no. 4.709

Tailwater Recovery for Surface Irrigation

by I. Broner[1]

Quick Facts...

- Use of tailwater can offer substantial savings in irrigation power consumption if the water supply is groundwater.
- A tailwater recovery system increases yields because of higher irrigation efficiencies.
- A tailwater recovery system will not save all the tailwater, but it can increase irrigation efficiency by 25 to 30 percent.
- Disadvantages are the loss of the area required for a reuse pit and periodic maintenance of the pump, storage and return facilities.

Provisions for the storage, disposal or reuse of tailwater must be included in all graded surface irrigation systems. It is impossible to obtain effective, efficient graded surface irrigation without tailwater. Use of tailwater can offer substantial savings in irrigation power consumption, especially if the supply is from groundwater.

Reuse systems contribute to the wise management of fertilizers (which can require substantial energy in their manufacture) because many of the nutrients in the runoff can be captured and reapplied. Reuse systems have been shown to increase efficiency and uniformity of irrigations, resulting in increased yields and decreased labor and operating costs.

Water distribution uniformity in furrow irrigation depends on the water intake rate of soil and the opportunity time. The goal in furrow irrigation is to have equal opportunity times for all points along the furrow length.

The use of level furrows permits the desired application to be rapidly and evenly spread over the set. The furrows provide storage for the water until it is absorbed into the soil. With level furrows and borders there is no runoff. However, with graded furrows the storage capacity of the furrows usually is quite limited and runoff can be substantial.

Since water distribution uniformity along the furrow depends on opportunity time, a good practice is to advance the water to the end of the furrow as fast as practically possible. The fast advance minimizes the differences in opportunity times at the upper part of the furrow and at the tail end of the furrow. A large furrow stream is usually required to complete the advance in a short time. This large furrow stream size is considerably in excess of the water intake rate of the soil. The result of using large stream is that a significant amount of the total applied water becomes runoff or tailwater.

Cutback irrigation methods control or reduce runoff water. Tailwater recovery systems reuse runoff water.

Cutback Irrigation

One method commonly used to reduce the quantity of irrigation runoff is the "cutback" procedure. This method uses a large furrow stream to rapidly advance the length of the field and "wet-up" the furrow. When the water has reached the end of the field, the size of the furrow stream is "cutback" to one-third to one-half the original furrow flow.

The manual cutback irrigation method is labor intensive and is difficult to implement because the flow relieved by the cutback is only sufficient for advance on a partial set. Recently two new methods that automate the cutback practice were developed. Surge irrigation is discussed in Extension Bulletin 543A, *Surge Irrigation Guide*, and cablegation irrigation is described in USDA Publication ARS-21.

Tailwater Recovery Systems

Tailwater recovery systems can be used with or without cutback methods. A tailwater reuse system will not save all the tailwater, but it can increase the effectiveness of the irrigation by 25 to 30 percent. For example, a well should be able to irrigate 40 percent more land if the 30-percent runoff can be saved. Or a high horsepower pump will run less time, resulting in considerable energy savings to irrigate the same amount of land. The reuse systems also can be used with sprinkler or other irrigation systems that might have significant runoff problems.

The most obvious advantage of tailwater recovery systems is the lower water use due to increased uniformity and higher efficiencies. This means lower energy consumption and higher crop yields. Nutrient losses also are reduced, due to higher uniformity and lower leaching. Nutrients in the surface runoff are reused, thereby resulting in lower fertilizer costs.

Primary disadvantages of tailwater recovery systems are the loss of the area required for a reuse pit, and the periodic maintenance required of the pump, storage and return facilities. There also are safety problems associated with the pits, such as protection for children, livestock and wildlife.

There essentially are two types of tailwater recovery systems in use. The most common is the sequential use system that collects tailwater for use on lands at lower elevations (Figure 1a). Sequential use systems usually flow by gravity into and out of a pond, canal or farm delivery ditch and are reused as needed.

The second type is a return-water system if the water will be reused on lands at higher elevations. Figure 1b illustrates two options for two fields. In Alternative A, the water is returned to the highest point in the field and is available for use by either field. Alternative B returns the water for use on the second field only. Figure 1c shows the water being returned for use on the same field. Figure 1d presents a situation where the return flows are used on additional lands. There are many other possible combinations of tailwater reuse systems.

Both types of tailwater recovery consist of tailwater ditches to collect the runoff; drainage ways to convey the water to a central collection point, sump or reservoir; a pump and power unit; and a pipeline or ditch to conduct the water to a point of redistribution. In reuse systems where gravity flow can be used, the pump and power unit may not be necessary. The size, capacity, selection and location of equipment and facilities for these systems depend on the type of irrigation system, topography and the farmer's irrigation practices and goals.

It generally is necessary that fields be leveled so that irrigation grades are uniform. All rows should drain well so no water collects and stands before entering the tailwater pit. The tailwater ditches and drainage ways can be pipe, concrete or earthen ditches and should be able to carry the maximum amount of tailwater without causing erosion and/or flooding.

Design

Proper design of tailwater recovery systems is not a simple task and it is recommended that the farmer obtain assistance from the local Natural Resources Conservation Service (NRCS) office or a competent consulting irrigation engineer. In addition, there often are cost-sharing funds available through the Farm Service Agency for these types of improvements.

Furrow flow rates. It is necessary that the maximum furrow flow rates be used to increase the uniformity of furrow irrigation. The maximum flow rate, which does not cause excessive erosion, can be estimated by the empirical NRCS formula: $q=B/s$, where q is the furrow rate in gpm, s is the average furrow slope in feet per 100 feet, and B varies from a value of 10 for erosive soils, such as sandy loams, to 15 for less erosive soils, such as clays. An upper limit of 50 gpm usually is accepted as the maximum flow rate unless special large-sized furrows are used. However, since every field and soil type will accept water at varying rates, the actual flow rate that works best for those conditions usually is established by experience, and provisions for the irrigator to adjust the furrow flows should be included in the design.

Tailwater pit. The pit or reservoir to collect the water for a tailwater recovery system should be able to hold about one-half the quantity of water furnished to the first set. For example, a 1,000 gpm (2.23 cfs) well and a 122-hour set requires a tailwater pit storage capacity of 360,000 gallons (1.1 acre-feet).

The pit rarely will exceed one-half acre in size, and should be 8 to 10 feet deep to control aquatic weed growth. If possible, the pit should be lined with concrete or buried plastic membranes. Earthen pits should have side slopes from 2 to 1 or 2.5 to 1. Concrete pits can have nearly vertical walls. All pits should have one end with a side slope of about 5 to 1 to provide access for cleaning and exit in case of accidents or for animals that might fall into the pit. The pit should provide about one foot of depth as unusable storage for sediment buildups and to maintain the prime on the pump.

Consider a sediment trap-trash removal structure to permit water to enter the pit without causing erosion of the pit walls and to trap as much sediment and debris as possible. Include a bypass to flush the sediment trap and to release excess water.

Return pumping system. The pumping equipment for a return-water system should have the capacity to pump about one-third of the quantity available at the primary source (e.g., irrigation well). This criterion is particularly compatible with cutback systems and can result in application efficiencies of 90 percent or more. The pumps can be mounted on floating or fixed platforms.

Control pump operation by a float or electrode-operated switch between predetermined water levels in the pit. Tailwater pumps usually vary between 2 and 10 horsepower, depending on the size of the system. Return-water systems use single-state turbine pumps as well as centrifugal pumps. However, the pumps should be adequate to overcome the elevation requirements plus friction losses, as well as any pressure at the distribution point, if it is a closed system.

Operation

There are many ways to design and operate tailwater return systems. Some systems are designed to collect water from several fields and enable the grower to entirely irrigate another field with tailwater. Other systems return the water to the upper end of the original field while still others return the water to intermediate fields, which contribute water back to the return-water system. Therefore some water may be recirculated many times.

The systems can be regulated by checking the water level in the reuse pit. The pit will be fullest at the end of a set. If the pit is too full, irrigate more rows (with the same water supply) in the next set. If the pit is about half full or less, irrigate fewer rows or increase the furrow flow rates, if possible. The proper operating range is a matter of the personal preference of the grower and should be established through experience.

Costs

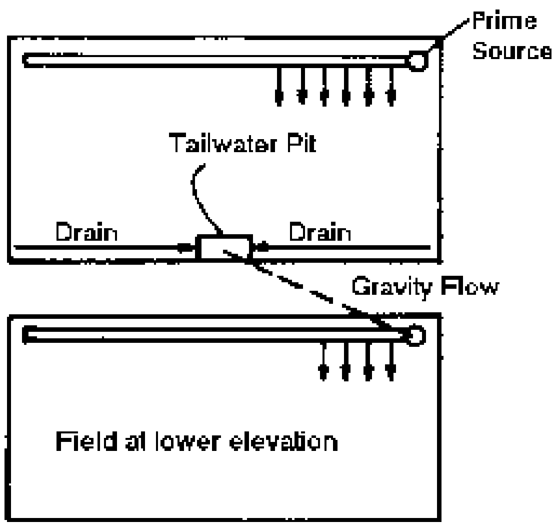
In general, return-water recovery systems cost from $150 to $225 per acre. System cost is composed of earth work cost, pipeline installation cost and pump assembly cost. Cost of a particular tailwater recovery system can be estimated using the following prices: $0.70 per cubic yard of earth work and $4.80 per foot for a 10" PVC high pressure pipeline installation. Add the cost of pump and power source, if needed, to the system cost. The local NRCS office can provide cost estimates and help in designing a system.

Floating tailwater pump assemblies cost from $1,500 to $3,000 or more depending on the size, make and power source. Generally, single-phase electric motors are more expensive to purchase and operate than triple-phase motors. Also consider the cost of providing electrical service. Costs for gasoline or tractor-driven pumps can vary considerably. Include anticipated costs and availability of fuel for at least 10 years in the economic analysis of internal combustion power sources.

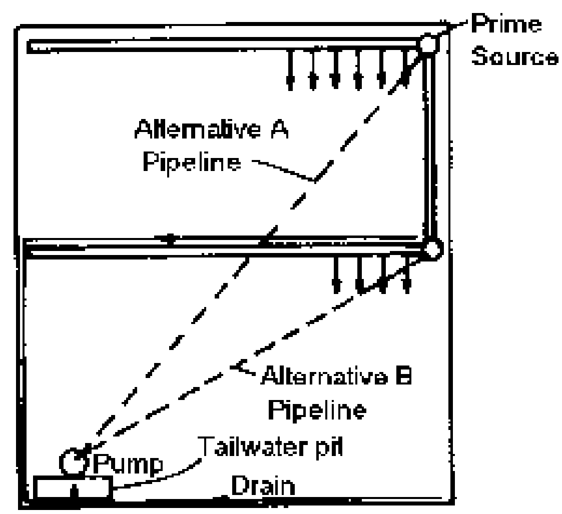
Excavation of tailwater pits often can be done by the irrigator with farm or rental equipment. Commercial contractors charge $.07 per cubic yard. Concrete lining of a tailwater pit may cost from $4 to $6 per square yard of surface depending on thickness and reinforcing. Concrete should be sulfate-resistant for most areas in Colorado.

Open discharge (surface irrigation) return-water pipeline should probably be about 80 psi rated PVC plastic for maximum durability and least cost. In some instances 50 psi rated PVC plastic pipe can be used. Fifty feet (low head) pressure rated plastic pipe is not recommended. Costs of pipe and installation vary significantly with location. Obtain local cost estimates from a NRCS office.

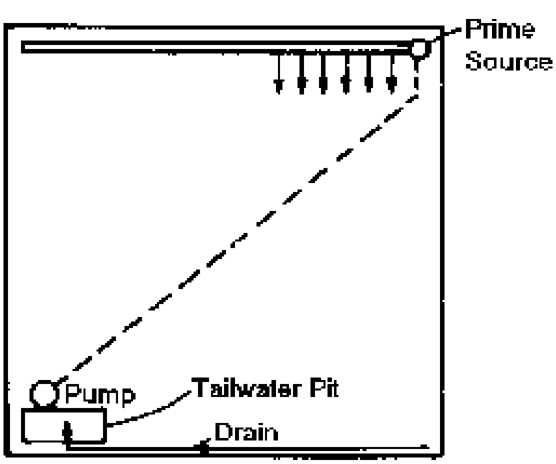
Return-flow pipelines that are used for sprinklers usually are Class 160 or Class 200 plastic pipe. Steel or concrete pipe usually is not competitive with plastic pipe for these uses, due to installation and/or materials costs. As with most products, the economics can vary significantly from area to area and year to year. Request quotations from several sources.



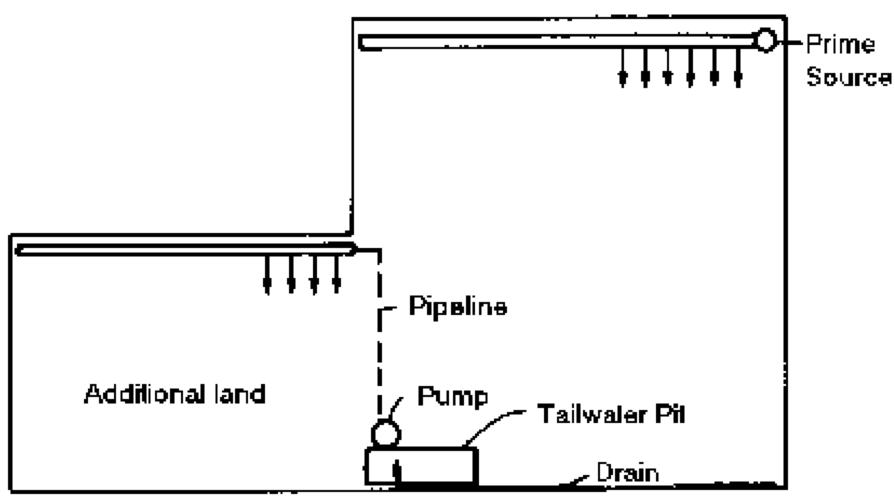
(a)



(b)



(c)



(d)

Figure 1: Alternative reuse systems: a) sequential reuse to irrigate lower-lying lands; b) alternative return reuse systems for sequential fields; c) return reuse system to the highest point in the same field; and d) return reuse system to irrigate new additional lands.

[1]I. Broner, Colorado State University Cooperative Extension agricultural engineer and associate professor, chemical and bioresource engineering. 6/94. Reviewed 9/98.

Go to top of this page.

Updated Wednesday, May 02, 2001.
