Report 2:

River, Acequia and Shallow Groundwater Interactions

Water Task Force

College of Agriculture and Home Economics
Cooperative Extension Service
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River, Acequia and Shallow Groundwater Interactions

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Importance of multiple water flow paths in irrigated agricultural settings

With an ever growing emphasis on water management, multiple interests' demands for water, and economic and political pressure on agriculture to conserve water, irrigators have been faced with the decision of whether to line acequias and other earthen irrigation ditches with impervious materials (such as concrete) for optimal delivery. While this practice seems logical for maximizing the amount of water delivered to specific farms, there may be drawbacks to lining acequias. In fact, researchers are now beginning to understand that unlined acequia water delivery systems may be beneficial from an overall river and floodplain management perspective. Previous and ongoing field study results indicate that the seepage associated with acequias increases recharge to shallow aquifers, enhances riparian vegetation and wildlife habitat along ditches, and improves water quality. In New Mexico, especially during periods of drought, the shared need for scarce water has generated emotionally charged water allocation debates. When considering changes to water resources management in agricultural corridors, it is important to analyze all potential impacts of changes and to have an understanding of the many factors that influence the hydrologic cycle of irrigated agriculture.

As demonstrated in the following figure, there are multiple flow paths for water in the hydrologic cycle of irrigated agriculture. The figure emphasizes interactions between surface water and groundwater along the irrigated corridor between an unlined irrigation ditch and a river. As shown in the diagram, water moves along many pathways. For example, crops receive water from precipitation, which is not dependable or sufficient for most crops in arid regions. Most of these crops also receive irrigation water supplied by ditch flow from diverted river water and/or pumped groundwater. Water not consumed by crops within fields or by riparian vegetation along wetted corridors either evaporates and goes back into the atmosphere or seeps into the ground. The seepage from ditches and flood irrigation contributes to shallow

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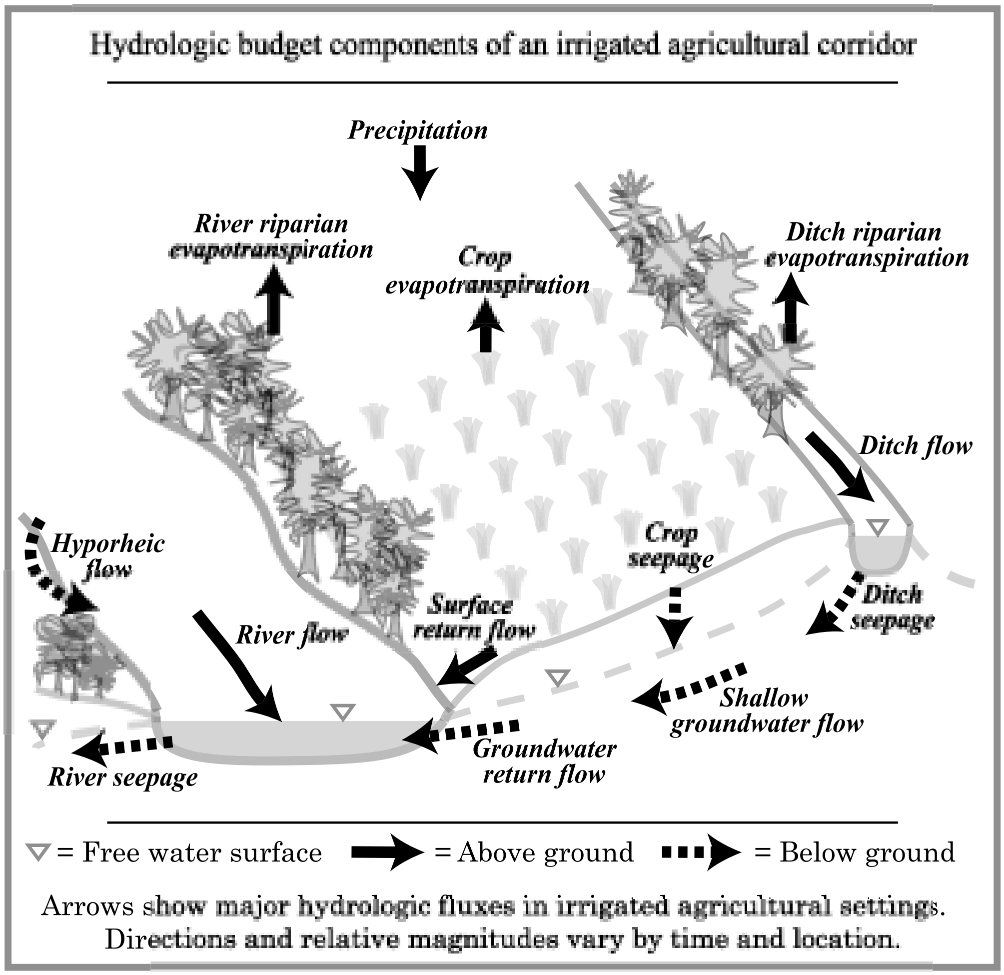

groundwater recharge and groundwater return flow to the river. The scenario presented here is intended as an illustration of the existence of multiple flow paths, and it should be recognized that directions, rates, and volumes of water moving through each path vary by time and location.

Water quantity and water quality implications of surface water groundwater interactions

Until recently, surface water and groundwater have been treated separately in most research and management situations. However, research from around the world is beginning to show the important interactions between surface water and shallow groundwater. Along irrigated cropland corridors between irrigation ditches and rivers, these interactions yield potential water quantity and water quality benefits.

Under certain conditions, there may be river seepage from a river channel into shallow groundwater. River seepage has been shown to cause temporary elevation of water tables, the water levels measured in wells, when the river is higher than the surrounding groundwater.

Analogously, studies of the hydrologic effects of seepage from irrigation ditch systems have shown that ditches are important sources of recharge to shallow groundwater. Ditch seepage causes groundwater mounds beneath ditches during the irrigation season, and these temporary groundwater mounds dissipate after the irrigation season when ditch seepage stops. Effects on water tables from ditch seepage can extend far from the ditch, causing a rise in shallow water tables and increased shallow groundwater flow beneath the agricultural corridor from ditch to river. The rise in shallow water tables due to ditch seepage has been confirmed through well measurements, stable isotope studies and mathematical modeling. Depending on the flow rate and the composition of the ditch bed and banks, the amount of water that seeps from an unlined ditch can range from a few percent to upward of 80 percent of all water that flows through the ditch.

Lining irrigation ditches and resultant decreases in seepage may have important effects on groundwater and surface water quantity. Lining irrigation ditches has been shown to reduce the availability of shallow groundwater that supplies wells to irrigate cropland. In places where ditch seepage reaches shallow groundwater flowing beneath the agricultural corridor to the river, lining ditches and reducing seepage reduces the amount of groundwater return flow. Therefore, because lining ditches can create less seepage and less return flow, lining ditches may affect the timing of downstream river flow.

Ditch seepage and the return flow it creates may maintain natural floodplain processes in places where river channels have been stabilized and simplified by man-made structures. In these cases, seepage from ditches may attenuate and redistribute river peak flows, performing functions similar to natural side channels previously distributed across the floodplain. Ditch seepage also supports ditch-side riparian vegetation with its many attendant wildlife, grazing and aesthetic values. It should be noted that along irrigation ditches, riparian evapotranspiration may intercept some ditch seepage before it reaches shallow groundwater.

Interactions between surface water and groundwater can have important effects on water quality. Of great interest in agricultural landscapes is the ability of these interactions to create conditions for microbial denitrification and resultant removal of nitrate from the water. One way surface water and shallow groundwater interact is through hyporheic flow, in which river water enters the river bed and banks, follows shallow groundwater flow paths and reemerges as river water downstream. Hyporheic flow across the riverbed can result in beneficial microbially mediated chemical transformations of nitrogen, carbon, phosphorus, and other nutrients. By transporting dissolved oxygen into the riverbed, hyporheic flow creates habitat for aquatic insects that are important for overall river system ecological integrity.

Ditch seepage and resulting groundwater flows can negatively and positively affect shallow groundwater quality and ultimately river water quality. Seepage can bring contaminants from the surface into the shallow groundwater and threaten groundwater quality. The contaminants in shallow groundwater could end up in deeper groundwater if a vertical downward gradient is caused, for example, by an active well nearby. On the positive side, seepage may dilute contaminants such as agricultural chemicals or septic tank leachate in shallow groundwater. Shallow groundwater flows beneath the agricultural corridor may protect deep groundwater quality by transporting contaminants away from the deeper aquifer. Stream temperatures have been shown to be cooled by the inputs of cool shallow groundwater return flows provided by irrigation seepage.

Implications of changing irrigation ditch management

In many locations irrigation water is not metered and the amount of water applied during typical irrigation events is not precisely known. In New Mexico alone, there are at least 720 traditional acequias along rivers and streams that support small farms interspersed with developing small urban areas. Small-scale irrigators are facing economic pressures to transfer water out of agriculture to other uses. When these transfers occur, constraints are placed on the remaining agricultural production along each affected acequia. Water allocation systems that reduce annual ditch flow also reduce total ditch seepage. Community involvement in maintaining acequias forms a strong link to the land that may be lost if traditional systems are changed. If water is sold to users outside of the acequia system, and if fewer irrigators participate in acequia irrigation and management, the hydrologic functioning of the entire acequia system can be affected.

Costs and benefits of lining ditches need to be evaluated on a case-by-case basis, taking into account the management objectives and the spatial scales of concern. Though costly, in certain cases lining acequias may be beneficial by reducing seepage and increasing water available for delivery within a farm or acequia system. Overall, water lost by seepage from fields or ditches will ultimately end up in the aquifer or the river, so lining ditches is an ineffective conservation measure at the regional scale.

Research has begun to characterize important interactions between ditch seepage and shallow groundwater flow. However, a thorough evaluation of the effects of ditch seepage in irrigated corridors requires comprehensive understanding of surface and subsurface hydrology, including flow in ditches and rivers, seepage from ditches and rivers, interaction of ditch and river surface water with shallow groundwater, hyporheic flow out of and back into rivers, infiltration from crop irrigation, and evapotranspiration from crops and riparian vegetation. Consideration of the water quantity and water quality implications of surface water groundwater interactions will allow irrigators, water resource managers, scientists and other community members to better manage their natural resources.

Rio Grande Initiative

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