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RELATIONSHIP BETWEEN GROUND WATER IN THE CHERRY CREEK ALLUVIUM AND CHERRY CREEK RESERVOIR

Purpose

This investigation was conducted by LRCWE to determine the relationship between ground water flow in the Cherry Creek Alluvium and the Cherry Creek Dam and Reservoir.

Conclusions

1) Approximately 2,400 acre-feet per year of ground water flows north towards Cherry Creek Reservoir in the saturated alluvium.

2) Because the Cherry Creek Dam cut-off trench does not go completely to bedrock, approximately 4,400 acre-feet per year of water flows beneath the Cherry Creek Dam. Of this total, 2,400 acre-feet is provided by natural ground water underflow, and 2,000 acre-feet is provided by recharge from the reservoir.

3) Ground water in the Cherry Creek Alluvium migrates at a rate of approximately 630 feet per year. At this flow rate, the ground water travel time from Parker to the Cherry Creek Dam (9 miles) is 76 years.

4) Ground water flowing in the alluvium is not intercepted by Cherry Creek Reservoir, therefore, phosphorous in the ground water does not impact the reservoir.

5) Because the reservoir recharges the ground water it may either a) add phosphorous to the ground water downstream of the reservoir, or b) dilute the phosphorous in the ground water and concentrate it in the reservoir. Insufficient data are available to evaluate these alternatives.

6) Because Cherry Creek and the aquifer are hydraulically connected, changes in water table elevation could change Cherry Creek from a losing to a gaining stream. This could affect runoff characteristics in the basin and alter the phosphorous levels in the Cherry Creek Reservoir.

7) Changes in the historic pumping pattern in the alluvium could change Cherry Creek from a losing to a gaining stream over part or all of its lengths. If this occurs the phosphorous loading to Cherry Creek could increase or decrease depending upon the charges in ground water elevation.

Geologic Setting

The Cherry Creek Alluvium is deposited in a valley incised into the Denver Formation. The alluvium consists of stream deposited, unconsolidated, sand, gravel, cobbles, silt and clay. The alluvial channel is 3,000 to 6,000 feet wide between Parker and Cherry Creek Dam. U.S. Geological Survey lithologic well logs were used to create cross-sections of the alluvial channel. Figure 1 is a cross-section at Arapahoe Road and is typical of the aquifer. The cross-section shows that the paleochannel is up to 110 feet thick and that the aquifer can be sub-divided into four geological units. In general, all of these units exhibit a fining upwards sequence with the coarsest, most permeable material at the base of the unit and the finer less permeable material at the top of the unit.

Cherry Creek Dam

Cherry Creek Dam is an earth-fill dam constructed by the U.S. Army Corp of Engineers as a flood control structure. Beneath the dam, over most of its length, all the unconsolidated material was excavated down to bedrock and replaced with impermeable material, to form a cut-off trench. Figure 2 is a cross-section of the central portion of the dam, showing the original ground surface, the top of the Denver Formation, and the base of the cut-off trench. This figure shows that the depth of the alluvium exceeds the depth of the cut-off trench at two locations by as much as 50 feet. These two zones allow ground water to flow beneath the dam and to continue downstream in the Cherry Creek Alluvium.

The dam is designed to allow for this underflow. To alleviate high hydrostatic conditions at high water conditions in the reservoir, the US Army Corps of Engineers constructed 14 pressure relief wells in the alluvium across the toe of the dam. These pressure relief wells are connected by a drain pipe at 5497 feet elevation. If the water level in the alluvium rises above that level, it drains by gravity to the stream. This removes hydrostatic pressure before it can build to dangerous levels at the toe of the dam.

The US Army Corps of Engineers monitors the water level changes in these and other wells. Most of the water table fluctuations are cyclic and seasonal, showing a definite drop during irrigation season and rebound during the winter and spring. These cycles are caused by pumping of irrigation wells on Kennedy Golf Course. The closest golf course well is only 380 feet from the nearest pressure relief well. Only during reservoir filling events do the water levels diverge from the seasonal pattern. When the reservoir quickly rises by 5 or 10 feet, the wells which are drilled directly into the deep paleochannel rise very quickly. The other wells also are affected by the reservoir rise, but much more slowly. These changes demonstrate that the ground water flow under the dam is directly related to the storage behind the dam.

Aquifer Permeability

In 1957 - 1959 the USGS conducted four aquifer tests in the Cherry Creek Alluvium in the vicinity of the Reservoir. The results of these tests as listed on Table 1 show that the aquifer is very permeable. The average hydraulic conductivity of these four tests is 2,300 gpd/ft². Results from other aquifer tests conducted in the Cherry Creek Alluvium by Arapahoe Water and Sanitation District and Denver SE Suburban Water And Sanitation District are also listed on Table 1. The average hydraulic conductivity from all the aquifer tests listed on Table 1 is 2,100 gpd/ft². The range in hydraulic conductivity is consistent with the variability of the aquifer as shown on Figure 1.

Estimate of Ground Water Flow in the Cherry Creek Alluvium

The amount of ground water flowing in the alluvium can be calculated using Darcy's Equation of Flow, $Q = KiA$.

Where:

Q = Flow Volume (gallons per day)
K = Hydraulic conductivity (gallons per day/ft²)
i = Gradient or Slope (ft/ft)
A = Cross-sectional Area (ft²)

At Arapahoe Road, the cross-sectional area is about 167,000 square feet, the slope is about 0.0057, and the hydraulic conductivity is about 2,300 gpd/ft. The estimated ground water flow at Arapahoe Road is approximately 2,400 acre-feet per year. Four miles upstream of Arapahoe Road, the estimated ground water flow is 2,100 acre-feet per year. This suggests that approximately 300 acre-feet per year is lost by the stream to the Alluvium in this four mile reach.

Dam Underflow Volume

The amount of ground water flow beneath the dam is approximately 4,400 acre-feet per year. This was derived using a flownet. Of this 4,400 acre-feet, 2,400 acre-feet is ground water moving uninterrupted beneath the reservoir. The other 2,000 acre-feet is surface water recharged by the reservoir, to the Alluvium.

Ground Water Flow Velocity

The ground water velocity was estimated by the equation $V=Ki$

Where:

V = Velocity (ft/day)
K = Hydraulic Conductivity (ft/day)
i = Gradient or slope (ft/ft)

TABLE 1

AQUIFER TESTS IN THE CHERRY CREEK ALLUVIUM

NAME AND LOCATION		Q gpm	SATURATED ALLUVIUM ft	TRANSMISSIVITY gpd/ft	HYDRAULIC CONDUCTIVITY gpd/sq ft
(1) CITY OF AURORA WELL	5S 66W 18cadb	1,685	93	230,000	2,500
(1) CITY OF AURORA WELL	5S 66W 19baa	1,570	101	150,000	1,500
(1) VALLEY COUNTRY CLUB	5S 66W 19daad	955	33	90,000	2,700
(1) CITY OF AURORA WELL	5S 66W 30aada	1,370	85	210,000	2,500
				AVERAGE	2,300
(2) ARAPAHOE WSD	5S 66W 29?	650	44	109,000	2,500
(3) DENVER SE SUB. WSD WELL A	7S 66W 22 NE NW	885	44	45,000	1,000
(3) DENVER SE SUB. WSD WELL B	7S 66W 15 SE SW	860	47	50,000	1,100
(3) DENVER SE SUB. WSD WELL C	7S 66W 15 SW SW	545	47	50,000	1,100
(3) DENVER SE SUB. WSD WELL D	7S 66W 10 SW NE	845	34	130,000	3,800
(3) DENVER SE SUB. WSD WELL E	7S 66W 10 NE NE	770	43	200,000	4,700
(3) DENVER SE SUB. WSD WELL F	7S 66W 3 SE SW	915	43	50,000	1,200
				AVERAGE	2,100

NOTES

(1) THESE TESTS WERE CONDUCTED BY THE USGS.

(2) THIS TEST WAS CONDUCTED BY THE ARAPAHOE WATER AND SANITATION DISTRICT.

(3) THESE TESTS WERE CONDUCTED BY MID-CONTINENT ENGINEERING.

Using a hydraulic conductivity of 307.5 ft/day (= 2,300 gpd/ft) the average ground water flow velocity in the alluvium is 1.74 ft/day, 630 ft/year. At this velocity it would take about 76 years for water to move from Parker to the Cherry Creek Dam, a distance of about 9 miles.

Interconnection Between Cherry Creek and the Cherry Creek Alluvium

Because the aquifer is very permeable, recharge to the Alluvium from Cherry Creek occurs wherever the water level in the aquifer is below the base of the stream. Conversely, wherever the elevation of the water table is above the base of the stream, discharge of ground water occurs to the stream. These conclusions are supported by the following previously presented evidence:

1) The ground water flowing in the Alluvium decreases by 300 acre-feet per year in the four mile reach above Arapahoe Road.

2) The ground water flow beneath Cherry Creek Dam increases by 2,000 acre-feet per year.

The implications of these conclusions are that any analysis of the Cherry Creek basin must include the interaction between the surface and ground water systems. Otherwise, potentially significant errors in the estimation of runoff in the basin could occur. Because the aquifer pumping demand is in the process of shifting from predominately irrigation to municipal uses, it is likely that the historic ground water levels and seasonal patterns of fluctuation will be different in the future. This could alter the runoff characteristics of the basin.

Impact of Phosphorous in the Ground Water on Cherry Creek Reservoir

Because the water table elevation of Cherry Creek Reservoir is above that in the aquifer as evidenced by the annual recharge to the aquifer from the reservoir, very little, if any, ground water enters the reservoir. Thus, the phosphorous level of the ground water does not affect that in the reservoir. Rather, it is possible because of the recharge that occurs, that the reservoir is increasing the phosphorous level in the aquifer downstream of the reservoir. It is also possible that the sediment on the bottom of the reservoir acts like a filter and removes phosphorous from the recharge so that the phosphorous in the ground water is reduced while the reservoir phosphorous is further concentrated. There is insufficient data to evaluate these alternatives.

Phosphorous bearing ground water can indirectly contribute to the loading of the Reservoir if ground water levels rise above the bottom of the stream thereby causing phosphorous bearing ground water to flow into the stream and then to Cherry Creek. Because

the reach of Cherry Creek between Arapahoe Road and the Reservoir is essentially dry, most of the time, this situation is likely not currently occurring. However, changes in pumping demand and storm runoff due to urbanization could alter this situation in the future. Depending on the degree of these changes, phosphorous levels in Cherry Creek Reservoir could increase or decrease. Again, there is insufficient data to evaluate either of these alternatives.