EVALUATING THE BENEFITS OF TAIL-WATER RECOVERY SYSTEMS FOR RICE PRODUCTION IN EASTERN ARKANSAS

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Overview

Irrigation is a major user of ground and surface water in the United States accounting for 80% of the Nation's consumptive water use and over 90% in many Western States (Windham). Rice requires constant water throughout the growing season to successfully develop. With increased aquifer exploitation the water table has declined. This has forced farmers to drill deeper and cerate additional wells to adequately irrigate their crops. This causes our water resources to be depleted even further. However, a recent emphasis has been placed on tail-water recovery systems, where crop irrigation water is collected and then reused.

What is Tail-Water Recovery?

Excess water (or tail-water) collects at the lowest point a rice field. At this point, the water may infiltrate into the soil or flow as surface drainage away from the field. Tail-Water Recovery involves constructing a large pit or ditch (Figure 1) down gradient from the rice field which captures and stores runoff water. Tail-water recovery systems require equipment of some kind to transport the tail-water from the storage pit to the point of reentry into the agricultural fields. This may involve installing a re-lift and pipeline (Figures 1 & 2) to return the water to the upper portion of the farm.

Figure 1:

The experimental site in Moro, AR. A 450 acre rice farm with a newly installed (460 X 60 foot) tail-water recovery pit to irrigate three fields. This feature collects and stores the tail-water

Figure 2:

Tail-Water is redistributed by a camel-back re-lift. This feature redirects the water to upper locations in the farm. Opposed to electric powered well water irrigation, a reduced amount of energy and resources are used. Energy input increases the higher the water is pumped from the ground. Therefore, significant energy is needed to pump from the Alluvial Aquifer, compared to the TWR pit

Is Arkansas' Current Irrigation Method SUSTAINABLE?

All of eastern Arkansas is underlain by the deep water of the Sparta Aquifer and the more shallow water Mississippi River Valley Alluvial Aquifer. The Sparta has limited irrigation use due to high pumping costs. The Mississippi River Alluvial Aquifer has developed cones of depression due to excessive pumping. The current irrigation system relies on ground water sources that are **not** sustainable in the long-run (Czarnecki, Hays and Terry).

Methods and Results

Water Quantity

The Arkansas Off-Stream Reservoir Analysis (ARORA) reveals the years 2000 and 2010 had similar precipitation data. Mathematical tests were ran for these two years. Differences in water consumption before and after the installation of the Tail-Water recovery system were realized.

1)Year 2000: Traditional Well ⟶ 1,356 hrs.
2)Year 2010: Traditional Well ⟶ 1008 hrs.

Well pumps 1,200 gallons/minute

1) 1,200 X 60,480 = 72,576,000 gallons
2) 1,200 X 81,360 = 97,632,000 gallons

Gals saved = 97,632,000gal X 72,576,000gal
25,056,000 gallons saved (450 acre farm)
25,056,000/450 = 55,680gal/acre
55,680 gallons/acre saved!

Water Quality

Literature review shows that nutrients are recycled. A slight increase in Phosphorous was detected. This nutrient is important. It's vital to the processes of photosynthesis, nutrient transport, and energy transfer. (Windham, T. E. and J. Lafferty). It is rare negative effect, but crop ailments and disease could also recycle through the tail-water. I will be following up with my own nutrient tests the week of November 22-26.

Economic/Financial Costs

Yield and Expense data were obtained for ten farming seasons. R^2 values were calculated for "Total Profit" and "Water Expenses" to see if there was a statistical trend between the two categories.

Total Profit = Crop Yield–(Water Expenses +Additional Expenses)

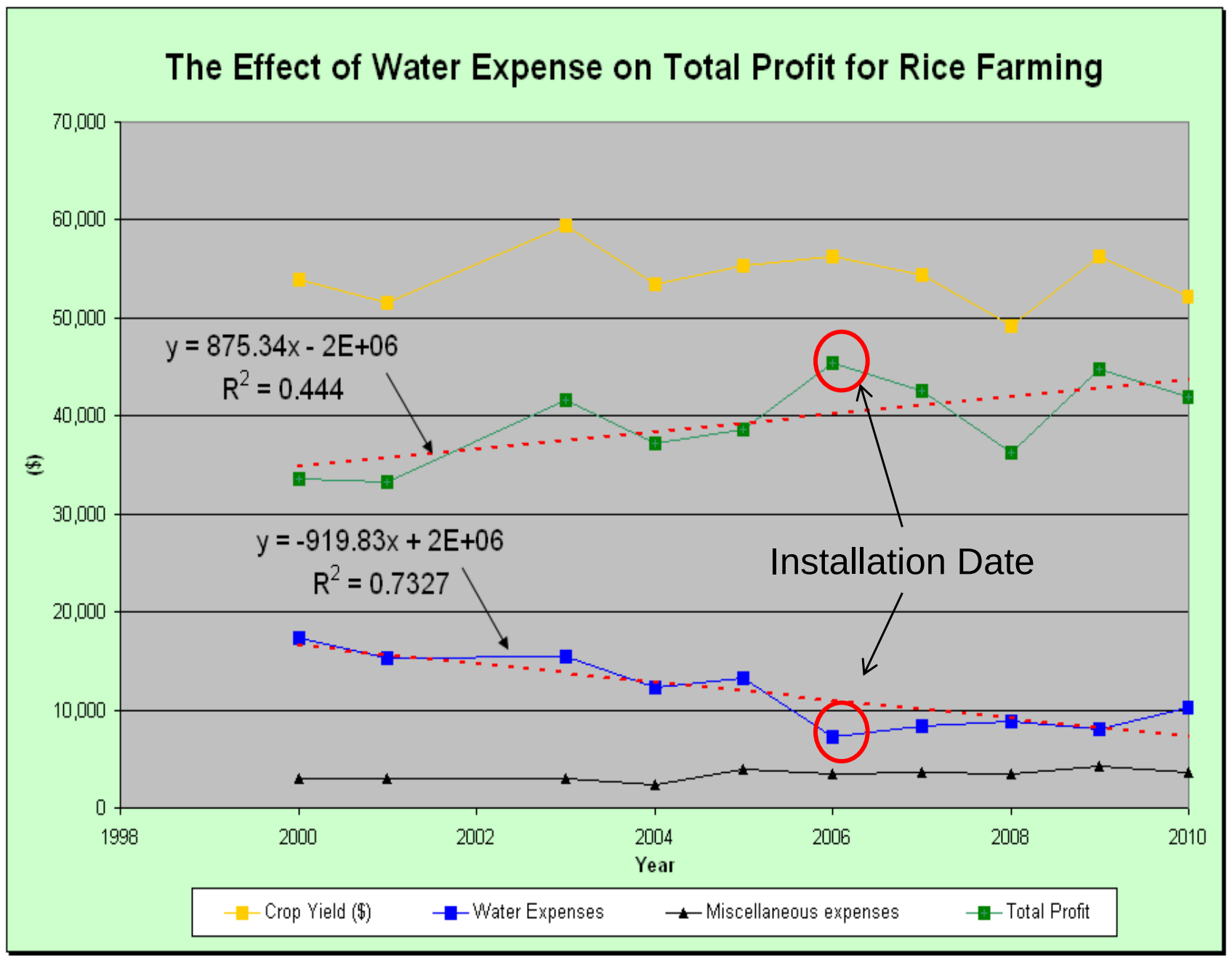
The Effect of Water Expense on Total Profit for Rice Farming

Figure 3:

There is an inverse relationship between Water Expenses and Total Profit. The installation price of the Tail-Water pit is not included in the expenses category (est. $150,000). Notice the decrease in water consumption after the installation in 2006.

Crop Yields

Data show little change in rice quality. Conversely, preceding studies indicate that cold water hinders rice growth. Root dry weight and plant height decrease significantly compared to warmer temperature treatments (Fitzpatrick).

- ***Mean Tail-Water Temperature: 73°F***
- ***Mean Site Well Temperature: 50°F***

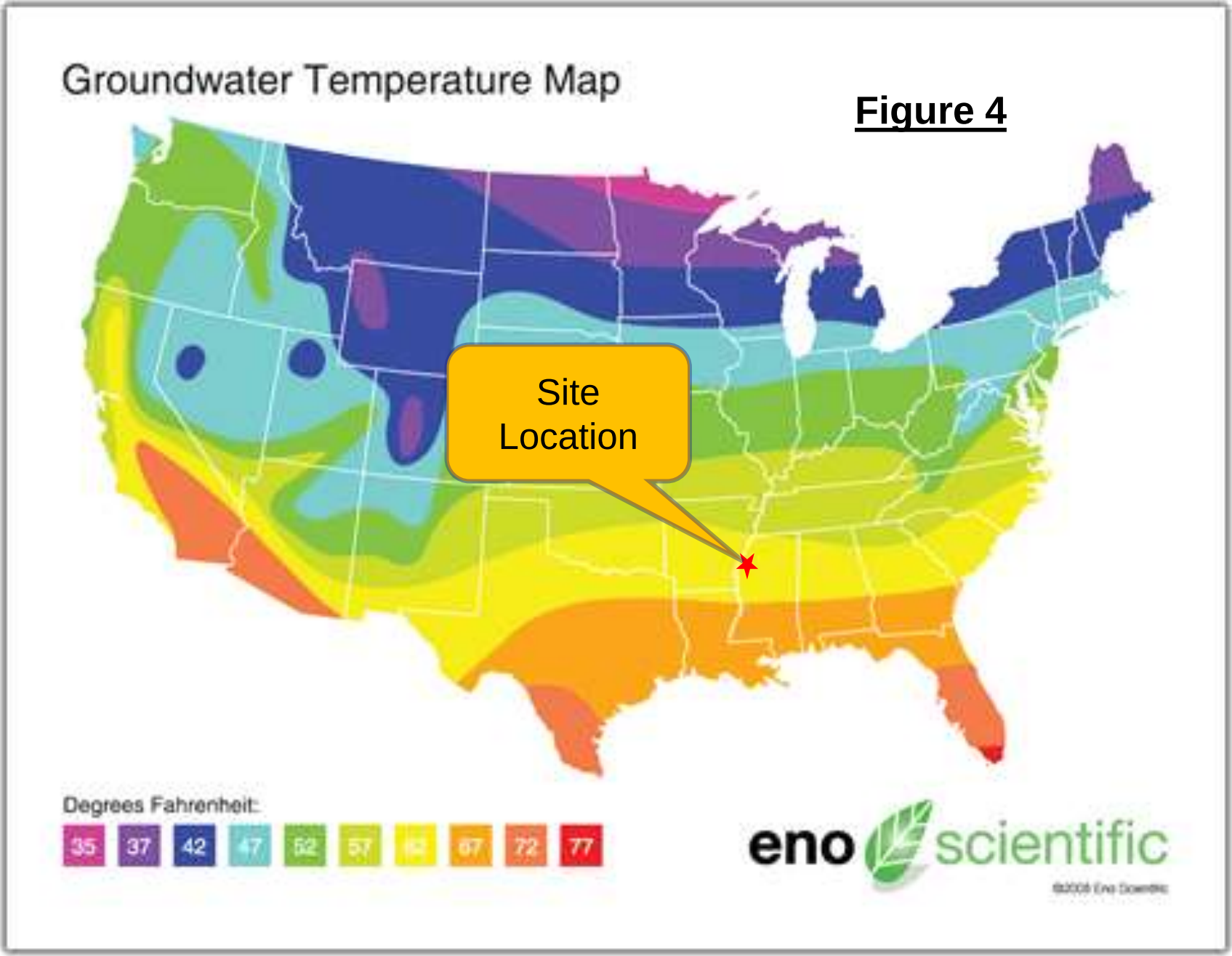

Figure 4:

Groundwater Temperatures in the United States. Site is located in the (Alluvial Aquifer) 57°F section. Tail-Water temperature is equivalent to groundwater in Southern Texas and Florida. Excellent water temperatures for rice production.

Environmental / Ecosystem Health

TWR's capture runoff water as it is leaving the field. They produce an additional benefit by reducing the amount of runoff sediment, nutrients, and pesticides that leave a farm. This is especially important, as sedimentation is the number one problem affecting surface waters in Eastern Arkansas (Czarnecki, Hays and Terry).

Aquatic Life: TWR's can prevent algae buildup by capturing fertilizer that could runoff into water bodies. Excessive decomposition of dead algae can result in hypoxic conditions (Lower Dissolved Oxygen) eventually killing all aquatic life and desirable fish species.

Wildlife:

TWR's are a suitable habitat for migrating Ducks. President Obama has encouraged the construction of TWR's to keep migrating Ducks from reaching the polluted Gulf of Mexico.

Figure 5:

The Oil spill in the Gulf has been fatal to many Duck species. TWR's could possibly be a temporary habitat for migration.

Discussion and Conclusion

Preliminary results show that with limited (and decreasing) water availability in the Alluvial Aquifer (Eastern Arkansas), tail-water recovery systems can decrease water consumption and lower farming costs. In addition, these systems might provide an additional benefit by controlling the amount of sediment, nutrient and pesticides that leaves the farm. The crop yield shows little change, which suggests the water quality from the Tail-Water Recovery System was appropriate to grow and successfully harvest rice.

Advantages:

1. Minimizes environmental impacts of irrigation water leaving the property.
2. Conserves irrigation water supplies, especially in areas where groundwater supplies are decreasing.
3. Reduces farming costs, which may be especially important where water costs are high.
4. Removes standing water, which can result in crop loss and weed and mosquito Infestations (a significant problem in Eastern Arkansas**)**.
5. Water is warmer.

Drawbacks:

1. High cost of purchase, construction, and operation of tail-water recovery system.
2. Requires land set aside for tail-water storage which could otherwise be used for rice production (pond or drainage canal)
3. Oil and gas are the source of energy to keep pumps operating.
4. Maintenance required.

Figure 6:

The effects expected to occur when this practice is applied correctly. These variables are subjective and dependent on climate, soil, and terrain. **Common Associated Practices** (CAP) are used in a Conservation Management System (*procedures for maintaining a species or habitat in a particular state*).

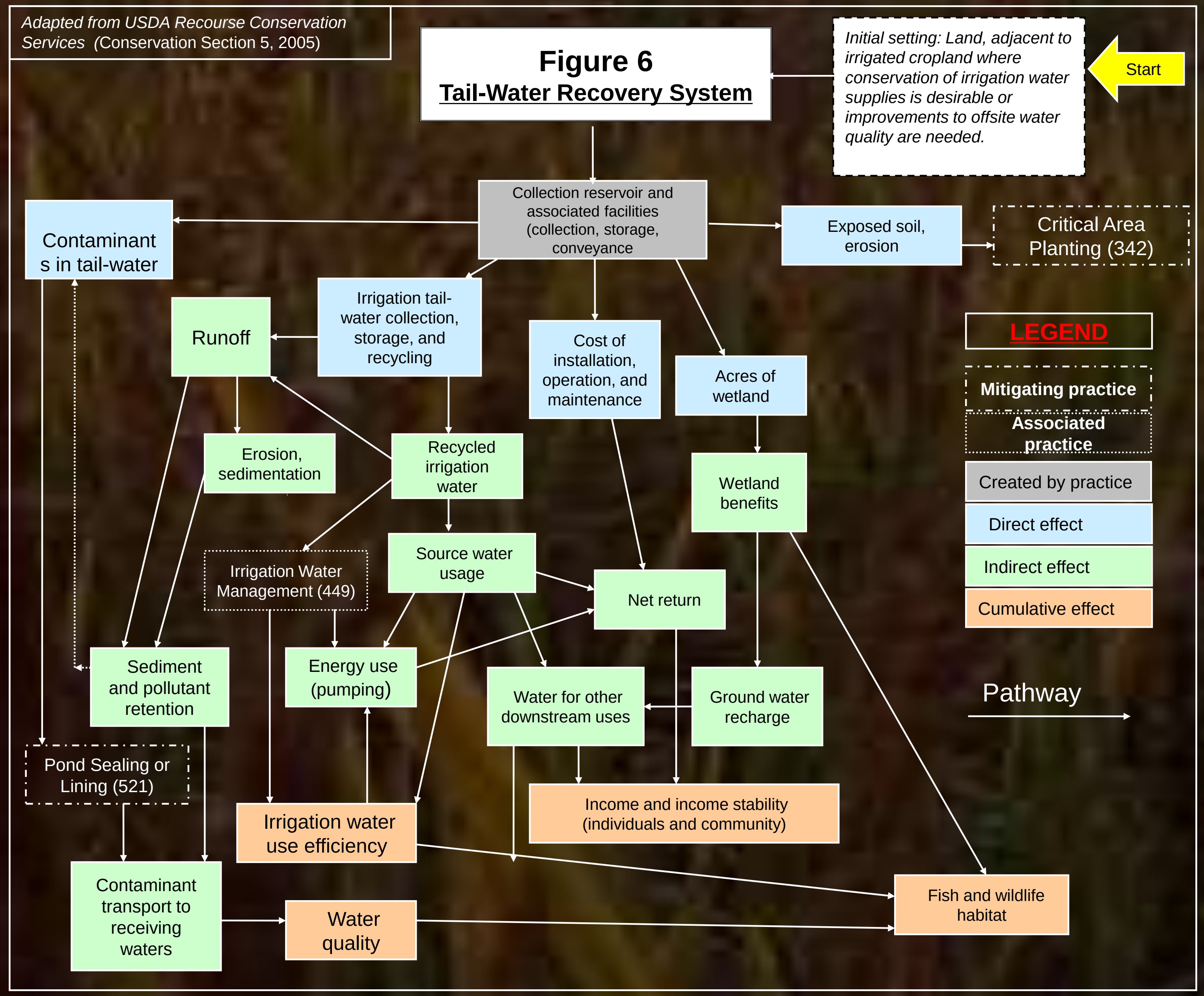
Adapted from USDA Recourse Conservation Services (Conservation Section 5, 2005)

Figure 6
Tail-Water Recovery System

Initial setting: Land, adjacent to irrigated cropland where conservation of irrigation water supplies is desirable or improvements to offsite water quality are needed.

Start
Collection reservoir and associated facilities (collection, storage, conveyance
Contaminants in tail-water
Exposed soil, erosion
Critical Area Planting (342)
Irrigation tail-water collection, storage, and recycling
Runoff
Cost of installation, operation, and maintenance
Acres of wetland
Erosion, sedimentation
Recycled irrigation water
Wetland benefits
Irrigation Water Management (449)
Source water usage
Net return
Sediment and pollutant retention
Energy use (pumping)
Water for other downstream uses
Ground water recharge
Pond Sealing or Lining (521)
Irrigation water use efficiency
Income and income stability (individuals and community)
Contaminant transport to receiving waters
Water quality
Fish and wildlife habitat

LEGEND
Mitigating practice
Associated practice
Created by practice
Direct effect
Indirect effect
Cumulative effect
Pathway

Sources:

Fitzpatrick, D.J., *A Preliminary Assessment of the Potential for Artificial Recharge in EasternArkansas.* USGS Water Resources Investigation Report 9 1990.Fooks, B., USDA-Natural Resource Conservation Service. Interviewed by Ken Young. March2002.
Windham, T. E. and J. Lafferty. *Rice, Silt Loam Soils, Eastern Arkansas, 2002.* Little Rock,AR: University of Arkansas Cooperative Extension Service, Pub. No. AG-650-11-01,2002a. Young, K.B., E.J. Wailes, and J. Smartt. 1998. "Analyzing Conjunctive Use of On-Farm Reservoirs for Irrigation in The Arkansas Delta: A Final Report, U.S. Geological14Survey." *Vulnerability and Use of Ground and Surface Waters in the SouthernMississippi Valley Region*. H. D. Scott, ed. Fayetteville, AR: Arkansas Water ResourceCenter.