STATE OF COLORADO

DEPARTMENT OF NATURAL RESOURCES
and
COLORADO WATER CONSERVATION BOARD

REPORT ON

GROUND WATER PROBLEMS AND RECOMMENDATIONS FOR FURTHER STUDY AND LEGISLATIVE CONSIDERATION

prepared by

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with the assistance of

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FOREWORD

This report is in three parts: the Report proper, pages 1 - 15, the Preliminary Report, pages 16 - 24, and the Appendix, pages 1 - 56. The appendix consists of 11 different items, each item is numbered separately at the bottom of the page. The appendix as a whole is numbered commencing with page 1 at the upper right hand corner of each page. The index refers to the number at the bottom of the page on the first two parts of the report, and to the upper right hand corner on the appendix items.

The papers delivered at the Western Resources Conference as well as publications of other states, are background papers for the report.

INDEX

REPORT OF CONSULTANTS AND GROUND WATER CODIFICATION AND RESEARCH STUDY COMMITTEE

Colorado's ground water problem is a problem in democracy, scientific research, public administration, legislation, economics, and community adjustment. The problem cuts across the property line of the individual farm, and the boundaries of cities and towns. It exists in every river basin and in the entire state. The problem is interrelated to surface waters, and other natural resources. The problem is different in each aquifer. The problem has been dealt with by the individual farmer, the individual homeowner, the largest as well as the smallest city in the state, the State of Colorado and its agencies, the federal government and its agencies, as well as by the voluntary organizations including the Colorado Farm Bureau, the Colorado Farmers Union, the Colorado Grange, The Colorado Agricultural Council, the Colorado Well Drillers Association, The Colorado League of Women Voters, and local well users' associations and well owners' protective associations.

Conversely, many individuals and some organizations have closed their eyes to the problem in the hope that it would go away. Some individuals and organizations have simply stated the water belongs to the owner of the surface to do with, if, as, and when he wishes. The public as a whole appears uninformed, disinterested, or apathetic in varying degrees. Your consultants with the help and cooperation of the Ground Water Codification and Research Study Committee, created at your suggestion, have attempted an overall approach to the problem.

There is wide disagreement upon the fundamental legal theory, administration, and possible legislation on ground water. Yet there is a concensus of agreement on some basic questions. All agree that the ground resources of Colorado should be applied to optimum beneficial use. Harold E. Thomas of the United States Geological Survey in a paper delivered to the Western Resources Conference, 1959, page 181, defines the term "optimum" as follows:

> "Optimum: Not the maximum, nor the most conservative or the most liberal, nor the most economical, but only the best and most favorable use of water. And if you ask 'best for what?' the logical answer is 'the greatest good for the greatest number'."

A second point of agreement is that ground water withdrawals by means of wells should not be permitted to take water which is a part of a stream from the established rights of the owners of priorities from the stream.

A third point of agreement is that the ground water resources of Colorado provide a large portion of the water supply available for domestic, agricultural, and industrial use. The number of acres of land irrigated solely by pumps exceeds the total number of acres that will be added to Colorado's irrigated land by all of the proposed units of the Upper Colorado River Project. It is estimated that the number of acre feet of water of ground water supplied to the farms in Weld County in one year alone exceeds the total amount supplied by the entire Colorado Big Thompson Project for the entire Northern Colorado Water Conservancy District. Approximately 22, 000 wells have been registered with the State Engineer as of December 1, 1960. Of these 11, 107 are irrigation wells. Many irrigation wells are unregistered. The total number of irrigation wells is estimated to be 15, 861.

Upon the basis of its investigations, the Ground Water Branch of the United States Geological Survey estimates that there are 25 million acre feet of water in ground water storage in the South Platte Basin that could be used to supplement or stabilize the water supply for the cities, the farms, and industry within this water-short basin.[1.] It is estimated that the ground water storage in the Arkansas Basin that could be used to supplement and stabilize the water supply of that basin is approximately 11 million acre feet. Recoverable quantities are about one-half of the stored amounts. It has been estimated that:

> "The amount of recoverable water in storage in the Ogallalla Formation in Colorado may be at least 100 million acre feet." [2.]

The total ground water in storage in the San Luis Valley of Colorado has been estimated to be 2 billion acre feet.[1.] Not all could be used because of economic lift and hydrologic limitations.

All agree that Colorado should make optimum use of its ground water resources consistent with wise planning, recognizing existing and vested rights, and with proper regard for the states' future growth. Optimum use of ground water will contribute untold millions of dollars to Colorado's economy. Non-use of this resource would constitute an

economic waste. Over-use or unwise use will result in financial disaster to tens of thousands of our citizens.

The purpose of this report and the purpose of the advisory committee has been to point up the problems and to suggest the possible approaches to their solution.

No one desires to shut down existing wells.

The United States Geological Survey, the Colorado Water Conservation Board, Colorado State University and other federal and state agencies have been engaged for many years in surveys to determine the location and extent of Colorado's ground water supply and the fluctuation of ground water tables. The reports already made and the projected program for research are summarized by Edward A. Moulder, District Engineer, Ground Water Branch, United States Geological Survey, and filed with the minutes of the Ground Water Codification and Research Study Committee. [3].

The fluctuations of the water table and the potential exhaustion of ground water storage in certain areas in the South Platte Basin have been the subject of extensive investigation by the United States Department of Agriculture Extension Service in cooperation with Colorado State University. [4]. The problem in other areas of the State of Colorado has also received considerable attention. The summary of Colorado's present ground water problems and the present areas of declining water tables or overdraft as against annual or cyclical recharge has been prepared by William E. Code of Colorado State University and Edward A. Moulder of the United States Geological Survey. Copies of these reports are attached as appendices to this report.

Up to the present time neither the state of Colorado nor the federal government has presented any plan for optimum ground water development. The wells have been drilled by private individuals, cities and towns, or industry to supply needed water. Each developer has paid his own bill. No state or federal funds have been invested in construction or installation.

Incentive toward ground water legislation and the effort to achieve its optimum use and its efficient regulation by the State of Colorado arises from the gradual depletion of ground water aquifers in some areas, the contention by some that ground water withdrawal depletes the stream flow and the desire to achieve a wise use of the non-replenishable assets in the high plains of eastern Colorado.

The resistance to ground water legislation comes from many who own the land overlying the ground water aquifer who contend that they are the absolute owners of the water beneath their land, [5] some whose wells are suffering from a declining water table who seek some means to recharge ground water aquifers and others who feel that regulation would curtail development of land and industry.

Ground water problems can be classified in many ways. They may be divided into physical and scientific, legal, administrative, economic, and human or social.

Physical problems relate to the facts as reported or discoverable by the sciences of geology, engineering, hydrology, meteorology, soil science and other fields of agriculture. All in some way relate to the occurrence of ground water; its measurement in volume, depth, rate of movement, age, source, replenishment, depletion, recharge, transmissibility, and recovery; its relation to precipitation, evaporation and infiltration; its use by plant life; its place in the hydrologic cycle; the results of ground water withdrawal upon other parts of the aquifer; the fluctuations of the water table; the effect of its withdrawal upon stream flow, seepage, water logging and drainage; its waste, efficiency of use, and conservation; the efficiency of pumping equipment; improved methods of irrigation; its use in domestic water systems, and in industry. All available facts should be compiled and collated. We need more scientific data and knowledge of these and many other fields.

The legal problems are manifold. We shall list a few. Does the state of Colorado have the right to determine ownership, control and the right of use to ground water? To whom does the water belong? Does it belong to the state of Colorado and its people? Is it the property of the owner of the overlying surface, the man who first tapped the aquifer, the one who holds the decree of priority on the stream, the first well user, or the entire group of owners of the overlying aquifer? Does the holder of the number one priority on the stream have the right to shut down all the wells on the stream or any of them? What is the legal meaning of the word "tributary"? What damages are recoverable? What constitutes beneficial use? Is there a right to recapture or the right to reuse? What rights do our neighboring states have? What are the relative rights and functions of the city or town, the irrigation district, the conservancy district, the State of Colorado and its agencies and the federal government and its agencies? Can ownership of the water itself be distinguished from the right to its use? What theory of law or what combination of theories

will result in the optimum use of ground water for the people of the state? Should a different system of law be applied to ground water from that applied to streams? Should a different theory of law be applied to replenishable aquifers from that applied to non-replenishable aquifers? Is the same rule of law to apply to the alluvium on the South Platte Valley, the Arkansas Valley, the Rio Grande Valley, as well as other river basins in Colorado, the numerous ground water aquifers in the San Luis Valley, the artesian aquifers in the Grand Junction area, Denver and other areas and the high plains of eastern Colorado?

Problems of public administration include: the number and type of organizations or districts to be provided for at the state, federal and local levels; the exercise of the sovereign powers of the state under existing provisions of the constitution and statutes, and the division of functions and authority between the state agencies. Should the existing state agencies continue to operate as they do now or should they be combined into one agency? What is the function of the many federal agencies, the counties, the cities, the towns, the irrigation districts, the mutual ditch companies, the soil conservation districts, the conservancy districts, and the voluntary local organizations?

Ground water problems are dealt with in some manner by the following agencies of the State of Colorado: The Colorado Department of Natural Resources and the agencies within the department, the State Engineer, the Colorado Water Conservation Board, the Colorado Ground Water Commission, the Colorado Geological Survey, the Weather Control Commission, the State Soil Conservation Board, the State Park and Recreation Board, The Game and Fish Commission, the Colorado Bureau of Mines, the Oil and Gas Conservation Commission; the Attorney General; the Colorado Department of Public Health; the Colorado State Department of Agriculture; and The Public Utilities Commission.

Federal agencies operating in the state with some ground water duties are: Department of Interior, Ground Water Branch, United States Geological Survey, Surface Water Branch, United States Geological Survey, Bureau of Reclamation, Fish and Wildlife Service, and Bureau of Sport Fisheries and Wildlife; U. S. Department of Agriculture, Soil Conservation Service, Extension Service, Forest Service, the Agricultural Stabilization and Conservation Committee, Rural Electrification Administration; U. S. Department of Commerce, the Weather Bureau; U. S. Department of Defense, Corps of Engineers; U. S. Department of Health, Education and Welfare, Public Health Service; Inter-Agency Committee

on Water Resources and the field committees consisting of the seven federal agencies, of Defense, Interior, Agriculture, Labor, Commerce, Federal Power Commission, Health, Welfare and Education, and the governors and their representatives, in each of the following: Missouri Basin Inter-Agency Committee, The Arkansas-Red White Inter-Agency Committee, and the Pacific Southwest Inter-Agency Committee.

If ground water is declared tributary to the stream, then ground water use may affect the administration of the numerous interstate water compacts to which Colorado is a party, particularly on the Arkansas River, the South Platte River and the Rio Grande River.

Independent federal agencies which have an interest in ground water are the Farm Credit Administration and the Federal Power Commission.

Semi-official agencies with an interest in ground water include the following: The Colorado Water Congress, the Watershed Conservation associations, the Ground Water Users Associations, the well protective associations and the well drillers association.

In addition, the local rural electrification associations, the investor owned power companies, the Colorado Farm Power Council and the mutual ditch companies have a large stake in ground water resources.

Colorado State University through its cooperation with the U. S. D. A. extension service and experiment station has made a great contribution to ground water knowledge. Colorado University, Colorado State University and Colorado School of Mines through the Western Resources Conference have considered ground water problems.

Most important are the problems of the people themselves. Here we have the whole realm of public opinion, the knowledge of the body politic, the need of widespread information, the requisite of general understanding by the individual pump owner of the scientific facts and the understanding by the scientists and experts, local, state and federal, of the individual and his problems. Just as withdrawal of water from an aquifer by a pump may be felt in some degree throughout the entire aquifer, so each of the problems in the scientific, legal, public administration, and public relations fields affects in some degree not only all the problems in the same field, but the problems in every other field.

It is obvious that your consultants, the advisory committee, and

the technical subcommittees were unable to deal with each of these many problems. The preliminary report of September 27, 1960 is attached as an appendix to this report. Research papers presented by the representatives of federal agencies and the participating states to the Ground Water Section of the Western Resources Conference have been very helpful to the Committee and the consultants. These papers give the experiences of our sister states.

Another approach is to consider one specific problem at a time. One such specific problem is that of recharge. Some states provide for recharge districts whose primary function is to recharge ground water aquifers. The state of California has adopted legislation enabling the people within a proposed area to create ground water recharge districts. Orange County, California levies an eight mill ad valorem tax plus a fluctuating replenishment charge. Amendments to the irrigation district acts and the water conservancy act could give existing and new districts power to conduct recharge operation.

In order to facilitate recharge of ground water aquifers it is recommended that ground water recharge be recognized by law as a beneficial use in application of any unused flood, and unappropriated water from the state's streams. It is the opinion of the consultants that an appropriation for ground water storage and recharge could be secured under existing law as a beneficial use. Possible litigation should be avoided by the adoption of a proper law so providing.

The Henrylyn Irrigation District in southern Weld County in cooperation with Colorado State University and the State Engineer, has engaged in recharge experiments that will be of great value to the state. Again, the Irrigation District Acts of 1950 and 1921 as amended do not specifically include ground water recharge as an authorized purpose of the district. It may be an implied purpose, but legislation should be adopted to make court decisions unnecessary.

In order to facilitate ground water recharge programs the irrigation district laws should be amended to empower the irrigation district to assess benefits of recharge of the aquifer against the overlying surface owners benefited by the recharge. This would enable the irrigation district to work out a more equitable distribution of its water as well as its financial burdens, consistent with the general theory that each acre of land within an irrigation district should be benefited pro rata.

Amendments to the irrigation district acts and the conservancy act to authorize such districts to engage in ground water recharge as well as ground water storage would permit the landowners in any area which had a ground water problem or adequate water supply for ground water development to organize either an irrigation district or a water conservancy district to work out a plan for the solution of the problem.

Another specific problem is that of possible interference of wells with stream flow. Holders of early priorities from our streams in many areas in Colorado charge that recently installed pumps for both domestic and irrigation uses take water from the streams and thus deprive priority holders of water to which they are entitled. Should such interference be established one possible solution would be the establishment of a district for the special purpose of maintaining stream flow. An example of a proposed district for the purpose of maintenance of stream flow is outlined by Edward A. Moulder of the Ground Water Branch, U.S.G.S. at the Western Resources Conference.

Special districts for special purposes are in keeping with the legal tradition of the State of Colorado. The General Assembly could enact legislation authorizing a designated percentage of landowners in a given area to form a district which could engage in ground water management, storage, recharge and regulation. The local board could provide techniques for optimum development and conservation.

The first such special district was the act enabling the creation of irrigation districts by the boards of county commissioners on petition of the landowners within the proposed district. This was followed by the act enabling the creation of drainage districts. Enabling acts for special districts such as mining districts, water works districts, soil conservation districts, sewer districts, fire protection districts, road districts, improvement districts, sidewalk districts, and paving districts, have been on the statute books for a long time. An enabling act gives the landowners themselves the right to create such a district.

The outstanding contribution by Colorado to the use of a special district for water conservation was the passage of the Water Conservancy District Act of 1937. This act for the first time in the entire west permitted general tax levies against all property within the district for irrigation development. The success of the Water Conservancy Act has encouraged laws enabling the creation of special districts such as fire protection districts and recreation districts. We are all familiar with the Moffat Tunnel Improvement District in Colorado. The multiplicity

of these districts is creating a great deal of resistance to them particularly by the large taxpayers throughout the state. Yet their effectiveness in achieving the needed public improvements cannot be doubted.

A law enabling the landowners within a particular area to create a ground water district with the necessary powers for ground water conservation, recharge and ground water storage would appear to be a step in the right direction. Such a ground water district could be given such general powers or specific powers as the legislature may determine. Nebraska passed an act enabling the creation of ground water conservation districts, legislative bill 554 of the 1959 Legislature. Inquiry of Mr. Dan Jones, State Engineer of Nebraska, reveals that no petition for the creation of such district had been filed. Powers granted by the Act include gathering information, assistance in ground water conservation, providing technical information concerning ground water conservation, instituting corrective measures for proper conservation and to levy a tax not to exceed one mill to carry out the functions of the district.

Both Kansas and California have laws which enable landowners to create ground water districts for the solution of their problems.

There was tremendous resistance to the creation of a critical ground water district under the ground water act because it did not start at the local level. Legislation enabling the landowners in the area to organize a district of their own selection would give them a maximum of local partition and enable those faced with declining water tables to work for a constructive solution.

Still another specific problem is that of determining what water is tributary to the stream. Legislation must recognize scientific data and physical facts disclosed by research and investigation. Ground water is a part of the hydrological cycle. But if all water is tributary to the stream each water development will be severely limited. The General Assembly in several sessions has debated the rule of presumtion. Proposed provisions that water was not presumed tributary have failed. So has a provision abolishing any presumption. So has a provision that all water is presumed to be a part of the stream.

W. E. Code has stated the problem in the following manner:

> "In my opinion the term 'tributary' as a description of ground-water movement should be dropped in legalistic considerations. It has been used as a mechanism by the

Supreme Court to fix a rule of law, thus tying up ground-water with considerable rigidity to prior appropriations of surface waters. One rule of law is deemed applicable to 'tributary' ground-water and another to 'non-tributary' ground-water. The 'tributary' idea may well lead to absurdities and prevent full conservative use of such water. The 'tributary' idea helped the courts in applying the rules governing surface streams to ground-water where rules were lacking. I think we need new rules which would recognize our modern conceptions of ground-water hydrology."

Every ground water aquifer differs in many respects from every other. Each river basin has resources and problems which differ from every other. While some general rules and laws could be made applicable to ground water on the state-wide basis, any law adopted should recognize the variations between scientific facts in the South Platte Basin, the Arkansas Valley Basin, the San Luis Valley Basin, the Colorado River Basin, the high plains of eastern Colorado, and the artesian aquifers. The people of each basin should be given the opportunity to conserve, develope and plan the optimum use of its ground water resource. A state agency for this purpose alone, or in conjunction with surface water and other natural resources, should be provided.

While not all members of the advisory committee so expressed themselves, it would appear to be true that a majority of the committee favored some basin-wide agency for the South Platte Valley, the Arkansas Valley, and the San Luis Valley. Basin-wide resource planning, development and administration in each of our major river basins must be achieved as soon as possible. Whether Colorado as a whole or any of its river basins is prepared for this step your consultants and the advisory committee are unable to answer. Perhaps an intermediate step of a basin-wide planning commission is advisable.

A study commission for both the South Platte Basin and the Arkansas Valley could be created to study the resource problems of each basin as a unit and propose a coordinated resource plan which recognizes all water and related resources. The Commission could be given the power to make a very small mill levy. It could be authorized to prepare an integrated plan for resource development and conservation for the entire basin. Limiting the existence of such a district to two or three years would avoid the charge of continuing taxes. Such a proposal could include participation of federal agencies in the same manner as the Texas Study Commission.

One of the many problems affecting both ground water and surface water is water conservation and prevention of waste by the adoption of improved irrigation practices and water conservation measures. This overall objective is the purpose alike of water conservancy districts, soil conservation districts and irrigation districts. These districts need additional powers not only in the ground water field, but also in the prevention of waste, and promoting more efficient use of water.

Pollution of ground water aquifers is a growing problem. Action should be taken to prevent ground water pollution.

Upon the question of theory of law to be adopted by Colorado, perhaps a majority of the advisory committee felt that the doctrine of prior appropriation as now applied to streams could not be applied without modification to ground water. Most members favored prior appropriation in some form.

A study of the papers presented at the Ground Water Section of the Western Resources Conference demonstrates that the adoption of the doctrine of prior appropriation in and of itself does not solve the ground water problem. An overall water management program for an entire river basin for both ground and surface water is desirable. A combined administration of ground water and surface water throughout the entire state on a uniform basis would not be feasible. It was also felt that if the Ogallala Formation in the high plains in eastern Colorado were to achieve its optimum development, a state agency covering the entire area with a large measure of local autonomy would be required.

The success of any ground water program and the success of efforts to adopt a workable ground water law depend upon public acceptance and cooperation. Our efforts to work out a solution to this problem must be brought down to the local level. The active cooperation of the surface owner, the well owner, and the local community is an absolute prerequisite to success. Summary presentation of established scientific facts should be given to the ground water users, the local businessmen, and community organizations in each area. Some of this has already been done by Morton W. Bittinger of C.S.U. to the Well Protective Association of Weld County, and to the Underground Water Users Association in the Wiggins area. Programs of this nature should be given in all the critical areas as well as in the entire area in which ground water has been developed. A thorough program of public information should be carried out. Likewise, a procedure should be established whereby the local well

owner and ground water user is given an opportunity to present his proposed solution of the problem. Throughout the areas of extensive ground water use, hearings should be held and should be reported in competent fashion as are the meetings of the Colorado Water Conservation Board.

Competent research in the ground water field as to physical facts, law, economics, and public administration does not of itself secure the adoption of a good ground water program. The need for active participation of the ground water user commencing at the local level on through the various proposed organizational steps have been emphasized throughout the meetings of the advisory committee. Participants at the Ground Water Section of the Western Resources Conference and the authors of the many papers submitted on the subject from various authorities in the field all emphasize the need of local participation, adequate public knowledge, and wide public support. Any task force to which this problem is assigned should be given adequate means of recording the comments of those who participate. Keeping a record for future reference is imperative.

The water shed associations with the help of the Extension Service, the local ditch companies, the county agents, and the county commissioners gathered a great deal of information. Their cooperation should be secured. Some such system supplemented by adequate reporting would give the task force a sound basis for its deliberations. In addition, the cooperation of the press, including the metropolitan newspapers, in dissemminating the information so developed is a great need.

Federal and state agencies have done an excellent job in gathering a great deal of information. They and the many competent men and women who have worked for a sound ground water program and adequate legislation have not been able to educate the public at large and ground water users in particular of the soundness of the work which they have done nor the possible solutions which they can provide.

Any success attendant upon the efforts of the consultants is primarily because of the active participation of the advisory committee. Our sister states, the federal agencies, the state agencies of Colorado, the Extension Service, and Colorado State University have responded generously to our requests. We are pleased to deliver to the Department of Natural Resources, the Colorado Ground Water Commission, the

Colorado Water Conservation Board, and the State Engineer's office the material and work which we have collected. Some attempt should be made to sort, file, and index the information to make it more readily available for any task force which is activated.

The consultants recommend the following:

1. Colorado's ground water law should be amended at the coming session of the General Assembly. No attempt should be made to rewrite or recodify Colorado's ground water law. Suggested amendments attached to this report are designed to accomplish the following:

   a. To declare that the ground water or public waters belong to the people of the state.

   b. To strengthen the registration provisions.

   c. To amplify the powers of the Ground Water Commission.

   d. To prevent pollution of ground water.

   e. To provide a more realistic definition of the term "tributary".

2. Ground water research is a necessity. The consultants and the committee agree that first priority should be given to the interrelationship of ground water to stream flow on the entire length of the Arkansas and the South Platte and their main tributaries. A recommended research program was presented by Morton W. Bittinger, Colorado State University, in consultation with the U.S.G.S. and the Bureau of Reclamation to the committee is a part of its minutes and is supported by the committee.

3. Additional information on fluctuations in ground water tables is needed. The committee recommends that well measurements be gathered by the personnel of the office of the State Engineer through the water commissioners and their deputies.

4. The water appropriation act should be amended to enable the proper district court to grant an appropriation decree for ground water storage and ground water recharge.

5. The irrigation district acts and the water conservancy act should be amended to permit both irrigation and water conservancy districts to engage in ground water management, storage and recharge.

6. An act authorizing the organization of a ground water conservation district for ground water management, conservation and recharge upon petition of the landowners merits serious consideration by the incoming legislature. Additional research and consultation with the legislative committees is needed before the drafting of such an act can be undertaken.

7. A study commission for preparation of an integrated or master plan for a river basin and the preparation of legislation after full consultation with federal, state and local government agencies, ditch companies and cities and towns merits serious consideration by the assembly.

8. A complete recodification of the ground water law should await further research.

REFERENCE NOTES

1. Thad G. McLaughlin. Ground-Water Series Circular 4 - 1956 United States Geological Survey in cooperation with the Colorado Water Conservation Board.

2. Morton W. Bittinger. Colorado State University Experiment Station Bulletin 504S. Ground Water in Colorado.

3. Letter from Edward A. Moulder, Ground Water Branch of United States Geological Survey, Denver, Colorado, dated October 27, 1960 and attached to the minutes of the Committee for the meeting of November 3, 1960.

4. W. E. Code. Water Table Fluctuations in Eastern Colorado. Colorado State University Experiment Station, Fort Collins, Colorado. Bulletin 500-S.

5. Edward J. Farmer. Water and the Law. Colorado State University Experiment Station, Fort Collins, Colorado. Bulletin 505-S.

September 27, 1960

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Judge Felix L. Sparks, Director
Colorado Water Conservation Board
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Mr. George W. Colburn
Engineer and Executive Secretary
Colorado Ground Water Commission
State Services Building
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Gentlemen:

Re: Preliminary Report
Ground Water Codification &
Research Studies Committee

The undersigned as consultants have performed services under two separate contracts. David J. Miller has served under a contract with the Department of Natural Resources. Samuel Chutkow has served under a contract with the Colorado Water Conservation Board. Your two consultants have had the benefit of consultation with the two departments, and the help of an advisory committee composed of technical personnel, and representatives of state and federal departments. The assigned objectives of your consultants were three fold:

A. A comprehensive written Report on the research programs recommended to be executed, the character and qualifications of the personnel to conduct the research, and the estimated annual costs of such a continuing research program; and

B. A digest of the ground water laws of neighboring states which will indicate the possible applicabilities of such laws or parts thereof to the known Colorado ground water conditions; and

C. Recommendations for revision of the present Colorado Ground Water Law to make the Law functional until it can be revised in the light of the basic data to be developed in a continuing ground water research program.

The objectives required an inventory and summary of Colorado's existing ground water data considered in the light of the experiences of the other states. An advisory committee designated Ground Water Codification and Research Studies Committee was created consisting of the following persons:

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A technical subcommittee of the advisory committee was created consisting of the following:

Morton W. Bittinger
Edward L. Clark
W. E. Code
John Cuykendall
Edward Moulder
Floyd Oliver

This subcommittee, after several meetings, submitted an analysis of ground water problems in Colorado which has been made a part of this report.

A legal subcommittee was created consisting of your consultants, Ray Moses, Felix L. Sparks, John B. Barnard, Jr., and Albert Menard. Your consultants with the help of the legal committee and the cooperation of the Law School of the University of Colorado through the Assistant Dean Menard and Librarian Jacobstein have prepared a tentative bibliography of ground water materials in the legal field. Through the cooperation of the Soil Conservation Service of the Department of Agriculture, summaries of the ground water laws of approximately twenty-five states are being made available to your consultants. These summaries were prepared by Frank R. Hedges, River Basin Division, Soil Conservation Service, Department of Agriculture, Washington D. C. The first group of summaries was given to George W. Colburn. The entire group is made available through Harold Engstrom, Department of Agriculture representative on the Missouri Basin Inter-Agency Committee.

A draft copy of the bibliography entitled, "Bibliography of Publications on State Water Laws and Certain Related Matters," prepared by Jack R. Turney and Harold B. Ellis has been made available. It covers legal materials on all water problems both ground water and surface. It is the recommendation of your consultants that a ground water bibliography in both legal and the scientific and engineering fieldsbe prepared. In this field, as in others, your consultants have been faced with the problem of locating the extensive research and information which is available from many states and their agencies as well as from the federal agencies. Your

consultants have found a lack of coordination and correlation of the research activities of the various federal agencies and the states in the ground water field.

Extensive efforts have been made to locate all possible materials. In keeping with the existing inter-agency committee system of the federal and the state governments, a proposal was made in February, 1960, to the Missouri Basin Inter-Agency Committee that the federal and state agencies participating in that committee create a special ground water subcommittee for dealing with the legal, engineering, and economic aspects of the problem. While the Missouri Basin Inter-Agency Committee has actually cooperated in securing the help of the different federal and state agencies, no special subcommittee has yet been created. Consideration of the creation of such a committee has been postponed until the next meeting held after the ground water section of the Western Resources Conference. Since the participation of the western states included states from other basins and since ground water problems exist in all basins, it seems appropriate to request that the Inter-Agency Committee on Water Resources and Related Activities at the Washington level create a subcommittee of that committee in order to treat ground water problems. A request along these lines to Frederick P. Stueck, Chairman, Inter-Agency Committee on Water Resources, with copies to all existing inter-agency committees, the Northeastern Resource Commission, and the Study Commission for the State of Texas is recommended.

A wealth of material has been furnished to your consultants by the agencies of many of the states having ground water problems. Your consultants recommend that all these publications and documents become a part of the library of the State of Colorado in such manner as may be determined by the Director of Natural Resources.

Ground water is no respecter of individual disciplines of the law, engineering, geology, economics, or public administration. Hence, a bibliography with appropriate references to all fields available to all who deal with ground water problems in Colorado is necessary. The many volumes of the law reviews, proceedings of the engineering societies, and other professional journals are not only expensive but limited in supply. Only a very small number of pages of the total volumes in these fields relate to ground water resources in any fashion. Microfilm reproduction of the more important of these and special compilation in separate volumes for ground water reference would make the material more readily available to state and federal agencies alike. Such a task might well be that of the federal agencies. Its results should be made available to all states.

The problem of securing the experiences of the other states together with a broad prospective of ground water problems as a whole, was approached with the thought of a separate ground water section of the Western Resources Conference which is set up by a joint operation of Colorado University, Colorado State University, and Colorado School of Mines. The proposal was made by letter from your consultants to Morris E. Garnsey, Ph. D., Chairman of the Western Resources Conference, a copy of that letter is attached hereto. The Ground Water Section was carried out as outlined in the letter to Dr. Garnsey. The proceedings of the Ground Water Section of the Western Resources Conference are being duplicated and should be considered a part of this preliminary report. The success of the Ground Water Section of the Western Resources Conference is attested to by the appearance at the conference of ground water administrators, or their representatives of eleven of the western states and the presentation by separate papers and correspondence of representatives of three additional states as well as participation by the Department of Interior and the Department of Agriculture of the United States. We quote from the remarks of Emmett B. Clark, Professor of Law, University of New Mexico, as follows:

> "We believe that these proceedings of the Ground Water Section will serve as valuable background or position papers to be considered by the consultants, the Department of Natural Resources, as well as the General Assembly in proposed amendments or proposed new legislation."

The proceedings of the Ground Water Section of the Western Resources Conference provide the experiences of the other states. By agreement between the consultants, these proceedings of the departments and representatives are to be made available to all members of the Colorado General Assembly. We believe that these proceedings and the summaries meet the assigned task in that field only in the general sense. Further research in analyzing the court cases and administrative regulations of the states would be desirable.

In order to avoid duplication of work by either of the consultants, but to provide for coordination between the consultants, the advisory committee, and its subcommittees, the work of the advisory committee as well as the subcommittees and the arrangements in connection with the Ground Water Section of the Western Resources Conference were the primary responsibility of David J. Miller. The drafting of the recommended amendments to the present Colorado Ground Water Law was primarily that of Mr. Chutkow.

Mr. Chutkow's reports were by the terms of his contract to be performed by November 1, 1960, whereas the reports of David J. Miller were to be provided by October 1, 1960. Inasmuch as this is a coordinated study, it is recommended that the report be a joint report of both consultants. The timing and the arrangements of the Ground Water Section of the Western Resources Conference were such that the completion of the proceedings of that conference will require some additional time. It is the thought of the consultants and the advisory committee that the recommendations as to legislation should take into consideration the material presented by the other states at the Ground Water Section of the Western Resources Conference. Your consultants, therefore, respectfully request that an extension of time be granted to December 1, 1960, for the completion of the reports. Your consultants further tender to you as a part of the preliminary report the minutes of the advisory committee including the summary statements prepared by the technical subcommittee on the present status of the ground water problems of the State of Colorado.

The Colorado Water Congress recommended to the Colorado Water Conservation Board a comprehensive recodification of both ground water and surface water law and investigations of scientific, engineering, and basic water research data required to prepare such a code. This matter was referred by the Colorado Water Conservation Board to the Colorado Water Investigation Commission which met and recommended to the Colorado Water Conservation Board and the Department of Natural Resources the expenditure of funds of approximately $50,000 for two years to complete such a study. A copy of the recommendations of the Colorado Water Investigation is appended to this report. One of your consultants is a member of the Colorado Water Investigation Commission and participated in the subcommittee drafting the recommendations. However, the task assigned under paragraph A above of the stated objectives requires additional consideration as to the technical and professional personnel. The portion of the broad recommendations of the Colorado Water Investigation Commission falling particularly within the task assigned to these consultants relates primarily to paragraph 3 (c) and 3 (d) on the inter-relationship of surface and ground water. It is the opinion of your consultants that the material presented at the Ground Water Section of the Western Resources Conference sheds considerable light upon the problems submitted generally by the recommendation of the Colorado Water Investigation Commission and that the recommendations of the consultants should take into consideration the material presented at the Ground Water Conference particularly in the papers presented by Mr. Robert E. Glover and Mr. Edward A. Moulder, which consider the question of the relationship between surface and ground water. In this preliminary report, your consultants desire to

call to your attention to the following:

> The general recommendation of Mr. Harold E. Thomas in his paper on "Essentials for Optimum Use of Ground Water Resources" as presented to the Western Resources Conference in 1959, particularly the summary on page 191 of the report of that conference; Colorado State University Experiment Station Bulletins 504-S, Ground Water in Colorado, and Water and the Law particularly, and pages 22 to 25 of 505-S. The article of Robert O. Thomas in Journal of Irrigation and Drainage Division proceedings of the American Society of Civil Engineers, December, 1959, page 41, particularly pages 53 through 63 on the question of ground water management, the use of ground water reservoirs, conjunctive operation of surface and ground water reservoirs, and the use of public districts in operation, regulation, and financing.

A candid examination of the reasons behind ground water legislation and the resistance to it involves the basic question of the relationship between ground water withdrawals and stream flow. The science of hydrology recognizes water as part of the hydrologic cycle whether it is ground water or surface water. Perhaps an extreme statement would be that if we disregard time and quantity, every withdrawal of water from the ground will effect surface water some place, some time, in some quantity, no matter how infinitesimal. The technical subcommittee placed its judgment of ground water withdrawals "which may effect streamflow promptly or within an irrigation season" perhaps within four miles or two miles on either side of the stream. The normal rate of movement of ground water to the stream is estimated at four feet per day.

The inter-relationship of ground water withdrawal upon stream flow requires a great deal of additional investigation. So far as is known to your consultants and to its technical subcommittee and advisory committee members, there is no established scientific method of measurement and computation. At the present time the problem of the possible adverse effect of pumping upon stream flow represents a more serious problem in the Arkansas Valley basin than it does in the South Platte basin. Your consultants request additional time to consult with the United States Geological Survey in both the ground water and surface water division, the experiment station of the Colorado State University, the State Engineer, and the Colorado Water Conservation Board, to document and determine the needs and possible method of carrying out the assignment in paragraph A above.

Robert O. Thomas, F. ASCE, California Department of Water Resources stated in Chapter VI, of the draft manuscript, "Manual of Ground Water Basin Management":

> "The existence or occurrence of water in the interstices of the materials composing the crust of the earth is not a separable, independent physical phenomenon but is inextricably linked with the preceding and succeeding phases of the hydrologic cycle. In passing through that cycle from precipitation, through infiltration and surface runoff, to capture and use, either by nature or by works of man, and finally to evaporation and return to the atmosphere, to fall again as precipitation, the water droplets many times pass through the state of temporary detention in underground storage. Such a broad concept is philosophically correct when made without regard to time, whether such be counted in minutes or in eons. Consequently, all subsurface water, even that which has been trapped underground for untold ages, is a part of the common supply and subject to the natural laws covering hydrologic phenomena. It follows therefrom that man cannot increase the common supply, although by the application of scientific principles to the conservation and use of the available water, he can so manage the available supplies as to increase the benefits to be gained through the utilization of this constantly renewed, and most important, natural resource.
>
> Suitable surface locations for conservation and control of water supplies are diminishing in number as development of such sites progresses. At the same time, agricultural, suburban, and recreational land uses are impinging on the remaining sites at a rapid rate. Increasing construction costs for major water control structures, and the inherent waste in dissipating costly supplies through evaporation, combine to enhance the natural advantages of utilizing available underground storage capacity for cyclic storage and regulation of the vast supplies necessary to maintain our national development.
>
> Utilization of ground water reservoirs for the maximum benefit to the area involved is dependent upon adequate geologic and hydrologic data, from which the results to be expected as a consequence of development can be estimated. Prerequisite to the full development of ground water storage is adequate technical information, including the basic data necessary for application of

proved hydrologic principles. Required data can be secured by a continuing program for measurement of the amount of water passing through each phase of the hydrologic cycle. With adequate hydrologic data, reliable estimates of the quantity of water that can be made available on a firm annual basis by coordinated or conjunctive operation of surface and subsurface storage or, alternatively by operation of the ground water basin alone, can be formulated.

* * *

Historical development of many ground water reservoirs has resulted in conflict between those pumping from ground water and those diverting from surface water supplies. Wherever ground water discharges into or is recharged from a stream, the utilization of ground water from the basin is likely to modify the natural regimen of stream flow. As development of the underground reservoir progresses toward full utilization, disagreements will increase, particularly in areas where the ground waters and surface waters are intimately related."

Very truly yours,

David J. Miller

Samuel Chutkow

DJM/nm

NOTES ON GROUND-WATER PROBLEMS IN COLORADO

by
W. E. Code
Professor Emeritus of Engineering
Colorado State University

Because it will develop subsequently in this discussion, it is my opinion that our ground water must be placed in at least two major classifications ignoring for the moment artesian water: I. Ground water that lies adjacent or close to streams carrying appropriated water, the extraction of which may affect stream flow promptly or within an irrigation season; II. Ground water occurring remote or reasonably so from streams carrying appropriated water, the extraction of which will not affect stream flow except after a very long period of time, perhaps never, and at the maximum would be inconsequential. There will be zones of time and quantity effect through which boundaries shall have to be arbitrarily drawn. These boundaries will have to be set where tributaries, normally dry, debouch into major streams. It will not be easy to set such boundaries. Whoever sets them must be able to defend himself with factual knowledge. There will be other occurrences where recoverable ground water exists at a considerable distance from a stream and not in a recognizable channel.

A study of water-table fluctuations reveals a rather consistent difference between areas where replenishment by irrigation exists and where replenishment occurs through natural conditions. In both of these cases it is assumed that irrigation from wells is also a factor.

In the first instance it will be found that normally, where there is a balance of conditions, the lowest water table occurs in the spring before irrigation starts and reaches a high point at the end of the irrigation season. In drought periods, when the pumping rate is high and surface water supplies low, this pattern can be upset. It will be noticed that frequently the seasonal amplitude of the swing is greater at a distance from a flowing stream than near it. The total swing between the extremes is also much greater at a distance than near a stream. At a distance, when the trend is downard, water is being taken from storage. When the trend is upward water is going into storage. Normally, near a stream, instead of water going into storage, it is discharged rather soon to the stream. If a consistency could be found here, a criterion might be developed to aid in drawing an arbitrary boundary dividing ground water closely associated with stream flow and that which is not. The trouble

in locating such a boundary lies in the fact that our data are vitiated by pumping. The idea seems not to hold with the water-table fluctuations in wells on the Arkansas River bottoms between Pueblo and Nepesta. Perhaps the reason for this can be accounted for but at present it is obscure.

The water table in areas where replenishment occurs from natural sources and is uncertain, the usual condition is that of overdraught for considerable periods of time. In this type of situation, hydrographs usually show a water table higher in spring than in fall. This is easily accounted for. Observation wells are usually pumped wells and during the pumping season they develop cones of depression around them. Readjustment occurs for sometime after the pumping season resulting in a local recovery during the winter. With overdraught occurring, each successive spring measurement will show a lower water table.

THE SOUTH PLATTE RIVER SYSTEM

Areas in Classification I.

From Waterton to Julesburg, the South Platte is underlain with sands and gravels from which ground water can be extracted easily and cheaply. It is now highly developed particularly below Denver. The valley which it occupies is reasonably well defined for most of its length. Generally the lands of the valley are composed of two levels; a low-lying or what might be normally defined as a flood plain and a somewhat higher terrace. Pumping plants are to be found on both levels. The total valley width seldom exceeds 4 miles. Tentatively I would place all of most of these lands in Classification I.

Sands and gravels also underlie the valleys of the Cache La Poudre, Thompson, St. Vrain, Boulder Creek, Clear Creek, Bear Creek, and Cherry Creek. All these streams carry appropriated water and in some of the valleys, irrigation wells are quite numerous. I would place most but not all such wells in Classification I.

Since the above areas in which ground-water use is occurring are also covered by surface water irrigation systems, replenishment has been adequate. Only for periods of short duration - a few years - has there been a serious lowering of the water table. These have occurred during drought periods and subsequent recovery has been complete. Not only has the replacement of lost storage been taken from stream flow but also a very large part of the water that was currently pumped from the wells. Herein lies the conflict of interests between surface and ground-water users.

Classification II.

The use of ground water in the tributary valleys will be discussed in their downstream order.

Sand Creek and First Creek

Both of these creeks are live at times in some places. There are a few irrigation wells in each of these drainages. Little is known as to the possible effect pumping may have on such flows or whether surface rights might be interferred with. Tentatively I would put such use in the second classification.

Box Elder Creek in District 3.

This creek becomes a living stream at a point about 3 miles south of Wellington and there are several appropriations between that point and where it empties into the Poudre. It is quite possible that wells near the stream affect its flow. If this effect could be ignored, then I would place all the area in this drainage in Classification II, beginning at some arbitrary line about 3 miles distant from the Poudre.

Practically all the area is under gravity irrigation and is now assured of adequate ground-water replenishment. The water table short distances north and south of Wellington receded considerably in the period 1945-1956 and had not water supply conditions improved, this area would have become critical. The additional water supply to the North Poudre Canal system from the Big Thompson project reversed the downward trend in 1957. Pumping in this area should actually be beneficial in controlling the water table. Large areas presently farmed under the North Poudre Canal and some other canals could become waterlogged with the increased use of water from the Big Thompson project.

Black Hollow

There are a few wells in this valley near Severance and on south. The farms involved all receive gravity water hence there would be no threat of grcund water exhaustion. I know of no surface rights that could be affected. In places, pumping could have a beneficial effect.

Lone Tree

A very large area is involved here extending from near Pierce to

near Greeley. There are a few wells north of the Pierce Lateral, otherwise the entire area is under gravity irrigation. Lone Tree Creek is a living stream near Dover where there is a gaging station but is dry to a point between Pierce and Ault. From here on to its confluence with the South Platte, it is a living stream but has dried up in places during drought periods. Its waters have been appropriated.

The water table reached its lowest point of record in 1956 which was only slightly lower than the low of 1941. In both these periods, many pumps were taking air. By 1944 in the first instance, water tables had recovered 5 to 10 feet. The more severe lowering of 1956 was followed in 1957, 58 and 59 by recoveries of up to 15 feet thus bringing the water table back to about the same elevation as in 1944. Ground-water use in this area has demonstrated its ability to recover promptly after several years of heavy withdrawals from storage. Its value as a means of equating water supply is very great.

All this ground water is moving towards the Poudre and the South Platte and consequently there is a contribution to those streams. The deviation in discharge between high and low water tables at some distance back from the streams is not of great magnitude. The magnitude of course increases as proximity to the stream decreases. It seems reasonable to believe that a satisfactory evaluation of the distance at which the effect is immaterial can be arrived at. Mathematics of ground-water flow can be very useful in this field.

Crow Creek

There are a few irrigation wells in the vicinity of Hereford and Grover. Most of the wells are in the vicinity of Gill and below gravity canals. There may be a few between Gill and Grover. No information is available as to changes in the water table north of Gill. Wells in the Gill area showed a gradual lowering over a long period of time reaching its lowest stage in 1956. In the following 3 years they recovered to about normal. No interference with surface rights is involved along this creek.

Beebe Draw

Seepage from Barr Lake and distributary ditches from it provide a small continuous flow in the draw which is captured in Milton Reservoir. There are irrigation wells scattered along its entire length and these conceivably could affect the flow in the draw. The few observation wells near Hudson indicate continuous lowering of the water table.

Box Elder Creek (District 1)

Box Elder Creek is normally dry in Adams County. A live stream develops below the Denver-Hudson Canal which continues for 6 or 7 miles. In this reach there are several small-channel reservoirs involving appropriations. Just above the Denver-Hudson Canal is Bootleg Reservoir in which there are appropriative rights to flood water. There is no gravity irrigation above this reservoir.

Overdevelopment in Adams County did not become apparent until 1949. Expansion of use since that time has caused a constant lowering of the water table reaching a maximum of about 15 feet. This is very serious in this location as the original saturated depth was on the order of 30 feet. A large part of the area is controlled by the Box Elder Farms Company which is cognizant of the danger of total loss. A pumping cut-back has been instituted by the company in the last two years. I would consider all the ground-water development in the valley in Adams County as having reached critical stage.

Irrigation wells in the south 5 miles in Weld County are rather numerous. These are under the Henrylyn system which during drought periods suffers severely from short water supplies. In the 1950-56 period pumping was very heavy and the water table dropped 5 to 15 feet. This caused a serious reduction in well capacity. Since 1956 there has been a recovery but the water table is not back to normal yet.

Ground-water development picks up about 8 miles north of Hudson and continues to the end of the valley east of Kersey. Only the final 7 miles are under canal irrigation. All the wells in this group showed a continuous water-table decline in the 1952-56 period. The group below canal irrigation showed incomplete recovery since 1956 but those above continue to show a decline in the water table. Danger of overdevelopment lies ahead for that area above canals.

Prospect Valley

A great amount of investigative work has been done in this valley by C.S.U. and U.S.G.S. Reports are available by both these agencies.

Prospect Valley is the easternmost part of the Henrylyn Irrigation District. As previously mentioned, the water supply for the District is uncertain and often inadequate. Storage rights compose most of its supply and are of rather late date. Water was very short in the

1930's and in 1932 exploratory investigations revealed favorable conditions for ground-water development. By 1940 there were 67 irrigation wells in use and this number has increased steadily ever since.

The water table is very sensitive to supply and demand for water. Initially there was a rapid decline of the water table and with more favorable surface water supplies in 1942, a substantial recovery occurred until 1950 when again a decline began which lasted through 1956. An improvement is in progress now. It is here where artificial replenishment is being practiced by diverting surplus water into a leaky reservoir. A considerable benefit is being derived by this operation.

Prospect Valley is a long way from the South Platte and surface drainage to that stream is non-existent. Yet geologically it is connected underground to the South Platte and ground water is moving in that direction. The effect of ground water use in the valley on the South Platte is nil.

Kiowa Creek

Ground-water development extends the entire length of the valley in Adams, Weld and Morgan Counties. The greatest concentration of wells is in Morgan County near Wiggins. The valleys of Kiowa and Bijou Creeks coalesce at this point. Three observation wells in Adams County show rather definite symptoms of water-table decline at a rate of about a foot per year. Those near Wiggins in Morgan County indicate about the same rate.

Bijou Valley

Investigations and reports on the ground water in Morgan County are available by both C.S.U. and U.S.G.S.

The principal development in Bijou Valley is in northern Adams County and in Morgan County. Development started in 1935 and progressed rapidly until about 1952 and at a much slower rate since then. Since pumping extends into the valley of the South Platte all the conditions of prompt and long-time effect on flow in the South Platte exist.

The water table has declined at an accelerated rate and in places now the total decline has been as much as 30 feet. As the result of the factual data available, the Colorado Ground Water Commission declared that portion of the valley north of Byers a critical ground-water district. Because of the veto powers of a local board, the action of the Commission was nulified. The situation is therefore unchanged.

Replenishment occurs through flood flows in Bijou Creek which is obviously inadequate hence under the present agricultural program, withdrawal from storage will continue. The present rate of water table decline, if continued, will result in great distress in some parts in another 10 years.

Except for a narrow belt along the South Platte I would place all of Bijou Valley in Classification II.

Badger Valley

The highest canal is the Bijou which terminates about 6 miles south of Ft. Morgan. Ground-water development is quite extensive in this general area and extends above the Bijou Canal. In the last 7 years a definite downward trend in the water table amounting to as much as 15 feet has been noted. It does not seem reasonable that this downward trend will continue. The situation above the Bijou Canal does not look hopeful.

An oil company operating the Adena field farther south has invaded this water bearing field and is transporting water to be injected into the oil bearing formations. To avoid legal complications, the oil company is reported to have purchased a large block of land from which ground water is being withdrawn. The effect of this operation is not presently known, but observations are being made by the consulting engineering firm of Wheeler and Wright. Their data will ultimately be available.

Tentatively at least, I would place all development on the terrace in Classification II.

Beaver Creek

The Fort Morgan Canal which is the highest here, tails out into Beaver Creek about 3 miles south of Brush. Below this point water shows in the channel to its confluence with the South Platte. Before much pumping had developed, water could be seen in the channel in places for 10 miles south of Brush. I do not know present conditions. Best water recovery conditions exist in the 12-mile reach north of the Washington County line and the wells are most numerous here. Since 1946 the water table has receded continuously in this heavily pumped area and shows no sign of abating. This lowering has amounted to 15 feet in a number of wells which is a considerable portion of the original saturated depth of 30 to 40 feet.

In the above 12-mile reach water in large amounts has been drawn from storage for at least 13 years. If the present rate of withdrawal is maintained, the resource will be exhausted for practical purposes in another 10 or 15 years.

Pawnee Creek

This creek has a small constant flow in it below the north Sterling Inlet Canal. The small amount of ground-water use has not disturbed the water table except for very short periods.

ARKANSAS VALLEY

Main Valley

Except for short distances above and below John Martin Reservoir, ground water is available and being used for irrigation from Pueblo to the state line. That part of the valley containing water bearing alluvial gravels is quite narrow seldom exceeding 4 miles in width. Pumping plants are to be found on the discontinuous terraces on both sides of the river as well as on the bottom lands. Because of the limited saturated depth, terrace wells have a capacity seldom exceeding 600 g.p.m. In nearly all cases the irrigation wells are in areas covered by surface supplies and water tables have remained stable. During drought periods there have been temporary declines but recovery has occurred during periods of good water supply. Since long-time observations are available only between Pueblo and La Junta, these statements are valid only in that portion of the valley. A system of observation wells has been set up by C.S.U. and U.S.G.S. below La Junta but these have been in existence but a short time. U.S.G.S. now has a survey of ground-water conditions in progress upstream from the state line and has completed Prowers County. This will be the first published report on ground water in the valley. Work done by C. S. U. has been limited to the establishment of observation wells and casual study of conditions in areas of development. Some of the records date back to 1929.

It is rather obvious to me that all the bottom land development belongs in Classification I. I am not so sure about terrace development. For instance, the St. Charles terrace on the south side of the river from Pueblo to Avondale contains a water table higher and independent of the flood-plain water table. The water bearing gravels lie on top of a shale terrace which itself is often higher than the flood plain. This gives rise to springs along the contact especially in the side drainages. The effect

of pumping on stream flow under these conditions is not immediate nor necessarily of any great magnitude, yet there is no doubt some effect.

Surface-water users have been disturbed for some time by the activities of the pumpers. Threats of injunction have cropped up a number of times during periods of short water supplies. The Oxford Farmers Canal has augmented its surface supply by means of wells near its headworks for 40 or more years. Other canals have toyed with the same idea. A tract of land near Boone having a river right was purchased by the C. F. and I some years ago and the water was transferred upstream to its head gate. In 1928 the purchaser drilled wells on the tract and the land has been under cultivation ever since. These two instances have added fuel to the existing conflict between the two kinds of water users.

North tributaries of the Arkansas offer the best opportunities for ground-water development. Very little development has occurred in the south tributaries. Of the north tributaries the Fountain, Black Squirrel and Big Sandy are the most important valleys.

Fountain

As in the valley of the Arkansas, terraces occur and ground water available for irrigation use has been developed on these terraces as well as on the flood plain. Because of the narrowness of the valley development has been restricted to a strip seldom more than 2 miles wide. Although wells are found the entire distance from Colorado Springs to Pueblo, the principal development and use is occurring between Colorado Springs and around Fountain. There are 113 wells being electrically served by the Mountain View Electric Association in the Fountain drainage. The recent entry of Colorado Springs and Security Village into the field of ground-water use has posed a water-table problem in the vicinity of Security which may prove very serious in the near future. Previous to that activity the water table had remained quite stable. An injunctive suit brought by a farmer against Colorado Springs was tried very recently but a decision has not yet been handed down. Injury because of lowered water table was claimed.

Because of the narrowness of the valley it might seem logical to place all ground water in Classification I. However, very detailed study by U.S.G.S. showed no effect of ground-water use near Security on stream flow. The creek contains a perennial flow throughout its length and the water supply is fully appropriated.

Ground water has been developed on Jimmy Camp Creek, an eastern tributary which enters the Fountain near the town of Fountain. Little is known about water-table movement here. Stream flow occurs only during periods of precipitation and no surface rights are known to exist. This valley could well be placed in Classification II.

Black Squirrel

This drainage enters the Arkansas near North Avondale after being joined by Chico Creek. I believe there is a perennial flow near its headwaters that has been diverted for irrigation. Although only 8 wells have electric service, I believe there are twice that many in the area near Elicott. The residents of this area showed some interest in forming a ground-water district under the 1957 law when Colorado Springs was foraging for water, and had looked into possibilities in this valley. There is no stream flow here other than flood flows. There are no observation wells hence no knowledge about water table stability. There is no information that there has been any lowering. Ground-water development would be in Classification II.

Horse Creek

Horse Creek enters the Arkansas about 6 miles above Las Animas. The Mountain View Electric Association serves 41 irrigation wells in the upper part of the valley and that is about all the information that is available. These would be classified in Classification II.

Adobe Creek

There have been some feeble attempts to develop ground water near Arlington. Information on the lower part of the valley will have to await the work of U.S.G.S. in Bent County.

Big Sandy

Big Sandy together with the Rush Creek tributary forms a very large drainage area. Its mouth is about 8 miles below Lamar. Favorable conditions exist nearly its entire length for wells of sufficient capacity for irrigation. These conditions are favorable principally in a very narrow belt in alluvial material following the stream. Between the upper branches of Rush Creek and Big Sandy, some water is being recovered from the Ogallala formation which is very thin here. Mountain View Electric Association serves a total of 23 wells in the area mentioned. There are also some irrigation wells near Brandon which is not on the creek.

The creek is dry for most of its length normally. However there are short reaches above Limon where perennial flow occurs. Flow may occur for a mile or so, disappear only to reappear again in a few miles. Perennial flow occurs also at the confluence with Big Spring Creek 6 miles below Kit Carson and below the confluence with Rush Creek. Several abortive attempts have been made in the past involving considerable sums of money to utilize flood flows. These were abandoned many years ago and it is safe to say that no water rights exist above the Amity Canal.

Flood flows are numerous enough to replenish any reasonable ground-water use. The bed of the creek is of such an absorptive nature as to facilitate replenishment. All this drainage, above the Amity Canal at least, should be in Classification II.

Two published reports are available for this area. One is of a reconnaissance type by C.S .U. in 1945. The other is by U.S.G.S. in 1946, and covers the valley above Limon. U.S.G.S. has established 4 or 5 observation wells above Limon which are being read regularly. No trends have developed in 13 years.

Wild Horse Creek

There are wells in this drainage quite some distance from the Arkansas that are probably taking water from the Ogallala formation. The U.S.G.S. report will contain more information in this area.

As mentioned previously, there is but little ground-water development in the south tributaries. There are a few wells in the bottom lands of the Huerfano. The city of Lamar obtains its water supply in Clay Creek valley.

SAN LUIS VALLEY

I sometimes think of the San Luis Valley as a million acres full of anomalies. One's impression on first visiting the valley is that it is suffering from too much water. This is actually the case in many places. The sad part is that water is not always available where and when wanted. The geology of the valley is most interesting. It is a very deep structural basin hemmed in by mountains on all sides. Stream flow has filled the trench to a depth of possibly 10, 000 feet. During geologic times when it was a lake, thick deposits of clay were laid down in haphazard discontinuous strata. These, together with lava flows, have set up conditions

for artesian pressures. It is believed that these deep waters are interconnected throughout the valley. Above the last confining strata are more recent deposits of coarser sands and gravels containing a water table influenced only to a minor extent by escape of water under pressure. Most of the water pumped is being taken from this zone.

The Rio Grande coming in from the west has built up a fan in such manner as to isolate the northern half of the valley into a closed basin. There is a ground-water divide a few miles north of the river and any waters entering the valley north of that divide remain in the valley. Water in excess of agricultural needs moves to the lowest point called the sump which lies well to the eastern side of the valley. Here it is lost by evaporation from the San Luis Lakes and by transpiration from useless vegetation.

Irrigation began in the central part of the valley near Hooper and Mosca about 1887. The farmers practiced sub-irrigation and the area was extremely productive for about 20 years. The end came when the land became water-logged and the soil saline. People moved westward and as of now the main body of farmed land is many miles from Mosca. Sub-irrigation is still practiced but by means of controlled drains, the danger of water logging is avoided. Ordinarily the water table must be within 18 inches from the surface during the growing season in this type of irrigation. When the crops are maturing, the drains are opened and the water passes overland towards the sump. In periods of short water supply, insufficient to bring up the water table to the desired elevation, surface methods must be employed.

To meet these emergencies, farmers began to employ wells in about 1929. Many frowned upon these activities as being imcompatible with sub-irrigation. However in a few years hundreds of wells were drilled into the water table. They have been of immense value during drought periods. Sub-irrigation remains the dominant method of applying water and each year, every effort is made to bring the water table up to the desired elevation. After a year of very low water supply a very large reservoir has to be filled to restore conditions. Thus an above-normal supply must be available. This sinking of what some might call surplus water could lead to contractual difficulties with New Mexico.

I would place all the area north of the ground-water divide in Classification II, and that between the divide and the river in Classification I at least in Rio Grande County.

Near Alamosa the river sweeps in a wide bend into a southerly direction. Below this bend, Alamosa, La Jara, Trinchero, Conejos and Culebra Creeks enter in that order. These creeks contain sizeable base flows all appropriated. Within this large area both sub and surface-irrigation is practiced. There are many irrigation wells within the drainage boundaries of the first 3 mentioned creeks. The picture is very confused as to what their effect might be on stream flow. Any boundaries would have to be set after mature consideration. The Rio Grande does not contain return flow in all its length. In some reaches, it is a losing stream at times. Such a condition might have some local bearing on boundaries.

As of now, there are 1425 pumps being served electrically. There are several hundred more operated by engines. A rather large number of the pumps are installed on artesian wells. The power load for the valley varies tremendously with the water supply. In one instance it dropped from 42, 000, 000 Kw. hr. to 5, 000, 000 Kw. hr. in one year.

Artesian wells are a common sight in the valley. There are some 7, 000 of them. Before 1930 they were used mostly for domestic and stock purposes. Since then and particularly within the last 10 years there have been many large diameter deep wells drilled. Some have flowed as much as 1, 000 g.p.m. at the surface while others have been pumped at a rate of over 2, 000 g.p.m. The drilling of these deep wells into artesian pressure zones has caused some concern throughout the valley. Aside from causing local pressure disturbances, probably the greatest concern was over improper construction procedures. The most pressure that resulted in the legislative act of 1955 came from this valley.

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OCCURRENCE OF GROUND WATER IN THE OGALLALA AND SEVERAL CONSOLIDATED FORMATIONS IN COLORADO

A report to the Ground-water Codification and Research Studies Committee

by

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Occurrence of Ground Water in the Ogallala and several consolidated formations in Colorado
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The aquifers herein discussed differ from the alluvial aquifers found along the principal streams. Withdrawals from these aquifers have very little affect on the surface-water resources of Colorado compared to those from the alluvial aquifers of the South Platte, Arkansas, and San Luis Valleys. The Ogallala formation receives very little recharge from surface streams and contributes very little water to the streams in Colorado. The perennial streams are in contact with the Ogallala and the principal consolidated water-bearing formations in Colorado only where they cross the outcrops of the formations; the contact area is very small compared to the areal extent of the aquifers. Therefore, in most areas, it may be possible, from a practical standpoint, to satisfactorily develop and manage the ground-water resources from these aquifers independent of the surface water.

High Plains aquifer. --Of the four major ground-water provinces in Colorado (South Platte Valley, Arkansas Valley, San Luis Valley, and High Plains), the High Plains province is the largest. It covers about 12, 000 square miles including all or parts of 15 counties in eastern Colorado. The province has been separated into three major parts by Big Sandy Creek and the Arkansas River. The largest part is northeast of Big Sandy Creek and centers around Yuma County. The part southwest of Big Sandy Creek is irregularly shaped, being eroded, in part, by tributaries to the Big Sandy and the Arkansas. The third part lies south of the Arkansas in the southeast corner of the State.

Deposits of the Ogallala formation make up the surface of the High Plains and form the aquifer. However, a part of the Ogallala formation is overlain by younger windblown deposits generally less than 50 feet thick. The Ogallala consists chiefly of sand and gravel, although it contains numerous beds of finer-grained material consisting of clay, silt, cemented sand, and limestone. In a few places the formation is more than 400 feet thick, but more generally it ranges in thickness from 200 to 300 feet. From one-third to one-half of the material is saturated.

The Ogallala formation extends far beyond the boundaries of Colorado. It is an important aquifer especially in Nebraska, Kansas, Oklahoma, and Texas. In fact, the aquifer is much more extensive in the other states than it is in Colorado. It is most extensively developed in Texas where many thousands of wells are furnishing water to irrigate about 5 million acres of land.

The Ogallala formation has not been extensively exploited for water in Colorado. However, enough wells have been drilled to prove that it is capable of supplying large quantities of water which can be used for irrigation. A recent estimate indicates that there were about 400 wells being used for irrigation in 1960; the number has been increasing each year.

Development of ground water in the High Plains of Colorado is behind that in Colorado's other major aquifers and several southwestern states for several reasons: (1) the depth to water and hence the cost of pumping water is much greater in the High Plains than it is in the other major ground-water provinces in the State; (2) dryland farming has been quite successful; (3) land owners are reluctant to make the large expenditure to convert from dry land to irrigation farming; and (4) climatic conditions are not as favorable for growing high-priced crops as they are in states farther to the south. Economic conditions are becoming increasingly favorable and probably irrigation farming in the High Plains of Colorado will continue to increase.

Extensive development of ground water will undoubtedly result in a depletion of the supply. The potential rate of development for irrigation is many times greater than the rate of replenishment. The aquifer is recharged only by precipitation on the surface. Of the normal annual precipitation (15 to 18 inches), probably not more than an inch reaches the aquifer. At least one foot of water is needed to irrigate most crops and some crops, under certain conditions, require several feet. Based on extensively developed areas in other states, it seems likely that extensive irrigation development in the irrigable areas of the High Plains of Colorado might cause the water table to decline at the rate of 5-10 feet per year.

To date, the withdrawals of ground water have not been great enough to cause a widespread decline although, in a few small intensively developed areas, the decline has been measurable. Water-level measurements in parts of the area are being made periodically

and additional measurements are planned to give more widespread coverage. This program will become more and more valuable as development increases; it will show the status and trends of depletion.

Ground-water investigations by the U. S. Geological Survey, appraising the ground-water situation in the High Plains of Colorado, are nearing completion. Field studies are complete except for one area--eastern Cheyenne and Kiowa Counties; this study was started in 1959 and is scheduled for completion in 1962.

Consolidated formations ("Artesian aquifers"). --The consolidated formations in Colorado generally are capable of yielding much less water per well than the unconsolidated formations. Very few areas are underlain by rocks capable of yielding more than 300 gpm (gallons per minute) per well; a few local areas have wells that yield more than 1, 000 gpm; but throughout most of the area well yields generally range from 5 to 50 gpm. At least three-fourths of the State is underlain by materials capable of supplying water for domestic and stock use although in some places the water is of poor quality. Where thick alluvial deposits overlie the consolidated formations, the alluvium generally is the most productive aquifer.

The principal consolidated water-bearing material is sandstone; however, some conglomerate, limestone, and volcanic deposits are known to yield water locally. The most widespread sandstone deposits are of Cretaceous age although older water-bearing deposits of Jurassic and Triassic age underlie considerable areas in the western part of the State, and important water-bearing deposits of Tertiary age underlie fairly large areas in the eastern part of the State. Rocks older than Triassic generally do not contain fresh water except in a few small areas where they occur near the land surface.

In eastern Colorado, the oldest important water-bearing unit is the Cheyenne sandstone member of the Purgatoire formation of Cretaceous age. The next younger important waterbearing unit is the Dakota sandstone which overlies the Purgatoire formation. Two other younger formations of Cretaceous age, the Fox Hills sandstone and the Laramie formation are separated from the older aquifers by thick deposits of dense material which include the Pierre shale. Younger consolidated formations that are considered important aquifers are the Dawson arkose and Denver formation of Tertiary age.

Although the named formations generally are permeable wherever found, they become unimportant as aquifers when they occur at great depths beneath the surface because the water in them is highly mineralized. Conversely, they generally become of increasing importance the nearer they are to the surface because depth is an important factor determining the cost of developing a ground-water supply. The greatest potential supply generally occurs in the areas where the thickest section of water-bearing units lie within the depth zone of fresh water. All of the named formations underlie the center of the Denver Basin where the Denver formation, the youngest of the group, is exposed at the surface. Only those above the Pierre shale, however, contain potable water. Radially out from the center, successively older formations are exposed at the surface and the fresh-water bearing zone above the Pierre becomes thinner. The Pierre surfaces to the west within a relatively short distance from the center of the basin, whereas, it appears at the surface to the north, south, and east at somewhat greater distances. Nearly half of the northern two-thirds of eastern Colorado has Pierre shale exposed at the surface or has it underlying the surface at depths generally less than 400 feet. The formation contains very little fresh ground water, and throughout most of the area, the water in underlying permeable formations is of a quality unsuitable for most uses. Where younger water-bearing deposits do not overlie it, ground water is scarce.

In the southern one-third of eastern Colorado the Dakota and Cheyenne are the most important consolidated aquifers. The younger aquifers are absent and the Pierre is present only in a small part. The Dakota and Cheyenne are known to yield moderate to large quantities of water near the Kansas line but their potential yields appear to be generally less west of Prowers and Baca Counties. However, the Dakota sandstone is capable of yielding at least enough water to supply domestic and stock needs in most places in the southern one-third of eastern Colorado. In the southeastern corner of the State, rocks of Jurassic and Triassic age contain some fresh water, but the area of occurrence is small.

West of the Front Range the principal aquifers are of Cretaceous, Jurassic, or Triassic age. These aquifers may yield small to moderate supplies of water. Older rocks generally are non-water-bearing or contain water too mineralized for most uses. The Dakota sandstone of Cretaceous age is probably the most extensive and best known. The Mancos shale of Cretaceous age, a thick, generally non-water-bearing formation similar in character to the Pierre shale overlies the Dakota sandstone and is at or near the surface in large areas in western Colorado. In these areas the underlying aquifers occur at varying depths and in some areas wells must penetrate a considerable thickness of material (more than 3, 000 feet in some places) to obtain

water. In some places, the deep penetration may be in vain because the underlying water is salty.

The consolidated formations younger than the Mancos contain water generally adequate only for domestic and stock supplies, although in some areas where these younger rocks are thick, supplies large enough to furnish small towns might be obtained. More information is needed however, before the water-yielding properties of the younger rocks, especially those of Tertiary age, can be properly appraised even in general terms.

For an understanding of the areal extent of the various water-bearing formations in western Colorado, the reader is referred to the geologic map of Colorado.[1/] Certain general statements, however, may be useful to those who do not have ready reference to the geologic map.

In the western one-fourth of the State, rocks older than the Mancos predominate at or near the surface south of the Grand Valley; whereas, rocks younger than the Mancos predominate at or near the surface north of the Grand Valley.

Between the western one-fourth of the State and the Front Range of the Rocky Mountains the complex geologic structure has exposed rocks of all ages, the occurrence of any one formation or group of formations within a particular age group being relatively small in areal extent. Again using the Mancos as a reference plane, most of this area has surface rocks older than the Mancos or is covered with igneous rocks of Tertiary age underlain by rocks much older than the Mancos. None of these are known to be good aquifers except locally. Scattered throughout the area, however, are small areas underlain by water-bearing beds belonging to the geologic units ranging from Triassic to Tertiary age. The water-bearing properties of these units probably are similar to those of corresponding units in the area to the west.

Ground water is known to occur in some of the dense rocks of sedimentary, metamorphic, or igneous origin where fracturing, faulting, weathering and water have created extensive cracks, crevices and solution channels that lie below the water table. Very detailed studies

1/ Burbank, W. S., Lovering, T. S., Goddard, E. N., and Eckel, E. B., 1935, Geologic map of Colorado: U. S. Geological Survey.

commonly are necessary to determine the extent of such areas and very few have been made in Colorado.

Most of the water in the permeable consolidated formations in the State is confined under artesian pressure by overlying dense beds of clay or shale. Some of the permeable beds crop out and are recharged at a considerably higher eleveation than a part of the area where they are confined. The artesian pressure in the areas of low elevations may in places be great enough to cause wells to flow.

Artesian aquifers have substantially different storage characteristics than most of the unconsolidated aquifers. Large amounts of water can be pumped from them without dewatering the materials near the well. Local dewatering occurs only when the pumping level is below the top of the water-bearing zone. Even in cases where the pumping level is low enough to cause dewatering, the zone will fill almost immediately when pumping ceases. The water is yielded largely from "artesian storage," a term that is used to describe the water yielded when the aquifer compresses and the water expands.

After a period of time, which depends largely on the distance of the outcrop from the point of withdrawal, water stored in the outcrop will move toward the well. Even though the total amount moving toward the well may be large, the rate of movement in the outcrop generally is slow because the area contributing water generally is large. Thus, the water levels in the outcrop tend to decline over a large area, but at a slow rate.

If perennial streams cross the outcrop in the area subject to deline and if they are hydraulically connected with the aquifer, the flow in them will be reduced. The loss in flow will tend to equal ultimately the ground-water withdrawal rate although it may take many year in some instances before the two are nearly equal. In many, perhaps in most, places in Colorado the effect on stream flow will be negligible owing to the scarcity of perennial streams, and the lack of extensive areas where they are hydraulically connected. As a result, water withdrawn from artesian aquifers generally would ultimately result in a decreasing amount of water in storage in the area of outcrop, but the affected area probably would be small.

From a practical standpoint, the amount of ground water that can be withdrawn from an artesian aquifer is not closely related to the amount of ground water in storage nor the amount of replenishment

available from surface sources. Other factors, such as the physical boundaries of the aquifer, the permeability and thickness of the aquifer, and the allowable drawdown of water levels in pumping wells, generally are much more important. The artesian aquifer, therefore, is substantially different from the major aquifers in unconsolidated materials where storage and replenishment rates are of considerable importance.

From the foregoing discussion, it appears likely that the ground-water resources of most artesian aquifers in Colorado can be managed separately from the surface-water resources. Regulations pertaining to the control of artesian pressures probably are the chief ones needed for planned management. The pressures could be controlled either by regulating spacing of wells and discharge rates, or by regulating pumping levels. Other regulations pertaining to the conservation of the supply might include one preventing the uncontrolled discharge from flowing wells, one preventing the intermingling of water from other aquifers, and others commonly considered for all aquifers.

Artesian aquifers have been extensively developed in only two major areas in the State--the Denver metropolitan area and the Grand Junction area. Wells tapping the Dakota in the Arkansas valley are closely spaced in some areas, such as those near Rocky Ford, Colo. The problems in these areas, however, probably are not as serious as those in the Denver and Grand Junction area. In other areas, the development is scattered and artesian pressures have not declined substantially.

The most highly developed artesian aquifers in the Denver area are the Denver and Arapahoe formations, the Dawson arkose, the Upper division Laramie, and the Fox Hills. The pressure in some of them was originally sufficient to make wells flow throughout a large area. The heavy withdrawals for industrial and domestic use are so great that, near the center of Denver, the pressure has declined as much as 700 feet in the Fox Hills sandstone, and the water level is now about 450 feet below the land surface in one well. Declines approaching this magnitude have been reported from wells tapping the Arapahoe.

Development of ground water in the Grand Junction area is much less extensive and the quantity of water being withdrawn is much less than in the Denver area. The area of substantial water level declines is less than 5 square miles. The artesian wells tapping

the Jurassic Entrada sandstone or the Triassic Wingate sandstone flowed from less than 1 gpm to 20-30 gpm when drilled. As the number of wells and the withdrawal rate increased, the artesian pressure declined (in some places about 100 feet). Although many of the wells still flow, some have stopped flowing and most are now pumped at rates of a few gallons per minute to a few tens of gallons per minute. Most of the wells are in Orchard Mesa and the Redlands, which border the southwestern side of the Colorado River, but a few are northeast of the river in and near Grand Junction. A few of the wells in these areas are spaced far enough apart that their artesian pressures have been little affected. A few wells scattered throughout the area tap other aquifers and have not experienced appreciable declines in artesian pressure. These include the Salt Wash member of the Jurassic Morrison formation, the Cretaceous Dakota sandstone and Burro Canyon formation; in most places, however, the latter two formations yield salty water. Water from the extensively developed aquifers generally is considered to be of excellent quality for domestic use.

Trends in population and industrial growth and the potential availability of water from other consolidated artesian aquifers suggest few, if any, areas that may become extensively developed in the foreseeable future. However, local problems may occur any place were two or more wells are closely spaced. Large withdrawals of water from artesian aquifers generally have far-reaching effects on water levels--the effects often extend several miles compared to several hundred feet in unconsolidated aquifers.

COMMENTS ON PAPERS PRESENTED AT THE GROUND WATER SECTION OF THE WESTERN RESOURCES CONFERENCE, AUGUST 24 and 25, 1960

BY
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It is impossible to adequately summarize the many excellent papers presented at this conference. However, a few words can be said about the major points of agreement and disagreement which have been presented during the meeting. The points of agreement are clear cut and were mentioned by many of the speakers. The physical aspects of ground water development and management in which there is general accord, include the following:

1. That legislation should recognize ground water as part of the hydrologic cycle and part of the total water supply of each area.

2. That the optimum use of the total water resources in a basin will result only when operation and management of the ground water reservoirs are coordinated with surface water use.

In other words, man-made laws must recognize and be compatible with the laws of nature. Legislation which does not recognize these facts will be difficult to administrate or will not serve the public purpose to the greatest advantage. The biggest problem for Colorado seems to be in getting a satisfactory marriage between the physical facts, which cannot be changed, and the existing legal, economic, social, and other institutional situations which resist change.

Another point brought out by many speakers is the great need for a wiser and better use of the water we withdraw from our ground water reservoirs. I believe we will all agree that we have a long way to go in this field and that it is a very important part of the proper management of our overall water resources.

Many speakers have recognized that there is no alternative but to deplete certain ground water reservoirs which have a very low recharge potential. However, the question of the proper length of life of the reservoir and the type of control needed to assure that the supply will last sufficiently long become points of dissension.

A basic question which Colorado must answer in the High Plains of the state where development is young, but depletion inevitable, is: should exploitation be allowed to progress with no control, or should this reservoir of ground water be held in reserve for future periods of greater need or national emergency? Colorado can still make this decision, whereas many other parts of the High Plains cannot. They are past the turning-back stage.

In closing, I feel that it is necessary to bring up a point which has been touched upon but not amplified to any extent. This is the need for the scientists and technical people, who must develop and set forth the plans for management of our ground water resources, to keep the public fully informed and to create confidence in their ability to do this planning wisely and scientifically. The use of ground water predates recorded history, and legends, superstitions and mysteries surround the use of ground water. Scientists must sweep away this mystery before the confidence of the average ground water user is obtained. Many of us have been guilty of not keeping the public informed of the capability of the ground water scientists to scientifically manage our ground water reservoirs.

COMMENTS ON THE GROUND WATER SECTION OF THE WESTERN RESOURCES CONFERENCE, UNIVERSITY OF COLORADO, AUGUST 25, 1960, BY ROBERT EMMET CLARK, PROFESSOR, SCHOOL OF LAW, UNIVERSITY OF NEW MEXICO, ALBUQUERQUE, NEW MEXICO

Thank you, Mr. Miller. I'm afraid that this very loyal group might be frightened a little. However, I am not going to summarize all of the laws mentioned. After the confusion you have listened to I am sure you don't want me to try. It is impossible, obviously, to try to summarize and evaluate all of these papers given in two days and try to do it in a few minutes. However, I do think there are several important things that should be said by way of emphasis. In the same way as Mr. Bittinger emphasized what has been said, I am sure that there are some other things that should be said by way of dispelling confusion, particularly about the law.

Now, I want to say, Mr. Miller, as a law professor and a person who has been involved in these problems, that I feel that this conference has been most rewarding to me as a person interested in the subject. And I say this for two reasons--one is personal and because I am a teacher. But I would like to say it for the third reason, which I think might express the feelings of others in this room. This represents, in my judgment, a very successful venture in getting persons from different areas of knowledge to talk to each other somewhat intelligently. I recognize that I may be mistaken about this when we talk about the law. This conference represents a great advance. I think that this conference proves that economists don't all sound like theologians, and that engineers and lawyers, who are more concerned with empirical facts rather than concepts, can communicate with each other. It has proved very rewarding for me, and I think some other lawyers in the room, to listen to these gentlemen from the other disciplines. I have two real regrets which I must express, Mr. Miller. I think some of the others here feel these. One is that some of these papers were not heard by the whole conference. Secondly, I am very sorry that I don't see or have not been able to find, after diligent search, any representative of the state of Montana here. The state of Montana is planning to have a conference beginning the 13th of September which is dedicated to the same purpose for which this conference was dedicated, I believe. And I am going to take all of the information that I can carry from this conference up there and make it available to the people in Montana who have a great problem and also a great opportunity because theirs is the last state in which there can be a "marriage of the different approaches," to use Mr. Bittinger's phrase. The scientific information and the technological know-how can be used and the institutional lag can be

brought up to date. Montana is the last state to have this opportunity, if I can except Colorado from this momentarily. I am mindful that the purpose of this conference was to try to educate the people of Colorado specifically, and all of us generally, and I think the emphasis here was on three things, the last of which I will discuss.

One emphasis was on the physical conditions and technological skills and opportunities. We had a number of excellent papers about these.

Second is the area of existing economic conditions and economic goals and economic and social consequences.

Third is the institutional factor that makes the use of technological information and scientific attitudes available and useful to us. Here I include, of course, the field of the law. Now I think that the thing that I got out of this whole discussion for two days dealt with this topic, if I can put it all in one sentence: Some kind of integrated or correlated management of all water supplies under some kind of system of rational public control. I would say that this was the theme of this discussion for two days. I think that Mr. Conover's statement at the outset emphasized this. It was interesting to me to observe the number of people who emphasized the law all the way through, until finally the gentleman from North Dakota thought he had prepared a paper in the wrong field, although he actually presented an excellent one on controls in North Dakota. The discussion of the legal problems is not a prerogative of lawyers. It was interesting to me to hear other people's concern about these institutional frameworks within which we must operate. I am reminded here of a story that is attributed to our State Engineer, whose assistant is here in the room. He says that it is well known among lawyers and maybe among engineers that water rights litigation has made poor lawyers out of some good engineers and some bad engineers out of excellent lawyers.

The emphasis on public control in this conference I think was stated both by Judge Dent in the area of Texas which remains unique in its property rights and by Mr. Broadhurst, the Chief Engineer for the High Plains District. They disagreed on the amount and the area of public control, but they were certainly both talking about the necessity for some kind of public control, whether self-controlled or imposed by a group in a small area.

I want to try to say a little bit about "rights" because I'm afraid of the mis-use of the term. I worried about this yesterday. Lawyers use the phrase "vested rights" the way some of you may use the phrase "national

pride." And it is not always clear what is being said. What has happened in Texas, and what has been the law in Texas, and what has happened in Kansas offer examples to compare. They present an opportunity to see very clearly, as we should, the difference in an attitude toward this phrase, this word "vested rights" in giving it an empirical reference. In Texas, a vested right in percolating ground water exists in a vacuum, so to speak. It is not measured by the amount you use. As Judge Dent told you, it is limited only by waste or by some kind of pollution or negligent use of it. Now in Texas the recognition of a need for some limitation under the police power of the state is recognized under the good legislation under which the High Plains District was organized. This legislation was permitted by the Constitution of Texas which says that resources can be taken care of in a certain way as the legislature provides. The legislature has authorized three districts. In those districts this absolute right, which can exist only theologically speaking, if I may use that phrase, can be limited in terms of what the people want in that district. Now we'll set that definition aside for a moment, and look at Kansas. The Kansas legislation says, and it was upheld by the Kansas Supreme Court, a vested right only exists in the amount you use. That means actual beneficial use or water that is put to use by a specific date. The Kansas court said, "We don't recognize any property rights in unused water." The argument that water in the ground is like uranium in the ground is fallacious, and I don't have to tell you scientists or engineers how fallacious it is. It is not the same water that's there all the time for many centuries. What I want to emphasize is that this constitutional problem is enlarged and embellished and distorted beyond the understanding of intelligent people like those attending this conference. The idea of "vested rights" does not mean some kind of a philosophical concept only. It has a specific kind of reference. That's been the stumbling block in much of this legislation.

One of the other problems of legislation, and I was glad that Mr. Kelly got to talk about it because he laid the ground work for this criticism, and I wish that he were here to hear it, is the distinction between non-tributary and tributary ground water in Colorado. This is a two-edged sword in Colorado. I live down stream from Colorado, and we know about both edges of that sword just the same as Texas knows about New Mexico's law. Colorado is the only western state that has a legal presumption that all water not shown to be non-tributary is tributary to a stream. The other side of that sword is this: It presents a great opportunity for Colorado to integrate rationally some kind of administration of both surface and ground water. Now with respect to non-tributary waters, I

am told that until we have more hydrological data and until we have more precise knowledge which we should gain by research and by legislation that compels data collection, it is going to be very difficult to separate all these waters into different kinds. One of the glories of the appropriation system--and I'm not saying this personally--one of the utilitarian aspects of it is that it lends itself to a system of unified control in the western states. You all must know that until about twenty years ago most of the courts in the west were still talking about appropriation of surface flow and appropriation of underground streams, but they were also talking about the English landowners' rule of unlimited use with respect to percolating waters. There are only two states left in that category. One is the state of Texas, and we just talked about the modification which they themselves made since 1949, and the other state only by way of dictum in a case is the state of Montana. New Mexico--and I'm not here to brag about New Mexico--I'm simply saying that New Mexico long since arrived at the conclusion that the appropriation system, at least the vocabulary of the system, could be used to manage some kind of a unified system. Here, I think the people interested in legislation have to look to see the two choices open with respect to legislative changes. You can have loose controls to cover the whole state that aren't very good, or you can have specific controls set up in a legislative framework that covers specific areas where data is available and where knowledge of its physical conditions exist. It seems to me that this is the choice for the Colorado legislature. The doctrine of reasonable use is a wonderful phrase--it sounds reasonable --but what kind of real reference does "reasonable use" have? When it gets down to application, sometimes it refers to the fellow who gets to the ditch first. Reasonable use has to be defined in terms that can be administered by the water masters, by engineers, by people who are going to deal with the physical facts. So I would say here that any kind of good legislation has to recognize not just those institutional factors, but must have available scientific and technological data and all those other sources of information that we acquire over a period of time through study and research.

I would say that although I am not optimistic by nature, I feel that if this many people can get the benefit from two days of discussion in as many different fields of learning and understanding as have been gathered here, there is considerable hope for some kind of rational development in the field of unified control of all water resources.

Thank you very much.

OUTLINE OF AMERICAN EXPERIENCE IN GROUND WATER

By

C. E. Busby*

Experience tells me to approach ground water management problems with real caution and to give special attention to the geology and soils of the area, the nature and extent of the water supply, the present and prospective uses, and the legal and political background of the State. It is a problem in social engineering to use the terms coined by Roscoe Pound. I shall talk about ground water in this setting.

In the case of the High Plains of Texas, the groundwater body is a vast sheet of water under a blanket of sedimentary rocks, without appreciable natural replenishment from precipitations or high snow sources. In the sense of a sheet, this is like the Ogallala formations in Colorado and the St. Peter and Dakota sandstones in the Plains. But in terms of natural replenishment and artesian pressures, it is not. So the supply in the Texas area is a "wasting asset," mined as if it were an ore body (unless some remote and feasible possibility of artificial replenishment develops in the future). The users are conservative in their attitude toward property rights, so change from the very conservative common law rules toward the most progressive statutory controls is presently impractical.

Thus, the local groundwater district laws of Texas[1/] seek mainly to reduce water waste and to control the spacing of wells affecting drawdown. These involve land use and conservation practices. This general method has real educational and technical-guidance value and places individual and group responsibility near home.

The life of the ground water reservoir supply is limited and the irrigated area will probably revert to grazing-dry farming in a century. But in the meantime, the landowners and users can work together to manage efficiently their common water resource. Here the water conservation and soil conservation districts can combine their powers and facilities, as they are now doing.

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1/ Tex. Rev. Civ. Stat. Ann. (Vernon, Supp. 1953) art. 7880-3c; Proceedings, Water Law Conferences, Nov. 1952, June 1954.

In many respects, using land according to its capabilities and treating it according to its needs is the first pre-requisite to a sound water policy. In this respect Colorado and Texas have much in common.

Ground water areas in California are subject mainly to the correlative rights (court) rules and to the court references--adjudication process. In this, mutual prescription is recognized when use exceeds replenishment for the statutory period. In other words, this policy calls initially for a sharing of the common supply but ultimately for a rationing of use to the sustained yield of each defined basin when use exceeds replenishment, based upon the recorded history of past use and current supply. The State Water Department serves as fact-finding agency for the courts and its findings are treated as prima facie evidence of the truth therein contained, but experts representing the parties sit in on the fact studies so as to reduce litigation time and cost. 2/

This method is very slow and costly but has important advantages in terms of providing for conservation and continued use of the resource, including the space which it occupies in anticipation of artificial replenishment under the California Water Plan. Our main and most efficient natural reservoir capacity in California lies underground.

The people of California have progressed from the more conservative common law rules to the somewhat more progressive correlative rights rules. But they have not gone as far as Utah and adopted statutory appropriation for ground waters after adopting correlative rights. They are almost that far, and eventually will be forced by necessity to do so because mutual prescription is only a judicial stopgap. And court administration has not been shown to be efficient in the long run in critical areas.

The California geology is different from that of the Texas High Plains, and there is both existing natural replenishment and feasible artificial replenishment possibilities. The Colorado situation has similarities to both those of Texas and California, but it also has dissimilarities. It is usually the differences which are most important in developing rules of fairness in management of water.

In addition to the foregoing, the California Recordation Act for certain southern California counties is a device with practical possibilities for recognizing past uses as an initial step in the long-time management

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2/ Katz v. Walkinshaw, 141 Calif. 116, 70 Pac. 663 (1902); 74 Pac. 766 (1903); Pasadena v. Alhambra, 33 Cal. 2d 908, 207 P. 2d 27 (1949); Cal. Water Code Ann. §1242 (1954).

control process. 3/ I cannot say how effective this has been, but it does fit into both the court reference and statutory control systems.

Systems of statutory appropriation in New Mexico, Kansas, Utah, Nevada, Oregon, and Washington are good sources of statutory control experience. In these states there has been steady adjustment from old rules of common law or reasonable use, to correlative rights and prescription in one State, and finally to controlled drilling and use under statutory and administrative appropriation methods. These states represent three broad types of supply and use areas, however.

In each state the geology is variable, sources of replenishment usually are feasible, supply short of need, and use largely of a depleting nature. To set out each act and discuss its strong and weak points of law and administration would take many pages. Furthermore, I think that there are new ideas worth considering which are flexible to fit each local area, (some of which are in one or more of these acts and some are not) and stable enough to encourage sound investments. I think that in any area the resource should be developed and used according to capabilities, and treated according to need, as the basic policy of the law.

Colorado has peculiar geologic, water supply, and water use factors to consider. The West Slope is markedly different from the East Slope. In a sense, Colorado straddles the continent-waterwise.

The statutory experience just above referred to fits the West Slope fairly well. But the East Slope has large sheet-like aquifers as well as localized groundwater bodies affected by streamflow. Both have snow storage and precipitation sources of replenishment and also depleting uses. Aside from Kansas, South Dakota, and Texas, there hasn't been much experience of substantial length of time (25 years or more) that fits this Plains type of ground water and surface water relationship. So I doubt if any of these states could fully serve as a model of proven experience.

Furthermore, the dispute over federal-state jurisdiction and ownership of water resources, including the interstate management aspects, throws this whole problem of groundwater management into confusion because part of Colorado was in the Louisiana Purchase, part in the Texas purchase, part in the cession from Mexico, and a small area was part of the special treaty with Spain, as I understand the history. All was public domain at one time, as far as Colorado is concerned, and title was in the United States, subject to the then existing and recognized rights. How much did the United States grant away and how much did it retain? And how are the granting instruments to be interpreted?

3/ Cal. Water Code Ann., Ch. 1869, Div. 2, Part 5 (1955).

In these circumstances, I would think it best to treat ground water as a public resource (leaving the final ownership-control decision to Congressional legislation and U. S. Supreme Court adjudication) and establish state policies and means of implementation to conserve and protect the resource for maximum and continued use (leaving guiding principles open for court interpretation and management problems open to limited local administration). I think there are sound scientific ways to do this.

I could cite the laws of New York, New Jersey, Maryland, Florida, Minnesota, Iowa, and other eastern states. But they don't provide much proven experience that fits Colorado conditions and needs. This brings the discussion back to the combined western experience and some new ideas.

My ideas are not in published form, however, the following is a summary of some of my ideas and suggestions.

1. The constitutional basis for state adjustment in rules of (water) property and administration is well developed out of the Oregon, Kansas, New Mexico, Utah, Wyoming, and Nebraska experience. The specific questions and analyses are set out in the Michigan Law School report.4/ That report substantiated what many water lawyers already knew but it also amplified earlier conclusions.

2. The general water policies of California, Oregon, Washington, and Nevada are comprehensive and progressive and have been pretty well tested for surface waters. But they have only limited experience for ground waters. None, as yet, fully recognizes the points set out below under No. 4, but the Oregon and Washington acts go part-way in this regard.

3. Colorado law is so mixed up as to common law for ground waters, statutory appropriation for surface waters, statutory preference for surface water rights as against ground water rights in tributary ground water sources, over-appropriation of stream systems, interstate compacts, and other matters, that I know of no model act that would fit your varying conditions and needs. I, therefore, suggest a study approach to develop an act to fit Colorado conditions alone.

4/ Water Resources and the Law, Legislative Research Center, University of Michigan, 1958.

There are alternative ways to go about this, of course. The usual one is to draft a bill and put it in the legislative "hopper". This usually fails because local people don't understand it. Another way is to set up a legislative committee and hold hearings and draft a bill. This often fails, too, in the long run, as the hearing method alone is much weaker than it appears. Local people are not really prepared to define their problems and needs without special preparation. The third method is for the legislators to set up a study commission with educational and fact-finding committees in each county and statewide, and then provide for full participation and decision on recommendation by organization leaders and officials who have rights and responsibilities. There isn't room to explain this fully here but copies of material are available from my office to illustrate it. This latter method helps local people define their problems and needs and, therefore, gives them a scientific basis to sanction basic policy changes in the law. Without this sanction no law can have lasting value.

4. Of primary concern is the fact that ground water in the East Slope is an interstate body of water that involves streamflow and natural precipitation replenishment. Thus, a unified scientific approach to the management problem in the whole area is indicated. First, the water supply should be defined and described (in law) in terms of the water cycle and the major connected natural reservoirs of that cycle (soil, watershed, ground water aquifer, and atmosphere). This would bring science and law together, so that the law actually represents the physical facts of reality. Such does not exist at present. This is what I think Roscoe Pound meant by his term "social engineering."

   Second, the basic policy of the law should be geared to maximum beneficial use over the years; and this expressed as the development and conservation of both land and water according to capabilities (of each natural reservoir) and treatment according to need (of land and water use practices and projects) for continuous use. This is only partially true today. But you do have good foundation for this policy in the soil conservation and water conservation districts of Colorado and in the interstate compacts. Perhaps, further improvements in these local and interstate control devices is desirable.

   Third, the rights in and to water should be geared to these two broad principles, so that they have a scientific foundation

in fact and in principles of policy. This may have to be approached in a series of steps, moving only as fast as the people are ready for it. My own experience tells me that educational devices are the most effective in making adjustments.

For example, one first step might be to lay down some broad comprehensive water policies (objectives, purposes, and guiding principles), such as those of California, Oregon, and Washington. A second step might be the enactment of a recordation act for all wells and springs, such as that of California. This would help provide facts and a way to verify them. A third step might be the strengthening and unification of local soil and water conservation districts. All might have water management functions. A fourth step might be the adoption of either the correlative rights or appropriation system or some combination of these and provide administrative machinery for enforcement. In one system there is sharing or common uses, while in the other there are exclusive uses. A fifth step might be to unify all water administrative devices in Colorado, so as to assure the most efficient management.

In this sort of progressive approach, it might be well to keep in mind that Nebraska is the only adjacent state which doesn't yet have the appropriation system for ground water. Ground water is too important in Colorado to approach its management in other than scientific ways. The scientific way is more satisfactory in the long run. But it does not have to be applied all at once and with full intensity. Education through participation of local people offers the best chance of success.

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COLORADO WATER CONGRESS' RECOMMENDED PROGRAM FOR THE IMPROVEMENT AND CLARIFICATION OF THE WATER CODES OF COLORADO

General Statement

As a semi-arid state, Colorado's economic growth and development are limited by the amount of the water supplies which can be beneficially utilized within her borders.

Since mining was the first activity which developed within the State and water was required in the working of the claims, the basic principles applicable to possession of property were applied to water. Hence, the miners provided for its appropriation by diversion and use and for recognition and protection of the rights which were thus claimed. Beginning with those principles more than a century ago, we have a body of law which was designed to determine and protect the rights to the use of surface water only. In spite of numerous efforts, Colorado has virtually nothing which provides for the determination, protection nor administration of rights to the recovery of water from beneath the surface of the ground.

Although Colorado's economy can neither grow nor even survive without dependable water supplies, she continues to operate under a body of law which was applicable to the circumstances existing 100 years ago. Those laws do not recognize the common source and comingling of surface and ground water supplies nor the complex interrelationships which arise from their use.

Since the close of World War II, Colorado has experienced tremendous growth of urban population; expansion of industry; influx of military and defense establishments and an increasing agricultural commodity production. All of the changes have increased the need of, and competition for, the already limited supplies of available water. Within the forseeable future, there is every indication that there can be nothing but increasing need and more severe competition.

Therefore, it is urgent that a program of study be initiated to design effective improvements and clarifications in the water code of the State of Colorado.

Objective

The purpose of the recommended program is the protection and development of the water rights of our citizens by creation of a clear, simplified and improved body of water law which, when applied and administered, will result in maximum beneficial use of all waters to which Colorado and its citizens are entitled.

Suggested Program

Accomplishment of the stated objective comprises a task so great that it can only be done by the State of Colorado itself for the ultimate benefit of all of its citizens. Further, its size and complexity is such that it cannot be assigned to and accomplished by any one existing department of the state government.

Therefore, it is recommended:--

1. That adequate funds for a period of not less than 2 years be included in the budget request of the Department of Natural Resources. (Attached hereto is a recommended minimum annual budget.)

2. That the Director of the Department of Natural Resources, with the advice and consent of the Attorney General, the State Engineer and the Director of the Water Conservation Board, contract for such expert legal, engineering or other technical consultants required to form a "task group" for the performance of the program.

3. That the "task group" be specifically assigned to the following:

   (a) A complete legal review of present procedural law and administrative statutes relating to the acquisition, the nature, the use and the administration of surface water rights.

   (b) A technical study and outline of physical facts and scientific knowledge which may be used as a basis for drafting of simplifications and improvements in the existing code.

(c) A further outline of physical facts and technical knowledge regarding the occurrence, movement and recovery of ground-waters which may be used to define the relation between those waters and their use and the existing rights to uses of surface water.

(d) Based on such review and the facts which are found to exist, the preparation of laws to protect existing rights and to govern the acquisition, the nature, the use and the administration of water rights. Adequate consideration must be given, in the drafting of these laws, to the relationship existing between the uses of surface and ground waters.

4. That the Director of the Department of Natural Resources provide for complete coordination and liaison between the several technical phases to be covered by the "task group" utilizing, in addition to the technicians under contract, the available talent from the offices of the Attorney General, the State Engineer and the Water Conservation Board.

5. That the Director of the Department of Natural Resources, or such "task group" coordinator as may be designated, consult with the Colorado Water Investigation Commission from time to time during the progress of the program so that the water user interests may be kept informed and be given opportunity to offer such suggestions as may be pertinent.

The present and future prosperity and economic growth of Colorado depend upon the conservation and best utilization of its water resources. Since water is the property of the people of Colorado, opportunity must be given for full public discussion and consideration of the proposals to the end that the legislature of the State will, for the general welfare, be encouraged to adopt an improved water code.

RECOMMENDED ANNUAL BUDGET

Personal Services	
Contract Services	
Task Group Coordinator	$12,000.00
Legal Services (part time)	5,000.00
Engineering Services (part time)	5,000.00
Geologic Services (part time)	5,000.00
Staff Services	
Secretary	5,000.00
Stenographic	3,600.00
Travel and Subsistence	6,000.00
Operating Expense	
Office Rental	3,000.00
Equipment Rental	2,000.00
Incidentals	3,400.00
Total	$50,000.00

NOTE: The above was presented to and approved by the Colorado Water Conservation Board at its meeting of October 11, 1960, with the provision "that the Director and the staff of this Board be authorized to expend such time and perform such duties, within the limitations of available time, as may be requested by the Director of Natural Resources in accomplishing the review and modernization of Colorado water law."

CURRENT GROUND WATER RESEARCH at COLORADO STATE UNIVERSITY (1960-61)

Morton W. Bittinger, Assistant Civil Engineer
Colorado State University

MEASUREMENT OF WATER TABLE FLUCTUATIONS

It is the purpose of this study to determine the effect of pumping upon the ground water levels in the state. This project has been in existence since 1928 and has been expanded as funds permitted. At present, some 250 observation wells, principally in the Arkansas and South Platte basins, are measured semi-annually. The older records dating back to before intensive pumping began are extremely valuable now as the resource becomes more limited. There is need for expansion of this project.

CLASSIFICATION AND EVALUATION OF GROUND WATER RECHARGE NEEDS, POTENTIALS AND PROBLEMS

It is the purpose of this study to determine the various needs, potentials and problems involved with artificial ground water-recharge of the various ground water basins in the State of Colorado. Existing information on ground water levels, geology, water supplies, and other pertinent information is being brought together in helping make this determination. This study involves no field work and is primarily a survey of existing information and an evaluation of needs.

STUDY OF ARTIFICIAL RECHARGE IN PROSPECT VALLEY, COLORADO

It was the purpose of this study to take advantage of existing artificial recharge operations to learn more about the mechanics of artificial recharge as well as the benefits derived therefrom. During the winter and spring of 1959-60, the Henrylyn Irrigation District serving Prospect Valley put approximately 10, 000 acre feet of water underground purposely. This was done by allowing it to seep out of a leaky reservoir stratigically located over the ground water aquifer and above most of the 200 irrigation wells in the valley. An observation well network was established to trace the flow of the replenishment water and to determine its benefits. The rate of intake of the water into the ground and rate of

flow of the water through the aquifer were determined. Mathematical relationships were developed to further extend the value of the existing field information. The field work and data collection for this study are essentially complete and a report of the study is in preparation.

STUDY OF NATURAL RECHARGE FROM KIOWA CREEK

It is the purpose of this study to determine the natural operation of Kiowa Creek as a recharge facility. It is felt that if more is known about the natural recharge processes that more intelligent design can be made of artificial recharge facilities. During the spring of 1960 flows in Kiowa creek were measured at a number of points to determine the losses in flow. Observation wells were established to determine the effect of losses in the stream upon ground water levels. Test drilling was conducted to help define the geology and the aquifer beneath the Kiowa Creek basin. Field work on this study will continue into following years.

STUDY OF RECHARGE INCIDENTAL TO IRRIGATION IN THE SOUTH PLATTE VALLEY

It is the purpose of this study to determine the basic inter-relationship between the ground water and surface water supplies in a section in the main stem of the South Platte Valley. Conflicting interests between ground water and surface water users makes it imperative that a better understanding of the inter-relationship of these two water sources are known so that an intelligent plan can be developed for optimum coordinated use of the resources. Field work on this study was composed principally of a inflow-outflow water measurement in the section of the valley and determination of the water use and water needs of that area. Field work is essentially completed and analysis of data underway. This study is considered as a pilot study prior to similar basin wide investigations needed both on the Arkansas and the Platte.

USE OF ARTIFICIAL RECHARGE BY COLORADO MUNICIPALITIES

It is the purpose of this study to determine what the possibilities and potentials are of Colorado municipalities stabilizing and possibly increasing their water supplies by making use of artificial recharge and storage of ground water. This study is being conducted by the ground water branch of the U. S. Geological Survey under the sponsorship of the Colorado Experiment Station.

ORGANIZATION REQUIREMENTS FOR MANAGEMENT OF RECHARGE FACILITIES

This study is of a legal nature. Existing Colorado enabling acts for public districts which have to do with the use and conservation of water are being analyzed to determine how applicable they are to serve as organizational units in ground water recharge activities. Thought is being given to some of the desirable characteristics of a ground water district which may wish to undertake artificial recharge activities. Statutes of other states are being consulted and information is being collected as to how adequate and satisfactory other state laws have been.

MEASUREMENT OF NATURAL RECHARGE FROM BIJOU CREEK

This is not a complete study but is worthy of note here. Observation wells are being drilled across Bijou Creek and on its banks so that the shape of the ground water mound as influenced by flows in Bijou Creek can be measured. All of the observation wells have been donated by local well drillers having an interest in obtaining some information on this subject.

EXCERPTS FROM THE RECOMMENDATIONS OF THE ADVISORY COMMITTEE ON NATURAL RESOURCES RE SPECIFIC WATER POLICIES OF THE STATE

March, 1959

* * *

The Appropriation Doctrine

One of the basic questions propounded to this committee was the desirability of a re-examination of the appropriation doctrine--the fundamental basis of Colorado water development. After careful study, we have concluded that the appropriation doctrine is basically a good one. It is too deeply imbedded in our fundamental law and in vested property rights for any sweeping changes to be made. However, with proper study, certain adjustments can be made in our statutory system of administering the appropriation doctrine, so as to bring it up to date and provide an improved system for the development and conservation of Colorado's water resources under modern conditions.

The State of Colorado should proceed with the development and conservation of all of its water resources within the general basic framework of the present constitutional doctrine of the appropriation of water for beneficial use. The state should not attempt to adopt any system of reservation, by the state, of blocks of unappropriated water for future beneficial use. Such a system would seriously jeopardize the position of this state in controversies over the allocation of the use of water of interstate streams and would undermine the foundations of the appropriation doctrine. Conditions in other states which have adopted such a system are highly dissimilar to conditions in Colorado.

The Department, through its proper agencies, should study and make recommendations for the enactment of new legislation governing not only the transfer of the place of diversion, but also transfers of the place of use and type of use, of water rights in this state under the appropriation doctrine, so as to encourage the freer transfer of water rights and the utilization of new engineering techniques in the storage, transportation, and use of water on the basis of integrated watershed planning.

* * *

Gathering of Data

Much information on Colorado's water resources and water use has been gathered by the various state agencies working in this field.

However, this information is not now compiled and published in such a way as to make it available for full use by the public or by the interested state agencies. In addition, great improvements could be made in the gathering and accuracy of water resources data.

The Director of the Department, in cooperation with the permanent interagency committee of the Division of Water, should devise ways and means of gathering, correlating, indexing, and publishing in useful form the water resource data collected by the Colorado Water Conservation Board, the Office of the State Engineer, the Ground Water Commission, and all other state agencies. The Department, through its proper agencies, should also obtain and compile complete records of stream flow, underground water supplies, and all diversions of water from streams and underground sources, and disseminate such information currently and regularly to all interested persons and to the public at large. The offices of the above three agencies should be centralized in one location so as to facilitate the interchange and dissemination of water information and water resource data.

A balance sheet, or inventory, should be drawn up for each major watershed and tributary watershed and each nontributary ground water aquifer in the state. Such inventory should include an accurate, up-to-date list of all decreed water rights, by priority. Some method should be established for determining which water rights are in use and which may have been abandoned, and a better statutory system should be worked out for the permanent registration of all water rights in the state.

Administration of Water Use

A great deal of time was spent on considering problems involved in state administration of the use of water, both under the present system of adjudication of priorities and under the present Ground Water Law. The Committee has concluded that, regardless of what policies and solutions are reached in the future concerning development and conservation of the surface and ground water resources of Colorado, these policies and solutions must be adequately administered by the state. Inadequate administration will inevitably lead to less than full development and conservation of the available water, with a resulting failure to realize the full economic potentials of the state. Neither agriculture, industry, nor cities can grow and survive in this state without the assurance of a dependable supply of water. Because of the complex inter-relationships within and among various watershed and

and underground aquifers of the state, administration of the use of water cannot be abandoned to piecemeal litigation between angry water users, but must be affirmatively and effectively supplied by the state.

Therefore, the Director of the Department, in conjunction with the permanent inter-agency committee of the Division of Water, should institute an immediate study of the statutes and regulations concerning state administration of the diversion and use of all water in Colorado, and the financial and legal support of the agencies responsible for such administration. On the basis of such studies, the Department should recommend, through the Governor, a new and revised administrative code, and such appropriations of funds as may be necessary for the improvement and modernization of the present administration system. Pending the results of such studies, the Department, through the Office of the State Engineer and the Ground Water Commission, should make every effort to enforce strictly all state laws governing the administration of the use of all water resources of the state.

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Adjudications and Records

We recommend that studies be made of the possibility and desirability of revising the present system of water rights adjudication in the state so as to centralize all adjudications in one state agency, for the purpose of making uniform the application of state laws and improving the public records of adjudicated water priorities and their transfers, with full recognition of local conditions and vested rights.

Underground Water

The pressing need of the state in the field of ground water use is for a fixed and stable body of effective law governing the relationships between ground water users from aquifers nontributary to surface streams, and also between ground water users and surface water users from aquifers which are tributary to or an integral part of surface streams. While the engineering and geological facts of the occurrence and movement of ground water in this state are not yet well known, enough is known to develop a basic legal framework. This framework must take into consideration the varying types of ground water occurrence and the interconnection of some types of ground water with surface flow. Without such framework, extensive use of our ground water resources will be seriously hampered by legal uncertainties and the threat of litigation. In addition, some protection of existing ground water resources against

wasteful withdrawals is needed to provide long-term stability for investment based on pumped water. Until these things are provided, there can be no large-scale investment of capital in ground water development and use.

We recommend continuation, at an increased tempo, of all current studies in the field of ground water, including those being made by the U. S. Geological Survey and by Colorado State University. Meanwhile, the Department, through its proper agencies, should study and recommend changes in present ground water law to make it more effective. As a guide to such study, we suggest exploration of the possibility and desirability of making the following changes in the law, which were presented to the Subcommittee on Water and Climate.

1. Removal of the local nullification provisions of the present ground water law, and the substitution of provisions for hearings before the Ground Water Commission on the question of dissolution of critical districts, under established principcles of administrative law.

2. Provision for judicial review of administrative proceedings before the Commission.

3. Provision for establishment of priorities in critical districts or proration of pumping in such districts.

4. Provision for the development of ground water recharge programs.

5. Revision of the present definition of "artesian well" to conform more closely with engineering facts.

6. Vesting of quasi-judicial powers in the Ground Water Commission to hear and determine priorities concerning ground water, and provision for the correlation of ground water priorities with surface priorities in areas where a clear and unquestioned relationship between ground water and surface flow has been demonstrated.

7. Clarification of the definition of "private driller" to differentiate private drillers from those who offer their services to the public.

8. Provision for penalties and enforcement of the Ground Water Code so as to permit its enforcement by the Office of the State Engineer and the Ground Water Commission.

* * *

Office of the State Engineer, Ground Water Section

To the Members of the House and Senate Water Committees

In the operation of this section of the Office of the State Engineer, certain changes for the existing statute have been studied and the following recommendations are made to be forwarded to the Legislature for consideration. These changes, in the main, are for clarification of the meaning, to facilitate certain administrative operations or to coordinate the fiscal procedures with the requests of the Appropriation Sub-Committee. The law will be followed section by section to facilitate the following of its provisions:

SECTION 1 - Definitions

Change the definition as numbered, to read:

(8) An "Artesian Well" as used in this act means any well which obtains its source of supply from an artesian aquifer.

(10) Change the definition of Private Driller in the last portion to read: "....a well or wells solely upon the property of such entity."

And add a new number:

(11) An "Artesian Aquifer" is a geological formation which contains water, under pressure, confined by impervious layers.

SECTION 2 - Filing Statement of Use

Add Paragraph 2 to Section 2, as follows:

(2) On transfer of ownership or user, it will be the responsibility of such owner or user to notify the State Engineer, in writing, of such change within ninety days of the date of transfer.

SECTION 3 - Ground Water Commission (See Below)

SECTION 4 - District Advisory Board

The recommendations concerning these two sections have been made by the Ground Water Commission to the Governor's Advisory

Committee through its committee on Water and Climate and do not affect the administration of the act by the Ground Water Section.

SECTION 5 - Permits to Use Ground Water

Add the following to Paragraph 2:

"This may include the installation of suitable measuring and/or recording devices when, in the opinion of the State Engineer, the same are required for the purpose of obtaining records and other data pertinent to the extent of use of ground water."

Change Paragraph 3 to read: "shall issue a 'Permit to Use Ground Water' except as provided in Section 3."

SECTION 6 - Modification of Well

The recommended change in this section is made to conform with the statement made by the Ground Water Commission as policy.

Delete the period after well and add:

"...but which substitute well shall not have any additional duty to that of the original well and shall be within 100 feet of the original well to be considered as a modification or substitute for the original well, which shall be properly plugged and abandoned."

SECTION 7 - Water Rights not Granted

Some code for the establishment of a right to the use of ground water, either on the basis of priority or other basis, should be set forth in the Law.

SECTION 8 - Exemptions

Delete present section and add new section to read:

"Ground Water used for non-commercial household and stock watering purposes shall be exempt from the requirements of this Act, except for Section 5 and Section 10 and the Fee for the Permit to Use Ground Water for these purposes as issued under Section 5, shall be $5.00."

SECTION 9 - Date of Initiation

No recommendation.

SECTION 10 - Driller Licensing Provision

Change Paragraph 1 to read:

The State Engineer shall have the power to regulate the drilling and construction of all water wells in the State of Colorado to the extent necessary to prevent waste of water, contamination or pollution of any aquifer or any injury to or destruction of other water resources, and shall require well drillers and private drillers to file a log, an electric log if required at the time the permit is issued, of each well drilled, within thirty (30) days after the rig is removed or excavation stopped. He shall adopt such rules and regulations as are necessary to accomplish the purposes of this section. Where a user proposes to tap an underground water source under circumstances such that rights of other users are likely to be injured if the well or other means of tapping is not adequately cased, capped or otherwise controlled, provision for such control shall be made a condition of the granting of a right to drill for such water.

Change Paragraph 3 to read:

No well driller, or private driller, as defined herein, shall commence to drill a new well or otherwise do work on any well until Permit to Use Ground Water, as specified in Section 5, shall have been secured.

Change Paragraph 4 to read:

No well driller, or private driller, as herein defined shall perform any function with respect to a well without first obtaining a well driller's license from the State Engineer. Each license issued shall terminate at the end of the calendar year in which the same shall be issued and shall be issued only upon payment of a fee therefor, as follows: Well Driller, $25.00; Private Driller, $5.00. Such license shall be issued by the State Engineer upon submission of a written application showing the qualifications of the well driller, together with a Bond in the amount of $5,000.00, with a corporate surety authorized to do business in the State of Colorado, conditioned

to require such driller to comply with the laws of the State of Colorado and the rules of the State Engineer promulgated in compliance with this Act, except that Private Drillers, as herein defined, are exempt from furnishing this Bond. In the event of a breach of the conditions of the Bond and upon failure of the principal to comply with the provisions thereof, it shall be the duty of the person upon whose land any well is drilled, re-drilled, cased, recased, or deepened or otherwise constructed or changed, to make such rectification of the work performed as will bring about a compliance with the provisions of law and the rules and regulations of the State Engineer. In case of failure to do so, the State Engineer may perform the necessary work and the landowner, the driller, and the surety on the Bond shall be jointly and severally liable for the cost of the work done and services performed to bring about compliance with the law, and the rules and regulations of the State Engineer.

We suggest the renumbering of present Sections 11 thru 18 to Sections 12, thru 19, and insert a new Section as follows:

SECTION 11 - Penalties

In addition to other provisions herein, any violation of this Act may be designated as a misdemeanor and, on conviction thereof, be subject to a fine not to exceed $300.00, or confinement in Jail not to exceed thirty days, or by both fine and confinement. Each successive day of such violation may constitute a separate violation.

SECTION 12 - Jurisdiction (See Below)

SECTION 13 - Water Conservation Board Duties (See Below)

SECTION 14 - Review of Order or Act (See Below)

SECTION 15 - Disposition of Fees (See Below)

SECTION 16 - Repeal of Other Acts (See Below)

SECTION 17 - Citation (See Below)

SECTION 18 - Severability (See Below)

SECTION 19 - Emergency Enactment (See Below)

No recommendations are made for the above Sections.

Respectfully submitted,

/s/ J. E. Whitten

State Engineer

/s/ Geo. W. Colburn

October 5, 1960

Engineer
Ground Water Section

REPORT ON LEGISLATIVE COMMITTEE

Colorado Water Well Contractors Association

November 12, 1960

The committee met and discussed the proposed changes by the Ground Water Commission to the Ground Water Law.

The committee has no objections to Section I, Section II, (2). We do not object to this change, but question the need and think that it would be hard to enforce this provision.

Section V - We oppose this addition to Section V, as we feel that it could be abused and that it would be expensive for ground water users to buy this equipment.

Section VI - We oppose this change, as we feel that the ground water user should be able to replace his well at any location that the original well was drilled. It is often an advantage to a well user to locate a new well a considerable distance from the original well.

Section VII - We feel that this section needs changing in the law, but any change should be delayed pending further study of the problem.

Section VIII - We have no opposition to this change and feel that it would make the law more effective.

Section X - We feel that the electric log provision in this section should be worded so that a driller would be required to furnish an electric log only when it is part of the specifications or is required by the owner. The thirty (30) day requirement for the Log and History of the well is too short of time and should be changed to sixty (60) days. We have no oppositions to the other changes in Section X. We have no objections, in fact we recommend Section XI the penalty provision.

Respectively submitted

LEGISLATIVE COMMITTEE

by /s/ Floyd Oliver
Floyd Oliver
Chairman

FO/nko

SECTIONS OF PROPOSED GROUND WATER LAW APPROVED BY THE GROUND WATER CODIFICATION AND RESEARCH STUDIES COMMITTEE

SECTION _____

All underground waters found within the boundaries of this state, are hereby declared to be public waters and the property of the public, dedicated to the use of the people of the state and, subject to all existing and vested rights, are subject to application for beneficial uses, under the laws of this state.

SECTION _____

LEGISLATIVE INTENTION - LIBERAL CONSTRUCTION

It is the intention of the Legislature to encourage the optimum development, managements, utilization, control, conservation and protection of underground water, within this state, and to prevent the waste, pollution and contamination of such underground waters, in the interest of the public welfare. This underground water code is intended to effectuate this purpose insofar as practical, and should be construed liberally.

The Legislature hereby makes the following findings concerning the development, management, utilization, control and protection of the underground water of this state:

(a) The development, management, utilization, control, and protection of the ground water resources must be administered to assure that the ground water resources of the state are employed for beneficial uses and not wasted.

(b) The optimum development, management, utilization, control and protection of the ground water resources of the state are vital to the people in order to assure more adequate supply for domestic, agricultural, industrial, and other beneficial uses.

(c) The administration of the development and utilization of the ground water resources of the state is essential to protect beneficial uses and to assure optimum supply for beneficial uses.

(d) The ground water resources of the state must be protected from pollution in the interest of the health, safety and welfare of the public.

(e) The ground water resources of the state can best be utilized and protected if utilization thereof is restricted to beneficial uses and controlled by a state agency responsible for proper development, management and utilization of the ground water resources of the state.

(f) Planning for the development, management and utilization of ground water resources is essential in view of population growth and the expanding economic activity within the state.