VOLUME I
SUMMARY AND CONCLUSIONS

Report On

ENGINEERING WATER CODE STUDIES FOR THE SOUTH PLATTE RIVER

Under Authorization of Senate Bill 407

46th Colorado General Assembly

Morton W. Bittinger & Assoc.
and
Wright Water Engineers

August, 1968

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August 29, 1968

Mr. James D. Geissinger
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Dear Mr. Geissinger:

We are pleased to submit herewith our summary report on "Engineering Water Code Studies for the South Platte River." This report contains conclusions and recommendations derived from individual area studies performed under authorization of Senate Bill 407 passed by the 46th General Assembly.

We sincerely appreciate the opportunity to participate in this very important work for the State of Colorado. Our studies have confirmed that it is highly desirable to implement planned utilization of our valuable groundwater resources and reservoirs in conjunction with surface water supplies and facilities. Formulation of legislation which will allow and encourage the integrated management, administration and use of surface water and groundwater, without infringement of present vested rights, will require considerable ingenuity on the part of the attorneys and legislators involved. We hope that this formulation will continue with the optimism, open-mindedness and advanced thinking that you, Mr. Eckles, Mr. Sparks and others have evidenced to date.

It is also important that the water users fully understand the legislation as finally proposed, the reasoning behind it and the alternatives. We believe that considerable thought and effort should go into a public information program prior to consideration of the proposed legislation by the General Assembly.

Sincerely yours,

Morton W. Bittinger

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Kenneth R. Wright

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INTRODUCTION

Background

Senate Bill 407 of the 46th session of the Colorado General Assembly authorized the Coordinator of Natural Resources to undertake a study leading to recommendations for legislation which would provide for the integrated use of ground and surface water and to a fuller utilization of the waters of the State.

In this undertaking he was authorized to call upon private engineers to work in cooperation with the Colorado Water Conservation Board staff. The initial assignments by the Coordinator of Natural Resources were made in August of 1967 and completed on January 1, 1968. Subsequent assignments were made in April of 1968 by Mr. James Geissinger, attorney at law, who is under contract to the Coordinator of Natural Resources.

The initial assignments were as follows:

Platte River Basin

1. Wright Water Engineers, Water District 64, Balzac to Julesburg at the State line.

2. Bittinger and Associates, Water District No. 1, Kersey to Balzac.

3. Colorado Water Conservation Board, Water District No. 2, Clear Creek to Kersey.

Arkansas River Basin

1. W. W. Wheeler and Associates and Woodward-Clyde and Associates.

In April of 1968, additional assignments were as follows:

1. Bittinger and Associates, Water Districts No. 2, 3, 4, 5, and 6, South Platte River from Denver to Kersey, the Cache la Poudre River, the Big Thompson River, St. Vrain Creek and Boulder Creek.

2. Wright Water Engineers, Water District No. 8, South Platte River from Denver to South Platte.

3. W. W. Wheeler and Associates and Woodward-Clyde and Associates, continuation of studies on the Arkansas River.

Scope of this report

This report is a summary of the conclusions contained in the reports on Water Districts 64, 1, 2, and 8 plus general conclusions from studies of Water Districts 3, 4, 5, and 6, all within the South Platte River Basin. Pertinent data has been abstracted from the separate reports. The Table of Contents, List of Figures, and List of Tables for each of the separate reports have been included in the Appendix for reference.

Basic Premises

The problem at hand is complex and controversial from many standpoints--physical (hydraulic interrelationships), legal (protection of vested rights), customs (water-use practices), organizations and individuals (overlapping and competing), administration (multitude of points of diversion), etc. It is desirable, therefore, that a few basic premises which have been established be stated:

1. That it is in the best interest of the State of Colorado and its water users to develop legislation which (a) will promote and allow an increasingly greater beneficial use of the total water supply, (b) will increase the dependability of supplies available to water users, and (c) will alleviate conflicts between water users.

2. That shutting off of wells to satisfy senior surface rights is a negative approach which does not allow utilization of a reserve of stored water when it is most needed. Thus, if senior rights can be served by other means, generalized shutting down of wells in areas such as that under study is not in the best interest of the State of Colorado and its water users.

3. That (a) greater beneficial use, (b) better dependability of supply, and (c) a mitigation of conflicts between water users can be attained through planned integrated management and use of surface water and groundwater in the area of study. Such integrated management not only includes the planned utilization of groundwater, but also the planned manipulation of groundwater storage in conjunction with surface water storage and conveyance facilities.

4. That the science of groundwater hydraulics and hydrology is sufficiently advanced--and information on the alluvial aquifer is adequate--to develop reasonably sound and equitable groundwater management plans. This is not to say there is no need for continuing to gather and improve the available information, only that we have sufficient information to improve management over that now being accomplished.

5. That irrigation and plant sciences are sufficiently advanced to allow approximation of optimum irrigation requirements for the various combinations of crops, soils, topography, and climatic conditions encountered in the study area.

6. That each water user is (or should be) primarily concerned with having a dependable and reasonably priced water supply which provides him with an adequate quantity and an adequate quality at the proper times at his point of use, regardless of whether it is furnished to him directly by closing down a junior right-holder or by compensation from an alternate source, such as groundwater.

7. That if it can be shown from a physical standpoint that a greater beneficial use, a better dependability of supply and an alleviation of conflicts between water users can be accomplished through planned integrated management without infringing upon vested rights, the legal problems of implementing and operating such a program can be surmounted.

From an engineering standpoint the problem is one of "systems analysis." As in any system, whether it be mechanical, electrical, or hydrogeological, it can be considered in three parts: (1) inputs and/or withdrawals of energy, matter, etc.; affecting (2) a system of interrelated and interacting elements to (3) produce responses which are of interest. In a hydrogeological system, there are inputs and withdrawals of water which vary both in time and location, and are the results of both natural and man-made conditions. The predictability of the inputs and withdrawals is dependent upon many factors and must be considered in terms of a probability based upon historical experience rather than a set figure.

The pertinent elements of the system include hydraulic and geometric characteristics of the groundwater-surface water system which affect the location and movement of water in the system. Responses of the system which are of interest include changes in groundwater levels and interchange of water between the aquifer and the stream.

GENERAL SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Based upon the detailed studies which have been made during the last year under authority of Senate Bill 407, certain findings, conclusions, and recommendations stand out as being particularly pertinent. These are set forth below.

Findings

1. The average annual water supply within the South Platte River Basin is adequate to meet present requirements. However, because of the wide fluctuations in runoff, the distribution of water availability is far from satisfactory.

2. The groundwater reservoir along the main stem of the South Platte River between Denver and the State line contains approximately ten million acre-feet of water. Only a small percentage of this capacity is utilized and this only in a haphazard and unplanned way.

3. Groundwater pumping and transmountain importations have been major factors in stabilizing water supplies in the South Platte Basin. However, the pumping of groundwater has caused infringement upon prior surface water rights. Studies indicate that this infringement is not as severe as many have felt it to be.

4. The water supplies of the South Platte Basin are not being utilized or administered as efficiently and effectively as they could be.

5. Deficiencies exist in the completeness and accuracy of water use records.

Conclusions

1. Planned utilization of 10 to 15 percent of the available groundwater storage capacity in the alluvium is reasonably attainable. Use of the groundwater storage capacity can provide more efficient utilization of the total resources of the Basin, reduce shortages, and minimize conflicts between water users. This planned utilization in conjunction with surface water supplies would basically involve a heavier draft upon the groundwater supplies during low runoff years with provision for replenishment of those supplies during years of surplus runoff.

2. To achieve more optimum distribution of water supplies and accomplish desired goals, certain surface water rights should be served from groundwater sources during low runoff periods. Such operations would allow more surface water to be diverted in the upper regions, making greater re-use of return flows possible.

3. Since the groundwater in storage adjacent to the main stem of the South Platte River is currently being used to support the flowing stream, and many users are dependent upon and have rights in the return flow which joins the River via the groundwater system, provisions must be made to protect these rights and to supply them with alternate sources of water to insure the continued utilization of the groundwater supply. The cost of providing such facilities should be borne by those who benefit.

4. Optimum use of water resources within the South Platte Basin cannot be achieved without control of nonbeneficial uses or waste of water.

5. Integrated management of groundwater and surface water can be best achieved on an overall South Platte River Basin basis.

Recommendations

1. It is recommended that legislation should be passed which will allow and encourage the integrated mangement and administration of groundwater and surface water in the South Platte Basin. It is recommended that this be accomplished through the establishment of basin water management districts. The districts should be given specific powers to own and operate well fields, reservoirs, and other facilities.

2. It is recommended that the State Engineer be granted the authority to review and overrule the operational plans of these water management districts and any agreements which may be made. The State Egnineer should continue to have the authority necessary to insure that all vested rights in the Basin are protected.

3. It is also recommended that the State Engineer should have the authority to define waste and beneficial use under the various circumstances and uses and be required to restrict diversions of water not being used beneficially. Water rights should be quantified in terms of acre-feet on the basis of beneficial use.

4. It is recommended that surface water right owners be given the opportunity to obtain alternate points of diversion at wells. Such diversions would be made under the Appropriation Doctrine.

5. It is recommended that immediate steps be taken to improve the completeness, accuracy, storage and retrieval of water measurements and records, utilizing automatic data processing methods wherever possible.

6. It is recommended that the State Engineer be granted administrative power to grant or deny changes in point of diversions, alternate points of diversion and transfers of water between uses and users, provided that investigations indicate that such changes or transfers will not materially injure the vested rights of others. Such decisions should be subject to court review.

SPECIFIC CONCLUSIONS

Each of the four reports covering the South Platte River presented conclusions, some pertaining to the particular District studied and some to the State in general. These conclusions as presented in the individual reports are contained on the following pages, along with general conclusions derived from studies of major tributaries of the South Platte as represented by Water Districts 3, 4, 5, and 6.

Water District 64

The investigations performed relative to water utilization and water availability in the Lower South Platte Valley have resulted in conclusions, some of which would apply to all river basins of the State, and others which apply primarily to the study area. The conclusions are:

1. The present utilization of Colorado's water resources is neither as efficient nor as effective as it should be.

2. Additional water is available which can be put to beneficial use. Large quantities of transient groundwater storage exist along several rivers which can be used to good advantage to help balance out seasonal surface supply variations.

3. The existing use of groundwater by well owners has many uncertain aspects which presently make these supplies undependable.

4. A continued threat exists to owners of vested surface water rights because of uncontrolled and increased well pumping.

5. Water resources and the physical mechanisms for better utilization of water resources exist, or could be constructed, which would provide for a more dependable water supply and/or increased water use.

6. Irrigation of additional lands will tend to decrease the quality of the river water downstream.

7. An opportunity exists for river basin authorities to provide more water for beneficial use, and to improve the dependability of that now being used.

The report covering Water District No. 64 also contained a proposal for increased water utilization.

Water District 8

The investigations which have been carried out in regard to the availability of water in the South Platte River have resulted in a number of basic conclusions. Some of these conclusions apply to all river basins of the State and some are related primarily to the area of study. As a result of this report, which deals with Water District No. 8, it has been concluded that:

1. The use of water in Water District No. 8 is predominantly for municipal use, particularly along the main stem of the South Platte River from which the cities of Denver, Aurora, Englewood and Littleton obtain all or a part of their municipal water supplies.

2. The use of water for irrigation along the South Platte River is diminishing as land is converted from farming to urban use.

3. Supplies from the South Platte River in Water District No. 8 are almost fully appropriated and municipalities such as Denver and Aurora must import water from the west slope to meet their increasing water needs.

4. Groundwater in storage in the alluvial aquifer of the South Platte is limited within District No. 8 and does not offer the potential for development that exists in downstream reaches of the South Platte River. The transient groundwater storage is estimated to be on the order of 30,000 acre-feet, which is relatively small in comparison to that in storage in downstream reaches of the River.

5. The groundwater alluvium does not provide a dependable source of supply for municipal use.

6. The potential exists for the development of storage and/or exchange agreements to re-regulate transmountain diversions, facilitate the re-use of return flows and for the capture and storage of flood flows; all of which can be used to effect a more efficient use of available supplies.

7. The conjunctive use of groundwater and surface water in District Nos. 1, 2, and 64 can provide for increased utilization of water in District No. 8. Return flow from increased diversions would be available downstream for direct use, for storage in reservoirs, and for recharge of groundwater aquifers. Similar increased water use could be made in the Poudre, Big Thompson, St. Vrain, Boulder Creek, and Clear Creek Basins.

8. The rapid expansion of municipal growth and corresponding municipal water use which has taken place within Water District No. 8 will occur in other areas of the State, and serves to illustrate the conditions that are encountered when urban development replaces the traditional agricultural economy.

Other conclusions which have been formulated and are applicable to all river basins of the State are given below:

1. The present utilization of Colorado's water resources is neither as efficient nor as effective as it should be.

2. Water resources and the physical mechanism for better utilization of our water resources exists or can be constructed which would provide for a more dependable water supply and/or increased water use.

3. The opportunity exists for River Basin Authorities to provide more water for beneficial use and to improve the dependability of that now being used.

In a previous report submitted to the Coordinator of Natural Resources in December, 1967, which dealt primarily with Water District No. 64, the Lower Platte River Valley from Balzac to Julesburg at the State line, seven conclusions were developed and presented. It is of interest to examine their applicability in terms of the data derived in this report for Water District No. 8. The Water District 64 conclusions are discussed in terms of the data derived from the study of Water District No. 8 in the following paragraphs:

1. The data for District No. 8 tend to reinforce the conclusion that the utilization of the State's water resources is not as efficient or as effective as it could be. The operation of District No. 8 is almost entirely for municipal use, but the administrative procedures are those developed principally for an agricultural economy. In many cases the need for cities to adhere to existing procedures governing the acquisition of water rights, changes in points of diversions, and river administration, has resulted in less than the most efficient utilization of the available water resources. Conversion of the consumptive use portion of direct flow rights to storage rights would be an example of increasing efficiency of water use, particularly advantageous to users in District No. 8.

2. There is no dependable surplus water available from the South Platte River in District No. 8. Additional water can be developed by storage such as the proposed Two Forks Project and possibly from smaller storage projects, but essentially the River is fully appropriated and used. The feasibility of storage projects such as Two Forks will be enhanced in the future as the importations of water from the west slope increase, resulting in a situation in which storage could level out imported flows and provide for more efficient use of transmountain diversions. Storage may also play a part in the utilization of return flows of transmountain water by providing opportunities for exchange. Development of storage would also provide for the capture and utilization of flood flows which now go unused.

The transient groundwater in storage in Water District No. 8, both along the South Platte and its tributaries, is limited by the shallow, narrow configuration of the alluvial valley and does not offer the potential for development that is available in downstream reaches of the river. Reducing downstream calls by managed pumping from the alluvium downstream in District Nos. 1, 2, and 64 could make more water available for District No. 8 municipal users.

3. The third conclusion is applicable to Water District No. 8 in which wells are used for municipal and irrigation supplies with the largest concentration of alluvial irrigation wells being located along Cherry Creek with smaller numbers being located along the main stem of the South Platte. The City of Littleton receives water from alluvial wells recharged by diversions from the River and from non-alluvial wells which penetrate the deeper aquifers. As previously mentioned, in June of 1968 the City imposed restrictions on the use of water for irrigation. Because groundwater does not provide a dependable source of supply adequate to meet its present and future needs, Littleton has entered into an agreement with Denver for the purchase of water under a long-term contract. The City of Englewood uses wells to meet peak period water needs, using direct-flow rights in the South Platte to more and more act as base load water supplies. Englewood's well use is uncertain and of questionable reliability.

4. In Water District No. 8 the threat to vested surface water rights does exist and must be recognized.

5. Conclusion Number 5 is equally applicable to Water District No. 8 as it is elsewhere. District No. 8 could benefit from use of wells downstream to reduce water calls.

6. In Water District No. 8 the amount of irrigated land is diminishing in the face of increased urbanization of the area surrounding metropolitan Denver and water quality in the main stem of the South Platte is affected less by irrigation than it is by the increased municipal return flows. The Metropolitan Sewer District which collects and treats sewage from many small communities which formerly returned raw or partially treated sewage to the River will have a beneficial effect on the water quality, as will the increasing pressure of Federal and State Governments for improved water pollution control measures.

7. The validity of conclusion Number 7 is substantiated by the data compiled herein on the operation of the main stem of the South Platte River in Water District No. 8. Because of its predominately municipal nature Water District No. 8 provides a case study of the problems which are encountered in areas in which operation of the River is for municipal use rather than for agriculture. District No. 8 would be a keystone in the building of a water management structure by a river basin authority charged with increasing water utilization. The foreign water imports and the storage there would provide many possibilities for exchanging on a large scale.

Water District 1

The following statements briefly summarize findings and conclusions to date:

1. The average annual historical supply of surface water available to users in Water District 1 is adequate for irrigation requirements.

2. The variability of the surface supply, ranging to less than 10 percent of the average during some months, makes sole dependence upon this source very unsatisfactory.

3. Surface storage facilities have reduced some of the uncertainty of supply by providing a better distribution of water through the season. The surface storage facilities, however, are quite inefficient, and of little value for long-term storage bridging a series of low runoff years.

4. Groundwater development and use has removed much of the uncertainty of supply for those water users fortunately situated. Subsequent exchanges and leasing of reservoir shares by ditches and individuals changing to greater groundwater use has tended to stabilize supplies even for those who have not been able to develop groundwater supplies.

5. The development of groundwater, and the subsequent exchanges and leasing of water, has come about haphazardly and without coordination on a basin basis. Although the development has improved the distribution and availability of water to most users, there has been no assurance that some parties have not been adversely affected. In addition, with little or no overall planning or coordination, the possibilities of achieving maximum beneficial use and minimum waste are nil.

6. The large alluvial aquifer underlying most of the irrigated land along the South Platte in Water District 1 can serve as a very efficient long-term storage facility with which, assuming economic feasibility, all uncertainties and inequities of supply can be virtually eliminated. The planned utilization and manipulation of groundwater storage in conjunction with surface water supplies, storage and conveyance facilities is referred to as integrated management of groundwater and surface water.

7. Full integrated management of groundwater and surface water should be planned for the entire basin, not just the area involved in this study, in order to achieve maximum benefits.

8. Full integrated management of the large and complex groundwater-surface water system of the South Platte Basin can be facilitated with computer model studies. These computer studies can help in the design and location of facilities, in the management decisions associated with operations and in determining benefits from the integrated management program.

9. Responsibilities for implementing and administering an integrated management program could probably best be handled by existing water conservancy districts. Certain problems in this regard need further study before legislation is proposed.

Water District 2

1. Water District 2 serves as a strategic link between mountain and front range tributary areas and downstream plains areas of the South Platte Basin. Because of this location, water users within Water District 2 are dependent upon inflow from several sources and at several locations. Thus, they experience quite different water supply situations within the various reaches from year to year. Urbanization is rapidly taking place in the districts above Water District 2, as well as in the upper section of Water District 2.

2. The amount of river water available for diversion under direct-flow decrees held by Water District 2 ditches has changed over the years. Some ditches in the upper portion of the Water District have experienced a reduction in diversions of direct-flow water, whereas some ditches in the lower portion have been diverting an increasing amount during recent years.

3. The amount of water remaining in storage within Water District 2 after the close of the irrigation season has been increasing over recent years, although the amount in storage at the beginning of the season does not show this trend.

4. A reservoir containing approximately 1.3 million acre-feet of groundwater underlies the main stem of the South Platte River in Water District 2. In addition, an estimated 320,000 acre-feet of groundwater underlies Beebe Draw between Barr Lake and Latham Reservoir, giving a total of some 1.6 million acre-feet of groundwater in Water District 2. During an average year less than 10 percent (120,000 to 140,000 acre-feet) of this storage capacity is actively used. During years of heavy pumping (such as 1954 and 1956) the amount withdrawn has reached 200,000 to 210,000 acre-feet within Water District 2.

5. The relationship of inflow to outflow of surface water for Water District 2 has not changed significantly on an annual basis. However, noticeable changes have occurred during certain parts of the year--particularly late summer and fall--indicating that the return flow pattern has been changing during recent years. This change started in 1953 for November and December, but not until the early 1960's during the summer months. The average annual depletion (inflow-outflow) for the Water District is about 126,000 acre-feet, some of which is transported to the Box Elder and Prospect Valleys.

6. Data and estimates of water used were obtained from a Farm Water Utilization Study prepared by the Bureau of Reclamation for the Narrows Project. The Study was for the 15-year period from 1947 to 1961, inclusive. It covered 17 of the canals which divert water for irrigation from the South Platte River in Water District 2.

7. The Bureau estimated a total of 124,635 acres as being irrigated by the 17 canals and/or by pumping from groundwater sources. Estimates from other sources show considerable discrepancy for the irrigated acreage under individual canals.

8. The estimated average annual diversion of water by the 17 canals (direct-flow plus reservoir releases) was 302,100 acre-feet. The amount diverted varied greatly from year to year. Most canals experienced a minimum diversion from the South Platte River during 1954 and 1961. Maximum diversions generally occurred during 1947 and 1952.

The estimated average annual canal loss was 84,700 acre-feet or 29 percent of the water diverted. Thus, an annual average of 217,400 acre-feet of surface water was estimated to be available at the farm headgates.

The estimated average annual amount of water pumped from groundwater sources for land under the 17 canals was estimated to be 148,600 acre-feet. Thus, the estimated total average annual supply of water at the farm headgates was 366,000 acre-feet or 2.94 acre-feet per acre. Groundwater provided about 40.6 percent of the total supply at the farm headgate.

Only a very minor amount of water was used for irrigation during the months of November, December, January, February, and March. The estimated average annual total water supply at the canal river headgates plus reservoir releases and groundwater pumped was estimated to be 450,400 acre-feet. (Some minor discrepancies will be noted in some of the above totals due to rounding of figures to the nearest 100 acre-feet).

9. The full water supply at the farm headgate was computed by the Bureau of Reclamation using (1) a combination of the Lowry-Johnson and the Thornthwaite methods to determine the consumptive use of water by crops and (2) an assumption of a 60 percent irrigation efficiency in the application of water to supply the consumptive use requirements for each of the 17 canals.

The estimated full water requirement at the farm headgate varied from 1.59 to 3.19 acre-feet per acre with an average annual headgate water requirement of 2.44 acre-feet per acre or a total of 304,200 acre-feet for the 17 canals. Monthly requirements averaged 0.08 acre-foot per acre for April, 0.14 for May, 0.47 for June, 0.66 for July, 0.60 for August, 0.36 for September, and 0.13 for October.

An assumed average of 60 percent irrigation efficiency for the combined 17 canals appears to be reasonable; however, because of different soil conditions, kinds of crops produced and methods of irrigation for each canal, it is not reasonable to expect the irrigation efficiency would be identical for each canal.

10. The canal headgate requirement includes the full requirement at the farm headgate plus canal losses. The estimated average annual requirement at the canal headgates was estimated by the Bureau of Reclamation to be 388,900 acre-feet.

11. An estimated annual average surplus of 61,500 acre-feet for the 17 canals was found as the difference between the total headgate supply and the total headgate requirement. However, 4 of the 17 canals experienced an average shortage during the 17 years and also had a shortage 50 percent of the 15-year time period. Also, many ditches experienced shortages during critical months, but showed an annual surplus because of excessive water use during other months.

The surplus would be greater than that estimated if the actual acreage irrigated were found to be less than that estimated.

If the assumed irrigation efficiency is actually less than 60 percent, the water requirements would be greater than estimated and the surplus would be less (or shortages would be greater).

Water Districts 3, 4, 5, and 6

1. The total annual supply of water available to Water District 3, 4, 5, and 6 is generally adequate for agricultural needs, although not always available at optimum times. Increasing urbanization of these areas is bringing increasing pressures on water supplies and undoubtedly will continue to do so even more in the future.

2. The natural runoff available to water users within the area under study varies considerably from year to year as influenced by widely fluctuating climatic conditions. For instance, the lowest annual natural supplies for the several water districts have been only 30 to 40 percent of the average annual values. In addition, the natural runoff pattern within each year does not match the pattern of need. The many surface storage facilities constructed by ditch and reservoir companies have greatly alleviated the latter situation by the short-term storage of surplus spring runoff for use in late summer and fall. But these, in general, are not of great value for long-term storage. In order to more fully regulate the natural runoff and provide storage to bridge a series of low-runoff years, larger and more expensive onstream reservoirs would be required. Recent studies by the U. S. Bureau of Reclamation of such possibilities in Water Districts 3, 5, and 6 have led to the conclusion that the benefits derived would not exceed the costs under present conditions.

3. Of the four water districts, only Water District 3 has a significant groundwater development. Water District 3 has approximately 900 irrigation wells, but another 700 are just outside Water District 3 in the Lone Tree and Crow Creek Valleys. The principal recharge to these 700 wells is from ditches originating within Water District 3. Less than 200 irrigation wells are located in the remaining water districts (4, 5, and 6) and are generally of rathern small capacity.

4. The addition of Colorado-Big Thompson Project water has materially augmented and stabilized the total water supply of the area. This augmentation has not only been by direct use of the Project water but also indirectly through increased return flows available to lower ditches. In addition, for those water users fortunately situated over productive alluvial aquifers, groundwater has provided a stabilizing supplemental supply. Both the C-BT supplies and the groundwater supplies are especially important and valuable because (a) they are available on demand and (b) they can be called upon heavier during extended drought periods, thus tending to serve the purpose of long-term storage facilities. In addition, the C-BT Project water has been an important factor in the urban growth of these areas. If this growth would have had to rely entirely upon the transfer of agricultural water, it would have greatly affected the agricultural economy.

5. Outflow from Water Districts 3, 4, 5, and 6 has increased relative to the natural supply to the Districts, principally as a result of the addition of Colorado-Big Thompson Project water. Thus, the net effect of changes within the Districts during the past 20 years has been of benefit to downstream water users rather than a detriment. The increase in outlfow is particularly significant from the Cache la Poudre and Big Thompson Basins.

6. With few exceptions, irrigation wells in Water District 3 are used to supplement surface supplies. The amount of water pumped varies inversely with the availability of surface water. Replenishment of water withdrawn occurs incidental to surface irrigation (seepage from ditches and over-irrigation) without facilities specifically constructed for this purpose. This type of "accidental" operation has been working remarkably well, but it is believed that planned utilization of the groundwater reservoir underlying parts of Water District 3 could further alleviate shortages and stabilize supplies. Such planned utilization may require an even greater amount of groundwater pumping during certain periods of time in order to reduce calls on upstream water users and/or to satisfy downstream demands. Consideration must also be given to the compensation of those who may be injured by such operations, and provisions for replenishment of groundwater during periods of favorable runoff must be made.

7. Study of diversions by ditches in Water District 3 which are heavily dependent upon return flow revealed no decline in diversions which could be attributed to increased groundwater utilization. In fact, these ditches, in general, have experienced an increased availability of water under their decrees during August and September of recent years. Many factors influence the amount of water available at a particular time and place. Besides the variable hydrologic conditions, changes in the character, pattern and efficiency of water use, importations, and groundwater utilization may all have important effects. Obviously the changes in use and importations have had a greater influence in Water District 3 than has groundwater pumping, although it should be understood that the groundwater utilization could be carried to an extreme that would adversely affect other water users.

8. As in other areas, there is a tendency to apply water in excess of crop needs during the early part of the growing season. This is water that, in some years, would be of considerably more value during July and August if it had been stored rather than used directly. At least a part of this problem is caused by outside influences, i.e., calls by downstream ditches early in the season which cut short the storage season in the upper areas.

9. Rules or agreements for operation which would be beneficial to the Water Districts under study include an agreement with water users in lower Water Districts which would allow some continuation of surface storage in the upper regions after the lower ditches go to direct irrigation and place calls against the upper districts. Such calls often result in water users applying irrigation water before needed in order to keep the water. Again, planned utilization of the groundwater reservoir to provide compensation to the downstream users may be an important part of this agreement.

10. The most important problem in need of solution within Water Districts 4, 5, and 6 is not that of groundwater-surface water integration. It is, instead, providing and planning for an orderly transfer of water from agriculture to municipal and industrial uses such that agriculture suffers a minimum in production capacity.

APPENDIX

This Appendix contains the Table of Contents and List of Tables and Figures of the individual reports. These are included to provide a ready source of reference to the substantiating material developed and presented in the separate reports covering individual water districts.

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Data Appendix A

Water Utilization Study, Water District 2

(Only a limited number of copies of the data appendices were printed. These are available for inspection at the Office of the State Engineer)

* Also same as grand total since no reservoir or C-BT water delivered to this reach.

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Water Utilization Study, Water District 2

(Only a limited number of copies of the data appendices were printed.
These are available for inspection at the Office of the State Engineer)

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Data Appendix B - Volume III

Water Utilization Study, Water District 2

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