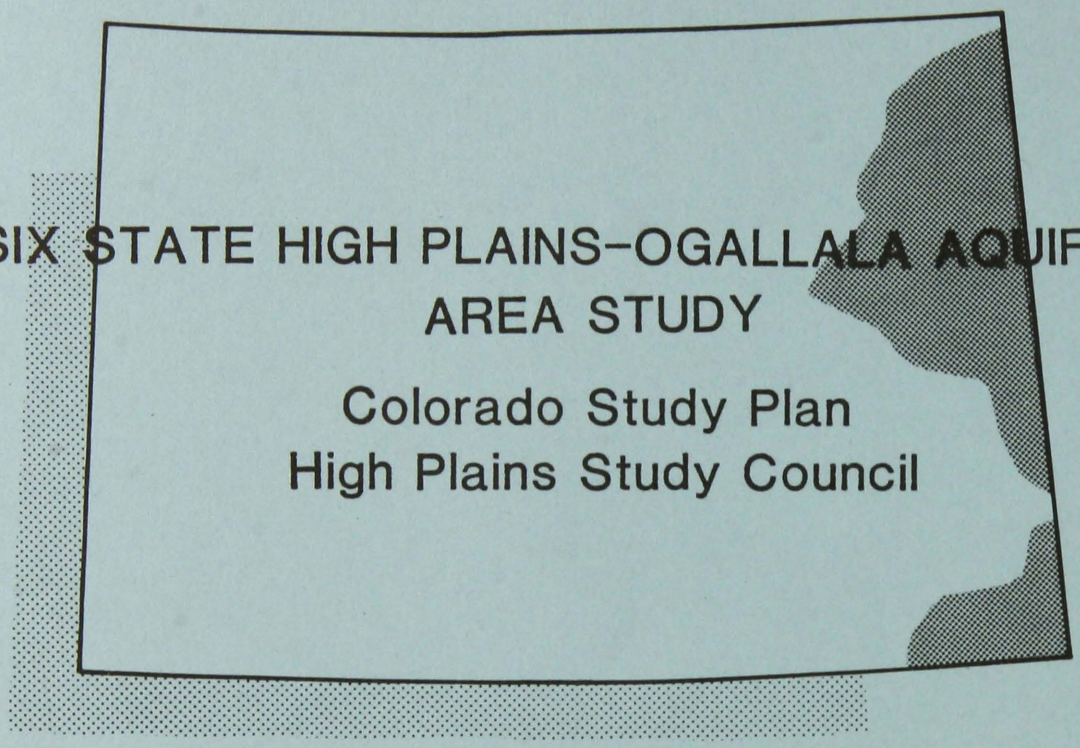
Longenbaugh



SIX STATE HIGH PLAINS-OGALLALA AQUIFER AREA STUDY

Colorado Study Plan
High Plains Study Council

DEPARTMENT OF NATURAL RESOURCES
Division of Water Resources

DEPARTMENT OF AGRICULTURE
Resource Analysis Section

OFFICE OF ENERGY CONSERVATION

COLORADO STATE UNIVERSITY

SIX-STATE HIGH PLAINS-OGALLALA AQUIFER STUDY

Colorado Study Plan

HIGH PLAINS COUNCIL

Governor Richard D. Lamm

Milton Mekelburg Harris Sherman Morgan Smith

LIAISON MEMBER
William R. Smith

TECHNICAL COORDINATOR
David L. Carlson

GENERAL CONTRACTOR
High Plains Associates

OCTOBER, 1979

SIX STATE HIGH PLAINS-OGALLALA AQUIFER AREA STUDY

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SECTION I

INTRODUCTION

RICHARD D. LAMM
Governor

W. R. SMITH
Acting State Engineer

DIVISION OF WATER RESOURCES

Department of Natural Resources
1313 Sherman Street - Room 818
Denver, Colorado 80203
Administration (303) 839-3581
Ground Water (303) 839-3587

September 14, 1979

Mr. Bob Keier
High Plains Associates
3445 Executive Center Drive
Austin, Texas 78731

Dear Bob:

Attached per our conversation today is a revised introduction to the Colorado State Study Plan, a copy of the map showing the subregions, a list of council members, and lead researchers in the study with their addresses and phone numbers, and six copies of the recommended amendment as suggested by our attorney general's staff.

I hope this will meet your needs at the present time and as soon as we have the published plan back from the printers I will send you a copy.

If you need additional information to make your records complete, please contact me.

Yours very truly,

William R. Smith

William R. Smith
Acting State Engineer

WRS:mas

Enclosures

OGALLALA-HIGH PLAINS STUDY
Colorado Study Elements

Introduction

Declining water levels in the Ogallala aquifer of eastern Colorado as well as in the States of Nebraska, Kansas, Oklahoma, Texas and New Mexico resulted in a common concern for not only the future of these state areas, but also for the effect of this decline on agriculture production as a significant part of the regional and national economy. This common concern for the economic impact of decline in irrigated agriculture coupled with decreasing energy production in several of the states lead to enactment of Public Law (P.L.) 94-587 Sec. 193 which provided for the six-state High Plains-Ogallala Area Study.

The intent of the Congress for the study is stated as follows:

> "Sec. 193. In order to assure an adequate supply of food to the nation and to promote the economic vitality of the High Plains Region, the Secretary of Commerce...is authorized and directed to study the depletion of the natural resources of those regions...presently utilizing the declining water resources of the Ogallala aquifer, and to develop plans, to increase water supplies in the area and to report thereon to the Congress...In formulating these plans, the Secretary is directed...to examine the feasibility of various alternatives to provide adequate water supplies to the area...to assure the continued economic growth and vitality of the region..." (emphasis added)

As a result of this legislation and the problems cited in it, the states requested the Department of Commerce through its Economic Development Administration (EDA) to formulate a study design to meet the need.

The six states, with EDA, formed the High Plains Study Council to assure proper state participation in and guidance for the study. Each state has three members on the Council appointed by their Governor as well as a member on a Liaison Committee to coordinate the state efforts with those of EDA and the General Contractor. Colorado Council membership includes Harris Sherman, Executive Director of the Department of Natural Resources; Milton Mekelburg, Yuma area farmer and businessman; and Morgan Smith, Commissioner of the Department of Agriculture. William R. Smith, Acting State Engineer is Colorado's representative on the Liaison Committee.

In October, 1976, the Congress authorized the study at a funding level of six million dollars. The allocation of funds provides for two million dollars to conduct the state elements as set forth in the study plan developed from the High Plains Project, noted below, approximately three-fourths of a million dollars for the U.S. Corps of Engineer's responsibilities to review interbasin transfer prospects to be noted later, and the remainder to be expended by the general contractor on the regional element assignments as set forth in the study plan.

A study design, known as the High Plains Project, (appendix A) was approved by the High Plains Council on February 21, 1977, which served as a basis for requesting proposals from potential contractors interested in conducting the study on behalf of EDA and the Council. Proposals were received and reviewed by members of the Liaison Committee and key federal agencies. The top qualified applicants were referred by this select group to Council and were interviewed by Council and EDA on May 30, 31, and June 1, 1978. On September 22, 1978, a contract was awarded to Camp Dresser and McKee Inc., as prime contractor in association with Black and Veatch as joint venturers, and Arthur D. Little, Inc., as subcontractor.

In addition to the states and the general contractor the U.S. Corps of Engineers has a significant role to play. The Secretary of the Army, acting through the Chief of Engineers, is directed in P. L. 94-587 to consider alternatives for transfer of water from adjacent areas as a means of supplementing available supplies. This work is an integral part of the overall study and is to be accomplished in collaboration with the general contractor.

Figure I shows the High Plains Study Organization. "Appendix A" contains a more detailed description of the entire High Plains Project.

Alternative Development Strategies

In order to accomplish the overall purpose of the study and to respond to P.L. 94-587, Sec. 193, alternative development strategies will be developed and integrated in the final report. The tentative list of strategies are as follows:

(O) Baseline - no new public action or deliberate change-continuation of current trends in water and agricultural management in public and private sectors.

(1) Voluntary Water Demand Management - incentives provided for technological change and improved water and agricultural management practices at the farm level.

(2) Alternative (1) above plus Mandatory Water Demand Management - institutional/regulatory change requiring water conservation, improved water and agricultural management practices at farm level, and/or restrictions on new irrigated agriculture developments.

(3) Alternative (2) above plus Local Water Supply Management - water supply augmentation (e.g., snowpack, vegetation, land use, evaporation, precipitation management, artificial recharge).

(4) Alternative (3) above plus Minor-Subregional Importation Supply Management - generally intrastate if long-term surpluses exist in certain intrastate regions.

(5) Alternative (4) above plus Major Importation Supply Management - major water importation schemes.

For each of the above, the outcomes or impacts can be measured in terms of (a) changes in agricultural production, income and employment induced by the change in available water supplies, both on the farm and in the agribusiness industrial sector, and (b) the nonagricultural production, income and employment necessary to meet shortfalls in continued regional economic growth and vitality. Outcomes and impacts will be evaluated and compared at the national, regional , state and subregional levels. This procedure will allow the High Plains Council and the Secretaries of Commerce and Army to develop policies and plans involving combinations of strategies at the state and subregional level, as appropriate to differing situations and subregions over time.

These are the alternatives as originally presented in the interim report to the Congress forwarded on January 15, 1979, however, minor modifications have been made as a result of study developmemt to date.

Regional Basin

The High Plains area extends over parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma and Texas in the Great Plains land resource region of mid-continental America as shown on Figure 2. Much of the High Plains is underlain by the Ogallala Formation, a major aquifer supplying most of the water needs of the area's large agricultural economy.

The Ogallala Formation is an unconsolidated remnant of vast deposits of gravel, sand, and silt eroded from the Rockies. Erosion has reduced the area of the extensive deposits that once covered all of the Great Plains region, leaving the Ogallala as the principal geologic unit associated with the High Plains today.

The specific area encompassed by this study includes 180 counties in the six-state region underlain in whole or in part by the Ogallala Formation, an area of about 225 thousand square miles. As a part of the overall study, the related economies of nearby cities including Denver, Oklahoma City, Tulsa, Kansas City, Albuquerque, and Lincoln and Omaha must be considered. Peripheral aquifers which are interrelated with the Ogallala must be taken into account. The interbasin transfer studies will consider potential sources of water outside the study area.

Colorado's Basin

The Colorado portion of the Ogallala-High Plains aquifer lies in the east-central and southeast part of the state in two separate basins. This portion of the aquifer lies beneath all or part of eleven Colorado counties and covers approximately 6.9 million acres. The northern Colorado basin lies between the drainages of the South Platte and Arkansas Rivers and covers a triangular area that could be described as extending from a point east of Limon in a northeasterly direction to the Colorado-Nebraska state line at a point a few miles south of Julesburg and from this same point east of Limon in a southeasterly direction to the Colorado-Kansas state line southeast of Sheridan Lake. The southern basin which covers the southeastern part of Prowers County, most of Baca County, and the southeastern corner of Las Animas County could best be described as that part of the state lying southeast of a line running roughly from Cheney Center in a south-

westerly direction to the Colorado-New Mexico state line south of Kim.

The two basins differ considerably, as the study will develop, both from the source of their basic water supply and the controlling factors effecting the economics of irrigated agriculture.

With the exception of limited surface and alluvial water supplies from the North Fork of the Republican River, Arikaree River and the South Fork of the Republican River, all of the northern basin's supply of water is from the Ogallala formation. The aquifer varies from a fingeredge on the westerly edges of the basin to variable thicknesses up to 400 feet on the east. Saturated thickness varies from O to in excess of 350 feet with extreme variables in some areas because of irregular bedrock elevations. Although transmissivity varies, for the most part yields are primarily a function of saturated thickness.

The Southern High Plains has a multiple aquifer development with very limited irrigation from surface supplies from Bear Creek and Two Buttes Creek. The Ogallala formation in this basin is quite limited and from a practical point of view is currently uneconomic for irrigation supplies because of little original saturated thickness, depletion, or loss to the lower aquifers because of early improperly completed wells. The other formations supplying water are the underlying Dakota, Cheyenne, and Dockum sandstones. Unlike the aquifer to the north, these formations are quite tight and the combination of limited yields and depth to pumping water level are the limiting factors controlling the irrigated agriculture in this basin.

Institutional Status

Both of the basins indicated above as Colorado's portion of the regional Ogallala study have been determined to be "Designated Ground Water Basins" as defined in the Colorado Ground Water Management Act of 1965. The northern portion or area, designated in 1966, is known as the Northern High Plains Designated Ground Water Basin and the other, designated in 1967, is known as the Southern High Plains Designated Ground Water Basin. These basins are administered differently from the historic surface streams and waters tributary thereto in other parts of the state.

In 1965, the Colorado Legislature passed the "Colorado Ground Water Management Act." This statute was the first effort by a Legislature to deviate from the strict priority, first in time is first in right, concept of the Colorado Constitution. The Legislature said in its declaration of policy"...While the doctrine of prior appropriation is recognized, such doctrine should be modified to permit the full economic development of designated ground water resources. Prior appropriation of ground water should be protected and reasonable pumping levels maintained, but <u>not to include the maintenance of historical water levels.</u> (emphasis added) All designated ground water in this state is therefore declared to be subject to appropriation in the manner defined in this article." This is from Article 90, Title 37, C.R.S. 1973.

In order to accomplish the purpose of the statute the Colorado Ground Water Commission was created and consists of representatives from the designated basins,

the San Luis Valley, two municipal and industrial representatives, one from the east slope and one from the west slope, and three ex-officio members. Ex-officio members include the state engineer designated as ex-officio executive director, the director of the Department of Natural Resources and the director of the Water Conservation Board. The Commission was given the authority to determine and administer the designated ground water of the state on a broad and comprehensive base. In order to allow maximum local participation, particularly in the area of management and control, the Legislature provided for the establishment of management districts upon petition of the tax paying electors, approval of the Commission, local hearings, and election. The statute provided that no district could be organized unless all ground water aquifers within the geographic boundaries of the proposed district had been designated as a part of the district and provided for divisions being established in the district with a governing board made up of one representative from each division. Following organization of the district, the board could adopt, after publication and hearing, such control measures as it felt necessary to fulfill its responsibilities under the statute.

Designated ground water is defined as that water which in its natural course would not be available to and required for the fulfillment of decreed surface rights, or ground water in areas not adjacent to a continuously flowing natural stream wherein ground water withdrawals have constituted the principal water usage for at least fifteen years preceding the date of the first hearing on the proposed designation of the basin, and which in both cases is within the geographic boundaries of a designated ground water basin.

All water in both of these basins except water in the natural surface streams and their alluvium have been defined as "designated ground water" and they are "designated ground water basins."

Colorado's Study Organization

Following the analysis of the High Plains Project and the general contractor's element and task recommendations, the Colorado representatives on Council (Harris Sherman, Director of the Department of Natural Resources, Milton Mekelburg, Yuma area farmer and businessman, Morgan Smith, Commissioner of the Department of Agriculture and the Colorado liaison for the study, William R. Smith, Acting State Engineer) met and devised a plan of element assignment.

State coordination of the project is the responsibility of the Colorado Department of Natural Resources. Mr. Bill Smith will continue to serve as state staff liaison between Colorado, the general contractor and the other states. In addition, Mr. Smith will provide overall fiscal management for the Colorado portion of this project. Coordination with university scientists will be handled through the Colo-Water Resource Institute.

The Colorado Department of Agriculture has the responsibility of coordinating timely completion of all state work elements and resolving difficulties and delays between state and regional work elements. In addition, the Department of Agriculture is responsible for conducting the public involvement component of this project. Dr. David Carlson, program administrator for the Department's Resource

Analysis Section, has been assigned overall technical coordination responsibility; he will be assisted by Mr. Jim Rubingh, resource analyst in the section.

Colorado's technical contribution to this study consists of five major components:

farm-level analysis
energy analysis
hydrology analysis
regional economic analysis
demographic and environmental analysis

The purpose of element A-1 (farm economics) is to analyze the relationships between declining water levels, rising energy costs and agricultural production at the individual farm level for a four-decade period (1980-2020). Dr. Robert Young, with the Department of Economics at Colorado State University, is responsible for this analysis. Important variables to be projected during this period include: production and value of selected crop and livestock enterprises; and quantity and value of inputs such as land, water, labor, machinery, energy, fertilizer and pesticides. Projections will be made for each of several different water supply, energy, and public policy scenarios. Linear programming models will be used to estimate direct projections.

The Office of Energy Conservation was assigned lead responsibility in the A-2 energy element. The purpose is to project time profiles for the study region in the areas of: 1) energy production, 2) royalty payments to landowners for energy production, 3) employment directly and indirectly related to the energy industry, 4) water used for energy production, and 5) energy requirements for irrigation. Mr. Ronald Cattany, Director of Energy Analysis and Program Assessment, has been assigned to manage these responsibilities. OEC will work closely with the Department of Natural Resources in the development of energy production data, the Division of Planning in employment and income data, and Colorado State University in irrigation data. OEC will review price projections and technology assessments of the general contractor as well as assemble the final report.

The Ground Water Section of the Division of Water Resources, Department of Natural Resources; headed by Dr. Bruce E. DeBrine, is responsible for the A-3a or water related element. The section, in constant contact and working very closely with the U.S. Geological Survey, has up-to-date detailed information on the geohydrologic characteristics of the aquifer, well development and yields, irrigated acreage and water table fluctuations. This information will be analyzed and reduced for computer entry to supply information and projections on water availability and well production lifts, and other pertinent data to the other study elements, A-3.1 through A-3.9 and for input to elements A-1 and A-2. A computer grid compatible with the needs of the other elements and adjoining states will be developed for each of the proposed subregions of the Colorado Ogallala Study area. Projections are planned for 10-year periods from 1980 to 2020 and will be made under conditions of a continuously declining water level (supply) assuming no recharge, and declines of well withdrawals related to declining water levels. The projection will be refined for inclusion in task A-3.9 as needed. Continuing coordination with the other study elements groups will be maintained at all stages.

The principal task of work element A-3b (regional economic analysis) is to describe the economic effects upon the High Plains region of alternate development strategies for the Ogallala Aquifer. Dr. John McKean, with the Department of Economics at Colorado State University, is the principal investigator of this element. Economic input-output models of the region (and the three planning and management regions which enclose the High Plains region) will be developed to project income, output, water use, energy use, and employment for each economic sector within the study region. In addition, the models will provide detailed projections of government receipts and expenditures, and projections of other required local social services. A secondary task of this work element is to use the existing 1970 state input-output model to measure the impacts of changes in the study region on the rest of the state.

Demographic and environmental analysis (remainder of work element A-3b) will be conducted by the Colorado Division of Planning under the direction of Mr. Charles Jordan. Mr. Jordan will insure that the development of input-output models are compatible with ongoing state studies. A detailed directory of state participants in this study is appended to this report.

Budget

The $300,000 for the cost of state element study has been allocated as indicated below. All elements were curtailed to some extent from our preliminary plan transmitted on May 14, 1979. Assumption of some staff costs by all participants, including Colorado State University and an indirect charge of sixteen percent, considerably below the charge generally levied against contracts and grants was necessary to accomplish the intent of element assignments within the allotted funds. The breakdown is as follows:

Elements:	Technical Coordination	30,000
	Public Awareness	20,000
	A-1 (Colorado State University)	78,125
	A-2 (Office of Energy Conservation)	38,500
	A-3a (Division of Water Resources)	35,957
	A-3b (Colorado State University)	49,225
	A-3b (Division of Planning)	26,700
	Total Direct Cost	278,507
	Less Colo. State Univ. Funding	20,000
	Total	258,507
	Cost 16%	41,361
	Total	299,868

Scheduling & Timetables

Work has begun on Element A-1 and subcontracts will be written and work will commence in other areas immediately on receipt of a contract or letter of commitment from the general contractor.

While every effort will be made to conform to the timetables as set by the general contractor in their overall study plan, adjustments may be necessary due to the late start. Requests for extensions will be directed through and coordinated by the liaison for Colorado or his delegate.

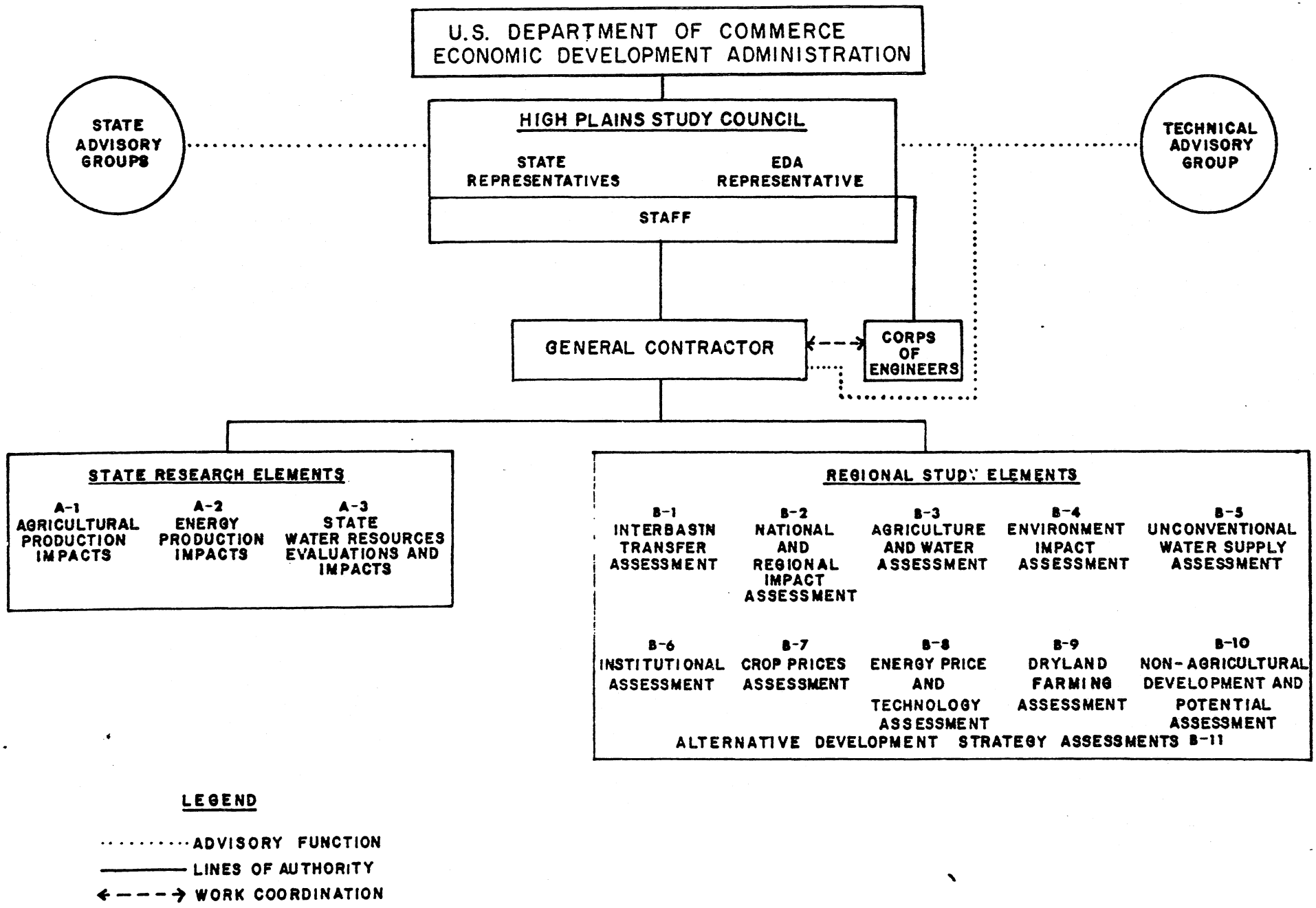
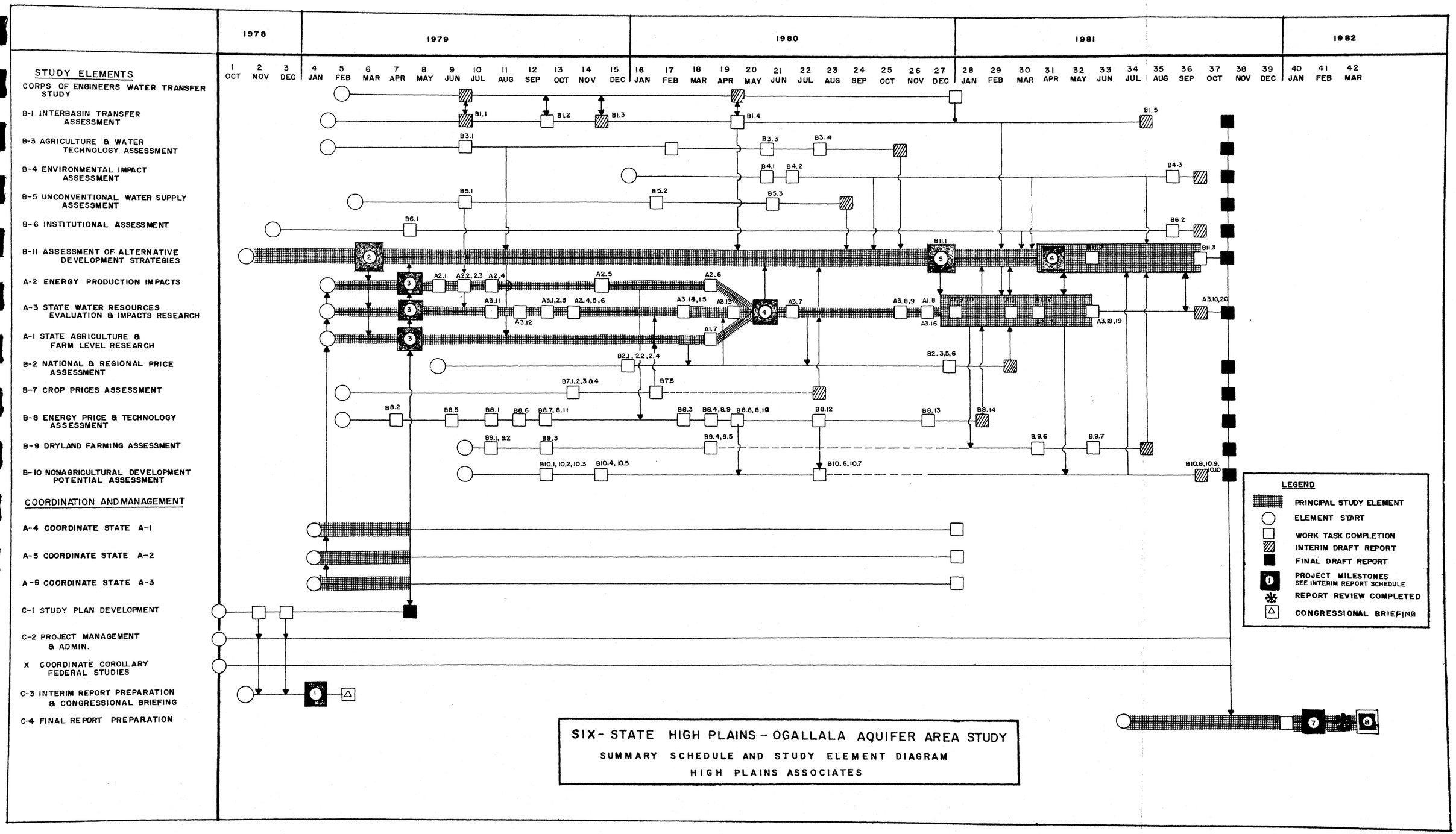


FIGURE 1 - HIGH PLAINS STUDY ORGANIZATION



SIX-STATE HIGH PLAINS-OGALLALA AQUIFER AREA STUDY

SUMMARY SCHEDULE AND STUDY ELEMENT DIAGRAM

HIGH PLAINS ASSOCIATES

SECTION II

COLORADO STUDY ORGANIZATION

Personnel

COLORADO HIGH PLAINS STUDY DIRECTORY

A. HIGH PLAINS COUNCIL

Mr. Morgan Smith, Commissioner
Colorado Department of Agriculture
1525 Sherman Street
Denver, Colorado 80203
(303) 839-2811

Mr. Harris Sherman, Executive Director
Department of Natural Resources
1313 Sherman Street
Denver, Colorado 80203
(303) 839-3311

Mr. Milton "Bud" Mekelburg
Route 1
Yuma, Colorado 80759
(303) 774-7475

COLORADO HIGH PLAINS STUDY DIRECTORY

B. HIGH PLAINS ADVISORY COMMITTEE

(to be selected)

COLORADO HIGH PLAINS STUDY DIRECTORY

C. STAFF

State Liaison and Fiscal Coordinator:

Mr. William R. Smith, Acting State Engineer
Division of Water Resources, Department of Natural Resources
1313 Sherman Street, Room 818
Denver, Colorado 80203
(303) 839-3581

Technical Coordination:

Dr. David Carlson, Program Administrator
Resource Analysis Section
Colorado Department of Agriculture
1525 Sherman Street
Denver, Colorado 80203
(303) 839-3218

Mr. Jim Rubingh, Resource Analyst
Colorado Department of Agriculture
1525 Sherman Street
Denver, Colorado 80203
(303) 839-3218

Agricultural and Farm Level Analysis
(Elements A-1.1 through A-1.10)

*Dr. Robert Young
Department of Economics
Room B-325, Social Science Building
Colorado State University
Fort Collins, Colorado 80523
(303) 491-7346

Dr. Robert Longenbaugh
Associate Professor of Civil Engineering
Room 208, Old Chemistry Building
Colorado State University
Fort Collins, Colorado 80523
(303) 441-5861

Mr. Lawrence R. Conklin, Research Associate
Department of Economics
Colorado State University
Fort Collins, Colorado 80523
(303) 491-6324

Energy Analysis
(Element A-2)

* Mr. Ronald W. Cattany, Director
Energy Analysis and Program Assessment
Colorado Office of Energy Conservation
1600 Downing Street, 2nd Floor
Denver, Colorado 80218
(303) 839-2507

Water Analysis
Element A-3.1 through A-3.9)

* Dr. Bruce De Brine, Water Resources Division
Department of Natural Resources
1313 Sherman, Rm 818
Denver, Colorado 80203
(303) 839-3587

Mr. Leonard A. Mercer, Chief-Designated Basin Branch
Ground Water Section, Water Resources Division
Department of Natural Resources
1313 Sherman, Rm 818
Denver, Colorado 80203
(303) 839-3587

Mr. Ben Saunders, Manager
Frenchman, Marks Butte, Central Yuma and Sandhills,
Ground Water Management Districts
144 W. Furry Street
Holyoke, Colorado 80734
(303) 854-3294, 854-3484, 332-4155

Regional Economic Analysis
(Elements A-1.11 through A-1.12 and A-3.10 through A-3.16)

*Dr. John McKean
Department of Economics
Room B-324, Social Science Building
Colorado State University
Fort Collins, Colorado 80523
(303) 491-5251

Dr. Joseph C. Weber
Department of Mineral Economics
Colorado School of Mines
Golden, Colorado 80401
(303) 279-0300 X 491

Demographic and Environmental Analysis
(Elements A-3.17 through A-7.18)

* Mr. Charles Jordan, Chief Planner
Colorado Division of Planning
1313 Sherman, Rm 520
Denver, Colorado 80203
(303) 839-2351

Public Involvement Component

(to be selected)

* Work Element Leader

SECTION III

STUDY ELEMENTS AND TASK ASSIGNMENTS:

PUBLIC INVOLVEMENT & TECHNICAL COORDINATION

AGRICULTURAL & FARM LEVEL RESEARCH
Elements A-1.1 through A-1.10

HIGH PLAINS ENERGY
Elements A-2

WATER RESOURCE IMPACTS
Elements A-3.1 through A-3.9

STATE IMPACT RESEARCH

a. Input-Output
Elements A-1.11 through A-1.12

b. socio Economic Impact
Elements A-3.16 through A-3.18

PUBLIC INVOLVEMENT & TECHNICAL COORDINATION

Richard D. Lamm
Governor

Morgan Smith
Commissioner

Donald L.Svedman
Deputy Commissioner

STATE OF COLORADO

COLORADO DEPARTMENT OF AGRICULTURE
406 STATE SERVICES BUILDING
1525 SHERMAN STREET
DENVER, COLORADO 80203

Agricultural Commission

William A. Stephens, Gypsum
Chairman

Ben Eastman, Hotchkiss
Vice-Chairman

Henry Christensen, Roggen
John L. Malloy, Denver
Elton Miller, Ft. Lupton
Don Moschetti, Center
William H. Webster, Greeley
Clede Widener, Granada
Kenneth G. Willmore, Denver

November 16, 1979

MEMORANDUM

TO: Bill Smith

FROM: David Carlson DL Carlson

SUBJECT: Public Involvement and Technical Coordination Components of State Work Plan

This memorandum contains program and budget details for these two components for the Colorado portion of the Ogallala-High Plains Project. It is understood that both components are to be managed by the Colorado Department of Agriculture, which will receive $58,000 in project funds to carry out the tasks described below. You will note that $20,000 is budgeted for public involvement, and $38,000 for technical management. This memorandum supersedes my memorandum of September 4, 1979, on the same topic.

PUBLIC INVOLVEMENT COMPONENT

Description

This component has three major objectives: (i) to disseminate information early on the goals and scope of work of the project to agricultural organizations, civic groups, government officials, and other interested groups and persons; (ii) to keep these groups and persons informed as to the progress of the project at regular intervals; and (iii) to identify issues, concerns, and suggestions from these groups and persons, and to transmit them to work element leaders and the general contractor whenever appropriate.

The key element of this component is the establishment of a regional advisory committee for the duration of the project. This committee will consist of 8-15 members, representing major interest groups and geographical areas in the region. The committee will be requested to assist Department staff in developing overall direction and details of the public involvement component.

One of two options will be selected after consultation with the advisory committee. The first option is to implement the program from Denver through a half-time coordinator hired and supervised by the Colorado Department of Agriculture. The second option is to implement the program from the High Plains region through a half-time coordinator hired and supervised by a High Plains organization yet to be identified. If the second option is selected, a subcontract with a suitable High Plains organization will be prepared and managed by the Colorado Department of Agriculture. Possible High Plains organizations include: soil conservation districts, regional councils of governments, or the advisory committee itself.

There are sound reasons for preferring the second option, even though it is more complex than the first. The second option actively involves the region more deeply in the project--a vital prerequisite to substantive regional involvement in discussing alternative strategies once the technical work is completed. Hiring a public involvement coordinator from the region who knows the local leadership will also save time and avoid major gaffes, such as ignoring ligitimate regional interests. Also, option two gives the regional advisory committee additional incentive to continue meeting throughout the project--particularly if this committee decides to assume responsibility for the public involvement program itself.

Regardless of which option is selected, each of the following public involvement activities and tools will probably be used to some extent: public meetings and workshops; public presentations to agricultural organizations, civic groups, government officials, and other groups; news releases; brochures; and a newsletter. Details will be worked out with the help of the regional advisory committee.

Although the High Plains region is the primary area for public involvement, the rest of the state will not be neglected. The public information officer of the Colorado Department of Agriculture will inform groups and persons throughout the state as part of her usual duties. In addition, state agencies will be kept informed through already established interagency committees and other channels.

TECHNICAL COORDINATION COMPONENT

Description

The coordination of Colorado portion of the High Plains project will be shared by two agencies: the Colorado Department of Natural Resources (DNR), and the Colorado Department of Agriculture (CDA). General coordination between Colorado, the other states in this project, and the General Contractor--including fiscal coordination--will be handled by DNR. More specifically, Mr. Bill Smith, Deputy State Water Engineer in DNR, will continue as state coordinator.

Technical coordination will be handled by CDA, under the direction of Dr. David Carlson, with assistance from Mr. James Rubingh, of the Resource Analysis Section of the Department. Technical coordination includes monitoring the progress of individual work elements to insure completion of these elements in a timely

manner, and resolving difficulties in timing and content, if any, between state and regional task elements. In addition, technical coordination includes management both technical and fiscal--of the public involvement program described earlier.

AGRICULTURAL AND FARM LEVEL RESEARCH

Elements A-1.1 through A-1.10

ELEMENT DESCRIPTION

ID NUMBER:	A-1
TITLE:	State Agricultural and Farm-Level Research
PURPOSE:	To project time profiles of cropping patterns, agricultural output, output values, input costs and employment, and income for each of the six High Plains states (or possibly aggregations of the Northern and Southern states of the High Plains) under alternative development strategies.

TASK ASSIGNMENTS

Element tasks will include:

A-1.1 Review crop budgets for different years and different parts of the High Plains; compile data on land classification and land uses

A-1.2 Evaluate previously developed agricultural simulation and linear programming models

A-1.3 Develop, with the General Contractor, consistent interstate assumptions of cost-price relationships for different crops and livestock

A-1.4 Develop, with the General Contractor, consistent interstate assumptions of projected fixed and variable cost components-providing for variation in energy and water costs and constraints

A-1.5 Develop, with the General Contractor, consistent interstate assumptions of public policies, yield trends, and variability for crop and livestock production

A-1.6 Develop reasonably consistent model structures among the states

A-1.7 Assemble and verify baseline data on agricultural and irrigation management practices, yields, agricultural output, employment and income, fixed and variable costs, etc.

A-1.8 Test and refine models

A-1.9 Simulate agricultural production under the varying assumptions developed in Tasks A-1.3 and 4 and 5, and the alternative development strategies formulated by the General Contractor with the concurrence of the High Plains Study Council

A-1.10 Project agricultural output, values, costs, farm employment, income, and water demand for the High Plains area of each state under alternative development strategies; project irrigation water demands and payment capacity for supplemental water for those strategies involving augmentation of supply.

DETAILED PLAN OF STUDY

OGALLALA HIGH PLAINS AQUIFER STUDY (COLORADO)

COLORADO AGRICULTURAL AND FARM LEVEL RESEARCH

(Elements A-1.1 through A-10)

Prepared under direction of R. A. Young.

Person to contact regarding Plan of Study

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INTRODUCTION

This study plan is with reference to the Colorado portion of a study of the region overlying the Ogallala Aquifer in parts of the six states of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas. The overall regional study plan is detailed in a document prepared by the High Plains Associates (the "General Contractor"), Interim Report: Six State High Plains-Ogallala Aquifer Area Study dated January 15, 1979. This section describes the workplan for state element A-1 and the economic input-output modeling in state element A-3 (elements A-3.10 to A-3.16, inclusive). This section is divided into two subsections. The first subsection describes the workplan for elements A-1.1 to A-1.10; the second subsection describes the workplan for elements A-1.11 to A-1.12, and A-3.10 to A-3.16.

The Ogallala aquifer formation underlies portions of counties in eastern Colorado. A very rough preliminary estimate suggests approximately one-half million acres are under irrigation from this groundwater source. Natural recharge is negligible, so that in the absence of large-scale importation of water from other sources, the irrigated portions of the region face an eventual return to non-irrigated production.

The principal crop in the study region is corn, accounting for some 75 percent of irrigated acreage. Hay accounts for another ten percent, and the balance is about evenly divided between wheat, dry beans and sugar beets. More than 2 million acres of non-irrigated cropland is harvested in this eleven-county area each year. Nearly 90 percent of this dry cropland produces winter wheat, while the balance is in hay or feed grains (sorghum, barley, corn). Some livestock operations are present, mainly cattle-feeding operations, which convert the feed grain and forage production into finished meat animals.

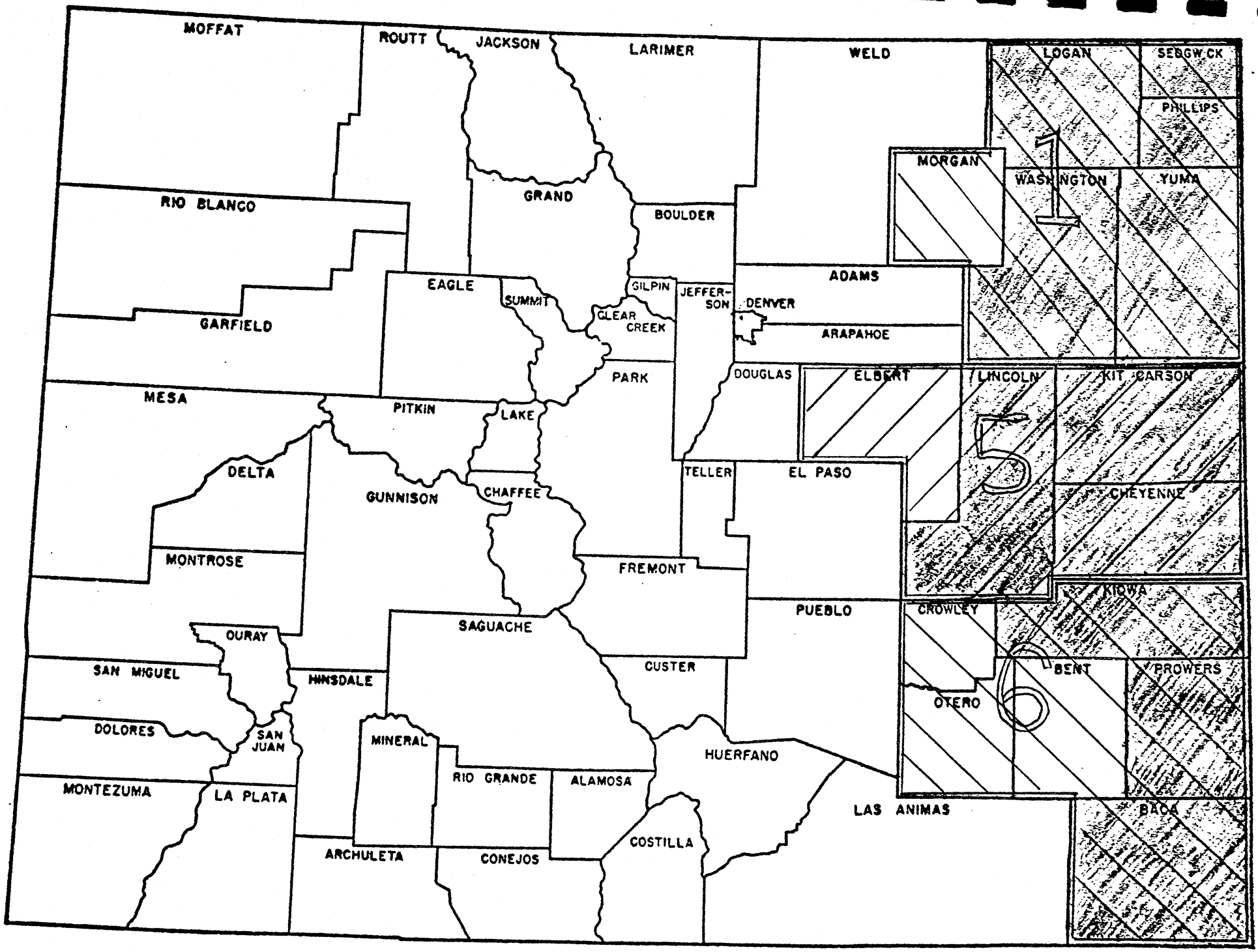
The counties in Colorado to be considered in this study are identified on the map on the following page. The shaded areas indicate the eleven-county region lying over the Ogallala formation in Colorado. Farm-level research will focus on this region. The map also displays the three planning and management regions which contain the eleven-county Ogallala area. The second subsection of this portion of the Colorado workplan outlines the steps for preparing an economic input-output model for each of these three planning and management regions, plus a model for the Ogallala area itself.

The purpose of Element A-1 is to develop projection of important variables describing agricultural production and agri-business activities for the Colorado portion of the Ogallala region for a four-decade period (1980-2020) for each of several specified water supply, energy and public policy scenarios. The important variables to be projected include production and value of selected crops and livestock enterprises; quantity and value of significant inputs, including land, water, labor, machinery, fertilizer, pesticides, etc. Projections are to be made for each of a number of alternative assumptions regarding public policy with respect to the region's water and energy supplies. Direct impact projections are to utilize linear programming models.

This will be done by constructing four input-output models in the eastern High Plains of Colorado--one model for the eleven-county region overlying the Ogallala, and one model for each of the three planning and management regions, which together contain the Colorado portion of the Ogallala. In order to obtain these additional models, Colorado State University is providing $20,000 in funds toward this project.

Responsibility for carrying out this portion of the Colorado workplan is the Department of Economics, Colorado State University. Project oversignt and review will be the responsibility of the Colorado Department of Agriculture. Professors Robert Young and John McKean are co-principal investigators. Dr. Young will have primary responsibility for work elements A-1.1 through A-1.10; Dr. McKean will have primary responsibility for work elements A-1.11, A-1.12, and A-3.10 through A-3.16. Dr. Joseph Weber, Colorado School of Mines, will assist Dr. McKean in compiling data for the input-output models and constructing appropriate tables. As their vitae indicate, these three men have had extensive experience in constructing linear programming and input-output models of the type needed in the present study.

At this time, it is anticipated that final reports covering these work elements will be ready by December 1980.



HIGH PLAINS-OGALLALA COUNTIES (SOLIDLY SHADED)

ELEMENT TASK A-1.1: CROP BUDGET REVIEW AND LAND CLASSIFICATION AND USE PATTERN ASSESSMENTS

A. Description of Sub-task

The initial step will be to review the validity and usefulness of budgets for individual crop and livestock enterprises available for the study area. These budgets will provide the basis for developing specific activities in the linear programming models in the main analysis. The number and type of budgets required will depend on the number of farm types (according to size, soils and/or enterprise combinations), as well as on the specifications of the linear programming models (see Task A-1.6, below). The possibility of introducing higher value crops with higher water costs will be examined.

The second part of this task will require compilation of data on land use and soil classifications in the study area. Separate budgets and L. P. models may be appropriate for different soil types.

B. Data Requirements and Availability

1. Crop Budgets

The study plan contemplates adopting the Oklahoma State University Crop and Livestock Budget Generator format (Walker and Kletke, 1972) (per memo from Wilkinson/ADL March 16, 1979).

The Oklahoma format has been adopted by the U. S. Department of Agriculture into a system of budgets applicable for climatic/soil resource regions nationwide. This system is called the Firm Enterprise Data System (FEDS). Budgets representing corn, wheat, and livestock enterprises are available for the Colorado study area.

The only alternative source of enterprise input-output data would include primary data collection in the region. Initially, agricultural specialists (CSU Extension Service agents and Farm Management organization advisers) in the area would be interviewed. If necessary, this information would be supplemented by sample surveys of farmers in the area to determine current production technology.

Since the available data are for current prices and technologies, adjustment would be required for each crop and soil-type category for alternative technologies and prices throughout the five-decade period of analysis.

2. Land Use and Soil Classificaiton Inventory

Soil type inventories are an important initial step, since crop and water productivity is largely determined by soil characteristics. Also, costs of crop production and feasibility of alternative production and irrigation technologies are contingent upon soil type. These data would be obtained from Soil Conservation Service publications and interviews with SCS and CSU personnel.

Land use patterns are available on an historical basis from the Census of Agriculture, and from the Colorado Crop and Livestock Reporting Service annual reports. SCS reports also provide estimates on this topic.

C. Personnel and Time Requirements*

1. Duration: 1.0 month--June 15-July 15, 1979

2. Personnel

(a) Senior agricultural economist--0.20 months.
(b) Research Associate in agricultural economics--0.75 months.
(c) Agronomist/Soils Specialist--0.15 months.

D. Inputs and Outputs

1. Inputs required from B-series activities by general contracts and regional coordinating committees for A-1.

2. One output of this phase will be a plan for formulating the range and type of crop budgets appropriate to be utilized in the models to be adopted in Task A-1.6. The plans would be carried out in Task A-1.7. The other major output would be the summary of soil classification and crop adaptability. Maps summarizing present and potential use patterns would be prepared.

3. Documentation--Report of sub-task findings and data sources will be prepared.

*Note: Personnel totals will normally not sum to the figure for duration.

ELEMENT TASK A-1.2: REVIEW OF AGRICULTURAL RESPONSE MODELS

A. Description

The overall assignment of Element A-1 is to project direct agricultural economic impacts of alternative policies, water supply situations and energy situations. This problems falls within the general framework of agricultural production response analysis. There is a large literature on this issue. The "modern" approach originated with John D. Black's (1951) analysis of interregional competition in dairy production which used budgeting procedures. The advent of linear programming theory together with the avialability of digital computers had led to a large outpouring of academic literature on production response analyses (Heady, et al., 1958). Recent adaptations have incorporated regional consideration in supply and demand, non-linear objective functions, risk aversion, etc. (H. O. Jensen, 1977).

Numerous adaptations to water allocation can be found in the literature. Those incorporating piece-wise lineraization of the irrigation water response function are of most interest for the present study (Young and Bredehoeft, 1972).

An issue of considerable importance for the High Plains study is to design the analysis so as to model the interaction between the aquifer and the water demand. This arises because the water use depends on the cost of pumping, which depends on the depth to water. Water depth in subsequent periods demands on previous demands for water, leading to a crucial interdependency between the hydrologic and economic considerations. Burdick, Martin, and Young (1969) develop a procedure for modeling this interplay.

The approach utilized the USGS analog model for the Central Arizona Aquifer combined with linear programming models of farm situations in the same area. Bredehoeft and Young (1970) adapted the procedure to the digital computer. A digital representation of the central Arizona aquifer was combined with the linear programming models to provide a simulation model which predicted water use and incomes in response to policy changes for a fifty-year period.

B. Personnel and Time Requirements

1. Duration: 0.75 months (July 1 - July 22, 1979)

2. Personnel:

   (a) Senior Agricultural Economist, 0.125 months
   (b) Junior Agricultural Economist, 0.25 months

C. Inputs and Outputs

1. Inputs--Coordination required from General Contractor and regional coordinating committee for A-1.

2. Outputs--Output of this phase would be a literature review evaluating previously developed procedures.

3. Documentation--Report summarizing literature review.

ELEMENT TASKS A-1.3 THROUGH A-1.6: DEVELOP CONSISTENT INTERSTATE MODELING ASSUMPTIONS AND PROCEDURES

A. Description of Sub-tasks

The major effort in this set of sub-tasks is to develop a model that is suitable for analyzing the effects or results of long-term water management alternatives in the High Plains area. For purposes of accurate aggregate projections, the models must be consistent in general format, assumptions and procedures. (See Wilkinson/ADL memo of March 16, 1979, for details.) In particular, the model structure for Colorado sub-areas must be consistent with those of the other states (Task A-1.6). Further, the models must be designed in such a way that projections of output prices, input prices, productivity relations under alternative scenarios are handled in an equivalent fashion for each area.

Specific issues to be addressed are:

1. Which crop and livestock enterprises in the model?

2. Input cost components for each enterprise; fixed and variable cost breakdowns. Input prices to be consistent with rest of region.

3. Incorporating energy and water cost variations into the model (consulting services from an irrigation engineer required here).

4. Product prices for selected enterprises. Such prices to be in accordance with historic regional differences.

5. Consistent assumptions regarding federal policies (price supports, acreage controls, direct payments, etc.).

6. Projections of trends in technology as reflected in factor-product relationships (i.e., yields) for relevant enterprises. (Consulting services from an agronomist familiar with High Plains irrigated crop production required here.)

7. How to reflect uncertainty of prices and yields in assumptions of model.

For an expanded discussion constructing the necessary LP models, please refer to Attachment A entitled "Linear Programming as a Tool for Regional Water and Energy Demand Forecasts."

B. Personnel and Time Requirements

1. Duration 2.5 months (July 15-September 30, 1979).

2. Personnel

   (a) Senior Agricultural Economist, 0.5 months
   (b) Junior Agricultural Economist, 2.0 months
   (c) Irrigation Engineer, 0.50 months
   (d) Agronomist, 0.50 months

C. Inputs and Outputs

1. Inputs--This sub-task will involve careful and detailed consideration with the HPA team and representatives of other states. Inputs from Elements B-1, B-2, B-3, B-5j, B-7, B-8.

2. Outputs--The results of this stage will be in the form of a general model structure which meets the criteria worked out among the states and HPA during Elements A-1.3 through A-1.5.

3. Documentation--A report specifying the general format, assumptions, and procedures for the Colorado direct impact model will be prepared.

ELEMENT TASKS A-1.7 AND A-1.8: DETAILED FORMULATION AND TESTING OF MODELS FOR YEARS 1980, 1990, 2000, 2010, 2020

A. Description of Sub-task

This task involves bringing together and conceptualization and projections decided upon in tasks A-1.1 through A-1.6 collecting additional data needed to formulate models representing each of the decades and scenarios in the projection.

The first stage in the sub-task would involve detailed data collection regarding current farm sizes, productivity, production technology, etc., in each of the study sub-areas. Data are to be collected from farmers, sellers of agricultural inputs, buyers of agricultural outputs (including energy sources, pump and irrigation system sales, etc.) by direct survey Whenever possible, data should be obtained from existing secondary sources. Much of these data would be used in the A-1.11 analyses in addition to A-1.9 and A 1.10. Approximately three months of time each from research associates and research assistants would be devoted to primary data collection.

The next stage of this sub-task would involve finalizing a model based on 1977 data and verifying its predictions against observed response for that year. After initial parameterization and debugging, adjustments in constraints and matrix coefficients would be made until an acceptable degree of accuracy is reached.

Coincident with the preliminary stage model development would be the process of developing the coefficients and constraints for future time periods. Experience with the base year model may provide the basis for further refinement of the subsequent models. Continued input from engineering and agronomist consultants would be necessary in addition to the economists.

Approximately 150 distinct models will be required to meet the work plan requirements proposed by HPA, assuming one model for each of five sub-areas for each of five time periods for each of six policy strategies, including the "no substantive action" base case. (5 x 5 x 6 = 150). For each of these models a number of solutions may be necessary, since it appears desirable to test the sensitivity of results to alternative assumptions concerning commodity prices, energy costs, and production technology.

B. Personnel and Time Requirements

1. Duration 8.0 months (September 1, 1979-April 30, 1980).

2. Personnel

   (a) Senior agricultural economist, 2.0 months.
   (b) Junior agricultural economist, 5.0 months.
   (c) Agronomist, 0.5 months.
   (d) Engineer, 0.5 months.
   (e) Research assistants, 5.0 months.

C. Inputs and Outputs

1. Inputs for Tasks A-1.7 and A-1.8 will come from previous Tasks A-1.1 to A-1.6, as well as from A-2 (farm energy prices) and A-3.1 and A-3.9 (water supplies and prices). Input will also come from B-1, B-3, B-5, B-7, and B-8.

2. Output of this sub-task would be a set of fully specified and verified models of the study area which are capable of simulating agricultural production under specified assumptions and policy options (as developed in previous stages). This sub-task will include detailed write-up of the models (objectives, assumptions, procedures, aprameter estimates, etc.) for inclusion in project reports. The written product would summarize the models for each period, together with the assumptions and procedures by which model aprameters were derived.

The output would also include time for consultation with state officials and general contractors regarding interpretation and use of results.

ELEMENT TASK A-1.9: COMBINE ECONOMIC AND HYDROLOGIC MODELS TO DERIVE FORECASTS FOR EACH TIME PERIOD UNDER ALTERNATIVE STRATEGIES

A. Description of Sub-task

Once the models have been formulated, tested, and verified as adequate, the final projection runs will be undertaken. This will involve coordination with the ground water modeling activities undertaken in Element A-3. Decisions must be made as to whether the simulation runs are to be done by an iterative process with separate computational steps, or by a combined hydrologic-economic model.

Analyses will be undertaken for the baseline case of no substantive action, plus each of the alternative development strategies agreed upon by the High Plains Study Council for each decade of the 40-year planning period.

From the model results, projections of agricultural output, gross income, net income, resource use, direct employment, and water demand by time period for each strategy will be derived. Changes in product mix will be included in projections of agricultural output.

B. Personnel and Time Requirements

1. Duration 4.0 months (May 1, 1980-August 31, 1980).

2. Personnel

   (a) Senior agricultural economist, 1.5 months.
   (b) Junior agricultural economist, 4.0 months.
   (c) Graduate assistants, 4.0 months.

C. Inputs and Outputs

1. Inputs--

   (a) Economic models from A-1.7 and A-1.8
   (b) Hydrologic models from A-3

2. Outputs--The sub-task will include tabular and graphic presentation of final results, interpretation of the projections and discussion of policy implications. One-third of the allocated time would be involved in report preparation and review. The results would be delivered to Elements B-1, B-9, and B-11.

ELEMENT A-1.10: ANALYSIS OF DEMAND FOR IMPORTED WATER AND PREPARATION OF FINAL REPORT ON DIRECT ECONOMIC IMPACT ANALYSIS

A. Task Description

As noted above in A-1.2, the projection models will require reformulation to measure properly the demand for imported water. This sub-task would include the reformulation of models for this purpose, performing the computer analysis and preparing and interpreting the results.

The sub-task would also include preparation of the final report on the analysis of direct economic impacts.

B. Duration and Personnel Requirements

1. Duration 4.0 months (September 1-December 31, 1980)

2. Personnel

   (a) Senior agricultural economist, 1.5 months.
   (b) Junior agricultural economist, 3.0 months.
   (c) Graduate assistants, 3.0 months.

C. Inputs and Outputs

1. Inputs would come from Task A-1.8, A-2, A-3, and from Elements B-1 and B-8.

2. Outputs

   (a) Projection of demand for aupplemental water (to B-11).
   (b) Final report and documentation.
   (c) Consultation with HPA and state agency officials regarding interpretation of results and conclusions.

R. A. Young
C.S.U. Economics
6/21/79

ATTACHMENT A

LINEAR PROGRAMMING AS A TOOL FOR REGIONAL WATER AND ENERGY DEMAND FORECASTS

Economic principles have, for over two centuries, embodied three fundamental concepts [Day, 1977]. First, much of individual behavior regarding economic production and consumption can be explained as being the result of individuals pursuing their own advantage. Second, a given group of individuals may be characterized as being in a sort of equilibrium when the individuals pursue their own self-interest. Third, under appropriate "rules of the game", and other conditions, the working of an economy can bring about individual and group optimum.

The High Plains water management problem can be characterized in terms of two important attributes. These are, respectively, (a) the consumption or more precisely, the demand for irrigation water and (b) the demand for energy to extract the water.

The theory of demand for resources (or production inputs) such as water and energy is derived from production economic theory [Ferguson, 1974, Heady, 1952].

The quantity of input utilized by a profit-maximizing producer is dependent upon (a) its price (or extraction cost), (b) its marginal productivity, (c) the price of products in which it is used, and (d) the price of other inputs used in the production process of subject to (e) institutional rules or constraints applicable to the production activity.

These notions can be expressed in mathematical form, and as early as 1838, the calculus was used to analyze the notions of process, equilibrium and optimum in markets. In the past three decades, it has become recognized that the realism of models based on calculus in many cases left something to be desired. Samuelson [1949] showed that the linear programming framework developed in World War II

to solve military allocation problems could be used in a wide variety of economic applications, including studies of resource demand.

The linear programming model can be expressed formally as (a) a set of alternative allocation choices, (b) an "objective function" which describes how alternatives are to be compared or ranked, and (c) a "choice space", the set of feasible alternatives. The set of feasible alternatives is usually defined by equations or ineqality constraints.

The model in the production interpretation can be expressed symbollically by

$$\max Z = \sum_{i=1}^{n} c_i X_i \tag{1}$$

$$\text{subject to} \quad \sum_{i=1}^{n} a_{ij} X_i \leq b_j \quad (j = 1, 2 \ldots m) \tag{2}$$

where X stands for a vector of decision variables representing alternative resource allocations, c_i represents the marginal contribution of a unit of X_i to the desired goal Z (profit). In the conventional farm production model, the X_i represents acres of crop i produced and c_i represents the profit per unit of product X_i.

Equations (2) represent the fixed conditions imposed on the decision maker, such that the quantity of resources used (land, water, labor, etc.) do not exceed the amounts available; that levels of output are consistent with levels of input; and that other technical, legal and social restrictions are approximated. The a_{ij} coefficients specify the number of units of resource j are required by the ith variable or activity.

Note in particular that the net revenue coefficients (c_i) are computed in terms of input prices, output prices and input-output relationships. Let

V: Quantity of variable input (water, labor, etc.)
Y: Quantity of product (corn, alfalfa, etc.)
P_v: input price
P_y: output price

Then

$$c_j = Y_j P_{y_i} - \sum_{d=1}^{P} V_d P_{x_d}$$

Thus, the concepts of prices and input-output relations are expressed in a linear programming framework in terms of constant coefficients.

It is often convenient to display a linear programming model in the form of an array, or a "tableau" as it is usually termed. The LP tableau shows the coefficients (a_{ij}, b_j and c_i) or parameters of the problem in a way such that they are easily comprehended. Figure 1 illustrates such a tableau for a simple example in five variables and three constraints.

FIGURE 1: SCHEMATIC LINEAR PROGRAMMING TABLEAU

X_1	X_2	X_3	X_4	X_5			Variables (activities 1-5)
a_{11}	a_{12}	a_{13}	a_{14}	a_{15}	$\leq$	b_1	Constraint Equation 1
a_{21}	a_{22}	a_{23}	a_{24}	a_{25}	$\leq$	b_2	Constraint Equation 2
a_{31}	a_{32}	a_{33}	a_{42}	a_{52}	$\leq$	b_3	Constraint Equation 3
c_1	c_2	c_3	c_4	c_5			Objective Function

Figure 2 presents a tableau of a simplified LP model for purposes of illustration of the concepts relevant to the High Plains Project.

The farm being modeled is assumed to have the following resource limits: 300 acres of cropland (Row 1), 150 of which, at most, can be planted to corn (Row 2) and a seasonal pumped water supply of 4,800 acre inches (Row 4). Column 1 represents corn production at a high water level. The a_{ij} coefficients show that one unit of corn uses 1 acre of land, 1 acre of corn restriction, 24 inches of water and yields a net profit of $220.

Variable (Column) 5 and Row 3 are each of special interest for the problem at hand. Variable 5 uses no land (Row 1) or corn restriction (Row 2). The coefficient -1 in Row 3 shows that every acre inch pumped offsets an inch of water

required in the crop activities (Columns 1-4). (Hence the zero constraint. Row 3 is called a balance equation). Row 4's coefficient (+1) indicates 1 unit pumped uses up 1 unit of pumping capacity to a maximum of 4,800 acre inches. The revenue coefficient is negative, indicating a cost rather than a profit.

FIGURE 2. LINEAR PROGRAM TABLEAU FOR SIMPLIFIED IRRIGATED CROP FARM MODEL

	X_1 (Corn 1)	X_2 (Corn 2)	X_3 (Alfalfa 1)	X_4 (Alfalfa 2)	X_5 (Pump Water)	Constraints
Cropland (acres)	1	1	1	1	0	300
Corn land limit	1	1	0	0	0	150
Water applied (acre inches)	24	20	30	24	-1	0
Pump Capacity (acre inches)	0	0	0	0	1	4800
Objective Function $	220	180	150	130	-.75	

Conclusion

Two general points may be made, first, the model can be seen to incorporate the theoretical conditions for specifying resource demands: (a) the physical input-output relation (production function), (b) commodity prices and (c) input costs. [The first of these, (a) is represented by the input-output coefficients, together with the yield estimate required to estimate c_i. The second and third (b) and (c) are represented in the net revenue coefficient c_i. (Recall the $c_i = Y_i P_{y_i} - \Sigma VP_v$)]. Water demand can be computed for any price and policy scenario.

Secondly, energy requirements can be directly derived for each sub-area model by reference to the quantity of water pumped. Thus, energy demand is derived as a function of energy price, the energy and other resources required to extract water and the technology available to withdraw water. Further, by holding technology and other input and commodity prices constant, the classical demand curve for energy resources can be traced out by finding the energy requirement for the

solutions representing each of a set of energy prices.

This approach has a considerable advantage over the econometric approach for the purposes at hand, in that impacts of technological advance, policy changes, water supply changes and price changes beyond those experience in the past can be analyzed by changing the basic parameters of the model.

The linear programming approach is suitable primarily for direct input analysis. That is, it can deal with on-farm economic impacts, water demands and energy demands. Indirect impacts must be reflected in a more general model, such as the Leontief-type interindustry approach. This will be the subject of a separate statement.

HIGH PLAINS ENERGY

Elements A-2

ELEMENT DESCRIPTION

ID NUMBER:	A-2
TITLE:	Energy Production Impacts
PURPOSE:	To project time profiles for the High Plains area in each state for energy production and consumption, royalty payments to landowners for energy production, employment and other locally induced incomes associated with energy production, and the amount of water used for energy production, including secondary and tertiary recovery; to determine other sources of energy in each state that would be available as necessary to provide continued support for the economies of the High Plains.

TASK ASSIGNMENTS

Element tasks will include:

A-2.1	Identify and review state energy data sources
A-2.2	Review energy data specifications
A-2.3	Determine method of satisfying the specification with the General Contractor
A-2.4	Identify/develop method of projecting energy data time profiles
A-2.5	Project energy data profiles as required by the specification
A-2.6	Compile data, prepare report and forward to the General Contractor.

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DENVER

RICHARD D. LAMM
Governor

BUIE SEAWELL
Director

July 20, 1979

HIGH PLAINS STUDY
WORK PLAN
ENERGY ELEMENTS

Purpose

The purpose of the A-2 Research Elements are to project time profiles for the High Plains area of Colorado for:

a) Energy production.

b) Royalty payments to landowners for energy production.

c) Employment and other locally induced incomes associated with energy production.

d) The amount of water required for energy production, including secondary and tertiary recovery techniques for oil.

Specifications

The principal output of the A-2 element is to be a series of projections of energy production and other energy related factors for the High Plains area of Colorado. The projections will be for the period 1980-2020. Specific values will be given for the years, 1980, 1990, 2000, 2010, 2020. These projections will be in tabular form. They will include a "most likely" projection as well as upper and lower bounds for the projections. These ranges will reflect demographic and economic variances as well as changes in technologies. The data will be displayed graphically where appropriate.

All projections will be based on the regulatory, energy technology, and energy price information furnished by the general contractor. The economic and financial projections will be expressed in terms of 1977 constant dollars assuming zero inflation. The required projections are summarized in Table 1.

Implementation

The descriptions of Table 1 outline the element tasks of A-2. They include:

A-2.1 Identify and review state energy data sources.

A-2.2 Review energy data specifications

1600 Downing Street, Denver, Colorado 80218 (303) 839-2507

A-2.3 Determine method of satisfying the specification with the General Contractor.

A-2.4 Identify/develop method of projecting energy data time profiles.

A-2.5 Project energy data profiles as required by the specification.

A-2.6 Compile data, prepare report, and forward to the General Contractor.

The Colorado Office of Energy Conservation will be the lead state agency in the delivery of the energy elements of the High Plains Study. The personnel for the project will consist of a Principal Researcher and contractual funds for data collection and/or analysis by other appropriate state agencies. The Principal Researcher will serve as both overall project manager and energy analyst for the study and have primary responsibility for preparation of the final report to the general contractor.

Coordination with other state energy-related agencies will be as described below with a steering committee consisting of the Office of Energy Conservation, Department of Natural Resources, and Department of Local Affairs. Activities will be coordinated as part of the Energy Policy Analysis Center of OEC.

TABLE 1

REQUIRED PROJECTIONS

I. Energy Production

A. Crude Oil

B. Natural Gas

C. Surface mineable and deep mineable coal - include coal types and typical heating values

D. Uranium

E. Electric Energy - include both energy production and generating capacity

II. Employment directly related to the energy industry (employment and income derived)

A. Crude Oil
- exploration
- extraction
- distribution

B. Natural Gas
- exploration
- extraction
- distribution

C. Coal
- exploration
- mining

D. Uranium
- exploration
- mining
- processing

E. Electricity Production

III. Employment indirectly related to the energy industry (employment and income derived):

A. Crude oil refining

B. Oil products manufacturing

C. Crude oil and natural gas field equipment manufacturers

D. Energy transportation

IV. Water used for energy production:

A. Electrical power production (including hydroelectric)

B. Crude oil and natural gas production (including secondary and tertiary recovery)

C. Uranium mining and processing

D. Coal mining operations (including reclamation requirements)

E. Other significant energy production activities.

V. Royalty payments to landowners

VI. Energy requirements for irrigation

A. Number of irrigation wells

B. Quantities of ground water pumped

C. Average depth of water

D. Energy used for irrigation pumping

E. Source of power for irrigation pumping

VII. Long term energy contracts

VIII. Review of energy price projections and technology assessments of the general contractor.

Energy Production

OEC will work with the Department of Natural Resources, the Oil and Gas Conservation Commission, and the Division of Mines/Colorado Geological Survey in the assembly of historical data and the projections of energy production in the High Plains area. These agencies will also provide analysis of 1) the water requirements to support the projected energy production levels, 2) royalty payments for fuel produced, and 3) long-term energy contracts.

Employment and Income

OEC will work with the Division of Planning (Department of Local Affairs) and CSU in deriving the employment and income estimates related directly and indirectly to energy production through the use of the Input/Output Model to be developed for Elements A-1 and A-3. Estimates must be compatible with the energy production estimates derived by the Department of Natural Resources.

Energy Requirements for Irrigation

The energy requirements for the irrigation elements identified in Table I will be coordinated with the appropriate agencies in the total study plan. The number of irrigation wells and the average depth of water will be obtained from Element A-3a. The quantities of ground water pumped will be assessed on a subregional basis through a joint effort of Elements A-1 and A-3a. The energy used for irrigation pumping and the source of power for irrigation pumping will be obtained from Colorado State University (cost included in budget for A-1).

Review of General Contractor Projections

OEC will review the energy price projections of the general contractor. It will also review the technology scenarios provided by the general contractor.

Final Report

The final report will include the results of the analysis described above. Support documentation will include:

a) A historical data base of at least ten years.

b) A description of the methods used to make the projections.

c) A description of any supporting analyses.

d) A description of assumptions made in the development of the projections.

Timeline

The general contractor has outlined a ten-month study period for Element A-2 (May 31, 1979 through March 31, 1980). Since the starting date has passed, the following timeline is proposed, pending project approval:

1. July 31, 1979 -- Completion of state study plans.

2. August 30, 1979 -- A-2.1 Identify and review state energy data sources.

3. September 30, 1979 -- A-2.2, A-2.3 Review energy data specifications and determine method of satisfying the specifications with the General Contractor.

4. October 31, 1979 -- A-2.4 Identify/develop method of projecting energy data time profiles.

5. February 29, 1980 -- A-2.5 Project energy data profiles as required by the specification for baseline projection.

6. May 31, 1980 -- A-2.6 Compile data, prepare report, and forward to the general contractor.

WATER RESOURCE IMPACTS

Elements A-3a

ELEMENT DESCRIPTION

ID NUMBER:	A-3a
TITLE:	State Water Resources Evaluation
PURPOSE:	Evaluation and Quantification of present water resources situation in the High Plains including projection of time profiles of the likely supplies and demands for water under alternative development strategies.

TASK ASSIGNMENTS

Element tasks will include:

A-3.1 In cooperation with the USGS and the General Contractor, compile available data and describe the geologic structure, hydrology and the groundwater and aquifer characteristics of the Ogallala and peripheral aquifers, including information on precipitation, streamflow, recharge, natural discharge, movement of groundwater, quality, interrelationships among aquifers, etc.

A-3.2 In cooperation with the USGS and General Contractor, and with inputs from Elements A-1 and A-2, divide the High Plains area within the state into subregions, consistent with subregions of adjoining states, which can be analyzed more or less discreetly, based on geologic, hydrologic and economic consideration.

A-3.3 In cooperation with the USGS, compile available data, and describe and quantify to the extent possible, the groundwater resources now remaining in the Ogallala Aquifer within the state, including quality problems resulting from point, non-point and natural sources, for each subregion.

A-3.4 Compile available data and describe and quantify, to the extent possible, existing and potential intrastate sources of water supply--surface, ground, reclaimed--other than the Ogallala Aquifer for use within the High Plains by subregions; describe any existing legal, regulatory, or other institutional constraints on development and use of such other sources.

A-3.5 Compile available data and describe and evaluate any current or planned activities and developments--regulatory or physical--at the federal, state and local levels of government and by private entities to augment the water supply to the High Plains or to extend the useful life of the remaining water resources in the Ogallala Aquifer, and their estimated costs; describe and evaluate actions being taken or planned to maintain or improve the quality of water in the Ogallala Aquifer and the estimated costs.

A-3.6 In cooperation with the USGS, compile available data on historic water use for various purposes in the High Plains area within the state by subregions.

(Task Assignments for Elements A-3.1 through A-3.9, continued)

A-3.7 In cooperation with the General Contractor work in B-8, as to future costs of energy and effects of inflation on costs, develop and verify costs of pumping from the Ogallala Aquifer by subregion over the planning period.

A-3.8 In cooperation with the General Contractor project water demands over the planning period for the various purposes and available supplies for each of the alternative development strategies by subregion.

A-3.9 In cooperation with USGS, project the response of the Ogallala Aquifer overtime by subregion for each of the alternative development strategies; this must be consistent with similar studies in adjoining states where the Ogallala Aquifer extends across state lines; existing groundwater simulation models, refined as necessary, will be used where available; new models will be developed as necessary and feasible within the limits of available data and time.

RICHARD D. LAMM
Governor

C.J. KUIPER
State Engineer

DIVISION OF WATER RESOURCES

Department of Natural Resources
1313 Sherman Street - Room 818
Denver, Colorado 80203
Administration (303) 839-3581
Ground Water (303) 839-3587

July 27, 1979

MEMORANDUM

TO: William R. Smith, Deputy State Engineer

FROM: Bruce E. DeBrine

SUBJECT: Revised Study Plan, Element A-3a, Water Resources, Six-State High Plains Ogallala Aquifer Area Study

Contracting Agency

This subject element study of the High Plains-Ogallala study will be conducted by the Colorado Division of Water Resources, Ground Water Section, under the direction of Bruce E. DeBrine, 1313 Sherman Street, Denver, Colorado, 80203. Overall supervision and direction will be provided by William R. Smith, State Liaison Officer and the Division's contracting officer at the same address as above, phone: (303) 839-3585 or 3587.

Summary of Work

This portion of the state's study will compile all available geohydrologic data, in cooperation with the U. S. Geologic Survey, and other investigators, for the six subregions, shown on the attached map, for the Ogallala area of Colorado. This data will be analyzed and reduced to supply the information and projections on water resources for elements A-3.1 through A-3.9 and for input to state study elements A-1 and A-2. This data will be used to generate the following information for 10-year periods from 1980 to 2020 by means of maps, tables, or other practicable methods:

1. Saturated thickness of the Ogallala aquifer
2. Volume of water in storage
3. Water level declines
4. Withdrawals (pumpage) from the aquifer
5. Pumping lifts

In addition, information will be provided showing irrigated acreage in study area's subregions.

The proposed subregions, based on geologic and hydrologic parameters will be integrated with the states of Nebraska, Kansas, and Oklahoma (if pertinent).

Description of Research

Element task A-3.1

Data on the bedrock structure, geology of the Ogallala and White River aquifers for the Colorado Northern High Plains (subregions 1-5) and of the Ogallala, Dakota, Cheyenne, and Dockum aquifers for the Colorado Southern High Plains (subregion 6) is available at the Division of Water Resources. Information on precipitation from at least four stations, stream flow for the North Fork of the Republican, South Fork of the Republican, and Arikaree Rivers, and recharge will be compiled from existing records either in the Division office or in Management District offices in these High Plains areas. Ground water movement, natural discharge, and pertinent aquifer characteristics, such as transmissivity, specific yield, thicknesses, historic water levels, and aquifer interrelationships, are available. This data will be assimilated and, where necessary, coded for computer input. It is planned to set up a grid network for the computer input of the data with nodes on a two-township spacing. This will provide a nine x sixteen network for the Northern High Plains (subregions 1-5) and a five x seven network for the Southern High Plains (subregion 6). Data provided at each point will be:

1. Elevation of Bedrock
2. Elevation of water table
3. Historic water level declines
4. Specific yield of aquifer
5. Average irrigated acreage in vicinity
6. Number of wells in affected area
7. Precipitation, recharge, and return flows

Element task A-3.2

Six subregions based on geologic (bedrock) configuration aquifer characteristics, and ground water movement have been established. These are depicted on the attached map. The subregion breakdown will be coordinated with the adjoining states of Kansas, Nebraska, and Oklahoma.

Element task A-3.3

The data from task 3.1 will be used to generate the available ground water resources remaining in the aquifer by the use of existing computer programs, particularly those available at the Texas Water Development Board, if they prove to be compatible.

Available ground water quality data will be analyzed to determine any trends or changes that could portend problems although this is believed to be of no importance in Colorado. Quality data is not abundant and may be of little value in this study.

Element task A-3.4

The Texas programs will be thoroughly investigated and every attempt made to utilize them to develop maps projecting the following information for the six subregions:

1. Saturated thickness
2. Volume of water in storage
3. Withdrawals (pumpage) from the aquifers
4. Water level declines
5. Pumping lifts

These projections will be made under conditions of a continuously declining water level (supply) assuming no recharge, and declines of withdrawals related to declining levels. The projections, at this point in the study, will be refined for inclusion in task A-3.9

Existing Colorado Ground Water Commission policies and guidelines, limiting appropriations of ground water and pertinent Management District Rules and Regulations, limiting withdrawals will be important factors in these projections. Other sources of ground water are not present in the Ogallala regions of Colorado, except in the adjacent South Platte and Arkansas Valley alluvium. This water is not available for diversion to the High Plains, unless no injury to the existing water rights in these valleys can be demonstrated, or plans of augmentation, or exchange can be developed to divert water from the streams. Surface water supplies in the North and South Forks of the Republican River will be considered as possible sources within the institutional constraints mentioned above.

Element task A-3.5

Management Districts Boards will be contacted to compile data or any recharge project or water importation schemes, currently underway. In addition, discussion will be held with the Districts to determine their

future plans and expectations. Very little information is expected in this task because of limited budgets, both at a state and local level. At the present time, there is not a state-wide water plan. The Department of Natural Resources is working on one.

Element task A-3.6

The U. S. Geological Survey's cooperative water use program with Colorado will be utilized to the extent possible to compile water use data, for various uses in the study area. In addition, local offices of the CSU Extension Service, U.S.D.A. field offices and private individuals reported to have historic use data will be contacted. A water resource engineer will be retained on a temporary basis to conduct this search.

Element task A-3.7

The water resources aspect of this task should involve the work of Bob Logenbaugh of CSU on well efficiencies and pumping costs.

Element tasks A-3.8 and A-3.9

These elements will be an extension and refinement of the computer programs and map generations of element task A-3.4. New programs may have to be developed or extensive revision of existing programs accomplished under these element tasks.

Schedule of Research and Reports

It is planned that the time schedule in the summary report will be followed.

Element tasks A-3.1 -- A-3.3 complete by end of October, 1979. Available data can be extracted for other Elements at any time however.

Element tasks A-3.4 -- A-3.6 complete by end of November, 1979.

Element task A-3.7 complete by July 1, 1980.

Element tasks A-3.8 and A-3.9 complete by November 1, 1980.

Required Inputs and Coordination

Inputs to these element tasks will be limited to coordination between Colorado and adjoining states with regard to the establishment of subregions.

The study personnel will be in constant contact with the U. S. Geological Survey during the data compilation phases of the tasks and the computer phases will necessitate coordination with the Texas group at least initially. It may be desirable for the general contractor to select a computer program for use by all states to generate geohydrologic data and maps.

Responsible Agencies and Individuals

The overall water resources study will be under the direction of Bruce E. DeBrine, Deputy State Engineer, in charge of the Ground Water Section of the Colorado Division of Water Resources. The staff of the Designated Basins branch of the Section, who have been working with the Ogallala Basin in Colorado for as many as 12 years will conduct most of the work.

Manpower Staffing Plan

Element tasks A-3.1, 3.2, 3.3
Water Resources Engineer "C" (present staff)
  5 months, 2/5 time = 2 man months
Supervising Water Resources Engineer (present staff)
  5 months, 1/5 time = 1 man month
Engineering Aide B (present staff)
  5 months, 2/5 time = 2 man months
Support personnel (present staff)
  1 man month

Element tasks A-3.4, 3.5, 3.6
Senior Water Resources Engineer (temporary addition)
  4 man months
Water Resources Engineer "C" (present staff)
  2 man months

Element tasks A-3.8, 3.9
Present staff engineers
  Engineer "C" - 6 man months
  Supervising Engineer - 3 man months
  Engineering Aide "B" and support personnel
    3 man months (both categories)

STATE IMPACT RESEARCH

a. Input-Output
   Elements A-1.11 through A-1.12 and
   A-3.10 through A-3.16

b. Socio Economic Impact
   Elements A-3.16 through A-3.18

ELEMENT DESCRIPTION

ID NUMBER:	A-3b
TITLE:	Input-Output Model Development
PURPOSE:	Define the problem with respect to decreasing water and energy supply and agricultural production, and the effects on the national and regional economics. Develop input-output models to reflect these factors.

INPUT-OUTPUT MODEL TASK ASSIGNMENTS

Element tasks will include:

A-1.11	Project agribusiness employment and income for the High Plains portion of each state under the varying assumptions and strategies.
A-1.12	Project agricultural output, employment and income, etc., for the non-Ogallala portion of each state.
A-3.10	Review economic base profiles for different years for the High Plains area within the state by subregion, and for other areas in the state.
A-3.11	Evaluate previously developed input-output (I-O) models for the state or for regions within the state.
A-3.12	In cooperation with the General Contractor, revise existing I-O models as necessary or develop new intra-state or multistate I-O models with reasonably compatible structures and consistent inter-industry coefficients.
A-3.13	Conduct additional research and interviews to disaggregate key crop, livestock and energy functions in the state-level models of subregional delineation.
A-3.14	Review economic/demographic basic data and projections, and project time profiles of inter-industry coefficients and any independent changes in basic economic activities.
A-3.15	Test I-O models over a relevant period.
A-3.16	Use I-O and relevant models to project time profiles of alternative economic structures and the economic impacts--irrigated acreage, production, employment, income, etc.--for each alternative development strategy for the Ogallala Aquifer area of the state by subregion, and for regions of the state outside the area.

DETAILED PLAN OF STUDY

OGALLALA HIGH PLAINS AQUIFER STUDY (COLORADO)

INPUT-OUTPUT MODELING OF REGIONAL IMPACTS
(Elements A-1.11 through A-1.12 and A-3.10 through A-3.16)

Prepared under direction of
J. R. McKean

Person to contact regarding Plan of Study

R. A. Young, Professor of Economics

Colorado State University

Fort Collins, Colorado 80523

(303) 491-7346

INTRODUCTION

This study plan is with reference to the Colorado portion of a study of the region overlying the Ogallala Aquifer in parts of the six states of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas. The overall regional study plan is detailed in a document prepared by the High Plains Associates (the "General Contractor"), Interim Report: Six State High Plains-Ogallala Aquifer Area Study dated January 15, 1979. This section describes the workplan for state element A-1 and the economic input-output modeling in state element A-3 (elements A-3.10 to A-3.16, inclusive). This section is divided into two subsections. The first subsection describes the workplan for elements A-1.1 to A-1.10; the second subsection describes the workplan for elements A-1.11 to A-1.12, and A-3.10 to A-3.16.

The Ogallala aquifer formation underlies portions of counties in eastern Colorado. A very rough preliminary estimate suggests approximately one-half million acres are under irrigation from this groundwater source. Natural recharge is negligible, so that in the absence of large-scale importation of water from other sources, the irrigated portions of the region face an eventual return to non-irrigated production.

The principal crop in the study region is corn, accounting for some 75 percent of irrigated acreage. Hay accounts for another ten percent, and the balance is about evenly divided between wheat, dry beans and sugar beets. More than 2 million acres of non-irrigated cropland is harvested in this eleven-county area each year. Nearly 90 percent of this dry cropland produces winter wheat, while the balance is in hay or feed grains (sorghum, barley, corn). Some livestock operations are present, mainly cattle-feeding operations, which convert the feed grain and forage production into finished meat animals.

The counties in Colorado to be considered in this study are identified on the map on the following page. The shaded areas indicate the eleven-county region lying over the Ogallala formation in Colorado. Farm-level research will focus on this region. The map also displays the three planning and management regions which contain the eleven-county Ogallala area. The second subsection of this portion of the Colorado workplan outlines the steps for preparing an economic input-output model for each of these three planning and management regions, plus a model for the Ogallala area itself.

The purpose of Element A-1 is to develop projection of important variables describing agricultural production and agri-business activities for the Colorado portion of the Ogallala region for a four-decade period (1980-2020) for each of several specified water supply, energy and public policy scenarios. The important variables to be projected include production and value of selected crops and livestock enterprises; quantity and value of significant inputs, including land, water, labor, machinery, fertilizer, pesticides, etc. Projections are to be made for each of a number of alternative assumptions regarding public policy with respect to the region's water and energy supplies. Direct impact projections are to utilize linear programming models.

This will be done by constructing four input-output models in the eastern High Plains of Colorado--one model for the eleven-county region overlying the Ogallala, and one model for each of the three planning and management regions, which together contain the Colorado portion of the Ogallala. In order to obtain these additional models, Colorado State University is providing $20,000 in funds toward this project.

Responsibility for carrying out this portion of the Colorado workplan is the Department of Economics, Colorado State University. Project oversignt and review will be the responsibility of the Colorado Department of Agriculture. Professors Robert Young and John McKean are co-principal investigators. Dr. Young will have primary responsibility for work elements A-1.1 through A-1.10; Dr. McKean will have primary responsibility for work elements A-1.11, A-1.12, and A-3.10 through A-3.16. Dr. Joseph Weber, Colorado School of Mines, will assist Dr. McKean in compiling data for the input-output models and constructing appropriate tables. As their vitae indicate, these three men have had extensive experience in constructing linear programming and input-output models of the type needed in the present study.

At this time, it is anticipated that final reports covering these work elements will be ready by December 1980.

WORK ELEMENTS A-3.10 THROUGH A-3.16 and WORK ELEMENTS A-1.11 and A-1.12

The tasks as clarified by subsequent meetings with the general contractor and the state are as follows:

> CONSTRUCT FOUR INPUT-OUTPUT MODELS IN THE EASTERN HIGH PLAINS OF COLORADO TO MEASURE AND PROJECT THE ECONOMIC IMPACTS OF ALTERNATIVE DEVELOPMENT STRATEGIES FOR THE OGALLALA AQUIFER AND USE THE EXISTING COLORADO INPUT-OUTPUT MODEL TO MEASURE IMPACTS FOR REGIONS OF THE STATE OUTSIDE THE AREA.

A. Description of Subtasks

The subtask consists of a major and a minor component. The major component requires the construction of four input-output models to project income, output, water use, energy use and employment for each economic sector within the study region. In addition, the models must provide detailed projections of local government receipts and expenditures and projections of other required local social services. The major component accomplishes element task A-1.11 and element tasks A-3.10 through A-3.15 and part of A-3.16. The minor component involves the use of the existing 1970 input-output model for the State of Colorado to measure the impact of changes in the study region on the remainder of the state. The minor component accomplishes element tasks A-1.12 and the remaining portion of A-3.16.

Data will be collected on a county by county basis so that various aggregations of counties may be achieved to meet the needs of the regional contractor and to meet the needs of local governmental planning units (such as regional councils of governments) and to fit within three state planning regions which are affected. To achieve the latter purpose, five counties not directly underlain by the aquifer will be included. State Planning region 1 includes: Morgan*, Logan, Sedgwick, Washington, Phillips, and Yuma counties. State Planning region 5 includes: Elbert*, Lincoln, Kit Carson, and Cheyenne counties. State Planning region 6 includes: Crowley*, Otero*, Kiowa, Bent*, Prowers, and Baca counties. The five counties not directly underlain by the aquifer but part of the state planning regions are delineated above with an asterisk. A total of sixteen counties will be surveyed. (Refer to map between pages 2 and 3).

B. Personnel and Time Requirements

1. Personnel.

Part of component (a) and all of components (b) and (c) will be subcontracted to the Department of Mineral Economics, Colorado School of Mines, while components (d), (e), and (f) would be conducted by the Department of Economics, Colorado State University.

(a) Field Survey: one senior economic analyst (3 man-months) and two research associates (2 man-months).
(b) Aggregation of Data: one senior economic analyst (2 man-months).
(c) Development of Total Sales Aggregates: one senior economic analyst (2 man-months).
(d) Revision of computer programs: principal investigator (2 man-months).
(e) Computer Analysis: principal investigator (2 man-months).
(f) Estimation of Impacts in Colorado outside the study region: principal investigator (1 man-month).
(g) Preparation of Written Reports: principal investigator (3 man-months), plus senior economic analyst (0.5 man-months).

A total of 17.5 man-months are required. It is noteworthy that less-experienced economists are only employed in component (a). Close supervision and careful instruction by the senior economic analyst in part (a) is necessary. Cooperation from the private sector enterprises is essential for the study. Understanding of accounting terminology and standards is essential in this component. Previous experience in the construction of input-output models from prim ary data and a detailed knowledge of the various data sources and their weaknesses is extremely important for components (b) and (c), thus the use of senior researchers. The computer analysis and programming in parts (d) through (f) assumes previously developed programs and an experienced economist-programmer to model the various growth scenarios. Presentation of the results and findings and interpretation of the economic models to the general public in part (g) requires previous input-output modeling experience.

2. Time.	Time
(a) Field Survey (excluding the agricultural processing sector which will be concurrently surveyed by cooperating researchers who are developing the linear programming models).	6 months
(b) Aggregation of data to county groupings required (four models).	2 months
(c) Development of total sales aggregates by economic sector from secondary data for the four regional models. (concurrent with part (a)).	2 months
(d) Revision of existing computer programs to process data and estimate projection scenarios for the four regional models. (Concurrent with part (a)).	2 months
(e) Computer projection (including periodic revision of trade and production relationships) of income, output, water use, energy use, employment, government receipts and expenditures, and socia services for 40 years.	2 months
(f) Estimation of the impact on the Colorado economy of the changes in the study region projected in part (e).	1 month
(g) Preparation of four written reports, one for each model.	3 months
Time Span Required, Excluding Concurrent	14 months

C. Products of the Research

The research output will consist of four regional input-output models consisting of models for Colorado Planning regions one, five, and six, and a fourth model consisting of the eleven counties underlain by the aquifer. Also, a fifth output will analyze and describe the impacts on the Colorado economy of changes projected within the eleven-county region over a 40-year period.

The first four reports will describe the process by which the three Colorado Planning region input-output models and the eleven-county model have been constructed. Documentation of the analytical method, the data collection and aggregation and computer analysis will be provided. The salient features of

the projections and implications of the findings will be summarized. The fifth report will describe the use of the Colorado input-output model to trace the impacts of changes occurring in the study region on the Colorado economy. A summary and explanation of the findings for the study region and for Colorado will be provided. Other special reports and the provision of findings and analyses may be required by the regional contractor or by Colorado governmental agencies. Subsequent project development will reveal these added required outputs.

Several advantages accrue to the development of the survey-based models of the study region. (1) great detail on local government receipts and expenditures and on other local social services which does not exist in prior models can be obtained; (2) county by county data can be debeloped allowing various aggregations by region appropriate for local, county, state and federal planning bodies; and (3) the accuracy and quality of the measurement of the direct plus indirect effects of resource change in the study region will be greatly enhanced. With regard to the last point, only two prior models exist. These models are quite old, do not cover a large part of the study region, are based partly or wholly on rough estimates from secondary data spirces and do not provide detail on governmental and social services. The usefulness of an input-output modelling effort is in direct ratio to the reliability and detail contained in the table of flows of spending (and physical inputs) among the economic sector of the region.

Purchases and sales data for the agricultural production sectors will be collected jointly by researchers involved in the Linear Programming modelling effort and researchers involved in the Input-Output modelling effort. Close contact and overlapping team membership will prevent unnecessary duplication of the field survey.

The following table provides a listing of the economic sectors appropriate for the easterh high plains of Colorado. A more detailed breakdown of the crops contained in the irrigated and/or dryland agriculture sectors may also be desired. The extent of this disaggregation will depend on the level of detail defined in the linear programming research. Sectors 20, 21, 28, 32, 33, and 34 bear particular note since they represent the social services provided for, or regulated by, various levels of government.

BRIEF SECTOR IDENTIFICATION,
COLORADO EASTERN HIGH PLAINS INTERINDUSTRY STUDY

Sector Number	Sector Description	1972 SIC Codes
Processing Sectors		
1.	Fruit Agriculture	01 (part)
2.	Irrigated Agriculture other than Fruit	01 (part)
3.	Dryland Agriculture	01 (part)
4.	Dairy Farms	02 (part)
5.	Livestock other than Dairy Farms	02 (part)
6.	Agricultural Services; Forestry	07, 08
7.	Oil and Gas Extraction; Related Services	13
8.	Nonmetal Mining; Related Services	14
9.	Construction	15, 16, 17
10.	Food and Kindred Products Manufacturers	20
11.	Lumber; Wood Products Manufacturers	24
12.	Printing and Publishing; Paper and Allied Products Manufacturers	26, 27
13.	Stone, Glass, Clay Product Manufacturers	32
14.	Fabricated Metals; Non-electrical Machinery Manufacturers	34, 35
15.	Electrical Machinery and Equipment; Transportation Equipment; Electronic Instruments and Components Manufacturers	36, 37, 38
16.	All Other Manufacturers, Textiles, Apparel, Furniture, Chemicals, Petroleum, Rubber, Leather, Primary Metals, Miscellaneous	22, 23, 25, 28, 29 30, 31, 33, 39
17.	Transportation	40, 41, 42, 45, 46, 47

BRIEF SECTOR IDENTIFICATION,
COLORADO, INTERINDUSTRY STUDY

Sector Number	Sector Description	1972 SIC Codes
18.	U.S. Postal Service	43
19.	Communication	48
20.	Electricity; Natural Gas Utilities	491, 492, 493
21.	Water, Sewerage, Trash Removal Services	494, 495, 496, 497
22.	Wholesale Trade	50, 51
23.	Automobile Dealers; Gasoline Service Stations	55
24.	Eating and Drinking Establishments; Hotels, Motels, Other Lodging	58, 70
25.	All Other Retail Trade Building Materials, General Merchandise, Food Stores, Apparel and Accessory, Furniture and Furnishings and Equipment, Miscellaneous	52, 53, 54, 56, 57, 59
26.	Finance	60, 61, 62, 67
27.	Insurance; Real Estate	63, 64, 65, 66
28.	Health Services	80
29.	All Other Services, Personal Business, Automotive Repair, Miscellaneous Repair, Motion Pictures, Amusement and Recreation, Legal, Museums, Membership Organizations, Miscellaneous	72, 73, 75, 76, 78, 79, 81, 84, 86, 89
30.	(Reserved in computer program to subtotal processing sector values)	
31.	Households	-
32.	Education	82
33.	Social Services	83
34.	Local Governments	91, 92, 93, 94, 95, 96
35.	Local Government Tax Accounts	-

BRIEF SECTOR IDENTIFICATION,
COLORADO, INTERINDUSTRY STUDY

Sector Number	Sector Description	1972 SIC Codes
36.	Local County Government	-
Final Demand Sectors		
37.	Federal Government	91, 92, 93, 94, 95, 96, 97
38.	Economic Investment	-
39.	Transfer Account	-
40.	Exports to Colorado Other than Study Region	-
41.	Exports to the Rest of the World	-
Final Payments Sectors		
37.	Federal Government	91, 92, 93, 94, 95, 96, 97
38.	Profits, Rents, Losses	-
39.	Depreciation; Net Inventory Depletion	-
40.	Transfer Account	-
41.	Imports from Colorado Other than Study Region	-
42.	Imports from the Rest of the World	-

A partial list showing typical secondary data sources pertinent to the construction of input-output models in Colorado is shown below. A complete listing of data sources which have proved useful for input-output modelling in Colorado may be obtained from the authors.

Colorado. Department of Agriculture. Colorado Crop and Livestock Reporting Service. Colorado Agricultural Statistics. Annual
[01, 02, 07]

Colorado. Department of Agriculture. Colorado Crop and Livestock Reporting Service. Colorado Farm Income. March, 1975.
[01, 02]

Colorado. Department of Agriculture. Colorado Crop and Livestock Reporting Service. Colorado Fruit Tree Survey - 1967, by William C. Dobbs. February, 1968.
[01]

Colorado. Department of Agriculture. Colorado Crop and Livestock Reporting Service. Colorado Peach Tree Survey - 1971, by Larry C. Johnson. February, 1972.
[01]

Colorado. Department of Education. Commission on Higher Education. Files.
[822]

Colorado. Department of Education. Revenues and Expenditures: Colorado School Districts. Annual.
[821]

Colorado. Department of Health. Colorado Vital Statistics. Annual.
[vital statistics]

Colorado. Department of Health. Files.
[80]

Colorado. Department of Highways. Colorado's Annual Highway Report. Annual.
[state highways, state patrol]

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[oil shale, coal, legislative recommendations]

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[oil shale industry, economic and social, impacts]

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[State of Colorado, general information]

ELEMENT DESCRIPTION

ID NUMBER: A-3b

TITLE: Socio Economic Impact

PURPOSE: To project at the state level likely economic adjustments and the socio economic and environmental impacts resulting from changes in supplies and uses of water and indigenous energy resources in the High Plains under alternative development strategies.

TASK ASSIGNMENTS

Element tasks will include:

A-3.16 Use I-O and relevant models to project time profiles of alternative economic structures and the economic impacts--irrigated acreage, production, employment, income, etc.--for each alternative development strategy for the Ogallala Aquifer area of the state by subregion, and for regions of the state outside the area.

A-3.17 Describe and evaluate the socioeconomic impacts of each alternative development strategy within the Ogallala Aquifer area and outside that area in the state.

A-3.18 Describe and evaluate the potential environmental impacts of each alternative development strategy within the Ogallala Aquifer area and outside that area in the state.

Department of Local Affairs
Colorado Division of Planning

Philip H. Schmuck, Director

Richard D. Lamm, Governor

MEMORANDUM

DATE: May 3, 1979

TO: Bill Smith

FROM: Phil Schmuck Phil

SUBJECT: Study Plan - High Plains Ogallala Aquifer

Work Element A-3.10 through A-3.16

The Division of Planning, in cooperation with the Department of Agriculture, will review and monitor the work of the contractor in carrying out the required tasks of elements A-3.10 through A-3.16. The Division will also monitor the work of the contractor to assure that the relevant models are adequate to perform their necessary functions and to assure that the modeling efforts are consistent with present and future economic and/or demographic programs of related State agencies.

Schedule

June 1979 through October 1980.

Work Element A-3.17

The Division will study the socio-economic impacts of alternate Ogallala Aquifer development strategies (Item A-3.17) that must be undertaken in concert with the economic and demographic modeling (Item A-3.16) and with the evaluation of the environmental impacts (Item A-3.18). Evaluation of the socio-economic impacts should follow the demographic and economic modeling since the outputs of this item--the change in population size and characteristics, the income changes and the changed labor force composition--are important imputs to the evaluation of the socio-economic impacts.

The socio-economic impact analysis will examine a broad range of issues and functional areas, which are grouped below in five categories:

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1. Impacts on infrastructure capacity and needs:

   a. transportation
   b. water and sewer facilities
   c. public safety
   d. housing
   e. education facilities
   f. recreation facilities
   g. health care facilities

2. Social and related community services impacts:

   a. welfare
   b. health, metal and physical
   c. education and training services
   d. public safety
   e. public transportation
   f. local financial institutions

3. Impacts on local government financing and State fiscal management; changing balance of revenues and costs;

4. Social value and behavioral impacts:

   a. community conflict patterns
   b. community attitudes
   c. life style changes

5. Public policy planning and resource allocation impacts.

Category 5, public policy planning and resource allocation impacts, is a subject that our FHA Section 111 grant can be used to explore in a preliminary way. I think we can draw upon the alternate resource case methodology used in the Growth and Human Settlement in Colorado study to begin examining with Section 111 assistance appropriate state level policy responsive to alternate high plains development scenarios. The Growth and Human Settlement in Colorado study principally examined growth scenarios; with alternate high plains scenarios the Division can start exploring the state-level community development policy implications of economic decline in a rural agricultural area.

Schedule

January 1980 through May 1981.

Bill Smith
May 3, 1979

Work Element A-3.18

The Division of Planning will review and monitor the studies to be conducted by the prime contractor of the environmental impacts based on alternative Ogallala Aquifer development strategies as required under element A-3.18.

Schedule

September 1980 through December 1980.

Budget

Staffing: The Division will provide necessary staff to monitor the work of the prime contractor.

Department of Local Affairs
Colorado Division of Planning

Philip H. Schmuck, Director

Richard D. Lamm, Governor

MEMORANDUM

DATE: July 19, 1979

TO: Bill Smith

FROM: Philip H. Schmuck Phil

SUBJECT: Study Plan - High Plains Ogallala Aquiver

The Division of Planning will perform the following steps with respect to socio-economic impact assessment of the alternate Ogallala Aquifer development strategies (A 3.17).

1. Inventory of existing infrastructure and services.

   Division of Planning will inventory existing infrastructure and will subjectively estimate its current deficiency, requirements for improvement, and its probable life span. We will assess current inadequacies in the infrastructure for the eleven county area. We will inventory existing services and relate service levels to existing population levels. Again, current inadequacies in service levels will be identified.

   Infrastructure to be considered will consist of:

   - transportation
   - water and sewer facilities
   - public safety
   - housing
   - education facilities
   - recreation facilities
   - health care facilities

   Services to be studies will consist of:

   - welfare
   - health care, mental and physical
   - education and training services
   - public safety
   - public transportation
   - local financial institutions

2. Division of Planning will prepare a fiscal impact analysis of the eleven county area relating the alternate development strategies to their effect on local government revenues and expenditures. The analysis will primarily consider the alternative effects upon property tax as the major revenue source for local governments in the High Plains. Revenues and expenditures will be projected for each of the eleven counties, but not for individual municipalities. However, significant differences in municipal fiscal circumstances will be explored and discussed qualitatively.

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Bill Smith
July 19, 1979

3. Division of Planning will coordinate with regional Councils of Governments to collect available information concerning:

    - community conflict patterns
    - community attitudes toward:
        - state and federal assistance
        - lifestyle changes
        - migration preferences
        - service demands.

4. Division of Planning will integrate the existing and projected needs identified for the area, along with local capability to provide for those needs as evidenced by the conclusions of the fiscal impact analysis, into a State policy for responding to those needs. The needs of the High Plains area will be prioritized with respect to the needs of other areas of the State, drawing heavily on studies and policy efforts already completed or underway, including:

    - Growth and Human Settlement in Colorado
    - Colorado Economic Development Plan
    - Front Range Project

5. Division of Planning will integrate the relevant information and conclusions of our HUD 701 land use planning effort and the division FmHA 111 rural planning program. The division will review our Growth and Human Settlement Policies in relation to the statewide dynamics of communities whose resource base appears to be relatively stable and not likely to experience further growth and communities whose resource base appears to be undergoing long-term decline. Within the Ogallala Aquifer area of the High Plains the division will give special consideration to the unique problems of this geographic region and will recommend draft policies necessary to address various forms of assistance to these rural communities.

PHS/btm

SECTION IV

APPENDIX

High Plains Project

Bibliographies

HIGH PLAINS PROJECT

Appendix A

HIGH PLAINS PROJECT

As Approved at the High Plains Council Meeting
February 21, 1977

OBJECTIVES

The objectives of this study are:

1. Determine potential development alternatives for the High Plains.

2. Identify and describe the policies and actions required to carry out promising development strategies.

3. Evaluate the local, state, and national implications of these alternative development strategies or the absence of these strategies.

STUDY PARTICIPANTS

The principals in this study are:

1. The High Plains Study Council -
This Council will direct and control this study.

2. The State Governments -
The State Governments will serve on the High Plains Council and will undertake responsibility for specific elements of the study described herein.

3. Technical Advisory Group -
This Advisory Group will include, but not be limited to, representatives of:

Economic Development Administration
Water Resources Council
U. S. Department of Agriculture
Department of the Interior
Corps of Engineers
U. S. Department of Labor
Missouri River Basin Commission
Arkansas White and Red River Basin Interagency Committee
Ozarks Regional Commission
Environmental Protection Agency
Old West Regional Commission
U. S. Department of Housing and Urban Development
Federal Energy Agencies
Representatives of each State's Congressional Delegation

This group will provide technical and institutional counsel to the Federal Representative to the High Plains Study Council for the conduct of this study.

4. General Contractor -
Under the policy guidance of the High Plains Study Council, the General Contractor will serve as the coordinator for this project and will contract and/or perform work herein described.

5. State Advisory Groups -
At each state's option, advisory groups may be appointed by the Governor. The size, composition, and function of such advisory groups shall be determined by each Governor.

STATE RESEARCH

A. In each state there will be performed three fundamental elements of the study and analysis. They are:

1. State and farm-level research
2. Energy production impacts
3. State impacts

At the election of the state this work may be contracted through a single State Agency and by such other mechanism that the state may desire that will be in compliance with applicable Federal and State laws and regulations. This work shall be performed to a quality and a time criteria mutually agreed upon by the states and the Council prior to the undertaking of the work. If an individual state desires that either part or all of these three elements not be performed by the State Government nor be the responsibility of the State Government, such work will

be performed/or contracted for by the General Contractor in a manner similar to that used for the work undertaken under the regional assessment studies.

A state may request of the Council permission to extend its work beyond the three enumerated states' areas of study, but any extension of state work must be in coordination with and not inconsistent with work of the Council.

The work to be performed in the State research is:

1. State farm-level research

   There will be developed for each state an agricultural simulation model for that part of its area overlying the Ogallala and peripheral aquifers. These models are operated to project a time profile for:

   (a) land cultivated, idled, fallowed, and in rotation pasutre with cultivated land broken down by crop and by irrigated and dryland farming;

   (b) agricultural output, by type (crop and livestock), and by irrigated and dryland farming;

   (c) gross and net value of agricultural output ("net" defined as "net" to the agricultural sector and "net" over variable production costs);

(d) farm employment and income (i.e., wages, entrepreneurial income and rents);

(e) variable and fixed production costs other that water (principal short-run production and long-run investment costs should be itemized and the breakdown between fixed and variable costs should be relevant to decisions to make significant changes in farm processes);

(f) water demand curve (i.e., how much water would be purchased if available in unlimited quantities at each array of p_w).

The farm-level research involves two stages. The first stage of baseline projection describes what is and what will be if nothing purposeful is done to change the system. There must be a high degree of interstate cooperation to ensure consistency regarding the many factors and assumptions likely to be common throughout the High Plains area such as capital depreciation rates and relative prices of outputs and inputs. The second stage of this element will project likely changes in economic activity that may be induced by each of an array of deliberate changes injected into the system.

2. Energy production impacts

Development of the region's energy resources also affects the economy of the High Plains.

Each state group will project a time profile for:

(a) energy production within the High Plains area;

(b) royalty payments to landowners within their High Plains area;

(c) employment within the area directly tied to the energy production;

(d) other locally-induced incomes due to energy production;

(e) water used for energy production;

(f) water used for secondary and tertiary recovery techniques for oil.

3. State impacts

Economic adjustments to declining supplies of water and indigenous energy resources in the High Plains extend well beyond both the geographical borders of the region and the agricultural and energy sectors of the High Plains economy. Formulation of a comprehensive development strategy for the region must take into account these broader impacts of the changing use and availability of these resources for both the water surplus and the water deficient areas, including associated social and environmental impacts.

An inventory should be made of present water resources and present water use and estimates of future water resources and future water requirements for all uses including municipal, industrial, power generation, agriculture and mining, in the water deficient and water surplus areas. Water requirements will be identified for levels of economic activity including status quo and ranging from agricultural production without supplemental irrigation (dryland farming) to the full irrigated potential of the study area.

REGIONAL RESEARCH

B. Principal regional topics to be performed and/or contracted by the General Contractor include:

1. Interbasin transfer assessment

The primary objectives of this element is to provide recommendations for future State and Federal actions and studies regarding interbasin transfers. For projects which already have been studied in depth such as the proposed transfer from the Mississippi River to the Texas and New Mexico High Plains, the cost of the water delivered to farms in the High Plains can be recalculated, using the range of long-term energy prices developed by the energy

price and technology assessment. For projects lacking detailed engineering studies, an initial rough range of estimated water delivery costs will be formulated without detailed engineering calculations. A comparison of these water cost estimates and the intertemporal water values generated by the state impact research groups can provide a guide for future action on specific water importation projects.

This study would include a determination of legal constraints under state law and applicable river compacts for local surface water development and distribution networks as well as interstate diversions.

2. National and regional impact assessment

The national regional impact assessment will prepare two reports. The first report will assess the national price implications of the aggregate agricultural production projections of the baseline and alternative scenarios developed by the six state farm-level research groups. The second report considers the national crop and livestock price implications of the alternative scenarios and, if it appears desirable, the interregional implications of these alternative scenarios to be analyzed by the state farm-level research groups.

3. Agriculture and water assessment

This is essentially a probe of conservation devices and includes:

(a) assess the technological and management advances likely to emerge from the current focus and level of agricultural research;

(b) indicate the priority areas for future research;

(c) estimate the impact of alternative funding levels and allocations on the time horizon for the development of alternative technologies;

(d) evaluate the impact of these advances on farming methods, input use, and yields to land and water resources;

(e) suggest measures to encourage a more rapid rate of adoption of specific technologies by farmers.

4. Environmental impact assessment

This would be a preliminary assessment, and should include the environmental impact of doing nothing.

5. Unconventional water supply assessment

Considerable research has been and is being done on ways to increase water availability such as desalting,

weather modification, and to increase the usable part of any given rainfall through measures to artificially increase aquifer recharge. Such projections will be made and will be properly qualified. This will have value since the alternative is for the overall study to make the implicit assumption that weather modification, desalting, and aquifer recharge technology will have no impact on the region during the time span of this study.

6. Institutional assessment

A comprehensive analysis of the development options available to the region must examine alternative institutional arrangements and the potential impact of institutional change on long-run water use and overall economic development.

These laws and water management institutions affecting water use in the High Plains differ significantly among the states. In some states the landowners have property rights to the water underlying their land; in other states water is part of the public domain, but a water right is nevertheless a property right. However, in all six states, regardless of whether the water is privately or publicly owned, State Agencies, policies and laws impose some restraints on its use.

7. Crop prices assessment

The relation between the farmers' prices and their costs are major determinants of the profitability of irrigated farming, how much farmers are willing to spend for water, the rate of depletion of the aquifer, the levels and projections of agricultural production, and the expected returns to projects to develop new water supplies for the High Plains. Clearly, the assumptions regarding input-output price relationships must be carefully chosen and defensible for the study results to have credibility and worth. Furthermore, the assumptions must be consistent. This effort must carefully evaluate alternative sets of long-term agricultural input-output price relations and trends to select sets to be used by those involved in the project.

8. Energy price and technology assessment

The cost and reliability of energy supplies are important determinants of the quantity of water pumped, the irrigation technologies and water conservation measures adopted, the overall profitability of irrigated agriculture, and the feasibility of any interbasin water transfer.

Questions to be addressed by this effort include:

(a) What are the effects of Federal and State energy regulations on the availability and cost of energy?

(b) Can the area be assured of access to the energy needed? If not, how will this uncertainty affect the region?

(c) What energy prices should be used to cost ground water pumping? Pumping for inter-basin transfers?

(d) How will the search for new energy supplies affect the demand for the quantity and quality of water in the region?

(e) What impact will existing natural gas leasing arrangements have on the cost and availability of natural gas in various states?

(f) What technologies are on the horizon which might significantly affect the costs, the demand, or the sources of energy used for pumping?

The energy price and technology assessment is to be based on the judgment of experts in the field relying on the best available data and studies; major new research efforts are not contemplated for this element.

9. Dryland farming assessment

If the region is forced back to dryland farming, this will have significant economic and social implications on both the region and the nation. The initial questions to be examined by this assessment are:

(a) What economic and social impacts will a decline in agricultural production have on the economic and social structure of the region?

(b) What will be the impact of a decline in agricultural production on the related industries?

(c) How sensitive are the impacts detailed in the answers to questions (a) and (b) to the rate of transition from irrigated to dryland farming?

These studies are to completed in time for use both by the General Contractor in preparing the alternative policy scenarios and by the state groups in evaluating the implications of policy alternatives.

10. Non-agricultural development and potential assessment

Expansion of non-agricultural economic activities is a possible means of mitigating the overall impact of a decline in irrigated agriculture on the economic and social structure of the region.

This element will analyze:

(a) the overall economic advantages and disadvantages of the area;

(b) industries that might be attracted to the area;

(c) policy incentives necessary to attract industry to the area;

(d) the water requirements of industry that might be attracted to the area;

(e) the possibility that rigidity in laws, regulations, and allocation policies might deter non-agricultural investment.

ADDITIONAL COMMENTS

C. The General Contractor will make recommendations to the Council on public and private institutions and organizations to perform the regional studies. The General Contractor shall undertake an inventory of existing reports and ongoing studies and research on the issues raised herein, and shall only undertake original research when it is determined by the Council that existing data is insufficient or inadequate to meet the needs of this project.

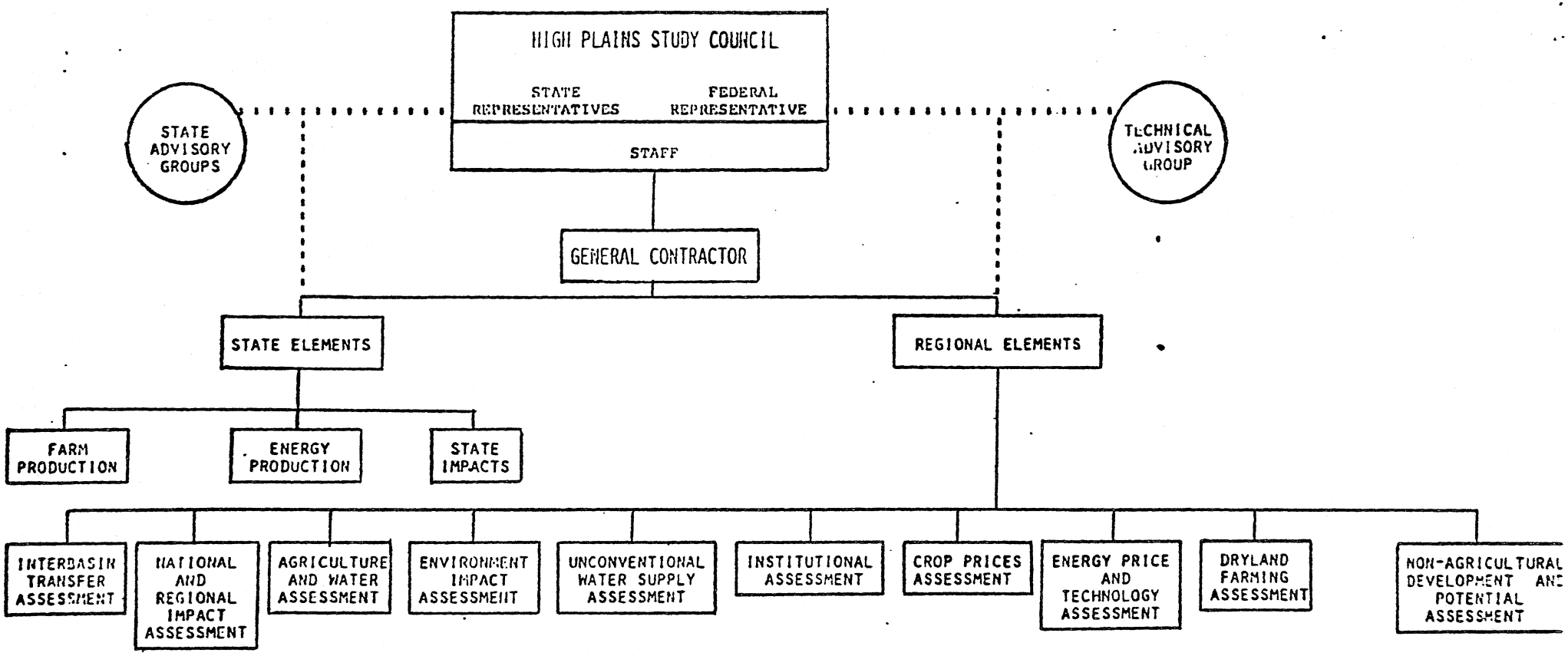
D. The Technical Advisory Group and the General Contractor will make a final recommendation to the Council on which of the regional studies will be performed where and will assure that standardized study techniques are followed in each case.

E. Background materials for the preparation of the General Contractor's (or grantee's) proposal will consist of the following:

* This outline and any supporting materials
* The outline of the "High Plains Ogallala Aquifer Study" and any other state materials
* The General Contractor's own internal ability and resources.

F. The General Contractor will prepare the draft report for the approval of the High Plains Study Council.

G. The High Plains Study Council will issue a final report with recommendations in compliance with applicable statutory requirements.

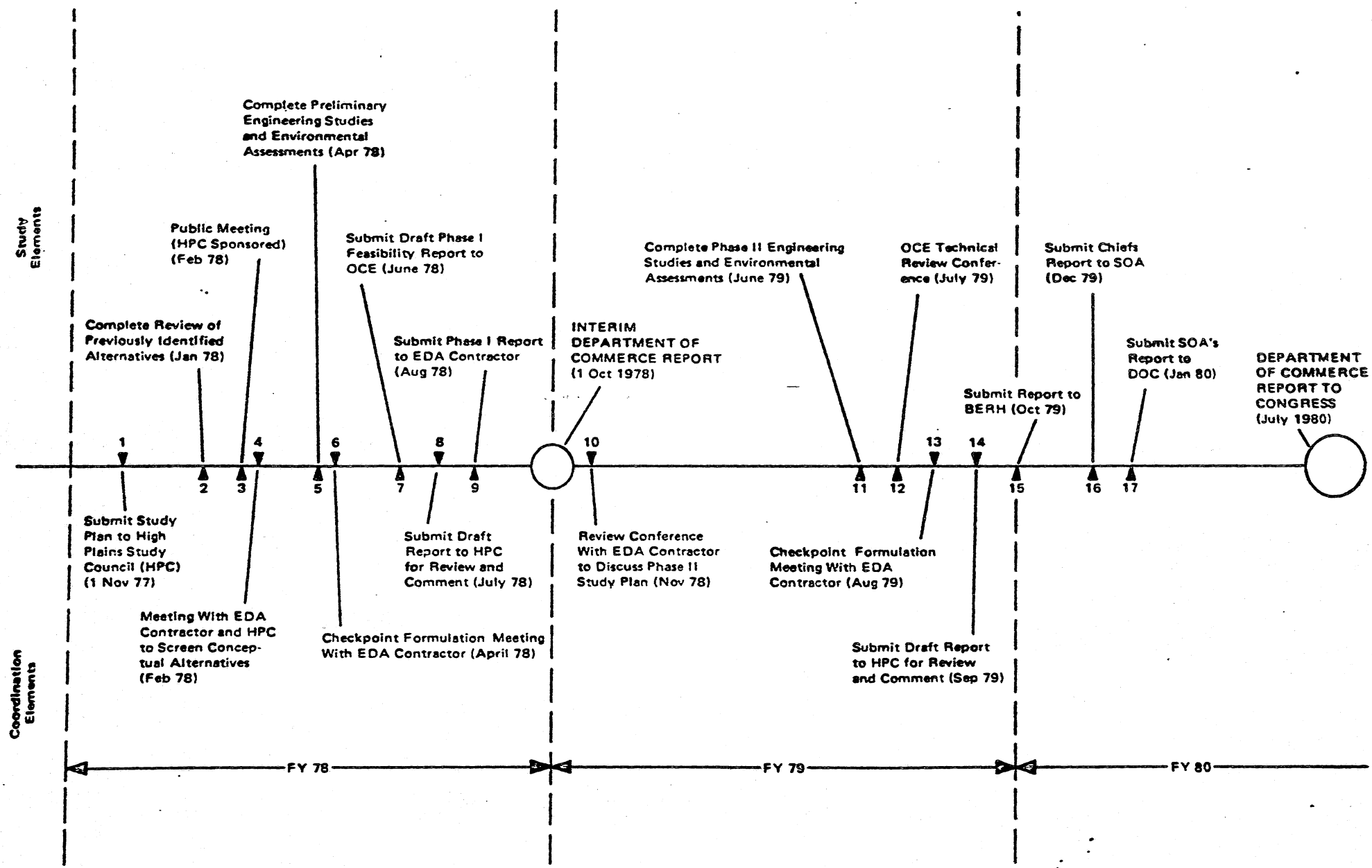


LEGEND

..... ADVISORY FUNCTION

——— LINES OF AUTHORITY

CONCEPTUAL STUDY SCHEDULE
HIGH PLAINS–OGALLALA AQUIFER STUDY
MAY 1977



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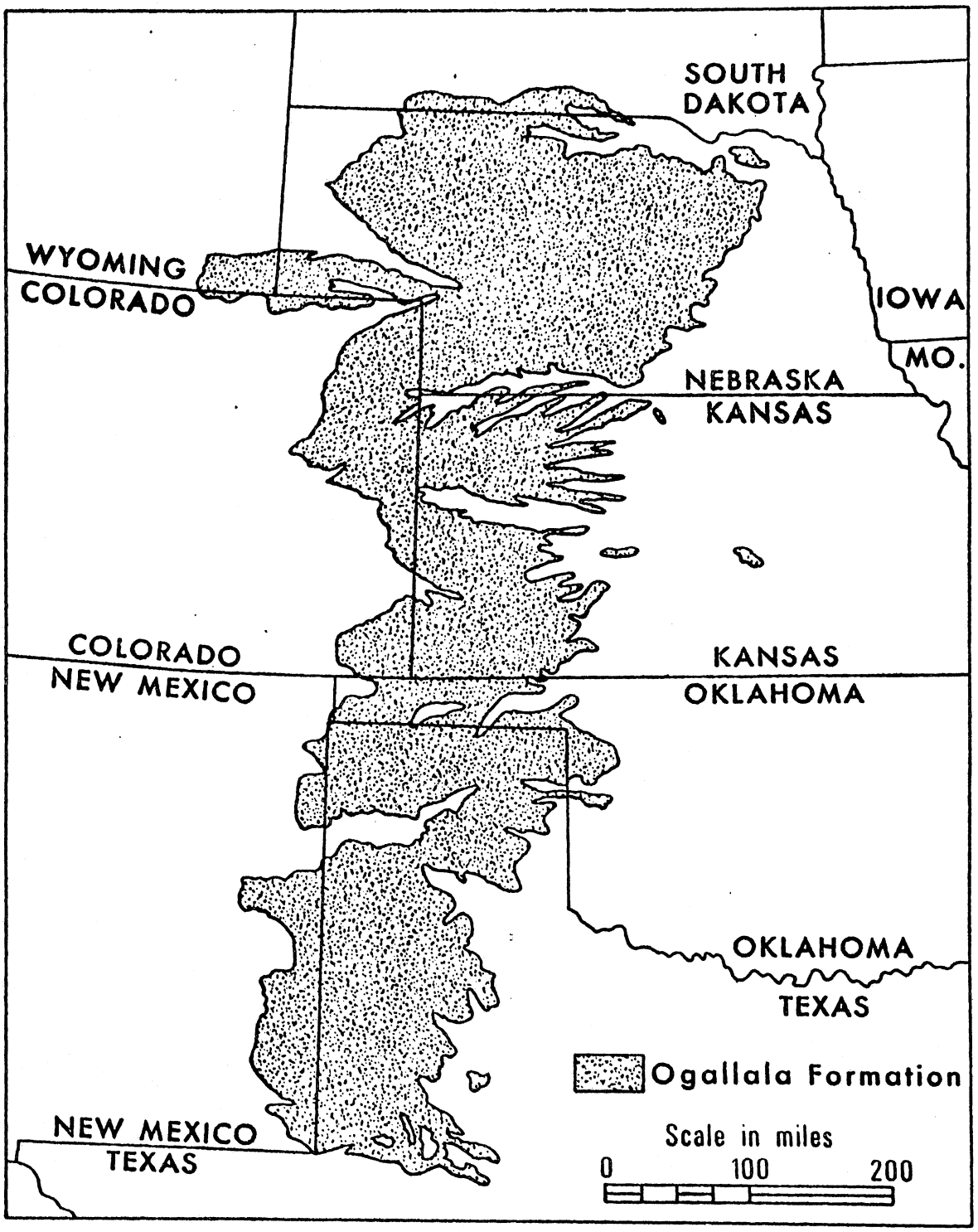

From: John C. Frye, "The Ogallala Formation—A Review," 1970
Ogallala Aquifer Symposium, Texas Tech University

Extent of Ogallala Aquifer

BIBLIOGRAPHIES

DAVID LEONARD CARLSON

ADDRESS

1471 South Gaylord
Denver, CO 80210

(303) 722-9892 home
(303) 839-3218 office

PERSONAL DATA

Birthdate: October 28, 1941
Family Status: Married, three children

EDUCATION

B. A., Carleton College, Northfield, Minnesota, 1963.
Major: mathematics

M. A., University of Michigan, Ann Arbor, Michigan, 1965.
Major: mathematics

Ph.D., University of Colorado, Boulder, Colorado, 1971.
Thesis: Good Sequences of Integers.

CURRENT POSITION

Since August, 1975

Resource Analyst, Colorado Department of Agriculture, Denver, Colorado.

Responsibilities include: Planning and supervising activities of the Resource Analysis Section, which provides technical research and planning assistance to the Department, other state, local, and federal agencies, and to the public, in analyzing water, land use, and energy matters of agricultural significance. These activities include:

- two-year study of agricultural land conversion in Colorado;
- development of computer mapping program for the Department;
- staff support for Colorado Gasohol Promotion Committee;
- preparation of several statewide LANDSAT satellite mosaics;
- written review and oral testimony regarding environmental impact statements;
- joint design and subcontract with Colorado State University on NASA project to test applicability of LANDSAT to determine drought impacts;
- review of state and federal water policy design;
- initiation of energy activity monitoring system;
- analysis of transmission line impacts upon agriculture;
- contract manager for solar energy malting house project.

David Leonard Carlson
10/78

PREVIOUS POSITIONS

1973-1975

Family Day Care Education Coordinator, E.I.D. Associates, Inc., Denver, Colorado.

Responsibilities included: Directing and administering the Colorado portion of three consecutive federally funded education programs for 180 family day care mothers; hiring, training, and supervising staff; preparing and presenting workshop materials on the financial aspects of day care, and training workshop leaders; project design and proposal writing; fiscal planning and monitoring of Colorado portion of projects.

Mathematics Consultant (part-time), Denver Public Schools.

Responsibilities included: Establishing a mathematics laboratory, writing metric materials, conducting in-service workshops for teachers and aides, and preparing performance objectives in elementary school mathematics.

1971-1972

Assistant Prefessor of Mathematics, University of Southern Colorado, Pueblo, Colorado.

1966-1968

Instructor of Mathematics, University of Minnesota, Duluth, Minnesota.

1963-1964

Junior High School Mathematics Teacher, Flat Rock High School, Flat Rock, Michigan.

COMMUNITY ACTIVITIES

- St. Paul's Lutheran Church (long-range planning, choir, teaching)
- Central Denver Community Service--a consortium of several downtown churches and agencies which provides emergency services to transients (former chairman of the board)
- Rocky Mountain Center on Environment (board member)

PROFESSIONAL MEMBERSHIPS

Mathematical Association of America, and
U. S. Metric Association, Inc.

PUBLICATIONS

Good Sequences of Integers, Journal of Number Theory; February, 1975.

Critical Agricultural Lands of Colorado (with James Rubingh); to appear.

State of Colorado

RICHARD D. LAMM
Governor

OFFICE OF ENERGY CONSERVATION
DENVER

BUIE SEAWELL
Director

RONALD W. CATTANY
State Energy Economist

Biographical Data

A native of Denver, Mr. Cattany was educated at Regis High School and Colorado School of Mines, where he received a B.S. in Mineral Engineering (1975) and an M.S. in Mineral Economics (1976) on a 5-year Board of Trustees Scholarship. Prior to joining OEC, he served as Assistant Director of the Mineral Economics Institute at Colorado School of Mines (CSM) (1976-1977). During that period, he was technical consultant to the Governor's Energy Policy Council in the planning phase of the Colorado Energy Conservation Plan (Base and Supplemental) in the areas of energy conservation methodology analysis and environmental impacts.

From 1975 through 1976, he served as energy analyst for the Colorado Energy Research Institute (CERI). During that time, he served as author, coauthor, or researcher of 5 publications on Colorado Energy. The areas of analysis included: energy supply and demand relationships on a state and regional level by fuel type and by sector; the impacts of policy decisions both local and national on the state's energy resources; the resources, exploration and mining methods, environmental impacts, capital and manpower requirements, socioeconomic impacts, and technology requirements of the development of various energy resources. In 1974, he served as researcher on the first comprehensive energy supply/demand study for Colorado (CSM). He was also employed as a junior engineer at Stearns-Roger, Inc. He has also served as consultant to the U.S. Bureau of Mines and the California Energy Resources Conservation and Development Commission. His M.S. thesis, The Impact of Energy on the Colorado Economy, is now published and available through OEC and CSM Publications. It relates the state economy to the energy needs and resources of the state.

Mr. Cattany is a member of the Research Advisory Council of the Denver Chamber of Commerce, the Denver Coal Club, the Society of Mining Engineers of the AIME, and the Institute of Management Sciences. He was nominated to Who's Who in the West, received the AMAX Technical Writing Award, honorary membership in Kappa Mu Epsilon, University of Colorado School of Journalism Award, Sertoma Award, Who's Who Among Amercian High School Students, and Outstanding American High School Students.

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Ronald W. Cattany
Areas of Involvement
Office of Energy Conservation

1. Energy supply/demand analysis for various regions in the state including the production, consumption, and prices by sector and by fuel type. Also aiding in the coordination of a comprehensive energy consumption inventory by CERI which will contain detailed consumption analysis for various regions in Colorado. Some energy production and consumption forcasting.

2. Coordinating and planning the Colorado Energy Emergency Contingency Plan to allow the state to handle energy emergencies.

3. Analysis of the economics of conventional and alternative residential energy options. Also aided in the development and evaluation of the residential (OEC) and commercial (ECAC) audit programs.

4. Monitoring and evaluation of the OEC energy conservation programs.

5. Analysis of the impacts on the resources and economy of various state and national energy policies.

6. Coordinator of the Colorado Energy Information Inventory Handbook which will identify the individuals and energy related information in Colorado government.

7. Planning the state participation in the Schools and Hospitals Program of the National Energy Plan.

8. Coordination of special projects including the OEC Energy Conservation Loan Program, Land Use and Energy Conservation, and Energy Conservation Programs for Utilities.

9. Available for workshops and panels regarding 1) the relationships between energy supply and demand with the state economy; and 2) the development cycle of various energy forms from resource identification through end-use. Will talk with any interested groups or individuals.

10. Will attempt to answer any energy related information or at least link the inquiry up with the proper source.

R E S U M E

Bruce E. DeBrine
1270 W. 3rd Avenue
Broomfield, Colorado 80020
(303) 469-0977 home --- (303) 839-3587 office

Born: April 18, 1928, Rochester, New York

Education:

B.S. Geology-- 1954 New Mexico Institute of Mining & Technology

M.S. Ground Water Hydrology-- 1965
New Mexico Institute of Mining & Technology

Ph.D. Geoscience-Dissertation in Ground Water Hydrology-- 1971
New Mexico Institute of Mining & Technology

Experience:

1971--present
Water Resources Engineer with Colorado Division of Water Resources. Started as Water Resources Engineer II, progressed through various levels to present position as Deputy State Engineer for Ground Water in charge of the ground water section in May, 1975. Present position involves supervision of the administration of all ground water appropriated and used in the State of Colorado under the direction of the State Engineer. Included in these duties is the maintenance of the records of all water wells in the state and the hydrologic and geologic data associated therewith, the use of this data in the evaluation of all applications for water well permits and ground water use, geothermal exploration and development, the planning and preparation of investigations necessary to sustain this work and other miscellaneous duties associated with these functions including coordination with other state agencies such as the Oil and Gas Conservation Commission, the Water Quality Control Commission, and the Water Conservation Board.

1960--1970
Research Assistant -- Research and Development Division of the New Mexico Institute of Mining & Technology. Planned and directed numerous research projects involving investigations of aquifers of Central New Mexico. These projects included the determination of geohydrologic properties of the aquifers monitoring programs for both water quality and quantities, and the design and implementation of drilling programs for ground water data collection. Designed, constructed and operated a weather station in the Estancia Valley, New Mexico.

Resume -- Bruce E. DeBrine

1954--1960

Development Geologist in Reservoir Geologic Section of the Pure Oil Company (now Union Oil of California) in Texas Producing Division, Fort Worth, Texas. Participated in and conducted various reservoir studies and evaluations, drilling programs, and subsurface geologic mapping in West Central and West Texas and Southeast New Mexico; 1958-1960 directed development department field operations in Hobbs, New Mexico district office of the company.

Professional Registration and Affiliations:

Registered Professional Engineer - Colorado No. 12334
Member - Society of Petroleum Engineers of AIME since 1954
Member - American Geophysical Union since 1961
Member - Technical Division of National Water Well Association since 1963.

Publications:

North Central Texas Oil and Gas Production, 1955, AIME, Statistics of Oil and Gas Development and Production, Volume 10, 1956.

Cenozoic Sedimentary Rocks in Socorro Valley, New Mexico, in guidebook for 14th Field Conference, New Mexico Geological Society, 1963.

Electrolytic Model Study for Collector Wells Under River Beds,Water Resource Research, Volume 6, No. 3, 1970.

Hydrologic Investigation of a Closed Basin with a Playa Discharge, Estancia Valley, New Mexico, unpublished Ph. D. dissertation on file, library, New Mexico Institute Mining & Technology, 1971.

SUMMARY VITA

CHARLES G. JORDAN

B.S. in Marine Engineering from U.S. Naval Academy in 1963

J.D. (Juris Doctor) in Law from University of Denver in 1970.

Admitted to Colorado Bar in 1971.

1971-1972 - Praticed law in Denver, Colorado

1972-1975 - Planning Administrator for Routt County and City of Steamboat Springs.

1975-1978 - Senior Planner for Colorado Division of Planning responsible for coordinating environmental reviews of federal projects.

1979 - Chief Planner, Colorado Division of Planning

BIOGRAPHICAL SKETCH

ROBERT A. YOUNG

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WATER RESOURCES
STATE ENGINEER
COLO.

TITLE OR RANK AND EMPLOYER	BIRTHDATE	MARITAL STATUS
Professor Department of Economics Colorado State University.	September 2, 1931	Married

PLACE OF BIRTH	SOCIAL SECURITY NUMBER	SEX
Minden, Nebraska	571-44-6254	Male

EDUCATION

University of California; Davis, California (Agriculture)	B.S.	1954
University of California; Davis, California (Agricultural Economics)	B.S.	1958
Michigan State University; East Lansing, Michigan (Agricultural Economics)	Ph.D.	1963

MAJOR FIELDS

Natural Resource Economics and Agricultural Economics

AREAS OF PROFESSIONAL WORK

Teaching and Research

HONORS, AWARDS, AND PROFESSIONAL LISTINGS

Memberships: American Economic Association; Western Agricultural Economic Association; American Agricultural Economics Association; American Association for the Advancement of Science; American Water Resources Association; International Association of Agricultural Economists.

Awards: Award for Outstanding Published Research, Western Agricultural Economics Association, 1965. Award for Outstanding Published Research, Western Agricultural Economic Association, 1970 (with W. E. Martin). Fulbright-Hayes Senior Research Fellow, 1976-1977.

Honors: President-elect, Western Agricultural Economics Association, 1978.

PROFESSIONAL EXPERIENCE

Professor, Department of Economics, Colorado State University, Fort Collins, Colorado. Teaching and research, 1972-present; Assistant Chairman 1977-78.

Sabbatic Leave, Fulbright-Hayes Senior Research Fellow, Lincoln College, Canterbury, New Zealand. Teaching and research, November 1976-May 1977.

Associate Professor, Department of Economics, Colorado State University, Fort Collins, Colorado. Teaching and research, 1970-1972.

Visiting Scholar, Resources for the Future, Inc., Washington, D.C. Research, 1968-1970.

Associate Professor, Department of Agricultural Economics, University of Arizona, Tucson, Arizona. Teaching and research, 1966-1968.

Assistant Professor, Department of Agricultural Economics, University of Arizona, Tucson, Arizona. Teaching and research, 1963-1966.

Research Associate, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan. Research, 1961-1963.

Research Assistant (Part-time), Michigan State University, East Lansing, Michigan. Research, 1958-1961.

PUBLICATIONS

DISSERTATION: An economic Study of the Eastern Beet Sugar Industry

(Attached List of Technical Publications)

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LIST OF TECHNICAL PUBLICATIONS

ROBERT A. YOUNG

BOOKS AND CHAPTERS IN BOOKS

"Evaluating Agricultural Effects of Salinity Abatement Projects in the Colorado River Basin: Agronomic and Economic Considerations," chapter in SALINITY IN WATER RESOURCES: PROCEEDINGS OF THE 16th ANNUAL WESTERN RESOURCES CONFERENCE. C. W. Howe and Ernest Flack, editors. (Boulder: Merriman Publishing Company, 1974). With K. C. Nobe and W. T. Franklin.

"Economic Impacts of Regional Saline Irrigation Return Flow Programs," chapter in SALINITY IN IRRIGATION AND WATER RESOURCES, D. Yaron, editor. (New York: Marcel Dekker Publishing Company, 1978).

Robert A. Young

JOURNAL ARTICLES AND BOOK REVIEWS

"The Economics of Arizona's Water Problem." Arizona Review XVI (3, March 1967), College of Business and Public Service, University of Arizona, Tucson, Arizona, pp. 9-18. With W. E. Martin.

"Review of Methods of Land Economics Research, W. L. Gibson, Jr., R. J. Hildreth, and Gene Wunderlich, Editors." Journal of Farm Economics 49 (3, August 1967): 772-774.

"The Need for Additional Water in the Arid Southwest: An Economist's Dissent." The Annals of Regional Science III (1, June 1969): 22-31. With W. E. Martin.

"Projecting Hydrologic and Economic Interrelations in Groundwater Basin Management." American Journal of Agricultural Economics 51 (5, December 1969): 1593-1597. With Thomas Burdak.

"Discussion: Role of Irrigation in the West's Expanding Economy." Journal of the Irrigation and Drainage Division (American Society of Civil Engineers) 95 (IR4 December 1969): 611-616. With W. E. Martin, M. M. Kelso, and J. S. Hillman.

"Temporal Allocation of Ground Water: A Simulation Approach." Water Resources Research 6 (1, February 1970): 3-21. With J. D. Bredehoeft.

"The Arizona Water Controversy: An Economist's View." Journal of the Arizona Academy of Science 6 (1, March 1970): 3-10.

"Safe Yield of Aquifers: An Economic Reformulation." Journal of the Irrigation and Drainage Division (American Society of Civil Engineers) 96 (IR4, December 1970).

"Irrigation Development and Agricultural Abundance: Conflicting Elements in Publ Policy toward Agriculture." Looking Ahead (National Planning Association, Washington, D.C.) 19 (7, October 1971).

"Digital Computer Simulation for Solving Management Problems of Conjunctive Groun and Surface Water Systems." Water Resources Research 8 (3, June 1972): 533-55 With John D. Bredehoeft.

"Price Elasticity of Demand for Municipal Water: A Case Study of Tucson, Arizon Water Resources Research 9 (4, August 1973): 1068-1072.

"Open Access and the Economics of Grazing Land Conservation: The Papago Case." Journal of Soil and Water Conservation 28 (4, July-August 1973): 165-168. With James R. Simpson.

"Yield and Economic Implications of Sugarbeet Production as Influenced by Irrigation and Nitrogen Fertilizer." Journal of American Society of Sugar Beet Technologists 18 (1, April 1974): 34-44. With M. Nicholson, T. Kibreab and R. Danielson.

"The Economic Value of Water for Waste Dilution: Regional Forecasts to 1980." Journal of the Water Pollution Control Federation 46 (1, July 1974): 1653-1662. With S. L. Gray.

CONTRACT AND CONSULTING REPORTS

Future Water Demands: The Impacts of Technological Change, Public Policy and Changing Market Conditions on the Water Use Patterns of Selected Sectors of the United States Economy: 1970-1990, prepared for the National Water Commission by Resources for the Future, Inc., Arlington, Virginia, National Water Commission, Report EES-71-001, March 1971. With Charles W. Howe and Clifford S. Russell.

The Economic Value of Water: Concepts and Empirical Estimates, report for the National Water Commission, National Technical Information Service (NTIS No. PB 210-036), August 1972. With S. Lee Gray and R. B. Held.

Assessing Economic Impacts of Increased Salinity on Irrigated Agriculture in the Colorado River Basin, report to the U.S. Bureau of Reclamation, Department of Economics, NRE-15, Colorado State University, Fort Collins, Colorado, August 1973. With W. T. Franklin and K. C. Nobe.

Systematic Design of Legal Regulations for Optimal Surface Groundwater Usage, Completion Report Series No. 53, Environmental Resources Center, Colorado State University, Fort Collins, Colorado, 1973. With J. H. Morel-Seytoux and G. E. Radosevich.

Economic and Institutional Analysis of Water Quality Standards and Management, OWRT Completion Report, CSU Environmental Resources Center, Colorado State University, Fort Collins, Colorado, March 1975. With G. E. Radosevich, S. L. Gray, and K. L. Leathers.

Systematic Design of Legal Regulations for Optimal Surface-Ground Water Management: Phase II, Completion Report Series No. 68, Colorado State University, Environmental Resources Center, September 1975. With H. J. Morel-Seytoux and G. E. Radosevich.

Evaluating Economic Impacts of Programs for Control of Saline Irrigation Return Flows: A Case Study of the Grand Valley, Colorado, final contract report to the Environmental Protection Agency, Denver, Colorado, June 1976. With Kenneth L. Leathers.

Models Designed to Efficiently Allocate Irrigation Water Uses Based on Crop Response to Soil Moisture Stress, Technical Report No. 8, Environmental Resources Center, Colorado State University, Fort Collins, Colorado, May 1977. With R. A. Anderson and D. Yaron.

Option Values, Preservation Values and Recreation Benefits of Improved Water Quality: A Case Study of the South Platte River Basin, Colorado, U.S. EPA600/5-78-001, Socioeconomic Environmental Studies Series Health Effects Research; Environmental Protection Agency, Research Triangle Park, North Carolina, January 1978. With R. G. Walsh, D. A. Greenley, J. R. McKean and A. A. Prato.

Economic Impacts of Selected Control Measures in the Upper Colorado: A Case Study of the Grand Valley, Colorado, chapter in J. C. Andersen and A. P. Kleinman, eds., Salinity Management Options for the Colorado River, Utah Water Research Laboratories Publication PRWG149-1, October 1977. With Kenneth Leathers and W. T. Franklin.

Recreation Benefit of Water Quality: Rocky Mountain National Park South Platte River Basin: Technical Report No. 12, Colorado Water Resources Research Institute, Colorado State University, May, 1978.

SERVICE PUBLICATIONS

"Summary and Conclusions from an Economic Study of the Eastern Beet Sugar Industry." The Sugar Journal 28 (3, August 1965): 53-54.

"Do Imports Affect Beef Prices?" Progressive Agriculture in Arizona (SVII (4, 1965): 10-11. With James Simpson.

"Beef Imports, Cattle Supplies and the Price of Fat Cattle." Progressive Agriculture in Arizona XVII (5, 1965): 14-16. With James Simpson.

"Economic Comparisons between Stripper-Type and Spindle-Type Cotton Harvesting Machines," in Cotton, A College of Agriculture Report, Series P-4, Agricultural Experiment Station, University of Arizona, Tucson, Arizona, February 1966, pp. 95-99. With W. E. Martin.

"Legal Quota System Governs Sugar." Progressive Agriculture in Arizona XVIII (3, 1966): 14-15.

"Grapefruit Consumption and Prices Go Down." Progressive Agriculture in Arizona XVIII (4, 1966): 14-15. With William Hunt.

"Sugar Beet Report from an Economist." Progressive Agriculture in Arizona XIX (5, 1967): 18-19.

"Organization and Pricing Policies of Major Water Distribution Organizations in Central Arizona," File Report 67-5, Department of Agricultural Economics, University of Arizona, Tucson, Arizona, 1967. With James W. Goss.

"Sources of Net Returns for Pinal County Growers." Progressive Agriculture in Arizona XX (5, 1968): 14-15. With W. E. Martin and Harold M. Stults.

"Costs and Returns on Field Crop Farms in the Sulfur Springs Valley." Progressive Agriculture in Arizona XX (3, 1968): 10-11. With V. Wilson Lee.

"Papago Floodwater Pastures Show Promise." Progressive Agriculture in Arizona XXI (2, 1969): 18-19. With James R. Simpson, P. R. Ogden, and C. W. Whitfield.

"Projections of Net Income and Water Use in Pinal County, Arizona." Progressive Agriculture in Arizona XXI (4, 1969): 3-4.

"A Method for Estimating Commodity Prices for Long Time Farm Planning." Colorado Agribusiness Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Winter 1975-76. With L. R. Conklin.

Robert A. Young

UNIVERSITY PUBLICATIONS

An Economic Study of the Eastern Beet Sugar Industry, Research Bulletin No. 9, Michigan Agricultural Experiment Station, Michigan State University, East Lansing, Michigan, 1965.

An Economic Study of the Winter Vegetable Export Industry of Northwest Mexico, Technical Bulletin 179, Agricultural Experiment Station, University of Arizona, Tucson, Arizona, 1968. With Robert S. Firch.

Data for Arizona Crop Farm Planning, College of Agriculture, University of Arizona, 1968. With William E. Martin and Dale E. Shaw.

"Cost of Owning a Self-Contained Recreational Vehicle." Service in Action, No. 9.127, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, July 1976. With John Daubert.

Robert A. Young

OTHER PUBLICATIONS

"Modeling Production Response Relations for Irrigation Water: Review and Implications," Water Resources and the Economic Development of the West, Proceedings of a Conference, December 14-15, 1967, Report No. 16, CEWRD/WAERC, Pullman, Washington, pp. 1-21. With William E. Martin.

"The Investment Decision for Seepage Reduction," Proceedings, Second Seepage Symposium, U.S. Department of Agriculture, ARS-41-147, Washington, D.C., 1969, pp. 139-143.

The Discount Rate in Public Investment Evaluation: Conference Proceedings of the Western Agricultural Economics Research Council, CEWRD Report No. 17, Denver, Colorado, December 17-18, 1969. Edited with B. D. Gardner.

Two Studies in Water Resources Management: "The Temporal Allocation of Ground Water-A Simulation Approach" and "Digital Computer Simulation for Solving Management Problems of Conjunctive Groundwater and Surface Water Systems," Reprint No. 103, Resources for the Future, Inc., Arlington, Virginia, October, 1972. With John D. Bredehoeft.

"Costs and Returns to Field Crop Farms in the Lower South Platte Valley, Colorado," Colorado Roundup, November 1974. With L. Conklin.

"Two Lectures in Water Resource Economics," Training Manual in Application of Principles and Standards of the Water Resource Council, H. Caulfield, editor, Colorado State University, Fort Collins, Colorado, March 1975.

"Economic Evaluation of Non-Structural Measures to Control Saline Irrigation Return Flows," Proceedings, Western Agricultural Economics Association, 48th Annual Meeting, July 20-22, 1975. With K. L. Leathers.

"Congestion, Success and the Economic Value of Colorado Deer Hunting Experiences," in Transactions; 42nd National Wildlife Conference, Atlanta, Georgia, 1977; 42; 129-136. With R. Miller and A. Prato.

NAME: LONGENBAUGH, ROBERT A. AGE: Born November 27, 1935
Durango, Colorado, USA

PRESENT POSITION: Associate Professor, Civil Engineering, Colorado State University

EDUCATION:

Ph.D. - Course work; Civil Engineering Department, University of California, Davis, 1967-70, Dissertation: Optimal Conjunctive Use from a Stream-Aquifer System, completion pending.

M.S. - Agricultural Engineering Department, Colorado State University, August 1962, Thesis: Statistical Techniques for Predicting River Accretion - South Platte River.

Attended U.S. Air Force Meteorology Program, UCLA, 1957-1958.

B.S. - Agricultural Engineering Department, Colorado State University, June 1957.

Professional Registration: PE No. 5912, State of Colorado

PROFESSIONAL CAREER:

July 1977 - Present Associate Professor of Civil Engineering, Colorado State University. Conduct research on groundwater management, conjunctive use of ground and surface water, irrigation pumping plant efficiencies, artificial recharge, and water resource planning. Extension irrigation engineer, teaching both graduate and undergraduate courses in the Civil Engineering and Agricultural Engineering Departments.

1970 - July 1977 Assistant Professor of Civil Engineering at Colorado State University. Co-leader of Groundwater Program in the Civil Engineering Department, Director of the Colorado Water Data Bank Project (72-77), project leader to evaluate water availability for energy development (75-77), conduct research on artificial recharge, irrigation pumping plants, groundwater modeling, and optimization of groundwater systems. Taught graduate courses in both Civil and Agricultural Engineering Departments.

1973 Two-month temporary assignment to University of California, Davis to teach graduate groundwater course and work on Ph.D.

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1967 - 1970	Sabbatical leave and leave without pay from Colorado State University to University of California, Davis to work on Ph.D. Assistant Development Engineer at UCD conducting research on optimum conjunctive use of ground and surface water.
1966 - 1967	Assistant Professor of Civil Engineering at Colorado State University. Principle Investigator of Cope Artificial Recharge Study. Conduct research on groundwater modeling and groundwater investigations. Taught groundwater graduate courses.
1961 - 1966	Junior Civil Engineer at Colorado State University. Worked on groundwater investigation studies, conducted research on groundwater modeling and was principle investigator for the Cope Recharge Study (1965) and Kiowa-Bijou Groundwater Evaluation Project (1964-65). Participated in Extension Service Education projects in Colorado High Plains.
1960 - 1961	Graduate Research Assistant in Civil Engineering Department at Colorado State University working on M.S. degree. Assisted on groundwater research projects.
1958 - 1960	Meteorologist in USAF assigned to Det 2, 15th Weather Squadron, Guam.
1957 - 1958	Student in Meteorology Program at UCLA, Los Angeles for USAF.
1957	Engineering Trainee for Caterpillar Tractor Company, Peoria, Illinois.
1946 - 1957	Farm labor on my father's farm. Responsible for irrigation, tractor work and supervision of part-time help.

CONSULTANT ACTIVITIES:

1977 - present	Peoples Natural Gas Company - evaluation of declining water levels on natural gas consumption for irrigation
1977	Vic Koelzer - Review well construction and pump selection for new irrigation enterprise requiring 2.5 million dollar investment.
1976	Clark Nichols, attorney - groundwater hydrologist for water law suite in Nebraska
1973 - 74	Colorado Public Service Company - Groundwater investigation for Fort St. Vrain Power Plant.

1973	One week short course on groundwater hydrology in San Carlos, Brazil.
1965	City of Akron, Colorado, groundwater investigation for domestic water supply.

AWARDS:

Distinguished Service Award for Education, U.S. Food and Energy Council. One of only two awards presented in 1977.

PROFESSIONAL AND HONORARY SOCIETIES:

American Society of Civil Engineers, Member
American Geophysical Union
International Water Resources Association
Colorado Water Well Contractors Association
Colorado Section of ASCE
Sigma Xi

PROFESSIONAL COMMITTEES:

Local Arrangements for First International Hydrology Symposium, 1967.

Co-Chairman of Local Arrangements for ASCE Irrigation & Drainage Specialty Conference, 1973.

Director of Second International Hydrology Symposium, 1972.

Member, National ASCE Water Resource Systems Committee (1970-74), Chairman (1973-74).

Chairman, National ASCE Committee on Calibration and Verification of Groundwater Models (1976-78).

Co-Director, Water for Energy Symposium, Denver, Colorado, 1977.

Robert A. Longenbaugh

Bibliography

Bittinger, M. W. and R. A. Longenbaugh, Theoretical Distribution of Water from a Moving Irrigation Sprinkler. Presented at the 1960 Winter Meeting - ASCE, Memphis, Tennessee. ASAE Paper No. 60726, and published in Transactions Vol. 5, No. 1, 1962. CER60MWB-RAL53.

Schulz, E. F., _____ and M. W. Bittinger, 1961. Natural Ground Water Recharge from Kiowa Creek. 1960 Progress Report. Prepared in February 1961.

Bittinger, M. W., _____ and E. F. Schulz, 1962. Natural Ground Water Recharge from Kiowa Creek. 1961 Progress Report. Prepared in March 1962.

_____, 1962. Statistical Techniques for Predicting River Accretion as Applied to the South Platte River. M.S. Thesis prepared in fulfillment of the requirements for the Degree of Master of Science in Agricultural Engineering. Copy on file with Colorado State University Library. July 1962.

_____, 1963. Ground Water Resources in Northeastern Colorado. 1963 Guidebook of Rocky Mountain Association of Geologists, pp. 205-7. CER63RAL19.

_____, 1963. Ground Water Recharge from Kiowa Creek. 1962 Progress Report. Prepared in February 1963.

_____ and M. W. Bittinger, 1963. Ground and Surface Water Relationships Studied by Statistical Techniques. Presented at the 1963 Winter Meeting of ASAE as Paper No. 63-740. Accepted for publication in forthcoming issue of ASAE Transactions. CER63RAL-MWB64.

Duke, H. R. and _____, Evaluation of Water Resources in Kiowa and Bijou Creek Basins, Colorado. Civil Engineering Department, Colorado State University, Fort Collins, Colorado, May 1966, 87 p. CER66HD-RAL19.

_____, Artificial Ground-Water Recharge on the Arikaree River, Near Cope, Colorado. Civil Engineering Department, Colorado State University, Fort Collins, Colorado, July 1966, 12 p. CER66RAL35.

_____ and M. W. Bittinger, Discussion of Colorado's Groundwater Problems. Presented February 24, 1967, Colorado Senate Committee on Water, Denver, Colorado. CER66-67RAL-MWB35.

Bittinger, M. W., H. R. Duke and _____, Mathematical Simulations for Better Aquifer Management. Presented at International Association for Scientific Hydrology Symposium on Artificial Recharge and Management of Aquifers, Haifa, Israel, March 19-26, 1967, Publication No. 72, pp. 509-19. CER66-67MWB10.

Eshett, A. and _____, Mathematical Model for Transient Flow in Porous Media. Progress Report, Civil Engineering Department, Colorado State University, November 1965. CER65RAL-AE59.

_____, Mathematical Simulation of a Stream-Aquifer System. Paper presented at the Third American Water Resources Conference in San Francisco, November 1967, 10 p. CER67-68RAL22.

Miles, D. L. and _____, Evaluation of Irrigation Pumping Plant Efficiencies and Costs in the High Plains of Eastern Colorado. Colorado State University Experiment Station General Series 876, December 1968, 19 p.

_____, Evaluation of the Method to Compute Volumes of Water Pumped from Power Records. Civil Engineering Department, Colorado State University, April 1970, 24 p. CER69-70RAL31.

_____, Determining Optimum Operational Policies for Conjunctive Use of Ground and Surface Water Using Linear Programming. Paper presented at the 18th Annual Specialty Conference Hydraulics Division ASCE, University of Minnesota, August 19-21, 1970.

Nalluswami, M., _____ and D. K. Sunada, Finite-Element Method for the Hydrodynamic Dispersion Equation with Mixed Partial Derivatives. Journal of Water Resources Research, October 1972.

_____, Groundwater Development in Eastern Colorado and the Related Problems. Presented at the Great Plains Council Meeting, Lincoln, Nebraska, July 24, 1972.

_____, Colorado Water Data Bank Quarterly Progress Reports. Civil Engineering Department, Colorado State University, October 1972, January 1973, April 1973.

_____, Annual Summary Report 1972-73, Colorado Water Data Bank Project. Civil Engineering Department, Colorado State University, July 1973.

_____, Analysis of Colorado State University's 1972-73 Expenses and Future Budget Requirements. Colorado Water Data Bank Project Technical Report 73-01, Colorado State University, July 20, 1973.

_____ and N. E. McMillin, A Data Manager Looks at the Development of the Colorado Water Data Bank. Paper presented at National Bureau of Standards "Symposium on the Management of Data Elements in Information Processing," Gaithersburg, Maryland, January 24, 1974. CEP73-74RAL-NM22.

_____, Analysis of Water Availability for Energy Development. A progress report and statement of work, Civil Engineering Department, Colorado State University, July 1975, 11 p.

_____ and N. Krishnamurthi, Computer Estimate of Natural Recharge from Soil Moisture Data - High Plains of Colorado. Completion Report, Environmental Resources Center, Colorado State University, August 1975.

Rios, Emilio and _____, Optimizing Conjunctive Use of Surface and Groundwater: A Case Study in Colorado. Paper presented at the ASCE Hydraulics Specialty Conference in Seattle, Washington, August 1975.

_____ et al., First Annual Report, South Platte Ditch Recharge Demonstration. Colorado State University, Engineering Research Center, September 1975, 18 p. CER75-76RL20.

_____, Analysis of Water Availability for Energy Development. First Quarterly Progress Report, Civil Engineering Department, Colorado State University, October 1975, 10 p.

_____, Optimal Conjunctive Use of Water from the South Platte River Stream-Aquifer System. A paper presented at the National ASCE Meeting in Denver, Colorado, December 1975.

Krishnamurthi, N., _____ and D. K. Sunada, Mathematical Modeling of Natural Groundwater Recharge. Paper presented at AGU meeting in San Francisco, California, December 1975, 15 p.

Krishnamurthi, N., D. K. Sunada and _____, On Oscillation of Numerical Solution of Modified Richards' Equation, submitted to Water Resources Research, Sept. 1976.

Krishnamurthi, N., D. K. Sunada and _____, An Inverse Method for Identification of Hydraulic Properties of Soils, submitted to Water Resources Research, Sept. 1976.

_____, South Platte Ditch Recharge Demonstration. Second Annual Report. Colorado State University, Engineering Research Center, November 1977, 24 p., CER77-78RAL18.

BIOGRAPHICAL SKETCH

JOHN R. MCKEAN

TITLE OR RANK AND EMPLOYER	BIRTHDATE	MARITAL STATUS
Professor Department of Economics Colorado State University	January 15, 1939	Single

PLACE OF BIRTH	SOCIAL SECURITY NUMBER	SEX
Centralia, Washington	534-34-5331	Male

EDUCATION

University of Washington, Seattle, Washington (Economics)	B.A.	1960
University of Washington, Seattle, Washington (Economics)	M.A.	1964
University of Washington, Seattle, Washington (Economics)	Ph.D.	1967

MAJOR FIELDS

Microeconomic Theory, Regional Resource Economics, Econometrics, Managerial Economics, and Computer Programming

AREAS OF PROFESSIONAL WORK

Teaching, Research, and Consulting

HONORS, AWARDS, AND PROFESSIONAL LISTINGS

Awards

Dissertation Research Supported by a Ford Foundation Grant for Investigating Sources of Economic Growth, 1964-1965.

Memberships

The Econometric Society
American Economic Association
Western Regional Science Association
Western Economics Association
Omicron Delta Epsilon
Industrial Organization Society

PROFESSIONAL EXPERIENCE

Professor, Department of Economics, Colorado State University, Fort Collins, Colorado. Teaching and research, 1974-present.

Associate Professor, Department of Economics, Colorado State University, Fort Collins, Colorado. Teaching and research, 1969-1974.

Assistant Professor, Department of Economics, University of Idaho, Moscow, Idaho. Teaching and research, 1968-1969.

PROFESSIONAL EXPERIENCE (Continued)

Lecturer, University of Washington, Seattle, Washington. Teaching and research, 1966-1968.

Assistant Professor, University of Alberta, Edmonton, Canada. Teaching and research, 1965-1966.

Teaching and Research Assistant, University of Washington, Seattle, Washington. Teaching and research, 1962-1964.

PUBLICATIONS

DISSERTATION: Regional Disaggregation of Rates of Return to Educational Investment.

(See Attached List of Technical Publications)

SPECIALIZED EXPERIENCE

Administrative (at Colorado State University)

Member, Executive Committee, Department of Economics
Chairman, Graduate Coordinating Committee, Department of Economics
Chairman, Research Coordinating Committee, Department of Economics
Chairman, Graduate Student Admissions Committee
Member, Ph.D. Examination Committee
Member, M.S. Examination Committee
Member, Library Committee
Member, CSU Faculty Computer Advisory Committee
Faculty Advisor, Omicron Delta Epsilon, CSU, Delta Chapter

Service

Editorial Consultant for The American Economist, The Journal of Water Resources Research, Rand McNally College Publishing Co; and Dickenson Publishing Co.

Teaching

University of Alberta, Edmonton, Department of Economics
- Econometrics, graduate level
- Business Statistics, graduate level, College of Business
- Principles of Economics

University of Washington, College of Business, Seattle, Washington
- Statistics for Decision Making
- Money and Banking
- Managerial Economics
- Introduction to Business Administration
- Intermediate Price Theory
- Alternative Theories of the Firm, graduate level
- Business History, graduate level

SPECIALIZED EXPERIENCE (Continued)

Teaching (Continued)

University of Idaho, College of Business, Moscow, Idaho
- Economic Statistics
- Price Theory, graduate level
- Intermediate Price Theory
- Principles of Economics

Colorado State University
- Principles of Economics
- Managerial Economics, joint course with College of Business
- Mathematical Economics
- Econometrics
- Intermediate Price Theory
- Price Theory, graduate level
- Price Theory Seminar (Ph.D. students)
- Regional Economics
- Welfare Theory

Research

Economic Consultant for:
- Mobile-Premix, Inc.
- National Park Service
- Larimer-Weld Regional Council of Governments
- Multinational Agribusiness Systems, Inc.
- GEOMAT, Inc.
- Colorado Energy Research Institute
- Centaur Management Consultants, Inc.
- EDAW, Inc.

Director or Co-Director of Contract Research for:
- Bureau of Land Management
- Office of Water Resources Technology
- Bureau of Reclamation
- Colorado State University Administration
- Colorado State Experiment Station
- Mountain Empire Dairymen's Association
- National Institute of Mental Health
- State of Idaho
- Colorado Energy Research Institute
- Bureau of Labour, Ottawa, Canada
- Larimer-Weld Regional Council of Governments
- E.S.C.S., U. S. Department of Agriculture

LIST OF TECHNICAL PUBLICATIONS

Books

Study Guide to Accompany Introductory Economics. New York: Harper and Row, 1971. With R. A. Wykstra.

Readings in Introductory Economics. New York: Harper and Row, 1971. With R. A. Wykstra.

Reprints in Readings or Sections in Books

"A Cross-Section Look at Employment, Growth and Inflation." Macroeconomic Readings. Revised Edition, John Lindauer, Editor. New York: The Free Press (Collier-MacMillan Ltd.), 1968.

"Managerial Control of the Firm," in The Pricing System. Section 11.1. New York: Holden Day, Inc., 1973. With John Kania.

"Ownership, Control, and the Contemporary Corporation: A General Behavioral Analysis," A Reader About Business Economics, Pedol and Cardini, Editors. Milan, Italy, Etas Libri, Forthcoming. With Jahn Kania.

Journal Articles and Book Reviews

"A Cross-Section Look at Employment, Growth and Inflation." Western Economic Journal (December 1964). With R. H. Scott.

"A Note on Administered Prices with Fluctuating Demand." Journal of Financial and Quantitative Analysis (March 1969).

"A Neo-Classical Foundation for a Theory of Manager Controlled Firms." Recherches de Louvain (April 1969). With R. H. Scott.

"Regional Differences in the Finance and Production of College Education." The Annals of Regional Science (December 1969).

"A Note on the Concept of Revenue Elasticity." Intermountain Economic Review (Fall 1972).

"Demand Elasticity, Product Differentiation, and Market Structure." Journal of Economic Theory (Spring 1973). With R. D. Peterson.

"A Technique to Study Tax Reform." Intermountain Economic Review (Spring 1974). With D. D. Hemley.

"Profits in the Manager Controlled Firm." Industrial Organization Review 3 (2, 1975). With R. H. Scott.

"Estimating the Impact of Higher Education from Input-Output Models: A Case Study." The Rocky Mountain Social Science Journal (January 1975). With S. L. Gray and D. D. Rohdy. (Colorado Experiment Station Scientific Series No. 1995.)

LIST OF TECHNICAL PUBLICATIONS (Continued)

Journal Articles and Book Reviews (Continued)

"Executive Compensation and the Theory of the Firm: An Empirical Study." Industrial Marketing Management (April 1975). With R. J. Monsen.

"Book Review of Economics of Involuntary Transfers by Talbot Page." The Annals of Regional Science (July 1975).

"An Oracular and Pretentious Comment on an Old Prescription to Alleviate Stagflation." Intermountain Economic Review (Fall 1975). With J. A. Diemer.

"Quality of Life and Environmental Social Overhead Capital." Journal of Water Resources Research (December 1975). With R. Ericson.

"A Note on the Presentation of the Optimal Inventory Problem." Intermountain Economic Review (Spring 1976). With Ronald Miller.

"Ownership, Control, and the Contemporary Corporation: A General Behavioral Analysis." Kyklos (2, 1976). Abstracted in Journal of Economic Literature, (December 1976). With John Kania.

"Book Review of U. S. Energy R and D Policy, The Role of Economics by John Tilton." The Annals of Regional Science (March 1976).

"The Development of Water Multiplier Impacts from Input-Output Analysis: An Empirical Example from Boulder, Larimer, and Weld Counties, Colorado." Journal of Water Resources Research (April 1976). With S. L. Gray.

"Book Review of Water Supplies and Economic Growth in an Arid Environment by Kelso, Martin, and Mack." The American Economist (Spring 1976).

"On Revising Micro Foundations for Analyzing Socioeconomic Organization," The Journal of Behavorial Economics (Summer 1976).

"A Note on the Demand for Skilled Leisure." The American Economist (Fall 1976). With Roy Allen.

"An Inventory Model Allowing for Backorders." The American Economist (Spring 1977). With Ronald R. Miller.

Book Review of "Towards an Efficient Allocation of Electric Energy by Noel Uri." Annals of Regional Science (July 1977).

"An Extension of the Market Power Index," Industrial Organization Review (Vol. 4, 1976). With Ronald Miller.

"Book Review of the Energy Balloon by Udall, Conconi, and Osterhout." Annals of Regional Science (forthcoming 1978).

"An Industry Approach to Owner Manager Control and Profit Performance," Journal of Business (April 1978). With John Kania.

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Service Publications

Graduate Student Guide, Department of Economics, Colorado State University, Fort Collins, Colorado, 1972.

Graduate Student Guide, Department of Economics, Colorado State University, Fort Collins, Colorado, June 1974.

"900 Mile Grain Pipeline Proposed," Feature Article, Colorado Rancher and Farmer, June 1974.

University Publications

"An Interindustry Study of the Colorado Economy," Colorado Agricultural Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Summer 1972. With S. L. Gray.

"Growth in Colorado Wheat Feeding," Colorado Agricultural Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Summer 1972.

"1970 Labor Inputs in Colorado Agri-Business," Colorado Agricultural Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Summer 1973. With S. L. Gray.

"1970 Flows of Payments in Colorado Agri-Business," Colorado Agricultural Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Summer 1973. With S. L. Gray.

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An Economic Analysis of Water Use in Boulder, Larimer, and Weld Counties, Colorado, With Projections to 1980, Natural Resource Economics Series #16, Department of Economics, Colorado State University, Fort Collins, Colorado, March 1974. With S. L. Gray. (Revised as Experiment Station Bulletin, General Series 953, Colorado State University, Fort Collins, Colorado, April 1976.)

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University Publications (Continued)

Estimating Water Multipliers from Input-Output Analysis: An Empirical Example from Boulder, Larimer, and Weld Counties, Colorado, Natural Resources Economics Series #18, Department of Economics, Colorado State University, Fort Collins, Colorado, June 1974. With S. L. Gray.

Alleviating the Impact of Resource Shortages: An Analytical Method, Experiment Station Bulletin, Technical Bulletin 131, Colorado State University, Fort Collins, Colorado, May 1977. With S. L. Gray and F. Ward. Natural Resource Economics Series #23.

"Employment Effects of Colorado Agriculture," Colorado Agribusiness Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Summer 1976. With S. L. Gray.

"The Importance of Water to Agribusiness Industries in Colorado," Colorado Agribusiness Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Summer 1976. With S. L. Gray.

"Hunting and Fishing Contributes to Rural Income and Employment in Colorado," Colorado Agribusiness Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Summer 1977. With Dwight Blood.

"Colorado Agriculture Sensitive to Natural Gas Supplies," Colorado Agribusiness Roundup, Cooperative Extension Service, Colorado State University, Fort Collins, Colorado, Spring 1978. With Edward Sparling and Joe Weber.

"Pecuniary Rewards from Efficient Automobiles," Colorado Economic Issues, Cooperative Extension Service, Volume 3, Number 4, December 1978.

Other Publications and Presentations

"Central Place Analysis Re-examined," Annual Meeting of the Western Regional Science Association, Department of Economics, University of Idaho, 1968. Reprints Circulated.

"The Neo-Classical Foundations for a Theory of Manager-Controlled Firms," Annual Meeting of the Western Economic Association, 1968, Department of Economics, University of Idaho. Reprints Circulated. (Abstracted in the Western Economic Journal, September 1968.)

Regional Differences in the Finance and Production of Education," Annual Meeting of the Western Regional Science Association, 1968, Department of Economics, University of Idaho. (Published in The Annuals of Regional Science, December 1969.)

Court Testimony on Behalf of Mobile-Premix, Inc., February 27, 1974 and May 8, 1974, U.S. Federal District Court, United States of America vs Mobile-Premix, Inc., Civil Action No. C-3917. (Anti-trust suit).

"Appendix D," in Future Energy Alternatives for Colorado, Colorado Energy Research Institute, Golden, Colorado, and the State of Colorado, January 1976, pp. 1-9. With S. L. Gray.

"Impacts of Alternative Economic Scenarios, Future Energy Alternatives for Colorado, Special Symposia, 89th Annual Research Conference, Colorado State University, Fort Collins, Colorado, April 1, 1976 (with officials and other consultants from Colorado Energy Research Institute.)

"Impact Analysis of Oil Shale Development on the Economy of Northwestern Colorado," Annual Meeting of the Western Regional Science Association, Department of Economics, Colorado State University, 1979. With Paul Huszar and S.L. Gray.

John R. McKean

CURRENT WORK IN PROGRESS

The Relationship Between All-Or-Nothing Demand and Utility for Marshallian Demand With Zero Income Effect. Unpublished paper with Ronald R. Miller. (Submitted to Land Economics.)

The Economy of the Upper Colorado Mainstem, Description and Analysis, Contract Report, Bureau of Land Management. With Joe Weber.

A Simultaneous Equation Test of the Marris Managerial Theory of the Firm. Unpublished paper with John Kania. (Submitted to American Economic Review.)

Effects of Public Grazing Lands on the Economy of Colorado, contract study in progress, U. S. Forest Service, Bureau of Land Management, Colorado State Experiment Station. With Larry Mack and Tom Bartlett.

A Cross-Section, Recursive Demand Analysis for Appliance Fuel Choice and Household Electricity Demand, contract study in progress, U. S. Department of Agriculture.

Costs and Benefits to Visitors of Alternative Recreation Land Use, Yosemite National Park, contract study in progress, National Park Service. With Richard Walsh.

Health Related Damages from Air Pollution, unpublished paper with Wendall Winger. (Submitted to Quarterly Journal of Economics.)

Shaping Utility Functions and the Neoclassical Paradigm, unpublished paper with Bob Keller and Rodney Peterson. (Submitted to American Economic Review.)

The Economy of Jackson and Grand Counties, Colorado, Description and Analysis, Contract Report, Bureau of Land Management. With Joe Weber.

Profits and Market Power: Is High Concentration Really Necessary for the Exercise of Monopoly Power? Completed paper with John Kania and Wallace Peterson. (To be submitted to Southern Economic Journal.)

An Input-Output Analysis of Energy Use for Space Heating in Greeley, Colorado. With Elmar Reiter and Joe Weber. Contract Report, Department of Energy.

"Current Colorado Laws Severely Reduces Mining Impact Funds to Counties and Municipalities After 1981," Colorado Economic Issues.

"The Economic Impacts of Non-Resident Sportsman Spending in Colorado," Colorado Agribusiness Roundup. With Dwight Blood.

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EDUCATION

1969 - 1973 Grand Valley State College, Allendale, Michigan. B.S., with honors, in Biology.

1973 - 1974 University of Northern Colorado, Greeley, Colorado. M.A., Biological Science.

1975 - 1977 Colorado State University, Fort Collins, Colorado. M.S., Regional Resource Planning.

Member of Gamma Sigma Delta, Honor Society of Agriculture and Lambda Sigma Tau, Honorary Science Fraternity.

EXPERIENCE

Summer, 1977 to Present — Resource Analyst with the Colorado Department of Agriculture. Responsible for Critical Agricultural Lands Project, an investigation into the conversion of agricultural lands within the state. Duties include computer mapping, management of contracts, review of environmental impact statements and state, federal, and local policy dealing with agriculture.

Fall, 1975 to Summer, 1977 — Graduate research assistant at Colorado State University. Research was in developing quantitative methods of land classification.

Summer, 1974 to Fall, 1975 — Conservation Technician for the Soil Conservation Service. Duties included assisting farmers and ranchers in conservation practices. Specifically assisting in surveying, construction checks, farm planning, construction designs, and public relations.

Fall, 1974 — Intern with the Greeley Planning Department. Duties included helping prepare an environmental statement for a proposed road construction project. Also assisted environmental designer on study of ribbon development in Greeley.

Fall, 1973 to Winter, 1974 — Part-time instructor at the University of Northern Colorado. Subjects taught were; Botany, Zoology, Introduction to

Biology, Anatomy, and Physiology. Responsibilities included teaching the labs of these courses, instructing students in proper laboratory procedures, and instructing them in various biological concepts.

PUBLICATIONS

"The applicability of Cluster Analysis in the Classification of Forest Land," Colorado State University, M.S. thesis, 1977.

"Suitability Analysis and Wildland Classification: An Approach," with David Betters in Journal of Environmental Management, (1978) 7, 59-72.

ACTIVITIES AND INTERESTS

Most outdoor activities, including backpacking, trout fishing and skiing. Served as National Ski Patrolman for several years. Am presently a member of the United States Volleyball Association and the Colorado Volleyball Association.

PERSONAL

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Date of Birth: October 23, 1942

Education:

B.S., Regis College, 1964; Major in Business Administration; Minor in Economics

M.A., Colorado State College, 1966; Major in Social Science; Class "A" Colorado Secondary Teaching Certificate

Ph.D., Colorado State University, 1976; Major in Economics - Specializations in Regional Economics, Natural Resource Economics, and Economic Theory; Dissertation Title - An Interindustry Economic Analysis of Northwestern Colorado

Work Experience:

1961-1964, summers, mill laborer, accounting clerk, Climax Molybdenum

1965-1966, Fellow in Administration, Colorado State College
Research: Special topics for the President's Office

1966-1967, Assistant Professor of Economics, Northern State College
Teaching: International Economics, Government Finance, Money and Banking, Principles of Economics

1967-1972, Assistant Professor of History and Social Science, Northern Montana College (leave without pay, 1972-1974)
Teaching: Seminar in Economic Issues, U.S. Economic History, Principles of Economics, Conservation, American History, American Government, Tax Law, Principles of Accounting, Business Law

1972-1976, Graduate Teaching Assistant (1972-1974), Research Assistant (1974-1975), Research Associate (1976), Department of Economics, Colorado State University
Teaching: Economics for Decision Making, Agricultural Economics, Principles of Economics
Research: Energy resources development

1976-Present, Assistant Professor of Mineral Economics, Colorado School of Mines; 1978-Present, Assistant to the Director of Research Services; 1978-Present, Manager, Policy Program, Mining and Minerals Resources Research Institute
Teaching: Regional Economics, Resource Economics, Intermediate Economic Theory, Principles of Economics
Research: Regional input-output models; gasohol marketing

JOSEPH C. WEBER

Publications:

Weber, Joseph C., "Another Look at the Robert M. LaFollette Seamen's Act." Proceedings of the Montana Academy of Sciences, 1969, pages 157-163.

Weber, Joseph C., "The Florissant Fossil Beds National Mounument: A Case for Welfare Economics." Proceedings of the Montana Academy of Sciences, 1970, pages 125-129.

Weber, Joseph C., "Experience of a Montana Barber." Proceedings of the Montana Academy of Sciences, 1971, pages 164-167.

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Gray, S. Lee, and McKean, John R., with contributions by Weber, Joseph C. and Sparling, Edward M. An Economic Analysis of Water Use in Colorado's Economy. (Office of Water Research and Technology Project No. B-058-COLO). Fort Collins, Colorado: Environmental Resources Center, Colorado State University, December 1975.

Colorado Energy Research Institute. Futute Energy Alternatives for Colorado. Summary report and 2 volumes. Golden, Colorado, January 1976. Volume II, Appendix D: Use of the Colorado Input-Output Model to Analyze the Impacts of Alternative Scenarios on Output, Income, Water Use and Employment in Colorado's Economy, by S. Lee Gray, J.R. McKean, Joseph C. Weber, and Edward M. Sparling.

McKean, John R.; Sparling, Edward M.; and Weber, Joseph C. "Colorado Agriculture Sensitive to Natural Gas Supplies." Colorado Agribusiness Roundup. Fort Collins, Colorado: Cooperative Extension Service, Colorado State University, Spring, 1978, pages 19-20.

Gray, S. Lee; McKean, John R.; Sparling, Edward W.; and Weber, Joseph C. "Measurement of Growth Equalized Employment Multiplier Effects: An Empirical Example." The Annals of Regional Science, Forthcoming.

Professional Societies:

American Accounting Association, 1963
American Economics Association, 1966
Phi Delta Kappa, Professional Fraternity in Education, 1966; Past President, Hi-Line Montana Field Chapter, 1970
Sigma Xi, 1979

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Grant and Contract Research Completed:

Gray, S. Lee; McKean, John R.; Sparling, Edward M.; and Weber, Joseph C., "Natural Gas Multiplier Impacts and a Colorado Energy Conservation Plan." Submitted to Colorado Energy Research Institute, March 1977,

Gray, S. Lee; McKean, John R.; Sparling, Edward M.; and Weber, Joseph C., "Employment Multiplier Impacts: The Colorado I-O Model." Submitted to Colorado Energy Research Institute, March 1977.

Gray, S. Lee; McKean, John R.; and Weber, Joseph C., "The Economy of Northwestern Colorado: Description and Analysis." Part I. "Executive Summary." Part II. "Technical Report." (U.S. Bureau of Land Management Contract No. 52500-CTS-1019.) Fort Collins, Colorado: Department of Economics, Colorado State University, 1977.

Gray, S. Lee; Huszar, Paul C.; McKean, John R.; and Weber, Joseph C., "An Interindustry Analysis for Garfield, Mesa, Moffat, Rio Blanco, and Routt Counties, Colorado." Submitted to EDAW, Inc. for the U.S. Bureau of Land Management, February 1978.

McKean, John R., and Weber, Joseph C., "An Interindustry Economic Analysis of Moffat, Rio Blanco, and Routt Counties, Colorado." Submitted to Centaur Management Consultants, Inc. for the U.S. Bureau of Land Management, November 1978.

Weber, Joseph C., and Long, Gregg A., "Colorado Gasohol-Gasoline Market Study - Phase I." Submitted to the Colorado Gasohol Promotion Committee, Colorado Department of Agriculture, December 1978.

Weber, Joseph C.; Long, Gregg A.; and Smith, Stephen G. "Colorado Gasohol-Gasoline Market Study - Phase II." Submitted to the Colorado Gasohol Promotion Committee, Colorado Department of Agriculture, June 1979.

McKean, John R., and Weber, Joseph C. "An Input-Output Analysis of the Upper Colorado River Main Stem Region." Submitted to Centaur Management Consultants, Inc. for the U.S. Bureau of Land Management, June 1979.

Grant and Contract Research in Progress:

Weber, Joseph C., 1979, "County Data for the Kremmling Region, Colorado," and "County Data for the Upper Colorado River Main Stem Region, Colorado," County Information Service, Colorado State University, $14,645.

Weber, Joseph C., 1979, "Market Development for Solar Industrial Process Heat," Solar Energy Research Institute, $24,777.

Weber, Joseph C., 1979, "Greeley Input-Output Model," Subcontract from Colorado State University on Department of Energy Contract "Effects of Atmospheric Variability on Energy Utilization and Conservation, $6,142.

Consulting:

Hvass, Weisman and King Law Offices, Minneapolis, Minnesota, 1972.

Bear Paw Development Corporation, Havre, Montana, 1972.

Thorne Ecological Institute, Boulder, Colorado, 1978.

Ford Foundation and Colorado Energy Research Institute Project - Higher Education and the State Review of Federal Environ-Mental Impact Statements. Arapahoe-Roosevelt Forest Plan; Federal Coal Leasing Programmatic; West Central Colorado Coal. 1978-1979.