Rice Irrigation Systems for Tailwater Management

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Rice Irrigation Systems for Tailwater Management

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Conventional, Flow-Through Irrigation System

The conventional irrigation system is also known as a "flow-through" system, because water is usually supplied serially from the topmost to the bottommost basin (check or paddy) and is regulated by adjustable wooden weirs or rice boxes (*fig. 1*). Spillage from the last weir, usually into a drain, is necessary to maintain water levels across all basins.

Rice boxes are placed about 4 inches below field grade, at one or both ends of each levee separating the basins within each field (*fig. 2*). Water level within the basin is regulated by adding or removing boards in the weir structures.

Initial flooding may take 3 or more days at maximum water-flow rates. Flow rates for field maintenance then decline to between 2 and 3 cubic feet per second per 100 acres.

Because of the large water surface area of the fields, precise water management can be difficult. To correct the depth in any particular basin, water must be introduced at the top of the field and then moved through all of the basins. To drain a basin in the middle of the field, the basins below it are often drained. Such changes can require a number of days to complete since many basins are involved.

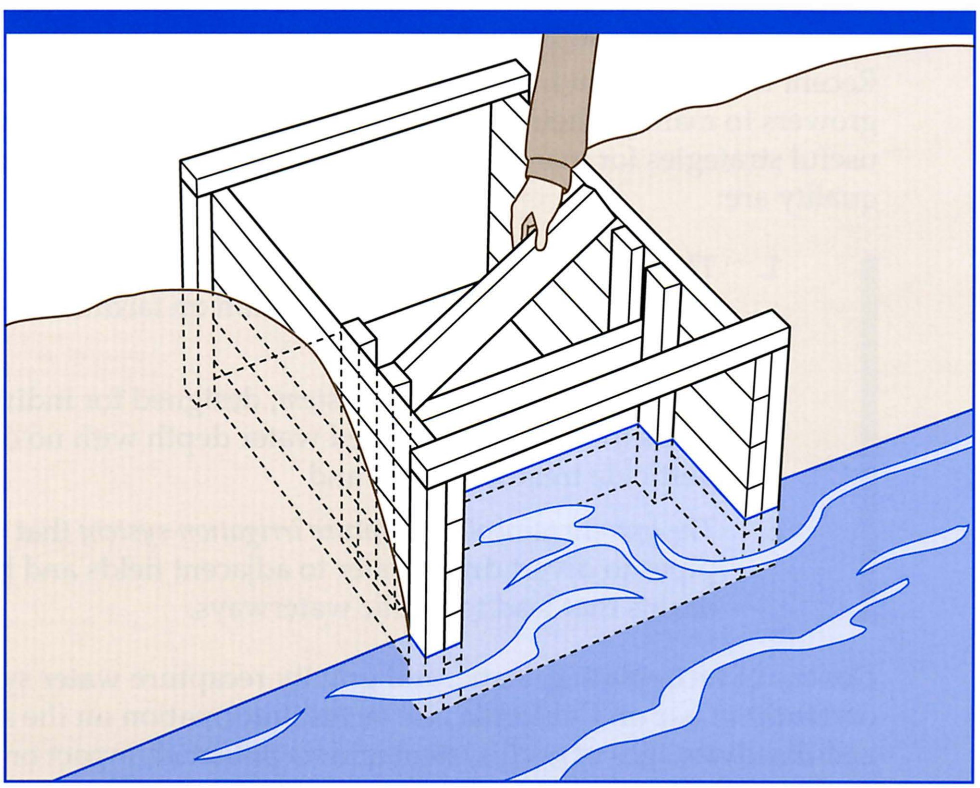

FIGURE 1. *A wooden rice box (weir) placed in a levee between adjacent basins.*

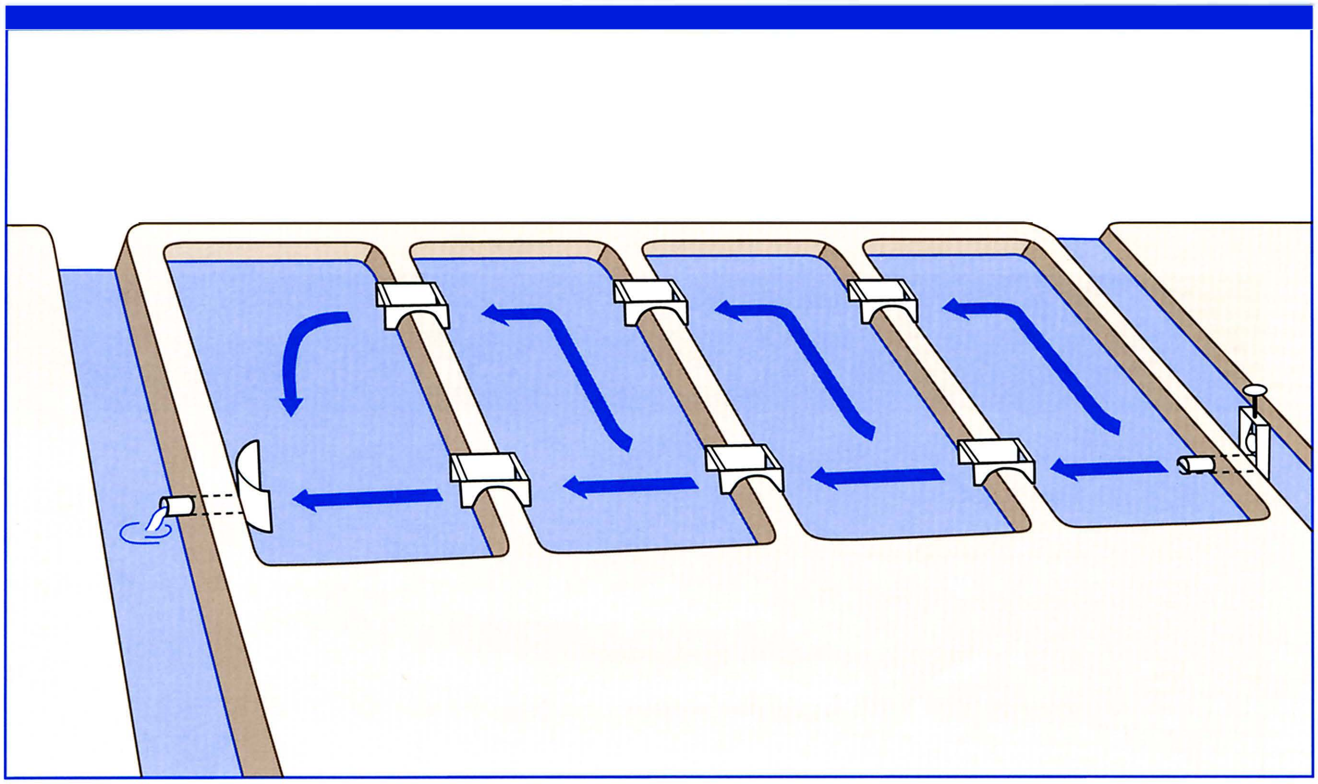

FIGURE 2. Schematic diagram of a conventional flow-through irrigation system.

The constant addition of cool water in the top basins often delays rice maturity and adversely affects yield in areas close to the inlet. Occasionally, a warming basin is used to mitigate these adverse affects. Additionally, introduction of water into the field too soon after an application of the herbicide LONDAX can result in poor broadleaf and sedge weed control in the top basins.

Because the water needs of every field vary with temperature, wind, relative humidity, soil type, and plant growth stage, spillage of water from the bottom basin is often necessary to maintain a desired water depth. In practice, to avoid underestimating water requirements, spillage rates can be high. It has been estimated that 20 percent or more of the water used for irrigation with a conventional system is spillage.

To keep spillage to a minimum growers precision level their fields to very flat slopes, thus improving water control. Current state regulations requires a no-drain (holding) period after pesticide applications. Producers manage this no-drain period by building up the water depth, blocking weirs, and restricting inflow, thereby creating a temporary static situation. Holding water can be difficult in conventional systems, because water tends to move downslope resulting in excessive water depths in the lower basins, and exposure of soil in upper basins. Occasional spring rains may raise water levels even more.

In summary, the flow-through system was designed to be self-regulating and was not intended for holding water as current regulations require. Growers can "block-up" fields and basins during mandatory water holding periods, but this limits water management options and is not always effective in keeping water from building up in the bottommost basins. Table 1 presents some of the advantages and disadvantages of flow through systems.

Table 1: Conventional flow through irrigation systems for rice production in California

ADVANTAGES

- ✓ Low cost
- ✓ Low management if water holding is not required
- ✓ Flushes salt from fields
- ✓ Easy to install, maintain, and remove
- ✓ Works well with irregular slopes

DISADVANTAGES

- ✗ Flow-through spill carries agricultural chemicals into public water
- ✗ Excess water may build up in bottom basins and water in the top basins may get too shallow during the water holding period.
- ✗ Requires careful water management during water holding period
- ✗ When many basins are interconnected, the large water surface area makes precise water management difficult
- ✗ In some areas, constant addition of cool water slows rice development in the intake basin and adversely affects grain yield and quality

Recirculating Tailwater Recovery System

Recirculating tailwater recovery systems facilitate the reuse of drainage water and help keep pesticide residues out of public waterways. Early recirculating tailwater recovery systems for rice were used to conserve water and were installed primarily in areas where water was in short supply or expensive. When pesticide-use restrictions mandated longer water-holding periods, the transition to completely closed systems was relatively easy for growers who already had recirculating systems. Although many of these systems have been developed for single farms, some neighbors share systems and some irrigation districts have developed districtwide recirculating systems.

Recirculating systems have been installed on only a small portion of the approximately 400,000 acres of rice in production in California. They are, however, gaining greater acceptance because they provide maximum flexibility for rice irrigation and require a shorter field water-holding period, after herbicide applications, than do growers who use conventional systems.

Small recirculating systems consist of a lowlift pump that picks up tailwater from a sump and delivers the water to the top of the field by pipe or ditch (*fig. 3*). Larger multi-field and multi-farm recirculating systems use pumps to pick up tailwater from the lowest elevation of the system and return it to supply ditches.

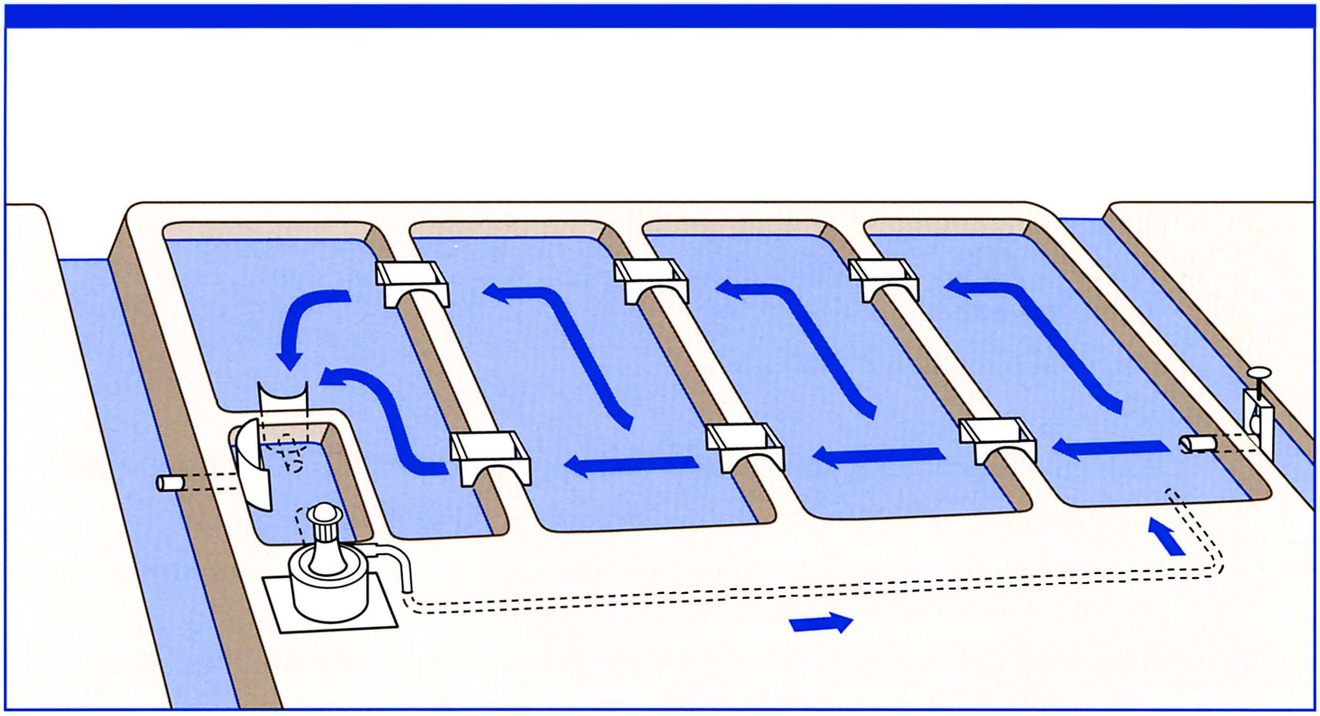

FIGURE 3. *Schematic diagram of a recirculating tailwater recovery system.*

Power for tailwater pumps may be supplied by electric motors or internal combustion engines where electricity is not available. Electric motors have the advantage of automatic start-and-stop control operated from float switches. Pumps are used to lift the tailwater either directly to the field or into a highline ditch. Water then flows via gravity back through the irrigation system.

To obtain optimal performance from a larger recirculating system, fields should be laser-leveled and the flow of water directed to drainage ditches leading to the main drain. The depth of water in each basin is controlled by conventional rice boxes.

The cost associated with construction and operation of a recirculating system depends upon the acreage served by the system, the slope of the land (the smaller the lift between the low and high point, the lower the pumpimg cost), and the layout of the fields (whether ditches will serve to recirculate all the tailwater, or whether pipelines are needed). System size has been found to greatly affect per-acre cost of recirculating systems. For example, observed costs have ranged from $20 per acre for a 1,000-acre system to $150 per acre for an 80 acre system (1990 costs).

Table 2 presents the advantages and disadvantages of a tailwater recovery or recirculating irrigation system.

Table 2: Recirculating tailwater recovery systems for rice production in California

ADVANTAGES

- ✓ Tailwater and pesticide residues can be contained in the system
- ✓ Best water management flexibility of all systems, especially during water holding period
- ✓ Recirculation reduces cold water effects on rice and the need for a warming basin
- ✓ Fewer problems than a flow-through system with seasonal shortages of irrigation water
- ✓ Potential reduction in water bill

DISADVANTAGES

- ✗ High cost of purchase, construction and operation of tailwater recovery system
- ✗ Requires land set aside for tailwater storage (pond or drainage canal)
- ✗ When many basins are interconnected, the large water surface area makes precise water management difficult
- ✗ High degree of management required to balance intake with use, since drainage is eliminated as a "safety valve"
- ✗ Weeds must be controlled in tailwater storage area

Static Water Irrigation System

The static water irrigation system keeps pesticide-treated water out of public drains and eliminates the need for a tailwater sump and return pump as used in the recirculating system. This system independently controls inflow water into each basin and limits it to the extent required to replenish the water lost to evapotranspiration and percolation. It also eliminates the possibility of spillage of field tailwater into public drains. This is a recent innovation in rice irrigation.

The static system consists of a supply/drain ditch that runs perpendicular to the levees in the field, serving each basin independently (*fig. 4*). The ditch is separated at each levee by flashboard drop pipes that control ditch and basin water depths (*fig. 5*). Water enters each basin near these drop pipes through flap-gated inlet pipes. The flap gates allow water to enter each basin when water in the supply ditch is higher than in the corresponding basin. However, when water in the ditch is lower than the basin, the flap closes and prevents reverse flow from the basin (*fig. 6*). This keeps treated field water out of the supply ditch. Because the supply ditchwater is fresh, it generally does not contain any pesticide residues from the field. Therefore, any excess spill from the ditch is clean water.

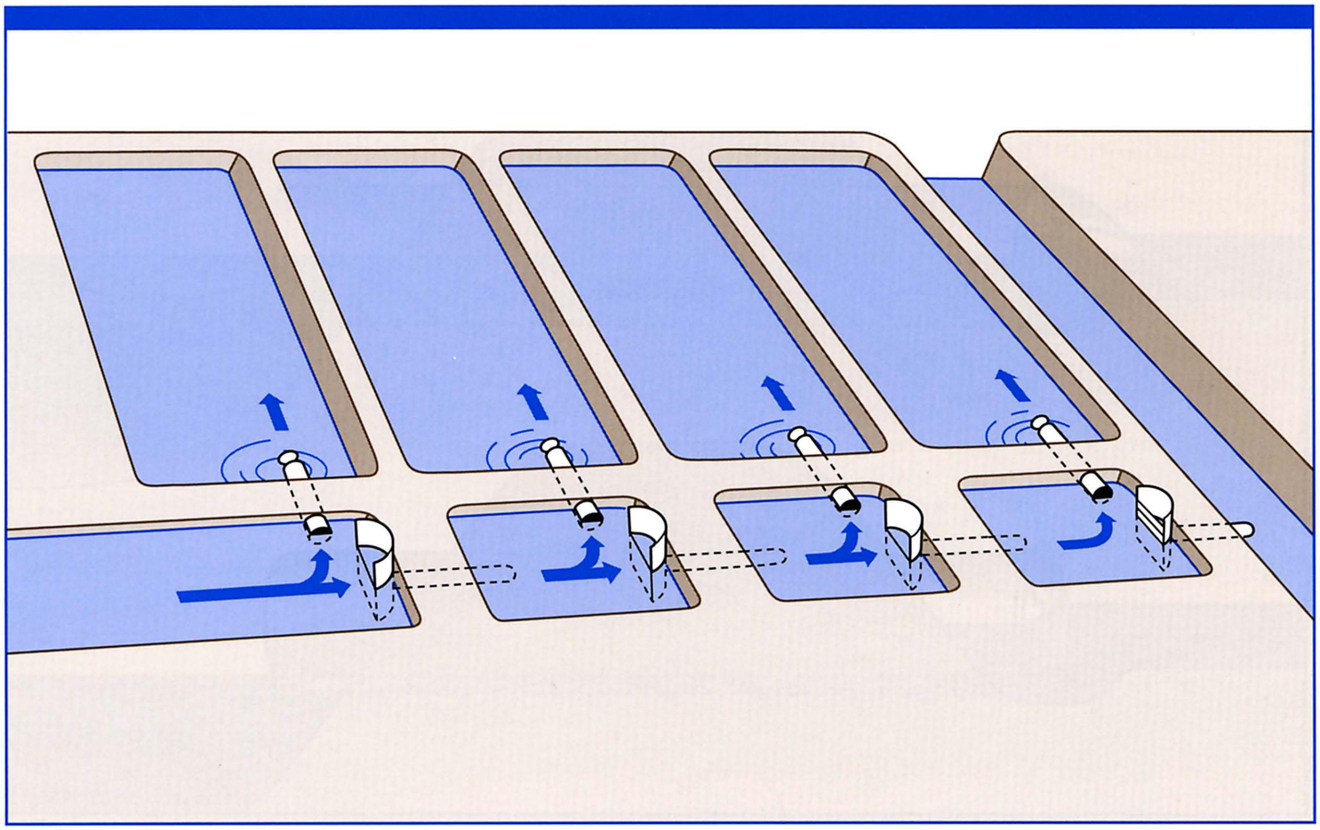

FIGURE 4. *Schematic diagram of a static water irrigation system.*

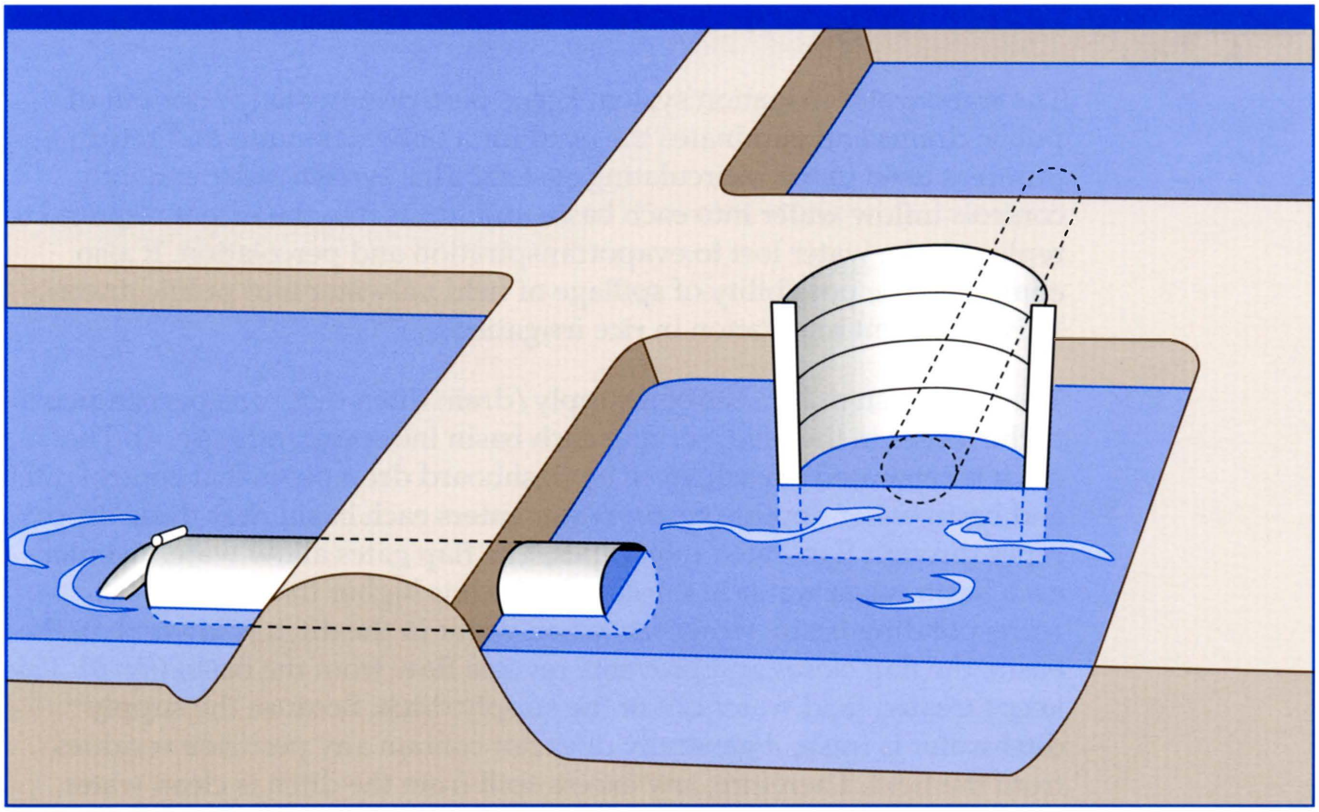

FIGURE 5. Flashboard drop pipe in the supply ditch.

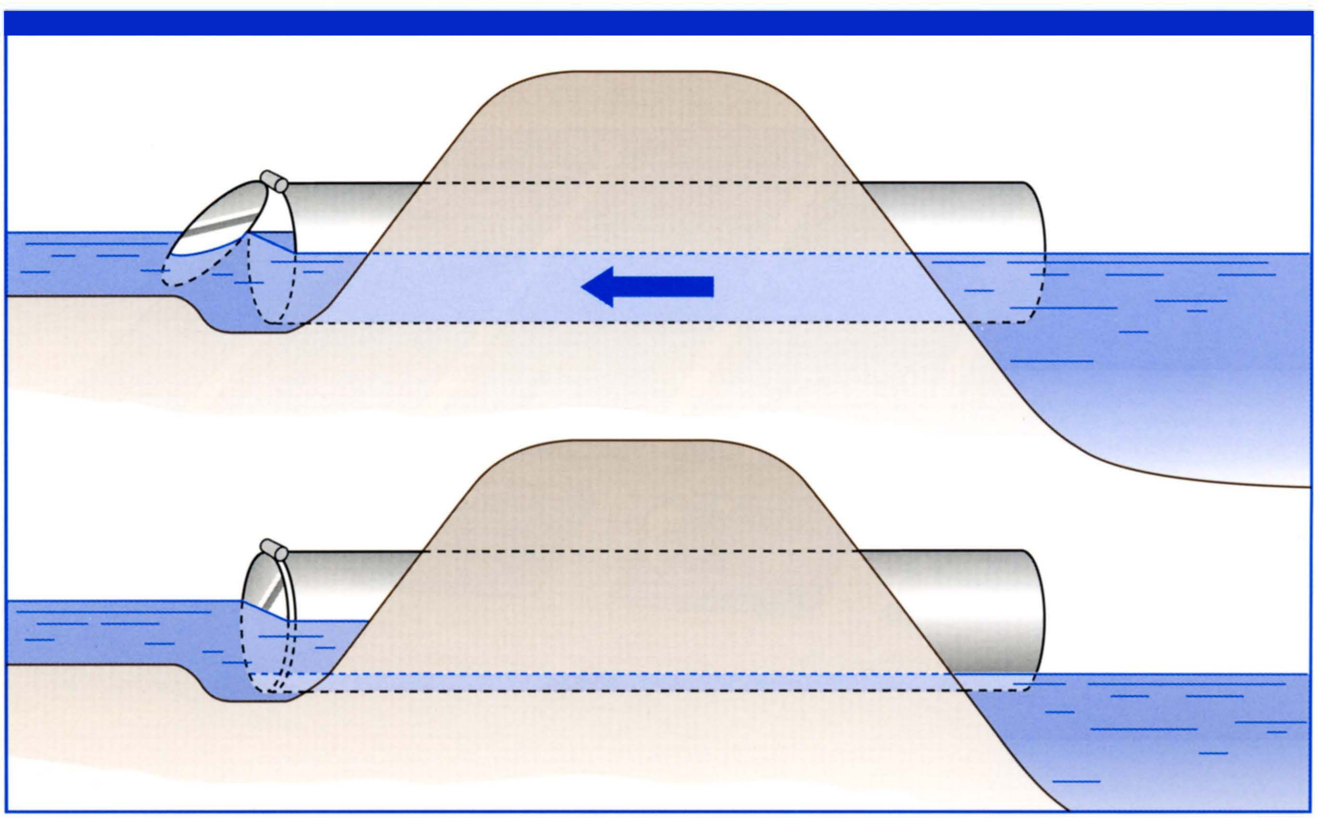

FIGURE 6. Flap-gated inlet pipe in the static water irrigation system.

In an emergency, all or part of the supply ditch can also be used as a drain. The weir boards from the ditch drop pipes can be pulled and the inlet flaps propped opened manually to allow field water out. Under these circumstances, and at harvest, the ditch serves as a drain.

This system has several advantages over other irrigation systems. Basins flood faster than other irrigation systems due to multiple inlets, which also allow for more precise and independent irrigation of individual basins. Water changes can be initiated almost immediately and completed without affecting the water in neighboring basins; thus management flexibility is increased.

Because inflow water is partially warmed in the supply ditch and does not flow through and out of the basin, the deleterious effects of cold water on rice may be minimized and the need for a warming basin may also be eliminated. Herbicide efficacy may be improved since field water flow is greatly reduced.

Disadvantages of this system include land out of production for the ditch and the need to control weeds in the ditch. Also, the system may not provide adequate flushing in fields with alkali soil or that utilize irrigation water high in salt. Costs of the static irrigation system are associated with the construction of the supply/drainage ditch, the flashboard drop pipes, and flap-gate inlet pipes (one of each for each basin). The cost of installing this system has averaged $95 (1990 dollars) per acre for 6- to 10-acre basins. Cost per acre should drop proportionately for larger basins. There are no pumping costs as for recirculating systems.

Table 3 presents the advantages and disadvantages of a static water irrigation system.

Table 3: Static irrigation systems for rice production in California

ADVANTAGES	✓ Tailwater and pesticide residues can be contained on the field during growing season ✓ Costs of recirculating pumps is eliminated ✓ Independent control of each basin provides greater management flexibility ✓ Precise water management is easier than other systems ✓ Agricultural chemicals stay where applied; herbicide effectiveness is improved ✓ Well suited for LONDAX application specifications ✓ Less cool water inflow may reduce cold water effects on rice and the need for a warming basin ✓ Crayfish burrowing around irrigation inflow structures may be reduced
DISADVANTAGES	✗ Ditch construction, flashboard drop pipe, and inlet pipes with flaps are costly ✗ The supply/drain ditch reduces land area available for crop production ✗ Reduced flushing of salts may be a problem on some soils ✗ Irrigation system is not suitable for many rotation crops because fields should be leveled to zero grade ✗ Weeds must be controlled in supply/drain ditch

Gravity Tailwater Recapture Irrigation System

The gravity tailwater recapture irrigation system utilizes pipes and gravity flow to divert tailwater from field to field thereby keeping drain water and pesticide residues out of public waterways. This system can be installed on single farms with multiple adjacent fields or among cooperative neighboring farms. These systems, relatively low in cost, are highly effective.

In the gravity-recapture system, water flows by gravity, eliminating tailwater pump and sump. Bypass drain pipes in upstream fields are installed in the bottommost basin for maximum effectiveness (*fig. 7*). The pipe can enter the downstream field at any point, although entry into the upper portion of the field allows the greatest flexibility. Drop pipes can be used to connect fields separated by drains, farm roads or air strips, while inverted siphons can be used under irrigation ditches. This system is particularly cost-effective for fields with significant elevation differences, where return systems are apt to be more expensive.

The cost associated with this system is the installation of drop pipes across drainage courses. A gravity system can be installed on several adjacent fields with a small tailwater recovery system to recirculate water in the last field.

Table 4 presents the advantages and disadvantages of a gravity tailwater recapture irrigation system.

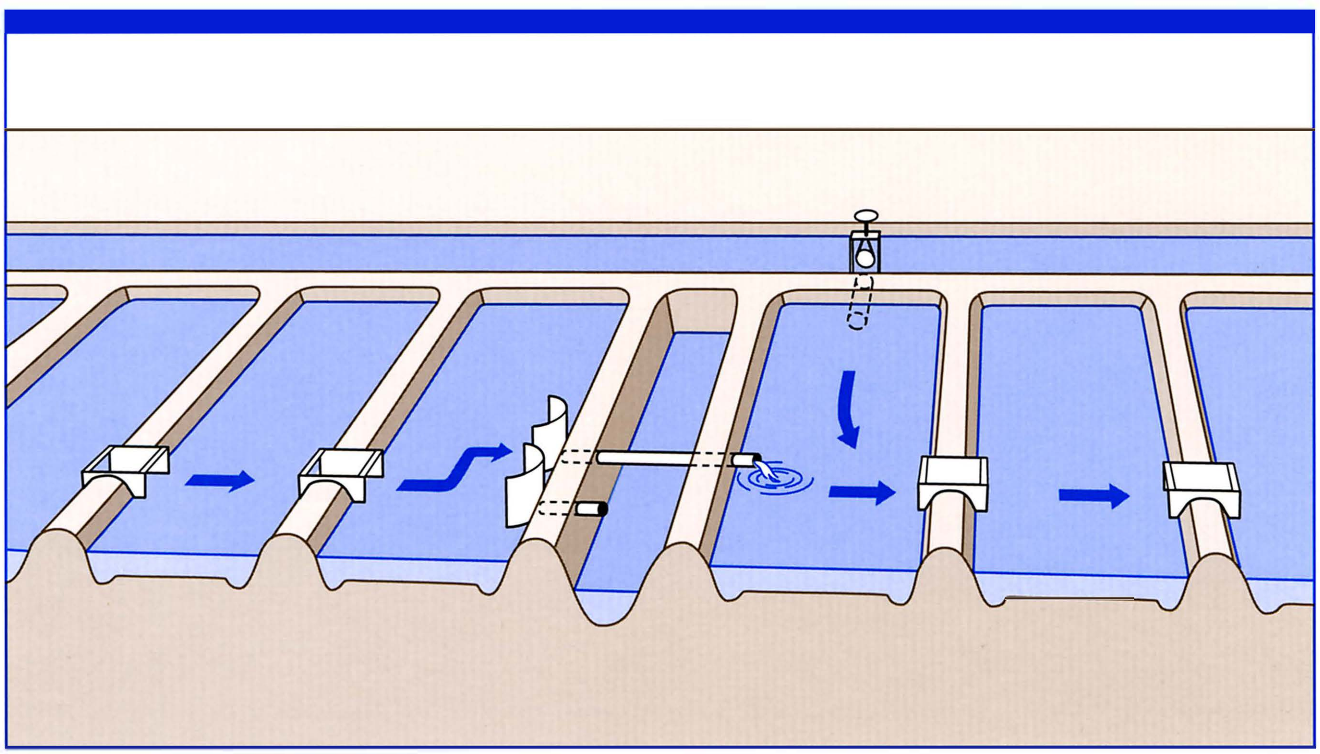

FIGURE 7. Schematic diagram of a gravity recapture system.

Table 4: Gravity Recapture Systems for Rice Production in California

ADVANTAGES

- ✓ **Tailwater and pesticide residue containment is improved**
- ✓ **Provides management flexibility during water holding periods**
- ✓ **Low construction and operation cost**

DISADVANTAGES

- ✗ **When many basins are interconnected, the large water surface area may make quick and precise water management difficult**
- ✗ **Requires coordination of water among many fields and may require neighbors to synchronize management with respect to pesticide applications and other cultural practices**
- ✗ **System is not completely closed and may allow some tailwater and pesticide residue to enter public waterways**

The Float Valve Rice Box

The conventional irrigation system can be improved by replacing the conventional rice weir with a "smart box." A smart box operates on the same principle as a toilet tank or a horse-trough valve. It consists of a float valve, mounted on the downstream end of a pipe that passes through a levee to connect adjacent rice basins. The float valve allows only enough water to pass through the pipe to maintain the desired water depth on the downstream side. An entire series of basins can be self-regulating, with respect to water depth, as long as inflow is not limiting.

The plastic container or float of a smart box is adjusted so that it opens and closes a vertically-hinged butterfly valve (*fig. 8*). When the water in the downstream basin is low, the plastic container floats downward and opens the flap gate, allowing water into the basin. When the water depth reaches the set level (adjustable by adding or removing water from the hollow plastic float) the container floats upward, closing the valve: water cannot enter the basin. As long as a source of water is available to the topmost basin, the series of basins is self-regulating. Each basin takes in water as needed, and shuts off when the desired water depth is reached, thereby eliminating much of the day-to-day management associated with traditional flashboard weirs. Once smart boxes are properly adjusted, no spill should occur from the bottommost basin.

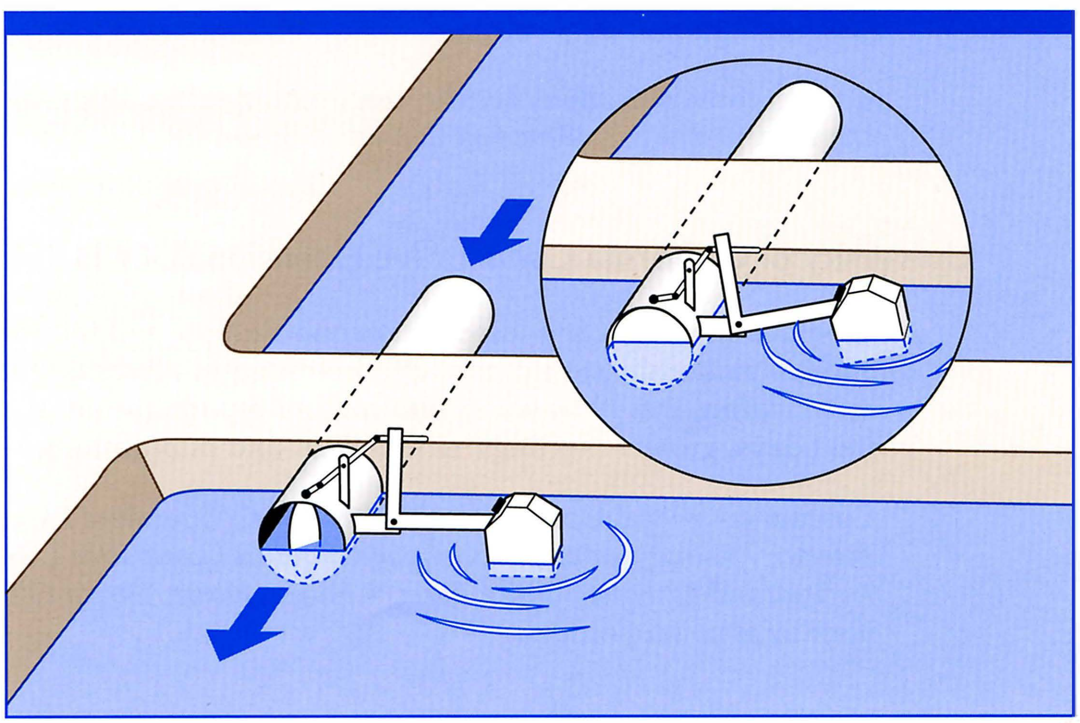

FIGURE 8. Close up of a float-valve rice box between two basins.

Sources of Information on System Design and Cost Sharing

Agricultural Stabilization and Conservation Service (ASCS)

ASCS conservation programs provide cost-share assistance to rice producers who wish to install improved water management systems. The special water quality conservation program (WC-4) provides a 75 percent cost share up to a maximum of $3,500 (1991) per farm per year. However, farmers who cooperate with each other to build multi-farm recirculating systems are eligible for up to $10,000 per farm per year. Multi-year "long term agreements" is an option that allows growers to receive $3,500 each year for phased construction. For projects constructed in phases, each phase must be operational on its own during the year constructed.

Contact local ASCS office. See directory listing under *U.S. Government, U.S. Department of Agriculture, Agricultural and Stabilization and Conservation Service.*

The Soil Conservation Service (SCS)

Provides survey, design, layout and follow up management recommendations. SCS also provides engineering assistance under the ASCS cost-share program.

Contact local SCS office. See directory listing under *U.S. Government, U.S. Department of Agriculture, Soil Conservation Service*

University of California Cooperative Extension (UCCE)

Provides education and information on irrigation and tailwater management and its relationship to rice farming. Investigates agronomic effects of recirculating and static water systems and reports the latest information via field days, grower meetings, newsletters, and publications.

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