $100,000, $500,000, $5,000,000, or $10,000,000 before anybody can cultivate anything. We find one of these two systems ultimately prevail: either the people are

put in possession of the rights by municipalities and work out their own systems of administration for themselves, as in the Spanish colonies and in Spain itself; or the British system prevails, where the Government owns the works, and takes possession of the waters and supplies the water to the farmers and charges them for it. This is the British system in India. The chief revenue which the British Government derives from India is the tolls on its irrigating canals. Now before you there are two bills, one looking in one direction, the other exactly in the opposite direction, in reference to this matter; one putting the control in municipalities, the other putting it in the National Government; and the issue has got to be met, because the people are commencing the work of irrigation. They have already irrigated seven or eight million acres of land in the country. They are flowing into the country in large numbers, and capital is ready to be invested, and the country will be irrigated because of the enormous increment in value to the property which arises from irrigation; and some system has to be adopted to regulate it.

The CHAIRMAN. The Constitution confers upon Congress the right to regulate commerce between the States, but it does not go far enough to reach this question of irrigation.

Mr. HERBERT. One method of getting the control of this matter into the hands of municipalities would be to turn over the lands to the several States and Territories and let them control it. Of course that would not answer for all these cases of which the Major is speaking, but it is a question whether that would not be after all the best we could do.

Mr. PICKLER. To turn the lands over?

Mr. HERBERT. Yes, sir; to the States and Territories.

The CHAIRMAN. That would be a good suggestion; the same difficulty would exist which still exists of conflicts between adjoining States and Territories unless you would enlarge the definition of commerce.

Mr. HERBERT. The Constitution is pretty elastic under the construction of some people. Commerce does not include simply that which flows upon the water and is transferred from one locality to another. It includes also what is produced in the ground.

Major POWELL. There is before you, Mr. Chairman and gentlemen of the committee, a map of the Bear River. It heads in Wyoming chiefly, up here in the mountains; then runs into Utah, passes into Idaho, and returns into Utah. The catchment area is in part in Utah and in part in Wyoming. It will be remembered, when we see a great area of country like that, that the catchment area is a mountain area, that there the water is concentrated and there the great volume of water falls, and that very little falls in the valley below.

Mr. HERBERT. It is a great water-shed.

Major POWELL. It is a great water-shed. The catchment area is chiefly in Utah, and the irrigation—not the whole of it, but a little of it—is in Idaho. Its reservoirs will be partly in Utah, partly in Idaho, and partly in Wyoming. A little agriculture can be practiced along here in Idaho, but the principal part of it commences near the line between Idaho and Utah and extends down the valley to Salt Lake. The greater part of the waters are to be utilized there. But in order to utilize these waters fully, somehow or other the right to control the irrigation works in Idaho and Wyoming also must be obtained. This is one of the most complex problems which we have. There is a very beautiful body of land along the Bear River, and irrigation has already been practiced, and the people are in conflict. The Governor of Idaho and the people of Idaho have petitioned the Secretary of the Interior to

stop the development of the irrigation works by the people of Utah. The matter is in controversy, and the controversy is very bitter between the two Territories.

The CHAIRMAN. Can you determine the volume of water flowing in those streams?

Major POWELL. We are measuring it.

The CHAIRMAN. You know that is an important element in the problem.

Major POWELL. When I come to explain what the survey is doing I will show you in regard to that.

Mr. Chairman, I now place before you a map of the great Snake River Valley. The river heads in Wyoming, and making a great bend southward passes through Idaho Territory, then turning northward it becomes the boundary line between Idaho and Oregon; then it forms a portion of the boundary line between Idaho and Washington, where it empties into the Columbia. It is thus that Wyoming, Idaho, Oregon, and Washington are interested in the waters of this great river and its tributaries. At the headwaters of the stream, in Wyoming, we have a great catchment area where deep snows and heavy rains fall. In the storage of the waters of this stream the mountain reservoirs must be chiefly in Wyoming, but the waters from these reservoirs must be used in Idaho. We have in the survey already discovered sites for reservoirs sufficient to irrigate more than 3,000,000 acres of land, and the water coming from the Wyoming mountains is sufficient to fill them. One of the great reservoir sites is in part in Wyoming and in part in Idaho. The survey of this region has just begun, but we already know where to take out the waters from these reservoirs and put them on Idaho lands to the north of the river. These lands lie comparatively low, are warm, the climate is salubrious, and ultimately there must be a great body of agriculture developed; but it is manifest from what I show you that some means must be provided by which the people of Idaho who engage in agriculture on these lands can protect their sources of water supply in Wyoming and have control of the irrigation works which they must construct there.

Passing down the river you see a number of streams which head in Nevada on mountains. These streams flow northward into the Snake or Shoshone River. The catchment areas are in part in the mountains of Nevada and in part in the mountains of Idaho, and the storage must be there and irrigating works must be constructed there, but the lands to be irrigated lie down the streams farther, in the Territory of Idaho. Idaho therefore depends upon Wyoming for the headwaters of the Snake, and on Nevada for the headwaters of these tributaries. The Owyhee River, that heads in Nevada, runs across the corner of Idaho into Oregon. The catchment area and storage basins are in Nevada and Idaho, but the irrigable lands are chiefly in Oregon; the people of Oregon, therefore, must by some means have control of the sources of their water supply in Nevado and Idaho.

All of these rights in Idaho involve the irrigation of from 6,000,000 to 8,000,000 or perhaps 10,000,000 acres of land. The principal agricultural values of the State are therefore involved in interstate contests and interstate rights. If these rights are not settled a vast and beautiful agricultural region in Idaho will remain undeveloped and agriculture will be driven into the mountains of Wyoming. If the water of the Snake is to be taken out in Idaho, the lands to which it is to be taken should be immediately designated, and the places on the river where the waters are to be diverted should also be fixed, for if rights to im-

provident works are acquired the development of agriculture to the extent of cultivating 1,000,000 or 2,000,000 acres will completely prevent the development of 7,000,000 or 8,000,000 acres, and perhaps more, by methods which I have already explained.

Mr. HATCH. That blue line represents the Snake River?

Major POWELL. Yes, sir.

Mr. HATCH. Is the upper part of that map north?

Major POWELL. Yes, sir.

The CHAIRMAN. It is a tributary of the Columbia?

Major POWELL. Yes, sir; the portion which is above that line is turned westward and runs into the Columbia, becoming the boundary line between Oregon and Washington.

Mr. HATCH. What is that small river up there?

Major POWELL. That is the Salmon River.

Mr. Chairman, the general facts which I have been presenting in relation to the utilization of the stream-waters of the arid lands can be illustrated in the same manner from a consideration of the rivers of the North, and I have prepared these maps which you see for that purpose. I could go on with a description of the Columbia and its tributaries and bring out essentially the same class of facts which I have elucidated in my statement up to the present time. The utilization of the Missouri River and its great tributaries for irrigation, if properly considered, would reveal just such facts as I have been presenting. It would show that there are many international, interstate, and intercommunity problems which must sooner or later be solved. In all of these streams it can be shown that if the entire service of the water is to be secured the lands must be properly selected, and that for this purpose the high mountain regions should be excluded, that is, irrigable lands should not be selected therein, but that everywhere lands should be selected as near to the mountains as possible, in order that the full value of the waters may be obtained. Everywhere it could be shown that the irrigable lands are dependent upon catchment areas where forests and grasses are abundant. Everywhere it could be shown that the great body of the water must be stored in the mountains on the catchment areas, and not in the midst of the irrigable lands. In like manner, it can be shown that all of the irrigating works must be constructed on these catchment areas, outside of the lands irrigated. It is thus that the farmers or the irrigable lands, when such lands are properly selected, are primarily and radically interested in the management of the catchment areas. Already the time is exhausted, and I cannot take up these additional illustrations.

I have attempted to divide all of the arid lands dependent upon stream waters into irrigation districts, and these provisional districts I have shown you on the maps which I have presented. There are about 140 of these districts as they are now planned, and each district is about as large as two ordinary counties; but they do not in any way conform to county lines, county lines being artificial, as are the State lines, while the irrigation-district lines which I have traced are natural. These irrigation districts as I have plotted them are only provisional; a final survey is necessary to determine them with accuracy. There are a number of trunk districts as I have laid them out which will ultimately be divided, but our knowledge at the present time is not sufficient to enable us to divide them wisely. It is probable that about 150 districts will be needed, and possibly more, so that each district shall be composed of its irrigable lands and catchment area. But I beg to say, in conclusion, that the division into natural irrigation districts is simple and can be readily accomplished

by a reasonably careful survey of the ground; and let me say that if that were done each district would have its catchment areas with timber lands and pasturage lands and sites for irrigation works, and in the midst of each district, or low down it, the irrigable lands would be found in a somewhat compact body.

Mr. HANSBROUGH. I would suggest, Mr. Chairman, that it is only two or three minutes to twelve o'clock.

Thereupon the committee adjourned to meet on Saturday, March 15, at half past 10 a. m.

As requested by the committee, the following extracts from constitutions and statutes of States in the arid region are appended by Major Powell:

[From the constitution of Colorado.]

SEC. 5. The water of every natural stream not heretofore appropriated within the State of Colorado is hereby declared to be the property of the public, and is dedicated to the use of the people of the State, subject to appropriation as hereinafter provided:

SEC. 6. The right to divert unappropriated waters of every natural stream for beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water for the same purpose; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using water for domestic purposes shall have preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have the preference over those using the same for manufacturing purposes.

[From the proposed constitution of Wyoming.]

ARTICLE No. VIII.

IRRIGATION AND WATER RIGHTS.

SECTION 1. The water of all natural streams, springs, lakes, or other collections of still water, within the boundaries of the State, are hereby declared to be the property of the State.

SEC. 2. There shall be constituted a board of control, to be composed of the State engineer and superintendents of the water divisions, which shall, under such regulations as may be prescribed by law, have the supervision of the waters of the State and of their appropriation, distribution, and diversion, and of the various officers connected therewith; its decisions to be subject to review by the courts of the State.

SEC. 3. Priority of appropriation for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interests.

SEC. 4. The legislature shall, by law, divide the State into four water divisions, and provide for the appointment of superintendents thereof.

SEC. 5. There shall be a State engineer, who shall be appointed by the governor of the State and confirmed by the Senate; he shall hold his office for the term of six years, or until his successor shall have been appointed and shall have qualified. He shall be president of the board of control, and shall have general supervision of the waters of the State and of the officers connected with its distribution. No person shall be appointed to this position who has not such theoretical knowledge and such practical experience and skill as shall fit him for the position.

[From the constitution of Montana.]

ARTICLE III.

SEC. 15. The use of all water now appropriated, or that may hereafter be appropriated, for sale, rental, distribution, or other beneficial use, and the right of way over the lands of others for all ditches, drains, flumes, canals, and aqueducts necessarily used in connection therewith, as well as the sites for reservoirs necessary for collecting and storing the same, shall be held to be a public use.

[From the constitution of Washington.]

ARTICLE XXI.

SECTION 1. The use of the waters of this State for irrigation, mining, and manufacturing purposes shall be deemed a public use.

[From the proposed constitution of Idaho.]

ARTICLE XV.

WATER RIGHTS.

SECTION 1. The use of all waters now appropriated, or that may hereafter be appropriated for sale, rental, or distribution; also of all water originally appropriated for private use, but which after such appropriation has heretofore been, or may hereafter be sold, rented, or distributed, is hereby declared to be a public use, and subject to the regulation and control of the State in the manner prescribed by law.

SEC. 2. The right to collect rates or compensation for the use of water supplied to any county, city, or town, or water district, or the inhabitants thereof, is a franchise, and can not be exercised except by authority of and in the manner prescribed by law.

SEC. 3. The right to divert and appropriate the unappropriated waters of any natural stream to beneficial uses shall never be denied. Priority of appropriation shall give the better right as between those using the water; but when the waters of any natural stream are not sufficient for the service of all those desiring the use of the same, those using the water for domestic purposes shall (subject to such limitations as may be prescribed by law) have the preference over those claiming for any other purpose; and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes. And in any organized mining district those using the water for mining purposes or milling purposes connected with mining, shall have preference over those using the same for manufacturing or agricultural purposes. But the usage by such subsequent appropriators shall be subject to such provisions of law regulating the taking of private property for public and private use, as referred to in section fourteen of Article I, of this constitution.

SEC. 4. Whenever any waters have been, or shall be, appropriated or used for agricultural purposes, under a sale, rental, or distribution thereof, such sale, rental, or distribution shall be deemed an exclusive dedication to such use; and whenever such waters so dedicated shall have once been sold, rented, or distributed to any person who has settled upon or improved land for agricultural purposes with the view of receiving the benefit of such water under such dedication, such person, his heirs, executors, administrators, successors, or assigns, shall not thereafter, without his consent, be deprived of the annual use of the same when, needed for domestic purposes, or to irrigate the land so settled upon or improved, upon payment therefor, and compliance with such equitable terms and conditions as to the quantity used and times of use, as may be prescribed by law.

SEC. 5. Whenever more than one person has settled upon or improved land with the view of receiving water for agricultural purposes under a sale, rental, or distribution thereof, as in the last preceding section of this article provided, as among such persons priority in time shall give superiority of right to the use of such water in the numerical order of such settlements or improvements; but whenever the supply of such water shall not be sufficient to meet the demands of all those desiring to use the same, such priority of right shall be subject to such reasonable limitations as to the quantity of water used and times of use as the legislature, having due regard both to such priority of right and the necessities of those subsequent in time of settlement or improvement, may by law prescribe.

SEC. 6. The legislature shall provide by law the manner in which reasonable maximum rates may be established to be charged for the use of water sold, rented, or distributed for any useful or beneficial purpose.

CHAPTER XXXIV.

AN ACT to provide for the organization and government of irrigation districts, and to provide for the acquisition of water and other property, and for the distribution of water thereby for irrigation purposes. [Approved March 7, 1887.]

The people of the State of California, represented in Senate and Assembly, do enact as follows:

SECTION 1. Whenever fifty or a majority of freeholders owning lands susceptible of one mode of irrigation from a common source, and by the same system of works, desire to provide for the irrigation of the same, they may propose the organization of an irrigation district under the provisions of this act, and when so organized such

district shall have the powers conferred or that may hereafter be conferred by law upon such irrigation districts.

SEC. 2. A petition shall first be presented to the Board of Supervisors of the county in which the lands or the greatest portion thereof is situated, signed by the required number of freeholders of such proposed district, which petition shall set forth and particularly describe the proposed boundaries of such district, and shall pray that the same may be organized under the provisions of this Act. The petitioners must accompany the petition with a good and sufficient bond, to be approved by the said Board of Supervisors, in double the amount of the probable cost of organizing such district, conditioned that the bondsmen will pay all said cost in case said organization shall not be effected. Such petition shall be presented at a regular meeting of the said Board, and shall be published for at least two weeks before the time at which the same is to be presented, in some newspaper printed and published in the county where said petition is presented, together with a notice stating the time of the meeting at which the same will be presented. When such petition is presented, the said Board of Supervisors shall hear the same, and may adjourn such hearing from time to time, not exceeding four weeks in all; and on the final hearing may make such changes in the proposed boundaries as they may find to be proper, and shall establish and define such boundaries; *provided*, that said Board shall notmodify said boundaries so as to except from the operation of this Act any territory within the boundaries of the district proposed by said petitioners, which is susceptible of irrigation by the same system of works applicable to the other lands in such proposed district, nor shall any lands which will not, in the judgment of the said Board, be benefited by irrigation by said system be included within such district; *provided*, that any person whose lands are susceptible of irrigation from the same source shall, upon application of the owner to said Board, be entitled to have such lands included in said district. Said Board shall also make an order dividing said district into five divisions, as nearly equal in size as may be practicable, which shall be numbered First, Second, Third, Fourth, and fifth, and one Director shall be elected from each district. Said Board of Supervisors shall then give notice of an election to be held in such proposed district, for the purpose of determining whether or not the same shall be organized under the provisions of this Act. Such notice shall describe boundaries so established, and shall designate a name for such proposed district, and said notice shall be published for at least three weeks prior to such election in a newspaper published within said county; and if any portion of such proposed district lie within another county or counties, then said notice shall be published in a newspaper published within each of said counties. Such notice shall require the electors to cast ballots which shall contain the words, "Irrigation District—Yes;" or, "Irrigation District—No," or words equivalent thereto; and also the names of persons to be voted for to fill the various elective offices hereinafter prescribed. No person shall be entitled to vote at any election held under the provisions of this Act unless he shall possess all the qualifications required of electors under the general election laws of this State.

SEC. 3. Such election shall be conducted in accordance with the general election laws of the State, provided that no particular form of ballot shall be required. The said Board of Supervisors shall meet on the second Monday next succeeding such election, and proceed to canvass the votes cast thereat; and if upon such canvass it appear that at least two thirds of all the votes cast are "Irrigation District—Yes," the said Board shall, by an order entered on their minutes, declare such territory duly organized as an irrigation district, under the name and style theretofore designated, and shall declare the persons receiving, respectively, the highest number of votes for such several offices to be duly elected to such offices. Said Board shall cause a copy of such order, duly certified, to be immediately filed for record in the office of the County Recorder of each county in which any portion of such lands are situated, and must also immediately forward a copy thereof to the Clerk of the Board of Supervisors of each of the counties in which any portion of the district may lie; and no Board of Supervisors of any county, including any portion of such district shall, after the date of the organization of such district, allow another district to be formed including any of the lands in such district, without the consent of the Board of Directors thereof; and from and after the date of such filing, the organization of such district shall be complete, and the officers thereof shall be entitled to enter immediately upon the duties of their respective offices, upon qualifying in accordance with law, and shall hold such offices respectively, until their successors are elected and qualified. For the purposes of the election above provided for, the said Board of Supervisors must establish a convenient number of election precincts in said proposed district, and define the boundaries thereof, which said precincts may thereafter be changed by the Board of Directors of such district.

SEC. 4. An election shall be held in such district on the first Wednesday in April, eighteen hundred and eighty-eight, and on the first Wednesday in April in each second year thereafter, at which an Assessor, a Collector, and a Treasurer and a Board of

five Directors for the district shall be elected. The person receiving the highest number of votes for any office to be filled at such election, is elected thereto. Within ten days after receiving their certificates of election, hereinafter provided for, said officers shall take and subscribe the official oath and file the same in the office of the Board of Directors. The Assessor shall execute an official bond in the sum of ten thousand dollars, and the Collector an official bond in the sum of twenty thousand dollars, and the District Treasurer an official bond in the sum of fifty thousand dollars; each of said bonds to be approved by the Board of Directors; and each member of said Board of Directors shall execute an official bond in the sum of twenty-five thousand dollars, which said bonds shall be approved by the Judge of the Superior Court of said county where such organization was effected, and shall be recorded in the office of the County Recorder thereof, and filed with the Secretary of said Board. All official bonds herein provided for shall be in the form prescribed by law for the official bonds of county officers.

SEC. 5. Fifteen days before any election held under this Act, subsequent to the organization of any district, the Secretary of the Board of Directors shall cause notices to be posted in three public places in each election precinct, of the time and place of holding the election, and shall also post a general notice of the same in the office of said Board, which shall be established and kept at some fixed place to be determined by said Board, specifying the polling places of each precinct. Prior to the time for posting the notices, the Board must appoint for each precinct, from the electors thereof, one Inspector and two Judges, who shall constitute a Board of Election for such precinct. If the Board fail to appoint a Board of Election, or the members appointed do not attend at the opening of the polls on the morning of election, the electors of the precinct present at that hour may appoint the Board, or supply the place of an absent member thereof. The Board of Directors must, in its order appointing the Board of Election, designate the house or place within the precinct where the election must be held.

SEC. 6. The Inspector is Chairman of the Election Board, and may:

First—Administer all oaths required in the progress of an election.

Second—Appoint Judges and Clerks if, during the progress of the election, any Judge or Clerk cease to act. Any member of the Board of Election, or any Clerk thereof, may administer and certify oaths required to be administered during the progress of an election. The Board of Election for each precinct must, before opening the polls, appoint two persons to act as Clerks of the election. Before opening the polls, each member of the Board and each Clerk must take and subscribe an oath to faithfully perform the duties imposed upon them by law. Any elector of the precinct may administer and certify such oath. The polls must be opened one hour after sunrise on the morning of the election, and be kept open until sunset, when the same must be closed. The provisions of the Political Code concerning the form of ballots to be used shall not apply to elections held under this Act.

SEC. 7. Voting may commence as soon as the polls are opened, and may be continued during all the time the polls remain opened, and shall be conducted as nearly as practicable in accordance with the provisions of chapter nine of title two of part three of the Political Code of this State. As soon as the polls are closed, the Judges shall open the ballot-box and commence counting the votes; and in no case shall the ballot-box be removed from the room in which the election is held until all the ballots have been counted. The counting of ballots shall in all cases be public. The ballots shall be taken out, one by one, by the Inspector or one of the Judges, who shall open them and read aloud the names of each person contained therein, and the office for which every such person is voted for. Each Clerk shall write down each office to be filled, and the name of each person voted for for such office, and shall keep the number of votes by tallies, as they are read aloud by the Inspector or Judge. The counting of votes shall be continued without adjournment until all have been counted.

SEC. 8. As soon as all the votes are read off and counted, a certificate shall be drawn up on each of the papers containing the poll list and tallies, or attached thereto, stating the number of votes each one voted for has received, and designating the office to fill which he was voted for, which number shall be written in figures and in words at full length. Each certificate shall be signed by the Clerk, Judge, and the Inspector. One of said certificates, with the poll list and the tally paper to which it is attached, shall be retained by the Inspector, and preserved by him at least six months. The ballots shall be strung upon a cord or thread by the Inspector, during the counting thereof, in the order in which they are entered upon the tally list by the Clerks; and said ballots, together with the other of said certificates, with the poll list and tally paper to which it is attached, shall be sealed by the Inspector in the presence of the Judges and Clerks, and indorsed "Election Returns of (naming the precinct) Precinct," and be directed to the Secretary of the Board of Directors, and shall be immediately delivered by the Inspector, or by some other safe and responsible carrier designated by said Inspector, to said Secretary, and the ballots shall be kept unopened for at least six months, and if any person be of the opinion that the vote of any precinct has not

been correctly counted, he may appear on the day appointed for the Board of Directors to open and canvass the returns, and demand a recount of the vote of the precinct that is so claimed to have been incorrectly counted.

SEC. 9. No list, tally paper, or certificate returned from any election, shall be set aside or rejected for want of form, if it can be satisfactorily understood. The Board of Directors must meet at its usual place of meeting on the first Monday after each election to canvass the returns. If, at the time of meeting, the returns from each precinct in the district in which the polls were opened have been received, the board of Directors must then and there proceed to canvass the returns, but if all the returns have not been received, the canvass must be postponed from day to day until all the returns have been received, or until six postponements have been had. The canvass must be made in public and by opening the returns and estimating the vote of the district, for each person voted for, and declaring the result thereof.

SEC. 10. The Secretary of the Board of Directors must, as soon as the result is declared, enter in the records of such Board, a statement of such result, which statement must show:

First—The whole number of votes cast in the district.

Second—The names of the persons voted for.

Third—The office to fill which each person was voted for.

Fourth—The number of votes given in each precinct to each of such persons.

Fifth—The number of votes given in the district to each of such persons.

The Board of Directors must declare elected the person having the highest number of votes given for each office to be filled by the votes of the district. The Secretary must immediately make out and deliver to such person a certificate of election signed by him and authenticated with the seal of the Board. In case of a vacancy in the office of Assessor, Tax Collector, or Treasurer, the vacancy shall be filled by appointment by the Board of Directors. In case of a vacancy in the office of member of the Board of Directors, the vacancy shall be filled by appointment by the Board of Supervisors of the county where the office of such Board is situated. An officer appointed as above provided, shall hold his office until the next regular election for said district, and until his successor is elected and qualified.

SEC. 11. On the first Wednesday in May next following their election the Board of Directors shall meet and organize as a Board, elect a President from their number, and appoint a Secretary. The Board shall have the power, and it shall be their duty, to manage and conduct the business and affairs of the district, make and execute all necessary contracts, employ and appoint such agents, officers, and employés as may be required, and prescribe their duties, establish equitable by-laws, rules, and regulations for the distribution and use of water among the owners of said lands, and generally to perform all such acts as shall be necessary to fully carry out the purposes of this Act. The said by-laws, rules, and regulations must be printed in convenient form for distribution in the district. And it is hereby expressly provided that all waters distributed for irrigation purposes shall be apportioned ratably to each land owner upon the basis of the ratio which the last assessment of such owner for district purposes within said district bears to the whole sum assessed upon the district; *provided*, that any land owner may assign the right to the whole or any portion of the waters so apportioned to him.

SEC. 12. The Board of Directors shall hold a regular monthly meeting, in their office, on the first Tuesday in every month, and such special meetings as may be required for the proper transaction of business; *provided*, that all special meetings must be ordered by a majority of the Board; the order must be entered of record, and five days' notice thereof must, by the Secretary, be given to each member not joining in the order. The order must specify the business to be transacted, and none other than that specified must be transacted at such special meeting. All meetings of the Board must be public, and three members shall constitute a quorum for the transaction of business, but on all questions requiring a vote, there shall be a concurrence of at least three members of said Board. All records of the Board shall be open to the inspection of any elector during business hours. The Board, and its agents and employés, shall have the right to enter upon any land in the district to make surveys, and may locate the line for any canal or canals, and the necessary branches for the same, on any of said lands which may be deemed best for such location. Said Board shall also have the right to acquire, either by purchase or condemnation, all lands and waters, and other property necessary for the construction, use, supply, maintenance, repair, and improvement of said canal or canals and works, including canals and works constructed and being constructed by private owners, lands for reservoirs, for the storage of needful waters, and all necessary appurtenances. In case of purchase, the bonds of the district, hereinafter provided for, may be used at their par value in payment; and in case of condemnation, the Board shall proceed, in the name of the district, under the provisions of title seven, of part three, of the Code of Civil Procedure. Said Board may also construct the necessary dams, reservoirs, and works for the collection of water for said district, and do any and every lawful act necessary

to be done, that sufficient water may be furnished to each land owner in said district for irrigation purposes. The use of all water required for the irrigation of the lands of any district formed under the provisions of this Act, together with the rights of way for canals and ditches, sites for reservoirs, and all other property required in fully carrying out the provisions of this act, is hereby declared to be a public use, subject to the regulation and control of the State, in the manner prescribed by law.

SEC. 13. The legal title to all property acquired under the provisions of this Act shall immediately and by operation of law vest in such irrigation district, and shall be held by such district in trust for and is hereby dedicated and set apart to the uses and purposes set forth in this Act. And said Board is hereby authorized and empowered to hold, use, acquire, manage, occupy, and possess said property as herein provided.

SEC. 14. The said Board is hereby authorized and empowered to take conveyances or other assurances for all property acquired by it under the provisions of this Act, in the name of such irrigation district, to and for the uses and purposes herein expressed, and to institute and maintain any and all actions and proceedings, suits at law or in equity, necessary or proper in order to fully carry out the provisions of this Act, or to enforce, maintain, protect, or preserve any and all rights, privileges, and immunities created by this Act or acquired in pursuance thereof. And in all Courts, actions, suits, or proceedings, the said Board may sue, appear, and defend, in person or by attorneys, and in the name of such irrigation district.

SEC. 15. For the purpose of constructing necessary irrigating canals and works and acquiring the necessary property and rights therefor, and otherwise carrying out the provisions of this Act, the Board of Directors of any such district must, as soon after such district has been organized as may be practicable, estimate and determine the amount of money necessary to be raised, and shall immediately thereupon call a special election, at which shall be submitted to the electors of such district possessing the qualifications prescribed by this Act, the question whether or not the bonds of said district shall be issued in the amount so determined. Notice of such election must be given by posting notices in three public places in each election precinct in said district for at least twenty days, and also by publication of such notice in some newspaper published in the county, where the office of the Board of Directors of such district is required to be kept, once a week for at least three successive weeks. Such notices must specify the time of holding the election, the amount of bonds proposed to be issued, and said election must be held and the result thereof determined and declared, in all respects as nearly as practicable, in conformity with the provisions of this Act governing the election of officers; *provided*, that no informalities in conducting such an election shall invalidate the same, if the election shall have been otherwise fairly conducted. At such election the ballots shall contain the words, "Bonds—Yes," or "Bonds—No," or words equivalent thereto. If a majority of the votes cast are "Bonds—Yes," the Board of Directors shall immediately cause bonds in said amount to be issued; said bonds shall be payable in gold coin of the United States, in installments as follows, to wit: At the expiration of eleven years not less than five per cent of said bonds; at the expiration of twelve years not less than six per cent; at the expiration of thirteen years not less than seven per cent; at the expiration of fourteen years not less than eight per cent; at the expiration of fifteen years not less than nine per cent; at the expiration of sixteen years not less than ten per cent; at the expiration of seventeen years not less than eleven per cent; at the expiration of eighteen years not less than thirteen per cent; at the expiration of nineteen years not less than fifteen per cent; and for the twentieth year a percentage sufficient to pay off said bonds; and shall bear interest at the rate of six per cent per annum, payable semi-annually on the first day of January and July of each year. The principal and interest shall be payable at the office of the Treasurer of the district. Said bonds shall be each of the denomination of not less than one hundred dollars, nor more than five hundred dollars, shall be negotiable in form, signed by the President and Secretary, and the seal of the Board of Directors shall be affixed thereto. They shall be numbered consecutively as issued, and bear date at the time of their issue. Coupons for the interest shall be attached to each bond signed by the Secretary. Said bonds shall express on their face that they were issued by authority of this Act, stating its title and date of approval. The Secretary shall keep a record of the bonds sold, their number, the date of sale, the price received, and the name of the purchaser.

SEC. 16. The board may sell said bonds from time to time, in such quantities as may be necessary and most advantageous, to raise money for the construction of said canals and works, the acquisition of said property and rights, and otherwise to fully carry out the objects and purposes of this Act. Before making any sale the Board shall, at a meeting, by resolution, declare its intention to sell a specified amount of the bonds, and the day and hour and place of such sale, and shall cause such resolution to be entered in the minutes, and notice of the sale to be given, by publication thereof at least twenty days, in a daily newspaper published in each of the Cities of San Francisco, Sacramento, and Los Angeles, and in any other newspaper, at their

discretion. The notice shall state that sealed proposals will be received by the Board, at their office, for the purchase of the bonds, till the day and hour named in the resolution. At the time appointed the Board shall open the proposals, and award the purchase of the bonds to the highest responsible bidder, and may reject all bids; but said Board shall in no event sell any of the said bonds for less than ninety per cent of the face value thereof.

SEC. 17. Said bonds, and the interest thereon, shall be paid by revenue derived from an annual assessment upon the real property of the district; and all the real property in the district shall be and remain liable to be assessed for such payments as hereinafter provided.

SEC. 18. The Assessor must, between the first Monday in March and the first Monday in June, in each year, assess all real property in the district, to the persons who own, claim, have the possession or control thereof, at its full cash value. He must prepare an assessment book, with appropriate headings, in which must be listed all such property within the district, in which must be specified, in separate columns, under the appropriate head:

First—The name of the person to whom the property is assessed. If the name is not known to the Assessor, the property shall be assessed to "Unknown Owners."

Second—Land by township, range, section, or fractional section, and when such land is not a congressional division or subdivision, by metes and bounds, or other description sufficient to identify it, giving an estimate of the number of acres, locality, and the improvements thereon.

Third—City and town lots, naming the city or town, and the number and block according to the system of numbering in such city or town, and the improvements thereon.

Fourth—The cash value of real estate, other than city or town lots.

Fifth—The cash value of improvements on such real estate.

Sixth—The cash value of city and town lots.

Seventh—The cash value of improvements on city and town lots.

Eighth—The cash value of improvements on real estate assessed to persons other than the owners of the real estate.

Ninth—The total value of all property assessed.

Tenth—The total value of all property after equalization by the Board of Directors.

Eleventh—Such other things as the Board of Directors may require.

SEC. 19. The Board of Directors must allow the Assessor as many deputies, to be appointed by him, as will, in the judgment of the Board, enable him to complete the assessment within the time herein prescribed. The Board must fix the compensation of such deputies, which shall be paid out of the Treasury of the district. The compensation must not exceed five dollars per day for each deputy, for the time actually engaged, nor must any allowance be made but for work done between the first Monday in March and the first Monday in August in each year.

SEC. 20. On or before the first Monday in August in each year the Assessor must complete his assessment book, and deliver it to the Secretary of the Board, who must immediately give notice thereof, and of the time the Board of Directors, acting as a Board of Equalization, will meet to equalize assessments, by publication in a newspaper published in each of the counties comprising the district. The time fixed for the meeting shall not be less than twenty nor more than thirty days from the first publication of the notice; and in the meantime the assessment book must remain in the office of the Secretary for the inspection of all persons interested.

SEC. 21. Upon the day specified in the notice required by the preceding section for the meeting, the Board of Directors, which is hereby constituted a Board of Equalization for that purpose, shall meet and continue in session from day to day, as long as may be necessary, not to exceed ten days, exclusive of Sundays, to hear and determine such objections to the valuation and assessment as may come before them; and the Board may change the valuation as may be just. The Secretary of the Board shall be present during its sessions, and note all changes made in the valuation of property, and in the names of the persons whose property is assessed; and within ten days after the close of the session he shall have the total values, as finally equalized by the Board, extended into columns and added.

SEC. 22. The Board of Directors shall then levy an assessment sufficient to raise the annual interest on the outstanding bonds; and at the expiration of ten years after the issuing of bonds by the Board, must increase said assessment, for the ensuing ten years, in the following percentage of the principal of the whole amount of bonds then outstanding, to wit: For the eleventh year, five per cent; for the twelfth year, six per cent; for the thirteenth year, seven per cent; for the fourteenth year, eight per cent; for the fifteenth year, nine per cent; for the sixteenth year, ten per cent; for the seventeenth year, eleven per cent; for the eighteenth year, thirteen per cent; for the nineteenth year, fifteen per cent; and for the twentieth year, a percentage sufficient to pay off said bonds. The Secretary of the Board must compute and enter in a separate column of the assessment book the respective sums in dollars and cents to be paid as an assessment

on the property therein enumerated. When collected the assessment shall be paid into the district Treasury, and shall constitute a special fund to be called the "Bond Fund of (naming the district) Irrigation District."

SEC. 23. The assessment upon real property is a lien against the property assessed, from and after the first Monday in March for any year; and such lien is not removed until the assessments are paid or the property sold for the payment thereof.

SEC. 24. On or before the first day of November, the Secretary must deliver the assessment book to the Collector of the district, who shall, within twenty days, publish a notice in a newspaper published in each of the counties comprising the district, if there be lands situated in more than one county in such district, that said assessments are due and payable and will become delinquent at six o'clock P. M. on the last Monday of December next thereafter; and that unless paid prior thereto, five per cent will be added to the amount thereof, and also the time and place at which payment of assessments may be made. The notice shall also specify a time and place within each election precinct of the district, when and where the Collector will attend to receive payment of assessments, and shall be published for fifteen days, and a printed copy of said notice shall be posted for the same time in some public place in each precinct. The Collector must attend at the time and place specified in the notice, to receive assessments, which must be paid in gold and silver coin; he must mark the date of payment of any assessment in the assessment book opposite the name of the person paying, and give a receipt to such person, specifying the amount of the assessment and the amount paid, with a description of the property assessed. On the thirty-first day of December of each year, all unpaid assessments are delinquent, and thereafter the Collector must collect thereon, for the use of the district, an addition of five per cent.

SEC. 25. On or before the first day of February, the Collector must publish the delinquent list, which must contain the names of the persons and a description of the property delinquent, and the amount of the assessments and costs due opposite each name and description. He must append to and publish with the delinquent list a notice, that unless the assessments delinquent, together with costs and percentage, are paid, the real property upon which such assessments are a lien will be sold at public auction. The publication must be made once a week for three successive weeks, in a newspaper published in each of the counties comprised in the district. The publication must designate the time and place of sale. The time of sale must not be less than twenty-one nor more than twenty-eight days from the first publication, and the place must be at some point designated by the Collector.

SEC. 26. The Collector must collect, in addition to the assessments due on the delinquent list and five per cent. added, fifty cents on each lot, piece, or tract of land separately assessed, one half of which must go to the district and the other to the Collector for preparing the list. On the day fixed for the sale, or some subsequent day to which he may have postponed it, of which he must give notice, the Collector, between the hours of ten o'clock A. M. and three o'clock P. M., must commence the sale of the property advertised, commencing at the head of the list and continuing alphabetically, or in the numerical order of the lots or blocks, until completed. He may postpone the day of commencing the sales, or the sale from day to day, but the sale must be completed within three weeks from the day first fixed.

SEC. 27. The owner or person in possession of any real estate offered for sale for assessments due thereon may designate in writing to the Collector, prior to the sale what portion of the property he wishes sold, if less than the whole; but if the owner or possessor does not, then the Collector may designate it, and the person who will take the least quantity of the land, or in case an undivided interest is assessed, then the smallest portion of the interest, and pay the assessments and costs due, including two dollars to the Collector for the duplicate certificate of sale, is the purchaser. If the purchaser does not pay the assessments and costs before ten o'clock A. M. the following day, the property, on next sale day, before the regular sale, must be resold for the assessments and costs. After receiving the amount of assessments and costs, the Collector must make out in duplicate a certificate, dated on the day of sale, stating (when known) the name of the person assessed, a description of the land sold, the amount paid therefor, that it was sold for assessments, giving the amount and the year of the assessment, and specifying the time when the purchaser will be entitled to a deed. The certificate must be signed by the Collector, and one copy delivered to the purchaser, and the other filed in the office of the County Recorder of the county in which the land sold is situated.

SEC. 28. The Collector, before delivering any certificate, must in a book enter a description of the land sold, corresponding with the description in the certificate, the date of the sale, purchasers' names, and amount paid, regularly number the description on the margin of the book and put a corresponding number on each certificate. Such book must be open to public inspection, without fee, during office hours, when not in actual use. On filing the certificate with such County Recorder the lien of the assessments vests in the purchaser, and is only divested by the payment to

him, or to the Collector for his use, of the purchase money and two per cent. per month from the day of sale until redemption.

SEC. 29. A redemption of the property sold may be made by the owner, or any party in interest, within twelve months from the date of purchase. Redemption must be made in gold or silver coin, as provided for the collection of State and county taxes, and when made to the Collector he must credit the amount paid to the person named in the certificate, and pay it, on demand, to the person or his assignees. In each report the Collector makes to the Board of Directors, he must name the person entitled to redemption money, and the amount due to each. On receiving the certificate of sale the County Recorder must file it and make an entry in a book similar to that required of the Collector. On the presentation of the receipt of the person named in the certificate, or of the Collector, for his use, of the total amount of the redemption money, the Recorder must mark the word "Redeemed," the date, and by whom redeemed, on the certificate and on the margin of the book where the entry of the certificate is made. If the property is not redeemed within twelve months from the sale, the Collector, or his successor in office, must make to the purchaser, or his assignee, a deed of the property, reciting in the deed substantially the matters contained in the certificate, and that no person redeemed the property during the time allowed by law for its redemption. The Collector shall receive from the purchaser, for the use of the district, two dollars for making such deed.

SEC. 30. The matter recited in the certificate of sale must be recited in the deed, and such deed duly acknowledged or proved is prima facie evidence that:

First—The property was assessed as required by law.

Second—The property was equalized as required by law.

Third—That the assessments were levied in accordance with law.

Fourth—The assessments were not paid.

Fifth—At a proper time and place the property was sold as prescribed by law, and by the proper officer.

Sixth—The property was not redeemed.

Seventh—The person who executed the deed was the proper officer.

Such deed, duly acknowledged or proved is (except as against actual fraud) conclusive evidence of the regularity of all the proceedings from the assessment by the Assessor, inclusive, up to the execution of the deed. The deed conveys to the grantee the absolute title to the lands described therein free of all incumbrances, except when the land is owned by the United States or this State, in which case it is prima facie evidence of the right of possession.

SEC. 31. The assessment book or delinquent list, or a copy thereof, certified by the Collector, showing unpaid assessments against any person or property, is prima facie evidence of the assessment, the property assessed, the delinquency, the amount of assessments due and unpaid, and that all the forms of the law in relation to the assessment and levy of such assessments have been complied with.

SEC. 32. When land is sold for assessments correctly imposed, as the property of a particular person, no misnomer of the owner or supposed owner, or other mistake relating to the ownership thereof, affects the sale or renders it void or voidable.

SEC. 33. On the first Monday in each month the Collector must settle with the Secretary of the Board for all moneys collected for assessments, and pay the same over to the Treasurer; and within six days thereafter he must deliver to and file in the office of the Secretary a statement under oath, showing:

First—An account of all his transactions and receipts since his last settlement.

Second—That all money collected by him as Collector has been paid.

The Collector shall also file in the office of the Secretary on said first Monday in each month, the receipt of the Treasurer for the money so paid.

SEC. 34. Upon the presentation of the coupons due to the Treasurer, he shall pay the same from said Bond Fund. Whenever after ten years from the issuance of said bonds, said fund shall amount to the sum of ten thousand dollars, the Board of Directors may direct the Treasurer to pay such an amount of said bonds not due as the money in said fund will redeem, at the lowest value at which they may be offered for liquidation, after advertising for at least four weeks in some daily newspaper in each of the cities hereinbefore named, and in any other newspaper which said Board may deem advisable, for sealed proposals for the redemption of said bonds. Said proposals shall be opened by the Board in open meeting, at a time to be named in the notice, and the lowest bid for said bonds must be accepted; *provided*, That no bond shall be redeemed at a rate above par. In case the bids are equal, the lowest numbered bond shall have the preference. In case none of the holders of said bonds shall desire to have the same redeemed, as herein provided for, said money shall be invested by the Treasurer, under the direction of the Board, in United States gold-bearing bonds, or the bonds of the State, which shall be kept in said "Bond Fund," and may be used to redeem said district bonds whenever the holders thereof may desire.

SEC. 35. After adopting a plan of said canal or canals, storage, reservoirs, and works, the Board of Directors shall give notice, by publication thereof not less than

twenty days in one newspaper published in each of the counties composing the district, provided a newspaper is published therein, and in such other newspapers as they may deem advisable, calling for bids for the construction of said work, or of any portion thereof; if less than the whole work is advertised, then the portion so advertised must be particularly described in such notice; said notice shall set forth that plans and specifications can be seen at the office of the Board, and that the Board will receive sealed proposals therefor, and that the contract will be let to the lowest responsible bidder, stating the time and place for opening said proposals, which at the time and place appointed shall be opened in public, and as soon as convenient thereafter the Board shall let said work, either in portions or as a whole, to the lowest responsible bidder, or they may reject any or all bids and readvertise for proposals, or may proceed to construct the work under their own superintendence with the labor of the residents of the district. Contracts for the purchase of material shall be awarded to the lowest responsible bidder. Any person or persons to whom a contract may be awarded shall enter into a bond, with good and sufficient sureties, to be approved by the Board, payable to said district for its use, for double the amount of the contract price, conditioned for the faithful performance of said contract. The work shall be done under the direction and to the satisfaction of the Engineer, and be approved by the Board.

SEC. 36. No claim shall be paid by the Treasurer until allowed by the Board, and only upon a warrant signed by the President, and countersigned by the Secretary; *provided*, that the Board may draw from time to time from the Construction Fund and deposit in the County Treasury of the county where the office of the Board is situated, any sum in excess of the sum of twenty-five thousand dollars. The County Treasurer of said county is hereby authorized and required to receive and receipt for the same, and place the same to the credit of said district, and he shall be responsible upon his official bond for the safe keeping and disbursement of the same, as in this Act provided. He shall pay out the same, or any portion thereof, to the Treasurer of the district only, and only upon the order of the Board, signed by the President and attested by the Secretary. The said County Treasurer shall report in writing, on the second Monday in each month, the amount of money in the County Treasury, the amount of receipts for the month preceding, and the amount or amounts paid out; said report shall be verified and filed with the Secretary of the Board. The District Treasurer shall also report to the Board, in writing, on the first Monday in each month, the amount of money in the District Treasury, the amount of receipts for the month preceding, and the amount and items of expenditures, and said report shall be verified and filed with the Secretary of the Board.

SEC. 37. The cost and expense of purchasing and acquiring property and constructing the works and improvements herein provided for, shall be wholly paid out of the Construction Fund. For the purpose of defraying the expenses of the organization of the district, and of the care, operation, management, repair, and improvement of such portions of said canal and works as are completed and in use, including salaries of officers and employés, the Board may either fix rates of tolls and charges, and collect the same from all persons using said canal for irrigation and other purposes, or they may provide for the payment of said expenditures by a levy of assessments therefor, or by both said tolls and assessments; if by the latter method, such levy shall be made on the completion and equalization of the assessment roll, and the Board shall have the same powers and functions for the purposes of said levy as are now possessed by Boards of Supervisors in this State. The procedure for the collection of assessments by such levy shall in all respects conform to the provisions of this Act relating to the payment of principal and interest of bonds herein provided for.

SEC. 38. The Board of Directors shall have power to construct the said works across any stream of water, watercourse, street, avenue, highway, railway, canal, ditch, or flume which the route of said canal or canals may intersect or cross, in such manner as to afford security for life and property; but said Board shall restore the same, when so crossed or intersected, to its former state as near as may be, or in a sufficient manner not to have impaired unnecessarily its usefulness; and every company whose railroad shall be intersected or crossed by said works, shall unite with said Board in forming said intersections and crossing, and grant the privileges aforesaid; and if such railroad company and said Board, or the owners and controllers of the said property, thing, or franchise so to be crossed, cannot agree upon the amount to be paid therefor, or the points or the manner of said crossings or intersections, the same shall be ascertained and determined in all respects as is herein provided in respect to the taking of land. The right of way is hereby given, dedicated, and set apart, to locate, construct, and maintain said works over and through any of the lands which are now, or may be the property of this State; and also there is given, dedicated, and set apart, for the uses and purposes aforesaid, all waters and water rights belonging to this State within the district.

SEC. 39. The Board of Directors shall each receive four dollars per day, and mileage at the rate of twenty cents per mile, in attending meetings, and actual and necessary

expenses paid while engaged in official business under the order of the Board. The Board shall fix the compensation to be paid to the other officers named in the Act, to be paid out of the Treasury of the district; *provided*, that said Board shall, upon the petition of at least fifty, or a majority of the freeholders within such district therefor, submit to the electors at any general election a schedule of salaries and fees to be paid hereunder. Such petition must be presented to the Board twenty days prior to a general election, and the result of such election shall be determined and declared in all respects as other elections are determined and declared under this Act.

SEC. 40. No Director or any other officer named in this Act shall in any manner be interested, directly or indirectly, in any contract awarded or to be awarded by the Board, or in the profits to be derived therefrom; and for any violation of this provision, such officer shall be deemed guilty of a misdemeanor, and such conviction shall work a forfeiture of his office, and he shall be punished by a fine not exceeding five hundred dollars, or by imprisonment in the county jail not exceeding six months or by both such fine and imprisonment.

SEC. 41. The Board of Directors may, at any time, when in their judgment it may be advisable, call a special election, and submit to the qualified electors of the district, the question, whether or not a special assessment shall be levied for the purpose of raising money to be applied to any of the purposes provided in this Act. Such election must be called upon the notice prescribed, and the same shall be held, and the result thereof determined and declared in all respects in conformity with the provisions of section fifteen of this Act. The notice must specify the amount of money proposed to be raised, and the purpose for which it is intended to be used. At such elections the ballots shall contain the words, "Assessment—Yes," or "Assessment—No." If two thirds or more of the votes cast are "Assessment—Yes," the Board shall, at the time of the annual levy hereunder, levy an assessment sufficient to raise the amount voted. The rate of assessment shall be ascertained by deducting fifteen per cent for anticipated delinquencies from the aggregate assessed value of the property in the district, as it appears on the assessment roll for the current year, and then dividing the sum voted by the remainder of such aggregate assessed value. The assessments so levied shall be computed and entered on the assessment roll by the Secretary of the Board, and collected at the same time and in the same manner as other assessments provided for herein; and when collected shall be paid into the District Treasury for the purposes specified in the notice of such special election.

SEC. 42. The Board of Directors, or other officers of the district, shall have no power to incur any debt or liability whatever, either by issuing bonds, or otherwise, in excess of the express provisions of this Act, and any debt or liability incurred, in excess of such express provisions, shall be and remain absolutely void.

SEC. 43. In case the volume of water in any stream or river shall not be sufficient to supply the continual wants of the entire country through which it passes, and susceptible of irrigation therefrom, then it shall be the duty of the Water Commissioners, constituted as hereinafter provided, to apportion, in a just and equitable proportion, a certain amount of said water upon certain or alternate weekly days to different localities, as they may, in their judgment, think best for the interest of all parties concerned, and with due regard to the legal and equitable rights of all. Said Water Commissioners shall consist of the Chairman of the Board of Directors of each of the districts affected.

SEC. 44. It shall be the duty of the Board of Directors to keep the water flowing through the ditches under their control to the full capacity of such ditches in times of high water.

SEC. 45. Navigation shall never in any wise be impaired by the operation of this Act, nor shall any vested interest in or to any mining water rights or ditches, or in or to any water or water rights, or reservoirs or dams, now used by the owners or possessors thereof, in connection with any mining industry, or by persons purchasing or renting the use thereof, or in or to any other property now used directly or indirectly in carrying on or promoting the mining industry, ever be affected by or taken under its provisions, save and except that rights of way may be acquired over the same.

SEC. 46. None of the provisions of this Act shall be construed as repealing or in any wise modifying the provisions of any other Act relating to the subject of irrigation or Water Commissioners. Nothing herein contained shall be deemed to authorize any person or persons to divert the waters of any river, creek, stream, canal, or ditch, from its channel, to the detriment of any person or persons having any interest in such river, creek, stream, canal, or ditch, or the waters therein, unless previous compensation be ascertained and paid therefor, under the laws of this State authorizing the taking of private property for public uses.

SEC. 47. This Act shall take effect immediately.

SELECT COMMITTEE ON IRRIGATION,
Saturday, March 15, 1890.

The committee met pursuant to adjournment, Mr. Vandever in the chair.

STATEMENT OF MAJ. J. W. POWELL—Continued.

Major POWELL said:

Mr. Chairman and gentleman of the committee, in presenting this subject to you heretofore I have tried to illustrate the facts to you by means of concrete instances, taking up one valley after another and indicating the more important problems which arose in those valleys. I had prepared a large number of maps in order to present the subject over the entire arid region, but the time taken up on one or two of these valleys has been so great that I fear I shall weary you with too long an account, and I have thought best, if the members of the committee agree to it, not to take up any more of these special basins, but to give a general outline of the subject, bringing together the problems which relate to the arid lands and to the use of the waters, so as to occupy very much less time than I have been doing heretofore.

If this is satisfactory, Mr. Chairman, I will proceed. I have also brought with me a number of diagrams relating to the artesian wells of the arid region, but perhaps it would be well to sum up first what I was going to say in relation to the districts. It will be remembered that when I presented the map I stated that the extent of the arid region irrigated is practically about 1,340,000 square miles. In addition to that there are about 250,000 square miles of sub-humid region where irrigation is being practiced to a small extent, and where crops can be raised some years without irrigation and other years can not be, so that the problem involves an area of more than one and a half million square miles. Within that region there are 8,000,000 acres of land which have already been irrigated, and as shown by the map, it is distributed throughout the States and Territories of the region, so that already there is a basis of experience in farming by means of irrigation sufficient to warrant the statements which have been made as to the necessity of irrigation and the value of the lands when irrigated, and this experience has also developed to a large extent the problems which arise under this new industry.

It will be understood, I think, from the concrete instances which I have presented, that not all of that land can be irrigated. It would be a large estimate to say that one-tenth of it can be irrigated by perennial streams. When all the waters are used—every spring, brook, creek, and river—when all the storm waters are used, when all the waters which now run to waste during the season of non-irrigation are stored, and when there is a complete and full development of that country, it will still be a large estimate to say that 10 per cent. of it can be irrigated. The amount of water falling is exceedingly variable, from 2 to 3 inches in some regions of country, and from 16 to 18 inches in other regions of country. On non-irrigable lands in the mountains the rain-fall rises to 60 and 70 inches, but on the lands to be irrigated there is nowhere within this region 20 inches of rain-fall, and the average will be less than 10 inches of rain-fall on such lands.

Mr. PICKLER. What amount of rain-fall is necessary to raise wheat, supposing it falls at the right time?

Major POWELL. Eight inches, if it falls at the right time, but if it

is distributed throughout the year, more than that is required. It being understood, then, that when all the waters are used only a portion of the lands can be served, it comes to be an important problem to know what lands shall be served. Now, all things considered, this is the greatest problem that the subject presents. It is possible to select the lands in such a manner that the good lands can be served, or in such a manner that poor lands can be served. It is possible to select the lands in such a manner that ultimately less than one-tenth of the country can be irrigated,—I mean less than one-tenth of the million and a half square miles of land.

If the lands are selected improperly at points far away from the catchment areas, then the amount of lands to be irrigated is diminished thereby. If the lands to be irrigated on the Rio Grande were selected low down on the Rio Grande, instead of distributed along its course in each catchment area, and the whole body was selected in New Mexico, it would not be possible to irrigate one-twentieth of the land that could be irrigated if the lands were selected by catchment basins and the water relegated to the lands close to where the waters are caught. I think that the illustrations which I have presented to you fully bring out this fact. For example, suppose it should be declared by some authority that the waters of the Rio Grande should be used to serve the lands in the Mesilla Valley and Bernalillo Valley, as I have pointed them out on the map before you, and that in order to irrigate these lands other lands should not be irrigated. Then certainly the amount which could be irrigated by all the waters of the Rio Grande would not be more than one-twelfth of what could be irrigated should the region of country be divided into catchment areas and the people in each catchment area be allowed to irrigate the land immediately connected with that catchment area. If I do not make myself clear, I beg of you to interrogate me in the matter.

The lands to be irrigated are of themselves, without water, practically valueless. The lands which can be irrigated to the best advantage in any region of country are practically valueless for pasturage purposes, and they never bear timber. It is an important fact in connection with this that the irrigable lands are neither pasturage lands nor timber lands. They lie lower in the valleys, where the rain-fall is less, and the pasturage on the lowlands is so exceedingly scant that they are comparatively valueless for pasturage purposes. The better pasturage lands lie higher, and all the timber lands are higher, and in general the timber lands are not valuable for agriculture by irrigation.

The increase of these otherwise valueless lands by putting water upon them is very great. I think it may be stated without bordering on exaggeration that in general an acre of land with the water right attached thereto, when once irrigated, is given an increase in value from comparatively nothing, or one or two dollars an acre, to from $30 to $200 per acre. I know of no irrigated lands that sell for less than that, and I know of many that sell for much more; and I think it is quite within the limits of a reasonable statement to say that the irrigable lands vary from $30 to $200 per acre, with the water rights attached thereto. It will thus be seen that the increment of value given to lands by reason of their being irrigated is sufficient to pay the cost of constructing the irrigation works many times over. So there is no need of any Government aid in the construction of irrigation works. The increase given to the lands themselves will always warrant the expenses necessary to construct the irrigation works.. There is no difficulty, therefore, to obtain capital to irrigate the lands. Capital is offered in vast quantities

for this work. The real difficulty lies in the fact that at present there is no security to the small farmer and no security to the investor.

Let me explain that a little further. The land itself is valueless without the water. If a company owns that water, unless protected by local national, or state law in some manner the farmer becomes the servant of the company. This has already led to a great deal of litigation and conflict in the country in the adjusting of rights between the farmer and the corporations furnishing the water, and it has led to the destruction in many places of the corporate properties, and in others to their impairment. On the other hand it has made some companies rich, because the process of litigation has sometimes worked one way and sometimes the other.

The general subject which I am just now mentioning is not a national subject, but rather one belonging to the State, and in general the States and Territories are taking up the question of water rights and solving them, some in one way and some in another; but in the main they are solving them in the direction which will give the management of the water to corporate companies and the management of the land to farmers. Another line of development is to give the water and the land to companies, and many of these companies are formed. The process by which this is done is threefold. Only one needs to be mentioned now. The company wishing to enter into an enterprise of irrigation, will go among the farmers and get options on their lands, or induce people to settle in the country with the understanding that they will buy them out, or will go among the farmers and make contracts with them to furnish water perpetually at such and such a rate, and the increase of value which it will give to the land induces the farmer to make contracts of this character. Whenever it is possible, the company usually prefers to buy the land. The vast increase of value given to the land enables it to get a profit.

The main difficulty which arises in the question is that there is at present no system whatever, local, State, or national, by which all the waters can be relegated to specific lands. There is a general theory of law which is sustained in the courts, and in some States and Territories by statutes, which provides for priority of right. But it does not affect questions of water right between different districts and between different States. Let us see. Here is a river which can irrigate a few hundred thousand acres of land. The land below where that river runs is rich and can be irrigated to good advantage, and canals are constructed for the purpose. In the immediate neighborhood, within, say, a county, a number of claims areestablished to the use of the water locally, then this use can be regulated under the law of priority. Now, suppose a man goes up that stream 50 or 200 miles on a creek or some smaller river and takes a portion of the water which runs into the great stream, he does not take it in such a way that the man far below, living in another county or State, can identify the water which he uses as the particular water taken out by that man from a spring or brook or creek or river far up; and the courts have generally claimed that a man must identify his water if he wants to enjoin the use of the river far above; that he must identify the water which he would have used below. This has led almost everywhere throughout the country to conditions which have protected irrigation schemes high up. The effect is to gradually drive the settlements up stream. They are moving higher up the streams. In doing this they move into regions of country where only hay and potatoes can be cultivated. In quite a number of regions, as in Utah and in some places in New Mexico and Idaho, they are be-

ginning to make settlements where they have snow six months in the year. People know that above they can not have their water rights cut off. They go up where the water falls, and the process is driving the agriculture of the country into the mountains.

Without the intervention of the Government, a condition of affairs is growing up through which there will ultimately be presented enormous claims. If in the State of Kansas the people are sold land under the desert-land act at so much per acre and required to irrigate the land before they can obtain possession, and if after the land is irrigated all the water is taken from them, they seem to think that they have a right to come back to the Government to protect them in the use of the land, saying that they have bought it from the Government under a virtual contract that if they would irrigate it they would have water rights, and that they did irrigate with this understanding and then the water was cut off above. Either the Government must prevent this or the rights of these people will be destroyed; and if the people above are allowed to go ahead and irrigate and redeem their lands, then the question arises, how shall the rights be settled between the two communities? They are in different States or different Territories, as the case may be, and shall the Government allow two communities to be established on the basis of agriculture, depending on the use of one body of water, one in opposition to the other, with a knowledge that in time one or the other of these communities will be destroyed?

You have had before you for consideration, gentlemen, cases of this kind, and it must be manifest that one or the other of the communities must be destroyed; the Government has given these lands at so much per acre under the condition that they shall irrigated. The outcome of it will be that from each community thus cut off, an appeal will be made to Congress for aid. They will say that for ten or twenty years, as the case may be, you sold land to people above and told them to irrigate it, and they irrigated it, and now the waters are taken away from us and we want compensation. It will be in this manner that a vast system of claims upon the Government will be established. How they will be settled by Congress, I do not know.

I spoke a moment ago about capital offering and people being desirous to engage in irrigation, so that the country is being developed very rapidly and will be much more rapidly in the future. Under the present conditions the great fortunes that are made by irrigation are made, in the main, by middlemen, by promoters, who get capital from the East and get options in the West, and construct works and organize construction companies and operating companies and companies for supplying water to the farmers; and in that manner, in the main, the vast increment of value which arises from irrigation is going into the hands of irrigation promoters, those who organize the companies, and the farmers and investors are left to contend for their rights and soon must be ruined. I especially dwell upon the fact—for it is one of the most serious—that every river of magnitude throughout the arid region runs through two or more States. The Rio Grande and the Colorado and the Columbia present international problems. On the north there are half a dozen smaller streams that lie between British America and our own territory. Omitting the international problems and passing them by, every State and every Territory is complicated with some other State or Territory. The State and Territorial lines chance to have been drawn across areas everywhere in such a manner, on every river of magnitude, that there is scarcely a creek of any magnitude or any smaller river in all that

country which does not involve interests of two or more counties or two or more States.

The present State lines and present county lines were not laid out with the end in view of securing a homogeneous body of people, a people having one common interest in one county or one State government. If this country had been divided into counties and States by river basins, that difficulty would have been avoided. If it had happened that States had been divided by river districts, all these problems could have been solved by the States themselves; but as the facts actually exist the problems can not be solved by State governments, and they are of the most serious character and involve interests of enormous magnitude. It is well known to you, gentlemen, how a fishing-ground on a little bit of territory between two States comes to be a matter of bitter contest between the States; but what will it be between States when a vast system of agriculture is in controversy between them?

This is no ideal difficulty. It has arisen between Colorado and Nebraska. Governors have threatened violence, and it has created a great deal of contention. The subject has been introduced into Congress and an investigation ordered. Questions between Colorado and Kansas have in like manner arisen in Congress. Shall the agriculture of Kansas be destroyed in favor of Colorado? or shall the agriculture of Colorado be destroyed in favor of Kansas? are questions already before the Congress of the United States. The same question arises between Texas and New Mexico. Soon it will arise between Colorado and New Mexico. There is a bitter contest at present in the Department of the Interior between Idaho and Utah. Conventions have been held; governors have petitioned the Secretary of the Interior in reference to a division of the water of Bear River.

Now they are beginning to develop agriculture in the States farther north, and the same question will arise between the Dakotas and Montana, and between Montana, Oregon, and Washington, and between Oregon and Nevada, and between California and Nevada. I have shown you that very often the bodies of irrigable lands are so situated that the waters caught in one State have to be used in another. Six million acres of land in Idaho will depend wholly upon waters caught in Wyoming. Three-fourths of the agriculture of Nevada depends upon water caught in California. So that the interstate problems are enormous, so enormous that I almost hesitate to state what I believe to be their magnitude. I think that there are not less than $500,000,000 involved. But one case that I have given you shows that over 5,000,000 acres of land in Idaho depends upon waters to be caught and stored in Wyoming Territory. This is simply one illustration; and suppose in that case they are worth only $30 per acre. That means lands to the amount of $150,000,000, just between two States.

Now, gentlemen, I have presented these facts to you, and I do not know whether it is modest for me to suggest a solution of the problems; but if you will hear me on the subject, I would like to speak a few minutes upon what I think is the solution.

Mr. HATCH. For one, I would be very glad to hear it. That is what we are here for.

Major POWELL. It takes me out of my proper function as an executive officer of the Government, to suggest legislative measures; but I think there are three methods by which it can be solved, two of which I deem impracticable under our form of Government; the other, I think, is wholly practicable under our form of Government.

The General Government may take control of these waters and con-

struct the irrigating works and be well remunerated thereby by charging the people for the water, and have control of the whole thing, nationalizing the agricultural institutions of the arid country. Or the General Government may declare, in accord with the theory of one of the bills before you, that while it will not construct the works, it will authorize the people to construct the works by granting charters for the same. If this form should be taken and rights be given to irrigate without a proper inspection, or be given at random, it will ultimately result in piling up against the Government the most enormous claims. I think the statements I have made heretofore are sufficiently explicit to show why this would be, without arguing the point further. It may institute a commission, as constituted in this bill, with an organization to make surveys, to examine the streams and the lands, etc., and authorize that commission to charter private bodies or corporations or individuals to do this work. That is the theory of this bill before you. That would need a great central commission and local State commissions and a vast body of marshals and United States courts, etc. By that scheme it is proposed that corporations shall control the water and farmers control the lands, and that farmers shall be supplied with water by the corporations, and shall not have control of the water themselves. That is like saying that the Government of the United States shall assume the control and supply of waters for all the cities and towns of the United States under one vast system through commissioners, who grant charters to individuals to supply this town or that town with water, or this city or that city as the case may be, and that all the waters supplied to cities and towns in the United States should be supplied under charters granted by a United States commission.

That is the theory of one of the bills before you, that the United States Commission shall, through the aid of a body of executive officers and a body of engineers and a body of surveyors, determine what ought to be done in granting charters, so that charters shall not interfere with charters, and right not interfere with right, and grant charters to water companies to supply farmers. Either of these methods of nationalizing the affair, I deprecate, without stopping to state my reasons.

On the other hand, a study of the problem for twenty years has led me to the conclusion that it is possible to solve it in a manner in harmony with the institutions of this country. I think it is possible to divide all the arid region where irrigation is dependent on living streams into natural districts. I am not speaking of irrigation by the storage of storm waters, artesian waters, etc. I am speaking of irrigation from sources where these great water rights are involved—that it is possible to divide into two or three hundred districts the whole of that vast empire, so that all the water, all the land, all the timber, and all the pasturage will be divided among these districts in such a manner that the people of one district will have control of the group of common values in these districts, and do as they please with them. My theory is to organize in the United States another unit of government for specific purposes, for agriculture by irrigation, for the protection of the forests which are being destroyed by fire, and for the utilization of the pasturage which can only be utilized in large bodies; that is, to create a great body of commonwealths. In the main these commonwealths would be like county communities in the States. In many cases the districts would compose portions of two States. If it were possible to solve it so that every district would be within one State, and let the whole thing be turned over

to the States, it would be to the best advantage, but to turn over the subject to the States under the facts which actually exist, is to turn over to the States an endless conflict. Let the General Government designate the boundaries of these districts and let the Government make the surveys and say that the waters of each stream shall be used on specified lands.

Mr. HATCH. If it will not interrupt you right there, I understand you to say you would refer to the Federal Government the jurisdiction over the waters and over the timber and over the pasturage?

Major POWELL. No, sir; I should turn all over to the people by districts and by States. I would have the Government declare the boundary of an irrigation district for this purpose, and then say to the people of these districts, control these interests for yourselves. Let Congress do something more—let it say within each district, *there* is a body of land which is irrigable, and you can use all the water in that district on that body of land and nowhere else. Then say to the people: You can settle that district which is declared irrigable; you can settle that by homesteads, and that pasturage and that timber we turn over to you on this condition, that the States will agree that the people who live in any district which is to be divided by a State line may themselves organize their own government and use the water belonging to them as a district. Declare further that this law is inoperative until the States agree to it. Leave it to the States to agree to it, and if they are willing that a part of their people shall organize with a part of the people of another State for the purpose of forming an irrigation district, but for no other purpose—if they allow the people to make their own laws and govern themselves in the distribution of that water, then the Government will turn over to the people of such district the use of the timber and the use of the pasturage.

The people living in a district are the only people interested in its pasturage and forests, as I have shown to the committee. Say to the States, if you will allow the people, wherever these interstate districts are found, to organize solely for the purpose of controlling the water, we will turn over all to them. We will not give the lands, but the General Government will declare that the pasturage lands and the timber lands are held by the General Government as the custodian of the people, and they are allowed the benefit and use of the timber and pasturage thereof, but that no individual shall get control of either the timber or pasturage lands.

Mr. PICKLER. Then the people in the irrigable parts of that district would practically own the pasturage land and timber?

Major POWELL. No, sir; they would own no land, but would practically own the pasturage and timber; the title must remain in the General Government.

Mr. PICKLER. That is, that these people would have the use of it?

Major POWELL. Precisely. Let them make their own laws to govern the use of that timber in their own way, and govern the pasturage in their own way. If they want that timber destroyed, if they want to sell it, if they want to destroy it and wipe out irrigation, they are responsible for it, and let them do as they please. Say to them, you can not sell this land, you need this wood, and you need this timber for your farms, and if you protect it from fires, and cut it in such a manner that it will not injure your rivers and sources of supply for irrigation, you may have the timber. The pasturage is a matter of some importance, but far less than the timber.

I believe, Mr. Chairman, that the simplest possible solution to this problem is as follows:

Let the General Government organize the arid region, including all of the lands to be irrigated by perennial streams, into irrigation districts by hydrographic basins in such a manner that each district shall embrace all of the irrigable lands of a catchment basin and all of a catchment basin belonging to those lands, and determine the amount of water which each catchment area will afford, and then select sufficient irrigable lands for that water to serve, and declare that the waters of the catchment area belong to the designated lands and to no other, and prohibit the irrigation of any other lands. In order to maintain existing rights, declare all lands irrigated at the present time to be irrigable lands. This will divide the water among the lands and prevent conflict, and rights will not grow up where they can not be maintained. Then let the people of each such irrigation district organize as a body and control the waters on the declared irrigable lands in any manner which they may devise. Then declare that the pasturage and timber lands be permanently reserved for the purposes for which they are adapted, and give to the people the right to protect and use the forests and the grasses. Let the Government retain the ownership of reservoir sites, canal sites, and head-work sites; but allow the people of each district to use them, as a body, so as to prevent speculation in such sites, which would ultimately be a tax on agriculture.

Some of these districts would lie in two States. To this arrangement the consent of the States should be obtained, and all the districts should be organized under State laws. The Government should not grant these privileges to the districts until the States themselves ratify the agreement and provide statutes for the organization of the districts and for the regulation of water rights, the protection and use of forests, and the protection and use of pasturage. This is the general plan which I present. There are minor questions to be considered, but the fundamental principles of the system are simple, as I have stated them.

Mr. HATCH. Take the arid region. That is subject to reclamation by irrigation, as you have described it. What are the general products which have been produced? What are the crops?

Major POWELL. In my testimony there is a good deal on that subject.

Mr. HATCH. I will not trouble you then to repeat it. I just wanted to know if it had already been stated.

Major POWELL. I can do it in one sentence: Everything that can be cultivated between the climate of Norway and the climate of Egypt. They are already cultivating date-palms in one portion of the country, oranges, lemons, and all the products of Egypt. One of the great products of California is the Egyptian corn.

The hour of 12 o'clock having arrived, the committee thereupon adjourned to meet on Thursday next.

SELECT COMMITTEE ON IRRIGATION,
Thursday, March 27, 1890.

The committee met pursuant to adjournment, Mr. Hansbrough in the chair.

STATEMENT OF MAJ. J. W. POWELL—Continued.

Major POWELL said:

Mr. Chairman and gentlemen of the committee, at the last meeting the chairman requested me to speak at this meeting about the artesian waters of the arid region and about the prospects of irrigating the Great Plains; and I have brought with me this morning maps and diagrams for that purpose. Here is before you a map ot the arid region like one which I presented before, except that it is colored to show the distribution of the artesian waters so far as known. Of course they are only known to a limited degree. The artesian districts are colored in blue, as you see. To the east of the arid region, on the Red River in Dakota, we have an artesian basin which is known as Lake Agassiz, the basin being an extinct lake. The geology of that basin has been known for some time, as the Red River country was examined by members of the Geological Survey some years ago. Mr. Chamberlin, now president of the Wisconsin University, had charge of the work.

Here in the James Valley of the Dakotas we have other artesian wells, which I will dwell upon somewhat later in my remarks and present a map of the two Dakotas giving them more in detail. On this map not all the individual wells are marked—that is to say, they are marked by groups, not by individual wells; so there are more of the wells than the dots indicate. Sometimes the colored spots represent two, three, or more, as the case may be. There are also wells in Texas. In Arizona we have a few artesian wells which are known; in Utah we have a few artesian wells, and in southern California we have some. There are a few at the north, as you see, in Washington and Oregon. This gives at a glance and in a simple way what is known as to the distribution of the artesian waters up to the present time.

It can not be doubted, however, that there are many more basins, as the country has not been examined very fully (only casually in fact) for artesian waters, and many more artesian basins may be expected. I present this to show the distribution of the artesian wells as known.

I will now take North and South Dakota more in detail. This [indicating] is the same general line, separating the sub-humid from the arid region, as shown on other maps which I have placed before you. This is a map of the two Dakotas. You will notice that the spots here are classified; that some of them are in solid color, and others are arranged with bars. The different characters of dots represent different artesian basins. A large part of the artesian water of the Dakotas where irrigation is necessary will be seen as coming from a geologic formation different from that of the wells farther east. To explain this subject I have a general diagram. It is a geological section of the two Dakotas, extending from the Rocky Mountains on the west to the eastern border of the State. The green represents rocks of the Cretaceous age. The formation you see below dotted in black represents the base of Cretaceous rocks, the Dakota Sandstone. This sandstone is pervious to water. It is composed of sands and gravels, and contains a greater part of the water represented by the artesian wells that are marked with rings and two cross-bars. On top of this Cretaceous formation we have

glacial formations, which are not represented in the diagram. They lie on top, and these artesian wells come from rocks below. Some wells are in the outlying strips of Tertiary rocks, but the great supply which has been found in the two Dakotas comes from this Dakota Sandstone. Here is Huron, here the White River, here Highmore, here Miller, and here the Missouri River.

Now the geological conditions under which artesian waters are found are very well known. The subject has been studied throughout the world. Most of the artesian waters of the world have been studied to such an extent that we know their geological conditions. It is known in the first place that in metamorphic rocks no water has been found. So in making an examination of a country we can exclude large areas, the geology of which is such that we know artesian waters can not be found therein. Artesian waters are found only in sedimentary rocks that are pervious to water—through which water can creep.

You will see that the diagram extends from the Rocky Mountains on the west to the eastern border of the Dakotas, and that this Dakota Sandstone, in which the best artesian wells are found, underlies the country throughout the entire distance. But on the west, along the foot-hills of the mountains, this sandstone comes to the surface, as represented in the diagram. In all the region from the northern boundary far to the south, the edge of the sandstone outcrops in this manner, and over this outcrop is found the catchment area for the waters which percolate down through the sandstone eastward, under the central part of North and South Dakota. All the water found in the artesian district, in the belt along the one hundredth meridian, comes from this distant outcrop. It is not possible to get from the artesian wells of the plains, that are derived from this sandstone, any more water than gets into this upturned edge. All that is evaporated at the surface is lost, and all that runs away in streams is lost. Only that which is caught and percolates down through the sandstone comes into central Dakota. We know, too, that there can not be a free flow from this upturned edge through the hundreds of miles of sandstone to the James River Valley. If there were a perfectly free flow of water in the James River Valley, it ought to have a sufficient pressure to throw it as high, or nearly as high, as the outcropping rocks of the catchment district, but the pressure is far less. This is testimony to the condition of flow through the Dakota Sandstone; the flow is not free but is obstructed on the way. The sandstone is not sufficiently porous to permit the catchment area at this great altitude to have its full effect in pressure on the wells of the James River Valley. The actual pressure found on the artesian wells of the eastern region is but a small fraction of what it would be if the hydrostatic pressure were equal to the difference of altitude between the wells and the catchment surfaces.

Now, I want to consider what are the sources of water for irrigation on the Great Plains and to give a little idea of the need for water, and the conditions under which it can be used. The region of country along the Great Plains lying near to the one hundredth meridian has considerable rain-fall. I should say from 15 to 22 inches of rain is found on an average. Some years it will be more and some years less. Under these conditions the rain-fall is sufficient for agriculture some years, and in other years it is insufficient, and it has happened in the last twenty odd years coming under my observation that the dry years fall in groups of one, two, or three, as the case may. When one dry year only occurs, and is followed by wet years, the disaster to agriculture is not

so great, but when two or three dry years come in succession the agriculture is cut off for a long time, and then the disaster is very great indeed. It has happened in the last twenty years that the district of country which I have pointed out, and which I have heretofore called the sub-humid region, has been settled here, there, and elsewhere, not bodily throughout the whole country, but in small districts. The people come in during wet seasons and commence agricultural operations, and in dry seasons abandon their homes. There are portions of Kansas that have been abandoned in this manner three times. The disaster occurring there has of course been very great. A part of Dakota has been settled, and they have had two or three dry seasons, and the people are suffering very greatly by reason of the failure of their crops, and it is manifest that for prosperity the people must provide against these disasters that come in dry years. That these dry years will come from time to time is certain. That there is any material change in the climate of the country, due to its settlement or other causes, does not appear from the records. It is denied by the experience of mankind everywhere that climatic changes come from trivial causes, or causes which are under the control of man. We know they come from secular causes through long periods of time.

Mr. HATCH. That is, they think history will repeat itself in a term of years.

Major POWELL. In a term of years; yes, sir. Investigations have been made by numbers of scientific men who have discussed the problem—the subject has been studied for a long time, and a vast system of data has been accumulated—and all show local and temporary oscillations, but no permanent change.

Here, then, is a district of country of 300,000 or 400,000 square miles, extending from the northern border to the southern border, where, during more than half the years of any lengthy period, we may expect agricultural operations to be prosperous by reason of sufficient rain, more prosperous than anywhere else in the humid regions of the United States. Whenever, in any district of country, there is just sufficient rain-fall and no more, that is the best condition for that agriculture which is dependent upon rain-fall. Any increase above that is injurious. For a portion of the time, say two-thirds to the east of the line, one-half along the line, and one-third west of the line, there is rain-fall enough. What then becomes necessary is to supply additional water in seasons of drought, so there may not be times when disaster comes to the farmer. To furnish the water necessary for these disastrous years, we have to furnish a smaller amount than in other regions of country.

Now, what waters can be found for this purpose? I will speak first of artesian wells. Something can be obtained from artesian wells, but not a very great amount. The experience from artesian wells fully warrants what I am stating now. They have been bored at different places in the world and used for irrigation wherever they could be used, and it bears out the statement I make that the supply from artesian sources is always limited, is always very small, and that no great area can be irrigated thereby. If all the artesian wells in the world which are used for irrigation were assembled in one county of Dakota they would not irrigate that county.

The CHAIRMAN. That is a strong statement, and I am afraid it will not be borne out by the facts.

Mr. PICKLER. There are many fine wells that I know of myself.

Major POWELL. Let me go into this somewhat in detail, so that you may see that I am not considering the matter carelessly. An artesian

well which will give a cubic foot of water per second is a well far better than the average; that is, a well which will give 7 to 8 gallons per second. There are wells that will give more, and there are wells that will give less than 1 cubic foot per second. A cubic foot of water per second in Dakota in the eastern portion of the sub-humid region will irrigate about 200 acres, and in the western portion about 125.

The CHAIRMAN. You say the wells marked by solid red would irrigate 200 acres, and those in the western portion marked with bars would irrigate about 125.

Major POWELL. I am not speaking of any specific well; I am speaking of a hypothetical well which will turn out a cubic foot of water per second. We measure flowing waters in cubic feet per second. There are wells in that region which will turn out several cubic feet each, but many which turn out less.

Mr. PICKLER. How many gallons will that make a minute?

Major POWELL. About 450 gallons per minute. That is to say, the experience of mankind shows that it takes a certain amount of water to irrigate an acre. That amount of water per acre is on an average throughout the United States an acre-foot of water for an acre of land, but in the region of which I am speaking now they do not need that much water, and would need, say, 6 inches of water for an acre of land. To get 6 inches of water over each acre of land, say 1,000 or 10,000, takes a pretty big supply. We see an artesian well in the arid country with a bore of about 4 to 6 inches, as the case may be, pouring out a fine stream of water, and it looks a large stream and strikes the eye with a good deal of force, but when you actually compute the amount of water which it supplies, you find that amount is small. Now, there is something more to be said in that direction, the number of artesian wells in every district that has been experimented with is always limited, and to make this plain, I have prepared a written statement which I will incorporate in my remarks unless you desire me to read it.

ARTESIAN IRRIGATION ON THE GREAT PLAINS.

Artesian reservoirs can never be an important source of water for irrigation. The supply of water thus naturally stored is small. The share of it which agriculture can economically obtain through wells is still smaller. Though irrigation has aided agriculture from the earliest times, and though artesian wells have long been understood, the world has succeeded in using artesian water for agriculture in but a few exceptional spots. The Great Plains may become one of these exceptional localities, but the conditions do not warrant great expectations.

In order to make these propositions clear, it is necessary to give consideration to some of the general facts and principles affecting artesian water supply, to the economic conditions limiting the utilization of artesian water for irrigation, and to the special conditions existing on the Great Plains. A brief account will also be given of such irrigation as is based on artesian water supply in various countries of the world.

GENERAL CONSIDERATIONS AFFECTING ARTESIAN WATER SUPPLY.

An artesian reservoir is usually a bed of sand or sandstone or other porous rock, included between strata of clay or shale or other fine-grained rock through which water can not freely flow. It is necessary

that the porous stratum come to the surface at some point so as to receive a supply of water from rain. If all the points at which it comes to the surface or communicates freely with the surface lie higher than the point at which water is to be drawn through wells, the reservoir is of a type which may be denominated as perfect; but if the stratum communicates with the surface also at points which lie lower than the point from which boring is made, the reservoir is imperfect. In the case of an imperfect reservoir, the possibility of an artesian flow depends upon the resistance opposed by the porous bed to the free flow of water.

Permanent flow.—The quantity of water which can be annually and in perpetuity drawn from an artesian reservoir manifestly can not exceed the quantity annually supplied to it. The quantity annually supplied depends on various factors, chiefly the extent of the high-lying outcrop, the rain-fall on the area of outcrop, and the capacity of the rock for absorption. Ordinarily the rock does not receive the whole of the rain-fall, but permits a part of it to run off in surface streams, while another part escapes from the surface by evaporation.

The amount which can be drawn from a reservoir may depend, in addition, on the ability of the porous stratum to convey water. Where the stratum is thin, or contains little interstitial space, the possible delivery of water is correspondingly small.

In the case of imperfect reservoirs the artesian possibilities are further limited by the natural escape of water at lower levels, and to this should be added the loss of water by slow transmission through the covering strata, for no rock is absolutely impervious to water.

From a perfect reservoir the water will rise in a well to the height of the outcropping edge of the stratum which receives the rain-fall; from an imperfect reservoir it will not rise so high, and the amount of difference is related to the amount of water which escapes at lower levels, as well as to the resistance to flow encountered in different parts of the stratum. The height to which water will rise in a well depends on the pressure exerted by the water upon the cover of the reservoir, and that pressure is diminished by any draught upon the reservoir. When an artesian well is opened and begins to flow, the pressure from the water of the reservoir is immediately diminished by the flow; in other words, the flowing pressure is less than the static pressure. If the discharge of a well be computed, by the aid of hydraulic formulæ, from the static pressure and the size of the bore, such computed discharge will always exceed the actual discharge, and the difference will usually be great. The difference is caused by the frictional resistance which the water experiences in moving through the porous stratum.

In this way the mutual interference of wells is occasioned. The boring of each well reduces the static pressure of the water of the reservoir all about it, the reduction diminishing outward in all directions. Any well bored within the range of this reduction meets with a relatively small water pressure and secures a relatively small flow. Reciprocally the boring of the second well diminishes the flow of the first.

If a series of neighboring wells be bored at the same level, the individual discharge of all the wells is progressively diminished, and the total discharge is at first progressively increased, but the limit of discharge for the locality is finally reached, and then the boring of additional wells gives no advantage. If two wells in the same vicinity head at different levels the one at the lower level discharges more water than the other, and the flow of a well or of a group of wells may be entirely destroyed by the sinking of new wells at a lower level. The same effect

is produced by pumping water from wells, which is equivalent to a discharge at lower level.

There is, moreover, in the case of most wells, a certain amount of waste through the escape of water from the well to porous strata lying above the impervious cover of the reservoir. Such waste is apt to increase with time, and it manifestly increases with the multiplication of wells. It is therefore possible in most artesian districts to destroy absolutely the artesian head by the boring of numerous wells.

Temporary flow.—Where the exposed outcrop of the artesian stratum covers a broad area and the rain-fall is ample, it is usually the fact that the amount of water supplied to it is more than can be transmitted through its buried portion; but if the outcropping edge is narrow and lies in an arid region, it may happen that the stratum has capacity for the transmission of more water than is delivered to it. If these latter relations subsist in the case of a perfect or nearly perfect reservoir, and that reservoir is tapped by numerous artesian wells, the initial discharge of water from the wells is greater than the permanent discharge. The wells in such case draw upon a body of water which may have required years for its accumulation, and their conditions of permanent flow are not reached until this accumulation has been exhausted. Thus in another and independent way the flow of artesian wells is liable to be diminished.

The following data, selected from the records of various artesian districts of the United States, illustrate chiefly the phenomena of interference, but they doubtless include also phenomena of temporary flow.

Denver Basin.—Artesian water was first obtained in the Denver Basin in 1883. The flow yielded by the first well was so large and the water was of such superior quality for domestic use that other wells were put down with great rapidity. There are now in the city and its vicinity about three hundred wells. Many of the first wells had sufficient pressure to force the water into tanks in the tops of the highest buildings in the city, but as the number of wells was increased the pressure and flow of the older wells began to diminish, and finally, in the region where they are most closely grouped, they have failed to furnish water without the aid of pumps. Outside the region of closest grouping pressure and flow have been diminished, but not to so great extent. Deep wells are still bored at Denver, but not with the expectation of obtaining artesian flow.

Dubuque, Iowa.—The first well at this point for artesian purposes was headed nearly 200 feet above the level of the Mississippi River. Water was obtained in great volume and rose nearly to the surface. A few years later another well was put down at a lower level, approximately 100 feet above the river. A good flow was obtained, and this led to the boring of numerous wells. At first all were successful, but it was observed that with the multiplication of wells the flow from the older diminished, particularly when the new wells were headed at lower levels. Finally an exceedingly large bore was headed in the lower part of the city, but a few feet above the river level, and through this an unprecedented flow was developed; but within a few hours the flow from the other wells diminished, and within a few days all of those at the higher levels ceased to flow. Eventually the flow from the last-bored well dwindled to not more than twice or thrice that of the first well at the 100 foot level, and it is said to be still slowly diminishing.

Chicago.—The city of Chicago lies over an artesian reservoir, and it was hoped that it could be supplied therefrom with water for domestic purposes. But experimentation proved that while a few good wells

could be secured, a great number was impossible, and that the pumping necessary to derive a large supply of water would deprive the entire group of its artesian head.

Rockford, Ill.—The municipality of Rockford obtains its water supply through five artesian wells which were bored in succession, and the supply was measured after the addition of each well.

Flow of wells for twenty-four hours.

	Gallons.
No. 1	1,000,000
Nos. 1 and 2	2,000,000
Nos. 1, 2 and 3	2,600,000
Nos. 1, 2, 3 and 4	3,000,000
Nos. 1, 2, 3, 4 and 5	3,500,000

The fifth well thus increased the supply only half as much as did the second. A private well was afterwards drilled at a distance of 1 mile and at a level 17 feet lower than the city wells, when the flow from the city wells immediately fell to 2,500,000 gallons.

Williams County, Ohio.—For the last thirty years it has been known that artesian water may be obtained from reservoirs in the drift in the northwestern portion of Ohio. In Bryan, the county seat of Williams County, an artesian well was bored in the public square, causing the village to be popularly called the "Fountain City." As the reservoir lay but a short distance beneath the surface, wells were easily produced, and their number was rapidly increased; but it soon became apparent that their source could be overtaxed. The force of the flow was abated; the highest wells began to fail altogether; a pump was introduced into the public square fountain; and at the present time a sluggish flow is obtained only in the lowest portion of the village.

Toledo, Ohio.—The conditions are similar at Toledo. When the wells were first bored the water rose to a height of 14 feet above the level of Lake Erie, and this head was gradually lowered as the number of wells was increased. At the present time water is pumped from wells by the corporation and by private owners, and the head has fallen to 40 feet below the lake level.

Ohio Valley.—In the vicinity of Pomeroy, Ohio, and Mason City, W. Va., brine for the manufacture of salt has been obtained from artesian wells for the last thirty or forty years. When first tapped the brine flowed freely, and it continued to do so for many years; but in 1865 the number of wells was greatly increased and the water head was thereby lost, so that pumping became necessary. Year by year the pumps have been lengthened, and now they are placed about 600 feet below the surface of the ground.

Alabama.—Although the lowlands skirting the Atlantic and Gulf slopes everywhere belong to what may be classed as an artesian district, artesian boring for supplies of water for domestic purposes was first inaugurated extensively in Alabama, and the history of interference is best known there. A representative locality is Finch's Ferry, where the bad quality of the surface water led the people to seek an artesian supply about fifty years ago. The first well obtained a strong flow of water from a depth of several hundred feet, and other wells followed. With the boring of each new well the flow from the older wells diminished, and this tendency became particularly noticeable when a well was bored at a lower level than any of the others on the bank of the Tuscaloosa River. In order not to destroy the older wells, it was found necessary to pipe the new well up to a height corresponding to the level at which the old wells were located. Even then the flow from the

wells was so far diminished that some of them were unable to clear the casing of sand and débris, and so became clogged and ruined. At the present time but three wells continue to flow at the surface.

ECONOMIC LIMIT TO UTILIZATION OF ARTESIAN WATER FOR IRRIGATION.

There is a certain economic relation between the cost of an artesian well designed for irrigation and the amount of land which can be redeemed by the water it furnishes. If the value added to the land is less than the cost of the well, the boring of the well is unprofitable. The conditions determining this problem are numerous and can not be fully discussed in a quantitative manner, but it will be advantageous to consider some of the simpler cases. First will be taken the general case in which the permanent conditions of flow are realized at once.

Let us assume that the value added to an acre of land by irrigating it is $50; that for the accomplishment of this result there must be applied to each acre of land a quantity of water amounting in an irrigation season of seventy days to one acre-foot; and that by means of storage reservoirs it is possible to save for irrigation purposes 70 per cent. of the water flowing from a well during the remainder of the year.

It follows from these assumptions that an artesian plant, including cost of storage reservoir if storage is employed, must not cost more than $1,000 for each 20 acres of land reclaimed.

It follows also that a certain daily flow must be realized. In case the water is not stored and is used only during the irrigating season of seventy days, a well, to be profitable, must yield perennially 65 gallons per minute for each $1,000 of cost of plant. The cost of plant in this case includes the boring, casing, etc., of the well and the construction of main ditches for the distribution of the water. If the water of the non-irrigating season (295 days) is stored, a well, to be profitable, must yield perennially 21 gallons per minute for each $1,000 of cost of plant. The cost of plant in this case includes also the cost of constructing storage reservoirs, headworks, etc.

These estimates of running gallons per minute must be increased if the value added to the land is less than $50 per acre, if the irrigation season is greater than seventy days, if the duty of an acre-foot of water is less than one acre of land, or if less than 70 per cent. of the water flowing in the non-irrigating season can be saved by means of storage reservoirs; and in the contrary cases they must be diminished.

The estimates are based upon assumptions of a general nature intended to represent the average conditions of the arid region. While they require modification when applied to individual localities, the necessity for such modification is limited by certain compensations among the conditions. These arise from the fact that the value added to land by furnishing it with water for irrigation is less in those localities where the duty of water is greater, and from the further fact that the value added to land is in general greater for those crops for which the irrigation season is longer.

Up to a certain limit, determined by the waste through leakage, the amount of water derived from an artesian basin in any limited locality is increased by increasing the number of wells, but the average flow per well is invariably diminished, and the economic limit is reached when the gain in land value from the total flow is equal to the total cost. This limit is reached before the maximum supply has been derived from the reservoir, and it is thus economically impracticable to approximate closely the natural limit of artesian supply.

If we take into account the slope of surface, which exists in all artesian districts, and the advantage enjoyed by the wells heading on low ground, it is evident that the last wells bored in a district will usually be at low levels, and that these will impair the value of those at higher levels. Profitable low-level wells may be bored after the limitation indicated above has been reached. Though each well of a district may be profitable at the time it is bored, the wells in the aggregate may cost more than the aggregate value of the water.

If the supply of water, impaired by multiplication of wells, is restored by pumping, the capitalization of the cost of pumping must be added to the cost of the plant in making the economic computation, and in such case the investment may be shown to be still more disastrous.

The United States has acquired through its oil and gas industries a large experience in the boring of wells, and the following estimates of average cost are based on this experience.

Passing now to the general case in which the permanent conditions of flow are not realized at the outset, but only after a store of water has been exhausted by means of a relatively large temporary flow, we have an additional factor tending to induce a greater expenditure in the boring of wells than will be ultimately profitable. The total amount of water obtained is in this case greater, but unless a more conservative policy be adopted with reference to the multiplication of wells, the economic result may be far more disastrous.

Test wells, that is, wells in localities where the succession of strata and other conditions affecting cost are unknown, can in general be put down by contract at the following rates:

Depth:	
500 feet	$2,000
1,000 feet	4,500
1,500 feet	7,500
2,000 feet	10,000

Individual wells may in exceptional cases cost much larger amounts. In a region where many wells are bored and the conditions are known the cost tends to fall to the following minimum:

Depth:	
500 feet	$1,000
1,000 feet	2,500
1,500 feet	4,500
2,000 feet	7,000

IRRIGATION BY ARTESIAN WELLS IN VARIOUS COUNTRIES.

The cost of boring wells is so great and the quantity of water thus obtained is so limited that in most localities the special use given to the water must have high value in order to warrant the sinking of wells. Most frequently it is sought for domestic use. It is also sought for manufacturing and medicinal purposes, for the watering of stock, and for the production of salt. In some desert regions wells have been bored from point to point to furnish water for the use of travelers, and the water flowing from such wells is also used for the nourishment of gardens, but the irrigation is in this case an incidental result and not a primary purpose. Such gardens associated with travelers' wells are found in Abyssinia, Upper Egypt, and at various places on the Sahara, and also in Australia.

Artesian water has been successfully sought for the purpose of irrigation in China. Italy, Spain, the Sandwich Islands, Algeria, California,

and Utah. Details in regard to Chinese wells have not been ascertained. In California they are employed almost exclusively in the cultivation of fruits, and the same is true in Algeria. In Utah they are made to serve vegetable gardens. In Algeria about 4,000 acres have been reclaimed, and it is estimated that the present supply of water is competent to double this acreage. In California the wells are restricted to Los Angeles, San Bernardino, and San Diego Counties, and it is stated by Mr. W. H. Hall, the State engineer, that less than 3,000 acres are irrigated. In Utah about 2,000 acres are irrigated. In each of the other countries named the extent of the irrigated land is very small.

The work in Algeria is peculiarly instructive, because agriculture was there initiated on the face of a desert, and because the institution of wells was scientifically planned. The following facts are selected from the extensive literature of the subject:

Irrigation in Algeria.—The initiative in the search for artesian waters in Algeria was taken by General Desvaux, of the French army, commanding at Batna, in the year 1855. At his request M. Ch. Laurent, a well known artesian expert, was sent to examine that portion of the Sahara Desert lying within and adjacent to the confines of Algeria, with reference to the possibility of artesian waters and the best method of securing them.

The work of boring was under the immediate direction of M. Jus, C. E., assisted by Lieutenant Lehaut of the army. The first well was sunk at Tamerna, in the oasis of Oued Rir'; begun early in May, 1856, completed June 19. Its flow was 4,010 liters (141 cubic feet, or 1,059 gallons) per minute; its depth, 60 meters (197 feet). From this date to 1860 fifty wells were sunk in the province of Constantine (Algeria), with a delivery of 36,000 liters (1,271 cubic feet, or 9,510 gallons) per minute.

Subsequent to 1860, records of wells are traced with difficulty, excepting for the oasis of Oued Rir', and it is probable that the information that follows is somewhat incomplete.

According to the best accounts at present available, the number of flowing wells now amounts to about 125, tubed with iron, and 500 native, tubed with wood; total, 625. Their yield is 240,000 liters (8,475 cubic feet, or 63,400 gallons) per minute. A well of 3,000 to 4,000 liters per minute (105 to 140 cubic feet) will irrigate from 100 to 200 acres, according to the nature of the soil. This gives a duty of from 42 to 84 acres per cubic foot per second, the former being nearer the average. With the present supply of water between 6,000 and 9,000 acres can be irrigated. At present not more than 4,000 acres are under cultivation, of which 3,706 are in the oasis of Oued Rir'.

It is stated that in the thirty years of well usage in this country the wells tubed with iron, with rare exceptions, due to defective tubing, have not varied in the amount of their delivery.

The following table is based on one by M. Rolland, printed in the report of the Société Agricole et Industrielle de Batria et du sud Algérien, made in connection with the society's exhibit at the Paris Exposition of 1889.

Principal groups of artesian wells.	Maximum depth of wells.	No. of wells.	Average flow per minute.
	Feet.		*Gallons.*
Group of Ourir Ensira, Mraier and Dendouga	269	12	640
Group of Sidi Khelil	318	4	260
Group of El Berd and Tinedla	321	3	560
Group of Zaouiet R'hab and Mellaah	256	2	340
Great group of Mazer, Ourlana, Chria Saiah and Tala-em-Mouidi, Ariana-Djama and Tiguedi-din, Couidiat Sidi Yahia and Sidi Yahia and Sidi Amran	372	18	1,125
Group of Tamerna Khedima and Tamerna Djedida	252	10	750
Group of Moggar, Sidi Sliman, Bou Rekhis and El Kessour	292	9	750
Lateral group of Sidi Rached, Bram, Ghamra and El Harihira	387	14	300
Great group of Megarin Khedima and Meggarin Djedida, of Zaouia Tebeshest and Tougourt, of Nezla and Coudiat el Koda	340	8	525
Terminal group of Temassin-Tamelath and Bledet Ahmar and El Gong	278	8	525

GEOLOGIC CONDITIONS AND STATISTICS OF ARTESIAN WELLS ON THE GREAT PLAINS.

Artesian water is now obtained in the region of the Great Plains from Cambrian, Carboniferous, Triassic, Cretaceous, Tertiary, and Pleistocene formations.

Three wells in the Red River basin give water from Cambrian strata, but this water is saline and the flow is moderate. It is not available for irrigation.

Carboniferous strata yield artesian water in eastern Kansas, eastern Nebraska, and at numerous points in Texas. This water is chiefly saline, and therefore unavailable for irrigation.

In Kansas artesian water has also been derived from Triassic sandstones and found to be saline and unfit for irrigation. From what is known of this formation in many parts of the country it is believed that no pure water will be obtained from it.

Water has been obtained from several horizons in the Cretaceous, which is a great formation covering a large portion of the Plains. Its principal water-bearing stratum is a sandstone at the base, known as the Dakota Sandstone. The water derived from this is usually suitable for irrigation and its yield is exceptionally large. It has been successfully explored in North Dakota, South Dakota, Nebraska, Kansas, and Texas.

Artesian basins in the Tertiary are comparatively limited. Those thus far discovered lie in Colorado, Kansas, and Texas.

In a single basin Pleistocene strata have yielded water by numerous wells. This is the Red River Valley of North Dakota and Minnesota. The water is mainly of a quality suited for irrigation, but it rises in a region where the need of irrigation is not felt, and its quantity is, moreover, too small to permit of extensive use for that purpose. In a second basin a little water has been found, and it is possible that yet other artesian basins may be discovered in this formation, but there is no reason to anticipate that they will afford a water supply of great value.

In the following tables are assembled such data as I have been able to gather with reference to the location, depth, flow, etc., of the artesian wells now existing on the eastern portion of the Great Plains, and thereto are added corresponding data for the wells of the Red River basin. As will be observed, they are arranged by States:

Wells of the Red River Valley.

MINNESOTA.

Location.	Depth.	Strata penetrated.	Water supply.
Traverse County:	*Feet.*		
Near Wheaton	110–162	Glacial drift (till) with included seams of water-bearing sand and gravel.	Fresh, abundant.
Tintah	55	ditto	Do.
Do	45	ditto	Do.
Do	67	ditto	Do.
Near Tintah	35–160	ditto	Do.
Wilkin County:			
Champion Township, many wells.	50–66	ditto	Fresh, very copious.
Atherton	11	ditto	Fresh.
Do	37	ditto	Do.
Do	45	ditto	Do.
Clay County:			
Near Barnesville	35		
Near Sabin	180		
Near Moorhead	100–228		
Kragnes	155		
Near Georgetown	180		
Becker County:			
Hamden	75		
Do	110		
Norman County:			
Perley	200	All these go through thin lacustrine and alluvial beds, then are for most of their depth glacial drift (till), with seams of water-bearing sand and gravel.	All fresh, with copious supply.
Halstad	250		
Eight miles northeast of Halstad.	165		
Do	219		
Ada	217		
Lockhart	140		
Lockhart vicinity	125–150		
From Ada to Crookston, many wells.	100–200		
Polk County:			
Near Kittson	80–112		
Do	140		
Carman	190		
Near Crookston	180		
Do	190	Alluvium and lacustrine beds, then glacial drift (till), in which are water-bearing seams of sand and gravel.	Fresh, copious.
Do	205	ditto	Do.
Do	236	ditto	Do.
Vicinity of Crookston, probably one hundred wells.	165–240	ditto	Do.
Fisher	285	ditto	Alkaline and saline, copious.
Near Angus	45	ditto	
Do	70	ditto	
South Angus	253	ditto	Do.
Marshall County:			
Argyle	150	ditto	Do.
Do	285	ditto	Do.
Tamarack and vicinity	74	ditto	Do.
Do	95	ditto	Do.
Do	218	ditto	Do.
Stephen	220	ditto	Do.
Do	240	ditto	Do.
Kittson County:			
Donaldson	45	ditto	Do.
Near Kennedy	95	ditto	Do.
Near Hallock	119	ditto	Fresh, copious.
Near Northcote	30	ditto	Do.
St. Vincent	165	ditto	Saline, copious.

NORTH DAKOTA.

Wells of the Red River Valley—Continued.

Location.	Depth.	Strata penetrated.	What supplied.
Richland County:	*Feet.*		
Farmington	93		
Dwight vicinity (ten wells)	85–110		
Colfax	85		
Do	125		
Do	128		
Do	135		
Walcott	110		
Do	120		
Walcott vicinity	104		
Do	131		
Do	227		
Cass County:			
Durbin	160	Thin alluvial and lacustrine beds; then the principal thickness consists of glacial drift (till) in which are water-bearing seams of sand and gravel.	Fresh, copious.
Everest	160		
Argusville	157		
Do	158		
Argusville vicinity	130		
Do	153		
Gardner	125		
Gardner vicinity (many wells)	96–200		
Grandin (within an area of 50 rods).	105		
	158		
	187		
	248		
Traill County:			
Quincy	213		
Kelso	109		
Do	110		
Kelso vicinity	110		
Do	175		
Blanchard (ten wells)	175–404	Partly in Cretaceous	Brackish, copious.
Hillsboro	105		
Do	125		
Do	175		
Do	198		
Grand Forks County:			
Grand Forks	265		
Do	270		
Manvel	166		
Do	175	Thin alluvial and lacustrine beds; below these a great thickness of glacial drift (till), in which are water-bearing seams of sand and gravel.	All in this northern part of the valley are brackish and alkaline.
Walsh County:			
Ardoch	164		
Minto	196		
Do	200		
Grafton	156		
Auburn	175		
Pembina County:			
St. Thomas	175		
Glasston	200		
Hamilton	179		
Bathgate	143		
Bathgate vicinity (eleven wells)	130–160		
Neche vicinity	220		

Wells in North and South Dakota deriving water from the Dakota Sandstone.

Locality.	Depth.	No. of wells.	Diameter of bore.	Temperature.	Pressure (per square inch).	Elevation (surface above sea).	Surface of Dakota (above sea).	Character of water.
	Feet.		*Inches.*	*° Fah.*	*Pounds.*	*Feet.*	*Feet.*	
Vermillion	350					1,150		
Yankton	610	15	6	62	32	1,196	616	Slightly hard; drinkable; used in boilers.
Do	165				140	1,196		
Yankton vicinity		15				1,196		
Tyndall	600				122	1,418		
Mitchell	1,300					1,301		
Plankinton	1,500				140	1,528		
Kimball	1,100				95	1,788		
Chamberlain						1,363		
Letcher	600					1,300		
Woonsocket	1,300				250	1,308		
Artesian City						1,313		
Vilas						1,480		In process.
Huron	863		6	60	170	1,285	422	
Brookings	900					1,636		Said to end in granite.
Miller	1,148		5	80	125	1,587	438	Excellent.
Highmore	1,552		6	68	25	1,890	338	Soft, and of good quality.
Harold	1,300				80	1,801		
Hitchcock	965		3½-4½		186-218	1,139		Used for irrigation.
Redfield						1,300		
Frankfort						1,296		
Faulkton	1,300					1,595		Abandoned; drilling another.
Gettysburgh	1,300					2,082		
Ashton	915		6	55	50	1,296	381	
Andover	1,070		4½	64	90	1,476	406	
Groton	960		5		187	1,301	341	
Aberdeen	908	Many.	5 3/16	60	140-160	1,300	396	
Columbia	965		4⅜	60	176	1,304	339	Soft.
Ipswich	1,270		6	65	70	1,530	260-300	Soft; slightly brackish.
Ellendale	1,087		4-5-6	65	125	1,453	366	Soft; not pleasant to the taste.
Jamestown	1,476	2	6	70	95	1,400	50	
Jamestown vicinity	1,321							Abandoned.
Devil's Lake	1,511		3½			1,470	39	

Locality.	Artesian head (above sea).	Water supply (per minute).	Area that can be irrigated, allowing six inches of water (estimate for average year).		Area that can be irrigated, allowing twelve inches of water (estimate for dry year).	
			With storage.	Without storage; irrigating season of 70 days.	With storage.	Without storage; irrigating season of 70 days.
	Feet.	*Galls.*	*Acres.*	*Acres.*	*Acres.*	*Acres.*
Vermillion		80	196	50	98	25
Yankton	1,270	3,000	7,333	1,857	3,667	929
Woonsocket	1,885	8,000	19,550	4,952	9,775	2,476
Huron	1,678	1,400	3,422	866	1,711	433
Miller	1,876	1,000	2,444	619	1,222	310
Highmore	1,948	14	34	9	17	4
Ashton	1,411	60	147	37	73	19
Aberdeen	1,670	300	733	186	367	93
Columbia	1,708	3,500	8,557	2,167	4,279	1,084
Ellendale	1,742	600	1,467	371	733	186
Jamestown	1,690	375	917	232	459	116
Devil's Lake	1,575	60	147	37	73	19

Other wells in the Dakotas.

Location.	Depth.	Strata penetrated.	Water supply (per minute.)
	Feet.		*Gallons.*
Grafton	915	Passed through stratified rocks to granite.	1,000.
Tower City	670	Fort Pierre shales to Niobrara horizon.	9½; rises 33 feet.
Casselton and vicinity	317–350	Passed through the Drift into Cretaceous rocks.	Brackish, alkaline, copious.
Amenia and vicinity	250–279	do	
Blanchard and vicinity (six wells)	300	do	Do.
Mayville	395	do	Do.

Wells west of the Dakotas.

Location.	Depth.	Strata penetrated.	Water supply.
	Feet.		
Glendive		Laramie or Fox Hills.	
Miles City (fourteen wells)	180–550	Laramie (?)	
Billings	1,000		Not flowing.
Bozeman			
Helena	160	River gravels	200 gallons per minute.

Wells of Nebraska.

Geological horizon.	Location.	Depth.	Delivery.	Remarks.
		Feet.		
Dakota	St. Helena, Cedar County	466	Copious	Pure.
Carboniferous	Omaha, Douglas County	750	Good	Do.
	Lincoln, Lancaster County	985	Copious	(1) Brine from 244′ (Dakota) cased off. Mineral from 544′ Carboniferous.
	Brownville, Nemaha County	1,001		(2) No other data.
	Beatrice, Gage County	1,200		(3) No flow.

Wells of Kansas.

Geological horizon.	Location.	Depth.	Caliber.	Delivery per minute.	Remarks.
		Feet.	*In.*	*Galls.*	
Tertiary	Edward's well, Meade Co	155	....	36.00	Pure.
Do	....do	165	....	32.4	Do.
Do	....do	185	....	29.6	Do.
Do	Mart's well, Meade County	140	....	66.6	Do.
Do	Bower's well, Meade Co	125	....	37.3	Pure; waters rise 15–20 feet above surface. Temperature Meade Co. wells 60° F.
Do	Norman's well, Meade Co.	127	....	37.3	
Do	Cox well, Meade County	175	....	9	Pure.
Do	.... do	142	....	9	Do.
Do	60 other wells, Meade Co	50–175	....	1–30	Do.
Tertiary?	Norton, Norton County	.....	....	.....	No data; may be Dakota; depends on depth.
Do	Hoxie, Sheridan County	.....	....	.....	
Dakota	Smith Centre, Smith Co	.....	....	.....	No data; may be Tertiary; depends on depth.
Do	Great Spirit Spring, Mitchell County.	.....	....	.....	Natural artesian flow.
Do	Miltonvale, Cloud County	.....	....	.....	No data as to water.
Do	Wa Keeney, Trego Co	.....	....	.....	Do.
Do	Hays City, Ellis County	.....	....	.....	Do.
Do	Great Bend, Barton Co	344	....	6.75	Saline; well bored to 1,400 feet, but water from 344 feet; rises 30 feet above surface.
Do	Kinsley, Edwards County	.....	....	.....	No data as to water.
Do	Dodge City, Ford County	.....	....	.....	Do.
Do	Santa Fé, Haskell County	.....	....	.....	Do.
Do	Ulysses, Grant County	.....	....	.....	Do.
Do	Opera House, Coolidge, Hamilton County.	239	....	45	Pure; water rises 15–20 feet above surface; now choked owing to opera house fire. Temperature 61° F.
Do	Peck's well, Coolidge, Hamilton County.	298	6	100	Pure and medicinal; water rises 15–20 feet above surface; medicinal properties slight. Temperature 61° F.
Do	Border's well, near Coolidge, Hamilton County.	200	....	8	Pure; water rises 15–20 feet above surface; used for irrigation. Temperature 61° F.
Do	Burt's well, near Coolidge, Hamilton County.	275	....	35	Do.
Do	Nolan's well, near Coolidge, Hamilton County.	240	....	53	Do.
Do	Rich's well, near Coolidge, Hamilton County.	240	....	50	Do.
Do	Syracuse, Hamilton Co	1,000	....	.....	Water rose only to 90 feet below surface.
Do	Ashland, Clark County	.....	....	.....	No data as to water.
Triassic	Richfield, Morton County.	600	....	6.3	Pure and medicinal: mineralization slight. Temperature 66° F. Dakota furnished no flow; penetrated Trias 265 feet; water from 570 feet.
Do	Larned, Pawnee County	750	....	250	Saline and medicinal; water spouts 10–15 feet high. Temperature 65° F.
Carboniferous	Russell, Russell County	977	....	Good	Saline; may be Triassic.
Do	Winfield, Cowley County.	1,200	....	..do ..	Saline; rises 6 feet above surface.

Wells of Texas.

Geological horizon.	Location.	Depth.	Caliber.	Delivery.	Remarks.
		Feet.	*In.*		
Tertiary	Carrizo Springs, Dimmit County.	175	4	Good..	Pure.
Lower Cretaceous (probably Dakota).	Cotulla, La Salle County..	1,008	....	..do ...	Medicinal; jets above surface 6 ft.; water alkaline-saline. Temperature 86° Fah.
Do	San Antonio, Bexar Co ...	225	....	..do ...	Pure.
Do	San Antonio (near), Bexar County.	450	....	..do ...	Pure and medicinal; could be used for medicinal purposes.
Do	Dallas, Dallas County	750	....	..do ...	Pure.
Do	Fort Worth, Tarrant Co..	350	....	..do ...	Do.
Do	Weatherford, Parker Co..	.....	....	.....	No data as to water.
Do	Canadian, Hemphill Co...	.....	....	.....	
Do	Tascosa, Oldham County..	.....	....	.....	
Do	Armstrong, Armstrong Co	.....	....	.....	
Do	Mobeetie, Wheeler County	.....	....	.....	
Do	Clarendon, Donley County	.....	....	.....	
Do	Childress County	.....	....	.....	
Do	Cottle County	.....	....	.....	
Do	Floyd County.....	.....	....	.....	
Do	Margaret, Hardman Co ...	.....	....	.....	
Do	Crosby County	.....	....	.....	
Do	Pepper's Ranch, Kent Co .	.....	....	.....	
Do	Haskell, Haskell County..	.....	....	.....	
Do	Anson, Jones County	.....	....	.....	
Do	Roby, Fisher County	.....	....	.....	
Do	Snyder, Scurry County ...	.....	....	.....	
Do	Dawson County.....	.....	....	.....	
Do	Trent, Taylor County.....	.....	....	.....	
Do	Sweetwater, Nolan County	.....	....	.....	
Do	Colorado, Mitchell County.	.....	....	.....	
Do	Big Springs, Howard Co .	.....	....	.....	
Do	Marienfeld, Martin Co....	.....	....	.....	
Do	Midland, Midland County.	.....	....	.....	
Do	Glasscock County	.....	....	.....	
Do	Coke County.....	.....	....	.....	
Do	San Angelo, Tom Green County.	.....	....	.....	
Do	Centralia, Tom Green Co..	.....	....	.....	
Do	Aroya, Ward County	.....	....	.....	
Do	Toyah, Reeves County....	.....	....	.....	
Do	Wild Horse, El Paso Co ..	.....	....	.....	
Carboniferous	Wichita Falls, Wichita County.	.....	....	.....	
Do	Archer, Archer County ...	.....	....	.....	
Do	Henrietta, Clay County ...	.....	....	.....	
Do	Montague, Montague.....	.....	....	.....	
Do	Throckmorton, Throckmorton County.	.....	....	.....	
Do	Jacksborough, Jack Co ...	.....	....	.....	
Do	Palo Pinto, Palo Pinto Co.	.....	....	.....	
Do	.....do	.....	....	.....	
Do	Albany, Shackleford Co...	.....	....	.....	
Do	Abilene, Taylor County ..	.....	....	.....	
Do	Tebo, Taylor County	.....	....	.....	
Do	Baird, Callahan County...	.....	....	.....	
Do	Eastland, Eastland Co....	.....	....	.....	
Do	Eastland County.....	.....	....	.....	
Do	.....do	.....	....	.....	
Do	Stephenville, Erath Co ...	.....	....	.....	
Do	Comanche, Comanche Co..	.....	....	.....	
Do	Coleman, Coleman Co.....	.....	....	.....	
Do	.....do	.....	....	.....	
Do	Runnells, Runnells Co....	.....	....	.....	
Do	San Saba, San Saba Co....	.....	....	.....	

Dakota sandstone.—As already stated, this sandstone is the most important source of artesian water in the region of the Great Plains. It is believed that it has greater importance as a store-house of water for irrigation than all of the other formations of the same region from which it is possible to derive supply by artesian wells. Its discussion and investigation must constitute the chief part of the discussion and investigation of the artesian problems of the Great Plains.

The formations of the northern part of the plains were early investigated by Dr. F. V. Hayden, who gives the following section:

Name.	Character of strata.	Thickness.
		Feet.
Loup River beds	Fine loose sand, with some layers of limestone	300–400
White River group	White and light drab clays, with some cavities of sandstone and local layers of limestone.	1,000
Wind River deposits	Exposed principally in Nebraska	1,500–2,000
"Fort Union," Laramie	Sandstone with shale	2,000–10,000
Fox Hill	Gray ferruginous and yellow sandstone and arenaceous clays.	500
Fort Pierre	Dark gray plastic clays above; dark beds of very fine unctuous clay, containing much carbonaceous matter with veins and seams of gypsum, etc., below.	700
Niobrara	Lead gray calcareous marls above; light yellowish and whitish limestones below.	200
Fort Benton	Dark gray laminated clays, sometimes alternating near the upper part with layers of light gray limestone.	800
Dakota	Yellowish, reddish, and occasionally white sandstone, with alternations of various colored clays and beds of lignite.	400

From this section it appears that the sandstone has such depth as to constitute it a large reservoir, and that it is covered by deep deposits of clay or clay-shale, admirably calculated to prevent the escape of the water. Further south the data in regard to its thickness are less precise, but there is reason to believe that it underlies a very large portion of the Plains from the Canadian boundary to Mexico, and from the foothills of the Rocky Mountains eastward to near the eastern border of the Dakotas and Nebraska and to the middle of Kansas and Indian Territory. In Texas it probably extends still farther eastward, but is divided by erosion midway. In North and South Dakota its eastern margin is concealed beneath Pleistocene deposits, but it is believed to terminate against the older rocks of that region, and to be overlapped by the clay of the Cretaceous in such a way as to prevent the rapid escape of water from its margin. In Nebraska, Kansas, and Indian Territory it reaches the surface along its eastern margin. In Texas these relations are not well known.

Its water supply is received along the foot of the Rocky Mountains, where it exhibits a nearly continuous outcrop. It is believed that there is a continuous discharge from its eastern margin, at least where that margin is not protected by heavy deposits of Upper Cretaceous clays. It therefore constitutes what has been styled an imperfect reservoir, but the conditions for artesian flow are more favorable in the Dakotas than in the States immediately south, and it is not improbable that they are again favorable in some parts of Texas. The above tables show that the wells of the James River valley exhibit higher pressure and a greater discharge than those of Nebraska and Kansas, where the eastern outcrop is uncovered, and further indication of the eastward movement of its water is found in the fact that the hydraulic head, as measured in the Dakotas, rises from east to west. The hydraulic head, or the height to which a column of water would rise under the static pressure, is 1,948 feet at Highmore, 1,876 feet at Miller, and 1,678 feet at Huron, reckoning in each case from sea-level. From Highmore to Huron the distance is 62 miles, giving an average fall of $4\frac{1}{3}$ feet per mile.

The sandstone reaches the surface at the west by an upward curve, and thus presents but a narrow belt of exposed surface. This belt is estimated to occupy an average width of about 800 feet for the region from Colorado to the northern boundary, and not enough is known of the border of the formation south of Colorado to form an estimate. The

outcropping edge pursues a sinuous course and thereby increases the exposed area. Taking this into account, the feeding ground for the reservoir is estimated as the equivalent of a belt one-third of a mile wide from the northern to the southern boundary of the United States. If the rain-fall of this belt be taken at 15 inches, and one-half of this be estimated as lost by running away from the surface and by evaporation, the remainder that goes into the sandstone, if it could all be brought up again by artesian wells, would cover a belt one-fifth of a mile wide from boundary to boundary with 12 inches of water. This may be regarded as the outside limit of the permanent water supply derivable from the sandstone.

In order to estimate the land which may be irrigated let us assume that but half of this supply escapes at the eastern edge of the formation; that the other half can all be brought to the surface through wells; that all the water flowing from the wells through the year can be stored without waste and applied to corps in the season of their growth, and that 6 inches of water will suffice to nourish the crops. We then have as the limiting area which can perpetually be served by the artesian water from the Dakota sandstone, the equivalent of a belt one-fifth of a mile wide and extending from boundary to boundary, or about 175,000 acres.

But the permanent supply is not all which can be drawn from the Dakota sandstone. There is an accumulated store of water competent to produce a temporary flow of importance. This is indicated by the phenomenal flow of some of the wells of the James River valley. The wells already sunk here and there over the valley furnish nearly half as much water as is annually received by the outcrop of the formation along the Rocky Mountains west of the Dakotas, and there can be no question that the flow in this valley can be increased several times by boring additional wells at points properly distributed and selected. The yield of such wells in excess of the permanent supply must draw upon an exhaustible store, and must, therefore, be only temporary, but it may nevertheless prove sufficient to compensate for the outlay, at least if the number of wells bored be not excessive. The determination of the quantity of water thus temporary available is a problem for the geologist and the engineer. The geologist can ascertain the extent, thickness, and porosity of that portion of the Dakota sandstone which lies sufficiently above the level of the James River valley and is otherwise related to it so as to afford a reservoir delivering water under pressure; the engineer can carefully measure the static pressure and the volume of existing and new wells from time to time, and thus get the data for estimating the rate at which the supply is diminishing. When this has been done it will be possible to give intelligent advice as to the exploitation of the formation in that region for purposes of irrigation.

The general character of the geologic data can be indicated by the information already at hand, but the result is necessarily very crude. At its outcrop along the foot of the Rocky Mountains and about the circumference of the Black Hills, the Dakota sandstone dips steeply beneath other rocks, and it is deemed probable that at all points it passes below the level of the James River valley within 3 miles of the outcrop. This gives as the maximum possible extent of efficient reservoir lying west of the Dakotas, 1,200 square miles. Assuming the average thickness of the sandstone as 400 feet, and that the interstices filled with water constitute one-tenth of its volume, we have stored a body of water equivalent to a lake 1,200 square miles in area and 40

feet deep. Such a maximum could only be attained if the reservoir was of the perfect type, and in that case the static pressure at Huron in the James River valley would be about 850 pounds to the square inch. As a matter of observation it is only 170 pounds to the square inch, and we are thus informed that the reservoir of water has a volume far below the possible maximum. If, in view of this consideration, we reduce our estimate 75 per cent., we still have a most important body of water—a body competent to serve, with a layer 6 inches deep, 24,000 square miles of land for one year, or 1,000 square miles for twenty-four years. The assumption that the feeding ground for the artesian water to be raised in the Dakotas is limited by the same parallels of latitude which limit the Dakotas is arbitrary and crude. If the Dakota sandstone is a continuous formation, then a portion of the supply thus derived must be drawn off through Nebraska at the exposed edge in the eastern part of that State, where it is probable that the water finds free escape. On the other hand it is possible that the Dakotas may draw from the sandstone water supplied to it beyond our northern boundary; while it is equally possible that a portion of the water absorbed along the outcrop of the formation in Montana flows northward rather than eastward, so as to contribute to the artesian supply of our Canadian neighbors.

The moderate yield of artesian wells penetrating the Dakota sandstone in Nebraska and Kansas does not warrant the belief that an accumulated store of water is there drawn from, and full data in regard to Texas wells are not yet at hand.

SUMMARY AND CONCLUSIONS.

It has been shown that the supply of water to be obtained through artesian wells is narrowly limited, the limitation arising from natural conditions of reception by reservoirs, transmission through them, and leakage from them, and being expressed practically through the interference of wells one with another. The permanent flow is in some cases much less than the initial flow.

Owing to the cost of well boring, it is not economic to bore wells for the purpose of reclaiming land by artesian water unless the flow obtained exceeds a certain minimum. The economic limit is quickly reached in any district upon the multiplication of wells, and unless well systems are wisely planned there is great danger that the economic limit will be exceeded, and especially that new wells at lower levels will have the effect of destroying wells previously sunk at higher levels. Disappointment is also incurred when the temporary flow resulting from antecedent storage is mistaken for permanent flow. For these reasons exploitation with a drill should be guided by the results of surveys—geologic surveys to determine the stratigraphy and geologic structure, and engineering surveys to determine the limitation of discovered reservoirs. While the Dakota sandstone is one of the most important of the known artesian reservoirs, the amount of land which can be redeemed to agriculture through its aid is yet so small that disastrous results might follow if great expectations were aroused in regard to it.

It is estimated that if all the water received by the Dakota sandstone could be brought to the surface by artesian wells, it would cover to the depth of 1 foot an area of land equivalent, at the utmost, to a belt one-fifth of a mile wide and extending from the Canadian boundary to the Mexican.

This is the outside limit for permanent flow. The temporary flow

may be large, but can not be eatimated from existing data. Such is the complexity of conditions, and so great is the danger of disaster through expensive exploitation in ignorance of the true conditions that the subject demands the most skillful investigation which can be bestowed.

Mr. Chairman, I have laid before you somewhat fully this question of artesian wells, because the people from time to time in the United States have sought to obtain waters for irrigation on the Great Plains from this source. Many years ago Captain (afterwards General) Pope, of the Army, attempted to discover artesian waters on the Staked Plains, and he commanded a military expedition to the country and bored for water, but he failed to find it. Some years ago appropriations were made by Congress to have artesian wells sunk in Colorado and Wyoming, and the work was continued for two years under the direction of the Agricultural Department. I believe that altogether $50,000 was expended, but no artesian waters were discovered. Still the people, now here, now there, from time to time, hope to obtain an artesian water supply sufficient for agriculture; and believing that this supply must always be inadequate, I have presented my views of the matter somewhat in full. It is manifest that the people of that region must resort in times of need to irrigation, and the question arises, is there an adequate source of supply to meet their wants? I think the answer to this question is plain. There are supplies which can be used, and the attention of the people should be called to them. A very small supply can be obtained from artesian wells, as I have shown; but there are other sources of vastly more importance, and I wish to point them out.

I shall call your attention next to the use of pump-wells for irrigation. This source is far greater than that of overflowing wells. The valley sands in all the region of the Plains where irrigation is necessary are great reservoirs of water. I mean that not only the sands of the valleys where great rivers run, but the sands which accumulate in all the small valleys, are storehouses of water. The experience of mankind shows that this supply is worthy of consideration. There is one district in India where 400,000 wells draw water from such reservoirs, and by them an area of more than 1,250,000 acres is irrigated. This, then, is a supply of some real importance that ought not to be neglected. The wells which can be sunk in the sands along the great river valleys are exceedingly important, and the waters can be pumped from them at a comparatively small expense. The sinking of the well itself costs but a trifle, and the pumping is done with great economy. A pump which will irrigate one or two hundred acres of land will cost but $200 or $300, and they are now constructed so simply that they can be operated with little expense and at little cost for fuel to produce the necessary power. These wells are being rapidly developed in some parts of the country, not only on the Great Plains, but in Arizona and elsewhere. If the attention of the people of the sub-humid region is called to this source of supply some good may be done and valuable results may be accomplished.

But yet pump-wells do not constitute the chief source of supply, nor are they the most economic. Irrigation in this sub-humid region will ultimately be practiced in the main by the construction of storm-water reservoirs, or "tanks," as they are usually called. Little valleys or ravines in the hills are dammed, and tanks are constructed in this manner, to be filled with water which is held in ponds or small artificial lakes to be poured over the lands below for their fertilization in times of need.

Much more than one-half of the lands of the world are dependent upon irrigation, and of this amount I estimate that about one-third is dependent upon the utilization of storm-waters in this manner. It is the great source of supply, and to it the farmers of the sub-humid region should be directed.

I have brought, to place before you, a little map of a district of country in India similarly situated on a plain, where the people irrigate a vast extent of country, to show you how they store the storm-waters in that region. The little valleys are well situated for the storage of storm-waters, and they build dams across them and across the running streams, where there are small streams, and store the water in what they call tanks. The sub-humid country, from the British line to the Mexican line, along the one hundredth meridian and eastward, will ultimately have to depend for irrigation chiefly upon the storage of storm-waters, and these can be stored with economy. You can get an acre-foot of water by storing the storm-waters very much cheaper than by getting it from artesian wells, for which you have to bore 300 or 400 feet; so that the general resource of water is from the storage of storm-waters. That is true not only in theory, but is abundantly shown by the experience of mankind throughout the world. In New South Wales $27,000,000 have been expended for the construction of tanks for the storage of storm-waters.

The CHAIRMAN. While on the tank system, I want to ask you a question. This Missouri River here—from a point about here, I think it is, to this point here—has nearly 1,000 feet fall?

Major POWELL. Yes.

The CHAIRMAN. There is a splendid opportunity, it seems to me, to establish a tank system through this country here in this region and obtain the torrential flow from that river, and thus relieve the Lower Mississippi from floods.

Major POWELL. I am going to speak of this other source. Across the Plains in this sub-humid district some great rivers flow, and a portion of these rivers can probably be used in the region under consideration; but not all of them. It is my opinion that the South Platte will ultimately be all used in the arid region of Colorado. The Arkansas will also be used in Colorado; but I do not believe that the Missouri will ultimately be wholly used in the arid region. I think a part, and a very considerable part, can be used in the sub-humid region of which we are now speaking, and that North and South Dakota will ultimately be benefited thereby to a large extent. It seems probable that the waters of the Missouri can be taken out at the great bend. Here it is on the map, Mr. Chairman.

Mr. HERBERT. About how much is it above the sea level in that arid country there?

Major POWELL. Speaking from memory, I should say it is about 2,700 feet.

The CHAIRMAN. I think it is 1,500 feet at Devil's Lake.

Major POWELL. Yes, that country is lower.

The CHAIRMAN. That is lower than the big bend of the Missouri.

Major POWELL. We now believe that the lands in here can be covered if we can get across or through the divide. It is so narrow we think it can be cut, but that has not yet been determined with certainty. All the water of the Missouri must be taken out on the east side, and for 400 or 500 miles the water can not be taken out because it runs in a deep cañon. So the large body of water must be taken out below, in the Dakotas, or wasted. That much we know.

Mr. PICKLER. Is not the artesian supply the same as that running in the bed of the river?

Major POWELL. We do not understand that the artesian supply comes from the river.

Mr. PICKLER. You stated awhile ago that it extended from the British line. Then it must be supplied from the meltings of the snows from the mountains, just as the Missouri River.

Major POWELL. From rains and snows on the foot-hills. The area of supply, so far as we know—and we know it for many miles along the hills—the catchment area, is on an average not more than one-third of a mile in width of exposed surface. That is the edge turned up along the hills.

Mr. PICKLER. Now, for instance, your theory is this water is coming from the Black Hills.

Major POWELL. Running from the west, as the Missouri River.

Mr. PICKLER. Where does that come from?

Major POWELL. The same way; from the west, but far back in the mountains.

Mr. PICKLER. What is the general direction of that subterranean flow?

Major POWELL. Eastward.

Mr. PICKLER. This is the question I asked: Whether or not this flow of subterranean water is as constant as the flow in the bed of the river?

Major POWELL. There is no doubt of it at all. This Dakota Sandstone supplies it perennially just the same way.

Mr. PICKLER. Is it not your theory that this is an underlying sea of water from the British possessions to Texas?

Major POWELL. No, sir; I believe it to be a slow flow through a permeable sandstone which carries the water.

The CHAIRMAN. Has any survey been made to determine the extent of the artesian basins whatever?

Major POWELL. We know this one pretty well now, but I am in hopes of finding more.

Mr. PICKLER. Right south of your finger is the greatest well in Dakota.

The CHAIRMAN. What is the depth of that well?

Mr. PICKLER. Seven hundred and some odd feet.

The CHAIRMAN. At this point here we have a well 1,500 feet, which has a great quantity of water. Here there is a well of 1,400 feet. Here is one of 1,300 feet.

Mr. PICKLER. At Faulkton, Faulk County, where I live, there is a good well, opened recently.

The CHAIRMAN. What is the flow?

Major POWELL. It is not as much as some of the others.

Mr. HATCH. Where is that tremendous flow?

The CHAIRMAN. At Woonsocket.

Mr. HATCH. Mr. Chairman, it is 12 o'clock, and there is a special order of the House, and the House has been in session since 11 o'clock.

Thereupon the committee adjourned.

SELECT COMMITTEE ON IRRIGATION,
Thursday, April 10, 1890.

The committee met pursuant to adjournment, Mr. Vandever in the chair.

STATEMENT OF CAPT. C. E. DUTTON.

The CHAIRMAN. I would simply ask, Captain Dutton, what position you now occupy in regard to this matter of irrigation?

Captain DUTTON. I have charge of the field work under the director of the irrigation survey proper; that is to say, of the engineer and hydrographic branches.

The CHAIRMAN. In connection with the Geological Survey?

Captain DUTTON. Yes, sir.

The CHAIRMAN. You belong to the regular Army?

Captain DUTTON. Yes, sir; I am detailed to the Geological Survey under special authority of law.

The CHAIRMAN. To direct your mind to the subject-matter which is of interest to us all, I would simply like to ask, in your judgment what relation the irrigation survey has to the topographical survey?

Captain DUTTON. That is a pretty broad question to answer. It is of course very largely a topographic question.

The CHAIRMAN. The idea is whether before proceeding with the irrigation survey it is necessary to have a topographical map of the country.

Captain DUTTON. Well sir, the question of necessity is one of degree rather than anything else. A engineer who makes a survey such as the law contemplates, must necessarily have a large amount of topographical knowledge of the district in which he has to work, and a large amount of that knowledge he could derive from a topographical map, but in any event it is absolutely necessary for him to see the country for himsef, and a practical knowledge of the country which an engineer would have to gain would be of a character which could be gained only by an inspection with the eye, and of course for that knowledge no possible map could ever be any substitute. A topographical map would give some information of a very valuable character, and some information of a very precise character, which the engineer could not very well obtain without making his own surveys and estimates.

The CHAIRMAN. Give us an idea of what a topographical survey is in contradistinction to an engineering survey.

Captain DUTTON. A topographical survey is a term about which there has been a good deal of question, as to how it should be defined. I think there is pretty general agreement among topographers and geographers that a topographical map is one which represents the features of the country by means of contour lines, or lines of level, which give us the means of determining with the eye, not merely the relative proportions of parts, but representations of both horizontal extent and vertical extent.

Mr. HANSBROUGH. In other words, a bird's-eye view.

Captain DUTTON. No, sir; it would not be that. You see, the contour represents the topographical feature of a particular country.

The CHAIRMAN. These contour lines of topographical survey, do they run parallel with the drainage of the country?

Captain DUTTON. They are lines of level.

The CHAIRMAN. Do they run transverse to the drainage of the country?

Captain DUTTON. A contour line is supposed to be a line on the surface of the ground, which is everywhere level.

Mr. HANSBROUGH. That is, if you are going to make a ditch run around a hill——

Captain DUTTON. No; an irrigation canal is not level. It has grade to it.

Mr. HANSBROUGH. Yet it would have to be surveyed in order to find that grade.

Captain DUTTON. Yes, sir; but in a certain distance it would pass on the map from one contour to another.

The CHAIRMAN. This goes back to the question I asked in the outset, whether a topographical survey is necessarily preliminary to an irrigation survey?

Captain DUTTON. Of course, the irrigation survey, such as the law contemplates could be carried on without any topographical map; no doubt of that, sir.

The CHAIRMAN. Does a topographical map materially facilitate the irrigation survey of the country? Is it a necessary preliminary to an irrigation survey? We would like to have a little information on this point.

Captain DUTTON. A topographical map would be of some assistance, on the whole a considerable amount of assistance. Perhaps the best evidence of that is the fact that the engineers who are employed now upon irrigation surveys are clamorous for good topographical maps, and they want the best they can get, and maps covering as wide an extent of territory as possible. They find them very useful; but the question of necessity is one of degree.

The CHAIRMAN. That is what we wanted to know. An irrigation survey is different from a topographic survey in what? How is it different from the topographical survey?

Captain DUTTON. My understanding is that the objects which the law contemplated in providing for an irrigation survey were the attainment of information of a character which would not appear at all on an ordinary topographical map. That is to say, what are the number of available reservoir sites, what is the amount of available water supply, where can it be put, upon what lands it ought to be put, how much land can be redemed, in what way and by means of what system of works can it best be done, and what will it cost to do it.

Mr. HANSBROUGH. That is the irrigation survey?

Captain DUTTON. That is the irrigation survey. The law further provides for the discrimination between what is termed irrigable land and non-irrigable land, and makes provision for the withdrawal of irrigable lands from occupation, sale, or entry.

The CHAIRMAN. Is a topographical survey necessary to determine all these questions; is it a necessity?

Captain DUTTON. It is not a necessity; no, sir.

The CHAIRMAN. To what extent is it useful? Does it retard or facilitate the irrigation survey? Is it necessary to wait for a topographical survey in order to determine the irrigation survey?

Captain DUTTON. No, sir; obviously not. The survey can be made without a topographical map. I would simply say a topographical map is a useful accessory to such a survey.

The CHAIRMAN. I understand, then, that the topographical surveys

have been carried on as an adjunct to the geological survey of the country.

Captain DUTTON. They have sir, for many years. To the geological survey I think you may say the topographical survey is absolutely essential in the most rigorous sense of the word, and the geological survey could not be properly made without one.

The CHAIRMAN. Does there seem to be any difference of opinion as far as you know, among irrigation engineers, as to the utility of the topographical survey in determining these drainage lines, these irrigation lines?

Captain DUTTON. So far as I have had opportunity of knowing the opinions of irrigation engineers on this point they do not materially differ.

The CHAIRMAN. What is their opinion—the prevailing opinion?

Captain DUTTON. That a topographical map would be a useful accessory in making a survey, but that a survey could be made without it.

The CHAIRMAN. How long have you been connected with this line of business?

Captain DUTTON. Twelve years, sir.

The CHAIRMAN. Have you traveled over the irrigation district considerably west of the one hundredth meridian, and has it come under your personal observation?

Captain DUTTON. I have spent most of the last fifteen years, except in the severe winter weather, traveling throughout the arid region, in very many parts of it; not quite all.

The CHAIRMAN. Then in your judgment you state you do not deem it particularly necessary to wait for a topographical survey in order to determine the location of reservoirs for the storage of waters and supply of waters to districts requiring irrigation?

Captain DUTTON. I think, sir, it is not absolutely necessary to wait for the maps.

The CHAIRMAN. Did you have anything to do with the Geological Bureau in regard to the apportioning out of the appropriation made by the last Congress for this work?

Captain DUTTON. Do you mean the proportion which was to be assigned to topography?

The CHAIRMAN. Yes.

Captain DUTTON. No, sir; nothing whatever.

The CHAIRMAN. Have we got that law, Mr. White?

The CLERK OF THE COMMITTEE. I will look for it.

The CHAIRMAN. To what does the hydrographic survey refer?

Captain DUTTON. The object of the hydrographic survey is to ascertain the amount of water which is available for purposes of irrigation and for storage in each and every district under observation; also to determine what we call the duty of water. That is, how much land a given quantity of water will irrigate in different parts of the country and in different soils; and incidentally a question of very great importance in that connection, of much more importance than might at first seem, is to determine the rate of loss of water by evaporation, the amount of water recovered by percolations back from the irrigation fields into the beds of streams, and in general to determine the amount of water which is available, and everything which relates to its utilization.

The CHAIRMAN. You consider, then, the hydrographic survey is necessary for an irrigation survey?

Captain DUTTON. Yes, sir. We can not tell to what extent lands of

the West are capable of being redeemed by irrigation until we know how much water we have got.

The CHAIRMAN. We know the quantity of land, and then you ascertain the water and its availability?

Captain DUTTON. Yes, sir.

The CHAIRMAN. How does the topographic survey enable you to determine the available water to any given quantity of land?

Captain DUTTON. The topographic map would give material information regarding the extent of water-sheds, and information as to the distance to which water would have to be carried, a large amount of general information. There are more or less important factors, as questions of distance and differences of altitude, which enter as parts of the problem.

The CHAIRMAN. I do not want to press you upon this point, captain, but you see what the committee desire, to draw these lines of demarkation between the irrigation survey, the hydrographic survey, and the topographic survey, and know how far they go in determining this question. That is the question suggested by the act itself. You know, the act is as follows:

> For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation and the segregation of irrigable lands in such arid region, and for the segregation of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation and for ascertaining the cause thereof and the prevention of floods and overflows, and to make the necessary maps, including the pay of employés in field and in office, and all other necessary expenses connected therewith, the work to be performed by the Geological Survey, under the direction of the Secretary of the Interior, two hundred and fifty thousand dollars, of which sum fifty thousand dollars shall be immediately available, and the Director of the Geological Survey, under supervision of the Secretary of the Interior, shall make a report to Congress on the first Monday in December of each year, showing in detail how the said money has been expended, etc.

The object the committee has in view would be to ascertain how far the topographical survey has gone, whether that is primarily necessary to enable us to solve the problem suggested by the act itself, and whether it is more incidental than primary.

Captain DUTTON. As I have stated, that is a question of degree, which I believe the committee could decide for themselves upon the basis of any facts which you might elicit.

Mr. PICKLER. Could the same result be arrived at without a topographical survey as with it?

Captain DUTTON. Oh, yes, sir, undoubtedly.

Mr. HANSBROUGH. What is the relative difference between the topographic survey and the engineering or irrigation survey over a given basis of country? For instance, take the State of Colorado; what would be the difference in making a topographical survey of an area as large as Colorado and making an irrigation survey? I would like to get the relative cost between the two.

Captain DUTTON. As regards the first part of your question, the topographical map, as I understand it, is designed to give the relative form and position of the surface features, including mountains, valleys, lakes, and rivers. The irrigation survey is intended, as the law provides, to ascertain the amount of irrigable lands, the amount of water available, and the means and the cost of bringing the water and the lands together. [To the stenographer:] Will you please read over the last part of that question?

The stenographer read as follows:

What would be the difference in making a topographical survey of an area as large as Colorado and making an irrigation survey? I would like to get the relative cost between the two.

Captain DUTTON. The cost of making a topograhical survey of course depends upon the amount of accuracy and the amount of detail that are given them. In short, it depends upon the standard of excellency and accuracy which you adopt. If you were to take the standard which is adopted by the present topographical survey, the best way would be to represent that in terms of cost per square mile averaged over the whole country. What that cost is per square mile I do not know exactly, but my impression is that it should be somewhere in the neighborhood of $7 or $8 per square mile; and the State of Colorado, as nearly as I recollect, has something over 100,000 square miles of territory.

Mr. HANSBROUGH. Seven or eight dollars per square mile; that is for the topographical survey?

Captain DUTTON. Yes, sir; the topographical survey. In Colorado, however, a very large proportion of the State has already been surveyed by Dr. Hayden, but upon a small scale, and of a much lower standard than the present geological survey adopts, and in order to obtain a map of that surveyed portion upon the present standard, it might be necessary only to slightly supplement the work, which has already been done at a comparatively small cost, thereby reducing the aggregate cost of the survey. Exactly how much it will be reduced I do not know, and it would be a difficult matter to estimate accurately.

Mr. HANSBROUGH. What I wanted to ascertain was this: if you go into an unexplored country to make a topographical survey, I wanted to find out about what it would cost per square mile to survey an area of country as large as Colorado, and also the cost of an irrigation survey over the same country. Of course I see the difficulty of getting that accurate figuring, but I thought probably you might aggregate something approaching the relative cost of the two surveys.

Captain DUTTON. In an entirely new country, where it is necessary to begin the topographical survey with triangulation and work of that sort, and to accomplish the work upon a scale of accuracy and dimensions now employed in the topographical survey, the cost would probably be in the neighborhood of $10 per square mile. I judge so from the fact, if my understanding is correct, that that has been the cost of similar surveys in Massachusetts and New Jersey, which have been under circumstances approximating very closely to those which you are supposing.

Mr. HANSBROUGH. That is for a topographical survey?

Captain DUTTON. Yes, sir.

Mr. HANSBROUGH. Then for making an irrigation survey of the same region, how much per square mile would you have to pay?

Captain DUTTON. I do not think it would be practical to estimate the cost of an irrigation survey by the square mile. It would have to be estimated by the degree and magnitude of the irrigation works and irrigation possibilities, and these vary enormously. In some of the States and Territories there are almost none at all, and it would not be worth wasting much money on surveys.

Mr. HANSBROUGH. Upon the whole, is a topographical survey more expensive than an irrigation survey?

Captain DUTTON. I do not well see how they can be compared without a little more definite understanding of what is intended by your

question. I have already stated we can reckon the cost of a topographical survey at a certain price per square mile if a standard map is first determined on; but we can not reckon an irrigation survey by the square mile at all. It has very little to do with the square mile. It is a question of the magnitude and the cost of the works themselves, and it would be a more rational way to estimate the cost of surveys at a certain percentage of the cost of finished works which they are intended to explain. We can reckon them at from 2 to 4 per cent. of the finished works. In some parts of the country these works would be very enormous and very expensive and very efficient, and would irrigate large quantities of irrigable land. In other portions of the country the works would be very few and far between, and would irrigate but a small quantity of land.

Mr. HANSBROUGH. What is the extent of the survey made on the Rio Grande by Mr. Follet, I think that is his name.

Captain DUTTON. Yes, sir; Mr. Follet's survey was limited wholly to a survey to see if a reservoir could be created by a dam across the pass at El Paso, and the cost of constructing that dam. That was the limit of Mr. Follet's survey there.

Mr. HANSBROUGH. Can you give us the expense of that survey? About what did it cost to make that survey?

Captain DUTTON. You mean the cost of making the survey there?

Mr. HANSBROUGH. Yes, sir; of the operations there.

Captain DUTTON. I have not the figures with me.

Mr. LANHAM. He was there about three to four months.

Captain DUTTON. No, I think he was there two months. I was looking at these figures a little while ago, and although I hardly dare trust my memory in this matter, I should say as nearly as I can recollect it cost about $2,200.

Mr. HANSBROUGH. Covering a large extent of country?

Captain DUTTON. Covering simply the reservoir site and the dam site. That included, however, some pretty extensive and difficult relocation surveys of two railroads through a very rocky and much cut-up country.

The CHAIRMAN. Unless the committee has other special questions to submit to Captain Dutton, I would like for the committee to hear Mr. Nettleton. Then, if necessary hereafter to clear up any questions, we can call on Captain Dutton again. If you have anything further to add to what you have already stated, we will be very pleased to hear you.

Captain DUTTON. I am only here to answer questions. I am not here to volunteer information.

The CHAIRMAN. Then we will hear Mr. Nettleton.

STATEMENT OF MR. E. S. NETTLETON, SUPERVISING ENGINEER, IRRIGATION SURVEY, GEOLOGICAL BUREAU.

The CHAIRMAN. Have you been engaged with the regular Army also?

Mr. NETTLETON. No, sir.

The CHAIRMAN. Will you please tell your profession and line of employment?

Mr. NETTLETON. I am a civil engineer, engaged at present as supervising engineer of the irrigation survey, eastern division.

The CHAIRMAN. You will see by the lines of the examination of Captain Dutton that we are in pursuit of definite information in regard to

the relative features of the topographical and irrigation surveys and as to whether a general topographic survey of the entire country is a necessary preliminary to determine an irrigation and hydrographic survey of a given region of country.

Mr. NETTLETON. No, sir; I do not think it is necessary. It may be convenient like all other maps, but I do not consider it necessary.

The CHAIRMAN. Do you know anything about the relative divisions of the funds appropriated under this act? But I do not know whether that is a proper question to address to you. What officer of the Geological Bureau—did Major Powell himself especially direct this division of this fund?

Mr. NETTLETON. I understand the Director made the allotment to the engineering and hydrographic survey, also to the topographic survey. I think the captain here can tell you what was allotted to him out of the appropriation. I only know it from hearsay.

The CHAIRMAN. You only know from hearsay in relation to special allotments to the topographical and hydrographic and irrigation work. Major Powell could probably answer that more definitely himself, perhaps. It was not made under your direction?

Mr. NETTLETON. No, sir. My work is simply to supervise the work of the engineers, without any supposed knowledge of the cost of the work or how the appropriation is allotted.

The CHAIRMAN. You have supervision of the entire district?

Mr. NETTLETON. Yes sir, of the eastern part of the arid region.

The CHAIRMAN. What portion is that?

Mr. NETTLETON. All that drained by the Gulf of Mexico. It includes upper Missouri, Montana, and Wyoming, the two Dakotas, Colorada, Nebraska, Kansas, New Mexico, and Texas.

Mr. PICKLER. I would like to ask what an irrigation survey of such a country as the two Dakotas, Kansas, Nebraska, and Texas would be; of what would an irrigation survey consist?

Mr. NETTLETON. It would consist, I think, mainly in determining how the arid country could be redeemed by waters that are available in that country; whether they are under the surface, whether running streams, or lakes, or artesian wells, or underground flows of any kind. That would be an irrigation survey.

Mr. PICKLER. Does this take a long or a short time, comparatively? Would that depend upon the surveys?

Mr. NETTLETON. That would depend upon the character of the country, and the degree of accuracy of the surveys. If better surveys were required to determine the farthest limit possible of the lands to be reclaimed by water, it might be a considerably expensive work; but generally it is not very expensive.

Mr. PICKLER. In what portion of this country have you been engaged?

Mr. NETTLETON. I have been twenty years in this irrigation work, mainly in Colorado, but considerably in Wyoming, Idaho, and New Mexico, and a little in Utah; but my work has been mainly in Colorado.

The CHAIRMAN. Right here allow me to ask you this question. I understand Captain Dutton is chief of the irrigation survey?

Captain DUTTON. I have entire charge under the Director, and am chief engineer of the whole field work. There are two supervising engineers who are appointed for this purpose. In determining what works are best suited for the development of the irrigation of that country, it is necessary to prepare projects after the inspection of the ground; and it was deemed unwise to leave the determination of such

questions solely to the division engineer who was sent there, and it was thought that at every step of the process the work should be inspected and should receive the opinion and judgment of the most competent men who could be found to investigate and pass judgment upon them. Mr. Nettleton was selected from his very high reputation and eminent standing as a practical irrigation engineer, and Mr. William Ham Hall, of California, was selected for a similar purpose. The administration of the work is wholly in my hands under the Director. The expert and professional part of irrigation surveys are under the supervision and inspection of Mr. Nettleton and Mr. Hall as consulting engineers.

Mr. HANSBROUGH. Can you give us the amount of money spent on this irrigation survey—spent under your direction in the field?

Captain DUTTON. Under the first appropaiation of $100,000, $36,000 was allotted for the engineering and hydrographic work, all of which was expended for the fiscal year ending June 30, 1889, and something slightly over that—a few hundred dollars over it. In the present fiscal year there was allotted for the engineering and hydrographic work $110,000, of which a balance of possibly $20,000 now remains unexpended.

Mr. PICKLER. You have spent, then, about $90,000.

The CHAIRMAN. What was done with the balance of the funds you say were allotted under the first appropriation of $100,000 and under subsequent appropriations?

Captain DUTTON. I only know by general information, and my information is not official. Of the first appropriation there was some reservation for a contingent fund, the nature of which I can explain if you desire, and the balance of it was applied to topography.

The CHAIRMAN. What proportion to topographic, and what proportion to hydrographic and irrigation surveys?

Captain DUTTON. Under the present appropriation of $250,000 my understanding is that $120,000 was allotted to the topographic work, $110,000 to the engineering and hydrographic work, and a reserve fund of $20,000 was kept by the Director to meet expenses for the general benefit of both branches for extra office work, and for payment of such expenses as could be paid only by the central office at Washington; also as a guaranty fund at the end of the year to prevent either branch from overrunning the total appropriation.

Mr. LANHAM. I would like to ask if Major Powell has made a report recently covering the expenses in his bureau?

Captain DUTTON. I do not know, sir.

Mr. LANHAM. I had some information of the fact that he had submitted a report recently, although I have not seen it.

The CHAIRMAN. Was that a report to the Interior Department?

Mr. LANHAM. I do not know, sir, but I believe it was to the Secretary of the Interior—how is that?

Mr. CROFFUT. He has made a report to Congress through the Interior Department, printed copies of which will be in your hands within a week. There are a hundred pages or over.

Mr. PICKLER. Has your irrigation survey and the topographical survey been over the same country?

Captain DUTTON. In only one drainage basin, so far as I know, and that is the Arkansas basin in Colorado.

Mr. PICKLER. Where a topographical survey has been made, must, as a matter of necessity, an irrigation survey be made for irrigation purposes? I mean, having a topographical survey, must you in addi-

tion have an irrigation survey, in order to derive results from irrigation?

Captain DUTTON. Yes, sir.

Mr. HANSBROUGH. Did I understand you to say that of the $250,000 appropriated for irrigation survey $120,000 has been spent for a topographical survey?

Captain DUTTON. That has been the amount allotted.

Mr. HANSBROUGH. And $110,000 has been allotted for irrigation survey?

Captain DUTTON. Yes, sir.

Mr. HANSBROUGH. And about $20,000 for incidental expenses?

Captain DUTTON. Yes, sir.

The CHAIRMAN. Mr. Nettleton, we have no further specific questions, and if there is any further information that you deem of importance on this question, we would be glad to have it. We do not want to put you on the stand and subject you to a systematic cross-examination as if we had you in court. We had only one object in having all this, and that is to get a full comprehension and understanding of this irrigation system, because of course we are not experts on this subject and you gentlemen have superior means of information, as you have charge of the practical workings.

Mr. NETTLETON. Of course we are aware this is a question to be settled by the two committees.

The CHAIRMAN. Does any member of the committee desire to put any further questions at this time? I was going to say that these gentlemen are here on duty, and can be reached at any time.

Mr. HANSBROUGH. I would like to ask something of the character of the proposed preliminary work in the artesian well districts, as to what you deem the proper work to be done—the preliminary work in the artesian well districts.

Mr. NETTLETON. Something as proposed in the bill you have drawn up here. This not only includes artesian wells, but underflow waters, I see.

Mr. HANSBROUGH. Would you advise the sinking of experimental wells to ascertain the extent of the artesian basis?

Mr. NETTLETON. Well, probably the first thing to do would be to make a geological examination, and also a better examination of the existing wells, ascertaining their depth and their flow and in what rocks the water is found, ascertaining the location with reference to the sea-level of these water-bearing strata, carrying that on over the whole extent of territory that has been developed by artesian wells. That would give data, and enable us to form a pretty good estimate of the dip and inclination of the water-bearing strata, and may give some idea and determine where that comes from by knowing the pressure in these wells.

Mr. HANSBROUGH. Would you advise an examination of the character of the waters now coming from these wells, with reference to the effect of that water upon vegetation?

Mr. NETTLETON. Certainly I would.

Mr. HANSBROUGH. That would be part of the investigation?

Mr. NETTLETON. Yes, sir. If I was examining for the purpose of irrigation from these wells, I would want to know not only its quality, but its temperature. Certainly these are very inexpensive things to examine.

The CHAIRMAN. The water of artesian wells comes surcharged from mineral properties, which adds to the fertilization of the land.

Mr. NETTLETON. No, sir, I think as a general rule it is the opposite.

The CHAIRMAN. How is it with the flow of water that comes from mountain sources?

Mr. NETTLETON. That is charged with properties, silted up with material which is very beneficial, and is a rich fertilizer; but the water which comes from artesian wells is generally not of a character of water which is running in the mountain streams, that contain the wash from the mountains, etc.

The CHAIRMAN. So that the artesian water is better for domestic purposes than for irrigation?

Mr. NETTLETON. Yes, sir.

Mr. PICKLER. Do you know of any artesian well water which is actually deleterious to vegetation?

Mr. NETTLETON. We have a good many salt artesian waters that would not be good waters for irrigation purposes.

The CHAIRMAN. Where are they located?

Mr. CONNELL. In Lincoln, Nebr., there is a stream from an artesian well nearly as large as that [illustrating], where the water is as salt as brine taken from a pork barrel. That is right in the center of the city of Lincoln.

The CHAIRMAN. You know salt is produced from artesian water.

Mr. HANSBROUGH. That will make a salt river.

Mr. CONNELL. That is a creek that some politicians go up occasionally.

The CHAIRMAN. I do not think, however, I understand that we ought to draw the inference that Salt Lake and Pyramid Lake were originally salt. We do not understand that their saline properties come from the artesian water from below; but, as I understand it, that is fresh water collected in these pools, but continual evaporation takes off the pure water and leaves only the salty remaining, so that in the course of time the water becomes very salt. However, I am not giving information, as most of us know that.

We are very much obliged for your attendance this morning, and perhaps some member of the committee may like to interview you again on this subject. You have given us a start in a new direction, and we desire to thank you.

Mr. HANSBROUGH. I would like to ask Captain Dutton if a topographical survey is necessary to the discovery and location of reservoir sites?

Captain DUTTON. Oh, no, sir. The discovery of reservoir sites would be a necessary incident of an engineer's visit and acquaintance with the country. When an engineer goes into a district to ascertain its resources for irrigation purposes, he must necessarily become personally acquainted with that district. He has to go over it and examine it with his own eye. A topographical map would be useful in such an examination, as any map would, but it never could take the place of the engineer's personal knowledge which he would naturally gain in the course of an examination or reconnaisance of that kind. An engineer would be very sure to find all the reservoir sites there were.

Mr. HANSBROUGH. Then a topographical survey would not be necessary before the segregation of the irrigable lands; that is, the segregation of the irrigable lands from the non-irrigable lands?

Captain DUTTON. The segregation of the irrigable lands is an extremely difficult question. It is one which has given great perplexity ever since this work was started. It was very difficult to decide what was irrigable land and what was not. Now there are large areas which can be irrigated if people choose to do so, but which ought not

to be irrigated. There are areas upon which it is possible to bring water but which no prudent man would think of doing. The question arises, where are we to stop in our attempt to delimit the irrigable land from the non-irrigable land? That happens to be the whole question which lies behind this irrigation survey. What was the law passed for? What did it endeavor to accomplish and what results did it endeavor to bring about? It gives no definition of irrigable land, and any decision as to whether a given tract is irrigable or not has got to be arrived at by a broad and far-reaching interpretation of the whole law. It involves the whole temper and tone of the legislation upon the subject. Well, now, my understanding is this, that the members of Congress, both in the House and Senate, from the western region moved Congress to take action in this matter because the way in which irrigation was going on was unsatisfactory. It developed a good many evils which it was hoped might be removed if Congress could be induced to take hold of the subject. What were the principal evils? If you go to the root of the whole matter, taking the facts as they are, with a knowledge of the subject and knowledge of the people and the practices out there, you will see that they resolve themselves into just two things; or perhaps you might put them under one general characterization. That is to say, it is a want of proper regulation; and that resolves itself into two different heads. The first is the unlimited license of any man to go on any river, at any point of that river, lay claim to any water running in that river, take it out by any route he pleases, through any country he pleases, and put it on any piece of land he pleases, utterly irrespective of how that may influence future developments, utterly regardless of how much of an obstacle it may become to future developments. The second difficulty has been a similar one in reference to the land.

Throughout the humid land through the Mississippi Valley and prairie country, it made no difference where a man settled. The land was equal, going from Canada to the Gulf of Mexico; one acre was just as good as another, and it made no difference whether a man took it up sooner or later. It would all have to be occupied by somebody and sooner or later every block would fall into its place and nobody was going to be hurt by any man settling on one place rather than another, but when you go out into this arid region it becomes a momentous question where a man should be allowed to take up land. It is a vital question to a whole community and to the whole future prospects of the people out there where people should settle, because it is more of a water question than a land question. The people of that country, in order that they may utilize their natural resources to the greatest possible advantage, ought to be growing up under a policy which will naturally drive the people or induce the people to settle upon the best lands where the product per acre will be the largest, where the utility of the water on every acre of land will be the largest, and where the greatest economy can be secured in the use and application of water to ground, because there is no water to spare, as the land is in excess, and water is a desideratum. At the beginning of the settlement of this region, a few poor people of the roving and straggling sort will go to a beautiful district which is in a state of nature, and they will take out with their picks and shovels and with not a dollar of what is usually termed capital a ditch which will irrigate a few acres of land, and they will make a success of their farm because that is a country where there is a vast local demand for the products of the soil. That will attract other settlers, and presently a new ditch has to be taken out, and it is

taken out in the same way. Of course these people only take out small streams because they can not handle the large ones.

So canal after canal and ditch after ditch is taken out, until you have got a vast multiplicity of small canals and ditches; but these small ditches are enormously wasteful of water. It is the most extravagant way in which water can be applied to the soil. Presently, increasing population demands more water, and how can you get it? A single "high-line" ditch, as it is termed, can be taken out, which will take all the water of the stream. Instead of having a long narrow strip of ground under it along which for many miles a little stream of water has to be carried, subject to evaporation on the way, it has a broad compact area under it commanded by a comparatively short line so that the water can be turned and applied with the utmost economy. Then if necessary for increased supply at any future time, any high line ditch can be supplemented by storage reservoirs, and the supply can be increased many fold, as it could not be under the primitive system. Now, here is the point. These primitive ditches acquire vested rights, which become in turn an almost insuperable obstruction to the enlarged and improved irrigation works. These vested rights have a fictitious value. It is a value which has grown proportionally to the profit which can be derived from the investment of capital, and somehow they must be gotten out of the way They must be replaced by a better system. Now the man who has got a right to obstruct a work of great importance is not going to get out of the way unless he is paid for it, and he has got to be bought out. Let us see how that works. Let us take for example the Snake River country. That is a comparatively new country for irrigation settlement, and the possibilities there are more magnificent than in any other region I know of in the West. They are simply immense. Under a thorough development, well systematized, well arranged, and a well organized system of hydraulic works, you can probably irrigate 3,000,000 acres of land. As the development is now going on, it will be extremely doubtful if we will be able to irrigate 300,000 acres of land. The disparity I believe to be at least ten to one.

There are dozens of men who are making most strenuous efforts to raise a few thousand dollars of capital to go there and take ditches out of that big river and run them anywhere, only so they get a ditch with some good land under it, not because they want to settle and occupy that land, but simply because they know the time is coming when great high-line ditches will be necessary, which will be compelled to buy them out at a fictitious valuation. These pioneer ditches become a great obstruction to the development of the country, and just as soon as people find that they can not get any more land in a more desirable part of the country, what do they do? They say they must have land somewhere, so they go up into the mountains, into the mountain meadows, and they take streams and turn them out on the high mountain lands, which are utterly unable to raise any crop except a little wild oats, and use the water to grow wild mountain grasses to make a little hay, a poor kind of hay, so as to keep a few starving cattle through the winter, and in these mountain meadows they will take up more water to irrigate an acre of ground than would suffice for the irrigation of 5 or 6 acres down in the better lands below. Any attempt to stop these men, and any attempt to interfere with the vested rights, is met with a shot-gun. They have filed their homestead and their pre-emption claims; they have got the lands and got the water, and nothing but warfare can ever wrest it from them. Now these people

should be prevented from going upon these lands, and the whole drift and whole tendency of legislation should be to influence men to go upon the best lands where the water can be utilized to the greatest advantage and where the largest number of men can settle and make the largest amount of profit by their doing so.

Mr. HANSBROUGH. That is a very strong point.

Captain DUTTON. If I was called upon to advise a man how to get a herd of cattle, horses, or sheep to go into a fine good pasture, I would suggest to him that he let down the bars of that pasture and put up the bars against every other; and in segregation of land I think I should do something like this. I would segregate every acre of land which could by any possibility be considered irrigable, no matter where it was, even if on the mountain tops. Provided we could get water to it I would segregate it. I would then find out the best lands on which water ought to be put and the lands which ought to be irrigated. These I would open to settlement and rigorously prohibit the opening and settlement for agricultural purposes of any other lands. In that way you can constrain settlement and open lands where they ought to be settled and close them where they ought not to be.

To come back to what I was saying a little while ago. It made no difference in the Mississippi Valley where people settled, but it makes a vast deal of difference in the arid region. It makes all the difference in the world. They ought not to be encouraged or permitted to settle in a region where they are going to imperil and obstruct the future development of the most productive and best parts of the country, and that is exactly what they are doing to-day; and that is exactly the reason which led to the application to Congress to take hold of this matter.

That is my understanding of it, and it has been that principle by which I have governed myself in making selections of irrigable lands. I have selected in some drainage basins every piece of land which could be by the utmost possibility considered a piece of irrigable land, and recommended it for withdrawal from occupation and entry. The law provides that the President may by proclamation open to homestead any lands which have been segregated whenever it becomes desirable to do so. If all the lands which can possibly be irrigated are segregated, and only the lands which ought to be irrigated opened to settlement, you have got the whole thing in your control.

Mr. LANHAM. I would like to hear the gentleman further, but I would suggest to the chairman that it is now after 12 o'clock, and I shall have to go over to the House. I would be very glad to hear him further myself.

Thereupon the committee adjourned, to meet on Thursday next.

SELECT COMMITTEE ON IRRIGATION,
Thursday, April 17, 1890.

The committee met pursuant to adjournment, Mr. Hansbrough in the chair.

STATEMENT OF MAJ. J. W. POWELL—Continued.

Major POWELL said:

Mr. Chairman and gentlemen of the committee, I want this morning to lay before you the operations of the Irrigation Survey, explaining what has been done up to the present time, and the plan and purposes of the work.

The first appropriation made for the survey was on October 2, 1888, being $100,000. The second appropriation, made for the present fiscal year (which will be expended by the close of the year), was $250,000; making in all an appropriation for the two years of $350,000.

The work of the survey is divided into three parts. I shall take these parts up in order, and try to show the relation of the parts or branches of the work and the outcome of the work.

The statute provides that the survey shall determine the extent to which the arid lands can be redeemed by irrigation. That is the first provision of the statute. The next provides that reservoir sites shall be selected and withdrawn from the market; that canal sites also shall be selected and withdrawn from the market. These canals are of two classes: those which carry the water from streams to reservoirs—the reservoirs in general are not put on the streams themselves, as will appear further on in my remarks—and those that deliver the waters from the reservoirs to the lands. So we have to discover two classes of canal sites: diverting canals—canals by which water is diverted from streams to reservoirs—and canals from the reservoirs to the irrigable lands; and such canal sites and head-work sites or dam sites and reservoirs are nominated in the statute. The next provision of the statute is that the irrigable land shall also be selected, and that all land susceptible of irrigation under the works planned shall be withdrawn from the market except under the homestead act. The President may restore at any time all of this irrigable land to the provisions of the homestead act.

But the statute practically provides that they shall be withdrawn from the operations of the desert-land act, the pre-emption act, and the timber-culture act, but restores the lands to sale under the homestead act. Again, the statute provides that the dams, canals, and reservoirs shall be planned, and the cost thereof determined and reported to Congress. Substantially these are the requirements of the statute.

In order to do this it becomes necessary to make a survey of the country, first for the discovery of the points on the streams where the water can be diverted to the best advantage. This is exceedingly variable along the course of a stream, there being some places where it can be taken out advantageouly, and other places where it can not be taken out without great cost, and many other places where it can not be taken out at all. So streams themselves have to be examined to discover points where diverting dams can be constructed and the waters taken out and put into the reservoirs and on the lands.

The next thing is to discover the reservoir sites. Now, in every region of country which we have examined, and of which we have any knowledge, there are more reservoir sites than are needed, but they vary

greatly in character, and many good reservoir sites are not sites where the water can be stored cheaply and economically, and the important point is then to discover all the reservoir sites and to make selection of the best, all things considered,—where reservoirs can be constructed cheapest, and where the water can be taken to them from the streams with reasonable economy, and where the water can be taken from them to the lands to advantage. Of course a great many reservoir sites could be discovered on low grounds. There is no difficulty in that; but that is where the water can not be taken out on the lands. It goes without saying. But the thing is to discover such sites that water from them can be utilized on the lands below.

It will be noticed, then, we first have to make discovery of places along the streams to divert the water and discover lines of canals from reservoir sites to the lands themselves. Now, it chances that the best reservoir sites are, in the main, far away from the lands. Whenever it is possible, water should be stored high in the mountains, where the evaporation is less. The evaporation on the plains and in the low valleys may be twice as great as in the mountains. The evaporation in the mountains may be 3 or 4 feet annually, and may be 6 or 8 feet annually on the plains, and the difference means a great loss of water. Still, it can not always be stored above, and when we have discovered the principal sites above, we have then to go below into the region occupied for irrigation, the region of irrigable lands, and to discover additional sites there. The waters stored in the mountains are discharged again to the channels of the streams, and flow down the natural channels until they are diverted below. Waters which are stored in the plains and valleys are taken out of the natural streams and stored there, and afterwards taken to the lands themselves. The problem, then, is to discover all these things, and having discovered them, to make accurate, comparatively minute, surveys of the dam sites, reservoir sites, and canal sites, and of the irrigable lands. A general survey of the entire country is necessary to discover these things. A special or specific survey is necessary after the sites and lands are selected, to report upon the cost of the works. For example, there may be from the river to the reservoir site many ways to take the water, and we wish to discover the best. There may be many ways to take the water from the reservoirs to the land, and we wish to discover the best; and having discovered the best line, that one line we survey with greater care, as the general survey is a survey for discovery. This survey for discovery we call a topographic survey, and its purpose is for discovery, as I have briefly stated.

It serves a further purpose, which I shall explain in this manner. In order to plan works, as the statute requires, and in order to discover the extent to which the arid lands can be redeemed by irrigation, it becomes necessary to determine how much water there is. You can not plan reservoirs until you know how much water they are to hold. You can not plan canals until you know how much water they are to carry. You can not discover the irrigable lands and determine their extent until you know what waters are to serve them. The lands being in excess of the water, that is, there being more land than the water will serve, the lands have to be selected, and we do not know how to select the lands until we know how much water can be found to be used upon them.

The question, then, of measuring the waters is the great problem to be solved, and to this problem I have devoted much time and much thought for many years. Fifteen or sixteen years ago I prepared a map of Utah. I was conducting surveys there, and I prepared a map of Utah and reported on irrigation in that Territory, and on that map I

delineated the areas which can be redeemed by irrigation during the season of irrigation without storage. At that time people were not thinking of storage, and were not resorting to storage. In order to do that it became necessary to discover how much water the streams would carry; what volume of water was in the several streams simply during the season of irrigation, which lasts from sixty to eighty days in Utah. The survey was not specifically for that purpose, but a topographic survey, and we did not stop to gauge the streams with great care, but to get at some general results, and we gauged in only a rough manner.

The method of gauging streams has been improved from time to time since then, until at last we can gauge streams with considerable accuracy, but it is expensive and takes a long time. To gauge a stream we need first to record its rise and fall during the year. Taking a section of the stream, we determine its rise and fall by means of a nilometer, as we call it, on which is recorded automatically the rise and fall. A float lifts an apparatus which makes a record on a paper, which shows how the river rises and falls from hour to hour, from day to day, from month to month, and from year to year. Then we make an examination and survey of a cross-section of the stream; we find what the cross-section of the water is during each hour and each day and each year, but the water may flow swiftly by or slowly by, as the case may be, and we must know something more; but to know this something more is quite expensive. We must know the velocity of the water passing through the cross-section. This is measured with a current gauge. Then the velocity varies from top to bottom, and from side to center, and we must know the velocity of all portions of the section. Then the velocity changes with the rise and fall of the river. When the river is low the velocity is slight, and when the river is high the velocity is great, and it becomes necessary to measure the velocity at different stages of the water, from low water to high water, with current meters.

We can gauge a stream to-day and find its volume, but that will give us no clew to its volume to-morrow; so this gauging has to be continued until the maximum flow of the stream is found, which may occur once in two, ten, or twenty years, as the case may be. Then the minimum flow of the stream, which may occur at long intervals, must be known. In order to know what that stream will carry from year to year—the mean flow, the maximum flow, and the minimum flow—it becomes necessary to keep up the gauging for a long term of years. If we resort to no other method than that which I have described, on a pretty careful examination of the matter we find that to plan these reservoirs we shall have to make gaugings of this character to determine the quantity of the water at from 16,000 to 20,000 places. I have a map of a little stream here—the Apishapa River in the Arkansas Basin—giving the reservoir sites, which are marked in blue, and the lands that can be irrigated, which are marked in green. Here is the catchment area in the mountains. Now, there are twenty-two reservoirs there on this little stream. To plan these reservoirs we must have twenty-two gauging stations or measurements of the amount of water. Now, going over the map of the arid region, as we have done with some care in the office, we have found that it will be necessary to have somewhere from 16,000 to 22,000 measurements of this kind, and by the plan which I have given you the measurements would extend over a great length of time and would be quite expensive, varying in expense from $200 or $300 to $2,000 or $3,000 each, and it is believed it would cost from $16,000,000 to $20,000,000 to make these gaugings of the streams.

The CHAIRMAN. Is this a hydrographic survey?

Major POWELL. Yes, sir.

Mr. PICKLER. Of the whole arid region?

Major POWELL. Of the whole arid region; and the problem was raised whether or not it was possible to adopt some cheaper method. We did devise a cheaper method, and it appears to be satisfactory. I will illustrate what that is. Suppose I wanted to find how much water can be caught on the roofs of the houses of Washington. I could put gauges on the gutters of each house and measure the flow from each one of these houses of the city from day to day, from month to month, from year to year, until I discover the average rain-fall and maximum flow from each roof and the maximum and the minimum annual flow from each roof. Suppose instead of that, I measured two, or three, or ten of these about the city, and then measured the area of all the roofs themselves. I could then compute what the flow would be for all. But in this matter, catchment areas of lands are not as simple as catchment roofs. It is very complex, and these complex conditions must be understood. If all the rain-fall would flow from the catchment basin, then knowing the rain-fall and knowing the number of square miles in the area, we should have the amount of water which would flow from it; but the problem is not so simple. In a region like that of the Hassayampa River, a map of which I had before you one day, and in many other regions of country, a very large proportion of the rain-fall will flow away, for the declivities are great and the water is gathered into the streams. If the declivities are slight and the country is level or nearly level, very little water will flow away. In a level country the sands and gravels accumulate, and the rain-water sinks into these sands and gravels and evaporates and does not gather in the streams, while on the mountains, where the surface of the country has a great deal of rock, the water gathers rapidly in the streams and can be used.

We might go to a district lying by the side of the Hassayampa district and find practically that all the water would be absorbed by the soil and evaporated and none discharged in the streams, while in the Hassayampa region a very large proportion of the water is gathered into the streams. Now, how can we get at the amount of water that is thus variable? Practically, it is a question of declivities. If you increase the declivities, you diminish the amount of sand and gravel which is disposed all along the slopes, and the increased declivities discharge the water more rapidly, and the greater the declivity the greater the amount that is discharged in the streams. The more level the country is the less the amount of water discharged into the streams, until in that region of country probably about one-third of the ground discharges no water in the streams at all. The ground is so level and sandy and the absorption is so great that all evaporates. What we have to do, then, is to determine the declivities. We want to determine the run of water in these sixteen or twenty thousand minor basins. We want, first, to find the catchment area of the water that is to be controlled by the dam and stored by the reservoir; second, we want to find the declivities, the slopes of the ground, and to find what portion of the water will be discharged and how rapidly it will be discharged, and, third, we want to find the rain-fall. For the rain-fall investigation we found it was not necessary to enter largely into field operations. The rain-fall data had been collected in part by the Signal Service and in part by our own observers, but chiefly by the people themselves, many of whom had been interested. Rain-gauges are employed all over that country, and different States and Territories have organized societies for doing the

work and they save us the expense of it; so, practically, we are at no expense for determining the rain-fall. But it is necessary to do the work of determining the catchment areas and the declivities of the catchment areas, and further than that the gauging of a few typical streams is necessary. By this means we believe the cost will be much less. I made an estimate to Congress two years ago when called on for an estimate of what this work will cost. I believe we can do the gauging for about $1,500,000. Thus it is that a topographic survey which is made for discovering sites is also made for discovering catchment areas and declivities, and is the basis of the hydrographic work.

Mr. PICKLER. What length of time would it take to do it?

Major POWELL. That will depend upon the rate of the appropriation, it being a method which does not take a long time. We do it just as rapidly as the appropriations are made.

This method, which combines topographical surveying with the gauging of typical streams, will give the results sooner, will be much cheaper, and will be, on the whole, more accurate than the method which depends entirely on guaging. Our anticipations in this regard are fully sustained by the experience and outcome of the last eighteen months' work.

Now, the method adopted for doing the hydrographic work, and the necessity for discovering the sites and lands, made a double reason for the construction of the topographic map. We could have discovered sites and lands by another method than that of a topographic map. That method is by the use of trial lines. We might, on looking over the ground, suppose we could run a canal from such a point to such a point. In order to prove it we might run a trial line. That is the method generally adopted in this country where surveys are made for lines of railroads. There has been in the United States an enormous experience in trial-line surveying. If a road is to be run from one place to another and they do not know the best way, they run a trial line where somebody thinks it would be a good site, then by other suggested routes, and select the best. Experience shows that trial lines cost, on a general average for the United States, $25 per mile. To adopt the trial-line system would be to run many lines at a cost of $25 per mile on the general average. To make a topographic survey was to get the same facts in a much more satisfactory way for a much smaller amount. The trial-line system would have cost at least three times as much as to make the topographic map. Let me illustrate that.

The Canadian Government attempted to discover the best line for the Canadian Pacific Railroad by running trial lines, and they spent $3,000,000. After the line had been selected in this manner they discovered they had made a mistake, and had to abandon a large section of the work and to make a new line. It is now discovered that the best line was not selected, and that they could have built that railroad very much cheaper if they had discovered the proper lines. Had they made a topographic map of the whole of that line and of a belt of country about it 150 miles in width, they could have made the map and discovered everything for one-half the money which it cost just to make the trial lines. All this cost of $3,000,000 was for discovery purposes. The line at last found had still to be run with great care as a basis for construction purposes.

You will see on the map before you the extent to which we have made a topographic survey. All marked in blue has been done by the Survey under my charge; these other colors represent districts surveyed by Messrs. Hayden, Wheeler, and King. Wherever we have

made a topographic survey in the region which you see upon that map no railroad company runs a trial line. They are guided in the selection of these lines by the maps made by the Geological Survey; so that with the whole United States surveyed as we have got that portion surveyed, any engineer of ordinary intelligence can plan any railroad line in the country. Now, the topographic maps which we are making give all the information necessary to locate diverting-dam sites, diverting-canal sites, reservoir sites, and to select irrigable lands, and give us the catchment areas for every reservoir—give not only the superficial dimensions, but the declivities and for that reason topography is necessary. To make this survey without a topographic map would increase its cost five-fold, and when made we would never be quite sure we had selected the best. When made in this manner we are sure we have got the best lines and the best sites and the most available lands; and more than that, we can present those facts graphically to the people who are to construct these works and use the water—these engineers and farmers. We can present the facts to them in such a manner as to show them no mistakes have been made. It gives all the contour lines and presents all the facts satisfactorily to everybody. It is for this reason, Mr. Chairman and gentlemen of the committee, that a topographic survey is made.

When called upon by a resolution of the Senate to report a plan to Congress, I reported, among other things, that a topographic map was necessary, a topographic survey and a hydrographic survey, and so on. When the act was passed creating the Survey, it was formulated in terms authorizing and directing a topographic survey. The law itself directed that the survey should be made, and it directed it in the same language in which the original law directed that the map should be made for the Geological Survey.

The Irrigation Survey was created by an act approved March 20, 1888. Thereupon the Senate, by resolution, called upon the Secretary of the Interior for an estimate of the work, including the making of a map or maps. In reply the Secretary transmitted a letter from myself. In this letter I formulated the plan of the survey, explaining the topographic work and the hydrographic work, and other things necessary to its completion. In that letter I stated, among other things, the following:

> To determine for a given stream, or for a given group of streams treated collectively, first, the maximum area of farming land and its most advantageous selection; second, the best selection of sites for reservoirs and their proper size; and, third, the best system of headworks and canals, there are three general requisites, as follows:
> (*a*) The construction of an accurate topographic map, with grade curves at such intervals as will properly represent the configuration of the ground.
> (*b*) The determination of the total annual discharge of water from the catchment basins, or where there are more than one, from each catchment basin, and the distribution through the year of that discharge.
> (*c*) An examination of the soils in the area from which, under existing topographic conditions, the selections of lands for irrigation must be made.
> (See Senate Ex. Doc. No. 163, Fiftieth Congress, first session, p. 3.)

And I made an estimate for the beginning of the work in the following language:

> Impelled by these considerations, I respectfully recommend that an appropriation of $250,000 be made for the first year's work, and would suggest the following clause for the appropriation bill:
> "For the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation, and the segregation of the irrigable lands in such arid region, and for the selection of sites for reservoirs and other hydraulic works necessary for the storage and utilization of water for irrigation, and to make

the necessary maps, including the pay of employés in field and in office, the cost of all instruments, apparatus, and materials, and all other necessary expenses connected therewith, the work to be performed by the Geological Survey, under the direction of the Secretary of the Interior, the sum of two hundred and fifty thousand dollars." (*Ibid.*, p. 6.)

It will thus be seen that, having plainly stated that a topographic survey would be necessary, I made estimates for it in these words: "and to make the necessary maps." The clause which I thus draughted was incorporated in the bill. Additions were made to it, increasing the work and causing the sites to be withdrawn from sale, and the lands susceptible of irrigation to be withdrawn from market except under the provisions of the homestead laws. This plan, with the estimates, was referred to the Appropriations Committee of the Senate, and the chairman of that committee called on me to explain the plan and estimates. This I did, and such statement was published in the report of the committee. (See Senate Report No. 1814, Fiftieth Congress, first session, pp. 112–119.) The bill became a law October 2, 1888, and immediately work was begun. On the last of December following, my report on the inauguration of the work was transmitted to the Congress and published. (See Senate Ex. Doc. No. 43, Fiftieth Congress, second session.) In this report I set forth the fact that topographic surveys had been begun in New Mexico, Colorado, Nevada, California, and elsewhere. Thus, I fully explained to the Congress how the work was proceeding, and that it embraced the topographic survey in accordance with the plan and in obedience to the statute. An estimate to continue the work was then sent for, and again I was called before the Appropriations Committee to explain the estimate, and presented to the committee a specimen of the work, which was a topographic map. On all of these occasions I explained to the committee, not only that I was doing topographic work under the appropriation, as directed, but that the larger part of the cost was involved in this work. Then a second appropriation was made in the same terms as the first. And so the work has proceeded to the present time. Thus it was that the original plan embraced the topographic survey, and the matter was fully explained to the Congress, and the appropriation act specified that the surveys should be made.

Mr. Chairman, let me again call your attention to the map. There is quite an area of country [illustrating on map] where we do not have to make a topographic map, because we have already made maps for geological purposes that serve for the irrigation survey. We make for the irrigation survey the same map we make for the geological survey, with the one exception that for the irrigation survey we make a careful determination of the gradients of the streams, the declivities of the streams. These have to be determined with more accuracy for the irrigation survey than for the geological survey. So all that topographic survey work which had already been done for the geological survey is available for the irrigation survey, and the topographic map was authorized primarily for the use of the geological survey. It was re-authorized for the use of the irrigation survey. It must be remembered that two maps are not necessary; only one survey is necessary. Whatever maps are made in the arid region for the geological survey are used for the irrigation survey, and whatever maps are made for the irrigation survey are used for the geological survey. These regions of country which you see indicated in dark blue have been surveyed as a part of the irrigation work. The districts are in Colorado, New Mexico, California, Nevada, and Montana, and there is a small district in Idaho.

The work of the Survey has been divided then practically into three branches: First, the topographic survey, which is the basis of all the work. It discovers all the sites and lands, and it discovers all the catchment areas, and also gives the means for determining the amount of water supply for each reservoir and for each diverting-dam. It also gives a basis for the determination of the total amount that can be redeemed in the arid region, as called for in the first section of the act, which requires us to determine to what extent the arid lands can be redeemed by irrigation.

The second work of the Survey relates to hydrography, and I have already explained a part of it. We have a hydrographic corps now engaged in gauging typical streams, the results to be used in our computations after the topographic work is completed. That hydrographic corps is also charged with certain other duties; wherever we have a station we have a rain-gauge; wherever our work is going on we have a rain-gauge, as that can be done without additional expense; so that to collect all the data relating to rain-fall is part of the duty of this hydrographic branch. We rely chiefly on the records of rain fall kept by the people and made by the Signal Service.

But there are other things of very great importance in the irrigation survey which are relegated to this branch of the work. In order to select the land we have to know how much water it requires to serve an acre of land. Some twelve or fourteen years ago I commenced that investigation in Utah, and with the methods then in vogue there were examined a little over 100,000 acres of land, and I discovered that a cubic foot of water per second would irrigate during one season of irrigation from 80 to 100 acres of land. But we must know more accurately than that, and we are going on with this investigation, and it is carried on by the hydrographic branch.

Then the life of the reservoir is an important thing. There are some portions of the course of a stream where it carries an enormous quantity of sediment, as I have already explained to the committee, and there are other sections of the channel where it is clear, pure water, and we want to determine the amount of sediment which the stream carries where it must be taken out, in order to determine the life of the reservoir. If a stream carries a great deal of sediment, it will fill up the reservoir and destroy it, and in order to determine its life, and whether it is worth while to construct it or not, we must determine the amount of the sediment. To get this is not a very expensive part of the work, but it is important.

Mr. HATCH. Can not you test that with filters? Take a barrel of that water and filter it and see how much sediment there is in 10, 20, 40 gallons?

Major POWELL. We have various ways of determining the question, but the best method is by evaporation. We let it evaporate in the sun and measure the amount of deposit.

There is still one other point, and that is the necessity of determining the amount of evaporation, which I have already explained.

Mr. PICKLER. One question right there. In what part of the arid country is evaporation most rapid?

Major POWELL. Probably in southern California and southern Arizona. It amounts to 100 inches in this region [illustrating on the map]. That is the lower Colorado. The evaporation is very great there, and of course we could not store water without enormous waste where there are a hundred inches of evaporation annually.

The next branch of the work relates to the dams, lines, reservoir sites,

and irrigable lands. Having discovered the sites, lands, and quantities of water, then the engineering branch can step in and plan works. In order to plan the works, a site for a dam must be examined and surveyed, so as to know how long and how high and how wide it must be constructed, and the amount of material which must go into its construction, etc., and to know the ground which furnishes the foundation of the dam. The site then is surveyed and the dam planned, and the elements of its cost examined, and report is made upon it. The reservoirs have to be discovered by a topographic survey for reservoir sites, and the engineer studies these sites from data placed before him by the topographers and selects the best, and, having made his selection, he then goes to a particular site and makes a careful survey, a much more elaborate survey, of that special site, to determine its capacity and the cost of its construction.

The canal lines having been selected from the great body of possible lines discovered by the topographic survey, the engineers make a selection, and then make minute surveys for the purpose of determining how much cutting is necessary here, or filling is necessary there, to find what the cost will be, as the statute provides. The engineers having selected specific waters, specific dam sites, specific reservoir sites, specific diverting canals, and specific delivery or surface canals, and knowing how much water they can get, and how much water it takes to irrigate an acre of land, they are enabled to determine what lands can be served. About 43,000 square miles have already been surveyed in the places I have mentioned. We had previous to that about 300,000 square miles already surveyed, of which we had a topographic map and to which had to be added only a more elaborate examination of the streams.

Mr. PICKLER. What is the immediate object of the survey in Missouri?

Major POWELL. It is a geological survey that has been going on for years. Hence much of it is in mining regions. All that work was planned to meet the wants of the mining districts, just as the work of the Irrigation Survey is planned to meet the wants of the irrigation districts. So we have been working in the great Appalachian Mountains, in this vast field of iron and coal. Under the Irrigation Survey we are pushing the work in the agricultural or irrigable lands. Here is one of the sheets. It is a sheet unpublished, just as it comes from the table of the draughtsman. Here is Arkansas Valley. This is in longitude 98° 30′, on the plains. Here is the Arkansas River. See how beautifully that great reservoir site is shown. That point is 1,800 feet above the level of the sea, on the Arkansas River. Following that contour line around here from the river, you see it runs along the margin of this basin, where a lake can be made. Thus you see how a reservoir site is shown on the map. This is what all these maps mean. We have lines of level, or contour lines, by which any engineer or any farmer even could plan works. [Hereupon various topographic maps were exhibited, showing the character of the work done; then plans of canals, reservoirs, and dams were shown and explained.]

Director Powell then continued:

Mr. Chairman, the outcome of the work, then, will be an atlas of each of the great irrigation districts. This atlas will contain topographic maps of the region, in contour lines or grade curves, representing, quantitatively, the topographic elements. The courses of all streams will be shown; the valleys, plains, hills, and mountains will be delineated in grade curves, so as to show their relative heights and shapes.

On these maps will appear the sites of all head-works, canal lines, reservoirs, and irrigable lands. In the atlas of each district there will also be plans of the reservoirs, canals, and head-works, such as you have seen. Then with each atlas there will be a descriptive text explaining the character of all the structures, the amount of material entering into their building, and the cost of the work.

Mr. Chairman, it will be noticed that the statute under which the irrigation survey is conducted provides that the extent to which the arid lands can be redeemed must be determined. It also provides that the sites for works shall be reserved for the people. And, finally, it provides that the lands under these works, to be cultivated by the waters controlled by the works, shall be reserved for homestead settlement. It seems to me that these provisions are all wise, but whether wise or unwise, as an administrative officer I am bound to carry out in good faith all of these provisions. The law is manifestly in the interest of homestead settlers, and it appeared to me on an examination of the statute that I should conduct the survey in the interest of homestead settlers—that the letter and spirit of the statute demanded this, and hence in planning my work I have had these ends in view. Immediately on the passage of the statute individuals and companies applied to me to make surveys for plans and schemes which they had devised, desiring thereby to get official indorsement of such schemes. From many districts throughout the arid lands promoters of schemes urged upon me the consideration of their plans, and requested official examination of the same.

After mature consideration I decided that such examinations were no part of my work, that I could not consistently under the law make the Survey an agency for the indorsement and advertising of the plans of promoters; that it was my duty to enter into each basin and make a complete examination of the same, and report the best system of works for that basin, and to reserve the sites and lands for homestead settlers. The course thus adopted has led in very many cases to disappointment. The promoters are active, vigorous men, standing between the capitalists and the farmers, who by all these irrigation schemes reap the chief reward. I deemed that the law was in the interest of the settlers, the actual farmers, who were making homes, and that I could do no act in compliance with the letter and spirit of the law that did not consider their ultimate interests. Under this theory of administration I have conducted the work. But the promoters are disappointed, and the hue and cry is raised that the survey does not aid the development of the country, and that it is not practical. And this is true so far as such development and such practical benefit are to come from the advancement of irrigation schemes by which lands and waters are aggregated in the possession of individuals and corporations. If this is a fault it is a fault of the law itself, as I act only in harmony with the statute.

Mr. Chairman, I have thus set before you the plans of the survey, the methods of the survey, and the underlying principles which have guided me in the administration of the trust, and now submit the subject to the judgment of the committee. For the patient hearing you have given me through many days, involving questions both of fundamental importance and of collateral interest, I must sincerely thank you.

Thereupon the committee adjourned to meet at the regular hour next Thursday.

SELECT COMMITTEE ON IRRIGATION OF
ARID LANDS IN THE UNITED STATES,
April 24, 1890.

Committee met pursuant to adjournment, Mr. Vandever in the chair.

STATEMENT OF MAJ. J. W. POWELL—Continued.

Major POWELL said:

Mr. Chairman and gentlemen of the committee, when last before the committee I failed to call attention to a provision of the statute relating to the segregation of lands, and have returned this morning for that purpose. In the act creating an Irrigation Survey there are the following words:

> And all the lands which may hereafter be designated or selected by such United States surveys for sites for reservoirs, ditches, or canals for irrigation purposes, and all lands made susceptible of irrigation by such reservoirs, ditches, or canals, are from this time henceforth hereby reserved from sale as the property of the United States, and shall not be subject, after the passage of this act, to entry, settlement, or occupation until further provided by law: *Provided*, That the President may at any time in his discretion by proclamation open any portion or all the lands reserved by this provision to settlement under the homestead laws.

This act was passed October 2, 1888. In December, three months following, I made a report of the organization of the work and the progress made at that time to Congress, and in that report I called attention to this special clause and its effect in this language:

> I respectfully invite your attention to the clause of the act providing for an irrigation survey which withdraws from "sale, entry, settlement, or occupation" the lands selected for reservoir sites and those segregated as irrigable tracts.
>
> It is apparent that the reservation from sale of the lands necessary for the sites of reservoirs is eminently wise, as no restriction or burden should be placed upon the development of agriculture by irrigation in arid lands, but some provision should be made by which such reservoir sites can be permanently useful for the purposes for which they are designed. It is shown that further legislation is contemplated from the fact that the reservation is made to extend only "until further provided by law." * * * .
>
> The propriety of preserving the irrigable lands from sale, settlement, and occupation until restored under the homestead laws through proclamation of the President, is worthy of further consideration. If the selections are wisely made—and this must be assumed—the best land, all things considered, that belong to the valley or plain of a given stream are segregated from the general domain, and peculiar restrictions are placed upon their disposal; that is, they can be settled only under the homestead provisions, and that after proclamation by the President, while titles to other lands can be secured under the homestead laws, the pre-emption laws, the desert-land laws, and the timber-culture law.
>
> The individual wishing to obtain title to lands will prefer to take up lands under the more liberal provisions, so that the selected lands will be neglected and the non-selected lands will be entered; and, as the statute now stands, the waters of the streams will be taken to the non-selected or poorer lands. It must in this connection be further understood that the difference between the good and the bad land will usually be very great. It may often be the case that the water necessary to irrigate a square mile of the poorer non-selected lands would, if taken to the selected lands, irrigate 2, 3, 4, 5, or more square miles. The individual making the selection can not be supposed to have the general good in view, but only his personal interests, and he will not consider the facts here presented.

The CHAIRMAN. Is that your report?

Major POWELL. That is from my report made to Congress a year ago last December.

The CHAIRMAN. If you have a copy of that report with you I would be glad to have it.

Major POWELL. A copy is here and I can leave it with you. The

effect, then, it would seem to me, would be largely to prevent the settlement of the best lands. If the best lands are segregated and put under the homestead law, and the other lands left free to all other statutory provisions for the acquisition of lands, it will result in taking the water on the poorer lands instead of on the better lands, as I explained in my report at that time.

There is another question of uncertainty in the statute. The statute says:

> All the lands made susceptible of irrigation by such reservoirs, ditches, or canals are from this time henceforth hereby reserved from sale, etc.

Now, there has not been a formal decision upon the interpretation of that statute. If it means, as I think perhaps it does, that all the lands, made susceptible of irrigation are to be reserved, then larger areas will be selected than the waters will serve, but if a reservoir on the side of a plain or the side of a valley——

The CHAIRMAN. Would it be construed in this way, susceptible of irrigation with reference to the water supply?

Major POWELL. That is the very point I wish to bring out. I want to call the attention of the committee to the fact that there is no legal decision of the question, but it will be raised in a few weeks.

The CHAIRMAN. Is it not entirely now in the discretion of the Interior Department to construe what the law is?

Major POWELL. The act will be construed in a few weeks. We have been conservative about the segregation of lands and are now making the first recommendations, and a case will now arise. When a decision is reached in this case an interpretation will be given to this clause. Allow me to explain what the effect would be on the lands susceptible of irrigation under that provision. Where a canal or reservoir may be able to irrigate 10,000 acres of land, 20,000 acres of land may be lying under it. Shall we segregate the 20,000 acres of land or the 10,000 acres of land, is the question. I think the question is worthy of consideration, and perhaps the statute needs amendment. I have suggested to another committee that the Survey should be directed more definitely how these segregations should be made, and these are the words which I proposed should be incorporated in the law as the conditions governing the selections:

> First, the conditions necessary to secure the greatest area of irrigable land.
> Second, the conditions necessary to secure the most valuable land for agricultural purposes by reason of climate.
> Third, the conditions necessary to secure the most valuable agricultural lands as determined by soil and subsoil.
> Fourth, the conditions necessary to secure land that can be irrigated and cultivated with the greatest economy.

I think there should be some legal restrictions placed upon the segregation of land, and that these conditions would meet the case.

The CHAIRMAN. Have you the suggestions in any form?

Major POWELL. Yes, sir; I have them in the form I have just read, which is in a bill introduced in the Senate.

The CHAIRMAN. Whose bill is that?

Major POWELL. Mr. Reagan's.

Mr. HANSBROUGH. This is an amendment to the Plumb bill?

Major POWELL. Yes, sir.

The CHAIRMAN. This would put the matter under the regulations and the ruling of the Interior Department at the present time, and I do not know whether the committee could consider that. I do not know whether it is best to incorporate a provision of that kind or not.

Major POWELL. This is the point I wanted to present to you so that you could consider it. The present law, I think, is defective; it works an injury, and I think something ought to be done to provide that specific lands should be irrigated, and rules provided under which they should be selected. It would be of interest to all the settlers to do that. The effect of the law at present is to withdraw all selected lands from settlement except under the homestead law. I do not know what the action of the President will be, but it is to be presumed that as fast as lands are selected the President will declare them open to homestead settlement. So that a body of land after being selected will not remain out of the market; it will be immediately brought into the market under the homestead law.

The CHAIRMAN. The homesteader would not be able to perfect the title until after the adjustment of the right to the water. The homesteader may go on and take a piece of land on which he thinks he can raise a crop in an ordinary season without irrigation, and he can hold it for a good while, and when the facts turn out he can not do anything with it at all.

Major POWELL. I simply wish to state these facts to the committee, so that it may have them before it for consideration. If the better lands are selected for the homestead settlers and the poorer lands are left to be taken up under the desert-land act, the timber-culture act, and so on, in large quantities, companies will acquire title to these poorer lands through the agency of persons employed for that purpose. Then they will get possession of the water by constructing the irrigation works, and the homestead settlers on the good lands will be left without water and powerless. The poor lands will be cultivated and the good lands will remain waste. If all of the lands which can be irrigated under the works planned are withdrawn from sale except under the provisions of the homestead act, then the companies will plan other lines and reservoir sites not so good and will take other lands not so valuable, leaving the reserved sites for works and the reserved lands to be managed by homestead settlers, who, not being capitalists, will not be able to command the situation, and thus the purpose of the law will be defeated. If the best sites for works are to be selected and the best lands under them selected, and then these sites for works and these lands are to be given to homestead settlers, they should be protected in their settlements by providing that the waters to supply the lands shall belong to their lands, and that they can not be used elsewhere. I suppose that it is well known to the committee that the desert-land privilege and the timber-culture privilege are the two great agencies by which the public domain passes from the possession of the Government into the hands of capitalists and corporations.

STATEMENT OF CAPT. C. E. DUTTON.

Captain DUTTON said:

Mr. Chairman and gentlemen of the committee, the subject of irrigation in the West is one to which I have devoted many years of thought, and investigation on the ground, and I have watched its progress and development for many years. Ten years ago it seemed to me that the Government should take some measures looking to the regulation of the development of a magnificent and important interest whose growth any one at that time could clearly foresee. In the last ten years, in some of the most important portions of the West, the growth of the

irrigation interest has brought to light a great many difficulties and a great many quarrels and contentions, the causes of which become evident only when you look thoroughly into the concrete facts of the case. Ten years ago a settler could go into almost any part of the West, and under the public-land law authorizing settlement could take up a large farm and secure water rights involving an expenditure of very little more than his own labor or that of his family. Land was abundant and water was more than sufficient for the wants of the people at that time. There is a very different state of affairs at the present time. There is more demand for water in the West and we have this remarkable state of facts confronting us. There is still a very large amount of good irrigable land left in the West——

The CHAIRMAN. In the course of your remarks, when it may become convenient, I would be glad if you would give us a definition of the difference you make between arable and irrigable lands.

Captain DUTTON. I used the term irrigable, not arable.

The CHAIRMAN. I know you did, but I would like to get your definition of these terms.

Captain DUTTON. Yes, sir; if you will call my attention to it again, I will do so.

The CHAIRMAN. I will leave it to you to select the point.

Captain DUTTON. I was saying there is a large amount of irrigable land. There is an unlimited amount of capital seeking investment, ready and anxious to be invested in uniting the water to the land. Lands which have been opened for occupation and settlement with water rights and ditches has an extremely high value, much exceeding that of farm lands in the humid region. Now, why is it that with plenty of land, and plenty of water, and plenty of capital to bring the two together, and with the enormous value given to the improved land, there is this check to improvement? I think I can explain the difficulty, to some extent. In some portions of the West one class of difficulties present themselves more prominently than in other portions. One of the chief difficulties has grown out of what might be termed the improvidence of the earlier legislation upon this subject, and also to the want of any legislation except of the most general and indefinite kind. The use of water for irrigation is a matter which all governments of the civilized world have found themselves obliged to regulate strongly. It is a subject which can not with prudence and with good effect be left to the unrestrained individualism, which is one of the strongest characteristics of our people. I am a firm believer in individualism, but I believe every great law has its exception, and this is an exception. A great want is the want of regulation in the use of water. The old law authorized a person to go anywhere upon any river, at any point upon that river, to lay claim to such water as he saw fit, to the whole water of that river if he liked, to take it and carry it where he pleased, and upon what lands he pleased. Naturally the Western settlers who came there took hold of streams which they could easily divert. They dug such small canals as they could handle. They acquired by that process vested rights.

This you might call the pioneer stage development, and so long as water was abundant and land was abundant, and so long as there were no other settlers to be interfered with by the unlimited and even prodigal use of the water, no harm would arise from it; but when population begins to increase, when other men come in and are demanding that they shall share this bounty of nature, then the difficulties arise. It is

evidently public policy that these waters should be economized in their use, and people who see plenty of water going to waste certainly have a right to ask of the proper authority that the necessary measures shall be taken to secure to them the same privileges which other producers in that district have enjoyed. The water rights thus given to the first individual are almost indefinite and unlimited in their extent. He has a right to use the water to any extent that he chooses, and the subsequent comer can only obtain what the first chooses to leave. There comes at length a second stage of the development. Men of large means recognize the fact that irrigated lands are of enormous value. They are ready to embark their capital in an enterprise which will secure to them some of that value, but in order to do it they must secure some right to the use of the water which shall not be constantly infringed by the rights acquired by these earlier settlers. There is no alternative for them but to buy out the rights of the older ditches. They find that this purchase is an enormously costly one. The water privilege now becomes a privilege indeed. It is the power to obstruct a new development, and the fact that a man can be an effectual obstacle in the way of a great improvement involving a large profit places him in a position to fix the price at which he shall be bought out. The result is that the capitalist who undertakes to buy out these older privileges is obliged not merely to furnish the man with water whom he is obliged to buy out, but he is obliged to pay him an enormous bonus simply to get out of the way and not obstruct him. The old settler is just as well off as before, but he must be paid for refraining to stand in the way, as a dog in the manger or as an obstacle. That necessarily means also a large increase to the capital invested in the new enterprise. It means more interest, which the new comer must pay. It is a legitimate expenditure. It is more than a mere watering for stock. It is an expense which the farmer must pay.

There is another difficulty of a very serious nature, and that is the operation of the desert land act. These irrigable lands have a value sufficient to tempt a class of men who neither desire to be settlers themselves nor have the means nor the disposition to embark any important amount of money in an enterprise for the redemption of the lands; in other words they are mere speculators. Now, it seems an obvious proposition if great improvements are to be made in any irrigation district there is one fund, and only one fund, out of which these improvements can really be made and this is the increased value of the land. The increased value of the land must ultimately pay for the improvements. The land in its desert condition is not worth 10 cents per acre, and in its improved condition I do not know any locality where it is worth less than $35 an acre, and I know many areas worth $50 to $70 an acre. The desert land tract is too small by itself alone to tempt the capitalist.

Mr. PICKLER. It is 640 acres.

Mr. DUTTON. It is 640 acres and it is a much larger tract than any man without capital can possibly farm by himself, and it is just about of the right size to be a temptation to a class of men who have not the least idea of spending an hour's work in the improvement of the land, or a dollar of money in redeeming it. This is easily effected by what is known in the west as the sale of relinquishments. Under a claim under the desert land act, just before the three years expire or at any time during the three years, he can by collusion with another party relinquish his claim in such a way that the favored party can get it, and there are towns and settlements in the West where desert land claims have a quotable value, and where so-called bankers and brokers make a regular

business in dealing in them precisely as brokers in New York deal in stocks and bonds.

Mr. HANSBROUGH. Do they sell options?

Captain DUTTON. I do not think they sell futures.

The CHAIRMAN. But a man can not make a desert land entry without paying 25 cents an acre on that land.

Captain DUTTON. It is all paid for, but you must remember the land is worth a good many dollars an acre.

The CHAIRMAN. These parties will go there and settle upon it if it is speculating, but to do it they must pay 25 cents an acre, and 25 cents on 640 acres means considerable money.

Captain DUTTON. Of course it is a class of men who have the means to pay the land office fees, but that is a trifling matter in comparison with the value of the land.

Now, it is obvious that this practice which permits the increased value of the land to pass out of the ownership and control of the settler and into the hands of a third party, who has no real or bona fide interest in the matter, except in the profits which he can make out of the transaction, is a very bad one. This is one of the great difficulties which a corporate company experiences in improvements; but when it happens that by any local combination of circumstances a corporate company can secure the control of or an interest in the land which it redeems, and if any considerable portion of that improved value of the land will accrue to the company itself, there is never any difficulty whatever in getting all the capital required to make the improvements in these irrigable regions. The pre-emption act and the timber-culture act would themselves alone, I think, be of no value to the speculator in that connection, but when you come to consider that a man can file a desert land claim, a pre-emption claim, and a timber-culture claim together, you see he can get quite a considerable tract of land; and when a single family, or group of persons go down there, and bring their relatives, their sisters, their cousins, and their aunts, and each one files a claim under each one of these laws, the amount of speculative land which can be obtained is something formidable. Ultimately that becomes a very serious check to the prosperity of these irrigating enterprises.

One other evil which arises is that persons who are already settled in a district naturally object to other persons coming and settling with them. The early settlers have excessive and unnatural rights to the use of water, and do not like to be abridged in the use of it.

Mr. PICKLER. Do not the statutes regulate it?

Captain DUTTON. The statutes attempt to regulate such matters, but the people, you must remember, regulate the statutes. It seems to me that this matter could be reached, in so far as the more important irrigation districts are concerned, by some important modifications of the United States statutes. I think that the desert land act should be repealed, and I am confirmed in that view by the opinion of nearly all of the western men interested in this subject with whom I have conversed.

The CHAIRMAN. Does not this reservation under the act of appropriation of the last Congress provide for the withdrawal of all those desert lands?

Captain DUTTON. That is a question. It would seem so, and I think that is the view which is held by the most accomplished land lawyers. It is obvious, I think, that the settlers ought to be urged to go into the best districts, and should be kept off other districts or localities where the water is of inferior value for agricultural purposes, and where its use is a damage and a check to the development of the greater works.

I think that if the public lands were for a time wholly withdrawn from any form of settlement except occupation for mineral purposes, coal land, town sites, and a few other purposes, and if we made a segregation of the most valuable irrigable lands accompanied by the official designation of irrigable lands, and if the designated lands were opened to occupation and entry, it would be a very great advantage, and it should be accompanied, I think, with the prohibition to take water from streams for the purpose of irrigating any lands not declared to be irrigable, thereby compelling all future development and irrigation to be upon the best irrigable lands.

The CHAIRMAN. Is not the object of the present survey to find out what lands are irrigable and what not.

Captain DUTTON. That is the object of the present survey. We have, however, been troubled with the difficulty which Major Powell spoke of this morning: That if the best lands were seggregated, and everything else was open to all forms of settlement under the more liberal provisions of the law, of course settlement would naturally seek the worst lands, and would never enter, except under duress, upon the best lands. In the interpretation of the law we have followed the utterances of the Secretary of the Interior, who has stated that it was plainly the object of Congress in passing that law to obtain the very best development of irrigation in the West. Well, if this is the object of the law, then it follows as a matter of necessity that any land which can be by any possibility declared to be irrigable ought to be segregated, and that is the course which has been pursued.

The CHAIRMAN. Now right here I wish you would give me the deffinition of what is irrigable and what is arable land; not irrigable and non-irrigable, but the difference between irrigable and arable land.

Captain DUTTON. The literal meaning of arable land is land which can be plowed.

The CHAIRMAN. Well, is it not land upon which you can raise a crop in ordinary seasons without irrigation; on which the rain-fall is sufficient to insure a crop in an ordinary season without irrigation?

Captain DUTTON. I should say it was irrespective of whether it required irrigation or not. Arable land is generally understood to mean land which is capable of being cultivated.

The CHAIRMAN. I saw a statement quite recently which said that the amount of arable land under the disposal of the Government would not exceed 10,000,000 acres, where there were 100,000,000 or more acres of irrigable land classed as desert land. That is, that the amount of arable land would not exceed at present 10,000,000 acres which is under the disposal of the Government (I do not know how correct that is), and that as compared with the lands susceptible of irrigation or within the region of irrigation would amount to 100,000,000 acres. That would take in the land west of the 100th meridian. I have the quantity I think from Major Powell.

Captain DUTTON. There are still other points which should come before the attention of this committee in relation to the laws as to the use of water. The question is, in whom or in what authority does the control of property in the natural water vest. In all the countries of Europe except England waters in the streams and natural lakes are regarded as part of the public domain, and that seems to be the most natural designation.

The CHAIRMAN. We take our common law from England in regard to riparian rights, and now we have come to that point where we have got to change that English rule and adopt the continental rule.

Captain DUTTON. The irrigation of the countries in the most civilized parts of the world are under the régime of the civil law.

The CHAIRMAN. The old oriental law with reference to the use of waters and irrigation of land——

Captain DUTTON. I think it is entirely within the power of the United States laws to declare the waters to be part of the public domain, excepting Texas, where the water should belong to that State, and should be part of the public domain of the State of Texas.

Also the nature of water rights needs definition. The course and development of decisions in State and Territorial courts have thrown a great deal of light upon that question and opened, I think, a way to its solution. There appear to be two kinds of right of appropriation; one is by the farmer who uses the water and the other is by the canal company that carries it. The effects of the decisions of the courts as regards the former is that the right to appropriate the water is inherent and practically appurtenant to the land settled. The right to appropriate water by a canal is merely a privilege to carry water as a common carrier; the canal or owners of a canal having no right to ownership of the substance or body of the water, nor even to the usufruct. They are simply common carriers and subject to the law as common carriers. The riparian law has been acknowledged in California, but in all the other States and Territories of the arid regions it is not acknowledged, and in the supreme court of the State of Nevada a decision has recently been made which explicitly and in terms declares that common law of riparian rights is not and can not be followed in a region where it is wholly unsuited to and adverse to the public welfare. The legislation of the irrigating States, with the exception of California, proceeds throughout on the assumption that riparian rights are wholly subject to the right of diverting the water for beneficial purposes, and the claim under riparian rights would have no standing in any of their courts. This has helped the matter out a great deal, and there is a feeling, I think, on the part of Californians that sooner or later the decision in the celebrated Lux & Haggin case will be overruled.

The CHAIRMAN. The act of California known as the Wright act practically overruled that.

Captain DUTTON. That is in regard to the irrigation of districts.

The CHAIRMAN. Yes, and recognizes the right of these parties to take water and use it irrespective of riparian rights.

Mr. LANHAM. Mr. Chairman, it is now ten minutes before the time for the meeting of the House, and I have a little matter about which I would like to talk to the committee a little while. The gentleman has been making a very interesting statement, and I would make a suggestion that if any of the gentlemen have any official suggestions to make to us they include them in their statements.

The CHAIRMAN. If they have any suggestions to make in conjunction with what they have already said we would be very glad to have anything further on this question.

Mr. LANHAM. And then we could have it before us in print.

Captain DUTTON. I am hardly prepared to make an off-hand statement on subjects of this kind and I have made no preparation before coming here.

Mr. LANHAM. You will have an opportunity to examine your statement, and when you have it, you can make such additions as you deem proper.

Mr. HATCH. I would suggest that the committee furnish to Captain Dutton and also to Mr. Bodfish copies of the stenographer's report,

and that each of them have permission to alter or change and make such additional statements as they may like to submit to the committee.

The CHAIRMAN. Unless there is objection by some member of the committee I think that is perfectly proper.

Mr. HANSBROUGH. Is anything beyond an irrigation survey necessary to a complete seggregation of the irrigable lands?

Captain DUTTON. I think not, sir.

The CHAIRMAN. I think that is also the express substance of Mr. Bodfish's remarks; at least I endeavored to draw his attention to that point.

Thereupon the committee adjourned.

STATEMENT OF MR. S. H. BODFISH, DIVISION ENGINEER OF THE ARKANSAS DIVISION OF IRRIGATION SURVEY.

The CHAIRMAN. Will you please state your official position?

Mr. BODFISH. I am division engineer of the Arkansas division of the Irrigation Survey.

The CHAIRMAN. Have you been upon the field yourself in person to make an examination?

Mr. BODFISH. I was in the field from the middle of June until the middle of November.

The CHAIRMAN. Engaged in what sort of work—surveys, hydrographical or topographical work?

Mr. BODFISH. I was present with my assistants in surveys for reservoir sites.

The CHAIRMAN. We would like a statement from you, without leading up to it directly, as to the methods you employed to determine the proper location of reservoir sites.

Mr. BODFISH. My method has been to examine the ground myself, and my intention was to examine all ground myself, before executing the surveys which were made for reservoir sites. I first examined and viewed locations so that I could put parties in the field to work, and I supervised their field operations, besides searching for more reservoir sites, and I traversed the streams myself, personally, to search for locations for basins, beginning at the head of the Arkansas River and its principal tributaries and working downward; and before the season closed I had not finished the mountain districts; that is, I had not gotten out of the mountains on to the plains in the reconnaissances.

The CHAIRMAN. Is that the method of topographic or hydrographic examination, or was it the engineering examination?

Mr. BODFISH. It was the engineers' examination preparatory to putting engineering parties into the field to make the surveys necessary for a careful estimate of the cost of construction.

The CHAIRMAN. Was preceding topographic work necessary to enable you to determine the proper location for these reservoirs?

Mr. BODFISH. I did not think it necessary.

The CHAIRMAN. Was it useful and aidful; as a preliminary work was it necessary to make this topographical survey?

Mr. BODFISH. No, sir; it is not necessary.

The CHAIRMAN. Would you have been aided very materially by the preceding topographical survey?

Mr. BODFISH. That would depend upon the accuracy and nature of the survey made.

The CHAIRMAN. Please describe a topographical survey in contradistinction to an engineering survey and a hydrographic survey.

Mr. BODFISH. A topographical survey is one that delineates the features of a country by lines of equal altitude or the approximate shore lines which would exist if the sea was raised distances indicated by the vertical interval between these lines; it illustrates the declivities.

The CHAIRMAN. I understand these topographical lines would correspond with the shore lines?

Mr. BODFISH. That is, if the sea was raised 20, 40, or 60 feet or any established interval between these lines.

The CHAIRMAN. How would these lines stand in relation to the drainage lines of the country.

Mr. BODFISH. The drainage lines would all be illustrated on that map.

The CHAIRMAN. The drainage lines would necessarily be at right angles with these lines?

Mr. BODFISH. They would cross these lines.

The CHAIRMAN. They meet at an angle?

Mr. BODFISH. The hydrographic survey consists in ascertaining the amount of water that is precipitated, the amount of evaporation, and also the amount of run-off which takes place.

The CHAIRMAN. Could not this subject be fully illustrated by a map prepared for this special purpose, with topographical lines drawn upon it to show in the Arkansas Valley, where you have been at work, following down the main water-courses of the stream—how would these topographical lines correspond with the course of the river? They cross the river?

Mr. BODFISH. Certainly.

The CHAIRMAN. They would not continue parallel to its course?

Mr. BODFISH. No sir.

The CHAIRMAN. Then a hydrographic survey would not coincide with the topographical lines. Does the hydrographical survey include the meandering of the stream?

Mr. BODFISH. No sir.

The CHAIRMAN. The meandering of the stream is a part of the survey?

Mr. BODFISH. It is part of the topograghical survey. The engineering work performed outside of the topographical survey would be minute surveys necessary to make correct estimates for the construction of reservoirs and canals; and they are surveys of a more minute character than a topographical survey. When I am sent to make a topographical survey, I first ascertain the reason for which it is to be used. If it is to be used for general purposes, it is made in a very general way. If it is made for careful irrigation work, it should be made in a very detailed manner. The money that is necessary to make a map sufficiently good for general purposes is not sufficient for a map to be used for engineering purposes.

The CHAIRMAN. I have no further question to ask the captain, unless some members of the committee desire further information, except to ask him if he has anything to do with this appropriation, whether it should be used for topographical survey or in any other branch.

Mr. BODFISH. I have nothing at all to do with that. There was an allotment of $19,500 assigned to the Arkansas division, part of which has been expended for engineering purposes.

Mr. HANSBROUGH. Was anything assigned for a topographical survey of that district, or was it used for engineering?

Mr. BODFISH. There was an assignment made for topographical surveys, but not under myself. I am immediately subordinate to Captain Dutton.

Mr. HATCH. I think that with propriety we may ask these gentlemen who are connected with this work to make any statement which they may desire to make that will give us information. And I hope that they will state it without our questioning them or cross-questioning them about it. If there is any information which Captain Bodfish has in regard to that section of the country over which he has control as an assistant engineer of this bureau, I would be very glad to hear any statement he has to make in regard to it. He knows, of course, the general scope and jurisdiction of this committee, which has before it all bills offered to Congress, both of a local and general character, in regard to irrigation, and it embraces the whole subject. We do not profess to be experts, and we would like all the information in regard to this subject which we can get. I do not believe, myself, that all the suggestions in all of these matters ought to be confined exclusively to the chief of the bureau. I have seen many a staff myself where the staff was a good deal heavier than the head of it, both in civil and military life, and in all these matters I do not think any of the subordinates, especially of Major Powell's bureau, ought to feel any hesitation in giving any information they have in regard to this work, because I know that heretofore the major has in the fullest manner endeavored to draw it out himself, and insisted upon it where they have been before the committee. I do not know that the gentlemen feel any delicacy about offering an opinion, except what they make in their official report; but if they have anything outside of it of interest to the committee which would be of value to us, I think it is their duty to make it, and I think the committee will be very much obliged to them for so doing.

The CHAIRMAN. We would be very glad to hear from the gentleman.

Mr. BODFISH. I leave that with Captain Dutton.

The CHAIRMAN. We would be very glad to hear from you and Captain Dutton both.

Mr. HANSBROUGH. Are you a subordinate of Captain Dutton?

Mr. BODFISH. Yes, sir.

The CHAIRMAN. Perhaps we had better take the statement from the head.

Mr. DUTTON. On what subject, sir?

The CHAIRMAN. The subject under consideration. Is there any hesitation on the part of either of you gentlemen to make a statement, except in answer to a direct question? I do not think you ought to hold back on these questions.

Mr. DUTTON. I believe there is a feeling, Mr. Chairman and gentlemen of the committee, on the part of all subordinates of all bureaus of the Government, that suggestions in so far as they are volunteered, can come more properly from the heads of bureaus. Of course, all subordinates of the Government feel it their duty to answer very fully and very frankly all questions which may be put by committees of Congress, but there is this feeling, and matters of public policy in so far as they originate from and have anything to do with the administrative branch of the Government, are more properly and more fully dealt with by the heads of bureaus or departments.

Mr. HANSBROUGH How would it do to have Captain Dutton proceed upon the line upon which he was proceeding the other day? With

your permission I will read the last paragraph of his testimony where he seems to be proceeding on a very interesting subject [reading]:

That is my understanding, and it has been that practice upon which I have been governed myself in making selections of irrigable lands. I have selected in some drainage basins every piece of land which could be by the utmost possibility selected as a piece of irrigable land, and recommended its withdrawal from occupation and entry. The law provides that the President may by proclamation open to homestead any lands which have been segregated whenever it becomes desirable to do so. If all the lands which possibly could be irrigated are selected, and only the lands which ought to be irrigated open to settlement, you have got the whole thing in your control.

Now, if the captain will proceed upon that line on which he was speaking when we were interrupted by the arrival of the time for adjournment, I think it would be of interest to the committee.

Captain DUTTON. Is it the desire of the committee that I should make any statement in that direction?

The CHAIRMAN. Certainly.

The testimony given orally before the committee embraced matters and statements which are embraced and more fully set forth in the following letter addressed to the chairman and the letter is subjoined as a substitute for such oral statement.

WASHINGTON, *April* 30, 1890.

SIR: Conformably to the wishes expressed by your committee, I respectfully submit to you the following views upon the subject of irrigation in the West:

The law creating an Irrigation Survey and providing for the segregation of the irrigable lands and their withdrawal from settlement was in response to representations coming from the arid region. The development of irrigation had reached a stage in which it was felt that Congress should intervene to the extent of providing laws for the cure of many evils which had grown up, and of removing obstacles to its further growth and expansion and of creating safeguards against a prospective water monopoly. In order to make intelligible the tendencies of present laws and the nature of present difficulties and prospective dangers, I will attempt the briefest possible summary of the subject.

The history of the development of nearly every important irrigation district in this country has been a history of small beginnings and subsequent growth. The various stages have been either identical or strikingly similar almost everywhere.

The first stage is that in which an individual or small group of individuals divert a small stream or portion of a stream into a little ditch for irrigating purposes with no other resources than their own tools and labor. Here there is no priority of right to water. The ditch is owned either as common property or in shares representing undivided interests, is maintained at common expense or by a pro rata tax, and the water inheres in the land.

The second stage is the multiplication of ditches. The success of the first settlers attracts others, and the capacity of the first ditch ceases to be sufficient and another and another ditch is constructed. At once priority of right begins until as many as a dozen or even twenty separate ditches are constructed, each arranged numerically in the order of its priority. Generally the assistance of capital is invoked for the construction of some, or even most of these new works, and a portion of the expanded community is practically buying or renting its water supply.

The third stage is the construction of a high line canal at a heavy outlay, which takes out all the water of the stream during the irrigating season. The older net-work of small canals is either obliterated or used as feeders or laterals, and the distributing system is reconstructed upon a far better plan. The priorities of right are bought out and extinguished and thereafter cease to exist as between holders under the same high line canal, though priorities may still exist as between different high line canals on different portions of the same stream. This stage has been reached by only a few large districts, but it is the one towards which all important districts utilizing considerable rivers are surely tending.

The fourth stage, which has not yet been entered upon, in this countty, though some districts are upon the verge of it, is the expansion of the system by the addition of reservoirs. This last stage marks the exhaustion of possibilities so far as it is now possible to foresee.

This mode of growth and development is the natural result of the necessities of early and progressive settlement, and it seems to me that legislation should accept it as a controlling condition to which it should conform its policy, and should confine

itself to removing needless obstacles to it on the one hand and to lopping off evil and parasitic growths on the other. These evils and parasitic growths are many, and unless they are removed by wise regulation, the resulting evils under existing laws and practices will become so serious that they will greatly impair, and may even overbalance the advantages of that final development towards which the irrigation system is tending. Each stage has difficulties of its own which must be dealt with separately. In order that they may be seen in their proper relations, I will proceed to specify the more important ones in their regular order.

In the first stage where the single ditch exists with a water privilege inherent in the land, and where there are no competing or conflicting rights, where the water supply is more than sufficient for the demand, it seems as if no difficulty could exist. But this stage contains the germs of evils which become formidable as development proceeds. The characteristics of the American pioneer are very marked. His instinct in the west is to go off by himself and to shun neighborhood. It is not misanthropy, but the desire for extreme independence and the impatience of social restraint. His propensity is to fasten upon some piece of land so situated that no neighbor is likely to come near him to share his title or contest his unlimited privileges. Thus, in the first stage, thousands of secluded little spots are taken up in localities where a single man or small group of men can control more than their lawful allowance of land, and more water than they can utilize. The water is used wastefully, and this prodigality it is impossible to prevent. The resulting agriculture is of the poorest kind and without any profit either to the settler or to the community. The right acquired is a check to better developments. There is no inducement to economy of water, because the early settler has the prior right to all he wants and economy means a little extra labor and expense. This centrifugal or dispersive tendency to settlement is opposed to sound public policy, which should seek to concentrate such interests into mutually sustaining communities. These isolated rights are by far the most difficult to buy out or expropriate, and the most obstructive to better developments. Similarly, where settlement begins in wide, fertile valleys, the future seats of large populations, the earliest vested rights soon acquire a ficticious value. Sooner or latter they must be bought out, and this fact enables the owner to demand a monstrous price for his mere priority, which he seldom fails to do. The difficulties arising in the first stage are the dispersive tendency of settlement and the acquisition of vested rights, which are obstructive to future developments and burdensome to future settlers, and which tend to the wasteful use of water with no incentive to economize it.

In the second stage, or that of multiplied small ditches, new difficulties arise. Each ditch having a numerical order or priority, and claiming far more water than it can really utilize or carry, many disputes are engendered. The right of appropriation is undefined in the law, and each claimant urges the highest demands. Extreme measures are resorted to by the local authorities to enforce a division of the waters according to priority. Laws and ordinances, often of a novel and heroic kind, are employed to enforce a division which shall insure to one man an abundant supply in time of scarcity and leave another man's crops to wither. The courts become overwhelmed with litigation in which laws and ordinances are opposed to natural justice, where disinterested juries are hard to obtain and where judges are at their wits' ends to obtain either principles or precedents on which to base their decisions. The multiple ditch stage is surely the stage of excessive litigation. The worst feature about it is that the courts have neither apposite laws nor well established principles to guide their decisions and are forced to fall back often on the common law or upon strained interpretations of statutes; and yet they are rapidly making law by force of these decisions. But of all forms of fundamental law, the worst possible for an irrigating country is the common law of England, so far as it relates to the use of natural waters. It is in this second stage that the demand arises for legislative interference and regulation, and the States and Territories have attempted to meet it. But their legislation pays little heed to the future and is formed for tiding over immediate difficulties. It is always enacted as if the second stage were the final and unalterable one. But it only establishes more firmly still the difficulties which must be overcome before the third stage is reached and still further retards and obstructs the advent of a better system. Under it, vested rights and priorities become more deeply rooted and acquire fictitious values, while their real values are in nowise enhanced.

In the third stage these evils and difficulties reach their maturity. This is the stage in which large amounts of capital enter the field and seek to absorb the older multiple system of ditches. The conditions which lead to this development are worth reciting. The older multiple system irrigates long, narrow strips of land, with canals of great length, small in cross section, very poorly constructed, expensive to maintain, and exceedingly wasteful of water. A large proportion of the water taken in at the head gates is lost before it reaches the land. The farmers insist on the fullest extent of their claims, whether they need the water or not, and what they do not use they waste. A single high-line canal taking the place of these ditches is incomparably more efficient and far better for the farmers. It sometimes increases three or

four fold the duty of the same original water supply and gives every farmer a much better service. Hence, whenever the conditions admit of its construction it pays, and this induces its creation. But the greatest difficulty arises from the necessity of buying out the older rights. New rights, of course, are given in exchange for the older ones, and for the real uses of the farmer they are of far more value. But the older ditches are in a position to exact an enormous premium besides. The premiums demanded and often realized are seldom less than three or four times the cost of the older works and sometimes very much greater. The thing which is really sold is not the right to have water, for the irrigator is better served after the exchange than before, but merely the right to obstruct a great improvement. This means an increased investment on the part of the new canal company on which the farmer must pay interest.

Along with this difficulty arises another. No sooner is a large and costly canal projected with a reasonable prospect of its consummation, than the land under it is rapidly filed upon. The entries are mostly made, not by bona fide settlers, but by settlers who expect to and generally do realize considerable sums by the sale of their relinquishments. Irrigated land is worth never less than $35 per acre and generally much more. In its desert condition, with no prospect of redemption, its value is nominal, or a few cents an acre. The temptation to secure a large slice of this sudden increment is altogether too much for average human nature, and American ingenuity has never yet been found wanting in methods of evading laws when large profits are in sight, and at the same time giving those methods the semblance of legality. The effects of this practice are most pernicious. The lands so entered are not improved, but are held in their desert condition awaiting collusive purchasers of the relinquishments. Thus the canal company loses the legitimate revenue which it ought to derive from its water service, and it is well if it does not become a third collusive party to the buying out of these obstructionists, thus further inflating its capital debt on which the farmer must ultimately pay still more interest.

These two evils are closely allied and contributory to a third evil more serious still. This is the almost hopeless separation of the ownership of land from the ownership of water. There is no difference of opinion about the results of this separation. There is no economic fact more firmly settled than that the owners of the land should also own the water supply and works which irrigate it. Wherever this is so agriculture flourishes, and where it is not so it must sooner or later languish. In districts undergoing development the advent of extraneous capital necessarily disjoins the two elements for a time, and perhaps in perpetuity. Interest must be paid on the investment, and the farmer must pay it, the obligation being a first lien upon his land and crops. But in all countries it is held to be sound and imperative public policy to regard this separation as an evil to be cured, and to provide, if possible, for their ultimate union under the control of the land-owners. Human ingenuity, however, has never found more than one way in which this union can be effected. The farmer must pay for it, principal and interest, for he is the beneficiary. But if this is the end for which public policy must strive, it is plain enough that the burden of payment to be laid upon the farmer should be the smallest that is consistent with justice to the extraneous investor. Here is seen the inevitable consequence of the sale of water rights at a high premium, and of the evasive entries of desert land claims. The first greatly increases the capital sum which the farmer must pay before he can really own his water supply. The second depriyes him of the chief means by which he must pay it. He must buy his claim to the land from a speculator at a large price, and thus is saddled with a heavy debt at the beginning of his improvements.

The catalogue of evils growing out of the present state of affairs might be greatly extended. Though enough, perhaps, has been said to indicate their character, there is one pernicious practice which is assuming such alarming proportions that mention ought to be made of it. In many districts advanced to the second or multiple ditch stage—and the greater part of the districts are in that stage—settlers who are unable to secure good lands in the most productive districts go with impunity into the high lands or mountain meadows among the sources of the streams and take out the water which supplies the older canals below. These high lands are subject to summer frosts and are fit only for the poorest crops. In fact, the chief product is the natural wild grass which grows thickly when watered. The land is converted into a swamp or quagmire, and more water is used for this purpose on a single acre than would suffice for half a dozen acres below. The lands in the lower valleys are thus robbed of their rightful waters, and a highly productive agriculture is damaged or even ruined to sustain a wretched and most unprofitable one. It might seem as if this clearly unlawful practice could be readily prevented by an appeal to the law. But in practice it is not so. The looseness, indefiniteness, and uncertainty of rights of appropriation, the difficulty of furnishing technical proofs of damage, the mutually hostile or conflicting interests of a dozen or two dozen claims below, the difficulty of discrimina-

ting the parties who are damaged and those who are not, and many other uncertainties arising from natural causes render an appeal to the law of little or no avail. Thus numerous districts which once were prosperous are now deprived of their water at the critical time of the year and their crops injured or destroyed and some of them have been ruined. Most stringent measures ought to be taken to put a stop to this destructive practice. It is an evil of the most ruinous kind, and is rapidly increasing.

Through all these evils there run two common causes. The first is the recognition of the right of any person to make an unlimited appropriation of water at any place and to carry it wherever he pleases and use it as he pleases, subject only to prior rights. This is obviously implied in all statutes, State and national, and is explicitly set forth in the Revised Statutes (3771), which declare that: "All unappropriated waters * * * together with the water of lakes, rivers, and other sources of water supply upon the public lands, and not navigable, shall remain and be held free for the appropriation and use of the public for irrigation, mining, and manufacturing purposes, subject to existing rights."

This law is analogous to the one which by a few words of enactment erected the local customs, rules, and regulations of mining districts into statutes and gave them the force and validity of United States laws. On the whole the mining law worked fairly well, though it swamped the courts with litigation and often inflicted injustice. But the conditions affecting the appropriation of water are wholly different. The law above cited is seen to be highly improvident and its underlying principle bad. It puts a premium on misappropriation under the name of appropriation and leaves to the individual what the State should keep within its control. If ever there were a subject which in a peculiar degree and more than any other demanded regulation by the Government, it is the use of water in an arid country, and above all its first appropriation. It most profoundly concerns the public in its united capacity how and where water shall be taken, whither it shall be conducted, and how it shall be divided up and used. To leave all this to the individual is most pernicious.

The second cause is of an analogous nature, and results from the laws for the entry and appropriation of land. The acquisition of public land has always been a matter of governmental regulation to some extent, and the system after a century of growth has become well developed. But it was designed for and grew up in the humid country, and in time became well adapted to it. In the humid country, however, the land is substantially homogeneous, one tract being about as fertile and valuable as every other. The system, therefore, could safely and with advantage allow a man to settle where he pleased, for it made no difference to the final development of the country where he settled. But in the arid region it makes a vast difference where he settles. Here the land is heterogeneous in the extreme, its quantity being many times in excess of the quantity which can be irrigated. It is for the general good that the available water shall be used on the lands best suited for irrigation, and on which it shall have the highest duty and efficiency. To irrigate 1 acre of bad land is to deprive 2 or more acres of good land of the use of water. It is equally necessary that the farming population should cluster in compact districts, utilizing large streams with works of the greatest economy and efficiency and owned by themselves. The dispersive tendency of settlement should be discouraged, and the robbing of tributaries to irrigate unproductive lands wholly prevented, for it renders the more advantageous development impossible.

To sum up, the present law allowing the free appropriation of water, subject only to prior rights, leads to the following consequences:

(1) The acquirement of vested rights which are burdensome and unjust to later settlers and obstructive to higher developments of irrigation.

(2) To the most wasteful use of water without incentive to economize it.

(3) To innumerable conflicts and litigation.

(4) To settlement upon the poorer lands and to the abandonment of good lands and to depriving the good lands of water.

(5) To dispersive settlement with an unprofitable agriculture and mutually repellant interests, instead of concentrated settlements with concordant and mutually dependent interests.

The present laws relating to the disposition of the public lands in the arid region lead:

(1) To the diversion of the sudden increase in the value of land as soon as it becomes irrigable into the pockets of the speculative class, who contribute nothing to the improvement either in the way of capital or labor, thereby saddling the bona fide settler at the outset with a heavy debt at high interest.

(2) To depriving the capitalist who builds great works of his legitimate source of revenue from water service, the lands filed upon being held unimproved, also depriving him of the legitimate security upon which his investment should rest.

(3) Expanding unnecessarily the cost of the work and its capitalized debt and increasing its risks and interest thereon.

(4) To maximum charges for water service and maintenance in order to secure even the most moderate interest.

(5) The almost hopeless separation of the ownership of land from the ownership of water.

THE REMEDY.

(1) The right to appropriate water for irrigation should be limited.

(2) The irrigable lands, *i. e.*, the lands which are most advantageous for irrigation, should be segregated from the non-irrigable or those which ought not to be irrigated and the segregation officially declared.

(3) The diversion of water upon non-irrigable lands for purposes of irrigation should be prohibited under penalties.

(4) The declared irrigable lands should be opened to settlement under a new law and the desert land and timber culture acts repealed, so far as relates to the arid region.

(5) The mode of settlement of public irrigable lands should embody the essential features of the homestead law with two important qualifications. The homestead tract should not exceed 80 acres. The land instead of being given for a small land-office fee should be sold to the homesteader for a sum sufficient to pay its full cost of redemption, the payment in installments to be spread out over a term of not exceeding, say ten years.

(6) There are extensive regions of the West where Government interference, except in a very limited and generally acceptable way, would be unadvisable. There are others where it is not only desirable but imperative. The latter regions or districts are generally those which must be redeemed by extensive systems of works and whose development is mostly or wholly in the future. It is practicable now to distinguish the two classes. The stress of Government action should be directed to selected districts. Such districts should be delimited and officially declared. They should be surveyed and their irrigable lands segregated. The works for their redemption should be projected so as to form a complete system under one control, the reservoir sites selected and withdrawn, the canal and dam sites located, marked, and designated and surveyed to estimates by competent engineers. They may be termed regulated sites for canals, dams, reservoirs, and other hydraulic works or by any other distinctive name.

(7) The right to appropriate water by means of a dam and canal in any regulated district should be made inherent in the designated or regulated sites, and should be the paramount and superior privilege of such sites as against any diversions which may hereafter be made, and should relate from the time of the passage of the act. No other appropriation hereafter made should be recognized as carrying any vested right, but they may be conceded as temporary privileges terminable without indemnity whenever the water is demanded by a canal constructed upon a regulated site with the approval of the Government.

(8) Permits to construct canals and other hydraulic works in regulated districts upon plans laid down by the Government and upon regulated sites may be granted subject to the following conditions: Proposals should be advertised for and accepted parties be required to furnish security for the performance of the work at the price accepted, the Government to assume no liability for the payment of principal or interest. The contract may stipulate that the land owners under the canal shall have the right to purchase the works after ten years at the price bid and 25 per cent. in addition. A part of the works may be contracted for at first and extensions provided for in a similar way as increasing settlement demands it, the cost of the works to be assessed upon the public lands redeemed to an amount 50 per cent. in addition to the cost of the works in the aggregate.

(9) After ten years the land owners as a body corporate to have the right to purchase the works and the fund accumulated from the sale of homesteads in the Treasury to be made available as purchase money for this purpose and for no other.

(10) The control of the waters of the State of California, not navigable, should be left wholly to the control of California.

(11) A similar provision may be made for all waters of North and South Dakota, Nebraska, and Kansas which have their principal sources within those States.

(12) No water should be hereafter permitted to be diverted from the Rio Grande River in New Mexico except by special authority from Congress and none should be permitted from the Colorado River below the Grand Cañon without similar authority.

(13) Provision should be made for utilizing storm waters by authorizing the construction of reservoirs on the public lands upon the application of private parties but not upon specially selected sites. Parties constructing such reservoirs should be protected in the use of the same but should not be permitted to fill them by diverting perennial streams useful for irrigation. This protection should continue so long as the

reservoirs are used for the purpose specified, but the title to the land should remain in the Government. This provision is much needed.

(14) The right of way to canals for irrigating purposes through the public lands should be granted only to canals conveying water to lands which are officially declared irrigable. The use of their waters for irrigation of non-irrigable lands should forfeit the right of way.

(15) The right of way for railroads and highways through selected reservoir sites should be prohibited except above the flow line fixed by the irrigation survey.

REMARKS ON THE FOREGOING SUGGESTIONS.

Many of the suggestions explain themselves. The proposition to limit the size of the homesteads and fix a price upon them is for two purposes: First, to prevent speculative entries, and second, to accumulate a fund which shall become ultimately available for purchasing the works and placing them in the possession of the land owners. The homestead of 80 acres is quite as large as a farmer without capital can operate; in fact, is, if anything, too large. It is too small, however, to offer any serious temptation for speculation. The desert land claim, which is eight times as large, is a strong temptation. Even the bona fide settler expects to redeem only a small part of it and to sell the rest at a profit. If, instead of paying 25 cents an acre, upon filing an entry, the claimant were required to pay a considerably larger price and to repeat the payment yearly for a term of years, another obstacle to speculative entry would be erected. The speculator would have to put up a larger ante for a smaller pot, and would, moreover, have much more difficulty in finding a purchaser on whom he could unload and less time in which to find him. If it be objected that the accumulation of a fund places a heavy burden on the settler, the reply is that he is now carrying a much heavier burden which would not and could not then be imposed upon him, for which this is a substitute. He is now paying annually more in interest at 12 to 24 per cent. on the money borrowed to buy a 640 acre relinquishment than the installments which in ten years or less will give him an unincumbered title to his land and the ownership of his water supply.

The proposed arrangement would also be of advantage to parties who might contemplate the construction of works. At present there is usually no security for the capital invested except the works themselves. Since the courts have decided that they are only common carriers of water their rates for water service are subject to regulation by the States, which means, by the communities to whom they furnish water. Instances might be cited in which these rates have been fixed by water commissioners elected by the farmers, at a point lower than the cost of maintenance alone. The companies in many cases become money lenders to the irrigators at high interest in order to enable them to take up the land, improve it, and buy water. Of course it is the obvious interest of the company to keep off the speculator and encourage the bona fide settler. But with the desert-land law in force the settler himself is partly a speculator, improving a part of his land only and holding the rest for sale or for relinquishment. It would obviously be for the benefit of the company if the tracts were smaller and each one cultivated. But especially would it be for their advantage if a gradually growing fund were in sight in the safe custody of the United States Treasury, which can ultimately be used for the liquidation of their capital.

This growing fund would also be a bond of common interest between the canal builder and the farmer. It would be the interest of the farmers to increase settlement whereas now the tendency is the opposite.

It is proposed to make the purchase price 25 per cent. above the cost of the works. This is because during the first few years the returns to the canal company will be less than a fair profit, and also because old water rights will in almost every case have to be bought out by private purchase or condemnation. The assessment is made 50 per cent. above because it is to be anticipated that some undesirable tracts will remain unsold.

The cost of redeeming desert lands ordinarily varies from $3 to $8 per acre, except in some localities like southern California, where land is of enormous value and water obtained only by very costly works.

Very respectfully, sir, etc.,

C. E. DUTTON,
Captain, etc.

Hon. WM. VANDEVER,
Chairman House Committee on Irrigation.

WASHINGTON, *May* 3, 1890.

SIR: I have the honor to acknowledge the receipt of your letter of 29th ultimo, in which you request me to furnish the Committee on Irrigation of Arid Lands a statement of the sum deemed necessary for continuance during the next fiscal year of surveys for the purpose of investigating the extent to which the arid region of the United States can be redeemed by irrigation, in pursuance of the legislation of the last Congress, as supplemental to my testimony heard by the committee; also requesting me to designate the proportion of expenditure required for engineering surveys, for hydraulic surveys, and for topographic work, and to state how the sum heretofore appropriated has been apportioned for these several objects.

In replying thereto I must infer from your letter that the estimate should involve the assumption that the law stating the nature of the work to be done will reman unchanged. I also assume that work is contemplated in each State and Territoryof the arid region, of which there are sixteen, viz: Washington, Oregon, California, Nevada, Idaho, Utah, Arizona, Montana, Wyoming, Colorado, New Mexico,Texas, North Dakota, South Dakota, Nebraska, Kansas.

The estimates should, I conceive, be made with reference to hydrographic basins rather than to political boundaries, but at the same time giving each State and Territory the benefit of a fair share of the work. Regard should at the same time be paid to the degree of urgency in the demand for each work, and this is greater in some basins than in others. There are some extensive regions in which it does not now appear that the work can be of any great benefit; others in which the benefits may be very great and even momentous.

The engineering work resolves itself into four heads: (1) Reconnaissance: (2) selection of reservoir sites; (3) segregation of irrigable lands; (4) location and estimate work.

RECONNAISSANCE.

(1) There are very extended regions in which irrigation has made hardly more than a beginning and is in its most primitive state. Knowledge of the irrigation possibilities there is exceedingly imperfect; the problems are undefined, and it would be highly injudicious to attempt solutions of them until they are properly formulated and stated. Some preliminary investigation is absolutely necessary. It is in the least developed regions that an irrigation survey can be of the greatest benefit to future development. Parties engaged in reconnaissance can at the same time select reservoir sites and make a preliminary segregation of the irrigable lands.

(2) Systematic engineering work involving location and estimates may follow at once upon reconnaissance work almost anywhere, and in many localities the problems are sufficiently obvious so that it may be started immediately, or as soon as money is available.

Reconnaissance work may be performed by an engineer or assistant engineer with no other help than a single man for a driver. He may travel on horseback or in a buckboard, and it would be cheaper and in every way preferable for him to buy a vehicle and pair of animals rather than to hire them. His outfit may be very inexpensive.

Location and estimate work, on the other hand, requires a considerable party, ranging from seven to ten men. They ought to perform field-work for about seven months in the year on an average. During the winter the head of the party and generally one other man are retained for office work, the remainder of the party being discharged.

The arid region may be divided up into divisions, and a division engineer assigned to each—his field being as large as he can cover. For this service a man of great skill and sound judgment is required. Upon his professional and general intelligence very grave interests depend. He is relied upon to initiate definite views and projects of the future development of irrigation in his division. He must become thoroughly acquainted with its possibilities and resources, its topography and its people, and must be a man who will command the confidence of the people among whom he works. He must be a master of his profession and a trustworthy judge of all engineering projects, acquainted with the public land system and with the jurisprudence of his business. He will often be called upon to furnish reliable information and advice upon grave questions. The initiative in all matters of detail must be with him. Such men have proved difficult to find and they command high salaries or fees in private practice.

The greatness of the responsibility devolved upon a division engineer and the serious consequences which might follow from any defect of judgment on his part call for strong checks and careful supervision. The questions he is called upon to investigate and to give advice upon are so weighty, and the discretion which must be placed in his power to initiate and to recommend is so large that the bureau, in order to guaranty the wisdom and integrity of its administration, must in common prudence

exercise a special supervision over him. For this purpose two supervising engineers have been appointed. They were selected as men who possessed a widely extended reputation for great knowledge of, and experience in, the subject of irrigation and irrigation engineering, and who may be said to be men of fame in that branch and of widely recognized professional authority. Their duties are not administrative, but consulting and advisory, and they are expected to be a check upon the division engineers. The administration of the whole field-work has been placed in the charge of a chief engineer, who, under the orders of the Director and as his representative, controls the whole.

I have estimated for the following reconnoitering parties and fully equipped location and estimate parties.

	Reconnoitering parties	Location parties.		Reconnoitering parties.	Location parties.
North Dakota	2	1	Idaho	1	1
South Dakota			Utah	2	.....
Kansas	2	1	Arizona	1	1
Nebraska			Nevada	1	1
Texas	2	.....	California	2	2
Colorado	2	2	Oregon	2	.....
New Mexico	1	1	Washington	1	1
Wyoming	2	1			
Montana	1	2	Total	22	14

The expense of a reconnaissance party consisting of an assistant engineer of rather high grade at $150 per month, and one hired man at $50, with all his field expenses, averages very nearly $400 per month, and twenty-two parties in the field seven months would amount to $61,600, and two and a half months in office would amount to $8,250.

The average expense of a location and estimate party is about $1,200 per month in the field, and fourteen parties at that rate for seven months would cost $117,600. The cost in office would be about $16,500.

The Division engineers, fourteen in number, are estimated as having average salaries of $2,500—some more, some less. Men of the requisite ability would be difficult to obtain even at that price. Their field and office expenses would average $1,500, or $56,000 for all.

The supervising engineers would need offices, one at Denver and one at San Francisco, which, with their salaries and field expenses, would cost about $10,000 each or $20,000 for both.

The office of the chief engineer, which includes three disbursing agents, record clerks for segregation work, draughtsmen, copyists, custodians of property, etc., is estimated to cost, with salaries and travel expenses, $20,000.

A reserve fund for salary of chief engineer, office rent, special investigations and experiments, purchase of stationery and office supplies, payments to bonded railroads, and a large variety of contingent expenses, is estimated at $20,000.

Summary estimate of the engineering work for sixteen States and Territories.

Location parties, field and office	$134,100
Reconnaissance, field and office	69,850
Division engineers	56,000
Supervising engineers	20,000
Chief engineer	20,000
Reserve fund	20,000
Total estimated engineering work	319,950

HYDROGRAPHIC WORK.

This work consists in gauging streams, making a continuous record of their rise and fall, investigating the sources of loss of water by evaporation and leakage, the amount of water returned to streams, and also the duty or efficiency of water. This work is in part independent of the engineering work. But in many important respects the engineer is so dependent upon its results that it is necessary that he

should have some voice in determining its character and even its methods. The two branches are closely interwoven.

I estimate that in order to cover the entire arid region the minimum organization and cost should be as follows:

	Salary.	Total.
1 Chief hydrographer	$1,800	$1,800
4 Hydrographers	1,500	6,000
4 Hydrographers	1,200	4,800
5 Hydrographers	900	4,500
16 gangers	720	11,520
Total salaries		28,620
Field laborers		3,300
Instruments		10,000
Field material		10,200
Subsistence of field parties		11,000
Traveling expenses		11,000
Field transportation		4,000
Total field expenses		59,500
Maintenance of river stations		16,000
Office expenses		8,000
Total hydrographic work		102,120

In regard to an estimate for topographic work, I feel myself unable to offer one for want of a predetermination of a basis on which to estimate the amount of work required. I may say that the cost of topographic work will be fixed and become capable of an estimate when its scale and degree of accuracy are decided upon. The more accurate the work, the more it costs. The scale adopted generally by this survey is 2 miles to the inch for the published maps, and for general topographic purposes this seems to be the best compromise between all the conflicting requirements which could be made. The cost must necessarily be a very small one per square mile surveyed, otherwise the aggregate cost would probably be regarded as extravagant. In considerable portions of the west much topographic work has already been accomplished, though until within the last year the work has been on a scale of 4 miles to the inch.

By a small additional expense and by utilizing the work already done the surveyed regions can be remapped on the large scale, so that the total work might, perhaps, be done at a cost of $3 to $6 per square mile with the same standard of quality as has been adopted during the past year. Such maps would be useful and convenient, not only to an irrigation survey, but also to all interests which require a knowledge and representation of the physical, geographical and topographical features of the country. An estimate of a definite amount of appropriation would require some authoritative indication of the extent of country to be mapped in a single year, and I find myself at a loss on this point. I can only say that a topographic map is a great, beneficent, and highly useful work which governments alone can accomplish, and that the largest sum which Congress may deem it wise to appropriate will undoubtedly be expended greatly to the public advantage.

In reply to your inquiry, how the sums heretofore appropriated have been apportioned, I submit the following:

Apportionment of funds appropriated for irrigation surveys for the fiscal year ending June 30, 1889 and 1890.

	1889.	1890.	Total allotments.
Topography	$60,000	$120,000	$180,000
Hydrography	36,000	34,000	70,000
Engineering		76,000	76,000
Reserve	4,0000	20,000	24,000
Total appropriation	100,000	250,000	350,000

Of the first appropriation the allotment of $36,000 was mostly expended for hydrographic work. The amount did not become available until about November 1, 1888, and it was deemed unwise to undertake engineering surveys in the winter. Near the close of the fiscal year the engineering work was organized, and about $7,600 was expended upon it out of the first appropriation, and about $29,000 was expended upon the hydrographic work. The reserve funds were expended for the benefit of all three branches.

Very respectfully, sir,

C. E. DUTTON,
Captain of Ordnance, Chief Engineer.

HON. WM. VANDEVER,
Chairman of House Committee on Irrigation.

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