Draft - Technical Memorandum on Conserved Water Volumes

Introduction

A high proportion of the water savings attributable to conservation practices that have been introduced within the service area of the East Side Canal and Irrigation Company are due to a number of lateral pipelining programs that have been implemented by the Districts and by local landowners using a variety of state, federal and local funding sources. Although smaller in magnitude, important water conservation benefits have also been achieved through implementation of tail water recovery systems that have been placed at strategic locations in the service area.

This technical memorandum describes the nature of the lateral pipelining and tail water recovery projects and presents analyses supporting the average annual quantity of conserved water attributable to the level of implementation of these measures that now exists in the service area. Figure 1 of the main report shows the locations of these measures.

Lateral Pipelining

The principal objectives of the various lateral canal pipelining projects implemented within the East Side Canal and Irrigation Company service area have been to conserve water and improve water supply reliability by eliminating lateral seepage and evaporation losses. This section of the technical memorandum presents an analysis of pre-pipelining seepage that was conducted to provide a foundation for estimation of the volume of conserved water attributable to pipelining. The document *Monitoring and Verification of Canal Seepage* published by the Agricultural Water Management Council was used as a guide to determine the technique for estimating lateral seepage losses that would be best suited to the conditions of the service area.

The pre-pipelining seepage and evaporation estimates presented in this section are essentially reduced to zero by conveyance of water through pipelines which eliminates both seepage and evaporation from the improved lateral reaches.

Selection of Methodology

Pre-pipelining seepage rates from open ditch laterals were estimated based upon a study conducted by Kleinfelder in 2002. Information taken from this study was used as the basis for the seepage analysis because conditions in the vicinity of the laterals in the service area made the generally recommended practices of ponding tests or inflow/outflow measurements unreliable and because the availability of information from the 2002 seepage study made this analytical approach practical and reduced the redundancy of additional field work.

Pre-pipelining monitoring in the service area was complicated by the extensive use of shallow wells that are pumped to augment surface water supplies for irrigation.

Groundwater pumping reduces the reliability of ponding tests and inflow/outflow measurements for the following reasons:

- Recorded flows into the lateral system are incomplete.
- The use of shallow monitoring wells to detect lateral seepage during a ponding test is likely to be confounded by pumping of shallow groundwater near the laterals being tested.
- Seepage from laterals is influenced by depth to groundwater in adjacent fields. Because the depth to groundwater increases after the irrigation season due to the cessation of irrigation and continued operation of drainage wells, ponding tests conducted after the irrigation season are likely to result in observations that overestimate seepage during the irrigation season.

For these reasons, lateral seepage estimates developed from the sampling and analysis program performed by Kleinfelder were used to estimate pre-pipelining seepage.

Overview of Analysis

Soil samples were collected with a hand auger from ten borings at depths ranging from two to eight feet below the bottom grade of the lateral canals. Sieve analyses and constant-head vertical permeability tests were used to determine the horizontal and vertical hydraulic conductivities of the soils sampled.

The modified Hazen method (Vukovic and Soro, 1992) was used to estimate the hydraulic conductivity from sieve analyses. The Hazen values were used in conjunction with laboratory permeability test values.

- Hydraulic conductivity values ranged from 6.43×10^{-5} centimeters per second (cm/sec) to 1.2×10^{-3} cm/sec, based on the modified Hazen method and the sieve analysis data.
- The average-lower and average-upper conductivities ranged from 8.26×10^{-4} cm/sec to 2.67×10^{-4} cm/sec, respectively and were used to compute lower-average and upper-average seepage rates that are the lower and upper bounds for the range of computed seepage values.

In mapping the hydraulic conductivities, no horizontal conductivity trend was evident. Seepage losses that could be prevented by pipelining are assumed to be restricted to the irrigation season (approximately 185 days between early April and late September). The period when water could be conserved by pipelining was further limited by assuming that, during the irrigation season, laterals contain water approximately 80 percent of the time, a period equivalent to 148 days per year.

Seepage values were computed using the Harr equation which is a standard method for estimating seepage from canals with steep side slopes. The equation has the following form:

$$Q = k(B + AH)$$

Where:

- Q = seepage volume per linear foot of canal section (acre-foot/foot)
- k = hydraulic conductivity (feet/second)
- B = bottom width (feet)
- A = function of B/H (unitless)
- H = depth of flow in the canal (feet)

The various lateral pipelining efforts have entailed conversion of open ditch laterals (with approximately six-foot bottom widths and approximately three-foot depths of flow) into piped sections. For these channels, the range in calculated seepage losses is a function of the variability in hydraulic conductivity measured in the laboratory and estimated by sieve analysis. Given the typical dimensions and wetted perimeters of open ditch laterals in the service area, the average-lower and average-upper conductivities described above convert to seasonal seepage loss rates of 0.050 and 0.154 acre-feet per linear foot of lateral, respectively. These values are used to estimate the pre-pipelining seepage volumes presented in Table 1.

Table 1. Estimated Pre-pipelining Seasonal Seepage from Open Ditch Lateral Sections Converted to Pipelines

Total Existing Pipelined Length (ft)	Lower Average Seepage Loss	Upper Average Seepage Loss	Average Seepage Loss
	acre-foot/linear foot per season		
	0.050	0.154	0.102
	Seepage Reduction Due to Lining (ac-ft/season)		
60,400	3,020	9,302	6,161

Evaporation losses are likely to be nominal when compared with seepage looses and are not expected to exceed 100 acre-feet per year.

Conclusion

In a study by Fipps (2000), unlined earthen canals in San Luis, California; Orissa, India; and Boise, Idaho had soil hydraulic conductivities ranging from two to 26 gallons per day per foot squared (gpd/ft^2). The upper and lower hydraulic conductivity values estimated during the Kleinfelder program of sampling and analysis convert to 5.66 gpd/ft^2 and 17.52 gpd/ft^2, values within the range of the Fipps study.

The volume of pre-pipelining seepage losses are likely to fluctuate due to a number of factors including changes in water table elevations. Other factors influencing seepage include deposition of sediment and other debris and maintenance to clear vegetation and remove accumulated sediment.

Tail Water Recovery Systems

Because of the high infiltration rates characteristic of soils in the service area, high heads of water are required to push water across the loamy sand soils to maintain relatively uniform distribution of water across the field and to prevent a condition where high deep percolation at the head of the field makes adequate delivery of water to the tail of the field impossible. For, this reason, typical irrigation heads in the service area are between 12 and 15 cfs.

The use of high irrigation heads results in the occurrence of tail water runoff, particularly at the beginning of an irrigation. Most tail water recovery systems are located in an area where fields border on the river. Therefore the tail water recovery systems intercept flow that would otherwise discharge to the river. Some individual farmers have tail water systems at the end of their field and return the water within the same field, but most recovered tail water is returned to the distribution system within the service area where it is reused at locations shown on Figure 1 of the main report.

SWD tail water pumpback systems are operated with each grower beginning each irrigation with an empty tail water reservoir and taking a full delivery head. After one-fifth of the irrigation set (or after the tail water reservoir contains a sufficient volume of water to support pumping), the grower cuts back to 60 percent of the initial delivery head and begins recycling tail water back into the system to prevent overflow of the tail water reservoir. This proportion of 60 percent gate delivery and 40 percent recycled water is maintained until the end of the set. Tail water accumulated after the end of the set is used to provide a finish head.

It is estimated that during each irrigation season, a typical 80-acre field in SWD generates an average of 45 acre-feet of tail water. Recapturing this water enables growers to reduce system deliveries required to meet irrigation requirements.

References

Agricultural Water Management Council, *Monitoring and Verification: Canal Seepage*, 2004.

Fipps, Guy, 2000, *Characterization of Conveyance Losses in Irrigation Distribution Networks in the Lower Rio Grande Valley of Texas*, Bureau of Reclamation, Texas.

Guilbert, Michael E., and Johnson, Christopher S., 2002, *Hydrogeologic Assessment – Proposed Pipeline Retrofit Areas - Merquin County Water District*, Kleinfelder.

Harr, M.E., 1990, *Groundwater and Seepage*, Dover, New York, 315 p.

Vukovic, M. and Soro, A., 1992, *Determination of Hydraulic Conductivity of Porous Media from Grain-size Composition*, Water Resources Publications, Littleton, Colorado, 83 p.