SRP831
HYDROGRAPHIC

The Underground Water Resources Of Arizona

A Report By

THE UNDERGROUND WATER COMMISSION

January 1, 1953

PREPARED IN ACCORDANCE WITH
CHAPTER 49, LAWS OF 1952
TWENTIETH LEGISLATURE, SECOND REGULAR SESSION
AN EMERGENCY MEASURE

Signed by
GOVERNOR HOWARD PYLE
March 17, 1952

SALT RIVER PROJECT
GROUNDWATER DIV.
HYDROGRAPHIC
7-212
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SALT RIVER PROJECT
SURFACE WATER RESOURCE

SRP833

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SALT RIVER PROJECT
SURFACE WATER RESOURCES

E. RAY COWDEN, Chairman
NEWTON S. COOPER, Vice Chairman
O. M. LASSEN, Secretary

ELMER D. HERSHEY, Executive Secretary
BRYANT W. JONES, Legal Adviser

UNDERGROUND WATER COMMISSION

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PHOENIX, ARIZONA

December 31, 1952

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John L. Kalb

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Norman Fain

YUMA
Wayne Wright

His Excellency
Governor Howard Pyle

The President
Arizona State Senate

The Speaker
Arizona House of Representatives
Capitol Building
Phoenix, Arizona

Gentlemen:

In compliance with Section 2, Senate Bill No. 56, Second Regular Session, Twentieth Legislature, submitted herewith is the report of the Underground Water Commission, entitled, "The Underground Water Resources of Arizona", together with conclusions and recommendations unanimously approved.

All of the background material gathered by the Commission and its staff is being assembled in a manner which will make a permanent record and will serve as a vital reference source for future underground water studies. This material constitutes the permanent files of this Commission, and will be delivered upon order to any agency or custodian you may designate.

We appreciate and acknowledge the cooperation and help extended to us by various State and Federal agencies, municipalities, water users' organizations, industries, businesses, the press and radio, and of the many individuals who testified at the public hearings.

If this Commission or its technical staff can be of further service to you in your consideration of the underground water problem, or if there are phases of this report on which you would like clarification or interpretation, please feel free to call on us at any time.

Respectfully submitted

E. Ray Cowden
Chairman

Newton S. Cooper
Vice Chairman

O M Lassen
Secretary

John R Beloat — Ray Eaton

Norman W. Hayes — Mark Davis

Leon M. Howell — Leo Ellsworth

Vance S Marshall — E. L. Jameson

E. L. Tidwell — M. D. Clemons

Alvin Luckett — A. H. Randall

John Kelly — Stephen L. Bixby

L. M. Jones — Ernest Chilson

K.W. Houston — John H. Williams

Dan W. Clark — N. J. Golding

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General Conclusions

Based on the public hearings held throughout the state and on the studies made for the Commission by the technical, economic and legal consultants, the following general conclusions have been reached:

1. Arizona's wealth has been increased more in recent years by agriculture than by any other single industry.

2. The income from irrigated crops totalled $282,100,000 in 1951. It is estimated that approximately $197,000,000 of this income resulted from the use of underground water. The 1951 income was $179,000,000 in excess of 1946 income, an estimated 16% of which was due to increased prices and the balance to increased production.

3. Almost 25% of the $1,151,000,000 income of individuals in Arizona was derived from irrigated crops in 1951.

4. Of the estimated total of 1,200,000 irrigated acres in 1952 over 800,000 acres, or almost 70% of the total derives its principal source of water from pumping.

5. Since 1946 approximately 425,000 acres have been put into cultivation, almost all of which is dependent on underground water for its irrigation supply.

6. The most serious underground water problem exists in the Salt River Valley and the Upper and Lower Santa Cruz valleys situated in Maricopa, Pinal and Pima Counties.

7. In the above areas the recharge of the underground water supply is much less than present withdrawals. Heavy withdrawals from underground water storage are causing an increase in pumping lifts and a decrease in well yields in many areas. There should be no further development of agricultural land in these areas and legislation should be enacted which will effectively produce this result.

8. Under 1951-1952 economic conditions, a material amount of underground water can be withdrawn and it may be a number of years before such withdrawals become unprofitable.

9. In other underground water areas of the state, such as the Duncan Valley, the Safford Valley, the southern part of the Upper Santa Cruz Valley, and the San Pedro Valley, pumping may cause some slight progressive decline in the water levels. However, the underground water problems are not generally serious at the present time, and in most of the areas there is little, if any, land available for further development. The necessity for closing these areas does not, therefore, exist at the present time.

10. Practically no water reaches the areas of underground water development from regions outside the watershed. However, in the southwest desert region, areas still exist where withdrawals of underground water for new irrigation developments are possible. The underground water storage in these areas is essentially non-replenishable, but would support irrigated agriculture for a limited time and create wealth that could never otherwise be produced. Small areas might still be developed on a sustained yield basis in the mountain valleys and northern plateau.

11. The majority of the users of underground water interviewed at the Commission's hearings are in favor of some type of regulation either in the form of a strengthening of the 1948 code or by new legislation which would prevent further development in over-developed areas, and which would embody the following points.

(a) All legal users of underground water should be treated on an equal basis;

(b) Underground water legislation should be administered through a state appointed commission with authority to employ necessary technical and other personnel;

(c) Any cut-back in the use of pumped water should be determined by local option;

(d) Ample funds should be provided by the Legislature for the administration of legislation and for further studies.

12. A majority also favored adoption of the following conservation measures:

(a) In the irrigated areas, water conservation measures such as lining irrigation ditches,

controlling weeds, leveling land and eradication of phreatophytes from stream beds should be encouraged and practiced.

(b) Water should be conserved at its sources by a watershed management program which encourages eradication of jack pines, junipers, brush and other uneconomic, deep-rooted plants. Over protection of these plants has promoted their spreading over the watershed, resulting in a decreased supply of both surface and underground water.

13. Any cut-back in the use of underground water based on the theory of prior appropriation would be difficult to enforce and more damaging to the economy of the affected areas and of the state than a cut-back applying equally to all users.

14. Secondary benefits resulting from the distribution of farm income among other segments of the state's population in the form of purchases of machinery, goods and services is at least equal to the total individual farm income. As a result the impact of any cut-back in the use of pumped water would reflect more on the over-all income of the state than it would on the farm income.

15. Domestic and stock water users have a superior right to use underground water, but such right does not extend to protection against a lowering water table. Municipalities, industry and agriculture rank in that order in their ability to pay for water, and they should not be permitted to increase the present rate of withdrawal in over-developed areas.

16. Approximately 2% of the state's total area of about 72,000,000 acres is agricultural land, only half of which is privately owned. Almost 20,000,000 acres, or 27% of the total, is Indian Reservation Land. The possible development through the medium of ten year development leases to non-Indians of Reservation lands in excess of 400,000 acres requiring 1650 wells presents a dangerous threat to the economy of the state as a large part of this projected development would be from underground water sources adjacent to or near present over-developed areas. The state should cooperate with the Indians and the Federal Government in a long range plan calculated to encourage an orderly development of Reservation lands for initial and continuing use by the Indians. In this way the existing economy of developed areas can be maintained, the Indians' rights can be preserved and the present limited water supply will not be increasingly over-burdened by comparatively short term developments which neither add materially to the well-being of the Indians nor add to the general wealth of the state. If this cooperative plan cannot be accomplished, the result will be a very rapid depletion of the state's underground water supplies with the consequent destruction of a large part of the state's agricultural economy which will at the same time provide nothing of lasting value for the Indians.

17. In the case of municipal or industrial use, provision should be made for transportation from the source of withdrawal to the place of use where there has first been eliminated an existing agricultural right to the underground water supply substantially equivalent in annual quantity to the municipal or industrial use. Provision should be also made for the transfer of the point of withdrawal under like conditions.

Recommendations of the Commission

Based on the foregoing conclusions and the studies and deliberations of the Commission, it is recommended:

1. That underground water legislation be enacted based on the doctrine of correlative rights or on such other theory as will provide an equitable apportionment of water among all present legal users in over-developed areas. In the event the doctrine of correlative rights is adopted, the impracticability of balancing recharge and withdrawal in certain areas of the state should be recognized.

2. That further development of new land by pump irrigation be prohibited in those areas of the Salt River Valley and the Upper and Lower Santa Cruz Valleys, as generally outlined on the map attached hereto, but that the administrative agency be given authority to make exceptions in the following cases:

(a) Where it can be established that pumping will not materially interfere with the underground water supply of present users;
(b) Where pumping is necessary for drainage;
(c) Where pumping is necessary for the control of phreatophytes.

3. That provision be made for prompt and effective closing of any area by the administering agency when it appears that further development will result in:

(a) Withdrawals in excess of the safe yield in areas where there is a sufficient recharge to warrant a safe yield basis of withdrawal; or
(b) Withdrawals from storage at rates which will endanger amortization of existing investments in areas where pumping from storage was initially determined to be economically desirable.

4. That districts in over-developed areas be established for the purpose of enabling the users in each district to determine the necessity for and the amount of any cut-back in use of water by a two-thirds majority of the acreage voted and a simple majority of those voting. District boundaries should be established by joint action of the state administrative agency and local users, and should be based as nearly as possible on a similarity of local conditions and not on hydrologic conditions alone. Each district should be required to finance its own formation, organization and operational expense.

5. That provision be made for the acquisition by industry and municipalities of underground water in over-developed areas by purchase and elimination of an existing agricultural right equal to the new industrial or municipal requirement. Incidental to this should be the right to transport water from the source, and the right to transfer the point of withdrawal.

6. That domestic and stock watering uses be superior to all other uses, but there should be no provision for indemnification against lowering water tables caused by withdrawals for other purposes.

7. That provision be made for the following:

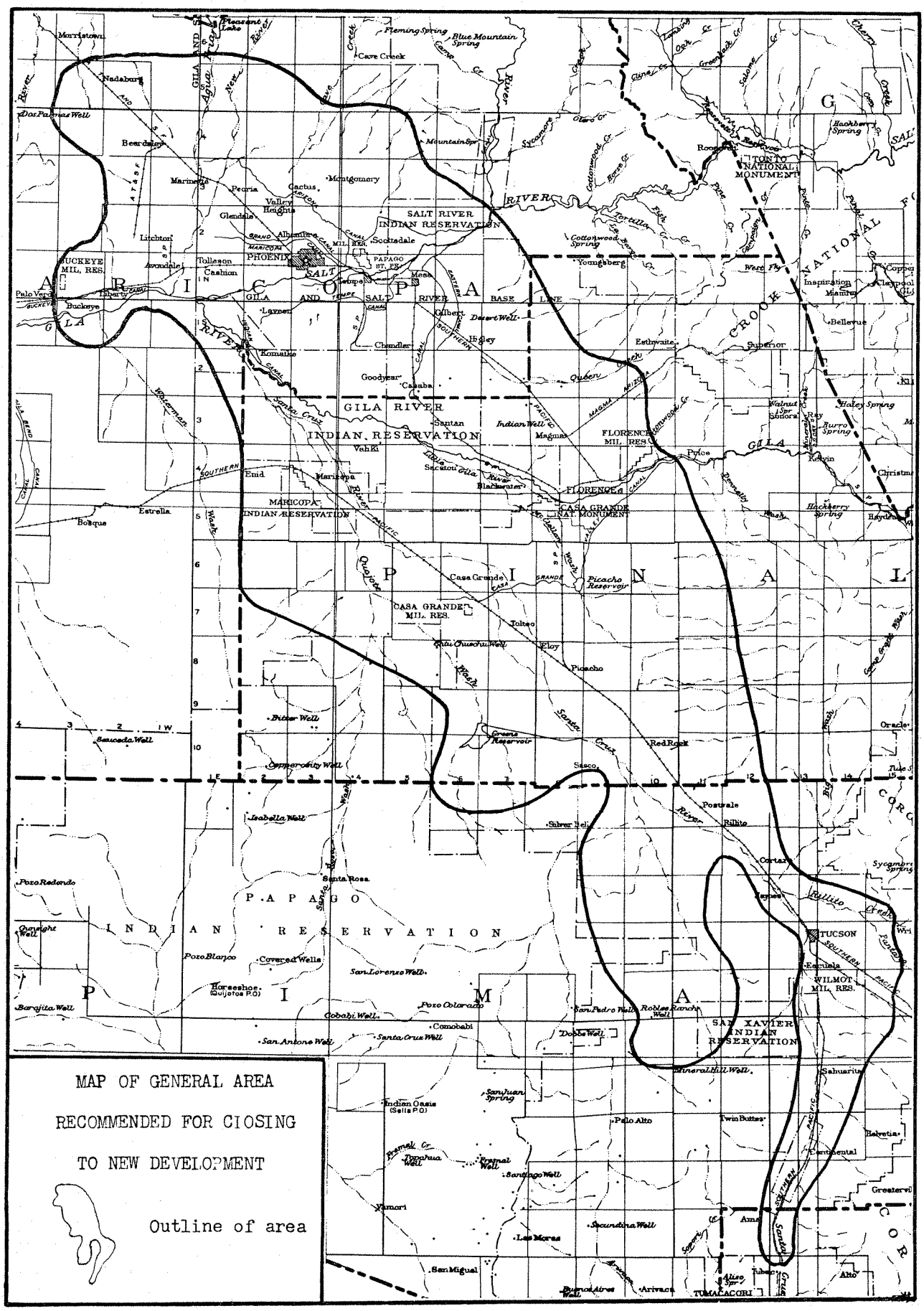
(a) Compulsory registration of all irrigation, municipal and industrial wells and of all acreage in cultivation which derives its water in whole or in part from the underground water supply.
(b) Licensing and bonding of all well drillers and compulsory filing of statistical records with the Commission.
(c) Equipping of all irrigation, municipal and industrial wells so that water level measurements can be made at any time.
(d) All flowing artesian wells be provided with cut-off devices and all abandoned flowing wells be plugged.
(e) Replacement and deepening of existing wells to maintain present yields.

8. That the administration of legislation be vested in a Commission appointed by the Governor with the advice and consent of the Senate, consisting of seven members with staggered terms of three years, allocated to provide representation for each geographically similar area of the state. This Commission should determine broad matters of policy but the actual administration of legislation should be entrusted to a competent engineer employed by the Commission, possessed with the executive ability to properly staff and operate the administering organization.

9. That the Commission be authorized, empowered and directed to cooperate with various Federal agencies administering Federal lands to provide a proper program of watershed management designed to furnish the maximum amount of water for surface streams and recharge to the underground.

10. That strong enforcement provisions be enacted providing adequate penalties and the injunctive process to punish and prevent violations.

11. That adequate financing by appropriation from the general fund be provided for the administration and enforcement of underground water legislation and for continued studies.


MAP OF GENERAL AREA
RECOMMENDED FOR CIOSING
TO NEW DEVELOPMENT
Outline of area
PHOENIX
SALT RIVER INDIAN RESERVATION
GILA RIVER INDIAN RESERVATION
MARICOPA INDIAN RESERVATION
PAPAGO INDIAN RESERVATION
SAN XAVIER INDIAN RESERVATION
CASA GRANDE NAT. MONUMENT
CASA GRANDE MIL. RES.
FLORENCE MIL. RES.
WILMOT MIL. RES.
TUCSON
TONTO NATIONAL MONUMENT
GILA AND SALT RIVER BASE LINE
PIMA
PINAL
GILA

SECTION I
Plan and Procedure

On March 17, 1952, Governor Howard Pyle approved Senate Bill 56, passed by the Second Regular Session of the Twentieth Legislature. This act created an Underground Water Commission to be appointed by the Governor, defined its duties, and provided that the Commission submit its report to the Governor and to the Legislature not later than January 1, 1953. The Commission was charged specifically with the duty "to make a comprehensive study of the source, extent and nature of the underground waters of the State of Arizona." The Commission in connection with its study, was directed to "make investigations as to the recharge of water into the various basins of the state and withdrawals of water from such basins, methods of conservation of water and other related investigations".

The act provided that all of the members of the Commission be primarily engaged in agriculture and that six members be appointed from Maricopa County, four members from Pinal County, two each from Pima and Graham and one each from the remaining counties of the state. Governor Pyle appointed the following members to serve on the Commission:

Mark Davis	Apache County
John H. Williams	Cochise County
Ernest Chilson	Coconino County
Stephen L. Bixby	Gila County
Vance S. Marshall	Graham County
E. L. Tidwell	Graham County
R. J. Golding	Greenlee County
John Beloat	Maricopa County
E. Ray Cowden	Maricopa County
Ray Eaton	Maricopa County
Leo Ellsworth	Maricopa County
K. W. Houston	Maricopa County
O. M. Lassen	Maricopa County
E. L. Jameson	Mohave County
A. H. Randall	Navajo County
Dan W. Clarke	Pima County
Alvin Luckett	Pima County
M. T. Clemans	Pinal County
Newton S. Cooper	Pinal County
L. M. Jones	Pinal County
Leon M. Nowell	Pinal County
John L. Kalb	Santa Cruz County
Norman Fain	Yavapai County
Wayne Wright	Yuma County

The Commission held its first meeting in the Senate Chamber of the Capitol Building on April 9, 1952. Governor Pyle addressed the Commission and outlined some of the problems which he felt would confront the Commission.

The Commission then selected Mr. E. Ray Cowden as Chairman, Mr. Newton S. Cooper as Vice-Chairman, and Mr. O. M. Lassen as Secretary.

An executive or working committee was created for the purpose of providing a smaller group to facilitate the operation of the Commission. This body was composed of the Chairman, Vice-Chairman and the following: John Beloat, Leo Ellsworth, Ray Eaton, O. M. Lassen, M. T. Clemans, Dan W. Clarke, Vance S. Marshall and Norman Fain. Alternates appointed were: K. W. Houston, L. M. Jones, Leon M. Nowell, Alvin Luckett and John H. Williams. This committee was authorized to act for the Commission on all matters and reported regularly to the full Commission.

The Commission decided to set up initially a staff consisting of an executive secretary, an office secretary, a field representative and, since the Commission was advised that the Attorney General's office would not be able to furnish the legal assistance the Commission would need, a legal adviser.

Elmer D. Hershey, an Arizonan, temporarily in Salt Lake City on the staff of the Secretary, Department of Agriculture, was employed by the Commission as executive secretary. Mrs. Katie B. Mott, former legislative attaché and employee of the State Highway Department was employed as office secretary. Mr. L. L. Lee, an engineer with 20 year's experience in surface and ground-water studies in Arizona, and who had just returned from an assignment as consultant with Overseas Consultants, Incorporated, in Iran and Indonesia, was employed as field representative of the Commission to collect and assemble technical data. In selecting a legal adviser it was considered advisable to secure a lawyer not previously involved in underground water litigation, preferably from an area not confronted with underground water problems. For these reasons Mr. Bryant W. Jones of Yuma was selected as legal adviser.

As soon as Mr. Hershey completed arrangements for a leave of absence from the Department of Agriculture, he returned to Phoenix and opened the Commission's office in the Security Building on May 6, 1952.

The Commission has met at least once each month and has been in session a total of fifteen days. The average attendance at these meetings was eighteen members. In addition the executive committee held seven meetings. There were from three to ten members of the Commission present at each of the sixteen hearings held throughout the state, the average attendance being in excess of six members. In addition a special committee of five members attended three separate meetings concerned with the problem which arose in connection with the development of Indian Reservation lands. A total of approximately four hundred thirty-five days exclusive of travel time was devoted to the work of the Commission by its members.

TECHNICAL STUDY AND REPORT

Soon after its organization the Commission contacted various technical consultants throughout the United States and interviewed several geologists and hydrologists for the purpose of retaining consultants to furnish the Commission with a technical report on the source, nature and extent of the underground water of the state. The Commission selected from the available consultants Mr. William F. Guyton, a consulting ground-water hydrologist of the firm of White, Guyton & Barnes of Austin, Texas, and Mr. Nicholas A. Rose a consulting ground-water geologist of Houston, Texas, as consultants. Mr. Guyton, a graduate of the University of Mississippi in mathematics and engineering, had made graduate studies in water supply at California Institute of Technology and the University of Mississippi, and was with the United States Geological Survey from 1939 to 1950. His service with the U.S.G.S. included assignments in charge of ground-water investigations in Kentucky, in charge of the Ground-Water Hydraulics Section involving research and reports throughout the United States, and in charge of the Water Utilization Committee involving studies and water resources appraisal reports throughout the United States. He prepared and supervised preparation of a large number of reports on ground-water resources and development. During 1945 Mr. Guyton served as a scientific consultant to the United States Army on ground-water supplies in the Pacific islands. Since 1950 he has been in private work as a consulting ground-water hydrologist and has worked on ground-water problems in ten states.

Mr. Rose was graduated in geology from Vanderbilt University in 1933. He served with the United States Geological Survey and with the Geological Division of the Tennessee Valley Authority for about twelve years. After that he was associated with the firm of Lockwood & Andrews, consulting engineers of Houston, Texas, as a ground-water geologist in charge of investigation and development of ground-water supplies for industrial plants, municipalities and irrigation projects. Since 1948 Mr. Rose has maintained his own offices and staff in Houston, Texas, and has fulfilled consulting engagements throughout the United States and in several foreign countries for such clients as Anderson, Clayton & Co., Alcoa Mining Co., E. I. Dupont de Nemours Co., Shell Oil Co., Proctor & Gamble Co., Ethyl Corp. and Phillips Oil Co.

After Mr. Guyton and Mr. Rose met with the Commission, it was decided that the services of a third consutant with a somewhat different background should be secured. The Commission was fortunate in securing as the third consutant Mr. R. J. Tipton, head of the engineering firm of Tipton & Associates, Inc., of Denver, Colorado.

Mr. Tipton received his degree in civil engineering from the University of Colorado. Upon his return from service with the Corps of Engineers in the A.E.F. in July, 1919, Mr. Tipton was employed as chief engineer for the San Luis Land & Mining Company in Colorado. In this capacity he designed and supervised construction of irrigation structures on a 100,000 acre project.

From 1922 to 1929 Mr. Tipton was engaged in private engineering practice in the San Luis Valley of Colorado. From 1928 to 1933 he served as designing engineer on a large reclamation project for the Mexican Government, engaged in special studies of water supply for Boulder Dam and served as special engineer for the Colorado State Engineer's Office in connection with interstate water problems and water resources study. In August 1933 Mr. Tipton opened a general consulting practice and now maintains offices in Denver where he is President of the firm of R. J. Tipton & Associates, Inc., and R. J. Tipton Associated Engineers, Inc. Both firms are engaged in consulting engineering work. R. J. Tipton Associated Engineers, Inc., was formed for the specific purpose of providing a general engineering service in the western hemisphere outside the United States and maintains offices in Bogota, Colombia and in Caracas, Venezuela. Mr. Tipton has been identified with much of the upper Colorado basin litigation and compact negotiation as a consultant to the State of Colorado and since 1937 as a consultant to the upper basin states. At present he is consulting engineer for the Colorado Water Conservation Board; Climax Molybdenum Company; Northern Colorado Conservancy District; American Section, Interna-

tional Boundary Commission United States and Mexico; Pecos River Commission; the United States Bureau of Reclamation, Department of the Interior, and many others.

In May Mr. Guyton met with the Commission to formulate a plan for securing all of the information and data necessary to prepare a technical report on the source, nature and extent of Arizona's underground water resources. It was recognized that it would be impossible with the funds available and within the time allotted for the completion of the report to make a new and independent field investigation of the problem. At the same time the Commission was cognizant of the vast amount of information which had been collected over a period of more than half a century by various State, Federal and private agencies. Among the available sources of information were data collected by the State Land Department, the University of Arizona, the United States Geological Survey, the Salt River Valley Water Users' Association and other irrigation districts, City of Tucson and other municipalities, individual well drillers and pump companies. Unfortunately this information and data had never been integrated and correlated to present a comprehensive picture of the underground water situation but remained in the files of each agency. Much of this information was known to be extremely valuable in that it consisted of logs of wells, pumping tests, static water level measurements, draw-down and salt tests. Estimates have been made that the collection of this information represented an expenditure of almost $2,000,000 over a period of years. A plan was formulated by the Commission, its staff and the consultants leading to the assembling of the pertinent parts of this material in useable form. Questionnaires were prepared and submitted to these agencies requesting answers to specific questions in report form. In some instances the Commission supplied funds to agencies for use in assembling the requested basic data. In order to verify the accuracy of the information secured under this plan, Mr. Lee of the Commission's staff made numerous trips into the field contacting well drillers, pump installers, individuals and irrigation districts. In all a thorough check was made of the basic data submitted to the Commission and only minor and unimportant discrepancies were found.

Mr. Lee visited each underground water area in the state in the course of his field trips and was able to secure a large amount of additional data which he assembled into report form for use by the consultants. The consultants familiarized themselves initially with the topography of Arizona by an airplane trip over the watersheds and desert valleys of the entire state. They later made field trips to all parts of the state and visited many of the agencies and individuals supplying information for the Commission. Mr. Guyton attended nearly all of the public hearings held by the Commission in order to further familiarize himself with local conditions.

From the data and information gathered and correlated, the consultants were specifically directed by the Commission to make a wholly independent study without regard to conclusions drawn by other agencies and from this study to furnish the Commission a technical evaluation of the source, nature and extent of Arizona's underground water supply within the limits set by available information and such additional information as it was possible to secure. This report is contained in Appendix A. The geological phase of the report was prepared by Mr. Rose and the hydrological phase by Mr. Guyton. Mr. Tipton reviewed the entire technical report in conferences with Mr. Rose and Mr. Guyton and all three of the consultants collaborated in the final draft of the report and concurred in the conclusions submitted to the Commission.

Mention should be made of the many statistical studies and analyses made by the agencies previously mentioned. All of those available together with the data secured by the Commission and used by the consultants as the basis for their report have been indexed and placed in bound volumes where it will be available for future use and study. Approximately forty-four volumes of material have been compiled in this manner.

ECONOMIC STUDY AND REPORT

The next step in the basic plan adopted by the Commission to secure the necessary background to enable it to appraise Arizona's underground water problem was an economic study designed to show the relationship of pump irrigated lands to the economy of the state and the possible effect on the economy of any reduction in the amount of pump lands in cultivation. Professor Raymond E. Seltzer, Acting Head of the Department of Agricultural Economics at the University of Arizona was contacted and asked to recommend someone capable of preparing such a report as the Commission contemplated. Mr. Theodore P. Jardine, Jr., a recent graduate of the University in the field of agricultural economics, was recommended by Professor Seltzer and employed by the Commission to make this study and to provide a report for the Commission. A tentative outline for the report was adopted at a meeting attended by Mr. Minton Moore of the statistical staff of the Valley

National Bank, Professor Seltzer, Mr. Jardine, and the Commission's executive secretary, Mr. Elmer D. Hershey. Mr. Jardine followed this outline in making his study and the report which is contained in Appendix B. Assistance and material were furnished by the University of Arizona, the Valley National Bank, the United States Department of Agriculture and various other statistical agencies and organizations.

PUBLIC HEARING

The third major phase of the Commission's program was the holding of public hearings throughout the state. The purpose of the hearings was twofold; to secure information on local conditions from individuals engaged in pump irrigation or connected with various mechanical phases of pumping operations and to ascertain the opinions of interested citizens in affected areas concerning the possible solution to the problem. Opinions were sought not only from farmers but from business and professional men connected either directly or indirectly with pump agriculture. The Commission felt that little could be accomplished without taking into account the feelings and wishes of the individuals who would be primarily affected by recommendations made by the Commission and possible legislative action based on these recommendations. Pursuant to this plan public hearings were held at Prescott, Cottonwood, Holbrook, Safford, Willcox, Nogales, Tucson, Marana, Coolidge, Eloy, Casa Grande, Phoenix and Parker. The hearings commenced early in September and were concluded in October. Well in advance of each hearing, notices were mailed to representative persons suggested by the member or members of the Commission from that area. The notices contained a general outline of the work of the Commission, the purpose of the hearings and a series of tentative questions designed to develop the information desired by the Commission. Newspapers and radio stations throughout the state carried advance news releases announcing the time and purpose of the hearings. In each instance the hearings were not concluded until an opportunity had been given everyone present to express his views.

Each hearing was attended by Mr. Cowden, Chairman of the Commission, and as many other members of the Commission as were able to attend. Elmer D. Hershey, executive secretary of the Commission and Bryant W. Jones, the Commission's legal adviser, were also present at all hearings.

The cost of providing a stenographic record of the hearings was estimated to be in excess of $5000, which the Commission considered prohibitive; however, a record was made of all hearings by means of a tape recorder. These tapes were indexed and have been preserved. The response to the hearings was noteworthy. Approximately 1000 persons attended the series of hearings and of this number 230 availed themselves of the opportunity to be heard. In addition many of those unable to attend wrote to the Commission outlining their views on certain phases of the subject matter. At the conclusion of the hearings a summary of the statements made by each individual was prepared. These are contained in Appendix C. Section V of this report contains a summary of the public sentiment expressed in each area visited and a composite analysis of public reaction to the underground water problem and possible legislative action. The hearings undoubtedly served another useful purpose in that they afforded the people of Arizona an opportunity to observe first hand the approach of the Commission to the problem.

LEGAL STUDY

The Commission directed its legal adviser to study the underground water laws of other western states and to furnish the Commission with the results of this study. The Commission was particularly interested in basic principles adopted by other states and methods of administration. In connection with administration of underground water laws, Mr. John Bliss, State Engineer of New Mexico and the Administrator of New Mexico's underground water law, met with the Commission and spent several hours explaining the underground water situation in his state and his methods of administration.

In connection with the Commission's study it was realized that any recommendations made would have to take into consideration the possible decision of the Supreme Court of Arizona in the case of Bristor versus Cheatham. The Commission was advised that the ultimate legal status of Arizona's underground water law could only be a matter of speculation until the Supreme Court decided the Bristor versus Cheatham case.

Based on the research made by its legal adviser, the Commission requested an opinion from the Attorney General on the interpretation of the ground water code of 1948 and the act creating the Commission. This request was intended to clarify an apparent conflict between the statutes and resulted in an opinion from the Attorney General that permits could not be issued for drilling new wells in established critical areas.

There was brought to the attention of the Commission the development by pump irrigation through

ten year improvement leases of some 4,000 acres of Indian land on the Ak-Chin reservation in northwestern Pinal County, and a projected development program of some 50,000 acres in or adjacent to present critical areas. This development caused considerable apprehension among the owners of land adjacent to the reservation as well as other pump irrigators in Maricopa and Pinal counties whose lands lay in the vicinity of undeveloped reservation land. The Commission recognized the gravity of the problem and in order to explore its many possibilities held conferences with Indian Office officials and with the Indians themselves. During the course of these discussions, the Phoenix Area Office of Indian Affairs furnished the Commission with a survey showing 533,800 acres of ultimately irrigable lands within Indian Reservations located in Central and Southern Arizona.

FINANCIAL REPORT

There was appropriated for the use of the Commission in carrying out the duties imposed upon it by the legislature the sum of $100,000. This appropriation lapses on April 1, 1953 and all sums unencumbered at that time revert to the general fund of the state. At the first meeting of the Commission held in May a tentative budget was adopted. This budget was of necessity revised from time to time but at each regular monthly meeting of the Commission the revised budget was presented and approved by the Commission. Following is a statement of the expenditures made from the appropriation to the date of the report:

Statement

Expense Items	Amount obligated to January 1, 1953
Rent	$ 1,048.49
Supplies & Services	1,519.96
Equipment	366.56
Printing & Binding	4,518.72
Office Personnel	17,362.71
Consultants	30,734.47
Cooperating Agencies	14,351.51
Travel	,826.38
TOTAL	$75,728.80

For clarity encumbered sums have been shown as actual expenditures.

The balance of the appropriation remaining on January 1, 1953 is $24,271.20. This sum is available for use in presentation to the Legislature of such additional information or explanations as may be requested from the Commission by the Legislature.

The act creating the Commission authorized the Commission to fix the compensation of its members at not to exceed $15.00 for each day actually spent in performing necessary work authorized by the Commission and also authorized the payment of actual and necessary traveling expenses incurred. None of the members of the Commission requested any pay for their time spent in attending the numerous meetings and hearings held and many of the members did not make any claim for reimbursement for actual traveling expenses.

SECTION II

Arizona's Ground Water Resources

PHYSIOGRAPHY

Arizona is divided into three physiographical regions: the northern plateau, the mountain region, and the desert region. The general location of these regions is shown on Figure 1.

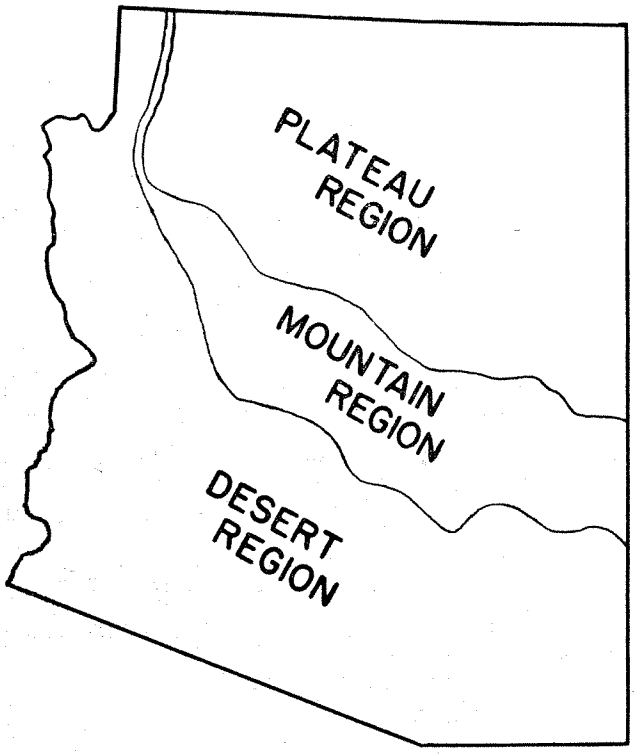


Figure 1—Map of Arizona showing Physiographic subdivisions.

Northern Plateau

The northern plateau region in the northeastern part of the state varies in elevation from 4,000 to 7,000 feet.

Along the creeks and river bottoms irrigation is practiced by diversion of surface flows. Although the growing season is short in this area and summer rains are rather prevalent, it has become necessary to supplement surface water diversions with pumped water.

In areas where no surface water is available irrigation is accomplished by means of flowing and pumped wells. Later developments in this region are of this type as all useable surface flow has been appropriated.

The majority of the water obtained from wells, whether flowing or pumped, is derived from the Coconino sandstones. These sandstones appear to be a reliable source of water, particularly in the area south of the Colorado River.

There has not been sufficient development in this region as yet to ascertain how much water is available from underground sources, but in parts of the region, the formations provide substantial quantities of underground water.

Mountain Region

The mountainous region lies south and west of the plateau region, extending from the New Mexico State line in a northwesterly direction to the Utah State line, and consists of rugged mountains with steep streams and narrow valleys.

Only scattered areas are under cultivation in this region and, in most instances, are irrigated by diversions from the creeks and streams. In some cases the surface waters are supplemented by pumping from wells located near the stream bed which may receive part of their recharge from stream flow.

The mountain valleys vary widely in their structure, some being shallow, recently deposited alluvium which is very porous and recharges readily from flood flows in the streams traversing the valleys. Others are of deep alluvium often more than a thousand feet in depth. They are recharged from streams and deep seated aquifers generally identified by artesian pressures.

Desert Region

The desert region covering the southern and western part of the state consists of part of the Gila River drainage area, together with a few isolated areas, such as the Sulphur Springs Valley and in the northwestern part of the region, tributaries of the Bill Williams and Colorado Rivers.

Irrigation of the desert region was originally accomplished by diversions from streams, but almost immediately more land was brought under cultivation than the streams could supply. Supplemental supplies of water were found to be available from underground sources and pumping became common.

Some of the irrigated lands became water logged and the practice of pumping for drainage was started.

Water thus produced was carried by canals to other lands where the supply was either inadequate or entirely lacking.

Since 1930 many desert areas in the broad valleys have been placed in cultivation by the sole use of underground water. At the present time the practice of supplying irrigation water from underground sources has expanded in several areas to an extent which is causing anxiety as to the limit to which pumping may be continued without exhausting the supply and thereby disrupting the economic balance of the area.

Appendix "A" of this report contains a full and comprehensive review of the geologic and hydrologic conditions within the State.

GENERAL SITUATION

Studies made by the staff of this Commission, the Agricultural Engineering Department of the University of Arizona and the Ground-Water Branch of the U. S. Geological Survey indicate that a decreasing supply of underground water will be available in most of the presently developed areas in the years ahead.

There is little possibility of appropriating additional surface water within the state. Future water requirements in excess of the surface water supplies must be met from underground sources or by importation from the Colorado River. It is estimated that in 1951 the contribution from underground sources was 70% of the total water supply.

The amount of water being withdrawn from underground supplies is in excess of the recharge from all sources. The original source of all water in Arizona is precipitation on the watersheds of the various streams as practically no water reaches the areas of underground water development from regions outside the watersheds.

With only 2 percent of the area in this state in cultivation, agricultural development should not be discouraged. There are areas within the state which are not fully exploited and others which have never been explored. While it is apparent that there is opportunity in Arizona for further agricultural development, it is also evident that inasmuch as new agricultural lands must depend on underground water for irrigation, future exploitation should be dispersed and concentration of pumps should be avoided.

Regulation of the use of water is necessary to an extent which will assure that a total depletion of the supplies will not occur. The draft on underground sources should be regulated to insure amortization of investments and public improvements.

It is inevitable that continued drafts on storage will cause water levels to decline, accompanied in some areas by decreases in the yields of wells. Such trends may be retarded somewhat if the present rates of withdrawal are not increased, but the only means of reversing these trends would be by a reduction of the amount of water pumped from wells.

INDIVIDUAL AREAS

In its natural state the Gila River system was in hydrologic balance. With the development of irrigation this balance has been disrupted to some extent, but it is evident that many of the individual areas are still interconnected. Where such interconnection exists, extractions of underground water in one area will eventually affect adjoining areas.

Heavy pumping in some of the districts within the areas has caused a rapid decline in water levels. As the water levels decline in the heavily pumped districts the shallower wells are materially affected and the cone of influence widens and extends toward the outlying sections of the districts.

At the present time, the most serious declines in water levels occur in the Salt River Valley, the lower Santa Cruz Valley and the northern part of the upper Santa Cruz Valley.

Salt River Valley

With the exception of the Indian Reservations and the lower end of the Valley west of Buckeye, the entire Salt River Valley has been declared a "critical area". Within the valley the decline of the water levels varies widely. In some districts such as the Liberty-Buckeye-Hassayampa area there has been little if any decline, while in Deer Valley and the Roosevelt Water Conservation District declines of over 100 feet have been observed in some wells during the past ten years. The Salt River Valley Water Users' Association, whose land covers about one-half of the cultivated area in the Salt River Valley, has for many years prepared weighted average depths to water on its project. These records show that the depth to water has increased from 15 feet in 1918 to 95 feet in 1951. In the ten years 1942-1951, a decline of 56 feet has been noted of which 31 feet occurred in the past 5 years, indicating an increased rate of decline.

The amount of water being pumped in the Salt River Valley is far in excess of the natural recharge

and even if the surface water supplies should improve, the amount of underground water necessary to supply the lands not having a surface water supply would exceed the net recharge to the entire valley.

Lower Santa Cruz Valley

The lower Santa Cruz Valley with the exception of the Indian Reservations, the Avra-Marana District and some outlying areas, has been declared critical and the drilling of wells for the cultivation of new lands prohibited.

The water-bearing formations of the lower Santa Cruz Valley appear to be directly or indirectly connected and form one common hydrologic system. The alluvial material is continuous into the Salt River Valley. However, the irrigated areas of the two valleys are largely separated by lands of the Gila River Indian Reservation and thus far there has been no material interference between wells in the two valleys.

The valley is comprised of the Avra-Marana, Eloy, Casa Grande-Florence-Sacaton and Maricopa-Stanfield districts. The last three of these districts are somewhat similar as in the past ten years declines on the outer edges of the districts amount to about 20 feet while in the central portions the declines were from 70 to 100 feet.

The decline of water levels has caused a decrease in the yields of some of the shallow wells. However, in the Eloy and the Maricopa-Stanfield districts the deepening of wells has in some cases restored the yield. In the Casa Grande-Florence-Sacaton district the deepening of wells has not generally proved successful.

The Avra-Marana district adjoins the Eloy district and as the two districts are hydrologically interconnected, pumpage in one affects water levels in the other. The Avra district has recently developed quite rapidly.

Upper Santa Cruz Valley

The Upper Santa Cruz Valley is that part of the valley extending from the Rillito Narrows south to the Mexican border. It is hydrologically connected with the Lower Santa Cruz Valley at the Rillito Narrows.

The southern section of the valley lying in Santa Cruz County is almost totally developed. The irrigable land lies within the inner valley of the Santa Cruz River and the recharge from the river and side washes is such that this area has not shown any persistent decline.

The northern part of the valley widens out at the southern border of Pima County and in this section the requirements exceed the recharge to the aquifers.

The present rate of decline is somewhat less than that in the Salt River and the Lower Santa Cruz Valleys but there has been a general lowering of the water table of from 20 to 50 feet since pumping was commenced. The declines to date have not seriously affected the economic operation of the wells for irrigation or other use but have accelerated during recent years.

If the declines continue, the highly productive shallow water-bearing formations will be largely unwatered, resulting in substantial decreases in the yield of wells. The water-bearing strata of the older fill are not as productive as those of the recent fill, but additional drilling may encounter more productive aquifers than heretofore encountered in the deeper alluvium.

San Pedro Valley

The San Pedro Valley is the structural trough of the San Pedro River, a tributary of the Gila. The Valley extends from the confluence of the Gila and San Pedro Rivers southeastward to the Mexican border. The continuity of the alluvial fill is at least partially interrupted by a series of rock exposures within the valley at the "Narrows", about 58 miles north of the Mexican Border.

Irrigation developments have occurred along the river from its mouth to the Mexican border. Although approximately 40,000 acre-feet of water were pumped for irrigation in 1952 practically no decline of water levels was experienced.

Safford-San Simon Area

The Safford-San Simon area lies in a large structural trough flanked on the northeast and southwest by mountains. The northwestern part is the Safford Valley which is traversed by the Gila River. The southeastern portion is the valley of San Simon Creek a tributary of the Gila River. Essentially all of the inner valley of the Gila River has been developed as far downstream as the San Carlos Indian Reservation. The lands are irrigated partly by diversions from stream flow and partly from wells. During periods of plentiful stream flow the major source of water is surface water but during low flow periods most of the water is obtained from wells. When

pumpage is heavy, the water level declines and the well yields decrease. Water levels rise during the winter and little progressive lowering occurs.

In the San Simon Valley the older alluvium supplies the water to wells. The principal source of recharge to the aquifers of the older alluvium is seepage from streams on the outcrops of the sands and gravels along the mountain fronts. Formerly many of the wells were flowing artesian wells but the artesian head has declined from 10 to 30 feet since 1915 and the flow of most of the wells has greatly diminished or completely stopped. Sufficient data are not available to determine whether the artesian pressure will be progressively lowered if the present rate of withdrawal is maintained.

Duncan Valley

The Duncan Valley is a relatively narrow valley extending from the New Mexico line to "The Box" along the main stream of the Gila River. Irrigation in the valley is partly by surface water and partly by wells which draw from the recent alluvial fill. Heavy pumping during the low flow period of the river causes a rapid lowering of the water level and the yields of some wells decline as much as 25 to 35% during the season. The recharge to the underground water is rapid and during the winter the water levels rise to about their previous level. Little if any progressive decline has been noted.

Sulphur Springs Valley

The Sulphur Springs Valley consists of the Willcox and Douglas areas. The northern part of the Valley, known as the Willcox Area has no exterior drainage. The Douglas Area to the south drains into Whitewater Draw which flows into Mexico. Water in the deeper sands and gravels occurs under artesian pressures and some of the deeper wells flow.

The Willcox Area composed of the Kansas Settlement and Stewart Districts, drains into the Willcox Playa. The principal natural discharge is from evaporation and transpiration of salt grasses and other plants. Irrigation from underground water began soon after 1900.

The Stewart district northwest of the Playa obtains its water from shallow aquifers, the depth of the wells averaging about 200 feet. Declines in this district varied from 10 to 25 feet during the period 1910 to 1946 and since that time the average decline has been about 10 feet.

Early development in the Kansas Settlement district was through the medium of shallow wells from 150 to 200 feet deep. Yields from these wells were very poor, but more recent wells drilled to depths of 500 to 750 feet have produced good yields. Only about 2 feet of decline in water levels were noted in the period from 1946 to 1951, probably due to the small amount of pumping in the district prior to 1952.

In the Douglas area earlier wells ranged in depth from 50 to 100 feet and were of small capacity. Since 1946 wells from 400 to 650 feet have been drilled which have much better yields. The decline in water levels between 1910 and 1946 was about 10 feet and from 1946 to 1951 about 7 feet.

The yields of some of the shallow wells have decreased somewhat as a result of the decline in water levels, but the decreases so far experienced have not seriously affected the availability of water for irrigation.

Lower Gila Valley

The Lower Gila Valley consists of that part of the Gila River Valley below the Gillespie Dam extending to its confluence with the Colorado River. The Valley is divided into four distinct areas: Gila Bend Area, Painted Rock-Texas Hill, Wellton-Mohawk and the South Gila Valley, all of which are hydrologically interconnected.

In the Gila Bend area irrigation is sustained by diversions at Gillespie Dam, diversions of flood waters in the Gila River and underground water pumped from various parts of the valley. The flow of the Gila has diminished over the past years until at the present time very little water is available for diversion. The water at Gillespie Dam is of high salinity and is mixed with underground water for irrigation. In general the underground water supplies have not been seriously depleted as yet but if the development in this area continues depletion may occur.

In the Painted Rock-Texas Hill area there are several small developments in tributary valleys as well as along the bed of the Gila River. Very little information is available on these developments.

In the Wellton-Mohawk area lands have been irrigated in the Mohawk Municipal Water Conservation District for many years. Originally the water was diverted from the Gila River but as the supply of surface water diminished, underground water from wells was used to supplement and replace the surface supply. The waters within the entire area are from moderate to extremely heavy in salt content ranging

from 1,120 to 16,000 parts per million. The high salinity of water necessitated the growing of special salt-tolerant crops.

The utilization of Colorado River water on the Wellton-Mohawk unit of the Gila Project, now being completed, will probably reduce the salinity of the pumped water within this area. It is possible that a water-logged condition in the lowlands of the valley will occur in the Wellton-Mohawk unit and drainage will be necessary.

The South Gila Valley lies south of the Gila River near its confluence with the Colorado River above Yuma. The water supply for this area is from shallow wells. There is little room for expansion in this area and it appears that there is a sufficient amount of water to supply the present demands.

Other Areas

A number of small areas have been developed in the tributary valleys of the Gila and Bill Williams River systems. These areas vary in size from a few acres to several thousand. Although these areas at present have little bearing on the overall ground-water problem of the state they may gain importance in the future.

These small areas include the Big Sandy, Bouse, Cibola, Rangeras Plains, Centennial Wash, Palomas Plain, Rainbow Valley, Waterman Wash and others. Little is known of the extent of the water-bearing formations of these areas and it is quite possible that further exploration will disclose other areas in which there are relatively large quantities of underground water.

One of the most important early artesian developments in the state is the Little Chino Valley lying within the drainage system of the upper Verde River. Irrigation in the little Chino Valley has been carried on for many years by flow from artesian wells. Later developments have been made by drilling wells and pumping water in areas where artesian pressure was insufficient to produce flowing wells. The water-bearing formations from which the wells draw their water are porous lava flows encountered at depths ranging from 200 to 1,000 feet. Due to the gradual increase in withdrawal of underground water, the levels have declined at an accelerating rate. From 1938 to 1952 the total decline was over 25 feet.

The headwaters of the Verde River known as the Big Chino Valley has some scattered pumps and development is increasing. The source of water is from the recent alluvium and sufficient data are not available upon which to base any conclusions as to the amount of water available for further development.

Several small areas near Holbrook, Snowflake, Hunt and St. Johns in the valleys of the Little Colorado River drainage system are irrigated by underground water. The water-bearing formation is the Coconino sandstone and in many places the underground water occurs under artesian pressure and flowing wells are obtained. The wells in some areas decline in yield during the summer period to an extent that they cease to flow but regain their flow during the winter period. Indications are that wells in this area are furnishing sufficient water to supply the present demands.

POSSIBLE FUTURE UNDERGROUND WATER SITUATION

In many areas within the state the static level of the underground waters has been falling for several years, indicating that these areas are developed beyond the point where their requirements can be met by annual recharge.

Although the indications are that the recharge to underground water is not sufficient to sustain the present demand for an indefinite period, there is no reason to believe that water cannot continue to be taken from storage in substantial amounts.

If it is realized that the supplies of underground water are to a certain extent non-replenishable, development can be planned on an economic basis. This planning can be done in such a manner that amortization of investment and payment of bonding or public service cost can be accomplished before a point of economic depletion is reached.

In sections where the water level is now receding at an accelerating rate, a non-economic lift will eventually be reached. When that occurs irrigation will be reduced to the amount of recharge or will be discontinued.

In many areas little is known of the character, thickness and extent of water-bearing formations, the recharge, or the quality of the underground water therein. It is possible that exploration may disclose a number of areas in which relatively large quantities of underground water may occur at depths economically feasible for irrigation.

Future developments of underground water should necessarily be more widely separated in order that the

rate of decline of the pumping levels will not be as rapid as now exists in the presently over-developed areas.

WATER CONSERVATION MEASURES

Water conservation measures can be separated into three general groups: (1) Those that can and should be performed by the individual; (2) those that require district financing; and (3) those of such magnitude and important that they should be undertaken by the state or federal government.

Measures Needed on Farms

Most farmers are conscious of the benefits to be derived from lining irrigation ditches, installing pipe lines, controlling weeds and leveling land. The extent to which these practices are used by farmers depends primarily on their ability to finance conservation measures and on the cost and scarcity of water. The conservation practice most difficult to get farmers to employ is better water application. Many farms must have their irrigation systems completely reorganized before efficient water application can be achieved. Some fields with excessively long runs lose a considerable amount of water through deep percolation. Other fields with too much gradient waste excessive amounts of tail-water. This waste can be partially corrected by the installation of pump-back systems. The cost of such an installation is seldom practical for small acreages; however, it is quite worthwhile and is recommended for large units.

The structural condition of the soil is another phase to be considered in conserving water. A soil with a good crumb structure, high in organic matter, will take water freely and have a high water holding capacity. The water holding capacity and structure of many soils can be improved by proper cultural methods, application of organic fertilizer, crop rotation or a combination of these practices. Too few farmers give enough consideration to the condition of the soil. Some soil takes water rapidly, but due to its low water holding capacity much of the water percolates below the root zone and is lost. Practices and crops which will maintain a high level of organic matter in the soil will save water and make this type of soil more productive. Some soil becomes so slick and hard that water runs over it without penetrating to sufficient depth to maintain proper plant growth. This type of land can often be improved by deep plowing or subsoiling; however, this treatment is usually temporary and should be followed by a green manure crop, heavy mulching or possibly the application of soil amendments.

Usually diversified farming uses water more efficiently than single crop farming. The diversified farm of Southern Arizona has a more uniform water demand and use throughout the year. This might prevent excessive draw-down in some wells and thus reduce pumping costs. Within an irrigation district the result would be a more uniform delivery of water throughout the year thereby avoiding peak deliveries which cause excessive canal and seepage losses.

Owners of artesian wells could save considerable amounts of underground water in some areas by equipping their wells with shut-off devices and the free flow of water stopped at times when it was not being beneficially used. The quality of water could be protected and maintained in many cases if discretion were used in perforating well casings to seal off aquifers with highly mineralized water.

Measures Needed on Irrigation District Projects

The conservation measures needed on most irrigation projects consist of lining canals and laterals and installing efficient diversion gates. Aside from the water that could be saved by the use of these measures the cost of delivering water, controlling weeds and repairing the delivery system would be greatly reduced. The management of most irrigation districts is aware of these benefits and is doing everything possible to install conservation measures as fast as financing can be arranged.

Measures Needed to be Undertaken by Government

The percentage of privately owned land in Arizona is so small that the Federal and state governments must assist in providing over-all water conservation measures and developing practices which will increase water supplies. The following table shows the present land tenure status:

Owner or Custodian of Land		Acres	% State Total
Federal Government	(Total)	53,186,163	73
Indian Lands		19,487,534	27
National Forests		11,484,933	16
National Parks and Monuments		2,063,410	3
Bureau of Land Management		16,217,120	22
Other Federal Lands		4,933,166	5
State Lands	(Total)	10,715,449	15
Grazing Lands		9,199,373	13
Agricultural and all other lands		2,516,076	2
Private Owned Lands	(Total)	8,936,788	12
Grazing and other		7,723,601	11
Agricultural		1,213,187	1
	TOTALS	72,838,400	100

The total cultivated acreage in Arizona, including dry farmed and irrigated, amounts to only 2% of the total area of the state.

From the above figures it is obvious that the various agencies administering lands must coordinate their program objectives if maximum production and conservation of water is to be obtained. Proper watershed management designed to provide a maximum amount of water for surface streams and recharge to the underground is a problem of such magnitude that it cannot be successful without the active cooperation of all federal and state agencies involved.

After a hydrologic study of the Salt River Basin above Roosevelt Dam, J. S. Gatewood, of the U. S. Geological Survey, Washington, said, "It has been shown that the runoff record for Salt River above Roosevelt Dam 1902-48 is consistent with precipitation except that since about 1925 there is apparently less runoff for a given quantity of precipitation than there was before 1925. The change about 1925 is significant and hence is not caused by chance but has some reason. The reason was not found. The following reasons were tested, but found inadequate to explain the change: Temperature trend, percentage of summer precipitation, change in accuracy of measuring high flows and inconsistency with Gila River record."

R. J. McMullin, General Manager of the Salt River Valley Water Users' Association, undoubtedly furnished the reason in a talk before the American Society of Range Management in Globe, Arizona, on June 6, 1952; in which he stated: "after checking our records and observing the watershed for years, there is no question in our mind that something has happened to reduce the livestock capacity and water yield of the watershed. We believe that this condition has been brought about by the infestation of large areas by wooded, deep-rooted plants, such as mesquite, manzanita and juniper. We do not join with many agencies and organizations in blaming the cattlemen for this condition, but are inclined to think it is due to over-production.

We have been advised for many years that it is necessary to protect this so-called cover, in order to control silt, but observation indicates that this type of cover does not materially reduce silt, but certainly reduces water yield by using water which would normally percolate below the root zones and reappear in springs to feed rivers."

L. R. Rich, hydrologist for the Southwestern Forest and Range Experiment Station in his paper "Consumptive Use of Water by Forest and Range Vegetation," April 6, 1950, gives the consumptive use of water in the chaparral zone as 81 per cent of the precipitation for grasses, 84 per cent of the precipitation for shrubs, and 78 per cent of the precipitation is lost from bare soil by evaporation.

From these figures it can be seen that shrubs and brush on the watershed use more precipitation than grass or bare soil. The percentage of precipitation saved by grass as compared to brush may seem rather small; however, when consideration is given to the vast acreage of the watershed which is primarily supporting brush, juniper and jackpines it can be seen that even a 3% saving in total precipitation would provide a tremendous amount of additional water for use in the lower valleys. At elevations above 5,000 feet where most of the winter precipitation falls as snow, considerable quantities lodge on the branches of trees and shrubs and is sublimated without reaching the ground. This is another reason for recommending the removal of uneconomic trees and brush from the watersheds.

Another potential conservation method is the eradication of non-beneficial phreatophytes (water loving plants) which grow and spread in areas where the water table is shallow. These areas are usually coincident with river channels and their flood plains. Salt cedars, cottonwoods, baccras, mesquite, willows and other phreatophytes waste in excess of 300,000 acre-feet of water annually in Arizona. In many areas the land these plants occupy could be cleared and planted to crop without increasing the draft on the underground waters. With sufficient research and experimentation economic methods may be devised to control these plants by chemical spraying from airplanes in areas where ground control is impossible.

There are some possibilities for increasing recharge to the ground-water aquifers by the construction of flood control dams which will desilt flood water before it is allowed to flow from the reservoir and percolate into the porous sands and gravel below the dam. The proposed Whitlow Dam on Queen Creek is an example of where this method could be used to recharge ground-water supplies. Generally dams of the type described are impractical in narrow river valleys or areas with a high water table. They can be most efficiently used where the recharge area is composed of a broad alluvial cone of porous material with a rather deep water table.

FUTURE UNDERGROUND WATER STUDIES

Underground water studies, on a continuous basis, are necessary to ascertain the possible economic life of the various pump irrigated areas. Information

regarding annual quantities of water pumped, static water levels, pumping water levels, mineral contents of the water and the depth and nature of the remaining saturated material should be obtained. If this data is properly correlated and analyzed there is no danger of a sudden depletion of the underground water supplies in any area without ample warning.

Underground water studies involving co-operative agreements between the state agency administering underground water laws and the U. S. Geological Survey should follow a revised policy in the future. A qualified technical staff of the state agency should outline and specify the nature and scope of the studies. The state agency should employ its own field personnel for gathering additional basic data necessary to a more complete evaluation of the underground water problem. This would also serve the purpose of avoiding duplication of effort as this staff could at the same time assume the duties of investigation, necessary to enforce possible legislation.

SECTION III

Economic Evaluation of the Underground Water Situation

In the consideration of any problem involving the manipulation of production factors, sound procedure requires evaluation of the possible economic results. For this reason the Commission tried to analyze the part underground water has played in increasing the development, wealth and annual income of the state. At the same time an effort has been made to predict the economic effect on local and state conditions assuming varying reductions in the use of underground water in combination with varying price relationships.

Mr. Theodore P. Jardine, Jr., the statistician who made the economic survey and report for the Commission, used data compiled by the Department of Agricultural Economics of the University of Arizona, the Research Department of the Valley National Bank, the United States Department of Agriculture and various other state and federal agencies. Mr. Jardine's report is attached as Appendix B under the title "Underground Water and Agriculture in Arizona." The time element permitted the use of only such data as was readily available, and it should also be pointed out that the conclusions contained in this report are those of the author and do not necessarily express the views of the members of the Commission.

UNDERGROUND WATER'S PART IN ARIZONA'S DEVELOPMENT

When the United States entered the war in 1941, the total irrigated land in the state was 731,000 acres. During the war years and to the end of 1946 an additional 44,000 acres had been developed. The price incentive during this five year period was sufficiently great to cause more development had it not been for shortages of machinery, labor and other items of production. Following this period civilian requirements began to be met and the state's irrigated agriculture grew from 775,000 acres in 1946 to an estimated 1,200,000 acres by the end of 1952, an increase of 425,000 acres. Except for a limited amount of new land developed with surface water in Yuma County, all of this new agricultural growth is dependent upon underground water for its irrigation supply. A combination of drought and the increase in irrigated acreage has increased the annual amount of pumpage by over 2,000,000 acre-feet from 1942 through 1951. From 1946 through 1951 the increase in annual pumpage exceeded 1,300,000 acre-feet. During this same period the cash value of crop income increased $179,100,000.

This increased income can be attributed to the use of underground water and increased crop prices. Underground water has also contributed to the development of Arizona by broadening the tax base, increasing business activity and attracting new residents.

During the period 1940 through 1951 the per cent of state income derived from crops has increased from 11.4% to 24.5% indicating the increasing relative importance of agriculture to Arizona's overall economy. While the agricultural economy was rapidly expanding through the use of underground water, the state's population and labor force also grew rapidly. The fact that from 27 to 31% of the state's total labor force was employed in agriculture during this period indicates that expanding agriculture has contributed substantially to Arizona's population growth.

Irrigated agriculture is at the present time about 70% dependent upon underground water. This does not mean that 70% of all irrigated land has

only a pump supply, but that 70% of the irrigation supply must come from underground sources. Irrigation districts with gravity water rights have turned more and more to the use of pumped water to stabilize their water supplies. The Salt River Valley Water Users' Association's policy calls for pumping an annual average of about 40% of its supply. In many years the actual percentage of water pumped greatly exceeds this amount. Other irrigation districts on the Gila River drainage system are even more dependent on pump waters. If it were not for the use of underground water, production would vary from year to year according to precipitation and flow of the rivers. In drought periods some irrigation projects would be virtually without water. An agricultural economy under these conditions could never be very prosperous or stable. The effects would also reflect on business and the total economy of the state.

Municipalities and industry are also dependent upon underground water for their continued growth and prosperity. Very few cities or industries in Arizona have an adequate surface water supply. This creates a problem of competition between municipalities, industry and agriculture for the state's limited underground water supply. If it becomes evident that our water resources are not sufficient to maintain our present economy, we have three alternatives. One is to bring water in from an outside source, another is to practice measures that will increase and conserve our present supply. The third and least desirable method is to reduce our use of water to a point where we can be assured of a perpetual supply.

When a reduction of any kind is considered everyone is apprehensive of the effect of the cut on his interests. From the hearings the Commission held, the majority of the people seemed to agree that municipalities should have a superior right to the beneficial use of water and that industry and agriculture should compete equally for the remainder. Using this premise it is obvious that the present industries in Arizona can well afford to pay more for water than the farmer, and that if competition and the laws of economics are allowed to operate freely, farm lands will gradually be taken out of cultivation as the underground water supplies become depleted in certain areas. The majority of the farmers and representatives of industry and municipalities agree that in those areas of limited supply future acquisitions of underground water should be based on the purchase and withdrawal from farming of sufficient agricultural lands to supply the industrial or municipal use. By this means industrial and municipal development would not be hampered and the draft on the underground water supply of the area would not be increased.

EXAMPLES OF RESULTS CAUSED BY A POSSIBLE REDUCTION IN THE USE OF UNDERGROUND WATER

The possibility of a cut in the use of underground water immediately presents the question: "What effect will a cut in the use of pump water have on the local and state economy?" The method used in applying a reduction in the use of pump water would to a varying degree affect the amount of production. If for example it were possible to base the reduction on the doctrine of prior appropriation whereby the use of all wells drilled on lands not irrigated prior to a date calculated to provide a 10, 20 or 30% cut in the use of pump water was prohibited, the following might be the result: Production would be reduced by about the same percentage as the reduction in water since entire farms would be taken out of cultivation. The tax base would be reduced as most of this land would be sold for taxes and return to desert. Other property would have to assume the repayment of bonded indebtedness. The owners of the land and wells excluded would lose their investments. The mortgage holders would lose and as a result credit would become tight and business and the remaining farmers would all suffer.

On the other hand, if a reduction based on the doctrine of correlative rights were made, providing for an equal cut to all underground water users in overdeveloped areas of 10, 20 or 30%, we might expect the results to be somewhat as follows: The reduction in production would not equal the reduction in use of water. The net income of the individual farmer after taxes would be only slightly reduced with a 10 to 20% cut in the use of pump water. Cuts of over 20% through 30% might result in a reduction in net income, but not in proportion to the cut in pump water. Most farmers might still be able to operate at a profit as they would probably get better production. This would be accomplished by conservation and better methods of applying water to their most productive land. Thus the over-all and local effects on the economy would not be so severe. No one would be forced out of business and no one's investment would be wiped out. Credit would be stabilized and the economy of the farming communities and towns would be established on a long term basis.

Any state legislation requiring general curtailed use of underground water would have a damaging psychological effect on the economy of the state. However, if enabling legislation is enacted, provid-

ing for local determination of cut-backs there will be little interference with the farmer's ability to finance his next year's crop, and the adverse psychological effect would be avoided.

EFFECTS OF CROP PRICES ON UNDERGROUND WATER USE

Prices received for crops have varying effects on the use of underground water. Rising crop prices encourage new development and a greater use of underground water. A lowering price structure will stop new development, but will not stop the pumping of the majority of wells already drilled and equipped. As wells go bad and pumping equipment wears out, land will go out of production. Also a certain amount of land will become marginal and be taken out of cultivation as prices decline; however, this will usually occur only after someone has taken a loss growing a crop on the land. A combination of price decline and a lowering water table would accelerate the rate at which land would be taken out of cultivation, but if enough land was removed from cultivation so that the water table became stabilized or improved there would probably be very little more reduction in cultivated land.

While crop prices over a short period of time decline faster than manufactured commodities and hired labor, there is still a relationship between them on a long time basis. Thus over a period of years it may be expected that the majority of the pump irrigated land would stay in production providing the underground water supply is not exhausted or greatly depleted. Land with inferior quality soil, excessive pumping lifts or low capacity wells would probably go out of production with a lowering price structure.

The economic impact on any area or county in the state due to a cut in the use of pump water is a function of the percentage of income derived from crops produced with underground water compared to the total gross income. Some areas of the state are from 85 to 90% dependent upon pump irrigated crops. Any reduction in the use of underground water in such areas will be great compared to a like reduction in an area where only 10 or 15% of the gross income is from pump irrigated crops. For example, if an equal cut in the use of pump water was applied to both Maricopa and Pinal counties, Pinal county would have its gross income reduced percentage-wise, much more than Maricopa county.

In an effort to determine what underground water's worth is to the over-all economy of the state a comparison of the total of individual's income with the crop cash income attributed to the use of underground water may be made. In 1951 the total of individuals' income was $1,151,000,000 and the total crop cash income was $282,100,000. Assuming that all irrigated land, regardless of the source of water, had on the average the same crop yields, it would follow that 70% or about $197,470,000 of the total crop cash income was due to the use of underground water. Although these figures indicate that about 17% of the total income received by individuals is due to the use of underground water, consideration must be given the substantial secondary benefits attributable to crop production.

There have been many estimates of the value of secondary benefits derived from the production of agricultural crops. Conservatively estimating that secondary benefits equal direct benefits it can be shown that 34% of the total income received by individuals is a result of the use of underground water.

Arizona's rapid rate of growth is attributable to its favorable balance of trade. The principal factors creating this favorable balance of trade are agriculture, mining and the tourist industry. Arizona's agricultural income has increased 840% since 1938, while the total individual income has increased only 440% in the same period of time. These figures considered in connection with the fact that 70% of the agricultural income is attributable to acreage irrigated from underground water demonstrate the vital role played by pump irrigation in the economic prosperity of Arizona. It necessarily follows that any cut in the use of underground water would immediately affect the state's growth and prosperity.

SECTION IV

Legal Study and Analysis

JUDICIAL DECISIONS AND LAWS

In early territorial days Arizona adopted the principle of prior appropriation governing the use of surface waters and of well defined underground streams. To date the legislature has not adopted any basic principle applicable to the use of underground percolating waters.

In 1904 in the case of Howard vs. Perrin, 8 Ariz. 347, 76 P. 460, affirmed 200 U. S. 71, 26 S. Ct. 195, 197, 50 L. Ed. 374, the territorial Supreme Court held that percolating water was the property of the owner of the soil. This decision followed the English law and is known as the common law doctrine, in the strict application of which, any land owner may withdraw as much of the underground supply as he chooses without regard to the effect of the withdrawal on his neighbor.

The question of the use of underground percolating waters has been before the Arizona Supreme Court in several later cases. The principal of these is the case of Maricopa County Municipal Water Conservation District No. 1 vs. Southwest Cotton Co., 39 Ariz. 65, 4 P. 2d 369, in which the late Justice Lockwood wrote the opinion. He reviewed the entire subject and in coming to the same conclusion as that reached in Howard vs. Perrin said:

> "Whether percolating waters in Arizona since the adoption of the Howell Code have been governed by the old English common law in its strictest form, or by the American modification known as the rule of correlative rights, as explained and defined in Katz vs. Walkinshaw, 141 Cal. 116, 70 P. 663, 74 P. 766, 64 L. R. A. 236, 99 Am. St. Rep. 35, and the cases which follow it, based on the doctrine of sic utere tuo ut alienum non laedas, we need not now decide. When the matter is properly before us, we will determine the rule which applies.
>
> After carefully reconsidering the statutes from 1864 to the present time, our previous decisions and the various reasons upon which they were based, we are of the opinion that our holding in Howard vs. Perrin, supra, that percolating subterranean waters were not subject to appropriation, was and still is the law of Arizona."

This case was decided in 1931, considerably prior to the advent of extensive pumping, such as now exists in Arizona.

The Eighteenth Legislature passed the Groundwater Code of 1948. This code did not adopt any basic principle but was an exercise of the general police power of the state in providing reasonable regulations for the designation and establishment of critical groundwater areas. Critical groundwater area was defined as any groundwater basin, or any designated subdivision thereof "not having sufficient groundwater to provide a reasonably safe supply for irrigation of the cultivated lands in the basin at the then current rates of withdrawal." Provision was made for the establishment of critical areas either upon petition to the State Land Commissioner by users in the area or by proceedings initiated by the Commissioner on his own motion. Machinery was provided for a hearing in each instance and for an appeal from the decision of the Commissioner. After the establishment of critical areas the development of new land was prohibited with certain exceptions in the case of wells contracted for or actually commenced. No attempt was made in the act to limit other than agricultural pumping. Wells or other works for the withdrawal of ground water for domestic, stock watering, domestic water utility, industrial or transporation purposes were specifically exempted from the provisions of the act. The administration of the act was vested in the State Land Commissioner.

On January 12, 1952, in the case of Bristor vs. Cheatam, 240 P. 2d 185 the Supreme Court of Arizona again considered the underground water subject and held that percolating waters were subject to appropriation, stating:

> ". . . . Our holding in the case of Howard vs. Perrin, supra, to the effect that percolating waters belong to the owners of the soil and subsequent decisions, to the same effect are in a large measure dicta, legislative in character and clearly in violation of the Desert Land Act of March 3, 1877, supra, which declared all waters to be separate from the soil, belonging to the public and subject to appropriation. The Supreme Court of the United States and other courts of last resort having in effect interpreted this act to include percolating waters, and our further study of the laws applicable thereto having led us to the same conclusion our earlier decisions, whether dicta or otherwise, on this subject are hereby overruled.
>
> Inasmuch as the Legislature has not provided the method by which natural percolating waters

may be appropriated the mere appropriation and application of such waters to a beneficial use had the effect of vesting in the user thereof a legal right thereto as of the date the same were put to a beneficial use."

A moton for rehearing was granted but to date a new decision has not been announced.

LAWS OF OTHER WESTERN STATES

Several of the western states have by legislation adopted the principle of prior appropriation as applicable to the taking and use of underground water. Among these are New Mexico, Utah, Idaho, Nevada and Washington. In others the doctrine of prior appropriation has been the result of judicial decision.

The Nevada Act however, does not guarantee against a reasonable lowering of the static water level for it provides in part as follows:

". . . . It shall be an express condition of each appropriation of groundwater acquired under this act that the right of the appropriator shall relate to a specific quantity of water and that such right must allow for a reasonable lowering of the static water level at the appropriator's point of diversion; and provided, that in determining such reasonable lowering of the static water level in a particular area, the state engineer shall consider the economics of pumping water for the general type of crops growing and may also consider the effect of water use on the economy of the area in general."

The Utah legislation followed decisions of the Utah Supreme Court in 1935 holding that the law of appropriation applied to the waters of subterranean and artesian basins. These decisions constituted a reversal of earlier decisions adopting the American rule of correlative rights and reasonable use. The diversity in the approach to the application of the doctrine of prior appropriation is illustrated by the recent Utah case of Hanson vs. Salt Lake City, 115 Utah 404, 205 Pac. 2d. 255. In this case the plaintiff brought an action against the city seeking an injunction and damages alleging that the city had drilled wells and pumped water therefrom which appreciably reduced the head of the plaintiff's artesian well used for domestic purposes. The court held that under the circumstances in that particular case, the plaintiff was not entitled to any relief. The majority opinion in the case was written by Justice Wade, who stated:

"We conclude that the waters of artesian basins are subject to appropriation in this state and that the first appropriator obtains a prior right to the use of such waters over subsequent appropriators, and that includes his means of diversion as long as such means are reasonably efficient and do not unreasonably waste water. It follows that where a subsequent appropriator draws a sufficient quantity of water out of an artesian basin to lower the static head pressure of a prior appropriator's well so that additional costs are required to lift sufficient water from his well to satisfy his previously established beneficial use of such waters, the subequent appropriator must bear the additional expense."

Special concurring opinions were written by Chief Justice Pratt, and by Justices Wolfe and Latimer. Justice Wolfe stated:

"I do not think we should hold, in view of our over-arching water policy, that at this stage of our knowledge of the distribution and inventory of underground water resources, prior users gain a vested right in a means of diversion of water.

This must be left flexible."

Justice Latimer stated:

"If we are to protect the prior appropriator under all circumstances, then the prior appropriator can require damages from every subsequent appropriator and each subsequent appropriator in turn can require damages from all subsequent appropriators, until the last one would have to pay tribute to all. . . .

The record does not convince me that the method of diversion used by the plaintiff in this case is reasonable under the facts and circumstances. I, therefore, feel that the cost of making his diversion reasonable should be borne by him and not by the city. He should be protected in the quantity of water he has appropriated and is beneficially using, but I believe that even though his original means of diversion may have been reasonable, it now should be changed to one consistent with the developments in the area, and that he should be required to assume the additional costs imposed on him by virtue of the changed conditions."

In New Mexico the State Engineer is charged with the administration of the groundwater laws. He has adopted a policy of closing underground water basins to further development when, in his judgment there is available for economic withdrawal sufficient water to supply present users for a period of approximately 40 years. Although there are nine separate basins administered by the State Engineer in New Mexico, there has been no attempt in any of them to prefer

a senior appropriator over a junior appropriator but to date all have been treated on an equal basis.

Other western states such as California and Oklahoma are committed to the doctrine of correlative rights or reasonable use. The doctrine of correlative rights is a modification of the strict English common law rule and was adopted by Californa in the case of Katz vs. Walkinshaw, 141 Cal. 116, 70 P. 663, 74 P. 766, 64 L. R. A. 236, decided in 1902. The court held in that case that the right to the use of percolating water was limited to a reasonable use in connection with each landowner's use of his land and that it did not authorize the transportaton of such water to distant lands. A recent decision of the California Supreme Court in the case of Pasadena vs. Alhambra, 33 Cal. 2d. 908, 207 P. 2d 17, involved a basin-wide adjudication of the rights of all parties concerned. In this case there was a determination that after the overdraft on the water supply commenced, continuous use for a period of five years established water rights of equal priority and effect with all others so established. Failure of earlier users to institute action to prevent further withdrawals after the overdraft commenced was the basis for the acquisition of these later rights. The lowest annual production in any one year of the five year period was used as the measure of the right. This right might be forfeited as a result of non-use for a continuous period of five years. This case was in the courts for almost twelve years and involved an expenditure by the plaintiff alone of over $100,000.

FACTORS TO BE CONSIDERED IN UNDERGROUND WATER LEGISLATION

Of paramount importance is possible public reaction to any proposed legislation. The application of the doctrine of prior appropriation would not only meet with stubborn resistance but the initial determination of the prior appropriators and the extent of their rights appears to present an insurmountable problem of adjudication and administration. In addition the chaotic effect of such an attempt on the economic stability of the state presents a grave danger. A modification of the strict appropriation doctrine whereby junior appropriators would be permitted the use of some water would present the same complex problem and would confiscate certain property rights although such confiscation might extend over a longer period of time and to a greater number of people.

Lesislation designed to prevent further development in areas where there is now a withdrawal in excess of recharge and which would provide machinery for some regulation appears to be possible with the adoption of the principle of correlative rights or of any other theory which would require an equitable apportionment of water among all present legal users. Thus confiscation of certain lands and of creditors' rights in those lands which would be inevitable under the doctrine of prior appropriation would be avoided. Legislation of this type would eliminate the problem of determining the extent to which the prior appropriator's means of diversion should be protected. Based on the difficulty recently experienced in California in the application of the doctrine of correlative rights, the definition of correlative rights should recognize the impossibility of any attempt to balance recharge and withdrawal in certain areas of the state.

Consideration should be given to the problem of preferences in use of underground water. In the case of domestic wells, no restriction should be considered which would deprive present or future domestic users of the right to withdraw water. On the other hand any attempt to secure or indemnify the domestic user against a lowering of his water table would only lead to multitudinous litigation. A sensible and workable provision should be made for the acquisition by industry and municipalities of the right to withdraw needed quantities of underground water without creating an additional draft on any over-developed supply. This could be accomplished by provision for acquisition of irrigated land at a fair price.

In the case of a possible cut-back in over-developed areas the determination of the necessity for and the amount of that cut-back should be a matter for the users of that area to decide. In connection with any cut-back and for the purpose of providing adequate records and a firm basis for restriction of new development and administration of cut-backs, all agricultural lands deriving their sources of water supply from percolating water should be registered by legal description with the administering agency. Adequate provision should be made for enforcing the prohibition against further development, severe penalties should be provided for violations and the injunctive process should be available to insure speedy action. To insure this result the administering agency should be provided with its own legal staff.

If consideration is to be given a possible local option basis for a cut-back, careful consideration must be given to the division of the state into local areas. As it appears that the upper and lower Santa Cruz Valleys and the Salt River Valley are hydrologically connected and as it further appears that this entire

area is probably over-developed, possible legal objections to the determination of these boundaries appear to be remote. In other words, if the entire area is closed to further development the question of interference between parties of the entire area would be of little importance. The determining factors in establishing local areas should be the occurrence of similar underground water problems and similarity to economic and political problems among the users. The areas should not be too large but should, wherever possible, conform to natural geographical boundaries.

The question of administration of any new legislation deserves primary consideration. A commission form of administration appears to be most desirable with its members appointed by the Governor with the advice and consent of the Senate. Perhaps seven members would be sufficient, selected in a manner to provide representation for each geographically similar area. The commission should determine broad matters of policy, but the actual administration of the legislation should be entrusted to a competent engineer possessed with the executive ability to properly staff and operate an organization capable of accomplishing the purpose of the law.

Adequate financing by general appropriation should be provided for the administering agency. The State Land Commissioner has not had sufficient funds to permit the proper administration of the Groundwater Code of 1948. At the present time this appropriation amounts to approximately $22,000 per year for the administering of both surface and underground water functions of his office. According to figures furnished the Commission by Mr. W. W. Lane, State Land Commissioner, Nevada has an annual appropriation of $61,000, Utah $500,000 and Montana $107,000. The figure for New Mexico was furnished the Commission by Mr. John Bliss, State Engineer of New Mexico, who estimates that during the present year he has available for the administration of both underground and surface water law approximately $300,000. Of this amount about one-half, or $150,000 was budgeted for underground water administration and studies.

Too much emphasis cannot be placed on the need for adequate financing. The amount necessary may at first appear large in comparison with present appropriations, but the contribution of underground water to the economy of the state is so tremendous, and the problem is of such vital importance that the expenditure of substantial sums is not only wise but essential.

SECTION V

Public Reaction to Underground Water Legislation

During September and October the Commission held sixteen public hearings in thirteen towns throughout Arizona for the purpose of securing information from people in different areas of the state regarding their underground water problems. Attendance totaled approximately 1,000 and ranged from 25 to more than 100 in the more populous areas.

A list of the questions used as a guide by the Commission at these hearings is included in Appendix "C" of this report. The questions were primarily designed to secure information on individual wells, general area conditions and the necessity for legislative action. Many of the persons appearing did not answer all of the questions. In some instances the questions were not applicable and in others no opinion had been formed or the individual did not care to express an opinion.

At each hearing Mr. E. Ray Cowden, Chairman of the Commission, explained the objectives of the Commission in holding the hearings and emphasized that the form of the questions should not be taken as an indication of the views of the Commission. The statements made by each of the 230 individuals interviewed at these hearings have been summarized and are contained in Appendix "C" of the report.

This section contains a general summary of the opinions voiced at the hearings and of written statements forwarded to the Commission in lieu of personal appearances before the Commission, followed by a resume of each hearing. Inasmuch as some of those interviewed did not answer all of the questions, the summary does not necessarily contain the opinions and conclusions of a majority of the persons interviewed.

SUMMARY OF HEARINGS

The majority of those interviewed expressed an opinion favoring an underground water code designed to provide for orderly development and use of the state's underground water supply. However,

many people expressed a general fear of state legislative action due to the impact of the original decision of the Supreme Court in the Bristor versus Cheatham case on the economic stability of certain agricultural areas. These persons felt that an attempt to enact new legislation during the regular session of the Legislature might again disrupt plans for financing and planting next year's crops and this was one of the primary reasons many farmers expressed opposition to a new underground water code.

The question of the type and amount of regulation which should be imposed by an underground water law disclosed a variety of individual opinions. While very few favored the balancing of pumpage and recharge in the present critical areas, the majority believed there should be no further development in over-developed areas. There was, however, a considerable difference of opinion as to whether some areas were actually over-developed. Some favored regulatory legislation which would provide a method of immediately stopping further development in any area where pumpage exceeded recharge; others wanted to continue with the 1948 code but with a sufficient appropriation so that adequate personnel could be employed to properly administer it; still others recommended that the 1948 groundwater code be amended to provide for quicker action in restricting areas and to provide for proper administration and policing, and some felt that the only solution to the problem was to cut back the present use of underground water to a safe yield basis. Many people were opposed to any legal control, but favored allowing the laws of economics to control withdrawals from the underground water supply. These people felt that farm prices would provide adequate controls.

The doctrine or principle to be used as a basis for any new legislation depended to some degree on which would be more beneficial to the individual questioned. Quite a few people favored the doctrine of prior appropriation, but a majority of those interviewed were opposed to it. The opponents of the doctrine of prior appropriation expressed a preference for several possible alternatives. Some of them believed that the doctrine of correlative rights or reasonable use was the only workable and fair principle upon which to base a code, while a great many people thought the state was committed to the strict common law doctrine and should continue with it. The greater number did not prefer any particular doctrine but believed the state had the right to apply reasonable police regulations to the underground water situation.

The type of organization and methods to be used in the administration of an underground water code varied considerably and depended to some extent on the possible severity of the code. The majority advocated the establishment of some type of state water resources commission with adequate financing and authority to employ technical and other personnel necessary to administer and police a code of a general nature or of an enabling type. However, in the event of a legislative provision for cut-backs in the use of underground water in over-developed areas, a large majority favored some provision for local administration. It was apparent that many of the people favored complete local control and determination of cut-backs, as they believed that certain unaffected groups were insistent upon the passage of a new underground water code and felt this procedure would provide a safeguard against possible bureaucratic state administration. Several people did not believe any underground water code would be of statewide benefit if it allowed districts or areas to provide local regulations; however, the majority favored providing local districts and areas some voice in any state action or decision applying to them.

On the question of superiority of use it was generally agreed that domestic and livestock needs must be given first consideration, but that industry, agriculture and, to some extent, municipalities, should compete on an equal basis for the use of underground water. It was generally conceded that cities should have the right to acquire water rights, but practically all of the farmers felt that there should be a provision in any legislation requiring the municipality to pay the owners of the land and water a fair price for what was taken. The same general feeling existed in regard to industrial use, as most farmers realized the economic benefits accruing from industrial development. They felt that in over-developed areas, industry should be permitted to acquire water rights by purchasing that quantity of agricultural land necessary to supply the required water and withdrawing that land from cultivation. The following recommendations presented to the Commission by Mr. William A. Evans, of the firm of Evans, Hull, Kitchel & Jenckes, attorneys for the Phelps Dodge Corporation, explain the position of the mining industry in regard to possible underground water legislation:

"1. Existing industrial uses should be fully preserved and protected and should not be subject to curtailment or allocation procedures, first, because the existing industrial uses do not represent a material factor in the groundwater picture, and, second, because any formula or procedure for allocation or

curtailment of agricultural uses simply cannot be made applicable to industrial uses.

2. In areas in which groundwater conditions are not established as critical, there should be no limitation or restriction on the extraction of groundwaters for new or expanded industrial uses, and if, as a result of later agricultural development in such areas, the ground water conditions are not established as critical, there should be no limitation or restriction on the extraction of ground waters for new or expanded industrial uses, and if, as a result of later agricultural development in such areas, the ground water conditions should become critical, the principle mentioned under (1) above should apply.

3. In areas in which ground water conditions have been established as critical, adequate provision should be made for acquisition of ground water for industrial uses through purchase and transfer of existing rights, including transfer of points of extraction. It is not suggested that a new industrial extraction should be permitted in a critical area without there having first been eliminated an existing right to the ground water supply substantially equivalent in annual quantity to the new industrial use.

4. No limitation should be imposed upon the right to transport water from a ground water area to the place of the industrial use."

Conservation methods were generally stressed by people in every section of the state. In the mountainous areas recommended conservation measures were the eradication of brush, junipers and jack pine. Suggestions were made that research might develop a method of converting these into pulp. In the agricultural areas the concrete lining of ditches, the use of pump-back systems and the eradication of brush and other uneconomic, water loving plants, were measures highly favored by nearly all farmers. The establishment of conservation districts with power to issue revenue bonds and levy taxes to finance conservation research and installations proved to be highly controversial. Several recommended that some sort of state financing be provided whereby individuals could secure loans for conservation work.

A majority of the people expressed approval of the following points:

The 1948 ground water code should be enforced and anyone who had drilled a well without a valid permit should be prosecuted and any further use of the well prevented;

Underground water legislation should provide for the drilling of replacement wells; however, further use of wells abandoned for a period of five years should be prohibited;

There should be a prohibition against the transportation of underground water away from the area of its source where such transportation would adversely affect other users in the vicinity;

There should be a state financed program for continued research and investigation of the underground water problem;

There should be a state financed program of study and research designed to develop and improve water conservation methods.

The majority of the people believed the agricultural economy of the state was primarily dependent upon underground water and that any forced reduction in its use would necessarily reduce production and total income. A majority from the over-developed areas expressed the opinion that any cutback in the use of underground water sufficient to balance recharge and withdrawal would have to be so severe that most of the farmers would be unable to farm profitably.

SUMMARY OF INDIVIDUAL HEARINGS

The Commission devoted considerable time at each hearing to questions about wells, pumping conditions, water levels, and other matters bearing on the underground water situation in the area. As most of the information obtained on the technical side of the underground water problem at the hearings is not included in the "Summary of Individual Statements," contained in Appendix "C" of this report, or the over-all summary above, this sub-section is included to give a picture of general underground water conditions in the various areas of the state as reported by the people appearing before the Commission. It also contains some of the general opinions expressed at the hearings.

Prescott Hearing

Western Yavapai and southwestern Coconino counties were represented at this hearing. The underground water resources of this area are not considered over-developed at the present time. Further expansion could create a critical water problem in some areas. The Chino Valley area has had a recession in static water level of about two feet per year for the last few years. Most of the areas are directly dependent on rainfall each year to recharge their underground water supply.

In general most of the people were not opposed to underground water legislation that could be used when the need for it occurred in a particular area.

The type of legislation preferred seemed to be an enabling act that would provide for local control, but which would establish a Water Resources Commission to co-ordinate underground water studies and advise the local districts. Most of the people favored some legal provision for setting up underground water conservation districts. There was considerable feeling that water should be conserved at its source by watershed management such as eradication of jack pines, junipers, brush and uneconomic water using plants. Conservation in the use, application and delivery of irrigation water was also favored, but not on a mandatory basis.

Cottonwood Hearing

The people attending this hearing primarily represented southern Coconino county and eastern Yavapai county. Most of the area is within the watershed and upper drainage system of the Verde River. The majority opinion expressed was that this area had just commenced its development of underground water supplies and that any future legislation should not put mandatory restrictions on development of this area. Legislation of an enabling nature which could be used and administered by local groups when the need arose to stop further development was generally favored.

An example of this is best illustrated by the following statement by Kenneth Waters of Rim Rock: "The people of the Verde Valley want to protect their future and their land and would be very loathe to see any legislation passed that would remove from the people of this valley the right to determine the use of that water at least until such time as they themselves had determined that it was a critical area."

Considerable fear exists that outside sources might try to pump some of the underground water supply outside of the valley. They did not want the Verde Valley to be treated as the Owens Valley was by the City of Los Angeles. The conservation of water at its source by eradicating uneconomic water using plants on the ranges and stream channels was stressed. It was suggested that efforts and research be made to promote a pulp mill which would use jack pines and possibly junipers. The removal of other uneconomic brush and shrubs which not only transpired great quantities of soil moisture but also intercepted snow fall and allow it to sublimate without reaching the ground was recommended as a method of increasing both the surface and underground water supplies.

It was recommended that the Forest Service and Indian Service be requested to co-operate with the state in the watershed management program. It was suggested that a Water Resources Commission be given authority and finances to carry out the state's responsibilities in this program.

Holbrook Hearing

The people attending this hearing represented Navajo and Apache counties. This area in general is situated on a high plateau and drained by the Little Colorado River. The water-bearing strata of the area are usually found in the Coconino sandstone. Alluvial material sufficient to store water is extremely limited in this area. In general underground water found to the south of the Little Colorado River is of good quality, while that north of the river is often high in total soluble salts. In some cases the first water found in drilling a well is of poor quality, while the deeper water is of good quality.

In general the underground water of this area is under artesian pressure. Flowing wells are common. However, there was general agreement that provision should be made to require cut-off devices on these wells to prevent waste during periods when the water wasn't needed. Also it was suggested that old artesian wells should be plugged to prevent wate of underground water. A few people expressed concern over the possibility that future heavy pumping on the south side of the Little Colorado River might allow salty water to flow in from the north side of the river in the area west of Holbrook.

Except for one or two, most people favored legislation which would establish a State Water Resources Commission with authority to make underground water studies, more for the purpose of helping find new areas where irrigation could be developed rather than for the purpose of limiting pumping. It was suggested that such a Commission catalogue and maintain logs and water levels of all wells in the state and have this information available for the use of well drillers and anyone else desiring the information.

The general sentiment favored legislation of an enabling type which would allow local districts to use law to enforce such restrictions as they deemed necessary when the underground water supplies of their district were developed to the point where there was danger of withdrawal exceeding the recharge. A few people seemed to think that one or two of their areas were already fully developed; however, the majority thought that due to their limited growing season and irrigable land the possibility of ever

seriously over-drawing the underground water supply was remote.

There was a general feeling that the increasing amount of brush, junipers and jack pines was using great quantities of water which could be saved by a program of eradication and possibly converting some of the trees to pulp. Other conservation measures, such as lining ditches and preventing waste of tail water, were also recommended.

Safford Hearing

Graham and Greenlee counties were represented at this hearing. Most of the people giving their views to the Commission were either from the Duncan Valley in Greenlee county or the Safford Valley in Graham county. These valleys are both traversed by the Gila River and their conditions are somewhat the same. The two valleys are separated by the Peloncillo Mountain Range through which the Gila River flows in a narrow rocky gorge. Both areas' underground water supplies are rapidly recharged in times of high river flow and good rainfall. Pump water is used to supplement irrigation supplies when gravity supplies from the Gila River are not sufficient to meet the demand. The Safford Valley has a salt problem not encountered in the Duncan Valley. The wells in the Safford Valley are quite shallow in general and as the water levels of these wells are lowered by excessive pumping during drought periods the salt content of the water increases to as much as 4,000 p.p.m. in some wells. The application of this water to the soil creates an alkali problem that requires the use of more water to leach it out and keep the soil productive. There is evidence that at depths of 2,000 feet or more there may be considerable quantities of water. However, the experience to date from the few wells drilled is that this deep water is very high in total soluble salts and unfit for agricultural purposes without diluting it with good water.

The condition of the underground formations in the Safford Valley and to a lesser extent in the Duncan Valley are not uniform or predictable. It was reported that some farmers had drilled 5 or 6 wells before they got water of suitable quantity or quality for irrigation. In some areas at rather shallow depths a certain amount of artesian pressure is evident. One of these areas was reported to be about a quarter of a mile from the Gila River. The water here has a temperature above other shallow water in the area.

There was a general agreement of those heard that no underground water code was needed or desired in this area. It was their view that a code would only hurt them in one way or another. When questions were asked that applied to critical areas or other areas of the state the answer usually received was: "I wouldn't know," or "let the people in that area give the answer." They stated that they were not opposed to enabling legislation which could be used by people in critical areas to help solve their problem, but they were opposed to any legislation which would allow another area of the state to place any regulation on their use of ground water. It was pointed out by several of those testifying that their area had not had any great rush of well drilling or development of new land. They were limited by nature on both their available tillable land and water supply, and therefore, there wasn't anything a code could do to help them.

Conservation of water was considered important, but most people were of the opinion that no one would pay for pumping water and then waste it. There seemed to be a general feeling also that the ratio of the cost of water conserving measures to the cost of water would determine to what extent a man would invest in lining ditches, leveling land, etc. It was stated that salt cedars along the Gila River from Safford to Coolidge reservoir used more water than was used for irrigation in the entire Safford Valley.

Willcox Hearing

At the Willcox hearing people from all of Cochise county's farming areas were present. This county differs somewhat from other areas of the state in that a considerable portion of the natural drainage does not have an outlet of streams that flow to the ocean. The northeast portion of the county is drained by the San Simon River and the southwest and western part of the county is drained by the San Pedro River. The south and central portion of the county drains into the Willcox Dry Lake or the Whitewater Wash which flows into Old Mexico where there is no outlet to the sea.

The underground water situation is quite varied in respect to quality of water, depth to water and capacity of wells. A considerable amount of artesian pressure exists at various places throughout the county. From the statements made at the hearing the underground water situation in the various pump areas can be summarized as follows:

Stewart district, north of Willcox—This area does not seem to have too great a pumping lift. However, the underground formation is slow to give up water, and therefore, the capacity of the wells in

general is quite small. Some people seem to believe the water supply is fully developed and further development should be stopped. There has been some lowering of the static water levels over the past few years.

Kansas area, southeast of Willcox—This area is a rather new development. These wells seem to be on the average the best wells in respect to capacity in the county. Apparently there is no shortage of water or excessive lowering of the water table.

Douglas area, north of Douglas—This area includes all of the land in the vicinity of Elfrida and McNeal. The wells are not generally of high capacity. The water levels are being lowered some, but there is no apparent concern of a water shortage or of the area becoming critical.

San Simon Basin, northeast of Willcox—This area has a great variety of conditions. Most of the wells are in the vicinity of Bowie or San Simon. Some flowing artesian wells existed in this area in the past; however, with the increased number of wells and pumping most of them have stopped flowing. There are quite a few cases of definite well interference. The capacity of the wells is from unsatisfactory to very good. There has been a lot of new development but the people generally are not alarmed about the development affecting their water supplies.

Hereford area, west of Bisbee on the San Pedro River—This area is limited in the land available for irrigation and it is not believed that future development could ever create a critical underground water situation.

Nogales Hearing

This hearing was concerned with all of the pump irrigated land in Santa Cruz county. These lands lie mostly along the Santa Cruz River from Nogales to the northern boundary of the county. Most of the land suitable for irrigation has already been developed. It was stated that a considerable amount of pump irrigated land was being developed along the upper reaches of the Santa Cruz River before the river goes into Mexico. There was also considerable concern that if some agreement with Mexico was not reached through the International Boundary Commission, future development in Mexico might greatly affect the underground water supply in Arizona.

There was considerable expression in favor of artificial recharge to the underground water supply from the flood flows of the Santa Cruz River. There was some variation of opinion as to whether the eradication of mesquite along the river channels would increase the underground water supply; however, the majority believed eradication of uneconomic water using plants both on the watershed and in river channels would be helpful if it could be accomplished by economical means. It was stated that conservation is the only answer to our water shortage.

Tucson Hearing

The people attending this hearing represented the area in Pima county from the Santa Cruz county line north along the Santa Cruz River to about Rillito. In the last two or three years there has been considerable new agricultural development. This development and the great expansion of the city of Tucson has created a great demand for underground water. Apparently there is considerable friction between the city and the farmers over water. In general the farmers agreed that cities should have the right to obtain water by purchasing land and diverting the water used on the land to municipal use. Under present underground water laws the only limitation on the volume of withdrawal is that the water must be put to beneficial use. In areas declared critical under the provisions of the Groundwater Code of 1948, drilling of irrigation wells to supply new land is prohibited, but wells for domestic, municipal and industrial use are specifically exempted from this prohibition. As a result municipalities and industries may drill any number of wells on any size tract of land and withdraw as much water as is needed without any compensation being made to existing agricultural users in the area. This situation has prompted the farmers to attempt to prove that the water under the Santa Cruz River low lands is an underground stream and subject to appropriation under the appropriation laws of the state.

The majority of the people were of the opinion that they were pumping out more water than the normal recharge, but were opposed to cut-backs in their use of water. Several people thought that by artificially recharging the underground water supply from flood flows, practicing conservation in the use of water and eradicating phreatophytes the recharge could be brought up enough to equal the withdrawals.

Marana Hearing

The people attending this hearing represented an area in Pima county which lies along both sides of the Santa Cruz River from a point a few miles southeast of Rillito to the Pinal county line and includes the Avra Valley which is drained by the Brawly

Wash and joins the Santa Cruz River southwest of the Marana Air Base. Within the older development of this area is the Cortaro Water Users' Association which is a 10,000 acre pump project dating back to the 1930's. Recently there has been extensive development of land and underground water in the Avra Valley south of Marana. Considerable new development has also taken place in the vicinity of Red Rock.

The Cortaro Water Users' Association wells can be considered as being in two different underground water areas. The wells southeast of the Rillito Narrows have a comparatively shallow lift while the wells northwest of the Narrows have a greater lift: hoever, the wells with the shallow lift are usually of smaller capacity than the wells with a deeper lift. It is assumed that the wells above the Rillito Narrows are pumping from an underground stream while those below the Narrows are pumping from storage and recharge. Several private pumpers below the Narrows believed they were pumping from underground streams. It was expressed that possibly the heavy pumping in the Eloy area was lowering the water table in this area. In general most people seemed to think further drilling and developing of land should be stopped in the area, but that any cutback was unnecessary at the present time.

Coolidge Hearing

The people at this hearing represented the Coolidge, Florence and Magma areas. There is a great deal of variation in underground water conditions within these areas as well as between the areas. The Magma area of Pinal county is part of the Queen Creek critical area. The wells, in general, are high in capacity and have a relatively small draw-down. Within the last year the static water level has declined more than during previous years. In the Florence and Coolidge areas there is a great amount of variation in depth to water, capacities of wells and salt content of water. Generally near the Gila River the water levels are still quite shallow and the well capacities high. Southwest of Coolidge lies an area which several people believe is the most critical underground water area in Pinal county. The water level has dropped considerably, but the major factor is the great decrease in the capacities of the wells.

The San Carlos irrigation project, composed at present of about 50,000 acres of white lands and 40,400 acres of Indian lands, lies partially within the Florence and Coolidge underground water areas. This project is a gravity water project supplemented by pump water. The land within this project during the past several years has received less water per acre from both gravity flow and project pumps than the pump lands outside of the project. This has caused many people on the boundaries of the project to drill wells just off the project land and pump water to their project land to supplement their delivered supply. This pumping along with project pumping has lowered the water levels to the point where many of the project's shallower wells have gone dry. Deepening wells in this area apparently has not increased capacities too much or in the same proportion reported in other parts of Pinal county.

The economy of this area is almost totally dependent upon agriculture. For this reason many of the people were very reluctant to see any type of legislation passed that would call for cut-backs in the use of underground water. Most of the people wanted protection against a decreasing water supply and some were willing to take a cut in water if it would prolong the period they could economically farm. There was considerable discussion as to the basis for possible future cut-backs. Some favored a cut on an acreage basis, others on a quantity of water basis and some believed it should be a combination of the two.

Eloy Hearing

Under the 1948 code the Eloy area was the first to be declared critical, but from the statements made at this hearing, it appears that the people of this area are better satisfied with the code than in any other area in the state. There was considerable feeling that the '48 code should be better administered and policed, however. The people were quite resentful of all the predictions about the future of their ground-water supply. They also disliked the newspaper and magazine publicity the area had received about the underground water situation. It was apparent that the people were very fearful of possible legislative action in connection with a new underground water law. The fear seemed to be more from their inability to finance next year's cotton crop than from the effect a new code might have on them.

There was almost unanimous agreement that they wanted to be left alone and strongly resented any interference from any source. They felt that they were able to take care of themselves without any assistance from other sources. Many of them referred to statements made years ago by members of the staff of the University of Arizona and U. S. Geological Survey that Eloy would in a comparatively short time become a dust bowl unless there was a cut in the use of water. They pointed to the increased acreage and prosperity of the area as proof of the fallacy of these statements and of the fact that many of the so-called

experts apparently had insufficient knowledge to make any sound predictions on their water problems. Several of them stated that if there had to be some kind of legislation, they favored some type of enabling legislation which would leave each area free to determine its own future.

Water costs were reported to be less this year than at any time within the last seven years even though pumping lifts were greater. Many wells have been deepened and their discharge greatly increased. It is not believed that this could be done with all wells, but with a majority it would be profitable. In general, it was not believed that a one-third drop in the cotton price would materially affect the acreage in cultivation. Some believed those people with marginal land or who had not installed adequate water conservation measures might be forced out of business by a drop in crop prices. Conservation practices necessary to secure the ultimate in the use of water were advocated. Some means of financing such practices was also advocated.

A few people were dissatisfied with the designation of critical areas under the 1948 code. They seemed to think that other areas were drawing from the same supply of underground water but were not included in a critical area.

Casa Grande Hearing

The people at this hearing were from the Casa Grande and the Maricopa-Stanfield areas. Underground water conditions vary considerably from well to well. The static water level is not necessarily any indication of pumping level. Some of the better wells have a deep static level with very little draw-down which results in a high capacity and a more efficient over-all pumping operation than wells with a relatively high static water level and a great amount of draw-down. The water levels have been dropping in varying amounts throughout the area. It was the general opinion that there was not enough known about the amount of recharge or the source of recharge to the area to intelligently control the use of underground water. Several people recommended more study before any new code was recommended. Others were of the opinion that if the U. S. G. S. figures were correct, that the area was so far overdeveloped that adequate controls would force most people out of business anyway. Some recommended enabling legislation and a commission to direct further study. Conservation was recommended in varying degrees. Most everyone was in favor of conserving all water possible by means of leveling land, lining ditches and installing pump-back systems. Several believed the state should finance these conservation practices on a loan basis.

In general, the 1948 code was considered ineffective in that it had not been strictly enforced. It was reported that many wells are still being drilled within critical areas. There was also some opposition to allowing development leases on Indian lands. Some believed the first violation of the '48 code should have been prosecuted to test the constitutionality of the code. A few people believed that with some changes the 1948 code could be made to work provided sufficient funds were appropriated to properly administer it.

In this area there was considerable fear from farmers and business men alike that the legislature might try to pass a new underground water code imposing controls which would upset the present economic structure. It was believed that the area was from 90 to 95 per cent dependent upon agriculture and any cut in water would have a like effect on business.

Phoenix Hearing

Four days were devoted to hearings held in Phoenix. The first three were primarily for those engaged in agriculture and later a fourth hearing was held to include representatives of business.

The majority of the people attending these hearings were from Maricopa county, although several people from other parts of the state were also present. The opinions and views expressed were as diverse as the underground water conditions throughout the Salt River Valley.

Two critical areas have been designated in Maricopa County under the provisions of the Groundwater Code of 1948. The underground water conditions existing within these critical areas are extremely varied. Water-bearing formations are not uniform. One well may have a high capacity and good quality water, while a well only a few yards away and drilled to the same depth may have a small capacity and very poor quality water. Some parts of the area have a drainage problem, while others may have excessive pumping lifts. Extremes also exist in the quality of the water. The water in some wells is of high quality, in others it is satisfactory for irrigation purposes and in still others it has such a high salt content that it cannot be ued for irrigation without diluting it with good water. In some places deep wells furnish the best quality water, while in other places only the shallow water is useable.

Many of those interviewed were unwilling to accept the findings of the underground water special-

ists up to this time, although at the same time furnishing well data showing progressive lowering of their water levels and decrease in the capacity of their wells. These people were generally of the opinion that underground water studies should be continued and that no attempt should be made to enact a code until sufficient information on the amount of recharge and source of recharge was obtained.

The majority favored a properly directed and adequately financed research program to investigate methods of conservation, nature of the underground water and means of recharging the underground water supply. Most people favored establishment of a State Water Resources Commission, or similar body, with authority and sufficient funds to employ competent engineers and other necessary personnel. It was felt that the members of this organization should represent all areas of the state and that their terms of office should be staggered.

At the hearing held on October 22nd for representatives of business, several persons were asked if they were in favor of a state conservancy act which would provide for the forming of districts with power to levy a small tax on all property within the district for the purpose of financing conservation and flood control work of general benefit to the district. Several of the business men were of the opinion that the indirect benefits from such projects would be of such value to them that they would be willing to contribute. A representative from a state conservation group expressed the opinion that more could be done through water conservation to maintain our economy than by any other single means. Several people thought the state should establish some method to finance private conservation work on a long term loan basis. Everyone was in accord on the necessity for the promotion and practice of conservation measures.

Several people suggested that there be an equitable apportionment of pumped water among all lands in each underground water area including undeveloped land. Some believed that all further development should be prohibited in critical areas and only present users of water should be entitled to share on an acreage basis. Several thought the doctrine of prior appropriation should be applicable and that in the event of a scarcity of water the later users should be deprived of water. Still others favored some basic allotment for the first users and an equal division of the remaining supply among all present users in a critical area, and a strict interpretation of the prior appropriation doctrine in areas not now critical. One group maintained that pumping was interfering with existing rights of surface users and that any pumping from river bed type formations should be stopped, as these formations delineated underground streams subject to appropriation. They reasoned that all of this water had already been appropriated by users of the water of the Salt River. Some believed that there could be no prohibition which would prevent a gravity irrigation project from pumping water artificially put into underground storage through deep percolation of the gravity water. One unusual solution suggested for the underground water problem was presented. Under this plan all farmers with more than 80 acres in cultivation who were not growing grapes or citrus would be asked to voluntarily reduce their planted acreage by 25%. As an inducement, all persons participating in this plan would be relieved of paying taxes and water assessments on the idle acreage. The opinion was expressed that such a cut would not reduce production in the same proportion as the reduction in acreage and that the net profit to the individual would be almost as much as with the full acreage in cultivation.

Opinions were diverse as to the result of a cutback in the use of pump water on the net income. Some thought any cut in use would effect a like loss in income. Others believed that a 25% cut in the use of pump water would result in only a 10% drop in production due to the use of only the best land and greater efficiency which would result from farming smaller acreage.

The majority of the people favored a commission plan of administration in the event of the enactment of new underground water legislation and urged that this commission be adequately financed to enable it to make further studies.

Officials of the Salt River Valley Water Users Association and many others urged an aggressive brush control program on the watersheds as a means of increasing surface and underground water supplies.

Parker Hearing

Mohave and Yuma county people were invited to attend this hearing, give their views and state their underground water problems. At the present time there is no particular evidence of over-development of the underground water resources in these two counties. There was quite a bit of concern about drilling wells in the vicinity of Salome, upstream from what the local people call the Reef, and transporting the water to irrigated land below the Reef. It seemed that in this isolated area there had been considerable lowering of the water in domestic wells.

The people from Bouse reported no recession in water levels in that area. One man reported that his present static water level was two feet higher now than when his well was first drilled. It was also believed that the natural recharge to the area was greater than has been reported by the U. S. Geological Survey.

Along the Gila River in Yuma county there is a considerable amount of pump irrigation but with the development of the Wellton-Mohawk Reclamation Project most of this area will receive 4 acre-feet of Colorado River water annually. It is expected that this new source of water may eventually create a drainage problem which will have to be remedied by pumping. In order that people in this district may be in a position to control their underground water and receive credit for water returned to the flow of the Colorado River, they would like to have underground water legislation which would allow them to control pumping in the vicinity of their project. If they do not get this right, they fear that people with land around their project and those with land within the project which has been classed as non-irrigable, will pump out the underground water supplies which they will be building up by the importation of Colorado River water.

Appendix "A"

Report On Ground Water in Arizona

By

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PHOENIX, ARIZONA
NOVEMBER 26, 1952

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November 26, 1952

Mr. E. Ray Cowden
Chairman, Underground Water Commission
Phoenix, Arizona

Dear Mr. Cowden:

There is transmitted herewith the report on Ground Water in Arizona prepared by your consultants. The report includes a description of general ground-water conditions in the state, a discussion of important areas of development, and our conclusions.

The detailed reports prepared for the Commission by the U. S. Geological Survey, the University of Arizona, Salt River Valley Water Users Association, and the City of Tucson were of great value to us in our study. To these agencies, as well as to other agencies and individuals who furnished data or otherwise assisted in this investigation, we wish to express our grateful appreciation. We particularly wish to thank the members and staff of the Commission for the wholehearted cooperation given us by them.

Respectfully submitted,

WILLIAM F. GUYTON

NICHOLAS A. ROSE

ROYCE J. TIPTON

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Introduction

During the second regular session of the 20th Legislature of the State of Arizona, Senate Bill No. 56 was enacted. The primary purpose of this legislation was the creation of the Arizona Underground Water Commission. Among the duties and powers delegated to the Commission were the investigation of the source, extent, and nature of the underground waters of the State of Arizona and the submission of a report to the Governor and Legislature by January 1, 1953.

The Commission employed three ground-water consultants to assist and advise the Commission and its staff in the execution of the technical phases of its responsibilities, and to evaluate the geologic and hydrologic data, and findings of previous investigations. This report to the Commission has been prepared by the consultants and comprises a description of the general ground-water situation in Arizona, with emphasis on the more important problems in the heavily developed areas. No attempt has been made to describe all of the details or to present the intricate analysis from which the conclusions have been reached. Those interested are referred to the appendices which contain the large mass of data upon which this report is based.

Ground water was being used for irrigation in the state as early as 1900. Large-scale developments of ground water were begun shortly after 1920. Between 1920 and 1940 withdrawals from wells increased significantly; and since 1940 the withdrawals have increased at a tremendous rate. The total pumpage now amounts to over 3½ million acre-feet per year. By far the greater amount of water withdrawn from wells in Arizona is used for irrigation. At present less than 5 per cent is used for domestic, industrial and other purposes.

Because of the importance of ground water as a resource, many agencies, both governmental and private, have studied the problem since before the beginning of the century. The principal agencies engaged in this work have been the U.S. Geological Survey, the University of Arizona, and the Salt River Valley Water Users' Association.

The first technical report to deal with ground water in Arizona was published by the United States Geological Survey in 1897. At intervals from that date to 1939 this agency published reports on its studies in various areas in the state. In 1939 a continuing cooperative investigation was initiated between the Geological Survey and the Arizona State Water Commissioner.

The first report prepared by the University of Arizona was published in 1903. Since that date the University has issued reports intermittently and has made continuing investigations of ground water in several parts of the state.

Special studies of ground water within its boundaries have been conducted by the Salt River Valley Water Users' Association since its organization in 1903. Also, independent studies of local problems have been made by irrigation districts, municipalities, consulting engineers and geologists, water well and pump contractors, and various individuals.

The reports and data available from these agencies and individuals constitute an extensive and voluminous record of certain phases of the ground-water conditions in Arizona. However, at the time of its creation, no single report was available to the Commission having an up-to-date analysis of the situation throughout the state.

It was apparent to the Commission that although the available reports and data were extremely valuable, they would have to be collected and compiled in an orderly fashion and brought up to date wherever possible. Furthermore, data obtained from different agencies would have to be compared and correlated to determine whether any serious discrepancies might exist. The Commission therefore requested the various agencies and individuals who had made studies of ground water to submit all pertinent basic data and analyses thereof in accordance with forms, instructions, and questionnaires prepared by the consultants.

Additional data were obtained by the Commission's consultants and staff from local sources and by field inspection. The Commission obtained a considerable amount of data and general information from a series of public hearings held in various parts of the state during September and October 1952.

A list of most of the reports and data upon which this report is largely based is given in the appendices. The reader is referred especially to reports of the Geological Survey, the University, the Salt River Valley Water Users' Association, and the City of Tucson. Of particular value is the report prepared for the Commission by the Geological Survey.

A thorough check has been made of basic data submitted by the various agencies and individuals.

Only minor discrepancies exist between the sets of basic data, and they are not considered significant as far as over-all conditions are concerned.

The findings contained in this report represent an independent evaluation of the data by the consultants, although the interpretations and analyses of data by the various agencies have been studied and have been valuable.

The authors have no major fundamental disagreements with the agencies which have made intensive ground-water studies in Arizona. Moreover, they believe that these agencies have no fundamental disagreements among themselves. The disagreements encountered have been chiefly a result of the usage of inadequately described ground-water terminology by different persons to mean different things, and the degree to which individuals have reached apparently firm conclusions based on inadequate data.

The outstanding difficulty faced by investigators in Arizona to date has been that sufficient information is not yet available on the occurrence of ground water to permit detailed conclusions on all phases of the problems. Many data have been obtained on the position of water levels in wells, but information obtained on other phases of the ground-water problem, such as geology, recharge and natural discharge, generally has been of a reconnaissance nature. Satisfactory quantitative answers cannot be determined at this time regarding the amounts of water that can be withdrawn from wells in particular areas on a sustained yield basis.

Nevertheless, sufficient knowledge now has been obtained so that generalized conclusions may be drawn relating to the sources and extent of the ground water and the probable effects of continuing withdrawals from wells at present or increased rates.

General Geologic and Hydrologic Conditions

Arizona may be divided geologically and topographically into three general regions, namely, the plateau, the mountains, and the deserts. The occurrence of ground water is different in each of these regions.

The plateau region is a part of the Colorado Plateau and embraces the north and northeastern part of the state. This region, which lies almost entirely in the Colorado River basin, is underlain by consolidated rocks consisting principally of sandstone, limestone, shale, and some older volcanic rocks. The principal water-bearing formation in the region is the Coconino sandstone, which generally yields water under confined, or artesian, conditions to wells. The amount of water being withdrawn from this formation is relatively small. In parts of the region the Redwall limestone contains well-developed systems of fractures, fissures, and solution channels in which occur large quantities of ground water. The principal discharge of ground water from this limestone is as a series of springs issuing at various points along the base of the Mogollon Rim and in the Grand Canyon region.

The mountain region consists of a comparatively narrow belt of mountains along the southwest margin of the plateau. This belt trends in a northwesterly direction across the central part of the state. The mountain region is characterized by short, nearly parallel ranges made up essentially of igneous rocks, separated by deep narrow valleys partly filled with stream deposits. The trend of most of the ranges is from northwest to southeast. The occurrence of ground water in commercial quantities in this region is confined to the sands and gravels of the alluvial deposits and the porous and fractured volcanic rocks.

The desert region is a part of the Basin and Range Physiographic Province which embraces a very large part of the southwestern part of the United States. It includes nearly all of Nevada, parts of Oregon, Idaho, California, New Mexico, as well as southern Arizona, and northwestern Mexico. This vast region is made up for the most part of broad valleys that lie between mountain ranges. The valley troughs contain tremendous deposits of rock waste that have been washed down from the surrounding mountains. All these alluvial sediments have been deposited since these troughs came into existence and are called valley fill regardless of their specific geologic age. The valley fill, which is the great waterbearer of the arid West, is very irregular in distribution, thickness, and structure, all of which affect the yield, head, and quality of its water.

The map attached at the end of this report shows the location of the alluvial deposits in Arizona, as determined from the geologic map of Arizona prepared by the Geological Survey.

The geologic history of the basin and range region may be summarized as follows. Prior to the development of the existing basin and range structure, the region was made up essentially of great masses of metamorphic, igneous, and stratified sedimentary

rocks which were for the most part impermeable and non-water-bearing. These rocks were subjected to pronounced faulting. Portions of the mountain masses were pushed up and adjacent areas settled along zones of weakness in the rocks. This process occurred at various times during several geologic periods. Indications are that adjustments are still taking place along some of the zones of weakness. As a result of these large-scale structural movements, the region was transformed into two strongly contrasting types of topography: broad valleys and rugged mountain ranges. The valleys exhibit smooth gentle slopes and nearly level plains. The mountains are steep-sided and almost infinitely varied in topographic details.

Concurrently with the structural formation of the valley troughs, complex and intricate drainage systems were established. As a result of the complicated processes of erosion and deposition by the streams, the valleys were gradually filled with rock waste from the surrounding mountains.

In their present stage of development, most of the alluvial valleys in southern Arizona, with the principal exception of Sulphur Spring Valley, are geologically and hydrologically interconnected, forming a single major valley system drained by the Gila River and its tributaries. At some time during their geologic history, however, most of the tributary valleys were more or less isolated into closed basins having interior drainage.

The following is a description of the sedimentary history of a typical desert valley, based on geologic findings in the Basin and Range Province.

> The valley in the beginning was almost surrounded by steep-sided mountains in which were cut innumerable canyons of various sizes. The main feature of the valley was a series of fault scarps that formed a large structural trough between the mountains. Hills and ridges of sand were heaped up by the wind, and in a few places mounds and terraces were built by springs issuing from the fault zones. Water that fell as rain or snow on the mountains or in the valley was the agent by which the rock materials were transported and deposited. The soluable material was carried in solution, the fine particles of sand and clay were held in suspension, and the pebbles and boulders were rolled over the surface by the impact of the water. The character and quantity of the contributions to the valley from each of the canyons was determined by the shape of its surface, the distribution and amount of precipitation, and the character of its water-bearing material, its soil, and native vegetation. An alluvial fan or slope of rock waste was built at the mouth of each canyon. Although the fans had, in general, the same form, they differed greatly in size, shape, and distribution. Inasmuch as the canyons were numerous and closely spaced, many of the small fans were superimposed on the larger ones and many merged with one another forming a single, large smooth slope. At their bases, the slopes became very gentle and usually merged into lakes, playas or alkali flats that occupied the lowest parts of the valley. The materials carried into these lowlands were very fine in texture and were deposited as stratified lake beds. In some places these deposits were interbedded with stream deposits. As these erosional and depositional processes continued, the steep-sided structural valley was gradually filled with a heterogenous mass of outwash material. At some point during this period, the valley became a part of a regional drainage system. To add to the complexity of the sedimentary history, some of the larger streams cut deep channels into the unconsolidated material, carrying sediments to lower parts of the drainage system. Moreover, as adjustments took place in the basement rocks below the valley, settling occurred. At times volcanic activity took place along some of the fault zones, resulting in the eruption of active volcanoes, followed by the extrusion of extensive flows, the development of cones, and the explosion and scattering of volcanic ash over the valley. In some instances volcanic flows dammed up the stream courses forming lakes into which silts and clays were deposited. The material deposited during this sedimentary period is considered to be the older fill.
>
> Following its deposition, the major streams of the region cut broad and deep channels into this older alluvium. Later these channels were filled with river deposits made up chiefly of sands and gravels which are known as the younger fill.

Consideration of the sedimentary history described above emphasizes the complex nature of the geologic formations from which ground water in this desert region is obtained. Vast differences exist in the character, depth, and productivity of the water-bearing materials within an individual valley, as well as in the different valleys of the region. Many outstanding examples of heterogenous geologic and hydrologic conditions can be found in the valley of the Gila River and its tributaries. Conditions encountered in these various areas reveal extreme ranges in every phase of the hydrologic system. The sands and gravels in the shallow alluvium are by far the most pro-

lific water-bearing materials in the region. The permeable sands and gravels in the deep alluvium yield water to wells, but in general are less productive due to finer texture and to cementation. In some valleys the older fill contains very few permeable strata and for practical purposes may be considered non-water bearing. The thickness of the outwash material and the depth to the basement rock ranges from less than 100 feet to as much as 5,000 feet; the productivity of the water-bearing formations, or aquifers, as measured by yields of wells ranges from a few gallons per minute to as much as 6,000 gallons per minute; and the texture of the water-bearing material ranges from fine silty sand to large gravel and boulders.

Extreme variations in the quality of ground water have been encountered in various parts of the state. In most places the water is acceptable for irrigation. In some places, however, the water is highly mineralized due to the presence of mineral salts in the alluvium or to the concentration of minerals by evaporation and transpiration. Water issuing from fault springs along the valley floor may have an effect on the quality of water found in the deep alluvium and, in some instances, the shallow alluvium.

In addition to geology and topography, the nature and occurrence of ground water is dependent upon the climatic conditions of the region. All water, whether ground water, surface water, or atmospheric water, is a part of the hydrologic cycle.

The original source of all ground water in Arizona is precipitation on the watersheds of the various streams which flow across the state. Practically no water reaches the areas of ground-water development from regions outside the watersheds.

The largest part of the precipitation which falls on the land surface is evaporated immediately or transpired locally by vegetation. Another part of the precipitation runs off in the streams and is either evaporated in the streams, stored in surface reservoirs, diverted for irrigation use, or flows to destinations outside of Arizona. The remainder of the precipitation, which is a small part of the whole, percolates into the ground.

Water that percolates into the ground in the mountains or on slopes may emerge into streams as ground-water seepage, which forms the base flow of many streams during periods of little or no rainfall. Percolation that occurs in desert regions moves very slowly downward around the soil particles to reach the water table as recharge to the aquifers. Percolation also may occur through the stream beds to reach the water table as recharge. In many instances the recharge to the ground water has taken a long and circuitous path in its movement from the place where it fell as precipitation to the point where it reached the principal aquifers.

Water within the zone of saturation below the water table occurs in minute pores and irregular spaces between the individual particles and grains that make up the aquifer. In general the pores and spaces are connected in all directions, allowing the water to move by gravity from areas of intake to areas of discharge. Under natural conditions the movement of water through the interstices of the sand and gravel grains is extremely slow, ranging from only a few inches per year to as much as a thousand feet per year or more. This movement is not regular or consistent but has infinite variations owing to the differences in the sizes of the pore spaces and in the gradient of the water table from one place to another. The rate of flow through a given area under normal conditions varies with the slope of the water table.

Considerable resistance to movement is developed by the friction of the moving water against the surfaces of innumerable closely-spaced particles making up the water-bearing material. Consequently, a substantial part of the material must be saturated in order for the water to move from the recharge areas to the points of discharge. This creates what is termed ground-water storage. Vast quantities of ground water make up the underground storage within the alluvial valleys and are many times greater than the water stored in the surface reservoirs of the state.

In Arizona the water in the alluvium of the rivers and the shallow outwash material generally occurs under water-table or unconfined conditions. The water in the deeper sands and gravels may occur under artesian or confined conditions, in which the water rises above the confined sands and gravels. In some areas the artesian head of the deeper sands and gravels is higher than the head in the shallow aquifers. The reason for the higher head is that the deeper aquifers are not connected directly with local areas of recharge but are connected with remote areas of recharge that occur at higher elevations.

Recharge is a vital part of the closely interrelated hydrologic system. It enters the permeable material at the edges of the mountains, in desert areas near the mountains, and along the stream channels, and moves through the ground to areas of natural dis-

charge, either as outflow at the lower ends of the valleys, as surface discharge to streams, or as transpiration by native vegetation.

Before any of the water resources of the state were developed, ground water, surface water, and water returned to the atmosphere through evaporation and transpiration were in a state of balance. As water flowed from the mountains into a stream, it fed both plant growth and underlying ground-water formations. During periods of flood, the ground water was recharged extensively, but during dry periods, when there was little or no direct runoff, some of the ground water moved back into the streams, creating base flow. Vegetation along the banks and bed were fed by the stream and also by ground water wherever the water table was within reach of the root systems. During drought periods, the ground water alone supported the plant growth.

When irrigation works were placed into operation, these natural equilibrium conditions were disturbed. Water to supply the irrigated crops was obtained from diverted stream flow and from ground water pumped from wells. The pumped water was obtained by intercepting natural ground-water discharge and by drawing on ground-water storage. As a result of these processes, less water became available to flow in the streams and to supply the natural plant growth.

The pumping of ground water has necessitated the lowering of the water table. Fundamentally, water produced from wells must be obtained from storage until the water levels are lowered sufficiently to intercept enough natural discharge to supply the wells.

This natural requirement of the development of ground water becomes a serious problem when the water levels must be lowered excessively in order to fully intercept the recharge. It becomes a much more serious problem when the required quantities of water exceed the recharge and continuous withdrawals are made from ground-water storage. Large important areas in Arizona are faced with the latter problem. The surface-water supplies in the principal valleys for many years have been developed to the greatest extent practicable, and recent large expansions of irrigation through the use of ground water have been possible only because of heavy withdrawals from ground-water storage. It is inevitable that such continued major draughts on storage will cause water levels to continue to decline, accompanied in some areas by decreases in the yields of wells. Such trends may be retarded somewhat if the present rates of withdrawal are not increased, but the only means of reversing these trends would be by a reduction in the amount of water pumped from wells.

Principal Areas of Development

GENERAL STATEMENT

In 1952 Arizona ranked second among the states in the amount of ground water withdrawn from wells. Approximately 95 percent of the ground water withdrawn in Arizona is used for irrigation. Practically all of it is derived from alluvial deposits in the desert valleys of the southern part of the state. Only small quantities are obtained in the small valleys in the central mountain region and in the artesian areas of the northern plateau region.

The primary purpose of this report is to discuss the areas of considerable ground-water development and their problems. These areas embrace a large part of the Gila River system and to a lesser extent the Sulphur Spring Valley and small areas along the lower part of the Colorado River Valley. The outlines of the various areas are shown on the map attached at the end of this report. Inasmuch as the geologic and hydrologic conditions in the individual areas are exceedingly varied and complex, the areas are discussed separately.

Before presenting the discussion of the individual areas, a clarification of the term "ground-water basin" as used in previous reports is desirable. Early in the course of the consultants' work, an effort was made to determine the exact definition of the term as used in the reports and whether the boundaries of a "basin" were based on physical conditions or had been set arbitrarily by the investigator. It was found that the term "ground-water basin" was applied primarily to an area in which ground-water conditions were similar and was not intended to delineate an isolated ground-water reservoir. Moreover, the boundaries of the "basins" had not been clearly defined and, except in a very few cases, one "basin" could not be isolated from an adjoining "basin." Because of the apparent confusion in the meaning and usage of the term "ground-water basin," the words "valley" or "area" will be used in referring to the described localities.

GILA RIVER SYSTEM

Practically all of the water available to streams and to ground-water formations in the Gila River system falls as precipitation within its watersheds. Hydrologically, the Gila and its tributaries form a single integrated system which cannot be separated into individual areas. Topographically, the valleys are interconnected. Geologically, a few of the valleys are cut off from other parts of the system by subsurface barriers; however, most of them have subsurface interconnections by means of permeable sand and gravel strata. Furthermore, the ground water and the stream flow are intimately interrelated throughout most of the drainage system. Consequently, an alteration of hydrologic conditions in one valley will have either direct or indirect bearing on other downstream valleys. In many cases the effects of such changes will not be significant for long periods of time.

The areas within the Gila River system will be discussed in the order of their occurrence from the headwaters downstream to the junction with the Colorado River.

Duncan Valley

The Duncan Valley is a relatively narrow alluvial-filled valley lying along the main stem of the Gila River, extending from New Mexico into Arizona.

Irrigation in the valley is partly by surface water from the Gila River and partly by ground water from wells which draw from the recent alluvial fill of the inner valley. Most of the irrigation water is taken from the river except during periods of low flow when wells are depended upon more heavily. During the dry years between 1942 and 1951, the use of ground water increased from about 2,000 to 34,000 acre-feet per year. Wells in the Arizona part of the valley, which at present number about 85, range in depth from 50 to 125 feet and in yield from about 100 to 3,000 gallons per minute. The water, in general, is suitable for irrigation. Most of the irrigable land is already in cultivation.

Recharge to the ground water comes primarily from seepage from canals and irrigated lands, and from underflow into the valley from tributary washes. The ground water and surface water appear to be intimately interconnected, and water generally moves from the ground into the river. However, during periods of heavy ground-water pumping, water may move locally from the river into the ground.

Water levels in wells are drawn down by heavy pumping during the summer, but recover rapidly during the fall. No major residual decline of water levels has been noted in the valley from one year to another. As a result of the seasonal lowering of water levels, yields of wells decline as much as 25 to 35 percent during the growing season. Therefore, enough wells must be available to provide an adequate water supply during such periods.

Although there is a possibility that deep wells could be drilled in the valley, the water apparently is not needed at present.

Downstream from the Duncan Valley the channel of the Gila River flows through a narrow gorge in the bedrock before reaching Safford Valley. Underflow of the river in the section between the two valleys is practically non-existent. The amount of surface flow reaching the Safford Valley through the Gila River is affected by the use of ground water in the Duncan Valley, owing to its intimate relationship with surface water in this area.

Safford-San Simon Area

The Safford-San Simon area lies in a large structural trough flanked on the northeast and southwest by mountains. The southeastern part of the trough, which extends into New Mexico, is drained by San Simon Creek and is known as the San Simon Valley. The northwestern part is drained by the Gila River and is termed the Safford Valley. San Simon Creek flows into the Gila River.

The structural trough has been filled with alluvial material to a depth of several thousand feet. The Gila River has cut through the older alluvium to a depth of about 150 feet and has deposited recent alluvium in a relatively narrow inner valley. The shallow recent alluvium furnishes water to most of the wells in the Safford Valley. The water-bearing formations in the older alluvium, which are usually several hundred feet deep and under artesian pressure, supply water to most wells in the San Simon Valley.

Essentially all of the inner valley has been developed in the Safford Valley as far downstream as the San Carlos Indian Reservation. The water for the lands is obtained partly from stream flow and partly from wells. During periods of plentiful stream flow the major source of supply is surface water, whereas, during dry cycles, most of the water is obtained from wells. The total amount of water used annually for irrigation is essentially the same from year to year. In 1941 the river furnished about 95 percent of the water for irrigation. In 1951, a dry year, the several hundred wells supplied about 125,000 acre-feet or about 85 percent of the total water used. The wells range in depth from about 30 to 100 feet and in yield from about 200 to 3,000 gallons per minute. In some places the wells are very closely spaced; for example, eighteen wells are reported to have been drilled on one section of land.

When pumpage is heavy in the Safford Valley, the water level declines, and the well yields decrease considerably. Therefore, enough wells must be available to provide an adequate water supply during such periods. Water levels generally rise in the winter, and during wet cycles the aquifers are completely replenished.

Principal sources of recharge are seepage from canals and irrigated lands, inflow from tributary washes, and movement from the older alluvium into the shallow alluvium. Other contributions to recharge include percolation from the Gila River when the water table is depressed by pumping.

The quality of water in the recent alluvium is dependent in large measure upon the source of recharge. During periods of heavy recharge from surface water, the mineralization of the ground water is lowest, but when most of the recharge is derived from the older alluvium and from side washes, the mineralization increases. Annual changes in dissolved mineral content amount to as much as 100 percent in some places. Although the over-all quality of the shallow ground water is not as good as in the Duncan Valley, it is useable in most parts of the Safford Valley.

A considerable amount of water is consumed by phreatophytes, plants which habitually draw water from the zone of saturation, along the flood plain of the Gila River. The loss of ground water in Safford Valley is estimated by the Geological Survey to be as much as 70,000 acre-feet per year. Destruction of the phreatophytes would increase the amount of water available to the flow of the river and for use on the land surface where phreatophytes now exist.

The older alluvium supplies water to wells at San Simon, Bowie, and Cactus Flat-Artesia in San Simon Valley, and in a few localities in the upper reaches of Safford Valley. The aquifers extend to several hundred feet in depth and are made up of lenses and layers of sand and gravel interbedded with clays and silts. The principal source of recharge to the aquifers of the older fill is seepage from streams on the outcrops of the permeable sands and gravels along the mountain fronts.

The yields of wells drawing from the older fill range from only a few gallons per minute to as much as 3,000 gallons per minute. Formerly, many of the wells were under sufficient artesian pressure to flow. The artesian head has declined 10 to 30 feet since 1915. The flow of most of the wells has gradually diminished, and in some cases has ceased completely. The gradual lessening of the head and flow of these wells is due to the development of a gradient toward points of withdrawal and does not necessarily mean

that the formation is being unwatered. The decline of pressure in these wells in 1951 was almost negligible. Sufficient data are not available to determine whether the artesian pressure in this aquifer will be progressively lowered if the present rate of withdrawal is not increased.

Indications are that the best quality of water in the older fill occurs in the upper reaches of the San Simon Valley and that the mineralization of the water becomes progressively greater down the valley to the northwest.

San Pedro Valley

The San Pedro Valley extends from the Mexican border in a northwesterly direction to the Gila River near Winkelman. The valley is a structural trough that is partially filled with alluvial material. The older alluvium has been incised by shallow stream channels which have been partly filled with recent alluvium. The continuity of the alluvial fill is at least partially interrupted by a series of rock exposures within the valley at the "Narrows", about 58 miles north of the Mexican border.

Ground water has been developed only to a minor extent and is obtained both from deep sands and gravels in the older alluvium and from shallow sands and gravels in the recent alluvium. Yields of the shallow wells range from about 500 to as much as 2,000 gallons per minute, and of the deeper wells from 400 to 1,000 gallons per minute. Development has occurred in several localities which are more or less regularly spaced along the San Pedro River from the Mexican border to the mouth of the valley. Although approximately 40,000 acre-feet of water was withdrawn from wells in 1952, essentially no decline of water levels was experienced.

The flow of the San Pedro River in its upper reaches is perennial, whereas in the lower reaches it is intermittent. Sufficient water is available to keep the water-bearing materials fully recharged and to supply a considerable growth of phreatophytes along the narrow inner valley. A large part of the valley is covered with thickets of mesquite and other phreatophytes, and the use of water by these plants probably exceeds the present use of water for irrigation.

Developments of additional irrigation from ground-water supplies would not necessarily affect the availability of water for discharge into Gila River. In most places, the phreatophytes would have to be removed in order to increase the irrigated area. The removal of the phreatophytes would result in a salvage of water for beneficial use on the irrigated area.

Upper Santa Cruz Valley

The Upper Santa Cruz Valley is the Arizona portion of a larger valley that extends from Mexico northward into Arizona for a distance of about 90 miles, terminating at the Rillito Narrows. The valley consists of a structural trough that has been partially filled by outwash material eroded from the surrounding highlands. The drainage is from south to north by the Santa Cruz River and its tributaries.

Productive water-bearing strata occur in the recent and older alluvium. The recent alluvium is best developed in the inner valley of the Santa Cruz and along the tributary valleys of Rillito Creek and Pantano Wash. It generally occurs to a depth of 75 to 150 feet but in some places is as deep as 300 feet. The wells yield from 150 to 3,000 gallons per minute. The older fill, which underlies the recent fill, extends to depths of at least 1,500 feet. Generally the water-bearing strata in the older fill are not as productive as those in the recent alluvium, but wells yielding as much as 500 gallons per minute have been developed. It is believed that additional drilling may encounter more productive aquifers in the deeper alluvium.

In 1952 about 1,000 wells were used for irrigation, over 100 for public water supplies, and a number for industrial purposes. According to data furnished by the Geological Survey the total pumpage in 1951 from the irrigation wells was about 140,000 acre-feet, and from the public supply and industrial wells it was about 50,000 acre-feet.

Recharge occurs principally from infiltration of rainfall into the coarse deposits along the mountain fronts, and seepage from channels of streams, and from irrigation ditches and cultivated fields. The older and recent deposits are hydrologically connected, and water moves from the older deposits into the recent deposits.

In Santa Cruz County the irrigable land, which lies within the narrow inner valley of the Santa Cruz River, is almost totally developed. Runoff in the river and from side washes furnishes sufficient recharge during wet cycles so that water levels in this area have not shown any persistent declines and probably will not do so in the future except during periods of extreme drought.

At the southern border of Pima County the inner valley widens and the requirements for irrigation,

public supply, and industrial uses in this area exceed the amount of recharge to the aquifers. Increases in the rate of pumping in several parts of this area have accelerated the declines of water levels in recent years. Since 1947 the decline has amounted to 15 to 20 feet in wells near Continental, Sahuarita and Tucson, and northwest of Tucson. The total decline near Continental and Sahuarita has been as much as 25 feet since 1932, and northwest of Tucson as much as 50 feet since 1910.

The decline to date has not seriously affected the economic operation of the wells for irrigation or other uses. If the decline continues, however, the highly productive shallow water-bearing formations eventually will be largely unwatered, resulting in substantial decreases of the yields of wells. At present an estimate cannot be made of the length of time involved in such a process. If the rate of pumping is not increased, the rate of decline will be retarded, but indications are that it will not cease entirely. The present rate of decline is somewhat less than that in the Lower Santa Cruz and Salt River Valleys.

Consideration has been given for a number of years to the possibility of artificially increasing the recharge to ground water in the Upper Santa Cruz Valley. Available data indicate that the most successful method would be to construct retention dams on the streams so as to regulate the flow of flood water and thereby increase the rate of percolation from the stream beds into the underlying water-bearing formations. Although such methods of artificial recharge would make additional water available to wells in the area, it appears that there is insufficient flood runoff to solve the ground-water problem in this manner.

The city of Tucson in the Upper Santa Cruz Valley is the largest city in Arizona depending entirely upon ground water for its supply. The pumpage from municipal wells in 1951 was about 15,000 acre-feet, and projected requirements for 1970 are about 22,000 acre-feet. Present plans of the City are to drill and equip a number of new wells located near Tucson. As water levels decline and as needs for additional supply increase, the City plans to extend its well fields to areas outside of its immediate vicinity. Potential sources have been investigated in the Avra-Altar Valley, in the San Pedro Valley, and in the valley of Canada del Oro. Undoubtedly these sources will supply the needed water. However, as the distance and number of wells increase, so will the cost of water increase.

The Upper Santa Cruz Valley is connected hydrologically with the Lower Santa Cruz Valley at the Rillito Narrows. Sources of water reaching the lower valley from the upper valley are runoff in the river during periods of floods, underflow, and water pumped in the Cortaro area which is carried by means of canals to lands northwest of the Narrows. Therefore, diversions of stream flow and pumping of ground water in the upper valley have some effect on the availability of water in the lower valley.

Lower Santa Cruz Valley

The Lower Santa Cruz Valley begins at the Rillito Narrows and extends to the Maricopa County line. It includes all of the irrigated land in Pinal County with the exception of San Pedro Valley and Queen Creek-Magma Area. It also includes the irrigated land in Pima County along the Santa Cruz below Rillito Narrows and in the tributary Avra Valley. The valley is subdivided into the Avra-Marana district, Eloy district, Casa Grande-Florence-Sacaton district and Maricopa-Stanfield district.

Most of the streams do not maintain permanent channels through the valley into its lower reaches. Flood waters spread over wide areas when the flow is too great to be intercepted and used for irrigation. All streams except the Gila River are intermittent and flow only during and immediately after floods.

The Gila River enters the valley through a gorge in the mountains northeast of Florence and flows across the northern part of the area. In its approaches the river is a continuously flowing stream, and it maintains a permanent channel through the valley. The normal flow is diverted into canals at the Ashurst-Hayden and Sacaton dams. In the extreme northwestern section the river intersects the water table and derives flow from ground water discharged into the channel.

The Lower Santa Cruz Valley occupies a series of interrelated and interconnected structural troughs, with mountains interspersed between. The thickness of the alluvium ranges from a few feet in areas overlying buried mountain ridges to several thousand feet near the centers of the troughs. The alluvium is made up of layers and lenses of clay, silt, caliche, sand, and gravel which vary in thickness and character from place to place. The most prolific water-bearing materials are the sands and gravels. Indications are that the deeper sands and gravels may be more consolidated and less permeable and, therefore, less productive than the shallower beds. The deeper alluvium, however, supplies large quantities of water to deep wells in some localities.

The water-bearing formations appear to be directly or indirectly interconnected to form one common

hydrologic system. Although there is a differential in the elevation of water levels between some shallow and deep wells, there is no evidence to show that the deeper formations receive any material recharge from sources outside the valley. Only relatively small quantities of deep-seated thermal waters enter the alluvium along faults in the bedrock. The deeper and shallower alluviums receive water from side washes and mountain slopes and are at least partially interconnected in these areas.

The alluvial material underlying the Lower Santa Cruz Valley is continuous into the Salt River Valley on both sides of Salt River Mountains and east of Santan Mountains. With the exception of the locality northwest of Florence, however, the irrigated areas of the two valleys are separated by the Salt River and Santan Mountains and uncultivated lands of the Gila River Indian Reservation. This separation has thus far prevented any material interference between wells in the two valleys.

Irrigation from wells in the Lower Santa Cruz Valley was begun about 1900 and expanded rapidly during the 1930's. According to the Geological Survey the total amount of water pumped in 1941 was about 350,000 acre-feet. In 1942 it was 500,000 acre-feet, which rate was more or less maintained during the war years. Following the war, irrigation was materially expanded, and in 1949 the total pumpage was over 1,100,000 acre-feet; since that time it has not increased appreciably. In 1952 about 1,500 irrigation wells were in use in the three districts of Pinal County and about 90 wells in the Avra-Marana district of Pima County.

All of the irrigated lands in the valley have been designated in critical areas by the State Water Commissioner with the exceptions of the Avra-Marana district and the Indian reservations. With these exceptions, expansion of irrigation in the valley has essentially stopped. The Gila River Indian Reservation and the Maricopa Indian Reservation include large blocks of land yet undeveloped in the northern part of the valley. Development of the ground water in these areas will affect water levels in adjoining areas.

Sources of recharge are surface-water flow and underflow of tributary streams and washes, seepage from surface-water irrigation in the San Carlos Project and from ground-water irrigation, precipitation within the area, and subsurface fault springs. Estimates of the amount of recharge to the entire valley and to its subdivisions have been made by various investigators. Although these estimates are based on but few quantitative data and vary over a wide range, all are in agreement that the recharge is small in comparison to the volume of water withdrawn from wells.

The principal natural ground-water discharge is water consumed by phreatophytes and flow of ground water into the Gila River in the northwestern part of the area. The Geological Survey estimates the use of water by phreatophytes between Sacaton and a point just southwest of Laveen in Maricopa County to be about 100,000 acre-feet per year. The water thus consumed could be partially salvaged by destroying the phreatophytes. The salvaged water could be beneficially used on lands from which the phreatophytes were expelled and on lands downstream. It could not benefit the heavily developed upstream areas unless the water could be pumped economically up the valley to these areas.

The quality of water is acceptable for irrigation with the exception of local areas west of Coolidge, west of Casa Grande, and along the Gila River in the northwestern section. In the Coolidge and Casa Grande areas the highly mineralized water may be coming from buried springs in the bedrock or from layers of salt or gypsum occurring in the alluvium. In the northwestern section the use of water by plants probably has concentrated the minerals in the ground water.

The quality of ground water is not expected to change very rapidly. However, as much more water is being used for irrigation than is being discharged from the valley, the salt content of the water is gradually increasing. Although in years to come this process may result in a serious problem through the lower parts of the valley, it is thought, however, that, at least for many years, it will not be as serious a factor in irrigation as the decline of water levels in wells.

The following section includes a description of ground-water conditions and a discussion of major problems in the four districts of the valley.

Avra-Marana District

Productive water-bearing sands and gravels in the younger fill occur to depths of as great as 800 feet in the Avra-Marana district. Recent test drilling shows that permeable strata in the older fill occur to depths of at least 1,950 feet. Yields of irrigation wells range from about 500 to over 4,000 gallons per minute, and the depth to water ranges from about 100 to 350 feet, averaging about 200 feet.

Pumpage in 1941 was almost negligible, in 1950 was about 25,000 acre-feet, and in 1951 was 80,000

acre-feet. An additional increase was experienced in 1952. The decline of water levels between 1940 and 1952 ranged from a negligible amount in the southern part of the Avra Valley to about 30 feet southeast of Marana. A large part of the declines have occurred in the last 2 years.

The Avra-Marana district adjoins the Eloy district, which has been designated a critical area. Inasmuch as the two districts are hydrologically interconnected, pumpage in one affects water levels in the other. Therefore, pumpage outside of the critical area is causing declines of water levels within the critical area.

The only immediate problem in the Avra-Marana district is that water levels will continue to decline at increasing rates as pumpage in the area increases. This means that greater pumping lifts will be experienced in the future. If pumping is not increased materially, the declines will continue but at a retarded rate.

Eloy District

Productive water-bearing sands and gravels occur in the Eloy district to depths of at least 1,100 feet. Although the alluvium is known to extend to much greater depths, very few data are available on the deeper water-bearing formations. Yields of wells range up to at least 3,000 gallons per minute and average about 1,200 gallons per minute. Depth to water ranges from about 100 to 300 feet and averages about 175 feet.

Heavy pumping began in the mid-1930's. In 1941 the withdrawals amounted to about 150,000 acre-feet, in 1949 about 420,000 acre-feet, and in 1950 and 1951 about 380,000 acre-feet. Since 1935 water levels in the central part of the district have declined as much as 130 feet; the rate of decline since 1941 has been almost constant, averaging about 10 feet per year. Along the outer edges of this district, except to the north, the total decline in the last 10 years has been in the order of about 20 feet. The average decline for the entire district in 1951 was about 7½ feet.

Although the pumpage during the last 3 years has been maintained at a more or less constant amount, the rate of decline in water levels has not decreased appreciably. If the present rate of pumping is maintained in the future, the decline will continue but the rate may decrease somewhat.

The two major problems in the district resulting from the general decline in water levels are the decrease in yields of the shallower wells, due to the gradual unwatering of the shallow sands and gravels, and the lowering of pumping levels in all wells. The first is being solved partially by a general program of drilling wells to depths of 600 feet or more, which in most cases has restored the former yields.

Casa Grande-Florence-Sacaton District

The Casa Grande-Florence-Sacaton district adjoins the Eloy district on the north. The irrigation development and the underlying water-bearing formations are continuous between the two districts.

Pumping from wells was begun about 1900. In the early 1930's the San Carlos Irrigation Project, which is within the district, began operating and developed a supplementary supply of water from wells. In 1940 the pumpage in the district was 160,000 acre-feet, in 1948 was 330,000 acre-feet, and since that time has shown a slight decrease. Pumpage from wells of the San Carlos Irrigation Project in 1951 was about 100,000 acre-feet, or a little less than one-third of the total in the district.

The alluvium is relatively shallow in parts of the district, including localities along the Gila River near Florence and west of Casa Grande. In the Coolidge area thick clays occur at depths of less than 400 feet and in a few places less than 300 feet. A number of wells drilled to several hundred feet in the clay series have not completely penetrated its total thickness. One well was drilled to a depth of 2,600 feet without penetrating it. Exploration in other parts of the area, however, may encounter water-bearing formations below the clay.

The yields of wells range up to more than 3,000 gallons per minute, although the average is less than 1,000 gallons per minute. The depth to water in the wells ranges from about 30 feet near the Ashurst-Hayden Dam to over 140 feet east and southeast of Coolidge. The average depth to water is about 75 feet. Declines of water levels during the last 10 years range from about 10 feet along the eastern and northern edges to about 70 feet in the southern section adjoining the Eloy district. The average decline has been about 20 feet or less near Sacaton and between 30 and 40 feet between Casa Grande and Florence. Although water levels rose in 1951 in some wells due to local reductions in pumpage, the average decline for the district during the year was about 6 feet.

As a result of the general lowering of water levels, the yields of shallower wells have gradually decreased. Due to the presence of shallow clay or bed-

rock in most localities, it has not been practicable to deepen the shallow wells. This continuing decrease in yields of the wells, together with the high mineralization of water west of Casa Grande and Coolidge, has created a serious ground-water situation. If the present rate of pumping is maintained, water levels will continue to decline and yields of the shallow wells will continue to decrease. It seems imperative that exploration should be made to determine the possibility of obtaining additional water from the deeper alluvium.

The San Carlos Irrigation Project, which is within this district, obtains the major portion of its water from the San Carlos reservoir on the Gila River. Although lands within the project have suffered a severe water shortage in the last several years, pumping from private wells within its boundary has been prohibited by project rules. In some places, however, the shortage of water has been partially alleviated by pumpage from outside private wells which has been transported through canals to lands within the project.

Maricopa-Stanfield District

The Maricopa-Stanfield district lies west of the Sacaton Mountains and adjoins the Eloy and Casa Grande-Florence-Sacaton districts on the west. Geologic conditions are similar to those in the Eloy district with productive sands and gravels occurring to depths of at least 1,200 feet. Along the eastern and western edges, however, bedrock has been encountered at shallow depths.

Wells yielding over 3,000 gallons per minute have been reported, and the average yield in 1952 was about 1,500 gallons per minute. Depths to water range from about 30 feet near Maricopa to over 300 feet in the southwestern section, with an average depth of about 145 feet.

In 1940 the pumpage was about 70,000 acre-feet, in 1946 was 150,000 acre-feet, in 1949 was 360,000 acre-feet, and it has remained essentially the same since that time. Declines in water levels in the last 10 years in the central and southern sections have been as much as 70 feet, but in the northern section they have averaged only about 20 feet. The average decline in 1951 for the entire district was about 8½ feet.

Inasmuch as there is insufficient recharge to supply all the withdrawals, the decline of water levels will continue. However, as a result of the more or less constant rate of pumping during the past few years, the rate of decline should decrease somewhat.

The decline of water levels has caused a decrease in the yields of some shallow wells, but the yields have been restored in most of these wells by deepening. The major problem in the Maricopa-Stanfield district is primarily the increase in pumping lifts. The water levels may decline many more feet before a serious problem of decreasing well yields is created.

This district is connected hydrologically with the adjoining Eloy and Casa Grande-Florence-Sacaton districts. Consequently, withdrawals from wells in any of the three districts will have some effect on water levels in the others.

Salt River Valley

Salt River Valley, which adjoins the Lower Santa Cruz Valley, is the most intensively developed area in the state. Over twice as much land is irrigated in this valley as in the Lower Santa Cruz Valley.

As pointed out in a previous section, water-bearing formations in the two valleys are hydrologically connected in several wide areas, although in these areas the irrigation developments are largely separated by the Gila River Indian Reservation.

At one time the Salt River contributed the major flow of the Gila River system. Today, with the exception of very rare flood flows, all of its water is diverted for irrigation in the valley. The flows of streams entering the valley below Granite Reef Dam are small, and with the exception of the Gila and the Agua Fria, have not yet been developed. The Gila River enters the valley in the extreme southwestern portion as a flowing stream and receives a small amount of ground-water discharge from the valley.

The valley is made up of a series of troughs created by structural processes, that are geologically related to those of the Lower Santa Cruz Valley. Although few specific data are available on the delineation of these troughs, apparently they are regional in extent and complex and intricate in nature. The major trough or troughs are continuous through the area and vary considerably in depth and width. In general the walls of the troughs are extremely steep. The alluvium filling these buried structures is known to extend in places to depths of more than 4,000 feet. Near the mountains and where a few buried ridges are near the surface, it is much shallower. The materials making up the alluvium consist of clay, silt, caliche, sand and gravel, which vary over wide ranges in thickness, permeability and texture.

In previous investigations the alluvium has been divided into the older and the younger alluviums.

The younger alluvium, which is generally considered to be more permeable, extends to depths of about 700 to 1,000 feet throughout a large part of the valley. In the area between Phoenix and Litchfield Park a thick clay occurs between the younger and older alluvium. This clay mass, with an average thickness of about 700 feet, is encountered at depths between 300 and 700 feet.

Irrigation in the Salt River Valley began before 1900 and received a major impetus in 1903 when the Salt River Valley Water Users' Association was formed. Since that time a number of other irrigation districts have been created, and a large amount of private development has come into existence. At first, most of the lands were irrigated with surface water. By the late 1920's, however, most of the available surface water had been developed, and additional irrigation since that time has depended largely on ground water. The greatest use of surface water recorded in the area was in 1920 when nearly 1,400,000 acre-feet was diverted at the Granite Reef Dam on the Salt River. In recent years the maximum diversions at Granite Reef Dam occurred in 1937 and in 1941, amounting to about 1,250,000 acre-feet. In 1951 less than 550,000 acre-feet was diverted. The sum of the diversions in 1951 from the Agua Fria River to the Maricopa County Municipal Water District and from the Gila River to the Buckeye Irrigation Canal was only 35,000 acre-feet. More surface water was available in 1952, but the total diversions are not yet known.

The total pumpage of ground water in the valley in 1904 was estimated at less than 35,000 acre-feet. From that time to 1920 seepage to the ground water from irrigated lands and canals caused larger and larger areas of land to become waterlogged. In 1913 the water table was within 10 feet of the surface in about 12 percent of the Salt River Project, and in 1920 it was within 10 feet of the surface in about 31 percent of the Project.

In 1918 the Association decided to develop wells to withdraw about 200,000 acre-feet of water per year for drainage purposes and for supplemental irrigation. The development of wells for these purposes proceeded rapidly. The Asosciation in 1951 pumped 450,000 acre-feet.

In addition to the development made by the Association, development commenced outside of the boundaries of the Salt River Project. Wells were drilled near the White Tank Mountains on the west, in the Buckeye Area, and in the Queen Creek Area. The more recent developments have been in the Queen Creek-Magma Valley, Deer Valley and Paradise Valley. Pumping from wells has increased steadily throughout the Salt River Valley. In 1930 about 500,000 acre-feet was pumped in the Salt River Valley. By 1942 the amount pumped per year had increased to over 1,000,000 acre-feet, and in 1951 it was 1,900,000 acre-feet.

In 1951 approximately 1,500 irrigation wells were in use in the Salt River Valley. Although a considerable number of public supply, industrial, and domestic wells were also in use, the total withdrawals from them were small in comparison to the irrigation use. Most of the water supply for the City of Phoenix is obtained from the Verde River and from shallow wells and an infiltration gallery within its flood plain.

Recharge, in the order of importance, is derived from the following sources: deep percolation from irrigation and canal seepage, recharge from stream flow in the Salt River and the minor washes, underflow of the streams, rainfall on the land surface, and buried springs in the underlying bedrock. By far the most important of these is the irrigation and canal seepage. The amount of recharge fluctuates from year to year depending upon climatic conditions, the acreage irrigated and other factors. Many studies have been made of the amounts of the recharge. The most reliable data obtained in these studies concerns the recharge from the irrigation and canal seepage, which makes up the major part of the total.

Natural discharge leaves the Salt River Valley by means of ground-water seepage into the Salt and Gila Rivers near the southwestern edge of the valley, by transpiration of water by phreatophytes along the Salt and Gila Rivers in that locality, and by ground-water underflow out of the valley. The amount of underflow through the formations has never been estimated, but probably is quite small. The amounts of water flowing into the Gila River and being used by phreatophytes have been estimated to be less than 150,000 acre-feet per year during the last several years, though formerly the amounts were larger.

In theory, if the recharge and the natural discharge can be maesured, the difference may be taken to represent the amount of water which can be withdrawn from the ground-water formations without perennially lowering the water levels in wells. Unfortunately, however, recharge and natural discharge are never distributed over an area in the same proportion as pumping. Serious local problems can develop even where recharge and natural discharge are in balance with the areal pumping. Additional

quantitative studies must be made before sufficient knowedge is obtained of the recharge and natural discharge of the water-bearing formations in the Salt River Valley. Little has been done to study local details, although estimates have been made by various agencies concerning the difference between recharge and natural discharge for the valley as a whole. Because of lack of specific data and sufficient analysis, even the areal estimates, which are the best available at this time, are considered to be accurate only in the general order of magnitude. Such estimates for recent years of the difference between recharge and natural discharge have roughly amounted to the equivalent of about ⅓ of the sum of the amount of water diverted from the streams and the amount of water pumped from wells.

Pumping from wells exceeded the difference between recharge and natural discharge early in the 1920's, when drainage of the water-bearing formations was commenced. By the early 1930's the water level in the formations had declined substantially as a result of this drainage. The rate of decline was greatly reduced during the mid-1930's because of less ground-water pumpage resulting from plentiful surface water and less need for drainage. However, since 1937, with the exception of the unusually wet year of 1941, pumpage has been relatively large and water levels have continued to decline. The decline has been accelerated since 1946, owing to the relative scarcity of surface-water supplies and to the large expansion in irrigated acreage.

Because thousands of records of water-level measurements are available, it is possible to discuss the declines of water levels by sub-areas, even though pumpage and other pertinent data are incomplete.

The Salt River Valley Water Users' Association has averaged the depths to water levels for the entire Project area. In 1903 the average depth to water inside the Project boundaries was about 48 feet. By 1913 it had risen to 24 feet, and in 1918 to 15 feet. Then began a gradual decline. The level was 17 feet in 1924, 37 feet in 1930, 37 feet in 1937, and 50 feet in 1940. The level rose to 38 feet in 1941 and 1942, then declined to 54 feet in 1947, and to 95 feet in 1951. A slight rise may be in prospect for 1952.

According to the Association's records, the average water level in 1945 was about the same as in 1903. Since that time it has been lowered about 45 feet. The amounts of local decline have been the greatest in the areas between Mesa and the Roosevelt Water Conservation District, and near Deer Valley. They were least in the local area just northeast of Phoenix and in the southwestern part of the project near the junction of the Salt and Gila Rivers. In the area near Deer Valley, for instance, the decline in one well was 85 feet between 1944 and 1951, whereas in a well near the junction of the Salt and the Gila Rivers it was only a little over 5 feet between 1944 and 1951. In a few places water levels in 1951 were higher than in 1903.

The decline of water levels in wells of the Roosevelt Water Conservation District between 1942 and 1951 ranged from as much as 100 feet or more in the northern section to about 50 feet in the southern section.

Records are not available for the full period since beginning of irrigation in the Queen Creek-Magma area, but those available indicate that the declines since 1940 have ranged from about 20 to 80 feet. Most of the declines in the Queen Creek section occurred after 1945, and in the Magma section after 1948.

The declines of water levels in Deer Valley have been large, with the greatest occurring in the eastern section. The decline in one well amounted to 130 feet between 1942 and 1952. In another, it amounted to 80 feet between 1946 and 1952.

In the Litchfield-Beardsley-Marinette area the declines from 1930 to 1952 averaged about 70 feet, with about 40 feet of this occurring after 1946. Declines were least in the area south of Litchfield Park.

The Liberty-Buckeye-Hassayampa area has experienced the least declines in the valley. This area is in the lower end of the valley. The natural underflow moving out of the valley is constricted between mountains, causing some water to discharge into the Gila River. The river, therefore, has a controlling effect on the water levels and limits the range through which they fluctuate. From 1930 to 1945 the average water level rose about 10 feet, and between 1945 and 1952 it declined about 10 feet. Thus, the levels in 1930 and 1952 were about the same.

Most of the waterlogged land in the valley is in this area. In 1930 0.3 percent of the land within the Salt River Project was underlain by water at depths of less than 10 feet, and in 1945 0.2 percent. For the Salt River Valley as a whole, the percentage was 2.5 in 1930 and 2.4 in 1945.

In those areas in the Salt River Valley where water levels have declined substantially, the yields of the shallower wells have decreased. Many wells have

been deepened. The effects on yields analyzed to date are not conclusive. In some wells deepening has restored the original yields, whereas in others the deeper formations were less permeable and produced little additional water. In a few places the bedrock is too shallow to permit much deepening. In the area between Phoenix and Litchfield Park the shallow position of the thick clay body has made it impracticable to deepen many of the wells.

The shallower wells should be deepened wherever practicable in order to preserve their yields as the water levels decline. Moreover, additional exploration should be conducted of the deeper alluvium. If productive water-bearing strata are found in the deeper alluvium, separated from the shallower beds by thick clays, the water pumped from the deeper beds will materially improve local conditions. It will not represent a new supply to the valley, though, because the shallow and deep aquifers obtain their water from the same source.

In recent years several serious quality-of-water problems have occurred in the valley because a balance no longer exists between the amount of dissolved minerals carried by water entering the valley and the amount leaving the valley. The problems have been aggravated by the pumping of fairly highly mineralized ground water and its distribution over wide areas. These problems are most serious in the area of the Buckeye Irrigation District and the Roosevelt Irrigation District. The mineral content of the water in the Buckeye Irrigation District wells increased from an average of 1,300 parts per million in 1930 to 4,100 parts per million in 1952.

Serious salt problems also exist in localities near the junction of the Salt and Gila Rivers, south of the Salt River Mountains, and a few miles southeast of Chandler. The problems are being accentuated in some places where local cones of depression have developed in the water level, so that ground water no longer flows out of the localities. Thus, all salts brought in by irrigation water are left to accumulate in these localities.

The salt problems must of necessity continue to increase in severity until some means is found to balance the salt discharge with the salt intake of the various sections. In most of the Salt River Valley the salt problems probably will not become a limiting factor ahead of the declining water level. In general, however, the salt problems will first reach their maximum severity in the lower end of the valley, where the least declines of water levels will occur.

Water is consumed by non-beneficial phreatophytes along the Salt and Gila Rivers in the southwestern portion of the valley. Phreatophytes also exist above Granite Reef Dam in the flood plains of the Salt River and the Verde River. The Geological Survey has estimated the transpiration in the Salt River and Gila River channels below Granite Reef Dam to be about 70,000 acre-feet per year. Destruction of the phreatophytes in this section would salvage some of this water for use downstream or on lands now occupied by the phreatophytes. It would have little benefit to the supply in other parts of the valley unless the water could be pumped up the valley. Destruction of the phreatophytes above Granite Reef Dam would make additional surface water available at Granite Reef Dam.

With the exception of the Indian reservation and the lowermost end of the valley west of Buckeye, the entire Salt River Valley has been declared a critical area by the State Water Commissioner. As a result, development of new lands has largely stopped. Many new wells have been drilled, however, to augment the existing surface and ground-water supplies.

Unless there should be a radical change for the better in climatic conditions, which is unlikely, there appears to be no possibility of alleviating the principal problems of the Salt River Valley without major action. The amount of water being pumped is substantially greater than the recharge from all sources; in other words, a substantial amount of water is being drawn from ground-water storage. If the surface-water supplies should improve to the extent that surface-water diversions woud be equivalent to the maximum that has been historically made, ground-water conditions within the Salt River Project and the other surface-water areas would materially improve. However, the major part of the withdrawals of ground water to supply those areas to which surface water is not available would continue to come from storage, and the total amount of ground water pumped still would exceed the net recharge to the entire valley. If the pumping does not continue to increase, the decline in water levels may be retarded somewhat, but the decline will certainly continue at a substantial rate unless pumping is materially reduced. Furthermore, the areas adversely affected by salt water will increase in extent. Deepening of wells will be of benefit in some localities, but will not make more water available to the valley as a whole.

Waterman Wash Area

The Waterman Wash Area, southeast of Liberty and Buckeye, is a small enclosed valley on the south side of the Gila River that probably was formed by

down faulting between surrounding mountains. Waterman Wash drains the valley and flows across bedrock at the eastern end of Buckeye Hills. According to the Geological Survey the parent rock, which encloses the valley, prevents subsurface drainage from the area.

The alluvial fill is made up of sand, gravel, silt and clay and has a proven depth in some places of between 1,200 and 1,300 feet. The alluvium shows extreme variations in the character and continuity of the individual strata.

Development of this area began in the last few years, and in 1952 about 3,500 acres were irrigated. Yields of wells range as high as 3,500 gallons per minute. Depths to the water table are in general 200 feet or less. Recharge to the alluvium comes principally from runoff in the washes and from seepage from cultivated lands. There is no evidence to show that water enters the valley from outside areas. Although no quantitative measurements have been made of the amount of recharge, preliminary studies indicate that the amount is small, that most of the pumped water is being taken from storage, and that water levels can be expected to decline progressively with time.

The quality of water is satisfactory for irrigation. The mineralization can be expected to become more concentrated as a result of transpiration and the absence of a subsurface outlet from the valley.

This comparatively small valley has sufficient irrigable land for additional developments. However, as most of it is owned by the state and federal governments, it is quite possible that the controlling agencies may restrict further development if they decide that insufficient ground water is available for perennial irrigation.

Centennial Wash Area

Centennial Wash enters the Gila River just above Gillespie Dam and drains a long narrow area that includes McMullen Valley and Harquahala Plain. Small areas are being irrigated with ground water a few miles southeast of Salome, farther down stream in the Harquahala Plain, and along the wash near its junction with the Gila River.

All of this irrigation has been developed quite recently, and few data exist concerning the availability of ground water. Wells have been drilled to depths of at least 1,300 feet and yield as much as 3,000 gallons per minute. Depths to water in the upper ends of McMullen Valley and Harquahala Plain are several hundred feet. In the lower ends of both areas, however, depths to water become shallower. The rate of recharge has not been investigated, but appears to be relatively small.

Gila Bend Area

The Gila Bend Area lies along the Gila River, beginning at Gillespie Dam and ending at Painted Rock Mountains. This area is immediately downstream from Salt River Valley and receives a small amount of underflow and runoff from Salt River Valley.

Ground water has been developed for irrigation principally in two localities—in Rainbow Valley just southeast of Gillespie Dam, and along the Gila River about 10 miles northwest of the town of Gila Bend.

Development began in the lower part of Rainbow Valley in 1937, although most of the wells in the upper part of the valley have been drilled in the last few years. Part of the water pumped in the lower part is delivered into Gila Bend Canal, mixed with surface water from Gillespie Dam, and carried to an area north and northwest of the town of Gila Bend.

According to data furnished by the Geological Survey, the pumping in the entire Gila Bend area in 1948, 1949 and 1950 was about 60,000 acre-feet per year, and in 1951 was slightly over 100,000 acre-feet.

Water-bearing formations occur in the valley alluvium, which has been only partially explored. Wells northest of Gila Bend average about 500 feet in depth and yield about 1,800 to 3,000 gallons per minute. The wells northwest of Gila Bend average about 350 feet in depth and yield about 2,000 to 3,000 gallons per minute. Depths to water near the river are relatively shallow but increase towards the mountains.

In the lower part of Rainbow Valley the decline of of water levels since 1937 has been about 20 feet, and during the last few years has averaged between 1 and 2 feet per year. The water level has not declined appreciably in the rest of the Gila Bend Area.

The mineralization of the ground water is comparatively high, although the quality is better than that of surface water from Gillespie Dam. Ordinarily the surface water is diluted with ground water to make it more suitable for irrigation. The annual diversion of surface water in 1949, 1950 and 1951 was less than 40,000 acre-feet.

The principal sources of recharge in the Gila Bend area are flow in the Gila River, seepage from canals and irrigated lands, runoff in washes from adjacent mountains, precipitation on the land surface, and underflow from Salt River Valley. The largest amounts are derived from surface flow and from seepage from canals and irrigated lands. Rare floods on the Gila probably contribute major amounts.

The natural discharge from the valley includes surface flow, underflow, evaporation and transpiration. The Geological Survey estimates that surface flow and underflow are small but that evapo-transpiration probably ranges from about 25,000 to 50,000 acre-feet per year.

In general, ground-water supplies have not been seriously depleted in this area. However, should the development continue to increase, depletion may occur, especially if long periods of drought are combined with heavy pumping. The mineralization of the ground water may increase due to the combined use of water by crops and non-beneficial phreatophytes.

Area Between Gila Bend Area and Wellton-Mohawk Project

During the last few years ground water has been developed in several small localities between the Gila Bend Area and the Wellton-Mohawk Project. It has been estimated that in 1952 about 3,000 acres were in cultivation north of Agua Caliente on the Palomas Plain, about 2,000 acres along the river bottoms below Painted Rock Dam site, and about 600 acres in the vicinity of Aztec. Very little information is available on these developments. The wells draw from the alluvium and apparently have satisfactory yields. The water table is shallow along the flood plain, but is as much as several hundred feet deep away from the river towards the mountains.

Wellton-Mohawk Area

In the last few years, between 40,000 and 50,000 acre-feet per year of ground water has been pumped in the Wellton-Mohawk Area from shallow wells in the alluvial fill near the Gila River. Most of the wells are less than 200 feet deep, and many are less than 100 feet deep. The yields range from about 500 to 4,000 gallons per minute. Water levels have gradullyy declined. The greatest decline since 1945, totaling about 10 feet, has taken place in the vicinity of Roll. The average pumping lift in the area is about 40 feet.

Recharge is from runoff and underflow in the Gila River and its tributaries, and irrigation seepage. Before pumping began in the area a considerable amount of water was transpired by non-beneficial phreatophytes along the river channel. Lowering of the water table has resulted in a decrease in the use of water by these phreatophytes. The total natural discharge, including some underflow along the river channel through the narrows near Dome, probably amounts to only a few thousand acre-feet per year.

Highly mineralized ground water has occurred in this area for many years. Moreover, studies in 1946 indicated that the mineral content had been increasing rapidly in recent years. Analyses of water from 74 wells in 1946 reveal dissolved mineral contents ranging from 1,120 to 16,500 parts per million, and only a few analyses show less than 2,000 parts per million. The ground water in a large part of the area contains over 4,000 parts per million of dissolved minerals.

Although the quality of water problem has become increasingly serious in the past few years, it soon will be largely solved by the Wellton-Mohawk surface-water project of the Bureau of Reclamation. In the spring of 1952 part of the canal system of this project was completed and some Colorado River water was being brought into the area. According to plans, by 1960 a total of 75,000 acres will be irrigated in this area by 300,000 to 400,000 acre-feet per year of surface water from the the Colorado River. Most of the lands presently irrigated by ground water will be irrigated with surface water. All indications are that the seepage from irrigated lands will build up the water table, thereby necessitating a program of drainage. Eventually the quality of the ground water may be improved by dilution with surface water.

At some time in the future, if the demand for additional irrigation should become sufficiently great, wells may again be used for irrigation in this area. Emphasis then may shift from drainage wells to irrigation wells, and a ground-water situation similar to that of the Salt River Valley in the 1920's may come to exist.

South Gila Valley

The South Gila Valley lies just south of the Gila River near its junction with the Colorado River at Yuma. Ground water is obtained from sands and gravels underlying the river alluvium to depths of about 100 feet. The Geological Survey states that in 1951 about 62,000 acre-feet was pumped from wells. Water levels, however, rose in 1951 as the result of the use of surface water for irrigation in

parts of the valley. Indications are that wells in this area are supplying water a good quality in sufficient amounts to supply present demands.

Little Chino Valley

Little Chino Valley lies a few miles north of Prescott and is tributary of the Verde River. Although this valley is within the drainage area of the Salt River, it is described separately because ground-water conditions are entirely different from those in the desert region. Except for water-level measurements and chemical analyses, studies made in this area have been of a reconnaissance nature, and little is known of the recharge and natural discharge of ground water.

Moderate-scale irrigation was begun before 1930 when the first artesian well was drilled. Since 1930 the number of artesian wells has increased considerably, and at present about 4,000 acres are irrigated by wells. The water-bearing formations from which the wells draw are porous lava flows encountered at depths ranging from about 200 to 1,000 feet. These lava flows are overlain by relatively impermeable alluvial materials which act as confining beds. Most of the wells supply water under artesian pressure, but only those in the lower part of the valley have sufficient pressure to flow. Surface elevations are the chief determining factor as to whether the wells have a natural flow. In areas of lower elevation the artesian head is in excess of 50 feet above the surface, whereas at higher elevations the water level is as much as 200 feet below the surface. The water levels are essentially at the same elevation, exhibiting a small gradient to the north.

The quality of the water is excellent, and some wells yield over 2,000 gallons per minute. Due to the gradual increase in the rate of withdrawal of ground water, the water levels have declined at an accelerated rate. From 1938 to 1952 the total decline was over 25 feet. In areas of heaviest withdrawal, water levels are lowered as much as 40 feet during the pumping season.

Data are not available upon which to reach conclusions as whether the declines in water level will continue indefinitely if no further increases in pumpage occur.

WILLCOX AND DOUGLAS AREA - SULPHUR SPRINGS VALLEY

Willcox and Douglas Areas comprise the Sulphur Spring Valley which lies in a long structural trough between mountains. The northern three-fifths of the valley is known as the Willcox Area and has no exterior drainage. The southern two-fifths is known as the Douglas Area and drains into Whitewater Draw which flows into Mexico.

The alluvium, which partly fills the structural trough, extends to depths of at least 1,600 feet in some places. It is made up of clays and silts containing interbedded and interfingered lenses of sand and gravel and a few lava flows. Water in the deeper sands and gravels occurs under artesian conditions, and some of the deeper wells flow. Irrigation from ground water began soon after 1900.

Recharge to the aquifer is from runoff along the mountain front, seepage from irrigation water, precipitation within the valley, and possibly from upper seepage along subsurface faults.

In the Willcox Area between 1945 and 1951 the pumpage increased from 8,000 to 38,000 acre-feet per year. The irrigated acreage in 1951 totaled about 14,000 acres, of which 11,000 acres were in the northern Stewart district and about 2,000 acres in the southern Kansas Settlement district. About 170 irrigation wells were in operation in the area in 1951. The yields ranged from 100 to 3,000 gallons per minute, and the pumping lifts from 80 to 150 feet. In the Stewart district the depths of wells average about 200 feet. In the Kansas Settlement district the older wells are from 100 to 200 feet deep, but more recent wells have been drilled to depths of from 500 to 750 feet. The deeper wells have the highest yields

From 1910 to 1946 water levels in the area declined 10 to 25 feet. Between 1946 and 1951 the average decline in the Stewart district was about 10 feet and in the Kansas Settlement district about 2 feet.

The Willcox Area has no exterior drainage of ground water or surface flow. The Willcox Playa is the principal area of natural discharge, and large quantities of ground water are evaporated from the playa or consumed by non-beneficial plants along its edges. This evapo-transpiration has been estimated at various amounts ranging from 20,000 to over 100,000 acre-feet per year.

In the Douglas Area, the pumpage between 1946 and 1951 increased from about 7,000 to 37,000 acre-feet per year. In 1951 about 270 wells were used to irrigate about 14,000 acres. Depths of wells range from 50 to 650 feet, and yields range from 100 to 2,000 gallons per minute. Depths of static water levels in 1951 averaged about 50 feet, and the pumping lifts averaged about 100 feet.

The decline of water levels between 1910 and 1946 was about 10 feet. Between 1946 and 1951, it was about 7 feet.

Natural discharge of ground water in the Douglas Area occurs as transpiration by phreatophytes along Whitewater Draw, underflow into Mexico, and small surface flows through Whitewater Draw. The consumption of water by phreatophytes has been estimated not to exceed 10,000 acre-feet per year, but estimates of the underflow have not been made.

The quality of water in the entire valley generally is acceptable for irrigation. The accumulation of highly mineralized water has been greatest in the vicinity of the Willcox Playa, but it has not extended into the pumped areas.

The yields of some of the shallow wells in the valley have decreased somewhat as a result of the decline of water levels, but the decreases so far experienced have not seriously affected the availability of water for irrigation. If the present rate of pumping is maintained in the valley, the decline of water levels will continue at least for a few years, but may not continue indefinitely at the present rate, owing to the possibility of intercepting the natural discharge as the water levels are lowered. More definite conclusions regarding this must await further investigation.

RANEGRAS PLAIN AREA

During the past several years a small area, known as the Bouse country, has been developed for irrigation in the Ranegras Plain of northern Yuma County. Ranegras Plain is drained by Bouse Wash which flows into the Colorado River about 100 miles upstream from Yuma.

Ground water is obtained from sands and gravels in the alluvial fill. In July 1952 there were 17 wells in use, and approximately 6,000 acres of land had been cleared, of which 4,000 acres were under cultivation. The wells range in depth from about 500 to 1,500 feet and yield from about 500 to 2,000 gallons per minute. The depth to the water table is about 30 feet near Bouse, but gradually increases upstream. Measurements since 1949 show some decline in water levels in the vicinity of the irrigation wells. Although the water is comparatively high in mineralization, it has been used for irrigation without apparent harm to the land.

Recharge is probably derived from runoff from rainfall, underflow of Butler Valley adjoining the Ranegras Plain, and seepage from irrigation. Natural discharge occurs as underflow from the valley near Bouse and a small amount of transpiration by mesquite. According to the Geological Survey, neither the recharge nor the natural discharge exceeds 20,000 acre-feet per year.

Although the alluvial materials contain a considerable quantity of ground water in storage, indications are that the recharge is not sufficient to sustain a large irrigation development without persistent declines of water levels.

HOLBROOK - SNOWFLAKE - ST. JOHNS AREA

Several small areas near Holbrook, Snowflake and St. Johns are irrigated with ground water in the valleys of the Little Colorado River, Silver Creek and their tributaries.

The water-bearing formation is the Coconino sandstone, which has an average thickness of about 600 feet and is encountered at the surface or to depths as great as several hundred feet. The formation consists principally of even-grained loosely cemented quartz sand, although its thickness and character vary from place to place. The ground water occurs under artesian pressure, and flowing wells are obtained in areas of relatively low elevation. The yields of the wells range from a few gallons per minute to over 2,000 gallons per minute. The ground water used for irrigation is of good quality; however, relatively highly mineralized water has been encountered in some places.

Recharge to the Coconino sandstone occurs along its outcrop to the south in the vicinity of the Mogollon Rim. Water from rain and snow percolates into the sandstone and moves in a general northeasterly direction toward the Little Colorado River.

Water levels have not declined excessively, owing to the relatively small amount of ground water now being withdrawn for irrigation. Available data indicate that under proper development additional withdrawals of ground water could be made from this aquifer without fear of excessive declines in water levels.

Considerable water is now being wasted due to uncontrolled flow from some of the artesian wells. As a remedy to this wastage, flow from these wells should be shut off when not in use.

Although the amount of land suitable for irrigation in this area is not extensive, a large percentage is still undeveloped.

OTHER AREAS

All of the principal areas of ground-water irrigation in Arizona have been described. A number of smaller areas, however, have not been discussed either because of their isolation from the major areas of development or because of lack of information. Irrigated lands involved range from a few tens of acres to over a thousand. Although these small areas are of considerable local importance, they have little bearing on the principal ground-water problems of the state.

These smaller areas include San Bernardino Valley, Upper Arivaipa Valley, Tonto Valley, Upper Verde Valley, Big Chino Valley, Lonesome Valley, Skull Valley, Big Sandy Valley, Virgin River Valley, and areas along the Colorado River near Parker and near Davis Dam.

Potential Areas of Development

NORTHERN PLATEAU REGION—COCONINO SANDSTONE

In the section on Holbrook-Snowflake-St. Johns Area the Coconino sandstone was described as a potential source of additional water for irrigation. Present developments are small and widely scattered, although this productive formation underlies an extensive region. Furthermore, conditions are favorable for recharge from rains and snows in the outcrop area of the formation along the Mogollon Rim.

Up to the pesent time the investigation of the Coconino sandstane by the Geological Survey has been restricted almost entirely to local areas and to the Navajo Indian Reservation. Consequently, little is known of its character, thickness, and productivity in other areas of potential development. The present investigation should be expanded or a new investigation made of these favorable but yet unexplored areas.

SOUTHWESTERN DESERT AREAS

A number of alluvial valleys in the southern and southwestern desert area are presently undeveloped, yet many contain potential supplies of ground water for irrigation. Developments on a small scale already are under way in some of the areas, such as Centennial Wash, Palomas Plain, and areas near Bouse and Aztec.

Little is known of the character, thickness, and extent of the water-bearing formations, the recharge, and the quality of the ground water in the areas. It is quite possible that exploration may disclose a number of areas in which relatively large quantities of ground water of good quality occur as storage at depths from which wells could economically produce water for irrigation.

Although indications are that the recharge is insufficient to sustain large developments for indefinite periods, there is no reason why water cannot be taken from storage if substantial volumes are available. If developers realize that the supplies are essentially non-replenishable, investments in wells and irrigation facilities can be planned on an economic basis. Once a point of economic depletion is reached, the amount of irrigation either will be reduced to the amount of recharge, or irrigation will be discontinued. Should the development be abandoned, the small perennial recharge will eventually replenish the ground water.

SMALL MOUNTAIN VALLEYS

A number of small valleys in the mountain region contain alluvial deposits. Ground water has been developed for irrigation in only parts of the valleys. Possibilities are favorable for obtaining additional small supplies in some of these areas. Most of the recharge is being lost at present by evapo-transpiration. Therefore, development in these valleys should have very little effect upon conditions in the major irrigation areas.

Alluvial deposits in these valleys usually are recharged extensively during wet periods and are partially depleted during dry periods. Should long droughts occur, the recharge would be exceedingly small and the irrigation developments could experience a shortage of ground water. On the other hand, if developments are not too extensive and are properly planned, the ground water should be adequate to supply a number of small irrigation areas in these mountain valleys on a permanent basis.

MAIN VALLEY OF COLORADO RIVER

Along the main stem of the Colorado River a number of alluvial areas contain potential ground-water supplies that may be developed for irrigation. An example is the area downstream from Davis Dam in which ground water has been developed on a comparatively small scale in recent years.

Although adequate exploration of the alluvial deposits has not been conducted in these areas, indications are that some contain shallow sands and gravels that are hydrologically connected with the river. Ground water is derived from recharge from adjacent mountains. Usually water moves from the sands and gravels into the river or feeds phreatophytes along the lowlands. Undoubtedly, this ground water can be developed by wells in some of the areas.

Methods of Improving Ground-Water Conditions

The two most obvious methods for improving ground-water conditions in Arizona are the development or importation of additional surface water and the use of less ground water.

Several less obvious methods include better design and construction of wells, drilling deeper wells, reduction of non-beneficial evapo-transpiration, and elimination of salt springs.

It has been reported that many wells produce excessive amounts of sand and that often the yields of wells are affected by inadequate development and improper placement of perforations. A program of education for well drillers and well owners would be beneficial in eliminating some of these problems.

The deepening of wells will partly eliminate the problems of decreased well yield and convert them primarily to ones of pumping lift. Also, where thick clays separate the shallower and deeper formations, the pumping of the deep wells will spread withdrawals from storage over much wider areas, resulting in less decline of water levels in the immediate locality.

The amount of water now being consumed by non-beneficial plants in the principal phreatophyte areas of the Gila River drainage system above Gillespie Dam has been estimated to be in the order of 300,000 acre-feet. All of this water cannot be salvaged, and the amount recoverable could not be a major factor in the solution of the ground-water problems of the state. Nevertheless, the amount is substantial and means should be found to eliminate this waste. Such methods as lowering of the water table in the phreatophyte areas, the straightening and deepening of stream channels, and the lining of canals will assist in this elimination. Means should be found to put the salvaged water to beneficial use in a manner that will assist in the solution of existing problems.

Water from flash floods on numerous small washes and creeks is largely lost by evapo-transpiration as it spreads over the desert floor. A part of this water can be salvaged by impounding the floods and slowly releasing the water to percolate into permeable stream beds. Perhaps the amount of water that can be saved is not large, but nevertheless may be of sufficient magnitude to make such projects economically feasible.

The salt-water springs in the upper reaches of the Salt River are sources of highly mineralized water to the downstream irrigated areas. According to reports on the Salt River Valley, the salt content of the low flow of the Salt River could be reduced by the evaporation of the spring water. This problem should be studied further and some action taken if the procedure is proven economical.

Need for Further Study

Although much is known about ground-water conditions in Arizona, much still is unknown. A great deal of work must be done before detailed quantitative evaluations can be made and before completely satisfactory knowledge of ground-water conditions can be obtained.

Many years and hundreds of thousands of dollars have been spent to obtain the generalized information now available, and the cost of the work needed will be even greater. However, when compared to the tremendous income derived from the ground-water developments in the state, these costs are exceedingly small.

Future ground-water investigations should be particularly concerned with:

1. Determination of geologic and hydrologic character of deeper aquifers in the alluvial fill. The studies, which require the close cooperation of well owners, well drillers, and basic data agencies, should include:

   (a) Additional analyses of existing logs of deep wells;

   (b) Collection of reliable drill cuttings and logs of future deep wells;

   (c) Drilling of deep test wells in strategic localities.

2. Quantitative study of recharge and natural discharge of the water-bearing formations. The only quantitative data available on these subjects in Arizona concern the Salt River Valley and Safford Valley, but even in these areas satisfactory conclusions have not been reached.

3. Salt balance problem. The progressively higher mineralization of ground water will become a limiting factor to irrigation unless remedied. Quantitative estimates cannot be made from present data with reference to the magnitude of the problem and the time element involved.

Conclusions

The most serious ground-water problems in Arizona exist in Salt River Valley, Lower Santa Cruz Valley and the northern part of Upper Santa Cruz Valley. These valleys constitute the Central Valley of Arizona and are the largest and most productive areas in the state. Although deep and prolific aquifers underlie these areas, the recharge to the ground-water is much less than the present withdrawals from wells. Heavy withdrawals from ground-water storage are causing increases in pumping lifts and decreases in well yields. In addition to these problems, the ground water in certain localities is becoming progressively more highly mineralized.

Although the increases in lifts and decreases in yields are causing a gradual increase in the cost of irrigation water from this source, the amount of ground-water storage in most localities that still can be withdrawn at a profit under present economic conditions is material, and it will be a number of years before the present rate of use becomes infeasible. It is inevitable, however, that at some time in the future the cost of the water will become so great as to make the use at the present rate uneconomical.

The amount of water now being withdrawn from ground-water storage is in excess of recharge from all sources. It is greater than the amount of surface water intended to be imported by the proposed Central Arizona Project.

The amount of ground water perennially available from the aquifers will be the same, regardless of when withdrawals from storage are stopped.

Areas of development outside the Central Valley, which include the valleys of the Gila River and its tributaries below Salt River Valley and above Santa Cruz Valley, and localities along the Colorado River, in small mountain valleys and in the northern plateau, have comparatively minor ground-water problems. In general the ground-water supplies in these areas are of sufficient magnitude to sustain the present irrigation developments for long periods of time or on a perennial basis.

Potential supplies of ground water for additional irrigation exist in undeveloped alluvial deposits of the southwestern desert region and small mountain valleys, and in the consolidated aquifers of the northern plateau. Small supplies could be developed on a sustained yield basis in the mountain valleys and in the northern plateau. Withdrawals in the southwestern desert region, however, would be from storage and essentially non-replenishable. Such developments, therefore, would be of limited life, similar to present developments in the Central Valley, but they would create wealth that would never be produced otherwise.

SRP897

Appendix "B"

Underground Water And Agriculture In Arizona

Some Economic Relationships, 1952

submitted to

UNDERGROUND WATER
COMMISSION OF ARIZONA
E. RAY COWDEN, CHAIRMAN
856 SECURITY BUILDING
PHOENIX, ARIZONA

by

THEODORE P. JARDINE, JR.
STATISTICIAN

1715 East Blacklidge
Tucson, Arizona
September 17, 1952

Mr. E. Ray Cowden, Chairman
Underground Water Commission of Arizona
856 Security Building
Phoenix, Arizona

Dear Mr. Cowden:

In compliance with your request, submitted herewith is a report titled "Underground Water and Agriculture in Arizona - Some Economic Relationships, 1952."

Due to time limitations, some aspects of the problems presented in the above mentioned report have been omitted, or only briefly discussed. Some questions asked by the Commission cannot be directly answered with the data available. These questions were discussed in general terms when sufficient data were available to indicate tentative answers. However, when possible, an attempt was made to avoid the inclusion of economic theories as solutions to certain economic aspects of the problem. If some discussions have no absolute conclusions, it is because the author and his advisors felt it unwise to be more specific without more reliable data.

The author wishes to acknowledge the cooperation he received from Mr. Raymond E. Seltzer, and the entire staff of the Department of Agricultural Economics, at the University of Arizona. Without their assistance, this report could not have been completed. The assistance of Mr. Minton Moore, of the Valley National Bank, Mr. Elmer D. Hershey, and various State and Federal Agencies is also appreciated.

Very truly yours,
THEODORE P. JARDINE, JR.
Statistician

TPJ:hr

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Underground Water And Agriculture In Arizona

Some Economic Relationships, 1952

Summary

The information developed on the relationship of Arizona's agriculture to underground irrigation water is briefly summarized as follows:

1. The eight major crops studied in this report, cotton, (long and short staple), alfalfa, grain sorghum, barley, lettuce, cantaloupe, grapefruit and oranges comprise approximately 90 percent of the crop cash income of the State.

2. During the last 52 years irrigated acreage in the State increased almost 600 percent. It is estimated that there are 1,200,000 acres of irrigated land in Arizona in 1952.

3. It is estimated that over 800,000 acres of farm land used underground water as the principal source for irrigation in 1951.

4. Arizona's agricultural income was approximately 379 million dollars in 1951. Irrigated crops accounted for 282.1 million of this total.

5. Short staple cotton has led the State in acreage increases during the last 12 years. The 1952 acreage equalled 306% of the acreage planted in 1940. Increases in cantaloupe and oranges have also been large.

6. In general, Arizona crop yields are substantially above the United States average.

7. In 1951, more than 60 percent of the crop cash income of the State was derived from cotton. Irrigated field crops have constituted over 60 percent of the total agricultural income during the last few years and may exceed 75 percent this year.

8. Average cash income per acre has increased more than 500 percent since 1938. An increase of 68 percent was due to production increases, while the remainder reflects price rises.

9. Irrigation water costs vary from 8 to 35 percent of the total production costs depending upon the crop raised, depth of lift and water requirements of the crop. Average water costs for all crops in Maricopa County, 1951, were estimated to be 11.4% of total production costs.

10. Under existing conditions, there is little possibility of lowered water costs in the future.

11. There is a difference between water cost and water value. Value is determined by the added production obtained by the application of additional water and farm prices. Therefore, the agronomic experimental approach is the most accurate method of determining water value. Experimental data is lacking, however, for most crops. Due to rising farm prices, the value of water is increasing yearly.

12. The value of one particular acre-foot of water applied to a crop is not the same as another acre-foot. It is difficult to place a dollar value on an acre-foot of water.

13. The net income approach values water as a factor of production. Assuming all production factors to have equal effect on crop production, water value is determined by the profit per acre attributed to water.

14. The gross income approach to water valuation determines on which crops water should be applied, to return the highest income to the State. Truck crops, grapefruit, oranges, and cotton in that order, were the most profitable to the State in terms of value per acre-foot of water applied.

15. In an area where water costs are increasing relative to other costs, and where water costs are a large percentage of total production costs, the price of commodities could well be influenced by water costs.

16. A precise dollar and cent valuation of water must await further scientific experimentation on water and its effects on crop production.

17. Lowering water tables increase production costs, cause uncertainty among farmers and eventually result in reduction in the land values of such an area.

18. Manufacturing, retail sales and service have increased more than 400 percent since the fiscal year 1939-40. Tourist trade and mining registered increases of more than 300 percent during the same period.

19. Almost 25 percent of the State income of individuals was derived from irrigated crops in 1951. This percentage increased from 14.5 in 1938 to 24.5 in 1951. Arizona crop cash income exceeded 282 million dollars last year.

20. The presence of irrigated acreage in a county increases the population, retail sales and general business activity of the county. Five counties, Graham,

Maricopa, Pima, Pinal and Yuma contain more than 90 percent of the irrigated land and almost 75 percent of the State's population.

21. Determining agriculture's share of the tax load is a difficult problem, but it is estimated that agriculture paid almost 51 million dollars in Federal, State and Local taxes in 1951.

22. It is estimated that a reduction in groundwater use of 15 percent would decrease crop production 5 percent, and acreage 7 to 8 percent if farm prices remain relatively high. With substantially lowered prices, crop production and acreage might decrease 10 to 15 percent.

23. Assuming a 50 percent reduction in pumping and relatively high prices, gross value might decline 25 to 30 percent and irrigated acreage as much as 40 percent.

24. A 15 percent pumpage reduction might decrease crop values by 15 million dollars. Sixty million dolars might be lost if ground water use were cut 50 percent. Even a cut of 60 million dollars in gross crop income would be less than the increase in cash crop income from 1950 to 1951.

25. Large pumpage reductions would cause a shift to high-value, low-water requiring crops. The shift would be away from forage and grain crops which could have a marked effect on the livestock industry.

26. Farm land values could decrease 40 percent on pump-irrigated farms following a 50 percent pumping cut.

27. Farm price reductions over a long period of time would probably be followed by price declines in industry. Lowered farm prices would have a directly proportional effect upon crop values.

28. Using average cost of production figures for 1951, the "break-even" price is as follows for various crops; cotton $0.22 per pound with $50 cottonseed, alfalfa $21.32 per ton, barley $2.68 per cwt and grain sorghum $2.53 cwt.

29. Assuming all other costs equal, the very deep pump-lift areas would go out of production first. It is estimated that 160,000 acres might be abandoned.

30. Because of steady markets, high quality crops and high capital investments in land, it is difficult to imagine any wholesale abandonment of irrigated acreage resulting only from lowered farm prices.

31. Of the four counties studied, Pinal county probably would be hardest hit if pumpage or price reductions should occur.

Conclusions

Approximately 70 percent of Arizona's agriculture is dependent upon ground water as the primary source for irrigation. With dwindling ground water resources, water conservation practices will have to be increased by farmers in many areas of the State.

A reduction in ground water use would have a noticeable effect upon the State's economy, but even a 50 percent reduction would not have as drastic an effect as would be supposed. The most predominate economic effect of a legislative reduction in pumpage would probably be psychological. The economic results of a lack of confidence in the stability of agriculture in this state might be more profound than the effect of decreased crop production. Another important aspect of pumpage reductions would be the shift to high value, low-water requiring crops which might act to the detriment of the livestock industry.

Declines in agricultural prices would affect some high cost areas. It is possible that fluctuating prices could cause certain deep-lift areas of the State to be farmed intermittently, however, it doesn't seem probable that lowered prices alone, would force large acreages of land out of production.

Introduction

During the last few years, much attention has been directed toward Arizona's irrigation problems. While all of these problems are very important to the State's economy, the problem of over pumping from our existing underground water supplies is the most critical problem facing the people of Arizona. It is realized that our underground water resources are not unlimited and may be depleted by excessive withdrawals of water. In other words when more water is pumped out of the ground than is being replaced by natural recharge, the potential supply of readily available water is reduced. It would not be true to say that our water resources are being depleted throughout the entire State, however, there are strong indications that such may be the case in specific areas of the State. This problem has become more acute in certain areas as increased acreages of desert land have been placed under irrigation.

The purpose of this report is to evaluate irrigated agriculture in certain specific areas of the State and to indicate its effect upon the State economy, upon agriculture in general, and to study the effects of possible future conditions as they might effect irrigated agriculture.

This report purposely has been limited to a rather detailed study of certain specific counties and certain

specific crops. Maricopa, Pinal, Pima and Graham counties have been selected for special study. These counties were not chosen because of their water problems, if any, but because they are representative of farming conditions in the area where water problems are most acute, and because they contain approximately 75% of the irrigated acreage in the State.

This report was limited to a study of eight crops, including cotton (long and short staple), alfalfa, grain sorghum, barley, lettuce, cantaloupe, grapefruit and oranges. These crops are the major crops grown in Arizona and comprise approximately 90% of the crop cash income of the State.

SECTION I

Development of Arizona's Agriculture

During the last 52 years the irrigated acreage in Arizona has increased from 198,000 acres in 1900 to approximately 1,200,000 acres under cultivation in 1952; an increase of more than 600 percent.

TABLE 1.1 DEVELOPMENT OF IRRIGATION IN ARIZONA BY COUNTIES

(Thousands of Acres)

YEAR	Maricopa	Pinal	Pima	Graham	State Total
1900	113	14	9	23	198
1905	146	20	9	29	247
1910	213	26	11	32	330
1915	245	27	13	33	391
1920	288	28	19	33	476
1925	325	29	29	33	518
1930	379	69	18	34	607
1935	329	76	18	33	560
1938	360	120	25	34	653
1939	365	119	25	34	665
1940	370	127	25	34	681
1941	390	155	25	34	731
1942	390	170	25	34	750
1943	390	170	25	35	753
1944	400	170	25	35	765
1945	400	175	25	35	775
1946	400	175	25	35	775
1947	415	200	30	35	825
1948	430	250	30	35	900
1949	475	280	30	35	1,000
1950	435	250	25	35	915
1951	512	264	47	34	1,100

Source: "Arizona Agriculture" published by the Department of Agricultural Economics, University of Arizona, and data on file in the Department of Agricultural Economics.

In the past seven years almost as much new land has been brought under cultivation as was farmed in the entire state in 1910!

There is no accurate information as to the amount of pump irrigated land under cultivation during recent years. However, by accepting the ground water pumpage estimates made by the U. S. Geological Survey Office in Tucson and by assuming that all irrigated land receives the same amount of irrigation water, regardless of source, a rough estimate can be made of pump irrigated farmland. Irrigation projects that used pump water as a supplement to surface water were credited with pump land equal to the percentage of the total water delivered that was obtained by underground pumping.

TABLE 1.2 ESTIMATE OF LANDS IRRIGATED BY GROUND WATER IN 1950

COUNTY	(1) Total Land in Irrigation	(2) Acre Feet Pumped for Irrigation 1*	(3) Total A/F Used for Irrigation 2†	(4) Column (2) divided by Column (3) x 100 3‡	(5) Acres of Pump Land Column (1) x Column (4)
Maricopa	435,000	1,917,000	2,741,000	69.9%	304,000
Pinal	250,000	1,000,000	1,116,100	89.6%	224,000
Pima	24,000	160,000	160,000	100.0%	24,000
Graham	35,000	96,500	164,600	58.1%	20,000
Cochise	20,000	75,800	75,800	100.0%	20,000
Santa Cruz	4,000	21,000	21,000	100.0%	4,000**
Yuma	100,000				18,000††
Other Counties	47,000				24,000‡‡
Total	915,000				638,000

Source: Total irrigated acreage figures from Arizona Agriculture, 1951, University of Arizona, Tucson.

1 * Pumpage figures supplied by U. S. Geological Survey, Groundwater Division, Tucson.

2 † See Appendix Table 1.B for gravity water delivered to various counties.

3 ‡ Percentage of total irrigation water supplied by groundwater pumps.

4** Estimated by the Department of Agricultural Engineering, University of Arizona, Tucson.

5†† Total irrigated acreage of Wellton-Mohawk area and the South Gila Valley, Tucson. Reported by the Bureau of Reclamation, Lower Colorado River District, Yuma.

6‡‡ Estimated. (It was assumed that at least half the acreage in the other counties was irrigated by pumps.)

By this method approximately 638,000 acres of land under cultivation in 1950 were irrigated from underground water sources. A rough check on this method is provided by data from the State Tax Commission of Arizona. The 1950 "Statement of Comparative Values" lists assessed acreage of pump irrigated land at 564,000. (see Appendix Table 2.B). Approximately 40% of the irrigation water supplied by the Salt River Valley Water Users Association was pumped from underground sources. Forty percent of the total irrigable land serviced by the Association would equal about 96,000 acres. Adding only this figure to the assessed acreage of pump irrigated land would result in 660,000 acres of pump land. It is felt that our figure of 638,000 acres is conservative. An additional 185,000 acres were under cultivation in 1951, of which probably more than 150,000 acres should be classified as pump irrigated land. Again admitting that this method is an approximation only, it would seem that at least 800,000 acres of pump

land were under cultivation last year. This means that three-fourths of the crop land in Arizona in 1951 was primarily irrigated by underground water. Almost all of the dependable surface water resources of the state, adjacent to the farming areas, have been utilized for irrigation. This indicates that unless a new source of surface water can be developed, any new lands brought under cultivation will be primarily dependent upon underground sources of irrigation water.

Ground-water pumping for irrigation in Arizona has increased more than 200% during the last ten years as shown in Table 1.3.

TABLE 1.3 IRRIGATION PUMPAGE IN ACRE FEET BY COUNTIES

YEAR	Graham*	Maricopa†	Pima‡	Pinal	State Total
1940	29,600	973,000	60,000	372,000	1,524,136*
1941	13,685	444,000	68,500	351,000	998,033*
1942	23,900	1,004,000	85,500	500,000	1,738,800*
1943	40,000	1,140,000	100,000	515,000	1,896,600*
1944	57,000	1,053,000	106,000	530,000	1,849,500*
1945	40,000	1,179,000	111,000	610,000	2,050,300*
1946	120,600	1,400,000	108,000	660,000	2,441,400
1947	105,600	1,453,000	145,000	700,000	2,579,600
1948	115,600	1,732,700	145,000	950,000	3,158,100
1949	45,600	1,716,000	150,000	1,100,000	3,230,400
1950	95,600	1,917,000	180,000	1,000,000	3,410,400
1951	125,000	2,020,000	240,000	1,030,000	3,750,000*

Source: U. S. Geological Survey Ground-Water Division, Tucson.
* Partially estimated by U. S. Geological Survey
† 1940-43 estimated by U. S. Geological Survey
‡ Includes municipal pumping for the city of Tucson.
All counties, totals partially estimated from 1940-43 by U. S. Geological Survey.

This increase is a direct result of increased acreage brought under cultivation during the same period.

In 1950 irrigation pumpage represented 75% of the total irrigation water used in the counties of Maricopa, Pima, Pinal and Graham. Any further increases in irrigated acreages in these four counties would seem to require even greater pumping from underground resources.

The use of irrigation water coupled with a long growing season enables Arizona farmers to grow a wide variety of crops with excellent results. Most of the farm land is concentrated in a relatively few areas of the state due to topography, elevation, soil types and water availability. This concentration of farm land results in more efficient use of farm labor and services and reduces the marketing problems confronting the producer. Because of the increased production costs arising from the use of irrigation, high yields, intensive farming and the growing of relatively high value corps have become standard procedures in Arizona's agriculture. Excellent climate coupled with improved transportation, marketing facilities, and market news enables farmers to take advantage of fluctuating price and supply conditions. This versatility of cropping tends to stabilize agriculture in the state and results in a higher relative income for the farmers. According to the 1950 Agricultural census, almost 22% of commercial farms in Arizona sold more than $25,000 worth of produce.

The following tables and graphs show the increases in total agricultural income and crop income in Arizona since 1938. Table 1.4 shows total agricultural income, that same income adjusted for price increases, and how much of the yearly change in income was due to increased or decreased production.

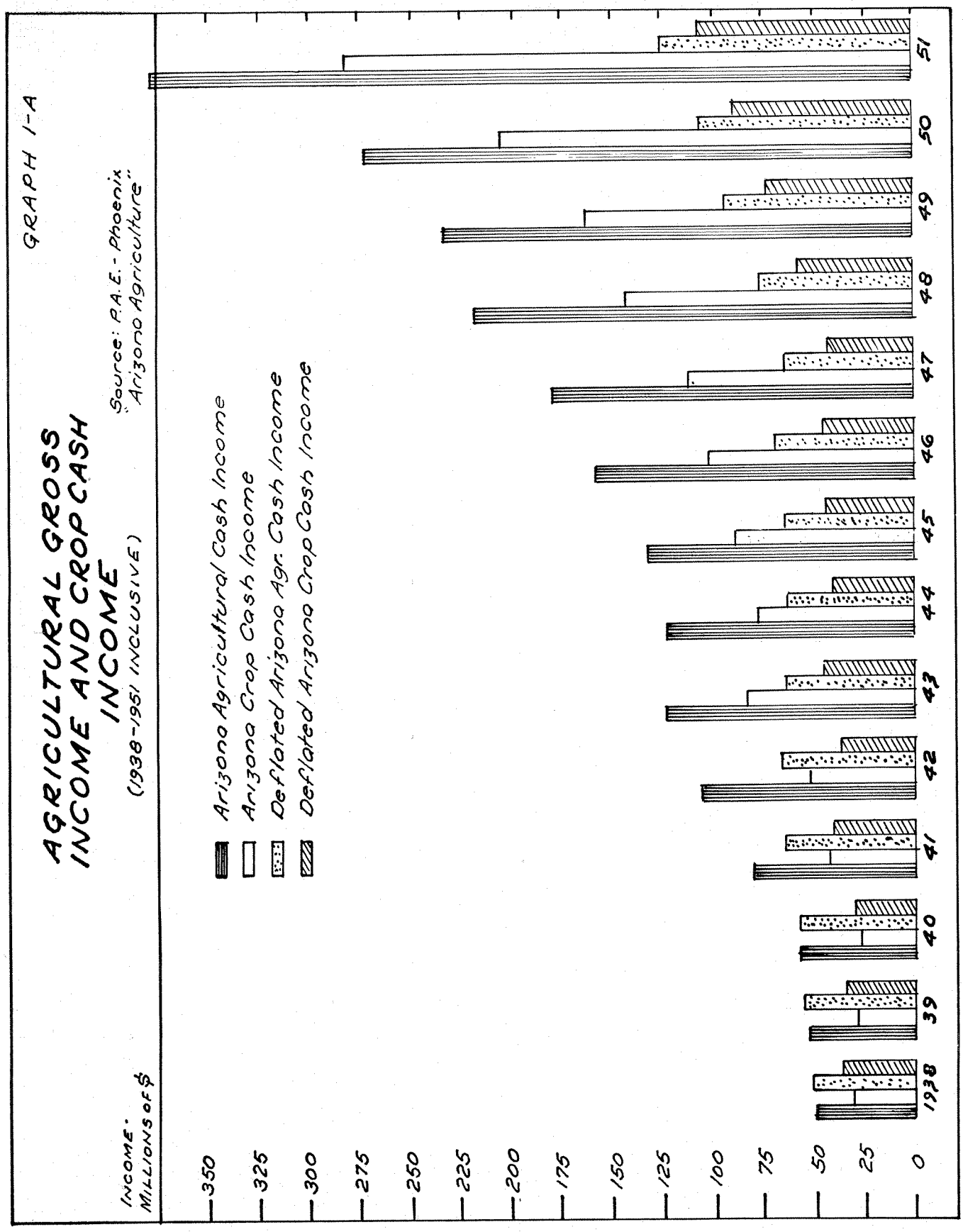
TABLE 1.4 CHANGES IN ARIZONA'S AGRICULTURAL INCOME DUE TO PRICE CHANGES AND TO PRODUCTION CHANGES, 1938-1951 INCLUSIVE

Year	(1) Arizona Agr. Income (Million $)	(2) Index Prices Rec'd by Farmers 1*	(3) Deflated Arizona Agr. Income (Million $)	(4) Actual Change in Income from Preceding Year (Million $)	(5) Change Due to Production (Million $)	(6) Change Due to Price (Million $)
1938	50.0	97	51.5	− 5.5	+ 6.0	−11.5
1939	54.0	95	56.8	+ 4.0	+ 5.3	− 1.3
1940	58.0	100	58.0	+ 4.0	+ 1.2	+ 3.8
1941	80.0	123	65.0	+22.0	+ 7.0	+15.0
1942	107.0	158	67.7	+27.0	+ 2.7	+24.3
1943	124.0	192	64.6	+17.0	− 3.1	+20.1
1944	124.0	196	63.3	0.0	− 1.3	+ 1.3
1945	134.0	206	65.0	+10.0	+ 1.7	+ 8.3
1946	160.0	234	68.4	+26.0	+ 3.4	+22.6
1947	180.0	275	65.5	+20.0	− 2.9	+22.9
1948	219.0	285	76.8	+39.0	+11.3	+27.7
1949	235.0	249	94.4	+16.0	+17.6	− 1.6
1950	273.0	256	106.6	+38.0	+12.2	+25.8
1951	379.0	302	125.5	+106.0	+18.9	+87.1

Sources:
Column (1) "Arizona Agriculture", Department Agricultural Economics, Arizona Agricultural Experiment Station, Annual Issues, 1939-1952, inclusive.
Column (2) BAE, Crop and Livestock Reporting Service, Phoenix.
Column (3) Column (1) divided by Column (2) x 100.
Column (4) Subtract preceding year from current year in Column (1)
Column (5) Subtract preceding year from current year in Column (3)
Column (6) Column (4) minus Column (5).
Prepared by Department of Agricultural Economics, Arizona Agricultural Experiment Station.
1* Index used (1910-1914 = 100).

Graph 1A shows the yearly crop cash income and the same income adjusted for price changes. As would be expected, both of these factors have increased rather steadily throughout the last twelve years. The increase shown by the adjusted income line, is the result of higher production due to farm technological advancements and increased acreage in crops.

Changes in Arizona's cash income from crops are set forth below.


GRAPH 1-A
AGRICULTURAL GROSS INCOME AND CROP CASH INCOME
(1938-1951 INCLUSIVE)
Source: P.A.E. - Phoenix "Arizona Agriculture"
Arizona Agricultural Cash Income
Arizona Crop Cash Income
Deflated Arizona Agr. Cash Income
Deflated Arizona Crop Cash Income
INCOME - MILLIONS OF $
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
1938
39
40
41
42
43
44
45
46
47
48
49
50
51

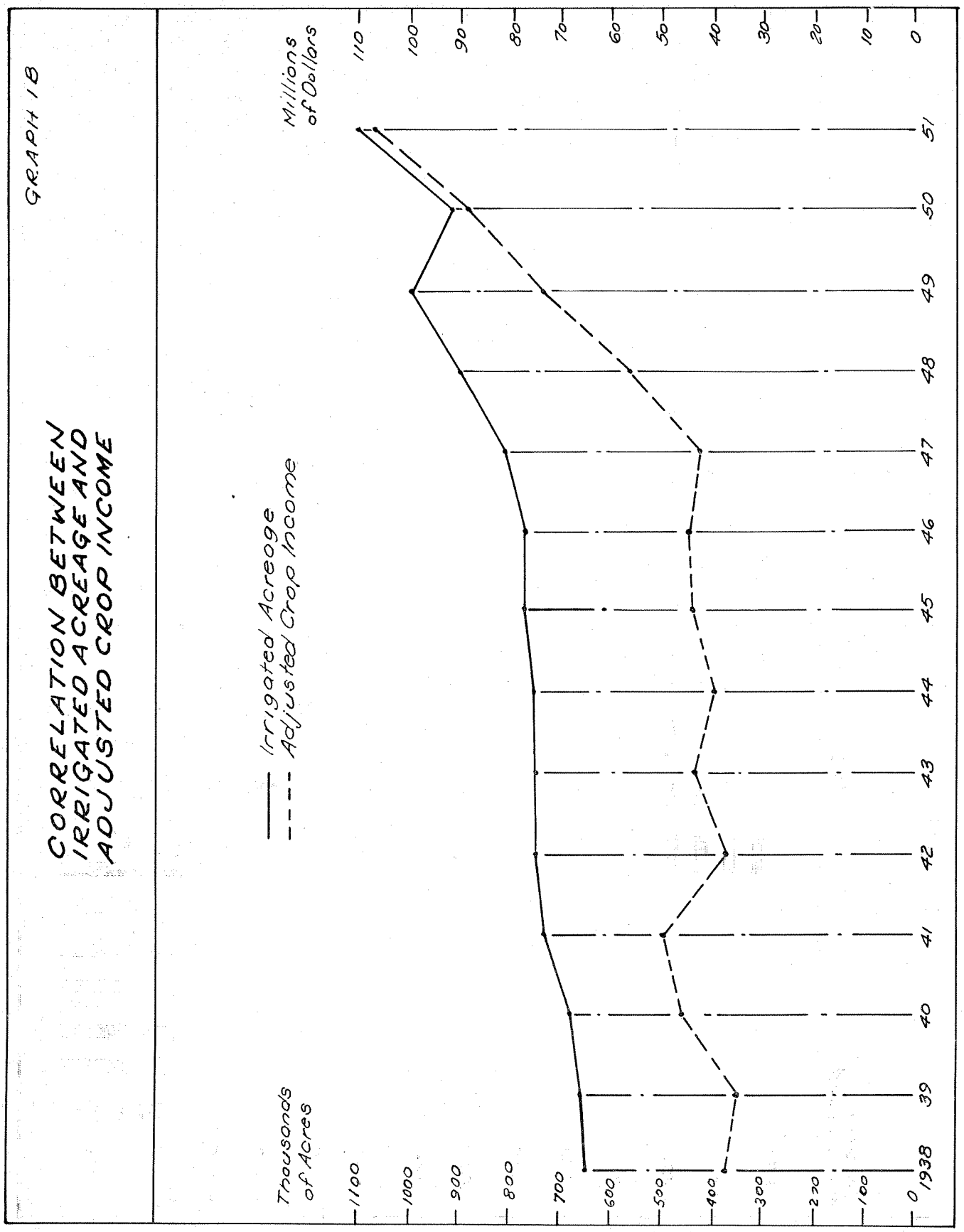

GRAPH 1B
CORRELATION BETWEEN
IRRIGATED ACREAGE AND
ADJUSTED CROP INCOME
Thousands of Acres
Millions of Dollars
Irrigated Acreage
Adjusted Crop Income
1100
1000
900
800
700
600
500
400
300
200
100
0
110
100
90
80
70
60
50
40
30
20
10
0
1938
39
40
41
42
43
44
45
46
47
48
49
50
51

TABLE 1.5 CHANGES IN ARIZONA'S ANNUAL CROP CASH INCOME DUE TO PRICE CHANGES AND TO PRODUCTION CHANGES, 1938-1951 INCLUSIVE

YEAR	(1) Arizona Crop Cash Income (Millions $)	(2) Index Prices Rec'd by Farmers 1*	(3) Deflated Ariz. crop Cash Income (Millions $)	(4) Actual Change in Income from Preceding Year (Millions $)	(5) Change Due to Production (Millions $)	(6) Change due to Price (Millions $)
1938	30.9	82	37.7	——	——	——
1939	28.8	82	35.1	− 2.1	− 2.6	+ 0.5
1940	27.0	91	29.7	− 1.8	− 5.4	+ 3.6
1941	43.5	108	40.1	+16.5	+10.4	+ 6.1
1942	52.8	144	36.7	+ 9.3	− 3.4	+12.7
1943	83.5	185	45.1	+30.7	+ 8.4	+22.3
1944	78.6	198	39.7	− 4.9	− 5.4	+ 0.5
1945	89.6	203	44.1	+11.0	+ 4.4	+ 6.6
1946	103.0	227	45.4	+13.4	+ 1.3	+12.1
1947	112.2	263	42.7	+ 9.0	− 2.7	+11.7
1948	143.1	252	56.8	+30.9	+14.1	+16.8
1949	163.9	223	73.5	+20.8	+16.7	+ 4.1
1950	205.4	232	88.5	+41.5	+15.0	+26.5
1951	282.1*	264	106.9	+76.7	+18.4	+58.3

Sources:
Column (1) BAE, Crop and Livestock Reporting Service, Phoenix. (Figures rounded to nearest $100,000.)
Column (2) BAE, Crop and Livestock Reporting Service, Phoenix.
Column (3) Column (1) divided by Column (2) x 100.
Column (4) Subtract preceding year from current year in Column (1).
Column (5) Subtract preceding year from current year in Column (3).
Column (6) Column (4) minus Column (5).
1* Index used (1910-1914 = 100).
Preliminary

As indicated by the index in Column (2), crop prices have not risen as much as have livestock prices. (The index in Column (2), Table 1.4 includes livestock.) In 1951, total agricultural income increased 18.9 million dollars because of increased production while Column (5) in Table 1.5 indicates that increased field crop production was responsible for all but one-half million dollars of that increase. Most of this production increase was due to increased acreage of irrigated land.

Graph 1B illustrates the correlation between total irrigated acreage per year and the adjusted crop income in Arizona as shown in Column (3) of the above table.

SECTION II

Value of Irrigated Crop Production in Arizona

Although Arizona total crop production has risen sharply since 1940, there have been great fluctuations in production of specific crops. These fluctuations were primarily the result of price changes and wartime demands of the government. (See Table 2.1) The only major crop showing a decline of acreage during the 1939-1951 period was grapefruit. This decline from 15,000 acres in 1939 to approximately 9000 acres last year has been continuous and even the high prices during the war years failed to more than temporarily halt this trend. All other major crops have registered acreage gains since 1939. Short staple cotton has led this increase with acreage planted in 1951 equaling 254% of the 1939 acreage. Long staple cotton acreage which has fluctuated markedly over the years was 42% less in 1950 than in 1939, but last year was approximately equal to the 1939 acreage.

Acreage increases in cantaloupe and oranges have been large during the last 13 years while grain sorghum and barley acreages have fluctuated widely, but have decreased markedly during the last year or two due to competition from cotton. Other crops have shown gradual increases in acreage since 1939.

In general, yields of major Arizona crops reflect the technological advances made during the last decade. Higher prices and production costs have stimulated Arizona farmers to increase their yields. (See Table 2.2) Taking 1938 through 1940 as the initial average and 1949 through 1951 as the current average, long and short staple cotton yields have increased 43% resulting in more than 200 pounds of additional short staple cotton and 113 pounds of added long staple cotton yield per acre. Relatively larger yield increases have been recorded for small grains such as barley and grain sorghum. In general, yields of other major crops have increased gradually during the last decade. Of course, water limitations and climatic conditions affect yields in specific areas during specific years, but over the long run, Arizona crop yields have been increased substantially. Today Arizona yields for many field crops are substantially above the U. S. average, as determined by the U. S. Department of Agriculture. (See Table 2.3 below)

TABLE 2.3 COMPARATIVE YIELDS PER ACRE OF BASIC FIELD CROPS, 1951

CROP	Arizona	U. S. Average
Wheat, bu.	26.0	16.1
Oats, bu.	41.0	36.1
Barley, bu.	50.0	27.1
Corn, bu.	10.0	36.2
Sorghums, bu.	42.0	18.9
Flaxseed, bu.	31.5	8.7
Cotton, lbs. (short staple)	719.0	274.5
Potatoes, bu.	365.0	240.7
Hay, tons[1]	2.8	1.5

Source: Table 2.2 and Arizona Statistical Review, published by the Valley National Bank, Phoenix.
[1] Does not include hay pastured or consumed on the farm.

Increases in acreage and in yield result in marked increases in crop production. Table 2.4 lists total crop production of major crops in Arizona. This table makes no allowance for hay or barley that is pastured or ensiled and registers increases in citrus yields only when the entire crop is marketed.

Table 2.5 is included to substantiate the crop value figures presented in Table 2.6. The table is self explanatory and the indices in Section VI should be referred to when analyzing this table.

The gross values of major Arizona crops, presented in Table 2.6 include allowances for pasturage by livestock. County totals were based on acreage planted in each county. Equal yields and prices were assumed for all counties. Gross value figures may differ from data published by agricultural reporting services, but the difference is due largely to methods of price computation rather than variations in production data. The years 1940, 1945 and 1951 were chosen to show prewar, World War II and postwar influences, and to indicate price and production trends. The average gross value of irrigated crops for the four counties as a whole increased from $60.35 per acre in 1940 to $131.00 in 1945 and to $278.80 per acre in 1951, a total increase of over 400 percent.

Annual cash income for crops, Table 2.7, is determined by the estimated prices received by the farmer for the sale of his crops. No allowance is made for home and farm consumption nor for pasturage. As would be expected, increased prices and production have resulted in a sharp rise in state cash income for crops during the last seven years.

During the last fourteen years, cotton has averaged more than 25 percent of the total agricultural cash income in Arizona; and truck crops have exceeded 20 percent of this total. These two major crops have accounted for almost half of the agricultural crop income. In 1951, more than 60 percent of the crop cash income of the state was derived from cotton alone.

Graphs 2A, 2B, 2C and 2D are included here to show the relative net profit per acre of cotton, barley, grain sorghum and alfalfa which might accrue under the conditions assumed. Cost of production data is the average cost for the three areas studied, the Salt River Valley Area, 150 foot and 250 foot pump lift areas. Yields of 3000 pounds per acre were assumed for barley and grain sorghum while the assumed cotton yield was one bale per acre and alfalfa costs were computed on a yield of four tons per acre. Gross value was determined by multiplying yield by average market price as shown in Table 2.4.

TABLE 2.1 IRRIGATED ACREAGE OF MAJOR CROPS BY COUNTIES IN ARIZONA
(In acres)§

COUNTY	Short Staple[1] Cotton	Long Staple[1] Cotton	Alfalfa (hay)	Grain Sorghum	Barley	Lettuce[2] fall	Lettuce[2] spring	Melons[1]	Grapefruit	Oranges
Maricopa 1939	88,270	22,790	101,000	9,169	16,098	11,700	18,000	7,000	13,000	6,900
Pinal	35,000	22,800	35,000	1,587	4,057					
Pima	5,700	3,700	1,768	132	112					
Graham	11,300	3,100	7,000	163	1,815					
State Total....	147,000	41,000	180,000	16,000	34,000	15,200	19,900	8,500	15,000	7,000
Maricopa 1940	91,710	24,520	109,000	19,500	24,000	9,100	11,000	7,470	13,000	7,000
Pinal	39,500	30,500	38,000	3,500	5,200					
Pima	6,600	3,700	1,900	600	400	180				
Graham	11,200	5,700	8,000	100	2,000					
State Total	155,000	65,000	194,000	32,000	37,000	12,000	14,000	9,880	14,000	7,000
Maricopa 1941	86,400	29,800	125,000	38,000	31,400	9,248	17,000	8,264	12,000	7,000
Pinal	43,100	53,100	34,800	9,000	5,900	107				
Pima	6,300	5,500	980	800	1,300	180				
Graham	9,600	12,100	3,500	200	900					
State Total	150,000	101,000	205,000	59,000	44,000	12,475	24,300	13,000	13,100	7,300
Maricopa 1942	83,000	45,200	118,000	31,300	39,600	10,000	15,600	4,300	12,000	7,000
Pinal	37,700	65,200	37,000	5,600	7,700			265		
Pima	6,000	6,800	1,000	1,100	3,000	260	200			
Graham	10,700	11,000	5,100	200	1,100					
State Total	142,000	129,700	205,000	48,000	58,000	14,260	23,100	11,565	13,000	7,300
Maricopa 1943	56,000	27,500	140,000	30,000	35,000	12,000	11,183	5,290	12,000	7,000
Pinal	37,700	50,000	47,000	11,600	8,600					
Pima	4,200	6,000	1,000	1,000	3,000	200	200			
Graham	6,600	11,300	6,000	300	1,900					
State Total	107,000	95,000	235,000	52,000	52,000	16,000	17,085	9,150	13,200	7,300
Maricopa 1944	40,000	3,100	160,000	50,400	48,500	12,350	16,141	7,200	11,500	7,000
Pinal	73,000	600	26,000	20,100	12,000	40				
Pima	8,200	1,100	1,700	1,600	2,700	300				
Graham	10,800	3,600	6,800	900	3,700					
State Total	135,000	9,000	237,000	83,000	74,000	17,031	23,000	10,540	12,600	7,300
Maricopa 1945	41,000	800	153,000	37,000	53,000	15,621	12,211	9,834	11,500	7,000
Pinal	86,000	50	26,000	16,000	12,000	110	265			
Pima	8,000	1,000	1,800	1,800	2,500	770				
Graham	14,000	3,150	6,900	900	3,300					
State Total	149,000	5,000	232,000	66,000	78,000	22,671	19,026	14,000	12,700	7,300
Maricopa 1946	33,200	200	156,000	47,000	60,000	14,204	17,444	9,290	11,400	5,300
Pinal	85,000	——	25,000	13,000	11,500	80	40			
Pima	11,100	20	3,000	1,900	2,600	370				
Graham	10,950	1,780	5,000	300	3,200					
State Total	143,000	2,000	233,000	68,000	85,000	21,500	24,800	16,800	12,600	7,300
Maricopa 1947	59,350	40	133,000	44,500	79,000	15,326	14,492	10,884	10,000	8,000
Pinal	128,800	20	23,000	8,000	12,600	175				
Pima	14,650	5	3,000	2,000	1,900					
Graham	15,600	235	5,500	400	2,300					
State Total	224,700	300	210,000	59,000	104,000	21,800	20,940	19,636	11,200	8,300
Maricopa 1948	84,600	130	106,500	67,000	131,000	15,873	11,479	11,747	8,800	8,500
Pinal	147,600	20	21,000	10,000	14,000	170	26	165		
Pima	14,600	.....	2,800	3,100	3,000					
Graham	18,000	1,450	5,100	600	3,600					
State Total	279,400	1,600	176,000	88,000	160,000	22,000	18,700	24,194	10,000	9,000
Maricopa 1949	126,500	500	127,000	56,000	99,000	14,131	12,120	11,665	8,900	8,600
Pinal	189,600	100	18,500	10,000	19,000	100	10			
Pima	21,350	150	2,900	3,500	2,900					
Graham	21,500	1,850	5,200	700	3,400					
State Total	382,400	2,600	201,000	78,000	136,000	23,372	21,500	21,270	10,000	9,200
Maricopa 1950	83,000	18,300	126,000	70,000	97,000	13,000	13,645	9,930	7,900	8,700
Pinal	112,000	16,700	19,000	14,000	42,000			700		
Pima	11,200	2,700	2,900	4,200	2,700					
Graham	14,700	5,900	5,200	900	3,000					
State Total	231,000	44,000	201,000	100,000	163,000	24,000	23,000	22,000	9,000	9,200
Maricopa 1951	212,000	11,500	120,000	24,000	57,000	.....	.....	10,446	7,900	8,700
Pinal	207,000	3,100	14,500	9,500	26,000					
Pima	33,000	2,600	3,000	500	2,000					
Graham	14,000	6,600	5,300	100	2,100					
State Total	521,000	24,000	195,000	40,000	98,000	24,000‡	23,000‡	23,627	9,000	9,200

Source: Arizona Agriculture, Agricultural Experiment Station, University of Arizona, Tucson, except where otherwise noted.
[1] Cantaloupe data supplied by The Crop and Livestock Reporting Service, Phoenix.
[2] J. M. Foote, Supervisor, Fruit and Vegetable Standardization Service, Phoenix.
[3] Estimated by the Department of Agricultural Economics, University of Arizona, Tucson.
§ Figures represent both irrigated crops and irrigated pastures. Acreage double cropped is counted but once.

TABLE 2.2 YIELDS OF IRRIGATED CROPS BY COUNTIES IN ARIZONA

COUNTY	Short Staple Cotton lbs./acre	Long Staple Cotton lbs./acre	All Cottonseed[3] lbs./bale	Alfalfa[4] Tons/acre	Grain Sorghum[1] bu./acre	Barley[1] bu./acre	Lettuce[5] spring crates/acre	Lettuce[5] fall crates/acre	Melons[1 6] crates/acre	Grape fruit[2] boxes/acre	Oranges[2] boxes/acre
Maricopa 1938	502	227									
Pinal	518	228									
Pima	615	309									
Graham	657	227									
State Average..	514	234	1,126.3	2.80	31.5	31	140[2]	109[2]	115	200	61.4
Maricopa 1939	544	303									
Pinal	612	335									
Pima	725	395									
Graham	638	361									
State Average..	569	323	1,051.5	2.50	25.3	34	104[2]	148[2]	130	193	85.0
Maricopa 1940	462	176									
Pinal	536	223									
Pima	716	328									
Graham	660	384									
State Average..	505	225	1,051.5	2.30	25.5	32	161[2]	150[2]	145	189	72.3
Maricopa 1941	425	208									
Pinal	442	184									
Pima	436	216									
Graham	585	220									
State Average..	441	197	1,051.5	2.55	31.0	32[2]	126	150.6	125	263	90.4
Maricopa 1942	420	177									
Pinal	474	201									
Pima	632	338									
Graham	597	306									
State Average..	456	208	1,051.5	2.70	35.0	32	131	143	115	200	100.0
Maricopa 1943	417	154									
Pinal	424	150									
Pima	431	223									
Graham	517	357									
State Average..	428	180	1,051.5	2.85	35.0	31	174.0	141.0	180	309	150.7
Maricopa 1944	452	214									
Pinal	438	224									
Pima	696	350									
Graham	504	368									
State Average..	463	302	1,051.5	2.65	34.0	38	155.0	163	140	298	157.5
Maricopa 1945	344	171									
Pinal	348	176									
Pima	490	272									
Graham	513	323									
State Average..	366	287	1,014.6	2.70	34.0	34	165	150	160	323	165.8
Maricopa 1946	570	420									
Pinal	473	.....									
Pima	664	250									
Graham	647	341									
State Average..	524	348	1,014.6	2.70	36.0	35	146	151	170	325	164.4
Maricopa 1947	649	142									
Pinal	412	210									
Pima	592	194									
Graham	566	285									
State Average..	497	259	1,014.6	2.45	41.0	37	168	154	145	268	106.8
Maricopa 1948	624	207									
Pinal	522	252									
Pima	697	.....									
Graham	570	331									
State Average..	559	320	1,014.6	2.60	40.0	40	187	136	145	188	83.5
Maricopa 1949	711	315									
Pinal	638	350									
Pima	661	506									
Graham	654	314									
State Average..	651	327	1,014.6	2.70	44.0	40	185	132	128	340	136.3
Maricopa 1950	965	471									
Pinal	911	320									
Pima	983	465									
Graham	740	402									
State Average..	906	402	1,014.6	2.70	44.0	40	163	137	155	350	152.1
Maricopa 1951	736	373									
Pinal	731	454									
Pima	740	450									
Graham	715	380									
State Average..	719	393	1,014.6	2.80	42.0	50	183	158	150	311	111.4

Source: The Federal Crop and Livestock Reporting Service, Phoenix, except as otherwise indicated.
[1] Arizona Agriculture, Agricultural Experiment Station, University of Arizona, Tucson.
[2] Estimated by the Department of Agricultural Economics, University of Arizona, Tucson.
[3] American-Egyptian Cotton, Bulletin 238, Agricultural Experiment Station, University of Arizona, Tucson.
[4] Does not include alfalfa tonnage pastured.
[5] J. M. Foote, Supervisor, Fruit and Vegetable Standardization Service, Phoenix.
In some instances, yields recalculated by the Department of Agricultural Economics due to revisions of acreage data.
[6] Cantaloupe only.

TABLE 2.4 TOTAL CROP PRODUCTION OF MAJOR CROPS IN ARIZONA BY COUNTIES

COUNTY	(1) Short Staple Cotton (bales)	(2) Long Staple Cotton (bales)	(3) All Cottonseed (000 lbs.)	(4) Alfalfa (tons)	(5) Grain Sorghum (tons)	(6) Barley (tons)	(7) Lettuce Total for Spring & fall (000 crates)	(8) Canta-loupe (cars)	(9) Grapefruit (boxes)	(10) Oranges (boxes)
Maricopa 1938	100,300	13,894	108,157	81,200			1,365*		2,600,000	423,100
Pinal	42,680	5,044–	44,840	30,800			16*			
Pima	7,935	2,328	10,232	10,360						
Graham	17,410	33	15,528	190						
State Total....	175,000	21,000	183,966	406,000	20,280	23,000	4,196	2,346	2,700,000	430,000
Maricopa 1939	99,980	14,445	106,461	55,000	6,500	13,100	2,275	2,000	2,509,000	586,000
Pinal	44,915	7,610	49,187	28,750	1,100	1,300				
Pima	8,605	3,035	11,337	9,000	94	100				
Graham	15,090	2,365	16,293	7,500	115	130				
State Total	174,260	27,600	189,091	390,000	11,330	27,700	3,418	2,827	2,900,000	595,000
Maricopa 1940	88,820	9,160	90,121	186,900	15,800	19,300	3,130	2,892	2,457,000	506,100
Pinal	44,520	14,400	57,074	59,400	2,550	3,600				
Pima	9,940	2,570	11,961	6,100	420	400	26			
Graham	15,450	4,700	19,446	23,100	70	1,600				
State Total	164,000	30,500	183,439	364,000	25,000	29,000	3,990	3,823	2,650,000	506,100
Maricopa 1941	77,690	12,890	84,747	268,000	34,700	24,500	3,535	2,123	3,156,000	632,800
Pinal	40,170	20,400	60,486	58,000	7,900	4,600	16			
Pima	5,830	2,490	8,208	8,000	500	1,060	271			
Graham	11,840	5,580	17,303	18,200	165	710				
State Total	139,500	41,500	175,194	456,000	51,000	33,800	4,940	4,007	3,450,000	660,000
Maricopa 1942	73,660	16,630	85,701	318,600	30,700	30,400	3,072	1,592	2,400,000	700,000
Pinal	37,860	27,360	66,877	99,900	5,500	5,900		94		
Pima	7,920	4,790	12,858	2,700	1,100	2,300	56			
Graham	13,450	7,030	20,495	13,770	180	840				
State Total	137,000	56,000	190,727	497,000	45,000	45,000	4,478	4,320	2,600,000	730,000
Maricopa 1943	48,720	8,830	54,051	399,000	29,400	26,000	3,638	2,093	3,708,000	1,054,000
Pinal	33,380	15,620	48,647	133,950	11,350	6,400		130		
Pima	3,770	2,790	6,739	2,850	980	2,200	63			
Graham	7,100	8,390	16,496	17,100	300	1,400				
State Total	95,300	35,700	104,960	587,000	49,000	39,000	5,229	3,448	4,080,000	1,100,000
Maricopa 1944	38,048	1,402	35,545	424,000	48,000	44,200	4,055	2,775	3,427,000	1,102,500
Pinal	66,671	279	59,643	68,900	19,100	11,000	60*			
Pima	11,890	910	11,680	4,500	1,500	2,500	450*			
Graham	11,335	3,065	13,801	18,000	800	3,400				
State total	130,347	5,658	122,907	628,000	78,000	67,000	6,120	3,954	3,750,000	1,149,750
Maricopa 1945	29,420	280	24,338	413,100	35,200	43,200	3,865	4,682	3,714,000	1,160,000
Pinal	62,480	20	50,898	70,250	15,200	9,800	58			
Pima	7,980	570	7,201	4,850	1,700	2,800	99			
Graham	12,370	2,130	12,675	18,600	850	2,700				
State Total	114.000	3,000	96,684	575,000	62.800	63,600	6,064	6,200	4,100,000	1,210,000
Maricopa 1946	39,525	175	32,453	421,200	47,400	50,000	4,692	4,700	3,705,000	871,320
Pinal	84,000	.....	68,519	67,500	13,100	9,700	18			
Pima	15,390	10	12,566	8,100	11,900	2,200	55			
Graham	14,789	1,262	13,594	13,500	300	2,700				
State Total	156.553	1,447	129,480	629,000	68,500	71,100	6,867	7,500	4,100,000	1,200,000
Maricopa 1947	80,600	12	65,760	325,850	51,000	70,100	4,793	4,696	2,680,000	854,400
Pinal	111,000	9	90,554	56,300	9,100	11,200	2,051			
Pima	18,020	2	14,701	7,350	1,300	1,700				
Graham	18,480	140	16,608	13,500	450	2,050				
State Total	233,837	163	190,942	514,000	68,000	92,000	6,875	8,600	3,000,000	886,000
Maricopa 1948	110,464	56	98,326	276,900	75,000	125,700	4,866	5,069	1,645,000	709,750
Pinal	161,309	11	143,497	54,600	11,200	13,400	28	71		
Pima	21,300	.....	17,374	7,300	3,500	2,800				
Graham	21,477	1,003	18,736	13,250	670	3,450				
State Total	326,930	1,070	267,995	485,000	98,500	153,000	6,302	8,480	1,880,000	751,500
Maricopa 1949	208,940	330	170,832	342,900	68,900	95,000	4,293	4,443	3,026,000	1,172,000
Pinal	250,260	75	204,228	49,950	12,300	18,200	15			
Pima	31,890	155	26,211	7,800	4,300	2,800				
Graham	31,960	1,210	27,538	14,000	860	3,300				
State Total	538,300	1,770	441,271	543,000	96,000	131,000	7,063	8,102	3,400,000	1,253,000
Maricopa 1950	167,367	17,993	158,386	340,200	86,200	93,100	2,224*	4,580	2,765,000	1,323,270
Pinal	213,320	11,154	187,540	51,300	17,200	40,300		320		
Pima	23,007	2,621	21,948	7,800	5,100	2,600				
Graham	22,735	4,956	24,559	14,000	1,100	2,880				
State Total	437,100	36,900	401,984	563,000	123,000	156,000	7,073	11,500	3,150,000	1,400,000
Maricopa 1951	326,300	8,950	277,024	336,000	28,200	68,400	——	unavail	2,456,000	969,180
Pinal	314,000	2,940	259,689	40,600	11,200	31,200				
Pima	50,700	2,440	44,317	8,400	580	2,400				
Graham	20,920	5,230	23,411	14,850	120	2,500				
State Total	783,300	19,700	626,492	546,000	47,000	117,600	8,001	12,015	2,800,000	1,025,000

Source: Arizona Agriculture, published by the Department of Agricultural Economics, unless otherwise indicated.
Col. (1) and Col. (2) Source: Federal Crop and Livestock Reporting Service, Phoenix.
Col. (3) Estimated by using seed-lint ratio of 2.846 in 1938 for American-Egyptian Cotton. A ratio of 2.571 was used for the years 1939-1951. Upland Cotton seed was estimated by using a seed-lint ratio of 1.857 for 1938 to 1944, and a ratio of 1.703 for the years 1944-1951. Source: "American Egyptian Cotton", by Scott Hawthorn, Jr., Bulletin 238, Agricultural Experiment Station, University of Arizona, 1951.
Col. (4) Does not include hay pastured by livestock. County production estimated by multiplying average state yield x county acreage. 1940-1941 estimated by Arizona Agriculture.
Col. (5) Includes grain harvested in silage and forage. 1951 Estimated by Department of Agricultural Economics, University of Arizona.
Col. (6) 1940-1941 estimated by Arizona Agriculture. County production estimated by multiplying average state yields x county acreage.
Col. (7) Source: J. M. Foote, Supervisor, Fruit and Vegetable Standardization Service, Phoenix. Includes only fall lettuce.

TABLE 2.5 AVERAGE MARKET PRICE FOR COMMODITIES IN ARIZONA

YEAR	(1) Short Staple Cotton cents/lb.	(2) Long Staple Cotton cents/lb.	(3) All Cottonseed $/ton	(4) Alfalfa $/ton	(5) Grain Sorghum $/100 lbs.	(6) Barley $/100 lbs.	(7) Lettuce[5] fall $/crate	(7) Lettuce[5] spring $/crate	(8) Cantaloupe $/crate	(9) Grapefruit $/box	(10) Oranges $/box
1938	8.33	18.5	21.00	8.37	0.80	1.00	1.25	1.90	1.30	0.81	.....
1939	9.20	21.9	23.13	9.36	1.23	0.98	1.70	1.45	1.60	0.89	.....
1940	9.30	28.2	19.50	10.05	1.10	1.13	1.15	2.02	1.50	0.71	1.58
1941	15.80	28.3	46.75	10.89	1.33	1.25	2.65	1.65	1.85	1.15	1.78
1942	18.30	43.3	45.75	14.78	1.45	1.34	3.90	1.87	2.65	2.18	3.14
1943	18.80	46.4	53.00	22.25	2.40	1.95	3.07	3.75	4.70	2.57	3.75
1944	20.40	45.9	52.75	21.17	1.79	2.40	3.10	2.45	3.15	2.87	3.76
1945	22.30	43.7	43.75	19.63	2.40	1.93	3.00	3.15	3.40	2.13	4.37
1946	33.40	46.5	78.00	27.28	2.37	2.91	3.15	2.65	3.50	1.83	3.36
1947	31.80	53.5	87.50	21.42	3.65	2.76	3.95	2.65	3.50	1.92	3.17
1948	31.10	60.0	69.75	26.22	2.28	2.76	3.25	3.00	3.20	2.32	4.23
1949	28.40	55.0	45.00	18.91	2.20	2.08	3.35	4.55	2.70	2.35	3.56
1950	41.50	69.1	90.75[1]	19.81	2.23	2.04	2.90	2.75	3.40	2.03	4.33
1951	39.15	97.6	68.90[1]	35.10	3.03	2.87		3.60	3.25	0.85	2.55

Sources: The Department of Agricultural Economics, University of Arizona, Tucson, unless otherwise indicated.

[1] Estimated from crop production and value data supplied by BAE, Phoenix.

Col. (1) Price is the average market season price for 1 inch, strict middling cotton at Phoenix, Arizona. Market season from Sept. through Dec.

Col. (2) Price is the average market season price for Number 2 grade cotton at Phoenix, Arizona. Market season from Sept. through December. Source: S. H. Hastings, Southwest Cotton Company, Phoenix, Arizona. 1948-1949 estimated by trade sources.

Col. (3) Price is the average market season price from September through December.

Col. (4) Price is average price baled at the ranches in the Salt River Vallley during market season from April through December.

Col. (5) Price is the average price at the Arizona Producers, Phoenix, during the marketing season from October through December. Source: Federal Crop and Livestock Reporting Service, Phoenix.

Col. (6) Price is the average price at the Arizona Producers, Phoenix, duing the marketing season of June and July. Source: Federal Crop and Livestock Reporting Service, Phoenix.

TABLE 2.6 GROSS VALUE OF MAJOR IRRIGATED CROPS IN ARIZONA BY COUNTIES[1]
(In thousands of dollars)

Crop	Graham 1940	Graham 1945	Graham 1951	Maricopa 1940	Maricopa 1945	Maricopa 1951	Pinal 1940	Pinal 1945	Pinal 1951	Pima 1940	Pima 1945	Pima 1951	State Total 1940	State Total 1945	State Total 1951
Alfalfa	322	547	744	4,382	12,005	16,848	1,528	2,040	2,036	76	237	421	7,799	18,217	27,378
Cotton	992	1,607	7,941	8,101	4,517	73,952	3,497	9,541	69,551	584	964	12,057	13,724	16,916	184,502
Barley	38	109	167	454	1,765	4,537	98	400	2,069	8	832	159	700	2,600	7,800
Corn	4	14	11	17	14	45	7	17	9	9	16	11	280	602	720
Oats	1	3	4	28	100	13	4	9	11	4	9	11	98	301	424
Grain Sorghum	2	44	7	431	1,750	1,709	77	753	676	13	84	36	707	3,110	2,848
Truck Crops	....	519	291	7,682	26,583	33,192	202	1,317	582	.....	.....	875	10,089	39,914	56,486
Wheat	18	25	56	427	309	514	56	107	151	7	33	56	640	857	1,230
Dry Edible Beans	1	27	....	1	3	....	.....	15	.....	6	17	.....	206	384	189
Grapefruit	....	....	....	1,744	7,912	2,088	.....	.....	.....	.....	.....	8	1,882	8,733	2,380
Oranges	....	....	....	800	5,069	2,471	.....	.....	.....	.....	.....	.....	800	5,287	2,614
Flaxseed	....	....	....	....	38	201	.....	4–	.....	.....	.....	.....	448	1,282	536
Misc. Crops	75	217	204	836	2,486	3,115	287	1,089	1,610	33	154	285	1,506	4,817	6,700
County Total	1,453	3,112	9,425	24,903	62,551	138,685	5,756	15,292	76,695	740	2,346	13,917	38,879	103,020	293,807

Note: County totals based on percentage of crop land per crop, reported for each county. Equal yields and prices were assumed.

[1] Includes estimate for value of pasture and farm consumption.

TABLE 2.7 ANNUAL CASH INCOME FROM ARIZONA AGRICULTURAL CROPS
(In thousands of dollars)

COMMODITY	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
Cotton Lint	13,671	10,767	8,289	19,397	14,587	21,154	18,376	14,449	21,339	31,340	39,860	76,832	102,322	157,418
Cottonseed	2,017	1,817	1,354	3,010	3,083	3,711	2,987	2,763	4,531	7,261	9,036	8,268	18,715	24,804
Truck Crops	8,603	9,311	9,886	12,544	19,245	35,615	31,179	37,073	38,318	42,110	52,147	46,104	40,370	54,267
Alfalfa & Hay	1,134	2,172	1,846	2,241	4,874	7,144	5,244	8,087	9,853	7,740	11,346	7,501	13,566	20,922
Barley	283	300	285	418	656	1,122	2,203	2,101	3,157	3,963	6,293	5,976	8,556	7,105
Grain Sorghum	214	121	68	312	313	825	871	1,698	1,528	3,099	3,945	3,323	4,646	1,922
Potatoes	130	176	203	211	710	1,759	1,507	2,841	2,542	2,998	3,221	2,498	2,311	2,219
Alfalfa Seed	683	958	967	981	1,553	2,107	599	2,342	2,562	1,890	2,277	2,803	2,668	2,736
Wheat	689	509	417	307	444	517	739	640	859	1,121	1,161	1,151	1,337	1,230
Grapefruit	1,834	843	1,457	1,661	3,610	4,280	6,953	9,066	6,977	1,476	976	1,212	2,142	2,380
Oranges	375	309	905	878	1,691	1,886	3,553	4,831	5,966	2,306	2,380	1,102	3,755	2,614
Misc. Crops	785	1,025	987	1,144	1,833	3,375	4,387	3,757	5,323	6,888	10,423	7,148	5,000	4,500
Totals	30,858	28,768	27,050	43,495	52,849	83,495	78,598	89,648	102,955	112,192	143,065	163,918	205,388	282,117

Source: The Federal Crop and Livestock Reporting Service, BAE, Phoenix.
Cash income is derived by multiplying the mid-month price of crops by the estimated percentage of the crops sold during that month.
No allowance is made for crops pastured or consumed on the farm.

TABLE 2.8 PERCENTAGE COMPARISON OF INCOME FROM EACH CROP TO TOTAL STATE AGRICULTURAL INCOME

YEAR	Cotton Lint & Seed	Truck Crops	Alfalfa & Other Hay	Barley	Grain Sorgium	Grape-fruit	Oranges
1938	28.7	15.8	2.1	0.5	0.4	3.3	0.7
1939	24.1	17.9	4.2	0.6	0.2	1.6	0.6
1940	18.1	18.6	3.5	0.6	0.2	2.7	1.7
1941	29.8	16.7	3.0	0.6	0.4	2.2	1.2
1942	18.2	19.8	5.0	0.7	0.3	3.7	1.7
1943	18.8	26.9	5.4	0.8	0.6	3.2	1.4
1944	17.1	24.9	4.2	1.8	0.7	5.5	2.8
1945	12.2	26.3	5.7	1.5	1.2	6.4	3.4
1946	16.0	23.7	6.1	2.0	1.0	4.3	3.7
1947	20.9	22.8	4.2	2.1	1.7	0.8	1.3
1948	21.8	23.2	5.0	2.8	1.8	0.4	1.1
1949	36.3	19.7	3.2	2.5	1.4	0.5	0.5
1950	39.7	13.3	4.4	2.8	1.6	0.7	1.2
1951[1]	64.6	19.2	7.4	2.5	0.7	0.8	0.9
Avg. %	26.2	20.6	4.5	1.6	0.9	2.6	1.6

Source: Table 2.7

[1] Preliminary

During the last few years, field crops have constituted over 60 percent of the total agricultural income and may exceed 75 percent this year.

Table 2.9 illustrates Arizona's crop production progress per acre for the last 14 years.

TABLE 2.9 GROWTH OF ARIZONA'S CROP PRODUCTION

YEAR	Irrigated Acreage Under Cultivation[1]	Cash Value of Farm Crops[2]	Average Cash Income Per Acre[3]	Average Adjusted Cash Income Per Acre[4]
1930	607,000	$ 23,976,000	$ 39.50	$ .....
1935	560,000	25,465,000	45.50	.....
1938	653,000	30,876,000	47.25	57.75
1939	665,000	28,372,000	42.50	52.75
1940	681,000	27,050,000	39.75	43.60
1941	731,000	43,839,000	60.00	54.85
1942	750,000	52,849,000	70.50	48.95
1943	753,000	83,163,000	110.50	59.90
1944	765,000	80,388,000	105.00	51.90
1945	775,000	89,648,000	115.75	56.90
1946	775,000	102,955,000	132.75	58.60
1947	825,000	112,192,000	136.00	51.75
1948	900,000	143,065,000	159.00	63.10
1949	1,000,000	163,918,000	164.00	73.50
1950	915,000	205,388,000	224.50	96.70
1951	1,100,000	282,117,000	256.50	97.25

[1] Acreage figures supplied from the files of the Department of Agricultural Economics, University of Arizona.
[2] Bureau of Agricultural Economics, USDA.
[3] Figures rounded off to nearest fourth of a dollar.
[4] Adjusted cash income figures from Table 1.4.

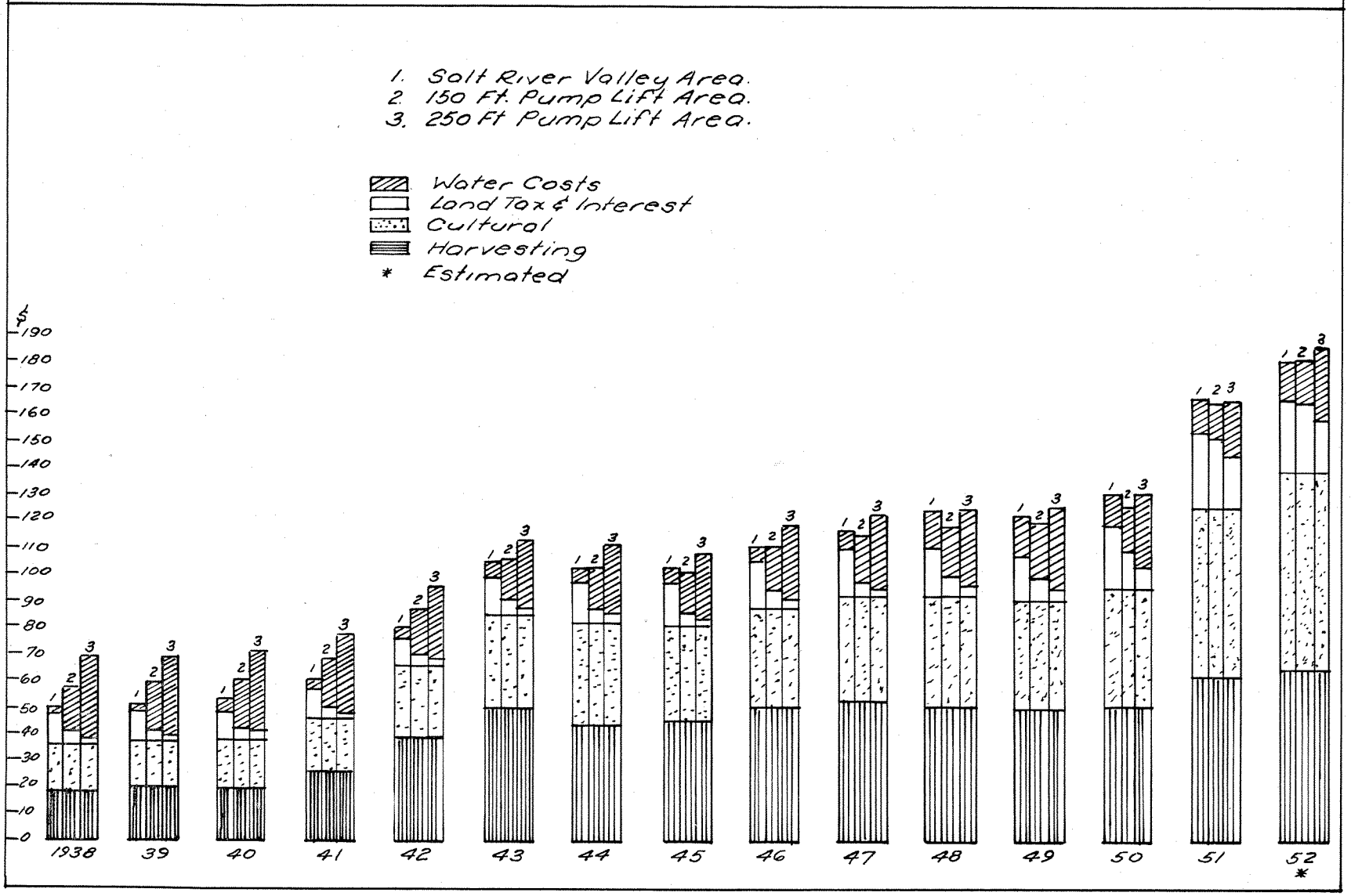
Column (3) indicates an increase of more than 500 percent in the cash income derived from an acre of cropland since 1938. Column (4) indicates that a 68% increase was due to production increases while the rest of the increase resulted from rising prices.

Graph 2A

COST OF PRODUCTION OF SHORT STAPLE COTTON (PER ACRE)

Costs Based on Yield of 1 Bale per Acre

Source: Table 3.1 Section III

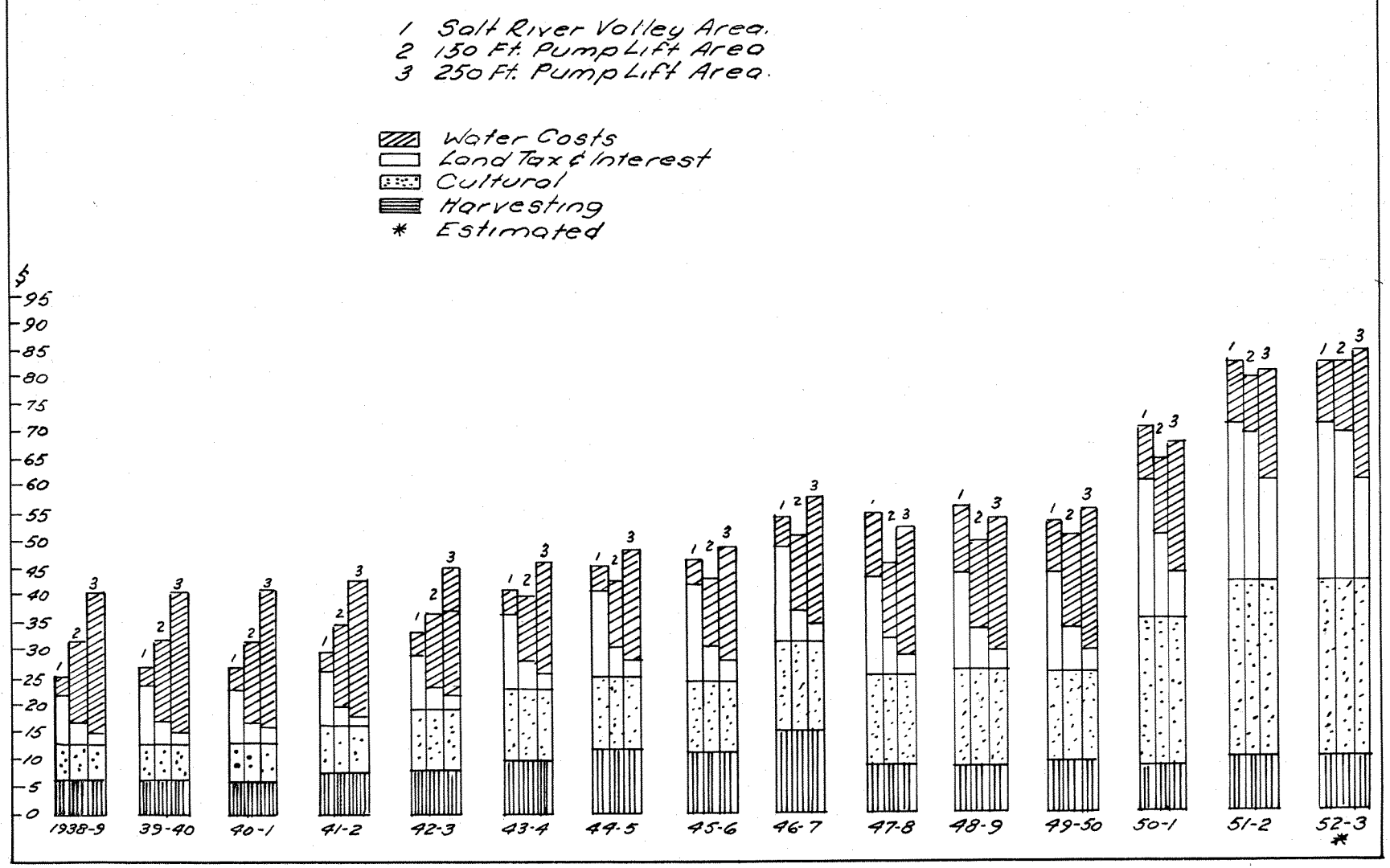


Graph 2B

COST OF PRODUCTION — OF BARLEY (PER ACRE)

Costs Based on Yield of 3000 lbs per Acre

Source: Table 3.3 Section III



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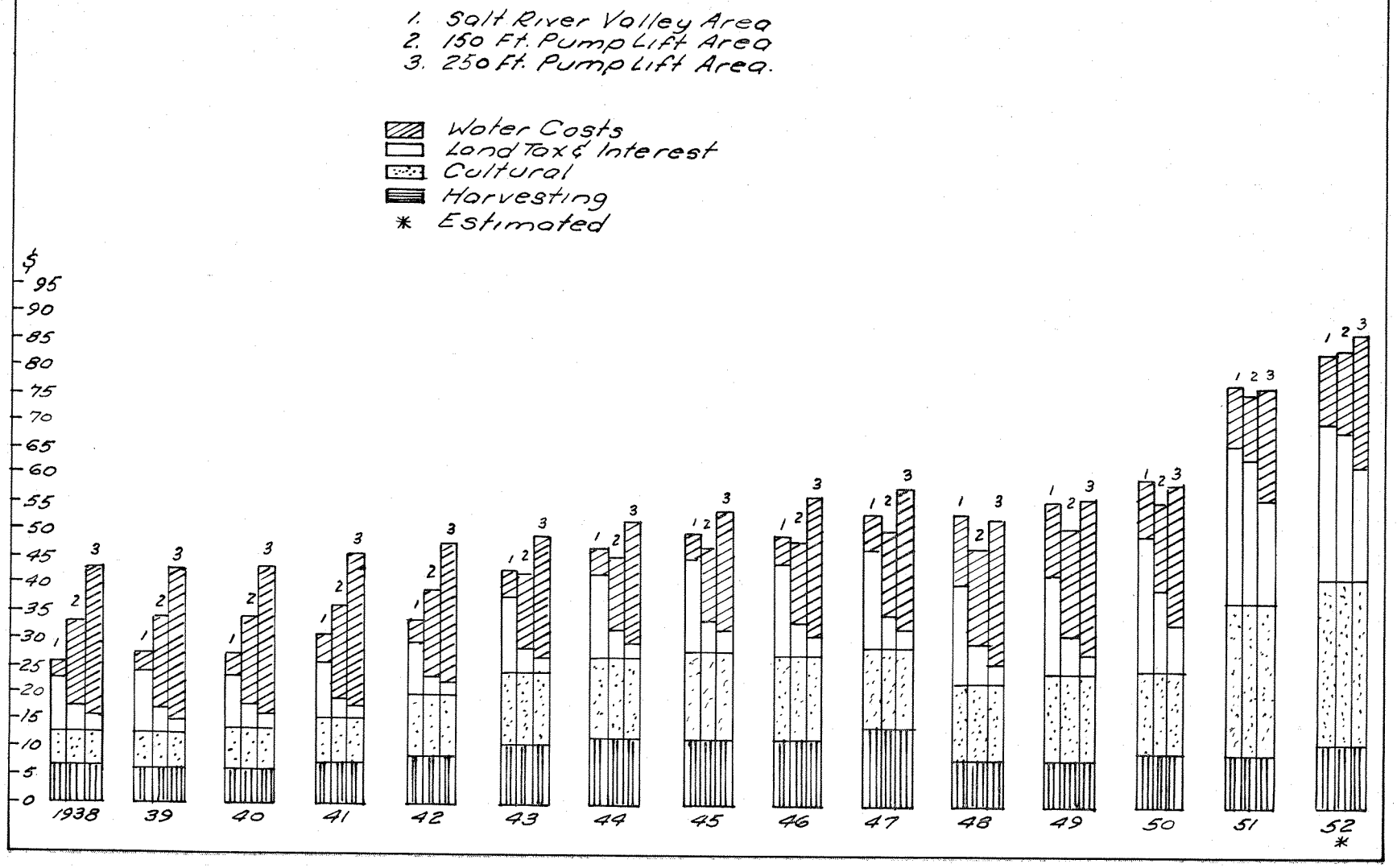
Graph 2-C

COST OF PRODUCTION OF GRAIN SORGHUM (PER ACRE)

Costs Based on 3000 lb Yield per Acre

Source: Table 3.4 Section III



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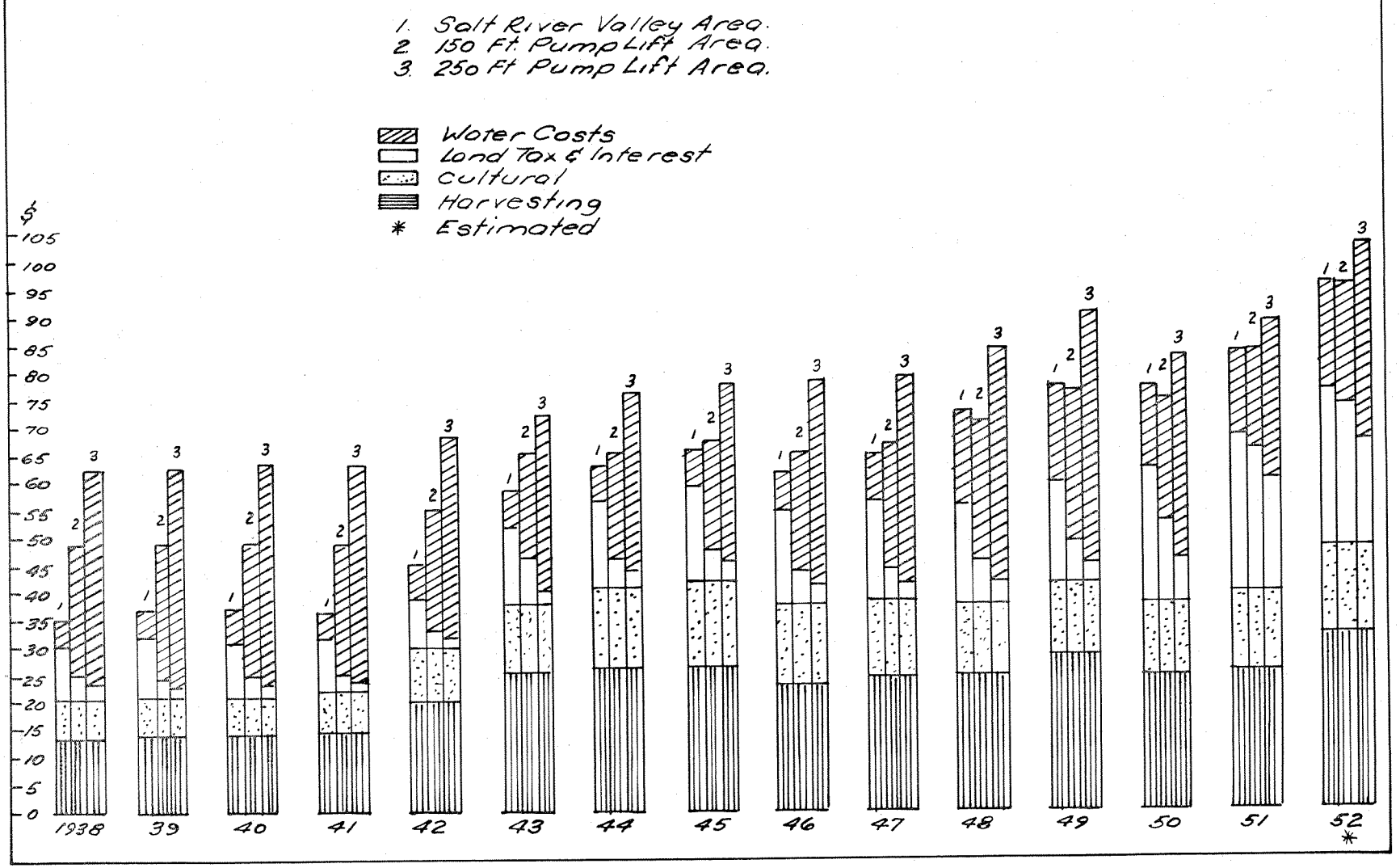
Graph 2-D

COST OF PRODUCTION — OF ALFALFA (PER ACRE)

Costs Based on 4 Ton Per Acre Yield

Source: Table 3.2 Section III



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SECTION III

Cost of Production of Major Crops

Cost of production studies have been conducted by the Department of Agricultural Economics at the University of Arizona for four major crops—short-staple cotton, alfalfa, barley and grain sorghums. Because cost figures may change markedly from year to year, these studies must be kept current to be of any real alue. The following four tables 3.1, 3.2, 3.3, and 3.4 show production costs from 1938 through 1951 under three different farming situations. The Salt River Valley area was chosen to illustrate production costs in a gravity water area. The other two situations are typical costs in pump areas having water lifts of 150 and 250 feet. In studying these tables, it should be remembered that the indicated costs are average costs for predetermined yields in the various areas. Individual farms, farm techniques, availability of factors of production and varying yields would all tend to influence the cost of production during any given year. These tables were adapted from cost of production figures published by Dr. G. W. Barr in the Uniersity of Arizona publication—"Arizona Agriculture", and adjusted to show actual costs for the year indicated.

To calculate the cost of water in the 150 and 250 foot pump areas, the following formula is used:

1.024 kwh x rate per kwh x A/F water used

.50 x .60

(pump efficiency) (cost of power as % of total water cost)

It requires about 1.024 kwh of electricity to raise one acre-foot of water one foot at 100% efficiency. An average pump efficiency of about 50 percent is assumed. The cost of power has been estimated at 60 percent of the cost of delivering water. Water costs are estimated on the assumption that electricity is the source of power. No formula has been created utilizing natural gas for power. During 1951-52, a study was conducted at the University of Arizona, by Dr. Rex D. Rehnberg, to determine the cost of pumping water for irrigation in Pinal County. This study was recently concluded and the results and conclusions have not been published at this time. However, the facts obtained are very significant and a few of them are presented here.

Both gas and electric wells were selected at random for this study. Two methods were used to compute the cost of pumping water. First there was *total cost.* The total cost of water includes a charge for interest on the present replacement cost of the well and a charge for depreciation on well and equipment. A rapid write off was adopted because of the uncertainty involved in the installation of new wells in some of the critical water areas (see Section V, Effects of a Receding Water Table). The second method used was *operating cost*—including such items as power, lubricants, repairs, attendance and taxes, but no charge for interest or depreciation.

The total cost of an acre-foot of water varied from about $7.50 at a 150 foot lift to about $16.50 at a 300 foot lift for electricity. This is an increase of approximately $6 per acre-foot for each 100 feet of lift. For natural gas wells the total cost ranged from $6 per acre-foot at 150 feet to $12.75 at 300 feet. This represented an increase in cost of $4.50 per acre-foot for each additional 100 foot of lift.

The operating cost of electric wells increased from $4.50 at 150 feet to $9.50 at 300 feet or $3.35 for each additional 100 feet of lift. For natural gas wells an increase in lift from 150 feet to 300 feet resulted in an increase in operating costs from $3.25 to $5.25 or $1.33 per additional 100 feet of lift.

As seen in Graphs 3 A and 3 B (graphs and calculations used with permission of the Department of Agricultural Economics) the cost advantage of natural gas over electric wells is much less at shallow lifts. As the lift increases, the cost advantage of gas over electricity increases. This relationship is the result of high installation costs for gas coupled with a steeply graduated natural gas cost curve. Costs decreased with larger consumption of gas, so that even with a rapid write off, natural gas appears to be a cheaper source of power than electricity in Pinal County.

These results are significant in that water costs shown in Table 3.1 for three acre-feet at 150 foot lift are only $16.15, whereas this study would indicate that the total cost should be $22.50 or an increase of 36 percent. This discrepancy becomes even larger at the 250 foot lift—being 50 percent above the costs calculated by the Department of Agricultural Economics at the University of Arizona. Even total costs for natural gas are slighly higher at the 150 foot level and are more than 15 percent greater at the 250 foot level.

Graphs 2A, 2B, 2C and 2D, Section II, show production costs in relation to gross crop value over the years. With the relatively lower value crops, farming

in pump areas theoretically has not been economically feasible prior to the advent of the period of high crop prices. Even so, if we accept the findings of Dr. Rehnberg's report, then, with exception of cotton, it is very possible that the crops shown here are not too profitable at the greater pumping depths even today. Many farmers, in critical water areas, pumping from depths of 250 to 400 feet would seem to be using operating cost instead of total costs in figuring their production expenses. It must be remembered, however, that Dr. Rehnberg's study assumed a rapid write off in capital investment in critical water areas. It would seem reasonable to assume that with a less rapid write off the figures used by the University would be reasonably accurate, at least for electrically powered pump motors.

Under conditions as they exist today there is little possibility of lowered water costs in the future. Even if pump efficiencies are improved and power costs lowered, the declining water table would tend to hold up the cost of pumping water. In the case of cotton, where water cost constitutes from only 8 to 15% of the total cost of production, the cost of water probably would not be a limiting factor even if prices were to decline somewhat. A study by Mr. Charles C. Ellwood, Extension Agronomist at the University of Arizona, estimates that break-even point 40-cent short staple cotton with present costs would be 350 pounds per acre. With the State average at better than one bale per acre, cotton would remain profitable for most farmers even at 25 cents per pound, if they could produce one and one-half bales per acre. Therefore, a five to 10% increase in water costs alone, where water is only 10-15% of production costs, would have little deterent effect on production. On a crop such as alfalfa, where water costs at the 250 foot pump level, may become as high as 35% of total cost, water becomes an important factor. The general assumption can be made that low value crops with lowered prices or higher production costs would tend to be marginal at the greater pump lifts. This subject of cost and prices will be discussed more fully in Section IX of this report.

TABLE 3.1 COST OF PRODUCTION OF SHORT STAPLE COTTON IN SALT RIVER VALLEY AND PUMP AREAS

	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952*
Water Cost 3 A/F															
Salt River Valley	$ 3.30	$ 3.55	$ 4.30	$ 3.30[1]	$ 4.30	$ 5.00	$ 4.85	$ 5.00	$ 5.00	$ 6.50	$ 13.50	$ 14.00	$ 11.50	$ 12.00	$ 13.90
150 ft. lift	17.85	17.85	17.85	17.70	16.50	15.00	15.00	15.15	16.30	16.70	19.15	20.60	16.70	13.05	16.15
250 ft. lift	29.75	29.75	29.75	29.50	27.50	25.00	25.00	25.25	27.85	27.85	28.70	30.85	27.85	21.75	26.90
Preharvest Cultural Costs															
Salt River Valley	$17.55	$17.60	$17.80	$20.20	$28.45	$ 36.00	$ 38.50	$ 35.50	$ 36.60	$ 39.50	$ 41.30	$ 41.00	$ 44.00	$ 63.25	$ 75.00
150 ft. lift	17.55	17.60	17.80	20.20	28.45	36.00	38.50	35.50	36.60	39.50	41.30	41.00	44.00	63.25	75.00
250 ft. lift	17.55	17.60	17.80	20.20	28.45	36.00	38.50	35.50	36.60	39.50	41.30	41.00	44.00	63.25	75.00
Harvesting Costs															
Salt River Valley	$18.20	$19.32	$20.54	$25.92	$37.95	$ 48.99	$ 43.24	$ 43.49	$ 50.80	$ 52.45	$ 50.60	$ 49.80	$ 50.20	$ 61.40	$ 63.75
150 ft. lift	18.20	19.32	20.54	25.92	37.95	48.99	43.24	43.49	50.80	52.45	50.60	49.80	50.20	61.40	63.75
250 ft. lift	18.20	19.32	20.54	25.92	37.95	48.99	43.24	43.49	50.80	52.45	50.60	49.80	50.20	61.40	63.75
Interest & Land Tax															
Salt River Valley	$ 9.75	$11.07	$10.04	$ 9.67	$ 9.91	$ 14.20	$ 15.75	$ 17.30	$ 17.50	$ 18.10	$ 18.00	$ 18.00	$ 24.20	$ 28.80	$ 28.80
150 ft. lift	4.00	4.25	4.00	3.50	3.50	5.00	5.50	5.90	5.90	5.90	7.65	8.00	15.00	26.70	26.70
250 ft. lift	2.50	2.50	2.50	2.25	2.25	2.75	3.25	3.40	3.40	3.40	3.90	4.00	8.00	19.80	19.80
Water Cost as % of Total Cost															
Salt River Valley	6.8%	6.9%	8.2%	5.6%	5.3%	4.8%	4.7%	4.9%	4.6%	5.6%	10.9%	10.3%	8.8%	7.2%	7.7%
150 ft. lift	31.0	30.2	29.6	26.3	19.1	14.3	14.7	15.1	16.3	16.0	19.0	17.1	11.5	8.5	8.9
250 ft. lift	43.7	43.0	42.1	37.9	28.6	22.2	22.7	23.5	25.4	24.5	26.6	24.3	18.2	14.1	14.5
Total Production Costs[1]															
Salt River Valley	$48.80	$51.54	$52.68	$59.09	$80.61	$104.19	$102.34	$101.27	$109.90	$116.55	$123.40	$122.80	$129.90	$165.45	$181.45
150 ft. lift	57.60	59.02	60.19	67.32	86.40	104.99	102.24	100.04	109.60	114.55	118.70	119.40	125.90	164.40	181.60
250 ft. lift	68.00	69.17	70.59	77.87	96.15	112.74	109.99	107.64	118.65	123.20	124.50	126.65	130.05	166.20	185.45

[1] Excessive rains in 1941 resulted in an average of only two (2) acre ft. of water being applied.

Source: Cost of production studies by the Department of Agricultural Economics, University of Arizona, and Arizona Agriculture.
1938-45 Land Tax and Interest are estimated.
Pump water costs estimated by using an average electric power rate and a pump water cost formula developed by Dr. G. W. Barr. University of Arizona.
Production costs do not allow for a return from cottonseed. No allowance is made for management, farm transportation, fencing, insurance or land depreciation.
Costs determined for a yield of one bale per acre.

* Estimated by Arizona Agriculture, 1952.

TABLE 3.2 COST OF PRODUCTION OF ALFALFA HAY IN THE SALT RIVER VALLEY AND PUMP AREAS

	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Water Cost 4 A/F															
Salt River Valley	$ 4.30	$ 5.05	$ 6.50	$ 4.80	$ 5.80	$ 6.50	$ 6.35	$ 6.50	$ 6.50	$ 8.50	$17.00	$18.00	$15.00	$15.50	$19.50
150 ft. lift	23.95	23.95	23.95	23.76	22.12	19.25	19.25	19.45	21.75	22.50	25.50	27.75	22.50	17.40	21.51
250 ft. lift	39.92	39.92	39.92	39.60	36.88	32.08	32.08	32.42	37.05	37.50	42.62	46.25	37.50	29.00	35.83
Land Tax & Interest															
Salt River Valley	$ 9.75	$11.07	$10.04	$ 9.67	$ 9.91	$14.20	$15.75	$17.30	$17.50	$18.10	$18.00	$18.00	$24.20	$28.80	$28.80
150 ft. lift	4.00	4.25	4.00	3.50	3.50	5.00	5.50	5.90	5.90	5.90	7.65	8.00	15.00	26.70	26.70
250 ft. lift	2.50	2.50	2.50	2.25	2.25	2.75	3.25	3.40	3.40	3.40	3.90	4.00	8.00	19.80	19.80
Cultural Costs															
Salt River Valley	$ 7.00	$ 6.85	$ 6.90	$ 7.02	$ 9.35	$12.37	$14.53	$15.70	$14.80	$14.00	$12.90	$13.00	$13.00	$13.55	$15.45
150 ft. lift	7.00	6.85	6.90	7.02	9.35	12.37	14.53	15.70	14.80	14.00	12.90	13.00	13.00	13.55	15.45
250 ft. lift	7.00	6.85	6.90	7.02	9.35	12.37	14.53	15.70	14.80	14.00	12.90	13.00	13.00	13.55	15.45
Harvesting Costs															
Salt River Valley	$13.00	$13.50	$13.50	$14.73	$19.50	$25.00	$26.00	$26.00	$23.00	$24.00	$25.00	$28.00	$25.00	$26.00	$32.00
150 ft. lift	13.00	13.50	13.50	14.73	19.50	25.00	26.00	26.00	23.00	24.00	25.00	28.00	25.00	26.00	32.00
250 ft. lift	13.00	13.50	13.50	14.73	19.50	25.00	26.00	26.00	23.00	24.00	25.00	28.00	25.00	26.00	32.00
Total Production Costs															
Salt River Valley	$34.05	$36.74	$26.74	$36.22	$44.56	$58.07	$62.63	$65.50	$61.80	$64.60	$72.90	$77.00	$77.20	$83.85	$95.75
150 ft. lift	47.95	48.55	48.35	49.01	54.47	61.62	65.28	67.05	65.45	66.40	71.05	76.75	75.50	83.65	95.66
250 ft. lift	62.42	62.77	62.82	63.60	67.98	72.20	75.86	77.52	78.25	78.90	84.42	91.25	83.50	88.35	103.08
Water Cost as % of Total Cost															
Salt River Valley	12.6%	13.8%	17.1%	13.3%	13.0%	11.6%	10.6%	10.2%	10.5%	13.2%	23.3%	25.4%	20.8%	18.5%	20.4%
150 ft. lift	49.9	49.3	49.5	48.5	40.6	31.2	29.5	29.0	33.2	33.9	35.9	36.2	29.8	20.8	22.5
250 ft. lift	63.9	63.6	63.5	62.3	54.3	44.4	42.3	41.8	47.3	47.5	50.5	50.7	44.9	32.8	34.8

Source: Cost of Production Studies by the Department of Agricultural Economics, University of Arizona, and Arizona Agriculture.
1938-45 Land Tax and Interest are estimated.
Pump Water costs estimated by using an average electric power rate and a pump water cost formula developed by Dr. G. W. Barr.
Calculations assume a yield of four tons per acre. No item is included for management, farm transportation, fencing, insurance or land depreciation.

TABLE 3.3 COST OF PRODUCTION OF BARLEY

	1938-39	1939-40	1940-41	1941-42	1942-43	1943-44	1944-45	1945-46	1946-47	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53*
Water Cost 2½ A/F															
Salt River Valley	$ 2.80	$ 3.05	$ 4.05	$ 3.55	$ 4.25	$ 4.10	$ 4.25	$ 4.25	$ 5.50	$11.75	$12.00	$ 9.25	$ 9.75	$11.25	$11.25
150 ft. lift	14.97	14.97	14.97	14.85	13.83	12.03	12.03	12.15	13.60	13.90	15.95	17.15	13.90	10.85	13.45
250 ft. lift	24.95	24.95	24.95	24.75	23.05	20.05	20.05	20.25	23.20	23.20	23.90	25.70	23.20	18.10	22.40
Land Tax & Interest															
Salt River Valley	$ 9.75	$11.07	$10.04	$ 9.67	$ 9.91	$14.20	$15.75	$17.30	$17.50	$18.10	$18.00	$18.00	$24.20	$28.80	$28.80
150 ft. lift	4.00	4.25	4.00	3.50	3.50	5.00	5.50	5.90	5.90	5.90	7.65	8.00	15.00	26.70	26.70
250 ft. lift	2.50	2.50	2.50	2.25	2.25	2.75	3.25	3.40	3.40	3.40	3.90	4.00	8.00	19.80	19.80
Cultural Costs															
Salt River Valley	$ 6.45	$ 6.45	$ 6.65	$ 8.60	$10.92	$12.87	$13.50	$13.25	$16.00	$16.75	$17.50	$16.50	$27.35	$31.85	$31.85
150 ft. lift	6.45	6.45	6.65	8.60	10.92	12.87	13.50	13.25	16.00	16.75	17.50	16.50	27.35	31.85	31.85
250 ft. lift	6.45	6.45	6.65	8.60	10.92	12.87	13.50	13.25	16.00	16.75	17.50	16.50	27.35	31.85	31.85
Harvesting Costs															
Salt River Valley	$ 6.25	$ 6.25	$ 6.25	$ 7.25	$ 8.25	$10.00	$11.50	$11.00	$14.50	$ 8.50	$ 8.00	$ 9.00	$ 8.50	$10.00	$10.00
150 ft. lift	6.25	6.25	6.25	7.25	8.25	10.00	11.50	11.00	14.50	8.50	8.00	9.00	8.50	10.00	10.00
250 ft. lift	6.25	6.25	6.25	7.25	8.25	10.00	11.50	11.00	14.50	8.50	8.00	9.00	8.50	10.00	10.00
Total Prod. Costs															
Salt River Valley	$25.25	$26.82	$26.99	$29.07	$33.33	$41.17	$45.00	$45.80	$53.50	$55.10	$55.50	$52.75	$69.80	$81.90	$81.90
150 ft. lift	31.67	31.92	31.87	34.20	36.50	39.90	42.53	42.30	50.00	45.05	49.10	50.65	64.75	79.40	82.00
250 ft. lift	40.15	40.15	40.35	42.85	44.47	45.67	48.30	47.90	57.10	51.85	53.30	55.20	67.05	79.75	84.05
Water Cost as % of Total Cost															
Salt River Valley	11.1%	11.4%	15.0%	12.2%	12.8%	9.9%	9.4%	9.3%	10.3%	21.3%	21.6%	17.5%	14.0%	13.7%	13.7%
150 ft. lift	47.3	46.9	47.0	43.4	37.9	30.2	28.3	28.7	27.2	30.9	32.5	33.9	21.5	13.7	16.4
250 ft. lift	62.1	62.1	61.8	57.8	51.8	43.9	41.7	42.3	40.6	44.7	44.8	46.6	34.6	22.7	26.6

Source: Cost of production studies by the Department of Agricultural Economics, University of Arizona, and Arizona Agriculture.
1938-45 Land Tax and Interest are estimated.
Pump water costs estimated by using an average electric power rate and a pump water cost formula developed by Dr. G. W. Barr, University of Arizona.
Costs do not include any return for management, farm transportation, fencing, insurance or land depreciation.
Calculations assume an average production of 3000 lbs. per acre.
* Estimated by Arizona Agriculture, 1952.

TABLE 3.4 COST OF PRODUCTION OF GRAIN SORGHUM

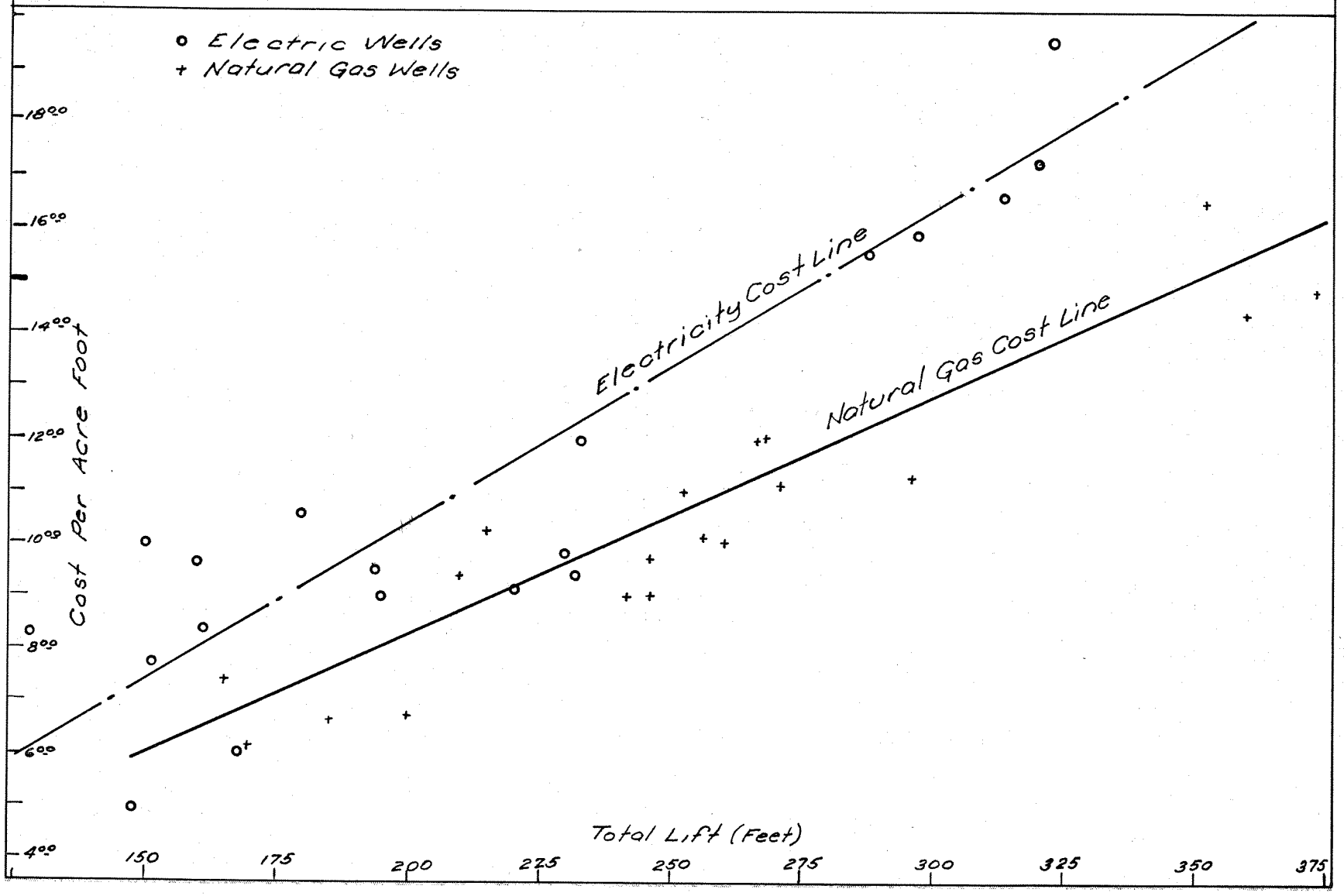
	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952*
Water Cost 2¾ A/F															
Salt River Valley	$ 3.00	$ 3.05	$ 3.43	$ 4.43	$ 3.93	$ 4.63	$ 4.48	$ 4.63	$ 4.60	$ 6.00	$12.63	$13.00	$10.15	$10.75	$12.62
150 ft. lift	16.35	16.35	16.35	16.35	15.15	13.20	13.20	13.35	14.95	15.30	17.50	18.90	15.30	11.95	14.80
250 ft. lift	27.25	27.25	27.25	27.25	25.25	22.00	22.00	22.25	25.50	25.50	26.30	28.30	25.50	19.95	24.65
Land Tax & Interest															
Salt River Valley	$ 9.75	$11.07	$10.04	$ 9.67	$ 9.91	$14.20	$15.75	$17.30	$17.50	$18.10	$18.00	$18.00	$24.20	$28.80	$28.80
150 ft. lift	4.00	4.25	4.00	3.50	3.50	5.00	5.50	5.90	5.90	5.90	7.65	8.00	15.00	26.70	26.70
250 ft. lift	2.50	2.50	2.50	2.25	2.25	2.75	3.25	3.40	3.40	3.40	3.90	4.00	8.00	19.80	19.80
Cultural Costs															
Salt River Valley	$ 6.75	$ 6.75	$ 6.95	$ 8.58	$11.18	$13.30	$14.71	$15.45	$14.70	$14.00	$14.00	$16.00	$16.35	$27.65	$30.65
150 ft. lift	6.75	6.75	6.95	8.58	11.18	13.30	14.71	15.45	14.70	14.00	14.00	16.00	16.35	27.65	30.65
250 ft. lift	6.75	6.75	6.95	8.58	11.18	13.30	14.71	15.45	14.70	14.00	14.00	16.00	16.35	27.65	30.65
Harvesting Costs															
Salt River Valley	$ 6.60	$ 6.60	$ 6.60	$ 7.55	$ 9.05	$10.75	$11.70	$12.20	$11.70	$14.50	$ 8.50	$ 8.00	$ 9.00	$ 9.00	$11.00
150 ft. lift	6.60	6.60	6.60	7.55	9.05	10.75	11.70	12.20	11.70	14.50	8.50	8.00	9.00	9.00	11.00
250 ft. lift	6.60	6.60	6.60	7.55	9.05	10.75	11.70	12.20	11.70	14.50	8.50	8.00	9.00	9.00	11.00
Total Prod. Cost															
Salt River Valley	$26.10	$27.47	$27.02	$30.23	$34.07	$42.88	$46.64	$49.58	$48.50	$52.60	$53.13	$55.00	$59.70	$76.20	$83.07
150 ft. lift	33.70	33.95	33.90	36.25	38.88	42.25	45.11	46.80	47.25	49.70	47.65	50.90	55.65	75.30	83.15
250 ft. lift	43.10	43.10	43.30	45.63	47.73	48.80	51.66	53.30	55.30	57.40	52.70	56.30	58.85	76.40	86.10
Water Cost as % of Total Cost															
Salt River Valley	11.5%	11.1%	12.7%	14.6%	11.5%	10.8%	9.6%	9.3%	9.5%	11.4%	23.8%	23.6%	17.0%	14.1%	15.2%
150 ft. lift	48.5	48.2	48.2	45.1	39.0	31.2	29.3	28.5	31.6	30.8	36.7	37.1	31.1	18.8	17.8
250 ft. lift	63.2	63.2	62.9	59.7	52.9	45.1	42.6	41.7	46.1	44.4	49.9	50.3	46.1	30.1	28.6

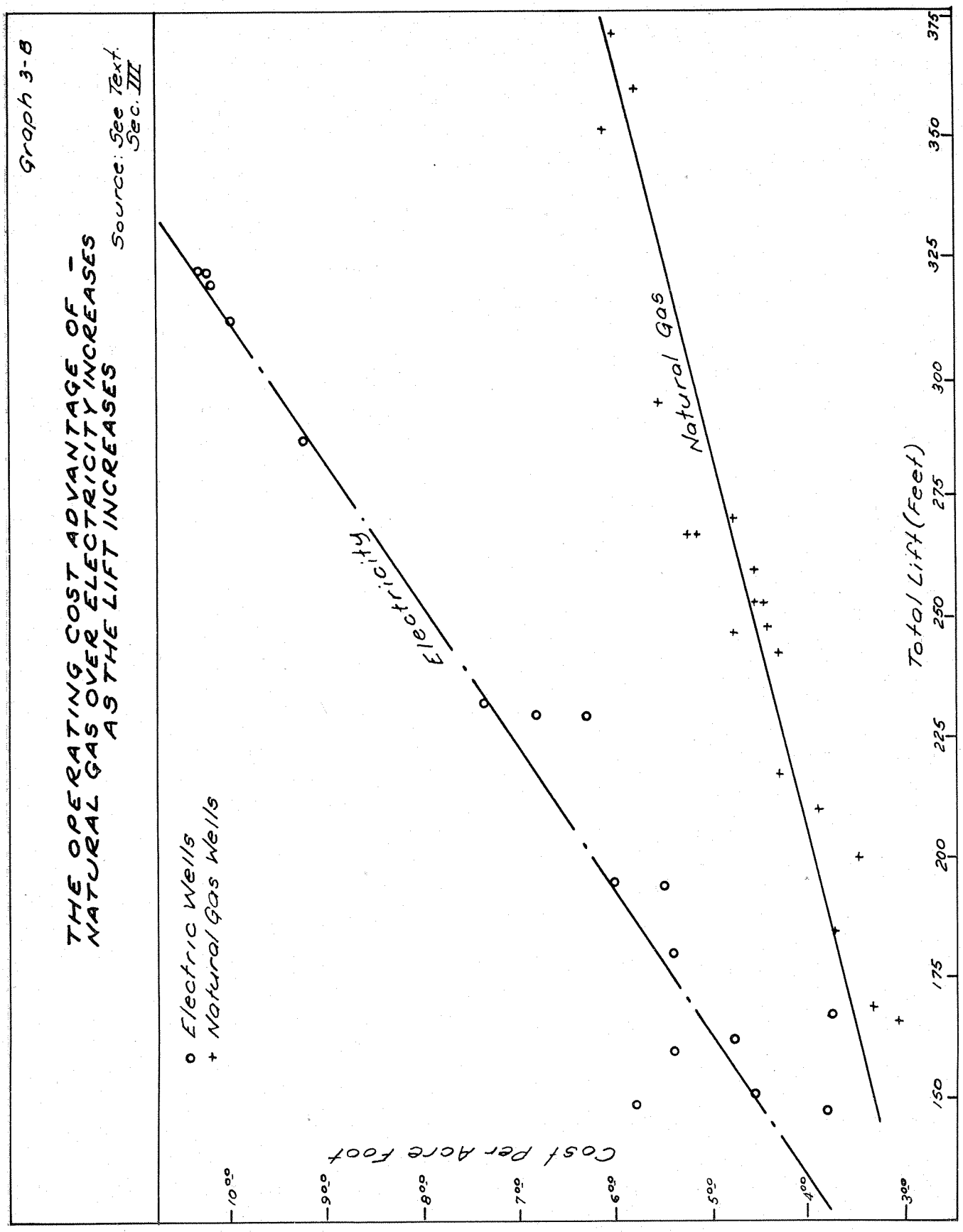
Source: Cost of production studies by the Department of Agricultural Economics, University of Arizona, and Arizona Agriculture.
1938-45 Land Tax and Interest are estimated.
Pump water costs estimated by using an average electric power rate and a pump water cost formula developed by Dr. G. W. Barr, University of Arizona.
No item is included for management, farm transportation, fencing, insurance or land depreciation.
Calculations assume an average production of 3000 lbs. of grain per acre.
* Estimated by Arizona Agriculture, 1952.

NATURAL GAS IS A CHEAPER SOURCE OF POWER THAN ELECTRICITY AT ALL LIFTS GREATER THAN 150 FEET

Graph 3 A

Source: See Text Sec. III




Graph 3-B
THE OPERATING COST ADVANTAGE OF
NATURAL GAS OVER ELECTRICITY INCREASES
AS THE LIFT INCREASES
Source: See Text. Sec. III
o Electric Wells
+ Natural Gas Wells
Electricity
Natural Gas
Cost Per Acre Foot
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
Total Lift (Feet)
150
175
200
225
250
275
300
325
350
375

SECTION IV

Value of Water When Applied to Various Crops

It should be noted at the outset of this discussion on water value that there is a difference between what an acre-foot of water is worth (its value) and what an acre-foot of water costs. There is also a problem of valuing an acre-foot of water for an individual and valuing the same acre-foot of water to the county or State.

The value placed on any factor (water) is dependent upon two things:

1. Conditions of production involving use of water.
2. Price of commodity sold in which water is an important production factor.

Since commodity prices in Arizona are determined to a great extent by a competitive market, and since individual farmers have little control over these prices, the principal problem involved in the determination of water value is the added production that can be attained by the application of additional water. Therefore, the only way to reasonably determine the value of water used in agricultural production is through the experimental method. An economic principle which should be kept in mind is that additional water will be applied to a crop until a point is reached where the cost of the last additional water application just equals the value of the resulting increased production.

The average water requirements for the major Arizona crops are shown in Table 4.1.

TABLE 4.1 WATE REQUIREMENT FOR MAJOR ARIZONA CROPS

Crop	Water Requirement for Normal Yield in Acre-Feet
Alfalfa for Hay	4½–5
Alfalfa for Seed	4 –4½
Cotton, Upland	3 –3½
Cotton, American-Egyptian	3 –3½
Barley	2 –2½
Grain Sorghums	2½–3
Citrus	3½–4½
Lettuce	2½–3
Cantaloupe	2½–3
Carrots	3 –3½
Flaxseed	2 –2½
Corn	3¼–3¾
Oats	2 –2½
Wheat	2¼–2½
Dry Edible Beans	3¼–3¾

Source: Alfalfa, Grain and Cotton, Agronomy Department. Fruits and Vegetables, Horticulture Department
Prepared by: Department of Agricultural Economics, Arizona Agricultural Experiment Station.

These figures are not absolute and water requirements depend upon many factors other than plant needs. Soil type, rainfall, temperature, techniques of application, etc., all tend to influence the amount of irrigation water needed by crops.

Recently the University of Arizona made available experimental data showing alfalfa production response to water application. Results of this experiment are adopted for use in the following table.

TABLE 4.2 A STUDY OF ALFALFA PRODUCTION RESPONSE TO WATER APPLICATION

Water Applied A/F per A	Alfalfa Yield tons per A	Additional Yield per A/F of Water	Cost of Added Water	Value of Added Hay	Net Marginal Return (profit)
0	0	0	$ 00	$ 00	$ 00
1	2.0	2.0	10.00	60.00	50.00
2	3.8	1.8	10.00	54.00	44.00
3	5.6	1.8	10.00	54.00	44.00
4	7.2	1.6	10.00	48.00	38.00
5	8.2	1.0	10.00	30.00	20.00
6	8.4	0.2	10.00	6.00	–4.00
7	8.0	–0.4	10.00	–12.00	–22.00

Source: Data available in the files of the Department of Agricultural Economics, University of Arizona.

If you assume that each acre-foot of water cost $10.00 and that hay standing in the field can be sold for $30.00 per ton, this experiment shows that water application should cease—if hay production is our only concern—somewhere between the fifth and sixth acre-foot of water.

This experiment also illustrates another important fact—that is, the value of one particular acre-foot of water applied to a crop is not the same as another acre-foot. An average of the net marginal returns would not determine the value of a *hypothetical acre-foot of water* since it is the added foot of water which is of most concern. It is readily seen, however, that the value of an acre-foot of water remains relatively high through the fifth application.

Where two or more crops are competing, a decision must be made as to where to apply the added acre-foot of water. If the farmer is chiefly concerned with money returns, the added acre-foot should be applied where the greatest *added profit* is forthcoming. Water costs per acre from 1940 through 1951 tended to lower due to decreasing electric power rates while returns per dollar inested were sharply increasing. This has led to an increase in the value of water as applied to these various crops. Water costs and values for four major crops during the years 1940, 1945 and 1951 are shown in Figure 4 A. (See calculations in Appendix Table 3 B.)

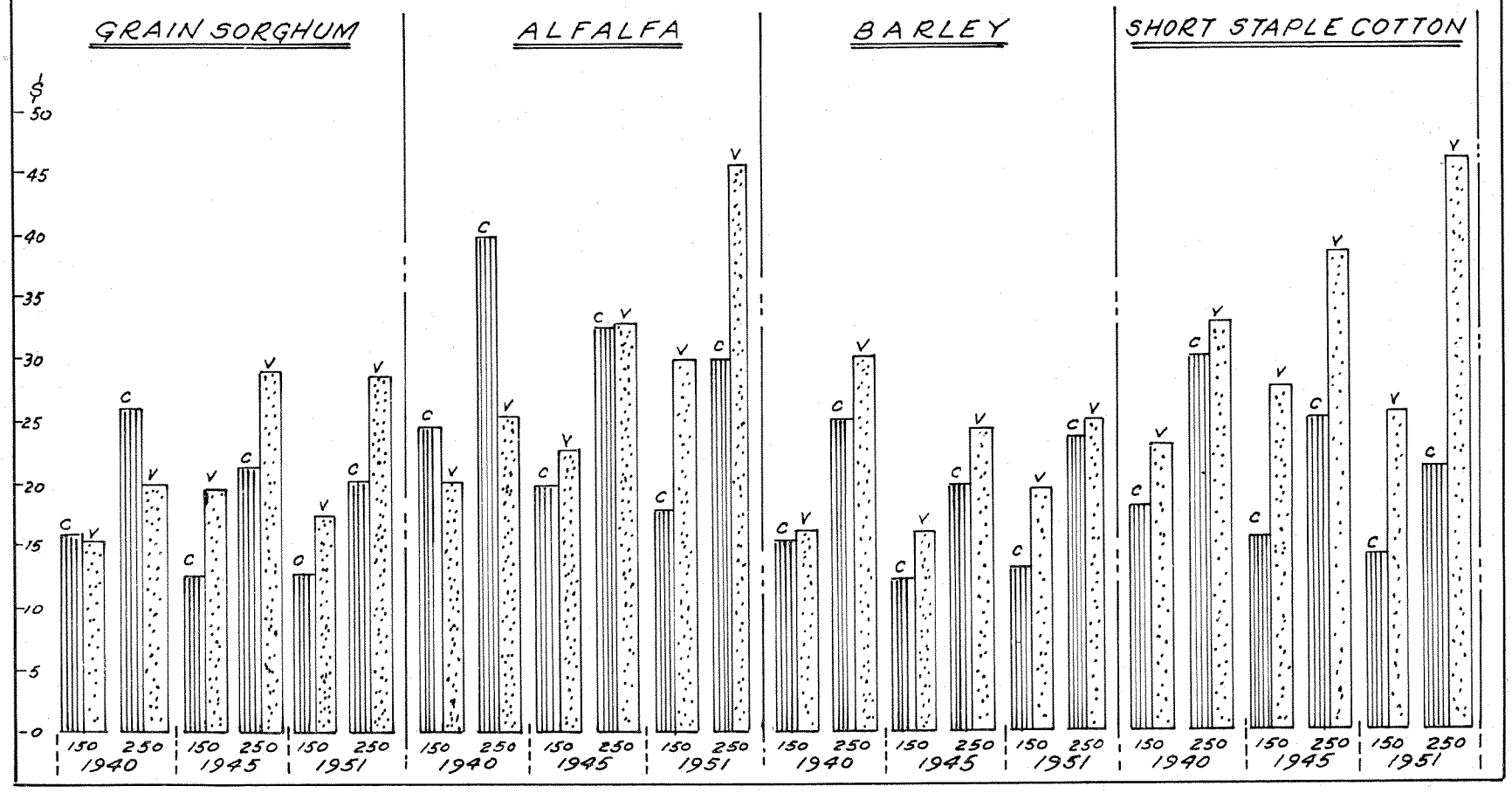
The left bar represents water costs while the right hand bar represents water values. Whenever the water costs exceeded water values, it was then unprofitable to apply water under the conditions that

Figure 4A

WATER COSTS & WATER VALUE
NET INCOME APPROACH

Source-Appendix. Table. 3B

C- Water Cost Per Acre
V- Value of Water when Applied to Various Crops



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existed during those given years. In 1940 these costs exceeded the values for alfalfa and grain sorghum at 150 foot lift and for alfalfa, barley and grain sorghum at 250 foot lift. The difference between water cost and water value bars in the graph represents a margin of profit which might be attributed to water as a factor of production. This method of water valuation assumes a competitive price paid for water as compared with land, labor and capital.

The consideration of gross income gives us still another approach to water valuation. If the average gross income per acre-foot of water for the years 1940 ,1945 and 1951 is taken as 100 then our calculations (Appendix Table 4B) show that water applied to cotton would have a value of 141 and water applied to alfalfa would only have a value of 39. See Table 4.3 below.

TABLE 4.3 INDEX OF WATER VALUE BASED ON GROSS INCOME PER ACRE WHEN APPLIED TO VARIOUS CROPS

CROPS	Index of water valuation based on gross income per acre for the years 1940, 1945 and 1951
Truck Crops	287
Grapefruit	210
Oranges	209
Cotton	141
Flaxseed	90
Barley	50
Grain Sorghum	43
Wheat	41
Alfalfa	39
Oats	29
Alfalfa Seed	27
Dry Edible Beans	17
Corn	13

Source: See calculations in Appendix Table 4B.

In general the index figure will be relatively higher for crops that are intensely farmed and have a high gross value per acre. It should be emphasized that these are *gross* not net income calculations.

There is another method by which the value of an additional acre-foot of water may be shown. The following table is self-explanatory.

TABLE 4.4

The value of an additional acre-foot of water in the Production of alfalfa hay on land for which 3½ acre-feet of water is normally available, Salt River Valley Water User's Area, 1933-1947[3]

YEAR	Profit, 3½ Acre-Feet of Water	Profit, 4½ Acre-Feet of Water[1]	Return from Extra A/F of Water[2]
1933	$–5.57	$ 0.18	$ 5.75
1934	11.75	23.21	11.46
1935	0.26	8.90	8.64
1936	–3.71	3.45	7.16
1937	6.94	17.38	10.44
1938	–3.20	4.16	7.36
1939	1.96	6.40	8.36
1940	0.44	9.48	9.04
1941	3.80	13.62	9.82
1942	9.45	22.73	13.28
1943	24.39	44.63	20.24
1944	17.22	35.39	18.17
1945	9.74	27.49	17.75
1946	34.23	59.51	25.28
1947	4.97	24.39	19.42

Source: Data available in the files of the Department of Agricultural Economics, University of Arizona.
[1] Here it is assumed that 4½ tons of hay are produced from 4½ acre-feet of water.
[2] Before any charge is made from this water.
[3] Table from Third Annual Report of the Arizona Interstate Stream Commission, July 1, 1949 to June 30, 1950, Phoenix Arizona, p. 159.

Still another method of valuing water, especially that lost through seepage is discussed on pages 16 and 17 of the publication "Irrigation Ditch Management on Arizona Irrigated Farms," Bulletin 237, Arizona Agricultural Experiment Station, October, 1951, by Dr. Rex D. Rehnberg. If, in an irrigated area, only a portion of the potentially irrigable land is under cultivation due to a shortage of water, the water lost through seepage or waste should be valued at the net return it would have yielded if applied to the idle land. It is evident that this method of valuation has certain requirements and limitations.

It can be seen from the preceding examples that the value of water and the cost of water bear little direct relationship to each other. The cost of water is influenced greatly by its relative abundance and availability. The value of water is determined by the value of the commodity—(which water is used to produce) and the techniques used to apply the water to the crops.

There is a direct relationship between the prices of agricultural crops and the value of water for irrigation. Water is a substantial cost item in crop production in Arizona, although its importance as a cost varies greatly between crops. In 1952, estimated water costs varied from approximately 10% of the average production cost of cotton to 25% of the average cost of producing alfalfa. (See production cost tables in Section III). While the cost of production does not determine price, it does establish a floor below which prices cannot fall for any considerable period.

Since the water cost is a major component of the total cost of crop production in Arizona, it may be assumed that the higher the level of agricultural prices, the more producers could afford to pay for water. Also the water would have higher value because the added production attributed to water would have a higher value.

In determining the value of water by the methods described above, certain qualifications should be pointed out.

Since the price of crops is one of the factors determining the value of crops, when prices vary, value of water will vary also. Hence, the value of an acre-foot of water will probably vary from year to year even if the conditions under which that water is applied are identical. Therefore, government price supports, production variations and export policies can all be expected to influence the value of water. Most agricultural crops in Arizona require a minimum amount of irrigation water before production

begins. Therefore, it is useless to place a value on the first acre-foot of water, if one acre-foot will not produce any crops.

Another qualification of the previously mentioned methods of computing water value is the conditions prevailing on a specific farm. The techniques used by one farmer may differ from that of another, resulting in different water values even when applied to the same crops of adjacent farms. The farm location, soil type, crop planted and the amount and time of water application will all affect gross net value of the crop production and therefore the value of water.

In an area where the water cost (because of dwindling supplies or lowering water table) is increasing rapidly relative to other costs, and where water costs make up a large portion of total production costs, the price of commodities over time could well be influenced by water costs. And, if commodity prices vary, the value of water as a productive factor would also vary.

(Much of this discussion on water value was based on a letter from the Agricultural Economics Department to Elmer D. Hershey, Executive Secretary of the Underground Water Commission.)

In the agronomic experiment set forth in Table 4.4 only one crop—alfalfa—was used, due to lack of dependable and conclusive data for other crops. However, under conditions of free competition, we may assume that the value of water is not going to vary greatly even when applied to various crops. Otherwise, the price of one commodity would rise rapidly relative to others and the consumer demand would tend to slacken. Actually, under conditions of perfect foresight and free competition in the purchase of water and the sale of commodities, it could well be assumed that the value of all acre-feet of water would be the same. These assumptions being unrealistic, a precise dollar and cent valuation of water must await further scientific experimentation of water and its effect on production of specific crops.

SECTION V

Economic Effects of a Receding Water Table

Most of the ground water studies conducted by State and Federal Agencies have indicated that the groundwater table in certain specific areas seems to be lowering. There are several economic effects of receding water table which should be mentioned.

The principal and most noticeable effect of a lowering water table is the increased costs of production due to increased water costs. The tables on Cost of Production in the preceding section illustrate the actual cash expenses which arise as the pump lift increases. Other increased costs include costs for deepening of wells, increasing the length of casing, lowering of bowls and decreasing pump efficiencies. Pumps and motors are designed for specific lifts and a lowering water table has a very noticeable effect upon the efficiency of pumping. An appreciable reduction in pumping efficiency results in higher power costs per acre-foot of water pumped or necessitates the replacement of old pumps and sometimes motors with new ones designed for higher lifts.

Another factor, which increases the cost of production, is the uncertainty of stable, future farming in an area of rapidly lowering water table. The fear of "running out of water" has caused some farmers to increase the depreciation rate on all permanent improvements or replacements. Dr. Rex D. Rehnberg's study of pump costs in Pinal County indicated that many farmers are depreciating new pumps and motors in five years and the well in 10 years. This action increases pump costs considerably, especially when relatively expensive natural gas motors are involved. It may also be assumed that many farmers have suspended all long-range conservation programs such as crop rotation, fallowing, etc. This might tend to reduce yields and thereby increase the ratio of cost to value of production.

One final effect of a receding water table is the eventual reduction in land value of pump irrigated land in such an area. Two of the major factors in determining land values are the relationship between costs of production and gross crop value and the stability and permanence of farming in an area. Generally speaking, if agricultural yields and prices remain constant and costs rise, the farming area becomes less desirable and land values decline. Similarly, if a declining water table threatens the stability and availability of irrigation water, thus increasing the possibility of crop limitations or failures, land values will decline.

SECTION VI

Business Activity and Growth and Their Relation to Agriculture

In a highly complex economy it is difficult to take one element and accurately determine its relative importance and its economic effects upon the whole economy. The interdependence of agriculture and business dictates that before we can determine the role of agriculture it is necessary for us to review the growth of business in Arizona. Several "growth indicators" have been selected, most of which not only illustrate the trend of business in Arizona, but also reflect the influence of agriculture upon these trends.

Most of these indicators are expressed in terms of dollars which may be misleading during a period of rising costs and prices. "The Wholesale Price Index, All Commodities" compiled by the U. S. Bureau of Labor Statistics, indicates the monetary increases in value of commodities due to rising prices. (see Graph 6 A). Therefore, when comparing these indicators, it would be well to bear in mind how much of the monetary increase is due to progress and how much is due to increased prices.

The following tables are for the most part self-explanatory and are included here to give an indication of Arizona's economic progress over the last fourteen years.

TABLE 6.1 MOTOR VEHICLE REGISTRATIONS IN ARIZONA BY COUNTIES
(In thousands)

YEAR	Graham	Maricopa	Pima	Pinal	State Total
1939	3.0	59.3	21.8	6.1	139.1
1940	3.3	62.4	23.3	6.4	147.0
1941	3.4	66.2	25.1	7.2	153.3
1942	3.3	65.5	23.4	7.6	150.1
1943	2.9	63.4	24.0	6.8	144.9
1944	2.9	67.9	25.3	6.0	146.3
1945	2.8	74.4	27.1	5.8	154.9
1946	3.1	85.1	30.9	6.5	176.4
1947	3.6	99.9	37.7	7.9	208.4
1948	4.0	113.3	44.1	9.3	237.9
1949	4.5	124.0	48.9	11.1	263.3
1950	5.0	139.7	53.6	13.0	294.1
1951	5.3	152.1	59.4	14.1	318.2

Source: Arizona State Highway Department.

TABLE 6.2 TOTAL NUMBER OF TELEPHONES IN SERVICE IN ARIZONA[1]
(Includes Extension)

YEAR	Total Telephones In Service	YEAR	Total Telephones In Service
1942	62,639	1947	98,085
1943	69,085	1948	110,481
1944	76,180	1949	125,778
1945	77,726	1950	144,969
1946	81,580	1951	156,102
		1952	171,610

Source: Arizona Commercial Manager, The Mountain States Telephone and Telegraph Co., Phoenix, Arizona.
[1] As of January 1, each year.

Tables 6.1 and 6.2 present indications of the technological advances and increased purchasing power of the economy and individual. They differ from the following table in that the statistics are quantitative, not monetary.

Table 6.3 sets forth state income by major businesses, excluding agriculture, indicating a rough picture of the non-agricultural business economy of the State.

TABLE 6.3 STATE INCOME BY MAJOR BUSINESSES EXCLUDING AGRICULTURE
(In thousands of dollars)

YEAR	Manufacturing	Tourist[1 2]	Mining	Gross Retail Sales[2]	Services[2]
1939-40	30,301	30,000	54,810	unavail	unavail
1940-41	30,427	25,000	62,478	174,939	87,450
1941-42	42,948	25,000	73,881	210,094	105,040
1942-43	70,173	25,000	85,589	247,312	123,650
1943-44	77,143	25,000	84,571	299,421	149,710
1944-45	108,962	25,000	74,573	324,887	162,440
1945-46	82,851	40,000	57,913	383,506	191,750
1946-47	101,673	60,000	127,197	516,861	258,430
1947-48	126,610	75,000	160,544	648,870	324,430
1948-49	134,775	75,000	183,817	735,837	367,910
1949-50	130,666	75,000	135,983	698,274	349,130
1950-51	158,710	100,000	215,516	776,576	388,280

Source: Reports of the Arizona State Tax Commission, unless otherwise indicated.
[1] Calendar year (includes restaurant and gasoline sa'es)
[2] Estimated by Research Department, Valley National Bank, Phoenix.

Manufacturing, retail sales and service have increased more than four hundred percent since the fiscal year 1939-40 while tourist trade and mining registered increases greater than three hundred percent during the same period. Graph 6 B illustrates the trend of major businesses in Arizona, including agriculture from 1939 through 1951. It would be misleading to add the figures in Table 6.3 and try to ascertain the total state income. There are two reasons for this: first, the figures used for service are merely estimates based on the "rule of thumb" that service is equal to approximately one-half of income from gross retail sales. Secondly, there is such overlapping between retail sales and service, as well as between the other items, that adding the figures gives a distorted picture of total State income. Adding such figures gives results similar to the case of the farmer who adds the cash value of his alfalfa pasture to the cash income received from his livestock using that pasture and believes that the total was his gross income for the year.

Having presented tables of statistics designed to show the increased business activity in the State since 1938, the question can now be asked: "How has agriculture influenced this business activity?" This question is still hard to answer, but at least some indications of this influence can be shown. It is generally agreed that agricultural income is reflected

to a great extent in retail sales, service and taxes. For the moment we shall exclude taxes from the discussion, for they will be handled separately.

One of the primary reasons agricultural income so strongly influences retail sales and service is because the farmer is in the rather unique position of buying, at retail, most of items necessary for his business as well as for his personal living. Since this is true most of his expenditures are made through local dealers rather than directly with the manufacturer—thus a very large proportion of the total agricultural income of the State is spent within the state borders and naturally appears in retail sales and service statistics. This is of great importance in determining the economic influence of the agricultural dollar upon business *within* the State of Arizona. While there is no direct method of determining the percentage of the agricultural dollar which appears in retail sales and service, Table 6.4, below, does give us one approach to the problem. It is possible to relate the agricultural cash income of crops to the total state income of individuals and arrive at an indication of the relative importance of irrigated land to the economy.

TABLE 6.4 TOTAL STATE INCOME BY YEARS FOR INDIVIDUALS AND AGRICULTURE'S PORTION OF THAT INCOME

YEAR	(1) Total of Individuals Income For Arizona	(2) Agricultural Crop Cash Income	(3) Percentage of State Income Derived from Crops
1938	$ 213,000,000	$ 30,876,000	14.5
1939	227,000,000	28,372,000	12.5
1940	237,000,000	27,050,000	11.4
1941	287,000,000	43,839,000	15.3
1942	449,000,000	52,849,000	11.8
1943	601,000,000	83,163,000	13.8
1944	591,000,000	80,388,000	13.6
1945	604,000,000	89,648,000	14.8
1946	644,000,000	102,955,000	16.0
1947	725,000,000	112,192,000	15.5
1948	832,000,000	143,065,000	17.2
1949	836,000,000	163,918,000	19.6
1950	936,000,000	205,388,000	21.9
1951	1,151,000,000	282,117,000	24.5

Column (1) Comprises all receipts and earnings as follows:
Wages, salaries, commissions, fees, bonuses, etc.
Net earnings of unincorporated businesses (including farmers).
Property income (dividends, interest, rent, etc.)
Pensions, relief payments, compensation insurance, etc.
Source: U. S. Department of Commerce.
Column (2) Source: Bureau of Agricultural Economics, U. S. Department of Agriculture.
Column (3) Column (2) divided by Column (1).
Figures rounded to nearest tenth of one percent.

The percentage of the total state income contributed by agricultural crops rose from 14.5 to 24.5 percent (Table 6.4, column 3) during the period 1938 through 1951. This change largely is a result of the gain in the relative position of agricultural prices as compared with other prices during this period.

The percentages shown in Column (3) agree closely with the U.S. Department of Commerce data showing the percentage of Arizona income derived from agriculture. In view of the large acreage in cotton at the present time, agricultural crop income should constitute an even larger percentage of the total state income than in 1951.

Another indication of the importance of agriculture is presented in Table 6.5. If allowance is made for livestock and dry-land farm employees, the percentage of total employment attributed to irrigated farming approximates the percentage of state income derived from irrigated crops. This fact strengthens the approach to determining agricultures position in the economy as shown by Table 6.5.

TABLE 6.5 TOTAL STATE AND AGRICULTURAL EMPLOYMENT BY YEARS

YEAR	(1) Total State Employment[1]	(2) Total Employed in Agriculture[2]	(3) Percent of State Total Employed in Agriculture
1943	195,700	53,300	27
1944	191,000	52,300	27
1945	186,700	51,700	28
1946	190,100	53,600	28
1947	201,800	56,500	28
1948	215,200	60,800	28
1949	219,700	67,000	30
1950	231,900	72,700[3]	31
1951	240,800	65,000[4]	27

Column (1) Source: Research Department, Valley National Bank, Phoenix.
Column (2) Source: Unemployment Compensation Division, Employment Security Commission of Arizona.
Column (3) Column (2) divided by Column (1).
[1] Does not include self-employed.
[2] Includes proprietors, unpaid family workers and seasonal workers. Totals are average of monthly employment.
[3] Estimated for September through December, 1950.
[4] Estimated and partially incomplete.

Between 25 and 30% of the State's gainfully employed are directly associated with agriculture. It is safe to assume, therefore, that more than one-fourth of Arizona's people live close to the soil.

The following graphs are included to illustrate further the effect of irrigated farming on specific counties in the State. Graph 6-C illustrates the relationship between irrigated acreage and concentration of population within the State. The five counties plotted on this graph, Graham, Maricopa, Pima, Pinal and Yuma, contained more than 90% of the total irrigated land in the State and their combined population was almost 75% of all the permanent residents of the State. Graph 6-D indicates that these same counties transacted 80% of the retail selling in the State during the year 1950-51. Graph 6-E points out the high correlation between population growth and the increase in irrigated acreage in the State. Most of the increase in the State's population since 1910 has been in the irrigated areas.

These graphs suggest the controversial topic of indirect benefits. Few subjects are more argued and less understood, yet the importance of such benefits resulting from our agricultural industry is generally

recognized. The following explanation of indirect benefits is from a study conducted by Mr. M. E. Marts of the Bureau of Reclamation, Department of the Interior, entitled "An Experiment in the Measurement of the Indirect Benefits of Irrigation—Payette, Idaho."

> "It has long been recognized that the farmers are not the only beneficiaries of irrigation development. From even the most casual observation of urban growth and other evidence of economic activity in irrigated areas, it is obvious that important benefits accrue indirectly to non-farm groups. The estimation of these indirect benefits is basic to x x x a realistic appraisal of the contribution made to the national economy by irrigation projects. Despite the importance of such information, however, data on indirect benefits are extremely sketchy, and need for additional information is felt keenly by those concerned with resource development."

The results of this particular study indicated that for each $1.00 in net income (direct benefit) which accrued to the farm segment of the local population, the non-farm population realized $1.27. Another way of stating this: for each $1.00 of direct benefit, the total benefit realized within the local economy was $2.27, distributed among such businesses as construction trade, manufacturing, public utilities, wholesale trade, retail trade, finance, service and government. It is evident that this type of study can be misdirected to prove that agriculture or any other basic industry controls the economy of an area. Indirect benefits can easily be added together to give figures which seem logical but are biased. Nevertheless, indirect benefits do exist and are extremely important. Although such indirect benefits cannot be determined exactly, it is entirely possible that nearly half of the income of the State might be closely dependent upon our agricultural industry. This does *not* mean that any given increase or decrease in agricultural income would necessarily cause a similar change in total state income. However, probably 50% of the State income would reflect these fluctuations to a greater or lesser degree.

The final portion of this discussion will include the influence of agriculture on the tax base of the State and nation. There are several methods that may be employed to determine agriculture's share of taxes, but any method used will have definite limitations and the results obtained must be generalized and rough. Table 6.6 sets forth the retail sales taxes paid in the State.

TABLE 6.6 TOTAL STATE SALES TAX COLLECTIONS BY COUNTIES

YEAR	Graham	Maricopa	Pima	Pinal	State Total
1939-40	60,400	1,538,500	734,900	174,800	4,033,100
1940-41	67,300	1,657,200	809,700	238,600	4,402,500
1941-42	78,400	2,070,700	937,200	319,100	5,343,100
1942-43	86,700	2,522,500	1,110,800	364,900	6,526,500
1943-44	96,200	3,038,400	1,320,700	361,500	7,353,100
1944-45	105,000	3,551,600	1,418,400	342,900	7,999,800
1945-46	141,900	4,548,400	1,746,500	375,800	9,673,400
1946-47	180,700	6,115,400	2,545,200	505,000	13,527,700
1947-48	220,500	7,635,900	3,241,000	705,700	16,782,500
1948-49	232,400	7,896,600	3,428,000	752,300	17,396,600
1949-50	229,200	7,555,900	3,106,500	802,300	11,000,000
1950-51	286,400	9,690,600	3,821,000	1,061,300	20,389,000

Source: Arizona Statistcial Review, published by the Valley National Bank, Phoenix, Arizona.

It is difficult to determine what portion of these taxes are paid by the agricultural dollar. Data for taxes on farm machinery, fertilizer, equipment, etc., are unavailable. The indirect effect of sales taxes paid with farm wages is also a matter of speculation, again returning us to the unanswered question of how far does the farm dollar go. It was stated earlier that as a relatively large proportion of the farm dollar was reflected in retail sales and Graph 6-C supports that premise. One might assume that the percentage of total income accruing to irrigated agriculture might offer the answer. However, let us develop the entire picture a little further before attempting to arrive at an answer.

Table 6.7 contains the assessed valuation of pump land according to the estimate of the State Tax Commission.

TABLE 6.7 ASSESSED VALUATION OF ALL IRRIGATED "B" LANDS BY COUNTIES IN ARIZONA[1]
(In thousands of dollars)

YEAR	Graham	Maricopa	Pima	Pinal	State Total
1939	300	3,100	600	400	5,000
1940	300	3,100	700	500	5,200
1941	300	1,600	700	700	4.000
1942	300	2,600	600	800	5,200
1943	300	2,600	600	1,000	5,400
1944	200	2,700	700	1,000	5,400
1945	.....	2,700	700	1,600	5,800
1946	.....	2,700	700	2,000	6,400
1947	.....	unavail	unavail	unavail	6,400
1948	.....	2,700	900	2,200	6,900
1949	.....	2,800	900	2,300	7,200
1950	.....	3,000	1,000	2,400	7,800
1951	.....	4,100	1,100	2,900	8,800
1952	.....	4,400	1,500	3,700	10,700

Source: Statement of Comparative Values, State Tax Commission, Arizona.
[1] The classification "Irrigated "B" Lands" includes all agricultural lands using pump water as the principal irrigation source.

In 1951 all irrigated land, both pump and gravity water, was assessed at $39,500,000—approximately 15% of the total assessed land value in the State according to the 1952 Statement of Comparative Values, published by the State Tax Commission of Arizona. However, this percentage figure cannot be used to determine what share of State and local taxes is borne by irrigation farmers. It might be fairly accurate for real estate taxes but because of

unequal distribution of this land, this figure offers no indication of school taxes paid by farmers. In some localities farmers pay practically all of the school taxes; in other areas they pay a relatively small share.

Because of insufficient detail in much of our tax statistics, this accumulative method of determining taxes paid would be inaccurate and misleading. For our purposes it might be more accurate to examine the overall tax picture and make some rough calculations.

The Federal and State taxes for the postwar years have averaged over 20% of the individual's income for the State. If it is assumed that agriculture pays its proportionate share of taxes, Federal, State and Local and if irrigated agriculture accounts for 24.5% of the individual income in Arizona, then it also would pay approximately 24.5% of the taxes of the State. As indicated by Column (3) in Table 6.8 irrigated agriculture paid almost 25 million dollars in State and Local taxes during the fiscal year 1950-51.

TABLE 6.8 ESTIMATED STATE AND LOCAL TAXES PAID BY IRRIGATED AGRICULTURE

YEAR	(1) Total State & Local Taxes Paid in Arizona (dollars)	(2) Percentage of Arizona Income Derived from Crops[1]	(3) Estimated Share of State & Local Taxes Paid by Crops (dollars)
1939-40	31,546,000	11.4	3,596,000
1940-41	31,597,000	15.3	4,834,000
1941-42	32,103,000	11.8	3,788,000
1942-43	35,578,000	13.8	4,910,000
1943-44	35,445,000	13.6	4,821,000
1944-45	39,707,000	14.8	5,877,000
1945-46	46,466,000	16.0	7,435,000
1946-47	62,234,000	15.5	9,646,000
1947-48	71,651,000	17.2	12,324,000
1948-49	78,406,000	19.6	15,368,000
1949-50	82,486,000	21.9	18,064,000
1950-51	101,360,000	24.5	24,833,000

Source:
Column (1) Arizona Statistical Review, published by the Valley National Bank, Phoenix.
Column (2) Column (3), Table 6.5.
Column (3) Column (1) x Column (2) x 100.
[1] Based on the calendar year.

Irrigated agriculture also paid over 26 million dollars in Federal taxes during the last fiscal year, as shown by Column (3) in Table 6.9 following:

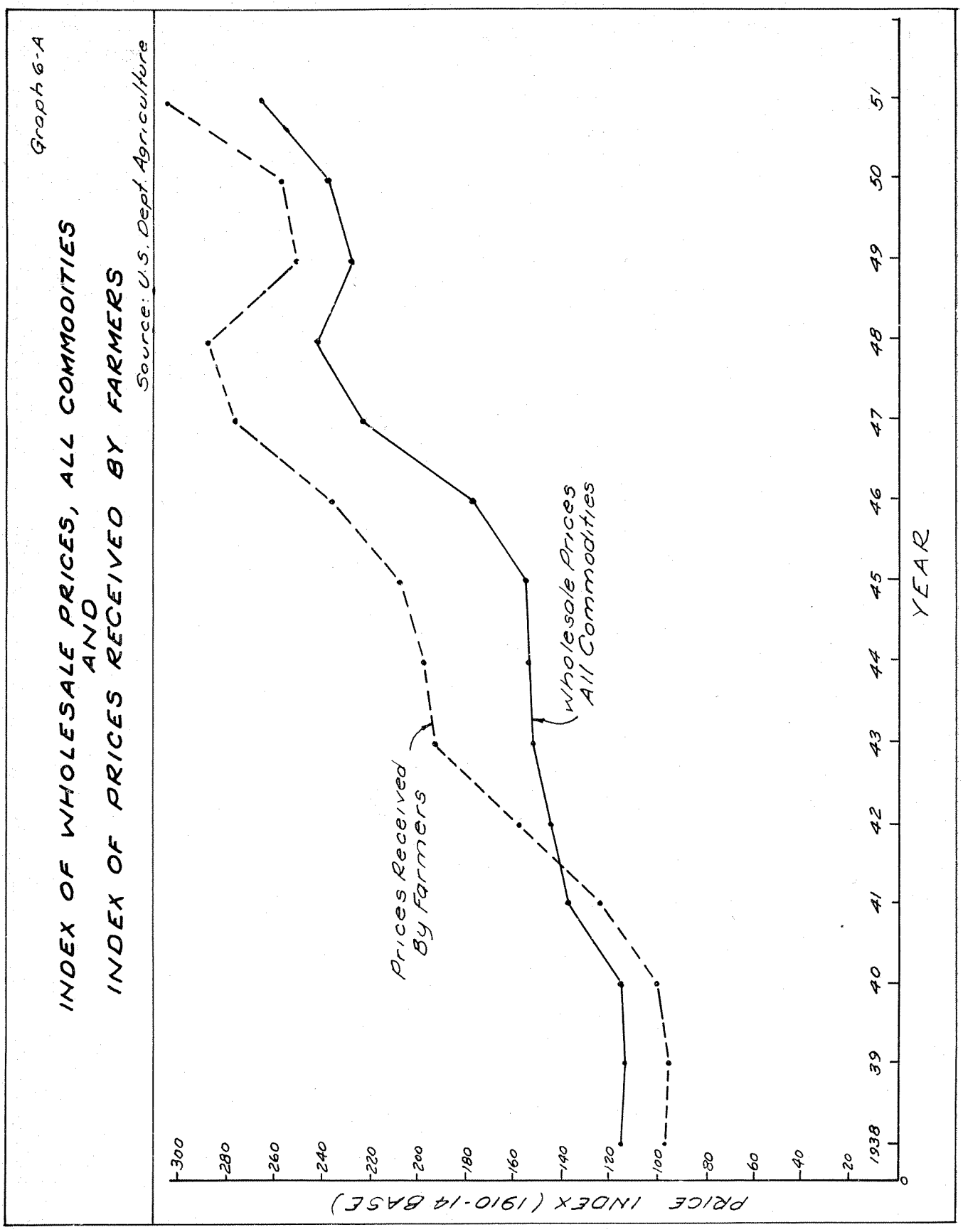
TABLE 6.9 ESTIMATED TOTAL TAXES PAID BY IRRIGATED AGRICULTURE

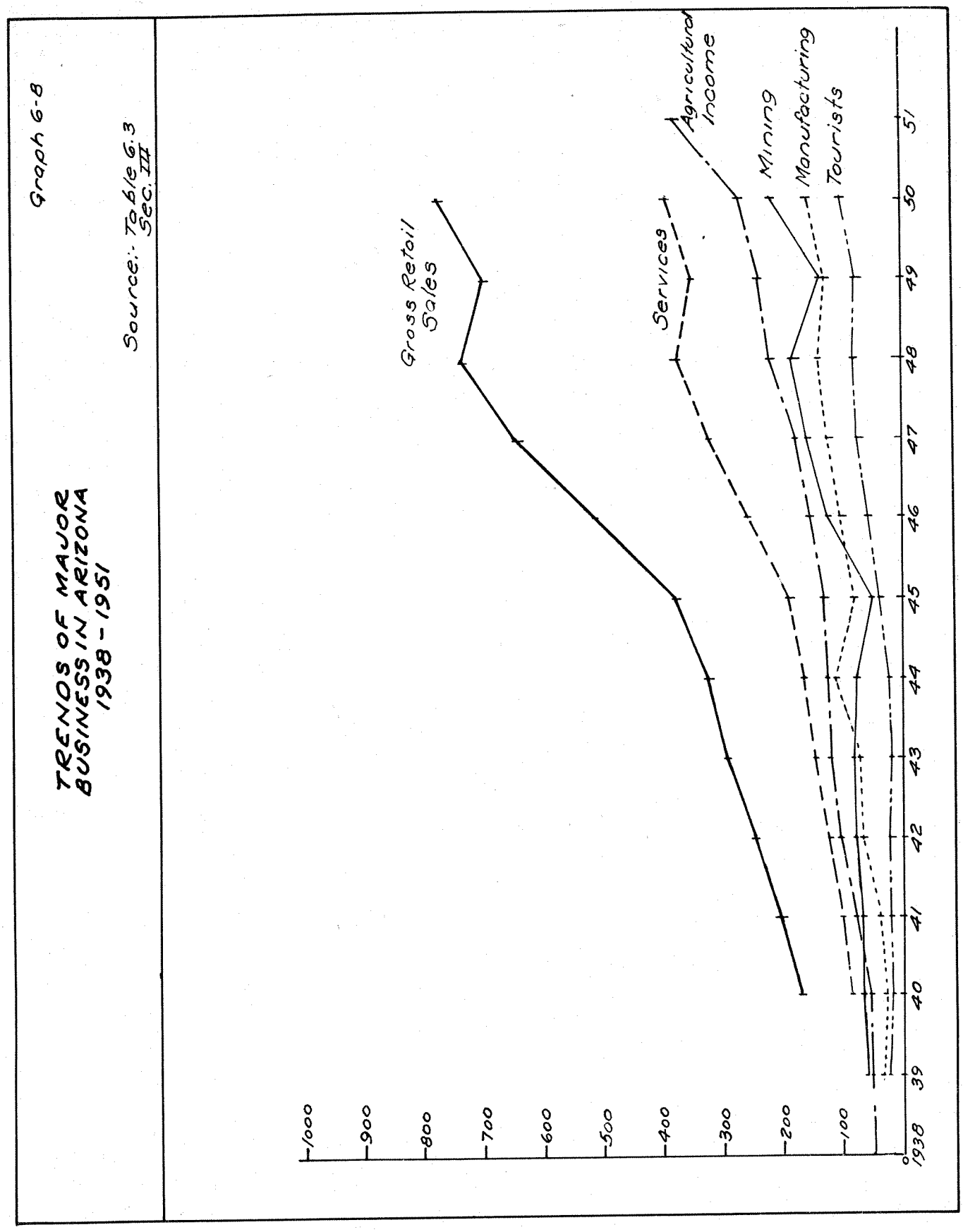
YEAR	(1) Total Taxes Paid by Arizona (dollars)	(2) Percentage of Arizona Income Derived from Crops[1]	(3) Estimated share of Taxes Paid by Crops (dollars)
1939-40	5,062,000	11.4	577,000
1940-41	6,174,000	15.3	945,000
1941-42	13,539,000	11.8	1,598,000
1942-43	33,488,000	13.8	4,621,000
1943-44	68,998,000	13.6	9,384,000
1944-45	71,282,000	14.8	10,550,000
1945-46	76,248,000	16.0	12,200,000
1946-47	75,952,000	15.5	11,773,000
1947-48	83,814,000	17.2	14,416,000
1948-49	82,128,000	19.6	16,097,000
1949-50	74,822,000	21.9	16,386,000
1950-51	106,438,000	24.5	26,077,000

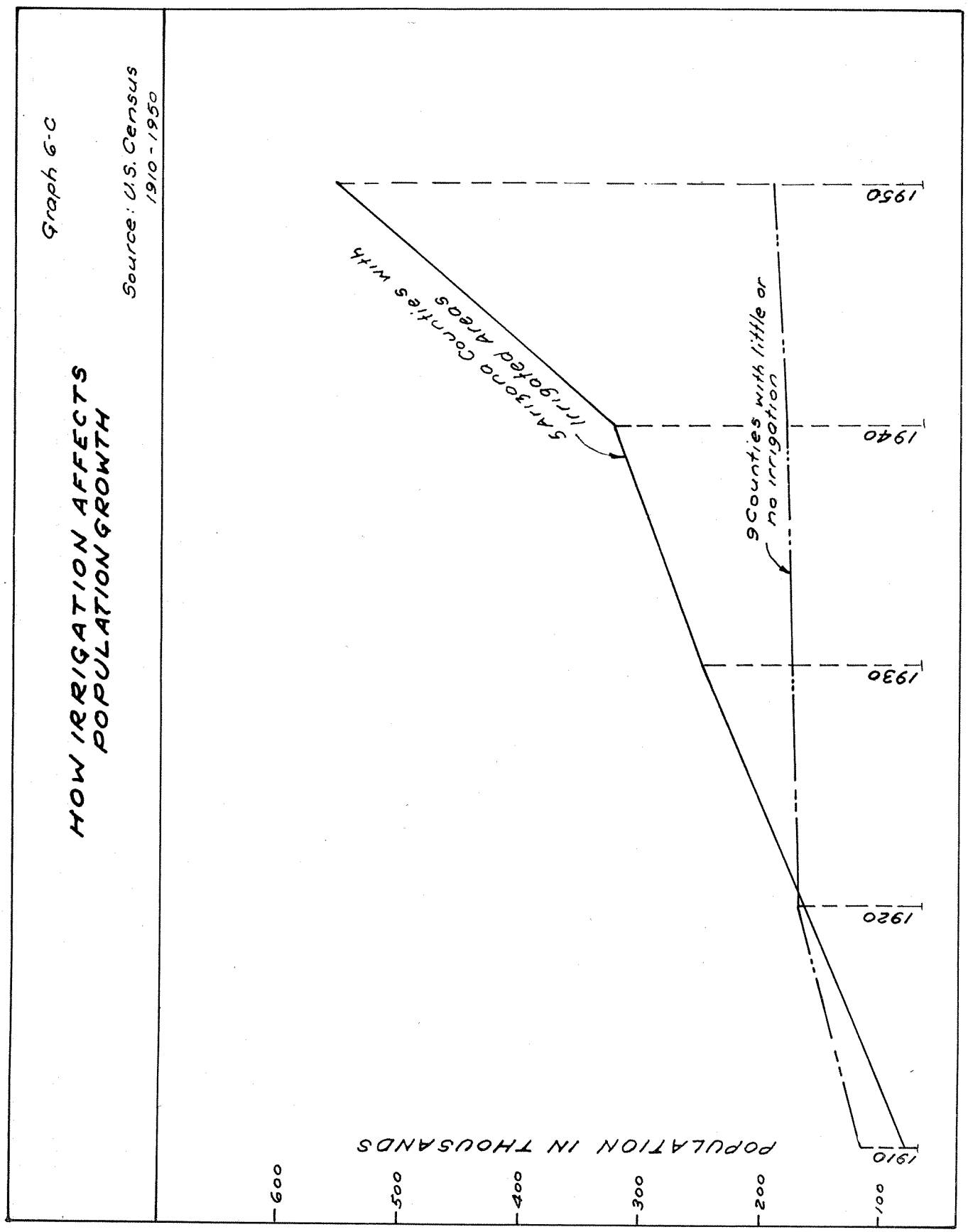
[1] Calendar year basis.

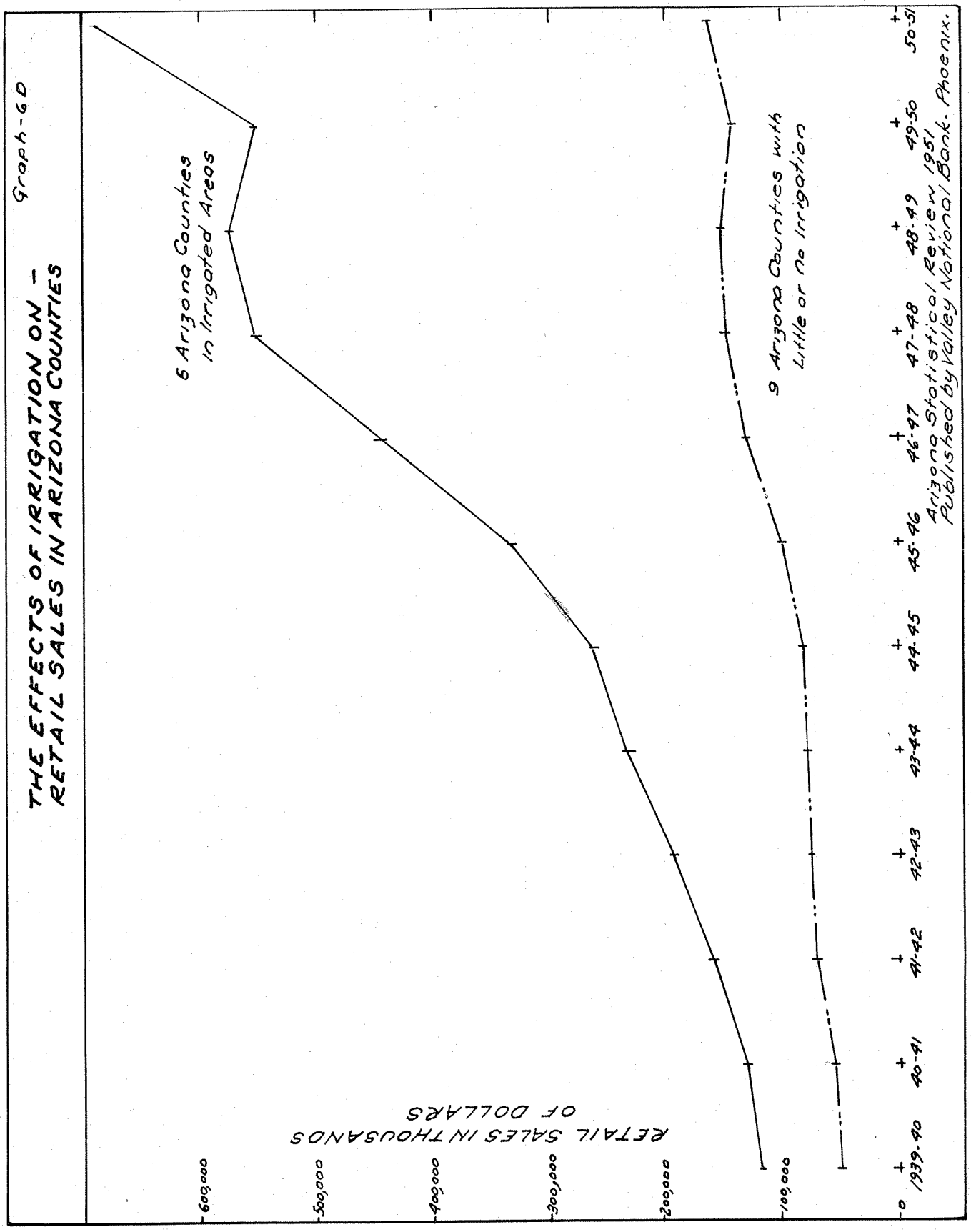
Source:
Column (1) Arizona Statistical Review, published by the Valley National Bank, Phoenix. Figures rounded to nearest 1000 dollars.
Column (2) Column (3), Table 6.5.
Column (3) Column (1) x Column (2) x 100.

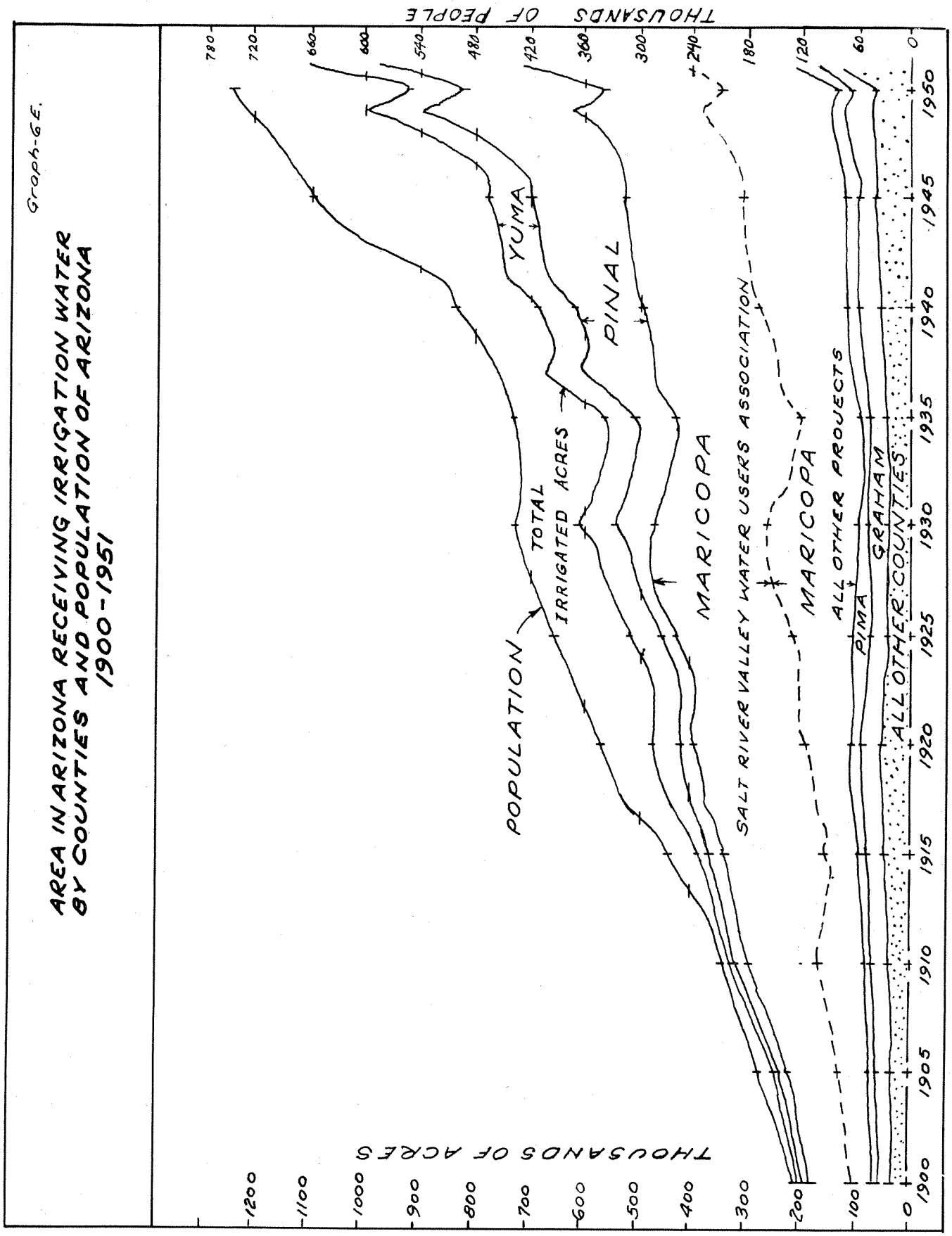
Therefore, irrigated crops in Arizona paid almost 51 million dollars in Federal, State and Local taxes during the last fiscal year.


Graph 6-A
INDEX OF WHOLESALE PRICES, ALL COMMODITIES
AND
INDEX OF PRICES RECEIVED BY FARMERS
Source: U.S. Dept. Agriculture
Wholesale Prices
All Commodities
Prices Received
By Farmers
PRICE INDEX (1910-14 BASE)
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1938
39
40
41
42
43
44
45
46
47
48
49
50
51
YEAR


Graph 6-8
TRENDS OF MAJOR BUSINESS IN ARIZONA 1938 - 1951
Source:- Table 6.3 Sec. III
Gross Retail Sales
Services
Agricultural Income
Mining
Manufacturing
Tourists
1000
900
800
700
600
500
400
300
200
100
0
1938
39
40
41
42
43
44
45
46
47
48
49
50
51


Graph 6-C
HOW IRRIGATION AFFECTS POPULATION GROWTH
Source: U.S. Census 1910-1950
POPULATION IN THOUSANDS
600
500
400
300
200
100
1910
1920
1930
1940
1950
5 Arizona Counties with Irrigated Areas
9 Counties with little or no irrigation


Graph-6D
THE EFFECTS OF IRRIGATION ON –
RETAIL SALES IN ARIZONA COUNTIES
6 Arizona Counties
in Irrigated Areas
9 Arizona Counties with
Little or no Irrigation
RETAIL SALES IN THOUSANDS
OF DOLLARS
600,000
500,000
400,000
300,000
200,000
100,000
0
1939-40
40-41
41-42
42-43
43-44
44-45
45-46
46-47
47-48
48-49
49-50
50-51
Arizona Statistical Review 1951
Published by Valley National Bank. Phoenix.


GRAPH-6E.
AREA IN ARIZONA RECEIVING IRRIGATION WATER
BY COUNTIES AND POPULATION OF ARIZONA
1900-1951
THOUSANDS OF PEOPLE
THOUSANDS OF ACRES
POPULATION
TOTAL IRRIGATED ACRES
YUMA
PINAL
MARICOPA
SALT RIVER VALLEY WATER USERS ASSOCIATION
MARICOPA
ALL OTHER PROJECTS
PIMA
GRAHAM
ALL OTHER COUNTIES
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950

SECTION VII

Estimated Economic Result if Groundwater Use is Cut

The major water resources of Central Arizona are fully developed. While additional water may be developed in a few new areas, or brought in from outside sources, it would appear that the existing water supply available for irrigation is already being used to capacity. There is no dependable surplus of water in the central section of the State, and average annual precipitation is not sufficient to grow field crops.

If, through depleted water resources or legislative action, the quantity of water available for irrigation were substantially reduced, a reduction in crop production would inevitably result. However, it is difficult to determine the actual decrease which might occur with varying reductions in the quantity of available irrigation water. It would be reasonable to assume that small reductions in pumping would result in less than proportional declines in production.

If it is assumed that today's high price level is maintained, ground water use reductions might be partially offset by water conservation practices. A partial list of these practices includes ditch and lateral lining, reusing tail water, more timely and efficient application of water, more intensive weed control, capturing and using flood water, reducing evaporation losses where feasible, proper watershed management to improve surface water yields, proper leveling of fields to insure maximum benefits from available water, the installing and maintaining leakproof gates in irrigation structures. An assumption could be made that farmers would be willing to invest in water conservation practices up to the value of the water saved. In some cases, when pumping reductions seriously threatened the continued operation of a farm, the operator would be willing to pay more for water conservation than its actual worth in water saved, in order to protect his capital investment.

In general, a reduction in pumping would cause farmers to reduce acreage in crops with high water requirements and low gross values. (For a partial list of such crops see Table 4.3, Section IV). Cotton acreage, with its high gross value and average water requirements, would not be affected significantly by a small reduction in pumping. It is estimated that the cotton acreage in Arizona today is 670,000, which is greater than 50 percent of the total irrigated acreage in the State.

If a reduction in groundwater pumpage of 15 percent is assumed, some indications of its effect on Arizona's agriculture can be made. Approximately 800,000 acres of irrigated land dependent upon pump water would be affected by such a cut. Granting that many farmers are practicing water conservation, it is probable that half of this reduction (seven to eight percent) could be countered by water conservation practices. It is also estimated that some crop shifts might occur which would tend to lessen the decrease in production accompanying a water reduction. Crop production probably would not decrease more than an estimated five percent if groundwater pumpage were cut 15 percent, providing prices remain high. If prices should drop to a point where the increased production derived from conserved water would not pay the cost of conserving it, a greater production decrease might result.

Inadequate data make it difficult to estimate acreage reductions which might occur. Some marginal land would undoubtedly go out of production, although much of it would not because of the high investment in irrigation equipment. It is also possible that farmers faced with a water reduction, might adopt the practice of planting every other row in a field, which conserves water and tends to increase the yields of individual plants.

It has been estimated by the Department of Agricultural Economics at the University of Arizona that a 15 percent reduction in ground water use could possibly result in a seven to eight percent reduction in acreage planted.

If the general price level of field crops were to drop substantially, fewer water conservation practices would be developed, and both acreage and production would be further reduced. A 10-15 percent reduction in production and acreage would probably result from a 15 percent water reduction.

Again assuming high prices, a 50 percent reduction in groundwater use would have a large influence on acreage, yields, production and gross income in Arizona. There would be a marked shift to intensive farming of high value crops with relatively low water requirements. Even this shift would not offset the probable reduction in gross farm income of the State. Alfalfa acreage would be reduced, yields would be small and the estimated production

would be lowered by approximately 50 percent. Production of small grains would be reduced, since there would be insufficient water to practice double-cropping. Also, truck crops would be reduced appreciably. It is estimated that ⅓ of the cotton acreage might lie fallow. Accurate estimates are difficult, but a 50 percent reduction in groundwater pumped might reduce the gross value of farm crops 25-30% and irrigated acreage as much as 40%. In the event of lowered prices, a reduction of this magnitude would probably be accompanied by equally large reductions in acreage and production. If it is assumed that at least 70 percent of our land is pump irrigated, the estimated results of reduced groundwater use on business activity can be determined. It was estimated that a 15 percent reduction in pumping would reduce gross crop value on pump irrigated land by seven to eight percent, and this would result in a five percent reduction in gross crop income. If we assume gross crop value in 1951 to be $300,000,000 this would result in a $15,000,000 reduction, which is less than 25 percent of the estimated increase in gross crop value in Arizona from 1950 to 1951.

A gross crop value reduction of 25-30 percent, the estimated result of 50 percent pumpage reduction, would decrease Arizona's crop value by approximately 20 per cent, or $60,000,000. While this is a large cash reduction, it should be emphasized that the agricultural cash crop income increased approximately $77,000,000 from 1950 to 1951. (See Table 6.4).

(The overall effect of a large reduction in groundwater use would be considerable). The shift to high value crops would drastically reduce the roughage and grain available for livestock, and probably decrease the number of livestock raised and fattened in Arizona. Businesses specializing in the processing and marketing of low-value, high-water requiring crops would be greatly affected. The indirect results of a $60,000,000 crop value reduction on the national economy would be multiplied several times.

A 20 percent reduction in crop cash income, or gross crop value, would probably reduce the total taxes paid by agriculture proportionately. The effect of this reduction on local and state taxes might be greater than 30 percent. Pump irrigated lands tend to be localized in specific areas in the State. When agricultural production is greatly reduced in such an area, the local effect may be very large. Specific school districts and counties supported by agriculture would have their taxes reduced by more than 20 percent. To find the exact reductions that might occur would require investigation of each district or county.

A reduction of 50 percent in groundwater use would have a marked effect on the value of pump irrigated land. It was assumed that 40 percent of the pump irrigated acreage would lie fallow. This idle land would not comprise an unbroken area, but would consist of unused acreage on a large number of farms. Agricultural land values, therefore, could be reduced approximately 40 percent on all pump irrigated farms. The only use for this land would be to permit farmers to alternate their crop land, possibly providing better weed control and longer fertility of the fields.

SECTION VIII

Estimated Economic Results if Crop Reductions Occur

In over-all terms, the agriculture in the United States is in a strong financial position today. Net farm income reached almost 15 billion dollars in 1951, an increase of two billion dollars from the postwar low in 1950. However, non-agricultural income reached an all-time high in 1951—more than a third above its 1947 level. In terms of goods and services, the positions of agriculture and industry are considerably better than just prior to World War II, although the positions of both are not as favorable as the current dollar figures suggest. The entire national economy reflects an existing inflationary spiral. Present data indicate a possible continuation of high income and prices for the next year or two.

It is possible, however, that agricultural prices might fall rather sharply, at least to support price levels, with or without a corresponding decrease in non-agricultural prices. The economic results of such a recession would affect Arizona's existing agricultural position.

There can be two analyses of this problem: (1) The short-term outlook and, (2) the long-term outlook.

In the short-term outlook, farmers tend to continue production as long as their returns cover the operating costs and pay something on their fixed investment costs. It is assumed that most production costs are "sticky," i.e. slow to adjust to price fluctuations. Assuming 1951 estimated average costs of production, the following table presents minimum prices required by farmers to "break-even" on various crops.

TABLE 8.1 MINIMUM PRICES NECESSARY FOR PRODUCTION OF VARIOUS CROPS

CROP	Yield Per Acre	Price per Unit of Production	Gross Value Per Acre	Av. Cost of Production Per Acre[1]
Alfalfa	4 tons	$21.32 per ton	$ 85.28	$ 85.28
Barley	3000 lbs.	2.68 per cwt	80.40	80.35
Grain Sorghum	3000 lbs.	2.53 per cwt	76.20	75.97
Cotton	1½ bales	0.22 per lb.	165.00	
(short staple)	1200 lbs. of cottonseed	50.00 per ton	35.00	197.00[2]
			$200.00	

[1] Cost of production figures for 1951. Average of Salt River Valley, 150 foot lift and 250 foot lift areas.
[2] No allowance made for return from cottonseed.

1951 production cost figures were used instead of 1952 data because a general farm price decline would result in some decline in production costs. An analysis of the citrus industry indicates that the prevailing prices in 1951 represent the approximate minimum prices necessary to keep the industry from collapse.

The cost of water is not generally the limiting cost factor in determining whether or not to produce a crop at a given price. It has been estimated by the Department of Agricultural Economics, of the University of Arizona, that the average water cost for all crops in Maricopa County during the period 1949-1952 equalled only 11.4 percent of the total costs of production. However, in the high pump-lift areas, water costs of low-value, high-water requiring crops would determine to a large extent "break-even" prices for these crops. The short-term outlook does not appear to allow enough time for drastic production or acreage fluctuations to occur.

The long-term outlook on farm price reductions assumes that lowered prices will require farmers to adjust to this new economic level. It is also assumed that a general price decline will occur in non-agricultural industries. In such a situation, production costs would decrease with the general decline in price levels. Even so, certain production costs including water, land tax and interest, machinery and equipment, etc., would tend to be "sticky." Fertilizer, labor, seed, insecticides and other agricultural production commodities would naturally react more quickly to a general decline in farm prices. More efficient farming operations and cost reductions, where possible, will necessarily accompany price declines, if farmers are to stay in production.

The cotton industry in Arizona presents a slightly different problem. The problem of high production costs is particularly serious in the Arizona cotton industry. A high cost per acre structure has been built in the cotton industry as a result of high cottonland prices and the development of deep-well areas specifically for cotton farming. Today, to be profitable, cotton farming requires high prices and/or high yields. The average production costs in the Salt River Valley, on one bale of cotton per acre, have increased from $59.09 in 1941 to an estimated $165.45 in 1951. This is a cost increase of 180 percent since 1941, while the price per pound

increased only 148 percent during the same ten-year period. In spite of the more rapid cost increase, cotton is a very profitable crop today; the reason for this being increased yield. The average short staple cotton yield has increased over 40 percent during the same period. Even this crop could be profitably grown on farms with average production costs, at a price substantially below the 1951 level. Savings through the use of mechanical harvesting may increase the ability of Arizona farmers to weather lower cotton prices. Arizona's flat, dry fields are admirably suited to the use of mechanical equipment.

Lowered farm prices would have a directly proportional effect upon crop value and cash income. The effect of lowered prices on production and acreage would be more difficult to ascertain. Assuming all other costs equal, the high cost of water in the very deep pump areas would result in these areas going out of production first. There is no reliable data on the acreage of deep-lift areas, but it may be assumed that approximately one-fifth of the pump land in Arizona today, or 160,000 acres, might be abandoned. This abandonment would mean complete loss of permanent equipment to each farm owner in the deep-lift area. Marginal land, with lower than average yields or requiring high production costs, would also be vacated. It is not possible to accurately estimate the total acreage or production cuts that might result from lowered prices. Arizona's farmers have a relatively steady market demand for their products; raise high quality crops, some with seasonal advantages; and have high capital investments in their land. In view of these factors, it is difficult to see any wholesale abandonment of irrigated acreage resulting only from a decrease in farm prices.

SECTION IX

Economic Influences of Irrigated Agriculture on Specific Counties

The following county data are presented to give a brief view of the position of agriculture in each county's economy. Sources for most of this data are to be found in the tables in Appendix A. No attempt was made to thoroughly analyze the entire economy of each county, but some general economic observations have been made.

GRAHAM COUNTY DATA

Irrigated acreage in 1950	35,000	acres
Estimated acreage of pump-irrigated land, 1950	20,000	acres
Total gross crop value in 1951	$9,425,000	
Percentage comparison of county crop value to total state crop value, 1951	3.2%	
Percent each crop was of the total county value as compared with the total state value, 1951	4.3%	Cotton
	2.7%	Alfalfa
	2.1%	Barley
Value of crop production per acre, 1951	$277	
Business indicators for 1950-51 unless otherwise indicated.		
Percentage of total retail sales	1.6%	
Percentage of State sales taxes collected	1.4%	
Percentage of State manufacturing production, 1949-50	2.3%	
Percentage of State mining income	0.3%	
Total county motor vehicle registrations	5,300	
County population, 1950 census	12,985	

Graham county is principally an agricultural county with livestock and field crops as the principal sources of income. Major field crops raised in this county include long and short staple cotton, alfalfa, barley and some truck crops. The county is relatively small in population. Neither mining nor manufacturing constitutes a large segment of the economy. More than one-half of the farm land is pump irrigated, but there has been no noticeable expansion of irrigated acreage in Graham County in recent years. Potential agricultural land is limited by topography and water availability, but the land in cultivation produces a high crop value per acre.

Graham County agriculture seems to be quite stable and while land values have increased, fixed investment costs are not abnormally high, and price reductions probably would not affect Graham County agriculture as seriously as some other more speculative areas. A reduction in groundwater use would affect the economy of the county because of the high percentage of pump land, but acreage and production reductions probably would be at a minimum.

Maricopa County is the wealthiest county in the State and contains about half of the State's irrigated acreage. The county's industry is very diversified, containing more than two-thirds of the manufacturing production of the State and buying more than one-half of the retail products sold in Arizona.

MARICOPA COUNTY DATA

Irrigated acreage in 1950	435,000	acres
Estimated acreage of pump-irrigated land, 1950	304,000	acres
Total gross crop value in 1951	$138,685,000	
Percentage comparison of county crop value to total state crop value, 1951	47.2%	
Percent each crop was of the total county value as compared with the total state value, 1951	40.1%	Cotton
	58.8%	Truck Crops
	61.5%	Alfalfa
	87.7%	Grapefruit
	94.5%	Oranges
	58.2%	Barley
	60.0%	Grain sorghum
Value of crop production per acre, 1951	$271	
Business indicators for 1950-1951, unless otherwise indicated		
Percentage of total retail sales	51.5%	
Percentage of total sales taxes collected	47.5%	
Percentage of total State manufacturing production, 1949-50	71.5%	
Percentage of total State mining income	1.3%	
Total county motor vehicle registrations	152,100	
County Population, 1950 census	331,770	

Although Maricopa County has a large acreage of gravity-irrigated land, pumps supply water for more than half of the county's farm land. Crop value per acre and gross crop values are high because of intensive farming practices. The county produces over half of the State's truck crops, alfalfa, and barley, and most of the citrus acreage of the State is located here.

Maricopa County is one of the oldest farming areas in the State but has a relatively stable surface water supply for less than one-half of its irrigated land. High land values, dwindling groundwater supplies and limited surface water resources would tend to cause Maricopa County agriculture to reflect price and pumping reductions. However, the large number of other industries in the county probably would minimize the effects of production and acreage reductions in the county.

Pima is the second largest county, in population, in the State. The economy of this county is quite well balanced, having a substantial portion of the retail sales and manufacturing and mining industries in the State.

PIMA COUNTY DATA

Irrigated acreage in 1950	47,000	acres
Estimated acreage of pump-irrigated land, 1950	47,000	acres
Total gross crop value in 1951	$13,917,000	
Percentage comparison of county crop value to total state crop value, 1951	4.7%	
Percent each crop was of the total county value as compared with the total state value, 1951	6.5%	Cotton
	1.5%	Alfalfa
	2.0%	Barley
Value of crop production per acre, 1951	$296	
Business indicators for 1950-51, unless otherwise indicated		
Percentage of total retail sales	19.2%	
Percentage of total State sales taxes collected	18.7%	
Percentage of total State manufacturing production, 1949-50	11.3%	
Percentage of total State mining income	14.5%	
Total county motor vehicle registrations	52,400	
County population, 1950 census	141,216	

Cotton, alfalfa and barley are the main crops grown on the 47,000 acres of land under cultivation in 1951. High yields, high gross value of crops and high crop values per acre are characteristic of this county. There is little or no permanent surface water irrigation in the county, and farmers are completely dependent upon groundwater. A reduction in groundwater use would affect the agriculture of this area to a rather marked degree. Land values have increased but are not out of line with values in other parts of the State, and crop price reductions would have few unique effects on Pima County agriculture.

The final county to be analyzed in this report is Pinal. This county ranks second in total agricultural acreage, crop value and number of pump irrigated acres. Crop value per acre is very high in this county due to the large acreage of cotton grown here. Long and short staple cotton, barley and alfalfa are the principal crops, although some truck crops are also grown on large acreages. The county is not heavily populated nor are the main sources of income well distributed. Agriculture and mining are the major income sources. Several towns in Pinal County are primarily dependent upon either agriculture or mining for their continued prosperity.

PINAL COUNTY DATA

Irrigated acreage in 1950	250,000 acres
Estimated acreage of pump-irrigated land, 1950	224,000 acres
Total gross crop value in 1951	$76,695,000
Percentage comparison of county crop value to total state crop value, 1951	26.1%
Percent each crop was of the total county value as compared with the total state value, 1951	37.7% Cotton 7.4% Alfalfa 26.5% Barley
Value of crop production per acre, 1951	$291
Business indicators for 1950-51, unless otherwise indicated	
Percentage of total retail sales	4.5%
Percentage of total State sales taxes collected	5.2%
Percentage of total State manufacturing production, 1949-50	2.4%
Percentage of total State mining income	12.0%
Total county motor vehicle registrations	14,100
County population, 1950 census	43,191

The high percentage of pump irrigated land and the high land values existing make this county highly vulnerable to price and groundwater fluctuations. Of all the counties studied, Pinal would probably be most affected by fluctuations in either of the factors named above.

APPENDIX TABLE 1A PERCENTAGE OF RETAIL SALES BY COUNTIES

YEAR	Graham	Maricopa	Pima	Pinal
1939-40	1.9	42.5	18.1	3.4
1940-41	1.9	42.0	18.4	3.8
1941-42	1.8	44.1	17.2	4.5
1942-43	1.6	42.9	17.6	4.6
1943-44	1.6	45.4	18.5	4.1
1944-45	1.5	47.0	18.6	3.9
1945-46	1.6	48.4	18.5	3.6
1946-47	0.8	48.6	19.0	3.7
1947-48	1.5	49.5	20.2	3.8
1948-49	1.5	48.7	20.5	4.0
1949-50	1.6	48.9	19.6	4.6
1950-51	1.6	51.5	19.2	4.5

Source: Table 6.1, Section VI.

APPENDIX TABLE 2A PERCENTAGE OF STATE SALES TAX COLLECTIONS BY COUNTIES

YEAR	Graham	Maricopa	Pima	Pinal
1939-40	1.5	38.1	18.2	4.8
1940-41	1.5	37.6	18.4	5.4
1941-42	1.5	38.7	17.5	6.0
1942-43	1.3	38.6	17.0	5.6
1943-44	1.3	41.3	17.9	4.9
1944-45	1.3	44.4	17.7	4.3
1945-46	1.5	47.0	18.0	3.9
1946-47	1.3	45.2	18.8	3.7
1947-48	1.3	45.5	19.3	4.2
1948-49	1.3	45.4	19.7	4.3
1949-50	2.1	48.7	18.2	7.3
1950-51	1.4	47.5	18.7	5.2

Source: Table 6.1, Section VI.

APPENDIX TABLE 3A PERCENTAGE OF STATE MINING INCOME PRODUCED BY COUNTIES

YEAR	Graham	Maricopa	Pima	Pinal
1939-40	....	0.2	17.3	15.5
1940-41	....	3.2	16.8	16.8
1941-42	....	0.3	17.6	17.5
1942-43	....	0.7	13.3	14.3
1943-44	....	1.1	15.0	12.7
1944-45	....	1.4	12.2	10.5
1945-46	....	1.9	10.4	11.8
1946-47	....	1.0	14.4	5.4
1947-48	0.1	1.1	12.9	8.6
1948-49	0.2	1.1	13.4	8.0
1949-50	0.2	1.4	14.0	10.8
1950-51	0.3	1.3	14.5	12.0

Source: Table 6.1, Section VI.

APPENDIX TABLE 4A PERCENTAGE OF MANUFACTURING PRODUCTION IN EACH COUNTY

YEAR	Graham	Maricopa	Pima	Pinal
1939-40	1.6	67.1	9.2	1.0
1940-41	1.9	64.2	10.1	1.1
1941-42	1.8	66.2	8.8	1.1
1942-43	1.5	75.0	6.5	0.9
1943-44	1.1	75.3	6.9	1.0
1944-45	1.0	80.6	6.0	0.8
1945-46	1.6	71.5	8.3	1.3
1946-47	2.2	68.8	9.0	1.6
1947-48	2.0	67.3	8.5	1.8
1948-49	1.8	73.0	10.0	1.9
1949-50	2.3	71.5	11.3	2.4
1950-51	Unavail.	Unavail.	Unavail.	Unavail.

Source: Table 6.1, Section VI.

APENDIX TABLE 1B IRRIGATION SURFACE WATER DIVERSIONS FOR GRAHAM, MARICOPA, PIMA AND PINAL COUNTIES

(Quantities in thousands of acre feet)

COUNTIES	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
Safford Valley Diversion total for Graham County	100.0	151.0	172.0	122.0	128.0	149.0	70.0	52.0	40.0	168.0	69.0	26.0
Ashurst-Hayden Diversion	155.0	295.0	372.0	357.0	287.0	200.0	84.0	68.0	71.0	260.0	116.0	47.0
Sacaton Diversion	2.5	1.4	.2	.7	.6	.8	.8	.5	.1	.1	.1	.1
Total for Pinal	157.5	296.4	372.2	357.7	287.6	200.8	84.8	68.5	71.1	260.1	116.1	47.1
Pima County[1]												
Granite Reef Diversion	600.0	1,240.0	1,090.0	975.0	990.0	1,000.0	875.0	670.0	680.0	805.0	735.0	530.0
Lake Pleasant Diversion[2]	20.9	92.9	102.6	18.7	40.7	35.3	7.1	13.2	4.1	26.0	12.0	0.5
Buckeye Heading Diversion[4]	75.8	117.8	82.9	72.0	67.6	65.8	67.1	52.0	40.2	38.9	31.9	31.6
Arlington Heading Diversion[5]	8.0	7.9	7.5	7.2	7.0	6.6	6.4	6.0	5.8	5.5	5.2	5.0
Gillespie Canal Diversion	55.0	106.7	64.8	72.1	69.8	76.5	81.0	59.6	41.0	39.1	28.3	Miss.
Gillespie (Enterprise Canal)	7.0	7.6	7.3	7.3	8.2	6.9	7.6	10.1	8.0	8.5	8.5	Miss.
Gila at Laveen Diversion	5.0	6.3	4.5	6.8	6.1	6.2	2.9	Miss.	5.5	4.2	3.1[3]	Miss.
Total for Maricopa County	771.7	1,579.2	1,359.6	1,159.1	1,189.4	1,197.3	1,047.1	810.9	784.6	927.2	824.0	567.1[3]

Source: U. S. Geological Survey Office, Surface Water Division, Tucson, unless otherwise indicated.
[1] No permanent diversion of importance.
[2] Reported on water year basis by the Maricopa County Municipal Water Conservation District No. 1.
[3] Incomplete
[4] Salt River Valley Water Users Association.
[5] Estimated by Underground Water Commission on information furnished by T. T. Harris of Arlington Canal Company.

APPENDIX 2.B ASSESSED NUMBER OF ACRES OF IRRIGATED "B" LANDS BY COUNTIES IN ARIZONA

County	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Graham	10,005	10,117	9,364	9,399	9,290	9,298								
Maricopa	216,291	215,508	113,623	192,424	192,400	198,473	198,954	198,932	unavail	193,791	201,177	209,430	210,296	217,580
Pima	22,596	23,796	27,793	23,810	24,016	26,010	27,406	26,625	unavail	27,803	26,380	26,380	31,581	47,089
Pinal	51,164	65,299	82,757	90,062	114,039	115,406	138,543	168,960	unavail	195,365	294,495	230,983	264,123	293,753
State Total	372,803	358,455	282,456	383,440	411,494	407,820	428,995	470,339	482,837	507,318	615,474	563,793	530,785	594,525

Source: Statement of Comparative Values, State Tax Commission, Ariz na.

APPENDIX TABLE 3B VALUE OF WATER WHEN APPLIED TO VARIOUS CROPS USING NET INCOME APPROACH

CROP	(1) YEARS	(2) Value of Crop Production per Acre for State	(3) Cost of Production per acre (3a) 150 ft. lift	(3b) 250 ft. lift	(4) Return per dollar invested in production (4a) 150 ft. lift	(4b) 250 ft. lift	(5) Water cost Per Acre (5a) 150 ft. lift	(5b) 250 ft. lift	(6) Value of Water When Applied to to Various Crops (6a) 150 ft. lift	(6b) 250 ft. lift
Cotton Short staple 1½ bales per acre	1940	$ 81.45	$ 65.94	$ 76.34	$1.24	$1.07	$17.85	$29.75	$22.13	$31.83
	1945	199.50	112.22	119.82	1.78	1.66	15.15	25.25	26.97	41.92
	1951	340.00	170.58	172.28	1.99	1.97	13.05	21.75	25.97	42.85
Alfalfa 4 bales per acre	1940	40.20	48.35	62.82	0.83	0.64	23.95	39.92	19.88*	25.55*
	1945	78.52	67.05	77.52	1.17	1.01	19.45	32.42	22.76	32.74
	1951	140.40	83.65	88.35	1.68	1.59	17.40	29.00	29.23	46.11
Barley 3000 lbs. per acre	1940	33.90	31.92	40.15	1.06	0.84	14.97	24.95	15.87	29.96*
	1945	57.90	42.53	48.10	1.36	1.20	12.03	20.05	16.36	24.06
	1951	86.10	64.75	79.75	0.97	0.76	16.35	27.25	15.86*	20.71*
Grain Sorghum 3000 lbs. per acre	1940	33.00	33.90	43.30	0.97	0.76	16.35	27.25	15.86*	20.71*
	1945	72.00	46.80	53.50	1.54	1.35	13.25	22.25	20.41	30.04
	1951	90.90	63.60	64.60	1.43	1.41	11.95	19.95	17.09	28.13

* Indicates years when cost of production under given conditions would have exceeded gross value of crops. Water value is less than water cost.
Column (2) Source: Gross crop value divided by total irrigated acreage.
Column (3) Source: Cost of production from tables 3.1, 3.2, 3.3, and 3.4.
Column (4a) Divide Column (2) by Column (3a).
Column (4b) Divide Column (2) by Column (3b).
Column (5) Source: Same as Column (3).
Column (6a) Column (4a) x Column (5a).
Column (6b) Column (4b) x Column (5b).

APPENDIX TABLE 4B VALUE OF WATER WHEN APPLIED TO VARIOUS CROPS USING GROSS INCOME APPROACH

CROPS	(1) Gross Value Per Acre 1940	1945	1951	(2) Index of Relative Value of Crops per Acre 1940	1945	1951	(3) Three year average of relatives	(4) Av. Water Requirement per Crop Acre Feet	(5) Water Requirement Index	(6) Index of Water Value When Applied to Various Crops
Truck Crops	$229.50	$532.00	$582.50	406	283	362	350	4	122	287
Grapefruit	134.50	688.00	264.50	238	336	164	256	4	122	210
Oranges	114.50	724.00	284.00	203	385	176	255	4	122	209
Cotton	88.50	109.00	331.00	157	58	206	140	3.25	99	141
Flaxseed	34.50	75.50	134.00	61	40	83	61	2.25	68	90
Barley	19.00	33.50	79.50	34	18	49	34	2.25	68	50
Grain Sorghum	22.00	47.00	71.00	39	25	44	36	2.75	84	43
Wheat	16.50	36.00	56.00	29	19	35	28	2.25	68	41
Alfalfa	22.50	78.50	140.50	40	42	87	56	4.75	144	39
Oats	9.00	25.00	47.00	16	13	29	19	2.25	68	29
Alfalfa Seed	19.50	50.50	61.00	35	27	38	33	4.00	122	27
Dry Edible Beans	14.50	27.50	21.00	26	15	13	18	3.50	106	17
Corn	11.00	16.00	22.50	19	9	14	14	3.50	106	13

Note: Average value of production for all crops was determined by a simple average of all crops listed. State Average Crop Values used to construct index in Column (2) were $56.50 for 1940, $188.00 for 1945 and $161.00 for 1951. This method of determining average crop value was used to prevent the total acreage of any one crop from influencing the average value per acre of all crops.
Column (1) Source: Gross value of crop production in Table 2.6 divided by total acres of crop harvested.
Column (3) Simple average of indexes in Column (2).
Column (4) Source: Table 4.1.
Column (5) 3.29 acre feet = 100.
Column (6) Column (3) divided by Column (5).

Appendix "C"

A Summary of Views Expressed and Answers Received from Individuals Attending Hearings of the Underground Water Commission Held Throughout Arizona

A Summary of Views Expressed and Answers Received from Individuals Attending Hearings of the Underground Water Commission Held Throughout Arizona

At each hearing Mr. E. Ray Cowden, Chairman of the Commission, opened the meeting by explaining that it was the purpose of the Commission to secure the views of the people in regard to the underground water situation as a basis for helping formulate recommendations to the Governor and Legislature. He was careful to explain that the questions asked by the Commission's members and staff did not necessarily indicate the views of the Commission, but were questions designed to secure answers to all sides of the problem. It was also explained that each person's statements would be recorded on tape and become a part of the permanent record of the Commission.

Mr. Bryant W. Jones, the Commission's legal adviser, discussed the present status of ground-water law in Arizona and explained the principles of the strict common law doctrine, the doctrine of correlative rights or reasonable use, and the doctrine of prior appropriation. He also explained that the 1948 Ground-Water Code was law based upon the right of the state to exercise police powers.

Following is a list of questions that were furnished to all witnesses as a guide to the type of information the Commission wished them to comment on:

I. General Information

1. Name and address
2. Business or occupation
3. How long have you lived in Arizona?
4. Give any personal background information that may be of interest to the Commission.

II. Ground-water Supply Questions

1. Do you have any wells? How many, and where are they located?
2. When were the wells drilled; what are the depths of the wells and at what depths did you find water bearing materials?
3. What was the static water level in the wells when drilled and what is it now?
4. Was there any indication of artesian pressures in any stratum when the wells were drilled?
5. What was pumping level when the well was first used and what is it now?
6. What was the capacity of your well when first pumped and what is it now?
7. Have you deepened any of your wells, and if so what was the effect on the static and pumping water levels and the capacity of the well?
8. Have you noticed any effect on your wells due to other wells being pumped nearby?
9. Has the quality of the water in your wells changed? Has it improved or increased in total soluble salts?
10. Do you agree that to maintain a proper salt balance in soil, it is necessary to apply more water to the land than is required by the crops so that some water will be lost by deep percolation? Do you believe it follows that to maintain a proper salt balance in ground-water supply some water must be allowed to escape from the basin to carry away excess salts?
11. On an average, what are your annual water requirements per acre?
12. What measures would you recommend to conserve water? How much could your water requirements be reduced by the application of these measures to your farming operation?
13. Do you believe areas with a shallow water table and needing drainage should be included in a critical ground-water area?
14. Do you feel that the wells in your area can be pumped indefinitely at their present rate of withdrawal or do you believe some of the water is coming from storage? If you believe some of the water is coming from storage, how long do you think you can economically continue to pump for irrigation?

III. Economic Questions

1. What was your cost of pumping water per acre-foot in 1942, and other past years? What was your cost in 1951? What has been the relation between your energy costs and your pumping costs?
2. Has your cost of water increased in proportion to the increase in prices of the crops you produce?
3. What proportion of your production costs are for water?
4. If your water supply dropped 50%, could you continue to operate at a profit at present price levels?

5. Do you feel that the lowering water table will force many pump farmers out of business if prices continue at the present level?
6. To what extent do you believe the development and increased income of your community and county are due to the use of pump water?
7. If a considerable amount of the land now under pump irrigation was abandoned, what would be the effect on the tax base, level of employment, and general economy of the area?
8. What do you believe the attitude of the financial institutions will be if the water table continues to drop? To date, has there been any curtailment in credit due to lowering water tables?
9. Do you know of any case where financial institutions have made independent check to determine the availability of water for the crops to be financed?
10. Do you believe agricultural lands under state lease bears its fair share of the local tax burden?
11. Would you suggest that the policy of the state should be changed to encourage the private ownership of state leased lands?

IV. Control measures

1. Should legislation attempt to balance ground-water recharge and withdrawal in present critical areas? In areas not now declared critical?
2. Would you recommend any type of law that would call for a cut-back in the use of pump water? Would you favor
   (1) legislative determination of amount of cut-back
   (2) state administrative determination of amount of cut-back, or
   (3) local option where the users in a designated local area could determine for themselves the amount of cut-back?
3. What kind of a state organization would you suggest to administer state water laws?
   a. State water engineer appointed by Governor?
   b. State water resources commission or similar body appointed by the Governor with power to employ such technical and other employees as necessary?
   c. Any other method?
4. Should provision be made for the establishment of ground-water conservation districts? Should these districts have the power to institute and enforce compliance with such conservation measures as elimination of non-economic water loving plants, metering of wells, concrete lining of ditches, preventing tail-water waste, installing district pumps and distributing all pump water? Should the districts be given power to tax and issue bonds to finance the foregoing conservation measures?
5. Do you believe there should be a general statutory limit on the consumptive use of pump water, or should it be left to the discretion of districts or individuals?
6. Should there be priorities for the consumptive use of ground water established by law? Should provision be made for just compensation when a higher priority user encroaches on the rights of a lower priority user?
7. Should people that have drilled wells without valid permits be allowed to use them?
8. Should there be a prohibition against the transportation of water to distant land where such use interferes with users in the vicinity of the source of pump water?
9. Should the drilling of replacement wells be allowed in critical areas? If so, under what circumstances and what limits should be placed on the location of the replacement well?
10. In your opinion, what is wrong with the 1948 ground-water code? Do you believe the '48 code could be amended to serve the needs of the State? What changes do you believe are necessary to put teeth in the code to make it workable?

These questions were not followed strictly throughout the hearings. In some instances different phraseology was used, and often a certain amount of background material was given, but the information gained generally coincided with the foregoing questions.

The following summaries have been edited to include the meanings of the questions asked along with the answers given, rather than presenting them in a lengthy question and answer form. Some of the technical information and well data have been deleted from these abstracts for the sake of readability. Stress has been given to opinions and methods of administrative control, and the over-all ground-water picture is included in the general summaries of the hearings, appearing elsewhere in this report.

PRESCOTT HEARING
SUPERIOR COURT ROOM, 9:00 A.M.,
SEPTEMBER 8, 1952

1. *Frank Guyberg, Verde Valley, Cornville, Arizona:*

In present critical areas an attempt should be made to balance pumpage and recharge to the area. Looking to the future regarding water development in this area, I think that state legislation should be such that water users in a designated local area could determine for themselves the amount of water that should be pumped. State water laws should be administered by a State Water Resources Commission in preference to State Engineer. No statutory limit should be placed on the consumptive use of pump water. Wells drilled in critical areas without valid permits should not be pumped. There should be a prohibition against transporting water out of an area when it interferes with users in the area. In regard to the 1948 ground-water code, I think it was too lax to serve its purpose here in the Southwest. "I think the '48 code needed a lot of tightening up if we are to conserve the underground resources of the state, and feeling definitely as I do in the matter of prior rights, it is folly to continue to drill more wells when there isn't enough water to supply those we already have."

After living along the Mogollon Rim for 40 years I think one of our biggest problems is the increasing growth of underbrush, junipers and phreatophytes. These plants use great quantities of water that would otherwise go on down our streams. "Just as an experiment we straightened out a small length of ditch, took the willows and cottonwoods off, and I frankly say that with six users on the ditch this is the first year in 30 years that we haven't had to trade water. There was plenty of water for all of us." We are losing the use of our range and our water by allowing noxious growth to spread on our ranges and river bottoms.

2. *Geo. S. Hill, City of Prescott:*

Priority rights should protect the first users of water on some sort of a percentage basis and the balance left for industry and new-comers on the same basis. I have continually and unsuccessfully maintained that the problem of pumping in excess of recharge should be solved by the U. S. Government. "I have maintained that as long as we are 34th in capital wealth and about third in per capita spending, some day the state of Arizona will be in trouble. I believe the same thing on water." We can't pump more water from the ground than is put back without running out eventually. In an area where the formations are deep and considerable amount of water is in storage, it is more of an economic problem as to what level pumpage and recharge should be balanced. In some cases there may be advantages to using the water in excess of recharge.

3. *Floyd Hawkins, farmer, Chino Valley, Arizona:*

Indicated that during pumping in the summer his wells had a smaller discharge and a greater pumping lift. Also each year the static water level dropped some. If his water supply dropped 50%, the operation would be unprofitable. The income of the community is 75% dependent upon pump water. A cutback in pumping would probably raise taxes on some lands as other land was abandoned. In some areas state agricultural leased lands do not bear their fair share of the tax burden, and, therefore, private ownership of these lands should be encouraged. "In most critical areas I think there should be some legislative attempt made to balance the water recharge and withdrawal, taking into consideration that recharge varies from one year to another. I would favor a water resources commission with representation throughout the state from different areas that would come under the law," to administer any water code. Favors local option for determining any cut-backs in use of groundwater. Providing for the establishment of ground-water conservation districts is all right, so long as they are not given power to issue bonds and tax the district.

Believes cities should have right to water for domestic use, but that industry should have no better right than agriculture. Wells illegally drilled should not be used and water should not be transferred out of an area when it interferes with the users in the area. Replacement wells should be allowed. The 1948 code did not have enough teeth in it, but with proper administration it could have been more effective than it has been. "I am of the opinion that we should start over, rather than amend or change the '48 code." In answer to the question as to whether he felt the State Land Commissioner had been given funds enough to properly enforce the '48 code, Mr. Hawkins replied, "Well, I think that with any appropriation we should have a better job than we've had so far." Does not believe one law or one regulation can fit the entire state; however, a commission could administer a state code to fit the needs of the various areas if the code was properly written.

4. *Robert Keikhefer, farmer and rancher, Big Chino:*

He does not believe any ground water shortage is possible in his area. "I am opposed to any legisla-

tion that would include that particular area in an underground water code." I believe that the water under a man's land belongs to him just like his house.

5. *Sherman Hazeltine, banker, Prescott:*

"I can remember very clearly when Chino Valley depended entirely upon the gravity water from the dams and it was an up and down proposition. When you had good years, people prospered out there, and when they had bad years, they suffered tremendously, and so this is an area which very clearly shows the importance of pumping water in our rather small agricultural situation as compared with the large areas in the southern part of the state."

Abandonment of land under pump irrigation due to a cut-back in pumping would have a material effect on our tax base. "We do not know of any critical situation here, so neither my own institution nor any of the others so far as I know, have shown any concern regarding a depleted water table. There is another economic factor which certainly should not be over-looked, and that is if due to a national condition there is an extraordinarily high price for a given commodity, such as has been obtained in the past few years, we can in this state over-develop and be economically sound at a given time, but then when a price control is dropped we find that we have lots of homes built, lots of land leveled, and a tax economy based upon that, which for something entirely beyond our control, can over night become relatively valueless."

Local option to me is the American way of handling anything like cut-backs in the use of pump water. A state water resources commission should administer state ground-water laws.

6. *Herbert D. Rees, farming, Chino Valley:*

Resident of Arizona for 29 years. The wells in this area draw down during the summer pumping season, but return during the winter. "I don't believe there are any wells in Chino that have a very definite effect on any other well. The wells all lower together. I don't believe the wells in our area could be pumped indefinitely; however, I think they could be pumped a long time without depleting the water completely. About a third of the cost of production is water. If prices stay at present level it would be quite a while before anyone would have to stop pumping because of a lowering water table."

"I don't suppose that in some areas the state leased land bears its fair share of the tax burden, and I certainly think that state lands, state agricultural lands, should be put under private ownership.

"I don't believe that there should be legislation to attempt to balance the ground-water recharge and withdrawal." All land should be entitled to the water under it. However, if it becomes necessary to cut down on pumping, "I believe that in each area all cultivated land should have its proportionate share of the water." Land that hasn't been under cultivation before should have the right to develop wells and use its proportioned share of the water. "I don't believe in prior appropriation." Cities should not be allowed to take water from a farming area.

Wells drilled without valid permits should not be used, but replacment wells should be allowed. Transportation of water for industry or other use should not be permitted for long distances. "I don't think there has been sufficient funds appropriated to properly administer the 1948 code; however, I do think that the code is a little too lax, but I believe that it would be quite workable if it were given a fair chance." I would favor a water resources commission to administer state water law with a provision for local option to take care of a local situation.

7. *W. M. Beveridge, Forest Service, Prescott:*

"The primary objective of the Forest Service is to protect watersheds. If we can do anything in the management of these lands to get the water into the soil so that it will again be put to beneficial use, we're really doing the job that we were hired to do." The elimination of undesirable vegetation, which is a heavy water consumer, would be helpful.

8. *Stewart Hall, Skull Valley:*

Recharge and withdrawal should be balanced on a percentage basis. Control should be by local option. State ground-water laws should be by a state water commission. Wells drilled without valid permits in critical areas should not be allowed to be used. Replacement wells should be allowed. Economics would eventually take care of excessive pumping; however, this would cause a bad situation due to an inflated tax base. "The Commission or engineer or whoever he is should have a little discretion in allowing mining of water, we'll say, where it is economical." Try to protect what we've got before we develop a lot of new areas.

9. *Charles H. Orme, cattleman, Mayer:*

Resident of state for 60 years. We have small basins in our area and we must depend directly on rainfall each year to replenish our ground-water supply. Areas with a shallow water table or needing drainage should not be included in a critical ground-water area. "There is no question but what the lowering of the water level will eventually turn a great

deal of land back to desert. It is just a matter of how fast you want to eat your cake. Our agriculture is certainly very important, and if it were greatly curtailed, business in the cities and the whole economic structure would suffer. I would think that for the good of the state that some forced curtailment is necessary. How much I wouldn't offer to say, but we should gradually come down on a curve to approach the amount of replenishment."

If considerable irrigated land was abandoned due to a cut in use of pump water the tax base would shift over to other business, affect level of employment and whole economy. "Banks to date have done a very good job. When everybody was in wild panic last winter after the Supreme Court's first decision, the banks took it very calmly and did a great deal to quiet matters down." Private ownership of state owned agricultural lands should be encouraged. In areas that are not now declared critical, I think there should be a very close study, because they can easily become critical. Controls of ground-water use should be by a combination of local option and legislation. Administration of ground-water laws should be handled by a commission. "I should think provision should be made for establishing ground-water conservation districts; however, I wouldn't want to say whether they should have the power to tax and issue bonds."

I don't think you can set any rigid limits on the consumptive use of water. Wells illegally drilled should not be used. Old wells should have more priority than recent wells. Transportation of water any great distance is not a good idea. Replacement wells should be allowed. The 1948 ground water code was so general, it amounted to almost no code at all.

10. J. Lester Sanders, Chino Valley farmer for 30 years:

Pumping at the present rate could be continued indefinitely if no new wells were put in; however, due to the depth of water in the undeveloped areas I don't believe there will be many new developments. "I think nature has just about regulated the problem." Eighty-five percent of the income of our community is dependent upon pump water. "If we ran out of pump water, all I can say is that the land would be sold for taxes. State agricultural lands should be sold at public auction to highest bidder. Attempts should be made to balance pumpage and recharge in critical areas. The cut-backs should be done on a local option basis. Administration should be by local committees working with the state engineer or whomever the state would appoint." I don't think it would be a good idea to have water conservation districts with power to tax and issue bonds. Wells drilled in critical areas should be required to have a valid permit. "I think one should be prohibited from taking water from one basin to land a few miles off." Replacement wells should be allowed. "I don't know much about the '48 code, but I do know one thing: it was too late when they started working on this code and they didn't give it enough thought. I think it would be just as much of a jolt to cut back pumpage immediately in areas where pumpage exceeds recharge as to run out of water."

11. Everett Brisindine, Chino Valley farmer:

Water could be conserved by installing concrete ditches and taking more care in applying the water to the land. Areas with a shallow water table should not be included in a critical area. We can see the water level going down and if it gets too deep it won't pay to pump and in time some farmers will go out of business. Private ownership of state agricultural leased lands would be a good thing. "I'm kinda inclined to think that the water under your land should belong to you and if you want to pump some of it out, that should be your privilege."

If a cut-back is necessary, you'd better treat everyone alike. Amount of cut-back should be worked out by a local group and a state commission. Enforcement of a ground-water code should be by local government. Wells illegally drilled shouldn't be allowed to pump. When one user of groundwater comes into an area and by pumping water interferes with the supply of an existing user, he should be compensated for the damage. No one should be allowed to pump water and transport it out of an area when it interferes with users in the area of the source of water. Replacement wells should be allowed.

12. John A. Thompson, Williamson Valley, cattle grower:

Has artesian pressure in wells that forces water to surface, but uses pumps to increase quantity of discharge. Districts that need drainage should not be put in a critical area. A lowering water table will eliminate those farmers whose costs are high. People farming state leased land should be required to buy the land. "I believe you'll have trouble setting up legislation that will pertain to every district in the state." The state should provide for conservation districts on a local option basis. A state water commissioner responsible to the Governor would be better than a commission. Water conservation districts with the power to tax and issue bonds is dangerous. Transporting water out of an area is all right if it does not interfere with users in area of

source. Replacement wells should be allowed. The 1948 code needs to be amended and revised. "I believe that when our critical period is over, if its ever over, and I don't mean critical for water, I mean our entire structure is released from the critical world situation that we're in today, and our demand for the products of these farms, especially your Salt River Valley farms, drops back more to where it used to be, that you won't have such a mad rush to pump water out of those deep wells down there. The law of supply and demand has worked a long time, and I think it will wind up operating here. I don't believe you can set up an artificial stimulant to a man who is in too deep a water area, or he has the wrong kind of land, or he's the wrong kind of operator. I don't believe you can hold him on his feet. With the population increase in this state, even with national recession, the demand on water in the Salt River Valley is apt to increase rather than decrease."

You are going to have to regulate the use of water, not on a prior right basis, but proportion the water. Development of groundwater in undeveloped areas should be encouraged. Industry should not have a priority over agriculture in the use of water.

13. *Joseph C. Hickerson, Soil Conservation Service, Prescott:*

A great saving in water can be made by preventing loss of tail water, lining sandy ditches, leveling land and better application of water. The people are in favor of transporting water from the Colorado River so they are not against transporting water unless it interferes with users in vicinity of the source who have a right to the water. The water table in Chino Valley is receding about 2 feet per year.

14. *Gerrie McGowin, Prescott:*

The destruction of leaf life on the watersheds is responsible for the decreasing rainfall. The destruction of junipers and other vegetation decreases rainfall and increases damage by insects.

15. *John McLernon, Ex County Agent, Yavapai County:*

"As County Agent I've listened to farmers for over 15 years discuss their problems in regard to control measures. I'm sure that the operators of the land, the great majority of them, much prefer local control; however, I feel that there has to be a superstructure of state control in order to make local control work."

Outside of cattle grazing our agricultural production would not amount to anything without supplemental pump water. "I don't have any faith in holding a water table at a definite point any more than I have faith in holding a lake out here three-fourths full, as some of the folks used to talk about. If you've got water and you need it, use it. If we need cotton, hay and alfalfa, we're going to use the water that's available if we can get it without going broke."

A commission to administer a ground-water code would be better than a commissioner. I don't think the 1948 code was vicious or bad legislation. The people of Arizona forced its passage by popular demand. They limited its effectivness by popular demand. Some people that wanted something done didn't want much done. The same problems will be faced when you try to amend it or make a new one.

16. *Jack Humphries, Bard Ranch, Kirkland:*

State leased agricultural lands would be better off under private ownership. Recharge and withdrawal should be balanced. Administration of ground-water laws should be by a commission. Ground-water conservation districts should come under a state water resources commission. Wells drilled without valid permit should be subject to penalty or their use refused. Replacement wells should be allowed. The main thing necessary is to put teeth in the 1948 code so as to change the disposition and temperament of people using water so that they look on the state of Arizona and its resources as something which is simply loaned to them to use to the best of their ability and pass on to future generations.

COTTONWOOD HEARING
COMMUNITY CLUB HOUSE, 9 A. M.,
SEPTEMBER 9, 1952

17. *Tom Pollock, rancher, Flagstaff:*

Resident for 35 years. Domestic water should have priority over all other uses. "I feel that the fellow who was using the water first should have the right to that water, even if something else could put it to better use, unless the new industry coming in would be able to buy out the smaller fellow. Ground-water control should be by state administrative determination, with the local areas working with it." There should be a state-wide commission with technicians and legal advisors, but there should be a local man to work with the commission and explain local problems. Local people would rather have some say in ground-water controls, rather than have controls forced on them by a state agency. Wells drilled without valid permits should not be used. A replacement well should be allowed as long as it wasn't for an abandoned well. I would much prefer the lessee of state agricultural lands to purchase the land, then the tax burden wouldn't be put on surrounding land.

18. *Kenneth Waters, Rim Rock, rancher:*

Believes wells can be pumped indefinitely as areas suitable to farming are widely separated. Industry should be in the same boat as any other user of underground water. At the present time, the Verde Valley could not, by any stretch of the imagination, be considered a critical ground-water area. For further expansion of the valley, we will have to turn to underground water, as all of the surface waters of the Verde River have been apporpriated.

"The people of the Verde Valley want to protect their future and their land and would be very loathe to see any legislation passed that would remove from the people of this valley the right to determine the use of that water at least until such time as they themselves had determined that it was a critical area. If workable, I would feel that a cut-back should be determined by a local group operating within the framework of a legislative vehicle that was set up for them in advance."

In the case of a man that drilled a well under the 1948 code without a valid permit, I believe a court would have to decide. The law may not be constitutional. Transportation of water to distant lands should be allowed, provided legal rights to the source of the water have been acquired. Favors private ownership of state leased agricultural lands.

19. *H. Herbert Metzger, rancher, Cottonwood:*

Native of Arizona. Eradication of bank growth, concreting ditches, and establishing grass cover in place of brush on the ranges would conserve water. Pressure should be put on Forest Service and Indian Service to get brush eradicated on their ranges. Encourage policy of moving state leased agricultural lands into private ownership so that they can be taxed. As long as there is just compensation to the individuals directly harmed, industry must take its place out here along with agriculture. I think that the previous group that was exploring this problem arrived at the only workable solution in this cut-back thing. A blanket cut would be neither fair nor workable. A mixture of state administrative determination and local option should be used in determining any controls. Prior use must be given some consideration in a water code. Administration of a water code should be by a Commission with some sort of provision for a local voice in it. The first violation of the 1948 ground-water code should have been carried to court. Something definite should be done about violations.

Transportation of water away from its source is the most important problem facing the Verde Valley. "It is enirely feasible for, say the City of Phoenix, to purchase land in the valley and pump it into the Verde River to be delivered in Phoenix." Any legislation should furnish protection for the individual area.

20. *Guido Mariani, farmer, Cottonwood:*

Resident of area for 45 years. We never had any water trouble until this year. This year the water went down 20 feet. A new well for irrigation a half mile away was drilled 1200 feet deep, and I believe it is lowering my domestic water well. Ground-water controls should be by local option. State leased agricultural land should be privately owned. Ground-water law should be administered by a water commission. Wells drilled without valid permits should be stopped from pumping. Replacement wells should be allowed to replace water used before.

21. *Frank Commiskey, rancher, Cottonwood:*

Resident 6 years. Suggest that state leased agricultural land be transferred to private ownership. Doesn't believe industry should have priority over agriculture, but makes an exception of mines and public utilities. Believes economics will regulate pumping in critical areas, and thinks that is best method of solving problem. Administration of a code by a Commission with local representation would be preferred. People should comply with 1948 water code. Replacement wells should be allowed.

22. *Wid Fuller, rancher, Camp Verde:*

Believes in conserving water at its source by eradication of useless brush, trees, etc. A program to do this should be financed by State and Federal Government. State should encourage private ownership of state leased agricultural lands. Believes resources should be used to the advantage of the greatest number. If industry could use water and benefit more people, I'd be 100% for it. A water code should be administered by state-wide board with local representation. Wells drilled without valid permits shouldn't be used. Transporting water out of an area should not be permitted when it interferes with users at the source. Replacement wells should be allowed. The 1948 code was too slow to act. Needed more help and money for its administration. A new code should be based on doctrine of prior appropriation, regardless of how this court decision comes out.

23. *Lindsay Loy, farmer, Cornville:*

Native of Arizona. The noxious growth in the Verde watershed should be destroyed. State leased agricultural lands should be brought under private ownership. Agriculture should come before industry in its right to use water. Administration of a state ground-water code should be by a state-wide water

commission with separate basins set up as advisors. Replacement wells should be allowed, but a well abandoned for five years or more should not be replaced.

24. *Dale H. Girdner, farmer, Cornville:*

Resident for 45 years. I think water should be used where it falls. This reduces evaporation and gets the water into the underground faster. Water should not be transported out of an area. Wells drilled without valid permits should not be used in critical areas. Replacement wells should be allowed.

25. *Kel M. Fox, rancher, Sedona:*

More and more of the snow-fall has been held up by brush and jack pines and never reaches the ground. Only 5% of the moisture that falls ever reaches the ground to be used for irrigation. Means should be found to reduce jack pines to pulp and profitably use them.

If industry wants to locate, it should pick a site where water is available, rather than take if from agriculture. State land should be released to private ownership. I believe in so far as possible that cut-backs should be determined on a local basis rather than on a state basis. "You will probably find it necessary to have an overall state administration of some kind to correlate the policies in the various basins; however, I'd like to see the enforcement of any law which you would recommend be pretty much left up to local option." The administration should be independent of any presently constituted state department. The 1948 code should be enforced. I certainly wouldn't want to see water rights purchased here and the water sent down to Phoenix, or any other place. It would materially hurt the tax situation up here. Doesn't believe the 1948 ground-water code did any particular good or harm. "If your committee determines that to the interest of the state's economy we have to have a code, I hope you'll recommend one that will have a little teeth in it. . . . I hope you gentlemen, in making your report to the Governor and legislature, will recommend that any such area as ours will have little or no restriction, at least at the present time, on drilling irrigation wells. I feel that we should have the opportunity to develop just as other areas to the south of us have already developed, bearing in mind that our development shouldn't exceed the amount of water your scientists tell us is under this ground."

HOLBROOK HEARING
NAVAJO COUNTY SUPERIOR COURT ROOM
SEPTEMBER 10, 1952

26. *William R. Bourdon, rancher, Snowflake:*

Came to Arizona in 1921. I have five irrigation wells in the Hay Hollow District. This is an artesian area, but the wells are pumped to get an adequate supply of water. There is a strong recharge there, but the wells haven't ever come back to their original capacity. In my opinion, we have all of the development now the water will maintain. All flowing wells should be equipped with shut-offs so that they do not flow when they are not needed for irrigation. Ditches in sandy areas should be lined with concrete as soon as farmers can afford it.

I believe we are entitled to a law that will protect us the same as the surface water users. My impression is that when they've reached a cut-back stage, they've let the thing go too far. In areas that have not yet become critical, the law should be such that cut-backs would never be necessary. Administration of ground-water law should be by a water resources commission. Ground-water conservation districts would be all right, but doubt the need for taxing powers. Replacement wells must be provided for. The 1948 code was to stop drilling in critical areas, to avoid, in non-critical areas, the necessity for having to adjudicate cut-backs. If the law could be administered to that end, I would be happy with it.

27. *J. R. McEvoy, banker, Holbrook:*

Resident of the area for 30 years. Farming is important to the business of the district. As this is a livestock area, I would not like to see any law that would prohibit drilling wells for livestock. Control should be by local users of the water.

28. *A. C. Whiting, farmer and business man, Holbrook:*

From what drilling we've done, we believe we have an ample source of underground water. I certainly hope you don't try to stop us down in the valley here. I've heard rumors that the Salt River Valley would like to curtail drilling up here; that they thought it affected their water down there. Restrictions may be necessary after more water is developed. Local control would be better than administration from Phoenix. A water commission would be better than a state water engineer. The commission could compile data for future use in the various counties and carry on investigations that would be helpful. Flowing wells should be controlled. I think as much as 2,000 more acres could be

irrigated on the south side of the Little Colorado River, west of Holbrook.

29. V. P. Richards, newspaperman, Joseph City:

Native of Arizona. So far as we can determine, our wells in this area have an indefinite supply of water. I'm not too familiar with what the state gets for its agricultural leased lands, but I doubt that it would be equal to taxes on private lands. I think the state would be well advised to encourage private ownership of state agricultural lands. The so-called critical areas in the state probably are not as critical as they are painted to be. I wouldn't recommend any type of law that calls for cut-backs. If any cut-backs are necessary, it should be done by local option. Ground-water conservation districts should be voluntary and not compulsory, and they shouldn't have the power to enforce anything to the extent of penalties. There should be no statutory limit on the use of pump water. An individual should have the same right with his ground water that he has with respect to surface water.

I don't think you can write a code to fit the whole state. I don't like the idea of having to get a permit to drill a well. There is a posibility that if we have a law that inventories annually all of the water pumped that our enemies will use it against us in our negotiations for Colorado River water.

Uncontrolled flowing wells should not be allowed.

30. Virgil Flake, rancher, Snowflake:

The underground water and recharge seems to be adequate for our land. The control of salt cedars in this area would conserve some water. Industry should not have any priorities over agriculture. Local people should settle their own problems. The underground water originates on the surface, so I don't see why you couldn't use the same rules as apply to surface water. Water should not be transported out of a critical ground-water area for use elsewhere.

31. Earl Platt, attorney, farmer and Ex-Legislator, St. Johns:

There should be encouragement of private ownership of not only state leased agricultural lands, but grazing land, both federal and state. I believe the state would receive as much revenue from the interest off the revenue of the sale of the lands as they now get from rent without nearly the administration cost. I think that eventually the situation will be reached where the courts will say that you own the water under your land, and you can use it as long as you don't take the water from underneath your neighbor's land, which is the substance of the correlative rights doctrine. "Now if this is true, you'll possibly have the question between agricultural interests and other interests (mining and manufacturing) that they may have to compensate the owners of the land according to the amount of land they're causing to be idle by reason of their pumping in excess of the actual acreage occupied by their industry.

I'm very happy the legislature did not try to pass any ground-water legislation last session in view of the muddled-up legal situation. "I doubt if you can do anything till you find out the basic rights the courts are going to say belong to the landowner. Then you're going to have to write a law that recognizes those basic rights, whether you like it or not. We've gone so far without any law that you now have to pick up and say what are the basic rights and then write a law that recognizes the basic rights that the courts say you have." Different situations exist throughout the state; however, I think as far as a basic law is concerned, it's going to have to be the same for the entire state. "I'm inclined to think that if you have to reach a stage of cut-back that for several reasons it's going to have to be done locally."

I don't know that it makes much difference whether we have a state engineer or water commission to administer state ground-water laws. I have no particular objection to the land commissioner, as we have it now. "I don't think he can do the job that is probably necessary with the present finances."

If the '48 code meant anything, I would presume that anyone that drilled in a critical area without a valid permit wouldn't be entitled to acquire rights on the well so drilled. Water should not be transported from one basin into another without specific authorization. Replacement wells should be allowed. The 1948 code was the best we could get at the time. I introduced a bill that passed the Senate but not the House that I think was better legislation. It was strictly a moratorium. In other words, it would stop all drilling in critical areas until such time as an investigation was made, on which we placed a time limit. Maybe the '48 code can be amended to get the law you want; however, if you start out on the theory of correlative rights, maybe you're going to have to start over again.

Does not believe much danger of critical area developing in his district, due to limited areas suitable for irrigation and the fact that the wells would have a six months' recharge period each winter. Flowing wells should be controlled to prevent waste of water during non-use periods.

32. *Rex Hunt, farmer, Holbrook and Hay Hollow:*

Has three wells and states the water level is definitely lower now than when wells were drilled. Water conservation can be accomplished by controlling flowing wells and leveling land. I think we should have some protection as I feel we have a very small basin.

Industry and agriculture should be on the same basis when it comes to rights to the use of underground water. I think the law should provide for determining in the various localities what constitutes a critical area. I don't think each critical area can be judged on the same basis.

A state ground-water law should be administered by a commission, but control should be by local boards. Replacement wells should be allowed.

33. *Ben R. Hunt, farmer, Holbrook:*

Resident of the state for 60 years. Pumps in artesian area. Pumping by neighbors affects artesian well, but as soon as pumping stops, well flows again. Artesian wells should be controlled. Doesn't believe state leased agricultural land is carrying fair share of taxes, and should be put into private ownership. Industry shouldn't have a priority over agriculture for the use of ground-water.

I think we should have a law that would prevent the necessity of cut-backs. Areas now over-developed should be cut back by a state law administered by local option. Water should not be transported out of area of source. Replacement wells should be permitted. The 1948 code was a step in the right direction.

34. *J. D. Hansen, farmer, Joseph City:*

Native of Arizona. There doesn't seem to be any water shortage in this area, but I think at some future time there is a possibility of its being over-pumped. We need some protection so that if area becomes over-developed, we can stop further drilling. Individuals should own the agricultural land rather than rent it from the state, but there should be a limit on the amount that any one person can buy from the state. Controls should be by local option, but I don't know if it will work. Maybe we'll have to have a state law. A state water commissioner should administer state ground-water code. Prior users of water should have some protection. I don't think water should be transported out of the area of its source; however, it should be put to use on the best lands.

Replacement wells should be allowed.

35. *D. P. Ward, rancher, Snowflake:*

Resident since 1932. I am of the opinion that we are pumping from storage and recharge combined. I think State leased land should be privately owned. Cut-baks should be handled by local option. Water conservation districts should not be compulsory. Replacement wells should be allowed to service original land irrigated.

36. *Arch Isaacson, farmer, St. Johns:*

Native of Arizona. State leased agriculture lands should be privately owned. I believe a state water commission could best administer a ground-water code. Agriculture should have priority over industry. Those who have drilled wells without valid permits should be made to comply with the law. Replacement wells are all right.

37. *Sam A. Walker, well driller, Springerville:*

At the present time we haven't drilled enough wells or drawn the water table down enough to know what our recharge is. I don't think we are drawing on our reservoir at all at the present time. I don't think we have any critical areas at all. Due to our short growing seasons and our large recharge area, it's doubtful if we ever use all the water we have. There is more water than tillable land.

38. *Jefferson B. Hunt, farmer, Snowflake:*

Resident of state 35 years. I feel that the necessary legislation should be enacted to protect ourselves when and if we need it. A local body could keep an eye on the situation with some technical help from the state. Believes in a state water commission as long as all areas are represented on it.

39. *W. C. Shelley, postmaster, farmer and business man, Joseph City:*

I believe the water is not in an underground lake, but is flowing from the north and south toward the Little Colorado River. The water coming from the north seems to be very salty, but that from the south is good. I'm afraid that if we pump too much on the south of the river, it will let the salty water come in from the north.

40. *Lewis K. Armstrong, Soil Conservation Service, Holbrook:*

Has lived in the area 9 years. Old wells and salty wells should be plugged from top to bottom to prevent contaminating good wells with salty water. The continued use of stored water will result in economic ruin in some areas. What is good for the most people in the long run is best for the individual now. The

fact still remains that the principle of optimum production on the indefinite period and the security of the state's economic system depends upon the long-time water supply, which is governed by the long-time recharge rate. We think in this country the recharge area is along the Mogollon Rim and on this side where we have great areas of cinder beds overlying Kaibab limestone and is a source of good quality of water. It is my belief that if a commission was formed and empowered to make studies and gather information about the underground situation which could be made available to the people, drillers and others, they would go a long way in solving the problems. Whatever law is passed should be adequately financed.

The 1948 code was inadequate and under-financed.

41. Lee Griner, rancher, Snowflake:

I am in favor of a ground-water code in the state tat would be possible for us to participate in up here. Don't favor any kind of law that would be mandatory or would be administered entirely from Phoenix, or for any other office in the state. The law should provide for local option.

42. Hollis L. Palmer, Forest Supervisor, Holbrook:

Resident of the state for 27½ years. The management of the watersheds is a very important factor in our water supply. Grass is a much better medium of percolation than juniper, jack pines and brush. I feel that the jack pines would be good for a pulp industry. However, steps should be taken to prevent loss of water by contamination due to a pulp industry. It might be economically feasible to offer a small bounty to any manufacturer of pulp based on a per acre basis. It would be much less than the cost to stockmen of eradication, but would still be some inducement to get the industry into the state.

SAFFORD HEARING
SUPERIOR COURT ROOM, 9:00 A.M.,
SEPTEMBER 12, 1952

43. Guy Anderson, attorney, Safford

I'm an attorney for the Gila Valley Irrigation District. I was born and reared in this county. We divert our water from the Gila River by gravity and it is supplemented by irrigation pumps in times of low flow in the river. There apparently is nothing very uniform about our underground formations. We have about 550 wells pumping that produce from 100 g.p.m. up. Most of these wells are under 100 feet in depth.

I own a deep well that was drilled in 1928 to about 3700 feet. It has produced about 2500 g.p.m. out of a 4″ casing since 1928. The temperature of the water is 138 degrees. The water from the well is very salty, but we mix it with oher water and irrigate with it. Many wells have a high salt content which increases as the water level is lowered. The high salt content of the pump water makes it necessary to use more water to keep the salt flushed out of the soil and allow seed germination.

Last summer we over-pumped and practically ran out of water. Last January we had some good rains and the washes and river ran and our wells recharged and we have had a pretty good supply of water this summer. A lot of this pumping will take care of itself if the cotton price drops 50%.

In periods of drought, I've never seen an irrigation district yet that kept the water levels up in the surface reservoirs and didn't use it. Now we have an underground reservoir in places all over the state, and in this period of economic high, we don't hesitate to go down and pump it out and use it as though it were a surface reservoir and make money out of it. Pumping costs have decreased due to cheaper power supply and the use of natural gas. In our area I don't believe there is anything that ground-water legislation could do to help us. The thing that looks most unfair to me is in some areas people with sufficient capital can come in and lower the water level and deprive those there almost to the right to make a living.

If the people in Maricopa and Pinal counties want some type of state ground-water law, let them have it, but it ought to be sort of enabling legislation of some kind that will let them regulate themselves. I think it should be written in any law that when a basin is classified, and there is a canyon or defile that the water passes through, then it should not be considered as a part of any other basin. There should be as little state control as possible; the problem should be left to the local people. It would have taken more people than the State Highway Department has to administer Senate Bill 66 proposed by the last water committee.

Phreatophytes are using more water from Safford to the Coolidge Dam than we use in this valley for irrigation. If we knew how to control these phreatophytes, I think we'd be trying to something about it.

44. Mark Bliss, Superintendent of U. of A. Experiment Farm, Safford:

Submitted data on analysis of water in experiment farm well. Total soluble salts reached around 4000 p.p.m. with a high sodium percentage as the pump-

ing lift in the well increased. The high salt content in the pumped water increased the amount of water needed to keep flushing the salts out of the soil. "I really feel that whether any legislation to control pumping is put in, I think very definitely there should be an office to correlate and gather continuously water information." If we are exhausting our water supplies, of course there are several ways of evening it up. One of these is to let economic conditions take care of it. Of course, that is the thing I think we are afraid of, and the reason you fellows were set up as a board to try to work something out.

45. *Jim Smith, farmer, Central:*

Lived in state 60 years. Conservation and re-use of tail water would save water. A cut-back in the use of pump water would have a material effect on the tax rolls and people employed. Putting state land under individual ownership is a good trend if it doesn't get into too few hands. I don't think a law can be passed that would be fair to present land owners that would balance pumpage and recharge. Prior wells should have no right better than new wells in any ground-water code. If the Supreme Court decision that was rendered had stayed in effect, there would not have been enough courts or attorneys to ever take care of all the cases. Any laws passed should be based on local option. No law should allow one county or area to put restrictions of water use on another county or area. Administration of a ground-water code by a water resources commission with representatives from the various localities would be best. The principle of correlative rights gets closer to solving the problem than any water code. "The 1948 law is so unconstitutional that they could never get by with trying to enforce it."

46. *A. E. Jameson, Safford:*

If there is any regulation of the ground water it should be handled locally. There should be no blanket law or control passed for the state that would apply to this valley. Let the local irrigation district board select the regulating officers and engineers.

47. *Clayton Hakes, banker, Safford:*

The small wells in this area have been a life saver in making crops. Without them we couldn't have got by the last 10 years. Any ground-water code should be administered by local irrigation districts.

48. *Allen Watkins, forest supervisor, Safford:*

The ground-water situation in this area is not ideal or adequate. There is a need for control of phreatophytes and noxious plants, but research is needed to find practical methods. Ground-water conservation districts could be used to an advantage.

49. *J. D. Lee, farmer, Safford:*

Deepening wells would not increase water supply unless they went to 2000 feet or more. "In my opinion this valley is regulatory in itself so that locally we can handle the underground situation." Thre are 200,000 acres of salt cedars in Graham County that use a lot of water. We've got to face up to the fact that there's got to be some limit to the amount of underground water and new development, or else we're going to wreck the agricultural economy. The longer we put it off, the tougher it's going to be. When I was first here there were no tamaracks. Now they are spread over a wide area and still increasing.

50. *W. B. Mattice, farmer, Pima:*

Discussed events leading up to the passage of Senate Bill 56 creating this Commission. "I feel that if the state could sell off its agricultural lands, the state as a whole would be better off in general for taxation purposes." I might say here that I also served in the legislature when the 1948 code was enasted, but I felt that it was a matter of local concern. A state code would be best administered under a commission. As far as the 1948 code was concerned, that was passed because we felt that we had to pass something to satisfy the Governor.

51. *Thomas Maddock, Secretary, Gila Valley Irrigation District, Safford:*

I have lived in the state all of this century and have been interested in water for the past 30 years. I served 8 years on the Colorado River Commission. It was the endeavor of our Board to try to show that this district is different from other districts. We haven't had any pump boom here or developed any great additional areas because of high prices. We have opposed a water code for 12 years for the simple reason that it would hurt us. "We do not need a water code."

He made a rather lengthy statement to prove that the ground water that would enter the Gila river from their area was very small, probably not over 5 or 6% of the total water. One fear of ground-water legislation was that it might prevent draining with pumps, areas with a high water table that were being ruined with alkali. He explained that their artificial flow back into the river due to surface diversions and application of the water to the land exceeds by many times the natural discharge to the river. Using U.S.G.S. figures, he explained that there was sufficient water in storage to last the state 20 years at

its present rate of use if its distribution coincided with the areas of use. With all of this water in storage, why shouldn't we draw on it?

When an operator with a big plant moves in and can pump water cheaper than the little fellow, let him pay the additional amount necessary to compensate the little fellow for his additional cost of pumping, but don't prevent the use of this estimated 60,000,000 acre-feet of water in storage. It would not be an easy job to regulate, but it seems to me to be the fair thing to do. Regardless of whether you pass a code or not, your economic code will be there, and you can't repeal or suspend it. He pointed out some of the dangers involved in declaring ground waters public, such as the danger of Federal control and loss of our right in the water of the Colorado River. "I want to state one thing more—We are inclined up here not to tell you people down below what to do in the hope that you'll reciprocate."

52. O. W. Claridge, farmer, Duncan:

We have 4700 acres of decreed land and 67 pumps. Our conditions are similar to the Safford valley. Conservation of water is economically forced or controlled by the cost of water. All the land in the area is now developed; therefore, not much need for increasing the amount of pumping. No attempt should be made to balance pumpage and ground-water recharge. Nature and supply and demand will take care of problem without regulation; however, if any regulation is ever necessary, it should be on a local option basis. I wouldn't favor any federal or state control whatsoever. I believe in the prevention of waste of everything including water.

53. Waldon J. Lunt, farmer, Duncan:

There is no evidence of artesian pressure in our area. We pump to supplement our gravity supply of water. There are no deep wells in the area. Any controls should be handled by local option. If some state organization is set up to work with ground-water problems, a commission with a representative from each county would be best. Our use of water may have increased some due to a shift to commercial vegetable production, primarily onions.

54. Gene O'Dell, farmer, Franklin:

Agreed with statements of Mr. Claridge and Mr. Lunt. Believes their ground-water basin is separate and distinct from any other basin in the state. "Presonally, I'm not in favor of any kind of control, because I believe in our area we can work the things out for ourselves; likewise, we wouldn't want to tell someone in some other district how to control their areas." The economics of cost of pumping and prices of commodities will govern the use of pump water in critical areas.

I don't believe in priorities or prior appropriation of ground-water.

55. R. E. Elledge, Duncan:

Takes a live-and-let-live attitude toward the water situation. If some people want priorities, controls or a ground-water law, it would be all right as long as it could not be put into effect in his community except on a local option basis. Water conservation districts might have too much authority; therefore, not in favor of them. There should be no restrictions on drilling replacement wells.

WILLCOX HEARING
VETERAN'S CLUB HOUSE, 9:00 A.M.
SEPTEMBER 13, 1952

56. Walter Holland, rancher, Dos Cabezas:

We are concerned with the fact that the water in our stock wells and domestic well is going down. There are a lot of big irrigation wells below us and we're just wondering if the big wells aren't depleting our water. " I believe it would be to the advantage of the state as well as all the citizens if they did encourage private ownership of state leased lands. I have been trying to buy some for 5½ years, but I don't believe they will sell until we get a law through giving the state the right to withhold mineral rights." I do feel that there should be legislation to protect every area of the state in the future against excessive development and taking out more water than is put back by our normal rainfall. The most practical way of solving the ground-water problems would be by a law to provide for state administrative determination.

57. Mark Bliss, Ex-County Agent, Cochise County:

Gave a general statement of the background of studies made in Cochise county and outlined the general geology of the aera. At the present time, there are some 20 to 25,000 acres producing crops in the county, or about 50 to 75,000 acre feet of water being pumped for irrigation. I made an estimate at one time that a top of around 25,000 acres of irrigated land in Sulphur Springs Valley would be the limit of their water supply. Believe that if prices stay at present levels, there could be more expansion and the people keep in business for a long time. I wouldn't know wether this area has been over-expanded or not. "I would say the sanest thing in this area would be to hold down the expans-

ion until you know, till they've had a chance to make engineering studies and determine whether its going to be over-developed or not. I wouldn't advocate a cut-back for this area."

In an area like this, it might be necessary to study the ground-water situation to find out where development could be made without affecting existing pumping operations. If there is any possibility of getting our quick run-offs into the underground, it would be a worthwhile type of conservation.

58. Gene Anderson, farmer in Kansas area, Willcox:

A native of the area. Leveling land and prevention of tail water waste best way to conserve water. "At the present time, I believe we've reached probably more than our annual recharge in the amount of water that's being pumped."

I have very definitely noticed a change in ability to pump water since the increase of land in production. "I certainly believe that some sort of control measures should be instigated to at least stop the increase in irrigated acreage until we determine whether we're going over our recharge." I would favor local control, but don't believe it would work, so I think there should either be legislative or state control. Wells drilled without valid permits should not be used. Believe the '48 code would have to be amended to make it workable. The farmer should be compensated if a city finds it necessary to take his water. Improper installation of wells has caused considerable loss in pressure in our artesian aquifers. There should be provisions in the law to stop this waste.

59. William E. Balcome, farmer, Willcox:

Native of Arizona. The water cost is about 25% of my production cost. I believe I could still operate if the water dropped 50%. I know that lowering the water table would put some farmers out of business. A cut in the use of pump water would decrease the value of land, reduce amount of state taxes and cause considerable land to be returned to grazing. "I'd like to see a policy of definitely making private ownership of state leased agricultural lands." I believe in prior rights for users of ground-water and don't like the '48 code.

60. Robert G. Folk, farmer, Kansas settlement:

Proper leveling of land will conserve water. Some of the water is coming from storage. A water code to conserve and protect the water of the state should be enacted. State administration of water laws should be a water resources commission or similar body. Restrictions on ground-water use should be by state administrative determination with local consultation. Provisions should be made for the establishment of ground-water conservation districts. "If a whole area can attract people who will put in more acreage and if there is a sufficient amount of water at a greater depth to do so, then it's better for the area to have that economic lift."

Replacement wells should be allowed. I think legislation should be included in the next code that would require industry to purchase enough land where water is now being used to take care of their water needs.

61. Tom Green, farmer, Kansas Settlement:

Came to Arizona in 1939. A survey of this water should be made to see what we've got and then development should stop when the amount of recharge is all developed. If restrictions are necessary, the theory of prior rights should not be used. The owner of the surface has a right to the water underneath. Replacement wells should be allowed on land already in cultivation. Tail water waste should be prevented. Ground-water conservation districts with power to issue bonds and levy taxes are all right. People within a local area should be able to agree on what should be done for that area.

62. Charles Kemper, attorney, Willcox:

Gave some discussion of water law and concluded that the reasonable use or theory of correlative rights is what we are going to come to. Efforts should be made to conserve water by lining ditches, preventing tail water waste and reasonable application of water. The last committee of the governor's never gave this area any consideration. Definitely, we are an area and must be considered. The old English common law doctrine to me is impossible. When the water under a piece of land is moving, it is impossible to say it belongs to any definite piece of land. The passage of an adequate water code will prevent this area from becoming over-developed as is the case in other areas of the state.

63. John Saylor, farmer, Elfrida:

A resident of Arizona for 62 years. "None of my pumps have lowered since I started 15 years ago." I don't think we should have regulatory measures enacted by the legislature to regulate pumping. I think control should be left to local option.

64. Brent Mott, farmer, Hereford:

Located in a narrow valley in the upper San Pedro. Wells are in an artesian belt. No one in area

concerned over water situation as there is not enough tillable land for over-development of supply. Not over 3000 acres in whole valley could be farmed.

65. *A. W. Steagall, farmer, Elfrida:*

Came to Arizona in 1943. At present I wouldn't be in favor of a code unless it was administered locally." New developments in my area have not affected my pumping.

66. *R. F. Burnett, farmer, Elfrida:*

Resident of state since 1910. I'd rather have the right to drill a well than have a lot of wells. I know they are going to pass some kind of a code and I'm not too much in favor of it." The man that has been in an area for a long time should have some prior rights. I haven't entered this race to drill wells, but I don't want to be deprived of the right when I do want to drill.

67. *Marshall H. Barnes, San Simon, farmer:*

Resident of San Simon for 40 years. Operates in an artesian area but the pressure has dropped to 10 feet below surface. The lowering water table won't force any farmer out of business at present prices. Maybe 60% of the community income depends on pump water. State leased lands should be under private ownership. I'm not in favor of a cut-back in our area. Administration of a water code should be left to local people with possibly some guidance from the state. In case of a cut-back, it should be on a priority basis. Wells drilled without valid permits should not be used. Replacement wells should be allowed. Argiculture should have priority over industry in use of ground-water.

68. *George Berry, farmer, Elfrida:*

Water level has gone down some. The recharge is probably less than what is being drawn out. Don't believe any control measures needed in Cochise county at present time. "I don't have much confidence in anybody taking care of me but myself." Controls may be necessary up by Casa Grande, Eloy, etc., but down here where we're pumping, why we're just closing up one end of a hole and it's running out the other end. Why control us, when just a little South of us there's no control? (Mexico)

69. *E. W. Powers, farmer, San Simon:*

A resident of the area for two years. If the area is ever restricted it should be voted in by the local people. There has been quite a bit of increase in land put in in the last two years, but there seems to be plenty of water. I am not worrying about over-development affecting my water.

70. *Fred Watts, farmer, San Simon:*

A man should be entitled to buy a piece of ground and farm it and work it to suit himself, and I think the state should build a law where each individual community could call on it at any time they felt they needed that law. I'm thinking of enabling legislation that would allow us to call on the state and they would immediately take steps to curb drilling and developing any new ground that might hurt us. A state agency to study the ground-water situation in the different areas would be desirable.

71. *F. E. Woolery, farmer, San Simon:*

Resident 5 years. "I see no immediate danger of a critical area at San Simon. However, I think we should have some regulation of some kind that we might start from, administered by the local community. The fact that my well was drilled in 1919, I don't know why that should give me a priority over the next fellow, other than I should be allowed a number of acre-feet according to the amount of land I have. I think it would be fair for them to curtail a certain amount of mine as well as the rest of them." Control should be done locally with guidance from the state. My wells haven't been noticeably affected by new development.

72. *J. W. Pratt, farmer, Willcox:*

Resident since 1949. I sold out and left the Pecos Valley in Texas to avoid the race of deepening wells and setting my pumps deeper. This race could have been avoided had there been proper legislation. "I think our district could, however remote, arrive at the same condition providing steps are not taken. I think the Stewart District now is developed up to the recharge capacity of the district. I don't think we can develop much more, if any, before we pass the recharge."

I would favor a combination of local and state administration. A ground-water law should not be based on the principle that the water under the land belongs to the land, because the water originates elsewhere and percolates under the ground. There should be some protection for the prior user of the ground-water.

73. *Jesse Williams, rancher, San Simon:*

Resident 40 years. I don't believe there is enough land in the San Simon valley to ever cause it to be critical. Control should be by state legislation and governed by reports from local committees. Administration should be entirely by local committee, but legislature should appoint a four or five man commission from different districts around the state.

74. *A. H. Armstrong, farmer, Willcox:*

I feel that we are drawing from storage rather than recharge, as the water level is going down two to three feet per year. "I feel that further development should be stopped in this area." At present we could stand a 25% increase in pumping costs. Each locality should have a board to adjust water use.

NOGALES HEARING
SANTA CRUZ COUNTY SUPERIOR COURT ROOM,
SEPTEMBER 22, 1952

75. *Col. Gil Procter, rancher, Nogales:*

There are a lot of people in this county that are definitely of the opinion that a lot of our water here is going to waste. Last year the question of making Santa Cruz County critical from Nogales to the south end of Baca Float was raised. At the hearing before Mr. Lane, there was so much opposition to creating a critical area that the question was dropped. At the time we were of the impression that the people down further in the valley wanted to have this end declared critical so that no more wells could be dug here and the water would be available to them.

From a study we found that there was very little acreage left, suitable for cultivation and this was our reason for not being a critical area. I think we should have control of some kind throughout the state of Arizona, and I was very definitely in favor of the proposition that was put up by the Governor's committee last year. Eventually, we'll have to have control throughout this end of the county, but I don't think the time is ready for it. I think the main control should be on the people that come in from the outside and try to make a quick buck. They use up the water and then leave the country.

I feel that a control that benefits the most people is a good control. I don't think you can satisfy everybody. Community interests should be foremost. I think regulation should be on a statewide basis. Regulations should be set by the legislature, and if that were done, we could obviate the selfish interests trying to get in their plug for their own. A lot of people think you should not have any control and a lot think that they own the water under their land and it's all right for them to take out all they want and to hell with the other guy further down. I think an agreement should be made with Mexico and some means made whereby they could be limited to so much water and the rest of it could be allowed to come over here.

"My water rights are the oldest in the state—the oldest continually operated ranch in the state. I would feel that I was not hurt at all if the state board put a control on me and allowed me to grow cotton on my acreage but say 'Now, you can't use more than so much water,' provided they gave me sufficient water to grow my crop." In the Santa Cruz Basin I feel that the withdrawal is exceeding the recharge, but in the southern part of the basin I don't think we are exceeding recharge.

Believes water commission should have some control over price of power for pumping.

76. *H. G. Chermin, Mayor, Nogales:*

Resident for 29 years. It seems to me that conservation is the only answer to the water shortage, but conservation has to be at the level where it is wasted. You can't cut everyone alike. State control would be favored over local control. By local control, a few would get the benefit and the majority lose. Water code should be administered by a 28 man commission—two members from each county, with one to represent the cities and one to represent agriculture. Flood waters should be salvaged. I believe something is now being done to the Santa Cruz River through the International Boundary Commission in working out an agreement for the division of water.

77. *E. R. Clark, farmer, Tumacacori:*

Resident since 1935. There should be some protection to prevent a city from pumping out a prior users water supply. The water level has lowered due to less run-off and increased pumping. I believe we are overpumping and should have controls that would stop new wells and new development. Local controls are better because the local people are more familiar with their immediate problems. I don't believe there is any need for a cut-back in my area. The water hasn't gone down much in the last couple of years. I feel that if the mesquite were eradicated, considerable water would be saved. Instead of one big dam on the river, I would suggest several smaller ones on the tributaries. State ground-water law should be administered by an engineer elected by the people.

78. *Dell Mitchell, Mgr., Citizens Utility Co., Nogales:*

A dam down here would definitely control the waste and that's one of the big problems in this end of the state. I don't know how the controls should be set up. I think you'll have to get people who know more about it than the average person does. I would think the best would be state control with guidance from the individual counties. I don't think local control would be practical. Whoever adminis-

ters a state code should be qualified; you just can't appoint a commission or engineer without qualifications for the job. That's my objection to the election part.

79. Herbert Merryweather, State Senator and rancher, Tumacacori:

I am presenting views as an individual. I think you gentlemen should give serious consideration to a dam on the Santa Cruz River. It's my opinion that it would stabilize our water table and be of benefit to all people down stream. "I also think you people would be wise to make recommendations concerning a possible treaty with Mexico insofar as water usage is concerned from the Santa Cruz River." Regarding the term "selfish interest," I think that every farmer in Arizona had a selfish interest, an enlightened selfish interest, and that's the reason this commission was appointed in the first place, so that all our selfish interests could be considered and balanced out and some decision made as to what would be a proper method of controlling our water. I think there is a great deal of danger involved in the possibility of having state control over your water table and over your water distribution, and it is something that should be analyzed and considered very seriously.

"I think that by organizing voluntary groups of conservation districts throughout the state that you may be able to realize a tremendous saving in water." I do not favor the election of a commission. The commission members should be appointed by the Governor, with the consent of the Senate. All counties should be represented on the Commission. "I think your municipalities come first and I think your industries are after all basically a part of your municipalities." The cities have a very serious obligation to the men whose land and water they appropriate. The idea of a city just going up and taking over a man's land and giving him what the city thinks right and proper is very much incorrect. I think the land should be properly evaluated and a man paid in accordance with true values of that land or water which is appropriated. A dense mesquite growth will use as much or more water than the same acreage put in cultivation and farmed to cotton. Legally, you can never overlook some sytem of prior rights in a ground-water law.

80. Tom A. Heady, rancher, Patagonia:

They talk about the Santa Cruz heading in the valley out there and going into Mexico and then back into Arizona at Nogales. One thought that hasn't been mentioned is that with all the big pumps being put in on ranches on the headwaters of the Santa Cruz that within two years you won't have to worry about the water at all—they'll have it. "I think the underground water from the head of the Santa Cruz River to the town of Santa Cruz is just about out as far as coming this way." In late years, we just haven't had the rainfall.

I don't favor eradicating water-loving plants.

81. Gilbert Sykes, Forest Service, Nogales:

The main job of the Forest Service is to maintain the upper levels with a fairly decent cover so that the water is clean. Mesquite encroachment should be stopped. Grass cover is more desirable in retaining water. In the northern part of the state juniper is just as bad as mesquite. Small dams technically placed would probably get considerable recharge. "I think we are using water in the upper Santa Cruz basin about two or more times as fast as it goes in, and the further down you go, it increases." Something very definitely should be done.

I don't know whether you could economically balance recharge against withdrawal, but some check should be established. I think the smaller basins of the Santa Cruz are pretty well connected. Groundwater control should be on a statewide basis, but I think the local areas should have at least a committee whose ideas should be weighed in the determinations. The state organization should be selected like this commission. Experts from various fields should be on the Commission.

82. Meade Place, farmer, Amado:

Mesquite should be eradicated. I feel that there should be a statewide commission such as this, with members possibly from every county, and also the possibility of a three man board from each county to handle local conditions and present them in turn to the State Commission. The 1948 code doesn't seem adequate. All users of ground water should have an equal right.

83. Roger D. Morris, forest supervisor, Tucson:

"It is true that if you could replace trees like oak, junipers and mesquite with grass you'd probably get larger revenue from the additional grazing of the grass and get a greater delivery of water. Our experiment station shows that proper manipulation of the watersheds can increase delivery by approximately 15%." The cost of this eradication would probably be uneconomical unless you can find some way of using these trees to help pay the cost of their removal.

"On re-seeding I'll say this . . . until you get to an elevation of 6,000 feet where you have from 22-24

inches of rainfall, I don't believe your range reseeding is going to be very successful. The Forest Service could operate a program of conservation which might be recommended by the Committee."

Doubts if recharge wells would be a practical means of recharging the ground-water supply.

84. *Gene Egan, Producers Cotton Oil Co., Phoenix:*

Believes we will have to depend on an over-all control for the state, due to fact boundaries of ground-water basins can't be definitely defined. The man before me mentioned that it may not be economical to remove water-using plants. "Are we sure that it's economical to draft a water code, develop an administrative body, establish a police force, and at the same time gain enough in savings to make it worthwhile, or would we be just as well off to let the economics of pumping water take care of the problem itself? It's just a thought; I'm not recommending either one of the two, but I think before any water code is established, we'll have to seriously consider whether that is the best thing to do for the state. I think we'd all be interested in a stabilized enterprise, if it could be stabilized at a level that would be productive to a rather large population of Arizona."

It wouldn't take a ground-water code to put some cotton farmers out of business if the price of cotton dropped a third.

TUCSON HEARING
TUCSON CITY HALL, SEPTEMBER 22-23, 1952

85. *Carlos Ronstadt, farmer and rancher, Amado:*

Native of Arizona. As president of the Santa Cruz Underground Water Users' Association, he presented a written report giving the views of the Board of Directors of the Association. He also presented a report by S. F. Turner, "Underflow of the Santa Cruz River," which was designed to prove that the water under the Santa Cruz River lowlands from the Mexican border to Tucson is an underground stream and subject to appropriation under the laws of the State of Ariozna.

Speaking for himself, Mr. Ronstadt stated that he thought the cost of pumping water had increased as the water table receded. However, according to U.S.G.S. records the water table had only dropped 8 ft. over the past ten years. I would say that better than 90% of the potential farm land has been developed in the upper Santa Cruz area.

"I think that a combination of prior and correlative rights should be followed so that the people who came in later, not knowing what the situation was and put their money in would not be put out of business. I think that any legislation that is enacted should be over a long term, maybe ten years with a gradual retirement to bring back, maybe, some of the land so it won't put anybody out of business at once. But I don't think that should be done until all other means are exhausted."

"Domestic and municipal use should have prior rights, but they should not be allowed to take it, especially where there are underground streams, without paying for it." Industry should have a right equal to agriculture. "I envision a district formed legally under the laws of the state of Arizona embodying cities, towns, utilities, farmland, and entering into cooperative agreements for the purpose of conserving water, with teeth provided for enforcement by state law." I would think that legislation that would require a cut-back should be by state administrative determination. If a ground-water law is passed, I would favor that it be administered by a Commission, appointed by the Governor and approved by the Senate. The Commission should have power to employ an engineer and such employees as necessary. State leased lands should be handled in the same manner as any privately owned land. No more development of state leased lands should be allowed in critical areas. Indian lands should cooperate in the same program and have the same rights as anybody else. "Simply because it is Federal land and has not been developed, is no reason why they should have any prior rights to any water." Areas with gravity water should be governed in the use of underground water the same as 100% pump users.

86. *Keith Waldon, Continental, Pres. Farmers' Investment Co.:*

Our company operates 3600 irrigated acres 25 miles south of here and 4400 irrigated acres 8 miles south of Picacho. The feeling is that any further wells south of Tucson that are drilled now are taking away from an existent supply. The amount of water now being withdrawn from the Santa Cruz Valley from Nogales to the Rillito Narrows is in excess of the recharge at the present time. "I am, however, equally sure in my own mind that the opportunity does exist in this valley if the proper effort is undertaken and executed to develop the recharge to the point where it is equal to the present output." This should be done by concrete lined ditches, applying water so there is no tail water loss, and increasing recharge by properly locating small check dams where the aquifers will absorb water readily from summer flash storms. This work should be done by the people who are interested in controlling their water supply by bonding them-

selves to the extent necessary to do the job. "I don't like government subsidies myself."

I'm confident it's only due to an excessive take-out upstream as compared to what it was 30 years ago that has helped lower the wells on the Continental farm. "My feeling is that there shouldn't be any preferential right distinguished for industry or agricultural or metropolitan areas. I don't think anyone will fight or argue with the right of the municipality to buy water, but I think most farmers would fight vigorously any municipality taking water that under the law was already appropriated as I feel is the situation here in this Valley."

There will never be a way to regulate underground water in Arizona to keep everybody happy. If we do not regulate the use of underground water, we'll go as long as we can afford to pump and we can all suck air at the same time. "I think the real future of Arizona is the Colorado River, and that's the only source. California has lots of other sources."

"Personally, I would prefer to have no legislation, and as an individual, farm and operate our farm and take our chances on the water supply under our property." I think, however, for the good of the state, we will have to have water control and enforcement of the controls should be left to local districts if possible. A state administrative organization may be necessary, but I wouldn't know whether the members of a Commission should be elected or appointed. The plan worked out last year by the Governor's committee is all right for an over-all state policy.

8. Carl Pistor, well driller, Tucson:

Resident of Tucson since 1916. The underflow of the Santa Cruz River does not follow the surface stream. You are pumping some from storage, but not at an alarming rate. A water code could be locally policed. The '48 code should be modified. Industry and agriculture would come under the same classification as far as preference is concerned.

88. C. F. Altfillisch, farmer, Sahuarita:

My water level has dropped about 8 to 10 feet since 1946. "I don't know much about the 1948 code. I don't like it because there are wells being drilled in critical areas where it's supposed to be prohibited." I think there is adequate water in my area. I'm in favor of restrictions. It's got to be some type of state legislation with an engineer at the head and with a local committee to cooperate with the state engineer. Any cut-back should be by local determination. Prior users should be favored, but not to the exclusion of others.

89. Phil J. Martin, Jr., Water Superintendent, City of Tucson:

"We're pumping from an area that is heavily pumped both from the standpoint of water used for domestic purposes and in certain areas in competition with agriculture. Our water table has dropped considerably in the last ten years and is continuing to drop. We think there should be some restrictions made. The area should be declared critical to prevent further marginal land being brought in." The old users should have some preference. "I know that the recharge must equal the withdrawal or somebody's going to be out of water. I think this should be done in every area, within the possibilities and limits of endeavor. In some areas it is certainly going to be impossible in the foreseeable future to balance recharge and withdrawal without virtually eliminating the agricultural economy of those areas."

90. E. M. Furrey, Superintendent of Flowing Wells Irrigation District, Tucson:

"I am very definitely in favor of having restrictions. I don't think the '48 code has affected continued drilling, as I can see. If they are going to keep on drilling, I don't see what good the code it.

"In Flowing Wells area there doesn't seem to be any possibility of determining an underground stream. In our thinking all underground water is the same, and should be considered the same, whether in an underground stream or not. I think the situation is more serious for all of us than was pointed out yesterday. I feel that in the event of restrictions in this area, all should be on the same basis with some priority based on date of drilling." The state should set the policy for cut-backs, but the actual work should be done by the local organization. All users of water should be on the same basis. If one type of user needed more water he should buy sufficient land to get it. Conservation practices should be used to save water.

91. Dr. Robert H. Forbes, retired University Professor and legislator, Tucson:

Resident of Tucson for 58 years. Delivered a talk in which he outlined various methods that the City of Tucson could use to increase its water supply without taking water from agriculture. He expressed the belief that bringing in outside water from the San Pedro River and Tombstone mines to the city would have a three-fold benefit. First it would secure revenue from its sale; second it would prevent putting farmers out of business, thereby allowing agricultural revenues to come in the town; and third it would promote growth of the city and increase taxable values. It would also drain the deep bodies of water

under the town of Tombstone, and probably allow continued mining operations there.

92. *Joe M. King, rancher and farmer, Marana:*

He expressed the belief that they also had an underground stream in the Avra and Altar Valley. Has fear of what will happen to water table if city of Tucson puts pumps in the Avra Valley. (Other statements to be made at Marana hearing).

93. *Lee Gardner, civil engineer, Phoenix:*

"The engineering association believes strongly in and have recommended a strong ground-water law —one that will recognize or establish some sort of prior appropriation schedule of things with known amounts, known values to each user, some scheme that you are trying to work out.

"It's been a little bit in the discussion of yesterday and today that the municipality is anxious to take water away from farmers, and I don't believe that is the condition. It's to the city's interest that a strong law be established as much as possible like surface waters with prior appropriation and beneficial use as the primary consideration. The municipalities will then be able to deal with individuals who have established rights in purchasing additional rights as they need them." Under the present scheme of things, the city of Tucson cannot buy a water right from anybody along the Santa Cruz as there are no established rights to the ground waters.

MARANA HEARING
OFFICE OF CORTARO WATER USERS' ASSOCIATION,
SEPTEMBER 23, 1952

94. *Joe M. King, rancher and farmer, Marana:*

The static water level has lowered from 128 feet in 1915 to 150 feet at the present time in my immediate area. I haven't noticed any effect on our wells from our neighbor's pumping. I feel that we are pumping from an underground stream. I believe the source of our water is from both the Avra Valley and the Santa Cruz River. The prior user of groundwater should have first right in use. Given the facts, I don't think we would have any trouble organizing and governing ourselves. "I definitely believe in letting the local groups handle their own problems." In critical areas, there would have to be a state law to have any effect. I would favor local people determining the amount of cut-back. "I feel that if any municipality goes into any area and takes that water, it should pay for it."

Both municipalities and farmers could conserve a lot of water by using better methods. Eradicating phreatophytes and other practices could have considerable saving effect. Prefers that these practices be undertaken at local level rather than at the state level.

"I don't think the '48 code was a code at all. I've heard of wells being drilled regardless. If their wells weren't drilled with valid permits, they shouldn't be allowed to pump them."

95. *Fred Davis, Tucson, Cortaro Water Users' Association:*

Presented data regarding static water levels, pumping levels and the general pumping characteristics on the Cortaro Water Users' Association project. He described their pumping areas as being divided into the Cortaro unit which lies along the Santa Cruz River southeast of Rillito Narrows and the Marana unit which lies northwest of the Narrows. In the Cortaro unit, the water level has dropped 28 feet since 1937. It is my understanding that we are pumping from an underground stream in this area. In the Marana district, it's from storage.

96. *J. W. Nordyke, farmer and president, Cortaro Water Users' Association, Cortaro:*

Our Marana wells vary in depth from 442 feet to 840. However, we do not find any material amount of water below the 500 foot depth. The decreasing water level naturally means a higher pumping lift and a greater cost. We could stand some increase in the cost of pumping, but any material reduction in well capacities would cause our crops to suffer. I think some control measures could be effected.

"I think it would be well to have all wells metered, or measured in some way and some record kept of discharge so that it would be known actually how much water is withdrawn and keep it within the limits of beneficial use. I believe there should be a limitation on further development of acreage in this area. We've reached the point where additional acreage would materially affect the water supply as far as the rest of the users are concerned."

We are pumping partly from storage and someday it is going to be necessary to attempt to balance withdrawal and recharge. We have found that 20 to 30% saving of water can be obtained by lining a ditch through sandy soils. "Apparently the effect of the Eloy and Coolidge area developments is gradually creeping back this way, and again I want to quote Professor Schwalen, who recently said that in his opinion it is creeping back and gradually drawing down the wells up this way."

A one-third cut in cotton prices would at least put some of the marginal land out of growing cotton.

"I don't feel very friendly toward the 1948 code. It permits so much laxity. It amounts to almost no code at all." In the event of a new code, I think local control would be beneficial and could be worked out to some extent. I think a local district should embody an entire area, as there would be danger if two adjoining districts with different rules of control both were drawing from the same body of water. A substantial cut in the amount of water pumped would be a severe blow to the economy of this community. If a ground-water law is enacted, I would favor it being administered by an engineer. He should be appointed without any set term and could be removed at any time. "In any new code there should be some provision made for compensating a farmer in case a municipality deprives him of his water." I believe that in the event it was necessary to curtail pumping in an area, preference should be given to those who first pumped in that area. I would prefer to see state lands in private hands and be developed by private individuals and owners.

97. *John Kin, farmer, Marana:*

I farm about 2100 acres and lease out about 2500 acres of land in this Marana District. I've been operating here for 8 years. As far as I am concerned I could make money if the cotton price dropped a third. I have 9 wells from 550 to 900 feet deep. The 900 foot well is much better than the shallower wells. "I believe we should have some controls but we don't want a law to come out here and tell us how many gallons we have to pump. I believe it should be controlled by local people."

98. *Tom Greenfield, farmer and Manager Santa Cruz Ranches, Inc., Marana:*

Our static water level at present is 165 feet. We draw down during pumping season to around 195 feet. The capacity of the wells is from 2800 to 3000 g.p.m. Four wells take care of around 940 acres of cotton and alfalfa. I am not in favor of any controls at the present time. We use natural gas entirely, which is ¾ cheaper than electricity for pumping. Therefore, I maintain that we can go down to 400 feet and operate as cheap as the boys at 200 feet with electricity.

"I don't believe it would be in my lifetime that we'd eventually reach the point of uneconomic pumping with gas. I'm speaking of no controls in this local area. I think where it's already been determined critical, they should have controls."

Each well should be measured for a year to determine how much it is producing before any control is put on and from there determine how much you're going to cut-back, and let that be enforced by a state man. "I have no use for the 1948 code. It has no teeth."

I think we're pumping from an underground stream and most of our water is coming from the Avra Valley. Indian land and state lands should not be leased for agricultural development.

99. *A. A. McDaniel, well driller and Vice President of Avra Farms, Co., Tucson:*

We have two wells in the north end of Avra Valley. They were drilled last year. "I feel that controls in this area are necessary." New land should not be brought under cultivation. Controls should be administered locally. Studies should be continued by the local people and financed by them if possible. If not, then the local group should appeal to state and federal agencies for relief. I don't think the 1948 code has been effective.

"I would propose to organize each basin on a local basis, and have them govern their area, with such advice and information as they might require from state authorities. They should be given full authority under state law to enforce all regulations propounded by them. New development should be stopped. I think maybe a 15 to 20% preference should be given to the early developers if cut-backs were put into effect. Industry should be on an equal footing with agriculture. Municipalities should be given preference in the right to water, but they should buy the rights when they take it away from another user.

State enabling legislation should put limitations on controls that might be used by local groups, for, after all, the public of Arizona should have an equal voice in determining how this thing is going to be controlled.

100. *Dale Gladden, farmer, Marana:*

"I'll give you my honest opinion— I don't think we should have any controls. Let economics and man's ability to pump govern the amount of water pumped." A certain amount of land will go out and then the water table will come back up. If a city owned the land and pumped the water out and dried me up, I wouldn't say I wanted any compensation. "Maybe those critical areas need some control, but if I were living there I'd just sell and get out." I don't think it would be possible to get a control through that would satisfy everybody. I don't think industry has any more rights than a farmer.

101. *Pat D. Tucker, farmer, Marana:*

I have a section of land with two wells drilled in 1951 in the Avra Valley. I've always been of the

opinion that if a man owned the land, he owns everything down as far as he went, but for the economy of the state, I presume we'll have to have some sort of control. I don't believe it is necessary in our particular area at the present time.

"I couldn't honestly say whether it would be better to have controls in effect before you needed them when an area becomes critical." If control legislation is passed, I would favor local administration with some guidance from an over-all state group. Agricultural, industrial and municipal use should be on the same level in the right to water. There would have to be just compensation when one user took the water from another user. If controls were established, new and old wells should be controlled alike. I believe that if state land is going to be developed, it should be owned by individuals.

102. B. G. Wong, farmer, Marana:

I am farming 1400 acres of cotton in the Avra Valley with 4 wells. "I personally don't think there should be any controls in this valley; however, for mutual benefit, I would favor stopping drilling now."

We have probably lined 90% of our ditches. I would favor limiting the number of wells to the present number but allowing those wells to pump whatever they want. Replacement wells should be allowed. All existing wells should be registered and I would look to the State to see that no more new wells were drilled; however, I think their power should be limited. "If the Government has too much say about everything, we lose our freedom of speech and enterprise and tend to lean toward a Socialist form of Government." With natural gas we could pump from 500 feet and still make money at the present price of cotton.

COOLIDGE HEARING
WOMAN'S CLUB, SEPTEMBER 24, 1952

103. John D. Goree, farmer, Coolidge:

When I started pumping in 1937 in the Eloy area, my costs were $6.50 to $7.00 per acre. In 1951, they were $13.50 an acre. The power rates are about the same, so I assume the difference is due to the extra 100 feet of lift. There would be a direct effect on the economy of the area if some of the water was cut back. "If you cut out 10,000 acres, you cut out 15,000 bales of cotton—that much work, that much money spent in town."

I would oppose any legislation to determine cutbacks, but if it was done I would rather see it determined at the local level. Assuming some legislation is enacted, I would prefer some sort of Commission to administer it, representing the whole state. I'd say the '48 code hasn't been very effective. "Looks like they are still drilling a lot of wells. To stop further development in this area would probably be the most practical thing to do, although I'm opposed to it in principle." In case of cut-backs, a district with both gravity and pump water should have its pump water cut the same amount or in the same proportion as the district using entirely pump water.

104. Dr. B. Steward, Coolidge:

Has a ranch with his brother with 3 wells that were drilled in 1938, 1939 and 1950. All of the wells are now 1000 feet deep. Water level in old wells has gone down 60 feet in 10 years. "I'm very much opposed to this appropriation of water. I think it interferes with our American rights. My answer to it is restriction of planting acreage. I've observed that when our acreage is restricted, that farmers farmed their acreage a lot harder, more efficiently and their production was better." There should be some attempt to adjust withdrawals and recharge, but not by appropriation of water. "I'd favor a uniform cutback applied to all users." Practically, all further development should be stopped, but in principle, no. I would prefer to have any cut-back determined by local option.

Water is about one-eighth our cost of production. I definitely do not believe state leased agricultural lands bear their fair share of the tax load. Private ownership of state agricultural lands should be encouraged. A cut in the use of ground water would materially affect the economy of the community. There should be some distinction between a public utility and other private corporation in regard to use of water in excess of what would normally be required for irrigation.

105. Lyle F. Warnock, Project Engineer, San Carlos Irrigation Project, Coolidge:

Resident of area since 1936. He presented a written statement giving some factual data concerning the project and concluded with: "Being an employee of the U. S. Department of Interior, Bureau of Indian Affairs, it is believed that I am disqualified to discuss the questions listed." Furthermore, I am not at liberty or authorized to speak for the department or the Bureau on matters pertaining to policy.

106. John Payne, farmer, Florence:

"I really do in some way think the water should be cut back or curtailed. I would say on an acreage basis." Control should be local. I think that a man that owns a piece of property has just as much right

to drill on it as the man that drilled five years ago. Since 1947 our static water level has dropped 38 feet in the Magma area. I don't think Eloy, Coolidge or Casa Grande affect our wells. "Don't misunderstand me; I didn't say I didn't want any controls, but I don't believe in taking it away from one man and giving it to another. I'd say all share alike."

No more state leased lands should be developed. Control should be on acre foot basis. I wouldn't shut the pumps down so many days a week. "I think the 1948 code is responsible for more new wells than anything that's happened." As an example, when they started talking of declaring the Queen Creek area critical, the Magma area had 8 sections in cultivation. Now we have 20 more sections in cultivation. "Those wells wouldn't be there today if it hadn't been for that." Industry should be on the same basis as the farmers. "I see no reason why we couldn't get a sufficient cut-back to keep the water level from dropping and still have enough water for enough of our farmland that it wouldn't hurt too bad. Water for half of any man's farm is worth more than a farm without water for any of it."

107. D. R. Brittain, farmer, Florence:

"I think that the fellows with good wells and ample water should be limited to the amount of acreage planted along with everyone else." I would want local administration. I think the law declaring the valley critical has done a lot more harm than good, although I voted to declare it critical. I'm not in favor of any more state land being developed in critical areas; however, if a man owns the land he should own the water under it.

108. C. H. Reed, Attorney, Coolidge:

I think the district lands of the San Carlos Project would be affected by an underground water code if the law was made applicable to them. As to the Indian lands, I couldn't answer, because the courts have never ruled upon it. There's just more land available than there is water to properly irrigate and farm. I think we're way too late already on controls in this particular area, and in all the highly developed agricultural areas in the state. I see no point in sitting around waiting for other areas which are not now fully developed to over-develop and face the same problem. It seems to me to be practical you would have to restrict the water and the amount of acreage to which water could be applied.

"I grant you that from the standpoint of justice the individual who hasn't developed his land has just as much right to as the other, but after all, you already have too much land in cultivation. You're going to have to draw the line somewhere. What good is it to reduce the acreage already in cultivation and at the same time bring in other lands so that you will have to reduce that in cultivation more. It would seem to me that the fairest place for it to fall is with those who have not yet brought their land into cultivation, rather than those who have made the investment and pioneered the area. It's the choice of two evils. This thing of saying that the water underneath my land belongs to me, might be all right if you only got the water under your land, but that isn't what happens."

Each area has to be treated different in the sense that its water conditions are different. I think that your strictly basic principle should be statewide. You shouldn't have one set of laws which apply to one district and another set applying to another group. I don't like the term local option. I see a lot of difficulties in it. How are you going to do it? Is it going to be on the basis of a vote? Is it going to be on an acreage basis, or each farmer have the same voice in it?

There should be a competent engineer to determine the boundaries of the districts, the recharge and decide how much water can safely be drawn from each ground-water district. I think the areas should be determined by including all the land in which the water is related. I don't think political subdivisions or lines on the map would have anything to do with where water flows or where it comes from. Anything that is done will have to be by state legislation because you just aren't going to get folks together voluntarily. It should be more or less an automatic thing. After you have determined the amount of water available; that should determine the amount of acreage to be in cultivation. "The enforcement problem is something that I just don't see the answer to."

109. Melvin Gammage, farmer, Coolidge:

Resident of state for 29 years. Since 1938 the static water level in my wells has gone down about 110′. Areas with a shallow water table should not be included within the general restrictions. It takes about 2½ times as much power now to pump water as it did in 1938. If the water supply should decrease 50%, I think most of us out there could continue to make a living. I know two agencies extending credit in this area have been measuring the output of wells during July and August in order to determine to some extent their policy for making loans in 1953. As to control measures, I think I could endorse everything that Charlie Reed said. I do not believe it possible to get orderly and equitable control on a local option basis. I think I would prefer state administrative determination, removed as much as possible from

politics. I think a Commission of not too many men whose integrity should be unquestionable, who have no political axes to grind, and whose terms of office did not coincide with any probable term of office of the Governor, might be the best solution, with, of course, the best technical assistant that could be secured.

Replacement wells should be allowed in critical areas. "I think the 1948 code was not passed as a control measure, but was a kind of stop for the national congress and senate, in order to possibly facilitate the enactment of the Central Arizona Project." Control measures should be put in effect certainly not later than the decline in water level is noticeable generally over the area. In this particular section through here, I would say that time was probably about ten years ago. "I know there are some lending agencies who would regard their loans more secure on a per acre basis than they will without control measures." I think restrictions will have to be on the water rather than on the acreage. I think it will be easier to work out an equitable law than to enforce it. "I think this is the most critical problem the people of Arizona have ever faced."

As to preference in water, I'll say that I don't accept the Kent Decree 100%. I do feel, however, that the individual who pioneered a given area should have some consideration over and beyond the individual who went into that area knowing the situation had already become critical.

110. Bradley Sizer, automobile dealer, Coolidge:

Business was materially retarded as a result of the Supreme Court's Decision, until they revoked the original ruling. (Bristor vs. Cheatham case). The water problem thirty years ago was as acute as it is today in some respects. The water table is dropping, but apparently there is still ample water to produce a pretty good crop at a pretty good price and has resulted in prosperity. Personally, I feel that allowing nature to take its course is preferable to having legal controls. Someday these prices will decline and there will be a self-imposed restriction on acreage and it will automatically relieve the underground pumping of water.

"It seems to me that this commission after making a study might find it advisable to recommend that there be a permanent water commission not to function necessarily on the control of underground or percolating water, but to carry on some research and probably do some experiments on deep drilling. Also do research and education on making the water that is available more productive and gather other factual data." I would visualize such a commission as purely advisory, without any authority so far as controls and restrictions are concerned. "The time may come when there will have to be some kind of controls but it is probably some time in the distance."

111. J. H. Zellweger, farmer, Florence:

The water level in my well was 136 feet in 1941; 144 feet in 1944, 172 feet in 1951, and 193 feet this year.

"I think we are a little late in putting in any controls. I'm restricted from wells and so forth, but within a mile or two of my well, they're putting in more wells and they're pumping a lot more water than I ever pumped out of mine. They've just been put in this year and on new ground. It's just out of the critical area."

"If state water laws were necessary, I don't know of any better group than I'm talking to right now to administer them."

In the event that it becomes necessary for a city to acquire more water, who should be compensated for the water taken . . . the farmer? If you are talking about Tucson, why that water comes clear over into this valley.

112. Cecil W. England, farmer, Coolidge:

"I'd rather not have any kind of code. I'd rather be left alone." I think basins should be defined before anything is done. Agriculture should have as much consideration as industry. I don't think industry should be allowed to use any more water per acre than a farm.

I'm not in favor of developing any new land. I think the 1948 code would have been all right if it had any teeth in it. Assuming that some legislation is necessary, I think a state commission should have over-all general control, but each district and each basin should control itself. If the majority of the people in there want to pump it till it goes dry, let them do it. I doubt if you could get farmers, even in a critical area, to agree to controls.

113. Jack Roberts, farmer, Coolidge:

I had some wells in 1938 with a static water level that averaged a little over 30 feet. I think today it is probably 160 to 170 feet. "I think definitely we'd be foolish not to get some kind of control." I'm against local control. I think it could be handled by a good State Water Commissioner with ample money for him to administer his duties. An acreage control would be easier to carry out than a water control, but I don't know whether it would be any better.

I think the right to domestic water has to be recognized.

"The 1948 code must have been better than the people who administered it, as it never was carried out."

114. George A. Dell, farmer, Coolidge:

My wells are located southwest of Coolidge in the poorest water district in Pinal County. We're all going down in there and going fast.

"The rest don't realize it, but we're under control right now and the rest are going to get it." Something sure has got to be done. When somebody shuts off a pump, I get a little more water. Every 160 acres has one or two wells on it.

I think a code could be administered by a commission like you gentlemen right here, made up from all districts. "We couldn't make up one from our own district because we could never get together."

I always believed that Eloy, Casa Grande, Maricopa, this district in here, Marana and the area southeast of Tucson were all in the same basin. There is no use of us doing anything in here unless we do something in Marana and Tucson, because I think that's where our water heads. I don't think our deep strata move very much, but our shallower strata are the ones that are holding up right now. There was a time when there was an underground flow here, but not any more. We used to get a rise in water around the 10th of June and it would hold until the 15th of July; then it would go back to what it was before. We're about 25 years late in starting this. Absolutely no new land should go in. State leased land should be privately owned and bear its fair share of the taxes.

115. W. R. Urton, farmer and merchant, Coolidge:

"I don't think any control measures are needed now. I think the horse was stolen fifteen years ago, and it's a little late to lock the barn." If it were not for fertilizer and cement ditches, there is a large part of our area right now would have already gone back to brush. If controls have to come, I think they should be administered by a Commission set up by the state and not on a local level. Water for domestic use should have preference. Water should be used for industrial or agricultural purposes according to where it will be most profitable to the community and the state. I think the '48 code has failed utterly to do any good, and I'm very confident that it has encouraged the drilling of a lot of wells that otherwise would not have been drilled. I don't think any further leases should be granted on state lands for agricultural purposes.

116. Clayton Hakes, Banker, Coolidge:

"I believe definitely it will affect the economy here if there is a cut-back in water." The bank is definitely concerned over the water situation. We require on gravity land at least 3½ acre feet per acre and on pump land 10 g.p.m. per acre. If he doesn't have that, we cut the acreage down in proportion. There are some disadvantages to any method of controlling a ground-water law, but a State Commission would probably be best.

117. C. B. Scheflit, land owner, Coolidge:

"I'm definitely in favor of some kind of means of conserving our water." It looks to me like control on an acreage basis is best. If four or five companies in an oil field can't be controlled, I don't know how you're going to control a hundred farmers in an area. If they can't control the amount of oil that's produced when it's pumped into a tank, I don't know how you're going to control it when it's pumped on the lands.

"I don't believe any engineer can tell you how much water you've got." A commission should be appointed to study increasing our rainfall. I don't believe any more acreage should be developed in this area.

118. A. G. Huffel, farmer, Coolidge:

I believe that the critical areas should be divided to take into consideration the kind of water and the character of the land the water comes from. My land has plenty of water but it is salty. The land south of us is short of water but what they do have is of good quality. These lands should be treated differently. "I want to see a code written that will equally distribute this water without hurting anybody, and it can be done." Prior rights might have been all right 25 or 30 years ago, but it won't work today. Replacement wells should be allowed. Everyone with land should have his share of water. In the event legislation were put into effect, I would want local men to run it. I'm opposed to spending any more money or creating any more departments. Water should not be transported to distant land; it should be used on the land on which the well is located.

119. Wyley Parsons, Pinal County Assessor, Florence:

"I believe that when the agitation was first initiated there were very few of the farmers in favor of any kind of controls. I believe that the proportion now has increased appreciably to where there's more tolerance of views of others and a definite recognition on the part of quite a percentage of them that per-

haps some regulatory code will have to be adopted."

The thing that I hear is that the most practical, if not hte most equitable method of control, would be an acreage control, supplemented by some restrictive measures on the use of water.

So long as your government is connected with the administration of any law, there will be a certain amount of politics in it. "There's nothing you can do about that, but see that you get the most competent and honest men you can to administer it. I believe you should have a curtailment of new acreage, if you can legally do it. I do not think state leased lands pay a fair share of the taxes."

120. *Raymond Sroaf, real estate, insurance and farm loans, Coolidge:*

"We find that farm land is much harder to sell with the water going down." Two questions our company asks twice a year are: "How much water is in the dam; and how are the pumps doing? On this information depends the amount or percentage of loans made on homes.

ELOY HEARING

LION'S CLUB BUILDING, SEPTEMBER 25, 1952

121. *Anthony Van Wagenen, Jr., Attorney, Phoenix:*

I have been an attorney for Electrical District No. 2 since 1923, and also Electrical District No. 5. I have three wells in the Eloy District. Our annual water requirements are from 3½ to 4 acre feet. By lining our ditches with concrete, eliminating water-loving plants, and saving waste water, I think we could save 25% of our water.

"I think we're all agreed that some of the water is coming from storage, but I don't believe most people of the state understand what that means." He roughly illustrated on the blackboard the general slope of the water table from Nogales down the Santa Cruz Valley through Tucson, Marana, Eloy, Casa Grande, and on down the Gila River to Yuma and the Gulf of California. There is storage in the underground, but it is moving slowly on. It's my opinion that if we don't pump it today, in a few days that water has moved on past our particular well and maybe somebody else gets it. It's a cinch you are not taking out all of the water, and a lot of it, I think, is going on down to the Gulf.

"Ten years ago we were successfully pumping with a 2.5 cent electric rate and now it is 6.5 mills or about one-fourth or one-fifth of what we were paying then. "In other words if we were pumping at 200 feet in those days, we should be able to pump at a thousand feet today on the same price of farm products. Our price of products has gone up and the price of water has gone down, in spite of anything that has been said about the falling water tables in the critical area of Eloy."

The cost of water was around $12.00 per acre-foot in 1942 as against $4.00 or $5.00 now. About one-fifth of production costs are for water. Personally I could continue to operate if my water supply dropped 50%. The development and increased income of the Eloy area is due practically 100% to the use of pump water, as is most of Pinal County. I think that all bank and loan companies look at the water supply when they make loans. I would favor private ownership of state leased agricultural lands. "I doubt that control measures will help in the Eloy area or the state of Arizona. The question is largely an engineering question and I doubt if there is enough engineering data available at the present time to say what the effect of control would be."

If you had a code and some kind of Commission appointed, it would probably be political, and if they were political, you'd probably find that they would go to the University for their information, and according to the last committee the information they got from the University would have put two out of three pumps in the Casa Grande area out of business. It would have put 13 out of 14 of the Eloy pumps out of business and in the Maricopa area, 36 out of 37 pumps would have had to go out of business, in order to maintain the balance of the water table. If a code is passed, I would say by all means that it should be left to local option. For State administration of a code, I would suggest a State Engineer, appointed by the Governor, but let the electrical districts or irrigation districts organize and police themselves. There should not be any statutory limit on the consumptive use of water.

I don't think they should be allowed to use wells drilled without valid permits; however, replacement wells should be allowed when wells go bad. The 1948 code encouraged a big development. Probably it forced at least three or four hundred percent more drilling during that year than would have been done otherwise. It has accomplished its purpose, however, and there would be drilling now if it weren't for the code. I think all users of water should be placed on an equal basis.

"I don't think if the cotton price was reduced by a third that it would have much effect. I think the acreage would be the same."

122. Henry Haley, farmer, Eloy:

Probably to a certain extent we are pumping from storage. New wells on new land should not be permitted, but replacement wells should be allowed. Any type of cut-back should be from the local level. To administer a state ground-water code, I would favor a non-political commission with authority to employ a competent engineer. I'm not in favor of a limitation on the amount of water that can be pumped; economics will do the regulating. The 1948 code is just beginning to operate, and I see nothing wrong with it except possibly a tightening up of its administration. I'm in favor of retaining it. I think state leased land should be purchased if at all possible.

123. Frank Hale, distributor of oil products, Eloy:

Mr. Van Wagenen and others here have expressed my opinions. I'm not in favor of seeing new wells drilled. "What we do in this locality has nothing to do with what they do in other localities." We can control ourselves. "I'm interested in bales and not acres." As fast as I can I put in concrete ditch to help conserve my water, and I'm using my tail water.

124. Glenn Shay, farmer, Eloy:

Native of Arizona. Our water cost is approximately 1/3 cheaper now than at any time in the past ten years. We could continue to operate with 50% less water, but I don't know how prosperous our economy would be. The way the water has held up in this area, I'd say that if we are as serious as they say we are, it is too late for a code, and if we're not that serious, then I don't think we need a code. If sufficient money was allotted to enforce the 1948 code, I think it would be all right. If a regulatory law is necessary, I think the determination should come at the local levels. Further studies should be made on the underground water system. I'd say a normal draw-down of the water table should be allowed, but studies should be made to limit the lowering so that the water would last for a number of years to come. I think there is a certain amount of land in this area not making much more than production costs. If cotton prices dropped a third, I would think a certain amount of this marginal land would go out of production.

I think the 1948 code should be enforced, if it is constitutional.

125. Richard Hunnicutt, farmer, Eloy:

I don't believe I'm pumping from storage, and I don't believe there is a need for a cut-back in this area. Any controls should be by local option. I think the 1948 code would be all right if enforced. Land owned by the state should be privately owned. I'd say the good land is 100% developed.

126. W. W. Chicky, pump machine dealer, Eloy:

Came from San Joaquin Valley two years ago. When I first went to the San Joaquin Valley, they were pumping roughly from 240 to 260 feet. Today they are drilling 2200 to 2300 foot wells and are pumping from around 500 to 600 feet and in some cases deeper. I think in this area that the word "critical" in respect to the water situation is strictly out of line. I would say the recession of the water is greater in the shallow wells than the deeper ones. That to me means that you can get more water by going deeper. To me shallow wells are from 350 to 600 feet deep in this area. There should be no further expansion in this area. I don't see why this county, with its type of soil, couldn't outlast the western part of the San Joaquin Valley. I'm not in favor of legislation to curtail the use of water. "I believe all this fear about a water code has already retarded the economic progress of Arizona several years by the publicity in National Magazines." So far as the 1948 code is concerned, I believe it could be workable.

127. Frank Shedd, Jr., farmer, Eloy:

Native of Arizona. My deepest well is 1585 feet. The water has not receded in this well while the water in the shallow wells has definitely receded. I don't think you can always get additional water by drilling deeper. I don't think the static water level in this area has much to do with the amount of water that is produced by a well. I'd say we have lost approximately 10 feet a year in our static water level, mainly in the last five or six years. There has been very little lowering of the static water level in the last five years in our deep wells.

I believe under the 1948 code the critical areas should have been throughout the basin rather than pin-pointing them in any particular area. I don't believe there has been enough tests made in this area to determine how much water is available. I'd prefer legislation that would leave present pumping status quo with provisions to make further studies of the water situation and decide what various basins should be required to do. Except for further studies, I believe control should be at the local level. I think that people pumping outside of this critical area are pumping from the same underground basin. I think this underground water is moving.

128. Tom Willmoth, farmer, Eloy:

We have a well we get fish out of. The University says you can't do that, but it happens. I be-

lieve our water is traveling and if you don't pump it out it will eventually go out to the ocean.

If the 1948 code was enforced, I don't believe I would be in favor of anything else. If controls are adopted, they will have to be on a volume of water basis or on an acreage basis with a limit of the acre-feet of water that can be pumped. My opinion is that you're going to have to have your authority come from the state level, but the state people should take the advice of the local people. I'd favor more study if you're going to do anything about the water. If it is as bad as they say it is, we should have been out of water years ago. At present prices, we could pump from 700 feet and stay in business.

I believe you should be able to transport water as long as it never gets off your land. "I think further conservation measures, with a possibility of some set up in this district to bond ourselves, would be a wonderful idea." More stress on saving tail water should be made.

129. Francis Curtis, farmer, Eloy:

I don't think we can continue our present rate of pumping and the water table not recede. I believe it will be necessary for the shallow wells to be deepened. I think the '48 code is all right. We are just now arriving at the time that we will feel the effect of the code. I believe there will be great benefits from the code if it is properly enforced. People who do not have too good soil and have not put their irrigation system on a basis to save as much water as possible may go out of business if prices drop very far. There should not be any legislation restricting use of water, at least until more is known about the underground situation.

130. John F. Nutt, farmer, Eloy:

If the cotton price dropped a third, I would imagine some of us would quit growing so much cotton. The labor and dusting is what costs, not water. Water is the cheapest thing I've got. I would favor putting teeth in the 1948 code to prevent new development.

131. John R. Keeling, real estate broker, Eloy:

I have 5 wells on 840 acres about half of which I farm. I think the pumping will regulate itself; I don't think we should have any restrictive legislation. I would favor further study of the underground water situation from the state level. I don't think any one of us knows where this water is coming from nor how much there is. I feel that the '48 code is ample legislation if enforced. Even talk of an underground water code has damaged the economy of this area. As a real estate broker I've had outside capitalists drop a deal on account of the scare over a water code. They are more afraid of a code than the water situation. Any cut-back type of legislation should provide for control at the local level.

132. William T. Elliott, farmer, Eloy:

I am in favor of the 1948 code. I believe I am drawing from recharge plus stored water. Believes controls should be at local level.

133. Norman Murphy, Manager Western Cotton Products, Eloy:

The water table is receding and about 25% of the wells have been deepened in the seven years I've been here. It looks to me like some restrictive legislation is needed as well as further study. We finance about 50,000 acres in the Eloy area. About 6,000,000 dollars is loaned out at this time in this area. When my company worries is when the legislature is in session and there is talk of a code cutting the water off. New developments should be absolutely stopped now, I think. Our water cost per acre this year is cheaper than it's been since I've been down here.

The '48 code is all right, but they sure did drill a lot of wells right after it went in, but I think it has leveled off now. There might be a few places we wouldn't finance if cotton dropped to support price. "There's one thing about economic controls, no one will raise as much hell about them as legislative controls."

134. W. W. Jarvis, farmer, Eloy:

"I'm not in favor of legislation to curtail withdrawal in this area. I would favor more studies on the ground water. I think the 1948 code was all right, but it needs more enforcement. New development should be stopped in this area. If the price of cotton dropped a third, I don't think there would be as many acres planted or as much water pumped."

135. Kenneth O. Clark, farmer, Eloy:

"I don't favor restrictive legislation, but believe more underground water studies should be made. I would consider that the entire geographic formation of the Santa Cruz River would be our basin and not just one portion of it declared a critical area. I think there is development going on around Marana and on up the valley there that definitely affects us. The '48 code caused the greatest immediate development that has gone on in the Eloy area since I have lived here in the past eight years.

136. Jim Stevenson, banker, Eloy:

Better than 90% of the community's economy is dependent upon agriculture. If pumping were cur-

tailed it would affect the economy of the area to the point "where farmers couldn't pay their loans and might have to quit."

(The tape recorder failed at this point, and testimony of the following individuals was regrettably lost to the record:

137. George H. Hodges, druggist, Eloy

138. George Wake, real estate broker, Eloy

139. Louis Elliott, farmer, Eloy

140. Alfred North, farmer, Eloy

141. R. J. Ellis, attorney, Eloy)

CASA GRANDE HEARING
WOMEN'S CLUB HOUSE—SEPTEMBER 26, 1952

142. John Beggs, farmer, Casa Grande:

In 1946 with the electric motor, pumping costs averaged around $17.00 per acre. At the present time the pumping costs are between $10.00 and $12.00 an acre. I feel this area is fully developed, if some of the figures they give us are true. At the present time we are possibly using 600,000 acre feet above our annual recharge. If it is true that the area is developed to that extent, it would be foolish to try to balance pumping to the annual recharge. It would ruin the economy of the area.

I think the 1948 code could be very effective if it had a few changes in it and sufficient money was appropriated to even begin to administer it. Before it is discarded it should at least be able to show what it could do.

A 50% cut in the use of pump water would very seriously affect the economy of Pinal County. Pump land in Pinal County is 99.9 percent responsible for any economic development that we've had and a 50% cut in pump land will cut the economy of the country 50%. I don't believe the remaining 50% could carry the tax burden if the change was as abrupt as any law would make it. There may come a day when we'll be operating 50% of what we now have, but it's my belief that that change will be gradual. I would prefer to see any law effecting a cut-back placed on a local basis with local people administering it. There may be some areas in the state where it would be practical to limit pumping to recharge, but in this area you'd ruin the economy.

I would say the Casa Grande pumping area would comprise probably three districts. We have three different sets of water conditions. One set just east of town, and a little way west of town which is entirely different from what we have a little further west. Then a little further west, we run into an entirely new set of conditions. That would be something that would have to be determined by a minute and detailed study.

I would think an attempt should be made to place state leased land under private ownership as rapidly as possible. Not necessarily because of taxes, but simply to place them on an equal basis. The '48 code could be improved to prevent the great rush of drilling that takes place during and immediately after any area is declared critical. In the Eloy area there wasn't must objection to declaring the area critical; however when hearings were held to declare the Marana area critical there was considerable objection and to my knowledge it still hasn't been declared a critical area. As I understand it, those areas are both pumping from the same supply of water.

What is going to happen on these Indian leased lands? Are you going to stop the white man from going in and developing his property and then turn around to the Indians across the line and allow them to drill five or six wells on each section?

Our water table goes down during the pumping season and comes back up during the winter, but not to the level of the previous season; however, it doesn't go down too far in any one year.

Cities, industry and agriculture should all have an equal right to the use of ground water. I think it would be a wise move to establish what we might call a state water resources commission or something of that kind which would be empowered to study the underground water as well as all water resources and attempt to arrive at a solution.

143. Parke Gilbert, farmer, Casa Grande:

There is not a great deal of difference in water costs now as against five years ago. The deeper lift is offset by cheaper power and more efficient equipment.

Not in favor of cutting amount of water by restrictive action. Would prefer to let economics take care of it.

"I helped draw the 1948 code, and the attitude of the administrators of that bill is a pretty good example of what you can expect of future legislation. I don't believe there has been any effort whatsoever to fulfill the obligations of the land commissioner under that legislation. Had he made an honest effort, there would have been a lawsuit long ago, carried to the Supreme Court, so that we would know whether it was any good or whether it wasn't."

Believes development should be stopped. "The present State Land Commissioner has pretty definitely proved that he is not capable of administering the 1948 code." Perhaps administration should be by a state water resources board or commission.

How do you know if a law is constitutional unless you make a case? It does not take money to deny a permit.

Does not believe anybody knows boundaries of basins, the source of the water or the definite areas. Believes there are some areas that definitely need conservation; this work should be done by the areas themselves. Would favor a further study of the underground water situation on a state level.

Would not oppose enabling legislation that would allow local control imposed by themselves.

Believes we cannot go forward until we have a lawsuit to determine the constitutionality of the 1948 code.

144. Jim Grady, merchant, Casa Grande:

Business depends upon farming from 90 to 95%. When all the publicity was given the possibility of a water code last winter, I had orders cancelled to a total of fifty to 60 thousand dollars. Finally wound up the year with a 33% decrease over the previous year.

"What would make you believe that a new code would work when the old one has never been enforced?"

Believes we should continue to make studies. Does not believe water should be drastically cut in any one year, as too many businesses depend on long range planning, and would simply go broke.

"I have never heard a farmer say he was scared he was going to run out of water. The only thing he's concerned about is what the state's going to do to him." (Applause.)

"If you could prove where this water was going, it would be a different proposition, but they can't tell you where that water is coming from or how much there is of it. They guess, but they don't know."

Would be in favor of conservation measures.

145. Melton Smith, farmer, Stanfield:

Believes the geological survey makes mistakes in taking their measurements. Says water table has dropped about 45 feet in seven years. We do not need curtailing. It will be a good many years before we know what the situation is in that area as there is too much new development to tell for a while. "Area has increased by 25 to 30 thousand acres in last year alone." This year he irrigated about 600 acres with tail water. Would not favor any restrictive legislation. Believes in state study. Believes '48 code is sufficient for now. "Don't drill any more wells for five years and see what happens." Do not put in any new land for a few years.

If cotton price drops, you could continue just as well as now, because other factors would go down also, and water amounts to only about 1/10 total cost.

The state might help a little on conservation. Should be a local problem, but should have state supervision. It might be well to put in compulsory conservation measures, but take it easy.

Believes we must have replacement wells, and should be able to deepen an existing well. State leased lands should be put up for sale. A man should be able to own his own land. If there is to be a cut, it should affect everybody the same. Municipalities can pay more for water than farmers. Believes local areas should have a voice in any restrictions put upon them. Believes flood waters should be captured if possible. Does not see why Indians have any right over anybody else.

146. Lowell Berry, farmer, Casa Grande:

Static water level has dropped from around 160 to 190 feet. "We are living and moving a little faster than we are going to be able to continue to do. Maybe it's the time to slow up a little bit." We don't have unlimited water resources, and perhaps we should stop some of the drilling and developing.

"I feel that something needs to be done. I think the first thing we ought to do would be to study and take active steps toward conservation of flood waters."

Suggests state conservancy districts, state financed.

"I would feel happy if somebody would say that you could pump half as much water as you formerly did and everybody else do the same; I would be just as well off, but I don't see how that could be policed."

Any cutback should be gradual. Should be an administrative determination with some local representation.

"I think that in addition to whatever effort is made to try and conserve our water, we would be glad to pay our share of taxes to try to get some Colorado River water. We want to stay here."

147. Harlan Russel, farmer, Casa Grande:

About 12% of production cost is for water. Cement ditches save approximately 25% of the water, besides the saving of labor. Any administration should be on the state level, with perhaps each water basin electing its own representative.

Would suggest encouragement be made for conservancy measures. Flood waters should be controlled by dams and perhaps deep wells. Should curtail Indians as well as the whites. Maybe you could compromise and get the Indian Service not to let leases. The best place to control flood water would be on the Indian lands, and we have no jurisdiction over there. You should encourage a deepening of wells. Diversify the farming and use more water in the winter time.

Would prefer a lending agency for conservancy projects rather than bonding to make one farmer pay for the ditch work done on the neighbor's farm.

Favors further study. Should be done by selective representatives similar to board or commission like we have now.

Neighboring wells all lower together, but does not know whether Marana and Eloy affect him or not. Believes it might be a separate basin. Would not favor further development at present.

Any regulation would have to be determined by a commission comprised of local representatives to permit uniformity of control.

148. Bruno Collerette, farmer, Stanfield Area:

The 1948 code is not working. Seems to be inadequate. It might be beneficial to stop any further development and have a cooling off period, but that steps on a lot of people's toes and violates the principles on which this country is built.

The large amount of speculative well drilling might be stopped, but that violates the rules of free enterprise.

More specific and definite scientific information is needed before controls.

Believes in leveling and contouring land to make full use of water. Do not make any waste water. Erosion is doing more damage than anything else.

Could lift another 75 or 100 feet without hurting. Would go to natural gas and not increase over-all costs.

It would be helpful to the state if it was made possible that the lessee own state land. The man who has been operating it and has invested his money in improving it should be given an option to buy it at an appraised price without having to bid against outsiders.

No limitation should be placed on amount of water an individual should pump.

Even a large team of the best engineers and geologists could not step in here today and make an accurate study unless there was stabilizing of the water withdrawals over a long period of time. I don't think there is anyone who has enough knowledge to say that this basin is thus and so, and the water comes from a definite place.

"It's too controversial; there's too much variation in wells in the same area."

If controls do come, I would like to see it administered by disinterested engineers and geologists, guided by a committee of farmers who have some understanding of the problems.

149. Earl Lane, Stanfield Area, farmer:

Has four wells in all; drilled between 1941 and 1950. Water level has dropped about 70 feet since 1941. The present pumping lift is about 250 feet. Water costs are considerably less, percentage-wise, than they were in 1941.

The 1948 code is all right. If it were enforced, it would help some. Not in favor of any curtailment. Should be administered by a commission type of state organization with district representation. Further study is necessary. Stop new land from coming in in critical areas, and "leave us alone."

Lessees should be given a chance to buy their state land. If the white man is curtailed, the Indians should be too. If the Indians had to make their own development and farm it themselves, it would be all right.

Would not be in favor of compulsory conservation practices. Some are applicable in some places and some in others. Tail water is not wasted or lost except by the man at the head, and perhaps by the man at the bottom of the development.

150. R. C. Smith, Box 581, Casa Grande, farmer, Stanfield Area:

I have put 40 feet of extension on all pumps; bowls are set at about 320 feet. Water costs run a little less than $15.00 an acre foot. Knows nothing about how the area was declared critical. Not in favor of restriction to cut pumping. It should be left to the people who use it. Would not favor additional study at state expense. Would not deny the right to develop to the young or the new.

If eventually we find that our water is running out, then we should make a study and do something. The farmers should decide it by vote.

151. *Virgil "Dusty" Owens, Operates a Machine Shop and Sells Deep Well Irrigation Pumps, Casa Grande:*

Has observed a gradual decline each year in static level. There has been a 70 to 80 foot drop since 1931. Believes that the politicians are the most frightened. "The farmers are very uneasy about what the politicians might do to them."

"Water is peculiar stuff. It varies widely in production from one well to another in the same area. Sometimes up on the hill you get a shallower lift than down below."

Feels that the 1948 code does not mean much, as it has never been enforced. "There are 1,300 or so drilling permits out now. I understand anyone can get a permit to drill a well."

"The economy of the state has to have taxes, and if you chop this thing off, where is the tax money coming from?" More efficient and cheaper power have made a deeper lift possible. Would not favor cut-backs. The law of averages will control. Marginal land will go out.

"I don't believe anybody has the answer to an underground water situation; where it comes from or where it goes. We have geologists and engineers and then we have doodle bugs. A doodle bug is a little gadget (I dont know what's in it; if I did I'd have one); they hold the doodle bug and walk over your land. They tell you where there is an underground stream, which way the water flows, whether it is coming in like the spokes of a wagon wheel, etc., and where is the place to drill." These fellows have gone out here to some land on which there was supposed to be no water, have advised the place at which the well should be drilled, and there have been some remarkable wells so produced.

"There are only a few wells that have been deepened that have not improved considerably. Some have improved as much as 50% within 300 feet."

152. *Bill Rugg, Farmer and Dehydrator Plant Operator, Casa Grande:*

States that it was 66 feet to water in 1941; 217 feet to water now.

Has 6 wells, three of which were witched and three were not. I got more water from a shallower lift from one witched well than from the three others combined.

"The '48 code wasn't any good. It didn't do anything. Anybody who had the right connections or wanted to lie a little bit, could drill a well." The thing has gone too far now to try to divide the water that is left. I don't think you can have a water code unless it is basin-wide or watershed-wide. There isn't enough coming in but what it is dropping 30 or 40 feet a year, so what difference does it make where it is coming from? "I really think they should not let anybody else drill any wells on anybody's land."

The state gets eight or ten dollars an acre for the best of their land on lease. They might just as well sell it and get something out of it.

"If you limit irrigation pumping, you just prolong the agony. If a fellow is going to go broke, he might just as well go broke all at once.

"You're pumping so much over the amount that is recharging that I don't believe it is going to make a whole lot of difference to try to divide it up at this stage of the game."

153. *Earl Thode, rancher and farmer, Casa Grande:*

Bowls have been changed from 140 to 250 feet. Water costs are about 15% of total costs. Thinks the 1948 code is not much of a code—anybody can get a permit. Localities should form their own districts and get together on controls. Would not be in favor of cutting back the amount of water that could be pumped. Better cut back acreage. Believes it will regulate itself as we go along.

Administration should be by a local group. Believes water situation is serious, but should not be given so much publicity. Does not believe legislation would work, but says "If you could regulate all, I'd be in favor of it."

Wells come back pretty well in the winter time. Rotation of crops would help. "If we can deepen our wells and get more water, we might be able to hold out a long time."

154. *M. H. Montgomery, Farms in Stanfield Area, Home in Casa Grande:*

I have put 20 feet of extension on pumps since 1946. Does not think much of the '48 code, and does not think we need it. Might not oppose cutbacks if not too drastic. There should be no new land put in. Stop drilling on state land. It should never have been put in in the first place, but people who have had land a long time should be allowed to develop it. Believes pump-backs would save some water. Says he has one old well 370 ft. deep that is pumping more water this year than it has ever pumped before.

Administration should be by local representation.

155. *W. S. Cleveland, Box 722, Casa Grande, farmer:*

My static water level is 30 feet; I pump a thou-

sand gallons per minute with a 65 foot lift. Don't know why I'm in a critical area.

"If a man has land for 30 or 40 years, he should be allowed to develop it." Believes '48 code is unconstitutional. "It takes away property without due compensation." Believes legislature should leave them alone. "As long as a man keeps his water on his land, he should not be regulated."

"The state has put more land under cultivation in the past 10 years than anybody else. A man on leased land is credited with his improvements and must be compensated for them before anybody else can bid it out from under him."

156. *Ted Marsh, Casa Grande, Farmer South of Stanfield:*

Opposed to any code. Does not believe the legislature can do anything that will improve the situation now.

Believes top strata of water is gone, but believes there is water deeper down.

157. *E. R. Guthrie, East of Casa Grande:*

Believes the water comes a long way from the north. "Our static water level is 65 feet and we have soft water, but very near me they have very hard water—good irrigation water but a different quality."

I believe there is plenty of water under my land. If there are going to be controls, there should be a three-man board in the area. They should be elected, should be certified and made an officer of the state, with the same powers as the legislature. You could present your local problem, and such a board would understand. The local and state should be combined.

The 1948 code did not apply to anything in particular and was inoperative.

"If the prices drop and costs go up, the farmers will drop out one by one." Not in favor of new development. "You cannot eat your cake and have it—if you cut off the water, you ruin the business."

PHOENIX HEARING
ADAMS HOTEL, SEPTEMBER 29, 1952

158. *Jules L. Vermeersch, Machinery Driller, Farmer and Mechanical Engineer:*

Some years ago, I had a driller drill a 24-inch well 280 feet deep on my farming property west of the Agua Fria. We did not get water and decided to abandon the well. About three weeks later, the water came in and the static level stood at 22 feet; the water stands at 16 feet today, and we are pumping 3,000 g.p.m. from that well. Pumping should not be curtailed in this area, but we are classed in a "critical area." If a hearing was held by the State Land Commissioner on declaration of the critical area, I had no notice.

Many times when first stratum does not produce good water and you go farther, you find an entirely different chemical analysis from first water. In the next stratum the same is true. Waters under the ground do not co-mingle. I don't believe anyone can tell you how much water is under the ground. Throughout the world the water level is receding, and I believe pumping has little to do with it.

He stated he wants what's best for all, but doesn't know about a code. If a law is passed, it should be administered by districts. There are about 24 areas in the state where conditions are different. Three men to a district possible, but frankly does not believe in any regulation whatsoever. Believes it will adjust itself.

Believes '48 code should be changed—re-written. Is in favor of conservation of water and further study. We should not limit acre feet or stop new development.

159. *Thayer Collier, Lower Agua Fria Farmer, Avondale:*

I am in the same area as Vermeersch and have found about the same conditions. Would favor further study on conservation of water. Would prefer administration on local level.

160. *J. T. Hartman, 3616 East McDowell Rd., Phoenix:*

Has a tax bill for $83.00 for a piece of property midway between Maricopa and Casa Grande. I have paid over $3.000.00 in taxes on that property. Have no well and I am not permitted to drill a well.

"Could this committee incorporate in its recommendations that cases like mine can have one well to raise a small crop on property of that kind?" Within the past year and a half others have come in from California and have sunk wells all around my property. Was not notified of the hearing when the area was declared critical.

161. *Chas. Brandon, Queen Creek:*

I have one well drilled in 1917, one in '36 or '38, and one in '40 all approximately 600 feet deep. They produce now about 1,400 g.p.m., with a 312 foot lift, as against a 115 ft. lift in the beginning.

I can't farm more than half of my land next year without spending around $15,000.00 on a well. We have to change to 250 horse power motor, and change all equipment. In answering a question as to whether he believed neighbors' wells affected his, he said "Well, we have more neighbors, and we have got less water, so they must be affecting it."

The 1948 code is a start in the right direction. It could be amended. Something like that is going to have to be done, because the water is going to run out one of these days. I don't think there should be any more new lands.

The fellow that is able to drill the biggest and the deepest will get the most, and the question is, "will we pump economically and let everybody live, or will we have a race?" "We must have regulatory measures, or else you will have one or two men, vote the bonds and build the schools, and the last acre that pumps water will have to pay the bonds."

Somebody is going to go out of business. Cutbacks should start at the local level. A state water commission should appoint competent engineers to check the amount pumped from each well. The static level is highest in February and lowest about the first of September. If you could keep a check on each well, you will know how fast water is coming in and how fast it is being taken out. You could cut back to where all of us could keep pumping. It should strictly be prohibited to take out more than is coming in. You should have a staff of engineers to work in different districts. Pass the information on to a local board.

Water seeks its own level, but lower pumping affects the upper areas, and upper affects the lower. You cannot define a basin. You must have an accurate check on the raise in the wells from September to February, and the loss from February to September. Should permit replacement wells. Believes the commission should determine whether illegal well should be pumped. State leased lands do not pay their proportionate share of the tax load; should be transferred to private ownership so that it might be put on tax rolls.

"When prices drop is when we'll quit pumping." I've been in that area nearly 30 years, and we're all going down together."

162. Arthur Pierce, Queen Creek, Farmer, Magma District:

Came to Arizona a little more than 2 years ago. Bought desert land to develop. Was unable to complete development because of the declaration of the critical area, but did get in three wells. I'm 14 miles south and east from Queen Creek, near the Magma Station.

Water costs about $20.00 an acrea.

We are in Pinal County, but are in the critical area of the Queen Creek district. Wells in our section do not show the drop that has been shown in other parts of this area.

"To satisfy everybody, it looks like some kind of regulatory measure will be necessary. I am an advocate of 'the government that governs least governs best'."

Anyone who says that they know anything about waters underground, I don't believe there is a man can tell for sure. The more we learn the more we find the less we know."

Wells illegally drilled should not be allowed to use the water, and owners should be prosecuted.

Believes that if cut-back is found to be necessary, it should be done on a local level. There were many who protested the area's being made critical, but the State Land Commissioner took what the engineers said. If an area can be determined, control measures should be restricted within that area. Any time you try to regulate a man's land, you are going to have difficulty. A local board would be most reasonable, and would came the closest to getting the job done.

An engineer should be maintained for consulting purposes.

Conservation is the big thing. I use at least one-third more water than I would need if the land were in good shape. I am not for subsidy. It should be set up as a loan to be paid back by the farmers, into a state or federal fund providing low interest and long-term payments.

Believes domestic water should have priority, but thinks industry should be regulated just as the agriculturists.

"I don't think any kind of law should be made that would be retroactive. I am a newcomer. I bought in good faith, and I don't believe any measure should penalize the newcomers. If there is a law, it should be on an equitable basis for all users."

163. Ted Decker, land owner, Phoenix-Stanfield:

In 1939 got four acres of cotton per horse power; today 1½ acres per horse power. The drop in the water table has been from a static level of 90 feet in 1939 to 250 feet today.

Last year and this year, we deepened five wells. In each well, we got about 50% more water. The

drop in the water table is over the entire area. "We're all going down together."

Should have had some regulation of underground water years ago. Should stop drilling any new wells; stop any new lands from going into cultivation. Should make accurate engineering surveys on all wells that are deepened and find out what's down there.

Believes in the principle of prior rights. Cutbacks should vary with local conditions. Legislation, if any, should be administered by a state engineer upon advice from a local board.

We should have the same rights as the Indians have.

Wells drilled without valid permits should not be allowed to pump—unless there is an Indian well across the fence.

Would favor a continuing study. Believes cement ditches save a lot of water.

Municipalities will have to deepen, just as the farmer, and they can better afford it.

164. Gertrude Evelyn, 2222 E. Fillmore, Phoenix:

Has 320 acre homestead in Pinal County. Has tried to find someone who was reliable to develop the land for its use, but has been unable to do so. Took out a permit and renewed it from year to year, until last year when Mr. Lane cancelled the permit. "That land is my scoial security and now it is worthless, after paying taxes on it for so many years." When they stop me from drilling, it is just like taking something away that rightfully belongs to me. Could have sold it for a song many times, but never for a fair price. Just wanted to give the Commission an idea of a situation which demonstrates the unfairness of preventing development. "My water right can be taken away under a retroactive law." Permit cancelled June 14, 1951.

165. J. M. Combs, farmer, 900 E. "C" Ave. Glendale:

"I accept regulation but exclusion never."

"I have desert land on two sides of me (Deer Valley) and I could conscientiously say to my neighbor that I hope he gets a good well if he drills. I have been here too long to want to exclude anybody."

Every land owner in the basin is a potential water user. If we have any regulation, it should be applied equitably to every land owner, any everyone should be entitled to participate in his proportion of that basin.

"I don't believe in prohibiting any man from putting down a well to provide himself a living. I don't believe in prior appropriation."

I accept regulation. I supported the '48 code at the time it was passed. I attempted to get a substitute bill that would treat the underground just as the stored waters. If the experts say that this basin can safely deliver a certain amount, that should be distributed equitably to all the land. You'll always find some that you will have to force.

If regulation were left to a local board, one area would increase pumpage, and that would affect another area. Probably should be from a state level on enforcement.

Believes he could lift water quite a bit farther at present prices. If prices go down, you won't have to tell me to stop pumping.

"I believe in legislation to compel me to put in cement ditches, providing you furnish the fund that I can draw from and give me a long enough time to pay for it." I know that wells are pumping more water than is necessary for economical application of the water.

"I am in favor of limiting the number of acre feet that can be pumped within a basin, if it is applied to all equitably."

Does not feel that you can set up a basin in Deer Valley when one basin directly affects another basin.

Definitely believes in continuing study.

166. Lawrence Mehren, farmer, 309 E. Mariposa, Phoenix:

Ranch property on Litchfield Road, 3 miles north of Luke Field.

"My interest is probably purely selfish, but I want to continue to live here and want to continue to stay in farming at the same place. With the receding water table, I do not feel that I will be able to stay in business too long at the same place."

Acreage divided between citrus and field crops, cotton at present. Citrus farmers must take a long range view, because of the lag between planting time and the time that you begin to realize a profit on your investment.

Static water level has dropped from 93 feet to 229 feet in twenty years, in increasing amounts in the later years. Wells have each dropped 12 feet in the past year. This is believed to be caused by the tremendous development of the whole adjoining area.

Believes that some water must escape from the basin to carry off salts. Conservancy measures should come with controls. Believes in critical areas.

Water cost is now running in excess of $6.00 an acre foot and does not believe that $10.00 water could be profitably used, particularly on citrus.

Capital requirements for new wells and equipment are continually increasing; an installation which 8 years ago cost $12,000 would cost $25,000 now. Does not believe banks will continue to loan money on a long term mortgage for new wells or replacement wells in areas where there is a receding water table.

Curtailing water use would certainly have an effect upon the state's economy, but would give some stability to the over-all picture.

Still feels that the provisions of the proposed code last year were sound. "They are still my recommendations."

Would favor administrative determination of the amount of cut-back. Would suggest that there be a State Water Commission to administer ground water laws. Conservation is a job for the state government working with county governments and it should come out of general funds. Water distribution measures should be on local option basis.

"Wells illegally drilled should be capped; the people should be taken to court and the book thrown at them.

"The 1948 code was so incomplete and so weak you might as well start all over again with a document that can be built on a better basis.

"You could allot water on an acre foot basis. Field tests in various areas could be made by state commission to calibrate at a certain time of the year the flow from wells. Check back on energy used from that well and you could tell whether or not a farmer was using more than his share. It would be fairly easy to figure out how many hours the pump has run. The individual is on his own as to what he withdraws, but make penalties stiff for over use and God help him if he gets caught."

167. Ernest Hawes, farmer, Queen Creek district:

From experience with his wells, he believes that deepening the wells makes more water available, but does not produce any new water or any new source.

This year wells are falling off rapidly and this includes the Magma wells, which have formerly held up very well. "We're coming nearer the end of it every year." Is very much in favor of a control of some kind. "I would rather cut my operation in half and put it on a sound basis than face a prospect of depleting our water supply and in a period of 10 years be completely out of business."

Put a definite acre foot allotment that can be used on any one piece of ground. If a man deliberately drills a new well in the face of a bad situation, I don't think he is entitled to as much of an allotment. "Unless you put some kind of control in, at least 50 per cent of that area will go out of cultivation."

Pumping costs with natural gas may have some advantage over electricity, although original cost is higher.

Controls could not be administered on a local basis; you would have to set up a set of rules that are administered uniformly. Believes there is too much land in cultivation already. Law breakers certainly should be prosecuted. Does not believe a law will work unless it has public support.

Would not be willing to express an opinion on advisability of future study until he has had an opportunity to see what this commission has been able to develop.

Believes that the water situation has gone so far that it is going to be hard to get public support for any regulation, because there is not going to be enough water to go around. "To balance pumping and recharge would necessitate shutting down two-thirds of the wells in our area." A 25 per cent cut in acreage would not do the job.

168. Jack Tracy, 921 West Monte Vista Blvd., Sunshine Farms:

"I just want to say that I am 'agin' this proposition period.

"I do not believe this water should be subject to prior appropriation by the state.

"It belongs to the owner of the land under which it is found, and should be handled the same as ore or any other material."

Pump development has contributed to the economy of the state to an equivalent extent with the surface supply.

Might favor that casings should not be perforated for first 200 feet for the protection of family wells. Does not believe local handling would be possible. Not familiar with the 1948 code. State water laws should be administered by someone of competence. Where you can get men of competence is beyond my comprehension.

Believes laws of economics will control better than any legislative control.

169. Art Bodine, Farmer:

Believes wells are affected by neighboring wells. "We are trying to conserve all water possible—concrete pipes, pump backs, etc. Hope to save 25 per cent by conservation measures. Doubt whether we could continue at present price levels if water supply dropped 50 per cent. The trend in vegetable prices is down everywhere. We would just have to eliminate a certain amount of acreage. The lowering water table will force many farmers out of business, especially in the produce area. The income of the community has been increased very heavily by this industry.

"The quality of lettuce in the project has dropped until there would have been very little vegetable business in the Salt River Valley at the present time if we had not gone out to the desert and developed new land.

"Some attempt should be made to balance groundwater recharge and withdrawal in critical areas. We should make a complete study of known critical areas and borderline districts, and perhaps put some control there also.

"Would say a board comprised of farmers and business men alike to determine cut-backs if found necessary. Wells drilled illegally since 1948 should be prosecuted. Replacement wells should be allowed." Does not favor any new land going in in critical areas. Believes a lot of land has been put in that should never have been put in. "It might be adviseable to abandon a great deal of the marginal land."

"None of us know what basin we're actually in. Believes all pumping districts should be classed as critical areas and should be handled on one basis. Acknowledges that possibly in some districts where the lift is shallow, it might be handled on a different basis.

Would favor a continuing study, with a supporting appropriation for every year. It is one of the most vital things in the state today. If code is passed, studies should continue.

(Mr. Cowden interjected a point of information at this time concerning the appropriations of Arizona and neighboring states for the administration of water laws. He said that the commission has been advised by Mr. Lane's office that his total appropriation for water is $22,000. The nearest to us would be Nevada with $61,000; New Mexico, $340,000; Texas, $238,000; Montana, $107,000; Utah, $500,000; and California, $1,700,000.)

Study should continue with an adequate appropriation to determine whether underground water can be supplemented.

Domestic wells should have prior rights; water companies should have no priority; industries, maybe, but provision should be made to compensate agriculture so put out of production.

170. Fred Ironside, Attorney, Phoenix, Arizona:

Complimented the commission on how they have gone at this business—"A fine, public spirited job you're doing," but the commission has not yet been equipped with the type of financing that this particular subject needs. It is hoped that additional finances will be forthcoming for the future. We need to determine where the water comes from and how much do we have . . . then we can proceed from there.

"Of the 1948 code, I believe it a real place of beginning. From it I expected a status quo position would be attained. Then there could have followed the establishment of a water resources board to do the things you gentlemen have done, and also check flood control and conservation measures for augmenting water."

Believes it is possible that within a ten year period we could so augment our recharge to actually bring the water back. Go after the federal government to subject all federal lands to whatever law you have in the State of Arizona. The Water Resources Board should have economists who would lay out data so that the public could determine what the code would do to the economy. The board might consist of farmers and business men, so as to combine those most affected, with those who could determine the effects on the economy. The public has a right to elect its destiny and decide for themselves what type of economy is best to go forward with.

Were I the commission—these would be my recommendations:

Legislation for water conservation to be permanently and well financed. Do this as a continuing job.

Get federal lands in Arizona subjected to whatever the water law in Arizona is.

Get behind and complete flood control jobs that are ready, such as the Whitlow dam and others.

Amend irrigation district laws to permit the agencies to issue bonds for conservation projects.

Legislation to allow farmers to group together to secure direct loans or financed loans, or this board to be the sponsoring agency for federal loans under something similar to the R.F.C.

An immediate enforcement of every law we have on the books with reference to tail water and waste water.

* * * * *

Does not believe a cut-back is called for. Believes '48 act should be enforced. Maintain status quo until studies are more complete.

"It would be too precipitous on facts that we have now to say whether we should or should not have a code."

Believes permits should be re-examined to determine whether false statements have been made.

A new approach should be made on management of watersheds. Lend support to such experiments as are now being conducted in the Sierra Anchas. When you let watersheds grow to bad wood, you cut off land for grazing. There are many ways to augment the aquifers—spreading, check dams, etc. This is being done in other places.

"This commission should make recommendations to the forest officials and to the United States of America. Here is an official body that can officially take a position on what should be done and how to go about it."

171. *Harold Lundberg, Avra Valley Farmer, Marana:*

Somebody is drilling an oil well near us and we are unable to acquire any water log on this well. It would be helpful to the community to have that information. We have reason to believe that water has been giving them trouble, but we have never been able to get any exact information on it.

West of Fresno the wells are from 2000 to 4300 feet in depth. They have a power problem there that we do not have here, and their average lift is between 600 and 700 feet. The wells are drilled with rotary rigs, cement off the high salt content strata, and take the water from between. We should have more information on deep wells that have gone down here.

Can't see any reason for cut-back until we further explore possibilities for additional water.

Favors local basis for administering water laws, once the area is defined. All wells in our area are very different in chemical analysis. Federal and state lands should be the last to be developed where there is any question of the availability of water. Deeded land is different. A man should be allowed to develop it if he has the money.

Would favor a continuing study with ample financing.

Believes further development in his area should not be stopped. "Avra Basin wells have not dropped as much this year as last."

172. *Charles Wetzler, 1625 North 11th Avenue, Phoenix, Beef Cattle Feeder and some Farming:*

Has one irrigation well which is within the Beardsley district. Have had a consistent drop of between 8 and 10 feet a year.

Would favor anything that will prolong the farming in terms of production, and under those terms I believe in the '48 code.

Believes farmers would agree to cut-back of 25 to 30 per cent if it would be generally beneficial. Believes in continued study. Either a commissioner or small commission should administer water law.

General conservation practices should be established. Management of watersheds should be changed to eliminate juniper and cedar. Believes that this commission should have courage enough to recommend that to the forest officials.

173. *S. T. Neely, Yaqui Town, Pinal County Farmer:*

"Whatever you do in the way of control, you should have a better determination of areas. Florence was put into the critical area, and there is no comparison between the wells in that area and the Eloy district. Our static level is 87 feet with a draw-down of 11 feet. We supplement gravity water with pumped water. Each basin or river bed should be definitely established.

If cotton dropped to support, I could still make a living, but do not believe some of them could, if they are pumping as far as they say they are.

Domestic water comes first. Industry should buy from somebody who has it to sell.

In favor of continuing study. Law should be administered by water commission with some help from local boards.

Believes in prior appropriation. "That puts me without too much right, but I believe that."

September 30, *Manor Room, Hotel Adams*

174. *H. S. "Casey" Abbott, Rancher, Avondale:*

Nothing has been accomplished by determining this a critical area. They have just gone ahead and drilled. I don't know whether they had permits or whether they did not have permits, but they have gone on with unlimited developments. There have

been many wells drilled in the past 12 months. Illegal wells should not be allowed to operate.

We felt no recession out there until Deer Valley came in.

"I fought the code—I fought it on the over-all basis that the farmers started the economy here and I could not see why we should assume the entire burden of saving the economy of the state. You had a code passed calling for permits and a complete stoppage of drilling in critical areas with exception of replacement wells. You should amend it, put teeth in it and enforce it."

Out in our country, we know where the bottom of the water is—560 feet—that's the end of it.

There is a well 2400 feet deep 1½ miles North of me. They are getting pure 95 per cent salt from 2155 to 2400 feet. I understand they are going to 3000 feet. They went out of their water formation at around 600 feet.

"When I drilled my well No. 6, we hit an old river channel. There were six water bearing strata above the clay, of which 3 had been pumped dry, the last very recently, because the limestone was still very blue. The bottom of that well is in 62 feet of gravel, and we pumped fish out of that well and still pump fish out of it."

Does not believe state leased lands pay fair share of taxes. The state should either let its land go to desert or put it up for sale. The man on state leased land is protected on his investment in improvements and is in competition with the man who owns the property and has all of the risk and all of the burden to bear.

First conservation of water should come out of our own actions in putting in cement canals. "I save one-third of my water in a mile."

Believes state should set up permanent commission with technical personnel advising and assisting in the application of existing code.

No more land should be developed in critical areas. Does not believe in cut-backs. "It's not up to the farmers to assume entire burden." In 30 or 40 years, two-thirds of central Arizona is going to be dry unless supplemental water is brought in.

"If you go back to support levels of '35 or '36 to '38 with present wage structure, at least 25 per cent of your pumped area today would go out of business, but as long as you have your present support levels, even with high wage structure we can last an average of 20 years in the pump area."

Municipal use of water comes first. Industry should not be given preferred rights to pump water. There should be just compensation to anyone whose water is taken away by municipalities, industries, etc.

Believes present set up is too much of a burden on land and water department. Should have an advisory water commission appointed by the Governor as a matter of public duty with sufficient funds to hire lawyers and engineers and to work out any problems which might come up. The appropriation should be between 150 to 200 thousand dollars annually and should have some permanence. Such a large part of the economy of the state is dependent upon this industry that the appropriation is definitely justified. "I am shocked at the size of the appropriation that Mr. Lane has and feel that the legislature should be censured."

175. O. P. Johnson, 366 Verde Lane Phoenix, Farming Business, Peoria district:

I believe we have to have regulations. The last man in should be the first man out. If we had had prior rights originally, that would have been the answer, but you can't back up and do it now. I have see some land come and go two and three times.

Believes state should make an effort to conserve all water possible. Some make a lot of money and take it and go. If you have permanent people, they would take restrictions. "The sooner you start controls, the better off you'll be."

The project has a right to pump water to supplement gravity water.

176. Clyde Neely, farmer, Gilbert:

Is in project and supplements gravity water with two wells. Does not know how much they use. Is in favor of conservation practices, but believes very little is wasted.

"The 1948 code accelerated pumping." Does not know how critical areas were determined. Does not believe an over-all cut-back should be made. "How can you police this thing?"

"Ten years ago we were told they would come out of Eloy bare-footed in five years . . . they come out now in Cadillacs. Suppose they do come out barefoot? Who have you hurt? They have contributed to the economy of the state and have had a good life while it lasted."

We should use all approved methods and seek new methods of conservation. Should continue study in cooperation with U.S.G.S. and others.

State leased lands should be put on the tax rolls. Government in business has never been very successful in my opinion. These lands should be sold to private ownership.

The people should be given the right to limit themselves if an area could be determined, but to set up a commission would only lead to injustice.

177. Oscar Strobel, Artist, Scottsdale, Paradise Valley:

"I am not a farmer, just an agriculturist. I make my money in town and blow it in on a farm." Something should be done to regulate the use of that water out there. Believes Water Users should not be allowed to pump water out of one area (as they are doing at Granite Reef) and take it down somewhere else.

178. B. F. Youngker, farmer, Buckeye:

Has some land in Roosevelt irrigation district, some in Santan Wash, some in Rainbow Valley—all west of Buckeye. Twenty-two pumps running at present.

Does not favor cut-back for state as a whole; "Let economics take care of it."

"If cotton prices dropped, I would produce as long as there was profit in it. It would depend on the bugs."

We should make further studies and save all the water we can and do anything within reason to keep it from going clear away. Should not prevent a man from developing land who has owned it a long time.

"If you have a code, it should be enforced."

If restrictions could be worked out on a fair basis, it might be desirable. If you're going to have a critical area, you should put everybody on the same basis.

Ask Uncle Sam about the Indians.

Wells should not be allowed too close together.

179. W. Wilkins, 1102 East Culver, Farming in Laveen district:

Lived in Arizona 65 years. Does not believe in cut-back. Believe in prior rights. We should first conserve and control what water we have. Believes a heavy run-off on the Agua Fria is lost that might be saved.

"When you take livestock off the ranges, brush grows up and holds back the water. Let cattle and sheep graze the country off and you get more run-off. The snow runs used to last six weeks to two months, but now the vegetation takes up the moisture and holds it. You cannot economically eliminate juniper and cedar; get the forest people to permit livestock. Sheep eat juniper, cedar, quaking aspen and little pines." Should continue study.

180. John P. Van Denburgh, superintendent, Buckeye Irrigation district, Buckeye:

"Our problem is over-expansion. Sould concentrate on bringing in Colorado River water. Will you legislate the farmers out of business, or let economics take care of it?" I would rather let economics take care of it. I have no sympathy for the man who has developed the desert and now has a dropping water table. If he goes out of business, it was a business proposition, and that was his chance." Let it jell; respect critical areas and develop no further here, but allow development in other areas. Don't exclude free enterprise.

181. Othel Narramore, Palo Verde:

In Buckeye irrigation district. Pumps from 65 feet now, originally 40 feet. Water table has dropped generally.

Believes '48 code might be amended to make it work. Has some water-logged land that was included in critical area. "These areas should be allowed to pump." You should not be allowed to pump areas adjoining critical areas if it can be determined that one affects the other. Would favor continuing study on source of water and conservation.

It would increase water supply if we could eliminate worthless wood.

I am opposed to the state leasing lands in competition with farmers and taxpayers. Believes Indians should be under the same regulations as whites. Let them develop their own.

182. W. W. Weigold, Buckeye, Secretary-Manager, Buckeye Irrigation district:

Static water level has dropped about five feet from 11 to 16 feet. In the west end of the district, the water level is around thirty feet and there has been very little change. Pumping lift is around 60 feet.

Does not believe there is any standard by which you can cut back. As gravity water has declined, pumping has increased. The increase has been from 25 to 75 per cent. Since the 1948 code is what we have, we should work under it until there is a better solution. We should develop no new land in critical areas. Believes study should continue. Ground water and surface water should be together and not considered separate and distinct.

Saving on concrete lined ditches are not too great in that area.

Administration of ground-water laws should be by a commission, selected by districts.

Mr. Weigold made it clear that he was not speaking for the district, but personally.

183. Kenneth McMicken and William Killip, Jr., Goodyear Farms Co., Litchfield Park:

Our average annual water requirements are 6.5 acre feet. All water conservation methods are being used, such as concrete ditches, re-leveling of land and increasing the size of ditches. The salt problem has increased in the older wells, but in newer deep wells, we have less salt.

In the exploratory well now being drilled, we found the usual supply of water to 700 feet; then silt and clay from 700 to more than 1000 feet with very little water; then some water-bearing material, then more silt and clay and at 2300 feet we struck pure sodium chloride, and have been going through that for the past 200 feet. Below 700 feet we have not found anything worth going after. We will go on to 3000 feet.

Our wells affect each other and neighboring wells affect ours.

We will abide by the findings of this commission on regulatory control. We feel that all water should be treated alike. Believe prior appropriators should be respected.

Would favor continued study. The 1948 code does not have many teeth, but it is the law, and we try to live by it. Inasmuch as the Indians are citizens, they should be treated the same as whites. It does not make too much sense for the state to increase the use of water on its own lands and ask conservation and restriction on private lands.

184. M. O. Best, Deer Valley Farmer, Phoenix:

Our pumping lift is 310 feet.

Had the 1948 code been enforced, we would not be in the trouble we are today, but as an amateur legal opinion, I very much question whether the 1948 code is constitutional. It could be amended. You cannot discriminate, and I doubt if this commission has enough information to know the recharge so that the water could be allocated on an acreage basis equal to everyone. Anyone should be allowed to develop, but amount of pumping could be limited.

I do not believe in prior rights. I believe there should be an over-all cut-back, but I do not believe there is enough information to know what the cut-back should be. I do not believe the effect on the economy would be in relation to a cut-back. In each case the marginal land would go out and better use would be made of the water. Production would go up.

Municipal and domestic water should always have preference.

When you consider the over-all economy and we are short of water and there has to be a cut-back, you have to consider what part of the burden is going to be carried by industry in relation to agriculture. I believe the same amount of water used by industry would produce more jobs and pay more taxes than would be the case if it were used for agriculture.

We need more study on conservation. I would like to see the continuation of this same commission with sufficient appropriation to complete the job. "I will go along with whatever this commission recommends. I'm willing to let you spend my money."

The 1948 code has been entirely inoperative. There has been a 50 per cent increase in development since 1948.

In administration you have to stay off the local level. Each district could be represented on an over-all commission. I believe there are a good many different basins in the state. Therefore, the same regulations would not apply to all. Any cut-back should be on an acre foot basis, so that crops can be diversified and water used as owner sees fit. If a man can spread his water and use it over the entire acreage and another man wants to double up, that should be his privilege.

If you put everyone on the same water supply, it would force the waster to wake up and put water to better use.

"It's going to take a lot of organization and a lot of money to set it up on a permanent basis, but I believe it can be done." Wells could be metered.

I believe in conservation practices—the lining of all ditches, the collection and re-use of tail water, etc., but I do not believe you can change the programs on forest and range lands. If we had more deep wells and the wells were perforated in the upper level, it might increase the water supply in the shallower aquifers.

185. Kenneth McElhaney, farmer, North and East of Luke Field:

The water in the entire basin has gradually receded. Our annual water requirements are approximately 5 acre feet. "I do not believe wells can be pumped indefinitely but, on the other hand, I have no feeling of pending disaster if nothing is done." I would feel more secure if some controls were put in.

If our water supply dropped 50 per cent due to increased lift and consequent increase in cost, I doubt if I could operate at a profit, but if the drop was due to legislative curtailment with no increase in lift or cost, I could probably make it. "The lowering water table may force some fringe operators out, but these would be few."

It is anybody's guess as to what the recharge in any area is. If we have to have a law, I would recommend a cut-back on an acre foot basis. Any law for the control of water should be administered on the state level in cooperation with local committees. There should not be a general state limit on the use of pump water, but it should vary with the available water in various basins. We should not establish priorities for consumptive use.

"The Supreme Court has told us at least three times in the past 20 years that the water belongs to the land and wells have been drilled with that assumption." Undeveloped lands are entitled to some water.

"I feel that the 1948 code is a law which defeated its own purpose. It did not have the teeth in it to bring about enforcement. It caused hysteria and accelerated drilling."

186. John M. Jacobs, farmer, Deer Valley Area, Phoenix:

Our water level has dropped somewhere in the neighborhood of 100 feet since 1940. Our first well dropped from 100 feet to 135 feet in the first year. It lost around 50 feet in the first three years. I believe the first water we had was obtained from pockets and sheets of water, and did not constitute a stable supply. The same ratio of drop did not maintain. From 1940 to 1952 the average drop was 11 feet per year, and in the last three years the drop has been only a little more than 5 feet. We believe that in the deeper water there is a replenishment.

It has been said that Deer Valley pumping was creating a basin, and that water was running back in there from under the Salt River Valley. In 1948 we employed an engineer who took a line above sea level to see where our static water level was. He went into the heart of the Salt River Valley, worked from an elevation of 1375 feet to an elevation of 1075 feet, the low point in Phoenix. There is a slope from the center of our place into the Salt River of something over 70 feet, and it is very unlikely that the water is running up hill.

It is very difficult to determine where the water is coming from. We now have approximately 20,000 acres in cultivation and still our annual draw-down has leveled off to an average of five feet a year. "If after sufficient data is gathered and correlated and it is found that there is just definitely so much water, that is all there is going to be, and when it is gone, it is gone, then some reasonable cut-back would be in order."

It is very important that we look toward supplemental water, and an opportunity eventually will come to get it. There are ways and means for the people of Arizona to in some way get Colorado River water in here, but as long as we have to go before the United States Congress to get support, you are up against a bad situation. They have no record of anybody in the State of Arizona suffering for water. We haven't arrived at a point on the cost of water that is alarming. If a situation comes where farmers can't farm with the same methods now in use, then they will diversify their operations and change to adjust to their water costs. Land prices are up, farm labor is up—every item of expense has gone up. We should accumulate every bit of factual evidence we can, but if we go out of business, it will not be because of the water situation. If commodity prices drop enough, you're going to go out of business anyway.

Concerning new development, the economy here was built by this development. If we find we are not going to get supplementary water, then we will have to do something more with our own.

I think you have to use a little judgment on new development. Can we know the possible relationship, for instance, between Deer Valley and the Eloy area?

We have just about reached the maximum development in Deer Valley. I believe deep wells should be encouraged if any individual wants to speculate on what may be found down there.

When I am not pumping, the static level in my deep well stands 40 feet above other wells. It is perforated, and I believe it is for the general good that that well is there. I reduced my lift 25 feet when I deepened that well, and unless the law stops me, I will lower others. When we're in our heavy pumping season, it takes a little longer for all wells to return to normal static level. We believe the deep well is helping the shallow wells, but have no figures to support this.

We do not know our problem yet. If you know what your over-draft is and what your recharge is, you could put in on paper and say "this is it" and all you would need would be a czar, but one area does not match another and we do not have enough facts. I believe it is mandatory that we go ahead with study to build a factual picture if such can be.

"If a control was put in over our area, I would go along with it."

Economically at present commodity prices, we could lift water quite a little further. If cut-backs should be found necessary, I believe it should be on an equitable basis, probably on acre foot basis.

In the over-all picture we should look at all our watershed problems, and even the forest is taking a new view on some clearance and under-brush burning. I think that conservation measures all the way down the line should be used wherever possible.

Domestic wells come first. To protect your economy, if industry comes in, it has to be recognized.

187. Joe Angle, Machinery Business and some Farmland in Casa Grande Area, Phoenix:

There has been a gradual lowering of water table in the Casa Grande area. The amount of water seems to be determined by the depth of the well. I do not believe in regulation. I believe that anyone who owns the land should be allowed to develop it and pump the water.

Twenty-seven or twenty-eight years ago the University said that area would be dry in 5 years. The lift is greater, but they are still doing pretty well down there.

I do not believe there is such a thing as not being able to enforce any law that you pass. I believe it can be enforced. If it is found that a law is necessary and this commission should recommend that restriction be set up, the people will fall in line. It should be on an acre foot basis, but I personally believe that economics should control. It has in the past. At times in the past some of that land has gone back to range twice over, caused by equipment break-downs, not by shortage of water. We can put water on the ground for less than $1.00 an acre foot for fuel cost, or for $2.50 an acre foot total cost with all gas equipment.

I believe a commission system would be better, if controls are found necessary, with a representative from each critical area.

188. A. J. Walker:

I own 560 acres of undeveloped land, on which I have paid taxes since 1917. I cannot be compensated for that in any way when I can be denied a permit to develop it. Under the present code, Maricopa county is in one basin, but on the south side in drilling wells over a period of 8 years I have found four different, separate basins. Big wells near me are pumping very heavily from a 1600 foot well one-fourth mile west of me. They do not affect my water and do not lower their own water. Just a short distance northwest of there, there is altogether different formation and a different water. Over in the Queen Creek area there is still a different basin.

I am in favor of this committee. It should have more money, but you should find these critical water areas. The Supreme Court has ruled that New Mexico has a right to control the underground water "where it can be traced". This means that you cannot control percolating waters.

I think a code would be all right. I feel that I should be allowed to develop my property and if the recharge is only a certain amount I should have the right to pump my share of the recharge in my locality.

189. Nat Dysart, farmer, West Side of Agua Fria, North of Glendale:

Our original static level was 72 feet; it is now standing at 202 feet. As income goes us, the water goes down. I believe we will cut back pumping, whether we like it or not. Fifteen or twenty years ago a prior rights system would have been all right, but now that we have expanded and bonded ourselves for a lot of schools and other things, I don't want my neighbor to move out and leave me to pay for those improvements. It is evident that we are over-pumping the supply. I believe a straight across the board cut-back would be better than letting nature take its course.

I believe all these basins are inter-connected and any cut-back will have to be on a basis that is equitable to all. Further study would be all right. It is possible that some estimate might be made on what could be conserved, and I believe a survey should be made to determine what wells have been drilled in violation of the 1948 code.

October 1, 1952 — *Corinthian Room, Hotel Adams*

190. Henry McKenzie, District Manager, Winthrop Pumps, 4020 East Washington, Phoenix:

I have been in the pump business since 1918 all over the country. The water situation has been critical wherever we have been. In 1921 in the San Joaquin Valley, in the west side, the present biggest pump area, we were told that the pump market was saturated and no more would be sold.

In most areas the determination has been that the farmer owns the water under his land, and so long as he keeps it in his natural watershed, he cannot be controlled. Many of our largest developments might never have been accomplished had controls been used. Conservation practices are widely used to re-

tard flood water and replenish the underground water supply.

With new pumping methods, the deeper lift is offset and costs are maintained very close to the same percentage. You must not try to retard human progress and new, unexplored areas should not be completely shut off. Agricultural people are getting worried about the amount of acreage necessary to take care of increasing population. There are not too many irrigable acres in Arizona.

A critical area creates an unfavorable publicity here and back east. The main pumping areas are pretty well filled with pumps.

I would not think it would be possible to devise a formula by which the economic depth of a lift could be determined because the costs vary so much. But I would say that the Arizona rate is more favorable than anywhere I have been.

191. P. Modesti, Agua Caliente, Arizona:

You cannot pass legislation to replenish water. You cannot say the water belongs to the state. Let economics take care of it. I am against regulation, at least for a while. If controls are established, let them be local. Stop the land office from selling or leasing agricultural land. Go ahead and create a permanent water commission, but do it in such a way that you are not going to stop the development of the state or leave a handful of people to pay off bonds that extend over a period of 25 years.

192. E. R. Spear, Deer Valley farmer, Phoenix:

The water table in our area has receded about 65 feet since 1943, most of that before 1948. The annual drop since 1948 has been from four to 5½ feet. We now have lots of wells out there, but in the first years when the drop was rapid, there were few.

In a well we drilled out near Mesa, we got hot water with an entirely different chemical analysis from the Deer Valley wells. I do not believe that our recharge is coming from any nearby source. I do not believe in restrictions and would not object to a neighbor developing his land. Would favor continuing study.

I think the 1948 code is dangerous legislation. I believe we can trust Lane, but you never know who you will have out there. The code could be amended. Conservation measures are all right.

There is very little acreage left for development in our area, mostly in the New River district. I had rather let economics take care of the development. State lands should be sold to private ownership. I would like to see state and federal lands controlled the same as private lands.

193. E. W. Michael, land owner, Phoenix:

Has lived in Arizona 43 years. In a written statement, which he had read for him, he stated he had three wells and one section of land under cultivation. The ground water of the state should be regulated by law. "I believe any law which you gentlemen recommend should be based on the primary fact that the owner of the land is the owner of the water therein, and that every such land owner has the right to drill a well on his land and withdraw the ground water therefrom. The law should provide for the establishment of irrigated lands into districts in accordance with natural boundaries or basins in which they are situated. Give the State Land Commissioner or a land board the authority to regulate the depth to which the water might be pumped in these various basins. Let every land owner in the district have the right to pump, but control the depths to which he might go." This should be provided for in enabling legislation.

194. J. H. Sossaman, farmer, Queen Creek:

I came to Arizona in 1916 and have been in the Queen Creek area as a farmer since 1919. I have three wells on my 960 acre farm. These wells are drilled to a depth of 1457, 927 and 720 feet deep and as of September 1st of this year were pumping from a depth of 360, 338 and 332 feet respectively. The big drop in the water level has been since 1940. The water strata remain almost the same to a depth of about 1,200 feet and from there down we run into hotter water with considerable sulphur content. The amount of pumping should be regulated by the price of the commodities produced. When the price of cotton and potatoes goes down, the amount of pumping will also go down. I believe the heavy peak in the drop of our water has more or less been reached. It's reaching a stage where the pumping will reverse the flow from the Salt River Valley, as well as the flow that comes from other sources.

I do believe that study should be continued on the underground water and money appropriated for the studies. In critical areas, there should be a moratorium on further drilling while these studies continue. This moratorium should not apply to non-critical areas. "Why should we go to work and restrict our state and private lands, and let the Federal lands go scot-free?" Maybe we shouldn't have a critical area around those Indian Reservations.

From a lot of the logs we have taken on wells, they show that at one time the Gila River flowed

through the Queen Creek valley, rather than through the Sacaton area. The silt in these wells compares with the silt in the soil over there. Queen Creek doesn't have enough watershed that it could ever have deposited 1,000 to 1,500 feet of fill.

195. Joe O'Connell, President of Arcadia Water Company, Phoenix:

I have one well and the Company has six. In 1919 we were pumping from 65 feet and now we are pumping from 220 feet. Something should be done about this underground water. One theory is that you should take each district by itself and with some guidance from this Commission let them all agree on how much they're going to cut or what they are going to do. If you can't get 3, 4 or 5 men together on anything, I don't know how you're going to get the whole state of Arizona to agree on anything. In other words, pass enabling legislation whereby districts could govern themselves. I think the districts should be geographical and can be defined close enough for this purpose. More money should be appropriated to continue underground water studies.

196. A.A. Evans, farmer, Tempe:

I have no wells. I am in favor of prior appropriation. The development of new land should be stopped until they have settled who owns the water. The '48 code is fair enough as far as it goes, if it could be administered. Under present laws, decrees and court decisions, there are people who had rights before these recent pumpers came in. There will have to be a law suit to start with regarding interference of decreed surface rights by underground pumpers. All wells going into gravel should be done away with to restore the river's original flow. In areas where no surface water rights exist the right to pump should be based on a first come, first serve basis. Established districts, such as the Salt River Valley Water Users Association and the Buckeye Irrigation District, should have their rights protected first.

197. R. J. McMullin, General Manager, SRVWUA, Phoenix:

Mr. McMullin presented a great deal of factual data which is filed with the records of the Commission. In part he stated that the S. R. V. W. U. A. consisted of 242,000 acres in the Salt River Valley and had 35,000 share holders. The Association has 250 deep well pumps within the project. The wells were drilled from 1901 to 1951 with depths of from 150 to 1,633 feet deep. The average depth is about 700 feet. The present kilowatt hours required per acre foot for 1951 was 254.7 as compared with 136.1 for 1942.

198. W. W. "Bill" Pickrell, President, SRVWUA, Phoenix:

Speaking on behalf of the Water Users, he stated that something should be worked out to conserve water for future generations. We are spending a million dollars a year for conservation. The funds are borrowed from the Government, interest free. As time goes on and we line more of our canals and ditches, we will need to pump less water as we will be delivering more gravity water.

I don't believe the 1948 code did this basin any good. It stimulated drilling of wells in our desert areas here rather than helping. "Most of the people that are against any code say they own the water down below. Well, if we all own the water down below the '48 code certainly can't control us."

I think legislation restricting pumping could be policed. Most people want to avoid all legislation if possible. "If you limit the water I'm going to get, I'm certainly going to do everything I can to conserve water—cement ditches or something."

I don't think cities should have a superior right over farmers. However, the law should allow transfer of water rights from agriculture to industry or domestic use. We are not letting the City of Phoenix get any more water than the lands they have sub-divided are entitled to.

Assuming that there will be some ground-water legislation, you'll absolutely have to have a commission that will determine the policies at the state level. You'll have to have a lot of engineers and legal help. There should be seven or nine men on the commission.

"I don't think the people are ready for anything yet; they'll have to suffer a few more years."

199. W. E. Springer, farmer, Phoenix:

In the two years I operated my well the water level receded four feet. I don't think any regulatory measures should be put into effect at this time. I don't know exactly how you would put boundaries on a critical area. I know places where the water stood at 120 feet and within a mile it was 80 feet. Also, if you're going to let one go, and restrict the man across the line, it's only a matter of time until they will both be pumping from a common source.

We have run several tests on the amount of water saved by lining ditches, and we have found that anywhere from 15 to 45% can be so saved, depending on the character of the soil the ditch goes

through. I feel that we need some kind of legislation that would permit districts to organize and sell bonds or raise money in some way so that every farmer could take advantage of that kind of conservation.

I think it will probably take years of study to determine the exact source of all our water and what the recharge is. However, studies should be continued from the state level, possibly by a water resources board of character who have power to employ engineers to do the work. "There is no doubt in my mind that there would be a great deal more water available for irrigation purposes if the Forest Service and whatever other services are connected with it handled our affairs in a different manner in regard to growths on the watersheds.

200. *J. S. Francis, cotton ginner and farmer, Peoria:*

We developed a section of land in Deer Valley in 1948. We had two wells pumping from 250 and 260 feet. After two years the lift had increased approximately 40 feet so we sold out. In that area I believe the water level is dropping about 20 feet a year. I think eventually we're going to be faced with some restrictions in pumping. My personal conviction is that if and when we have a reduction in pumping, the reduction should be applied by the same percentage to everyone who has drilled a legal well up to this date. "I think the 1948 code was all right as far as it went. It was better than nothing. It works a hardship on people who have undeveloped land in critical areas, but I don't think any legislation could be enacted that wouldn't hurt someone."

"I don't believe people as a whole over the state are ready for restrictions in pumping, but I believe people in certain areas would agree with their neighbors to restrict pumping if they could do so without being damaged by other basins." I think a lot more geological data is needed before boundaries of basins can be determined, but when the boundaries can be determined they could be set up by enabling legislation.

"If there is enough acreage of Indian lands under Federal control to materially affect our underground water supply, we would have to try to get them to agree to join with us. Otherwise, I think we would be foolish to give our water to them." If two-thirds of the people in a defined groundwater basin wished to restrict pumping, I think the other third should have to go along with them.

I think there should be a state commission appointed by the Governor with consent of the Senate, that is empowered to employ competent engineering personnel to continue groundwater studies. I would venture to say that in certain areas we could reduce pumping by 50% and by water conservation, better farming practices and the use of the better land, we wouldn't reduce production by more than 25%.

201. *Bob Fletcher, farmer, Phoenix:*

Native of Arizona. "Most of the points I would have liked to have brought up have been covered." I have four wells. I am opposed to any kind of restrictions. However, if the majority believes controls to be for the general good, I feel I can still get along the same as the other fellow. I agree with Mr. Pickrell on his ideas about the 1948 code. Who is to say what is critical? As I see it, it is all related to economics.

If there is any regulation, I feel the only fair way is to allocate it on an acreage basis. Each acre, whether it is in desert now or whether it is in farmland, should be allotted so much water. If I had 100 acres and was allotted so much water and wanted to use it on ten acres, that would be my privilege. I think the state should definitely continue groundwater studies, and a permanent state board should be set up to continue the program. A gravity water user should be allowed his share of pump water over and above his gravity supply.

202. *W. S. Williams, well driller, Phoenix:*

There is a lot of variation in wells. I've been drilling here in Arizona 37 years, and I think the water table is receding. I don't believe any man or any group of men will ever determine the basin lines on a fair basis to all concerned. In drilling deeper wells, I have not always picked up more water, but many times I have.

203. *Anthony Bennett, farmer, Glendale:*

In 1942 we drilled a well on some acreage in Deer Valley. The static water level was 135 feet then; now it stands at 305 feet. We figure that little fellows like us will be out of business unless we get some help from a water code, and there are some kind of restrictions. We figure we can probably go down to 450 feet if cotton stays at 35c a pound. We irrigated about 360 acres when we first started and pumped about 300 miners inches; now we are irrigating 220 acres and pumping about 125 or 130 inches.

I think the 1948 code was the biggest help to well drillers. There's been more wells drilled in the four year period since 1948 than any period preceding. Our area has been declared critical, and there are still wells going in right now.

Our power bills were about $400 a month when we started. Now they run a little over a thousand, and we farm less land. I would suggest that the people elect a committee to decide on how much to cut and the committee should make a thorough study of the recharge and cut back the acreage to that proportion. I wouldn't be in favor of putting in any additional land in this area. I don't think the water should be allotted on "time of first use" basis. I would cut the acreage rather than the water.

204. *Edwin M. LeBaron, farmer and real estate broker, Mesa:*

I have 2,000 acres of land and 2 wells. I am lifting water 400 feet. "I don't believe we should curtail pumping or drilling either. I am opposed to any step which would stop my neighbor from using his land or getting his part of the water." I think we should set up machinery for the well owners themselves to control the amount of water pumped, based upon farm prices, pump efficiencies and power costs. All of these things will level off and the law of supply and demand will take care of it to a great extent. But where it won't, I think the state should provide for a permanent water commission, empowered to carry out the terms of whatever act is finally passed by the legislature. If this Commission ordered a cut in acre footage to be used, that could be done. Restrictions should be on the amount of acre-feet of water per acre.

If we had legislation by which we could organize improvement districts, with the power to borrow money or issue bonds to raise funds and do conservation work, I think it would be one of the most constructive approaches to this problem. "I don't think the 1948 code should ever have been passed. The boy with the money got in and got his wells drilled."

205. *Bryan Akers, Secretary, Arizona Water Conservation Association, Phoenix:*

Mr. Akers, a native of Arizona, discussed at length studies their organization had made of conservancy laws of the state of California, Colorado, Montana, Utah, Wyoming and others. He believes that water conservation is the only solution to legislation to allow for the establishment of legal conservancy districts, which have the power to issue revenue bonds, levy taxes and perform conservation work.

First he believes the state should establish a permanent water conservation board and points out that Montana did this 17 years ago, Colorado 10 years ago, and Utah 5 years ago. His organization is drafting conservancy legislation which he offered to the commission for their consideration when it was completed.

206. *Hugh Nichols, farmer, Higley:*

I definitely think we have a supply of water coming from some place else besides out from under the Water Users' project for two reasons:

(1) The temperature of the water and (2) the chemical analysis of the water. It seems to me that it is very possible that we have different strata of water all in the same valley.

"As far as an underground code is concerned, I have said for years that I was in favor of one if an equitable one could be worked out and eventually I think we will come to one." There should be local organizations to work with the State Land and Water Commissioner to administer any code.

207. *Cliff Armstrong, farmer and legislator, Tolleson:*

He maintains that the '48 code should be amended if we are going to use it, so that when it is advertised that a hearing to declare an area critical is to be held, no more wells may be put in and no more contracts for drilling made from the date the hearing time is announced. Another thing I would suggest changing is to provide that the water must be used on the specified land for which rights to drill the well were obtained.

There should be continued study and more conservation practices used. In the event new legislation is passed, I would like to see the state create an impartial review board. I would like to see a simple bill passed at the next legislature stopping any groundwater development for the rest of the year, and then in September call the legislature back to pass a groundwater code. By that time we should have full information and have had enough time to write a code.

PARKER HEARING
FIRST NATIONAL BANK OF ARIZONA BLDG.
OCTOBER 3RD, 1952

208. *Ernest R. Hall, Salome:*

There are no wells for irrigation at Salome, all domestic. The water level around Salome now is about four feet less than it was in 1904. I figure all our water comes from rainfall in the Centennial Wash above there. I've always figured there is probably enough water for at least 1,500 to 2,000 acres of irrigation from that wash. The Edwards outfit came in and took up some land about ten

miles below Salome. They drilled there but didn't get water below what we call the reef, so they came up above the reef in the vicinity of the Nord place and drilled where the water was only 35 or 40 feet. They put in a number of wells and are running the water down to the land below. It has lowered the wells below them, but hasn't affected the wells at Salome. Generally I am opposed to commissions, but to administer a state water code I believe a commission would be preferable. The opinion of four or five men should be better than one man. I certainly think they should appropriate money to continue studies.

The water needs regulating for the future. The Edwards', Johns' and Fresno outfit are getting all the water they want but it is water that's been stored up in there, I think, for generations and generations and they're taking it out far, far faster than it's coming in. I think the present water code is along the right lines but it needs to be reinforced a whole lot.

209. *August Nord, Salome, Rancher:*

Resident for 47 years. We have two irrigation wells but both have gone dry. We now get water from the Edwards', who are just about a mile from us. They have four or five wells and four of them surging all of the time. We pumped about 500 g.p.m. till the wells went dry early in July. I think there is a need for a code.

210. *Ben Simmons, Bouse, Farmer:*

I drilled a well in January of this year and it seems to be better now than when first drilled. I think our water basin is entirely different than the Salome basin. I don't think the water in our area is dormant. My water level is two feet higher now than when I drilled. I definitely do not feel that the development in our area is critical. I don't know how much more land can be developed. It costs about $5.00 per acre foot for electricity.

I think that anyone who had a pump drilled from '48 back should have the same priority as the first settlers that came into the country. I think the water should be apportioned out, and there should be no priorities on any of the water. I think development should be stopped in the critical areas. In other areas the water table should be watched and as soon as they notice the water level is dropping there should be something done to prevent any more drilling. About a third of my production costs are for water. If the price of cotton dropped to support there wouldn't be much profit in my growing cotton.

211. *J. M. Bell, Salome:*

It doesn't look just right to take the water out of one district and deplete the water there and try to farm in another district. I wouldn't say whether Mr. Edwards' wells will dry up my well, but my well has gone down more than it ever has before in the last year. My well is shallow, 50 feet.

212. *Chet Johns, Phoenix, Farmer:*

I have three wells southeast of Bouse, drilled in 1947, 1948 and 1951. My water level has not gone down any, if anything it has raised. I see no objection to further study in any area, but want the state to do it rather than the U. S. G. S. "I think the '48 code is all right but I think there should be research run on it and I also think that it should be kept in bounds as it is today. I would favor the state appropriating more money for continued study before you harness this water problem."

213. *Norman Hansen, Phoenix Pump Machinery Dealer:*

He commented on various ground water conditions encountered in different areas. "There are areas that I feel that are over-pumped, but the critical areas as now set up were more or less taken as a blanket." There are areas within there that will become waterlogged if you restrict pumping 25%. "There are areas that could use some kind of control but I'm not in favor of anything that restricts a man's freedom. Just because a man isn't financially able today to drill a well, the law shouldn't stop him tomorrow."

Most any area you want to name other than those immediately adjacent to the river are receding. The largest drop in Deer Valley has unquestionably come in the last two years. In reply to the question of what type of organization would you prefer to administer a groundwater control act, Mr. Hansen said "I wouldn't want any of them, commission, commissioner, or local option, if I had any land out there. I would let economics control it. I don't believe in any control law." I would favor further study to determine, if possible, where this water is coming from, but not to restrict general areas and take away individual rights. I believe the '48 code is improving the value of land already in cultivation in critical areas, but I don't know if it is beneficial to the area as a whole.

214. *Joe Mansfield, Yuma Attorney:*

I represent the North Gila Valley Irrigation District, the Wellton-Mohawk District and the Unit "B" Irrigation and Drainage District. In general our problems of drainage are greater than shortage of

underground water. The views that I want to give are primarily those of the Wellton-Mohawk Irrigation District.

"I for one do not agree with the theory that you should go back to the legislature and ask for money for further study. I feel, myself, that you have to have a starting place. I think this commission is going to serve a very useful function in correlating all the information which you have available, but in any subject as complex as this, you could study it for years and years, and I'm sure not know all of the answers. And looking at the statewide picture, if you don't get a start on an underground water code now, it's going to get worse instead of better. At least that's been the experience of the state since 1948 and the wet season we had last year was just, I think, a reprieve. The tooth is still aching, but you put some medicine on it and as soon as that water runs out it's going to ache maybe a little worse than it did last time. So it's high time, I think, the state as a state went to the dentist and found out or at least got a start in trying to correct the situation as it exists. I for one would feel and recommend to the commission that a step be made at this time for the promulgation of a code and I don't believe the '48 code satisfactory. It's not working. I understand there have been many people who came before the commission and told you about the wells they have drilled since '48 in critical areas. And I'm sure that exists probably more than you know. There's one other element why I think it is important and that hasn't been mentioned yet and that is the fact that you still have in the Colorado River, in excess of 1,000,000 acre feet available for use in Arizona. There's lands that water can be used on in Mr. Jameson's county up in Mohave, Maricopa County and Yuma County. That 1,200,000 acre feet represents the irrigation of several hundred thousand new acres of supplemental water for an even larger amount of acreage, and it's very doubtful that any legislation could ever be attained to start the use of that water either supplemental or on new projects, unless and until some type of enforceable water code is put into effect.

Let me go to our specific problems. As to why we think we have an interest in an underground water code, you'll notice that the Wellton-Mohawk District follows along the area of the Gila River. That land has been in irrigation some of it, as far back as 1900. The larger development started in the early 1920's by wells. At that time by mid-1920 the water elevation here in the valley when the farmers first came in was something in the neighborhood I believe of 20-30 feet. Now, of course, it's dropped down to where it is about 170 feet. The whole valley is under-layed by a very thick clay strata which means that they merely use and reuse and reuse the same water. The only way any fresh water comes in to recharge that underground basin there, is by water running down the Gila River. After they built all the upstream dams on the Gila River, as you know, no water comes down the Gila River. The last time the Gila River flowed with any amount was in 1941 when the storage dams became full upstream. The moment that flow begins, we notice a very marked effect on our underground water supply. The constant re-use of that water built up the saline content so high that in some cases in an average year of irrigation there in the Mohawk valley, they were dumping on their land the equivalent of about 30 tons of salt per acre. Of course the result was that all they could grow was Bermuda grass and alfalfa.

In 1947 the Wellton-Mohawk project was authorized for 75,000 acres of land. The average repayment cost will be $560.00 per acre.

In addition to this the farmers must pay the cost of lifting the water some 180 feet to get it on their land. Now after several years of bringing in 300,000 acre feet of water from the Colorado River the groundwater should be sweetened and replenished to the point where pump irrigation is again feasible. The water being put in this basin is just like storing water in a reservoir and should belong to the people that brought the water into the area and recharged the groundwater basin. Therefore, we feel that as an irrigation district we should have the right to control all pumping within the geographical boundaries of our project. Our concern over this problem lies in the fact that there is considerable land within the boundaries of the project that were omitted from the project due to soil texture and topography and we do not feel that the owners of these lands should be entitled to profit from the water that owners of project lands paid to bring into the area. Now our thought is, if a code is written and presented to the legislature, that perhaps a provision can be written into the code which would give the districts this right. We would be happy to work with your legal staff in drawing such legislation.

We think by controlling pumping, it also helps us in establishing an orderly drainage program.

215. Harold Woodhouse, Roll, Farmer:

Have been farming in the roll area since 1925. I moved in there when the pump development was going in. In about 1920 we formed an irrigation district, sold bonds and put in a series of wells on the north side of the Gila River to irrigate 18,000

acres, the wells were about 100 feet deep and some of them were salty. We had quite a bit of flow from the river at that time, but then they put in the dams and we had to use and reuse the water until it got so salty we couldn't do much with it. The last flow we had to amount to anything was in 1941. When I first went there we could strike water at 18 feet, now it is 55 feet to water.

"Our problem is a little different from the rest of the state in that we are bringing the water in now to replace the pump water and we do need to control it.

We're allotted 4 acre feet for consumptive use and we think maybe that isn't going to be enough to raise the crops, but we expect to be able to use this water over again as it replaces the salty water in the underground basin and we think we should control it as a district. The district includes most of the irrigable acres in the basin."

216. *Paul Edwards, Phoenix, Farmer:*

We put in some wells southeast of Salome during the last two years. We found a sheet water proposition there and the wells yield from 300 to 2,000 g.p.m. I believe with deep wells you'll strike more water. Ours are from 175 to 400 feet deep.

I think the 1948 code has probably helped in a mild sort of way. It isn't really set up with any teeth in it. If we're going to have a law we might just as well have a good one. The only way an area can become critical is through pumping and if we don't go ahead and pioneer these valleys in the state, they certainly never will become critical. We can't have any controls on these new areas because it would absolutely stop any new development.

PHOENIX HEARING
CORINTHIAN ROOM, ADAMS HOTEL
OCTOBER 22, 1952

217. *Cecil Miller, Phoenix, Farmer:*

I think you'll have to have some controls. There's two ways controls would be effective. One is through rather drastic legislation enforcing a reduction of pumping and the other is economic controls. I can't conceive of much difference between gravity water and underground water. Their origin is the same in my opinion. I think the law that will adequately and satisfactorily take care of one will take care of the other. "I'd like to call to the attention of the committee that today without any code or restrictions that are effective, my opinion is that it restricts the development of the state more than anything else." No man with good business judgment wants to go into an area and develop land when he has no protection against future developers coming in and pumping out his water supply and making his original investment worthless. I believe it is just as easy to establish priorities on underground water as on gravity water. I would in some measure have cut-backs to the people in the area affected. Conservation districts might be wise but be careful that local people control it.

218. *H. S. "Casey" Abbott, Avondale, Farmer:*

With the view of escaping a lot of litigation and expense, I would like to see a new approach to the problem that confronts us. I would like to see a survey run through the existing P.M.A. committees for voluntary action on the part of the farmers, where any man who is farming over 80 acres would agree to cut his acreage 25% providing he is dependent wholly or in part upon underground water. I believe you would receive a very favorable response. Together with the policy which I am proposing, I want to see teeth in your code, which would stop any further development in the central valley.

In order to remove this stigma of confiscating property, I would say that when a man applies for a right to drill a well on land he intends to bring into cultivation, the Governor be empowered to immediately order an appraisal of that land by a disinterested party as to value and that the land be purchased by the state and returned to desert. Another gimmick would be to put the burden of taxes and water assessment on that 25% acreage left out of cultivation on the cities and towns. I don't believe vineyards, orchards or any man who is farming 80 acres or less should be asked to go into this deal.

219. *Maurice D. Brown, Phoenix, Attorney:*

"I think there is too much thinking in this country that a man has to double his capital or make 50% on his investment every year." I think the purpose of the citizens of this state is to develop and improve the state, not restrict it. There is sufficient authority in the state and by using its police powers we can limit the amount of water pumped. It should be done on a pro-rata basis in various districts. I don't believe the pioneer has any more right than the man who will come tomorrow. I believe it would be very simple in a given area if every owner was allowed a fixed amount of water per acre. This would not prevent a man from drilling a well on new land, but it would discourage him if he knew he was limited in the amount of water he could have per acre and that by bringing in this new land the amount would be further cut under the law.

Farmers should be able to organize and set their own figures on water to be pumped within any district or basin. Water shouldn't be transported, it should be used on the land where it is pumped. Any land to be considered for new development would have to be suitable for irrigated farming. I would make no distinction with reference to quality or size of a man's well or limiting his water supply. I believe the 1948 code should be repealed.

220. *Dean Stanley, Phoenix, Farmer:*

"I am very definitely of the opinion that we do not have enough information about the underground water to cut back the economy of the present farming in Arizona." In areas that are already declared critical, new development of desert land should be stopped until more is found out about the underground waters. It is my opinion that you should recommend a more thorough study of the groundwater situation and some kind of a proper conservation act. I think a study should also be made as to how much farmers can afford to pay per acre foot for water before there is a law passed cutting back the use of water. "I would like to say very definitely that I am sure the U. S. G. S. reports are incorrect, inconclusive and that we should not rely on them."

I would favor districts levying a tax for the benefit of the community as a whole for water conservation purposes. I think a new water resources board with proper personnel should be authorized. I would not favor any limit on the consumptive use of water in pump areas.

221. *Archie M. Kroloff, President, Allied Grain Co., Phoenix:*

I would say that if some controls were put in, it might affect the income somewhat, maybe materially as of the given year, but over a period of twenty or thirty years it might increase the income or the average over the long pull. I think a state conservancy law would be helpful in this state if it were put on a district basis. I think all business in an agricultural area depends upon agriculture for the livelihood and that they should participate in a conservancy district and be taxed. I don't know much about state leased agricultural lands, but if they create a local problem, provision should be made for the rent to get back to the local level to help pay for the expense of roads, schools, etc. If a code is passed I would favor allowing local people to get together and work out their own problem. The state could have a commission with trained personnel to whom the local group might go for information or study of the technical problems within their district. Industry coming into a community should be treated just like the farmers. I think if they use more water than needed for irrigation they should buy more land to use the water with.

222. *Jim Mayer, Vice-President and General Manager, Producers Cotton Oil Co., Phoenix:*

The economic feasibility of producing cotton as it relates to water cost is the same as the other costs in producing the crop of cotton. "I think anything that can be done to increase the conservation of a scarce commodity is important to all the people. Personally, I'm not an advocate of a lot of excess laws and regulations." Water costs vary from $25 to $70 per acre to produce a cotton crop, depending upon the area. I think this commission has done a good job, and I think the farmers will have confidence in what you will recommend, but whatever is done, try to do it with timing that doesn't leave the farmer up in the air.

223. *Frank Feffer, President, Arizona Fertilizers, Inc., Phoenix:*

My opinion is that we need some sort of an act to help conserve water in Arizona. I agree that it should be more or less on a local level from the standpoint of conservation districts. Favors a commission with varying lengths of office for the members and ultimately by law be given authority to determine what the policy should be. If you have to continue to put this thing before the legislature it will take a long time to get it settled. I rather think from the farmers and growers with whom I talk that most of them seem to recognize that something more has to be done than is presently being done—some law more definite and concrete than we have at the present time. It would be a fine thing for the state if there was no new development in critical areas.

224. *F. M. Cocke, Tempe, Farmer:*

Mr. Cocke presented the following letter in behalf of the Kyrene Farm Bureau:

"The Kyrene Farm Bureau members are nearly all owners of land in the Tempe-Mesa-Chandler groundwater basin as such basin is recognized by the United States Geological Survey. Most of the members are stockholders in the Salt River Valley Water Users' Association.

In order that our views on some of the matters before this Ground-water Comission may be subject to the study which we hope they will receive, we offer this brief outline for your consideration.

1. This Ground-water Commission has been appointed, and $100,000.00 appropriated for its use, to formulate the basic principles upon which to write a ground-water code.

2. A ground-water code cannot add to the total supply of ground-water, so in order to be effective must by regulation reduce the amount of water pumped and used, and not merely allow to those landowners who have exhausted the supply underlying their own land the privilege of invading any other supply within reach.

3. Any general principle of law or equity upon which a late-comer might base his claim to establishment of a right to water by the mere taking of it from a falling water-table must necessarily leave such claimed right subject to invasion by another who comes later, and his claimed right open to invasion by still another who comes still later, so that eventually the result would be the spreading of the available water over such a great area of land that it would amount to little more than the rainfall, and be of little benefit to the landowners or the community.

4. It was to guard against this very situation that early in the history of the formulation of Arizona water law the legislature and the courts came to accept the principle of prior appropriation as the only equitable principle upon which the water resources of the state could be developed for irrigation for the good of the state as a whole. This is the principle that he who by the expenditure of time and money first made beneficial use of water on his land, established a right to its continued use on that land as against a subsequent appropriator.

5. The early settlers who write the Arizona Water Code, making the water of our streams subject to prior appropriation for beneficial use, realized that a considerable part of the water in the lower stages of our rivers was flowing beneath the surface, moving slowly through the river gravels deposited in the river bed by the river itself, but still a part of the living stream.

6. Section 75-101, Arizona Code, 1939, reads as follows:

> 'The water of all sources, flowing in streams, canyons, ravines, or other natural channels, or in definite underground channels, whether perennial or intermittent, flood, waste, or surplus water, and of lakes, ponds, and springs on the surface, belongs to the public and is subject to appropriation and beneficial use, as herein provided.'

7. The statute states clearly that waters of a stream, whether on the surface or underground, are subject to appropriation, and this principle has been repeatedly upheld by our courts.

8. It is our opinion that most of the water pumped for irrigation in the lower valleys of this state has its source in underground streams, and that the underground formations in these areas are similar to those in the San Fernando Valley of California as discussed in the case of Los Angeles vs. Pomeroy (57 Pacific 585) as follows:

> '(14) The Los Angeles River is composed of its main stream and any branches it may have, whether surface or subterranean.
>
> '(15) While a water course must have a bed and banks or sides, yet such bed may consist of any material which keeps the waters from penetrating below a certain depth, and such banks or sides may consist of any material which has the effect of confining the waters within circumscribed limits.
>
> '(16) It does not always follow that water which does not flow on the surface in a visible stream is for that reason not a water course, or not a part of the water of a stream which does at some place run on the surface; nor need it flow in a defined channel underground, as a solid body of moving water of any particular dimensions, in order to constitute a water course. If you find from the evidence that there is a bed or a river bottom filled to a considerable depth with sand, gravel, or other porous material, meandering over which a stream runs on the surface, and through and in which the water moves underground, enough of it rising to the surface to supply the surface stream, and the other portions of the underground water moving with a much less velocity than the surface stream, and in connection with it, and in a course and within a space reasonably well defined,—the conditions being such that the existence and general direction of the body of water moving underground can be determined with reasonable accuracy—then that portion of the water moving underground should be considered as a part of the water course, as well as that part which flows over the surface. If such water course exists, it is immaterial, so far as the water course is concerned, from or through what lands the waters flow in reaching the channel, or whether they reach the same by percolation or by clearly defined streams.
>
> '(17) So, also, if you find that the water coming down on the surface in the streams known as the 'Tejunga', 'Little Tejunga', and 'Pacoima' creeks, in the northeastern portion of the watershed, is discharged on the plain known as the 'San Fernanda Basin', and there sinks in the sand, washes

and flows down southwardly underground through sand, gravel, or other material easily permeable by water, and along the courses and its channels which have been made by the streams of water long ago filled up with this porous material; that these waters now flow in these channels beneath the surface to the land in controversy; that on this land there is a range of hills extending easterly and westerly, so as to change the course of these underground channels, and combine or collect the water into one general body of water, and force the same to turn and move eastwardly in a similar channel through these lands, and on down along the general course of the Los Angeles River; that upon arriving at this land a portion of the water rises to the surface, and flows aboveground as the Los Angeles River, and the remainder flows underground along in the same general direction, and in connection with the surface stream, in porous material formerly deposited by the same stream in its bed,—then all this body of water, both above and below the ground, should be deemed a part of the same stream from its sources to its outlet.'

* * * * *

'There is no dispute between the parties, and no conflict in the authorities, as to the proposition that subterranean streams flowing through known and definite channels are governed by the same rules that apply to surface streams. * * * * *
'The point to be specially noted here is the meaning ascribed to the words 'defined' and 'known'. 'Defined' means a contracted and bounded channel, though the course of the stream may be undefined by human knowledge and the word 'known' refers to knowledge of the course of the stream by reasonable inference.'

9. It is our opinion that percolating water seeps too slowly through the soil to be available to wells and pumps in sufficient quantities for irrigation, and that only after percolating water has reached the gravel of an underground stream does it flow rapidly enough and collect in quantity large enough to serve an irrigation well.

10. We therefore recommend:

(A) That any statute dealing with underground water recognize that water drawn from underground river formations laid down in the lower valleys of this state, where such water exists in quantities sufficient for practical irrigation purposes, must reasonably be presumed to be drawn from an underground stream, unless otherwise shown.

(B) That the Commission take steps to obtain and make public all available information as to the location of underground streams in basins now declared critical.

(C) That the Commission take steps to determine the actual boundaries of natural groundwater basins not now recognized by the State Water Commissioner.

11. We are enclosing copies of seven letters written by this committee concerning water, and excerpts from a number of court cases, surveys and Interior Department rulings also bearing on this matter.

KYRENE FARM BUREAU WATER COMMITTEE

(Signed) A. M. Polley, Chairman
H. C. Hanger
F. M. Cocke
A. A. Evans

For the general administration of a code, I believe a commission would be far superior to an individual. It seems to me it is high time we came up with something. I certainly believe in prior appropriation.

225. *J. Earl Peterson, Phoenix, Business Man:*

"If I had had my way seven years ago I would have blocked all drilling even though it was a police action, because it was very plain that the price of cotton was making a rush of well drilling. I would rather not have any regulation whatever if we have to go in with the bureaucrats. I'll take a free-for-all if we have to." I think there's only one solution and that is to keep this commission. If we don't have something like this, we'll have two or three people managing this thing and have all sorts of discord. I've been asked what would happen if we had 25% of our land taken out and allowed to fallow. I said we'd have 90% of our present production and be just as well off. I agree with "Casey". It would be just as well now if we don't wait for all this information. I think that if we had some kind of enabling act providing for a two-thirds rule then the people in a locality could come under the law and they would cut down 25%. I think the '48 code was an awful thing. It created a rush of drilling rather than helping. If the people of an area by democratic vote wanted to cut back then there would have to be some provision for enforcing it. Any cut would have to be on an average basis.

I think the business man even though he doesn't have much to do with it would welcome a conservancy act. I think people are sold on convervation methods. Enforcement as much as possible should be left at the local level.

226. *Gale Baker, Phoenix, City Engineer:*

As the city expands and more land is taken out of cultivation we maintain the present water right and convert to domestic use. I would say we are certainly approaching a dangerous point. It's a question of whether you want to prosper today or over a long period of time. Certainly if you continue at the rate of pumping that we have been in the last two or three years there is going to be trouble sooner than if the water is pro-rated. I think that beginning as soon as possible controls on strictly a priority basis should be put into effect. By priority, I believe existing wells will have to be considered on an equal basis, but in areas where there is water available for future development it would be on first in use would be first in right. Existing wells in an overdeveloped area would have to be cut back on a more or less equal percent in the different basins. I think any cut-back would have to be worked out jointly between the local people and the state administrative agency. I think the law could be administered by the state water commisioner, maybe including an actual commission that he could be directed by. I would favor a conservancy act in this state. I'd make the tax base as broad as possible.

227. *Henry Sargent, President, Arizona Public Service Company, Phoenix:*

We have seven wells at the steam plant west of town. Two were drilled in 1929, one in 1938, one in 1940, and 3 in 1948. The average drop in water level since 1925 was five feet per year. In 1930 the company was serving power to 80 wells which had a total requirement of roughly 5,000 kilowatts. At the present time we are serving 1,029 wells with a total connected load of 93,400 kilowatts. In addition to power served directly for pumping we serve about 28,000 kilowatts of power to those industries which are directly connected with agriculture. The two include 44% of the load we have on our system. That does not include the things which are very closely allied to the agricultural activities such as farm equipment companies and well drilling companies. I think any cut-back in pumping would affect our load in the same proportion.

I am not familiar with the conservancy acts of other states, but I believe I would favor such an act in this state. Every effort should be made both at state and local levels to increase the supplies of water by cloud seeding, recapturing of water which is now going to waste, and solving the Colorado River problem. Also everything reasonably possible should be done in respect to the conservation of water. My personal opinion is that the state water laws should be administered by a commission, representative of the entire state, with sufficient funds to employ such technical and other assistants as they need to help them. The answer to whether or not an industry should be allowed to come in and use water should be determined by an economic study of what the particular industry's benefit to the overall area would be. Consideration should include requiring the industry to buy up water rights if their use of water is beyond what is reasonable. A time may come when for various reasons there may be a decline in agriculture in this area. Now I think part of the loss in economy of agriculture will be off-set by industrial development as they can afford to pay more for water.

My personal belief is that if a cut-back is necessary it should be handled at the state level by the commission. Before, or along with it, there will have to be an extensive program for educating the public.

228. *Fred T. Elder, Arizona Machinery Co., Phoenix:*

It's the concensus of opinion of those I've talked with that we do have a problem on our hands. It seems to me that some of these things when we look back over the last twelve years such as the commodity prices have prevented any cut-back and what the future holds is naturally anybody's guess. I think any cut-back in farming would have pretty close to a direct cut-back in business too. I think we have just barely tapped the surface with some of our conservation methods. I would think anyone in an area should be included in a conservancy act, because as I see it, particularly in Central Arizona, our town economy is pretty much affected by our agriculture. To administer state water laws I think a commission of some form with the various districts concerned as members would be desirable.

229. *Jim Blasdell, Phoenix, Farmer:*

My opinion of controls or the things you public-spirited gentlemen are digging into, is that no one has the answers on what to do. "In my mind I don't think there should be any cut-back by anyone until they know more than they know today." I don't think the water table is to a serious stage in any of the deals I have and I'm pretty widely scattered. We farm in Eloy, Rainbow Valley, Buckeye and Waddell. I think commodity prices are going to drop but what it will do I don't know. Maybe we'll grow something else tomorrow. I think a cut-back would injure some very seriously and affect the economy to a point it possibly could be disastrous.

230. *A. S. Hansen, Phoenix, Pump Dealer:*

Have been in business 30 years. The water table, from my experience has gone down very much. One

of the tendencies is for the owners to try to get more water out of the same wells by increasing horsepower and lowering their pumps. I think a state conservancy act would be very helpful in this state. I would think that all the business in the area should be taken in and be taxed because we are all in it together. In certain districts I believe the situation is critical enough that there should be some legislation passed to restrict pumping. I don't see any other way than to cut back the acreage because to cut water would be too expensive to police. I think that if enabling legislation was passed the farmers within a basin would be able to agree, because it would be beneficial to each one of them. I doubt if legislation can be passed that would be equitable to all valleys and the different conditions that exist within them. We have places where if water was conserved it would drown other areas. I think the study of the water situation should be brought more up to date because what studies we have do not coincide with what we find today. It is hard to say whether these districts could be defined so as not to conflict with one another. Records of well capacities and well depths should pretty well determine districts. I think that if the water were cut back 25%, that the economy of the land would not be reduced anywhere near that much, because as you cut back you'll possibly get into more profitable crops and also produce more per acre. It is hard to say if new development should be stopped. I think there should be stoppage of new development for a period of time to see what the come-back really is.

A number of persons who were unable to appear at the hearings made written statements to the Commission, and the following are excerpts from some of these letters:

231. G. Mariani, Cottonwood:

"I am quite convinced that water transportation should be prohibited because it could very well upset the whole economic structure of the affected area. Water has always been a controversial issue and in our valley especially now, it is the foundation of all our economy, since it is the only resource left to us because of the discontinued operation of mines and smelter.

As far as local business is concerned it is evident that its continued existence is now based on the ranches with their various phases of farming. Its survival and naturally the prosperity of this community also depends on the water supply in question, as does the movement of new land development, which started several years ago and is continuing to grow and add to our local progress as well as to the benefit of the state, and we are interested in both.

It is therefore quite evident that if we should be forced for some urgent reason (which we are not contemplating) to sell our water the question would be just how could the matter of price be settled. In my opinion it should be the farmers and ranchers privilege to establish the amount, since they alone could estimate the damage to this area's security because of loss of water. This represents not only my personal opinion, but also that of most of the farmers and ranchers in this area."

232. Aubrey Gist, 226 N. Pleasant St., Prescott:

In most of the underground basins of Northern Arizona little development has been made. Many of these basins fill up to an underground outlet and there is no surface indications of the water trapped beneath the surface. The future will require the use, locally, of all such water, and no law should restrict the beneficial use of this water on adjacent lands. I realize that the whole matter will come before the legislature, and no one can foresee what the law will ultimately provide. Let us hope all sections will be fully protected.

233. George W. Leech, Electric and Refrigeration Service, Globe:

I own a twenty-inch well, 440 feet deep, with a lift of approximately 200 feet in the western part of the Queen Creek district in Maricopa County, which puts out 3000 g.p.m. of warm water.

From information that I have gained from the neighbors, their wells of similar depth have entirely different capacities, chemical analyses and temperatures, and for this reason "I do not think that my well is on the same water strata as the other wells and I also think that some committee should make a further study of the situation before any controls are made."

234. E. L. Kirchoff, Rt. 1, Box 576-A, Farmer, Mesa:

"Present water requirements are from four to four and a half acre feet per year. Lining all ditches and lining tail-water return ditches would probably reduce my requirements from six inches to one foot per acre.

I believe critical ground-water areas should be determined by basins. If a shallow water table is present in one area of a basin and a receding water table is present in another area of the same basin, both conditions must be considered for control of both areas.

It is entirely possible that some of the pumped water in this area is coming from storage. However, I feel certain that we are using it faster than it is

being replenished. Many areas of this basin could not pump water economically today if crop prices were normal.

If a considerable amount of the land now under pump irirgation is abandoned, there would be a tremendous effect on the economy of the state, to be sure. However, we must consider that if we continue in this uncontrolled expansion, the economic effect of the down-fall that must come some day would then be considerably more extensive than it would be today. So it isn't so much a question of whether or not it would hurt us economically as we know it would. The question is: Do we want to get hurt a little today or would we rather wait and get hurt a lot tomorrow?

Legislation should definitely attempt to balance ground-water recharge and withdrawal in present critical areas and in so-called border line areas. In non-critical areas the mechanics should be set up to control them also, should they ever become critical areas.

I would favor a state administrative determination of the amount of cut-back. The areas considered must be individual ground-water basins.

A state water resources commission or similar body would be best. There should be a statutory limit on the use of pump water within each basin.

We must have rigid control with severe penalties. Older ground should have prior rights over underground water as it does over gravity water. An underground water code should correct this situation for all time. It should be corrected as soon as possible in order that we might better be able to chart our futures. Correction now will be much less costly than at any later date."

235. J. F. Winchester, 802 W. Avalon Drive, Phoenix (Farm in Eloy Area):

Presented a written statement containing well information and pumping costs.

Concerning policy, the following opinions were expressed:

"Stop development of new land in critical areas. If wells have been drilled against public policy or state laws, then they should be held accountable to the authorities."

Legislation should contain strict penalties and should permit county committees to regulate the problem locally, with over-all supervision by the state.

I am a firm believer in water conservation districts, and believe Arizona could secure money at reasonable interest rates from some government agency to assist with such a program.

236. J. L. Hodges, Farmer, Buckeye:

A written statement containing detailed information on his wells, a careful and thoughtful analysis of power and production costs, together with agriculture's place in the economy of the community and of the county as a whole, was presented and is in the permanent files of the commission. Concerning policy, Mr. Hodges stated:

"I do not believe that any attempt by legislation should be made to balance ground-water recharge and withdrawal in any area.

I would not recommend any type of law that would enforce a cut-back in the use of pump water. I do believe it should be possible for users of pump water to agree among themselves both on designating the area and determining the amount of cut-back, if any, they desire to make therein.

I would not recommend any type of state organization to administer water laws. I do not believe it is possible for any man, or group of men, to do so without gross discrimination and injustice, even unintentional, and I think the result would be worse than no regulation whatever.

I can devise no method under which I think it would be fair and just to establish ground-water conservation districts except by majority agreement within such districts. I certainly do not think such districts should have the right to institute and enforce compliance with such measures as elimination of non-economic water loving plants, concrete lining of ditches, and prevention of tail-water waste. I see no objection to metering of wells or installing pumps and distributing water.

I do not believe in a general statutory limit on the use of pump water. I believe it should be left to individual or to self-made districts working under the laws of economics. One farmer may save enough on economy of operation to pay two or three times as much for water as another farmer could afford. One may grow more valuable crops where the cost of water is not an important factor.

I do not think it is possible to establish priorities for the use of pump water without a multitude of rank injustices. I am heartily opposed to such priorities. Certainly the drilling of replacement wells in any area should be allowed; might as well prohibit a man rebuilding his store after a fire. No limit should be placed on the location of replacement wells.

I believe the 1948 ground-water code is wrong because it discriminates against the owners of unde-

veloped land and because it allows for the establishment of critical area without majority control. To say a man cannot develop his land because there is too much competition for water is just as unreasonable and as unfair as to prohibit the owner of a vacant lot from building a drug store because there is too much competition in that line. I believe the 1948 code should be abolished.

In general I do not think it is possible to regulate the use of pump water by legislative limitation without stirring up more trouble than will result from leaving such regulation to economic laws; without gross injustices; without cluttering the courts with lawsuits and ruining people with their prosecution; without curtailing initiative in exploration. The diversity of conditions such as salt content of water, soil type, sub-drainage, water requirement for and profit from various crops, individual conservation measures, soil productivity, and other factors is too great to permit general application of law. Had it been illegal to drill wells in 1944 and 1948 I would never have found a new source of water, separated by a clay bank of approximately three hundred feet, below the known supply. To allot a definite quantity of water without regard to salt content would be equivalent to giving land with a sweet water supply up to twice as much water available for plant use as land irrigated with water high in salt, and to apportion water allotment on salt content would be an insuperable task."

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UNDERGROUND WATER COMMISSION

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The material contained in this index includes forty-one bound books, five miscellaneous books, one case of tape recording reels and one file with maps.

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