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FIRST BIENNIAL REPORT

OF THE

STATE ENGINEER

TO THE

GOVERNOR OF NORTH DAKOTA

1904

E. F. CHANDLER, State Engineer

BISMARCK, N. D.:
PRESS OF THE TRIBUNE
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LETTER OF TRANSMITTAL

November 30, 1904.

To the Honorable Frank White,
Governor of North Dakota:

SIR: In compliance with custom, I have the honor at this time to submit herewith a report of the work of this office for the past season, with recommendations concerning such action as in my judgment will conduce to the interests of the state.

Yours very respectfully,

E. F. CHANDLER,
State Engineer.

MAJOR JOHN W. POWELL
Died September 23, 1902
Director of the United States Geological Survey from 1881 to 1894.

INTRODUCTION

No legislation having been yet enacted concerning the office and duties of state engineer, I have endeavored, since you appointed me to that office July 7, 1904, under the direction of the executive committee of the State Irrigation Association, to accomplish as a beginning those portions of the customary work of that office of which there was the most immediate need. The following quotation from the Laws of the State of Wyoming (Rev. Stat. 1899, Sec. 104), sums up briefly the customary duties:

"The state engineer shall make, or cause to be made, measurements and calculations of the discharge of streams, from which water shall be taken for beneficial purposes, commencing such work upon those streams as are most used for irrigation or other beneficial purposes. He shall collect facts and make surveys to determine the most suitable location for constructing works for utilizing the water of the state, and to ascertain the location of the lands best suited for irrigation. He shall examine reservoir sites and shall, in his reports, embody all the facts ascertained by such surveys and examinations, including wherever practicable, estimates of the cost of proposed irrigation works, and of the improvements of reservoir sites. He shall become conversant with the waterways of the state, and the needs of the state as to irrigation matters, and in his reports to the governor he shall make such suggestions as to the amendment of existing laws or the enactment of new laws as his information and experience shall suggest, and he shall keep in his office full and proper records of his work, observations and calculations, all of which shall be the property of the state."

Taking up these separate clauses in order, I will here state briefly what has been done under each this season, and report in detail in the pages following.

Stream measurements and calculations of the discharge are a necessary prerequisite to any intelligent and advantageous utilization of the streams, and such work comes first in point of time in investigations as to the feasibility of any proposed irrigation works. Without a long continued series of stream flow records, sufficient to show clearly what flow may ordinarily be expected, plans can be made only blindly. This fact is discussed in detail in the chapter on "Methods of Stream Measurements," in the current report of the State Geological Survey, a chapter which was prepared by me in fulfillment of a promise at the opening of the season and which is reprinted as an appendix to this report. Such records have the greatest value when continu-

ously maintained for each stream throughout several years. Although that work would ordinarily receive considerable attention from the office of the state engineer, it did not seem best this season to devote time to it, for the reason that a comprehensive system of measurements of the principal streams is already carried on under federal appropriation by my assistants and myself in the capacity of district hydrographer for the U. S. geological survey, so that records are available when needed. A brief summary of these measurements is included here at the conclusion of the discussion of the river systems of the state and a more extended tabulation for some of the streams is published in the current report of the state geologist. The complete detailed statement of results is published, some months after the close of each year, by the U. S. Geological Survey in the "Water Supply and Irrigation Papers" series.

Some investigations for determining the most suitable locations for irrigation works and the extent of irrigable lands were undertaken. About six weeks were spent in the field, with a small party or with one assistant, in work along the Cannon Ball and Knife rivers and other streams, this being merely a preliminary reconnaissance with the object of discovering in what regions the possibilities were great enough to justify the expenditure of time and funds in more thorough investigation hereafter. An effort was made to obtain an approximate estimate of the total amount of irrigable land along the streams traversed and to note any especially favorable points for irrigation that might be seen. All other available information has been collected, and the chief results of these investigations are embodied herein.

Reservoir sites deserve investigation and consideration. There are but two streams in the state (the Missouri and the Red river) whose summer flow may not be expected to fall below 200 second feet, a quantity hardly sufficient for irrigating 25 sections of land; many of the streams of the state are almost or quite dry for a portion of the summer. In order that irrigation may be extended through the season, storage of the floods is a necessity. There is almost always an early spring flood, when the ice goes out; usually a "June rise," which sometimes surpasses the spring flood in amount of flow; and on some of the streams frequent small rises after storms, in which an immense amount of water flows down to waste. If the water of these floods can be conserved till needed, a supply sufficient for irrigation works of reasonable extent is assured. It did not seem advisable this first season to go to the expense of making elaborate surveys and complicated designs for reservoirs, but when apparently favorable sites were found in the course of the field work, rough surveys were made to secure data for approximate calculations of dimensions and capacity. These results are noted

at the proper points in the discussion of the respective streams, and the sketches and calculations are filed in the office.

The fact that North Dakota has as yet no irrigation laws made it fitting that a suitable code should be framed for submission to the legislature. The states of Oregon and Washington, at their last legislative meetings, appointed commissions to prepare such codes, and these commissions requested the assistance of the U. S. Reclamation Service; finally a complete code was drawn up by Mr. Morris Bien of the reclamation service and submitted for comment and criticism. The various suggestions and emendations made have brought it into a shape that seems to combine the most advantageous features of the codes of all the states and to offer few points for further criticism, and with the various amendments incorporated by Mr. Bien this is printed as an appendix here. In the following chapter I make a few suggestions regarding changes that would adapt it to local conditions, and urge its favorable consideration by the legislature. The general features of this code are such as will undoubtedly meet the needs of this state well, and it will be a great advantage to be as nearly as may be in line with the other western states in our laws on this subject.

It is also proper that the state should, through its state engineer and otherwise, cooperate so far as possible with the engineers of the U. S. reclamation service wherever those officials are undertaking investigations whose favorable outcome will lead to the development and prosperity of the state. North Dakota is one of the states included under the provisions of the reclamation law, and it may be hoped that the various investigations that have lately been undertaken by the reclamation service in the state will result favorably and will lead to the prosecution of many other projects in different portions of the state. A brief statement of the various investigations that the engineers of the reclamation service have carried on is included under a separate heading. These federal engineers are presumably of greater ability and experience in their respective lines than any that the state would ordinarily be able to secure; but from the same reason they are often transferred from one place to another in their work. It may facilitate their work when coming to unfamiliar localities if the office of the state engineer can be regarded as a local bureau of information; if the work of the office be continued, it will become continuously better equipped for this duty.

The citizens of the state may also fairly request for the present much individual attention from this office. Irrigation is comparatively new in North Dakota, there are few residents who have had much experience, nor are there many who, attempting to introduce that method of agriculture, are able to profit by the experience of neighbors; definite information is not yet easily accessible here. It therefore seemed fitting and advan-

tageous that I should give any reasonable assistance within my ability in the way of advice or information on the subject. Before beginning the summer field work, after receiving the appointment to the office, I published quite widely in the newspapers and otherwise an invitation for the sending of inquiries concerning methods, lands and projects. Many such inquiries were received and answered or visits made. It unfortunately happened that frequently the inquiries were made just after I had visited some region, instead of before I went, so that, being at the time in ignorance of the location of those interested, I could not always assist as I should have liked. But these inquiries have been properly filed, and advantage should be taken of the first convenient opportunity to visit these various lands and inspect their possibilities.

A list of the addresses of those in the state employing irrigation is in preparation and inquiries are being made of them concerning their methods, crops, and success. It was intended to publish as a part of this report such portions of their answers as would be helpful for general distribution. But more of my own time than had been expected was needed by the reclamation service in connection with the work on the Missouri river project and elsewhere, so that this work is not yet finished. It could if desired perhaps be published advantageously as a bulletin early next season. Other future bulletins needed are upon the methods of constructing substantial and economical dams across the small coulees and ravines so as to store the spring or storm waters, and upon the preparation of fields for irrigation and the methods and implements to be most conveniently used.

So far as time has permitted, available information on this subject has been given to all inquirers or prepared for publication as opportunity has offered. At the meeting of the National Irrigation Congress at El Paso, Texas, Nov. 15 to 18, I was present as the representative of the state, and also presented a paper on the spring floods of this region; but as the complete proceedings of the congress will be published by its officers soon, it is unnecessary to make report here.

In response to frequent inquiries, there is inserted here for convenience of reference the text of the National Reclamation Act, which was introduced in congress on motion of our honored senior senator, Henry C. Hansbrough, and became a law by the signature of President Roosevelt, June 17, 1902.

The primary application of this law is evidently for the reclamation or improvement of the public lands. Where the lands are in large part in private ownership, as is the case in North Dakota, the benefits of the law may be received only if the owners request it and voluntarily pledge themselves to the ultimate repayment of the expenditures as provided by the law. If the detailed surveys show the projects now contemplated

in the state by the reclamation service or others to be feasible and profitable, there will undoubtedly be required before construction is begun some such agreement between the land owners as is shown by the articles of incorporation of the Lower Yellowstone Water Users' Association, which are reprinted in this report.

Great benefit may come to the state from the intensified and diversified farming, the certainty of results, and the stability of agricultural values that will follow the practice of irrigation where it is made possible under the extensive projects that it is the province of the federal bureau to carry through. Still greater results, in the sum total, may be expected from the small projects constructed by individual enterprise, the reservoirs and canals that are the work of a single owner or of three or four cooperating, and that cover only a score or a hundred acres. The whole practice of irrigation is still in the experimental stage in North Dakota; the most economical methods of preparing the fields, the most profitable crops, the best methods of bringing water to the land and applying it and the proper time and amount of application, all these can be learned best from experience. A farm for irrigation experiment in an appropriate section of the state would if properly conducted at public expense repay its cost many times, and should be established at the earliest opportunity. If the Bismarck pumping project should be carried out as contemplated, a suitable location may perhaps be found in that vicinity; this would be very advantageous on account of its accessibility and for other reasons.

It should not be forgotten that, no appropriation having been thus far made by the state directly for such irrigation investigations and similar work as the present emergency seemed to require, the work of the office of state engineer was begun as the result of a cash guarantee filed with the governor by six of the leading bankers of the state. It is trusted that the legislature may see the way clear to reimburse to these public spirited gentlemen the funds that they have so generously advanced. These expenses have not been as great as will be necessary if irrigation develops to the extent requiring elaborate investigations of water rights for adjudication and many other lines of work that would then arise, but have been sufficient to make a good beginning in this first season. A brief summary of expenditures up to Nov. 30 is shown elsewhere in this report.

The other immediate needs of the state in irrigation matters would all be fully provided for if the legislature should enact the irrigation code submitted herewith, or any other law including the same essential features, the discussion of which with my recommendations follows.

DISCUSSION OF IRRIGATION CODE

The discussion of the irrigation laws desirable for this state may be introduced by a quotation from the speech delivered by Major J. W. Powell, director of the U. S. Geological Survey, on August 5, 1889, before the North Dakota Constitutional Convention then in session.

"I was a farmer boy and had been engaged in farming, and have spent a good deal of the time studying many other problems which interest your people. I remember in my childhood my father moved into Illinois. Then I remember when Wisconsin and Minnesota were making states and now you are making two states of Dakota. All these years I have watched the march of progress across the continent and have seen all this western half of America grow up as if from a wilderness. Of the questions that practically interest the people who are engaged in farming, I have made some study, and in my remarks I will confine myself wholly to some practical questions relating to irrigation, and then I will show what the constitutional convention should have to say about them.

The state of North Dakota has a curious position geographically in relation to agriculture. The eastern part of the state has sufficient rainfall for agricultural purposes; the western part has insufficient rainfall, and the western portion is, practically, wholly dependent upon irrigation. In the western portion all dependence upon rain will ultimately bring disaster to the people. They are not willing yet, a good many of them, to admit it, but the study of the physical conditions which prevail in this country and the application of the knowledge which has been given to mankind through the study of the same problems in Europe and Asia and Africa, all prove this one fact—that in the western portion of this state they will have to forever depend on artificial irrigation for agriculture. In the eastern portion they may depend upon the storms that come from the heavens, and there's a middle belt between the two regions which is of very great interest. They will soon learn in the western portion to depend upon irrigation and provide themselves with agencies for the artificial fructifying of the soil with water. In the eastern part they will depend on the rainfall, and in the middle portion they will have a series of years when they will have abundant crops; then for two or three years they will have less rainfall, and there will be a failure of crops and disaster will come to thousands of people, who will become discouraged and will leave. Up and down the temperature of agriculture will

rise and fall with the seasons in this manner, and the only practical way to do is to look the thing squarely in the face and remember that in middle Dakota agriculture will always be liable to meet with failure unless you provide against it. That is the history of all those that live on the border between the humid and the arid lands. Years will come of abundance, and years will come of disaster, and between the two the people will be prosperous and unprosperous, and the thing to do is to look the question squarely in the face and provide for this and for all years. You hug to yourselves the delusion that the climate is changing. The question is four thousand years old. Nothing that man can do will change the climate. A long succession of years will give you the same amount of rainfall that any other succession of the same length will give you. The settlement of the country, the population of the country, the planting of the country, the cultivation of trees, the building of railroads—all these matters will have no influence upon your climate. You may as well not hope for any improvement in this direction. There is almost rainfall enough for your purpose, but one year and another you need a little more than you get. It is flowing past you in the rivers. Storms come and spread over the land and the water runs off into the rivers and is carried into the waters of the Gulf of Mexico. There are waters rolling by you which are quite ample to redeem your land and you must save those waters. I say it from the standpoint of the history of all such lands. Civilization was born in arid lands. Taking the world at large most of the agriculture of the world has depended on irrigation for more than 4,000 years. The largest populations have depended upon irrigation, so it is an old problem, and it has been solved time and again, so that it may be said that there is nothing to learn. All you have to do is to learn the lessons already taught by history, and that it is in these lands you have to depend on placing the water on the soil. In humid regions the storms come, and the fields receive the gentle shower, but frequently just before the harvest a great storm devastates it all. In this arid region if you depend on artificial irrigation, you are independent of storms. The waters that are brought on the land by irrigation are sources of fertilization beyond all other sources. There are fields in the eastern world that have been cultivated for 4,000 years—where water was brought on the land to irrigate, and all other fertilization is unnecessary. Now in all these lands of high culture, when the fields are irrigated, they are ceasing to use any other fertilizer. In France where they are irrigating their lands, they have commenced a system in every county and township—the same in Spain and Germany. The find that they must pour the waters of their streams upon their lands.

As members of this convention this is what I want to say to you. Not being a public man, it may be considered a little

presumptious for me to say it—in Dakota you are to depend hereafter in a great measure on the running streams—in small part on your artesian wells, and in part on the storage of the storm waters. The chief source will be the running streams. These waters are to be preserved and stored during the seasons of non-irrigation. There are, say, two months of the year when you need to irrigate, and ten months when you should store the water. All other wealth falls into insignificance compared with that which is to come from these lands from the pouring on them of the running streams of this country. Don't let these streams get out of the possession of the people. If you fail in making a constitution in any other respect, fail not in this one. Take lessons from California and Colorado. Fix it in your constitution that no corporation—no body of men—no capital can get possession and right to your waters. Hold the waters in the hands of the people. Think of a condition of affairs in which your agriculture—which you will have to depend on largely—depending on irrigation, is at the mercy of twenty companies who own all the water. They would laugh at the ownership of land. What is the ownership of land when the value is in the water? You should provide in this constitution that you are making that the water which falls from the heavens and rolls to the sea, down your great rivers—that water shall be under the control of the people subject always to the will of the people; that property in water should be impossible for individuals to possess. You should forbid the right to acquire property in water. The property should be in the land, and the right to the water should inhere in the land, and no company or individual should have property in the running streams. Such a provision will prevent your great agricultural resources falling into the hands of the few."

Acting upon the suggestions and advice of Major Powell, the state constitutional convention adopted the following constitutional provision with regard to irrigation:

"Sec. 210. All flowing streams and natural water courses shall forever remain the property of the state for mining, irrigating and manufacturing purposes."

The title to the streams thus must remain with the state, and the state retains an absolute control over their use by the people. It is the province of the state to so regulate the use that the greatest benefits may accrue to the people from that use. Some means must be provided by which the man who has by his enterprise and industry developed and applied to beneficial use the waters of any stream may have thereafter a fixed right so long as he continues that use. Otherwise his success might encourage later settlers to go higher up the same stream and appropriate its waters even to the utmost, when he would be deprived of all benefits from the stream whose use he was the first to develop.

With the change of a few phrases, this paragraph from the report for 1896 of the state engineer of Wyoming is appropriate here:

"It is easy to fix the boundaries of land and to mark these by monuments which shall be enduring and known to all men. The nature of the land patent is simple and the kind of title it confers easily understood, but it is otherwise with rights to the river which flows past the farm and determines its value. We have here to deal with a form of property which exists today and is gone tomorrow. To regulate the division of a common and fluctuating supply in such a way that the farmer may be assured that his portion of the snows which fall on distant summits will find its way certainly and surely to his fields before the streams runs dry, and that he shall have his proper share and others not suffer unwarranted loss, is one of the most complex administrative problems which has ever taxed the mind of man. We can fix no boundaries to ownership in the stream nor can we give a patent to the snows which may or may not fall next year, nor to the waters which flow today and are gone tomorrow. The stream that we deal with today is not that of yesterday, and the supply which meets the demands of this month will not be the same next month or next year. Yet the waters are of value and must be divided. The irrigated home is important, and its productiveness must be made secure, not for this year only, but for next year and for all time."

A satisfactory irrigation code chiefly concerns two general topics. First, the procedures for acquiring the right to the use of water; second, the means for avoiding so far as possible interference between conflicting water rights and for affording prompt and simple relief when such occur, for preventing waste of the water in seasons of scarcity, and for securing to all the land owners the fullest advantages from its use.

The right that any individual receives from the state is based only upon beneficial use and is appurtenant to the land which is benefited. No person, however, can rightfully gain control of more water than he can use properly, hence his appropriation is measured by the acreage of land irrigated. Furthermore, since the right to the water is based on the ability to use it advantageously, the title to the appropriation that he claims is not complete unless he actually carries out the necessary constructions with due diligence and applies the water to the land; and if abandoned for more than a reasonable period the right is lost. This gives the water to those who desire to use it, and permits no monopolies under paper titles.

The acquirement of water rights must be carefully guarded, because wherever irrigation is a success there is sure ultimately to be a desire to appropriate and use more water than is available in the stream at ordinary stages. At any period of scarcity waste must be avoided and each appropriator restricted to his

actual needs. If the supply is still insufficient, as is likely to be the case at some seasons, priority of appropriation gives priority of right; the earliest appropriator of course has the best right to the use of the water in subsequent years. Only the smallest streams are included within a single county, hence the recording of appropriations in a county office is a mere temporary expedient; in order that all the water users along a stream may be properly arranged in priority it is therefore necessary that the claims should be recorded at one central office; thus arises one of the duties of the office of state engineer; the collecting of all the data and records at a single office in order to facilitate the intelligent division of the streams among the various claimants unifies the work, conduces to economical investigation of the state resources in that direction and leads readily to the collection by the engineer and the assistants of varied information on the subject and to its convenient distribution. The state is thus able, through the office of the state engineer, to retain the general control of the streams and yet give the fullest possible use to the people, and to encourage and develop irrigation where the opportunities are not fully improved.

The irrigation code, prepared by Mr. Morris Bien of the United States reclamation service, that is printed as an appendix to this report, is based on the principles stated above. After its preparation this summer it was widely distributed for consideration; at sessions of the irrigation congress at El Paso in November it was thoroughly discussed, and since the incorporation of various suggested changes and amendments it is now considered a model in its sound and effective provisions, in its well balanced inclusion of all essential features, and in its freedom from ambiguous language, and it will undoubtedly be used by many states as a goal towards which to gradually alter their own codes. It is somewhat more elaborate than the present development of irrigation in North Dakota requires, but all its clauses are reasonable in purpose, and the unnecessary striking out of any portions might, in the coming days of larger development, be found to have resulted in troublesome omissions that would destroy the consistent unity of the code.

There are various points at which minor modifications, without changing the general principles, would adapt it more closely to the local conditions or existing statutes in North Dakota. These may be mentioned as follows:

In section 32, on the obtaining of copies of all previous water right decisions or records from the counties, for the words "county recorder" there should be substituted "county register of deeds."

North Dakota is not classified as an arid state; it is not only a fact that crops can be raised without irrigation, but it is also true that in unusually wet seasons irrigation might be of no benefit. It will therefore happen that even the most elaborate

works for utilizing water may sometimes for a single season stand idle. I recommend, therefore, that in section 48, the period necessary for abandonment of claim be made three years instead of two. Likewise in section 49 the amount of water fixed as the maximum amount which one land owner should be entitled to claim in time of scarcity to the impairment of the claims of later appropriators may, in this latitude and climate, safely be reduced from "one cubic foot of water per second for each seventy acres" to "one cubic foot of water per second for each eighty acres."

In section 61, it should be provided that any state lands needed by the United States for irrigation works shall be sold to the United States at the lowest price authorized by law.

In sections 8, 17 and 62, in conformity with existing methods of procedure here, claims for services rendered, expenses incurred and materials and supplies furnished should not be filed in the office of the secretary of state, but of the state auditor.

Section 17 establishes a revolving fund for the purpose of paying the expenses of such hydrographic surveys as may be ordered by any court in order to obtain the necessary data for the proper adjudication of suits that have been filed for the determination of the right to the use of the waters of any stream system. These expenses are charged in the costs of the suit and at its conclusion are repaid into the fund by the parties. Up to the present time water has been appropriated here by comparatively few land owners; if proper regulations are now established, it may be hoped that there will be less confusion and trouble between conflicting claims than has existed in some of the other states, that there will be few suits arising and that the hydrographic survey fund will be drawn on infrequently. It therefore seems that, at least for the present until the irrigation interests are more completely developed, in this state instead of $5,000 a fund of $2,000 would be ample for all demands.

The most logical and convenient water divisions as called for in section 37 would be bounded as follows:

"Water Division No. 1 shall consist of all that portion of the state west and south of the Missouri river.

"Water Division No. 2 shall consist of all lands within the state drained by the Mouse river and its tributaries, and of all lands within the state north and east of the Missouri river drained by the Missouri and its tributaries from the boundary of the state of Montana as far down as Fort Berthold.

"Water Division No. 3 shall consist of all lands within the state east of the Missouri river drained by the Missouri and its tributaries below Fort Berthold, and of all lands within the state drained by the James or Dakota river and its tributaries.

"Water Division No. 4 shall consist of all lands within the state drained by the Red river or its tributaries, except the Mouse

river as hereinbefore specified, and of all lands within the state drained into Devils Lake."

Sections 38, 39, 40 and 41 relate to the office and duties of the board of water commissioners. These are the officers that under the state engineer have the general supervision, control and apportionment of the waters in their respective divisions, through such water masters as it may be found necessary to appoint in each locality. These sections concerning water commissioners and water masters follow in all essential points the practice of most irrigation states, but it will undoubtedly appear that so elaborate preparations for state supervision are not yet necessary in North Dakota. Water masters are customarily appointed only when local difficulties arise concerning the division or use of the water, and although provided for in the general law, would not be appointed in any locality until requested or needed by the irrigators who would be benefited by the control of the waters and who would pay for such services. This is foreseen in the provisions of the code, in that districts are to be established from time to time as necessary, and that the water masters are to be paid only for such time as they are actually employed.

If it is considered that the office of water commissioner is as yet unnecessary in this state, its temporary omission may be easily arranged, with resulting economy in expenditure, by changing "shall" to "may" in the second line of section 38 so as to read "A water commissioner may be appointed by the supreme court," etc., and by adding at the end of the section the words, "Provided, further, that during any temporary or permanent vacancy in the office of water commissioner, the powers and duties of such water commissioner shall devolve on the state engineer."

In sections 5, 6 and 7 the appointment, duties and compensation of the state engineer and his assistant are outlined. The question of compensation was discussed at some length at the session of the National Irrigation Congress this fall, mentioned above, and it was generally agreed that the annual salary of $3,000 per annum as fixed in the code under discussion, with the provision requiring the whole time of the engineer, or rather forbidding him to engage in private practice, was insufficient to attract an engineer of long and varied experience such as is demanded for the office of state engineer in the states where irrigation is, and has been for years, the source of support of the whole agricultural population; for in those states the large irrigation corporations are able to offer to qualified men a much greater recompense than that mentioned above. On this account the clause was opposed by some speakers. In North Dakota, because the irrigation interests have not yet developed to such an extent as in the states further west, there will perhaps be a feeling in the minds of some citizens that the expenditures

should be kept within the lowest reasonable limits. I beg leave, however, to suggest that unless some special arrangement should happen to be convenient (in conjunction with the reclamation service work or otherwise) for securing an engineer's services for a portion of the time at a proportionately smaller total compensation, it would hardly be for the ultimate advantage of the state by a mistaken economy to reduce the quality of the work of the state engineer's office very much below that contemplated in Mr. Bien's code. In any event, within a few years that work will undoubtedly have increased to such an extent as to require the entire time and exclusive services of a state engineer, so that any other arrangement could be only temporary. The provisions of the code as it stands seem to me most advantageous for North Dakota even now, but the whole question is hereby respectfully submitted to the consideration of the legislature.

RIVER SYSTEMS OF NORTH DAKOTA

The Cannon Ball river, which drains the northern part of Morton county, Hettinger county, and the southeastern portions of Billings county, enters the Missouri river about thirty miles below Bismarck (51 miles following the Missouri), is one of the largest streams in the state, and offers many opportunities for irrigation after certain general difficulties are overcome. The headwaters are 140 miles west of its mouth along the general course of the valley, or at least twice that distance following the bends of the stream, at the crest of the divide at the eastern boundary of the Little Missouri valley. The elevation of this portion of the state is not yet definitely known, but the divide may be assumed to be at about 2,800 feet elevation above sea level. The small streams flowing eastward and slightly toward the south unite in two branches, the north branch of the Cannon Ball (to which the general name Cannon Ball is applied) and the south branch, usually called the Cedar. The Cedar flows parallel with the South Dakota boundary and near it, being for fifty miles between five and ten miles from that line. About forty miles from the Missouri river the branches unite and flow northeasterly to the mouth, whose elevation is 1,591 feet. For seventy-five miles the lower Cannon Ball and Cedar form the northern boundary of the Standing Rock Indian reservation. The entire area drained by the Cannon Ball is 4,200 square miles or a little more, less than one-eighth of this area, however, being included within the Indian reservation. The greater portion of this area is best adapted for grazing, but there are narrow portions along the streams aggregating many thousand acres where agriculture is or can be practiced to advantage now, and where irrigation might add greatly to the returns.

The valley of the main stream may be characterized in a few sentences. The river runs in a narrow meandering channel usually ten to twenty feet deep cut in the lowest flats. Above this plain rise other "benches" or terraces, each being from ten to forty feet above the terrace below. The benches are nearly or quite level, except that they usually descend gradually at the same grade as the valley, but the descent from one bench to another is usually quite abrupt. There is often a succession of benches, up to the high prairie bounding the valley, from half a mile to three miles distant and from one hundred to three hundred feet or more above. If these benches were continuous, the location of extensive canals would be a simple matter, and the whole valley could be easily brought under irrigation. Unfor-

other, forming cut-banks or precipitous slopes that in many cases are fifty or a hundred feet high. The level tracts in the valley are so separated and divided by these cut-banks, ravines and occasional "bad lands" that it would in some sections be impossible to run a ditch or canal more than a mile or two without long stretches of fluming and other constructions that would require a disproportionate expense both for construction and for maintenance. Therefore it would not as a rule be convenient to carry water to the higher benches, although more careful survey than the rapid reconnoissance of this summer may perhaps discover a few points where this is feasible.

The average fall of the Cannon Ball is about five feet to the mile, measured down the middle of the valley. This is not uniform for its whole length and depends upon the nature of the bed and the consequent power of the stream to aggrade its channel to a uniform slope. A slope nearly twice as great is occasionally found for half a mile or a mile at sections of unusually stony channel, but in passing through stretches where the channel has been easily scoured out, less than half the usual fall may be found. Near the headwaters the descent is presumably more rapid.

This stream has, pre-eminently after the Little Missouri, the characteristics of all the streams west of the Missouri river, a very spasmodic flow. Its flow at times of greatest flood is at least thirty times its average flow for the year, and more than a thousand times its smallest summer flow; it is sometimes reduced for a few weeks in the dry season to a mere series of standing pools, the evaporation from which is more than all the inflow from springs. But after storms the river quickly rises, in floods that are sometimes impossible to ford. At the spring thaw a high flood may be expected. In 1904, for example, half of the entire quantity of water discharged by the Cannon Ball in the whole year was poured into the Missouri river during the first fifteen days of the month of April. The records have not yet been maintained through enough seasons to tell whether this is greater or less than the usual ratio.

If irrigation should be attempted, a single spring flooding could ordinarily be made without storage, but any summer irrigation will evidently require storage reservoirs, large or small, if it is to be employed in the dry seasons when it would be most profitable. The topography of the valley is such that fairly advantageous reservoir sites are quite frequent, although there is scarcely any rock in the sides of the valley or at the bottom, so that the question of foundations for a dam would be perplexing, and considerable attention would be necessary to build a dam that would be secure against floods.

The references to township and section given in the following pages are not supposed to be always absolutely correct, as government monuments sometimes could not be found without

too prolonged search, but are believed to be approximately correct, and as precise as the other measurements in this first examination.

The river at its outlet passes through the usual low woods that border the Missouri and that are flooded during exceptionally high spring stages of that stream. Above this, from Sec. 16, T. 134, R.79 (where there is a single tract of 500 acres of fine land all on the north side of the Cannon Ball river just below the postoffice of Cannon Ball, located 10 to 30 feet above the river bed), up to town 134 R. 80, the width of the bottom lands and lower benches not more than 30 feet above the river averages about one-fourth mile. In Sec. 13 and 24, Town 134, R. 80, there is a tract of 700 acres from 10 to 25 feet above the river, mostly on the south side. Above Sec. 34, T. 134, R. 80, the valley is narrow with no low flats or mere fragments, and the frequent cut-banks would make canal constructions difficult.

At Sec. 26, T. 134, R. 81, the valley widens, and there 300 acres on the south side of the river at 20 to 30 feet above low water; the land is, however, rather uneven. On sections 28 and 29 there was estimated to be 850 acres of fairly level land, mostly on the south side of the river and from 15 to 25 feet above the channel.

Beginning in Sec. 30, T. 134, R. 81, and in T. 134, R. 82, the flats stretch along the north side of the river for one and a half miles in sections 25, 26, 36 and 35, with a width of 200 rods and upwards; there are several low benches, between the heights of 10 and 30 feet, including a total estimated area of 800 acres, most of this being between 20 and 25 feet above the river. These flats are smooth and well adapted to irrigation if water can be conveniently secured, and are situated below the mouth of Dogtooth creek, up which they extend. It would perhaps be more easy to bring water from this stream than from the Cannon Ball.

In sections 2 and 11, T. 133, R. 82, there is a smooth flat of 400 acres extending along the river more than a mile on the north side at an elevation of 15 to 20 feet, and a quarter section on a third bench 15 higher. Above this the valley bottom has a width of only a quarter mile, and is cut by the meanderings of the river.

Beginning a mile below Stevenson postoffice, in sections 16, 15, 21 and 22, there is a fine flat of some 400 acres unusually near the river level, at an elevation of only about 15 feet above low water, and nearly an equal amount on the second and third benches from 20 to 35 feet above the river, all on the north side. In sections 28 and 29 there is on the north side a smooth flat of 300 acres from 15 to 20 feet above the river, and as much more on the upper benches. At the north side of Sec. 32, however, there is a long cut-bank that would almost forbid canal construction.

Above this the valley bottom is only about one-quarter mile wide, to sections 4 and 9, T. 132, R. 83, where there is a 400-acre tract on the north side of the river at 20 to 25 feet elevation. Just above Shields postoffice, section 30, T. 132, R. 83, there is about 250 acres of very smooth land on the north side of the stream, but on the third bench, 30 to 40 feet above low water. At the same point there is also 250 acres of level land on the second bench, 15 to 25 feet high, in Sec. 31, T. 132,R. 83, and Sec. 36, T. 132, R. 84.

In the southeast quarter of Sec. 3, T. 131, R. 84, a possible reservoir site was noted where a low ridge projecting from the north side of the valley leaves only a small gap through which the stream flows. The table below is a mere estimate, and as levels were not run up the stream, it is likely that backwater would extend up farther than estimated, increasing the capacity. The heights of the dam do not include foundation.

Section 3, Township 131, Range 84

DAM			RESERVOIR	
Greatest height	Average height	Length	Estimated area	Estimated capacity
5 feet	3 feet	150 feet	6 acres	15 acre-feet
10 "	6 "	200 "	14 "	65 "
15 "	7 "	350 "	35 "	190 "
22 "	8 "	800 "	70 "	550 "
28 "	8 "	2,200 "	110 "	1,100 "

A similar location was noted at the southern side of section 16, T. 131, R. 84. At this point the flats are about 20 feet above the river, but a ridge rising 10 to 15 feet above the flats stretches across the valley except for a narrow opening at the channel, leaving a basin of 160 acres extent on the flats above.

From Sec. 29, T. 131, R. 84, up to Sec. 27, T. 131, R. 85, the bottom width of the valley averages a half mile, at an elevation of from 15 to 30 feet, but the flats are badly divided by the river, which winds back and forth from one bluff to the other.

Lignite coal is found in sufficient quantities for convenient use from this point up the river, and with that fuel it might be found profitable to pump up to the lower benches. On the lower Cannon Ball only very thin veins of coal have yet been found, but a three foot vein is worked near the center of township 131, R. 85, and others are reported south of the river; the coal is found to be more abundant as the river is ascended.

A half mile below the confluence of the Cannon Ball and Cedar an opportunity for a reservoir where a single dam would give storage capacity in the valley of each stream was noted. The difficulties are, first, the uncertainty as to substantial foundations; second, the fact that (in the very rapid examination that

time allowed) no good building material was found; third, the value of the flooded land, which is the best land in the vicinity and is in part cultivated by the settlers. A rapid instrumental survey was made and the results computed as given in the following table for reservoirs of different depths, although levels were not run up stream as far as the highest flow line, so that the table is based partially on estimate; but the areas and capacities except of the largest reservoir may be assumed to be within ten per cent of the exact values.

Section 34, Township 131, Range 85

DAM			RESERVOIR	
Greatest height	Average height	Length	Area	Capacity
15 feet	4 feet	820 feet	160 acres	790 acre-feet
25 "	9 "	2,450 "	480 "	4.000 "
35 "	15 "	3 450 "	1,250 "	12,600 "
45 "	24 "	3,750 "	2,040 "	29,000 "

The flats near the confluence of the branches of the Cannon Ball include, within a distance of about a mile above and below the junction, more than a thousand acres at an elevation not greater than 35 feet.

On the north branch, just above Wade postoffice, in Sec. 30, T. 131, R. 85, there is a fine flat of 250 acres on the north side of the river at an elevation of about 20 feet.

Above this, the valley bottom for several miles is from a quarter to a half mile wide at an elevation of from 15 to 25 feet, but with the usual cut-banks occasionally.

Near the line between sections 3 and 4, T. 131, R. 86, the valley is so nearly closed by projecting bluffs that the width between the tops 65 feet above the river is only a quarter of a mile. This affords a possible location for a reservoir, and a few measurements were made upon which the following rough estimate is based.

Sections 3, 4 and 5, Township 131, Range 86

DAM			RESERVOIR	
Greatest height	Average height	Length	Area	Capacity
15 feet	8 feet	300 feet	110 acres	650 acre-feet
20 "	7 "	1,200 "	200 "	1,400 "
25 "	12 "	1,250 "	350 "	2,800 "
30 "	17 "	1,250 "	530 "	5,000 "

If material were conveniently at hand for its construction, and if the nature of the foundations were such as to be able safely to sustain a dam extending to the top of the bluffs, it would be possible at a not disproportionate expense to have here a reservoir large enough to contain the entire ordinary spring flood discharge of the river. But these conditions are probably not satisfied.

Above this point, to section 19, T. 132, R. 86, the width of the valley averages more than a half mile, but the flats, from 20 to 30 feet above the stream, are so uneven and so divided by the winding of the stream, and high cut-banks and bluffs close under the foot of which the stream flows are so frequent that irrigation would be impracticable except by local pumping.

In Sec. 30, T. 132, R. 86, at a constriction of the valley between 60 foot bluffs, a dam 1700 feet long closing the gap, 40 feet high at the channel and 20 feet high for most of its length, would hold back an estimated amount of 13,000 acre-feet.

Above this point no considerable opportunities for irrigation were noted for many miles. The valley bottom is narrow (rarely more than a quarter mile wide), uneven, and broken into small tracts by the twisting and turning of the river, and the frequent cut-banks would prevent economical canal construction. Here, as elsewhere, there are many large tracts of land level and with a gentle and convenient slope on the highlands near the river, but so high above the river that no method of raising water to them except by pumping would be possible, which would ordinarily be unduly expensive here. For example, near Sec. 22, T. 132, R. 87, a single field approximating a thousand acres was seen 100 feet above the river, and near Secs. 22 and 23, T. 133, R. 89, fifteen hundred acres at about the same height.

At the river ford in Sec. 30, T. 133, R. 88, a dam 600 feet long, 30 feet high at the middle, and averaging 13 feet high, would hold back an estimated quantity of nearly a thousand acre-feet.

In Sec. 12, T. 133, R. 91, a low ridge runs across the valley a few rods above the mouth of Thirty Mile creek, so that a dam 35 feet high at the middle of the channel and not more than 600 feet long would hold perhaps four thousand acre-feet of water.

In Range 93 the valley begins to widen and its depth is not quite so great nor the sides so abrupt. Although the width of the flats in the valley bottom through towns 133 and 134, R. 93, T. 134, R. 94, and T. 134, R. 95, is about one-half mile, any extensive irrigation projects would be made difficult by the necessity of frequently crossing the meanders of the river by flumes, which would be liable to destruction from ice at the spring floods.

In Sec. 25, T. 135, R. 96, a good reservoir site was roughly surveyed; the area and capacity of the reservoir formed by the greatest height of dam are estimates, but the others are chiefly from the measurements.

Section 25, Township 135, Range 96

DAM			RESERVOIR	
Greatest height	Average height	Length	Area	Capacity
14 feet	6 feet	400 feet	65 acres	410 acre-feet
24 "	13 "	660 "	195 "	1,700 "
34 "	15 "	1,560 "	475 "	5,000 "
44 "	22 "	1,860 "	670 "	10,800 "

The land at this location is not yet cultivated, the nearest settlers being cattlemen or sheepmen. On the north side of the stream here there are scoria hills. The scoria is unusually hard and appears fit for use in concrete. There is also considerable stone of fair quality (petrified stumps, etc.) scattered in the stream and on the side hills. On the south bank, a mile above the location for the dam, there is a good vein of lignite coal, 7 to 10 feet thick, at about the level of the flow line of the largest reservoir tabulated above. This might be used for pumping water from the reservoir for the irrigation of extensive flats on the south side of the river at this point, and estimated to be from 40 to 60 feet higher. The area drained by the river above this point is only about 400 square miles, and it may be inferred that a reservoir of the largest dimensions given would be sufficient to control the entire ordinary annual flow of the stream, so that none would be wasted. For even if the total flow in a year were somewhat greater than the capacity of the reservoir, the use of the water would have begun before the whole of the spring flood had passed, so that there need be no overflow.

If inquiry is made as to the total amount of irrigable land in the Cannon Ball valley, the question is difficult to answer. Between New England (Town 135, Range 97) and the mouth of the river, a distance of 125 miles along the general course of the valley, the total acreage of the flats along the main stream and not more than 30 feet above the low water, may be set down as about 40,000 acres. How much of this land can be classed as "irrigable" is a perplexing question, the answer depending upon one's opinion as to how great profits might be expected from irrigation, and therefore how great expenditures would be justifiable in order to obtain it.

I have not estimated the lands above the height of 30 feet, nor ordinarily mentioned them in the foregoing pages, for two

reasons. First, the topography of the Cannon Ball valley is such that, with the not large fall of the river, it will not as a rule be economical to attempt to carry a gravity canal far enough to reach land higher. Second, when irrigation becomes general, the lack of land will not be so evident as the lack of a sufficient quantity of water. In August, 1904, (an unusually dry month) the entire flow of the river during the month would have been insufficient to irrigate a half section of land. In July, 1903, the whole flow would have been needed for three or four sections. It is necessary to store the spring floods before any considerable amount of irrigation can be carried on except a single early spring flooding.

For this reason I have emphasized on the preceding pages the topic of reservoir construction. It is not assumed that the sites examined this season are the only possible reservoir locations, nor necessarily the very best. More detailed survey later will undoubtedly discover other advantageous locations, but the figures here given should be fair samples of the possibilities on the Cannon Ball. If reservoirs can be constructed large enough to retain the whole volume of the floods, this can be released as needed and be available for use. Small reservoirs of any dimensions would also be advantageous to the valley; by them the water would be held back for use instead of all running to waste in the Missouri—at a season, too, when the inhabitants of the lower Missouri valley are frequently flood sufferers. They suffer from an over-supply of the water that would benefit us greatly if it could be kept here.

One form of construction that scarcely deserves the dignified name of reservoir would prove very advantageous at many points along the Cannon Ball and other similar streams if not unduly expensive. This is the construction of low dams at frequent intervals where the channel is deep and narrow and winds through broad flats with a sluggish current, so as to convert the stream that otherwise would almost run dry in summer into a series of standing pools of depth depending on the height of the dams. The water is thus held in the river within a few feet of the surface of the flats, and seeps out gradually from the sides of the channel until in a few months the subsoil will be found filled with water under the entire flat, and alfalfa will have assured support and luxuriant growth. The soil in many of these flats is rich, but water soaks into it with such difficulty that the rains never sink in more than a few inches or a foot or two.; most of the rain runs off into the stream; the river is bank full for a few days in the spring, but water seeps in with more difficulty then because of the frozen condition of the ground. And so at a little distance from the stream the subsoil under the flat may remain dry as dust for years, even ages, unless a large quantity of water is held on the surface by irrigation, or unless the land is, so to speak, sub-irrigated by raising the river surface

nearly to the level of the flats. Such small dams might be built of timber if it were easily accessible in sufficient quantities; but there are few such points in North Dakota. Another form, ordinarily the most economical here, is constructed by dumping loads of stones and boulders across the channel until a ridge of the required height is built. If these are placed in position singly with a little care, and only a portion is built at one time, the mound being raised each successive season, the spring flood rushing over it will ordinarily do little damage, merely rolling off any stones not properly placed and settling the others more firmly, and the floating twigs, leaves and debris that gradually become lodged in the crevices will in the end make such a loose rock dam almost absolutely water tight.

Irrigation will for a time present considerable difficulty to small individual land owners on streams like the Cannon Ball in the matter of constructing effective diversion weirs or head works. The stream is at most points running in a channel fifteen feet or more below the flats that it is desired to irrigate, and must be brought out of the channel up onto the fields. If there is a flood rise of five, ten or fifteen feet to be expected, a canal running along the side of the bank will be destroyed or seriously injured at the first flood, certainly at the spring break-up, when the huge ice floes crowd down the channel grinding against the banks. If to avoid this the canal is begun above the high water mark, and the water raised to the head of the canal by a dam, the dam must be very substantial in order to escape destruction the next spring. If the form of the dam is such as to cause the current to rush against the bank at the end, a new channel may be scoured out, leaving the dam on dry land. These are the various difficulties that must be met in such conditions as are found here; if they are foreseen and the proper precautions taken, success in the work may be expected.

As mentioned above, it will be the water, not the land, that will be first lacking for irrigation. It is true that a vast quantity of water rushes down the Cannon Ball each spring, but not (as has been sometimes said) "enough to irrigate millions of acres." So far as the records up to the present time furnish data, the total ordinary annual outflow from the mouth of the Cannon Ball is 140,000 acre-feet, enough water to irrigate adequately perhaps 70,000 acres of land. About two-fifths of this water comes from the North Branch and its tributaries, two-fifths from the drainage basin of the Cedar, and one-fifth from the streams that enter the lower river below the confluence of these two. On many of these tributaries there are no extensive irrigation works possible, the water supply being insufficient even if the land is favorably situated. Most of the water courses are mere coulees, dry except for a few weeks in the spring. But there are many places where a score or a hundred or a few hundred acres can be irrigated, where a coulee will be dammed and the melting

snows held to be run out upon a garden patch during the drought of summer, and these smaller areas will aggregate so many thousand acres that all the available water will be utilized without waste.

In this connection it should be stated that it will not be the effect of irrigation, if properly managed with storing of the spring floods, to lessen the lowest summer flow of the stream. It will not run dry more frequently than at present. When a large quantity of water is spread over the land in the early season an appreciable portion seeps back into the river from the springs later in the season, adding to the summer flow. The tendency of irrigation when generally employed along a stream such as this is to modify the extremes, lowering (that is, storing near the headwaters) the floods, and increasing the low water flow more or less.

Brief mention may be made of a few of the tributaries of the Cannon Ball. Two miles above the mouth, Chanta Peta creek enters from the north. This creek, which heads about fifteen miles back from the river, has a drainage area of 80 square miles; it may be assumed that if the entire drainage from this area could be utilized, it would be sufficient for the irrigation of one or two thousand acres. From section 20, T. 136, R. 80, to the mouth there are nearly continuous level bottom lands from ten to twenty feet above the water with a total area of 1,500 acres or more. These could readily be treated to a single spring flooding, but, as on most such streams, any considerable application of water later would be impracticable without storage.

Dogtooth creek, which enters the river from the west on the northern side about twenty miles above the mouth, drains a valley thirty miles long. With Louse creek, which joins it, the total area drained is 340 square miles. The conformation of the stream valley is said to be favorable for irrigation, although of course the stream is often very small during midsummer, a mere brook a few feet wide and ankle deep, with a flow of less than one second foot. A broad valley extends from the big bend of the Heart river (twenty miles southeast of New Salem) through the Dogtooth creek drainage area toward the Cannon Ball, and the possibility of bringing water upon the land here from the Heart has often been suggested, but so far as known no definite figures concerning it have been published. A survey should be made of this locality at an early date.

No exact data are at hand concerning the south branch of the Cannon Ball, known as Cedar creek. Its drainage area is 1,700 square miles, more or less.

Thirty Mile creek, which enters the north branch midway between the mouth of Cedar creek and New England, drains about 250 square miles. It is said never to run entirely dry, but during the summer drought this year (August 10) its flow

was found by measurement at the mouth to be only one-half second-foot.

The next drainage basin north of the Cannon Ball is that of the Little Heart river, a stream 25 miles long that flows into the Missouri nine miles directly south of Bismarck. The drainage area of this stream is 250 square miles. There are some large flats fine for irrigation, for example in Town 136, R. 82, if convenient points for storage can be found; but only the upper branches of the stream flow through this township, so that the water supply would be limited.

North of this is the Heart river, a stream of about the same length as the Cannon Ball, which flows into the Missouri opposite Bismarck, after draining the northern half of Morton county and Stark county, a total area of 3,360 square miles. A hundred and thirty miles of the Northern Pacific railway is in the Heart river valley, and in some portions the river is followed quite closely; from the railway elevations the estimates of the river elevations in the following paragraphs are taken. No surveys were made of this stream by me this season except at a few special points, hence only a brief summary of the drainage areas of its principal tributaries, etc., will be inserted here.

At Mandan, near the mouth of the Heart river, its elevation above sea level is about 1,625 feet. Ten miles above, it receives Sweet Brier creek, which drains 260 square miles. Further up stream, twenty miles to the southwest, is the "big bend" where it is claimed that (as mentioned on a preceding page) the water could be diverted to irrigate a wide valley stretching southeasterly toward Dogtooth creek and the Cannon Ball. Along all this portion of the Heart river the fall probably does not average more than four feet to the mile.

Eight miles above the big bend, at a point sixteen miles due south from New Salem, Big Muddy creek enters the Heart river from the northwest. The length of this creek (exclusive of its meanders) is thirty-five miles, and it drains a tract of 480 square miles, which includes that portion of the Northern Pacific railway from New Salem to Hebron. There are many wide level flats along this stream or its branches, the chief difficulty to be met with being the construction of a dam to raise the water up from the narrow stream channel to the level of the flats that will be substantial enough to withstand the spring floods. It is likely that, with the abundant lignite coal found in the vicinity, the installation of pumps to lift the water 10 or 20 feet from the channel to the fields when needed would be convenient and profitable. Judging from the size of the drainage area, if it were possible to completely utilize the whole flow of this stream, including the spring floods, the water would be sufficient to serve about 10,000 acres, but no measurements of this creek have yet been made.

Ten miles higher, one of the numerous Antelope creeks with which North Dakota is favored flows in from the southwest. The length of this is about 30 miles and its drainage area 200 square miles. Fifty miles further up stream, five miles below Gladstone, another Antelope creek enters, also from the southwest, which drains 250 square miles. This portion of the river is said to flow through a narrow valley between high bluffs offering no extensive opportunities for irrigation, but a careful survey should be made to determine whether there may not be abundant opportunity for individual land owners to take up such work on a small scale. The flow of the river here often becomes very small in summer, until there remains a mere rivulet that can be crossed at a single step; but in the spring a raging torrent filling the channel to the top of the banks for a few days may be expected, and at this time the reservoirs, for which there seem to be many good locations, would be filled.

At Gladstone the elevation of the river is about 2,260 feet above sea level; from this point it ascends more rapidly, being at Dickinson (eleven miles west) at an elevation of perhaps 2,350 feet; at South Heart (eleven miles further) slightly above 2,450 feet. Three hundred and forty square miles, which is two-fifths of the area above Gladstone, is drained by the Green river, which enters at Gladstone. The Green river and the upper Heart river above Dickinson offer many fine opportunities for the irrigation of small tracts by pumping and otherwise, and a careful examination may reveal opportunities for more extensive utilization. At many points a series of small dams across the channel as mentioned in the description of the Cannon Ball, even if no larger reservoirs were constructed, would be of benefit. The oft repeated maxim, "store the floods," applies here with great force. At Dickinson the pumps draw out from the Heart river about 150,000 gallons per day, or not quite one-fourth of a second-foot, to fill the railway water tanks there, yet during the seasons of smallest flow in winter and in late summer this often consumes almost or quite the entire flow of the river.

Above the Heart river the next stream running into the Missouri is Square Butte creek, seven miles above Mandan, a stream 30 miles long, flowing from the northwest; the area of its drainage basin, central Oliver county, is 260 square miles. It may be assumed that if the entire yearly flow of this stream could be completely utilized, it would be sufficient for thoroughly irrigating five or six thousand acres, but the data as yet are not enough to give very certain conclusions. At the point where the stream emerges into the Missouri valley there are 3,500 acres of the Missouri bottoms that are occasionally flooded by that stream, but to which in ordinary years water from the creek could be applied advantageously. In the lower part of the creek valley for a few miles the width of the flats is nearly or quite a half mile, above that a quarter mile or less. The fall of the stream is

large, at some points fifteen feet fall being found in a mile along the valley, and fair locations for storage reservoirs are abundant. The following table gives the estimated area and capacity of a reservoir at one point at which measurements were made. Much better locations were seen a few miles further up the stream.

Sections 22, 27, 28, Township 141, Range 82

DAM			RESERVOIR	
Greatest height	Average height	Length	Area	Capacity
17 feet	6 feet	390 feet	33 acres	160 acre-feet
27 "	9 "	1,500 "	110 "	850 "
37 "	18 "	1,640 "	160 "	2,000 "
47 "	26 "	1,760 "	220 "	3,300 "

The bottom lands in this valley are very good agricultural land, and there is already much cultivation by the settlers. But it is certain that, wherever the expense is not prohibitory, very much more profitable crops will be obtained and better forage by those engaged in dairy farming, where surface irrigation can be practiced, or where the land can be sub-irrigated by raising the stream level by a series of dams.

The next considerable stream that flows into the Missouri is the Knife river, which enters 65 miles above Bismarck. This river, rising on the Little Missouri divide, drains an area 90 miles in length, including most of Dunn and Mercer counties, and the western portion of Oliver county, a total area of 2,490 square miles. There are more extensive opportunities for irrigation in this valley than have been definitely reported on any other stream west of the Missouri. The soil is fairly good in this valley bottom, and agriculture is now carried on to a considerable extent and with very good success in the years of sufficient rainfall. But there seem to be favorable opportunities here for applying water to the land at a moderate expense, so as to insure a good crop every season and often greatly increased returns.

The records have not been maintained long enough to justify any statement as to whether the average flow of the Knife river is greater in proportion to the area of its basin than the flow of the rivers farther south, although it seems to be slightly greater. But there is little doubt but that, on account of the numerous springs along its course, its minimum flow is not so extremely small as that of some other streams. Measurements near the mouth on August 25 and 26 of this summer, after a very dry month, found a flow of almost 30 second-feet, which is several times the probable flow of the Cannon Ball or Heart at that time.

The lower course of the river is through a fine valley with bottom lands averaging three-fourths of a mile in width and ranging from 15 to 25 feet above low water. The land is fairly even and almost the whole of it could conveniently be covered from a canal, or rather from two, one on each side of the river. The river meanders through the flats, but it does not cut against high bluffs at the side of the valley nor are there any serious difficulties in construction to be met. The estimated acreage in the valley within 30 feet of the river bottom from the mouth up to and including Town 144, R. 86, is 6,000 acres. An Antelope creek, otherwise called Apple creek, draining a hundred square miles on the north side of the river, enters in this township.

Above that point the valley is somewhat narrower, and the bottom flats, usually from 20 to 30 feet above low water, are more uneven and somewhat narrower, but the width is about half a mile. Although there are a few high cut-banks where fluming would be necessary for a canal, these are short and not frequent.

In Sec. 35, T. 144, R. 88, Spring creek enters from the northwest and west. The drainage area of this creek is 570 square miles and it is said to be fed by perennial springs. On August 25, 1904, the flow was measured as only six second-feet, hence these springs are nothing wonderful. This was, however, probably the smallest flow of the season. This creek has a wide open valley for several miles at the lower end, including a thousand acres or more of land possibly irrigable, and it is reported that there is four to six thousand acres along the middle course of the creek, from T. 144, R. 90, to T. 145, R. 91.

Through range 88 and 89 the sides of the Knife river valley become more abrupt, and there are some troublesome cut-banks, that might make it necessary to carry a canal across the river on flumes occasionally, but most of the valley bottom here could be brought under a canal without the expense being prohibitive. The total acreage to be considered in this portion of the valley is perhaps 6,000 acres.

Elm creek, which meets the river in Sec. 10, T. 142, R. 90, has some beautiful flats not more than ten feet above its branches near the northwest corner of T. 141, R. 89, but the sufficiency of the water supply is questionable, as the whole creek drains only 90 square miles.

From this point to the mouth of the Little Knife, Sec. 15, T. 142, R. 91, the valley averages more than half a mile wide, and most of the bottom land is fairly level and from 18 to 28 feet above the river. As the fall of the valley in this portion of its course is from 5 to 6 feet in the mile, it would be entirely practicable to raise the water to that height. If pumping is desired for bringing the water to small tracts, the lift is not large and abundant lignite is at hand along most of the valley. At this point, however, although there are occasional cut-banks, it does not seem that they are frequent enough to make the cost

of a canal unduly expensive. Through range 90 and 91 there is 4,000 acres of valley land, to most of which it ought to be possible to apply water advantageously.

The Little Knife river valley, which was not examined in detail by me, is reported to have six or eight thousand acres of land suited for irrigation if enough water can be obtained. On August 19 of this year the channel was dry at the mouth, but as it drains 240 square miles, the ordinary spring floods, if locations for sufficient storage reservoirs could be found, would presumably furnish enough water for irrigating 4,000 acres through the season, or for treating a larger area to a single spring flooding.

Through range 92 the valley is more broken by the river channel and narrower, but in range 93 and up to the mouth of Crooked creek, Sec. 21, T. 143, R. 94, it is of fair width and very even and the chief difficulties to be overcome in canal construction would be passing the occasional cut-banks. In the last two mentioned townships an estimated area of 2,400 acres could be brought under irrigation.

It is said that there are favorable locations on Crooked creek, the drainage area of which is 145 square miles, but I have not seen it above its mouth.

There are on many of the tributaries of the Knife very attractive and extensive fields that can at least be given an early spring irrigation. For example, on one of the branches of Deep creek (the total drainage area of that creek being 170 square miles), there was seen a single tract a mile wide and four or five miles long, 2,500 acres in all, a gentle sloping plain of unexcelled form for the application of water if locations can be found in the coulees in the surrounding hills for conserving the melting snows for use on a part or the whole of that area. This was in the southeastern part of Town 141, R. 94.

The question of storage on the Knife river is perplexing. A series of dams across the channel could be constructed without difficulty, thus sub-irrigating the lower flats. But no suitable points were seen for the location of reservoirs larger than this. The absence, along most of the river's length, of such a series of benches as is found on some of the streams and the fact that the whole valley bottom is ordinarily at nearly the same level across from the foot of the hills on one side to the other, makes the flats convenient for applying water, but does not furnish any advantageous points for a dam. Apparently the only possible plan would be to build a wall across the flats from one side of the valley to the other; such a plan is of course feasible, but it is expensive; yet without storage irrigation would be impossible after the early spring except for half a dozen of the first appropriators.

It is likely that many opportunities for reservoirs can be found on the tributary streams; if so, the desired end may perhaps

be more easily obtained without storage in the main valley. On Deep creek, for example, in section 8, T. 142, R. 93, (a mile above the mouth) a long ridge from 5 to 20 feet high runs across the flats of the valley, so that a dam a quarter mile long averaging not more than 8 feet high except for 200 feet across the channel would hold back a volume estimated at 3,000 acre-feet. which would be nearly half the year's outflow of the creek.

The Little Missouri river, which flows into the Missouri 132 miles above Bismarck, rises at the south in northeastern Wyoming and includes also in its drainage area a small tract in the northwestern part of South Dakota, a triangular strip of southeastern Montana 40 miles wide at the south end and 150 miles long, and a strip of North Dakota, through Bowman, Billings, McKenzie, Wallace and Dunn counties about 30 miles wide west of the headwaters of the Grand, Cannon Ball, Heart and Knife rivers, thence turning abruptly east and running parallel to the Knife river to its outlet. The entire length of this valley is about 300 miles, and its area between ten and eleven thousand square miles. Its principal tributary, Beaver creek, which flows parallel to the main stream along the eastern border of Montana, joins it at the big bend about 90 miles above the mouth and drains nearly 2,000 square miles of the whole area.

The Little Missouri flows through the "Bad Lands," a region so broken and gullied as to be in many places almost absolutely impassable. Its valley and the possibilities for irrigation are discussed at length in the current report of the State Geological Survey, especially the lower hundred and forty miles below the Northern Pacific railway crossing at Medora. A party in charge of Mr. L. H. Wood, assistant state geologist, made an examination of the whole of this portion in the summer of 1903, going down the stream by boat, and devoting especial attention to the lignite coal outcropping there. This is of the highest importance because this will ultimately be much used as the source of power for irrigation by pumping. Opportunities will doubtless be found for putting dams across the tributary coulees and for other small improvements, but no opportunities for any extensive irrigation works operated by gravity have ever been reported on the Little Missouri. The fall of the river from Medora to the mouth is 510 feet, or less than four feet per mile of valley, and the area of the irrigable bottom lands, which are divided by numberless ravines, cut-banks and similar obstacles, is not great enough to justify the very large expenditures necessary for the construction through so difficult a locality of such long canals as would be necessary for raising the water to any considerable height from a river of no more rapid slope. There is, however, unlimited lignite coal along the valley, and the flats are often very advantageously located for irrigation by pumping.

The flow of this stream is very irregular. At Medora, where the U. S. geological survey maintains a gaging station, the dis-

charge sometimes increases from a few hundred second-feet to as many thousand within twenty-four hours. On account of its large drainage area, its discharge is much greater than that of any other rivers west of the Missouri; it has the further advantage, so it is said, of having the greatest flow usually not during the spring break-up but during the "June rise," just at the time when the water would be needed for use.

It has been often suggested that if water could be diverted from the Little Missouri near the southern state line and carried up the eastern slope of the valley and out of the "Bad Lands" across the divide it could be used to great advantage on the prairies around the headwaters of the Grand, Cannon Ball or Heart rivers, which are comparatively level. A preliminary survey was made this summer by the Reclamation Service to determine the facts in regard to this. The slope of the river here is between six and seven feet to the mile, but the eastern slope of the valley is so broken by ravines, draws and terraces that no diversion canal could be built in a direct line; many meanders would be necessary. At the best location found, the length of a diversion canal would be about 170 miles, much of it through expensive construction. This seems to make such a project impossible at present.

Above the Little Missouri, in Town 154, R. 97, Tobacco Garden creek enters the Missouri river from the south; this stream drains a considerable part of Wallace county, about 300 square miles, and it is reported that there are some advantageously located bottom lands along its course.

A few miles below the Montana line the Yellowstone enters the Missouri. There are about fifty sections of Allred county, North Dakota, included between the Missouri and the Yellowstone on the west side of the latter stream. Extensive flats run down through this area, and it is probable that they will be brought under canal by the carying through of the Lower Yellowstone or "Fort Buford" project mentioned elsewhere.

On the north side of the Missouri, the Little Muddy river enters at Williston. This stream drains the center of Williams county, an area (excluding the valley of Stony creek, which joins it at the mouth) of 850 square miles. This valley seems to present the best opportunities for irrigation of any region in the state. The bottom lands are wide, the side hills have a gentle slope, and the stream has a fair grade. The width of the flats at elevations that could be reached by a canal at a reasonable expense varies from one-half to two miles, and I estimate that there is approximately 18,000 acres along the lower twenty-five miles of the main valley that could be reached without canals needing to be longer than five or six miles, besides a very large additional area on the tributaries. So here again we come to the search for locations for storage. Only one season's records of this stream have yet been kept, hence but little confidence

can be placed in my estimate that the total ordinary flow if entirely utilized would serve for twenty-five thousand acres. During half of this summer the surplus flow over a small amount now used for irrigation was ten second-feet or less. Most of the irrigation at present (which is further developed in Williams county than in any other county in the state) here consists merely in a single spring flooding; otherwise the flow would be already used to the last drop.

In Sec. 32, T. 159, R. 100, a good reservoir site was noted. where (by estimate. without instrumental survey) a dam 20 feet high at the middle and 850 feet long would hold perhaps two or three thousand acre-feet of water, or a dam 30 feet high at the middle and 1,200 feet long, eight to twelve thousand acre-feet, or as much as the entire annual discharge of the stream at that point. Abundant building material is on the site. There are also many opportunities for small reservoirs on the tributary streams. Numerous small reservoirs have already been constructed here, and photographs were taken of some of these and are available for use in a later bulletin. It is recommended that a detailed survey be made of the valley at the earliest opportunity, and also that it be suggested to the reclamation service as possibly an advantageous field for their work.

The southeastern portion of Williams county, amounting to about 160 square miles, is drained by Beaver creek, a stream 25 miles long that in its lower course passes through the Hofflund and Grinnell flats, where irrigation was successfully employed before 1880.

White Earth river, a stream 35 miles long, draining nearly 400 square miles, that flows along the western boundary of Ward county, is also reported to present favorable opportunities for irrigation.

Below this the larger streams entering the Missouri on the left hand side are these: Little Knife river, draining 170 square miles; Shell creek, that meets the Missouri near the center of the Fort Berthold reservation after draining nearly 400 square miles; Douglas creek, in McLean county, draining area about 300 square miles, at Fort Stevenson; Apple creek, which has a drainage area in Burleigh county of about 600 square miles and enters the Missouri near Bismarck; Big Beaver creek, which drains about 800 square miles in its length of 60 miles through McIntosh, Logan and Emmons counties. I have made no special investigation this season of the prospects on any of these streams but such a survey would doubtless be well worth making when possible. Utilization of the water, especially in connection with pumping from the Missouri, could be easily accomplished on the lower course of some of these streams.

The Missouri river itself offers an apparently unlimited supply of water, and projects for its utilization are very attractive themes for consideration. But any irrigation by the usual

gravity methods seem hardly possible. The survey made in 1890 by the U. S. geological survey in investigation of this question is mentioned more fully on page 40. The fall of the Missouri is from eight to nine inches per mile of channel, in its 405 miles of length through this state, or only about one foot per mile measured along the general course of the valley. As a grade of one foot in the mile would be the smallest practicable grade even for a large canal, and as the length of such a canal would, on account of the many detours necessitated by the ravines and valleys tributary to the Missouri, until after reaching the prairie level be at least as great as that of the river channel itself, it is evident that water could not be raised a single foot above the river surface by any ordinary canal.

It is sometimes proposed to raise the water from its natural level to the prairies where it is desired by a huge dam of sufficient height. Such a structure would cost a stupendous sum, not only for its construction but because of the damages due to the many thousand acres of the best land in the state submerged in the enormous reservoir, but the advantages resulting from having at command so vast a quantity of water to apply to the upper plains seem at first glance proportionate. There is, however, one apparently insuperable difficulty, the lack of any foundations sufficient for such a structure. The river pilots report that at no point in the whole length of the river in North Dakota is anything more permanent than loose stones and gravel in sight, nor does it seem likely from the geological structure that there is at any reasonable distance beneath the surface any rock better than very soft shale and sandstone. It must be borne in mind that the pressure behind a dam is proportionate to the height, that foundations that would be secure for a dam twenty feet high will not answer for one of ten times that height. For although there may be ample support for the weight of the structure, under such pressure the water will gradually seep through any underlying rock except of the most impervious nature and spring out in increasing volume until the whole dam is undermined and suffers sudden destruction. We therefore look askance at so dangerous an undertaking, and are likely to decide that, unless some unexpectedly advantageous site be found, such a project is impossible.

There remains one method that seems especially adapted to the conditions along the Missouri river in North Dakota, irrigation by pumping. With an unlimited quantity of lignite coal outcropping along the bank, so vast a quantity of water flowing by at all seasons, and beside the river at elevations of only twenty, forty or sixty feet, so many thousand acres of fertile flats, land that needs but the certainty of sufficient water to insure the most satisfying crops, we have an unexcelled combination.

In many places an early spring flooding from some creek or coulee that discharges in the neighborhood can be followed (unless there has been abundant rainfall through the season) by a late irrigation with water pumped from the river. Thus the consumption of fuel can be reduced to the lowest figure.

During the summer of 1903, F. A. Wilder, then state geologist, with a small party spent about a month along the river from the Montana line to the mouth of the Cannon Ball, making a geological survey with particular reference to the lignite and the land along both banks that could be irrigated thus. A detailed account of this survey appears in the current (third biennial) report of the state geologist, which also includes tables showing the sizes of pumps, horse power of engines, and amount of fuel that might be assumed as required for different lifts and areas, and other related information.

The expenses of this survey by Dr. Wilder were borne in part by the reclamation service. Following his preliminary report, a large party was put in the field this fall by the reclamation service to make definite examinations of some selected areas, as mentioned elsewhere, the results of which have been so favorably reported to the secretary of the interior that $550,000 of the reclamation fund has been by him reserved if needed for use on the projects in two localities, the Buford-Trenton flats near Williston and the flats near Bismarck.

In accordance with the provisions of the national law, all money expended in the construction of such works is charged against the land and ultimately repaid in installments without interest into the fund. Since almost the whole of the land to be benefited by these Missouri river projects is already in private ownership, the plans will not be carried out unless a large majority of such owners willingly pledge themselves to undertake their share, and it is likely that the organization of a water users' association of the usual form in each of these localities will be considered a necessary prerequisite to further work. It is to be hoped that this may be done this winter so that, if no unexpected difficulties arise, the work may be pushed rapidly to a practical success. Then as a result it may be expected that the surveys that are contemplated along other sections of the Missouri valley will be carried forward at once to the further development of large areas of the valley.

The Mouse river is important from the standpoint of irrigation. This stream, arising in Assiniboia, flows southeasterly into Dakota, and after a course of 80 miles in that direction swings to the east, north and northeast in a huge loop and back into Canada, where it flows through Manitoba to a junction with the Red river at Winnipeg. The northeastern part of Williams county, and most of McHenry and Bottineau counties, are included in its basin. The total area drained by it, between its sources and the point where it leaves the state, is 12,000 square

miles, more or less, and the flow of the stream is at times considerable, although in the summer it dwindles to a very few hundred second-feet. The fall of the river is very small, being only about a foot and a half per mile along the valley between Minot and Towner, and not much different for many miles above. With so slight a fall it is practically impossible to carry a canal up to the level of the prairies unless its head is so far up the river as to be on the further side of the Canadian boundary, which would introduce international complications. As mentioned elsewhere, the proposition to divert a canal from the river near the boundary line and carry it up the east side of the valley and across the prairie was last season made the subject of survey by the reclamation service, but it was found that, in comparison with the area covered, the length of the necessary canal would be so great as to make its expense larger than the owners to be benefited seem to care to undertake, at least at present. If, however, the lignite coal of the region were used for operating pumps to overcome a part of the lift, the canal might be so much shortened as to make a combined gravity and pumping system very successful.

The Des Lacs river, which flows into the Mouse river eight miles above Minot, has the advantage of a satisfactory fall, in some portions as much as seven or eight feet to the mile. At Kenmare, 42 miles above the mouth, the elevation above sea level of low water in the river is 1,783 feet, which is 238 feet above low water at Minot, or more than 220 feet above the mouth. Records of the discharge of this stream have been kept only since the middle of the present season, but from the area of its drainage basin (800 square miles, more or less) it is inferred that the annual flow might be sufficient for the irrigation of at least 15,000 acres. Along the upper thirty miles of the valley there is a series of narrow lakes which it is reported could by a few small and inexpensive dams be made to serve as reservoirs sufficient for storing the whole spring run-off of that portion of the drainage area, which is about half of the whole area. No large projects are possible on this stream, but there seems to be good opportunities for carrying out smaller projects at an ununusually light expense. I recommend its detailed investigation at an early date.

Another project deserving early examination is for the diversion of the Mouse river to Devils Lake; it is said that from Willow City to Devils Lake there is a series of valleys and sloughs so low that a very slight amount of excavation would construct a canal capable of diverting the spring high water of the Mouse. The practicability of this is doubtful for the reason that (so far as known from present data) although the distance in a direct line is more than fifty miles, the difference of level between high water in the river and low water in the lake is not over forty feet, and the ordinary difference of level much less; the

current in such a canal would not be sufficient to keep it from filling with weeds. Pumping with a small lift would carry the water over many thousand acres in this region and this plan may ultimately be found very profitable as a means of insuring good crops whatever the rainfall.

The James river, which flows through the central and southeastern portion of the state, is a stream of small flow except in the spring or in unusually wet seasons. At such times its floods are proportionate to its drainage basin, which is perhaps about 3,000 square miles. No records of the quantity of its flow in this state are maintained now. Its fall is very small, averaging little more than two feet to the mile along its valley for the whole distance from Manfred or New Rockford to the South Dakota line; at many points the fall is so much less that at low water stages the stream scarely has a perceptible current. Along some portions of its valley there are said to be extensive bottom lands to which the water could be easily brought by pumping, or possibly by a gravity canal. Much of this low land, however, suffers as often from a surplus of water in the spring as from a deficiency later in the season, so that the real need is for a combined system of irrigation and drainage.

The Sheyenne river parallels the James, but has a deeper valley and a greater fall, averaging nearly three feet to the mile, from Harvey to its junction with the Red river ten miles below Fargo. Its spring flow is large, as should be expected from the size of its drainage area, nearly 7,000 square miles, so that the discharge of the stream is sometimes nearly equal to that of the Red river at their junction, but in the late summer its flow is often less than a hundred second-feet.

Along the lower Sheyenne and all along the Red river valley the fields are so level that it sometimes happens in the spring that the land is flooded so long as to prevent proper cultivation, and there are tracts of low land that reach the proper condition only in unusually dry years. In this region drainage would benefit the land owners more than irrigation, and under the drainage laws as at present established much land has been reclaimed or improved by the county ditches. In Minnesota the same work is being carried on still more extensively, resulting in the great increase of land values. As shown by experience in other states further east, as for example New Jersey, irrigation (if combined with proper drainage so as to avoid the danger of too great water supply in a rainy season) is a benefit to the land no matter how great the natural rainfall, leads to larger and more certain crops, encourages intensive farming, and increases the profits. The question is whether these benefits will be great enough to repay the expense, which of course depends upon the nature of each locality, favorable or unfavorable; I have not this season attempted any investigations on this subject, but it evidently deserves consideration.

Storage of the spring floods at convenient points on the headwaters of the Red river and its tributary streams might be of benefit in several ways. First, by lowering the height of the flood along the lower courses of these streams so that the prairies of the valley, draining more quickly, would earlier be in proper condition for cultivation. Second, by affording a supply of water stored at sufficient elevation for use in summer irrigation if desired. Third, perhaps, by improving navigation on the Red river. The U. S. War Department has made occasional efforts to improve navigation on the Red river and to maintain with dredge and snag boat a ruling depth of three feet in the channel from Fargo to Grand Forks, and of four feet below Grand Forks, but there has been difficulty in maintaining a sufficient depth during the low water stages of the late summer, although there is much more than needed during the early spring. Below the confluence with the Red Lake river at Grand Forks, the spring floods attain in different years to a volume of from 8,000 to 35,000 second-feet, while the low water flow falls below 1,000 second-feet. The U. S. Department of Agriculture is this winter establishing a considerable number of new observer's stations for the purpose of predicting the time and extent of the floods.

The Red river is supplied largely from the eastern side, from the forest-fed streams of Minnesota. The Red Lake river supplies usually between one-third and two-thirds of the total flow below Grand Forks. The flow from the lakes on the eastern side is more nearly constant, but from the prairies on the west the flow is very irregular. It would evidently be advantageous, where it could be done without undue expense, to store the flood waters till needed instead of permitting them all to run to waste and to injure the lands bordering the river. I recommend, therefore, that, as opportunity offers, information concerning suitable or possible sites for storing the flood waters of the Red river valley and concerning the expense of such work be collected.

In this state, the absence of trees and the steadiness of the winds are conditions favorable for the use of windmills for pumping. There are many points where gardens and such small tracts can be easily irrigated thus, either from a well or from a stream. The objections or difficulties to be met are these: First, an ordinary mill and pump do not supply a large enough stream for convenient use; if it trickles along down the slope continuously, in dry weather it may all evaporate or seep into the ground before passing a hundred feet from the well. It is therefore necessary to let the pump fill a tank or reservoir, from which the water may be quickly drawn in large quantities when desired. Second, the wind is uncertain even at the best, and days may be calm just at the time when the water is most needed; it is therefore necessary for this reason also to have ample reservoirs (such, for example, as illustrated on page 242 of the report of the State Geological Survey for 1902). Third, the quantities of water

necessary for irrigation are incomparably greater than those required for domestic purposes or for stock. A pump that lifts ten gallons each minute would cover less than one acre a foot deep by three weeks of continuous pumping. Where the wells are not deep, water may be lifted at small expense by home made windmills and inexpensive pumps; but except where the conditions are unusually favorable any attempt to irrigate large areas by wind power would involve expenditures for wells, mills and pumps altogether disproportionate to the benefits received except where vegetables or other produce bringing very large returns per acre are to be cultivated.

There are limited portions of the state where artesian wells are possible. Prof. D. E. Willard of the State Agricultural College has been making investigations in this subject the past two years. Where the pressure is great enough to give a good strong flow, and where the waters are not so charged with alkali as to be injurious to vegetation, a very satisfactory water supply is thus assured, reliable and constant. If its quantity is too small for continuous use, it can easily be stored in tanks from day to day until needed. Many acres of irrigated land in South Dakota depend upon artesian wells and such work will develop in some localities in this state, although the area here included within the artesian belt is comparatively small and the pressures ordinarily are weak.

Many of the facts upon which the statements in the foregoing pages are based are taken (with the permission of the Survey) from the records of the U. S. Geological Survey, of which the Reclamation Service is one division. This Survey now maintains continuous records of the flow of all of the principal streams in the state. The earliest such observations, on the Red river, were commenced in 1901, but they were begun on none of the streams in the western part of North Dakota earlier than May, 1903. The records, therefore, have not yet been maintained long enough to allow any very definite deductions to be made concerning the amount of flow to be expected in coming years, although they may afford a basis for estimates. The complete records are published each year by United States Survey and a brief summary of reuslts can be found also in the current report of the State Geologist, Dr. A. G. Leonard.

As a partial answer to the numerous inquiries that are made concerning the subject, some figures selected from the longer records are published below. I also add some estimates of the probable ordinary flow in an "average year" of the streams. But it is too early to make such estimates with reasonable accuracy, so that these estimated figures may be subject to very great correction later; and furthermore it must be remembered that an "average year" rarely occurs, the seasons being often unusually dry or wet.

The units of measurement used below are described in detail in the appendix. By a flow of one second-foot is meant one cubic foot of water per second passing by the point of measurement; one second-foot of water, flowing continuously through the irrigation season, may be assumed as sufficient to irrigate eighty acres of land. The total amount of water passing by the point of measurement in a month or year may conveniently be stated in acre-feet, one acre-foot being enough to cover one acre a foot deep, i. e. 43,560 cubic feet. A continuous flow of one second-foot amounts to about two acre-feet each day.

FLOW OF RIVERS IN NORTH DAKOTA

River and Point of Measurement.	Drainage area—Square miles.	Greatest flow 1904—Second-feet.		Least flow 1904—Second-feet.		Estimated ordinary total flow in year—Acre-feet.
Cannon Ball, Stevenson	3,650	April 2	3,720	Aug. 15	0	120,000
Heart, Richardton	1,270	April 5	3,485	Aug. 1	0	60,000
Knife, Broncho	1,250	April 5	3,430	Aug. 30	3	65,000
Little Missouri, Medora	6,600	June 8	6,280	Oct. 10	2	200,000
Little Muddy, seven miles north of Williston	1,090	April 11	3,000	Aug. 5	6	50,000
Mouse, Minot	8,400	April 20	12,000	Nov. 10	47	240,000
Pembina, Neche	2,800	May 2	3,870	Nov. 20	120	
Sheyenne, six miles west of Fargo	5 400	April 23	1,950	Sept. 5	about 50	
Red, Fargo	6,000	April 20	5,550	Aug. 30	380	
Red, Grand Forks	25,800	April 27	32,900	Aug. 30	1,320	

TOTAL FLOW IN ACRE-FEET, BY SEASONS

River at point named	April May, 1903	June, 1903	July Aug., 1903	April, May, 1904	June, 1904	July, Aug., 1904
		about				
Cannon Ball.....	.....	1,600	28,000	80,000	37,000	2,000
Heart.....	.....	1,300	1,300	66,000	6,000	400
Knife.....	.....	1,800	6 400	68,000	4.400	1,000
Little Missouri.....	.....	14,000	208,000	59,000	71,000	7,000
Little Muddy.....	.....	.....	.....	85,000	1,500	1,200
Mouse	.....	19,000	27,000	588,000	48,000	24,000
Pembina.....	.....	8,900	4,400	250,000	96,500	75,000
Sheyenne.....	78,000	9,[illegible]00	7,800	149,000	24,900	18,700
Red (Fargo)	110,500	27,400	38,800	233,000	75.400	98,700
Red (Grand Forks)..	967,700	198,900	153,500	2,162,000	357,500	349,300

SUMMARY OF EXPENDITURES ON ACCOUNT OF STATE IRRIGATION ENGINEER, JULY 7 TO NOVEMBER 30, 1904.

Per diem of state engineer	$ 427.00
Per diem of assistants, draftsmen and clerk.....	136.75
Traveling expenses of engineer	156.20
Provisions and subsistence for field party and assistant.....	72.02
Hire of teams for field work, stabling and ferriage.....	131.81
Camp equipage*	16.96
Instruments*	73.80
Express, telegraph, stationery and miscellaneous.....	30.35
	$1,044.89

*Available for further use next season.

Vouchered accounts of all these expenditures fully supported by sub-voucher receipts, according to the form prescribed by the regulations of the U. S. Geological Survey for the employees of that service engaged in work of the same nature, have been filed and are open for inspection.

SURVEYS MADE BY THE UNITED STATES GEOLOGICAL SURVEY

The engineers of the United States Geological Survey have from time to time done considerable work in North Dakota as elsewhere, but when irrigation was the avowed object in view, they were not cordially received by the residents until in recent months. Nor did the state formerly cooperate to any extent. So that the knowledge of the possibilities in this respect has been less advanced in North Dakota than in some other states. The principal investigations will be summed up here, especially those of the past season.

In 1890 two field parties under the direction of Morris Bien investigated the possibilities for diverting water from the Missouri river across the divide that separates the Missouri valley from the valleys of the Mouse and the James. Working from Minot as headquarters, during the late summer and the fall they ran 730 miles of levels in the course of the work, but without success. The lowest point found in that divide was about 200 feet above the low water level of the Missouri river at Buford, where it enters the state, so the project was abandoned.

After the enactment of the Reclamation Law, in the spring and early summer of 1903, Frank E. Weymouth spent some months making examinations in the localities where it was reported that the most extensive projects might be located. Hé began the systematic series of records of river flow now maintained in the western part of the state, and traversed all the important streams west of the Missouri river. That season the streams were unusually low, giving an appearance of small possibilities, while even at the best the possible projects in this state are of comparatively small acreage, and perhaps no single tract of a hundred thousand acres or of fifty thousand can be developed. After this fact was clearly shown by his surveys, he was transferred to the Lower Yellowstone (or "Fort Buford") project; this is chiefly in Montana, but includes several thousand acres in North Dakota. He has charge of all the work on that project this season.

Early in the spring of 1904, S. B. Robbins made a rapid reconnaissance of various sections chiefly in the Mouse, Heart and Little Missouri valleys for the purpose of finding any possible locations for projects smaller than the first magnitude, but yet large enough to demand detailed survey this season. As a result the party in charge of J. A. French spent the early summer in the Mouse river valley, in examination of the possibilities for

taking water from the river near the international boundary line above Minot, and carrying it by a gravity canal to the land north and south of the railroad in the "Mouse river loop." Later in the summer this party worked in the upper Little Missouri valley, investigating the question of carrying water from that stream eastward out of its valley and across the divide to the lands around the headwaters of the Grand, Cannon Ball or Heart rivers, which are topographically more suitable for irrigation.

During the fall, under the direction of H. A. Storrs, parties in charge of P. M. Churchill and of J. A. French have been making surveys of the Missouri river flats, especially above and below Williston and in the vicinity of Bismarck. These flats may be irrigated by pumping from the river, using as source of power the abundant lignite coal found near at hand. This method of irrigation has not been extensively used in the United States, but the location here seems exceptionally favorable so that the consulting engineers have provisionally approved the project and pending the completion of this survey and the preparation of detailed plans for the irrigation works the Secretary of the Interior has reserved $550,000 of the Reclamation Fund for use on this project if it is ultimately found feasible and profitable.

STREAM MEASUREMENT AND RUN-OFF OF STREAMS IN NORTH DAKOTA

BY E. F. CHANDLER

METHODS OF STREAM MEASUREMENT

Accurate or even rough measurements of the water flowing in rivers, creeks, and other streams are very infrequent in comparison with measurements of the land that borders the streams. The most definite call for land measurements arises for the purpose of fixing the price of this real property, yet at all times there is in the owner's mind a fairly precise idea of the magnitude of his possessions, and he has at least approximate methods of measurement whereby he can estimate the area of each portion of his farm; he will tell you how many acres have been plowed, how much has been seeded for each crop, and so on, as long as desired. It is a necessity if he would carry on his work intelligently and to advantage. He can probably at a single glance estimate within twenty-five per cent the area of a field or tract that falls under his eye.

If, however, he were called upon some day to estimate the amount of water flowing in a creek passing across his farm, he might find himself unable to fix a figure that was not ten times larger or smaller than the facts. Any estimate that might be desired concerning the length of time it would occupy for the stream to fill some proposed tank or reservoir would find him entirely at a loss. He would hardly know whether to say five minutes or five weeks. There are so many factors to take into consideration that the task seems difficult. "The operations of measuring the volume of a flowing stream, although not complicated, possess an element of mystery to the average citizen, largely because he has not been accustomed to consider fluctuating quantities. It is possible to form a very definite conception of the amount of water standing in a pond or reservoir, but in the case of a stream the quantities considered are of water in motion, and therefore another and somewhat novel element enters, that of time."*

The width of the stream must be noted, and this, especially for a large stream, is not readily done by a person accustomed to

*F. H. Newell, Irrigation in the United States, Chapter 3.

walking on the dry land; appearances deceive him. The depth must be known, and here again appearances are often misleading. If the stream be shallow a small error in estimate of depth leads to disproportionately large errors in the result. In the muddy streams of North Dakota, small or great, it is rarely that the eye is a guide. Lastly the speed of the stream need be known; and here great uncertainty again arises in the observer's mind; even if there were mile-posts along the bank, floating objects move so irregularly, now speeding down the center of the channel, now lingering in an eddy or lodging on the bank, that no definite result seems readily attainable.

These difficulties arise, however, in part from lack of experience, from never having given any consideration to methods of measurement. Land is real property, to be definitely measured and individually owned and to be the chief part of one's wealth. But water, even if hardly "free as air", was classed with the rain that falls alike on the just and the unjust, a boon to which no one man can acquire title; its ownership or sale being unusual; its measurement seemed unnecessary and methods were scarcely developed until recently.

"It is to furnish information upon which to base estimates of available water supply that the Hydrographic Division of the United States Geological Survey has been, during the last fourteen years, collecting data in regard to the flow of the rivers in the United States, and their variation from season to season and throughout a series of years. The necessity for such data is frequently brought to the attention of the engineer, sometimes in a most startling manner. The lack of this information frequently leads to the most disastrous mistakes in the construction of hydraulic works. One of the best examples of this in the design of a hydraulic plant was the construction of a dam and water-power plant at Austin, Tex. After an expenditure of $1,600,000 it was found that a grave mistake has been made in the low-water flow. The works were constructed by the city in accordance with a vote of the citizens of Austin in 1890. It was estimated that 14,000 horsepower could be developed, and the people felt that their city was to become a great manufacturing center. No hydrographic data had been collected, except from the hazy memory of the "oldest inhabitant." In the spring of 1890 a measurement of flow giving 1,000 cubic feet per second was taken as the minimum. This estimate was more than five times too great, as was shown by subsequent measurements. An error of 500 per cent had been made in the estimate, but this was not ascertained until the works were nearly completed.

Mistakes of this kind have occurred in every part of the country in hydraulic works. The Sweetwater dam in California is a good example of a project carried through on insufficient data. The dam was built after a series of wet years and was soon after filled to overflowing, so that increased spillways were constructed,

but since that time the water in the reservoirs has never reached an elevation near the crest of the spillways, and during most of the time there has been the greatest scarcity of water.

The Bear Valley dam is a more marked case, as the reservoir formed by the dam has been practically dry for several years, so that wells have been driven in the bottom of it.

The Gila Bend, Arizona, project is another example of the expenditure of a large sum—$900,000—upon insufficient data, and subsequent abandonment of the scheme. In this project the dam was carried away before its completion, but if it had been completed the scheme must have proved a financial failure.

Many diversion canal projects for irrigation have been either partial or complete failures on account of shortage of water; that is, developments have been made far beyond the capacity of the stream.

A great number of waterpower plants have been constructed upon insufficient data, and later, auxiliary steam has been found necessary. Allowance was not made in the original estimates, so that in a number of instances the project has been found unprofitable. Knowledge of the flood flow is also of great importance in designing the dams and waste ways.

The measurement of the larger streams of the United States is an important undertaking, and capital will be invested in power developments, irrigation, sanitary and other hydraulic works more freely when information as to the flow of the streams is available. In making measurements of streams it is of course desirable that rapid and economical methods be used, if such are of sufficient accuracy."*

The usual methods will be outlined here, with special attention to the simpler methods that are readily available for use by the man without special technical training, without elaborate instruments or long computations, if he desires to obtain a basis for rough estimates of stream flow for any use; if, for example, it is desired to know whether some spring or creek can possibly irrigate a whole township or whether it is absurd to consider it as a means for irrigating more than a garden-patch.

There are three methods of measurement in general use: first, by current-meter; second, by weir; third, by floats.

The first and most elaborate method, by current-meter, is the one used customarily by the United States Geological Survey, but is not convenient except for those regularly employed in the business of stream measurements. The current-meter is an instrument which measures the velocity of the water by means of a wheel that is lowered into the water and revolved by the current. This wheel may be shaped like the screw propeller of a steamship, or like the wheel of an ordinary windmill, but in the most approved form consists of several cups arranged on the circum-

*H. A. Pressey: Observation on the flow of rivers in the vicinity of New York City.

ference of a circle about six inches in diameter, all opening in the same direction around the circumference. When placed horizontally in the water, this wheel (like the ordinary form of whirling cup anemometer for measuring the speed of the wind,) is revolved by the current catching in the interior of the cups and is turned with a speed very nearly proportional to the velocity of the current. This relation is accurately determined for all the various patterns of meter, (each turn of the wheel indicating from two to five feet flow of water, according to the size and form of the wheel) so that from a count of the revolutions of the wheel the speed of the current is definitely known. Suitable weights and rudder-vanes are attached for sinking the meter into the stream and holding it steady, and an electric connection or other means is used to indicate to the person operating it how many revolutions are made.

The speed of flow of a stream is not everywhere the same, but it is least at the bottom, and greater near the surface. At mid-depth the velocity will evidently be nearly the average for the whole channel, but is found to be slightly greater than the average except in very shallow channels. In an ordinary unobstructed channel the average velocity will be found at about six-tenths of the whole depth below the surface, or in deep smooth flumes at two-thirds the whole depth.

A suitable place for the use of meter is selected, where the current is without eddies, fairly uniform, and as nearly as may be of an even speed from one side of the stream to the other, preferably on a straight stretch, and necessarily where the channel has a reasonably even cross section (width and depth) for some little distance and is not obstructed by rocks, logs, brush, or vegetation. At a favorable place in the middle of this stretch the measurement is made on a line perpendicularly across the stream by measuring width, depth, and velocity. The measurements of depth are made with sounding-pole or sounding-line at ten or twenty points (or more on a large river) at equal distances along the line. The area of the cross-section of the stream at this line is thus closely determined. The velocity is of course different at different points in the width. Therefore in order to obtain a reasonably correct result the cross-section is divided

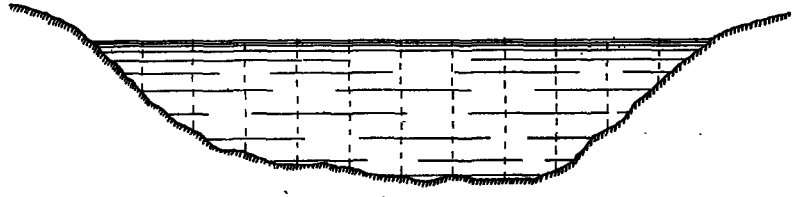

Fig. 5

into ten or more smaller sections (most conveniently of uniform width) by imaginary vertical lines, as shown in Figure 5, each

of these being approximately a trapezoid (or rectangle, or at the margin, a triangle) whose area can be readily computed from the soundings. These small sections are taken narrow enough so that, if the velocity is different at the sides of a small section, the velocity at the middle point of the width of each may nevertheless be assumed to be a fair average. The velocity at the middle of each small section is then measured with the meter; when this velocity is multiplied by the area of the small section, the flow through that section is obtained; and then, by adding the flow of all the small sections together, the total flow of the stream is found.

Using the foot as unit of length and depth, the area of the cross-section will be given in square feet; using a speed of one foot per second as the unit of velocity of flow, the product of the cross-section and the velocity will give as a result the total number of cubic feet of water flowing by the observer each second, or the number of "second-feet", as the term is. For example, the statement that the flow of a stream is six second-feet does not indicate anything concerning the dimensions of its channel or the velocity of its current, but merely says that six cubic feet of water is discharged each second. The channel might be one foot wide and one foot deep with a current speed of six feet a second, or six feet wide and two feet deep with a current speed of one-half foot per second, or three feet wide and one foot deep with a current speed of two feet a second, or in any other ratio giving the same total product. The total flow will of course be the same, whether measured at a narrow, contracted point of large velocity or at a point where the current is wide, deep and sluggish.

This method is applicable to streams of any size from the largest rivers down, except very small ditches and brooks, and gives reasonably accurate results (with an error rarely as much as five per cent) if the stream is flowing in a good straight channel with even and unobstructed flow. It may be used from a bridge, from a small car running on a cable stretched across the river, from a boat, or in a small stream by wading, provided in these last cases that some means is used for holding the meter upstream from the observer, so that it will not be effected by the eddies caused by his feet or by the boat.

This method of measurement can be accurately employed on any artificial channel of appropriate form, such as a ditch or canal, if the speed is sufficient to turn the meter-wheel freely. If the channel is a timber flume or other form not liable to be changed, eroded or obstructed, a careful determination can be made once for all of the quantities of water flowing for various depths in the flume. In large irrigation canals it is a frequent custom to install rating flumes, timber-lined sections of a few rods in length; the side of such a flume is marked at each possible height of water surface with a number indicating the quantity of water flowing when the water rises to that height in the

flume. It is then an easy matter for the ditch-rider or gate-tender to keep a continuous daily record of the total flow.

In a natural channel, if there are no dams or other obstructions for a considerable distance below the point of measurement and if other conditions are suitable, it will be found that the same amount of water flowing causes always almost the same height of water-surface in the channel, so that, after a series of such measurements of second-feet discharge at different stages of water, a rating-table can be prepared showing with fair precision (say within five per cent) the probable flow for any height of water. It is such representative points that the United States Geological Survey selects for the location of gauging stations. At these stations a vertical gauge rod painted in feet and fractions is placed in the water at a bridge pier or at the river margin, or other suitable device is installed, by means of which the height of the water surface may be accurately seen and recorded daily by a local observer. These observations are reported regularly to a district hydrographer who visits the stations from time to time to take soundings, velocity measurements, etc., for the purpose of finding the amount of flow corresponding to different heights of water on the gauge, and thus finally computing the total amount of water flowing down the stream in a year, and the greatest, least, and average flow for each month.

The United States Geological Survey has commenced in this state, chiefly within the past two years, since popular interest in irrigation has arisen here, a comprehensive system of stream measurements of this nature, gauging stations having been established on all the principal streams. At present one of the faculty of the University of North Dakota is the engineer in immediate charge of that branch of work for North Dakota and Minnesota.

The second, or weir-measurement, method affords still more accurate results when the conditions are favorable. A weir is a dam or small barrier with level crest over which the water flows. The depth of water on the crest evidently will be greater for a greater flow, and experiment has shown that the relation between

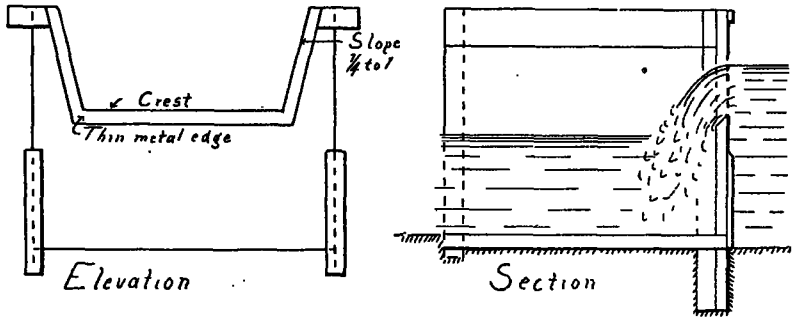

Fig. 6.

them can be stated in definite figures if the weir is properly constructed. There are two forms of weir most frequently used, although special circumstances sometimes make other forms more convenient. The rectangular weir has vertical ends; the trapezoidal or Cippoletti weir, as shown in the illustrations (figures 6,

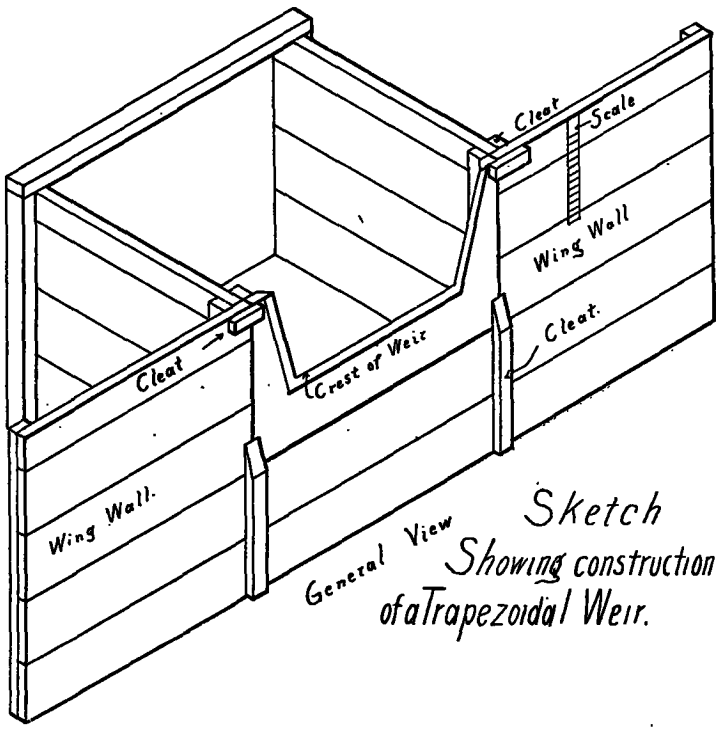

Fig. 7.

7, and 8) widens above the crest, each end sloping outward one inch in every four inches rise; the second pattern has the simpler formula for computation of flow.

In using the ordinary weir, it should be placed in the middle of the channel at right angles to the stream with its up-stream face in a vertical plane. The crest should be chamfered so as to slope downward on the lower side with an angle of not less than thirty degrees, leaving a sharp edge over which the water can leap freely without retardation by friction, or better still a stiff sheet of thin metal may be placed vertically to form the edge, and the ends should be chamfered likewise. The air thus has free access under the falling water. In the pond caused by the weir, the water will be brought nearly to rest, and must approach the crest evenly and without cross-currents; this requires that the approaching channel should be straight and

even and be at the weir more than twice the depth and at least three times the width of the jet passing over. The length of the weir opening should be three or four times the depth of the jet at the time of the greatest flow.

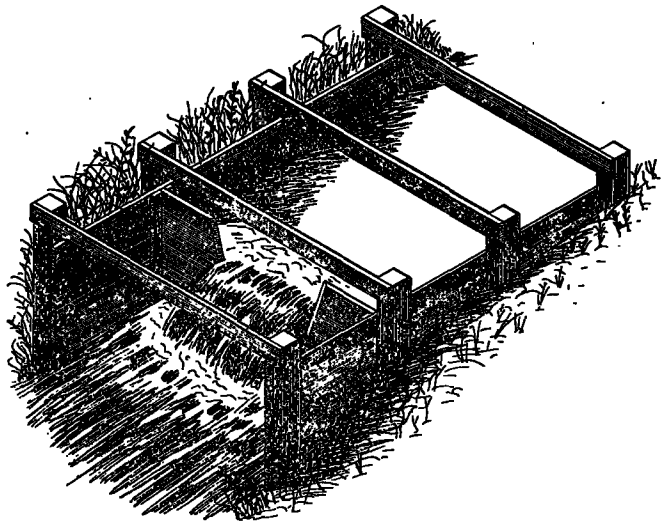

Fig. 8.

If the length of the crest of the weir, L, and the depth of water on (or rather, height of the water surface above) the crest, H, be measured in feet and decimals of a foot, the number, Q, of cubic feet of water per second flowing over a rectangular weir can be computed from this formula,

$$Q=3.33\ (L-0.2\,H)H\sqrt{H}$$

and over a Cippoletti weir

$$Q=3.37\ L\,H\sqrt{H}$$

The height above the crest of the weir of the level water-surface a few feet behind the weir may be readily found without level or other instrument thus: When the water is first filling the channel behind the weir, if a stake be driven in the water with attention that the top of the stake be exactly at the water surface at the instant that the water begins to flow over the crest, the subsequent depths of water over the top of this stake will be the required heights.

The formula for the flow is not a complicated one, and for a trapezoidal weir may be expressed in words, "multiply the square root of the depth above the crest by three and three-eighths times the product of the depth and the length of the crest, all being expressed in feet and decimals." But tables are prepared

for all the standard sizes of weirs, and may be prepared for any with a few hours work, that give at a glance the amount of flow for each depth of water.

Convenient dimensions for weirs according to the expected amount of flow are given in this table:

For a discharge less than two-thirds second-foot make crest of weir one foot long.

For a discharge between two-thirds and two second-feet make crest of weir one and one-half feet long.

For a discharge between two and four second-feet make crest of weir two feet long.

For a discharge between four and ten second-feet make crest of weir three feet long.

For a discharge between ten and twenty second-feet make crest of weir four feet long.

For a discharge between twenty and forty second-feet make crest of weir five feet long.

Weirs are advantageous for use in canals and ditches wherever sufficient fall can be afforded so that the water leaps freely over the crest without interference from backwater. They are often placed permanently in such cases, for variation in the amount of water flowing in a canal while in use is not great, hence the weir may be small enough to measure accurately the minimum flow, and yet be able to carry the greatest usual flow. In a natural stream, and especially in small streams, the seasonal variations are likely to be greater, and therefore any particular weir will be available for use only at certain stages; while on large streams the cost of constructing a weir would be disproportionately great. Sometimes there are water-power dams on such streams that have level crests and are otherwise so constructed as to permit such measurements; for, although they are not usually sharp-crested as required above, there are suitable formulas, similar to the preceding, giving the flow over wide-crested weirs and other forms.

In a small stream the summer low water flow may be determined without difficulty by making a weir of a few planks and placing it in the top of a small temporary dam of stones and turf, but this will of course be destroyed by the first flood.

One of the earliest units of water measurement was the "miner's inch," a unit of simple application which was measured in a similar fashion. According to Colorado statute, a miner's inch is defined as the quantity of water delivered through an inch-square orifice, under a five inch pressure measured from the top of the orifice to the surface of the water, in a box set in the banks of the ditch. It would evidently be inconvenient to measure large quantities of water by this unit, nor is it an accurate and definite unit, for a change in the shape of the orifice will change much the amount of water delivered, therefore its use is being abandoned. It is variously defined in different states, but a statement now accepted in many regions is the ratio that one second-foot equals fifty miner's inches.

The float-measurement method, though not giving accurate results, is quite simple and is fairly good if there is no strong wind or other such disturbing factor, and if on the stream a suitable straight portion with smooth, even current can be found. By stretching cords or wires across or by setting range poles on the opposite shores, two parallel lines are marked perpendicularly across the stream so as to include a convenient portion of the channel from ten feet to five hundred feet long according to the size and character of the stream, speed of current, etc. The width is measured and soundings with line or rod are made at numerous points across the width so as to give the average depth and therefore the area of the cross-section. This should be done under each of the parallel lines, and also if the stretch between them is long at one or two lines intermediate between them. Floats of some sort are then thrown singly into the stream above the upper line, the time each passes the upper line precisely noted, and the time it passes the lower line. If the total distance between the lines (in feet) be now divided by the time in seconds occupied by each float in passing down that distance its velocity in feet per second is found.

The average velocity of the stream may be assumed to be from four-fifths to eleven-twelfths of the surface velocity, according to wind, character of channel, etc. For a large stream in an unobstructed channel with smooth mud or sand bottom, the average velocity is likely to be nearly nine-tenths of the surface velocity; but in a smaller stream with bottom of pebbles and small stones the average may not be more than five-sixths the surface velocity. Also a wind if down stream of course increases the surface velocity and if upstream decreases it.

The floats may be sticks and chips or anything else convenient, but must be as nearly submerged as possible, especially if the current is sluggish, to avoid catching the wind. Bottles tightly corked after being partially filled with water so as to be almost submerged are good in a river.

Other more elaborate floats, such as rods weighted so as to float vertically, extending nearly to the bottom of the channel, or double floats with a weighted vane in the lower portion of the stream hanging by a cord from the visible float at the surface are sometimes employed, with the intention of obtaining directly the average velocity; but their use is as troublesome as the employment of the more accurate current-meter.

On a large stream this work requires several persons, but one person alone can obtain after a little practice fairly good results on a small stream, especially if a cheap stop-watch is used for timing. The computation of a float measurement may be made by several methods. Most simply, after floats have been timed along every part of the width the velocity given by each float may be found, their average taken as the average velocity of the stream, and the cross-section of the stream multiplied by the

average velocity to obtain the flow. If the stream is of considerably different depth in different portions of the width, quite large errors may enter unless more floats are taken in the deeper portions, somewhat in proportion to the depths. Note that the velocities should be averaged, not the times of floating down, in order to avoid giving undue weight to any float that happened to be delayed in the edge of the stream. This method is fairly satisfactory for a small brook, and is illustrated by this example:

Float measurement of Little Muddy river twenty-five miles north of Williston, September 14, 1904:

Length taken for run of floats, 20 feet.

Average width, 5 feet 6 inches.

Depths (taken at equal intervals on four lines across stream):

1, 2, 2, 3, 2 inches.
1, 1, 2, 2, 1 inches.
1, 2, 3, 2, 1 inches.
2, 2, 3, 1, 1 inches.

Therefore the average depth is 1.75 inches or 0.146 feet.

Depth multiplied by width gives area of cross-section, 0.80 square feet.

Number of seconds taken by floats in running 20 feet: 13, 11, 9, 10, 8, 10, 13, 12, 12, 22, 8, 10, 9, 11, 9 seconds.

Length of run divided by time gives speed of each float in feet per second: 1.54, 1.82, 2.22, 2.00, 2.50, 2.00, 1.54, 1.67, 1.67, 0.91, 2.50, 2.00, 2.22, 1.82, 2.22. Average surface velocity, 1.98.

Slight wind downstream; if total average velocity is taken as four-fifths of surface velocity, four-fifths of 1.98 is 1.58.

Area of cross-section multiplied by velocity gives total flow; 0.80 multiplied by 1.58; total flow, 1.26 cubic feet per second.

A better method is to imagine the stream divided (as detailed under the description of the current-meter method) into sections of narrower width, say one foot, two feet, five feet or ten feet, and to run several floats in each small section, from the velocity of which with the measurements of depth the amount of flow through each small portion of the whole cross-section may be separately computed, and the total flow obtained by adding these.

This method is illustrated by the following example:

Float measurement of Knife River, ten miles above mouth, August 26, 1904—whole width, thirty-two feet, divided into sections four feet wide. Depths taken and floats run through middle of each section. Length of run, fifty feet.

Distance from right bank—feet	Depth at upper line—feet	Depth at lower line—feet	Average depth—feet	Width of section—feet	Area of each section—square feet	Average time of floats—seconds	Surface velocity—feet per second	Discharge of each section—cubic feet per second
2	0.4	0.6	0.5	4	2.0	193	0.26	0.52
6	0.9	0.9	0.9	4	3.6	108	0.46	1.66
10	1.3	1.1	1.2	4	4.8	46	1.09	5.23
14	1.6	1.4	1.5	4	6.0	39	1.28	7.68
18	1.4	1.2	1.3	4	5.2	34	1.47	7.64
22	1.2	1.2	1.2	4	4.8	41	1.22	5.86
26	1.0	1.2	1.1	4	4.4	62	0.81	3.56
30	0.9	0.9	0.9	4	3.6	235	0.21	0.76
Total discharge.....								32.91

No wind. If average velocity is taken as seven-eighths of surface velocity, seven-eighths of 32.91 is the total flow, 28.80 cubic feet per second.

(NOTE. The distances, depths, and times are found in the measurement, and the other columns filled in the computation. Area of section multiplied by velocity equals discharge).

Several units for water-measurement are frequent. The one used above is the "second-foot" which means a flow of one cubic foot each second, and is the most convenient unit. Gallons per minute or per day are often used, especially in connection with city water supply. One second-foot is equal to about 7½ gallons per second, 450 gallons per minute, or 650,000 gallons per day, which affords much larger and more impressive figures for presentation to the tax-payers who are meeting the expenses of the pumping plant. The "miner's inch," or merely "inch," is another unit, of rather indefinite value as described above. The most frequent unit for measurement of water stored in reservoirs is the acre-foot, a quantity of water sufficient to cover one acre a foot deep. A flow of one second-foot will amount to almost two acre-feet per day.

If it is prospective use for irrigation that gives value to the stream, after a measurement of the amount of flowing water has been made the next question that arises is "How much land will this stream irrigate?" This leads to a discussion of the duty of water. The duty of water, as the ratio between the number of units of land and of water properly to be applied to it is called, is not everywhere the same, but depends upon the climate, upon the character of the soil tilled, and upon the nature of the crops cultivated; experience will bring more definite knowledge concerning the needs of the land in this state. But as a conservative estimate the general statement may be made that eighty acres may be irrigated with one second-foot of water. In most of the western states some such figure is set as the legal duty of water, that is to say as the amount of water that the owner of any particular tract of land is not entitled to exceed in his claims.

Another phrase which is especially convenient in deciding how much land a storage tank or reservoir full of water will irrigate is the the statement, as yet tentatively made, that in North Dakota two acre-feet of irrigation-water to each acre of land per year should be sufficient for most crops, i. e., enough water to cover the land two feet deep if none of it were soaking in or running off. It may be noted that a continuous flow of one cubic foot per second would cover eighty acres two feet deep in about eighty days; so that, assuming an irrigating season of eighty days, the phrases above would have the same value.

Whatever quantity of water is assumed as needed, be it a flow continuously during the irrigation season of one second-foot for each eighty acres or an amount sufficient to cover the land two feet deep or more, or less, an approximate knowledge of the amount of water available for use is the prime essential, and it will be found that with a very little practice this can be at least roughly obtained by some of these methods. A few such measurements at high water, medium stages and low water on any stream will prove very helpful if its use for irrigation or any other purpose is contemplated. Advice or assistance in any

difficulties arising in such measurements will be freely offered in reply to any letter of inquiry sent either to the State Irrigation Engineer or to the State Geological Survey, at the post-office, University, N. D.

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HON. HENRY C. HANSBROUGH

U. S. Senator from North Dakota, 1891 to 1900. Chairman of the Committee on Public Lands, Fifty-seventh Congress, who introduced and urged the passage of the National Reclamation Act.

APPENDIX

GIVING TEXT OF NATIONAL RECLAMATION ACT, DRAFT OF A PROPOSED STATE IRRIGATION CODE FOR NORTH DAKOTA, ARTICLES OF INCORPORATION OF THE LOWER YELLOWSTONE WATER USERS' ASSOCIATION, AND OTHER PAPERS AND MATTERS RELATING TO IRRIGATION.

APPENDIX

TEXT OF THE NATIONAL RECLAMATION ACT

An Act Appropriating the Receipts from the Sale and Disposal of Public Lands in Certain States and Territories to the Construction of Irrigation Works for the Reclamation of Arid Lands.

Be it enacted by the senate and house of representatives of the United States of America, in congress assembled, that all moneys received from the sale and disposal of public lands in Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Utah, Washington and Wyoming, beginning with the fiscal year ending June thirtieth, nineteen hundred and one, including the surplus of fees and commissions in excess of allowances to registers and receivers, and excepting the five per centum of the proceeds of the sales of public lands in the above states set aside by law for educational and other purposes, shall be, and the same are hereby, reserved, set aside, and appropriated as a special fund in the treasury to be known as the "Reclamation Fund," to be used in the examination and survey for and the construction and maintenance of irrigation works for the storage, diversion and development of waters for the reclamation of arid and semi-arid lands in the said states and territories and for the payment of all other expenditures provided for in this act: Provided, that in case the receipts from the sale and disposal of public lands other than those realized from the sale and disposal of lands referred to in this section are insufficient to meet the requirements for the support of agricultural colleges in the several states and territories, under the act of August thirtieth, eighteen hundred and ninety, entitled "An act to apply a portion of the proceeds of the public lands to the more complete endowment and support of the colleges for the benefit of agriculture and the mechanic arts, established under the provisions of an act of congress approved July second, eighteen hundred and sixty-two," the deficiency, if any, in the sum necessary for the support of the said colleges shall be provided for from any moneys in the treasury not otherwise appropriated.

Sec. 2. That the secretary of the interior is hereby authorized and directed to make examinations and surveys for, and to locate and construct as herein provided, irrigation works for the storage, diversion and development of waters, including artesian wells, and to report to congress at the beginning of each regular session, as to the results of such examinations and surveys, giving estimates of all contemplated works, the quantity and location of the lands which can be irrigated therefrom, and all facts relative to the practicability of each irrigation project; also the cost of works in process of construction as well as of those which have been completed.

Sec. 3. That the secretary of the interior shall, before giving the public notice provided for in section four of this act, withdraw from public entry the lands required for any irrigation work contemplated under the provisions of this act, and shall restore to public entry any of the lands so withdrawn when, in his judgment, such lands are not required for the purposes of this act; and the secretary of the interior is hereby authorized at or immediately prior to the time of beginning the surveys for any contemplated irrigation works, to

withdraw from entry, except under the homestead laws, any public lands believed to be susceptible of irrigation from said works: Provided, that all lands entered and entries made under the homestead laws within areas so withdrawn during such withdrawal shall be subject to all the provisions, limitations, charges, terms and conditions of this act; that said surveys shall be prosecuted diligently to completion, and upon the completion thereof, and of the necessary maps, plans, and estimates of cost, the secretary of the interior shall determine whether or not said project is practicable and advisable, and if determined to be impracticable or unadvisable, he shall thereupon restore said lands to entry; that public lands which it is proposed to irrigate by means of any contemplated works shall be subject to entry only under the provisions of the homestead laws in tracts of not less than forty nor more than one hundred and sixty acres, and shall be subject to the limitations, charges, terms and conditions herein provided: Provided, that the commutation provisions of the homestead laws shall apply to entreis made under this act.

Sec. 4. That upon the determination by the secretary of the interior that any irrigation project is practicable, he may cause to be let contracts for the construction of the same, in such portions or sections as it may be practicable to construct and complete as parts of the whole project, providing the necessary funds for such portions or section are available in the reclamation fund, and thereupon he shall give public notice of the lands irrigable under such project, and limit of area per entry, which limit shall represent the acreage which, in the opinion of the secretary, may be reasonably required for the support of a family upon the lands in question; also of the charges which shall be made per acre upon the said entries, and upon lands in private ownership which may be irrigated by the waters of the said irrigation project, and the number of annual installments, not exceeding ten, in which such charges shall be paid and the time when such payments shall commence. The said charges shall be determined with a view of returning to the reclamation fund the estimated cost of construction of the project and shall be apportioned equitably: Provided, that in all construction work eight hours shall constitute a day's work, and no Mongolian labor shall be employed thereon.

Sec. 5. That the entryman upon lands to be irrigated by such works shall in addition to compliance with the homestead laws, reclaim at least one-half of the total irrigable area of his entry for agricultural purposes, and before receiving patent for the lands covered by his entry shall pay to the government the charges apportioned against such tracts, as provided in section four. No right to the use of water for land in private ownership shall be sold for a tract exceeding one hundred and sixty acres to any one land owner, and no such sale shall be made to any land owner unless he be an actual bona fide resident on such land or occupant thereof residing in the neighborhood of said land, and no such right shall permanently attach until all payments therefor are made. The annual installments shall be paid to the receiver of the local land office of the district in which the land is situated, and a failure to make any two payments when due shall render the entry subject to cancellation, with the forfeiture of all rights under this act, as well as of any moneys already paid thereon. All moneys received from the above sources shall be paid into the reclamation fund. Registers and receivers shall be allowed the usual commissions on all moneys paid for lands entered under this act.

Sec. 6. That the secretary of the interior is hereby authorized and directed to use the reclamation fund for the operation and maintenance of all reservoirs and irrigation works constructed under the provisions of this act: Provided, that when the payments required by this act are made for the major portion of the lands irrigated from the waters of any of the works herein provided for, then the

management and operation of such irrigation works shall pass to the owners of the lands irrigated thereby, to be maintained at their expense under such form of organization and under such rules and regulations as may be acceptable to the secretary of the interior: Provided, that the title to and the management and operation of the reservoirs and the works necessary for their protection and operation shall remain in the government until otherwise provided by congress.

Sec. 7. That where in carrying out the provisions of this act it becomes necessary to acquire any rights or property, the secretary of the interior is hereby authorized to acquire the same for the United States by purchase or by condemnation under judicial process, and to pay from the reclamation fund the sums which may be needed for that purpose, and it shall be the duty of the attorney general of the United States upon every application of the secretary of the interior, under this act to cause proceedings to be commenced for condemnation within thirty days from the receipt of the application at the department of justice.

Sec. 8. That nothing in this act shall be construed as affecting or intended to affect or to in any way interfere with the laws of any state or territory relating to the control, appropriation, use or distribution of water used in irrigation or any vested rights acquired thereunder, and the secretary of the interior, in carrying out the provisions of this act, shall proceed in conformity with such laws, and nothing herein shall in any way affect any right of any state or of the federal government or of any land owner, appropriator, or user of water in, to, or from any interstate stream or the waters thereof: Provided, that

Sec. 9. That it is hereby declared to be the duty of the secretary of the interior in carrying out the provisions of this act, so far as the same may be practicable and subject to the existence of feasible irrigation projects, to expend the major portion of the funds arising from the sale of public lands within each state and territory hereinbefore named for the benefit of arid and semi-arid lands within the limits of such state or territory: Provided, that the secretary may temporarily use such portion of said funds for the benefit of arid or semi-arid lands in any particular state or territory hereinbefore named as he may deem advisable, but when so used the excess shall be restored to the fund as soon as practicable, to the end that ultimately, and in any event, within each ten-year period, after the passage of this act, the expenditures for the benefit of the said states and territories shall be equalized according to the proportions and subject to the conditions as to practicability and feasibility aforesaid.

Sec. 10. That the secretary of the interior is hereby authorized to perform any and all acts and to make such rules and regulations as may be necessary and proper for the purpose of carrying the provisions of this act into full force and effect.

Approved June 17, 1902.

DRAFT OF A PROPOSED STATE IRRIGATION CODE

PREPARED BY MORRIS BIEN.

GENERAL PROVISIONS.

Section 1. WATERS OF THE STATE PUBLIC WATERS.—All waters within the limits of the state from all sources of water supply belong to the public and, except as to navigable waters, are subject to appropriation for beneficial use.

Sec. 2. BENEFICIAL USE, APPURTENANCE, PRIORITY.—Beneficial use shall be the basis, the measure, and the limit of the right to the use of water, and all waters appropriated for irrigation purposes shall be appurtenant to specified lands owned by the person claiming the right to use the water, so long as the water can be beneficially used thereon. Priority in time shall give the better right. In all cases of claims to the use of water initiated prior to the passage of this act, the right shall relate back to the initiation of the claim, upon the diligent prosecution to completion of the necessary surveys and construction for the application of the water to a beneficial use. All claims to the use of water initiated after the passage of this act shall relate back to the date of receipt of an application therefor in the office of the state engineer, subject to compliance with the provisions of this act, and the rules and regulations established thereunder.

Sec. 3. EMINENT DOMAIN.—The beneficial use of water is a public use, and any person, corporation or association may exercise the right of eminent domain to acquire any right now or hereafter existing to the use of water for beneficial purposes, or to acquire right of way for the storage or conveyance of waters for beneficial use, including the right to enlarge existing structures and use the same in common with the former owner. Such right of way shall in all cases be so located as to do the least damage to private or public property, consistent with proper and economical engineering construction. Such rights may be acquired in the manner provided by law for the taking of private property for public use.

Sec. 4. RECLAIMING WATERS.—Water turned into any natural or artificial water course by any party entitled to the use thereof may be reclaimed below and diverted therefrom by such party, subject to existing rights, due allowance for losses being made, as determined by the state engineer.

STATE ENGINEER.

Sec. 5. STATE ENGINEER, APPOINTMENT, DUTIES, POWERS, QUALIFICATIONS AND SALARY.—There shall be a state engineer, who shall be a technically qualified and experienced hydraulic engineer, to be appointed by the governor and such appointment confirmed by the senate. He shall hold office for the term of six years from and after his appointment, or until his successor shall have been appointed and shall have qualified. He shall have general supervision of the waters of the state and of the measurement and appropriation thereof, and shall receive a salary of $3,000 per annum, and actual and necessary traveling expenses while away from his office in the discharge of official duties. He shall not engage in private practice.

Sec. 6. ASSISTANT STATE ENGINEER AND EXPENSES OF STATE ENGINEER'S OFFICE.—The state engineer shall have power to appoint an assistant state engineer, at a salary not to exceed $1,800 per annum and actual and necessary traveling expenses while away from the office in the discharge of official duties. The state engineer may employ other and additional assistants and purchase materials and supplies for the proper conduct and maintenance of his office and department, in pursuance of appropriations as made from time to time for such purposes. The salaries and expenses of the office of the state engineer shall be paid at the same times and in the same manner as those of other offices of the state. The office of the state engineer shall be located at the seat of government.

Sec. 7. OATH AND BOND OF STATE ENGINEER AND ASSISTANT STATE ENGINEER.—Before entering upon the duties of his office the state engineer shall take and subscribe an oath of office and give bond with good and sufficient sureties to be approved by the

governor, in the sum of $5,000, for the faithful performance of his duties, which oath of office and bond shall, upon approval, be filed in the office of the secretary of state. The assistant state engineer shall also take and subscribe an oath for the faithful discharge of his duties, which oath shall be filed with the secretary of state together with his appointment by the state engineer.

Sec. 8. AUDITING OF CLAIMS.—All claims for services rendered, expenses incurred, or materials or supplies furnished under direction of the state engineer, and which are payable from the funds appropriated for the prosecution of the work under his direction and supervision, shall be approved by the state engineer and properly vouchered and filed in the office of the secretary of state, who shall, if he finds the same to have been incurred in accordance with law, audit and allow such claims and issue his warrant on the state treasurer in payment thereof.

Sec. 9. STATE ENGINEER'S REPORT.—The state engineer shall prepare and deliver to the governor, on or before September 30 of the year preceding the regular session of the legislature, and at other times when required by the governor, a full report of the work of his office, including a detailed statement of the expenditures thereof, with such recommendations for legislation as he may deem advisable.

Sec. 10. FEES OF STATE ENGINEER.—The state engineer shall receive the following fees, to be collected in advance and to be paid by him into the general fund of the state treasury on the last days of March, June, September and December of each year.

(a) For filing and examining an application for permit to appropriate water, map and field notes of the same, five dollars.

(b) For recording any permit, certificate of construction or license issued or any other water right instrument, one dollar for the first hundred words and fifteen cents for each additional hundred words or fraction thereof.

(c) For filing any other paper, one dollar.

(d) For issuing certificates of construction, or license to appropriate water, one dollar each.

(e) For making copy of any document recorded or filed in his office, fifteen cents for each hundred words or fraction thereof.

(f) For blue print copy of any map or drawing, ten cents per square foot or fraction thereof. For other copies of drawings, actual cost of the work.

(g) For certifying to such copies, one dollar for each certificate.

(h) For examining and approving, in connection with water right applications, plans and specifications for any dam, not exceeding 10 feet in extreme height from the foundation, ten dollars; for a dam higher than 10 feet and not exceeding 30 feet, twenty dollars; for a dam higher than 30 feet and not exceeding 50 feet, thirty dollars; for a dam higher than 50 feet, fifty dollars; or for a canal or other water conduit of an estimated capacity exceeding fifty and not more than one hundred cubic feet per second, twenty dollars; for an estimated capacity exceeding one hundred cubic feet per second, thirty dollars.

(i) For inspecting dam sites and construction work when required by law, or when necessary in the judgment of the state engineer, ten dollars per day and actual and necessary traveling expenses. The fees for any inspection deemed necessary by the state engineer and not paid on demand shall be a lien on any land or other property of the owner of the works, and may be recovered by the state engineer in any court of competent jurisdiction.

(j) Rating ditches or inspecting plans and specifications of works for the diversion, storage and carriage of water, at the request of private parties, not in connection with an application for right to appropriate water, actual cost and expenses; and the state engineer shall attach his approval to such plans and specifications if found satisfactory.

(k) For such other work as may be required of his office, the fees provided by law.

Sec. 11. RECORDS OF STATE ENGINEER.—The records of the office of the state engineer are public records and shall remain on file in his office and shall be open to the inspection of the public at all times during business hours. Such records shall show in full all permits, certificates of completion of construction and licenses issued, together with all action thereon, and all action or decisions of the state engineer affecting any rights or claims to appropriate water.

(a) Certified copies of any records or papers on file in the office of the state engineer shall be evidence equally with the originals thereof; and when introduced as evidence shall be held as of the same validity as the originals.

Sec. 12. RULES AND REGULATIONS.—The state engineer shall make all necessary general rules and regulations to carry into effect the duties devolved upon his office, and may change the same from time to time, in his discretion. All such rules and regulations relating to applications for permits to appropriate water, for the inspection of works, for the issuance of license, and for the determination of rights to the use of water shall be modified by the state engineer if required by a vote of the board of water commissioners hereinafter established, at least three of the four water commissioners voting in favor of such modification.

Sec. 13. APPEAL TO BOARD OF WATER COMMISSIONERS.—Such modification of the rules and regulations of the state engineer shall be voted upon by the board of water commissioners only on appeal from a decision of the state engineer.

DETERMINATION OF WATER RIGHTS.

Sec. 14. HYDROGRAPHIC SURVEYS AND COOPERATION.—The state engineer shall make hydrographic surveys and investigations of each stream system and source of water supply in the state, beginning with those most used for irrigation, obtaining and recording all available data for the determination, development and adjudication of the water supply of the state. He shall be authorized to cooperate with the agencies of the federal government engaged in similar surveys and investigations, and in the construction of works for the development and use of the water supply of the state, expending for such purposes any money available for the work of his office, and may accept and use, in connection with the operation of his department, the results of the work of the agencies of the government.

Sec. 15. SUIT FOR AJUDICATION OF WATER RIGHTS.—Upon the completion of such hydrographic survey of any stream system, the state engineer shall deliver a copy thereof, together with copies of all data necessary for the determination of all rights to the use of the waters of such system, to the attorney general of the state, who shall within sixty days thereafter enter suit on behalf of the state for the determination of all rights to the use of such water, and shall diligently prosecute the same to a final adjudication. Provided, that if suit for the adjudication of such rights shall have been begun by private parties, the attorney general shall not be required to bring suit. Provided, however, that the attorney general shall intervene in any suit for the adjudication of rights to the use of water on behalf of

the state if notified by the state engineer that in his opinion the public interest requires such action.

Sec. 16. PARTIES AND COSTS OF SUITS.—In any suit for the determination of a right to the use of the waters of any stream system, all who claim the right to use such waters shall be made parties. When any suit has been filed, the court shall, by its order duly entered, direct the state engineer to make or furnish a complete hydrographic survey of such stream system as hereinbefore provided, in order to obtain all data necessary to the determination of the rights involved. The costs of such suit, including the costs on behalf of the state, and of such surveys, shall be charged against each of the private parties thereto in proportion to the amount of the water right allotted.

Sec. 17. FUND FOR HYDROGRAPHIC SURVEYS.—For the purpose of advancing the money required for any surveys so ordered by the court, there is hereby appropriated and set apart from any moneys in the general fund in the state treasury, not otherwise appropriated, the sum of $5,000, to be known as the Hydrographic Survey Fund, which shall be a permanent fund and which shall be used only for the payment of the expenses of such surveys; and all claimes for services rendered, expenses incurred or materials or supplies furnished under the direction of the state engineer in the prosecution of said work shall be approved by the state engineer and properly vouchered and filed in the office of the secretary of state, who shall, if he finds the same to have been incurred in accordance with law, audit and allow such claims and issue his warrants against the Hydrographic Survey Fund on the state treasurer, in payment thereof. The amounts paid by the parties to said suits, on account of such surveys, shall be paid to the state treasurer, who shall credit the same to such fund, which shall continue to be available for advancing the expenses of such surveys, as ordered by the court from time to time.

Sec. 18. FILING OF DECREE ADJUDICATING WATER RIGHTS.—Upon the adjudication of the rights to the use of the waters of a stream system, two certified copies of the decree shall be prepared by the clerk of the court, at the cost of the parties, one copy shall be filed in the office of the state engineer and the other in the office of the water commissioner of the water division in which stream system is situated. Such decree shall in every case declare, as to the water right adjudged to each party, the priority, amount, purpose, place of use, and, as to water used for irrigation, the specific tracts of land to which it shall be appurtenant, together with such other conditions as may be necessary to define the right and its priority.

APPROPRIATION OF WATER.

Sec. 19. APPLICATION FOR WATER RIGHT.—Any person, association or corporation hereafter intending to acquire the right to the beneficial use of any waters, shall, before commencing any construction for such purpose, or before taking the same from any constructed works, make an application to the state engineer for a permit to appropriate, in the form required by the rules and regulations established by him. Such rules and regulations shall, in addition to providing the form and manner of preparing and presenting the application, require the applicant to state all the data necessary for the proper description and limitation of the right applied for, as to the amount of water and periods of annual use, together with such information, maps, field notes, plans and specifications as may be necessary to show the method and practicability of the construction and the ability of the applicant to complete the same. All such maps, field notes, plans and specifications shall be made from actual surveys and measurements, and shall be retained in the office of the state engineer after the approval of the application. The state engineer

may require additional information not provided for in the general rules and regulations, in any case involving the diversion of 500 cubic feet of water per second, or more, or the construction of a dam more than 30 feet high from the foundation. The owners of works proposing to store or carry water in excess of their needs for beneficial use, may make application for such excess, and shall be held as trustees of such right for the parties applying the water to a beneficial use; and shall be required to furnish the water for such parties at reasonable rates for storage, or carriage, or both, as the case may be.

Sec. 20. FILING AND CORRECTION OF APPLICATION.—The date of receipt of such application in the state engineer's office shall be endorsed thereon and noted in his records. If the application is defective as to form, or unsatisfactory as to feasibility or safety of plan, or as to the showing of the ability of the applicant to carry the construction to completion, it shall be returned with a statement of the corrections, amendments or changes required, within thirty days after its receipt, and sixty days shall be allowed for the refiling thereof. If refiled, corrected as required, within such time, the application shall, upon being accepted, take priority as of date of its original filing, subject to compliance with the further provisions of the law and the regulations thereunder. Any corrected application filed after the time allowed shall be treated in all respects as an original application received on the date of its refiling. Provided, that the plans of construction may be amended, with the approval of the state engineer, at any time; but no such change shall authorize an extension of time for construction beyond five years from the date of the permit, except as provided in section 30.

Provided, further, that a change in the proposed point of diversion of water from a stream shall be subject to the approval of the state engineer, and shall not be allowed to the detriment of the rights of others having valid claims to the use of water from said stream.

Sec. 21. PUBLICATION OF NOTICE.—Upon the filing of an application which complies with the provisions of this act and the rules and regulations established thereunder, the state engineer shall instruct the applicant to publish notice thereof, in a form prescribed by him, in some newspaper of general circulation in the stream system, once a week for four consecutive weeks. Such notice shall give all essential facts as to the proposed appropriation, among them the places of appropriation and of use, amount of water, the purpose for which it is to be used, name and address of applicant and the time when the application will be taken up by the state engineer for consideration. Proof of publication, as required, shall be filed with the state engineer within 60 days from the date of his instructions to make publication. In case of failure to file satisfactory proof of publication in accordance with the rules and regulations applicable thereto, within the time required, the application shall thereafter be treated as an original application filed on the date of receipt of proofs of publication in proper form.

Sec. 22. APPROVAL OF APPLICATION.—Upon the receipt of the proofs of publication, the state engineer shall determine from the evidence presented by the parties interested, from such surveys of the water supply as may be available, and from the records, whether there is unappropriated water available for the benefit of the applicant. If so, he shall endorse his approval on the application, which shall thereupon become a permit to appropriate water, and shall state in such approval the time within which the construction shall be completed, not exceeding five years from the date of approval, and the time within which the water shall be applied to a beneficial use, not exceeding four years in addition thereto.

Sec. 23. REJECTION AND APPEAL.—If, in the opinion of the state engineer, there is no unappropriated water available, he shall reject such application. He shall decline to order the publication of notice of any application which does not comply with the requirements of the law, and the rules and regulations thereunder. He may also refuse to consider or approve an application or to order the publication of notice thereof, if, in his opinion, the approval thereof would be contrary to the public interest. Any applicant may appeal from such decision of the state engineer, or from any other decision by him which denies a substantial right, within sixty days from the date thereof, to the circuit court of the county in which the proposed plan of diversion or storage is situated. In the absence of such appeal, the decision of the state engineer shall be final.

Sec. 24. PROSECUTION OF WORK.—The construction of the works shall be diligently prosecuted to completion, and if one-fifth of the work shall not be completed within one-half of the time allowed, the state engineer may accept and approve, as herein provided, an application for the use of all or any of the waters included in the permit issued to the prior applicant, and the right to use such waters under the former permit shall thereupon be forfeited. Provided, that the state engineer shall allow an extension of time on request of the prior applicant, equal to the time during which work was prevented by the operation of law, beyond the power of the said applicant to avoid.

Sec. 25. COMPLETION OF WORK.—On the date set for the completion of the work, or prior thereto, upon notice from the owner that the work has been completed, the state engineer shall cause the work to be inspected, after due notice to the owner of the permit. Such inspection shall be thorough and complete, in order to determine the actual capacity of the works, their safety and efficiency. If not properly and safely constructed, the state engineer may require the necessary changes to be made within a reasonable time, not to exceed six months, and shall not issue his certificate of completion until such changes are made. Failure to make such changes shall cause the postponement of the priority under the permit for such time as may elapse from the date for completing such changes until made to the satisfaction of the state engineer, and applications subsequent in time shall have the benefit of such postponement of priority. Provided, that for works involving the diversion of not exceeding 20 cubic feet of water per second or a dam not exceeding 10 feet in extreme height from the foundation, the state engineer may, in his discretion, accept the report of an inspection by a reputable hydraulic engineer.

Sec. 26. CERTIFICATE OF COMPLETION.—When the works are found in satisfactory condition after inspection, the state engineer shall issue his certificate of construction, setting forth the actual capacity of the works and such limitations upon the water right as shall be warranted by the condition of the works, but in no manner extending the rights described in the permit.

Sec. 27. INSPECTION OF WORKS.—If the state engineer shall, in the course of his duties, find that any works used for the storage, diversion or carriage of water are unsafe and a menace to life or property, he shall at once notify the owner or his agent, specifying the changes necessary and allowing a reasonable time for putting the works in safe condition, not exceeding three months. Upon the request of any party, accompanied by the estimated cost of inspection, the state engineer shall cause any alleged unsafe works to be inspected. If they shall be found unsafe by the state engineer, the money deposited by such party shall be refunded, and the fees for inspection shall be paid by the owner of such works; and, if not paid by him within 30 days after the decision of the state engineer, shall be a lien against any property of such owner, to be recovered by suit instituted by the

district attorney of the county at the request of the state engineer. The state engineer may, when in his opinion necessary, inspect any works under construction for the storage, diversion or carriage of water, and require any changes necessary to secure their safety; and the fees for such inspection shall be a lien on any property of the owner and shall be subject to collection as provided herein. Provided, that any works constructed by the United States, or by its duly authorized agencies, shall not be subject to such inspection while under the supervision of officers of the United States.

Sec. 28. USE OF UNSAFE WORKS.—The use of works for the storage, diversion or carriage of water, at any time after an inspection thereof by the state engineer and receipt of notice from him that the same are unsafe for the purpose for which they are used, until the receipt of notice from him that in his opinion they have been made safe, shall be a misdemeanor and it shall be the duty of the state engineer to give prompt notice to the district attorney of the county in which such works are located in case of such violation. The district attorney shall at once proceed against the owner, and all parties responsible therefor.

Sec. 29. APPLICATION TO BENEFICIAL USE.—On or before the date set for the application of the water to a beneficial use, the state engineer shall cause the works to be inspected, after due notice to the owner of the permit. Upon the completion of such inspection, the state engineer shall issue a license to appropriate water to the extent and under the conditions of the actual application thereof to a beneficial use, but in no manner extending the rights described in the permit.

Provided, that the inspection to determine the amount of water applied to a beneficial use shall be made at the same time as that of the constructed work, if requested by the owner, and if such action is deemed proper by the state engineer.

Sec. 30. EXTENSION OF TIME.—The state engineer shall have power to extend the time for the completion of construction, or for application to beneficial use, for three years and two years, respectively, but only on account of delays due to physical or engineering difficulties which could not have been reasonably anticipated, or by operation of law beyond the power of applicant to avoid.

Sec. 31. ASSIGNMENT OF PERMIT OR LICENSE.—Any permit or license to appropriate water may be assigned, but no such assignment shall be binding, except upon the parties thereto, unless filed for record in the office of the state engineer. The evidence of the right to use water from any works constructed by the United States, or its duly authorized agencies, shall in like manner be filed in the office of the state engineer, upon assignment. Provided, that no right to appropriate water for irrigation purposes shall be assigned, or the ownership thereof in any wise transferred, apart from the land to which it is appurtenant, except in the manner specially provided by law. Provided, further, that the transfer of title to land in any manner whatsoever shall carry with it all rights to the use of water appurtenant thereto for irrigation purposes.

Sec. 32. TRANSFER OF WATER RECORDS.—It shall be the duty of the county recorder and the county clerk of each county in the state, within thirty days after the passage of this act, to prepare and forward by express or registered mail, at the expense of the county, to the office of the state engineer, a transcript of all records relating to water rights. Provided, that they may forward any original records in their offices which have been duly recorded. The state engineer shall classify and arrange such records to conform to stream systems, and shall send copies thereof relating to each water division to the

water commissioner thereof. He shall likewise forward to the water commissioner copies of all records, permits and licenses to appropriate water relating to his division, and shall advise him of all acts and decisions of the state engineer's office affecting the apportionment of waters in his division.

Sec. 33. REFEREE IN WATER SUITS.—In any water suit the court may appoint a referee or referees, not exceeding three, to take testimony and report upon the rights of the parties, as in other equity cases.

Sec. 34. ATTORNEY GENERAL AND DISTRICT ATTORNEY ADVISERS OF STATE ENGINEER.—The attorney general and the district attorney of the county in which legal questions arise, shall be the legal advisers of the state engineer, and shall perform any and all legal duties necessary in connection with his work, without other compensation than their salaries as fixed by law, except when otherwise provided.

Sec. 35. CHARGE FOR CARRYING AND DELIVERING WATER.—The owner or owners of any works for the storage, diversion or carriage of water, which contain water in excess of their needs for irrigation or other beneficial use for which it has been appropriated, shall be required to deliver such surplus, at reasonable rates for storage, or carriage, or both, as the case may be, to the parties entitled to the use of the water for beneficial purposes. In case of the refusal of such owner or owners to deliver any such surplus water at reasonable rates, as determined by the state engineer, they may be compelled to do so by the circuit court for the county in which the surplus water is to be used.

Sec. 36. APPROPRIATION OF WATER BY THE UNITED STATES.—Whenever the proper officers of the United States, authorized by law to construct works for the utilization of waters within the state, shall notify the state engineer that the United States intends to utilize certain specified waters, the waters so described, and unappriated at the date of such notice, shall not be subject to further appropriation under the laws of this state, for a period of three years from the date of said notice, at which time the proper officers of the United States shall file plans for the proposed work in the office of the state engineer for his information, and no adverse claim to the use of the waters required in connection with such plans, initiated subsequent to the date of such notice, shall be recognized under the laws of the state, except as to such amount of the water described in such notice as may be formally released in writing by an officer of the United States, thereunto duly authorized. Provided, that in case of failure to file plans of the proposed work within three years, as herein required, the waters specified in the notice given by the United States to the state engineer shall become public waters, subject to general appropriation.

WATER COMMISSIONERS.

Sec. 37. WATER DIVISIONS.—The state shall be divided into water divisions, as follows:

Sec. 38. WATER COMMISSIONERS.—A water commissioner shall be appointed by the supreme court for each water division, as hereinafter established, to serve for a term of six years or until his successor shall have qualified, and shall be subject to removal by the court. Provided, that the water commissioners first appointed after the passage of this act, shall serve for terms specified as follows:

Water Division No. 1, six years.
Water Division No. 2, four years.
Water Division No. 3, two years.
Water Division No. 4, six years.

Sec. 39. DUTIES OF WATER COMMISSIONERS.—Each water commissioner shall have the supervision of the apportionment of water in his division, according to the licenses issued by the state engineer and the adjudications of the courts. Each commissioner shall have the custody of the records relating to his division, which shall be public records, and shall be transmitted to his successor in office. Each water commissioner, before entering upon the duties of his office, shall take and subscribe an oath of office and give a bond with good and sufficient sureties, to be approved by the supreme court, in the sum of $2,000, for the faithful performance of the duties of his office, which oath and bond shall upon approval be filed in the office of the secretary of state.

Sec. 40. BOARD OF WATER COMMISSIONERS.—The water commissioners of all the water divisions, together with the state engineer, who shall be president thereof, shall constitute the board of water commissioners, which shall have general supervision of the apportionment of the waters of the state. The board shall adopt general rules and regulations to govern its proceedings and the operations in the various divisions. The state engineer shall have a vote on all matters coming before the board, except appeals, authorized by law, from his acts as the state engineer. The board shall meet on the first Monday in March of each year, at the office of the state engineer, and at such other times and places as may be agreed upon by a majority of its members, whereupon the state engineer shall give notice of such meeting to all members.

Sec. 41. PAY OF WATER COMMISSIONERS.—The water commissioners shall be paid from the state treasury out of the moneys appropriated for such purposes at the rate of ten dollars per day for the time actually engaged in official duties, not exceeding two hundred days in any one year, and shall also be paid actual and necessary traveling expenses while away from their homes on official business.

Sec. 42. WATER DISTRICTS.—The state engineer shall, from time to time as may be necessary for the economical and satisfactory apportionment of the water, divide each water division in conformity with drainage areas, into water districts to be designated by names, and to comprise as far as possible one or more distinct stream systems in each district. The districts may be changed from time to time as may in his opinion be necessary for the economical and satisfactory apportionment of the water.

Sec. 43. WATER MASTERS.—The water commissioner of each division shall appoint, subject to the approval of the state engineer, a water master for each district in his division, who may be removed by the commissioner or by a majority of the board of water commissioners. The water master shall have immediate charge of the apportionment of the waters in his district under the general supervision of the water commissioner, and he shall so apportion, regulate and control the waters of the district as will prevent waste.

Sec. 44. APPEALS TO STATE ENGINEER.—Any person may appeal from the acts or decisions of the water master and water commissioner, to the state engineer, who shall promptly and at a stated time and place, to be fixed by him, upon due notice to the parties, hear and determine the matter in dispute, and his decision shall be final, unless an appeal is taken to the courts within thirty days.

Sec. 45. PAY OF WATER MASTERS.—The water master shall be allowed pay at the rate of four dollars per day and actual and necessary expenses in the performance of his duties. He may employ assistants in cases of emergency, upon the specific authority of, and at the rates of pay as authorized by the water commissioner, such employment to continue only during the existence of the emergency. The

water masters and assistants employed by him shall be paid by the county, upon accounts approved by the water commissioner. If the district is more than one county, each county shall pay its proportionate part of each account rendered. The accounts of the water master shall in all cases specify the distribution of the amounts charged, based upon the amount of work performed as to each ditch and water right, showing the charges to be allotted to each owner. The amounts paid by the counties shall be a lien upon the property of the water users and ditch owners, in accordance with the distribution thereof, as shown by the accounts of the water master, and shall be collected in the manner provided by law for the collection of taxes.

Sec. 46. REPORTS OF WATER MASTERS.—Each water master shall report to the water commissioner, as often as may be deemed necessary by the commissioner, as to the amount of water needed to supply the requirements of his district, the amount available, the works which are without their proper supply, the supply required during the period preceding his next regular report, and such other information as the commissioner may require. These reports shall, at the end of each irrigation season, be filed in the office of the state engineer. The water commissioner shall give directions for correcting any errors of apportionment in his division that may be shown by such reports.

MISCELLANEOUS PROVISIONS.

Sec. 47. UNITS OF MEASUREMENT.—The standard of measurement of the flow of water shall be the cubic foot per second of time; the standard of measurement of the volume of water shall be the acre-foot, being the amount of water upon an acre covered one foot deep, equivalent to forty-three thousand five hundred sixty cubic feet. The miner's inch shall be regarded as one-fiftieth of a cubic foot per second in all cases, except when some other equivalent of the cubic foot per second has been specially stated by contract, or has been established by actual measurement or use.

Sec. 48. ABANDONMENT.—When the party entitled to the use of water fails to beneficially use all or any part of the water claimed by him, for which a right of use has vested, for the purpose for which it was appropriated or adjudicated, for a period of two years, such unused water shall revert to the public and shall be regarded as unappropriated public water.

Sec. 49. AMOUNT OF WATER FOR IRRIGATION.—In the issuance of permits to appropriate water for irrigation or in the adjudication of rights to the use of water for such purpose, the amount allowed shall not be in excess of the rate of one cubic foot of water per second for each 70 acres, or the equivalent thereof, delivered on the land, for a specified time in each year.

Sec. 50. WATER APPURTENANT TO LAND FOR IRRIGATION PURPOSES.—All water used in this state for irrigation purposes shall remain appurtenant to the land upon which it is used. Provided, that if for any reason it should at any time become impracticable to beneficially or economically use water for the irrigation of any land to which the right of use of the same is appurtenant, said right may be severed from said land, and simultaneously transferred, and become appurtenant to other land, without losing priority of right theretofore established, if such change can be made without detriment to existing rights, on the approval of an application of the owner to the state engineer. Before the approval of such application the applicant must give notice thereof by publication once a week for four weeks in a newspaper of general circulation in the stream system in which the tracts of land are located, in the form required by the state engineer. Upon the receipt of the proofs of publication, the state engineer shall render his decision thereon in writing, which shall be final, unless

some party interested in the same source of water supply shall, within sixty days, bring appropriate action in the circuit court of the county in which the land is located, for a review of such decision. If the owner of the land to which water has become appurtenant abandons the use of such waters upon such land, said waters shall become public waters, subject to general appropriation.

Sec. 51. CHANGE OF USE OR PLACE OF DIVERSION.—Any appropriator of water may use the same for other than the purpose for which it was appropriated, or may change the place of diversion, storage or use, in the manner and under the conditions prescribed in Section 50 of this act.

Sec. 52. MEASURING DEVICES.—Every ditch owner shall construct and maintain a substantial headgate at the point where the water is diverted, and shall construct a measuring device, of a design approved by the state engineer, at the most practicable point or points for measuring and apportioning the water as determined by the state engineer. The state engineer may order the construction of such device by the ditch owner, and if not completed within twenty days thereafter the water commissioner shall, upon instructions from the state engineer, refuse to deliver water to such owner. The taking of water by such ditch owner until the construction of such device and the approval thereof by the state engineer shall be a misdemeanor. Such devices shall be so arranged that they can be locked in place, and when locked by the water master or his authorized agent, for the measurement or apportionment of water, it shall be a misdemeanor to interfere with, disturb or change the same, and the use of water through such device after having been interfered with, disturbed or changed, shall be prima facie evidence of the guilt of the person benefited by such interference, disturbance or change.

Sec. 53. UNLAWFUL INTERFERENCE WITH RIGHTS TO THE USE OF WATER.—Any person, association or corporation interfering with or injuring or destroying any dam, headgate, weir, bench mark or other appliance for the diversion, storage, apportionment or measurement of water, or for any hydrographic surveys, or who shall interfere with any person or persons engaged in the discharge of duties connected therewith, shall be guilty of a misdemeanor and shall also be liable for the injury or damage resulting from such unlawful act. The water master or any authorized assistant, within his district, shall have power to arrest any person offending against the provisions of this section, and deliver him to the nearest peace officer of the county. It shall be the duty of the person making the arrest to make complaint at once before the court having jurisdiction thereof. The state engineer, the water commissioners, the water masters and their authorized assistants and agents, may enter upon any private property for the performance of their respective duties, doing no unnecessary injury thereto.

Sec. 54. UNLAWFUL USE OF WATER AND WASTE.—The unauthorized use of water to which another person is entitled, or the willful waste of water to the detriment of another shall be a misdemeanor. It shall also be a misdemeanor to begin or carry on any construction of works for storing or carrying water until after the issuance of permit to appropriate such waters, except in the case of construction carried on under the authority of the United States.

Sec. 55. BRIDGES OVER DITCHES OR CANALS.—The owner or owners of any ditch, canal or other structure for storing or carrying water, shall construct and maintain a substantial bridge where the same crosses any highway or publicly traveled road, not less than fourteen feet wide; or reconstruct the road in a substantial manner and in a convenient location for public travel. Any violation of the provisions of this section shall be a misdemeanor. The county com-

missioners shall be authorized to construct such bridge or road, if not built by the owner of the work within three days after the obstruction of the road, and may recover the expense thereof and costs in a civil suit, unless the same shall be paid by the owner of the works within ten days after demand therefor. The county commissioners may make reasonable requirements as to the size and character of such bridges along public highways, or for the necessary reconstruction of roads, and upon failure to comply therewith, may do the necessary work and collect the expenses thereof and costs as hereinbefore provided. After the construction of such bridge or road as part of a public highway, the same shall be maintained by the county commissioners.

Sec. 56. OBSTRUCTING WORKS.—Whenever any appropriator of water has the right of way for the storage, diversion or carriage of water, it shall be unlawful to place or maintain any obstruction that shall interfere with the use of the works, or prevent convenient access thereto. Any violation of the provisions of this section shall be a misdemeanor.

Sec. 57. PENALTY FOR MISDEMEANORS UNDER THIS ACT. —All violations of the provisions of this act, declared herein to be misdemeanors, shall be punished by a fine not exceeding $250 nor less than $20, or by imprisonment in the county jail not exceeding six months, or by both such fine and imprisonment; and any justice court of the county in which such misdemeanor has been committed shall have jurisdiction thereof.

Sec. 58. LIENS ON LAND.—All liens on land, provided for in this act, shall be superior in right to all mortgages or other incumbrances placed upon the land and the water appurtenant thereto or used in connection therewith, after the passage of this act.

Sec. 59. SEEPAGE WATER.—In case of seepage water from any constructed works, any party desiring to use the same shall make application to the state engineer, as in the case of unappropriated water, and such party shall pay to the owner of such works reasonable charge for the storage or carriage of such water in such works. Provided, that the appearance of such seepage water can be traced beyond reasonable doubt to the storage or carriage of water in such works. The state engineer shall not issue a permit to appropriate such seepage waters until an agreement for the payment of such charges shall have been entered into by the said parties.

Sec. 60.—RIGHT OF WAY OVER STATE LANDS.—There is hereby granted, over all the lands now or hereafter belonging to the state, a right of way for ditches or canals constructed by authority of the United States. All conveyances of state lands hereafter made shall contain a reservation of such right of way.

Sec. 61. DISPOSITION OF STATE LANDS.—No lands belonging to the state, within the areas to be irrigated from works constructed or controlled by the United States, or its duly authorized agencies, shall hereafter be sold except in conformity with the classification of farm units by the United States, and the title to such lands shall not pass from the state until the applicant therefor shall have fully complied with the provisions of the laws of the United States and the regulations thereunder concerning the acquisition of the right to use water from such works and shall produce the evidence thereof duly issued. After the withdrawal of lands by the United States for any irrigation project, no application for the purchase of state lands within the limits of such withdrawal shall be accepted, except upon the conditions prescribed in this section. Any state lands needed by the United States for irrigation works, shall be conveyed to the United States without charge. (Note:) If this is contrary to the

constitution, it should be provided that the land shall be sold at the lowest price authorized by law.

Sec. 62. APPROPRIATIONS.—There is hereby appropriated out of any moneys in the general fund of the state treasury not otherwise appropriated, the sum of $12,500 annually, or so much thereof as may be necessary, for the payment of the salaries and expenses of the state engineer and assistant state engineer, and the services of assistants and expenses of the office and department of the state engineer, as provided by this act; and for the payment of services and expenses of the water commissioners of the several water divisions as provided by this act, the sum of $12,000 annually, or so much thereof as may be necessary. All claims for services rendered and expenses incurred and materials and supplies furnished under the provisions of this act shall be audited and paid by the secretary of state in accordance with the provisions of the general statutes relating to the auditing of claims against the state.

Sec. 63. REPEAL.—All laws and parts of laws in conflict with the provisions of this act are hereby repealed.

Sec. 64. EMERGENCY.—Whereas, an emergency exists, this act shall take effect and be in force from and after its passage.

ARTICLES OF INCORPORATION OF THE LOWER YELLOWSTONE WATER USERS' ASSOCIATION

Know All Men By These Presents, That we, the undersigned, have voluntarily associated ourselves together for the purpose of forming a corporation under the laws of the State of Montana, and hereby certify:

ARTICLE I.

The name of the corporation shall be and is "Lower Yellowstone Water Users Association."

ARTICLE II.

The names of the incorporators are: Burton S. Adams, Charles R. Marshall, F. H. Lovering, William B. Herbert, W. M. Post. But others may become members of this association by subscribing to these articles of incorporation, or a copy thereof, or by the transfer of stock to them in the regular course of the administration of the affairs of the association.

ARTICLE III.

The principal place of transacting the business of the association shall be at Sidney, in the county of Dawson, in the state of Montana.

ARTICLE IV.

Section 1. The purposes for which this association is organized and the general nature of the business to be transacted are: To acquire, furnish, provide for and distribute to the lands of the shareholders of the association, as herein provided, an adequate supply of water for the irrigation thereof; to divert, store, develop, pump, carry and distribute water for irrigation and all other beneficial uses, deriving the same from all available sources of supply, to construct, purchase, lease, condemn, or acquire in any manner whatsoever, and to own, use, sell, transfer, convey, control, maintain and operate any irrigation

works, structures, telephone systems, electric or other power plants, and transmission lines and property, both real and personal, of any kind whatsoever, necessary or appropriate for the accomplishment of any of the purposes of this organization; to generate, create, transmit, use and sell power and electric energy; to act as trustee, agent or attorney for the sale, disposal and transfer of lands in order to facilitate the disposal of such lands or any part thereof to persons qualified to perfect rights to the use of the water under the laws of the United States applicable thereto, and the rules and regulations established thereunder; to have and exercise all powers and to perform any and all acts necessary or appropriate for the accomplishment of any one or more of the said purposes or anything incident thereto.

Sec. 2. This association shall have the power to enter into any contract or other arrangement with the proper representative of the United States, or any other person or persons, corporation or company, for the accomplishment of any of the aforesaid purposes, by means of the construction, acquisition or control of appropriate works or structures, or in any other manner whatsoever.

Sec. 3. It shall have the power to enter into any agreement with the proper representative of the United States with reference to the collection and payment of any and all charges made under the federal statutes for the works providing water for the lands of its shareholders.

Sec. 4. It shall have the power to comply with the provisions of any federal statutes applicable to the work done by the United States in connection with such system of water supply, and any rules and regulations established thereunder.

Sec. 5. The territory within which the lands to be irrigated as aforesaid are situated, to be known as the Lower Yellowstone Irrigation district, includes all lands within the boundaries described as follows:

All of the following townships in Montana, and the entire portions thereof lying to the west and north of the right bank of Yellowstone river and south of left bank of Missouri river, to-wit: T. 18 N. R. 56 E.; T. 18 N. R. 57 E.; T. 19 N. R. 57 E.; T. 19 N. R. 58 E.; T. 20 N. R. 58 E.; T. 21 N. R. 58 E.; T. 21 N. R. 59 E.; T. 22 N. R. 58 E.; T. 22 N. R. 59 E.; T. 23 N. R. 59 E.; T. 23 N. R. 60 E.; T. 24 N. R. 59 E.; T. 24 N. R. 60 E.; T. 25 N. R. 59 E.; T. 26 N. R. 59 E.; and all that portion of the following townships in North Dakota lying to the west and north of right bank of Yellowstone river, and south of left bank of Missouri river, to-wit: T. 150 N. R. 104 W.; T. 151 N. R. 104 W.; T. 152 N. R. 104 W.

ARTICLE V.

Section 1. The capital stock of the association shall be One Million Eight Hundred Thousand Dollars ($1,800,000), divided into 60,000 shares of the par value of Thirty Dollars ($30.00) each.

Sec. 2. Only those who are owners of land, or heirs of lands, or occupants of public lands having initiated a right to acquire the same, within the area described in Article 4, or within such extensions thereof as may hereafter be duly made, shall be qualified to own the shares of this association. Not more than one share shall be alloted for each acre of land, but a fractional acre thereof shall be alloted a correspondingly fractional part of a share.

Sec. 3. As a condition of continued ownership of said shares of stock and participation in any of the benefits thereof, each subscriber therefor, his heirs or assigns or his transferee in pursuance of these articles, shall promptly make application for a water right to the proper authorities of the United States for the lands represented by his shares, and duly proceed to the perfection thereof, in full compliance with the law applicable thereto and the rules and regulations

established in pursuance thereof, as soon as official announcement shall be made that water for such lands is available from the works constructed, owned or controlled by the United States.

Sec. 4. Upon the failure of any shareholder to make prompt application for such water right for any land owned by him or to comply promptly and in good faith with the law and the rules and regulations applicable thereto, he shall forfeit to the association the shares of stock appurtenant to such lands and all rights incident thereto or that could by any means be claimed thereunder; and such person, his heirs and assigns, shall hereafter have no right whatsoever as a member or shareholder of this association as to such shares.

Sec. 5. Any shares of stock so forfeited shall be cancelled and shall not again, under any circumstances, be renewed, revived or re-issued. Other stock in lieu thereof up to the limit of the total number of shares authorized by these articles may be subscribed for, and issued subject to all the conditions of these articles and to the approval of the secretary of the interior.

Sec. 6. That the ownership of each share or fractional share of stock of this association shall carry as incident thereto, a right to have water delivered to the owner thereof by the association for the irrigation of the lands to which such share is appurtenant.

Sec. 7. The amount of water to be delivered to such owner shall be that proportionate part of all water available for distribution by the association during any irrigation season, as the number of shares owned by him shall bear to the whole number of valid and subsisting shares then outstanding, such water to be delivered to and upon said lands at such time during such season as he may direct.

Sec. 8. By subscribing to the shares of this association each signer agrees that the right to any water therefor appropriated to him, or to his predecessors in interests for the irrigation of the lands described in said subscription, or customarily used thereon, shall become appurtenant to such lands and be and remain incident to the ownership of the shares appurtenant to such lands. There shall be further incident to the ownership of such shares, the right to have such water delivered to the owner thereof by the association for the irrigation of said lands, as the association shall from time to time acquire or control means for that purpose. Provided, that the whole amount of water actually delivered to such lands from all sources shall not exceed the amount necessary for the proper cultivation thereof.

Sec. 9. The records of the association and each and every certificate or other evidence of ownership of the shares of stock in the association, when issued, shall contain a description of the lands to be irrigated, and to which the aforesaid right and shares shall be perpetually appurtenant; and thereafter all rights, whatever their sources or whatever their manner of acquisition, to the use of water for the irrigation of said lands, shall forever be inseparably appurtenant thereto, together with the said shares of stock, and all rights and interests represented thereby or existing or accruing by reason thereof, unless such rights shall become forfeited under the provisions of these articles of incorporation, or of by-laws adopted in pursuance thereof, or by operation of law, or by the voluntary abandonment thereof by deed, grant or other instrument, or by non-user for the term prescribed by law; but no such abandonment shall be for the benefit of any person designated by such shareholder, directly or indirectly, or to his use, nor center any right whatsoever upon the holder of any grant, release waiver, or declaration of abandonment of any kind. Provided, however, that if for any reason it should at any time become impracticable to beneficially use water for the irrigation of the land to which the right to the use of the water is appurtenant, the said right may be severed from said land simultaneously

transferred and attached to other lands to which shares of stock in this association are or shall thereby be made appurtenant, if a request for leave to transfer, showing the necessity therefor, shall have first been allowed by a two-thirds vote of the board of directors at a regular meeting and approved by the secretary of the interior. All the provisions and agreements of this section shall be set forth in the said certificate or other evidence of the ownership of shares of stock in the association, together with any other provisions and agreements made necessary by these articles, and such certificate or other instrument shall be signed, executed and acknowledged by the president and secretary of the association, and by the person to whom it is issued, in the manner required by law for the execution and acknowledgment of deeds for the conveyance of real property, and the board of directors shall pass by-laws prescribing the form of such certificate or other instrument, not inconsistent with these articles.

Sec. 10. Every transfer of the title to any lands to which the said rights and shares are appurtenant, whether by grant or by operation of law, (except where the land may be subject by grant, or involuntarily under any law, to an easement, the exercise of which does not interfere with the cultivation of the soil by the servient owner), shall operate, whether it be so expressed therein or not, as a transfer to the grantee or successor in title, of all rights to the use of water for the irrigation of said land, also all rights arising from, or incident to, the ownership of such shares, as well as the shares themselves; and upon presentation to this association of the proof of any such transfer of land, the proper officer shall transfer such shares of stock upon its books to the successor in title to said lands.

Sec. 11. Any transfer or attempted transfer, of any of the shares of this association, made or suffered by the owner thereof, unless simultaneously a transfer of the land to which it is appurtenant is made or suffered to or in favor of the same party, shall be of no force or effect for any purpose and shall confer no rights of any kind whatsoever on the person or persons to whom such transfer may have been attempted to be made.

Sec. 12. No payments for the shares of capital stock of this association shall be required, except in the manner following:

The shareholder shall, as prescribed in section 3 of this article, make application to the proper representative of the United States for a water right, at the rate of one acre for each share. Upon proper proof to the association that such application has been accepted and that he has complied with all the requirements in relation thereto, such subscriber shall be deemed to have paid on his stock subscription the amount to or for the use of the United States for such right; and when all payments required for such right shall have been made, and when the proper evidence of the perfection of such water right has been issued, his stock shall be deemed and held to have been fully paid up.

Sec. 13. If it should be determined by the United States that the amount of water available from the entire irrigation system as owned or controlled by it and by the association shall be sufficient to properly irrigate one acre of land for each share of the capital stock, then no shares in excess thereof shall be issued, and the number of shares shall be so reduced by appropriate amendment of these articles as not to exceed the number of acres determined by the United States as irrigable, from the entire available supply of water:

Sec. 14. If, when such determination is made, the number of shares subscribed shall be in excess of the number of acres so determined, an allotment of shares shall be made to the subscribers equal to the number of acres irrigable, giving preference to the cultivated land. The surplus of shares so subscribed shall thereupon be cancelled and shall not be reissued until such time as the water supply is sufficient to properly irrigate said land.

By-laws shall be adopted to govern such allotment.

Sec. 15. If the number of acres of irrigable land or the costs of the works, or both, as determined by the United States, shall exceed the number of shares or the capital stock authorized herein, appropriate amendment of these articles as to the number of shares, the par value thereof, and the capital stock shall be made in compliance with the laws applicable thereto.

Sec. 16. Lands of stockholders not ready for cultivation because of timber growth, and unfit for cultivation because of such timber growth at the time notice of water for irrigation is given, or such lands afterwards acquired, may have shares of stock issued upon the same. And payment to the United States government shall commence only upon such lands as are prepared for cultivation, and each year additional land must be prepared, until the entire tract is under irrigation and cultivation.

Suitable by-laws as to what constitutes a timber growth and the number of acres to be prepared for cultivation yearly, shall be adopted by the association, subject to the approval of the secretary of the interior. And providing that the first payment upon such land shall be made within the ten year period from the time water is ready for delivery to said lands.

ARTICLE VI.

Section 1. Revenues necessary for the accomplishment of the purposes of this association shall be raised by an assessment thereof from time to time as required upon and against the shareholders.

Sec. 2. The shareholders shall have power to make and enforce necessary by-laws for the making, levying, collecting and enforcing of such assessments.

Sec. 3. Assessments for the cost of operation, maintenance and repair of the works owned, controlled or to be maintained by the association, shall be equally assessed against all the shareholders in proportion to the number of shares held by them respectively.

Sec. 4. Assessments for the construction, acquisition or control of any works, property or rights, by the association, or for renewing, replacing, or any way improving, adding to, enlarging or increasing any of its works, property or rights, or for the fulfillment of any obligation undertaken by it, or for the carrying out of any of its powers, may be equally assessed against all the shareholders in proportion to the number of shares held by them respectively.

Sec. 5. Assessments for expenditures for purposes that are of benefit to a part only of the shareholders may be specially assessed in proportion to such benefits against such shareholders, but no expenditure to be provided for, or covered by, such special assessments shall be made, or obligation to expend the same incurred, except upon the petition of the holders of two-thirds of the shares to be so specially benefitted.

Sec. 6. Assessments shall become, from time to time as they are made and levied, a lien on the land of the shareholders against which they are levied, and upon the shares of stock appurtenant to said lands, and all rights and interests represented by such shares; and until they are paid or otherwise discharged shall be and remain a lien thereon. The manner of fixing the lien and enforcing the same shall be prescribed by the by-laws.

Sec. 7. Except for operation, maintenance and repair, no work shall be undertaken, purchase made or indebtedness incurred or to be authorized during any year, whereof the cost shall exceed Fifty Thousand Dollars ($50,000.00) until it shall have first been ratified by at least two-thirds of the shares represented by the votes cast at an election to be called and held for that purpose. Special elections may be called and held for such purposes under such by-laws as the board of directors may prescribe, not inconsistent with these articles.

ARTICLE VII.

Section 1. The exercise of the corporate powers of this association and the management of its affairs shall be vested in five directors elected from different districts to serve one year. The board of directors shall annually elect a president and vice president, who must be one of their members, and also elect a secretary and treasurer.

Sec. 2. Each director shall at the time of his election be the owner of land situated within the irrigation district, to which shares of stock of this association are appurtenant, and shall also be a resident of the district.

Sec. 3. If a person elected as a director from his district at any time during his term of office, cease to have any of the qualifications prescribed, such office shall thereupon become vacant. In event of a vacancy in any of the said offices from any cause, or by reason of death or resignation, the vacancy shall be filled by the board of directors appointing a shareholder from that district, unless a petition within ten days signed by shareholders representing at least ten per cent of the shares within that district be presented to the board of directors, in which case a special election shall be held in the district in which the vacancy occurs to fill the unexpired term.

Sec. 4. The annual election of the directors after the first election on the first Monday in January in 1905, shall be held on the first Monday in December in each year in such manner as the by-laws may provide. The president and vice president shall be elected annually. The term of office shall in each case commence on the third Monday in January following their election.

Sec. 5. The names and residences of the president, vice president and other directors who are appointed for the first three months and until their successors are elected and qualified are as follows:

Burton S. Adams, president, Newlon; F. H. Lovering, vice president, Newlon; William B. Herbert, Ridgelawn; Charles R. Marshall, Newlon, Dawson county, Montana; W. M. Post, Dore, Allred county, North Dakota.

Sec. 6. The association shall have power to enact, adopt and provide for the enforcement of by-laws, not inconsistent with these articles, for the government of the members of the association, for the management of its business and the conduct of its affairs, and to repeal, modify and amend the same from time to time. But the association shall not have the power to adopt or to enforce any by-law that will in any wise conflict with any federal statute or the rules and regulations established thereunder for the administration of water from any reservoir, or other works acquired, constructed or controlled by the United States, and which may be used for supplying water to the lands of the shareholders of this association.

Sec. 7. Regular and special meetings of the board of directors shall be called and held in such manner and at such times and places as may be prescribed by the by-laws.

Sec. 8. The board of directors shall have the power in the name of the corporation to prosecute, defend and compromise all law suits; to make all contracts, in the name of the association, necessary and proper for the conduct of the affairs and the carrying on of the business of the association, subject to all limitations and regulations prescribed by these articles or the by-laws.

Sec. 9. The board shall have the power to estimate, make and levy all assessments against the shareholders of this association, to the extent and the manner authorized by these articles and the by-laws.

Sec. 10. The board shall have the power to make, publish and enforce rules and regulations concerning the distribution, use and application of the water under its control, subject at all times to, not inconsistent with, these articles, or with the by-laws or with the federal

statutes applicable thereto, and the rules and regulations established thereunder.

Sec. 11. The board shall keep, or cause to be kept, a record of its transactions, which shall at all times remain in the office of the association, and shall, during office hours, be open to the inspection of the shareholders, or their properly authorized agents.

Sec. 12. The board shall hear and determine complaints of shareholders of non-service, or of improper service or distribution of water, or of improper performance of duty by any employee of the association relative to the distribution of water.

Sec. 13. No by-laws shall be passed or enforced which shall interfere with or affect any present vested right of any member of this association to the use of water for irrigation.

Sec. 14. All by-laws shall be of general application so far as general laws can be made to apply.

Sec. 15. The members of the board of directors shall receive such compensation as may be prescribed by the by-laws.

ARTICLE VIII.

Section 1. At all elections the electors shall possess the following qualifications:

(a) Shall be at the time of the election the owner of at least one share or fraction of a share of capital stock of this association, and shall have been the owner thereof, as shown by the books of the association, for at least 20 days before such election.

(b) Shall be of the age of 21 years or more and of sound mind.

(c) The stock of minors and persons of unsound mind shall be represented by their natural or legal guardian, and of deceased persons by the executor or administrator of the estate.

Sec. 2. At all elections each shareholder shall be entitled to one vote for each share of stock owned by him, not, however, to exceed in the aggregate one hundred and sixty votes.

Sec. 3. The votes shall be by written or printed ballot, be voted only by the electors at the polls in person.

Sec. 4. The board of directors may make reasonable by-laws for the registration of voters and the method of holding elections.

Sec. 5. At all elections the person receiving the highest number of votes for any office shall be deemed elected to such office.

ARTICLE IX.

Section 1. The president, vice president, treasurer and secretary shall perform such duties as are prescribed by these articles, and the by-laws, wherein such by-laws shall not be inconsistent with law or with these articles, and shall receive such compensation as may be fixed by the by-laws, which compensation shall neither be increased nor diminished during their respective terms of office.

Sec. 2. In case of the absence, illness or inability of the president to act from any cause, or in case of a vacancy in that office, the vice president shall act in the place of the president.

Sec. 3. The president shall be the chief executice officer of the association, and shall have general supervision over all other officers of the association in the performance of their duties as such, and of the conduct of the business and affairs of the association. He shall preside at all meetings of the board of directors and shall perform such other duties as may be devolved upon him by the by-laws.

Sec. 4. All certificates or other evidence of the ownership of shares of stock in the association issued by the association shall be signed by the president and secretary of the association and shall have the seal of the association affixed.

Sec. 5. All contracts and instruments in writing executed for, or in behalf of the association, shall be executed in the name of the association by the president and secretary and shall have the seal of the association affixed.

Sec. 6. The treasurer shall receive and be the custodian of all moneys and other funds of the association. No money shall be paid out by the treasurer unless upon warrants drawn on him by the president and secretary, except as provided in article 11, section 8. No warrants shall be drawn on the treasurer by the president and secretary except upon the order of the board of directors, recorded in the minutes of the board and in a warrant record to be kept by the secretary.

Sec. 7. The treasurer shall keep a full, complete and accurate account of all moneys of the association received and disbursed by him, in books belonging to the association, and shall present a report and account thereof at every regular meeting of the board, and shall, at the expiration of each quarter, prepare and publish, in such a manner as the by-laws may prescribe, a quarterly statement to shareholders showing all such receipts and disbursements during the last preceding quarter; and the treasurer shall perform such other duties as may be devolved upon him by the by-laws.

Sec. 8. The secretary shall act as the clerk of the board of directors and keep a record of all their proceedings. He shall immediately upon their adoption record in a book of by-laws to be kept by him in his office, all by-laws adopted, and shall keep such book open to the inspection of any member of the association, or his properly authorized agent, at all times during business hours.

And the secretary shall perform such other duties as may be devolved upon him by the by-laws.

Sec. 9. The treasurer and secretary shall give such bonds as may be prescribed by the by-laws. Provided, that neither the president, vice president or any member of the board of directors or the secretary shall be accepted as a surety on the bond of the treasurer.

ARTICLE X.

Section 1. The board of directors may create such other offices as may be necessary for the carrying on of the business and affairs of this association and prescribe the manner of appointment, powers, duties, terms of office, eligibility and compensation thereof by by-laws not inconsistent with these articles.

Sec. 2. Upon proper complaint, the board of directors may remove from office the treasurer, secretary or the incumbent of any office created by the board, for incompetence, neglect of duty, misappropriation of funds of the association, or for violation of any of the provisions of these articles, or of any by-law. The association shall adopt by-laws to govern the procedure for such removal.

ARTICLE XI.

Section 1. The lands under each separate distributing canal system within the territory described in Article 4 of these articles, shall on the petition of the owners of two-thirds of the shares of the capital stock of this association appurtenant to the lands in such proposed canal division, be formed into a canal division, and the boundaries of such division be fixed by the board of directors. On the petition of the holders of the majority of the shares in this association, owning the lands affected thereby, or without such petition, whenever in the judgment of the board it will be beneficial, the board may change or modify the boundaries of any canal division.

Sec. 2. A board of water commissioners to consist of three members shall be appointed annually for each canal division by the

board of directors. Such appointment shall be made in the month of February in each year and no one shall be eligible to such office unless he be a resident within the canal division for which he may be appointed, and a qualified elector as provided in these articles. The term of office of the members of the board of water commissioners shall be from the time of their appointment until the first of March in the following year, and until their successors have been appointed and have qualified, and they may be removed for cause by the board of directors, who may fill any vacancy in any board of water commissioners.

Sec. 3. If a petition signed by shareholders in this association, constituting a majority of the qualified electors, residing in any canal division, shall be presented to the board of directors at their first regular meeting after March 1st, naming not more than three persons eligible for appointment as water commissioners, in said canal division, and asking for their appointment to such office, the person or persons so named shall be appointed as such water commissioners.

Sec. 4. In each canal division the board of water commissioners thereof shall have the control and management of the local affairs of the canal system therein, and of the distribution of the water therefrom, subject to the provisions of these articles, and to the by-laws and to the rules and regulations established by the board of directors, or by the proper representative of the United States.

Sec. 5. The board of water commissioners in each canal division may appoint a secretary of the board of water commissioners and employ a division superintendent removable at their pleasure.

Sec. 6. The board of water commissioners may call a meeting at any time of all the land owners in their canal division who are shareholders in this association, to consider and determine whether an assessment or assessments for their special benefit should be levied on the shareholders in said division. At least ten days' notice of such meeting shall be given by the secretary of said board, by posting a notice thereof in three public places in said canal division, and mailing a copy of each notice, postage prepaid, to each shareholder residing in said canal division.

Sec. 7. If a majority of such shareholders who are the holders of a majority of the shares of this association appurtenant to lands in said canal division shall at said meeting approve the levy of such special asessment or assessments and sign a petition to the board of directors that the same be levied on the shareholders in this association owning lands in said canal division, and specifying the amount of said proposed assessment and the purpose for which it shall be levied, and said board of water commissioners shall recommend it in writing, endorsed on said petition, it shall be the duty of the board of directors to levy said special assessment on all the shareholders in this association owning lands in said canal division.

Sec. 8. When so levied the said assessment may, when collected, be disbursed by the board of water commissioners: Provided, however, that nothing in this article shall limit or abridge the right of the association to make, levy and collect assessments, as elsewhere in these articles provided.

ARTICLE XII.

Nothing in these articles of incorporation, or in the fact of becoming a member of this association, shall be construed as affecting, or intending to affect, or in any way interfere with the vested rights of any person to the prior use or delivery of any water.

ARTICLE XIII.

The individual property of the shareholders shall be exempt from liability for the corporate indebtedness of this association, except as herein provided.

ARTICLE XIV.

The corporate indebtedness shall not exceed two-thirds of the amount of the capital stock.

ARTICLE XV.

Section 1. These articles of incorporation can only be amended by the shareholders, at a regular annual election or at a special election called for that purpose, by a majority of the number of the votes cast. No proposed amendment shall be submitted to the shareholders until it shall have first received the approval of two-thirds of the board of directors at a regular or duly called session thereof, nor any such proposed amendment be so submitted until it shall have been published in full at least once in each week for four consecutive weeks in a newspaper of general circulation within the territory described in Article 4, and published within Dawson county, Montana, the last publication shall not be more than seven days before any such election.

Sec. 2. These articles shall not be so amended as to in any wise conflict with any federal statutes, or the rules and regulations established thereunder, for the administration of water from any reservoir or other works acquired, constructed or controlled by the United States, and which may be used for supplying water to the lands of the shareholders of this association.

ARTICLE XVI.

This association may accept and avail itself of, or subject itself to, the provisions of any law or laws enacted, or that may be enacted by congress or the legislative body of the state, which may be applicable to corporations organized for like purposes as this association. Such acceptance or subjection shall be valid when ratified by at least two-thirds of the shares represented by the votes cast at any annual election, or at any special election called for the ratification thereof.

Notice of such election shall be given as prescribed in Article 15, stating the purpose thereof.

ARTICLE XVII.

The seal of this association shall be a figure of two concentric circles, the outer being two inches and the inner one and one-half inches in diameter. In the space below the two shall be the words, "Lower Yellowstone Water Users' Association," and bearing within the center space an enrolled scroll with the words and figures thereon, "Incorporated," .....1904.