WATER OPERATION AND MAINTENANCE

BULLETIN NO. 99

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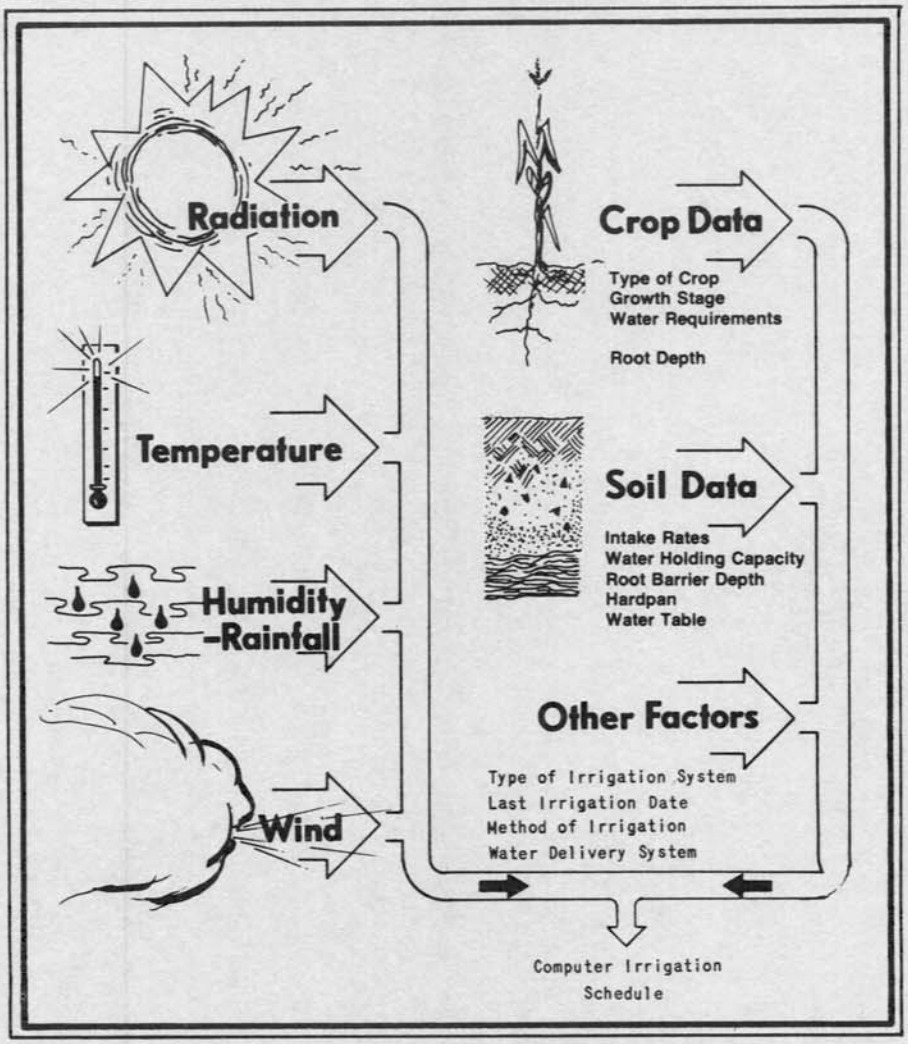

IN THIS ISSUE

UNITED STATES DEPARTMENT OF THE INTERIOR
Bureau of Reclamation

The Water Operation and Maintenance Bulletin is published quarterly for the benefit of those operating water-supply systems. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. It is hoped that the reports herein concerning laborsaving devices and less costly equipment and procedures will result in improved efficiency and reduced costs of the systems for those operators adapting these ideas to their needs.

To assure proper recognition of those individuals whose suggestions are published in the bulletins, the suggestion number as well as the person's name is given. All bureau offices are reminded to notify their Suggestions Award Committee when a suggestion is adopted.

Any information contained in this bulletin regarding commercial products may not be used for advertisement or promotional purposes and is not to be construed as an endorsement of any product by the Bureau of Reclamation.

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Engineering and Research Center
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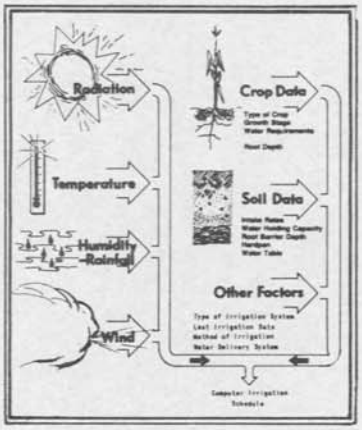

COVER PHOTOGRAPH:

This graphical sketch illustrates some of the factors which are taken into account by the computer in the irrigation scheduling program designed to assure efficient use and conservation of irrigation water.

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF RECLAMATION

WATER OPERATION AND MAINTENANCE
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INTRODUCTION

Proper irrigation scheduling for optimum use of water is important to those who operate water-supply systems, as pointed out in the first article beginning on page 1. Irrigation scheduling helps the farmer in many ways: increased income through greater yields and improved crop quality, lower production costs, and reduced drainage needs. Scheduling of water throughout the distribution system enables the operating entity to utilize the project water supply in an efficient manner.

As described in the article on page 11, 90 percent of the energy used on some irrigated farms is used in pumping; therefore, the growers should be getting maximum efficiency from their pumps instead of the 51 percent most of them are now experiencing.

A simple solution for the control of pondweeds is explained in an article on page 20.

How to build an entrance gate on a steep grade is described in the short article on page 22.

A listing of current safety color designations recommended by OSHA can be found on page 24.

Some biological methods for the control of aquatic and terrestrial weeds are given in the article starting on page 26.

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CONSERVING IRRIGATION WATER[1]

At present, there are more than 20 million hectares (50 million acres) of land under irrigation in the 17 Western States. Continuing development of irrigation projects along with improved irrigation methods, such as sprinkler and drip irrigation, has brought land under irrigation which previously was considered unsuitable. In some cases, this has resulted in the allocation of all the water available for irrigation. This extensive use of water for irrigation coupled with the increasing demand imposed by municipal and industrial development, including the more recent fossil-fuel resource development, has made efficient use of available water a necessity. But efficient use of water implies efficient storage, efficient distribution of water through a series of canals, laterals, and farm ditches, and efficient application of that water to the field.

It has been estimated that the irrigation of crops accounts for approximately 80 percent of the water used in the Western States. Most of this agricultural use occurs in the arid and semiarid West. Therefore, it stands to reason that a great potential, as well as need, exists for better water utilization in the irrigated areas of the West.

> The purpose of the program is to assure effective use of our natural resources by irrigated agriculture.

The Bureau of Reclamation has developed a program which will provide the tools and concepts for improving irrigation efficiencies and project operation for effective utilization of irrigation water with an improved economic base to the irrigation enterprise. This program, using the principle of irrigation scheduling, is called the Irrigation Management Service program, or IMS. The principal thrust of the IMS program is to direct and assist irrigation and water districts toward more effective and efficient use of water. The results are increased net returns to the farmer/irrigator through greater yields and improved crop quality with lower production costs, reduced irrigation project operation and maintenance requirements, improved criteria for irrigation planning and development, and more favorable environmental impact of the water resource development for irrigation.

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[1] This article was prepared especially for this publication by the Irrigation Management Service Team at the Engineering and Research Center, Denver, Colorado.

IRRIGATION MANAGEMENT SERVICES: Irrigation Management Services (IMS) is offered to farmers or individuals who request it through irrigation districts and associations. It provides in-the-field advisory service and timely data designed to improve your water management. The program is provided with the cooperation of the Bureau of Reclamation and other Federal, State, and local agencies.

The IMS program is the outgrowth of a study made a few years ago by the Bureau of Reclamation on some 300 farm fields on 18 study areas throughout the irrigated West. We wanted to know what was going on out there in the water user districts and on the farms where the water was being delivered. These studies were very revealing and showed that even though more water was being applied throughout the entire season than was necessary to produce good crops, oftentimes during the critical growing period, the crops suffered from a lack of moisture because they did not have enough water.

IRRIGATION SCHEDULING - WHEN TO IRRIGATE AND AMOUNT TO APPLY

IMPORTANCE

Proper scheduling for optimum use of irrigation water is important to the farmer, the irrigation district, the community, and the Nation.

The studies further revealed that as a general rule the irrigator did not know when he should apply irrigation water or how much water he should apply to fill the rooting zone of the soil. It was also apparent that deficiencies related to applying water efficiently on the farm had an effect on the efficient management of water throughout the distribution system. Probably the most important conclusion drawn from the study was that before any substantial change in present irrigation and water delivery practices could be expected, the irrigator will need to have better information as to when he should irrigate a particular crop and how much water he should apply when he does irrigate. Along with this information, he often needs technical assistance in the preparation of his land for irrigation and in distributing the proper amount of water uniformly over the field.

Recognizing this need, the Bureau of Reclamation set about to develop a program which would supply the irrigator with information on when he should irrigate and how much water he should apply. At the same time, the program would provide the farm-water demands to the operating personnel of the water district to allow them to more effectively schedule water throughout the distribution system.

HOW IMS WORKS:

Field sampling and laboratory analyses determine soil moisture-holding capacity. Then, through careful measurement of local daily temperatures, wind, humidity, rainfall, and solar radiation, crop water needs can be determined. With this information, an irrigation schedule can be tailored to your specific farm situation. By combining irrigation schedules for several farms, a delivery schedule can be developed for a distribution system.

Basically, the program involves keeping a water budget on each field under irrigation. The amount of moisture in the soil at the start of the growing season will be measured. Figure 1 shows water being

Figure 1

measured and distributed to a field. As the season progresses, the amount of moisture used or "withdrawals" by the crop will be computed from climatological data such as temperature, solar radiation, and wind movement. "Deposits" to the water budget will be effective rainfall and irrigation water stored in the rooting zone. At any time, a budget analysis will provide the amount of moisture in the rooting zone of a particular crop and with current "withdrawals," it will predict when an irrigation should be applied. The analysis will also indicate how much water should be added to the field when the irrigation is applied. The water user will be kept advised of the time for irrigating and the amount of water to apply. First, an estimate, based on crop development and climatological data from past years, will be made of the irrigation date considerably in advance of the actual date. This estimate will be reconfirmed or updated once or twice a week with current climatological data so that the proper irrigation date is selected.

BECAUSE OF THE LARGE AMOUNT OF DATA PROCESSED, COMPUTERS ARE BEING USED

Because of the large amount of data required on many fields and the need for frequent updating, modern computers and data handling systems are being utilized. The use of the computer makes it possible to carry out the program on a large number of fields. Once irrigation scheduling is developed on the farm, these farm irrigation demands are combined into a schedule for water deliveries throughout the distribution system and on to the storage system. Thus, the IMS program is integrated into the regular ongoing operation and maintenance program of the water users district.

The Bureau is currently providing two levels of irrigation scheduling assistance to the irrigator - the "Irrigation Guide," and "Field Irrigation Schedule." Both levels delegate to the irrigator the final decision of when and how much water to apply. They are briefly outlined as follows:

The Irrigation Guide gives irrigation intervals for principal crops in an area based on daily evapotranspiration rates and average water-holding capacities for several soils in the area. The guide is updated weekly with current climatic data from a central location in the area. It gives the average daily water use and the total water use for the week, the seasonal water use to date, and forecasts crop water use for the next week. This information is provided for crops with either an early, average, or late planting date and a corresponding stage of growth that is general for the

update period in the area. The Irrigation Guide is proving very effective as a supplemental service along with the other irrigation scheduling approaches. Where the data base and experience enable accurate definitions of the general conditions of the area, the recommended irrigation intervals are quite accurate.

BOOKKEEPING:

Modern computers are used as "bookkeepers." They keep records of all information and provide printouts, recommending irrigation dates and application amounts for each crop grown on your farm.

The Field Irrigation Schedule provides the irrigator or farm manager with the up-to-date soil moisture status of each of his fields in the program. It gives him recommended optimum irrigation dates and amounts to apply at each irrigation. If adequate input data are available, application rates and set times can be included. One field technician is needed for every 2000 to 4000 hectares (5,000 to 10,000 acres) served by this program. Techniques and equipment being developed will ultimately expand the area that one person can serve.

Figure 2 shows the Irrigation Management Service field man visiting a farm to check field and crop conditions. He may also be able to advise on such matters as fertility, insect and disease control, and other aspects related to irrigation.

Figure 2

The Field Irrigation Schedule program provides the irrigator with a computer printout once or twice weekly which is an "update" of his irrigation program. This update or schedule incorporates the measured climatic parameters during the period of elapsed time since the last update. Evapotranspiration potential, based on long-term historic data, can be modified by a short-term (5 days or less) adjustment for anticipated climatological anomalies occurring during the forecast period. A listing of the various fields that make up a farm or operational unit is included on the printout. Data also included are the soil moisture status for each field at the end of the update period. Other items included are the water-holding capacity for the effective rooting zone, the recommended allowable depletion, the date of the last irrigation, and the recommended date for the next irrigation on each field. A Field Irrigation Schedule is shown in figure 3.

FARM NO. 1 MR. I.M. NOBODY DATE: JUL 23
ROUTE # 1
SOMEWHERE,
ALASKA 99911

FIELD IRRIGATION SCHEDULE

FIELD-CROP-ACRE	PLANT DATE OR ID	RT ZN FT	AVE DAY USE INS	USE BETWN IRR INS	TO-DAYS DEPL INS	DAYS INTERVAL PCT-REFILLED 50	75	100	LAST IRR. DATE	NEXT IRRIGATION DATE	AMT INS
1 WHEAT 20	ID413	4.0	.23	1.7	12.6$	4	6	9			2.2
2 POTATOES 60	ID226	1.9	.25	1.0	.7	2	3	4	JUL 20	JUL 24	1.3
3 CORN 30	ID311	3.6	.24	1.2	1.2◆				JUL 17	JUL 22◆	1.6
4 BEETS 40	ID124	2.7	.24	1.5	1.1#	2	3	5	JUL 19	JUL 24◆	2.0

◆ FIELD HAS NOT BEEN CHECKED
INCLUDES CARRYOVER DEPLETION
$ ACCUMULATED IRR.REQ.TO DATE

Figure 3

Neutron probes for measuring soil moisture and water use rate shown in figure 4, is both consistent and accurate.

Figure 4

The neutron probe is being used in several areas to measure soil moisture and water use rate to enhance the IMS program. A metal tube is placed in the soil shortly after the crop is planted and is used throughout the irrigation season as an access tube. When moisture levels are desired, the neutron source and counting device are lowered to the desired depth within the access tube. The reading obtained in a unit of time is proportional to the moisture content of the soil at that depth.

The speed and direction of neutrons emitted from the source are altered by hydrogen present in the water. Any neutrons which reach the counting device are recorded. The greater the number of neutrons registered by the counting device the greater the water content of the soil. Through the use of the neutron probe, the quantity of water available to the plant may be determined accurately. The neutron probe data are utilized by the computer to develop an irrigation schedule or may be graphically plotted to determine the irrigation requirements. In both cases, the closer the observation is to the scheduled irrigation date, the greater the accuracy.

SCHEDULING OF WATER DELIVERIES THROUGHOUT THE DISTRIBUTION SYSTEM

Scheduling onfarm demands throughout the distribution system is an integral part of the IMS program.

Scheduling of water to fields for optimum crop yields must take into consideration the constraints and limitations imposed by the farm delivery system as well as those of the project distribution system. The compilation and organization of water delivery schedules for the farms on a lateral are referred to as system scheduling. Optimum delivery schedules to farms on the laterals are compiled and adjusted, thus allowing the scheduling of water deliveries throughout the entire distribution and storage system in such a manner as to make the most effective and efficient use of the total water supply. Printouts of farm delivery schedules on a lateral are utilized by the ditchrider or other operating personnel to enable them to schedule and utilize water in the lateral in an efficient manner.

In most cases, system scheduling can be utilized with a minimum of change in present delivery procedures. However, scheduling provides for the allocation of water for delivery in accordance with the actual and projected crop water use, modified by rainfall, cultural practices, delivery system carrying capacity, and field irrigation characteristics, which may result in changes in the water delivery systems of some projects.

System scheduling computer programs have been developed to accommodate either gravity or sprinkler irrigation systems. The system scheduling programs use the forecasted farm irrigation events to determine the optimum delivery demand at each turnout. Adjustments are made in these optimum turnout delivery demands to reflect constraints imposed by the capacity of the distribution system. Daily flow requirements for each turnout are adjusted as necessary and totaled to determine the lateral diversion requirement and its demand on the main distribution system.

An IMS program has been developed to assist an irrigation district in forecasting their seasonal water demands. The program determines this seasonal demand from the consumptive use of the acreage of crops grown within the district. The program may be used to compare the consumptive use with the district's water delivery records. On a regular basis throughout the season, the program may compare the district current water delivery records with the consumptive use determined from the field or system scheduling programs. This program may be run on any or all segments of the district conveyance system.

For example, it may include all the irrigated lands below a given turnout (lateral, canal, or reservoir). The program's "printout" will tabulate the total water diversions and deliveries to date, the crop consumptive use to date, and will also project forecasted water demands for the next day, week, and month.

THE PRESENT PROGRAM INVOLVES 126 650 HECTARES (313,000 ACRES) AND 25 DISTRICTS

The IMS program is economically worthwhile and environmentally sound to the irrigator, the water-user district, and to the Nation.

From 1969 to 1976, the Bureau's IMS program has expanded to 25 different areas in 14 states. The present IMS program involves more than 126 650 hectares (313,000 acres). As a general assessment, the anticipated benefits of the IMS program have been divided into three categories reflecting their beneficiaries. All impacts have not been studied, but some benefits have been documented. Generally, trends and studies support the following ideas:

FARMER - BENEFITS
- Increased income
- High-quality crops
- Higher yields
- Save fertilizer
- Save labor
- Reduce drainage needs

An increase in crop quality and yield is most important. Irrigation scheduling provides for better use of labor and water with fewer restrictions on water deliveries during periods of peak water use. By proper management the farmer can reduce leaching of soil nitrogen and other soluble plant nutrients.

IRRIGATION DISTRICT - BENEFITS
- Control deliveries
- Reduced water demands
- Water savings
- Reduced drainage problems
- Computerized water records

Scheduling will improve the economic base associated with the irrigation enterprise in that an operational program enables better use of reservoir storage and reduces the load on the delivery system during periods of peak water use. With the use of the computer, the district will have the capability of forecasting delivery requirements and computerizing water storage and delivery records. IMS may reduce drainage requirements and associated problems. By controlling field and farm runoff, some of the district's maintenance requirements would be reduced.

NATIONAL - BENEFITS
- Improved agriculture economy
- Reduced environmental impacts
- Improved use of natural resources

An irrigation management program helps reduce adverse environmental effects from irrigated agriculture, such as salt loading of a river, while improving the utility of the natural resources, particularly where chemical fertilizer and pesticides are used. Irrigation management improves the economics of irrigated agriculture and provides needed information for planning and operation of irrigation systems.

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