WATER RESOURCE MANAGEMENT
IN
THE PROSPECT VALLEY AREA, COLORADO

by

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Scope

This paper is essentially a summary of observations and conclusions of a 3 year hydrologic study in Prospect Valley.(1) A general description of the area is presented, including a brief review of the geology and hydrology with special emphasis on the surface and ground-water supplies for irrigation. The effect of an artificial ground-water recharge operation on ground-water levels and ground-water quality are discussed. Based on historical water deliveries some water resource management aspects are proposed involving conjunctive use of surface and ground-water supplies.

Description of the Study Area

Prospect Valley, a tributary to the South Platte River, is located approximately 40 miles northeast of Denver. The area is typical of the many alluvial-filled trenches or erosion channels in the western part of the United States. The valley is about 20 miles long and 4 to 5 miles wide. The alluvial fill beneath the surface varies in thickness from a few feet near the edges to about 150 feet near the central part of the valley. Two ephemeral streams, one on either side of the valley, serve in part to recharge the underlying ground-water reservoir.

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The irrigated area, about 13,000 acres, comprises only a portion of the valley. The upper end is limited to dry-land farming due to lack of either canal or ground-water supplies, while the lower end is overlain by a considerable aeolian deposit of typical sand-hill topography.

The water supply for the irrigated area is derived from ground-water and limited canal supplies. The valley is one of the most productive agricultural areas in Colorado, with the major crops being sugar beets, corn, beans, alfalfa and small grains. Cattle feeding operations, utilizing locally grcwn feeds, are becoming quite common.

Prospect Valley is included at the east edge of the Henrylyn Irrigation District, but has been plagued by lack of irrigation water supplies since the inception of the district in 1907. The underlying ground-water reservoir was successfully exploited in 1932 to provide a much needed supplemental supply. Ground-water levels immediately began to decline and ~~between~~ during the period of 1933 to 1942 a general decline of about 20 feet occurred in the pumped area. During the 1942 to 1949 period, however, canal deliveries to the area were generally above normal and some recovery of ground-water levels occurred. The trend of ground-water levels in the area has been generally down with periods of partial recovery due to above normal amounts of canal deliveries.

In 1939 the Henrylyn Irrigation District discovered that a fairly efficient artificial ground-water recharge site existed in one of their surface reservoirs which they had abandoned shortly after ~~1907~~ 1918. Olds Reservoir, ideally located near the upper end of the pumped area has been purposely used since that time for recharge purposes whenever surplus water was available. Limited amounts (approximately 15,000 acre-feet) were recharged through this facility during the 1942-1948 period with increased amounts (approximately 36,000 acre-feet) being recharged during the period 1957-1962. The beneficial effect of this activity was noted in rising ground-water levels in nearby irrigation wells. A quantitative evaluation of the recharge potential at Olds Reservoir as well as a fairly intensive hydrologic analysis of the surface water - ground-water system was initiated in 1959 by the Civil Engineering Section of Colorado State University. The purpose of the study was to determine the operating characteristics of the system which could eventually be utilized in a conjunctive water resource management plan for the area.

Quantitative Recharge Study at Olds Reservoir

The initial phase of the investigation included the establishment of an extensive ground-water level observation well network which would give a representative indication of the effect of recharge from Olds Reservoir. In the majority of cases, observation wells were selected from existing irrigation wells. A limited number of abandoned or specially drilled wells were utilized. Some observation wells were fitted with continuous recorders.

Inflow to Olds Reservoir was established at a rated section in the delivery canal. Daily infiltration rates in Olds Reservoir were obtained by comparing the inflow to the change in surface storage.

During the period of December 3, 1959 to April 20, 1960 approximately 9400 acre-feet of water were recharged through Olds Reservoir. The average daily infiltration rate amounted to about 68 acre-feet per day or about 1.2 feet per day over the areal surface of the reservoir ($\approx$ 58 acres). The average depth in Olds Reservoir (storage volume $\div$ areal surface) during the majority of the recharge period was about 5 feet.

No appreciable change in the stage-infiltration rate relationship was noted during the 4-1/2 month recharge period. The infiltration rate was, however, about 30 percent greater than that rate determined by Code during the period 1940-1944.(2) The obvious increase of detergent content and other contaminants in the canal supplies since about 1955 may have some effect on increased infiltration rates.

Ground-water level rises in observation wells in the immediate vicinity of Olds Reservoir were predicted quite well through the use of modified heat flow equations.(3) For distances of observation greater than about 2-1/2 times the radius of the recharge site, it was found that the source of recharge may be considered as a recharge well and that the Theis, non-equilibrium equation may be used to predict the rise of water levels.

Characteristics of the Aquifer

A heterogeneous mixture of gravel, sand, silt and clay deposited in a trough-shaped erosion channel provides the ground-water aquifer beneath Prospect Valley. An inspection of drillers logs indicated that interspersed layers of clay, often times of considerable thickness, but with no apparent continuity over any sizable area, are quite common. The layers of clay overlying the ground water in some areas produce a confining or semi-artesian effect. A barometric efficiency of about 60 percent was noted in one observation well.

The average specific yield was reported by Code to be about 17 percent.[2] Irrigation wells, generally drilled to the underlying bedrock were reported to produce flows ranging from 500 to 1700 gallons per minute. The average specific ~~yield~~ capacity of 73 wells tested during the period 1947 to 1949 was 63 gallons per minute per foot of drawdown.[4]

Since the aquifer is underlain by a relatively impermeable boundary and the level of the ground-water surface is generally beyond the effect of evapotranspiration losses, the storage efficiency of the aquifer is quite high. According to mathematical calculations by R. E. Glover, water recharged at Olds Reservoir may be recovered by pumping at some later date with relatively small loss.[5]

Unusually high water use efficiency also exists where the irrigated area overlies an unconfined ground-water reservoir. A given amount of water stored in a surface reservoir is generally applied only once by an individual surface water user; in the case of ground-water storage in Prospect Valley, part of the applied water returns to the ground-water reservoir for re-use.

The re-use phenomenon is evident by the increased total dissolved solids content of the ground-water in the down valley direction. Total dissolved solids content of the ground-water ranges from 200 to 300 ppm in the upper valley to 2000 to 3000 ppm in the lower valley - a distance of about 10 miles.

In addition, canal deliveries to the area since about 1955 have had a certain detrimental effect on the ground-water quality especially in the area immediately adjacent to the artificial recharge site - Olds Reservoir. Since the canal diversion point is located on the South Platte River only a short distance downstream from Denver sewage plant outfalls, the quality of the water diverted to Prospect Valley depends to a high degree on the extent of the sewage treatment process and the dilution effect of the River. Concentrations of both detergent and nitrates in the ground-water are approaching the limits of recommended maximum concentration for domestic use.[6]

Proposed Water Resource Management Aspects for Prospect Valley

The 20 year (1942-1962) average annual gross application rate (surface water and ground water) for irrigation in Prospect Valley has amounted to slightly over 3 acre-feet per acre. During the 20 year period ground-water supplies have furnished approximately 76 percent of the total irrigation water in the valley. Historical ground-water level hydrographs illustrate an overdraft on the ground-water reservoir. An estimated evaluation of the reduction in ground-water storage amounted to an average of about 10,000 acre-feet per year during the period 1942-1962:

Estimated average annual supply (acre-feet) to the Prospect Valley ground-water reservoir for the selected period 1942-1962---

Recharge through Olds Reservoir	2,500
Canal seepage losses	3,000
Deep percolation of field applied water	9,000
Precipitation penetration to water table	2,500
Deep percolation of ephemeral stream flow	3,000
Ground-water inflow	6,000
Total	26,000 acre-feet

Estimated average annual discharge (acre-feet) from the Prospect Valley ground-water reservoir for the selected period 1942-1962---

Ground-water pumpage		28,000
Ground-water outflow		8,000
	Total	36,000 acre-feet

In order to maintain long term ground-water level equilibrium under present irrigation water demands, an average annual increase in the supply to the ground-water reservoir of about 10,000 acre-feet must be affected.

The possibility of obtaining additional direct canal diversions, from the all ready over appropriated South Platte River, are quite remote, but several other altervatives seem feasible:

1. improved irrigation efficiency resulting in less pumped-water requirement and a greater portion of the canal supplies available for direct ground-water recharge....

2. more efficient utilization of ephemeral stream runoff in the area - In the past some flood flows in the streams have spread out over the valley with a good deal of the water being evaporated. Suitable recharge facilities would provide a direct supply to the reservoir and in some instances reduce flood damage.

3. reduction of seepage losses in the surface-water conveyance system - According to diversion delivery records a conveyance loss of about 60 percent exists between the diversion point below Denver and Prospect Valley. Based on canal deliveries to the Valley during the period 1942-1962, the average annual conveyance loss approaches 13,000 acre-feet. A sizable portion of the 13,000 acre-feet could undoubtedly be salvaged through appropriate seepage reduction methods.

From both the quality and quantity standpoint, the enlargement of portions of the conveyance system may be worthwhile in order to take advantage of limited periods of flow of unusually good quality water occurring during the spring runoff or flood periods in the South Platte River. High capacity recharge sites may be advantageous for handling large flows of better quality water, that cannot be temporarily stored in the surface conveyance system. If flow is available during the normal irrigation season and can be beneficially applied, the water may be used directly on the land without the added cost of pumping. Obviously the number of unnecessary cycles of the flow from the ground-water reservoir to the ground surface and back again to the ground-water reservoir should be kept to a minimum from the standpoint of economy, quality and consumptive use.

Conclusions

The recharge through Olds Reservoir in Prospect Valley represents the only sizable artificial ground-water recharge operation in Colorado at the present time. If the filing recently made to the State Engineer for 40,000 acre-feet of excess water from the South Platte River for recharge purposes is approved, this action will represent the first decree of water for this use in the history of Colorado.

Through a well planned management program, including artificial ground-water recharges, improved irrigation efficiency, reduction of non-beneficial water consumption and water quality control the outlook for a continued irrigation economy in Prospect Valley looks bright. Due to ever-increasing demands and the resultant re-use of available water supplies adequate irrigation water of suitable quality for future use will require the immediate implementation of a conjunctive water resource management plan in the area.

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