4.0 GROUNDWATER SEEPAGE FROM THE ALL AMERICAN CANAL

4.0 GROUNDWATER SEEPAGE FROM THE ALL AMERICAN CANAL

4.1 LOCATION AND RATE OF SEEPAGE

The Bureau of Reclamation (1991) has provided estimates of water seepage from the AAC. Two approaches were employed to estimate seepage: (1) quantification based on gauge measurements of total canal flow along gauge-defined reaches of the canal, and (2) estimates for structure-defined reaches of the canal based on site-specific conditions at each location. This section presents a brief overview of the seepage estimates. Additional documentation can be found in the AAC EIS/EIR report and geohydrology appendix (Bureau of Reclamation 1991).

4.1.1 Measured Seepage Along Gauge-Defined Reaches

Canal seepage rates along two gauge-defined reaches were estimated based on total canal flow measured at three gauge stations located at Pilot Knob, 1 mile west of Drop 1, and at the East Highline Canal check (Figure 4-1). The recorded flow values at each gauge station were corrected for water removed from the canal by diversions and evaporation between each gauge reach. The corrected flow values were used to estimate the seepage rates given in Figure 4-1. These seepage rates are affected by errors in estimated annual total canal flow at each gauge station. Such errors account for some of the yearly variation in the annual seepage rate. The seepage rates along the lower gauge-defined reach account for water recovered in the All American Canal drains between Drop 4 and the East Highline check and returned into the East Highline Canal rather than the AAC. Consequently, seepage rates for the lower gauged reach are slightly higher than the net seepage because they include water recovered in seepage drains and returned to the IID canal system.

Seepage rates in the upper gauge-defined reach initially averaged 95,800 acre-feet per year (af/yr) between 1948 and 1953. They gradually declined to a relatively constant value averaging 68,600 af/yr during the period from 1959 to 1988. The 30 percent decline exhibited by the upper gauge-defined reach seepage is typical for that from unlined impoundments where seepage is controlled by percolation into unsaturated sediments. A larger decline in seepage rates would be expected if the water table had risen above the base of the canal. In such a case, seepage would be controlled by the difference between the canal and groundwater levels.

Current seepage rates in the upper gauge-defined reach are estimated to be unchanged from values reported in the 1970s and 1980s because percolation conditions have not changed since that time.

Although the groundwater table has declined along the Coachella Branch due to its lining in 1980, the lining did not affect the upper gauge-defined reach seepage rates because they are not controlled by the groundwater table elevation (see Section 4.2).

Between 1950 and 1953, the seepage rates in the lower gauge-defined reach of the AAC averaged 122,500 af/yr. Seepage rates then quickly declined to a relatively constant value, averaging 37,900 af/yr from 1959 to 1988. The 70 percent decline in seepage from this lower gauge-defined reach is larger than would be expected for a situation in which seepage occurs from unlined impoundments and is controlled by percolation into the unsaturated zone. The large decline in this case is attributed to the water table rising above the base of the canal during 1954 (see Section 4.2). Initially, seepage rates were controlled by percolation into the unsaturated zone, but later seepage rates were controlled by the head difference between the canal and the aquifer. Current seepage rates in the upper gauge-defined reach are estimated to be similar to values reported in the 1970s and 1980s because seepage conditions have not changed since that time. Although the groundwater table has declined along the Coachella Branch due to its lining in 1980, the CB lining did not affect the groundwater table elevation along the entire lower gauge-defined reach. The CB lining had limited effect on the lower gauge-defined reach seepage rates.

4.1.2 Estimated Seepage Along Structure-Defined Reaches

The best overall estimate of the seepage rate in the AAC would be from measured flow at gauging stations. However, seepage rates vary along each gauge-defined reach due to differences in the subsurface geology and hydraulic conditions along the canal. Three major factors, the hydraulic conductivity of the canal bottom, the presence of an unsaturated zone beneath the canal, and the groundwater table gradient, were used to break the AAC canal into the six structurally-defined reaches presented in Table 4-1.

Seepage rates were assumed to be negligible in the canal section immediately below Pilot Knob because the canal bottom was cut into low permeability rock. Seepage rates were also assumed to be negligible in the lined canal section at Drop 1. Seepage rates were then proportioned to each structure-defined reach at a rate of 0.47 feet/day when seepage percolates into the unsaturated zone beneath the canal and

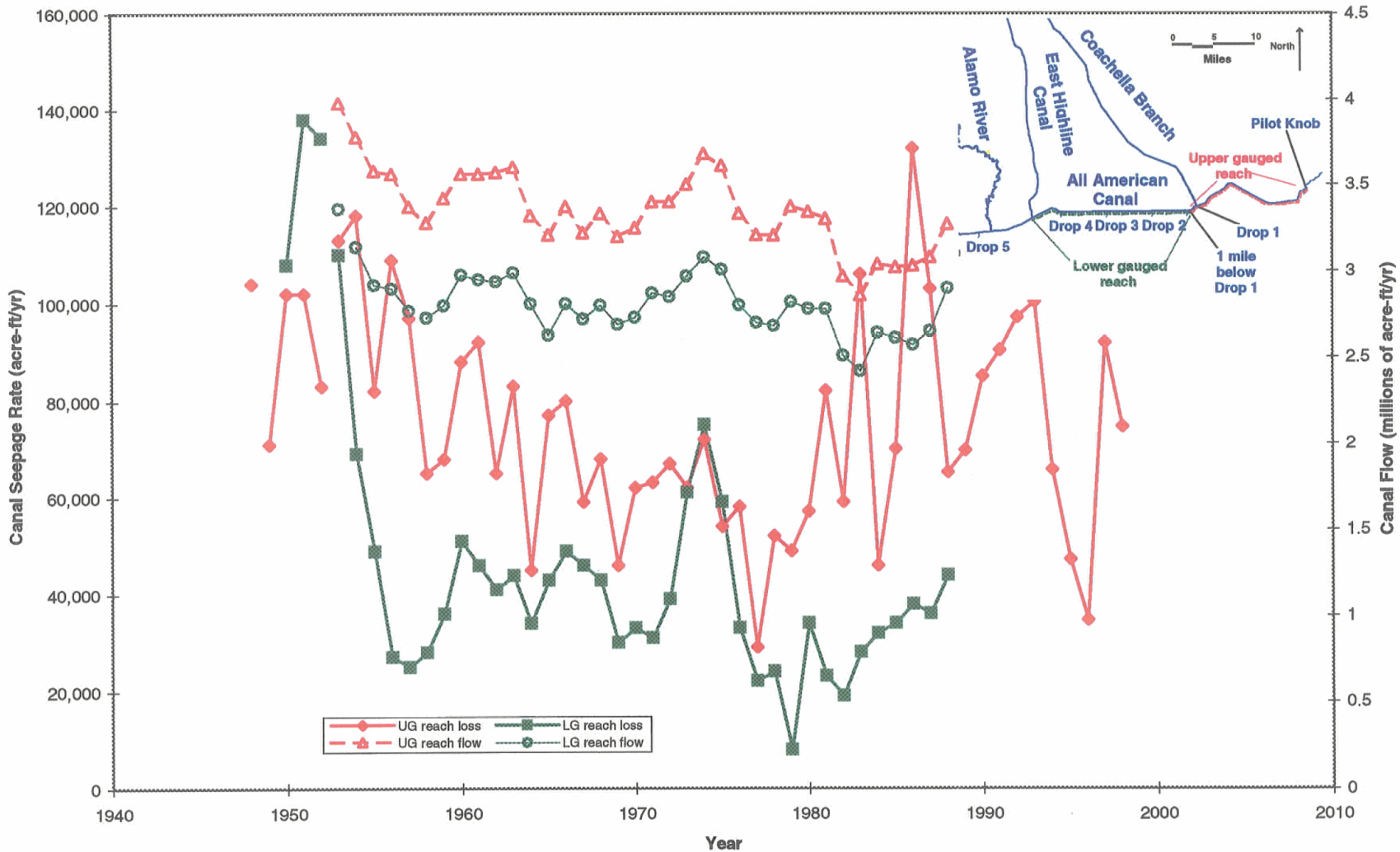

Figure 4-1 Gauged Loss in the All-American Canal

0.17 feet/day when seepage discharges directly into the groundwater beneath the canal. Thus, the seepage rate due to unsaturated zone percolation is roughly 2.8 times the seepage rate due to direct discharge into the groundwater. The seepage rate for direct discharge into groundwater (0.17 feet/day) was also further decreased by 50 percent between Drop 4 and the East Highline Canal because the gradient was 50 percent lower than areas between Drop 2 and 4. Conversely, the seepage rate for direct discharge into the groundwater (0.17 feet/day) immediately at Drop 2 was increased by 100 percent because the gradient was 100 percent higher than areas between Drop 2 and 4.

Table 4-1
AAC Seepage Along Structure-Defined Reaches

Reach Name	Unsaturated Zone Present	Canal Bottom	Relative Gradient	Length (mile)	Seepage (af/yr)[1]	Leakage Rate (af/yr/mile)	Comment
Pilot Knob to Rock 2	yes	impermeable	NA[2]	0.3	0	0	rock bottom
Rock 2 to Drop 1	yes	permeable	NA	13.9	59,187	4,245	lining proposed
Drop 1 to Drop 2	mostly yes	permeable	2	5.1	17,883	3,503	lining proposed
Drop 2 to Drop 3	mostly no	permeable	1	5.4	7,415	1,362	lining proposed
Drop 3 to Drop 4	no	permeable	1	5.3	7,084	1,340	not to be lined
Drop 4 to EHC	no	permeable	0.5	4.0	2,637	658	not to be lined
Total				34	94,206		

Notes: [1](af/yr) = acre-feet per year
[2]NA = Not applicable

The total seepage loss between Pilot Knob check and the East Highline check is estimated to be 94,206 af/yr. Figure 4-2 illustrates that over 63 percent of the seepage occurs above Drop 1 due to both the longer length of this reach and the higher leakage rates for percolation into the unsaturated zone.

The preferred alternative for lining of the AAC has been identified as the section between 1 mile west of Pilot Knob and Drop 3 (Bureau of Reclamation 1994). This reach accounts for 84,500 af/yr of the seepage reported in Table 4-1. The proposed lining is expected to conserve only 67,700 af/yr of seepage water because it is estimated that 15,800 af/yr will leak through the new lined canal and 2,000 af/yr of additional seepage will occur below Drop 3 due to the lowering of the water table above Drop 3.

4.2 GROUNDWATER LEVELS NEAR CANALS AND SEEPS

4.2.1 Pre-Canal Conditions

In 1939, prior to the construction of the AAC, regional groundwater flow directions in the East Mesa and northern Mexicali Valley approximately conformed with the ground surface topography (Figure 4-3). Groundwater elevations that year also appear to have been influenced by recharge from the old Alamo Canal and the Rio Colorado, causing some directional variation from surface topography, particularly south of the international border.

Along the AAC, the groundwater elevation was at 33 feet MSL at the East Highline Canal turnout, 73 feet MSL at the Coachella Branch turnout, and 118 feet MSL at Pilot Knob. Ground surface elevations are 45 feet MSL at the East Highline Canal turnout, 155 feet MSL at the Coachella Branch turnout, and 200 feet MSL at Pilot Knob. The depth to groundwater, therefore, increased from 12 feet at the East Highline Canal turnout, 82 feet at the Coachella Branch turnout, and 82 feet at Pilot Knob.

4.2.2 Impacts of Canal Seepage

As a result of seepage from the unlined AAC and its CB, groundwater elevations immediately began to rise in the vicinity of the canal. This is illustrated by water levels listed for two monitoring wells in Figure 4-4. Groundwater levels rose approximately 20 feet during the 1940s and 1950s in East Mesa wells 7906.37 and 7904.37, located immediately above and below Drop 2, respectively. The water level then stabilized in Well 7904.37 at approximately 114 feet MSL, which is more than 17 feet below the canal bottom elevation above Drop 2 (132 feet MSL). In contrast, the water level stabilized in Well 7906.37 at approximately 112 feet MSL, which is more than 4 feet above the canal bottom elevation below Drop 2 (108 feet MSL). These wells illustrate that the water table above Drop 2 rose and stabilized far below the canal bottom, whereas west of Drop 2 the water table rose and stabilized above the canal bottom. Figure 4-5 depicts 1965 variations in the water level along the AAC and canal bottom elevations, and clearly indicates the change in conditions that occur near Drop 2. Thus, seepage above Drop 2 is controlled by percolation into the unsaturated zone beneath the canal, and seepage below Drop 2 is controlled by discharge directly into the water table which had risen to contact the canal bottom. Note that groundwater levels below Drop 3 and Drop 4 are above the local canal water level, suggesting that the canal may be gaining water immediately below these drops.