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HOW SCHEDULING FITS IN THE IRRIGATION PROGRAM IN THE GRAND VALLEY OF COLORADO

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The Grand Valley is an irrigated area of about 26,000 hectares (65,000 acres) adjacent to the Colorado River near Grand Junction, Colorado (Soil Conservation Service 1977). Grand Junction is near the Colorado-Utah border due west of Denver, Colorado.

Implementation of the on-farm Grand Valley Salinity Control Program was initiated in January 1979. The program is authorized under Title II of Public Law 93-320. The purpose of this law is "to authorize certain works in the Colorado River Basin to control the salinity of water delivered to users in the United States and Mexico." Title I of Public Law 93-320 authorized certain works of improvement below Imperial Dam in southwestern Arizona. Some of these works of improvement have been completed or are under construction (Strand et al 1981). Title II of Public Law 93-320 authorized construction of four upstream projects on the Colorado River and studies on twelve additional projects. The Grand Valley Program is one of the four authorized projects. About 1.7 million dollars per year of U.S. Government funds have been used since 1979 to cost-share the installation of on-farm irrigation systems.

The Colorado River is one of the most used rivers in the world. The water supply is utilized in seven Colorado River Basin states for public water supplies, irrigation, and energy development.

The downstream states of Arizona and California have used most of their water entitlement, while the Upper Basin states are still developing their water rights. Each new irrigation project has the potential of increasing the salt content of the Colorado River because of the salt in the substratum below the irrigated land. Subsurface return flows dissolve this salt and carry it back to the Colorado River. Also, increasing irrigated acreage increases consumptive use and thereby increases salinity concentrations. Transmountain diversions in the upper reaches of the Colorado River also affect its salinity level. The water diverted in the mountains is quite pure; after diversion it is not available to dilute downstream Colorado River water supplies.

The purpose of Title II of Public Law 93-320 is to keep the salt loading of the Colorado River from increasing as water development is increased. This objective is being met through work in existing projects such as the Grand Valley Program.

The Grand Valley contributes 700,000 Mg (630,000 tons) of salt per year to the Colorado River. Of this total salt load, on-farm ditch seepage contributes

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145,000 Mg (130,000 tons) and on-farm deep percolation contributes 125,000 Mg (112,000 tons)(Keys 1981). Each dam^3 (0.8 acre-foot) of seepage from ditches or deep percolation of water below crop rooting depths carries about 3.7 Mg (3.3 tons) of salt back to the river in underground irrigation return flows.

AGENCY COOPERATION

The Agricultural Stabilization and Conservation Service (ASCS) provides cost-sharing to farmers through the Agricultural Conservation Program. The Soil Conservation Service (SCS) provides technical services. The Agricultural Research Service (ARS) provides technical expertise in several areas including monitoring of the installed on-farm systems and the semiautomation of surface irrigation systems. The Bureau of Reclamation (USBOR) assists in the monitoring activities and improves the canals and some of the laterals by installing concrete lining or pipelines. The Mesa Soil Conservation District (SCD) has taken the lead in information activities and in helping to shape local programs. Colorado State University (CSU) is assisting in the monitoring program and in ongoing research (Strand et al 1981).

ON-FARM PROGRAM

Water Management

Water seepage from on-farm ditches can be reduced by lining the ditches with concrete, installing gated pipe systems, and/or underground plastic pipelines to carry the required irrigation water.

Deep percolation of the irrigation water below the crop root zone can be reduced through effective water management techniques. Good Water Management has two basic requirements:

A. An irrigation system that can deliver irrigation water uniformly to the crop in the right quantity and at the right time.

B. An irrigator who knows and follows good water management principles and practices including:

    1. How to determine when water should be applied, based on the rate of water use of crops and on the stages of plant growth.

    2. How to measure or estimate the amount of water required for each irrigation, including the leaching needs.

    3. The normal time needed for the soil to absorb the required amount of water and how to detect changes in the intake rate.

    4. How to adjust stream size, application rate, or irrigation time to compensate for changes in such factors as intake rate or amount of water to be applied.

    5. How to recognize erosion caused by irrigation.

    6. How to estimate the amount of irrigation runoff.

    7. How to evaluate the uniformity of water application (Soil Conservation Service 1973).

Soils in 'and Valley are generally fine textured, such as silt loams and silty cl. s. Typically, furrow and corrugation irrigation systems are

used. Sprinkler irrigation has been evaluated in Grand Valley and is presented to landowners as an alternative irrigation system. Very few sprinkler systems are actually installed, however, because of high energy costs and soil characteristics. The soils of the Grand Valley are heavy enough to cause runoff from sprinkler irrigated land unless special designs are adapted to the site.

Soils in the Grand Valley do not correspond to the standard SCS intake families. Evaluations, discussed elsewhere in this paper, are being conducted to provide intake values that will be representative of Grand Valley soils.

Most farmers in the grand Valley also have jobs off their farms. Thus, the present practice is to change irrigation sets in the early morning or in the evening because of the inconvenience of changing sets at night or during midday. The result is 12-, 24-, or 36-hour set times.

The furrow equations used by SCS typically require 16- to 18-hour sets to apply a 7.5- centimeter net irrigation. The common practice of irrigating longer than is needed causes excessive deep percolation and salt loading in the Colorado River.

Semiautomated Irrigation Systems

Semiautomated surface irrigation systems allow flexibility in the set time because the farmer does not have to be present to change the water. The semiautomated equipment is generally quite simple. Mechanical and battery-powered time clocks are used to control equipment because electricity is not available in remote field locations. The most commonly used semiautomated surface irrigation systems are the ported ditch system and the gated pipe system.

Ported Ditch System: The ported ditch system is preferred by some farmers because of its permanence and ease of operation. Set widths are determined from SCS furrow equations and the farmer's historical water supply. Generally a flow rate of 0.6 to 0.9 liters per second (10 to 15 gallons per minute) is needed for each 75-centimeter (30 inch) spaced furrow. Typical water supplies vary from 0.03 to 0.09 cubic meters per second (1 to 3 cubic feet per second). Therefore, set widths vary from 25 to 110 meters (75 to 330 feet), widths of 25 to 45 meters are the most common.

The ported ditch system consists of a concrete-lined ditch that "stair steps" across the top of the field. Each section of ditch is installed at a uniform grade and its length corresponds to the width of an irrigation set. A grade of 0.10 percent is used to prevent sedimentation. Holes are drilled through the concrete lining and ditch berm, and 5-centimeter (2 inch) diameter plastic tubes are installed about 15-centimeters (6 inches) below the top of the ditch. The plastic tubes are long enough to protrude through the ditch bank and into the field area. An adjustable cover is installed on the tube inlets to provide flow adjustments through the ports. All ports are installed at the same elevation for each irrigation set.

The installation error in port elevations caused by mechanical difficulties in drilling through the concrete ditch lining is $\pm$ 0.75-centimeter ($\pm$ 0.25 inch) from level. Furrow flows are adjusted the first time the system is operated in the spring. The rate of advance of water down the furrow is observed, and the furrow stream size is adjusted to obtain as uniform a rate of advance as possible in all furrows. Trash plugging of ports does not appear to be a large problem.

"Drop-closed" or "drop-open" gates are installed at the downstre d of each ditch section. The normally open "drop-closed" gate is the common ditch check used. It is equipped with a timer that releases the at a predetermined time. The gate drops closed and moves the irrigation water one set upstream.

A minimum drop of 10 to 15 centimeters (4 to 6 inches) is installed at the downstream end of each ditch section. Thus, when the ditch check located just upstream of this drop is opened, the water surface is below the ports in an upstream section while flowing out of ports in a downstream set.

The normally closed, "drop-open" gates are used where irrigation is to start at the upstream end of the field. At the required set time the timer allows the gate to open and the irrigation head flows downstream to the next irrigation set, where the gate is closed.

Gated Pipe System: Another type of semiautomated irrigation system commonly used is the "flow-through" gated pipe system. Gated pipe is installed in sections on a "stair-step" grade similar to the ported ditch system.

A timer-controlled valve is installed in each section of pipeline corresponding to an irrigation set width. The timer is mounted on top of the check valve. The check valve, built by a local Grand Valley manufacturer, operates in the pipeline similarly to a "drop-closed" gate in a ported ditch. When released by a timer, the check valve closes and moves the irrigation water one set upstream. This type of valve has the disadvantage of causing a condition similar to water hammer in the gated pipeline. As the check drops into the water surface the water velocity slams it shut, causing the gated pipe to separate or rotate.

A spring-actuated butterfly valve has been developed by the second author and Grand Valley manufacturers to take the place of the check valve. This valve is also operated by a 24-hour mechanical timer. At a preset time the timer releases the butterfly valve and allows the irrigation head to proceed downstream to the next irrigstion set. This valve eliminates the shock associated with the closing of the check valve and also costs less.

The gated pipe is placed so that the gates are at about 30 degrees from vertical. This placement allows the water to flow beneath the open gates as open channel flow for downstream irrigation sets, so the gated pipe must be about one size larger than would otherwise be used. Thus, the gated pipe operates as both a water carrier and a water distribution system.

Water flowing out of the upturned ports sometimes causes erosion unless "erosion socks" are installed to dissipate the energy of the water. Erosion socks are made of fabric and held in place by a wire fastened around the gated pipe. The water falls into the sock and flows out onto the ground without causing serious erosion although the "erosion socks" sometimes kink and cause serious erosion next to the pipeline. An alternative erosion control method involves placing 5- to 6-foot wide sheets of plastic on the furrow side of the gated pipe. The water falls onto this plastic, which dissipates the water's energy without causing serious erosion.

Pneumatically controlled valves are also used in gated-pipe irrigation sets. Portable air tanks are used to provide the high-pressure air supply. Water pressure is used to control valve changes in a commercially available valve.

"Cablegation" is a new technique being tested in the Grand Valley. In "cablegation" a polyvinyl chloride pipe is placed on a constant grade and is buried so that the top is about even with the ground surface. Orifices spaced to correspond to furrow spacing are drilled in the top of the pipe. The pipe is sized to carry the full water supply without filling the pipe to the top. A geared down electric motor controls the rate of movement of a plug on a cable inside th[illegible]e which forces the water out of the pipe. As the plug moves downstream, [illegible]ad" on each orifice decreases, thus decreasing furrow flow rates (K[illegible] et al 1980).

MONITORING PROGRAM

The SCS contracted with ARS to provide monitoring services for the on-farm program in Grand Valley for calendar year 1980. This contract has been renewed for 1981. The purpose of the monitoring effort is to determine how effective the on-farm program is in reducing salt loading of the Colorado River.

The monitoring service is provided by CSU under contract to ARS. Water budgeting is used to determine the amount of deep percolation of water in irrigated fields. Deep percolation is the amount of water applied to the field minus tailwater runoff, and crop consumptive use, plus effective rainfall. Effective rainfall is precipitation falling during the growing period of the crop that is available to meet the consumptive water requirement of the crop. The leader of the Grand Valley on-site monitoring team has a desk in the SCS office. This location promotes frequent exchanges of information.

SCHEDULING PROGRAM

A SCS water-management technician was assigned to the Grand Valley on May 1, 1981. This technician helps landowners and operators to obtain proper water management on farms that have improved irrigation systems. Thirteen farmers were selected for this year's scheduling program. The basis for selection included the possession of fields with different soils, the production of different crops, and the farmer's willingness to participate in this program.

After the farms are chosen, the semiautomated equipment installed under the salinity control program is evaluated to determine that it is all in working order and is properly used. The second step is to evaluate the furrow irrigation systems. This evaluation consists of running furrow trials on several irrigations to determine intake families and how they vary from irrigation to irrigation. Information is also gathered on advance-recession time and depth to which irrigation water penetrates the soil at several locations in the field.

Soil augers and probes are used to determine the depth of water penetration after all gravity water is drained out of the soil profile. Water penetration is checked in at least five locations in each irrigation set. The locations monitored are at the center of the field and in the four corners. A distance of 30 meters (100 feet) is paced diagonally from the corner of the field towards the center. The resulting points are the approximate locations of the four corner checks. The effects of seepage from headwater and tailwater ditches on soil profile wetting are minimized at these locations. Different soils, unusually flat lands or steep slopes in the irrigation set, are also checked for water penetration.

Early research by CSU and ARS in the Grand Valley indicated that the first two irrigations of the season contribute the most deep percolation (Evans et al 1978). These early irrigations are on soils that are not yet water compacted and are, therefore, loose and easily penetrated by the irrigation water. The furrow intake rate is highest on the first irrigation and somewhat lower on the second irrigation. Later irrigations have lower intake rates than the first two but do not vary much from one another. Knowing how the intake rate varies will help SCS personnel to better design furrow irrigation systems.

The third step in the water management program is the irrigation scheduling. Proper scheduling of irrigations in the Grand Valley keeps the soil moisture level between 50 percent and 100 percent of field capacity with minimum deep percolation. Farmers can obtain maximum crop growth while red[illegible] deep percolation to the minimum needed for the necessary leaching fra[illegible] Farmers are being shown how to determine when to irrigate and how much water to apply to minimize excessive deep percolation.

A combination of the "bookkeeping" method and soil moisture monitoring is used in scheduling. Daily consumptive use is deducted from the maximum amount of water that can be extracted from the soil. Several days before the bookkeeping account shows that it is time to irrigate, soil moisture in a number of locations in the field is examined for verification. The account is adjusted if there is a significant difference.

SUMMARY

The Grand Valley contributes 700,000 Mg (630,000 tons) of salt per year to the Colorado River. The Grand Valley Salinity Control Program was implemented in January 1979 to help farmers improve their irrigation systems. Good water management reduces deep percolation of water below crop root zones, thus, salt pickup is reduced in subirrigation return flows to the Colorado River.

SEMIAUTOMATED IRRIGATION SYSTEMS

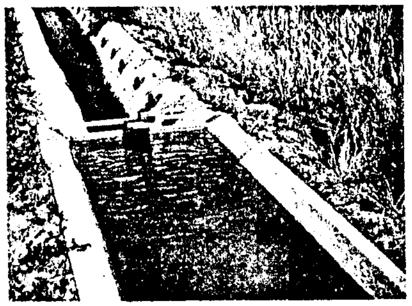


Fig. 1. Ported Ditch System

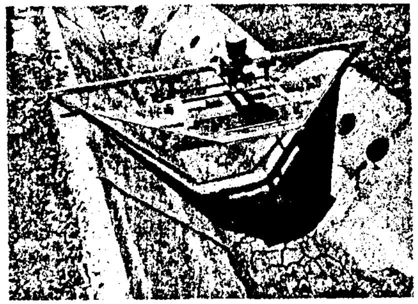
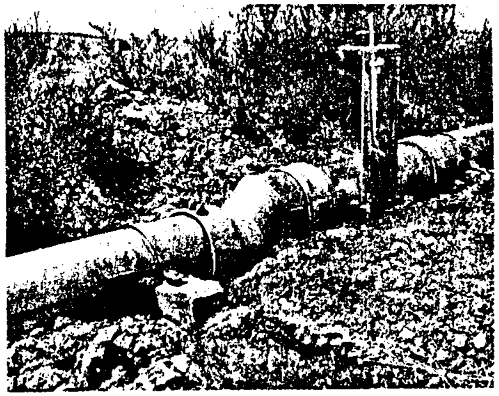


Fig. 2. "Drop-closed" Gate



g. 3. Semiautomated Gated Pipe System

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