

Irrigation Return Flow

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"Irrigation return flow" is that portion of water which returns to its source after being used to irrigate crops. A good example is found in the Texas rice industry, where water is usually diverted from a river, used to flood the field and then released back into the river before harvest. With increasing environmental concern, the term "irrigation return flow" has been extended to include irrigation water that makes its way to any body of water after its use on a crop.

There are many examples of this broader definition in Texas. Tailwater from furrow irrigation and runoff caused by excessive irrigation or poor system design can make its way into small creeks and draws which eventually lead to our major rivers and reservoirs. Water from irrigated land that is artificially drained must go somewhere, often into the same river it was taken from or to major drainage outlets which flow into coastal bays.

Irrigation return flow is becoming an important issue because of its potential to be a nonpoint source of pollution. However, this is not the only reason irrigators should use return flow management practices. Excessive runoff is a symptom of poor irrigation system design or poor management of irrigation water. It is also water wasted. Wasting water not only has immediate financial ramifications, but also threatens the long-term availability of water for irrigation. Sound management practices can reduce irrigation return flow while ensuring the most efficient use of our water resources.

Pollution Transport

The major concern is the direct runoff which may occur from irrigated land. Many of the fertilizer nutrients and chemicals used in agriculture, as well as soluble salts contained in the irrigation water, are easily adsorbed onto soil particles. When runoff occurs, soil particles containing these adsorbed pollutants are picked up and transported out of the field. Eroded sediments constitute the major potential for pollution from surface return flows. In addition, soluble chemicals are dissolved by runoff and carried with the water as it flows over the soil.

In some parts of the country, there is concern over subsurface return flow, particularly where

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basin and border type irrigation is practiced. These systems produce little soil loss, but can result in soluble salts and dissolved fertilizers and pesticides moving through the soil with the irrigation water. In Texas, most subsurface return flow problems result from unlined water delivery and drainage ditches. Saline seeps and improper leaching practices also contribute to the problem.

Preventing Return Flow

There are three basic approaches to eliminating pollutants in surface return flows:

1. eliminating or reducing surface runoff;
2. eliminating or reducing soil loss; and
3. removing pollutants from irrigation return flow.

The first two approaches are achieved by properly designing, operating and managing irrigation systems. Following the directions on the pesticide label will usually solve any problems associated with chemigation, the application of agricultural chemicals through the irrigation system. The third approach involves the use of grass buffer strips, artificial wetlands, settling basins and ponds, and similar structures to remove pollutant bearing sediments. Treating return flow is more costly and troublesome than preventing it.

Practices which may be used to reduce subsurface return flow include:

1. proper leaching; and
2. impervious conveyance systems.

Many factors determine which practice or practices would be best in a given situation. Some of these are listed in Table 1. The objects of any management program are to diminish or prevent pollution caused by return flows, conserve water resources, reduce erosion, maximize the effectiveness of chemicals and increase the profitability of irrigated agriculture.

Table 1. Factors affecting the selection and effectiveness of practices for preventing irrigation return flow.

■ climate
■ topography
■ degree of control required
■ type of irrigation system
■ type of problem pollutant involved
■ environmental and economic impacts of a control practice



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Irrigation System Design

Factors that should be considered in the design of irrigation systems are listed in Table 2. The goal is to provide enough water to meet crop demand without causing runoff. The capacity of the irrigation system is usually based on the peak water needs or consumptive use of the crop.

Table 2. Principal data needed for farm irrigation system design.

Data	Specific Requirements
Crop	Distribution and area of each crop to be grown; suitability of each crop to climate, soils, farming practices, markets, etc.; planting dates of each crop to be grown over the expected life of the project.
Soils	Area distribution of soils; water holding and infiltration characteristics, depth, drainage requirements, salinity and erosion potential of each soil.
Water requirements	Daily and seasonal water requirements for each crop.
Water supply	Location of water source; amount of water or pumping capacity; water surface elevation; hydrologic and water quality information for assessing the availability, costs and suitability of the water for irrigation; and water rights information.
Energy source	Location, availability and type of source(s); cost information.
Capital and labor	Capital available for system installation, operation and management; level of technical skill and cost of labor.
Other	Topographic map showing location of roads, buildings, drainways and other physical features that influence design; financial situation of farmer; farmer preferences.

Sprinkler and Drip Irrigation

Emitters and nozzles should be sized so that the irrigation application rate does not exceed the water intake rate of the soil. For center pivot systems, conservation practices such as furrow diking and planting in a circle may be needed.

Basin and Border Irrigation Systems

Basin and border irrigation are used on flat land or land which has been artificially leveled. As a result, these systems normally produce little erosion. However, these systems can lead to pollution from dissolved chemicals if they are not managed properly. Field and border levees should be maintained at a grade and height to provide maximum freeboard water storage capacity, such as a 4-inch freeboard. The volume of return flow can be minimized by avoiding the continuous discharge of water from the system. Irrigations should be reduced long enough before harvest so that evaporation and plant consumptive use will reduce the amount of water in the

field. Chemicals and fertilizers should be applied when water levels are as low as possible, and flood waters should be retained for as long as possible after the application of chemicals.

Furrow Irrigation

Furrow irrigation is used on more than half the total irrigated land in Texas. Proper system design improves the distribution and uniformity of applied water, reduces water use and produces higher yields. The U.S. Soil Conservation Service (SCS) has developed furrow system design standards and guidelines, based on soil type, for most areas of the state. The important factors are proper slopes, proper stream size and proper furrow run length. Furrow run length and stream size both depend on the slope, and should be selected to minimize tailwater while providing a good distribution of water in the entire furrow.

Proper slopes – Excessive slopes may cause severe erosion that transports sediment and adsorbed pollutants. Slope recommendations for reducing return flows vary from location to location because of differences in soils and rainfall conditions. Generally, furrow grade should not exceed 0.8 percent. In areas of intense rainfall, furrow grades may need to be 0.5 percent or less. Proper slopes sometimes can be obtained by changing the direction of the furrows. On smooth, uniformly sloping fields, furrows may be run across the slope of the field as long as they are deep enough and the soil stable enough so that irrigation water or rainfall runoff does not break over one furrow to another. In other situations, land leveling may be the only method of obtaining proper slopes.

Proper stream size – Proper stream size may prevent potential erosion. For graded furrows, the stream size should be kept as small as possible to provide reasonable efficiency while minimizing soil loss. From an erosion standpoint, the maximum stream size in gallons per minute (not to exceed 50 gpm) can be calculated as:

$$\text{stream (gpm)} = \frac{10}{\text{percent furrow slope}}$$

Cut back irrigation and surge – An effective practice for reducing tailwater is the use of cut back irrigation. A greater initial flow is normally required to push the water to the end of the furrow. Once the water has reached the end of the furrow, the stream size is reduced or cut back so that the flow corresponds more closely to the intake rate of the soil. A less labor intensive practice is to use automatic surge valves to release water into the furrow in a series of on-off cycles; this can reduce tailwater and improve distribution efficiencies. Surge irrigation appears to work because of the natural surface sealing properties of many soils during wetting and drying cycles. Properly managed surge irrigation has been found to increase efficiencies from 6 to 30 percent over nonsurge furrow irrigation, depending on soil type.

Proper furrow run length – Run length and furrow stream size are closely related. The stream size must be large enough to meet the infiltration requirements of the entire furrow length. Decreasing the run length therefore decreases the required stream size. This reduces erosion and tailwater, thus minimizing potential return flow problems. A general rule is that the run length should be such that the furrow stream will reach the end of the furrow before approximately one-fourth of the total application has entered at the head of the furrow.

Tailwater Recovery

A basin or pond located at the lower end of an irrigated field can be used to catch surface tailwater. The water can be returned to the top of the field or conveyed to a different field for reuse. This practice eliminates surface return flow and prevents pollutants from entering streams. The tailwater recovery system is normally designed to safely bypass rainfall runoff due to the extra costs of providing storage if all water was collected. Debris basins or settling channels can be used to reduce the amount of sediment entering the basin or pond.

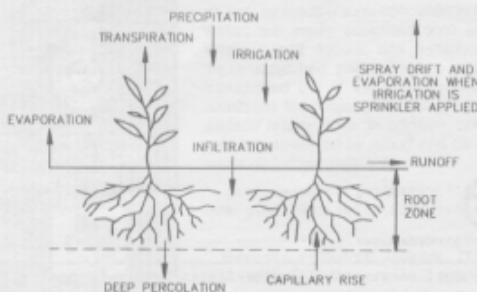
Impervious Conveyance Systems

Seepage losses from unlined canals and ditches commonly range from 20 to 40 percent of the total flow and may carry dissolved pollutants. Lining ditches with concrete or flexible membranes will prevent seepage losses, often saving enough in water costs to more than pay for the lining materials. Unlined canals are sometimes acceptable in heavy clay soils with low infiltration rates.

Transporting irrigation water through pipelines has proven to be the most trouble free and cost effective method. Gated pipe in furrow irrigation can reduce water and labor costs 35 to 50 percent over siphon tubes and unlined canals. As with other return flow management practices, reducing seepage losses not only helps prevent pollution problems, but has direct economic benefits.

Irrigation Water Management

Proper irrigation water management means timing and regulating water applications in a way that will satisfy the needs of a crop and efficiently distribute the water without applying excessive amounts of water or causing erosion, runoff or percolation losses (Fig. 1). Good irrigation water management can reduce moisture extremes and associated plant disease problems, which in turn may reduce the need for pesticides. The irrigator should have a good understanding of the factors influencing proper irrigation scheduling and water management (Table 3). The timing of irrigations and the total amount applied per irrigation should be based on both the crop's water use and the moisture content of the soil, as well as on expected rainfall and any additional amounts needed for leaching to maintain a specific salt balance. Monitoring soil moisture with gypsum blocks or tensiometers can help take the guess work out of irrigation scheduling.



Irrigation return flow.

Cultural Practices

Many cultural practices can reduce erosion and runoff. Proper use of chemicals to control weeds may reduce the number of cultivations required, thereby reducing erosion. Crop residues left on irrigated land reduce erosion by decreasing water velocity and increasing infiltration. Conservation tillage can be adapted to irrigated land and is showing promise for decreasing erosion. Furrow diking (sometimes called reservoir tillage) for row crops and chain diking for forage crops are very effective at preventing runoff and retaining rainfall. Alternate furrow irrigation is a viable option for soils which permit adequate lateral water movement.

Table 3. Factors important in proper irrigation water management and irrigation scheduling.

Soil factors	
■	soil water holding capacity
■	soil intake rate
■	current moisture deficit
■	moisture content at field capacity
■	depth of soil profile
Crop factors	
■	rooting depth
■	water depletion tolerance
■	peak consumptive use
■	variations in consumptive use during each growth stage

Proper Leaching

In many areas, leaching is required to prevent the harmful accumulation of salts in soils irrigated with saline water. Leaching involves the application of irrigation water in excess of the amount needed by the crop. Proper management involves making detailed analyses to determine the exact amount of leaching needed, and the timing of leachings to minimize return flow. In most instances, the extra water for leaching need not be applied at every irrigation, but should be applied during periods of lower plant use to avoid the leaching of applied nutrients and pesticides.

Land Leveling

Reshaping the land surface to planned grades is known as land leveling. By establishing uniform grades, irrigation water can be applied more efficiently. This can increase yields. The practice also reduces erosion, water pollution and damage to land caused by water logging, while providing adequate surface drainage. All leveling work should be planned as an integral part of an overall farm irrigation system. Design criteria for land leveling have been established by the SCS for almost all areas of the state.



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