Artificial Ground-Water Recharge On The Arikaree River Near Cope, Colorado

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ARTIFICIAL GROUND-WATER RECHARGE ON THE ARIKAREE RIVER NEAR COPE, COLORADO

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Introduction

The arid and semi-arid west must utilize its total water resources and promote water conservation in order to meet the ever increasing demand. Fresh water supplies originate from precipitation; thus maximum use and conservation of the water that falls on the land is essential. Some of the water that falls as precipitation immediately flows across the land as surface runoff. Rivers have been used for years by man as a domestic water supply, for irrigation, as a transportation mechanism, and as a means to carry waste materials. Floods have always occurred on our rivers resulting in a loss of fresh water to the sea without utilization of the resource. Man has constructed dams and other works to retard flood flows and store the water for later use.

In the arid and semi-arid areas only about one third of the water that falls as precipitation flows from the source area as streams or rivers. Evaporation from the land surface and transpiration by plants returns a large part of the water that falls as precipitation to the atmosphere. Only a small amount of the precipitation percolates through the soil to porous sand and gravel materials below, thus recharging the ground water supply. In some areas such as along the South Platte River, the deep percolation of irrigation water contributes more to ground-water recharge than precipitation although the water for irrigation originated as precipitation.

Large ground-water supplies exist in many areas throughout the world. Much of this water has accumulated over many millions of years. Recent heavy pumping in some areas has exceeded the natural recharge, resulting in depletion of the ground water in storage. Reduced pumping or increasing the recharge artificially will be required to prevent further overdraft on the ground-water reservoirs. Many of the ground-water reservoirs can store more water if excess surface water can be artificially recharged to the porous aquifer material. Water stored in the underground aquifers may later be removed by pumps to satisfy man's needs.

The development and use of artificial recharge practices using excess surface water or flood flows will help to utilize and conserve more of our fresh water.

What Is Artificial Recharge ?

Artificial recharge is defined as the augmentation of the natural infiltration of surface water into underground formations by some method of construction, spreading of water, or by artificially changing natural conditions. Natural recharge is the infiltration of surface water into underground formations under natural conditions and occurs irrespective of man's activities.

Methods of artificial recharge - Several different methods have been devised to artificially recharge water to the underlying ground-water aquifer. The most common technique is known as water spreading. Water spread over a selected land surface is allowed to percolate downward to the aquifer. This approach is very satisfactory where the soil is very sandy or permeable allowing high infiltration of the surface water. It can not be used if some impermeable layer such as a clay lense or a shale layer exists between the land surface and the aquifer. The use of small detention dams to spread water over larger areas or over irrigation to allow more water to percolate downward are two examples of this technique.

Artificial recharge using pits is practiced where impermeable layers exist near the land surface. Pits dug through the impermeable material allow water

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to percolate through the bottom and sides of the pit, thus, recharging the aquifer. Abandoned gravel pits have been used for this purpose.

In some areas wells have been used to artificially recharge the ground water. If deep underlying impermeable strata exist or if the geologic formations near the surface have a high salt content, wells can be used to inject the water directly into the aquifer. Artificial recharge with injection wells has been used to prevent salt water intrusion from the ocean along some of the coastal areas.

Requirements for water spreading - When selecting an artificial recharge site, one must consider the water supply. If surface runoff including flood flows is to be utilized, it is essential to locate the recharge facilities near the stream. Areas having very permeable soils are preferred. A large unsaturated aquifer beneath the recharge area should exist to accept the recharged water. High water tables resulting from the recharge can cause seepage areas to develop or basements of buildings to fill in the immediate area. If pumping has caused the water level to drop in certain areas, then artificial recharge within or near the area should be considered as a means of correcting the problem. Good quality water should be used, if available. If the water contains bacteria, it may be necessary to treat the water prior to recharge. Flood flows often contain large volumes of sediment that may seal the recharge area requiring periodic removal of the sediment to maintain high infiltration rates.

Initiation Of Recharge Study

Research sponsors - The Colorado Ground Water Commission was appropriated $10,000 for use during the fiscal year 1965 by the Colorado Legislature during the Second Regular Session of the 44th General Assembly. This appropriation was requested by legislators from eastern Colorado to initiate an artificial recharge study using flood flows for a water supply. The Ground Water Commission actively supported the project realizing that we must conserve our ground-water supplies and increase the recharge to prevent excessive drawdown of water tables in the aquifers.

It was desirable to select a study area where the local residents would help support the project. Near Cope, Colorado, along the Arikaree River, there were about sixty irrigation wells that had inadequate water supplies to maintain extensive pumping. Residents from that area asked that the artifical recharge project be initiated along the Arikaree River and local area financial and political support was pledged. The Cope Soil Conservation District encouraged the study and offered to act as a subcontracting agency for the construction of the project. The District also pledged support to obtain easements from land owners for the necessary area upon which to construct the spreading basins.

Contracts for the study - The Ground Water Commission contracted with the Civil Engineering Department at Colorado State University to select the recharge sites, design the necessary structures, supervise construction, collect data, and make the necessary analyses to evaluate the study. A contract was also prepared between the Commission and the Cope Soil Conservation District to cover the construction costs. The contracts have been renewed for succeeding years.

Site selection - Preliminary investigation indicated several recharge sites existed on the Arikaree River near Cope, Colorado. Cost analyses indicated one or two experimental sites might be possible. Brief geologic investigations were made to determine if the proposed sites were suitable for water spreading as a means of artificial recharge. Two sites indicated on Figure 1 were selected. Both sites have irrigation wells nearby that benefit immediately from the artificial recharge. Other wells along the Arikaree will undoubtedly benefit from rising water levels.

A check was made with the State Engineer to see that the proposed study would not jeopardize downstream surface water rights. Few surface water decrees exist on the Arikaree River in Colorado and thus a conflict was unlikely. Mr. Whitten, the state Engineer for Colorado, further contacted representatives from Kansas and Nebraska and enlisted their support for the study. On other streams in Colorado that have an over appropriated water supply it may not be possible to obtain water for artificial recharge.

Easements were obtained from Mr. Ezra Page and Mr. Oscar Higgason for approximately 80 acres of land along the Arikaree for site No. 1. This encompases parts of Sec. 3 and 10 T5S R5OW. Lynn and Fred Laybourn signed easements for

COPE RECHARGE STUDY

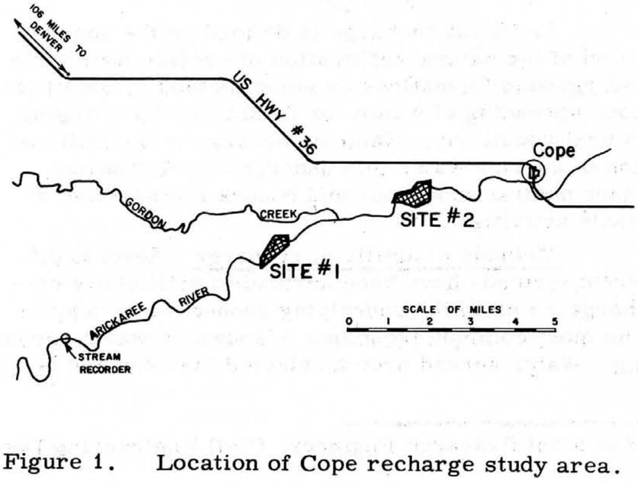

Figure 1. Location of Cope recharge study area.

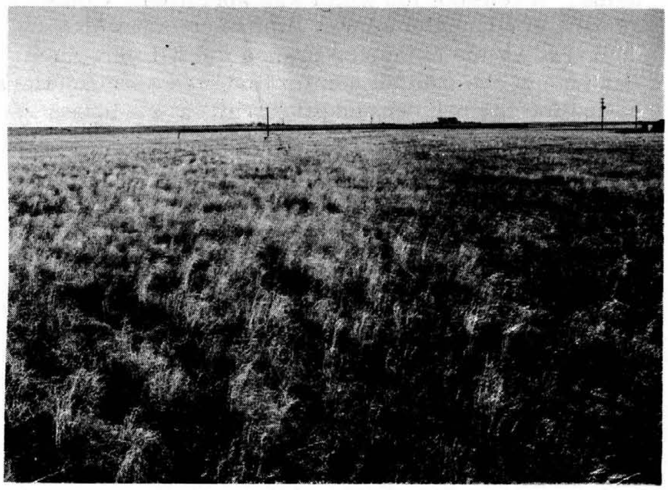

Figure 2. View looking northeast across site No. 1 prior to construction.

approximately 150 acres for location of site No. 2., on Sec. 31 T4S R49W. Landowners at both the sites were enthusiastic about the study and were cooperative. Both sites were located on wide sections in the flood plain corresponding to old stream meanders. Figure 2 shows a northeasterly view across site No. 1, indicating the flat area upon which the water was spread and showing one of the irrigation wells in the upper right hand corner.

Site No. 1 was located in a large curve in the river channel. The water level was about 20 ft below land surface at this site, thus providing the necessary reservoir to be recharged. Test holes drilled 50 ft to bedrock showed no impermeable layers to prevent downward movement of the water.

Site No. 2 was selected below site No. 1 and below the confluence of Gordon Creek with the Arikaree River in hopes that flows in Gordon Creek would provide water for recharge at times when there was no flow in the Arikaree. Local residents stated that Gordon Creek usually flowed several times each year and the Arikaree River may not have flow for several years at a time. The water level was only about 12 feet below land surface for site No. 2 and thus the volume of water that could be stored before the aquifer became completely saturated was limited.

Design of structures - One of the principle objectives of this study was to evaluate several different types of inexpensive construction that could be used to spread the flood waters. Preliminary investigations indicated the nonavailability of rock or other natural materials that could be used. It was finally decided that the structures would be earth fill dams constructed from materials existing on the sites. To limit erosion the existing topography and vegetation were utilized to provide grass spillways where possible.

Figures 3 and 4 show sketches of the two recharge sites indicating the structures that were constructed. The purpose of the three dams, D-1, D-2, and D-3 at site No. 1 was to divert the flow out of the existing channel spreading it over a much larger area to allow the water to infiltrate into the soil. These dams also impounded about one hundred acre feet of water during the brief flow periods which later seeped away as recharge to the ground water. The dikes I-1, I-2, and I-3 were constructed to control the movement of the water forcing a meandering pattern with reduced flow velocities. Some protection to existing irrigation wells was also provided by the dikes and they prevented development of a new stream channel.

At site No. 2 there were originally only three structures; D-1, D-2, and D-3. The dam D-1 diverted the water out of the existing river channel into an old abandoned channel. Structure D-2 then diverted the water back to the existing channel and

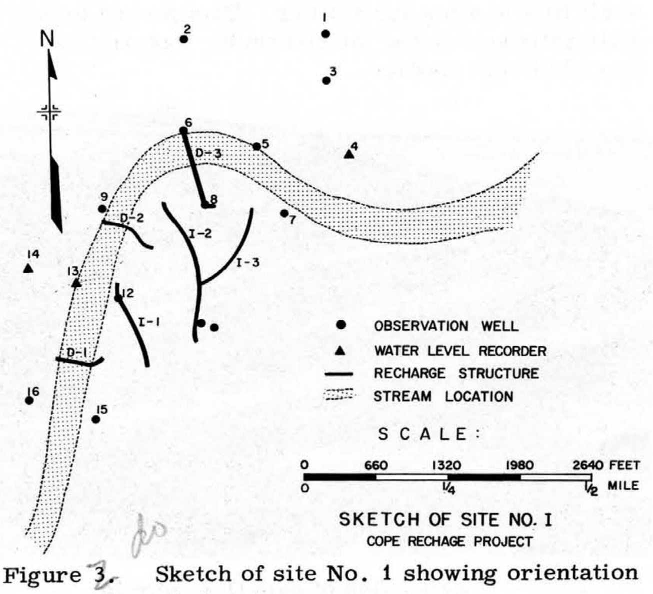

Figure 3. Sketch of site No. 1 showing orientation of structures.

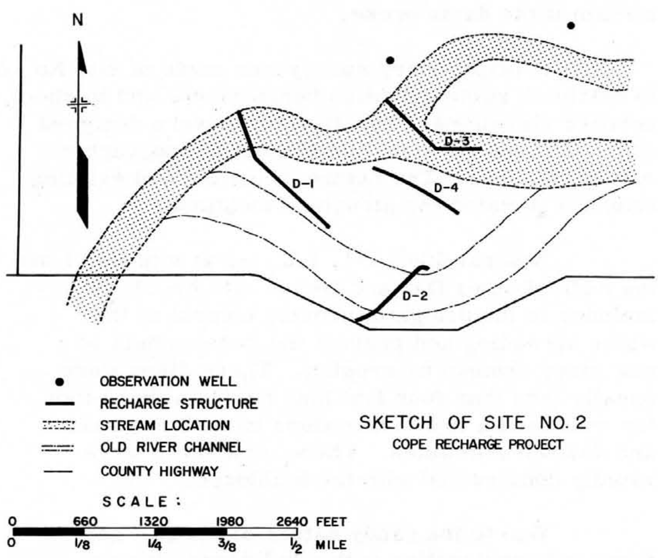

Figure 4. Sketch of site No. 2 showing orientation of structures.

D-3 spread the water over a wide section of flood plain upon which the river had meandered from side to side. It was necessary to construct the dam D-4 to prevent a head cut from eroding its way back into the spillway for dam D-2. Very high recharge rates were experienced in the old abandoned channel which had a coarse sand bottom.

The watershed areas above site No. 1 and 2, respectively are 582 and 725 square miles. Hydrologic analyses indicate that very large flows could be expected from drainage areas of this size and historic floods of very large magnitudes have occurred. Due to the lack of good building materials and the danger of large flows, it was decided that any structures that were built should be considered expendible during the large floods. It was recognized that the first flow might destroy the structures but it was hoped that some smaller floods might occur which would allow an evaluation of the artificial recharge principle using flood flows and the inexpensive structures. Earth dams constructed from material on the sites and having a relatively small volume of water trapped behind them were designed.

Site No. 1 was surveyed and a detailed topographic map was prepared. This map was used to determine structure locations so as to provide maximum flooding with the least amount of impounded water. Spillways around D-1, D-2 and D-3 were designed to carry about 1200 cubic feet per second with a velocity of three feet per second. It was felt that if water velocities within the recharge site could be kept below three feet per second that a minimum of erosion would occur. Thus, spillways of over 200 feet in length were selected assuming the maximum depth of flow to be two feet. The designs called for only one and a half feet of freeboard on all dams above the proposed high water elevation. The minimum freeboard was used so that during floods exceeding 1200 cubic feet per second, the structures would be breached before large volumes could be impounded that would cause devasting floods downstream if the dams broke.

A preliminary survey was made of site No. 2 to establish some elevation bench marks and to check relative elevations. The structures were designed and staked for construction without a topographic map of the area. The nature of the old and existing channels dictated the structure locations.

Several dikes I-1, I-2, I-3 at site No. 1 and the ends of dams D-1 and D-3 at site No. 2 were included in the design to provide control of the water spreading and prevent the development of a new river channel by erosion. These dikes were usually less than four feet high having a three foot top width and a two to one slope on both upstream and downstream sides. These structures were rapidly constructed with the bulldozer.

Due to the sandy nature of the soil and the proposed construction with a bulldozer, it was necessary to have a 3:1 slope on both faces of the dams. A ten-foot top width was specified. Compaction of fill material was limited to that which occurred as the bulldozer pushed the fill into place. Because of the limited compaction, the specifications called for ten per cent additional fill at all points to allow for settlement.

Computations on the amount of fill yardage were made from a survey at the time the dams were staked. Both centerline and upstream and downstream toe stakes were placed.

Construction - Funds for construction were contracted by the Colorado Ground Water Commission to the Cope Soil Conservation District. The District called for bids on the earth moving and contracted with Mr. Lyle Goble of Akron, Colorado to do the work. Mr. Goble completed both the initial and reconstruction phases of the project.

It was found that in the sand and sandy soil at both sites No. 1 and No. 2, it was better to move all the material with a dozer because it was difficult to load and transport the fill material in a carryall. The fill was not compacted other than by operation of the dozer. Riprap was not used on the structures.

During the initial construction, the earth was all pushed from the borrow area immediately upstream of the dam. Figure 5 shows dam D-2 under construction at site No. 1. During reconstruction in the spring of 1966, the material was pushed from borrow areas immediately upstream and downstream from the dam. It was felt that the additional travel on the downstream face of the dam would provide additional compaction and more stability of the fill material. The contractor found that for most cases it was easier and quicker for him to push more fill dirt, resulting in a flatter than three-to-one slope, than it was to try and maintain exact design specifications. This caused him to move some dirt for which he received no pay. Because of the lack of compaction, the contractor was required to add ten per cent to all fills to allow for settling. This proved to be quite satisfactory and the contractor was paid for this additional yardage.

Figure 5. Construction of dam D-2, site No. 1.

Figure 6. Continuous water level recorder installed on an observation well.

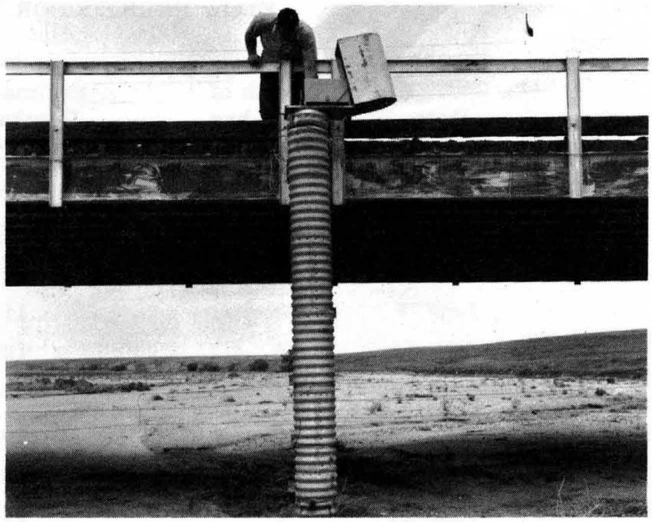

Figure 7. Continuous water stage recorder on bridge upstream from site No. 1.

Inspection upon completion included a brief survey to determine if sufficient fill had been placed. Top widths were measured and side slopes were visually checked with the initial toe stakes. The upstream faces of the small diversion dams were left somewhat rough to prevent rapid sealing by the fine sediments during flow. Wave action kept the irregular surfaces swept free of much of the fine sediments during the June 1965 flow periods.

Specifications called for two-to-one upstream and downstream slopes and a three foot top width on dikes I-1, I-2, and part of I-3 at site No. 1 and on portions of dam D-1, and D-3 at site No. 2. These smaller dikes were found to be quite satisfactory in diverting the water back into the main channel. Most of these dikes were about four feet high, while fills of over nine feet were included in the diversion dams.

Instrumentation - Measurement of flow rates during floods in streams such as the Arikaree River is nearly impossible and the development of stage versus discharge relationships is even more complicated. With this and the limited operating budget in mind, the decision was made to evaluate the artificial recharge benefit at the Cope sites by computing the amount of water stored from measurements of water table fluctuation. Sixteen observation wells were established at site No. 1 but only two at site No. 2. Those at site No. 1 include six irrigation wells. The other ten were constructed by drilling a seven-inch hole with a rotary drilling rig and placing either one and one fourth-or five-inch pipe into the hole as casing. Three of the wells are equipped with automatic-continuous recorders as shown in Figure 6. Water levels in all wells were measured periodically with a steel tape and the measurement recorded on field data sheets and the respective recorder charts.

Numerous photographs including color movies, color slides, and black and white snapshots were taken to show the flow phenomena into and around the recharge structures. Sediment deposition and erosion damage were also recorded on film. On June 18, 1965, aerial pictures were taken and two of these are included as the cover page and Figure 8 of the report.

A continuous operating automatic recorder was placed on a county highway bridge about six miles west of site No. 1, west side of Sec. 23 T5S R51W. Records on periods of stream flow were collected from May 19 to June 30, 1965. The July 24, 1965 flood destroyed the bridge, and the recorder was lost. Figure 7 shows the recorder placed on the downstream side of the bridge.

Use Of Flood Waters

Flow periods - The water stage recorder mounted on the bridge six miles west of site No. 1 recorded flows in the river during May and June but was lost in the July 24 flood. The following table lists recorded flow periods at the bridge and indicates whether water did or did not reach the two recharge sites. Detailed records for flows from July 24 to July 30 are not available because the bridge upon which the recorded was mounted was destroyed at about 5:00 a.m. on July 24 and intermittent flow occurred for several days following the peak flood. The intermittent flows were due to the time lag in stream flow from the west end of the watershed and runoff from additional thunderstorm activity occurring during the period.

Direct measurements of the flow during the July 24 flood were not possible, but two slope-area calculations based upon the high water mark indicated the peak discharge at approximately 18,000

FLOW PERIODS FOR THE ARIKAREE RIVER IN 1965

Date	Length of flow--hrs	Estimated Peak Discharge-cfs	Water Reached Site No. 1	Site No. 2
May 22	14	380	Yes	No
May 26	7	80	No	No
June 4	7	150	No	No
June 5	20	110	No	No
June 13	5	100	No	No
June 16	9	350	Yes	No
June 17	20	1000	Yes	Yes
June 19	10	30	Yes	Yes
June 23	6	290	Yes	No
June 24	20	1600	Yes	Yes
July 24	19	18,000	Yes	Yes
July 25 to July 30	inter- mitt- ent	—	Yes	Yes

cubic feet per second. Flows during the July 25-30 period were observed and estimated at two different times to be from 2,000 to 3,000 cubic feet per second.

There hadn't been any flow in the Arikaree or Gordon Creeks during the year 1963 or 1964 and there hasn't been any flow from July 31, 1965 to July 1, 1966. Because of the extremely dry river bed the May 22, 1965 flow just reached structure D-1 at site No. 1 with little if any artificial recharge occurring. Later, flows proceeded further in the wet stream bed.

Recharge by structures - Flows during June 1965 did not exceed the design flows for long enough periods to cause much damage to the structures but did provide significant amounts of water for recharge. Figure 8 is an aerial view of site No. 1 on June 18 showing how the water was spread over the entire recharge area. The photo on the cover is also an aerial view on June 18.

In Figure 8 you can see a small erosion channel in the lower part of the photo which later worked its way upstream to the spillway of dam D-3. This caused some lowering of the water behind D-3 and had to be repaired after the June 24 flows.

Flow velocities were quite low within most of the recharge area and infiltration rates were very high initially but dropped off some as the fine sediments tended to seal the surface area. It was felt the structures performed very satisfactorily, spreading the water over a large area and impounding some of the intermittent flow allowing it to seep away and recharge the ground-water supply after the stream had stopped flowing.

The structure design was satisfactory, although there was a need for some additional spillway capacity around the end of dam D-2 on site No. 1 during periods of peak flows. Vegetation in the spreading basins retarded stream flow, prevented erosion and trapped some sediment.

Water behind the dams seeped away fairly rapidly after the June 18 flows but remained as much as two weeks after the June 24 flow due to reduced infiltration rates caused by sealing of the surface with fine sediment. Figure 9 shows the water impounded behind dam D-1 shortly after the June 18 flow.

The structures at site No. 2 performed as satisfactorily as those at site No. 1 and the recharge

Figure 8. Aerial view of site No. 1 on June 18.

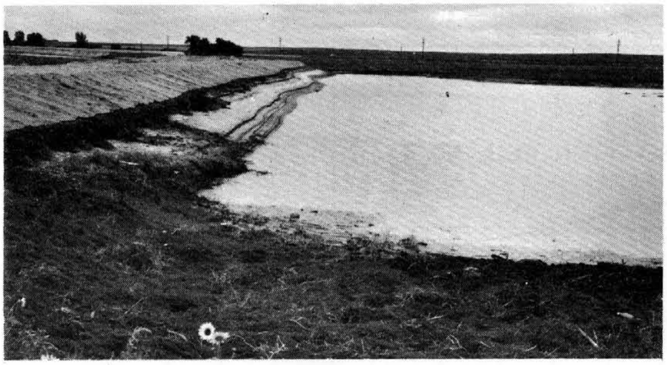

Figure 9. Water impounded behind dam D-1, site No. 1 after June 18 flow.

rate within the old river channel appeared to be very high. It was necessary to construct dam D-4 at site No. 2 to prevent erosion that started to develop between dams D-2 and D-3.

A drop of about two feet in water surface from one dam to another when the structures were placed similar to those at site No. 1 seems quite satisfactory. Some trouble was expected and did occur in returning water flowing through all the structures to the existing stream without having excessive erosion near the downstream spillway. This seems to be the weakest point in the system and might require continued maintenance after each flow.

Figure 10. Flood flow destroying structures at site No. 1 on July 24, 1965.

Destruction by flood - On the morning of July 24, a large flow reached site No. 1 at about 5:30 a.m. and destroyed all structures. Figure 10 shows flow across site No. 1 several hours later. Note the breached dikes visible in the center of the photo and the large flow which was still occurring. All structures were overtopped and quickly eroded away as planned. Similar destruction occurred at site No. 2 except for dam D-2 at that site. When dam D-1 at site No. 2 was destroyed the amount of water diverted into the old channel was reduced and dam D-2 held.

It would have been impossible to have designed any recharge structures that could have withstood the July 24 flood. I think this event emphasized the need for low-cost expendible structures in this type of operation.

Effect On Water Levels

Water levels prior to recharge - A water table contour map for site No. 1 was drawn for June 16, 1965 prior to any significant flow in the river, Figure 11. This map shows that the water table sloped toward the northeast and showed no apparent influence of the river. This was to be expected because there hadn't been any flow in the river in either 1963 or 1964 to recharge the water table. Water levels were steadily declining in all the observation wells and irrigation pumps near site No. 1 were sucking air prior to June 16.

Effect of recharge - Water levels were measured several times daily in the observation wells during and immediately after flow occurred in the river. Figure 12 shows six representative water level hydrographs for observation wells at site No. 1. See Figure 3 for location of wells. It should be noted that water levels rose in all wells on or about June 17 and again during July. These rises correspond with the June recharge period and the July flood. The reason that well number 8 did not rise during July is attributed to destruction of dam D-3 which had recharged water all the way to the land surface in late June, but the July flood flows did not recharge the surrounding area significantly after the dam D-3 was washed away. Water levels rose over 15 feet in ob-

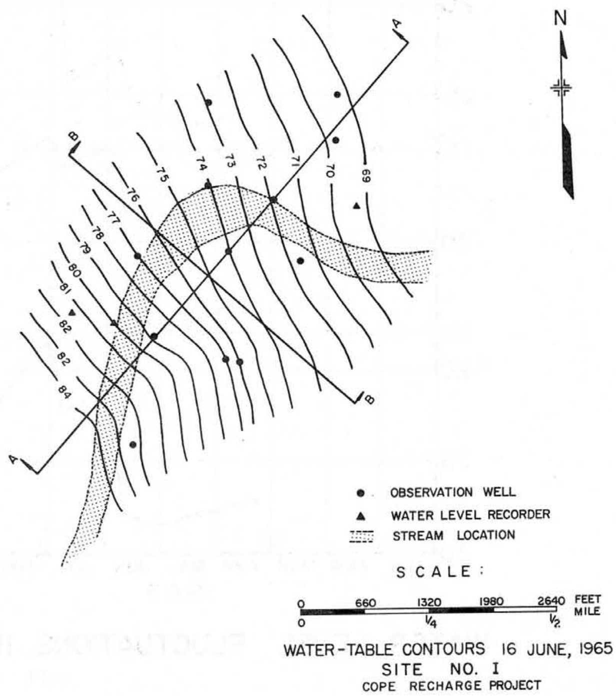

Figure 11. Water table contour map prior to flow in the river.

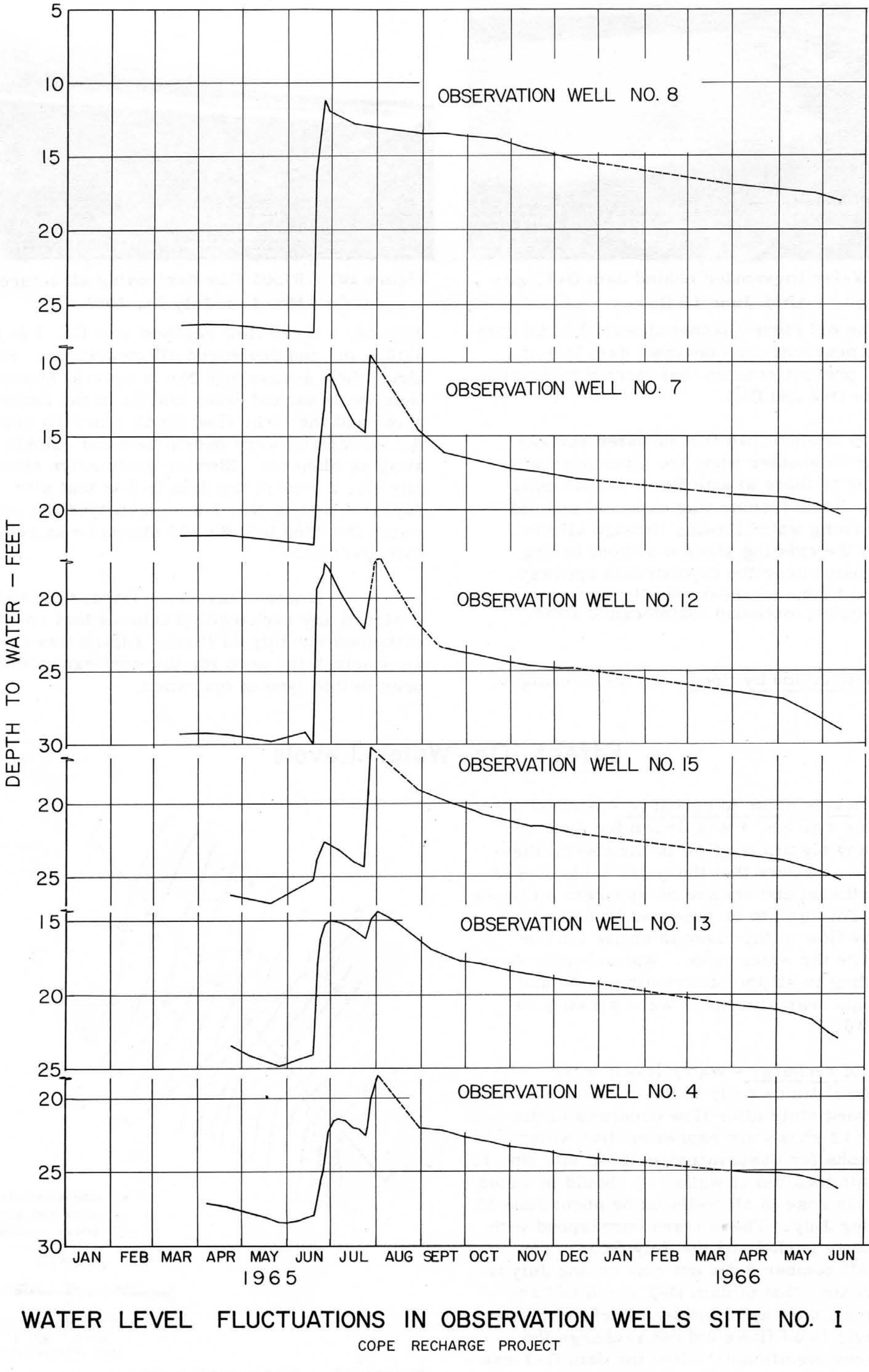

Figure 12. Representative well hydrographs for six observation wells at site No. 1.

Fig 1 | scale of miles S9-52
Fig 2 | Scale

Fig 7 | Scale
Fig 8 | Scale
Fig 9 | Scale

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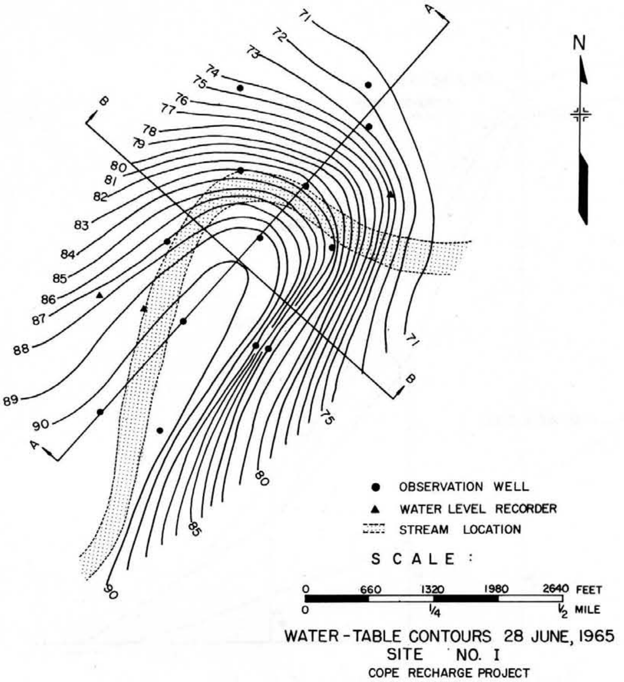

Figure 13. Water table contour map on June 28 after flows in the river on June 16 and 26.

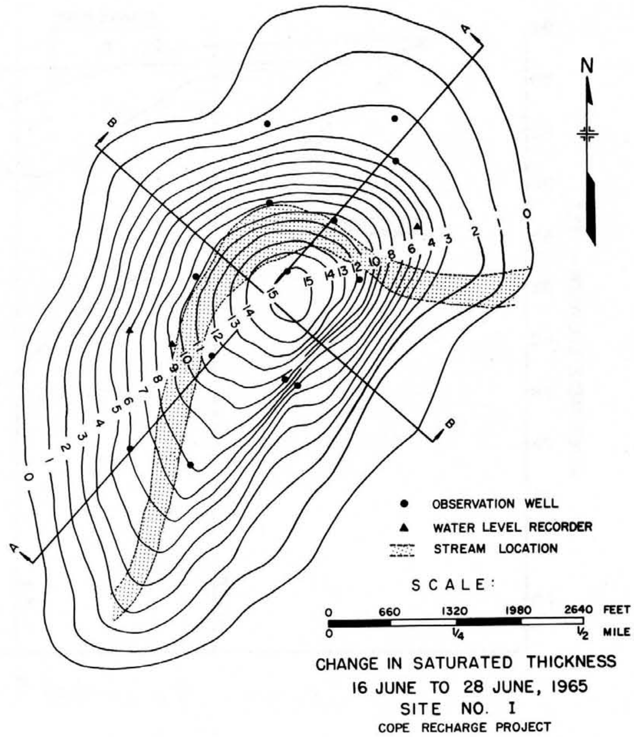

Figure 14. Map showing the rise in water level between June 16 and June 28.

servation well number 8 and more than ten feet in most of the other wells. Note that the water levels have dropped steadily since July 1965 associated with the lateral spreading and down valley movement of the ground water mound developed by the recharge.

A water table contour map, Figure 13, was drawn for June 28, 1966. The water table configuration has changed considerably since June 16, and is fairly flat immediately below the spreading basin, but slopes sharply downward to the east and northeast.

Water table contour maps were also drawn for July 22 and 26 to show the effect of the flood flows. In most cases the water levels did not rise more than about five feet due to the July floods which maintained intermittent flow in the stream for nearly a week. The water tables due to the July floods did not rise above the late June elevations.

Quantity of water recharged - A change in saturation thickness map was prepared, Figure 14, to show the effect of the recharge. This map indicates the amount of water level rise that occurred at site No. 1. Note the maximum rise of over 15 feet. A planimeter was used to determine the volume of sediments that were saturated due to the water level rise from June 16 to the 28th. This totaled about 2260 acre feet. Assuming a porosity, ratio of the void spaces to total volume, of 20 per cent, this would indicate that about 450 acre feet of water were recharged. A similar calculation was made for the July flood period indicating about 540 acre feet of sediments were saturated representing a recharge of only 108 acre feet of water. A comparison of the two volumes of water recharged could indicate that there was a sizeable increase in the water recharged when the structures were in place in June versus the natural recharge from the stream during the July flows after the structures were destroyed. High velocities associated with the peak flow of the July 24 flood scoured away most of the fine sediment deposited in June and it is assumed that reduced infiltration rates were not present.

Two cross-sections, Figure 15 were prepared across the length and width of site No. 1 to show the size and shape of the recharge mound. See Figure 11 and 13 for cross-section location. The vertical scale has been exaggerated for Figure 15 but it does show how the water table rose during periods of recharge and spread laterally with time.

With only two observation wells at site No. 2 it was impossible to make the detailed analyses prepared for site No. 1. Water level rises were observed in the wells but adequate data were not available to prepare well hydrographs to be included in this report.

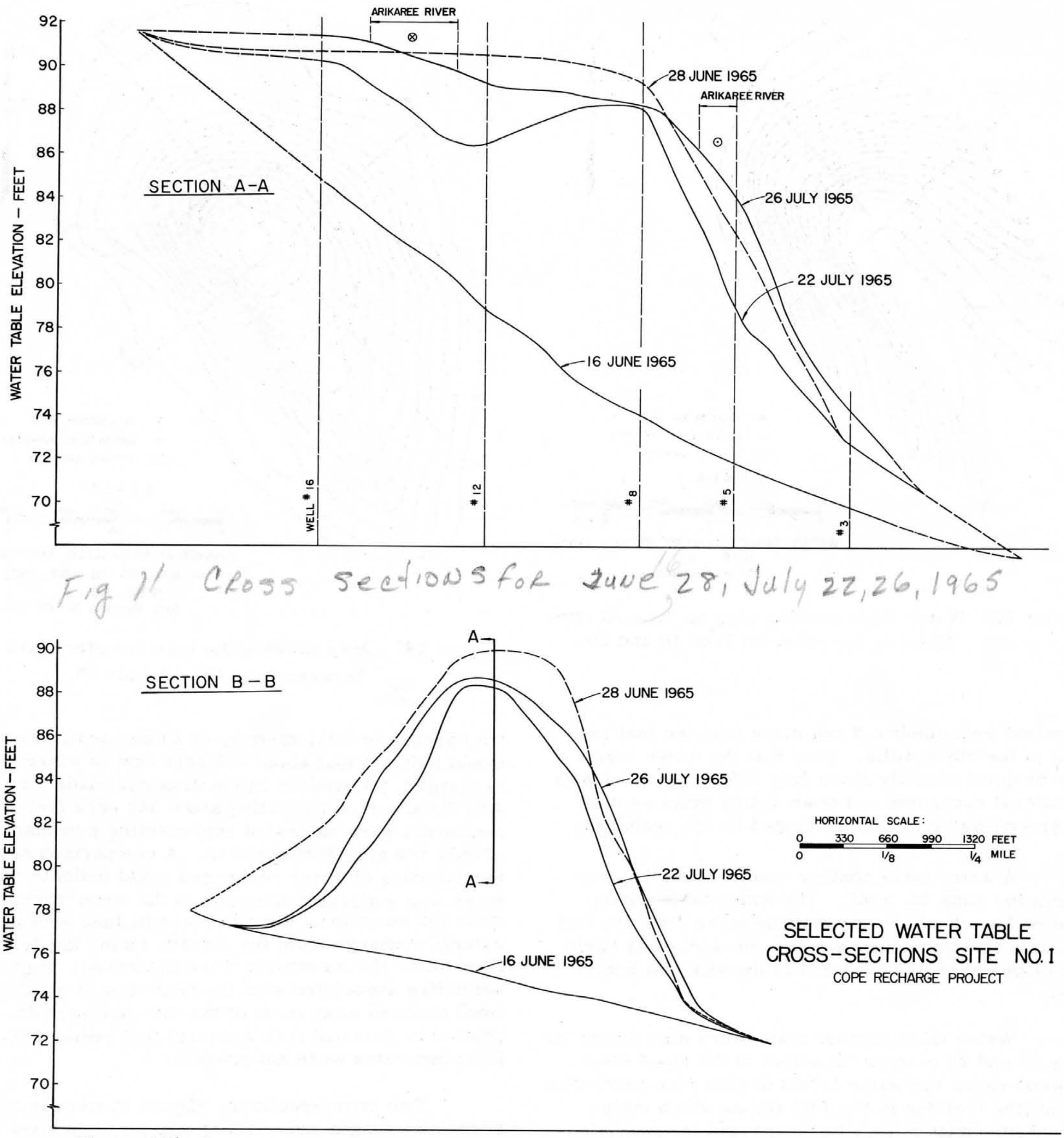

Figure 15. Cross sections showing development of water mound below the recharge site.

for June 16, 28, July 22, 26, 1965

Problems Encountered

Design for large floods - It is impossible to design recharge structures that would be considered adequate to handle the large floods, such as the one on July 24, for the entire Arikaree watershed. A complete watershed program consisting of many small recharge facilities placed throughout the entire drainage area might prevent such floods, recharge more water, and prevent the massive soil erosion which occurred.

Sediment deposition - The flood waters contained large volumes of sediment as suspended and bed load. The coarser material was trapped in the first structure but the finer sediments settled out over other parts of the spreading basins, sealing off the coarse material and thus reducing the infiltration or recharge rate. Figure 16 is a photo across a portion of site No. 1 after the June flows showing the deposition of the fine sediments. Figure 17 is a

Figure 16. View across site No. 1 showing deposit of fine clay sediment.

Figure 17. Excavation shows about 6 inches of fine clay deposited on top of original coarse sand.

photo showing approximately six inches of fine silt and clay-sized sediment which was deposited on top of the originally sandy soil. The photo for Figure 17 was taken near dam D-2 at site No. 2 following both the June and July flows.

Removal of fine sediment deposits from at least part of the spreading area would be required after each flow to maintain high infiltration or recharge rates. In a sense the July 24 flood performed a service by scouring away all the fine sediments.

Evaluation Of Study

Demonstrational purposes - The Cope recharge study has shown that artificial recharge from ephemeral streams with floods flows is possible. The rise in water levels returned some of the irrigation wells to productive operations. The type of structures utilized seems satisfactory and the cost of installation was reasonable. Many similar sites exist throughout most of Eastern Colorado and the semi-arid west.

Cost - benefit analyses - approximately $4600 was used to construct the structures on sites No. 1 and 2. This covered the cost of moving about 27,000 yards of dirt. The water recharged at only site No. 1 totaled 450 acre feet for the June flows. Assuming a return value of ten dollars per acre foot, which seems reasonable because this is water that was available to mature a crop, the return from only site No. 1 would be $4500. Additional benefits were gained at site No. 2 and if the big flood hadn't occurred then benefits would still be accruing. Some maintenance cost should be expected on any recharge structures.

Recommendations

Several recommendations can be made from experience gained on the Cope recharge study. They are:

1. Artificial recharge is practical, and similar installations should be constructed in other areas in Colorado to obtain maximum use of the water resources.

2. The benefits from the recharge exceeded the costs on this study, and when other water projects are planned consideration should be given for including artificial recharge in the cost benefit analyses.

3. Further study is needed to determine how to solve the sediment deposition and restricted recharge problems.

4. Water Conservancy and Management Districts should consider building artifical recharge facilities to conserve all possible water supplies.

Acknowledgments

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Summary

It is possible to describe the accomplishments of this small but experimental study as follows:

1. Inexpensive and expendible artificial recharge structures were designed and constructed on the Arikaree River near Cope, Colorado during late 1964 and early 1965.

2. Flood flows during June 1965 provided approximately 450 acre feet of water that was recharged to the water table at one of the two recharge sites. Benefits occurred at the other site but could not be evaluated.

3. A large flood on July 24, 1965 destroyed all the structures except dam D-2 at site No. 2. The structures have since been reconstructed and the study will continue.

4. Recharge benefits exceeded the cost of original construction.

5. The recharge facilities operated quite satisfactorily and demonstrated that similar installations could be built in other parts of Colorado and the semi-arid west.

6. Analyses indicate that artificial recharge benefits should be considered when constructing new water projects.

7. Reduced infiltration rates due to sealing of the spreading basin with small sediment particles may limit recharge and cause some maintenance problems.

Colorado State University
Water Resources Archive
Separation Sheet

Collection title: Groundwater data collection

Collection code: WGDC

Description of item(s) separated: 7 B&W photos of various sizes

Old location: Series V—Artificial ground-water recharge on the Arickaree River near Cope, Colorado

New location: Photographs series

Name of processor: PJR

Date: 12/12/03