Third Conference of Irrigation and Drainage Engineers' Experiment Stations of the West Logan, Utah

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF PUBLIC instruction

OFFICIAL BUSINESS
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BERKELEY, CALIF.

June 1924

Mr. R. L. Parshall,
Colorado Agricultural Experiment Station,
FORT COLLINS, COLORADO.
The article discusses the importance of irrigation water resources and the need for a comprehensive study of Colorado's water resources. The state engineer, Fred A. Warren, mentions the need for a strategic plan to address the water needs of the state, which is currently experiencing a severe drought. The article highlights the importance of water conservation and the need for a coordinated effort among all stakeholders to ensure the sustainability of water resources.

The text also mentions the potential for federal assistance in the form of grants and loans, as well as the federal government's responsibility to ensure the conservation of water resources. The article emphasizes the need for ongoing research and development to improve water management practices and technologies.

The article concludes by urging the state's leaders to take immediate action to address the water crisis and to invest in the necessary infrastructure to meet the state's long-term water needs. The article also highlights the importance of public education and awareness campaigns to promote water conservation and responsible use of water resources.
Professor R. L. Parshall  
Irrigation Department  
Colorado Agricultural College  
Fort Collins, Colorado

Dear Sir:

In pursuance of the work of the committee on irrigation of the American Society of Civil Engineers, I am requested by the chairman of the committee, Professor M. R. Lewis, to obtain certain information concerning the states of Arizona, Colorado, New Mexico, and Texas. I enclose herewith a copy of the outline of objectives and program for the present Society year.

You will see that the data called for is "The possibilities of supplemental irrigation and supplemental water supply" and I would like to have a statement from you as to the possibilities in your State.

I did not feel entirely clear as to what Professor Lewis was aiming at and I wrote him asking for more detailed information. In his reply he states as follows:

"I realize that it is impossible to draw any sharp line between an irrigation project which is designed primarily to supply supplementary water to land already irrigated, and one which is designed for the irrigation of new land, since most of the newer projects have some of both features. However, it does seem to me that it should be improved in these two ways.

"When I prepared the program for the committee I had in mind including under supplementary water supplies for irrigated lands such projects as the Federal project in the Salt Lake Basin, and a little project I have been working on in Baker County, Oregon, where we propose to put in wells for the dual purpose of drainage and supplementary water supply.

"Are there not areas in Colorado and Texas, if not in New Mexico and Arizona where irrigation might profitably be applied to lands which are normally farmed without irrigation. In the Willamette Valley in Oregon the normal type of farming is non-irrigated. However, in spite of the fact that the annual rainfall is from 30 to 50 inches the summers are dry enough so that irrigation is highly beneficial on certain lands and certain crops. As you know, the same thing is true in large portions of the Middle West and to some extent on the East coast."
I do not know whether that is true of any of the states mentioned or not, but think it very probable."

I understand, therefore, that under the head of supplemental irrigation we should include areas which can be operated in a more or less unsatisfactory manner by dry-farming but which would be made very profitable if there were available some water for irrigation each season, and further, that the term "supplemental water supply" is applicable to propositions like that in the Salt Lake Basin where the Echo Lake Dam is being built to serve quite a number of large projects which have been under irrigation for a long time, but which have had bad periods due to lack of adequate water supply.

Assuring you that I shall appreciate an early reply,

I am

Very cordially yours

[Signature]

G. E. P. Smith
Irrigation Engineer.
OUTLINE OF OBJECTIVES AND PROGRAM OF WORK

of

COMMITTEE ON IRRIGATION

(For the Society year 1929-30)

OBJECTIVE

At the present time there is a rather widespread feeling that large scale reclamation, by irrigation, drainage and land clearing, of new lands should not be undertaken. This feeling is reflected in the Platform and Program of the Society as proposed for the June meeting.

The Society is more particularly interested in these problems in irrigation which are more closely associated with the soil and the individual farm.

Without admitting that the feeling noted above is justified, but in view of that feeling and the more particular interest in the Society, it is suggested that the objective of the irrigation committee be to further the use of supplementary irrigation in those areas where irrigation is not generally practiced and of supplementary water supplies where the usual supply of irrigation water is deficient in so far as such supplementary use is economically justified.

PROGRAM

A first step toward this objective is to estimate the benefits which could be realized by its successful consummation.

A report showing the estimated area of land in the various states or climatic regions which might profitably be supplied with supplementary water will be prepared. This will include both normally irrigated and non-irrigated areas.

This report will point out the reasons for believing that the areas included would profit by more water. The more common reasons are type of soil, length of drought period and kind of farming. Supporting data where available will be included.

Each member of the committee will be asked to prepare a report for a certain section of the country and the chairman will summarize the individual reports.
Professor G. E. P. Smith
Department of Irrigation Engineering
University of Arizona
Tucson, Arizona

Dear Professor Smith:

By this time you will have received notification from Mr. Olney of your appointment on the Irrigation Committee of the American Society of Agricultural Engineers. As you will note in the proposed objective and program, I am attempting to get together a report on the use of supplemental irrigation and supplemental water supply.

On the assumption that two more members will be appointed on the committee representing eastern and southeastern states, I have divided the area of the United States into sections and am requesting each member on the committee to prepare a brief report on the section assigned to him. In your case that section covers the states of Arizona, Colorado, New Mexico and Texas. I realize that this is a very large area, but since the committee is already rather large, there seems to be no help for that. I also realize that it will be impossible to prepare a detailed report covering so large an area. However, I do feel that a somewhat general report can be prepared which will give a fairly good picture of the situation over the country as a whole. I shall, therefore, appreciate it very much if you can prepare a brief report on the possibilities of supplemental irrigation and supplemental water supply in the area mentioned.

Trusting that I may meet you at the mid-year meeting of the land reclamation division at Kansas City, I am

(signed) M. R. Lewis
Irrigation and Drainage Specialist.
Dear Professor Lewis:

In further answer to your question relative to the possibilities of supplemental irrigation and supplemental water supply, I state that some attention is being given to this subject in Colorado.

Years of deficient water supply always creates discussion of means and methods of increasing the water supply for irrigation. About two years ago a comprehensive study was made by the Bureau of Reclamation looking into the possibilities of the Poudre Valley. It was determined that some water, still available (flood flow) which could be stored in reservoirs to be built in the channel of the main stream. These proposed reservoirs to have a capacity of something less than 50,000 acre-feet and where the cost of storage to be more than $50 per acre-foot. At the present time no activity in this
direction. In my opinion the cost of storage as outlined in the final report is not warranted. Following the Poudre Valley study there is now being investigated, by our State engineer, the whole of the South Platte drainage basin which constitutes six main tributaries to the river together with several small streams. This study has been under way for a couple of years and because of the completeness of detail will result in substantial and basic data sufficient to base sound conclusions. It is expected that the final outcome will show where waters are available, their extent, and propose means of storage.

Attention is being given to the subject of transcontinental diversions from the Pacific watershed. This development will require tunnels from 10 to 20 miles in length through the mountains and fire again the cost will be considerably greater than present condition (economic) will stand.
Such western slope diversions are being considered both for the South Platte and Arkansas valleys.

In the Arkansas Valley work has been done in the investigation of the possibilities of building a channel reservoir at Caddo, about 15 miles east of Las Animas. Such a reservoir to store flood flows entering the river from the Purgatoire River. This side stream has a large drainage area and is capable of supplying a large amount of flood water. This enterprise will be rather expensive and likely to be rather short lived because of the vast quantities of deposit carried into the basin. Because of its being located well down the Valley renders it less effective from the standpoint of real service to the whole irrigated area of this valley.

In a smaller way supplemental water for irrigation is being provided by means of pumping from underground
serves. We have made observation on a well which is serving a dual purpose, first furnishing an irrigation supply and second reclaiming about 15 acres of seeped land. The discharge from the well being about 1000 to 1100 g.p.m.

Direct attention is being given to the matter of better administration of the present available water supply in the better and more dependable measurement of supplies.

The main thought at present back of proposed development of supplemental supplies is not with the idea of expanding the irrigated area, but merely the rounding out and strengthening of minor appropriations.

Sincerely yours,

R. H. Pearson
Fort Collins, Colorado  
March 22, 1951

Prof. H. E. Murdock  
Agricultural Eng. Dept.,  
Bozeman, Montana.

Dear Professor Murdock:

I have just received your letter and also  
copy of one from Dr. Smith concerning the coming meeting  
of the Western Irrigation and Drainage Research Association.  
As far as I personally am concerned, I would have  
no choice in the proposed dates of this meeting. It will  
only be necessary for me to arrange my schedule accord-  
ingly.

Very truly yours,

Senior Irrig. Engineer

RIP/b

c. c. to Dr. Smith
March 14, 1931

Professor H. E. Murdock
University of Montana
Bozeman, Montana

Dear Professor Murdock:

Your letter of February 19 concerning date of summer meeting came to hand and I immediately wrote to Frank Adams and asked him to write me and to speak for and in behalf of his whole staff and of Mr. McLaughlin and his staff. Yesterday I received the reply from Professor Adams and I am writing you forthwith. I explained to Professor Adams your position as stated in your letter of February 19. He states that his representatives will be Beckett, Huverty and that Huverty will probably spend the month of May on a vacation trip down through Mexico. It is probable that those two men could come at any date in June or July if they have some advance information. (Personally I shall be disappointed if Dr. Veihmeyer does not come and I think we shall have to make special efforts to get him.)

In summing things up and after looking up the dates of commencement of the various colleges I find that June 4, 5 and 6 would not be such a bad date for me and that would give you the two weeks which you desire, to get from here to Ames, Iowa. The first half of June we usually have fair weather, from June 20 to July 10 we have the most disagreeable weather. After that the summer rain helps out a good deal. We can find cool weather for our meetings.

The week of June 16 to 20 is preempted by the American Association for the Advancement of Science, and the following week is the week of the Ames meeting. I would not like to have the group here on the week beginning June 28 or on the week beginning July 5. I therefore, propose as the best arrangement, July 14, 15 and 16. This will give you the two weeks which you desire and you can proceed leisurely. Also, Parshall, Lewis, Powers, Winsor and others may desire to attend the Tacoma meeting of the American Society of Civil Engineers on July 8, 9 and 10, and it would give time then to get from Tacoma to Tucson. Possibly it would suit them a little better if the dates were made July 16, 17 and 18. I would suggest therefore that you send out a letter setting the date of the meeting for that week and asking each in his reply to express a preference for the first three days or the last three days of the week. You need not send letters to Professor Parshall or to Professor Lewis, as I am writing them today and I will enclose carbon copies of this letter. I will ask them to write to you.

Very sincerely yours,

G. E. P. Smith,
Irrigation Engineer.

I am sending this to you to save time.
March 18, 1931

To: Heads of Departments, Western Irrigation and Drainage Research Association
Re: Biennial convention

You will recall that last fall it was decided, through your ballots, to hold the next conference in Arizona this coming summer. It was desired to make the time fit into conventions of other societies if possible so that delegates could take in more than one meeting on the trip.

The conventions of other societies that our members may be interested in are: Southwest Section of the American Association for the Advancement of Science at Pasadena, June 16-20; American Society of Agricultural Engineers, Ames, June 22-25; American Society of Civil Engineers, Tacoma, July 8-10.

After getting all facts possible at this time, Dr. Smith suggests that the week of July 13-18 would probably fit into the plans of the delegates better than another date. Is this time for the conference satisfactory with you and would prefer the meeting the first or last of the week?

Please let me hear from you as soon as possible so that the date may be decided upon in a short time.

H. E. Murdock, Secretary
Western Irrigation and Drainage Research Association
Notes Logan
Meeting 6-18-29
June 1929
Director Peterson

Snow erodes 5%

Rain 75

Erosion

Sedimentation

Ground water movement

Research in movement rate

Action of removing water underground

Springs

Meteorology - sedimentation

Humidity
Novo to express appreciation

Mrs. Wiesen & Isredlsen

Work out projects

New Catchy Problems
Discussion on laws and regulations - underground permits

Has the Stations been active in financial problems

Fears of irrigation district
Ariz. - Schwallen
Calif. - Beckett
Colo. - Purshall
Idaho - Bennford - Neal - Mag.
Mont. - Murdock
Nevada - Hardman
New Mex.
Oregon - Lewis
Utah
USDA
Wash.
Wyo.
Pumping and use of concrete pipe on the farm

Use curve

Thin
Evapotranspiration: Free water; soil moisture

Measurements: Water, adjustable setup

Sampling:

Water balance survey and irrigation plan

Agronomy Dept: Irrigation period of wheat

Conditions governing procedure of project
Run off data should consider evapo and temperature
Snow in inter-caps and no run-off:

Characteristics of water shed may be explained by this factor:

Monteuse snow tube

Lag in run-off: temperature

Contribution from each stream made possible by series of obs.

Washed characteristics of run-off dependent upon geological formations.
Prepare brief statement of projects for Secy-

Engineer State org. possible combine meeting with us

Permit to direct underground water
Dr. G. E. P. Smith  
Univ. of Arizona  
Tucson, Arizona.

Dear Dr. Smith:

Your letter to the Coordinators, W. I. & D. R. A., has been received, and since Mr. McLaughlin, who is now in Washington, is expecting to visit us soon, I prefer to write you in detail as to the paper which I might prepare after having had an opportunity to discuss this meeting with him.

I have every reason to believe that I shall be able to present a paper for consideration and hope that I may be present on this occasion.

Yours very truly

Senior Irrig. Engineer

Fort Collins, Colorado  
May 5, 1931
To the Coordinators, W.I. & D.R.A.,

O. W. Israelsen
E. H. Beckett
R. L. Parshall
M. R. Lewis
Wells A. Hutchins

The plan of program as adopted by common agreement at informal conferences during the past year is for each coordinator to arrange for a paper, either a "report" or a summary on his field of work or a paper on a narrower subject within his field, to be prepared by himself or some one designated by himself, but at any rate the coordinator to be responsible for it. Our program next July will then have five "points of departure". Each paper will provide the "motif" of an animated discussion until we feel the need of "cuts" or a plunge in the swimming pool.

If each of you will give me your subject right away, and a suggestion as to the duration of time desirable for discussion thereon, I shall be glad to arrange the program and mail copies to all of our membership, so that some thought on these matters, can be given by the members prior to the meeting. It might lead some one to bring along graphs on other data.

I have taken the liberty to invite attendance at our meetings of the Experiment Station Staff, the men at the (Carnegie) Desert Botanical Laboratory and the men of the Forest Service Research Station, which was moved from Flagstaff to Tucson last fall.

As soon as I get a good estimate of the number of those who are coming, I will take up with a local hotel the matter of rates and will arrange for space on the coolest and most comfortable floor.

Our present plan is to drive, either Friday or Saturday morning, thru the project of the Pima Farms Company, the Casa Grande (Coolidge) project and the Salt River Valley, to Phoenix.

Awaiting your several replies, I am

Cordially yours,

G. E. F. Smith
Irrigation Engineer

GEFS-v

cc. to: Prof. Murdock, Bozeman, Montana, Sec'y, W.I. & D.R.A.

P.S. I can arrange program for first day to better advantage if I can know what trains you are coming on. Trains from East arrive 3:25 a.m., 5 p.m., 6:40 p.m., 6:50 p.m., - Trains from West arrive at 1:35 a.m., 3:40 a.m., 10:10 10:35 a.m., 11:10 a.m. Hope we can begin at 9 a.m. with all present.
Fort Collins, Colorado

November 8, 1930

Director C. P. Gillette
U. S. Army

Dear Director Gillette:

In comment on the circular letter to you from Prof. H. E. Murdock, Secretary of the Western Irrigation and Drainage Research Association, may I say that this association is the result of a meeting called in September, 1925, at Berkeley, thru a call issued by you at that time for the purpose of securing direct information as to conditions then existing in the western irrigated states.

Three meetings have been held, two at Berkeley and one at Logan. These meetings have been the means of stimulating research work in drainage and irrigation, and have made it possible for the engineers of these western states to get together and confer upon the problems under study. It has been my privilege to attend all these meetings, and personally I must say that in my opinion they are very much worth while, and I believe that the work reported upon by Colorado has been of much importance to those in attendance, especially our work on hydraulics and also the evaporation studies.

Since the time and place for the 1931 meeting (which is to be held next summer) have not been decided on, it might be well to suggest to Secretary Murdock that possibly Colorado would be a desirable place. I believe that one of the important points in deciding the place of meeting is that those in attendance might find it opportune to meet with other societies at that time. If that be the case, it is not likely that a meeting in Colorado could be coordinated with either the American Assn. of Agr. Engineers or the American Assn. for the Advancement of Science.

If there are any questions or detail information you would like to have regarding this association and its purpose, I would be only too glad to confer with you personally in the matter.

Yours very truly

[Signature]

Senior Irrig. Engineer
Fort Collins, Colorado

October 20, 1930

Prof. H. E. Murdock
Agr. Engineering Dept.
Bozeman, Montana.

Dear Professor Murdock:

I have received your letters relative to the meeting of the next convention of the Western Irrigation and Drainage Research Association.

I was rather hopeful that arrangements could be made to have such a meeting in Tucson sometime this winter; however, next summer no doubt will be quite as satisfactory.

Very truly yours,

Senior Irrig. Engineer

RLP/b
Professor R. L. Parshall
Irrigation Engineer
Agricultural Experiment Station
Fort Collins, Colo.

Dear Professor Parshall:

Under separate cover I am sending to Director Gillette a copy of the summaries of the investigations carried on in irrigation and drainage research in the far western states.

I presume that Director Gillette will turn this material over to you in the near future. I feel that this will be a preliminary step for the next convention of the Western Irrigation and Drainage Research Association.

Sincerely yours,

[Signature]

H. E. Murdock
Secretary W. I. & D. R. Assoc.
Montana Experiment Station
Agricultural Engineering Department
October 15, 1930

To: W. W. McLaughlin, Federal Bldg., Berkeley, Calif.
    Frank Adams, Hilgard Hall, Berkeley, Calif.
    Prof. R. L. Parshall, Fort Collins, Colo.
    Prof. H. Beresford, Moscow, Idaho
    George Hardman, Las Vegas, Nev.
    Prof. W. L. Powers, Corvallis, Oregon
    Prof. O. W. Israelson, Logan, Utah
    G. C. Wright, Prosser, Wash.
    W. K. Lewis, Corvallis, Oregon

Re: Date for biennial convention of the Western Irrigation
    and Drainage Research Association

The following is a summary of the replies to letters sent out to
get a vote on time and place of the next convention of the Western Irrigation
and Drainage Research Association.

Professor Lewis indicated a preference for January 1, 2, and 3,
but it does not make very much difference to him. Professors Clyde and
Winsor prefer one or the other of the winter dates. Montana, Israelson of
Utah, Veihmeyer of California, and McLaughlin all vote in favor of the
summer of 1931. Either date will be satisfactory for Colorado and Nevada.
Veihmeyer cannot come in the winter period and McLaughlin cannot come on
January 1st to 3rd. No one has stated that they cannot attend in the sum-
mer of 1931.

Chairman Smith has therefore called the meeting for the summer
of 1931, and trusts that this will be agreeable to the entire Association.
The exact dates for the meeting will have to be determined later so as to
fit them in with dates of conventions of other societies. For instance,
I should like for it to follow the 25th annual convention of the American
Society of Agricultural Engineers to be held in Ames, Iowa, and to pre-
cede the annual convention of the American Association for the Advance-
ment of Science, if possible, so that those of us who have so far to go
can take in all of the conventions in which we are interested.

I have notified the directors of the experiment stations that
the date has been set and, as stated recently, have just sent them the
summary of the investigational projects carried on by the western states
in irrigation and drainage. We are asking them for constructive criti-
cisms and comments on the investigational work and to have them ready for
the next convention.

H. E. Murdock, Secretary
Western Irrigation and Drainage Research Assoc.
September 15, 1930

Professor R. L. Parshall
Irrigation Engineer
Fort Collins, Colorado

Dear Professor Parshall:

At the last meeting of the Western Irrigation and Drainage Research Association held at Logan, Utah, those in attendance discussed the time and place to hold the next convention. As you may recall, the sentiment seemed to be in favor of the Southwest (Arizona) for the place and this winter for the time. It was also decided that the officers try to arrange the meeting this winter at such a time that another convention might be taken in on the same trip by the delegates, and that a ballot be taken on the time and place by the states after such information was obtained.

Your chairman, Dr. G. E. P. Smith, with others interested, has canvassed the situation. For those of us who will have a long way to go it will be necessary to determine upon the time and place definitely very soon so our plans may be made. The tentative plan is to hold a three-day meeting at Tucson and Phoenix, Arizona, with a trip through the Casa Grande Valley enroute, and possibly a side trip to the four big dams on Salt River. At Tucson all the University representatives interested in irrigation matters can be at the meetings, and at Phoenix, engineers and others connected with the Salt River Valley project will be interested and may attend. Will you kindly let us have your approval of this plan or your alternate suggestion at once?

The next point to be decided upon is the time. Members in Arizona and California had suggested December 29, 30, and 31, 1930. When they learned that the Reclamation Division of the American Society of Agricultural Engineers is to meet in Berkeley January 6 and 7, it was proposed to hold our meeting January 1, 2 and 3, 1931, so that men from the north and northwest could make the round trip without loss of time.

Professor Smith now states that he has a letter from Dr. Veihmeyer stating that he will be at the Cleveland meeting of the A. A. A. S. which continues the whole week of December 29 to January 3 and that he would like very much to have Veihmeyer there. And this brings up the question again of the best date to select. Another suggestion is this: The general meeting of the A. A. A. S. is to be held at Los Angeles in the summer of 1931. Should our
meeting be delayed until that time and be held just before or just after that meeting? These are the suggestions coming from the southwest where it was fairly well agreed that the next convention should be held. If you have others, let us have them along with your recommendations.

We should also like to have you vote on the three dates: (1) December 29 to 31, 1390; (2) January 1 to 3, 1931; and (3) just before or just after the general meeting of the A. A. A. S. (date not yet fixed).

Please let me have your suggestions and votes as soon as possible.

Sincerely yours,

H. E. Murdock
Secretary W. I. & D. R. A.
September 15, 1930

Professor R. L. Farwell
Irrigation Engineer
Fort Collins, Colorado

Dear Professor Farwell:

At the last meeting of the Western Irrigation and Drainage Research Association held at Logan, Utah, those in attendance discussed the time and place to hold the next convention. As you may recall, the sentiment seemed to be in favor of the Southwest (Arizona) for the place and this winter for the time. It was also decided that the officers try to arrange the meeting this winter at such a time that another convention might be taken in on the same trip by the delegates, and that a ballot be taken on the time and place by the states after such information was obtained.

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Please let me have your suggestions and votes as soon as possible.

Sincerely yours,

H. E. Murdock
Secretary W. I. A. D. R. A.
Bozeman, Montana. August 27, 1930.

Mr. R. L. Parshall,

Ft. Collins, Colorado.

Dear Mr. Parshall:

I am writing for the Civil Service Commission examination for some grade of civil engineer for service on the Boulder Dam and am taking the liberty of giving your name as reference as there is not time to get your permission first. The announcements show that there will be opportunity for me to use my mathematics, mechanics, strength of materials, and physics if appointment is received. I have been able to use them quite a bit here but I will have greater opportunity in the Dam work.

The work I did with you at Ft. Collins and other similar work I have been doing here, strengthened by the Illinois experience in mechanics, hydraulics and laboratory work have furnished a good foundation for the mathematical and testing work as announced in the examination.

To refresh your memory I give the following brief review of my work: 1906 to 1912 teaching and experimental work at the University of Illinois. Hydraulics, mechanics, strength of materials, testing beams, testing steels, etc.

1913 and 1914 I was irrigation engineer in the U. S. D. A. 1914 to date I have been agricultural engineer in the Montana Experiment Station and Extension service, and Prof. of Agricultural Engineering in the College. I have tested pumps, wells, tractors, implements, etc. and have made surveys for irrigation and drainage works, deduced laws for silage pressure, tractor characteristics, measurement of hay, etc.

If you are called on by the Civil Service Commission and can give some qualifications that fit me for the position I shall greatly appreciate your courtesy.

Sincerely yours,

[Signature: H. E. Murdoch]

P.S. I still want to get further south.
Mr. R. L. Parshall  
Irrigation Engineer  
Fort Collins, Colorado  

Dear Mr. Parshall:  

I thank you very much for your letter of September 21 with the information on the development of supplemental irrigation and supplemental water supplies in Colorado.

There is a surprising amount of interest in supplemental irrigation in this part of Oregon and in the use of pumps for experimental supplies in Eastern Oregon and Southern Idaho.

Yours very truly,

M. R. Lewis  
Irrigation Engineer

MRL:AP
At the Colorado Experiment Station is maintained a battery of 18 buried metal tanks for the purpose of studying the evaporation loss from moist soil surfaces and a free water surface. All tanks are provided with an individual automatic water feed which keeps the water table at a definite fixed depth below the soil surface. Six of these tanks have the water table at one inch below the surface. Of this series, two are medium and coarse clean river sand, two are very fine river sand containing a fair proportion of silt, one of heavy black adobe soil having a large percentage of alkali, and the remaining one of fairly heavy clay loam soil. In another series of five tanks, the water table is held at six inches below the soil surface. These soils are of the same kind as found in the 1-inch series. In the third series the water table is at 12 inches below the surface, with similar soils. Two of the 18 tanks have a free water surface, in duplicate, under similar conditions.

The surface of all soils has been kept free from all plant growth and in an undisturbed condition. Movable covers are provided for the tanks to prevent moistening by rain. Soil and water temperatures are recorded, also wind in miles per hour.

Observations were formerly taken twice each day, morning and evening, in the attempt to show the relation between the day and night rates of evaporation loss. The results so far have not been consistent enough to establish this relation.

During the year 1927 the apparatus was improved and the time of observation changed to about midnight, for the reason of more uniform temperatures
affecting the Mariotte feed regulation.

The results of the past season show that for the water table at 1 inch the coarse and medium river sand lost about 10 percent more water by evaporation than from the free water surface. The fine river sand being about equal to the free water surface, while the heavy adobe soil was 15 percent less and the clay loam soil about 10 percent less. For the 6-inch depth to the water table, the fine and medium river sands, as well as the loam soil, all agreed closely with the loss from the free water surface. The heavy adobe and coarse river sand were approximately 30 percent less. With the water table at 12 inches, the fine river sand shows a loss equal to that from the free water, loam soil about 20 percent less, medium river sand 40 percent less, and the coarse sand and heavy adobe soil about 70 percent less.

During 1926, tanks 1, 2, 3 and 4 contained a fine river sand with an admixture of silt. These samples were very similar. The results are as shown where the loss from the free water surface is taken as 100 percent.

<table>
<thead>
<tr>
<th>Tanks</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss in pct.</td>
<td>102</td>
<td>96</td>
<td>100</td>
<td>100</td>
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</table>

For the purpose of studying the relation of the loss by evaporation from large and small water surfaces, such as tanks 3 feet square, buried flush with the ground surface, a standard U. S. Weather Bureau pan 4 feet in diameter and 10 inches deep, set above the ground surface and fully exposed, and a floating pan 2 feet square, there has been provided at the Colorado Expt. Station a copper lined basin 6 1/2 feet deep, 35 feet in diameter with side slopes 1 to 1. This basin or reservoir has the top edge flush with the ground surface. The floating pan is placed near the center of this basin, while the U. S. standard pan and small buried pan are located about 6 feet back from the rim of this circular reservoir. Air and water temperatures
are taken at the center, mid-radius and edge of circular reservoir. These temperatures are also observed in the floating and land pans. Vapor pressures are determined by an Assmann psychrometer. Wind velocities over the reservoir and near the land pans are observed by three standard Robinson anemometers. The drop in the water surfaces in all tanks is determined by hook gages reading to 0.001 of an inch. One gage is used for each of the smaller tanks. For the reservoir, four gages are mounted around the circumference of the basin at the NE, SE, SW and NW points. Special hook gage wells are provided for all gages.

It is found that the relation existing between the evaporation loss from the small pans and the reservoir is not constant but depends upon the advance and recession of the temperatures of the season. During the season 1926, where the loss from the large reservoir is taken as 100 percent, Mr. Rohwer has found that the floating pan lost 127 percent, the 3-foot square buried tank 116 percent, and the U. S. standard 131 percent as a mean of about 6 3/8 months, April to October.

From the standpoint of better use of water in irrigation practice, there has been perfected at the Colorado Experiment Station a measuring device known as the improved Venturi flume. Laboratory and field tests indicate that this flume is a practical device and is meeting conditions in the field where the ordinary weir or rating flume has been found to be unsuited. The improved Venturi flume has been calibrated for the smallest size, 6-inch throat, for discharges of 0.06 to 2.5 second-feet, and for the 10 and 12-foot size for discharges up to 200 second-feet. There has recently been completed in the Holbrook Canal, near Rocky Ford,
Colorado, a 20-foot flume which is designed to carry more than 1000 second-feet. At this time only two flow tests have been made on this structure, however, the indications are quite encouraging as to the utility of this large flume.

The Lake Canal, near Fort Collins, is completely equipped with the improved Venturi flume. There are in use two large flumes, one with a 12-foot crest and the other having an 8-foot crest. To distribute the water to the users along the canal, there are approximately 60 small reinforced concrete structures, of these more than 75 percent being of the 1-foot size, and the remainder 2-foot and 3-foot sizes. The experience with this installation of flumes, which replaced the rectangular weir, indicates a marked improvement in the distribution.

Success is being attained in the Arkansas Valley in Colorado, where the large sized flumes are used to measure the diversion by canals and ditches from the river. Because of the accumulations of sand and silt in the channel and the filling in over the floor of the rating flume, past experience shows this type of measuring device to be wholly inadequate and at times grossly in error. Tests on a 10-foot improved Venturi flume in the Las Animas Consolidated Ditch, near Las Animas, Colo., show the measured discharge by current meter gagings to agree remarkably well with that computed by the standard free-flow discharge formula. Tests in flows from 50 to 130 second-feet show a maximum deviation of about 2 percent. For a discharge of about 12 second-feet, with a head of approximately 0.5 foot the agreement was not so good. Three observations on these small discharges show a mean deviation of 5.4 percent. The current meter gagings were made within the converging section of the structure where the depth of water was about 6 inches. Best current meter results cannot be obtained for the shallower depths.
NOTES CONCERNING THE EXPERIMENTAL WORK IN COLORADO

By

R. L. Parshall
Senior Irrig. Engineer, Colo. Expt. Station, Fort Collins

As chairman of the committee concerning recommendations relative to Section III of the 1925 conference project outline, namely, Irrigation Water Supply and its Physical Control, I can report nothing of a constructive nature. In expressing my own opinion, I believe that project outlines of the various experiment stations dealing with the same general study or investigation can not be similar in all details. One of the fundamental considerations underlying the 1925 conference project outline was the quite general application of the scope of investigation as applicable to all the western irrigated states. However, it was recognized that not all our problems could be studied advantageously in all states, and, therefore, for some projects the work could be better accomplished in one state than in another because of the local conditions and limitations to the study.

The correlation of projects according to the outline set up at the Berkeley conference in 1925 has not been fully developed at the Colorado Station. Since the first conference only one major project has been initiated, namely, a study of Pumping for Irrigation and Drainage in Colorado. This study is rather broad in its scope and touches upon all the subheadings of the 1925 conference outline, Section III, Item 3, Pumping for Irrigation. In this investigation, attention is being given to: Equipment and power, pumping from surface sources, pumping from ground water, economic limits of pumping lift, and, further, a compara-
tive study of the costs of pumped and gravity-flow irrigation water.

At the present time there are three general projects actively pursued in Irrigation Investigations at the Colorado Experiment Station: Studies in Evaporation, Measurement of Water, and Pumping for Irrigation and Drainage. The studies in Evaporation Losses from Free Water Surfaces have been virtually completed and a report prepared by Mr. Carl Rohwer. During the past three years, studies have been conducted on Evaporation Losses from Moist Soils, where the water table has been carried at depths of 1, 6 and 12 inches. (See April Proceedings, Am. Soc. Civil Engineers.)

Beginning this season, this soil evaporation equipment has been revised, where all tanks were filled with the same soil. For the 6-inch water table, five tanks are included in this series. One is without plant growth, two with bluegrass sod, and two with a sod of a mixture of wire grass and a sedge grass of the genus Carex. For the 12-inch water table there is a similar plan, while for the 18-inch series six tanks are included of which two are without plant growth, two with bluegrass and two with wire grass and sedge. In the whole series, two tanks are maintained to determine the loss from a free water surface as a matter of making comparisons on the relative rates of evaporation and transpiration losses. The Mariotte tube regulation apparatus is being used to maintain a constant water level.

The studies in connection with the Water Measurement project are confined to the investigation of the law of flow through large sized improved Venturi flumes. At the present time there are under investi-
gation flumes having 10-, 12-, 20-, and 40-foot throats, this largest flume having a maximum capacity of 2,000 second-feet. The rate of discharge through these large structures is based upon the experimental data derived from the laboratory work on small sized structures, and also the development of the law of flow through successively increasing sizes. Last March a bulletin was issued on the Improved Venturi Flume. Reports seem to indicate that this type of measuring device is gaining favor in the irrigated West, as well as many foreign countries.

In order to perfect a measuring device which is accurate and dependable in meeting conditions where small loss of head is available for measurement, and, further, to successfully meet conditions of sand and silt deposit, a device has been developed known as the Adjustable Tube Meter. It consists, in its present design, of a converging and diverging section with an intermediate throat section having a level floor and vertical side walls. The top side of this throat is defined by a horizontal plate attached to the lower edge of a vertical gate. The size of opening of the throat is regulated by an ordinary screw lifting device. This meter is equipped with an indicating mechanism of such a type that by the simple multiplication of two indicated values the rate of discharge can be determined, these accessories eliminating the necessity of measuring depths, reference to tables, charts or curves, as is the usual practice for submerged orifices. It is expected that when this meter is fully developed, it will be able to meet conditions now beyond any of the practical devices in use where flat grades and silt deposits are contending factors.
The study on Pumping for Irrigation and Drainage consists of the study of typical pump set-ups throughout various irrigated areas in Colorado, with occasional tests for efficiencies and the cost of pumping. Particular attention is being given this season to ascertaining the relative costs of pumped water for irrigation as against ditch or gravity flow. A number of farms in Weld County are equipped with the improved Venturi flume as a means of measuring the water delivered, both from ditches and pumps, and daily records are being kept as to the use of this water on the farm.
Professor E. B. House,
Agricultural Experiment Station,
Ft. Collins, Colorado.

Dear Professor House:

"Every day in every way", throughout the fiscal year I receive and answer questionnaires until I wonder if there will ever be a diminution in the supply, but now I am about to join the guild of the guilty.

Some time ago President W. W. McLaughlin asked me to serve as Chairman of the committee on Soil and Irrigation Relationships, one of the five interim committees of the Association of Irrigation and Drainage Research Workers. These five committees are charged with the duty of co-ordinating research of irrigation workers along their various lines and it is desirable to survey the field now in preparation for the forthcoming meeting at Logan, Utah so that recommendations can be made at that meeting.

The outline for Committee No. I, as adopted by the Association, is as follows:

I. Soil and irrigation relationships
   1. Water holding capacity of soils as influenced by
      (a) Texture, structure, and other soil properties
      (b) Depth to ground water
   2. Analysis of forces affecting soil moisture movement
      (a) Driving forces
      (b) Resisting forces
   3. Conditions governing the application of irrigation water
      (a) Soil and water properties
      (b) Topography and preparation of land
      (c) Rate, duration, and frequency of water delivery
      (d) Crops grown
      (e) Depth to ground water
      (f) Storage of water in the soil
      (g) Cost of land, water, and labor

With a view to finding out what progress has been made and where we stand, I desire to ask that you furnish the following information:
1. A brief description of active projects of your Station which might be classed in the group.

2. Thus far, has an attempt been made to rewrite or adjust your projects to conform with the recommendations made in paragraph 3 of the report of the 1935 meeting, which is as follows:

"That we recommend to these experiment Stations that they rewrite their irrigation and drainage research projects in accordance with this regrouping"?

3. What subjects relating to soil and irrigation relationships are your group presenting at the forthcoming meeting at Logan, and please state whether by paper or orally, and by whom.

4. What subjects would you like to propose for open, round-table discussion?

Since the time is short I shall be very grateful for an early reply.

Very cordially yours,

[Signature]

C. E. P. Smith,
Irrigation Engineer.

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Parshall:

Please answer as much of this as you can.
To the Irrigation Research Workers:

It would seem desirable that the Irrigation and Drainage Research Workers agree upon a name suitable to the organization.

I am, therefore, inclosing several names which have been proposed, with the request that you check these carefully indicating your choice and that if none of these are satisfactory you indicate the name you would prefer.

Yours very truly,

[Signature]

Secretary.

Suggested names:

1. Western States Irrigation Research Workers.

2. Irrigation Workers of the Western Agricultural Experiment Stations.

3. Association of Western Irrigation Workers.

Your suggestions:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Professor R. L. Parshall,  
Colorado Agricultural College,  
Ft. Collins, Colo.

Dear Sir:

The annual meetings of the Irrigation and Drainage Workers have been definitely scheduled for from June 18 to 20, and will be held on the Utah State Agricultural College campus, at Logan, Ut.

The selection of the date was made after writing nearly all of the various workers representing the eleven western states, and the choice of the period from June 18 to 20 was almost unanimously expressed.

It is hoped that you will find it in your power to attend this meeting and to aid in furthering the work of the Irrigation and Drainage Workers.

Very truly yours,

[Signature]

Secretary
March 23, 1929.

W. W. McLaughlin,
Box 180,
Berkeley, Calif.

Dear Mr. McLaughlin:

With respect to the date of the proposed meetings of Irrigation Workers Mr. Parshall is anxious to know, as soon as possible the definite date in order that he may arrange an appointment for a meeting of the Irrigation Hydraulics Committee, of the American Society of Civil Engineers at San Francisco, now tentatively scheduled for May 31 to June 3 or from June 7 to 10.

I think there are other advantages in fixing the date as soon as you can do so. Professor Smith of Arizona raised the question of availability of funds so late during the fiscal year. Doubtless he called your attention to his desire to come after July 1.

Professor Powers of Oregon advises that their school continues until June 7. He urges also that according to present plans the Western Agronomists meeting is in Moscow, Western Soil Scientists and Western Division of the American Association convening in San Francisco. For this reason Mr. Powers says it would probably be impossible for him to attend the Logan meeting. He therefore suggests that you appoint Professor R. M. Lawrence as chairman of the Drainage Committee. Professor Lawrence is already chairman of a similar committee in the American Society of Agricultural Engineers. Professor Powers says that he will do his best to see to it that Oregon is represented in the proposed Logan meeting of Irrigation Workers. Apparently he is favorable to Professor Lawrence attending the Logan meeting.

Very truly yours,

[Signature]

OWI/J

Professor of Irrigation & Drainage Engineering.

Dear friend Parshall, I will advise you further about date of meeting just as soon as I get definite instructions from McLaughlin.

Sincerely OWI
May 2, 1929

Mr. R. L. Parshall
Irrigation Engineer
Colorado Agricultural College
Fort Collins, Colorado

Dear Mr. Parshall:

At the meeting of the second conference of Irrigation and Drainage Investigators of the Experiment Stations of the Western States, held in Berkeley, in December, 1927, a resolution was passed recommending that a chairman be appointed under each of the major divisions of the outline as adopted at the first conference, the duty of the chairman being to lead in the coordination of each of the divisions.

In notifying me of my appointment as chairman of the Committee on Plant and Irrigation Relationships, Professor Israelson states:

"It is tentatively planned that the next meeting be held at Logan, Utah, during June, 1929. You are urged to give careful thought to the possibility of coordinating research of irrigation and drainage workers in the matter of plant and irrigation relationships and to attend the Logan meeting with a view to making definite and specific recommendations concerning your problem."

The outline as adopted at the meeting last year was as follows:

II. Plant and Irrigation relationships.
   1. The moisture relations of plants
      (a) With reference to growth
      (b) With reference to disturbance of normal functioning
   2. The moisture requirements of plants
      (a) For maximum yield
      (b) Economic
      (c) For practical field requirements
   3. The quantity of water required per acre for economic irrigation

I believe you will agree with me that the recommendations, if any are to be made, must necessarily be based on the work which the various stations are doing along the lines of plant and irrigation relationships, and I am therefore asking that you furnish me with the following information:
1. A brief description of active projects of your Station which might be classed in this group.

2. Thus far, has an attempt been made to rewrite or adjust your projects to conform with the recommendations made in Paragraph 3 of the report of the 1925 meeting, which states:

3. "That we recommend to these Experiment Stations that they rewrite their irrigation and drainage research projects in accordance with this regrouping."

3. In view of the wide differences in climatic and soil conditions under which the various stations are working, do you think it practicable or possible to adjust your projects to fit the outline?

4. Have you any suggestions concerning changes in the outline on plant and irrigation relationships as adopted?

It is hoped that the information thus obtained may be used as a basis for a full discussion of the problem at the June meeting to be held at Logan.

Very truly yours,

S. H. Beckett,
Professor of Irrigation Investigations and Practice
It is the sense of this Conference that we report to Director Gillette as follows:

1. That we have studied, restated and regrouped into four major divisions the subjects of irrigation research in the Experiment Stations of the eleven western states.

2. That we recommend to these Experiment Stations that they rewrite their irrigation research projects in accordance with this regrouping.

3. That the Directors of these Experiment Stations be asked to state:
   a. Whether they approve the restating and regrouping as proposed by the Conference.
   b. Whether the Experiment Stations are ready to rewrite their irrigation research projects in accordance with this regrouping.
   c. In which of the particular studies outlined each station is ready to cooperate with one or more stations.

4. That if justified by the responses received by the Experiment Stations, Director Gillette appoint a chairman to lead in the coordination and cooperation under each major division.

5. That if chairmen are appointed for each major division as suggested in 4 above, these chairmen shall together constitute a coordinating committee to which all irrigation research not covered by the classification adopted by the Conference shall be reported for placing in the classification.

6. That from time to time, probably not more frequently than biennially, further conferences of irrigation workers in the eleven western states be called and that in case future conferences are held, call for the conferences shall include interested agencies not directly connected with the Experiment Stations.
III. The Irrigation Water Supply and its Physical Control

1. The Hydrology of Arid Regions
   (a) Relation of precipitation to stream flow
   (b) Ground water sources with special reference to average annual safe yield
   (c) Seepage and return flow

2. Irrigation Hydraulics
   (a) Measurement of water
   (b) Conveyance of water
   (c) Evaporation from water surfaces
   (d) Irrigation appliances and structures

3. Pumping for Irrigation
   (a) Equipment and power
      Factors affecting the economy and efficiency of irrigation pumping equipment
      Comparative economic tests of various types of power
      Community organization for power development
      Community vs. individual pumping plants
   (b) Pumping from surface sources
   (c) Pumping from ground water
      Sinking and equipping wells
      Factors affecting the economic yield of wells
   (d) Economic limits of pumping lift

4. Control of ground water including prevention of waterlogging and alkali injury.

IV. Drainage and Reclamation of Waterlogged, Alkali, and Overflow Lands.

1. Methods of drainage and water control

2. Reclamation after drainage
   (a) Soil and water analyses
   (b) Chemical, physical and organic treatments
   (c) Leaching
   (d) Tillage and cropping
   (e) Determination of proper irrigation methods.
V. Institutional Irrigation and Drainage Relationships

1. Irrigation and drainage laws, regulations, and customs.

2. Conservation of Irrigation Water through the Merging and Extension of Irrigation Works or Enterprises Having a Common Source of Supply.

3. Organization and Management of Irrigation and Drainage Enterprises

4. Quantitative Analysis of Factors Determining the Feasibility of Irrigation and Drainage Projects
   
   (a) Usual methods of determining feasibility
       Private
       State
       Federal

   (b) Adequacy of present methods

   (c) Factors affecting value of land and water
       Physical
       Economic
       Social
       Political

5. Irrigation and Drainage Costs.

6. The Settlement of Irrigated Lands
NOTES CONCERNING THE EXPERIMENTAL WORK IN COLORADO

by Ralph T. Staggers

As chairman of the committee concerning recommendations relative to Section III of the 1925 conference project outline, namely, Irrigation Water Supply and its Physical Control, I can report nothing of a constructive nature. There appeared to be little activity in the discussion of project relations, and as a personal opinion I believe that project outlines of the various experiment stations dealing with the same general study or investigation cannot be similar in detail because of the general local conditions involved in the limitations of the study. One of the fundamental considerations underlying the 1925 conference project outline was the quite general application of the scope of investigation as applicable to all the western irrigated states. However, it was recognized that not all our problems could be studied advantageously in all states, and, therefore, for some projects the work could be better accomplished in one state than in another because of the local limitations and imposed restrictions.

The correlation of projects according to the outline set up at the Berkeley conference in 1925 has not been fully developed at the Colorado Station. Since the first conference only one major project has been initiated, namely, a study of Pumping for Irrigation and Drainage in Colorado. This study is rather broad in its scope and touches upon all the subheadings of the 1925 conference outline, Sec. III, Item 3, Pumping for Irrigation. Attention is being given in this investigation to: Equipment and power, pumping from surface sources, pumping from ground water, economic limits of pumping lift, and, further, a comparative study of the costs of pumped and gravity-flow irrigation water.
At the present time there are three general projects actively pursued in Irrigation Investigations at the Colorado Experiment Station: Studies on Evaporation, Measurement of Water, and Pumping for Irrigation and Drainage. The studies in Evaporation Losses from Free Water Surfaces have been virtually completed and a report prepared by Mr. Carl Rohwer. The past two years studies have been conducted on Evaporation Losses from Moist Soils, where the water table has been carried at depths of 1, 6 and 12 inches. Beginning this season, this soil evaporation equipment has been revised, where all tanks were filled with the same soil. For the 6-inch water table, five tanks are included in this series. One is without plant growth, two with blue grass sod and two with a sod of wire grass and sedge. For the 12-inch water table, there is a similar plan, while for the 18-inch series six tanks are included of which two are without plant growth, two with blue grass and two with wire grass and sedge. In the whole series two tanks are maintained to determine the loss from a free water surface as a matter of making comparisons on the relative rates of evaporation and transpiration losses. The Mariotte tube regulation apparatus is being used to maintain a constant water level.

The studies in connection with the Water Measurement project are confined to the investigation of the law of flow through large sized improved Venturi flumes. At the present time there are under observation flumes having 10-, 12-, 20-, and 40-ft. throats, this largest flume having a maximum capacity of 2,000 second-feet. These large structures are built from the experimental data derived from the laboratory work on small sized structures, and also the development of the law of flow thru successively increasing sizes. Last March a bulletin was issued
on the Improved Venturi Flume. Reports seem to indicate that this type of measuring device is gaining favor in the irrigated West as well as many foreign countries.

In order to perfect a measuring device which is accurate and dependable in meeting conditions where small loss of head is available for measurement, and further, to successfully meet conditions of sand and silt deposit, a device has been developed known as the Adjustable Tube Meter. In the present design this consists of a converging and a diverging section with an intermediate throat section having a level floor and vertical side walls. The top side of this throat is defined by a horizontal belt attached to the lower edge of a vertical gate. The size of opening of the throat is regulated by a paddle stem lifting device. This meter is equipped with an indicating mechanism of such a type that by the simple multiplication of two indicated values, the rate of discharge can be determined, these accessories eliminating the necessity of measuring depths, reference to tables, charts or curves, as is the usual practice for submerged orifices. It is expected that when this meter is fully developed, it will be able to meet conditions now beyond any of the practical devices in use where flat grades and silt deposits are contending factors.

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As chairman of the committee concerning the recommendations relative to section III of the 1925 Conference project outline, namely, Irrigation Water Supply and its Physical Control not only a more natural can be proposed a constructive nature. There appeared to be little activity in the discussion of project relations and as a personal opinion believe that project outlines of the various experiment stations dealing with the same general study or investigation cannot be similar in detail because of the general local conditions involved in the limitations of the study.

One of the fundamental considerations underlying the 1925 Conference outline was the quite general application of the spirit of investigation as applicable to the western irrigated states. At the same time it was recognized that all our problems could not be studied advantageously in all states and therefore some projects the work could be better accomplished in one state than in another, because of local limitations and imposed restrictions.
The correlation of projects according to the outline set up at the Berkeley conference in 1925 has not been affected at the Colorado Station. Since the first conference only one major project has been initiated, namely a study of Pumping for Irrigation and Drainage in Colorado. This study is rather broad in its scope and briefly touches upon all the subheadings of the 1925 conference outline Section III Item 3, Pumping for Irrigation. Attention is being given in this investigation to equipment and power, pumping from surface sources, pumping from ground water, economic limits of pumping lift and further a comparative study of the costs of pumped water and gravity flow irrigation water.

Evap., Soil moisture set up.
Venturi flume
Adjustable tube meter
IRRIGATION WATER SUPPLY AND ITS PHYSICAL CONTROL

By

R. L. Parshall

(Paper presented at the Fourth Biennial Meeting of the Western Irrigation and Drainage Research Association, Tucson, Arizona, July 16-18, 1931)

As chairman of the committee on the Division of Irrigation Water Supply and its Physical Control, I wish to present a brief report concerning conditions applicable to Colorado, as well as to touch upon the progress of work in connection with the cooperative irrigation investigations in this state. This cooperative relation is between the Bureau of Agricultural Engineering, of the U. S. Dept. of Agriculture, and the Colorado Agricultural Experiment Station at Fort Collins.

For some years past, there has been a general trend to emphasize the idea of more efficiency in the utilization of our water supply, rather than to attempt expansion in the irrigated area. In carrying out this policy, there has just been completed by our State Engineer, a very comprehensive survey of Water Division No. 1 of Colorado, embracing about one-quarter of the area of the state. This had for its purpose the analyzing of facts relative to storage of flood flows in suitable reservoirs as a means of strengthening the supply to junior appropriators, not, however, with the intention of expansion of area but primarily as a supplemental water supply. Also, attention is being given to the matter of constructing a large channel reservoir on the Arkansas River, east of Las Animas, which would store the flood waters of both the main river and the Purgatoire, a tributary. This project
would very materially augment the present available water supply of
the Arkansas Valley in Colorado, and possibly in Kansas. In this
valley, too, is being considered the enlargement of a large storage
reservoir at an estimated cost of less than $10.00 per acre-foot. After
more than fifty years of irrigation experience in Colorado, storage re-
servoirs of moderate cost have now been developed, leaving for the future
the more expensive construction. It does not appear economically feas-
ible, under existing conditions, to seriously consider expensive stor-
age. It is generally believed that the economic limit for acre-foot
storage is about $15.00. The present depression of agricultural prod-
ucts is, of course, no criterion of the general or average profit re-
turns from the irrigated farm. Some have predicted wheat at 25¢ to
35¢ a bushel early this fall, and others have gone so far as to picture
many fields of grain on irrigated land left uncut. The annual charge
of irrigation per acre in northern Colorado, including labor, may ap-
proach about $7.00, and for a yield of 40 bushels of wheat per acre
would not an exceedingly small return. At present, the outlook is
not conducive to expensive water supplies.

Personally, I am inclined to the idea of creating supplemental
water supplies by pumping from wells where possible, and also to a more
efficient use of our present supply. This season we are finding the
outlook for water below normal. As I view the problem, a great deal
may be accomplished in improving the distribution of the water to the
user. In Colorado especially, we believe we are working toward this
end by giving more attention to the matter of better measurement of the
water supply. In the use of the old type rating flumes in measuring
the decreed appropriation from natural streams, it has been known for a long time that this device was impracticable and, in some cases, wholly unsuited. For the past three or four years considerable success has been attained in the use of the Parshall measuring flume, formerly known as the Improved Venturi Flume, as a means of more dependable and accurate measurement of stream flow varying in amount from less than 1 second-foot to more than 2,000 second-feet. These large measuring flumes not only increase the efficiency of the supply but establish confidence on the part of the several appropriators of the common water supply.

As a specific instance, the 40-foot flume on the main canal of the Fort Lyon Canal Company in the Arkansas Valley, may be cited. Their measurements constitute important river regulations, and this flume has not only been the means of solving a perplexing condition of contention among the several canal companies along the river, but since its installation has measured the flow well within practical limits of accuracy. The previous experience of the old rating flume on this canal indicated that over a period of one year the rate of discharge for the same gage height could vary 100 percent. The filling in and scouring out of sand accumulations along the bed of the channel resulted in a constant shift of the gage height-discharge relation. This large flume, having a throat width of 40 feet and a capacity of more than 2,000 second-feet, has measured the rate of discharge since December, 1928, within the limit of error of 1 or 2 percent. Generally speaking, these large flumes are equipped with a specially designed double-head recording and indicating instrument, mounted in a nicely designed and built instrument house of ample proportions. This instrument records graphically
the upper head, $H_a$, and the lower head, $H_b$, both in feet. On white pyrnelin drums which carry a graduated scale, neatly marked in feet, tenths and hundredths, it is possible to observe the two effective heads within close limits. Ordinarily these flumes are not equipped with a staff gage. Observations show that for these large flumes, the free-flow rate of discharge appears to be applicable up to a submerged flow limit of about 80 percent. On the $H_a$ indicating drum is also shown, in bold-faced type, the free-flow rate of discharge, and when the ratio of the heads $H_b$ to $H_a$ exceeds 80 percent, a simple correction diagram gives the amount in second-feet to be subtracted from the free-flow rate of discharge to determine the submerged flow for any value of $H_a$ and percent of submergence.

At the present time there are several hundred of the small Parshall measuring flumes in use, which are increasing the efficiency in distributing the water directly to the farmer. The Fort Lyon Canal has some 200 of these smaller flumes used in the distribution of water over about 96,000 acres; while the Twin Lakes Canal Company, at Ordway, is now measuring about 90 percent of the water to the user thru these small flumes. Reports from the management of several irrigation companies indicate that more efficient and better use of the water has resulted.

However, in Colorado, much yet remains to be done. I have estimated that possibly 75 percent of the total irrigation supply now being distributed to the farmer is either improperly measured or, in many cases, no measuring device is used, merely an estimation being made of the rate of flow by the ditch rider. Much is yet possible in improving
our methods, and it is earnestly believed that by giving stricter attention to proper distribution, we can extend our present water supply by at least 25 percent. This does not mean that we can increase the amount of our total supply by one-quarter, but rather by greater care we can get the rightful amount of water into the canal and the proper amount to the user, which increases the duty or efficiency of this extremely valuable asset. The construction of expensive reservoirs entails additional financial burdens in taxes and time, whereas the improvement in efficiency of canal operation is immediate and relatively inexpensive.

It may be said that since the very beginning of the practice of irrigation, where water was lead to the fields thru earthen channels, the accumulation of sand and silt has been a matter of immediate concern. Even to-day this serious problem exists, and to rid ourselves of this menace various and innumerable devices have been tried out with varying success. Quite recently some new ideas have been developed in our irrigation investigational work in Colorado in studying the principles of a new type of sand trap, which it is believed will be ultimately practical, not only for irrigation and power canals, but for rivers in setting aside the bed load of the channel and very greatly reducing the extent of accumulation of such deposits. At the present time two distinct underlying principles have been investigated, both of which possess considerable merit as evidenced by laboratory experiments; namely, the vortex tube and the deflector riffle.

You are familiar with the vertical vortex formed in the wash bowl when the stopper is withdrawn at the bottom. By use of a specially formed tube, laid across the bottom of a channel and inclined upstream at an
angle of 45° and outletting at the side, it is possible to create a very effective horizontal vortex which catches the bed load passing down the channel and ejects this material thru the outlet end of this tube. The downstream edge of a horizontal plate forms a straight definite lip or edge, and underneath this plate is the conical tube whose vertical diameter agrees approximately with the lip. The downstream portion of the tube is opened. As the current passes over the edge of this horizontal plate, a negative pressure is created just underneath the slightly projecting lip which causes the water, next to the back or upstream wall of the tube, to rise upward toward the lip or the area of deduced pressure. After the current has passed over the lip, there is a certain component of the motion effective downward along the downstream wall of the tube, this combination of forces producing a rotation of the mass of water within the conical vortex tube. The elevation of the floor or bottom of the channel downstream from the lip is depressed, the amount depending upon the size of the tube. The action of the water within this vortex tube is intensely interesting; as, for instance, a leaf may pass over the trap at an elevation of some 2 or 3 inches above the lip. This leaf will settle downward, sometimes a few inches downstream from the trap, and then gravitate upstream along the floor and into the tube. If near the back end of the tube, the leaf will travel in a spiraled path of almost maximum radius; however, as it is carried nearer the outlet end the radius of the travel becomes shorter and the speed increases. In a tube 3 feet long, it was noted that at about the mid point, the leaf had moved into the center or core of the vortex and here the velocity of exit was very greatly increases, possibly for a mean velocity of 2 feet per
second over the lip the translation of the core of the vortex might be 4 or 5 feet per second. In a crystal clear water, a bright colored red dye was injected into the vortex by means of a long, slender small bore metal tube. The trace of the brilliant color clearly depicted the spiral motion within the tube. Another interesting phenomenon occurs at or near the point of maximum rotation. Here a vacuum tends to form in the core of the vortex, and at the limit air works its way back to the far end of the tube, thus forming what might be called an air rope— for want of a better name. Color introduced by the color gun gives the effect of a rapidly revolving, definitely shaped rod of color marking the path of the core of the vortex. A shot of sand placed in the tube at the back end, under a maximum condition of rotation, will almost instantly be carried the full length of the tube, thus displaying a miniature dust cyclone inside the rapidly revolving mass of clear water. Briefly, it has been found that the translation velocity is essentially the mean velocity of the water passing over the lip times the cosine of the angle of the axis of the tube to that of the channel. Careful measurements of the rotation by means of special turbines of different diameters, show that for one particular size and setting of the vortex tube, a maximum of 204 revolutions per minute was observed for a mean velocity of 2.6 feet per second over the lip of the trap. Angular stones weighing nearly 4 pounds have been removed, and cobblestones the size of golf balls or hen's eggs are violently agitated and rapidly carried to the exit end of the trap. Many have observed the characteristics of this device and believe it to possess real merit, as well as being entirely practical.
The spectacular features of the vortex tube are outstanding; nevertheless, no more so than the deflector riffle. It is the common experience of engineers to note the nature of the movement of sand in channels downstream along the bottom. Here they find the formation of crests and valleys, and at times these crests are as much as 3 feet high. Since the action of the vortex tube is directly dependent upon the velocity of the current over the lip, it was quite apparent that from a practical standpoint a sand wave might approach which would engulf the tube. Steps were taken to prevent this condition in the use of various forms of riffles laid on the floor upstream from the lip of the trap. It was discovered that by using specially shaped riffles, set at the proper spacing and angle, it was possible to transfer the bed load from one riffle to another almost at right angles to the direction of the current. Our first laboratory tests with a special triangular riffle used to arrest the advance of a sand wave proved to be ineffective. We provided a larger riffle of similar proportions and found where the point of the riffle extended above the crest of the sand wave, its travel downstream was quickly arrested and dissipated.

The flume at the laboratory in which these riffle experiments were conducted, was 6 feet wide and about 2 feet deep. The floor here sloped laterally 3 inches in this width; however, was level longitudinally. These triangular deflector riffles were set in a regular pattern on this slightly inclined floor, where the axis of the riffle was placed at 45° to the axis of the flume. Openings 4 by 6 inches were provided at the floor
line at the lower side. No quantitative tests have been made as to the efficiency of these riffles; however, to indicate what is possible, a scoop-shovelful of coarse sand and small gravel was introduced near the wall on the higher side, where it is estimated that the weight of sample was about 25 pounds. It was observed for a velocity of the current at about 2.5 feet per second that at least 90 percent of the charge had been transferred across the flume to the exit opening in 50 seconds, and the remainder cleared in less than one minute. The action of the sand among the riffles is not unlike that of dust or dry snow on the pavement when moved by a moderate wind. At the downstream edge of the triangular riffle, a very decided eddy current is formed which, under certain conditions, lifts the sand particles to the tip of the riffle where they spray off only to be caught again and moved nearer to the openings by the riffles downstream. It is believed that when sand and gravel are placed upstream in the riffle deflectors, very little, if any, reach the vortex tube which was in operation a few feet downstream from the last set of riffles.

The combination of these two principles is thought to possess such advantages that practically the entire bed load passing down a channel may be caught and delivered to a suitable exit opening at the side.

The great expense involved in the maintenance of both large and small channels where silt and sand accumulations are troublesome, is appreciated. The solution of this problem, from an economic standpoint, means a tremendous saving in actual outlay of funds, as well as a saving of water now sacrificed in abating and which in times of drought is greatly needed by thirsty crops. Plans have been prepared for the installation, on a practical scale, of the deflector riffle sand trap, also
more extensive laboratory settings are being conducted. With the completion of this season's work, it is fully expected that this device will be so developed as to more efficiently promote the operation of irrigation canals and further increase the efficiency of our water supply.
Fourth Biennial Meeting of the Western Irrigation and Drainage Research Assoc.
Tucson, July 16-18, 1931

Irrigation Water Supply and Its Physical Control

by R. L. Parshall,

As Chairman of the Committee on the Division of Irrigation Water Supply and Its Physical Control, I wish to present a brief report as to conditions applicable to Colorado, as well as to touch upon the progress of work in connection with the cooperative irrigation investigation in this state. This cooperative relation exists between the Bureau of Agricultural Engineering and the Colorado Agricultural Experiment Station at Fort Collins.

For some years past there has been in evidence a general trend to emphasize the idea of more efficiency in the utilization of our water supply, rather than to attempt expansion in the irrigated area. There has just been completed by our State Engineer, a very comprehensive survey...
of Water Division 17th of Colorado, embracing about one-quarter of the area of the state, for the purpose of analyzing the facts relative to storing of flood flows in suitable reservoirs, as a means of strengthening junior appropriations, but primarily as a supplemental water supply. Attention is also being given to the matter of constructing a large channel reservoir on the Arkansas River, east of Las Animas, which would store the flood waters of both the main river and the Purgatoire, a tributary. This project would very materially augment the present available water supply of the Arkansas Valley, in Colorado and possibly Kansas. Also in this Valley is being considered the enlargement of a large reservoir, at an estimated cost of less than $10 per acre-foot, storage. After more than 50 years of irrigation experience in Colorado, storage reservoirs of moderate cost have now been developed, leaving for the future the more expensive construction.
does not appear economically feasible, especially under present conditions, to seriously consider expensive storage. It is generally believed that the economic limit for acre-foot storage is about $15. The present depression of agricultural products, of course, no criterion of the general or average profit returns from the irrigated farms. Some have predicted wheat at 25¢ to 35¢ a bushel early this fall and others have gone so far as to picture many fields of grain on irrigated land, left unrestored. The capital charge of irrigation per acre in northern Colorado, including labor, may approach about $7, and for a yield of 40 bushels of wheat per acre would not exceedingly small return. At the present the outlook is not conducive to expensive water supplies.

Personally, I am inclined to the idea of creating supplemental water supplies by pumping from wells, where possible, and also to a more efficient use of our present
water supply. This season we are finding the outlook for water below normal. As I view the problem, a great deal may be accomplished in improving the distribution of the water to the user. Especially in Arizona we believe we are working toward this end by giving more attention to the matter of better measurement of the water supply. In the use of the old type rating flume in measuring the decreed appropriations from natural streams it has been known for a long time that this device was impracticable and in some cases wholly unsuited. In the past three or four years considerable success has been attained in the use of the Parshall measuring flume, formerly known as the improved Venturi flume, as a means of more dependable and accurate measurement of stream flow—ranging in amounts from less than 1 second-foot to more than 2000 second-feet. These large measuring flumes, in contrast to the old rating flume as a means of better measurement of
As a specific instance, the 45-ft. fence on the main canal of the 7H. Type Canal Company in the Arkansas Valley was to be tested. These measurements were subject to important river regulations, and this fence has been the subject of serious contention among the several canal companies along the river. It is since its installation, however, measured the flow well within practical limits of accuracy.
the amount diverted, not only increases the efficiency of the supply but establishes confidence on the several appropriators of the common water supply. The specific instance of the Fort Lyon Canal Co. in the Arkansas Valley in the use of their 40-foot flume in the main canal, where these measurements constitute important river regulations, has been the means of solving a very perplexing condition of contentions among the several canal companies along the river, but has since its first being installation measured the flow well within practical limits of accuracy. The previous experience of the old Fort Lyon ranging flume on this canal indicated that for a period of one year the rate of discharge for the same gage height could vary 100 percent. The filling in and removing out of sand accumulations along the bed of the channel resulted in a constant shift of the gage height-discharge relation. This large flume, having a throat width of
40 feet and a capacity of more than 2,000 second-feet has measured the rate of discharge since December 1928 within one or two percent. In the most part these large flumes are equipped with a specially designed double-head recording and indicating instrument, mounted in a nicely designed and built instrument house of ample proportions. This instrument records graphically the upper head \( H_a \), and the lower head \( H_b \), both in feet. On some paper roll drums, which have the nearly marked, the a graduated scale in feet, tenths, and hundredths it is possible to observe the two effective heads within close limits. Ordinarily these flumes are not equipped with a staff gage. Observations show that for these large flumes the free-flow rate of discharge appears to be applicable up to a submerged flow limit of about 80 percent. On the \( H_a \) indicating drum is also shown in bold faced type, the free flow rate of discharge, and when the ratio of the heads \( H_b \) to \( H_a \) exceed 80 percent, a simple
correction diagram gives the amount in second-fut to be subtracted from the free flow rate of discharge to determine the submerged flow for any value of H and percent of submergence.

At the present time there are several hundred of the small Parshall measuring flumes now in use which are increasing the efficiency in distributing the water directly to the farmer. The Fort Lyon Canal Co. has about 200 of these smaller flumes in the distribution of water over about 26,000 acres, while the Twin Lakes Canal Co. are now measuring about 90 percent of the water to the users through these small flumes. Reports from the management of several irrigation companies indicate that more efficient and better use of the water has resulted. However, in Colorado much is yet to be done. I have estimated that possibly 75 percent of the total irrigation supply distributed to the farmer is either improperly measured or wasted.
In many cases no measuring device is used and merely an estimation made by the ditch rider. Much is yet possible in improving our methods and it is earnestly believed that by given strict attention to proper distribution we can stretch out or extend our present water supply by at least 25 percent. This does not mean that we can increase the amount of our supply by one quarter, but rather by greater care we can get the rightful amount of water into the canal and the proper amount to the user which increases the duty or efficiency of this extremely valuable asset. The construction of expensive reservoirs entails additional financial burden in taxes and time, whereas the improvement in efficiency of canal operation is immediate and relatively inexpensive.
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binations of forces producing a rotation of the mass of water within the conical vortex tube. The elevation of the floor or bottom of the channel downstream from the lip is depressed, the amount depending upon the size of the tube. The action of the water within this vortex tube is intensely interesting, as for instance a leaf may pass over the trap at an elevation of some 2 or 3 inches above the lip. This leaf will settle downward, sometimes a few inches downstream from the trap and then gravitate up stream along the floor and into the tube. If near the back end of the tube the leaf will travel in a spiral path of almost maximum radius, however, at it is carried nearer the outlet end the radius of the travel becomes shorter and the speed increases. In a tube 8 feet long it was noted that at about the mid point the leaf had moved into the center or core of the vortex and here the velocity of exit was very greatly increased, possibly for a mean velocity of 2 feet per second over the lip the translation of the core of the vortex might be 4 or 5 feet per second. In a crystal clear water
a bright red colored dye was injected into the vortex by means of a long slender small bore metal tube. The trace of the brilliant color clearly depicted the spiral motion within the tube. Another interesting phenomenon occurs within the tube at or near the maximum rotation; here a vacuum tends to form in the core of the vortex and at the limit air works its way back to the far end of the tube, thus forming what might be called an air core for want of a better name. Color introduced by the color gun gives the effect of a rapidly revolving definitely shaped rod of color marking the path of the core of the vortex. A handful of sand placed in the tube at the back end, under a maximum condition of rotation, will almost instantly be carried the full length of the tube, thus displaying a miniature dust cyclone inside the rapidly revolving mass of clear water. Briefly it has been found that the translational velocity of the tube is essentially the mean velocity of the water passing over the lip times the cosine of the angle of the axis of the tube to that of the channel.
Careful measurements of the rotation by means of special turbines of different diameters show that for one particular size and setting of the vortex tube a maximum of 204 revolutions per minute was observed for a mean velocity of 2.6 feet per second over the lip of the trap. Angular stones weighing nearly 4 pounds have been removed and cobble stones of sizes of golf balls or hen's eggs are violently agitated and rapidly carried to the exit end of the trap. Many have observed the characteristics of this and believe it possesses real merit as well as practical entirely practical.

The spectacular features of the vortex tube are outstanding; nevertheless, no more so than the deflector riffle. It is common knowledge to engineers who have experience with sand in channels to note the nature of sand moving downstream along the bottom. Here we find the formation of crests and valleys and at times these crests are as much as 2 feet high. Since the action of the vortex tube is directly dependent upon the velocity of the current
over the lip it was quite apparent that from a practical standpoint a sand wave might approach which would engulf the tube. Steps were taken to prevent this condition and experiments were made with the use of crude designs of various forms of riffles laid on the floor up stream from the lip of the trap. It was discovered that by using specially shaped riffles, set at the proper spacing and angle, it was possible to transfer the bed load from one riffle to another almost at right angles to the direction of the current. Our first laboratory tests with a special triangular riffle proved to be ineffective. We provided a larger riffle of similar proportions and found where the point of the riffle extended above the surface of the sand, its travel downstream was quickly arrested and dissipated.

The flume at the laboratory in which these riffle experiments were conducted was 6 feet wide and about 2 feet deep. The floor sloped laterally 3 inches in this width, however, level longitudinally. These
-triangular deflector riffles were set in a regular pattern on this slightly inclined floor, where the riffle axis of the riffle was placed at 45° to the axis of the flume. Openings 4 x 6 inches were provided at the floor line at the lower side. No quantitative tests have been made as to the efficiency of these riffles, however, to indicate what is possible a scoop-shovelful of coarse sand and small gravel was introduced near the wall on the higher side, where it is estimated the weight of sample was about 25 pounds. It was observed that for a velocity of the current at about 2.5 feet per second the total that at least 90 percent of the charge had been transferred across the flume to the exit opening in 30 seconds and the remainder of the sample cleared in less than one minute. The action of the sand among the riffles is not unlike that of dust or dry snow on the pavement when moved by a moderate wind. At the downstream edge of the triangular riffle is formed a very decided eddy current which under certain conditions lifts
the sand particles to the tip of the riffle where it sprays off only to be caught again and moved nearer to the opening by the riffles downstream. It is believed that changes of sand and gravel are placed up stream in the riffle deflectors very little, if any, reach the vortex tube which was in operation a few feet downstream from the last set of riffles. The combination of these two principles is thought to possess such advantages that practically the entire bed load passing down a channel may be caught and delivered to a suitable exit opening at the sill.

The tremendous expense in the maintenance of both large and small channels where silt and sand accumulations are troublesome is appreciated. The solution of this problem, from an economic standpoint, means a tremendous saving in actual outlay of funds, as well as sacrifice in water use now unsafeguarded in pleading a fishes of time for stemming in deployment to the numerous needs at times to save the live-thirty crops. Plans have been prepared for the installation on a practical scale of the riffle deflector riffle sand trap, also more
extensive laboratory settings are being conducted. It is expected that shortly these ideas, when more completely studied, will be found useful in promoting the more efficient operation of irrigation canals and increasing the efficiency of our water supply.