PROPOSAL TO THE

ENERGY RESEARCH AND DEVELOPMENT
ADMINISTRATION

CONCERNING

DEMONSTRATION OF THE TECHNICAL FEASIBILITY AND ECONOMIC VIABILITY OF NEW TECHNOLOGIES FOR REDUCING CRUDE OIL AND NATURAL GAS CONSUMPTION IN THE IRRIGATION OF U. S. AGRICULTURAL CROPS

SUBMITTED BY:

LARIMER-WELD REGIONAL
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JULY 20, 1977

TABLE OF CONTENTS

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July 20, 1977

Energy Research and Development
Administration
Operations, Division of Procurement
Washington, D.C. 20545

ATTN: DOCUMENT CONTROL SPECIALIST
T. J. POLICASTRO

Gentlemen:

REFERENCE: PON EC-77-N-01-5000

Attached herewith is a proposal from the Larimer-Weld Regional Council of Governments, Loveland, Colorado, in response to a notice in the Commerce Business Daily, June 24, 1977, regarding:

DEMONSTRATION OF THE TECHNICAL FEASIBILITY AND ECONOMIC VIABILITY OF NEW TECHNOLOGIES FOR REDUCING CRUDE OIL AND NATURAL GAS CONSUMPTION IN THE IRRIGATION OF U. S. AGRICULTURAL CROPS.

We believe that our proposal, if implemented, would contribute significantly to the understanding of the complex interrelationships between energy conservation, water resource conservation, and water pollution control goals of our National government as they pertain to irrigated agricultural practices. We believe that the project could lead to the formulation of effective policies at the National level to maximize the attainment of these oftentimes conflicting goals as well as demonstrate the effectiveness of intergovernmental cooperation in its carrying out.

The proposal can be readily integrated into related ongoing studies being administered by the Larimer-Weld COG, including Section 208 Water Quality Planning for irrigated agriculture and drought planning and coordination. We have a sufficient data base to initiate the proposal with ease at relatively low cost to ERDA. We will, of course, provide a price proposal following discussion with ERDA to determine needs and budgetary limitations and development of a detailed workplan.

Our primary technical expertise would be supplied by Toups Corporation of Loveland, Colorado. Additional technical assistance would be solicited from the Department of Agriculture, Soil Conservation Service, and Colorado State University in Fort Collins, Colorado, as needed. We have a proven track record of conducting research and demonstration projects with support from Toups Corporation, Colorado State University, and the Soil Conservation Service, in addition to a close working relationship with area farmers. In fact, we are in the process of conducting on-farm flow and water quality measurements this irrigation season with the objectives of determining methods to increase irrigation efficiency for water quality purposes.

We sincerely hope that our proposal will stimulate discussion between our respective organizations. Mr. W. Tom Pitts, Vice President of Toups Corporation, and I would be happy to travel to Washington, D.C., to confer with you on this matter.

Sincerely yours,

F. A. Eidsness, Jr.
Director, 208 Water Quality
Planning

FAE:psj
Enc.

1.0 INTRODUCTION

The Larimer-Weld Regional Council of Governments (LWRCOG) is a regional planning agency representing two county governments and thirty-three municipal governments. Steeped in Western heritage and traditions as described in James Michener's best selling novel, CENTENNIAL, the 6,600 square mile region is an agricultural area of state and national significance. Irrigated agriculture embraces approximately ½ million acres with more than 2,700 individual farming operations. Crops include corn, alfalfa, sugar beets, wheat, and a variety of truck crops. With the increased urbanization of the Front Range Corridor at the foot of the Rocky Mountains, a substantial growth in sprinkler irrigation systems is occuring to the east utilizing ground water supplies from the alluvium of the South Platte River.

Because of the importance of agriculture to the economy and environment of this north Colorado area, the Larimer-Weld COG has become a leader in the West in developing new approaches in implementing more efficient irrigation systems. This has been made possible through funding assistance from the U. S. Environmental Protection Agency in the form of a 208 Water Quality Management Planning grant.

In addition, the COG is currently engaged in an EPA-funded research project entitled, "Identification of Methodology and the Technical and Institutional Feasibility for Development and Implementation of Best Mangement Practices for Irrigated Agriculture."

Basic elements of the study which are directly related to this proposal, include:

- Detailed definition of agricultural practices
- Determination of conveyance systems
- Determination of efficiency of on-farm irrigation systems based on an extensive program of farm sampling and flow measurement.

The project is being undertaken with technical assistance from Toups Corporation, the Department of Agriculture, Soil Conservation Service, and Colorado State University. In addition, an intergovernmental cooperative agreement which includes local Soil Conservation Districts has maximized resources, expertise, and farmer input. A summary of the ongoing Research and Demonstration Program is attached.

The Larimer-Weld COG is proposing a Research and Demonstration project for the Energy Research and Demonstration Administration to be integrated into related ongoing programs. The preliminary proposal includes the following elements:

- Statement of the Problem
- Proposed Research and Demonstration Project
- Project Overview
- Project Management
- Qualifications of Toups Corporation

2.0 STATEMENT OF THE PROBLEM

Over the past several decades, agriculture in America has undergone two major evolutionary changes:

1. A growing trend towards larger cooperative or corporate agricultural enterprises coupled with a decline in independent family-owned and operated farms;

2. Increased mechanization.

The principal stimuli for these changes are deeply rooted in improving the economic well being of the agricultural industry by:

1. Increasing the predictability and reliability of crop productivity through a greater degree of control over the farm environment through increased mechanization;

2. A corresponding reduction of the individual or corporate risks associated with an unpredictable and oftentimes unstable market by high volume production, which increases the possibilities of supplying national and international markets; and enabling investment in farm futures.

Only in recent years has the cost of energy become a significant factor in the agricultural economy. Mechanization of the agricultural industry was not developed with an eye towards energy conservation. This reality coupled with recent international petroleum embargoes and apparent national shortages of crude oil and natural gas has kindled an awareness on the part of the national government of a need to conserve these unrenewable energy resources.

As part of the nationwide effort to reduce energy consumption, the Energy Research and Development Administration (ERDA) is proposing to undertake a Research and Demonstration project to evaluate the technical feasibility and economic viability of new technologies for reducing crude oil and natural gas consumption in the irrigation of U. S. agricultural crops.

One example of Research and Demonstration cited by ERDA in the Commerce Business Daily publication of June 24, 1977, is:

> "(4) Research and demonstrations leading to the reduction of water consumption by agricultural crops through optimum water scheduling and improved instrumentation for monitoring crop water needs."

Though cited only as an example, ERDA has identified what we believe to be one of the most significant problems

and formidable challenges that agriculture faces in meeting three National objectives. They are:

1. Energy conservation;
2. Water Conservation and increased efficiency;
3. Water quality control.

The missing link in developing or modifying irrigation systems which meet the stated objectives is a proven methodology for optimum water scheduling and associated instrumentation which can be effectively implemented in the field on a wide-scale basis.

Although technology exists to scientifically schedule water including instrumentation, methodologies have not been developed and assessed in terms of the feasibility of application of scientific water scheduling on a wide-scale basis in a social/political/economic framework.

Currently, most irrigation water supply practices are determined by the farmer based upon his experience and judgment which takes into account soil type, crop type, and topography. Frequently, irrigation practices are based upon those of his forebearers. However, with the advent of the energy policies, pollution control laws, and nationwide drought conditions, changes in irrigation practices can be expected. Scientific methods will play a more significant role in the future of irrigated agriculture.

A perplexing aspect of determining and implementing appropriate modifications in irrigation practices is the attainment of oftentimes conflicting goals. Conflicts will arise, for example, between energy conservation goals and water quality goals when consideration is given to reducing tailwater runoff. Sprinkler irrigation systems are proven to optimize soil moisture conditions with little or no runoff; however, as compared to flood irrigation, sprinkler systems are high energy consumers.

Federal and state agencies will need to coordinate their policies and programs regarding energy conservation, water resource conservation, and water pollution control. A methodology is needed to assess the relative tradeoff of meeting individual goals where conflicts may exist among them. An assessment of the tradeoffs can be made effectively only if the methodology is sensitive to social and politicial attitudes and daily operational and manpower problems experienced by the farmer.

3.0 PROPOSED RESEARCH AND DEMONSTRATION PROJECT

The Research and Demonstration Project being proposed would involve the following:

1. Assessment of various water scheduling practices including instrumentation to determine crop water requirements in terms of their effectiveness in reducing energy consumption;

2. Evaluation of the relative significance of achieving lower energy requirements as compared to water resource conservation and water quality control with specific emphasis on determining complementary and conflicting practices under varying physical conditions, crop types, and agricultural practices;

3. Determination of the feasibility of implementing scientific measuring and flow scheduling on a wide-scale basis from economic and operational standpoints and social acceptability;

4. If feasible, determination of methodologies for widespread application of scientific flow scheduling (including instrumentation) on farms;

5. Evaluation of the institutional requirements associated with implementation of scientific flow scheduling on a wide-scale basis, including needs for technical and financial assistance to farmers;

It is anticipated that the bulk of the Research and Demonstration resources would be focused on determining optimum water scheduling, instrumentation, and operational requirements through in-field demonstration. Correlating various strategies to energy savings is considered to be a relatively straightforward assignment of which the necessary analytical tools are available.

4.0 PROJECT OVERVIEW

There are three basic components associated with agricultural irrigation systems:

1. The water delivery system, consisting of canals, pipelines, pumps, and wells, which deliver water to the farm;

2. The on-farm application system which includes both the means of delivering water to individual fields within the farm through on-farm laterals and pipelines and the means and methods of applying water to the crop, such as irrigation tubes, sprinkler systems, ditch and furrow methods, and flood irrigation;

3. The water removal system which includes facilities by which excess irrigation water is removed from the farm.

Each component of the agricultural irrigation system offers opportunities for improvement in water management and reduction in water demand. In many cases, the water delivery system consists of unlined irrigation canals. A common rule of thumb used in the latter half of the nineteenth century was to design unlined canals to carry three times the amount of water needed in the field in order to compensate for system losses. The basic problem associated with on-farm irrigation is to answer two questions: 1) when is water needed, and 2) how much water is needed. The first question can be answered through the use of soil moisture tests or probes - that is more commonly left to the qualitative judgment of the individual farmer. The second question concerning crop water requirements has been asked many times and answered many times through various research efforts. However, application of the correct amount of water to an individual field is a major problem which results from lack of measuring devices on individual fields and in many cases, built-in inefficiencies associated with irrigation methods such as ditch and furrow irrigation and flood irrigation.

The third element of the agricultural irrigation system, the water removal system, is a direct reflection of the inefficiencies associated with the water delivery system and the on-farm application system. However, it does offer an opportunity for reducing overall demand through controlled recovery of excess water and recycling of that water.

Development of methods for optimizing irrigation water use is complicated by the great variety of conditions under which agricultural irrigation is conducted in the United States.

The variables include: soils, crop types, and topography, in addition to variation in the three basic components of the irrigation system. These variables must be taken into account if research and demonstration is to produce meaningful results.

The program described below recognizes the complexities associated with research and demonstration in the area of irrigated agriculture. It is divided into two phases. The first phase, which we anticipate could be accomplished during calendar 1978 would provide background data necessary for defining ways and means of reducing water demand for irrigation systems and making the systems more efficient. The second phase, which could be conducted in 1979, would include the design and installation of improvements to various components of irrigation systems to improve water management, the operation of monitoring those systems, and a critique of the actual success of various means of improving water management. The first phase could, however, stand alone and would provide much valuable information towards research, development, and administration concerning the potential overall reduction of water consumption by agricultural crops. The section below describes the tasks in phase one and phase two.

PHASE ONE:

Task 1: Develop Site Selection Criteria

The objective of this task is to develop criteria which would lead to the selection of representative farms in the Larimer-Weld region for detailed analysis and monitoring. It is anticipated that between 10 and 20 farms would be selected. The farms would be divided into three groups. Group one would include farms which have had intensive water management and conservation practices applied to the farms primarily through SCS and ASCS programs. Groups two would include farms which have had medium level water conservation measures applied through the same or similar programs. Group three would include a number of farms which have not had any water conservation measures applied previously. Site selection criteria would take into account the variability of irrigated conditions, i.e., soils, topography, irrigation methods, variations in delivery and removal systems. The criteria would be designed to provide representative farms in all three groups.

Task 2: Site Selection

In this task the criteria developed in Task 1 would be applied to the Larimer-Weld region, and the 10 to 20 farms needed for the program would be selected. Individual farmers would be contacted and their cooperation in the program would be solicited. Farmer cooperation has been demonstrated in the LWRCOG 208 program,

and it is anticipated that full cooperation will be achieved for the proposed Research and Demonstration project.

Task 3: Review and Selection of Site Instrumentation

The type of instrumentation applied to an individual farm will vary with the type of problem involved, i.e., problems with the water delivery system, on farm application system, or removal system. Instrumentation must be able to monitor the magnitude of the problem and to monitor improvements after better management practices are applied. The instrumentation could include such items as electrical consumption meters, seepage meters, flow measuring devices, and piezometers to measure ground water fluctuations, flow recorders, and soil moisture probes. Along with the instrument selection, a program of monitoring and measuring would be defined. This program would include such things as the frequency of monitoring and measuring and the type of data collected.

Task 4: Instrument Installation

In this task the selected instrumentation would be installed on group one, two, and three farms. The instrumentation should be installed prior to the irrigation season, i.e., during the winter and spring of 1978.

Task 5: Data Collection

This task would consist of implementing the monitoring program during the irrigation season. The data to be collected would include such items as variations in soil moisture before and after irrigation, the amount of water applied to the farm, the amount of water running off the farm, seepage losses in canals, losses to deep percolation, and energy use. The objective of the data collection program is to obtain the data necessary to evaluate overall irrigation efficiencies and efficiencies in the various components in the irrigation system on the group one, two, and three farms.

Task 6: Analysis

The objectives of this portion of the program include:

1. Comparison of the efficiencies among group one, two, and three farms;

2. Evaluation of the effectiveness of traditional water conservation measures designed and installed under existing water conservation programs;

3. Identification of the best means of achieving water and energy optimization from group one, two, and three farms and the effectiveness of various techniques for achieving water optimization.

Task 7: Conclusions and Recommendations

A report will be prepared in the latter part of 1978 which would fully document all of Phase One and its tasks and provide conclusions and recommendations based upon the analysis in Task 6.

PHASE TWO:

The decision to implement Phase Two of the program is completely discretionary with ERDA, and it would depend to a large extent on time and budgetary limitations confronting the Agency. The Phase Two program is designed to test the conclusions and recommendations developed in Phase One through the actual implementation of the optimization measures for the group one, two, and three farms. Task descriptions are provided below.

Task 1: Design of Water Optimization Measures

Phase One would provide the necessary information for defining those measures which would be most effective in optimizing the agricultural irrigation system with respect to water demand. Effective measures might include canal lining, lining of on-farm laterals, irrigation scheduling, implementation of flow controls and measurement devices, modification of irrigation methods, or land leveling. Information provided in Task 1 would provide the information needed to specify effective measures on the group one, two, and three farms. These measures could be designed recognizing budgetary constraints for each of the farms in order to field test their effectiveness.

Task 2: Installation of Water Optimization Techniques

This task would include the actual construction or implementation of the optimization techniques on the individual farms. In some cases, such as testing methods of irrigation scheduling, the instrumentation would have already been installed in Phase One. This would also be the case with water measuring devices. For the case of irrigation scheduling, intensive discussions with individual farmers

would be conducted to insure that they fully understand the program and to acquaint them with the techniques to be used.

Task 3: Operation Monitoring

This task would be conducted during the irrigation season of 1979. It would consist of monitoring delivery systems, on-farm application systems, and removal systems which have been upgraded to optimize water use. The data collection program would be established and implemented in this task.

Task 4: Analysis

All the data collected in Task 3 would be analyzed to measure the actual field effectiveness of water optimization measures. The analysis would be compared with the analysis in conclusions and recommendations developed in Phase One. An overall evaluation of the effectiveness of various water and energy optimization techniques under a variety of conditions would be provided.

Task 5: Conclusions and Recommendations

A report would be developed documenting Phase Two and providing conclusions for recommendations regarding the potential for water and energy optimization. The information developed would be extrapolated to determine the overall effectiveness of these techniques in irrigated areas throughout the United States. The documentation would meet the objectives stated in Section 3.0 of this proposal entitled "Proposed Research and Demonstration Project."

5.0 PROJECT MANAGEMENT

A project team is proposed consisting of the Larimer-Weld Regional Council of Governments and Toups Corporation. Both organizations are located in Loveland, Colorado, (50 miles north of Denver). One hundred percent of the analytical work would be conducted in Loveland.

The Larimer-Weld COG, represented by F. A. Eidsness, Jr., Director of Water Quality Planning, will assure overall charge for project administration, management, intergovernmental coordination, and public participation. Mr. Eidsness, a civil engineer, will also participate in the technical analysis.

Toups Corporation will provide the necessary technical expertise to undertake the project on a subcontract basis. W. Tom Pitts, P.E., Vice President of Toups, will assume responsibility as project technical manager.

Additionally, it is anticipated that technical assistance will be provided by staff of the Soil Conservation Service (SCS) by an extension of the current Intergovernmental Personnel Act (IPA) Agreement between the Larimer-Weld Regional Council of Governments (LWRCOG) and the Department of Agriculture. The SCS representative will provide continuing liaison with area Soil Conservation Districts (SCD) and farmers, provide necessary technical data and information held in the files of the SCS and SCD's, and participate in the technical analysis.

Public participation will be accomplished by a continuation of the current formal cooperative agreement between the LWRCOG, State Soil Conservation Board, U.S. Department of Agriculture, and the ten regional Soil Conservation Districts. A steering committee will be continued whose responsibility will be to review the progress of the program and provide input as to the operational, legal, and social opportunities and constraints associated with the project.

It should be recognized that as a result of past associations developed under an Areawide Waste Treatment Management Planning program funded by the Environmental Protection Agency under Section 208 of the Federal Water Pollution Control Act Amendments of 1972, the management and coordination proposal has a proven track record. Additionally, as a result of past and current related studies and anticipated future analysis now being contemplated by the LWRCOG, investments made by ERDA in the proposed project will result in maximum returns and intergovernmental coordination and cooperation.

In addition to the coordination and management strategy, a substantial body of information has already been collected and analyzed including technical, operational, financial, and institutional data and analyses. This proposal, if implemented, will be fully integrated into ongoing studies of a related nature.

6.0 QUALIFICATIONS

Qualifications of Toups Corporation to participate in the proposed project can be found on the following page. Upon request, additional background information on the Larimer-Weld Regional Council of Governments and resumes of individuals who would play key roles in the program will be furnished. Additionally, names of federal and state government representatives who are familiar with the ongoing related studies of the Larimer-Weld COG will be provided as references upon request.

TOUPS CORPORATION QUALIFICATIONS

Toups has expertise in water resources management, irrigation engineering, environmental engineering and planning, geology, and hydrology. Toups has achieved national recognition in the field of agricultural irrigation and water pollution evaluation and control. The firm's expertise relates to defining the extent of water quality degradation attributable to irrigated agriculture on a regional or site-specific basis, optimizing agricultural water resources, and formulating best management practices for mitigating or eliminating pollution. Projects of particular interest to ERDA include:

- Areawide Water Quality Management Plan (208) - Larimer-Weld Region, Colorado, LWRCOG
- Research and Development - Best Management Practices Analysis - Irrigated Agriculture - Larimer-Weld Region, Colorado - EPA
- Manual of Pollution Control Practices for Irrigated Agriculture - EPA - Region VIII
- Cost and Effectiveness of Nonpoint Source Pollution Control Options for Irrigated Agriculture - National Commission on Water Quality
- Characteristics and Problems of the Water Supply Systems - South Platte River Basin - Corps of Engineers
- Water Quality Management Plan (303) - South Platte River Basin - State of Colorado
- Evaluation of Water Supply Systems in Energy-Impact Areas - EPA - Region VIII
- Water Resources Management Plans - Santa Maria and Santa Barbara - South Coast areas, California

A key element of the 208 Plan being developed by Toups for the Larimer-Weld Regional Council of Governments (LWRCOG) is a recently completed analysis of the water quality impacts of irrigated agriculture in the Larimer-Weld Region of Colorado. Irrigation constitutes approximately 90 percent of the total water demand in the Region, and control of agricultural pollution directly relates to the control of amounts of irrigation water.

The best management practices (BMP) analysis being conducted for EPA by Toups will enable definition of the relationship among the factors affecting agricultural water quality, i.e., on-farm irrigation practices and water supply characteristics, and resulting water quality in irrigation return flow. The on-going program includes extensive sampling and measuring of sources of irrigation water, irrigation water applied on farms, seepage water, and surface return flows. The results of the sampling and measuring program will be correlated with information concerning soils, irrigation methods, drainage practices, topography, and applied water quality. Subsequent phases of the analysis will examine the cost-effectiveness of applying best management practices to solving water quantity and quality management problems in the region. The cost of specific practices as applied within some areas of the region will be identified as well as their effectiveness in reducing water consumption and mitigating agricultural pollution control problems. The results of the study will lead to on-farm demonstration of the optimum BMP program.

Toups Corporation is currently under contract to develop the "Manual of Pollution Control Practices for Irrigated Agriculture" for EPA Region VIII. The manual is designed to provide guidance to federal and state officials, regional and local governments, irrigation districts, water districts, soil conservation personnel, and individual irrigators on the water quality problems associated with irrigation return flow, methods of identifying those problems, and the potential solutions to those problems. The manual will include descriptions of the pollutants associated with irrigation return flow, the methods by which those pollutants enter streams and groundwater basins, and descriptions of potential pollution control measures which could be applied to irrigation return flows. The manual describes the implications of water law of various western states on the implementation of structural and nonstructural best management practices. Another section of the manual describes the methodology for defining local and regional problems associated with irrigation return flow. This section describes how to use existing data, how to set up a sampling program, and how to correlate water quality and quantity data. The final section of the manual provides the methodology for determining the applicability of individual best management practices to solution of specific local and regional problems.

The cost-effectiveness study completed for the National Commission on Water Quality was performed to determine the economic and environmental impacts of agricultural return flows in the United States. The study accomplished the following objectives: 1) Inventory of the nature, extent and distribution of irrigation return flows; 2) Description of the distinguishing characteristics of the Nation's irrigation system in terms of form, size, source of water, and irrigation method;

3) Definition of loading functions describing the waste-loads emitted to surface water as a result of agricultural irrigation; 4) Identification of irrigation practices and treatment options which could be implemented to reduce quantities and/or concentrations of pollutants in irrigation return flows; 5) Assessment of the effectiveness and costs of pollution control options and determination of the manpower, materials, and energy requirements for these options. Principal pollution control options investigated include: irrigation management services; particularly optimum water scheduling; canal lining; tailwater recovery systems; desalination; and improved on-farm water management.

As part of the urban regional studies program for the South Platte Basin, the Corps of Engineers contracted with Toups Corporation to assess water resource and water supply problems in the South Platte Basin portions of Colorado and Wyoming. The assessment involved defining physical, legal, and administrative problems associated with the water resources and water supply of the South Platte Basin. Problem assessment included defining specific water supply problems in 157 communities in the Basin ranging in size from the Denver Water Board system which serve 800,000 people to the smaller towns spread throughout the Basin. In addition, specific problems associated with 92 major agricultural water supply systems were identified. Following assessment of the water resource and water supply problems at the individual supply level, basin-wide problems in water resource, water supply, and associated water quality problems were addressed. These included problems with inefficient use of water, administrative problems as the state level, and problems resulting from the application of Colorado water law.