CONSOLIDATION OF IRRIGATION SYSTEMS: PHASE 1 ENGINEERING, LEGAL, AND SOCIOLOGICAL CONSTRAINTS AND/OR FACILITATORS

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CONSOLIDATION OF IRRIGATION SYSTEMS: Engineering, Legal, and Sociological Constraints and/or Facilitators

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PART ONE

IRRIGATION SYSTEMS DEVELOPMENT AND PROBLEMS

INTRODUCTION

The development of irrigation systems began thousands of years ago. Early civilizations were created and thrived near natural irrigable alluvial soils. Their success at developing an irrigation system that would produce agricultural products for their populations is well known. As early as 2627 B. C., the Chinese irrigated lands through a system of canals, the largest, the Imperial Canal, being 700 miles long and large enough to also be used for navigation. Large irrigation systems were developed by the Aryans in the naturally fertile arid valleys of the Tigris and Euphrates. Engineering skill was highly developed for the times as noted by the large irrigation reservoir, 42 miles across and 35 feet deep, which captured flood waters for use in the irrigation system, and by the high cement and brick embankments on both sides of the Euphrates, designed to protect ancient Babylon.

The history of Babylon also exemplified remarkable development in the legal area, particularly in water law. Local customs and practices in the art of irrigation were given specific provision in a written code, the Code of Hammurabi, promulgated about 2050 B. C. This code provided guidelines for water use and penalties for individuals violating rules within the water system.

Other civilizations have contributed greatly to the use of water and development of irrigation systems. The Egyptians, Carthaginians, Greeks, and Romans have added elements which, combined, provide a wealth of ingenuity and skill. Canals, aqueducts, reservoirs, and tunnels for domestic, irrigation and sanitary uses were constructed some of which are still in operation.

On the American continents, the earliest developments appeared in Peru, a semi-arid country where canals and aqueducts conveyed and spread water over lowland deserts; as well as lands along the Gila River in Arizona, which were irrigated centuries ago by Indians. Irrigation was practiced in Mexico in the early Christian Era, and spread northward to the areas now comprising California, New Mexico and Arizona, by the Spaniards and missionaries. Later, groups of Mormons entered the Salt Lake Valley in Utah and began diverting water through ditches to irrigate crops. Shortly thereafter, pioneers in Colorado and California developed irrigation systems that are still in existence.

Early irrigation systems in the arid western states grew from need, custom, and ingenuity of the settlers. Once built, the physical characteristics of the early systems were modified only to expand water supplies for system enlargement or provide low cost improvements. A concept of property rights to water was developed that further

solidified the permanency of the system; and, concurrently, individual pride in, attachment for, and fear of loss of, his segment of the system emerged.

Irrigated agriculture has an important role in development of the West. Without the application of water, these arid lands were usually worthless. Hence, development depended upon the availability of a water supply. Where an adequate supply and climatic conditions conducive to irrigated crop growth existed, settlement grew. The federal government, having adopted a policy of encouraging western growth in the late 19th century, contributed greatly to the rapid increase of the agricultural sector.

With agricultural development, there also follows population increase with eventual urban and industrial encroachments which place greater constraints on the existing water supply, thereby requiring a more conscious use of this valuable resource. However, the irrigation systems and agricultural communities have grown accustomed to an untampered use of their water; storage and conveyance facilities, which have been constructed and the associated costs repaid, are deemed sufficient for the needs of the particular communities. Individuals within the systems are being taxed by irrigation and conservancy districts, along with assessments by local water organizations, to the point where development is directly related to additional capital or financial outlay. Tradition and complex cultural rules seem generally to characterize many modern-day irrigation systems.

The generally inflexible and static nature or irrigation systems, as contrasted with the dynamic changes of population, industrialization, and new water uses, has caused irrigated agriculture to fail in developing its full potential. In addition, there is a constant competition for water between uses: municipal, industrial, pollution abatement, flood control, power, fish and wildlife habitat, recreation, and aesthetics. If irrigated agriculture is to successfully meet the competition of today, it must be constantly alert to technical, social and institutional advancements and practices which will improve the systems' efficiency and conserve water.

In the past, when water shortage problems appeared, all efforts were geared toward exploring and creating new avenues to develop additional water supplies, rather than developing programs to deal more effectively with existing supplies. The development of supplemental water has frequently involved the importation of water into the drainage area (or river basin), additional reservoir storage to catch winter and spring runoff, or additional pumping from the groundwater reservoir, or any combination of the above. As the water supplies in any particular river basin become more fully developed, it becomes necessary to improve water management practices in order to meet increasing water demands. The paradox then emerges that to continually import additional water supplies from adjacent river basins will usually forestall development of efficient water management practices.

One may ask the question why water users should be allowed to import water from another river basin if, at the same time, they are not using their present water supply in a "reasonably" efficient or "beneficial" manner.

The utilization of additional supplies as a solution to growing demand is becoming increasingly difficult as population increases and urban and industrial development compete for the available water supply. To be able, then, to meet increasing demands, three major areas of concern must be elaborated and analyzed, and proposed solutions presented: first, physical or technological improvements in present water systems; second, legal re-arrangements which will permit streamlining of antiquated or customary practices; and third, organizational improvements in the delivery and management systems and accounting of the complex social, political, and economic factors involved in any system of water use. Ultimately, the above three areas of concern and alternatives are nothing more than an expression of the challenge of change, and of the transition from traditional ways of meeting water demands to the complex requirements of expanding and modernizing regions.

The above remarks are also true for entire irrigation systems. Improved efficiencies will be required in order to free water supplies for competing uses, as well as to improve the quality of receiving streams. In fact, the present national emphasis on water pollution will likely become the catalyst for bringing about additional impetus for improved water management in agricultural areas since such improvements are frequently directly proportional to water quality enhancement. On the other hand, in the case of irrigation systems, consolidation appears to be an institutional mechanism for bringing about increased efficiencies in water management which may also result in water quality benefits to the region.

An irrigation system is shown schematically in Figure 1. It can be subdivided into three sub-systems; namely, the water delivery, farm, and water removal sub-systems. The water delivery sub-system begins at the diversion works along the river, where water is diverted into the canal, and continues to the head of the farm. This sub-system transports water from the river to the farm and consists of a conveyance and distribution network along with associated control and flow measurement structures. The farm sub-system is defined as the cropland beginning at the head of the field, which is usually the point of highest elevation, and terminating at the low point(s) in the field, from which surface runoff leaves the field. In a vertical direction, the farm sub-system begins at the ground surface and terminates at the bottom of the plant root zone. The water removal sub-system involves the surface drainage network

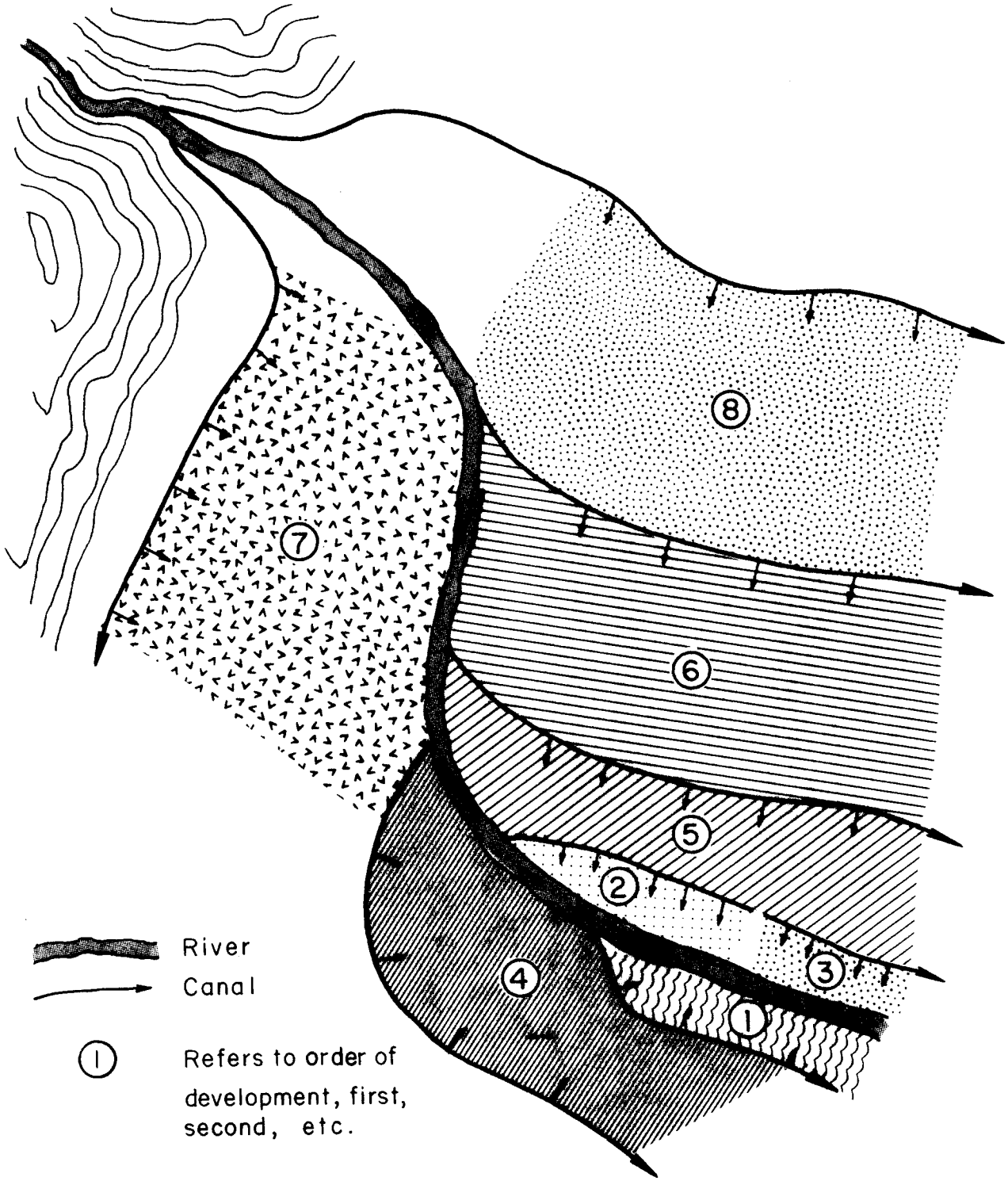


Figure 1. Schematic of Irrigation Systems Development

from the low points of the fields back to the river, along with the subsurface drainage beginning in the soil profile at the bottom of the plant root zone and continuing to the groundwater reservoir and/or the river. In some cases, the water moving below the root zone is picked up by tile drains and open drains for return to the river.

Within the irrigation system, definite organizational structures exist, ranging from the private individual, and irrigation company, to irrigation, conservancy and conservation districts. In many instances, a great variety and multitude of irrigation companies within a given system interact in complex ways in distributing water, providing intricate patterns of inter-organizational arrangements.

Irrigation companies consist of two types -- commercial and mutual. Commercial companies came on the scene first. They were operated by individuals for the sale of water or to distribute water to farmers and later the public. These were profit motivated organizations. In the 1870's and 1880's, investors in the East and from Europe contributed capital toward this new discovery in water development. However, early agricultural development in the West was not a very profitable venture and investors began to look elsewhere to place their monies.

These commercial irrigation enterprises evolved into three basic categories: (1) construction and development companies, (2) private contract companies, and (3) public utility companies. Of the three yet in existence, there are a number of private contract companies in certain local areas supplying water to farmers, there are but a handful of private public utility water companies still in existence, and very few if any construction and development companies per se.

Not having large sums of money available to pay for services offered by the commercial companies, and being the individuals that they are, farmers soon developed an organization that fit their needs -- the mutual irrigation company. At first these enterprises were nothing but an agreement between neighbors for the construction of canals and ditches from the source to their lands. Later this was made formal by written agreement and usually incorporated under the corporation laws of the state.

These mutual companies are owned and operated by consumers who are also the shareholders. They are non-profit organizations, consisting of voluntary members who, as stockholders, received water in proportion to their shares. Assessments in proportion to ownership are paid for operation and maintenance of the company and facilities. Instead of distributing profits as dividends, the companies distribute available water to their members. In many areas, these mutual enterprises own and operate storage reservoirs and large conveyance works. These local institutions have made a significant impact on the water development of the

West, but there is a definite need to re-examine these arrangements and their operation. This study is primarily concerned with the mutual irrigation company, since it is the predominanat type in each system investigated.

Similar to the mutual irrigation company is the water users association, organized under the corporation laws of the state. These associations were formed to enter into repayment contracts with the Secretary of Interior.

It is at this level that strong resistance and legal restraints against consolidation may be found. A majority of the companies are incorporated under the corporation laws of the state. These laws normally define the legal possibilities and requirements of the corporation and set forth the procedure and complexities of mergers or consolidation of domestic and foreign corporations. The laws and cost consequences shall be considered in the legal investigation. Although the enterprise structure is primarily controlled by statute with respect to requirements for creation and limitation of activity, the internal rules and regulations contain many organizational features preventing flexibility of action and may even specifically inhibit merger or consolidation.

WATER SUPPLY AND IRRIGATION SYSTEMS IN THE WESTERN UNITED STATES

As a whole, the nation has abundant water resources. At the same time,hhowever, the distribution and timing of the water resources differ in the various regions of the country, from season to season and from year to year. The massive study of the Water Resources Council published in 1968 under the title, The Nation's Water Resources[1] provides the most comprehensive analysis of the role of the water for the life and development of this country. A major point and recommendation in this study is the hypothesis that as the nation grows the limitation of water and related land resources available to competing regions becomes more important from a national policy point of view. Comprehensive planning, community and regional development, balanced population and economic growth are all parts of major national goals for the future development of this country.

While it is relatively easy to talk about the West demographically, it is more complicated to do so from the water development point of view. The West is comprised of a number of regions formed by natural river drainage basins not necessarily coinciding with administrative boundaries. To generalize, however, one may say that with the exception of the Columbia-North Pacific Region and some portions of the California and Missouri Regions, the area and states in what is known as the Mountain and Western states are expected to have severe water shortages by 2020.

The anticipated water shortages in the West are a consequence of the following national and regional trends:

1. Increasing population, particularly the continuous movement of people to the West. While the population in the nation increased by 14 percent between 1960 and 1970, most of the states in the West increased substantially above the national average (e.g. Colorado increased in this period by 26.9 percent, Nevada by 72.6 percent, Arizona by 37.3 percent and so on while only a few states -- such as Wyoming and Montana -- remained more or less stationary in terms of population).

2. Increasing urbanization and the augmented demand for municipal services with a resultant conflict between farm and nonfarm water uses. As the urban centers in the West continue to grow, the most pronounced feature of population movement in the Mountain region is the increased concentration of population around metropolitan cores, so that by late 1960 we have emerging megalopolises such as the Front Range Megalopolis in Colorado (encompassing almost 80 percent of the total population of the State), the Wasatch Front Megalopolis in Utah and other megalopolitan formations such as the Santa Fe-Albuquerque emerging megalopolis, the Phoenix-Tucson conurbation, and of course, the vast strip cities in California.

3. Increasing industrialization which not only affects the total volume of water use but also the quality of receiving streams. Major industrial concerns have moved, for example, to formerly sparsely industrialized areas of the Mountain states - IBM and Kodak in Colorado and Litton and Sperry Rand in Utah, etc.

4. Increasing concern with ecological mismanagement, with increased pollution costs, will affect both agricultural and nonagricultural water uses. This is particularly true in the case of the Mountain states where a fragile ecological environment compounds typical problems of pollution. Colorado, again, is a typical example of the fragility of the physical environment and of the potentially disastrous consequences of ecological mismanagement of water and air. For example, the high altitude of Denver and its locational pattern provide similar inversion patterns to those of the Los Angeles area.

These trends will create new and different demands for water to be supplied to communities. The urgency for a more cogent water development policy is due not only to past and present trends of population increase, urbanization, industrialization, and ecological awareness, but also to projections and forecasts of forces of continuous rapid growth in the coming decades. Although projections and extrapolations are a risky enterprise, numerous official and unofficial studies predict rapid growth in population and urbanization. It is estimated that the Colorado Front Range population complex will increase from 1,750,000 people in 1970 to about 3,500,000 by the year 2000. If population

growth follows present forecasts, water must be reaching metropolitan Denver by the early 1980's from supply systems not yet in existence. Similarly, estimates of population increase in Arizona indicate a total of 2,400,000 people by 1980, with an average annual rate of growth of 34.0 percent. There seems to be general agreement in various studies that the greatest percentages of all projected population growth will be in the western third of the nation, west of and including Montana, Wyoming, Colorado and New Mexico. It is expected that the West will increase its present national share of population from 17 percent to 22 percent by the year 2000. In all Mountain states, three interrelated trends will be crucial in the solution of emerging problems of water supply and use: flight from the countryside and abandonment of small towns, increased metropolitanization and urban sprawl, and total population growth from both natural increase and continuous in-migration.

Another insight into water resources problems can be gained through a comparison of historical community growth with the development of irrigation systems in the West. During the pioneer development period, settlements were formed on the streams where water supplies were available. Even the smallest creeks have a small community at their mouths and much of the water for irrigation in the West comes from small mountain streams. Utah now has nearly 400 cities, towns and villages resulting from this development. By contrast, however, the 1959 Agricultural Census lists 984 irrigation organizations in Utah. Of these group enterprises in Utah, 316 are unincorporated mutual companies, 651 are incorporated mutual companies, five are cities, two are irrigation developments of the U.S. Bureau of Indian Affairs and one is a Bureau of Reclamation operated project (other U.S. Reclamation projects in Utah are operated by water users' associations or irrigation districts). The area irrigated by the 984 group enterprises in Utah is 1.1 million acres, making the average approximately 1100 acres per enterprise.

In 1946, Israelsen and others[2] published the results of a survey of irrigation companies in Utah. Data were obtained from 688 separate companies. There is no legal limit to the minimum land size of an irrigation company as seen by the fact that 179 of the 688 companies serve areas of less than 300 acres, some even less than 100 acres. The other 509 serve areas larger than 300 acres, the largest one serving approximately 50,000 acres. To staff the 688 separate companies in Utah requires the services of 2,606 officials. Although water delivery and distribution is considered to be largely an engineering problem, only 69 of the 688 companies regularly employed an engineer. The importance of water rights is evidenced by the fact that 167 of the 688 companies regularly employed attorneys.

Table 1 shows the number of irrigation organizations for the five study states (see later section on "Research Areas") and totals for the 17 western states and Louisiana. It is

Table 1. Comparison of number and types of irrigation organizations* in the West.

			Private			Public		
			Mutual					
State	Year	Total	Un-incorp	Incorp	Comm-ercial	Irrig Dist	U.S. Bureau of Recl	U.S. Bureau of Indian Affairs
Arizona	1959	155	42	34	-	15	2	59
	1950	163	61	37	1	12	2	48
Colo.	1959	1,933	1,261	642	4	14	6	2
	1950	2,302	1,579	686	6	20	4	1
Nev.	1959	116	61	42	1	4	-	8
	1950	157	90	47	2	4	-	14
Utah	1959	984	316	651	1	8	1	2
	1950	1,058	406	634	2	5	1	3
Wyoming	1959	686	521	113	1	37	7	6
	1950	693	538	120	2	27	5	1
Subtotal	1959	3,874	2,201	1,482	7	78	16	77
	1950	4,373	2,674	1,523	13	68	12	67
Change		-499	-473	-41	-5	+10	+12	+10
18 states	1959	8,749	4,989	2,737	246	558	54	123
	1950	10,491	6,464	2,884	401	483	37	141
Total		-1,742	-1,475	-47	-155	+75	+7	-18

(Data from Summary Table 7 - Number of Irrigation Organizations and Acreages Irrigated by Type of Organizations 1920-1959, U.S. Bureau of Census, U.S. Census of Agriculture, 1959 Vol. III, Irrigation of Ag. Lands[3]).

*Irrigation organization is defined by the Census Bureau as a business comprising a group of two or more water users, a company, corporation or governmental district or agency that operates facilities to supply water for the irrigation of farm and ranch lands, being either a formal, legal organization or an informal or cooperative arrangement.

interesting to note the decrease in all organizational sectors between 1949 and 1959 with the exceptions of an increase in incorporated mutual ditch companies and in the number of irrigation districts for this period of time.

These irrigation organizations have a high degree of interrelationship, transferring water from one to another to complete distribution from natural sources through direct diversion or storage facilities to on-farm use. For example, of the 8,749 irrigation organizations accounted for in 1959, five percent received part of their water from another organization and eight percent received all their water from other organizations.

Not all of these enterprises, of course, could be considered badly in need of improvements, but a large percentage of the companies would profit by being combined into consolidated systems. For example, if 25-50 percent of the group enterprises fell into this class, it would mean that 2,000-5,000 systems should be consolidated and modernized. In many cases, the consolidation of five to 30 irrigation companies in an irrigated valley is required. Each western state has a large number of irrigated valleys that could benefit by consolidation.

PHYSICAL DEVELOPMENT OF WESTERN IRRIGATION SYSTEMS

The early pioneers in the West engaged in the construction of diversion structures and canals in order to irrigate reclaimed lands. Initially, the lands placed under irrigation were located adjacent to the river, thereby minimizing the effort required to deliver water to the fields. Later settlers would then undertake the construction of diversion works and a water delivery system to serve newly cultivated lands immediately above the original canal. Usually, this accomplishment resulted from a cooperative effort among the farmers to be served by the new canal. This process was continued until either land or water resources became limiting. As a result, an irrigated valley would consist of a series of fairly parallel canals traversing the valley. Most of these early canals are still in existence today.

Although the organizational framework for constructing the early canal systems offered a very practical means for developing irrigated agriculture, the lack of change after completing this development has resulted in a number of present-day problems. The addition of each canal usually resulted in the formation of a new irrigation enterprise with the result that many irrigated valleys in the West have a multitude of entities managing the delivery of water in the valley. Problems involving the lack of cooperation among the various entities in bringing about improved water use efficiency appear to be inherent among many groups. In addition, the duplication of water delivery systems has resulted in higher costs for irrigation system rehabilitation, increased operation and maintenance costs, and greater

water losses such as seepage, operational bypassing or spillage, and surface and subsurface return flows.

The historical roots of irrigation system developments in the West, along with the emerging needs for meeting large scale organizational objectives, make it imperative to consider technological alternatives for improving a number of cumbersome water use systems. Alternatives for improvement include lining of canals to prevent seepage losses and transpiration by phreatophytes; installation of closed water distribution systems; small storage or regulation ponds along the water delivery system to allow improved timing of delivery and conserve water during periods of precipitation; use of more and better flow measuring devices to improve the control and equitable distribution of water supplies; and improving the efficiency of water use in the farm by land leveling, use of modern irrigation practices, provisions for allowing field runoff to be used on lower fields or recirculated, and use of sprinkler irrigation on fields not suited for surface irrigation.

LEGAL DEVELOPMENTS

Coinciding with the physical development of water resources was the legal development of the right to use water. Initially, water was regarded as community property available for use by all. But as development in the semi-arid West took place, investments made upon a dependable water supply, as well as recognizing the value of water, resulted in the early miners and settlers respecting a property interest to the water user. At this point, the benefits of a predictable water supply exceeded the costs of internalizing externalities prevalent in the community property status of this resource. The pioneer was willing to recognize an interest in others in order to gain the same treatment for his use of the water. Through custom, miners had previously developed a moral code prohibiting claim jumping, and this same respect was accorded the use of water. As a consequence, a firm "property right" developed, subject to certain restraints (i.e., beneficial use and nonwaste), but accorded the same protection under the law as real property. Legally described as a usufructary right, the possessor could use the water once it was captured and it then became his personal property, but this right did not attach to any specific waters because of the resource's fugitive nature.

Since the inception of the property right concept in water, there have emerged several basic doctrines, a multitude of institutional arrangements and volumes of cases and agency rules to protect and insure its existence. The humid East had adopted the English "riparian water law" giving owners of land adjacent to a water body a proportionate right to use the water. This "water right" was undependable and indefinite, and existed by virtue of land location. In the 18 western states, the doctrine of prior appropriation

was adopted. The gold rush days of 1849 in California provided its foundation. In 1855, the customary law was accepted by the courts in Irwin v. Phillips (5 Cal. 140). The court recognized a right of use for the person who was first to appropriate and divert water from the stream for mining purposes regardless of land proximity to the water source. Colorado was the first to include the doctrine in its constitution in 1876; since that date it has been adopted by constitution or statute in the other 17 western states.

Basically, this doctrine is stated as "first in time is first in right." The early pioneers who first developed the water obtained the first rights to use the stream, while later settlers acquired junior rights. Many of the original water rights are for direct flow only, while some of the later rights combined storage rights with flood flow diversion.

There are certain basic principles which exist in all the appropriation states, even though statutes and cases have modified the doctrine. The first is that beneficial use must be made of the water. Many different uses have been recognized, some given statutory preference such as domestic and municipal uses, and recent trends witness acceptance of such uses as aesthetics and recreation. In the past, emphasis has been placed on "type" rather than "method" to determine beneficial use, with most states also applying a non-waste concept.

The second principle, priority of use shall determine water allocation among users when a water deficit occurs, thus closing diversions in an inverse order of priority regardless of type of use. Those uses given legal preference have the right to condemn and compensate non-preferred users for a water supply.

The third principle, a water right is for a definite quantity and does not depend upon the amount flowing in the stream. The last major principle is that so long as beneficial use of the water is made, a property right in the appropriation exists. Definition and application of beneficial use varies from state to state and among uses.

The prior appropriation doctrine provided the needed security of a water supply for mining, agricultural, municipal, and industrial interests, so they proceeded to mold institutional sophistication to meet their needs.

Farmers soon realized individuals could not financially build adequate diversion, storage and transmission systems for water conveyance and hence created ditch companies. Initially, these companies consisted of a few or more farmers bound by a gentlemen's agreement to cooperate in construction and maintenance of a simple delivery system for no monetary profit. They owned the water rights and the diversion and conveyance works. Some of these

private mutual ditch companies took on greater sophistication and incorporated under state laws. Coinciding with the development of mutual organization was the privately owned commercial company, profit motivated and organized to construct irrigation storage and delivery systems, as well as reclaim land, for prospective farmers.

States provided the legal mechanism for including larger areas of farm land under organized control in the form of irrigation districts and later conservancy and conservation districts. These districts, requiring a set landowner-voter consent for organization, allowed expanded development and improvement through ad valorem taxing within the area.

Economies of scale and physical efficiencies were accomplished by these various institutions. Frequently, many different types of water users worked side by side to meet their requirements. As a consequence of population increases, technology and satisfactory institutional arrangements (at the state level, not to mention the federal efforts in this area), irrigation systems were developed and are still growing.

This is the situation. On one hand, we have an established legal and institutional system existing with many water users satisfied and unwilling to change. On the other hand, water is a scarce resource, water requirements have multiplied rapidly in recent years and the political and social structure of our society has changed significantly. The laws and institutions have not remained static; they have changed and remain flexible to a certain degree. To what extent have they facilitated efficiency within irrigation systems through providing a consolidation mechanism, trade-offs and water transfers among users or other means? To what extent has, or is, the legal and institutional structure of water law impeding consolidation of irrigation systems?

The important point in the water right picture is that mere possession of a water right may not guarantee any water to the right holder. When the water supply of a stream fails to satisfy the diversion requirements of existing water rights, the stream, of course, is overappropriated and junior rights must give way to prior rights. This condition may happen only in dry years on some streams, whereas it may happen every year on others. This situation will be accentuated with extensive and intensive farming, urbanization and industrialization. A good example of this situation can be obtained by superimposing the water right demand on the hydrograph of flow for most any of the western streams.

Consolidation of irrigation companies will most certainly bring together water rights of different priorities. The evaluation of one right in terms of another will be most difficult, for in a good water year a junior right may obtain as much water as a prior right; but in drought

years, the junior right may get no water at all. Any water right evaluation must have as its foundation a complete analysis of the water supply. After consolidation, the water rights must maintain their identity to satisfy legal requirements. Many companies do obtain their water supply under several separate water rights, but this identity feature creates no problem.

SOCIAL ASPECTS OF WATER USE

Parallel to physical developments, water use in the West was also determined by changes in the surrounding social environment. As indicated above, development in the West was primarily shaped by the deliberate policy of concentrating in areas of available water supply and surrounding relatively fertile lands. The federal government itself, with its reclamation policy initiated in 1902, provided the impetus for the settlement of land in family size parcels. On the other hand, states like Utah were part of a deliberate case of colonization and intensive agricultural development.

Essentially, the pattern of settlement in the West, as well as in other parts of the country, followed a series of interrelated stages of development. Initially, individual farmers would settle in small parcels of land close to the water sources, followed by small services for farmers, such as blacksmiths, wagon and wheel makers, etc. Agribusiness was the next order of development, serving the farmers through such services as mills, farm implements, etc. The small settlements of the early pioneers were then augmented by the influx of other people. The transformation from primary to secondary industry began towards the end of the last century. As in the rest of the nation, but to a lesser degree in Mountain states, creeping urbanization and the meshing of the urban fringe with the rural hinterland characterize the more recent history of community development.

There are two additional considerations in the analysis and understanding of the social environment in the West in relation to water and related natural resources. First, part of the cultural background and customary use is shaped by the presence of an indigenous population with senior rights under the "reservation doctrine." Secondly, the Spanish legacy has left a district cultural tradition of customary practices and attitudes toward water use. Thus, to speak of the social environment of the West, one should consider quite a variagated combination of normative resources, community environments, cultural traditions, water management systems, sources of social conflict, and images toward water resources.

Sociologists traditionally have included the environment in their theoretical frameworks, but the interconnection between physical and social environments has not been clearly stated. To speak of general categories such as

"institutional factors" or "human problems" does not necessarily answer the question of the social use of natural resources. Consolidation of irrigation companies, or any other form of change, requires a much broader view of natural resources, along with careful delineation of individual and aggregate levels of analysis. As a matter of fact, a highly complicating factor in combining irrigation systems is the attitude of the present owner. He has a special relationship to water rights; he developed the right. He has had to guard it jealously for fear of losing his right. He has adapted his farming to the water supply represented by this right. He will probably resist any combinations because of the uncertainty of the result. He knows what to expect from the present right. This is true whether the owner is an irrigation company or an individual.

Changes and combinations may require modifications in farming practices and it is only natural for owners of water rights to resist change. The development of the water supply and water rights has sometimes developed jealousies and hard feelings against adjacent water users, and even though the original settlers may in many cases be dead, the antagonisms, fears, and jealousies of the original pioneers have been passed on to their heirs and successors and the problem has remained alive down to the present time. Thus, an attitude or viewpoint towards the existing system has developed that is deep seated, accentuating the difficulties involved in any effort towards consolidation.

Although not central in the present analysis, political and economic considerations are also essential for an understanding of the development of irrigation systems in the West. In considering the economics of the old irrigation system, one must recognize the fact that most of the development work was done by the owners of the land benefited. The early settlers diverted water directly from the streams by means of individually constructed dams and ditches which were planned and built for the purpose of solving their individual irrigation problem. The irrigation works constructed by individuals or small groups were considered private property; subsequent developments were seldom combined with existing systems. The resulting developments, in many cases, are debt free. Original construction charges have been repaid, and the present cost of water to the users is for operation and maintenance of the system. Some irrigation companies provide an active betterment program to rehabilitate their system.

After the initial canal construction, the later water resource development projects were primarily concerned with furnishing supplemental water supplies to irrigation companies which frequently encountered water shortages during the late stages of crop growth, such as July and August. Frequently, a new organization was formed but still retaining the separate irrigation companies (no consolidation), in order to operate the new facility and be responsible for the repayment of construction costs. Again, the new

facilities were merely added onto the older irrigation systems, with few changes being made to the original water delivery systems.

Economic development is also evident upon examining the growth pattern of agriculture within a system. Lands nearer the population center or market were subjected to intensive farming and a higher degree of cooperation among water users, resulting in greater organizational sophistication. In areas further from the market, economies of scale were gained by cooperative efforts of landowners constructing diversion and conveyance structures. Since cash was scarce, farmers placed high value on labor and time savings acquired through joint efforts.

The construction of each diversion structure and associated canal system usually resulted in the formation of an irrigation company. Each irrigated valley, therefore, contained a multiplicity of companies who frequently competed with one another for rights to river flows. In the valley system, these joint enterprises served as a political and economic base around which the members became active in local and state politics. As these organizations grew in size and stature, they gained the political clout necessary to become influential in establishing policy guidelines and forcing legislative action. In the history of an irrigation system, one can find many important court battles fought between two or more enterprises, where such decisions affect the operation of all other companies in the system and state.

As time wore on, the competition for water supplies included cities and industries in the valley, or other agricultural, municipal, and industrial interests either upstream or downstream of the valley. The increased competition for water resulted in combining of interests among the separate irrigation companies to combat outside interests, but has seldom led to the consolidation of the irrigation companies. Instead, a water users organization might be formed which represented the interests of the separate irrigation companies, thereby providing more political strength in the water arena. Now, with the hue and cry about water pollution, the need for uniting in order to bring about improved water management, which will result in water quality improvements to receiving streams, becomes even more apparent.

Another interesting aspect of the social dimensions of water resources utilization is the fact that quite a number of water resources programs at the local level frequently operate in relative isolation from the surrounding community. In larger and especially federally run programs, few local resources are utilized in the implementation of specific water system technical plans. On the other hand, in smaller, predominantly agricultural systems, there is a much closer participation of local residents with strong interconnection between the community and water organizations. Water development as a whole has never been met in

an integrated, consistent manner. Proposed beneficial projects have been usually introduced from the national level with only limited interaction with people on the local level. Such a procedure produced either strong reaction from local participants because of their non-involvement or ignorance about the project; or, more often, apathy and tacit approval of superimposed water improvement projects.

It seems appropriate at this point to make the general statement that more and more many of the basic decisions in relation to water development are made not only outside the local level, but at the same time, such decisions increasingly call for a better knowledge of the political, legal, and socio-economic institutions which control the supply and allocation of water. However, the unknown processes of the complex interactions of physical, economic, political and social factors in water development do not permit accurate measurement and prediction of the consequences resulting from proposed water projects, or even rebuttals to arguments in favor of large-scale water policy. In the past, water development policies have been characterized by an inflexible simultaneous determination of both ends and means with little consideration as to emerging effective ways of meeting changing circumstances and goals in water use. The limited water supply, the increasing population, and the multiplicity of uses call for new integrated forms of the interaction between policy determining institutions, local participants, and water users at large. In the future, each area, organization, or other institution must provide precise evidence incorporated long-range planning before a project is undertaken in order to insure its wider acceptance, continuous monitoring of performance, and eventual success.

THE CONSOLIDATION CHALLENGE

The physical development of the canal system and appurtenant works, the legal development of the right to use water, the organizational entities which have been formed to operate and maintain the irrigation systems, and various social and economic problems have created the present predicament which exists in many of our western irrigated valleys. In order to achieve maximum water resource benefits, something must be accomplished to facilitate increased water use efficiency. The consolidation of irrigation systems is among the necessary steps to achieving improved water management, since it provides the essential organizational framework to maximize water use efficiency within the total irrigated valley. To solve the problems inherent in irrigation system consolidation presents a major challenge to numerous disciplines, including engineers, lawyers, social scientists, and economists, as well as water user groups.

To implement a program for consolidating irrigation systems in any particular valley will require the development of a comprehensive consolidation plan which will take

into account the engineering, legal, organizational, and economic characteristics of the total irrigation system. An in-depth plan must be prepared to insure that all of the parameters have been accounted for in sufficient detail to engender confidence among the water users that the consolidation will be reasonable, practical, equitable and consequently successful.

In order to adequately present the facts to the water users involved, a careful appraisal must be made of each individual system. The existing physical facilites, water rights, water supply, legal problems and social conditions in each community must be inventoried. Since the water supply is the foundation of the enterprise, an evaluation of the water supply with respect to its occurrence in time and amount is necessary in order to evaluate the comparative desirabilities of the systems to be integrated. Hydrographic and land use data must be collected where such data are not available. Hydrologic studies can be undertaken once the necessary water supply and land use information is available.

Potential water supplies must be investigated such as storage, ground-water development, and transbasin diversions. Methods must be found for improving the efficiency of the existing water conveyance channels through canal lining or changes in administrative procedures. Water delivery methods used by the companies must be studied in relation to the water supply to determine if operational changes might be made that would be advantageous. In short, all of the facts connected with the water resource must be obtained.

The water delivery sub-system for each irrigation company must be evaluated as to physical facilities, maintenance costs, and operational procedures. Where present conveyance channels would appear to benefit by being combined, designs and cost estimates for a unified conveyance system should be prepared. Existing structures should be inventoried and evaluated as to their adequacy in managing and controlling water deliveries. Additional structures required to control and measure the water should be delineated. Possibilities for improving canal alignments should also be studied. The operation and maintenance costs of the existing physical facilities must be evaluated. Costly operation or maintenance practices should be eliminated. From this information, a plan for rehabilitating the irrigation system, which will usually include a partial consolidation of physical facilities, can be prepared.

Studies of on-the-farm water management should be made in order to assess the efficiency with which the present water supplies are being used. Improvements in the design of surface irrigation systems may be possible on many of the fields by either land leveling or shortening the length of irrigation runs. Also, a change in irrigation methods may be feasible. Tailwater runoff could be nearly eliminated by careful management of the waters supplied to the

farm, or completely eliminated by use of a pumpback system to recirculate the water. A program for irrigation scheduling could be utilized which would pay for itself by increased crop production, while at the same time, the water use efficiency would be increased, thereby providing an opportunity for better distribution of the water supply.

The legal approach to systems consolidation must begin with an understanding of state water laws before conducting an examination of local legal institutions within the project areas. Water law varies from state to state, although there are many basic similarities. All of the states involved in this study are strictly appropriation doctrine states. That is, a system of priorities and distribution of the water based upon diversion, application to beneficial use and further compliance with state statutory requirements.

Of particular importance to this study are legal restrictions to consolidation in either the water and corporation codes or corporation documents, the administration and conflict resolution practices within the state agencies and local public and private institutions, the duty of water, and the administration officials' discretion in establishing water efficiency requirements.

The legal relationship of the water supply to the water rights and need, along with methods of combining the water rights for integrated companies, must be determined to implement a consolidation or merger plan. Under present legal philosophy, the identity of the water rights must be maintained, but water represented by a water right should be combined and distributed according to requirements of water users under the combined system. Within the companies corporate structure, pooling of stocks having different priorities or different basic values must be worked out and the stock reissued, either in different classes or having an equal par value and representing the same quantity of water per acre.

Many problems will be presented by operating within a given legal system, but the role of law must be thoroughly understood. Law provides an orderly means for development as expressed by interests exerted at the time and exercised in legislation and litigation. Law is not an end in itself, but rather the means to attain a definite goal, and it must be understood that any man-made law is subject to revocation or amendment in order to implement a physically possible, socially desirable and economically feasible goal. It is with this premise in mind, that the law should be applied.

The economics of consolidation must also be more clearly outlined. The cost of construction and the benefits must be determined. The savings of water affected by eliminating overlapping systems must be evaluated in terms of the savings anticipated and the cost of the construction required to bring about the savings. Savings in water,

savings in operation, and savings in maintenance must all be evaluated in terms of dollars. Technological externalities must be determined and measured to demonstrate which externalities have been internalized by the existing companies and which externalities accrue as additional cost to others within the system. Costs of new construction, costs of new programs, and changes necessary to modernize the system must be carefully estimated. The financial conditions of each company must be determined and debt obligations liquidated or adjusted within the framework of the proposed consolidation. The economics of the area and the economics of the country must also be given consideration.

The problem of consolidation, however, is not only one involving careful consideration of physical potentialities, legal alternatives, and economic feasibility. Part of the problem involves a two-fold delineation of the organizational capability of present irrigation systems for new alternatives and the understanding and utilization of a social climate of receptivity towards change and new organizational forms.

As repeatedly emphasized, because of larger national and regional trends and new demands, while the supply and quality of water are vital in any future planning of resource utilization, equally important will be the organizational innovations applied to increased efficiency in the distribution of water. Thus, the problem of consolidation is not one of just changing attitudes of individuals. Such attitudes, and the process of the adoption of innovative forms of water use, are part of an understanding of the broader community culture and the institutional structures involved in the obtainment of water supply and its allocation to the members of the particular system. A central concern is the alternative organizational forms possible in a given community and the delineation of the process of adoption, communication, and diffusion through which implementation of consolidation plans becomes feasible.

Consolidation of irrigation systems presents a viable alternative for more efficient utilization of water resources. Where consolidation can be achieved, existing water supplies can be more effectively and efficiently used by eliminating duplicate systems and organizational management can be improved through centralization of functions and reduction of enterprise personnel, while at the same time permitting employment of technically trained assistants. The resulting institution will enjoy less legal expenses per unit acre, greater visibility, voice and influence on political and lobbying issues of interest, taking full tax and insurance advantages and improved morale and safety by modernizing and improving company facilities and equipment.

Even when larger, general studies have been made on the technical feasibility, economic desirability, and organizational preparedness for consolidation, there still remains the very central problem of individual receptivity to

change, and of the effort of harmonizing conflicting interests involved in a unified purpose. Despite technical, economic and organizational evidence favoring consolidation, little progress has been achieved and public sentiment has not provided the momentum for an incorporation of the envisaged change. Attempts toward consolidation depend also on the individual's knowledge and attitude toward water use patterns, on the nature and extent of his relation with the particular irrigation company, his socio-economic background and property characteristics, and on a cluster of predispositions toward change and modernity, level of satisfaction and perception of alternatives. In essence, then, we are talking about three major categories of social factors which may operate as either facilitators or constraints to a proposed consolidation scheme: community environment and culture, organizational structure and networks, and general perception of change and of organizational alternatives by individual users.

Finally, in any study of consolidation, a note of caution must be inserted. Because of the complex interrelationships of diverse factors, each area of proposed consolidation presents both unique problems, but at the same time, common principles of organizational intervention. Although in every consolidation scheme, the merits and advantages of consolidation must be considered individually, it is possible, when proper caution is exercised, to develop more general principles from common factors operating in different irrigation systems. To be able to provide the common ground and extract general guidelines for consolidation, each area of concern where duplicating irrigation systems exist must be given the same detailed examination and consideration with regard to engineering facilities, political-economic factors, legal principles and implications of water rights, and social conditions which influence present arrangements and provide the background for a measurement of the benefits to be derived from consolidation.

PART TWO

MEETING THE CONSOLIDATION PROBLEM

In Part One, some introductory remarks were provided on the general aspects of water use along with a preliminary outline of problems, advantages, and challenges in consolidating irrigation systems. Part Two contains a brief discussion of the eight research areas in the western United States selected for specific study; the engineering, legal, and sociological objectives in pursuing this research effort; and the methodologies used to evaluate the constraints and facilitators involved in irrigation system consolidation. The underlying common thread of this research effort was the attempt at developing an integrated approach, trying to account, as much as possible, for crucial interrelationships between physical and non-physical environments in the irrigation systems selected.

RESEARCH AREAS

In order to evaluate the engineering, legal and sociological factors affecting the consolidation of irrigation systems, a number of irrigated valleys located throughout the Intermountain West were selected for study. The general location of these systems is shown in the accompanying figure. The areas chosen for this research effort are:

1. Poudre Valley, Colorado
2. Grand Valley, Colorado
3. Ashley Valley, Utah
4. Utah Valley, Utah
5. Eden Valley, Wyoming
6. Riverton Valley, Wyoming
7. Truckee-Carson Irrigation District, Nevada
8. Salt River Valley, Arizona

There are a number of reasons for selecting the above research areas. In each case, considerable data collection and/or research has taken place, or is presently underway, thus providing adequate background information for most of the systems.

The research areas have been chosen to include irrigation systems which are already essentially consolidated in addition to systems which would appear to benefit considerably by consolidating. Thus, each area will not be discussed with the same intensity, but the amount of effort for any one study area will be dependent upon whether or not the area operates as a consolidated system or contains some unique characteristic which provides leads toward an understanding of the consolidation process.

In addition, areas have been chosen that would include some similar and some dissimilar characteristics. For example, in some cases, the area operates the irrigation

water supply essentially as a consolidated system, while in others, there is considerable fragmentation among quite a number of communities.

Poudre Valley, Colorado was chosen because of interest within the valley to consolidate the irrigation systems, along with incorporating rapidly increasing municipal and industrial water demands. This system is unique in that it represents a high degree of cooperation among the major irrigation companies to meet the seasonal requirements for water. By trading or renting water within the system to take advantage of geographic conditions in the valley, these water entities have been able to circumvent certain rigid, complex and costly legal procedures with respect to changing points of diversion and time of use.

Grand Valley, Colorado was chosen partly because of physical similarities with the Truckee-Carson Irrigation District which is located along the Lower Carson and Truckee rivers in Nevada. Institutionally important in Grand Valley is the presence of both mutual and commercial irrigation companies, presenting additional possibilities in seeking more efficient water allocation and utilization. On the other hand, the Nevada system is essentially operated as an integrated system, but considerable improvements in the management of the water supply are still needed. The Nevada system is attractive as a research area because of a present confrontation involving conflicting demands upon the system for irrigation, recreation, and wildlife, which will probably necessitate improved management of the available water supply. Nevada has a unique statutory provision allowing the State Engineer to determine the duty of water throughout the state to prevent waste and encourage efficient and optimum use of this scarce resource.

Ashley Valley, Utah is an area which has recently gone through the consolidation process with apparent success. The Vernal Unit of the Central Utah Project was constructed by the United States Bureau of Reclamation during the early 1960's to supply supplemental water to irrigated lands in the valley. Following completion of construction, joint efforts by local irrigation company officials and Extension Service personnel resulted in the consolidation of the irrigation companies into a central office for operation and management of the surface water supplies.

Utah Valley, Utah contains a complex irrigation system involving approximately 50 irrigation companies. The water rights of the various companies vary considerably. Some irrigation companies are typically short of water during the late season, while some companies will rarely ever be short of water. The northern part of Utah Valley is rapidly changing from a rural to an urban society. The urban growth rate in this area is among the highest in the Intermountain West.

The two areas in Wyoming were chosen to reflect two separate situations. The irrigation systems in Eden Valley

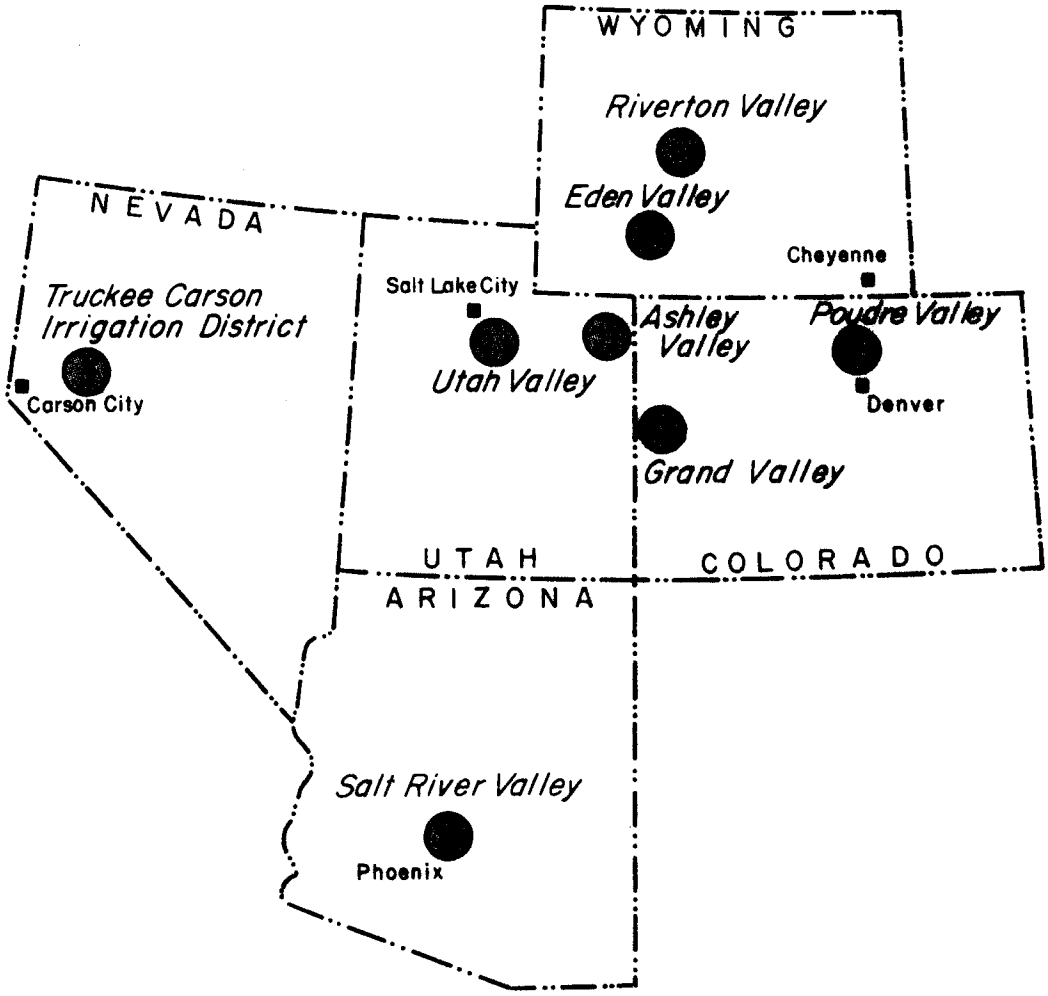


Figure 2. Consolidation of Irrigation Systems Study Areas

operate essentially on a call basis, which has become possible because of a recently completed U.S. Bureau of Reclamation (USBR) project. The project was recently taken over by a locally formed irrigation district, and presents an opportunity to observe the social reaction and ability to cope with physical and legal problems that are on the horizon. For example, the repayment of project construction costs begin in 1972, a fact which will increase the total annual charges beyond the farmers' ability to pay. The area also provides an interesting manipulation of Wyoming water law which ties direct flow rights to the land but permits transfer of direct flow to storage rights. Riverton Valley has also had the benefits of a recently constructed USBR project, but has some problems due to conflicting water demands. Here, also, in addition to the three irrigation districts that encompass the area, the bordering Shoshone-Arapahoe Indian Reservation gives rise to possible water claims under the "reservation doctrine."

The Salt River Valley, Arizona is being studied primarily as a success area in that the irrigation water supply is operated essentially as an integrated system. Also, the area is relatively progressive in seeking solutions to water management problems and at the some time it offers the special challenge of meeting water demands in the rapidly expanding metropolitan area of Phoenix.

Three of the areas selected for study (Poudre Valley, Utah Valley, and Salt River Valley) are undergoing rapid urban growth, with consequent decreases in agricultural lands. Of the three areas, only Salt River Valley is operated as an integrated irrigation system, whereas water users in Poudre Valley are studying the consolidation process, and Utah Valley remains a complicated maze of irrigation systems. Urban planning is being conducted in each area, but little thought is given to the effects of urban and general population growth on the irrigation system. Not only are there changes in land and water use, but water transfers are continually occurring in these areas.

In summary, the selection of these eight areas has been guided by an implicit understanding of a "continuum" of characteristics of irrigation systems. Such a continuum involves dimensions of population and organizational size, urban-rural differentiation, aspects of socio-demographic characteristics, political, legal and administrative variability, and diversified forms of organizational structures and processes.

Thus, these areas afford two-thrust comparative studies. On the one hand, they offer the opportunity for a comparative synthesis of engineering, legal and social facilitators and constraints in a number of similar irrigation systems; and, on the other, they permit comparative analysis of similarities or dissimilarities of characteristics in each substantive area (engineering, legal, social) for each geographical area or for the total number of

systems under examination. A final synthesis will involve the creation of expanded matrices incorporating physical and non-physical factors affecting present performance of, or influencing future developments in, irrigation systems in the West. Such an organizing scheme permits also evaluation of the relative success of some organizational units as contrasted to other comparable but ineffective systems. A measurement (in terms of both physical and non-physical dimensions) of the relative efficiency and effectiveness of consolidated versus nonconsolidated irrigation systems implies also specific recommendations for organizational alternatives, demarcation of variables, and development of policy for implementing decisions for innovative forms of water resources use.

Of particular importance is the fact that advantages in consolidating irrigation systems pertain not only to benefits accruing to irrigators within the system, but that such benefits also extend beyond limited geographical bounds. Improved water use efficiency may release water for other demands. For example, increasing municipal and industrial water requirements, either inside or outside the bounds of the irrigation system, might be partially or entirely satisfied by continual improvements in the irrigation system. The costs of such improvement could be allocated among all beneficiaries, thus providing the interesting case of working out effectively and efficiently the interphase between rural and urban systems.

OBJECTIVES

Recognizing that no single discipline (engineer, lawyer, economist, sociologist, or political scientist) can adequately evaluate all the requirements to effect the consolidation of a number of adjoining irrigation systems into a single management unit, a two-phase "interdisciplinary" research project has been undertaken. The first phase involves a general outline and discussion of engineering, legal, and sociological aspects of consolidation. The second phase will add the dimension of economics as well as a more detailed examination of the two systems facing most acutely the impact of rapid population growth, urban sprawl and conflicting water demands (Poudre Valley and Utah Valley). The objectives of the first phase of the research being directed toward the consolidation of irrigation systems are:

1. To determine and evaluate the engineering characteristics of the system:

    a. The hydrology of the water supply to the area will be assessed in order to evaluate the magnitude of the supply, but more important, to evaluate its time variation;

b. The physical characteristics of the system will be ascertained with respect to capacity, conveyance losses, water measurement and control structures, land served, and type of agriculture;

c. The method(s) of operating each system will be determined with respect to delivery, flow measurement, operational losses, conveyance efficiency, farm efficiency, and operation and maintenance costs;

d. Water deficits and surpluses will be computed for each irrigation company in a valley in order to ascertain the need for water transfers within the total irrigation system; and

e. Alternative physical and operational systems will be studied for improving the efficiency of water use in each area.

2. To identify and analyze from a legal perspective:

a. The project state's basic water laws and philosophies and their effect upon consolidation;

b. The federal and state laws and court decisions which relate to local water organizations and determine whether they operate as impediments to consolidation;

c. The institutional arrangements which control the use of water and to determine possible organizational impediments to consolidation;

d. The state laws regarding business organizations and corporations to determine procedures for merger, along with possible impediments; and

e. The water rights held by these institutions to establish the legal right of individual users in a consolidation proposal.

3. To provide an understanding of the social factors involved in the water systems:

a. Delineate a water management system by answering three key questions:

i) what are the dimensions that define the external environment within which the organization operates,

ii) what are the dimensions that define the characteristics of the organization (internal environment), and

iii) what are the criteria for measuring organizational effectiveness.

b. Examine the perceptions of satisfaction with the organization or the extent of positive expressions by members and/or officials and/or users in the irrigation system, in relation to rules, forms, roles, control, and performance of the organization under a variety of ecological, social, legal, and economic settings. More specifically focus on:

i) present organization arrangements, administrative practices, and general goals concerning available water supply and distribution;

ii) cultural practices and attitudes related to the development and use of water; and

iii) relationships between organizations (such as sharing of resources, opportunities for inter-organizational communication, etc.).

c. Explore the perception and presence of organizational alternatives, as expressed in new organizational schemes of consolidation. In particular, the following aspects will be considered:

i) the general orientation towards social change or the degree of traditionalism among officials and/or users of a given irrigation system;

ii) the beliefs associated with consolidation and the existing level of information about consolidation; and

iii) the perceived social risks and the degree of anxiety involved in the cases of potential consolidation or the alternatives to present organizational arrangements.

ENGINEERING INVESTIGATIONS

The engineering investigation will involve determinations of how the system can be adapted to accommodate the physical land features and water supplies. At the same time, the new system must meet the problem of delivering

the needed amount of water at the proper time to satisfy crop requirements. The engineer must completely define the material aspects of the present system and the proposed system and their respective advantages and limitations. This requires a complete analysis of the natural river flows, interbasin transfers of water, operation of storage facilities, present groundwater use as well as potential groundwater use, geologic features, potential consumptive use, rainfall duration and intensity, methods of distribution and application of irrigation water, and identification of water losses such as seepage, surface runoff, deep percolation, and operational losses. Since water is only one of the physical resources used in crop production, information must be gathered regarding climate, topography, soil type, fertility, soil moisture characteristics, cropping patterns, new crop potentials, soil drainage conditions, land preparation, required frequency of irrigation, and farm water management. The entire system must be analyzed as the completely integrated unit that it is.

A computer program has been prepared to facilitate the analysis of the volumes of data collected for analyzing the irrigation systems. The amount of available data varies considerably from one irrigated valley to the next. Consequently, the procedure for arriving at a water budget must be varied according to the type and amount of data, with a resultant effect on the accuracy of the water accounting. Most water budgets are prepared on a month-by-month basis using the time period for which actual monthly data are available. The month-by-month budgets are then averaged to obtain mean monthly budgets. The mean annual water budget can be obtained by averaging the annual accountings obtained for each year having sufficient data. The mean annual budget is adjusted, where necessary, to reflect a long-term mean, and is also adjusted for physical conditions existing as of the present time. A flow chart illustrating the water budgeting procedure is shown in Fig. 3.

The data necessary to prepare water budgets involves stream gaging station records published by the U.S. Geological Survey which show how much water is available at different periods of time for use in the river basin. Also, streamflow records of any imports (transmountain diversions) are usually available from the U.S. Geological Survey or the water users receiving the imports. Records of the amount of water diverted from any river into an irrigation canal are usually maintained by the River Commissioner, who is a state employee responsible for distributing river flows to each irrigation company, municipality, or other water user. Consequently, the canal diversion records reflect the water rights held by each irrigation company.

A major undertaking for any irrigated region is the development of agricultural land use maps which portray all vegetation using water in excess of natural precipitation. Thus, the land use maps delineate the boundaries of different classifications of croplands and phreatophytes. Also, open water surfaces (e.g., lakes, canal water surfaces,

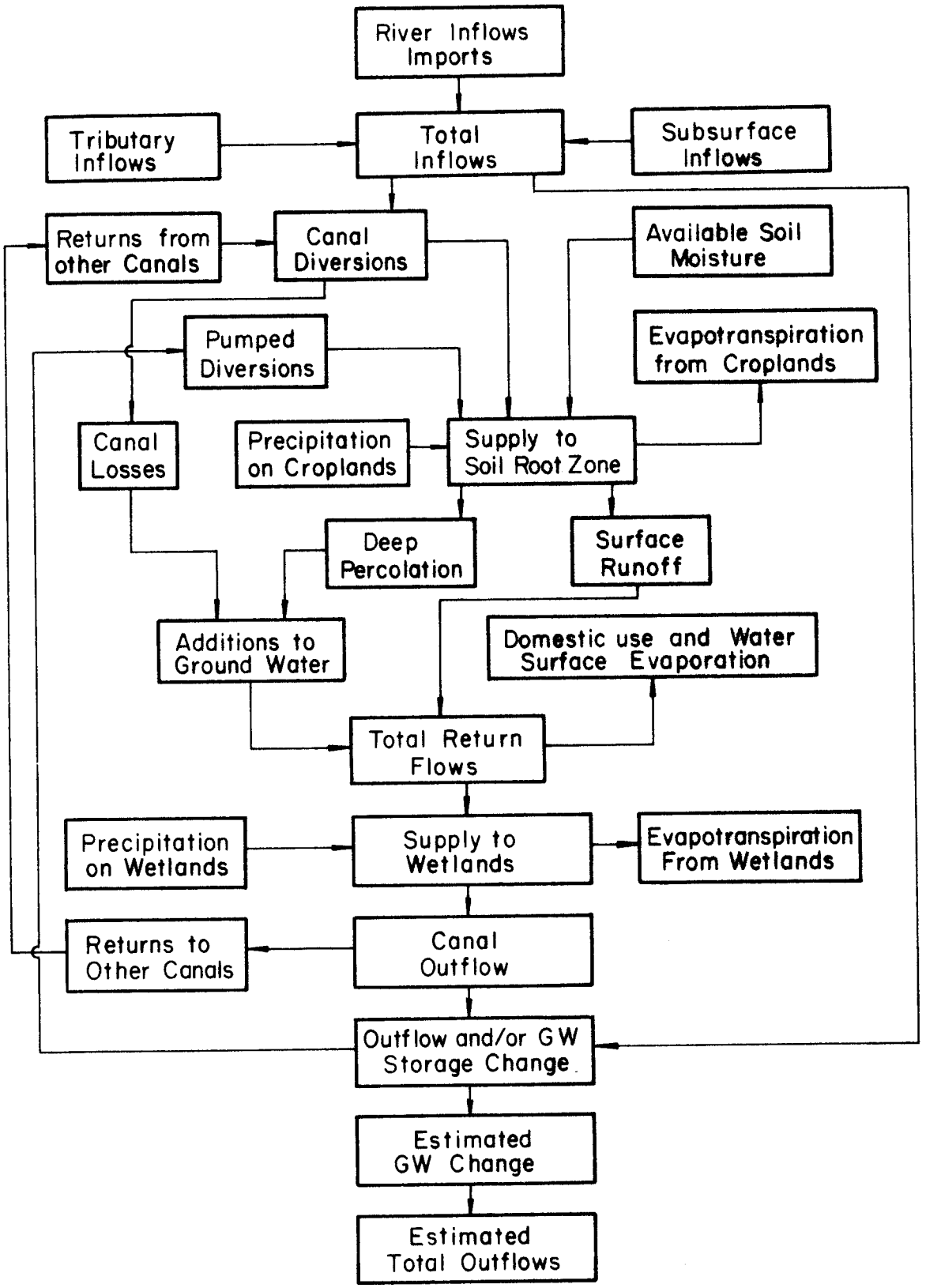


Figure 3. Water Budget Flow Chart.

farm ponds, etc.) are portrayed on the maps. A typical classification system is listed in Table 2. The classification (e.g., A4, C3, F1, etc.) is marked on aerial photographs in the field. This information is then transferred to base maps in the office. Next, the acreage of each classification is determined for each section of land, as well as under each canal or irrigation company. Thus, the breakdown of vegetation and open water surfaces is known for each section of land and for each irrigation company.

One of the key elements in preparing water budgets is a determination of the water requirements for crops and phreatophytes. In fact, the principal purpose in making the land use surveys is to determine the acreage of different types of crops and phreatophytes under each irrigation system, thereby providing needed information for computing water requirements. The acreage data for each irrigation system is combined with climatological data in order to compute the potential consumptive use. Then, an analysis of the water delivery system, including conveyance water efficiencies and farm irrigation efficiencies, along with the types of soil under each system, allows a determination as to whether or not the potential consumptive use can be satisfied. At the same time, then, the amount of water shortage, as well as the timing (July, August, etc.) of the shortages is known. Thus, the amount of water depleted from the area by evapotranspiration is known, as well as the amount of water returned to the system (irrigation return flows).

Initially, water budgets are prepared for each irrigation company (or irrigation canal) on a month-by-month basis for a number of years. Consequently, any water shortages or water surpluses are for the entire irrigation company. For example, the water budget analysis for a particular irrigation company may show a water surplus (more water was diverted from the river into the canal than was necessary to meet crop requirements) for the month of July, 1957, but it is very conceivable that a few of the farmers along this canal may not have had enough water. Thus, it becomes necessary to analyze the water requirements for each individual farmer along an irrigation system to insure first of all that the needs of each individual are being met. Then, it becomes possible to discuss alternative methods for satisfying the needs of adjoining irrigation companies.

Another real benefit in preparing water budgets is that once a water accounting is tied down, it then becomes possible to test various water management alternatives as to their usefulness and effect upon the system. For example, the effects of lining any portions, or all, of the irrigation canals in meeting crop requirements could be evaluated. Also, changes in diversion requirements due to changes in irrigation practices could be determined. One of the most crucial questions that can be answered is the ability of the present physical facilities to

Table 2. Agricultural Land Use Classification.

A. Irrigated Cropland

1. Corn
2. Sugar Beets
3. Potatoes
4. Peas
5. Tomatoes
6. Truck Crop
7. Barley
8. Oats
9. Wheat
10. Alfalfa
11. Native Grass, Hay
12. Cultivated Grass, Hay
13. Pasture
14. Wetland Pasture
15. Native Grass, Pasture
16. Orchard
17. Idle
18. Other

B. Dry Croplands - Precipitation Only

C. Municipal & Urban Land Use

1X. Inhabited Farmsteads
1. Uninhabited Farmsteads
2. Residential Yards
3. Urban
4. Stock Yards
5. Schools

D. Industrial

1. Power Plants
2. Refineries
3. Meat Packing
4. Other

E. Open Water Surfaces

1. Major Storage
2. Holding Storage
3. Sump Ponds
4. Natural Ponds

F. Phreatophytes

1. Cottonwood
2. Salt Cedar
3. Willows
4. Rushes or Cattails
5. Greasewood
6. Sagebrush and/or Rabbitbrush
7. Wild Rose, Squawberry, etc.
8. Grasses and/or Sedges
9. Atriflex

accommodate water transfers from companies having water surpluses to those areas chronically experiencing shortages. If water transfers are not physically possible at the present time, then alternatives for the construction of additional physical facilities to accomplish such transfers could be investigated.

The next step is to study the water delivery system to determine the potential for consolidating physical facilities. Once the various alternatives for physical consolidation have been delineated, then more detailed studies will be required to develop engineering designs and cost estimates, as well as showing economic feasibility. The designs must include the construction of canal enlargements or new canals, regulation and control structures, and flow measuring devices. A comparison of water use efficiency and costs will be needed for the various alternatives for physical consolidation, rehabilitation of the existing water delivery system, and leaving the existing irrigation system unchanged.

In addition, other means for conserving water should be explored to assure that an adequate supply is available to each water user, if possible. Of prime consideration would be the implementation of improved farm water management practices. The costs associated with implementing various farm water management practices will have to be determined, including not only the cost of physical irrigation systems, but labor savings and labor costs, as well as comparisons with other alternatives for achieving the same goals in water use efficiency.

LEGAL INVESTIGATIONS

The legal investigation requires a thorough examination of various areas of substantive water and corporation law, procedural law, administrative law and provisions regarding revenue producing authority and tax liability of irrigation companies. Complexity is created by the lack of uniformity among the study states as to the substantive water law and judicial interpretation of doctrines. In addition, legislation regarding irrigation companies, a segment of water law, may reveal constraints to be considered in any consolidation scheme. Once the statutory and case law is identified and analyzed, individual irrigation company documents in each area will be examined for specific clauses presenting impediments.

Substantive Water Law

The term substantive law refers to that part of law which creates, defines and regulates rights. In the case of water law, its origin may be found in state constitutions, statutes and case law. The initial task is to determine the basic doctrine in each state and to identify what concept of ownership is attached to waters within

the state's boundaries. The five study states have endorsed the appropriation doctrine in the following manner:

ARIZONA - Arizona Revised Code 1928, section 3280

The water of all sources, flowing in streams, canyons, ravines or other natural channels, or in definite underground channels, whether perennial or intermittent, flood, waste or surplus water, and of lakes, ponds and springs on the surface, belongs to the public, and is subject to appropriation and beneficial use, as herein provided.

COLORADO - Colorado Revised Statutes 148-21-2

148-21-2. Declaration of policy.--(1)It is hereby declared to be the policy of the state of Colorado that all waters originating in or flowing into this state, whether found on the surface or underground, have always been and are hereby declared to be the property of the public, dedicated to the use of the people of the state, subject to appropriation and use in accordance with law. As incident thereto, it shall be the policy of this state to integrate the appropriation, use and administration of underground water tributary to a stream with the use of surface water, in such a way as to maximize the beneficial use of all of the waters of this state.

NEVADA - 48 Nevada Water Laws § 533.025, 030, 035.

533.025. Water belongs to public. The water of all sources of water supply within the boundaries of the state, whether above or beneath the surface of the ground, belongs to the public. (1:140:1913, 1919 RL p. 3225; NCL § 7890)

533.030. Appropriation for beneficial use. Subject to existing rights, all such water may be appropriated for beneficial use as provided in this chapter and not otherwise. (2:140:1913; 1919 RL p. 3225; NCL § 7891)

533.035. Beneficial use: Basis, measure and limit of right to use. Beneficial use shall be the basis, the measure and the limit of the right to the use of water. (3:140:1913; 1919 RL p. 3225; NCL § 7892)

UTAH - Utah Revised Statutes. 73-1-1, 73-1-3

73-1-1. Waters Declared Property of Public. All waters in this state, whether above or under the ground are hereby declared to be the property of the public, subject to all existing rights to the use thereof.

73-1-3. Beneficial Use Basis of Right to Use. Beneficial use shall be the basis, the measure and the limit of all rights to the use of water in this state.

WYOMING - Wyoming Constitution Art. I and VIII

§ 31. Water - Control of -- Water being essential to industrial prosperity, of limited amount, and easy

of diversion from its natural channels, its control must be in the state, which, in providing for its use, shall equally guard all the various interests involved.

§ 1. Water Is State Property. -- The water of all natural streams, springs, lakes or other collections of still water, within the boundaries of the state, are hereby declare to be the property of the state.

§ 3. Priority of Appropriation. -- Priority of appropriation for beneficial uses shall give the better right. No appropriation shall be denied except when such denial is demanded by the public interests.

Upon examining these basic provisions, one subtle distinction can be made regarding ownership of waters. In Arizona, Colorado, Nevada and Utah, all waters belong to the public, but placed in trust with the state for administration in the public interest. Wyoming, on the other hand, has retained ownership of its waters and can, when necessary, exercise a greater degree of administrative discretion in the adjudication of rights and distribution of water to various uses and users. It has been held, however, that Wyoming also holds the water in trust for the public.

Certain aspects of substantive law in each state under examination as having an effect on consolidation are: (1) the concept of ownership of water in the state; (2) water rights and the appurtenancy requirements; (3) meaning and application of the concept of beneficial use; (4) the related concept of waste in the allocation and distribution of waters; (5) duty of water doctrine; (6) permissibility of transfer of water rights and/or use of water among users or to other uses; and (7) the degree that conjunctive use of surface and ground waters is authorized or encouraged.

Procedural and Administrative Law

Procedural law is defined as that which prescribes the method of enforcing rights or obtaining redress for their invasion. Administrative law is narrower in scope in that it pertains to the various governmental agencies and prescribes in detail the manner of their activity. The former laws, for our purposes, may be found in the state water statutes, judicial procedures acts, and internal rules and regulations, while the latter is usually a formal code adopted by the state and applying to all state agencies.

Although the substantive law may seem to dominate the procedural and administrative law, the importance of the latter two to our project cannot be disregarded. It may very well be a procedural requirement that consciously or unconsciously creates efficiency impediments in irrigation systems. For example, lengthy and costly required litigation to effectuate certain changes in an irrigation system may deter the implementation of those changes.

Water Organization

Water organization in the state can be divided into two general classes -- public and private. Public entities include the state engineer's department and irrigation, conservancy and conservation districts. The function and scope of authority of these organizations must be examined to determine their impact on irrigation systems. In most states, the state engineer is charged with administration, allocation and distribution of water. With the increased pressure on states to meet interstate compact requirements, this office may significantly affect the use of irrigation water. Irrigation and conservancy districts have greatly assisted in the development of irrigation systems, but being public entities, they likewise have a duty of encouraging non-waste and beneficial use.

Aside from being directly concerned with the operation of irrigation companies, these public agencies are facing a new trauma. We are in an environmental protection oriented era of time in which federal and state agencies charged with protection of the environment are being brought to task by a multitude of citizen lawsuits under the public trust doctrine. In the near future, these suits may be directed to state water quantity and quality departments, demanding that they require more efficient use of this resource by water right holders.

The major emphasis of this project is directed to the private enterprises and principally, the mutual irrigation companies. They have been explained briefly at the beginning of this report, and will be discussed here only to the extent of legal constraints to consolidation. Mutual companies can either be unincorporated or organized under the corporation codes of state. If unincorporated, their existence may be by verbal or written agreement and usually their organization structure is informal and flexible. Their ratio is almost two to one over incorporated companies. Impediments to consolidation in this type of entity exist almost solely with the personalities involved.

Companies formed under the corporation code must comply with specific legal procedures and are subject to greater public scrutiny and control. Articles of incorporation are filed with the secretary of state, setting forth the legal purpose of organization. By-laws are filed and regular minutes kept. Shareholders are issued stocks based either on the number of acres irrigated or the amount of water rights transferred to the company.

The corporation codes of the five study states contain no impediments to consolidation other than procedural requirements. Representative of code requirements is the following Wyoming provision:

Procedure for Merger

Section 63. Any two or more domestic corporations may merge into one of such corporations pursuant to a plan of merger approved in the manner provided in this Act.

The board of directors of each corporation shall, by resolution adopted by each such board, approve a plan of merger setting forth:

(a) The names of the corporations proposing to merge, and name of the corporation into which they propose to merge, which is hereinafter designated as the surviving corporation.

(b) The terms and conditions of the proposed merger.

(c) The manner and basis of converting the shares of each merging corporation into shares or other securities or obligations of the surviving corporation.

(d) A statement of any changes in the articles of incorporation of the surviving corporation to be effected by such merger.

(e) Such other provisions with respect to the proposed merger as are deemed necessary or desirable.

Procedure for Consolidation

Section 64. Any two or more domestic corporations may consolidate into a new corporation pursuant to a plan of consolidation approved in the manner provided in this Act.

The board of directors of each corporation shall, by a resolution adopted by each such board, approve a plan of consolidation setting forth:

(a) The names of the corporations proposing to consolidate, and the name of the new corporation into which they propose to consolidate, which is hereinafter designated as the new corporation.

(b) The terms and conditions of the proposed consolidation.

(c) The manner and basis of converting the shares of each corporation into shares or other securities or obligations of the new corporation.

(d) With respect to the new corporation, all of the statements required to be set forth in articles of incorporation for corporations organized under this Act.

(e) Such other provisions with respect to the proposed consolidation as are deemed necessary or desirable.

In either case, the board of directors must submit the plan of merger or consolidation to the shareholders for approval.

Any restrictions on consolidation are most likely to be found in the articles of incorporation, by-laws, or legends fixed upon stock certificates. These impediments represent the greatest obstacle because shareholder approval must be sought to amend or remove them.

Whenever applicable, federal involvement in irrigation systems development must be considered. Federal laws, cases and agencies affecting a particular area shall be examined to document sources for or impediments to consolidation. For instance, the impact of the Bureau of Reclamation in the Fallon, Nevada area cannot be overlooked. The Fallon, Nevada area must be recognized for its water development role. Of importance to the irrigation system at the individual and irrigation company levels is the acceptance by the Bureau of a local contracting agency.

These are the legal perspectives that must be thoroughly explored in determining impediments or facilitators to consolidation or alternatives for efficient use of water, manpower and capital within irrigation systems. In general, the methodology will include a state by state examination of the (1) state laws, (2) state judicial decisions, (3) laws pertaining to creation and authority of state and local water agencies, (4) conducting of interviews and submission of questionnaires to the state and local agencies and companies and to individuals influencial at all these levels, and (5) an examination of the federal laws, cases and reports relative to the study areas. Secondary data will be utilized where available, but with primary emphasis on the use and compilation of primary data.

SOCIOLOGICAL INVESTIGATIONS

The central question of the sociological portion of this query is how to theoretically and methodologically approach the social dimensions of natural resources. The previous general categories of institutional or human factors and other sensitizing categorizations provide little observational direction and analytical focus for the study of the social dimensions of any water management system. The existing literature provides little guidance as to the sociological approaches to water resources, with the sparse and spotty work being more descriptive than analytical and with few verified generalizations.

In essence, the core argument of this part of the study is that although water supply and quality themselves are vital in any discussion of resource utilization, a key element will be the specific mechanics of organizational structures which will determine and secure constant monitoring and expansion of water supply, adequate distribution operations, and the meeting of local, regional and eventually national water use goals.

The alternatives of better organizational structures and processes to meet present and future demands require recognition of both physical and social dimensions of the given water system. Such a systems analysis views water management as a system operating in a given environment where inputs (physical and social) processed through the

"organization" result in outputs or goals established for the functioning of the system.

If one is to look at any organizational unit, including water use systems, one must take into account some systematic format which brings together component parts. To start with, there are two major environments within which component systems or subsystems operate: a) the external environment which is both natural and man-made, and b) the internal environment, encompassing all subsystems operating primarily inside the boundaries of the external environment. Any model then would integrate external and internal environments, where inputs (resources), through the system (means) will contribute to outputs (objectives or goals). Simply, a particular system implies a collection of people, devices, and procedures intended to perform some function. A systems model is a working model of a social unit which is capable of achieving a goal and involves the systematic exploration, analysis and evaluation of all the possible consequences of proposed alternatives to an on-going system.

The general preoccupation with a systems approach in this study is part of the overall thrust of the present research in integrating physical and non-physical dimensions of irrigation systems. At the same time, such a systemic approach includes not only the conditions under which particular structures are maintained, but also the conditions under which processes and activities contribute effectively in the service and achievement of a given goal.

While the specific variables required to analyze a system are innumerable, indicative of the thrust of the research on the general or macro-level are the following:

1. Input considerations, such as the physical environment population characteristics, normative resources, economic viability, political networks, and technological developments;

2. System considerations, or the specific structures and processes within an irrigation company with major emphasis on such component parts as personnel, facilities, and procedures;

3. Output considerations, referring to the established goals of an irrigation company revolving around such goods or services as total volume of water supply, water quality, flow and distribution, enhancement of life, and long-range water resource development.

In line with the major emphasis of this research in delineating the factors facilitating or hindering consolidation of irrigation companies, the primary focus of analysis will be the following inputs or constraints of an irrigation system:

1. Engineering inputs (part of natural resources inputs) having two major dimensions:
   a. Hydrology or water supply problems, such as time history, diversions, and crop water demands;
   b. Network requirements (water facilities), such as canals, pumps, delivery systems, and irrigation return flows.

2. Legal inputs such as the substantive water law (prior appropriation), legal aspects of surface and ground water, duty of water, administrative aspects of law, requirements and limitations, and the specific allocations of individual water rights as well as State and Federal water rights.

3. Social inputs such as ecological and demographic characteristics and the normative resources of communities within which irrigation systems are located.

(See Figure 4 for an example of the proposed systems analysis.)

Given, then, such existing inputs in each of our eight irrigation systems, one must look at the organizational arrangements devised to meet the goals of irrigation companies. A more long-range goal of such an approach will be not only an analysis of each organizational form per its component parts, but also a delineation of organizational sets, or "interorganizational environment," since most irrigation systems have quite a number of companies interacting within a particular area. Since the research question is that of the desirability, or not, of the consolidation of a number of companies within an irrigation system, we want also to know the "organizational field," i.e., the interrelatedness and exchange among companies and the differential performance between systems which do, or do not, have such interrelatedness (or have it in varying degrees).

Another key question that faces this research effort is that of measuring organizational effectiveness of the irrigation companies. Before one proceeds with any kind of technical decision or policy guidelines as to the advisability or necessity of consolidation, one must examine not only the manner and extent of how present goals are met, but also the manner by which irrigation companies can meet future goals resulting from changes in both the external and internal environments. Thus, the sociological examination of an irrigation system and the measuring of relative effectiveness of consolidated vs. non-consolidated irrigation systems involves preoccupation with three types of changes and their consequences:

a) changes in the external environment which lead to changes in inputs (people, money, technology);

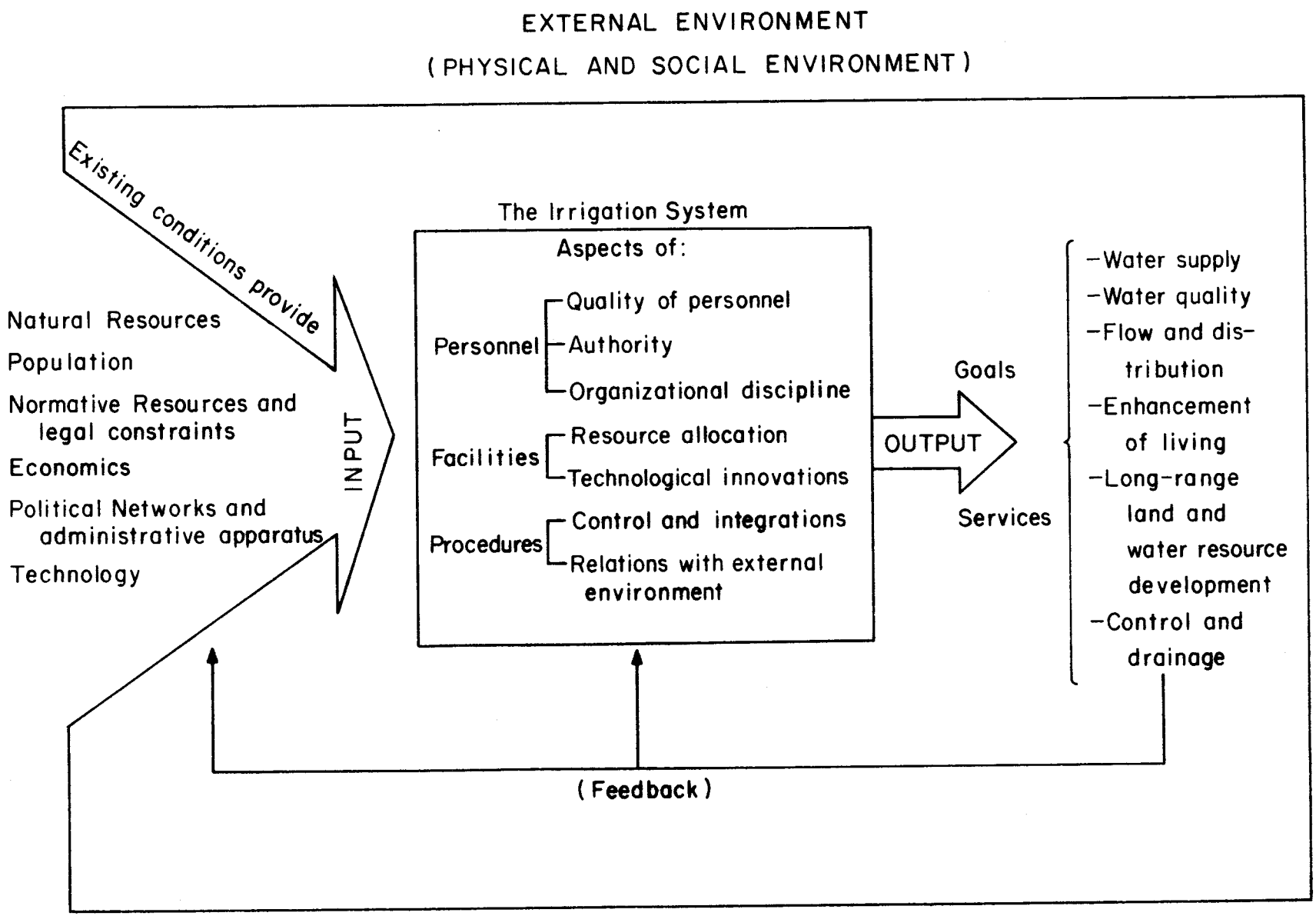


Figure 4. Towards an Input/Output Model of an Irrigation System.

b) changes in organizational structures and procedures because of changes in size, capacities and technology, different roles or organizational forces, power, etc.;

c) changes in output or "goal alterations" which result from the interchange of goals between manifest and latent levels, goal displacement, etc.

All in all, these changes require consideration of how new organizational forms can be devised to meet new and growing demands. We are essentially asking the question: what preparedness for alternative schemes exists in our systems? And how much interrelatedness and exchange among companies in a particular water system not only exists but contributes to differential performance between systems?

The proceeding systematic examination of irrigation systems emphasizes a central argument of the research, namely that of measuring each possible engineering case of consolidation against non-physical constraints and facilitators affecting long-term water use goals. In addition, organizational preparedness and response of agencies and communities also provide important indicators about the ability of a particular irrigation company or system of companies to effectively meet future demands. Organizational effectiveness would then imply the extent to which an irrigation system achieves its objectives without incapacitating its means and resources and without placing undue strain on its members. The question of our research is whether this is more apt to occur within a consolidated or a non-consolidated irrigation system.

It is important to notice at this point that the determination of "productivity" and the consideration of alternative designs in an irrigation system provide the opportunity for an important tripartite distinction in the evaluation of the relative levels of performance of the irrigation systems under examination. First, efficiency has to do with the relationship between Input (resources) and Output (goals) and it is primarily measured in terms of economic benefit-cost analysis. Secondly, effectiveness indicates the relationship between System (thruput) and Output (goals) evaluated mostly in terms of organizational performance, or the meeting of purely organizational goals. Last, but not least, efficacy incorporates the meeting of social goals and assumes the consideration of social cost criteria or some delineation of qualitative indices. Qualitative criteria and consideration of social goals transcending purely utilitarian criteria provide us with the difficult task of trying to strike a balance between fulfilling water use goals in expedient, technologically and economically feasible ways, as related or contrasted to questions of environmental deterioration or the pursuit of not easily measured larger social policies. The questions of "social utility" are part of subjective models which are much more difficult to construct, yet they contain desired long-range policies for a social use of natural resources.

The design of the sociological aspects of this investigation can be summarized in a series of interrelated propositions, encompassing the essential argumentation regarding the importance of a systematic view of an irrigation company:

1. New and expanding demands from the sources, indicated repeatedly above, generate the need for a reconsideration of present irrigation systems;

2. Such a reconsideration is necessitated by the realization that existing water systems have either physical limitations or deficiencies or are organizationally (and legally) ineffective in meeting future demands;

3. Possible consolidation of fragmented systems of companies has to be considered, first, as desirable (from the specialist's as well as the user's point of view) and, second, as feasible (again from both the specialist's as well as the user's point of view);

4. What makes consolidation an important research question are the systemic linkages of three major clusters of facilitators or constraints in the achievement of such an operation:
   a) Engineering constraints and facilitators having to do essentially with problems of supply and aspects of distribution
   b) Legal constraints and facilitators involving the two interrelated aspects of the substantive law and of the implementation machinery
   c) Social constraints and facilitators as affected by and affecting first, the community environment, second, the organizational structure, and, finally, perception of alternatives and change;

5. From the sociological point of view, attempts toward consolidation depend on the individual's knowledge and attitude toward each of the above three clusters of constraints and facilitators as well as his overall orientation toward change. This means an understanding of:
   a) Perception of the individual's interpretation of engineering, legal and social characteristics of the irrigation system (the social world, or the actual environment), on both the informational (knowledge) and attitudinal levels;
   b) Perception of the individual's predisposition toward change of engineering, legal and social alternatives as related to irrigation systems (again, on both the knowledge and attitudinal levels);

6. An important question on successful consolidation is also the nature and extent of the inter-

relationship of knowledge and attitudes by an individual towards a specific irrigation company or irrigation system. This implies an analysis of the types of congruence between the degree of satisfaction with present arrangements, the predisposition towards change, and the perception of alternatives vis-a-vis present arrangements.

The sociological analysis of an irrigation system requires, then, an understanding of broader problems involved in the large matrix of interrelated environments and subsystems. A different approach is required involving technological assessments and evaluations that include much broader constraints than have been imposed in the past. The so-called "human problem" is part of closely related forces operating on both the individual and group levels. It is a major assumption of the proposed design, however, that organizational response of agencies and communities is primarily shaped by the constraints and facilitators of the encompassing external environment (physical and man-made), rather than by capricious individual acts.

In order to meet the broad objectives of this sociological research, a number of specific techniques and procedures are proposed. To start with, a general social reconnaissance of the valleys selected is supplemented by a number of informal interviews with officials and irrigation users. A review of archives and secondary source material related to the selected irrigation systems and to the ecological setting of specific irrigation companies is reinforced by an analysis of the 1970 census returns for the same areas as well as earlier population data. Because of the extensive material and the stated purposes of the study, a decision was made to concentrate the effort towards the collection of primary data in three irrigation systems: Eden Valley, Ashley Valley, and Poudre Valley. These cases were selected as part of a smaller scale continuum (Eden, small with 71 users and only one irrigation company; Ashley, intermediate with approximately 1200 users and five main irrigation companies; and Poudre, large with approximately 6200 users and 34 principal irrigation companies).

The in-depth study of these three irrigation systems was accomplished by a questionnaire survey of a randomly selected sample of individual users and a number of interviews with company officials. The design of the questionnaire contains information around two major clusters of independent variables: socio-economic background of irrigation users and property characteristics of their holdings; and the relationship and identification of the individual user with the particular irrigation company. An intermediate variable of particular significance contains a cluster of questions around water use patterns of individual users. Finally, three clusters of variables contain the dependencies of the present research: the degree of traditionalism - modernism, the extent of satisfaction with

present arrangements, and the perception of alternatives to present irrigation system arrangements.

The primary data collected has been coded and processed on IBM cards and advanced analytical techniques are employed per selected socio-economic and ecological indices. The results of the survey and the utilization of available data provide the background effort for an integrated analysis of major factors affecting the decision to consolidate or not.

SUMMARY

An imaginative water resource program and an efficient and effective water management policy are necessary ingredients of meeting the challenges of growth and the required adjustments resulting from new and expanding demands. Water allocation involves very broad segments of society, and water must be managed in a manner that is a compromise between technical feasibility and competence and general public interests in order to insure the socially, as well as the physically, efficient utilization of this resource.

Consolidation of irrigation companies in particular seems to be an imperative for the Intermountain region where perennial scarcity coupled with strong trends of population growth and new demanding economic activities provide both the impetus and the needed urgency for a prudent policy of water management under effective organizational structures and processes. As George Clyde[1] has succinctly stated, there are seven direct benefits to be derived from consolidation of irrigation companies, benefits which in turn would be passed on to the farmer. These are:

"1. Reduce conveyance and administrative water losses in a multitude of duplicating ditches;

2. Decrease costs of water distribution by reducing the numbers of directors and watermasters;

3. Increase flexibility and efficiency of available water supplies;

4. Make it possible to employ trained men to operate, maintain, and improve the irrigation system;

5. Strengthen the financial structure so that adequate financing for O&M, replacements and betterments may be secured;

6. Make possible the effective integration and use of natural flow, surface storage and ground water supplies;

7. Provide a more effective organization to participate in basin-wide development and to contract

with Federal Government or other agencies for additional water supplies to improve the distribution systems."

The problem of consolidating irrigation companies in the West and the quest for an interdisciplinary approach of physical and social sciences provide an excellent opportunity for the application of macro-models, for handling organizations as units, and for the establishment of long-range policies of social intervention. The overall study on the consolidation of irrigation systems tries to provide the synthesis for such an integrated approach by focusing on the following major research themes and dimensions:

1. An attempt towards "interdisciplinary" synthesis by a complex accounting of a host of physical and non-physical factors which act as either facilitators or constraints towards efforts of consolidation;

2. A by-product of the above emphasis is the orientation towards an integrated model of water management systems incorporating aspects of external and internal environments through an Input-System-Output analysis;

3. The target areas have been selected as parts of a "continuum" representing not only cases of consolidated and non-consolidated irrigation systems, but also other important differentiating dimensions of size, complexity, and socio-economic characteristics. Such a comparative approach attempts to delineate important similarities and dissimilarities in order to provide some verified generalizations concerning the feasibility and effectiveness of consolidation;

4. Finally, the present study has the additional advantage of involving both macro- and micro-level considerations. There is not only an effort to account for the major parameters of the organizational units and of the essential constraints of the external environment; important at the same time is the examination of the individual response to the particular organization, his patterns of water use, and his generalized predisposition towards life, his community, and future orientation. After all, although collectivities and larger environments provide the background of determining forces, the individual and the considerations of social utility of efficacy remain a primary preoccupation of the research and of the envisaged water policy recommendations.

Water as a precious natural resource requires an intensive and continuous effort of study and analysis so that the concern with the "environmental crisis" will not remain

only as a generalized anxiety of doomsday prophesies, but will act as the impetus and the motivating force for an intelligent, methodologically consistent, theoretically incisive, and socially conscious systematic work of natural resources management and conservation.

PART THREE

LEGAL ASPECTS OF THE CONSOLIDATION PROPOSITION

INTRODUCTION

This chapter contains the essence of formal legal involvement in the operation of irrigation systems. The key issues to be described and analyzed are: (1) the substantive water code of each state, in general that being the appropriation doctrine, in specific, that being the distinguishing variations in the code effecting consolidation propositions as one alternative to improved water utilization in irrigation systems; (2) the organizational arrangements that prevail with the irrigation systems, their legal status and function; and (3) the corporate code position on consolidation or merger for each state studied. Although the majority of water organizations are unincorporated, as opposed to incorporated mutual companies, the key constraints to consolidation in the former exist within the organization itself, while the incorporated feature of the latter requires compliance with legislated law and thus a determination of the external (and possible overriding) constraint.

SUBSTANTIVE LAW

The term substantive law refers to that part of law which creates, defines and regulates rights.[5] In the area of water law, this substantive material if found in state constitutions, statues and case law.

Lack of uniformity in the law among the study states requires that the material be divided according to state. All five of the study states, however, base their water law on the appropriation doctrine. A brief look at the basic principles of that doctrine is therefore appropriate at this time.

Appropriation Doctrine - In General

The primary principle of the appropriation doctrine is priority in right.[6] This principle has been stated as "first in time is first in right"[7] and means, basically, that when a water deficit occurs, allocation diversions among users are closed in an inverse order, i.e., the latest allocation right granted is the first to be closed. This order is followed regardless of the type of use being made of the water.[8]

The second principle of appropriation is that the water in question must be the subject of a diversion.[9] This is usually a man-made mechanical diversion but not necessarily so.[10]

A third principle of appropriation is that a beneficial use must be made of the water appropriated.[11] The doctrine of beneficial use was developed to limit the amount of water diverted to that reasonably needed for use--the assumption apparently being that if a use was "reasonable," it was beneficial.[12] There is no precise definition of beneficial use that can be applied to all water uses so the measure of "reasonableness" is crucial.[13] It thus becomes circular--what is beneficial is reasonable and what is reasonable is beneficial. In view of the dynamic state of American water law and the additional demands placed on water by growth in this country, it is perhaps wise not to make definitions of crucial concepts too rigid.[14]

The fourth principle is that a valid appropriation of water is a right in real property.[15] This right of property can readily be recognized as an impediment to easily changing existing water use arrangements in spite of the demands of a dynamic society.[16] This property right is not absolute[17] but is, rather, a usufruct[18] in a stream consisting in the right to have the water flow so that some portion of it may be reduced to possession and be made the private property of the individual during the period of possession, and it is, therefore, the right to divert water from natural streams by artificial means and apply the same to beneficial use.[19]

Finally, an appropriative right in water must exist for a definite amount.[20] This is known as a "duty of water" and serves to quantify the doctrine of beneficial use by setting a maximum consumption which will be recognized as a reasonable beneficial use.[21] This right or duty of water is usually expressed in terms of quantity of flow per second but may also be stated in acre feet, time or season of the year or the amount of beneficial use which can be made of the water.[22] The statutory provisions prescribe the maximum amount allowable but it is understood that if the reasonable beneficial use is less than this amount, the need will prescribe the limit.[23]

In considering these areas, it will be noticed that the word "reasonable" is used repeatedly. In considering methods of consolidating water systems, it might prove fruitful to consider whether a practice which is resulting in wasted water is "reasonable." The concept of reasonableness may be an effective legal vehicle for achieving the desirable goal of eliminating practices which waste water.

Each study state has modified the appropriation doctrine to some extent but all of them have adopted it. These modifications are best seen on a state by state basis. The salient point to be considered is to what extent consolidation of water system in each of these states has been aided or impeded by these modifications.

Arizona

In Arizona, the waters of all sources belong to the public and are subject to appropriation and beneficial use[24] but are placed in trust under the state land department which controls and supervises the water for the public.[25] The state land department will divide the state into water districts,[26] each with a superintendent whose duty it shall be to divide, regulate, control and prevent the waste of water within his district.[27]

Appropriation Doctrine. The appropriation doctrine has been adopted in Arizona.[28] Any person including the United States, the state or a municipality desiring to make beneficial use of water must apply to the state land department for an appropriation permit.[29] All applications for an appropriation permit for beneficial use will be granted unless there is a conflict with vested rights or the appropriation would be against the vested interests of the public.[30] The decision of the department's commission relating to the appropriation permit is not appealable to the Supreme Court.[31] The granting of this permit authorizes the applicant to immediately begin taking steps to beneficially use the water requested.[32] This permit may be assigned to another person.[33] When work to put the water to beneficial use is completed, a certificate of right is issued.[34]

The state land department is authorized to determine the state of conflicting claims to water rights.[35] A public notice must be given of the pending investigation,[36] the lands and streams must be examined,[37] notice of the hearing given to the claimants,[38] and, upon hearing all the evidence, and administrative determination is handed down which is conclusive,[39] unless a claimant exercises his right to appeal this determination to the Supreme Court.[40] Upon final determination, a certificate of right is issued.[41]

The criteria for approval is that the proposed right must be for a beneficial use and not be in conflict with a vested interest or the best interests of the public.[42]

An appropriator has been judicially defined as one who makes an application of public water on land he owns, said application to be for beneficial use.[43] An appropriation was defined by an early court as the intent to take, accompanied by some open, physical demonstration of the intent, for some valuable use and consummated without delay.[44] Added to this are the requirements that the appropriated water be a specified amount, diverted, for a beneficial use,[45] and that only waters in their natural, as distinguished from artificial, condition are appropriable.[46]

Water Right. A water right is the right to use water consisting of its prior appropriation and beneficial application to the soil.[47] From this, it can be seen that the right is unufructory in its nature and not absolute.[48]

Priority. This has been stated as "first in time is first in right"[49] and means that the first person appropriating the water shall have the better right.[50] In Arizona, the appropriation dates from the time a purpose to make an appropriation was definitely formed and actual work on a project had begun[51]--more notice of appropriation is ineffective.[52] The appropriator's right may "relate back" to the initiation of appropriation when diligence is exercised in applying appropriated water to beneficial use.[53] As a general rule, actual construction on appropriation projects must begin within two years after approval of the application and must be completed within five years.[54]

Diversion. The term "diversion" per se is not statutorily defined per se in Arizona but a list of offenses for tampering with another's water provides a list of items which might reasonably serve as a starting point for definition.[55] Perhaps trying to define diversion would result in needless confusion. The judiciary in Arizona has proceeded as if the word's meaning was so obvious that it did not require formal definition.[56] The important concept seems to be that the property claimed be segregated from the rest of the resource so as to indicate separate ownership.

Beneficial Use. The term "beneficial use" per se is not statutorily defined per se in Arizona.[57] Though undefined it is the "basis, measure and limit to the use of water" in Arizona.[58] It follows that no appropriation is valid unless it is pursuant to a beneficial use.[59] Judicially, the term has been defined as "to the effect that a water right is attached to the land on which it is beneficially used..."[60] Perhaps in view of the dynamic state of the law the best course is to leave definition to judicial determination on a base by case basis.[61]

Relative Value of Uses. When a deficiency of water occurs in a given water supply, the state land department shall give preference to one applicant for water over another applicant according to the relative values to the public of the proposed use. These relative values shall be:

1. Domestic and municipal purposes. Domestic purposes shall include gardens not exceeding one-half acre to each family.
2. Irrigation and stock watering.
3. Power and mining uses.*
4. Recreation and wildlife, including fish.[62]

Real Property. A water right is generally considered to be a real property right or land.[63] This appears to be the state of the law in Arizona--especially in view of the fact that the waters are supervised by the state land department.[64] In addition, though a nonirrigation right may be severed from the land to which it is appurtenant for nonirrigation or uses unconnected with land,[65] an irrigation

*The use for mining, however, does not include the right to send tailings and waste from reduction works downstream to the detriment of prior users for irrigation. Arizona Cooper Co. v. Gillespie, 230 U.S. 46, 33 Sup. Ct. 1004(1913)

right may only be severed from its land by attaching it to other lands and then excluding the cut-off lands and including the new lands in the irrigation district.[66] In effect, this makes irrigation rights appurtenant to their irrigation districts--not to the land. Also, it has been judicially decreed that land transferred is subject to any valid water rights attaching thereto.[67]

Further substantiating the position that water is real property in Arizona is the statutory determination that "real property means lands,..., including appurtenances...[68] and the fact that this property, is to be condemned under the powers of eminant domain.[69] This means that the state recognizes a property right deserving recompense. This is compared with the police powers where no such right is recognized.

As can be seen, water rights are not absolute in their nature.[70] In addition to the foregoing limitations, the "duty of water" limitation must be mentioned. In Arizona the only limit to the amount of water appropriated is that which can be beneficially used.[71]

Wasted Water. Wasted water is not statutorily defined in Arizona but may be referred to here as that water which is now lost under current systems and practices but which might be saved.[72]

It is the public policy of Arizona to make the largest possible use of the water within its boundaries.[73] To this end, the superintendent of each water district is charged with regulating waters within his district to apportion the resource according to right and to prevent waste.[74] It is a misdemeanor to waste water.[75] It is decided by an early court that an irrigation company could conserve surplus or wasted water as there was no vested property right in this unappropriated water.[76] The picture was clouded by the Kovacovich decision holding that waters gained by conservation practices was to be applied only to the land to which it was originally appurtenant.[77] However, a recent statute has opened the way to conserving surplus water and taking it where it is needed.[78]

Abandonment of Water Rights. Relevant to wasted water is the topic of abandonment of a water right through non-use. Arizona provides that if the owner of a water right ceases or fails to use that right for five consecutive years, the right in question shall cease and revert to the public.[79] It has been held that there must be "intent" to abandon a right,[80] but this intent is not necessary to "forfeit" a water right[81] --a judicial circumvention of a technicality.

Colorado

In Colorado, the waters within the boundaries of the state, not heretofore appropriated, are the property of the public and are dedicated to the use of the people of the

state[82] but the state retains the right to distribute the use of waters.[83] The state will be divided into water districts[84] under the control of the state engineer and district engineers for the purpose of maximizing the benefit and welfare of the citizens of the state through proper water management.[85]

Appropriation Doctrine. The appropriation doctrine is recognized in Colorado.[86] The right to appropriate water for a beneficial use shall never be denied.[87] Prior appropriation applies as well to underground waters not adjacent to any natural stream.[88] An appropriation is defined as the diversion of a certain portion of the waters of the state and the application of some to beneficial use.[89] This does not require new facilities to be built.[90] Any person who desires a determination of a water right or a conditional water right and the amount and priority thereof will file an application with the water clerk setting forth facts supporting the ruling sought.[91] Opposition, if any exists, must be filed by the last day of the second month following application.[92] Rulings on applications and oppositions will be made within sixty days of filing of opposition arguments by the referee of the water district[93] and these ruling may be appealled to the district water judge.[94]

A plan for augmentation which is a detailed program to increase the supply of water available for beneficial use by one of several available, appropriate means[95] will be administered in essentially the same manner except that all applications will be handled directly by the water judge in each district.[96] Water judges will exercise the broadest latitude possible in encouraging augmentation plans.[97]

Water Right. A water right is defined as a right to use in accordance with its priority a certain portion of the waters of the state by reason of the appropriation of same.[98] From this it can be seen that it is unufructory in nature.[99]

A conditional water right is the right to perfect a water right with a certain priority upon completion with reasonable diligence of the appropriation upon which the right is based.[100] Conditional decree statutes are to be construed and applied to aid and encourage rather than block development and early use of state water resources.[101]

Priority. This has been described as the "first in time is first in right."[102] Priority means the seniority by date as of which a water right is entitled to divert or conditional water right will be entitled to divert and the relative seniority of a water right or a conditional water right in relation to other water rights and conditional water rights deriving their supply from a common source.[103] Priority of appropriation shall give the better right as between those using water for the same purpose.[104] Date of priority may "relate back" when a conditional water right is perfected by completion of construction by reasonable diligence.[105] Showings of reasonable diligence are required

during every even-numbered year under conditional water rights.[106] A list of priorities of water derived from a common source will be made and maintained by the engineer of each water division.[107] Priorities have been held to be not appurtenant to land.[108]

Diversion. Diversion means removing water from its natural course or location, or controlling water in its natural course or location, by means of a ditch, canal, flume, pipeline, conduit, well, pump, or other structure or device.[109] One point of diversion may serve two or more appropriations.[110] There must be a fixed purpose and intent to effect a valid diversion pursuant to an appropriation.[111]

Beneficial Use. No final decree can be awarded for an appropriation until the water is first put to a beneficial use.[112] A beneficial use is defined as that amount of water that is reasonable and appropriate under reasonably efficient practices to accomplish without waste the purpose for which the diversion is lawfully made and without limiting the generality of the foregoing, shall include the impoundment of water for recreation purposes, including fishery or wildlife.[113] Beneficial use is a fact question depending on the circumstances of the case.[114]

When the waters of any natural stream are not sufficient for the service of all those desiring the use of same, those using the water for domestic purposes shall have preference over those claiming for any other purpose, and those using the water for agricultural purposes shall have preference over those using the same for manufacturing purposes.[115]

Real Property. A water right is generally considered to be a real property right.[116] In Colorado, it has been held that a right to divert water is an "interest in real estate."[117] This is substantiated by the rule that in all conveyances of water rights, except where the ownership of stock in ditch companies or other companies constitutes the ownership of water, the same formalities shall be observed and complied with as in the conveyance of real estate.[118] Too, any corporation formed for the purpose of constructing ditches, reservoirs or pipelines may require title to such right of way or easement as provided by law for the condemnation of real estate.[119]

In transferring a water right, a request for a change of water right or plan for augmentation will be approved if no injury to vested interests results.[120] Also, owners of water rights may loan to each other for a limited time, the water to which each may be entitled for purposes of saving crops or effecting a more economical use.[121] However, water being used for irrigation of a particular tract of land will be confined to that land as long as that use is being made and cannot be made to do duty to that land and at the same time be used for irrigation elsewhere.[122] Too, when water in a drainage canal is turned back into a natural stream, it becomes part of that stream and is subject to appropriation.[123] The "duty of water" is limited to the amount needed for and put to a beneficial use.[124]

Wasted Water. Wasted water may be defined as that water which is now lost under current systems and practices but which might be saved.[124] It is public policy to maximize the beneficial use of all water in the state.[125] The division engineer is empowered to order discontinuance of diversion within his division to the extent that the water is not needed for a beneficial use.[126] The owner of any irrigating or mill ditch is charged with keeping the ditch in good repair and preventing water from wasting.[127] Violation of an injunction issued pursuant to § 148-21-35 will allow the injured party to collect threefold the damages sustained plus the cost of the suit and attorney's fees.[128]

Adverse Possession. There must be open, notorious, actual, visible, continuous, hostile, exclusive possession of water for adverse possession of a water right to be recognized.[129] From these requirements, it is obvious that this is to be discouraged. Too, the adverse possessor may not acquire title to unappropriated water--these are the property of the public.[130]

Abandonment. Failure to use a water right for a beneficial purpose for a period of ten years creates a rebuttable presumption of abandonment.[131] Abandonment of a water right means the termination of a water right in whole or in part as a result of the interest of the owner thereof to discontinue permanently the use of all or part of the water available thereunder.[132] Abandonment of a conditional water right means termination of a conditional water right as the result of failure to develop with reasonable diligence the proposed appropriation.[133] The question of abandonment of water rights is one of intent that must be shown by clear and unequivocal evidence. Mere lapse of time does not constitute an abandonment[134]--though it may be relevant to show intent.[135] It is a question to be determined from surrounding facts.[136]

Nevada

In Nevada, the waters of all sources within the boundaries of the State belong to the public.[137] The State, however, may prescribe how water is to be used[138] and to this end the state engineer is charged with assuring proper distribution of water.[139] This office is under the control of the department of conservation and natural resources.[140]

Appropriation Doctrine. The appropriation doctrine is recognized in Nevada.[141] An "appropriation" was defined early as an actual diversion of water with intent to apply it to beneficial use, followed by an application to such use within a reasonable time.[142] The requirement that water which is appropriated be applied to a beneficial use remains.[143] It is statutorily provided that all vested rights prior to 1913 will not be disturbed.[144] Judicially this was extended to 1905.[145] Determination of relative rights on a stream is to be made by the state engineer after notice has been sent to all claimants and a proper investigation has been accomplished.[146] Aggrieved parties may file a notice of exception to a determination which requires that final determination

be made by district court. This notice of exception must be filed at least five days prior to determination hearing date.[147] The judicial determination is appealable to the Supreme Court by either the state engineer or another aggrieved party.[148]

Water Right. The right is usufructory, the basis of which is beneficial use.[149] This right to use the water is acquired from the government.[150]

Priority. The first appropriator of the water of a stream has a right to the quantity of water he has appropriated as against subsequent appropriators from the same source[151] and the rights of the latter are subject to that of the one who was first in time regardless of their relative locations on the stream.[152] When water is appropriated for a certain period of time, a later appropriator may acquire a right to the same water during different periods of time.[153] Owners of lands to which water is appurtenant may rotate in the use of water to which they are collectively entitled. A single use may do this as well as long as no earlier priorities are injured.[154] All permits are subject to existing rights to the degree and modification thereof entered in such adjudication proceedings.[155] The date of priority may "relate back" to the time when the first step was taken in cases where construction is needed if the work is completed with due diligence.[156] Proof of reasonable diligence may be required by the state engineer if good faith progress is doubted.[157] Before beginning construction or performing any work on an appropriation or changing of place or use, an application[158] to the state engineer must be made.[159] Construction work pursuant to a certificate of appropriation must begin within one year of date of approval of application and be finished within five years. This time limit may be extended with good cause.[160] Work progress statements are required within 30 days after the date set for commencement of work and will be filed as required by the state engineer under penalty of forfeit of permit for failure to do so.[161]

Diversion. "To establish an appropriation of water, the proof must show.., an actual diversion from the stream..."[162] It is immaterial whether the water is taken by ditch, flume or pipe or any other method.[163] Segregation of the water from its natural source to indicate ownership seems to be the controlling factor.

Beneficial Use. The term "beneficial use" is not defined *per se* in Nevada.[164] Though undefined, it is "the basis, the measure and the limit of the right to use water."[165] Beneficial use is a public use and any person[166] may exercise eminent domain to condemn lands required for construction or maintenance of works for diverting water to a beneficial use.[167] A beneficial use must be made of an appropriation within 10 years after the appropriation is approved.[168] A verified statement showing proof of beneficial use is required on or before the date set for endorsement.[169] Failure to provide the statement of proof showing beneficial use will result in cancellation of the permit.[170] Water may be stored for beneficial use.[171]

Real Property. A water right is realty.[172] However, absolute property in the corpus of the water of a natural stream while flowing therein does not exist; the only right that can be acquired and the only right by reason of which one can divert such waters from their natural course is for a usufructory purpose.[173] A certificate of appropriation will be sent to the county recorder of the county in which the water is diverted from its source to be recorded.[174] Changing the place of diversion requires an application for permission from the state engineer.[175] Assignment of rights which are binding between the immediate parties is allowed as well as to outside parties if these assignments are recorded in the office of the state engineer.[176]

Appurtenance. All water used for beneficial purposes shall remain appurtenant to the place of use provided.[177]

1. That if it should become impractical or uneconomical to use water at a place, it may be severed and simultaneously transferred to another place to which it will become appurtenant with no loss in priority.[178]
2. That this provision does not apply to ditch and canal companies who have appropriated and diverted water to persons for a charge.

Adverse Possession. No right to the use of water may be established by adverse possession no matter how many years adversely held.[179]

Duty of Water. The right to use water is limited to so much thereof as may be necessary for beneficial purposes.[180] The duty will be determined by the state engineer and shall take into consideration the area of the state where the use will be made, the growing season, type of culture to be irrigated, transportation losses and any other data he may consider relevant.[181] The legal standard for measurement is a cubic foot of water per second of time[182] and volume is measured by acre feet.[183] Allowance for conveyance losses will be allowed if the conveyance facilities are reasonable and economic.[184] The measure of water that is relevant is the flow at the headgate and owners are not to be penalized for losses upstream.[185]

Wasted Water. Wasted water has not been defined per se but it may be referred to as that water which is now lost under current systems and practices but which might be saved.[186] It has been held that it is water running from irrigated land; water not consumed by irrigation.[187] This has been statutorily expanded upon in providing that when the necessity for the use of water does not exist, the right to divert it ceases--no water will be diverted unless required for beneficial purposes.[188] It is a misdemeanor to waste water as well as make an unlawful diversion during irrigation season.[189] Possession of water without right is prima facie evidence of guilt.[190]

Abandonment and Forfeiture. Failing to use diverted water for five successive years shall operate to abandon the water and forfeit all rights, easements, appurtenances and water and such water will revert to public domain.[191]

Abandonment needs an intent to relinquish rights[192] as well as overt acts to the same effect.[193]

Forfeiture operates upon mere failure to do a required act and, indeed, may operate to take rights from someone who has every intent to use them.[194]

Utah

In Utah, all waters are the property of the public[195] subject to appropriation[196] and beneficial use[197] but are placed in trust under the state engineer who is charged with appropriating, distributing and conserving water to allow as much beneficial use as possible in the interest of the public welfare.[198]

Appropriation Doctrine. The appropriation doctrine has been adopted in Utah.[199] Any person desiring to make beneficial use of unappropriated water must, before beginning construction on projects, make application for such use to the state engineer's office[200] who will approve the application unless the new use will interfere with an existing water right or impair a more beneficial use of water.[201] When the state engineer is satisfied that the beneficial use proposed will not operate in conflict with or to the detriment of existing rights, he will issue a certificate of appropriation which operates as prima facie evidence of the owner's right to use water in the quantity, for the purpose, at the place and during the time specified therein.[202] This decision is reviewable by district court.[203] The state engineer will investigate conflicting claims upon water rights acting in a quasi-judicial capacity.[204] This investigation is initiated by the signatures of five or more users of water of a stream or a majority of those users. Upon determination of the conflict, a copy of the engineer's report will be sent to all claimants and this report may be appealed to the district court within ninety days.[205]

The criteria for approval for an appropriation certificate, basically, is that there must be an intent to use the water for some useful and beneficial purpose.[206] Additionally, there must be a diversion or actual taking and using of water from a natural channel by means of a ditch or other structure and a beneficial application of the water within a reasonable time.[207] An appropriator must have some sort of possessory right to the land though title need not reside in him.[208] The appropriation must be for good faith purposes[209] --not for speculation--and in cases where construction is needed, financial ability to complete the needed work is required.[210] The appropriation must be for a specified amount.[211]

Water Right. The appropriative right to water is a right to use the water and is, therefore, a usufruct.[212] This use is derived from the State[213] and is a right to divert from the source of supply the quantity of water reasonably necessary for the purpose of the appropriation, not an ownership in the corpus of the water while flowing in the stream.[214]

Priority*. Between appropriators, the first in time shall be first in rights[215] except that when a conflict occurs between beneficial uses, the approval of new applications will be administratively determined by the state engineer.[216] Also, in times of scarcity, domestic use shall have preference over all other uses followed in importance by agricultural uses.[217] The appropriation is dated by the application date filed in the state engineer's office.[218] It has held that this priority may "relate back" to the date of filing when construction is needed but that the priority is fixed only for the applicant who can perfect his appropriation.[219] No right may be acquired without compliance with statute provisions,[220] i.e., construction will not work an estopped benefit for a party who has not filed his application. Nor will rights be acquired by adverse possession.[221]

Diversion. Though the term "diversion" is not statutorily defined, this requirement has proven critical in judicial decisions.[222] This requirement pertains to appropriative right--not riparian.[223] Mere use for cattle from a natural stream is not a diversion that will satisfy the requirement for an appropriative right.[224]

Beneficial Use. The term "beneficial use" is not defined statutorily in Utah,[225] but it is the "basis, the measure and the limit of all rights to the use of water" in the state and has been repeatedly substantiated.[226] Determination of what constitues a beneficial use is apparently made by the state engineer when considering an application for an appropriation certificate. In view of the dynamic state of the law, perhaps it is best to leave difinition to the state engineer and the judiciary on a case by case basis.[227]

Relative Value of Uses. Though there is no extended hierarchy of values, in times of scarcity, the use for domestic purposes shall have preference over use for all other purposes and agricultural use will have preference over any other use except domestic uses.[228]

Real Property. A water right is generally considered to be a real property right.[229] This appears to be the state of the law in Utah but it is qualified in several respects. Water rights shall be transferred by deed in substantially the same manner as real estate but such rights shall not be deemed as appurtenant to the land.[230] This deed is recordable with the recorder for record and serves to impart notice to all persons of the contents therein.[231] The requirement of a deed does not apply to transfers by corporations--shares of stock operate in its place.[232] Some waters are appurtenant to the land, however, in which case the right to use the water passes to the grantee unless specifically reserved by the grantor in which case it may be separately conveyed.[233] Acquiring title to public lands does not also acquire title or interest to the waters on those lands.[234]

*Priority is a property right and transferrable as such. Whitmore v. Murray City, 107 U. 445, 154 P2d 748(1944). Priority supplies only to vested rights. Tanner v. Bacon, 103 U. 494, 136 P2d 957(1943).

Duty of Water. The unit of measurement of the flow of water is the discharge of one cubic foot per second of time [a second-foot]; the unit of measurement of volume is the acre foot or the amount of water upon an acre covered to a depth of one foot.[235] The limits of volume are not statutorily set; rather, an appropriation will be measured by the amount of water needed for the particular beneficial use in question.[236]

Wasted Water. Wasted water is not defined in Utah but may be referred to as that water which is now lost under current systems and practices but which might be saved.[237]

It is contrary to public policy in Utah to waste water.[238] To the end of preventing such waste, the state engineer is charged with regulatory waters to prevent uses of water that are detrimental to the public welfare--a welfare that includes recreation and stream environment.[239]

Abandonment of Water Rights. When an appropriator or his successor in interest abandons or ceases to use water for five years the right shall cease and revert to the public unless an extension is issued by the state engineer for a period not to exceed five years.[239]

Abandonment. In order for there to be an abandonment, there must be an intent to abandon coupled with some act of relinquishment by which the intent is carried out.[240] Intent is an essential element and over water rights are established the burden of proof is upon the person claiming an abandonment to show that the water has, in fact, been intentionally abandoned.[241]

Forfeiture. Forfeiture is based on the failure to use the right to water for the statutory time limit.[242] Forfeiture will not operate where the failure to use is due to physical causes.[243]

Wyoming

Wyoming adopted and has maintained a pure form of the appropriation doctrine. It has constituted significantly to the institutionalizations of an integrated administrative arrangement accepted by many western states.

Ownership of Water Within the State. The Wyoming Constitution provides that ownership[244] and control[245] of the state's water resides in the state--not in the public. This has been interpreted to mean that the state holds the water in trust for the use of the public.[246] This means that a water right is for the use of the water--not for the water itself.[247] This ownership by the state of the water within the state allows much discretion in distribution[248] and adjucation[249] of water rights.

Adjudication. In adjudicating water rights,[251] it is felt that the state Board of Control is better equipped than are the courts to determine the intricate and involved matters relating to appropriation of water. This feeling has resulted in the Board's decrees being considered correct on a prima facie basis and being clothed with the dignity of court decrees.[252] However, the jurisdiction of this Board to adjudicate water rights is not exclusive of the jurisdiction of courts to quiet title to water rights, determine priorities or to redress grievances.[253]

Water Right. A water right in Wyoming is subject to the constraints of the appropriation doctrine and will be discussed in that context.

> A water right is statutorily defined as
> a right to use the water of the state when such use has been acquired by the beneficial application of water under the laws of the state relating thereto...[254]

From this it can be seen that the rights are not absolute but usufructory in nature.[255]

A water right may be obtained by any person, association or corporation[256] including municipal corporations.[257] There must be an appropriation in good faith with any construction necessary preceeding with reasonable diligence and the water must be applied to a beneficial use.[258] To constitute an appropriation there must not only be intent but some open physical demonstration.[259] These requirements are met by having a registered engineer or surveyor conduct a survey and prepare maps and plans[260] after which the applicant files these plans with the State Engineer[261] which must be done prior to initiating any construction.[262] This filing date becomes the date of priority.[263] When the State Engineer has satisfied himself that everything is on order and if there is available water to fill the request, a permit will be granted that requires construction if any is needed--to begin within one year.[264] This construction must be completed within five years or sooner if the State Engineer requests it.[265] This time may be extended if a valid reason exists.[266] The applicant must inform the Engineer of his progress from time to time.[267] After public notice has been posted of the new right of water and after any objections have been cleared, the State Board of Control will issue an appropriation permit,[268] a copy of which will be filed with the Clerk of the County in which the land is situated[269] and this certificate is evidence of an adjudicated right to use water.

Priority. This has been stated as "first in time first in right."[270] In Wyoming priority dates from the date of filing of an application for appropriation in the State Engineer's office.[271] Though a right to the use does not vest until a beneficial use is made of the water,[272] the priority "relates back" to the date of the filing. This filing is crucial for mere use will not suffice to establish a prescriptive title.[273] New priorities are limited to surplus water.[274]

Diversion. The term "diversion" is not statutorily defined in Wyoming though there is a set of provisions for requests to change a point of diversion.[275] Perhaps it is felt that anyone can recognize a diversion when they see it and trying to define it would result in needless complication. At any rate, a segregation of the property claimed from the natural source would seem to be the most prudent action to ensure that a diversion has been made.

Beneficial Use. The term "beneficial use" is not described statutorily in Wyoming.[276] The sentiment seems to be that a beneficial use is a use that is reasonably beneficial. It is a nebulous concept which, in the face of a dynamic society [277] is perhaps best left to judicial determination on a case by case basis.[278] Not all uses are beneficial however[279] but there is no set list of excluded uses in Wyoming. Irrigation is the only term specifically designated by statute as beneficial.[280]

Though the term is undefined, it forms the "basis, measure and limit of all appropriations" of water in Wyoming.[281]

Preferred Use. Though "beneficial use" remains undefined per se Wyoming statutes establish hierarchical preferences for certain classes of uses[282] and methods for changing a right being used for a nonpreferred use to one used for a preferred use.[283] The order of those preferences:

1. Water for drinking purposes for both man and beast.
2. Water for municipal purposes.
3. Water for the use of steam engines and for general railway use, water for culinary, laundry, bathing, refrigerating (including the manufacture of ice) steam and hot water heating plants and steam power plants.
4. Water for industrial purposes.[284]

Though the statute refers to "preferred uses" it must be understood that priority of a senior non-preferred user will prevail over a junior preferred user and that the preferred user only has the right to condemn a non-preferred use and, after just compensation, change it to a preferred use.[285] The express exception to the right to obtain a prior non-preferred use is the use for steam power plants and industrial purposes.[286] Also, the prohibition against simply shutting down a prior nonpreferred use is excepted to in cases where "water turbines or impulse wheels are installed for power purposes" in which cases preferred users have the right to call for water even though they may be junior to the water turbines or impulse wheels.[287] However, after these uses, the actual usability of the waters is alone the limit of the public's right to so employ them.[288] Also, irrigation is regarded as a superior preferred use.[289]

Real Property. A water right is generally considered to be a real property right or land.[290] This appears to be the nature of the right in Wyoming for it is provided that, though a water right is a right to merely use the water,[291]

this use shall attach to the land for which the use is granted.[292] As such, this right is protected as property by constitutional provisions.[293]

Property rights, however, are not absolute in their nature and water rights are no exception.[294] The water right is subject to priority[295] and the water must be used for a beneficial use.[296] Additionally, this right is limited by a "duty of water" standard of one cubic foot per second per seventy acres of land.[297] There is, however, a provision allowing for a doubling of this amount by supplemental adjudication for all pre-March, 1945 rights.[298] Too, there is the appurtenancy requirement, as a general rule, that the right to use water is attached to the land for which it was appropriated.[299] Exchange of water may be allowed, however, where (a) the source of the appropriation is at times insufficient to fully satisfy such appropriation, or (b) a fuller conservation and utilization of the state's water resources can be resultantly accomplished.[300]

Wasted Water. "Wasted water" is not statutorily defined in Wyoming but may for purposes here, refer to that water which is now lost under current systems and practices but which might be saved.[301] The commissioners of each water district in the state are given the power to prevent wasting of water or use in excess of an appropriation right.[302] Since wasting water would seem to be unreasonable on its face, the requirement of a beneficial use of water--reasonable by definition--[303] would appear to give these commissioners substantial powers in regulating the wasting of water within their districts.

Abandonment. Relevant to a discussion of wasted water is the topic of abandonment of a water right. Wyoming provides that if a water user fails to use water for irrigation or other beneficial purpose for five consecutive years, the water right shall be considered as having been abandoned.[304] It is not necessary for a water right holder to intend to abandon his water right.[305] However, the statute is not self-executing--that is, a right is not legally abandoned automatically after five years. Instead, a water user who might be affected by the abandonment may petition the State Board of Control to abandon another's water rights.[306] Upon establishing a prima facie case of abandonment, a meeting is held before the Division Superintendent[307] who reports to the Control Board. If the Board feels that rights have been abandoned an abandonment order is issued.[308] These orders are appealable to the District Court and to the Wyoming Supreme Court.[309]

ORGANIZATIONAL ARRANGEMENTS

At the local level, there are two major organizational entities designed and developed to accomplish the task of water resources utilization and management within a system. The dominant type of public entity is the mutual irrigation company. It is divided into unincorporated voluntary associations and incorporated entities under state law. The second type of organization at a quasi-private/public level is the water user association. The following materials define and elaborate on the features of these entities regarding their ability, agility or legal constraints to consolidate.

Unincorporated Voluntary Associations

In General. These organizations may be described as voluntary associations of persons--usually along the same water supply source--who organize for the purpose of better protecting their rights and the division of water of the stream between respective owners, without formally incorporating. Such associations construct the necessary works for the diversion of water and transport it only to the lands of members of the association and not for hire.[310] The principal difference between these mutual voluntary associations and mutual corporations herein after discussed is that the latter are formally incorporated under law but the former are not.[311] This type of organization is suited to communities where irrigation problems are fairly simple.[312]

Membership Qualification. As a general rule, there are no personal qualifications for stock ownership or membership in a mutual or voluntary organization although an ownership of land or participation in agricultural production may be required.[312] This requirement is logical inasmuch as the purpose of the association is to provide water for land which results, in turn, in increased agricultural production.

Organization*. These associations are often organized with a considerable degree of formality, officers being elected, and by-laws, rules, and regulations being adopted for the government of the respective rights of the members, and of the general affairs of the association.[313] Though verbal agreements may be made easily enough between members, it is easy for misunderstandings to arise so it appears best to have a written agreement (which may be called the articles of agreement) signed by each member.[314] Though much formality may attend the organization, title to the water rights remains in the individual members and not in the association.[315]

*There is a good general discussion of mutual company and voluntary association organization in a pamphlet by Wells A. Hutchins entitled, Organization and Operation of Cooperative Irrigation Companies published by the Farm Credit Administration as Circular No. C102, Washington,D.C., 1936.

By associating in this manner the water users become tenants in common[316] of all the waters owned or controlled by all the members of the association and also of the diverting work, ditches, and canals used in connection with this water; and each landowner of such association is entitled to his distributive share of the water, according to his rights. The legal title to the water rights not being in the association, as is the case where there is a corporation, but, rather, in the individual members according to their respective shares,[317] certificates may be issued by the association to these members as evidencing the share of water to which each member is entitled.[318] But whether the individual member's shares are represented by such a certificate or not, he has the right to sell or assign his interest--or any portion thereof--with or without the consent of the other members and the purchaser or assignee succeeds to all the rights of the vendor.[319]

Statutorily Defined Voluntary Association

In some jurisdictions, the status of voluntary associations is defined by statute.[320] This is seen where a community ditch or "public acequia" was the usual means for diversion and distribution of water. Here, each village or groups of farmers constructed its own common ditch.[321] Elections, management, construction and control of these ditches is regulated by law[322] and under statutory provisions, every landowner under such a ditch, whether he uses the water or not, is required to contribute his quota of labor or money substitute, required to maintain and preserve the ditch.[323] Associations formed around community ditches are considered political subdivisions of the state[324] but, anomolously, the ditches themselves are considered to be the private property of the persons who completed the ditch[325] which necessarily means those who live under its irrigation. In these jurisdictions it is provided that all community ditches, (or perhaps more accurately the communities using them), shall be considered as corporations, or bodies corporate, with power to sue to be sued as such.[326]

Tenancy in Common. Often, in arid lands the owners of several neighboring farms construct ditches and diversion works and make the appropriation of water necessary for irrigation of all their lands without formal organization of any company or association.[327] Where a ditch through which water is appropriated and applied to beneficial purposes is owned by several proprietors, and their relationship is not defined by special agreement to the contrary, they are regarded as tenants in common[328] of the ditch and their rights are determined by the law governing the same. Too, as each ditch may have a number of priorities, appropriators with different priority dates may be tenants in common in the dam, ditch or other works without losing their priority and without there being any tenancy in common in the water rights themselves.[329] Tenants in common may also agree among themselves as to how and when the water appropriated by all may be used by said co-tenants.[330]

Two definitions of tenancy in common may be of some help. Black's Law Dictionary, 4th ed. (Rev.) (1968) defines tenancy in common where property is held by several and distinct titles by unity of possession, neither knowing his own severally and therefore all occupy promiscuously. The holding of property (*) by different persons under different titles, but there must be unity of possession (**) and each must have the right to occupy the whole in common with his co-tenants.

Burley***describes the same material as a sole and several tenancy. Each tenant in common is the owner of an undivided interest in the whole estate, not a joint owner of the whole estate. Only the unity of possession is essential to the existence of a tenancy in common. Upon the death of a tenant, his undivided interest passes to his heirs or devisees--there is no right of survivorship in the other tenants.

Rights Between Tenants In Common. Where the relationship between proprietors is one of tenancy in common, it appears settled that where one tenant diverts a greater quantity of the water than belongs to him by right and damages others in so doing, he will be enjoined from further so diverting.[331] Too, each member or co-tenant has the right to assign or sell his interest or any portion thereof without the consent of his co-tenants,[332], except, of course, that he may not transfer more than he owns.[333]

Majority Interest Has Right of Control. Generally, it has been held in the past [334] that as to general policy the majority of members has the right to control matters of the organization with the caveat that a person joining such a voluntary association does not vest in the majority the power to injure the rights of such person.[335] It can be seen that from the nature of water there may be times when it may be indispensible to the success of the operation that where all cannot agree, the majority have the right to control policy to avoid working at a disadvantage. Where this policy which the majority adopts does not materially injure the vested rights of the minority, a majority of tenants in common have the right to control the affairs of the ditch...Neither law nor equity will aid a stubborn minority in preventing the majority from doing an act for the manifest good of the whole community, where no one is injured, but all are benefitted.[336] Also, an association--though composed of a majority of water users from a certain source--has no right to interfere with or regulate the use of the water of the minority owners who did not join the association.[337]

*May be real or personal. Drum v. Molloy, 22 C.2d 132, 137 P.2d 18(1943)
**The association provides the unity of possession.
***Burley, William E. Handbook of the Law of Real Property (2nd ed.) West Publishing Co. St. Paul (1954) p338.

It has been held that co-tenants are entitled to use all the water appropriated to them. Therefore, a wrongful diversion injures all co-tenants. It follows that all co-tenants have preventative powers to stop acts of a trespasser without joining the rest of the co-tenants in the action-they may act alone.[341]

Contributions for Necessary Expenses. Each tenant in common is individually bound to keep the ditch or other works in repair and those making such repairs may compel a contribution upon the part of those who failed to bear their share of the expense or labor.[338] Too, because assessments are the chief means of raising revenue for these associations and corporations, the companies may compel the members to pay their share of assessments[339] and may stop water delivery to insure compliance.[340]

Control of the Organization by Member. The stockholders, or members of the mutual companies--including voluntary associations--have the final control of its policies through the vote. Their functions are few but vitally important. They elect the directors[342] and may remove them from office.[343] They may make and amend or repeal by-laws[344] or may leave this power to the board of directors. All amendments to the articles of incorporation require their prior approval.[345] Such fundamental steps as consolidation with other corporations or unincorporated associations[346] and voluntary dissolution of the corporation or association can be taken only with their consent.[347]

Stockholders Meetings. The stockholders of such corporations and associations usually meet at least once a year.[348] Each stockholder has the right to vote at any election.[349] The voting is done on either a one vote per share basis[350] or a one vote per member basis.[351] If different classes of stocks are issued, the voting privileges of these classes may be varied[352] though there is nothing compelling an arrangement of this sort.[353]

Management by Board of Directors. Sole responsibility for managing the affairs of such associations or companies is given to the board of directors.[354] This board has the power to formulate policies, make contracts, levy assessments, incur obligations, approve expenditures and make rules and regulations for operation of the irrigation system and delivery of water to users.[355] From the operational point of view, all activities of the board should be designed and carried out to provide effective delivery of water to the former stockholders. See Figure 5. The flow of authority from stockholder to board to the company is shown in Figure 6. Generally speaking, to avoid dissension it is best to limit the number of members on the board of directors to as few as possible.[356] The terms of office for directors and officers may be statutorily prescribed[357] or may be determined by the articles of incorporation or by-laws.[358]

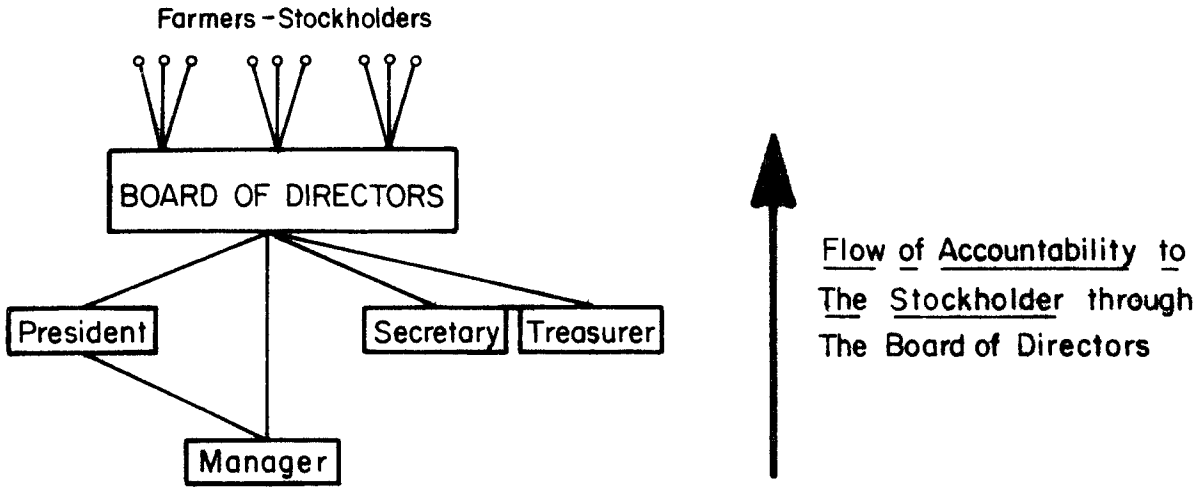


Figure 5. Voting Control of Mutual Company Emanating from Stockholders.

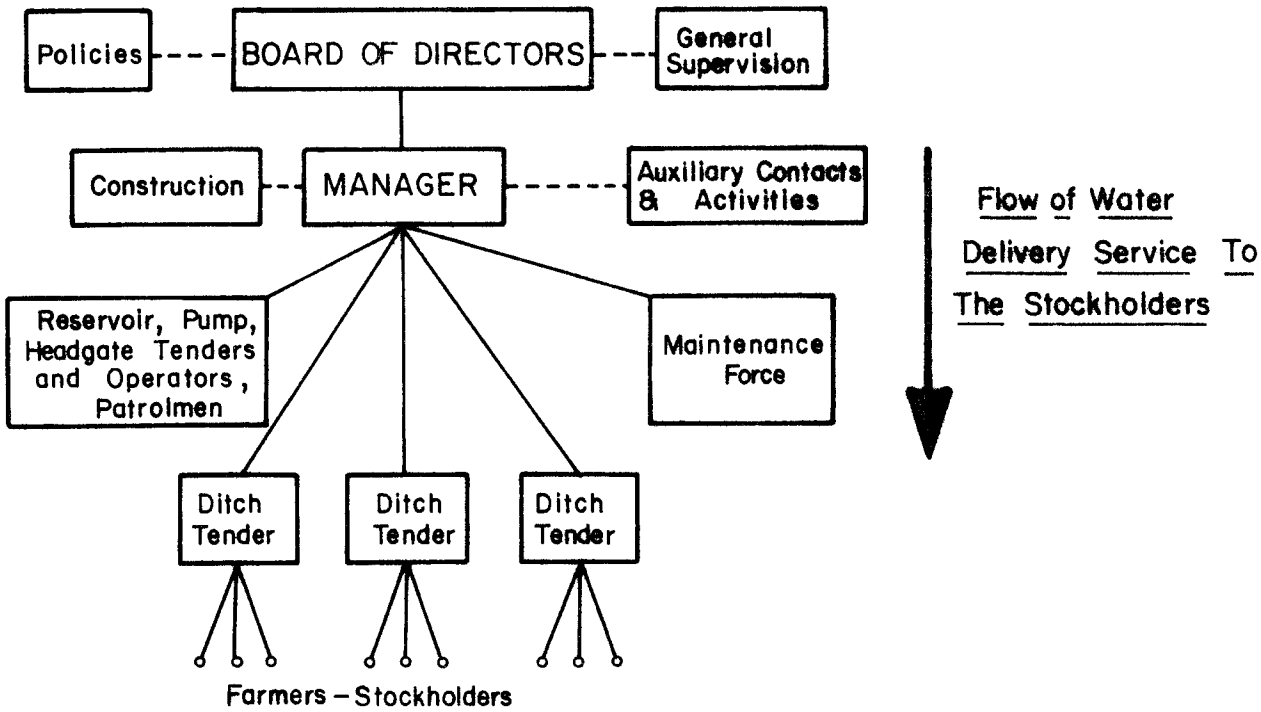


Figure 6. Control of Water Service to Stockholders of Mutual Company Emanating from Board of Directors.

Executive Officers. The president is usually selected from the board of directors[359] but in cases where a vacancy occurs, the position may be filled by the members or stockholders in a special election.[360] Other officers might include a vice president, secretary and treasurer--these offices may be occupied by the same person.[361] The president's function is to generally supervise affairs, approve vouchers and sign papers. A manager may be required to supervise operation and maintenance, construction, land, farming and contracts with other organizations. It is advantageous if he has engineering experience. Obviously, in small companies, the office of president and manager might easily be combined.[362] Clerical functions such as recording and disbursing to members the minutes of stockholders meetings can be taken care of by the secretary who does not need to be a director or member.[363]

Removal of Officers and Directors. The control emanating from the stockholders (See Fig. 6) would be little more than an illusion if the only direct control available to them was through the ballot box at the annual elections. To allow greater control, sections for removal of undesirable[364] directors and officers are provided in the statues of the various western states.[365]

Incorporated Mutual Irrigation Company

General. A mutual water company may be defined as a private association[366] which is organized for the express purpose of furnishing water to the shareholder or members thereof at cost[367] and not for hire for uses or irrigating the stockholders' lands and for use of the corporation works to conserve, treat and reclaim waters.[368]

The mechanics of organization are the same as for any private corporation[369] except that if the stock is to be made appurtenant,[370] the articles of incorporation must so provide. Additionally, the stock certificate must describe the lands to which the shares are appurtenent as well as any other special provisions such as the source of the water, point of diversion, etc. which may be required.[371]

Mutual companies possess such powers as are conferred on them by statute[372] and may engage in such enterprises, and such only, as are set forth in the certificate of incorporation and all other powers beyond those given are by implication excluded.[373]

Generally speaking, a mutual company is distinguished from the normal corporation organized for profit by only two major features:[374]

1. Assets are limited primarily[375] to water rights and canal systems and sometimes to canal systems alone.
2. The corporation is not organized for profit, but rather to distribute water to shareholders.[376]

Public Utility Status. In some jurisdictions the matter is covered by statute,[377] but even where statutes are lacking,

a company which holds itself out generally to serve for compensation[378] those who may apply for water[379] within the area served by its irrigation system is not a mere private corporation, but is affected with a public interest and is subject to regulation and control as a public or quasi-public corporation.[380]

A company may retain its private status if it is organized for the purposes of delivering water to its stockholders and members at cost or those with which it has fixed contractual obligations.[381] It is to be noted that a water company which has become a public agency may not discontinue its service in whole or in part so as to regain its private status.[382] However, a private corporation may, with the consent of the owners of the rights to receive water for private use, change the use to a public use so as to make the service and terms of delivery subject to regulation and control by public authorities.[383]

Factors to be taken into account in determining the public or private nature of a corporation include the following:[384]

1. What are the provisions of the articles of incorporation and bylaws;[385] and are they broad enough to permit public sale of water?
2. To whom has water been sold aside from shareholders and in what quantities?
3. What has been the intent of the shareholders in selling to other persons than themselves?[386]
4. What amount of water has the corporation agreed to supply to its members and others?
5. What degree of acquiescence to public sale is evidenced by shareholders?
6. Has the corporation directly or indirectly used condemnation?[387]
7. Are there close financial director or other corporate relations with admitted public utilities?
8. Has there been a dedication to a public use by positive action of all or any part of the whole water rights?

Relationship Between the Corporation or Its Officers and Shareholders--Rights and Duties. The relationship between private corporations whether organized as mutual or commercial corporations, and their shareholders is that of contract, and the rights and duties of both parties grow out of the contract implied in a subscription for stock, and construed by the provisions of their charters, or articles of incorporation.[388] From this contract springs a trust relation between the company and its stockholders, with the corporation being charged to conduct the common business in the interests of the stockholders[389] and, being trustee for its stockholders, the corporation is bound to protect their interests.[390] It follows that a duty is incumbent upon the corporation to prosecute actions in the matters of protecting water rights or other company property, as representing its stockholders, without joining them in the action.[391] The officers, managers and boards of directors also hold trust relationship to both the corporation and its stockholders. This means that the validity of a contract entered into by a board of directors may be challenged by the stockholders.[392] Also, officers are bound to avoid dealings where

there is a conflict of interest between them and their stockholders though they may have dealings in company matters where there is no conflict.[393]

In the formation of mutual corporations, it is common--though not universally the case--for owners of the original water rights to deed to the corporation their water rights and rights in the works, and then to take shares of stock for the same in exact proportion as the value of the individual rights granted bears to the whole value of the property granted by all. Where this is done, the legal title is transferred to the company but equitable title remains in the original owner.[394] In other words, the company holds the legal title in trust for its respective shareholders. The terms of this trust are governed by the articles of incorporation or bylaws of the same.[395]

Stock in Mutual Company. The shares of stock which are received for legal title to an individual's water rights represent those water rights. These shares are said to be miniments of title to an interest in the property of the association, and as evidencing the proportional amount and extent of the appropriation of water which each holder possessed.[396]

There is some split of opinion as to whether stock is personal property or real property. The more persuasive authority holds that where the title to water rights, and the ditch, canal and other works is in a mutual corporation which issues shares of stock representing both the water rights and works of the company, such stock is considered personal property and a sale of such operates as a sale of both water rights and the interest in the works.[397] However, a minority maintains that stock represents water rights and is real property.[398] The general rule is that for the sale and transfer of water rights--except those represented by stock shares--all the formalities of a transfer of real property must be observed.[399] In any case, it is important to remember that the right to the use of the water follows the shares of stock.[400]

Duties. From the contractual relationship established by the transfer of legal title to water rights to the corporation, a duty evolves to deliver to each shareholder that amount of water to which he is entitled by virtue of his stock.[401] The shareholder does not need to depend on an implied contract for his water right as this right is an adjunct of his membership in the corporation--membership means water.[402] The corporation is under a duty to use reasonable care and diligence in making ratable distribution.[403] It is also the duty of corporation to keep ditches, canals and other works in repair. This duty is imposed in order that the property may be utilized as far as present needs are concerned and to preserve the property and prevent its future destruction.[404]

Liability. Where a corporation fails to furnish the proper proportion of water to one of its shareholders, it is liable for the damages resulting from such failure.[405]

Suggested Plans for Stock Issue. Generally, there are two types of plans for issuance of stock. These are where stock represents land and is appurtenant or where stock represents a part of the total water supply.

1. Generally, where stock represents acres of land and where the stock is appurtenant to the land, there are at least two options available.
   A. The first option is to have a share of stock fix by amount the definite quantity of water which is allowed[406] to each unit in the area of land represented by the stock certificate.[407]
   B. Divide the available water in a given period among the shareholders in proportion that the number of acres owned by any one individual bears to the total acreage of all shareholders in the company--or proportionately by shares of stock of the total issued.
2. Stock may also represent a specific part of the total supply owned by the corporation or subject to its control for purposes of distribution. This plan is advantageous where the company's supply varies and where the stock is not to be appurtenant to any specific land.

Levy and Enforcement of Assessments. One of the main objects of incorporation is to obviate the difficulties arising in enforcing the prorata contributions of the co-owners of the water rights for the maintenance of the works and other necessary expenses. By merging individual rights, each shareholder may be compelled to contribute his proportion of all necessary expenses or forfeit his right to use of the water.[408] The same implied contract which obligates the company to deliver water[409] implies the reciprocal duty on the part of the shareholders to pay their assessments.[410] Of course, in order to render such assessments valid, the purpose for which they are levied must come within the purposes of the corporation as set forth in the articles of incorporation or charter and, also, must meet the statutory requirements.[411]

When assessments are made, they become liens on the water stock itself rather than on the land.[412] However, where stock is appurtenant to land, there is authority that the assessment becomes a lien on the land,[413] superior to the lien of a mortgage on that land.[414] A more direct method of enforcement of payment is to simply refuse delivery of water. Such methods are recognized in New Mexico (see: New Mexico Stats. § 75-14-24 and 75-14-41,1953)(in the case of community ditch or co-operative association) and in Wyoming (see: Wyo. Stats., § 36-106 and 41-221,1957). In New Mexico, a fine may be assessed before the water is denied (New Mexico Stats. § 75-14-34,1953).

Stockholders may be exempt from assessments if it is so provided by the terms of their agreement made at the time they purchased their stock.[415] Further, it has been held that an assignee of a water right on which a past assessment is due is not personally liable for such past assessments unless expressly assumed.[416]

Power to Make Rules and Regulations. Mutual corporations may adopt such rules and regulations not in violation of law governing the distribution and use of the water furnished among their shareholders as are equitable and reasonable. But all rules and regulations have no effect unless authorized by the charter or articles of incorporation or are assented to by the stockholders whose rights are affected.[417]

Implied Powers. In some cases, in the absence of express restrictions, implied powers are seen to be inherent in the company to enable them to exercise the powers expressly conferred and to accomplish the objects for which they were created. Subject to charter restrictions, companies have been allowed to borrow money to finance an authorized project, or may guarantee bonds issued therefore.[418] More important, a power to sell water rights may be implied from the power to acquired and own water rights.[419]

Limitations. As has been noted, a corporation may not act to the prejudice of the water rights of any one of its stockholders.[420] Pursuant to this position, it follows that where stock with water rights is sold on the theory that water users buying such rights are to have a reasonably dependable supply of water,[421] the company may not dilute such rights by selling more shares of stock when water actually available is barely sufficient for present holders of water rights.[422]

As an aside, it is to be noted that where a corporation is formed, it has no rights--even if it comprises a majority of co-owners of a ditch or water supply--to control or regulate the use of owners who did not come into the corporation.[423]

Water Users' Associations

General. Water users' associations are incorporated associations[424] organized by actual or potential water users in a specific area who contract with the government[425] to build irrigation works pursuant to reclaiming or improving land. These arrangements are made pursuant to the appreciation by the government of the potential of land that might be realized by conserving and storing the surplus waters of the rainy seasons and more efficiently utilize these waters for irrigation. The advantage of such a system is that it provides a means for many poor landowners of small parcels to pool their limited funds to enable them or irrigate their lands and increase their crop yields, thereby increasing their incomes. Indeed, such a plan encourages purchases of arid but fertile land which can be purchased often at low prices. After irrigation, the land should support itself and increase in value thus adding to the well being of the farmer.

Generally, the object of these associations are three-fold:

1. To provide for irrigation in an area where individuals do not have the money to finance such a venture independently.
2. To allow the government to deal with one organization representing all water users in an area rather than having to deal with many users on an individual basis.

3. To have a responsible organization to which management or an irrigation organization, as comtemplated by a reclamation act, may be turned.

The organization of a water users' association must be in such form as will be acceptable to the arbiter[426] though the government takes no active role in operating and managing the works.[427]

Essential features of the articles of incorporation should include providing a means of effecting the reclamation law regarding ownership of the reclaimed area and for guaranteeing repayment to the government of the cost of the reclamation works.

It must be recognized that a water users' association of this type is merely a temporary arrangement. All groups of persons using water are, in effect, water users' associations. When the governmental agency responsible for overseeing these projects transfers the works entirely to a water users' association of this type, the organization is reclassified according to the successor-type of association such as a mutual company or district.

Acquisition of Lands

A. Public Lands

The reclamation laws give the Secretary of the Interior broad authority to withdraw from public entry those public lands required for irrigation works as well as those believed to be susceptible of irrigation from the works.[428] The current practice is that Reclamation withdrawals shall embrace all lands required for the construction, operation and maintenance and protection of main irrigation works and minor structures. All public land apparently susceptible of irrigation from a project or probable of being required in connection with the development of the project are included in the withdrawal. This decision by the Secretary raises a nearly insurmountable barrier to reversal. Fraud appears to be the only grounds recognized by courts for review.[429] However, where the question of withdrawal involves lands which are already properly devoted to federal purpose, there is a serious question raised as to the Secretary's power.[430]

B. Private Lands

Purposes of reclamation involve the acquisition of land and water through exercise of the eminant domain power. Ample authority is provided for this purpose.[431] Pursuant to this, Congress has provided that, "The Secretary...shall pay just compensation, including severance damages, to the owners of private land utilized for ditches or canals in connection with any reclamation project.[432]

Rights of Water Users*. In the U.S. the Supreme Court regards as settled that a project user has a vested property right which cannot be withdrawn at the will of the Government.[433] However, the Secretary has authority to restrict water uses to those which are "beneficial"[434] and to protect project lands against deterioration due to improper use of water.[435] Too, requirements have been upheld limiting users to a certain quantity per irrigated acre as a means of preventing waste.[436] He also has powers "to make general rules and regulations governing the use of waste in the irrigation of the lands within any project."[437]

The conflict arising under private systems of appropriation has not arisen under reclamation. This appears to be due largely to the practice of apportioning available water during shortages rather than using a seniority scheme which totally cuts off junior users.[438] Too, matters often litigated are commonly handled by the Secretary or his representative.[439]

Repayment of Costs to the Government**. The costs of these works fall into two general categories: (1) construction costs and (2) operation and maintenance costs. The difference is important in light of the construction contract. Once a repayment contract is executed, the government is powerless to impose any liability upon the water users to pay for additional or supplemental construction--unless the users willingly contract to pay such additional costs.[440] However, the costs of operating and maintaining the works may be imposed on the water users whether or not they want to pay and whether or not they want the maintenance work done.[441] Further, the necessity of the work is at the discretion of the governmental agency (in the case of the United States it is the Bureau of Reclamation).[442]

Repayment of Construction Costs. One of the distinguishing features of reclamation is the requirement that water users reimburse the Government for at least part of the cost of building the project.[443] A recurrent problem is that of deciding which costs shall be subject to repayment by the water users. It appears best to recover the actual--as distingushed from estimated--cost of construction.[444]

Deferment of Charges Due. As noted, the basic provision for repayment of construction costs is forty years. In addition, the Secretary is authorized to defer the time for repayment of any installments of construction charges in order to adjust payments to the ability of water users to pay.[445]

Plans for deferment of payments are extremely desirable because of the nature of a reclamation project. These projects are composed of farmers who are in a precarious position because of lack of water. Any setback is likely to put them in financial ruin. In explanation, these water users associate under the pertinent laws of incorporation and issue shares of stock to each member. These shares usually represent land--

*For a discussion of this, see R.E.Clark, Id., § 118.2 through 118.4.
**See R.E.Clark, Id., §§ 123.1 through 123.4.

one share for one acre, for example. The shares have a par value based on the value of land which they represent. This stock is then committed to secure the cost of a reclamation project which they desire the government to build.[446] Since the stock usually represents land, this means that the land is mortgaged, in effect, to secure the repayment of the estimated cost of construction.[447] Failure to make the payments results in a selling of the security--which is the farmer's land if the stock is made appurtenent to the land. Thus, the purpose of the project is defeated.

A plan for deferment of payments would eliminate much of the problem of forfeiture. For example, if a poor settler was induced to buy arid land, but after living expenses had no money for seed, teams and future living expenses, he would be unable to produce crops on his land when the water arrived. A crop failure would have the same result; the land would be unable to support itself and the farmer would forfeit everything.

This problem could be resolved by extending the time of payment and allowing a low interest rate on the principal for the first few years--say, five years. Settlers need more than watered land. They need money to live and time--time to prepare the land, plant, cultivate and harvest. A plan with deferred payments with a small interest charge would allow this.

A. Development Period Deferment

In cases where it is feasible to irrigate parts of a project before the entire project is completed, it may be advisable to defer payments for these small sub-areas. The purpose of such a provision is to give water users an extra margin of time to establish themselves during the difficult beginning years on a farm when production is being developed and cash return is likely to be low.[448]

B. Variable Repayment

Because of the variability in farm income from year to year, a program for repayment which sets fixed sums for repayment years in advance is likely to prove unsatisfactory. A combination of long repayment period and variable repayment formula permitting a variance in the required annual payments in light of economic factors pertinent to the ability of the water users to pay would probably be best.[449] This variable formula can be based on any number of considerations--price indices, crop production, etc.--and it may provide for both lower payments in below average years and increased payments during good years.

In allocating the costs of repayment among water users of a project, the measure of ability to pay is based on productive capacity per acre of farms, cost of operation and net income. From this, it is obvious that classification of land is essential for good land can support a higher debt

burden per acre than poor land.[450] The per acre burden can be assigned on the basis of the water users' association classification of each farmer's land and the Secretary's classification for all the project land in total. After a repayment burden has been established for the entire project by the Secretary, the water users can assign burdens to individuals based on the projected productivity of each farmer's land.[451]

These same arrangements can be made to pay operation and maintenance costs as well as construction costs.

Enforcement of Payment. Persons deliquent in paying their annual share of expenses face several possible sanctions. These are an imposition of an additional charge;[452] shutting off of the water supply;[453] or cancellation of the water right with forfeiture of payments already made.[454]

Corporation Law - Merger & Consolidation

In legal jargon corporations organized formally under state codes have two alternative methods uniting, they are merger and consolidation defined as:

merger - two or more companies combine into one of the original companies, the others ceasing to exist.

consolidation - two or more companies combine into a new corporation, all of the original companies ceasing to exist. The combining companies are the constituent corporations, the new company is the consolidated corporation.

Irrigation companies organized under the state corporate acts resemble any other business corporation created thereunder and are required by law to adhere to the same standards and procedures. Therefore, although no specific mention is made to incorporated irrigation enterprises, by definition they are included in the law.

Arizona, Colorado, Nevada, Utah, and Wyoming all allow merger and consolidation of corporations under their respective business corporation codes patterned after the Model Business Corporation Act.[455] The Colorado Corporation Act, the Wyoming Business Corporation Act, and the Utah Business Corporation Act are adoptions of the Model Act with minor variations. The merger and consolidation statutes in Arizona and Nevada are virtually identical with the Model Act.[456]

To legally accomplish consolidation or merger of business corporations, the states require a resolution be passed by the board of directors and notice be given to the shareholders. Notice of the planned merger or consolidation must be given to the shareholders ten days (or more depending upon the state) prior to when they are required to vote on the matter.

In each of the states, ALL of the shareholders are permitted to vote, even though they do not hold voting stock in the normal sense of the word. For the companies to merge or consolidate, a majority of the shareholders of each company must vote in

favor of the plan in Arizona, Nevada, and Utah.[457] In Colorado and Wyoming two-thirds of the shareholders of each company must be in favor of the plan.

All five states have buy-out provisions, allowing a dissenting shareholder who voted against the merger/consolidation to force the company of which he is a shareholder to purchase his shares of stock at fair market value.[458]

The Model Act provision on the effect of merger or consolidation has been adopted in Colorado, Nevada, Utah and Wyoming to the effect that the "surviving or new company shall possess all rights, privileges, immunities, and franchises, as well of a public as of a private nature..." Arizona makes no mention of rights, privileges, immunities and franchises in 10-349 - Effect of merger or consolidation, but in 10-346 states that debts, liabilities, duties, property and assets of the combining companies pass to the consolidated company.

Colorado Revised Statutes also make provision for the organization of Water Users' Association under the State Corporate Act.[459]

The following extractions from the Wyoming Business Corporation Code is indictive of the procedural requirements for consolidation or merger:

Procedure for Merger

Section 63. Any two or more domestic corporations may merge into one of such corporations pursuant to a plan of merger approved in the manner provided in this Act.

The board of directors of each corporation shall, by resolution adopted by each such board, approve a plan of merger setting forth:

(a) The names of the corporations proposing to merge and name of the corporation into which they propose to merge, which is hereinafter designated as the surviving corporation.

(b) The terms and conditions of the proposed merger.

(c) The manner and basis of converting the shares of each merging corporation into shares or other securities or obligations of the surviving corporation.

(d) A statement of any changes in the articles of incorporation of the surviving corporation to be affected by such merger.

(e) Such other provisions with respect to the proposed merger as are deemed necessary or desirable.

Procedure for Consolidation

Section 64. Any two or more domestic corporations may consolidate into a new corporation pursuant to a plan of consolidation approved in the manner provided in this Act.

The board of directors of each corporation shall, by a resolution adopted by each such board, approve a plan of consoldation setting forth:

(a) The names of the corporations proposing to consolidate, and the name of the new corporation into which they propose to consolidate, which is hereinafter designated as the new corporation.

(b) The terms and conditions of the proposed consolidation.

(c) The manner and basis of converting the shares of each corporation into shares or other securities or obligations of the new corporation.

(d) With respect to the new corporation, all of the statements required to be set forth in articles of incorporation for corporations organized under this Act.

(e) Such other provisions with respect to the proposed consolidation as are deemed necessary or desirable.

The examination of state corporation codes failed to reveal any legal constraints to consolidation or merger on irrigation companies organized formally according to statutes. As obscened in the decision of incorporated mutual companies, some states make specific provision in the statutory enactments for such action.[460]

PART FOUR

DESCRIPTION AND ANALYSIS OF THE RESEARCH AREAS

INTRODUCTION

The previous parts have introduced in broad terms the general thrust of the project, the challenge for consolidation, some methodological considerations in meeting the goals of the study, and, the general legal framework involved in the operation of irrigation systems. The present part is devoted to a more detailed presentation of the irrigation situation prevailing in each of the areas under consideration. While some of the areas have a more detailed presentation, others contain only general information and a broad outline of physical and social parameters of the irrigation system. Throughout the following exposition an attempt was made in adopting a consistant outline of argumentation, although occasionally this was not possible given the lack of data or re-depth exploration in some areas. Essentially, the following outline of presentation tends to characterize the analysis of each research area:

- Description of the Area
  - Background and ecology
  - Population
  - Economy
  - The cultural setting
- Historical Irrigation Development
- The Organization of the Irrigation System
  - Water resources
  - Patterns of water use
  - Water rights
  - Organization and management of irrigation companies
- On-farm Water Management
  - Land resources
  - Soil and water management
- Prospects and synthesis
  - Future trends and developments
  - Overall evaluation

At the end of this part, a summary table is provided containing key characteristics of the eight irrigation areas vis-a-vis an understanding of the consolidation question. The detailed discussion of Part Four, is subsequently extended to a comparative analysis of the areas and to a discussion of the attitudes of a sample of users in two areas: Eden, Wyoming and Ashley, Utah. In addition, an extension of the conceptual scheme of the study, prepares the ground for Phase II of the project.

Before we proceed with the various irrigation areas, we need a short introduction concerning the Intermountain region, or the larger area of the arid West within which irrigated agriculture is both a means of survival and a source of growth.

THE INTERMOUNTAIN WEST

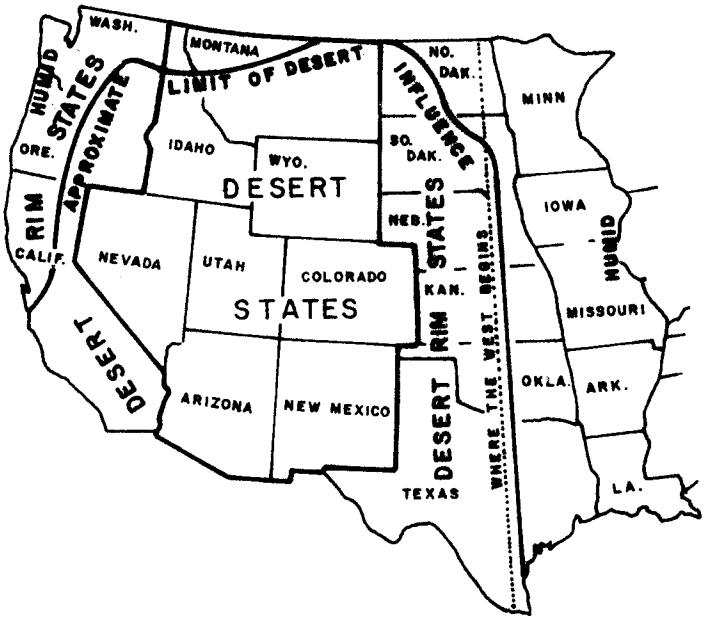
The West has always been an area of mythical proportions for most of Americans. The vastness and beauty of the region around the spine of the Continental Divide between the Pacific coast and the Great Plains provides the inspiring scenery of the semi-arid or desert states of Montana, Idaho, Wyoming, Colorado, Nevada, Arizona, Utah, and New Mexico.

In the eight mountain states of the region the average annual precipitation is only 12 inches. This precipitation is only a few points more than the mark of ten inches used to describe a desert territory (Figure 7). The dryness of the region and the general desert character are among the common denominators of the area. What used to be disadvantages for the region, namely relative desolation and dryness, are increasingly turning to be powerful magnets attracting people and industry at rates exceeding that of the nation as a whole. The very same vistas of the desert, the open spaces, the hospitable climate, and a salubrious physical environment are now reasons for steady streams of in-migration.

As discussed earlier, four regional and national trends are affecting present and future life in the area: a) increasing population, particularly the continuous movement of people to the West; b) increasing urbanization, metropolitanization, suburbanization, and rural decline; c) increasing industrialization, with the attendant changes resulting from new and massive capital influx and new values and patterns of behavior; and, d) increasing concern with ecological mismanagement, especially because of a fragile ecological environment which compounds typical problems of degradation.

In order to discuss more cogently the interrelationship between population growth, economic growth, and the limitations of the surrounding natural environment, we need to see a little bit closer some of the crucial demographic trends in the area. The central argument in the following demographic presentation is not so much the total growth of population in the area, but, more important, the continuous shift of the population from the countryside and the progressively faster rates of growth in the larger urban concentrations of each state in the region.

Although the United States population increased in the 1960's at a slower rate than in any other decade except the 1930's, the growth of population in actual numbers during the same period (23,861,597) was the second largest on record. At the same time, more impressive gains were recorded in the western part of the nation (Figure 8). Of this growth, more than three-fourths occurred in metropolitan areas, with the suburban rings showing the fastest gains and surpassing the population of those living in the inner city. The results of the 1970 census also confirm what many demographers have already outlined as a crucial trend of the 1960's. The population of central cities and of farm areas is stagnant or declining, while suburbs are experiencing dramatic gains. From the final census count, it becomes apparent that for the first time the suburban



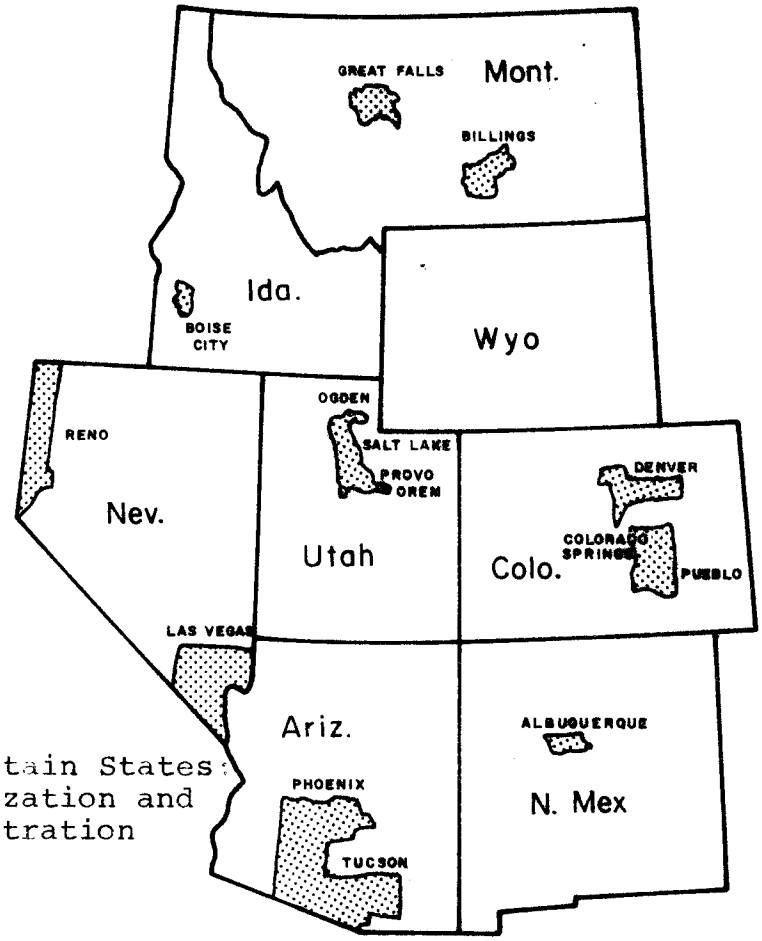


Figure 7. The Mountain States: Climatic characterization and Metropolitan Concentration

Year	New England Thousands	New England %US	Middle Atlantic Thousands	Middle Atlantic %US	East North Central Thousands	East North Central %US	West North Central Thousands	West North Central %US	South Atlantic Thousands	South Atlantic %US	East South Central Thousands	East South Central %US	West South Central Thousands	West South Central %US	Mountain Thousands	Mountain %US	Pacific Thousands	Pacific %US
1790	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1800	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1810	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1820	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1830	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1840	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1850	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1860	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1870	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Source: Department of Commerce, Bureau of the Census

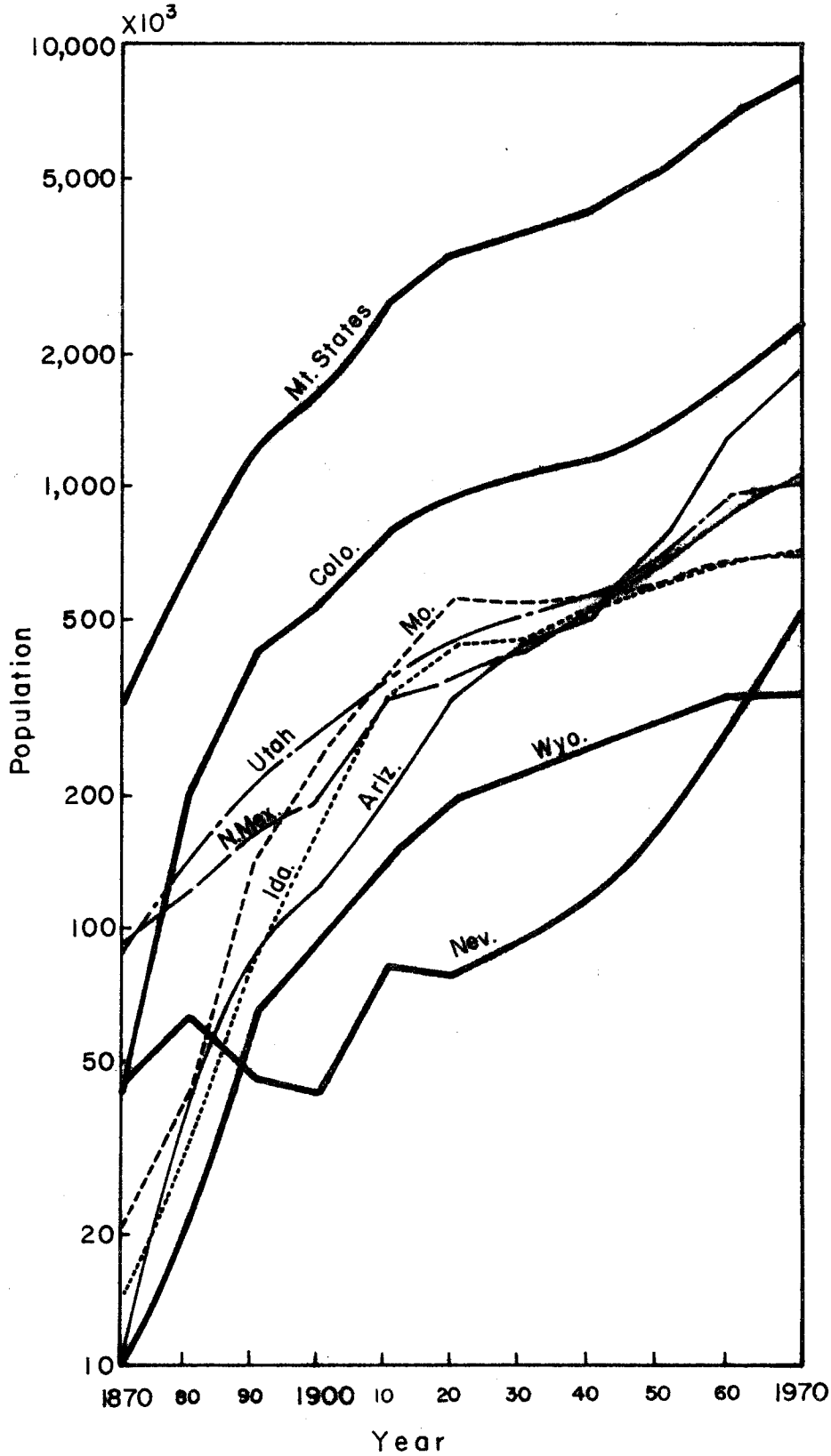


Figure 8. Trends of population growth in the mountain states.

or fringe population constitutes the larger segment of the United States population in the 1970's.

Similarly, there seems to be general agreement in various studies and projections that the greatest percentages of all future population growth will be in the western third of the nation. It is expected that the West will increase its present national share of population from 17 per cent to 22 per cent by the year 2000. Thus, in most western states, three interrelated trends will be crucial in the solution of emerging problems of water supply and use: flight from the countryside and abandonment of small towns, increased metropolitanization and urban sprawl, and total population growth from both natural increases and continuous in-migration.

If one looks at the map of the population distribution in the various states of the mountain region, especially in the fast urbanizing states of Colorado, Utah, Arizona, and New Mexico, one can see the particularly large concentration of people along urban corridors of well-irrigated land. The generally unbalanced distribution of population within each one of the above States is a result of both physical and social factors. For example, in Colorado the unbalanced distribution of population along the eastern slope of the Rocky Mountain is a result of both physical factors and economic geography. Physical geography largely determines the western half of the state, while economic geography is a crucial factor in the formation and vital role of the Front Range urban cities and foothills from Fort Collins to Pueblo. Thus, the bisecting nature of the Continental Divide and the combination of physical and economic geography has produced in Colorado a distinct potential "urban corridor" or even a "megalopolis" of immense consequences for the future of the state. By size alone, even the total population of the State in 1970 cannot qualify as peer among the large "strip cities" in the United States today (in 1962 the metropolitan areas of Colorado accounted for only 1.1 percent of total metropolitan population in the country). What is most important, however, is the fact that due to physical factors and to historical antecedents going back to the establishment of the State, the urban corridor of the eastern slope provides an unusual case of rapid growth when examined in the context of the ecological limitations of the region. Parallel remarks can be made also for other regions in the States of the region. In Utah, the megapolitan concentration between Ogden and Provo accounts for over 50 percent of the population. Extremely large gains in population are also to be experienced in the concentration of population between Phoenix and Tucson from 929,000 in 1960 to 1,833,000 in the year 1980. The population in Albuquerque, on the other hand, grew from 201,189 in 1960 to 243,751 in 1970, while Las Vegas showed a population of 236,288 inhabitants in 1970, a 164.7 percent increase over 1960. Thus, the Western United States has been steadily moving from an economy dominated by agricul ture and the resource producing industries of forestry and mining, to an economy increasingly shaped by urban growth, manufacturing, and service and recreational industries.

Although the quantity of the water being used by agriculture still seems to increase, more and more urban oriented considerations will be influencing the nature of water development in the coming years in this part of the nation.

In an era when urban congestion is becoming a major problem, 49 percent of the nation's area is still classified as "farm land," although only a small fraction of it is needed for agricultural production and only five percent of the nation's population lives on it. At the same time 80 percent of the nation's population is crowded into less than 10 percent of the land area, with all the assorted problems of a deteriorating livability. In trying to develop a much more comprehensive plan of national growth and land use, the Mountain region stands once again as a major attractive pull for future development. New population is likely to be drawn to new locations as a result of many factors, but essential among them is the suitability of the new area as determined by such physical features as terrain, climate, accessibility, availability of water, and other resources. These natural elements provide the basis upon which other non-physical factors, such as economics and social attractiveness will eventually determine the success of a policy for deconcentration and population dispersal.

However, it should be remembered that the seventeen western states with the exception of parts of the Columbia Basin, parts of northern California, and the High Rockies are not well endowed in terms of water. While it is easier to talk about the Mountain region demographically, it is much more complicated to do so from the water development point of view. The west is comprised of a number of regions formed by natural water runoff districts not necessarily coinciding with administrative boundaries. Generally, however, one may say that with the exception of the Columbia-North Pacific region and some portions of the California and Missouri Regions, the area in states in what is known as the Mountain and Western States are expected to have water shortages by the year 2020.[461]

In view of the population trends in the Rocky Mountain states it becomes apparent that water is vitally linked both as a constraint and as a tool for control in future developments in the area. It has been repeatedly asserted that water can be the key in determining the economic and demographic future of the area, and that proper water management is one of the vital goals relative to population stabilization and economic development of the region. The choices are rather narrow: either total use is brought into line with supply or one type of use might be sacrificed to maintain another.[462] The high dominance of consumptive use by agriculture (almost 90 percent of the total water) has brought forward very strong questioning of the policy to permit agriculture in rain-short regions, while idling land in moisture-rich areas of the country. The constant hunt for water in the west is coming under increased criticism, especially for all these big projects designed to bring more of it to arid lands. Many basic questions are increasingly raised concerning the continuous federal funding for new dams, reservoirs, and aquaducts in the arid west.[463]

These ambitious projects, necessary for the survival of the region, are coming under closer scrutiny by many groups in the nation who question the policy of trying to develop cities on natural deserts like Arizona and Southern California. The question is being asked as to what is the logic of multi-million dollar reclamation projects that create new farmland on which government subsidized crops will be grown and which in a sense force farmers from other areas in the country out of work. (In a recent study of the National Water Council, the very strong recommendation was made that no further irrigation should take place in the West unless other conditions, especially economic reconsiderations, were met[464]). One should also not forget that a major debate concerning growth looms when we consider that many of the areas in the mountain states contain large Indian reservations and there is increasing danger of the abbrogation of Indian water rights. Thus, a real water crisis is looming for many mountain states.

To continue with some examples, it has been increasingly recognized that the future of southern Arizona relies literally on a drop of water. Irrigators in the state are taking 2.4 million acre feet more out of ground water supplies annually than is replenished by nature. The underground water table, which has been the source of most water and the basis for economic development, has dropped as much as twenty feet in some places and at a few points the aquifers have been depleted to depths of 300 to 450 feet.[465] The land, once supported by water, has caved in, creating cracks in the desert thirty feet deep and twenty feet wide. More than one subdivision is sprouting for sale signs as homeowners try to sell their residences before the lengthening cracks in the nearby desert reach their neighborhoods.[466]

To quench the thirst for water from a booming Arizona population, the Central Arizona Project (CAP) has been proposed as a billion dollar Federal effort to transport 1.2 million acre feet of Colorado River water 200 miles to arid parts of the state. Strong questions, however, have been raised about the overall policy of growth as well as opposition to the forming of a double barrier aquaduct surrounding hundreds of miles across open desert with the assorted environmental consequences. Others have been questioning the state's agricultural base, at least that portion producing low value forage crops as not worth saving and they argue that existing ground and surface water supplies, if used to economic advantage, are sufficient for the foreseeable future.[467] And still others, point out to the implications of a loss of economic appeal for agriculture. For example, a tempting calculation estimates that in 1960 just less than half of the groundwater pumped in the immediate vicinity of Tucson went into agriculture that supported only 1500 people. Yet, that same water could support a city of 200,000 domestic users.[468] One should hasten to add, however, that such comparisons are meaningless unless seen in the context of long-range planning and with strong considerations of equity in mind.

In essence, without new sources of water, disaster could come around first for agriculture and perhaps eventually for

the rest of the population of Arizona. Arizona has already been obliged to place a moratorium on further wells for irrigation purposes and a third of the lands once farmed have already been forced out of production as they are being replaced by industries and homes which require substantially less water. The question of balanced growth becomes accentuated if we recognize that the beneficiaries of the present system in Arizona are few: less than 900 farms, all of 2,000 acres or more, which account for 36.7 million of the state's total farm acreage of 38.2 million acres. Such data are consistent with a current top-level report to the Congress by the General Accounting Office to the extent that loopholes in the 70-year-old reclamation law have benefited significantly large farm operators and corporate farms. Within the seven districts of the Central Valley Project (California), the report indicates that a total of 71,645 acres of land benefiting from the irrigation works was owned or leased by only seven of the largest operators with their farms ranging in size from 1,774 acres to 40,404 acres (Denver Post, December 3, 1972).

It has been predicted that even with CAP only one-third of the amount that would really be needed to correct Arizona's depletion of its residual underground water will be available. In not too many years the last major underground sources will be exhausted. When the projected population growth for 1980 is added, the state will annually overdraft around three and a half million acre feet of water.[469] Many authorities in Arizona recognize that multi-purpose planning for use of water and conservation is essential to assure long-range survival. Among possible sources and methods of future water development, are included development of groundwater at greater depths in alluvial basins, capture of surface water for artificial recharge, conversion of brackish water, increased runoff from vegetation and soil modification, etc.[470]

Other states in the region are becoming very wary of the problems of Arizona and of southern California and they look sternly to their neighbors as raiders of their own water supply. For example, Idaho's great fear is that California and other areas of the parched southwest will try to tap the Snake River and other Idaho waterways by gigantic diversion schemes. One proposal would divert water from the Snake in Wyoming, channeling the water into the Green River and then to the Colorado River system and from there on through trans-Nevada siphon water to southern California. It is on the basis of such fears and of increased rivalry on the use of water in the mountain states that at least until 1978, government planning for trans-basin diversion is frozen. A ten year moratorium was written in the 1968 Colorado River Act, which also included the Central Arizona Project.

Similar cases of water difficulties can be offered for many other states in the region. In Colorado, for example, since water supply is limited and 50 percent of the surface water goes downstream in two months (May and June), storage facilities are necessary if water to which Colorado is entitled is to be utilized. Yet, water development on a grand scale

is approaching an end. On the other hand, Colorado is out of surface water supply in the Rio Grande Basin, and as a result of suits brought against Colorado by the state of Texas and the state of New Mexico there is an obligation to assure these states at least the scheduled compact delivery each year. Texas and New Mexico allege that Colorado is in arrears by 800,000 acre feet in meeting past commitments. Similarly, there is overall water shortage in the Arkansas Basin where the future of water development hinges more on efficient management of water. It should be noticed that as water use becomes more intense, being reused more as it moves downstream, the problem of salt is compounded. Repeated use increases salt content, progressively reducing water quality; too much salt renders water useless for agriculture. California has expressed concern for the increasing salt content in the Colorado River and Mexico has repeatedly protested loudly about the low quality water reaching its frontiers.

For the Mountain States, as well as the West in general, one thing is becoming apparent: water needs exceed supply since the total water demand for the West is put at 215.4 billion gallons per day in 2000, nearly 40 percent above the maximum dependable stream flow of 154.1 billion gallons per day.[471] To repeat an earlier statement, the present data as well as the projections for the future point out that either total use will have to be brought into line with supply or one type of water use must be sacrificed to maintain another. It should be noted, however, that in a study prepared for the National Water Commission, more optimistic projections concerning future water options have been made. It was indicated that projected domestic demand and exports of food in the year 2000 could be met even with some reduction in the use of water for irrigated farming. For the Western states in particular, it appears that projected urban, manufacturing and other nonfarm uses of ground and stream water will not require large diversions of irrigation water from agriculture by the year 2000. Hence, in the case of potential future water scarcities, especially in the West, agriculture need not use more but actually can release a fairly large supply of water for industrial and urban uses.[472] As such studies' results indicate, an increase of the water price to thirty dollars per acre foot as a minimum for the 17 Western States would allow release of an additional 36.2 million acre feet per year from agriculture (in Arizona many farmers believe that they cannot pay more than twenty dollars for an acre-foot of water for low-value crops and make a reasonable profit). Clearly, if value of water in nonfarm uses specifies it, water can be released from agriculture to uses in other sectors and locations.

Looking at the prevailing demographic trends, it is expected that as population increases, consumptive use will increase and the tendency is for agriculture water to be diverted to municipal-industrial uses. However, at the same time a certain amount of water is required to maintain adequate stream flow for the fish habitat, wildlife support, recreation, interstate compact commitments and waste carriage and disposal. As a result of reduced water supply, insufficient stream flow

may create problems for diluting waste and, therefore, may compound water pollution. Problems of consumptive use and stream flow requirements are also compounded by on-site water requirements, such as the preservation of lakes and marshlands, which not only provide support for wildlife but are also important ingredients of the aesthetic and recreational attraction of the region.

What all these mean is that the future of the region depends in both augmenting the natural supplies and in developing alternative means for meeting competing demand. The first, involves such items as tapping groundwater potentials, attempts for desalination, weather modification, vegetative manipulation, brushland conversion in the areas below the commercial zones, treatment of riparian vegetation, etc. Parallel to the efforts for augmenting the natural water supplies, alternative means for meeting increased demand include not only conservation of use and efficient management, but also such items as recirculation of water, reduction of losses by suppression of evaporation or rather conveyance losses, and pricing of water services which can have significant implications to water use practices.

From all trends discussed above and from the physical conditions prevailing in the region, it becomes apparent that new, different, expanded, and competing demands will increasingly characterize the water scene of the states in the area. Many commissions in the various states have urged policies on water management to be coordinated with policies on land use, natural resource management, and policies on population and environment. Since in many areas water constitutes the limiting factor for agricultural production and it is more valued than the land, every reform or planning effort can be more efficiently carried out if it concentrates on water rather than land. At the same time efficient water administration, supported by adequate legislation, may also establish more pertinent criteria for the allocation of scarce resources, and channelize growth to preferred areas of future growth.

However, the urgency for a comprehensive water development policy depends not only on past and present trends of population increase, urbanization, industrialization, and ecological awareness, but also on other factors complicating the physical and technological aspects of water resources planning and use. The major problems are the numerous governmental jurisdictions, each with specific responsibilities for water conservation and management. Contrasted to the usually unified government unit managing water supplies in most of the nations in the world, the American federal system divides power between national (Federal government) and the States. The last delegate powers to several types of local authorities, including counties, cities, districts, and special administrative units. Thus, upon the numerous river basins of the Western United States and in addition to the national government represented by 17 states, there are to be found over 14,000 units of local government, all with various responsibilities for determining the allocations of water for specific uses. At the same time, segments of

private enterprise vie with publicly owned and operated enterprises.

When we look at the problem of water management from a macropoint of view, we have also to acknowledge the larger difficulty where each State is obligated under either a compact, a court decree, or a judicial allocation to apportion the water of the interstate stream between States. Two problems are immediately associated with this fact, one of quantity and the other of quality. Thus, although liability for water distribution rests with the particular State, there is no effective or efficient mechanism for proper transfer of this obligation to the people using the water. At the same time, through the use (or misuse) of his water rights, the individual holder is effecting the quality of the stream, either through misapplication (resulting in salt concentration), or by taking the water out of the system and thus maintaining (and in some cases increasing) natural salt pick-up. As water supplies become more fully utilized, the importance of irrigation return flow quality will be of even greater significance in the over-all water management and development in a river basin.

What we have, then, in the West is a complicated system of demographic, administrative, and natural water districts which, in addition to natural overlaps, create a multitude of problems in jurisdiction and use. At the same time, given the open character of the water systems, we have major ties of every kind of a major basin with surrounding water systems. For example, the Colorado Basin is not a self-contained system but has many ties with surrounding areas, such as the provision of water from the Colorado to the Great Basin through the Central Utah Project, water from the Colorado Basin to the Missouri basin through, for example, the Denver water withdrawal system, the Fryingpan-Arkansas transfer of water, the San-Juan Chuma transfer of water to the Central Arizona project, and finally the major transfer of water from the Colorado River to the Southern California project (MWD). When we think of the problems of water management, we have to keep in mind the existence of a myriad of systems and subsystems, each only relatively autonomous, and open since they have a wide variety of linkages on different levels. In other words, a specific irrigation company is usually part of a federation of irrigation systems within a subsystem of a given basin and part of larger interbasin exchanges.

The previous general discussion has attempted to show the overall trends affecting water use in the West. This part of the country will also continue to have continuous (although not highly increasing) water demands for irrigated agriculture. As Table 3 indicates, the western region of the United States will experience moderate increase in agricultural irrigation between 1980 to 2020. Various other studies have shown similar trends in the slow rate of increase in irrigation water use. A most interesting estimate of water use and projected requirements by region is that included in the composite Table 4, based on projections of the Water Council. As contrasted to other regions of the nation, most of the western regions present

Table 3. Projected estimates of agricultural irrigation in the Western Regions of the United States, 1980-2020 (thousands of acres).

Region	1980	2000	2020
Souris - Red - Rainy	90	230	250
Missouri Basin	8,050	8,950	9,600
Arkansas - White - Red	5,600	6,400	6,690
Texas Gulf	6,510	7,350	7,770
Rio Grande	2,050	2,180	2,200
Upper Colorado	1,900	2,150	2,250
Lower Colorado	1,820	2,190	2,400
Great Basin	2,340	2,510	2,570
Columbia - North Pacific	7,350	7,810	8,490
California	9,050	9,600	11,540
TOTAL - WESTERN REGIONS	44,760	49,370	53,760
MAINLAND UNITED STATES	49,990	56,910	62,890

Table 4. Regional projections of population and irrigated land in the conterminous United States, 1960-2020.

	Population				Thousands of Acres				
	1960	1980	2000	2020	1960	1965	1980	2000	2020
North Atlantic	43,896	56,693	74,993	101,726	240	310	380	550	700
South Atlantic - Gulf	19,727	29,099	42,602	61,438	850	1,500	1,800	2,750	3,750
Great Lakes	25,474	33,171	43,293	57,640	100	140	230	350	470
Ohio	18,793	23,498	30,742	41,241	35	55	90	180	260
Tennessee	2,979	4,118	5,643	7,785	15	20	30	40	50
Upper Mississippi	11,759	15,180	20,004	26,766	80	140	210	390	550
Lower Mississippi	4,619	5,871	7,815	10,587	700	900	2,100	3,050	4,150
Souris - Red - Rainy	652	791	1,023	1,368	10	15	90	240	250
Missouri	7,845	10,337	14,260	20,079	6,600	7,400	8,050	9,000	9,600
Arkansas - White - Red	7,122	8,972	11,952	16,055	3,100	3,800	5,600	6,400	6,850
Texas Gulf	8,109	12,491	18,230	25,901	5,100	5,500	5,500	5,500	5,500
Rio Grande	1,604	2,649	4,173	6,063	1,950	2,000	2,050	2,050	2,050
Upper Colorado	317	454	700	1,025	1,370	1,440	1,800	2,000	2,000
Lower Colorado	480	3,038	4,768	7,194	1,520	1,660	1,750	1,800	1,800
Great Basin	970	1,790	2,822	4,285	1,700	1,860	1,950	2,000	2,000
Columbia - North Pacific	5,359	7,581	10,463	14,444	5,450	6,250	7,700	9,500	11,200
California	15,584	28,167	43,317	64,003	8,420	8,850	10,150	10,750	11,100
TOTAL	176,289	243,900	336,800	467,600	37,240	41,840	49,480	56,550	62,280

regions of the nation, most of the western regions present us with stationary trends of projected irrigated land use.

We need to add a few words on the problem of water quality associated with irrigation in the Western United States. Two interrelated problems help us clarify the status of water resources in the arid west: first, the question of water supply which is also associated with the present wasteful use of limited water; and, second, the economic impact of increased natural, as well as man-made pollution. According to EPA, BLM, and CRBC estimates, man in his works is already significantly increasing the salt load in the Colorado River's natural salinity. As a general rule, in salinity concentrations above 500 mg/l, the value of water begins to diminish not only because of increased costs in water softening, corrosion, etc., but also because of the need for greater amounts of leaching water and the damages incurred from diminished crop yields or the inability to grow certain high-value crops. It is now estimated that the bill for this salt reaches $16 million a year and it is expected to reach $28 million by 1980 and $51 million by the year 2010, unless the salt loads are reduced substantially. At the same time, it should be noticed that the major efforts concerning return flow quality problems are directed at control of the source, rather than treatment and reclamation of degraded water.[475]

The natural problems of salinity are accentuated by the larger trends of growth described above. So as man has been and will be taking water out of the river and its tributaries, as well as daming the streams and polluting existing water supplies, water used for irrigation will not only be picking the salts in the land, but will be increasing the salt levels because of the above conditions. The vast natural evaporation, municipal use, and the malpractices in the use of water based on the convenience of the irrigator and protection of his water right, are not only diminishing water supplies and increasing natural water salinity, but they are also accelerating problems of man-created pollution in the water systems of the West.

Given the natural problems of water salinity, the increasing demands for water and the parallel trends of population growth, urbanization, and industrialization and increasing water quality requirements, we may have also increasing conflicts in water use. On the one hand, water quantity is assuming greater importance due to the pressures of population growth, municipal expansion and competition among a wide variety of uses of this limited resource. On the other hand, with each water use there are also associated quality considerations pertaining to both the water extracted from and that returned to the source.

All in all, water in the region remains a central point of concern and a sensitive issue, reinforcing a widely shared conviction about the need for control and coordination. Around water as an organizing concept the broader policies of development can be interwoven into an integrated effort for managing growth in an ecologically fragile region. Comprehensive

planning and management implies immediate attention to such items as:

1. The status of water rights and the concepts of beneficial or reasonable use.
2. Increased efficiency by means of modernizing facilities and equipment, checking of evapotranspiration and transmission losses, modification of delivery schedules, water measurement, run-off reclamation, etc.
3. Organizational re-arrangements and administrative effectiveness, including pricing restructuring, consolidation of fragmented companies and districts, and improved administrative mechanisms of intelligence, coordination and control.

A crucial facet of any water management system are the types of incentives and the structure of the organizational arrangement that may permit efficient irrigation. Incentives for efficient management usually come in the form of economic incentives, either negative or positive. At the same time, the larger law regulations contribute substantially to both the creation and the solution of irrigation problems. Indeed, in many instances, there is no incentive to conserve water in most of the irrigated valleys in the West. A key problem is that most irrigators feel that they must use their full water right because they are afraid of losing any portion of the unused right. Despite repeated observations and findings that such attitudes of excessive use of water right frequently contribute to local drainage problems, the practice persists because it is rooted in deep-seated personal fears as to water use and on the notion that the exercise of the right means the preservation of the right. A paradox then seems to emerge, i.e., that efficient farmers who through improved technological practices save water, are not able at the same time to use the conserved or saved water to irrigate additional land or to supplement their water supply for lands having an inadequate water right. A farmer who has used inefficient and many times flooding techniques has a built-in advantage and, thus, any incentive from the legal point of view is diminished by the realities of the persistent attitudes in the use of present water rights. This simply compounds any effort for improving his water management practices.

Thus, if one is to understand the overall picture of water in the West, and develop efforts for comprehensive planning in the context of changing prevailing practices and attitudes, attention should be focused to the following concerns:

1. Priority of use (and the interpretation of legal doctrine).
2. Geographic area (and the increasing scope of planning).
3. Population affected.
4. Political units involved.
5. Disciplinary scope (and the attempt towards a multidisciplinary synthesis).

As it was pointed out above, to bring about changes in the organizational behavior of all types of units involved in water management, as well as effective responses from individual irrigators, three major categories of policy decisions and social action must be made: first, strong incentives for efficient or new uses (economic benefits, redefinition of the doctrine of beneficial use, etc); second, structural changes (such as new organizational arrangements, creation of inter- and intro-state agencies, appelate bodies, water brokerages -- either private or public.); and third, "regulatory counter-incentives" (such as stricter enforcement, pricing policies, etc.). More than anything else, however, all the above changes or attempts for modification must be guided by a pervasive spirit of social consciousness and a new world outlook of individuals and collectivities away from their small closed system of their particular communities, to the larger and much more complex regional scene.

The previous discussion concerning socio-demographic and water resources trends in the Rocky Mountain region, was a necessary introduction for being able to analyze the irrigation systems of the eight research areas of the study. While each of these systems is characterized by an idiosyncratic combination of physical and non-physical parameters, they all share the common backdrop of a fast urbanizing region, characterized by relative water scarcity, competing demands, and the challenge of maintaining agricultural efficiency.

POUDRE VALLEY

Location and Physiography

The drainage area for the Cache la Poudre River lies in north-central Colorado on the eastern side of the Rocky Mountains and is shown in Figure 9. The eastern side of the Laramie and Medicine Bow Ranges forms the western hydrologic boundary. The Mummy Range forms the southern hydrologic boundary between the Big Thompson River and the Cache la Poudre River. The northern boundary is in the high plateau region of southern Wyoming. The Cache la Poudre discharges into the South Platte River on the eastern boundary near the city of Greeley.

The maximum difference in topographic relief is approximately 7550 feet; the altitude above mean sea level for the agricultural area ranges from a minimum of 4650 feet near Barnesville to about 5800 feet near Livermore. At the Continental Divide, the maximum altitude is 12,200 feet.

Slightly more than 50 percent of the land area lies in the mountainous region and the dividing line is a belt of foothills along the eastern base of the mountains. A rough undulating area which extends along the foothills and into Wyoming along the northern boundary forms the headwaters for the two principal plains tributaries to the Cache la Poudre; namely, Boxelder Creek and Lone Tree Creek. Most of the torturous mountain tributaries head among high mountain snowfields about 75 to 100 miles west of the plains.

The Cache la Poudre River technically heads at Poudre Lake on the Continental Divide (by Trail Ridge Road), but in actuality it heads at Chambers Lake. The Cache la Poudre River is the last major perennial tributary to the South Platte River before its confluence with the North Platte River in Nebraska.

From its headwaters, the Poudre proceeds in a north and east direction to the mouth of Poudre Canyon, where it swings east and south for about 35 miles until it meets with the South Platte River just east of Greeley, Colorado.

The agricultural portion of Poudre Valley lies mostly in the Colorado Piedmont section of the Great Plains Province. Basically, the Poudre Valley consists of a series of lowlands lying along the stream separated by gently rolling uplands.

The river flood plain averages about a mile in width with an irregular topography caused by oxbow lakes, abandoned meander scars, and scattered remnants of eroded terraces. As a general rule, the majority of the flood plain lies north of the river with the south side bounded by high bluffs and no terraces. The northern terraces, on the other hand, have a gentle rise to the bench lands. The average rate of rise of the terraces is about 25 feet per mile in the irrigated areas. Most of the irrigated agricultural activities take place in this northern section. The top of the southern bluffs is also gently rolling, but is largely dry farmed because of difficulties in reaching this area with water due to the steep eroded

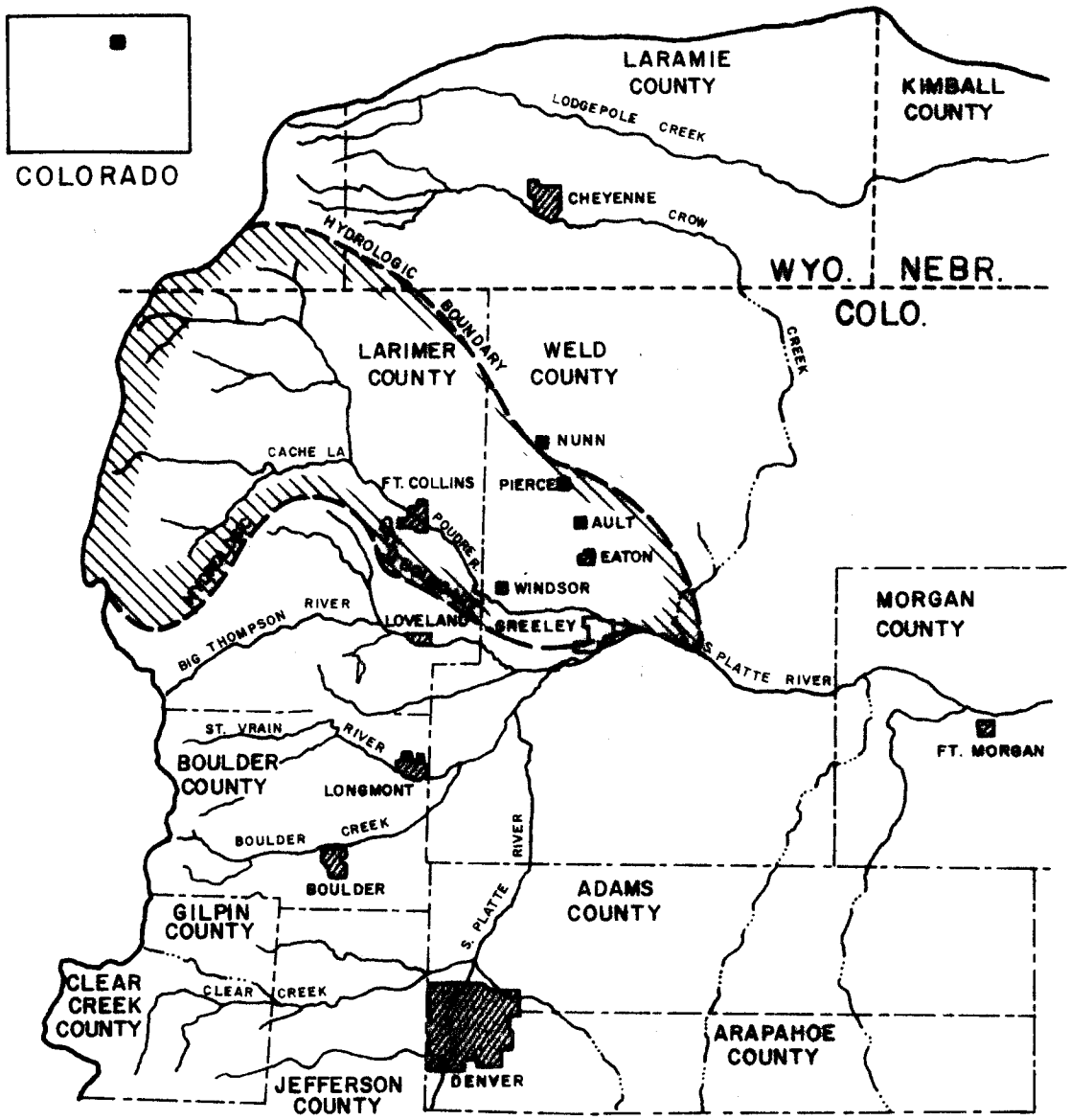


Figure 9. Hydrologic Boundary of the Cache la Poudre River.

escarpment near the river. Some of this land, however, is irrigated with water from the Big Thompson River.

The rolling topography of most of the area is a result of ancient winds. There are also numerous scattered lakes and reservoirs which are the result of this undulating landscape; they were the result of wind action forming depressions in which the natural precipitation collected. Many of these lakes have been enlarged by constructing dikes and levees to increase their storage capacity for irrigation purposes. The lakes and reservoirs in the Poudre Valley are filled primarily by the existing canal system.

Climate

The climate of the Cache la Poudre is characterized by low annual precipitation, a high rate of evaporation, low humidity, an abundance of sunshine and wind, and a wide range of temperatures. The summers are moderately hot and the nights are relatively cool. The winters are generally mild but have short periods of severe cold, and there are usually several heavy snowstorms during the winter. However, the snow does not accumulate in the valley.

Precipitation (Figure 10) is generally sufficient to support a light cover of native grasses and shrubs, some winter grains, and a little hay. Most successful farming depends on irrigation for its water supply. Fall and winter precipitation is usually in the form of snow, while spring and summer precipitation usually occurs as thunderstorms with intermittent strong winds and hail. The precipitation is nearly always erratically and unevenly distributed. The mean annual precipitation is 14.19 inches at Fort Collins, 12.38 inches at Windsor, and 12.15 inches at Greeley. The maximum monthly precipitation usually occurs in May while the minimum usually occurs in January in the form of light, dry snows.

The mountain agriculture, which is primarily hay and pasture, often has only a 90-day growing season. Depending on the location, the average length of growing season in the irrigated area is from 175 to 185 days. Generally speaking, however, the growing season is sufficient to raise most temperate zone crops such as corn, sugar beets, potatoes, alfalfa, etc. The mean annual temperature at Fort Collins is 48.1°F, and 48.3°F at Greeley (Figure 11).

Water Supply

The natural water supply is totally supplied from melting snow and the perennial snow fields in the mountains, and precipitation. However, the transbasin diversions, of which the Colorado-Big Thompson is the largest, provide a very significant contribution to the total flow. These foreign waters are also derived from melting snow sources in other high mountain watersheds.

The natural flow of the Cache la Poudre River and its mountain tributaries contributes about 44 percent of the total

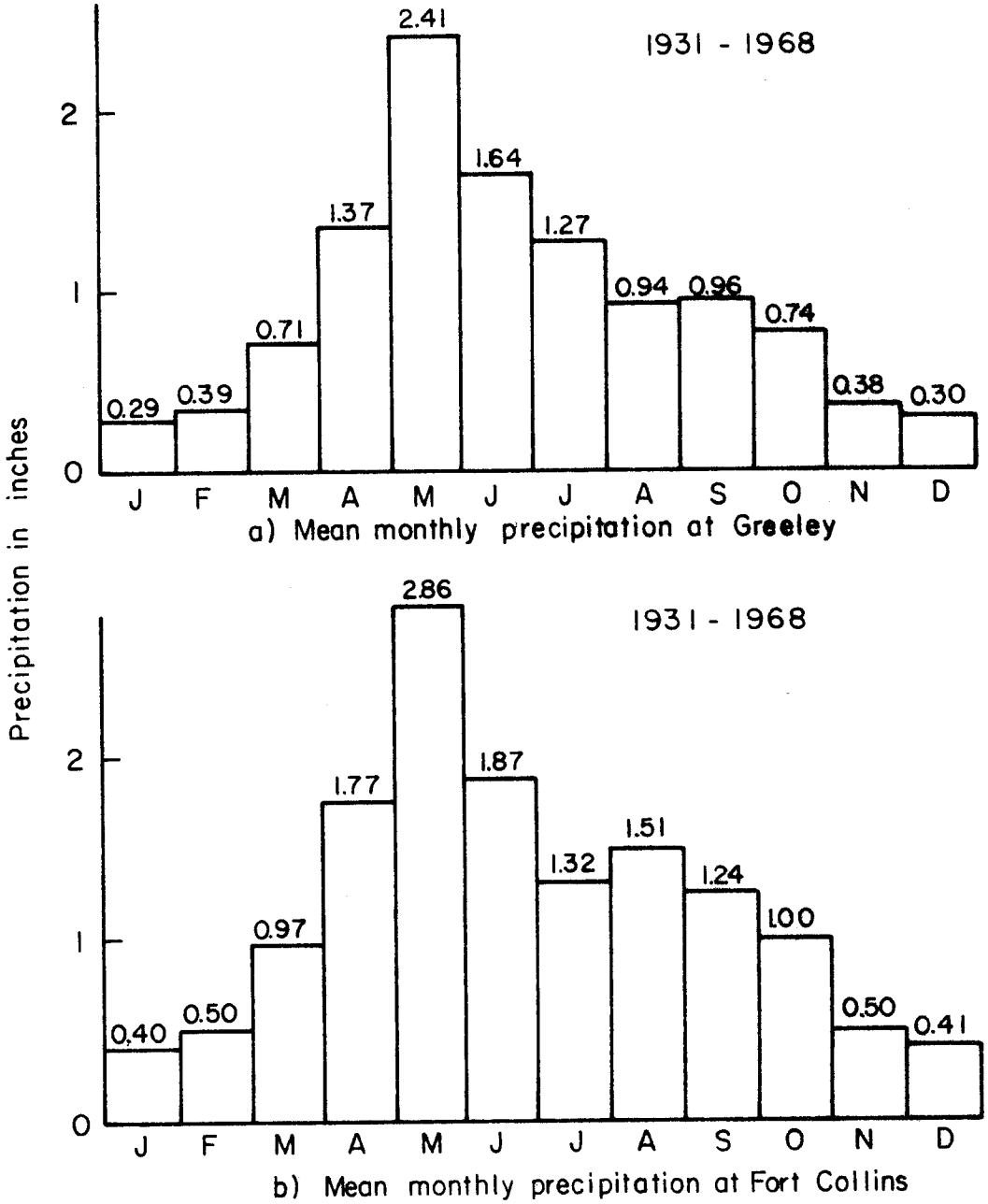


Figure 10. Mean monthly precipitation at Greeley and Fort Collins.

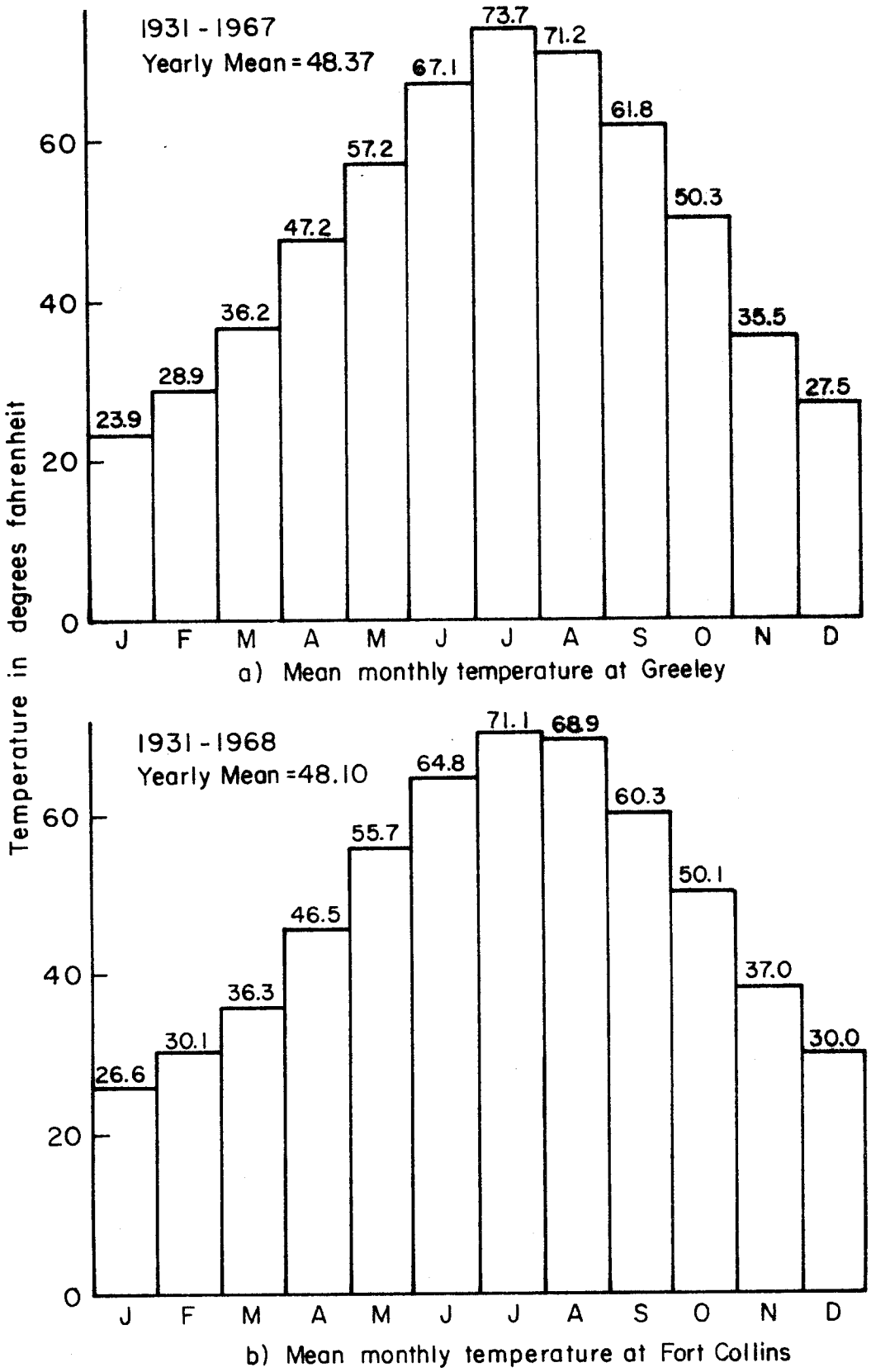


Figure 11. Mean monthly temperature at Greeley and Fort Collins.

water supply to the valley. The Colorado-Big Thompson contributes another 17 percent and the other transmountain diversions furnish 6 percent. Pumped water yields another 33 percent (Figure 12). Intensive reuse of return flows from irrigation and municipal waters, plus the natural flows of the plains tributaries, yield (in effect) an additional 145,400 acre-feet per year.[476]

Agricultural Economic Conditions

The Cache la Poudre Valley is an area of widely diversified agriculture ranging from native hay to corn and sugar beets to carrots, potatoes and cucumbers. Although many crops grow well in this area, the three major crops are corn, sugar beets, and alfalfa.

The principal agricultural industries are general farming, livestock feeding and dairying. The alfalfa and corn are usually raised for consumption in the area by the large number of feeder cattle and sheep. Sugar beets are sold to Great Western Sugar Company, and the tops and pulp used to supplement the livestock industry. The small grains such as oats and barley are primarily consumed in the area.

The farming in the area is of two types, one being irrigated, the other being dry farming. The dry farming is found on the hills that are too high or the cost incurred in delivering the water to these hills would be too great, or the soil was deemed as marginal. These dry farm plots are primarily used for small grains. The irrigated lands, on the other hand, are used for farming and they have been leveled under the direction of the SCS, with various nutrients plowed into the ground to enhance the production capacities. The products which are grown are primarily sugar beets, small grains, corn, alfalfa and some soy beans.

The cash value of agricultural crops during 1967 for Larimer and Weld counties was $9,600,000 and $43,600,000, respectively. Of the total cash value of $53,200,000, the value of crops from irrigated lands was $47,000,000. Thus, the average cash value of crops from irrigated lands was approximately $190 per acre.

Human Community

Poudre Valley contains two northern counties of Colorado, Larimer and Weld. Both of these counties are fairly similar in terms of population, size, and composition, but with Larimer County increasingly becoming highly urbanized, as contrasted to Weld County's firmer agricultural basis.

Larimer County, which is located on the west edge of the valley, with a population of 89,000 according to the 1970 census, has shown a high increase of 68.53 percent over the previous census. The number of the inhabitants of Larimer County classified as urban in 1970 were 59,557, with the remaining 23,644 classified as rural. However, Larimer lists only 2,167 persons as full-time employed in agriculture, a rather small

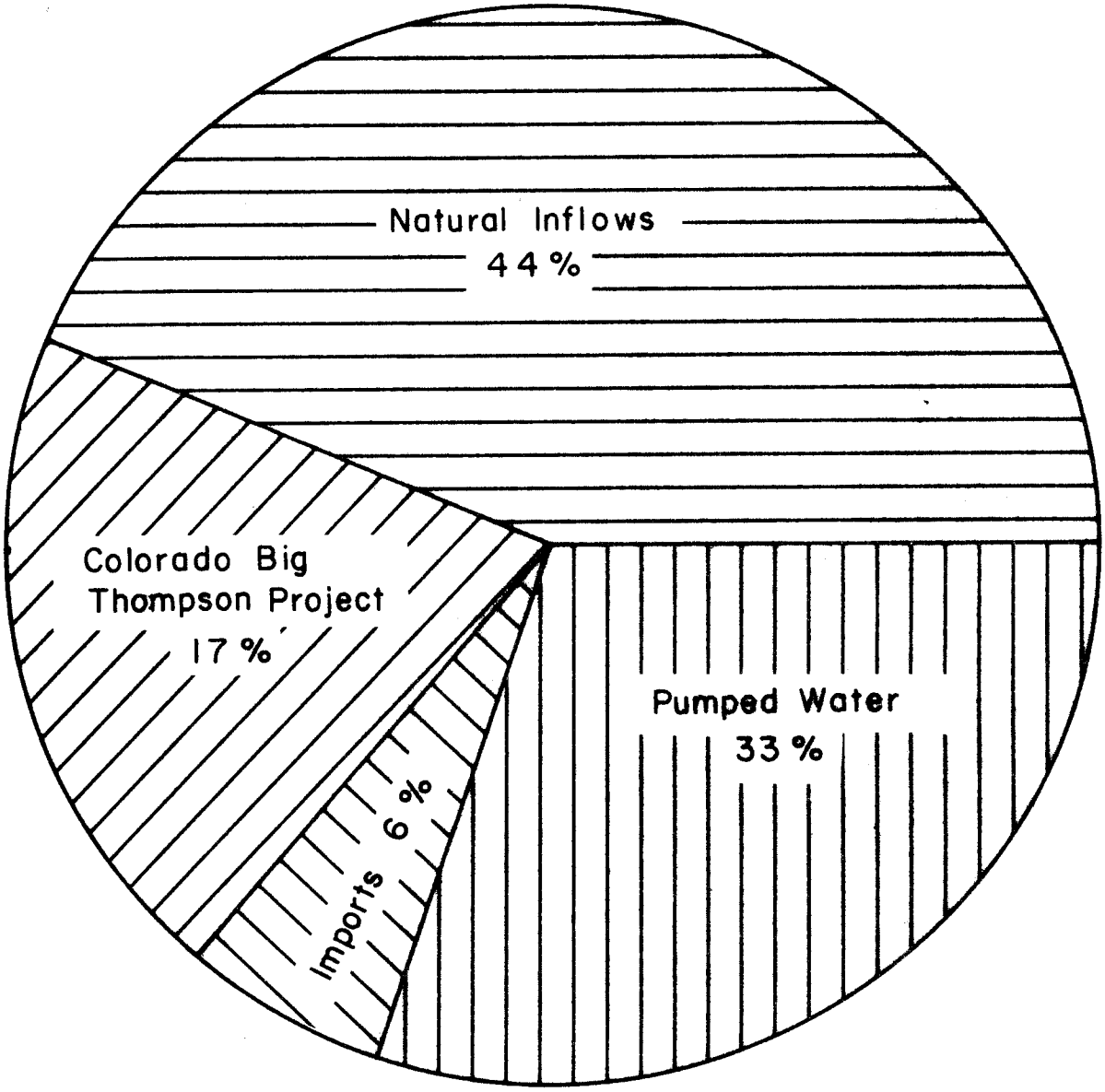


Figure 12. Relative proportions of water supply sources to the Cache la Poudre Valley.

proportion of the 34,094 persons gainfully employed in the county. The largest number of employed persons in any single category is to be found in manufacturing, followed by education and construction. The population of the county is rather young, with high in-migration and high levels of educational attainment. The principal city in Larimer County is Fort Collins. Fort Collins has been growing much more rapidly than the rest of the county showing an increase of 72.2 between 1960 and 1970 for a total population of 43,098 inhabitants in 1970. Fort Collins is the eighth largest city in the state, rapidly becoming the populous pole in the emerging Colorado megolopolis stretching all the way from Fort Collins to the north to Pueblo to the south. As a matter of fact, projections to the year 2000 estimate an approximate population of 200,000 persons in the county with an even higher number of people by the year 2020 (estimated to about 355,000 inhabitants).

The urban growth of the city of Fort Collins is part of a rapidly growing urban hinterland contained between the cities of Fort Collins, Loveland, and Greeley (the last in Weld County) forming an idealized "urban triangle." The population of this triangle which is superimposed on Poudre Valley is expected to increase from about 95,000 to more than 400,000 people by the year 2020.

The rapid urban growth of Poudre Valley represents a situation where a great deal of agricultural land and agricultural water are rapidly being converted into water used for municipal and industrial purposes. Part of the industrial growth in the Poudre Valley has been through the recent influx of new industry such as the new Kodak plant, right across the Larimer County line in the neighboring Weld County. There are also other large manufacturing establishments such as the Hewlett Packard plant in Loveland, which employs many Fort Collins residents, Woodward Governor which maintains a fairly large facility in the Fort Collins area, and Colorado State University, absorbing for its supporting personnel a significant number of people in the Larimer County region.

Similarly, Weld County which is located in the eastern part of the Poudre Valley is experiencing parallel trends of growth although not as pronounced as the ones in Larimer County. The population of Weld County according to the 1970 census was 89,297 inhabitants. This is a 23.43 percent increase over the 1960 census. Overall, Weld County is not growing as rapidly as the Larimer County region, but the agricultural land in this county is much more fertile and productive as compared to Larimer County. Indeed, the Weld County area was the earlier of the two areas of the Poudre Valley to be settled and the growth in this county has been much faster until the latest census which showed decreasing rates of increase for the entire county. This is particularly true for the urban population of Weld County which according to the latest census was comprised of 41,272 persons. The major city of the county, Greeley, grew by 48.8 percent between 1960 to 1970 (showing a total of 39,167 inhabitants according to the 1971 census). The general trends of population growth in the valley can be seen in Table 5.

Table 5. Population increase in Larimer and Weld County (and their major cities) 1900-1970.

	1900	1910	1920	1930	1940	1950	1960	1970
LARIMER COUNTY								
Population	12,108	25,270	27,872	33,137	35,539	43,554	53,343	89,900
% Change	--	107.67	10.29	18.88	7.24	22.55	22.47	68.53
Fort Collins								
Population	3,053	8,210	8,755	11,489	12,251	14,937	25,027	43,337
% Change	--	168.90	6.60	31.20	6.60	21.90	67.60	73.20
Loveland								
Population	1,091	3,651	5,065	5,506	6,145	6,773	9,734	16,220
% Change	--	2,346.47	387.29	8.70	11.60	10.20	43.70	66.60
WELD COUNTY								
Population	16,808	39,177	54,059	65,097	63,747	67,504	72,344	89,297
% Change	--	133.08	37.98	20.41	-2.08	5.89	7.16	23.43
Greeley								
Population	3,023	8,179	10,958	12,203	15,995	20,354	26,314	38,902
% Change	--	170.60	34.00	11.40	31.10	27.30	29.30	47.80

It should be recalled that the major factory of Kodak was established in the western-most part of Weld County or right across the county line from Larimer. Thus, despite the slowing of the rates of growth in Weld County, similar factors seem to operate promising future growth for all the area of the Poudre Valley. The Kodak plant is equally accessible to the residents of Greeley, as to the rest of the population in the valley.

The continuous trends of urban and industrial growth and the emergence of an industrial-commercial complex (including development of transportation companies, material supply commercial businesses, and service enterprises) are expected to become the standard features characterizing life in Poudre Valley in the coming years. What should be remembered here, both in the context of changing communities and from new conditions resulting from the conversion of water uses, is that when the location of industrial plants occur and urban growth rapidly takes place, they are often accompanied by sudden, and sometimes traumatic, changes in the lives of surrounding communities. In addition to vast changes brought about with the new and massive capital influx, new values, and conflicting demands for natural resources, the old social structure is also altered and traditional and established patterns of community life and employment are also disrupted.

Against such a background of a rapidly changing and fast-urbanizing valley, we need to see the past developments of irrigation, the present role of agriculture and some prospects concerning water and land use in the valley.

Irrigation Development

One of the first large areas to be developed for irrigation in Colorado was the area along the Cache la Poudre River. The first attempts to raise crops in the Poudre Valley were at Laporte in 1860. Vegetables, small fruits, native hay and oats were raised. The ditches were small and irrigated the "first bottom" where the labor and the expense of operation were minimal and permitted the easy cultivation of the alluvial soils.

The actual speedy development of the Cache la Poudre began with the completion of the Union Pacific Railroad and the coming of the Union Colony to the Greeley area in 1870. The Colony, under the leadership of Nathan C. Meeker and under the patronage of Horace Greeley, was founded on the belief that the higher lands above the river could be successfully adapted to cultivation with irrigation. Prior to the settlement of the Union Colony, there were only about 1000 acres under cultivation, with several small irrigation ditches conveying water to the lands along the margin of the river. The Greeley No. 2 Canal, constructed by the Colony, was the first large canal in the state designed to irrigate the terraces above the river. Since its original construction, this canal has undergone significant changes and it is now known as the New Cache la Poudre Irrigation Co.[477]

The leaders of the Union Colony planned a number of canal systems (Figure 13) designed to irrigate the lands of the benches above the river. The first of these, Canal No. 1, was never constructed, but it was planned to head near the mouth of the canyon and end near Crow Creek. This canal would have served most of the lands now irrigated by the Larimer County Canal and the Larimer and Weld Canal. Canal No. 2, now known a as the Greeley No. 2 Canal, was begun in the fall of 1870. Canal No. 3 was the first built after the arrival of the colonists on the southside of the river near Greeley. Canal No. 4, also not constructed, was to have headed on the Big Thompson River and irrigated the bluffs to the south of Greeley. This land is now irrigated by Big Thompson River water with supplemental Colorado-Big Thompson water through the Greeley-Loveland Canal.

The next large canal constructed, which involved the enlargement and lengthening of an existing ditch, was the Larimer and Weld Canal. This canal was constructed during the period 1879-1881, when it was enlarged to 571 cfs. The Larimer and Weld Canal, the largest of the canals drawing water from the Poudre, heads just north of Fort Collins and runs to Crow Creek near Barnesville.

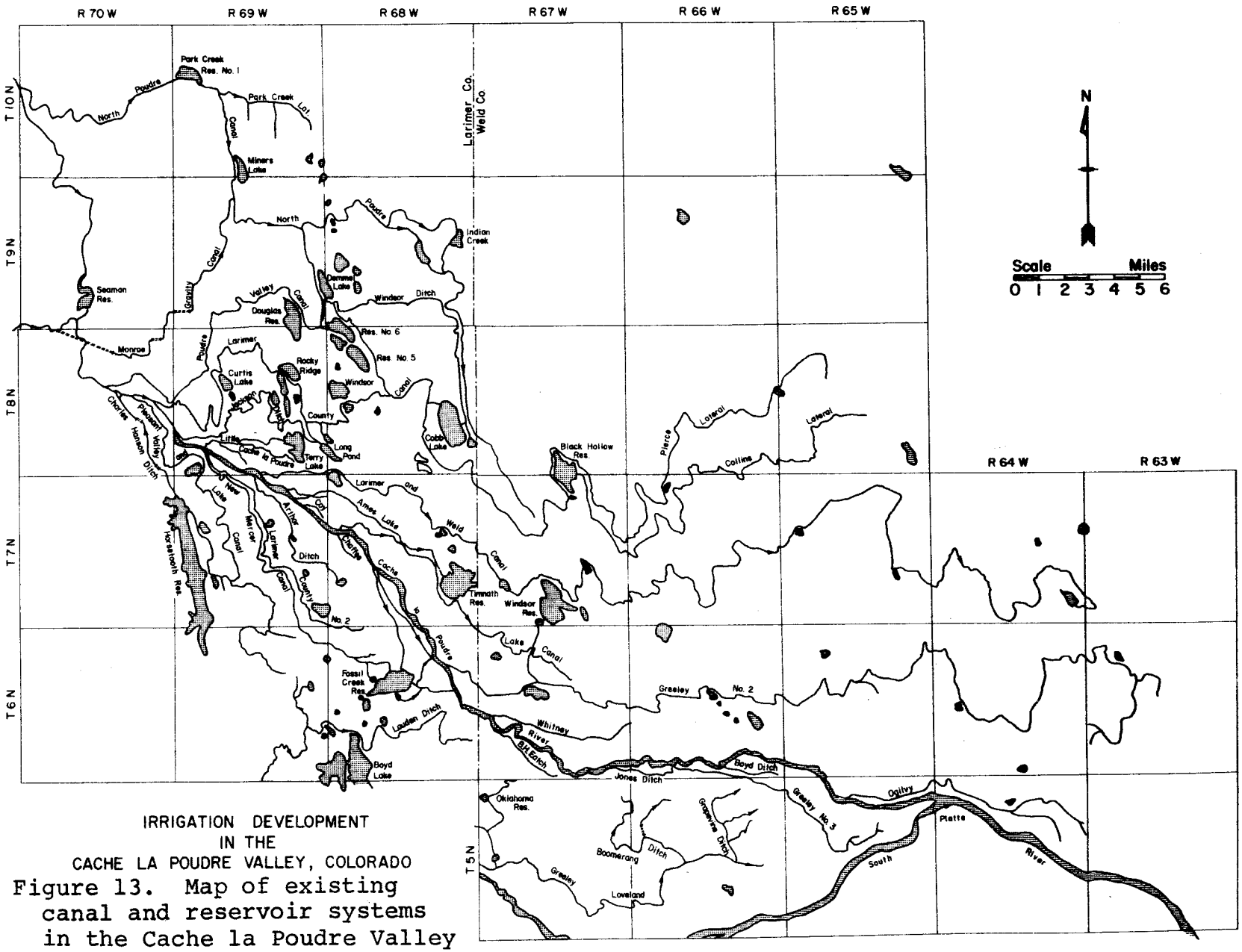
There is an extensive and detailed system of laterals to deliver water from the main canals to the fields. Generally, these laterals follow the tops of the ridges and, therefore, run at the slope of the ridges and require drop structures. Where there are several farms under a lateral, the owners have often formed lateral ditch companies. These small companies operate in the same manner as the large companies and, although they use water from a canal, are often completely independent.

Another ditch constructed above the Larimer County Canal which extends past the end of the North Poudre Canal was the Laramie-Poudre Canal. This canal ran discontinuously for a few years until 1928 when it was abandoned.

The above discussion pertains only to the large canals, but there were several smaller ditches constructed during the period of interest. The listing of water rights for each irrigation company as listed in Table 6 provides a vivid picture of the multitude of canals and ditches traversing the valley.

The framework of the canals conforms approximately to the contour lines and provides a general indication of the character and slope of the country. As the map in Figure 5 shows, most of the irrigated lands lie north of the river; the most notable exceptions are near Fort Collins and a small area near Greeley.

Most of the ditches have been operated and managed on the premise of collecting the return flows from canals lying above and reapplying this water to the land. In fact, many of the canal companies could not operate, would not have enough water to irrigate all of their lands, if it were not for this additional water from return flows. The Bureau of Reclamation has made the observation that the seepage losses of a canal are



IRRIGATION DEVELOPMENT
IN THE
CACHE LA POUDRE VALLEY, COLORADO

Figure 13. Map of existing canal and reservoir systems in the Cache la Poudre Valley

Table 6. List of water rights by irrigation company.

Canal Name	Priorities	Amount	Date(1800's)
Ames Canal (Cap. 20 cfs)	25	17.97	10-1-67
Arthur Ditch (Cap. 110 cfs)	2	0.72	6-1-61
	19	2.165	7-1-66
	29	2.165	6-1-68
	32	1.67	6-1-69
	38	31.67	4-1-71
	52	18.33	7-20-72
	66	52.28	4-1-73
B. H. Eaton (Cap. 40 cfs)	9	29.10	4-1-64
	18	3.33	6-1-66
	53	9.27	7-25-72
Boxelder (Cap. 60 cfs)	15	32.5	3-1-66
	23	8.33	5-25-67
	30	11.93	7-1-68
Greeley #3 (Cap. 185 cfs)	35	52.0	4-1-70
	46	41.0	10-1-71
	50	63.13	7-15-72
	59	16.66	5-15-73
Chaffee (Cap. 22 cfs)	48	22.38	3-10-72
Coy (Cap. 32 cfs)	13	31.63	4-10-65
Jackson (Cap. 60 cfs)	3	11.67	6-10-61
	36	14.42	10-21-70
	67	12.13	9-15-73
Jackson	91	12.70	7-15-79
Ft. Collins Pipeline	1	3.5	6-1-60
(Cap. 28 cfs)	5	2.5	3-1-62
	6	7.0	3-15-62
	12	2.78	9-15-64
	14	4.5	5-1-65
Greeley Pipeline (Cap. 30 cfs)	6	5.0	8-1-62
	6½	7.5	
Jones Ditch (Cap. 25 cfs)	24	15.52	9-1-62
Lake (Cap. 165 cfs)	54	158.35	3-1-62
Larimer County Canal	5	10.77	3-1-62
(Cap. 500 cfs)	12	13.89	9-15-64
	28	4.66	3-15-68
	56	4.0	3-20-73
	84	7.23	4-1-78
	100	463.0	4-25-81
Larimer County #2	14	3.5	5-1-65
(Cap. 180 cfs)	57	175.0	4-1-73

Table 6. (Continued)

Canal Name	Priorities	Amount	Date(1800's)
Larimer & Weld (Cap. 850 cfs)	10	3.0	6-1-64
	16	1.47	4-1-66
	21	16.67	4-1-67
	45	75.0	9-20-71
	73	54.33	1-15-75
	88	571.0	9-18-78
Little Cache la Poudre	31	62.08	
(Cap. 125 cfs)	58	20.42	
Munroe Canal - North Poudre	199	250.0	
(Cap. 250 cfs)			
Greeley #2 (Cap. 600 cfs)	37	110.0	10-25-70
	44	170.0	9-15-71
	72	184.0	11-10-74
	83	121.0	9-15-77
New Mercer (Cap. 105 cfs)	25	7.03	10-1-67
	33	4.17	9-3-69
	47	8.33	10-10-71
	49	15.0	7-1-72
	98	136.0	2-15-80
North Poudre Canal	2	.72	7-20-72
(Cap. 125 cfs)	17	4.75	8-15-73
	19	2.165	5-15-74
	29	2.165	2-1-80
	40	4.0	3-1-83
	52	15.0	10-1-84
	60	7.2	10-1-88
	61	9.38	2-20-90
	63	3.32	5-1-94
			Date(1900's)
	66	11.0	4-30-00
	69	3.32	8-1-01
	77	6.72	5-15-03
	79	6.72	11-1-04
	80	6.72	11-2-04
	82	2.85	12-31-24
North Poudre Canal	97	307.0	
Ogilvy (Cap. 70 cfs)	122	91.0	7-1-81

Table 6. (Continued)

Canal Name	Priorities	Amount	Date(1900's)
Pleasant Valley & Lake	4	10.97	9-1-61
(Cap. 138 cfs)	11	29.63	6-10-64
	51	16.50	7-10-72
	92	80.83	8-18-79
	102C	-----	10-10-81
Poudre Valley Canal	--		
(Cap. 450 cfs)			
Taylor & Gill (Cap. 20 cfs)	17	12.17	4-15-66
Whitney Ditch (Cap. 70 cfs)	7	48.23	9-10-71
	43	12.95	

"reclaimed" by catching the return flows and seepage from the higher canals.

Because the Poudre was one of the first rivers in Colorado to be heavily used for irrigation, it was also one of the first to encounter the associated problems of irrigation. The problems were similar to the difficult questions confronting all heavy water-use areas, but the solutions appear to be unique -- due mostly to the large numbers of reservoirs and large total storage capacity of the system in the Poudre Valley.

The Reservoir System

The profitable cultivation of the Cache la Poudre area is made possible by an intricate system of reservoirs and the exchange of water which has evolved from necessity.

There are numerous depressions scattered through the plains drainage area which are a result of natural phenomena. The depressions or basins, 5 to 50 feet deep, are the result of wind action which scoured the soil, carried it to other areas, and then deposited it.

Some of these depressions collected rain water and formed watering holes and "Buffalo Wallows." These same basins now provide facilities for storing surplus water at a relatively low expense as demonstrated by the listing of reservoirs in Tables 7 and 8.

The discovery was made at an early date that these natural depressions could have their holding capacity tremendously increased by building an embankment across a saddle in a rim and joining it to higher ground. This construction process was undertaken at a large number of depressions to form the existing reservoir system. Many of the small depressions were not improved and consequently these areas provide excellent habitat for mosquitoes and contribute to an existing local problem of high water tables from seepage. Also, this land is not available for agricultural production because it is too wet to farm.

As an example, the North Poudre Irrigation Company has an extensive system of canals, tunnels, syphons, and interconnected reservoirs. One of the largest groups of natural basins in the state lay below this canal and promised easy development of reservoir sites, which was the main reason for construction of the system. However, the rights of the system are subsequent to almost all the rights on the river. Due to this shortage of water, development of lands tributary to this canal has not been as rapid or as advanced as that of the lands elsewhere in the valley. Ground water mining was the only source of supplemental water. Today, the North Poudre irrigation system is thought by some to be one of the most important factors in the local economy because of playing a larger role in the general exchange system than any other irrigation company in the area.

Table 7. Major reservoirs and capacities in the Cache la Poudre system.

Name	Cap (AF)	Ownership
Black Hollow	7,485	Water Supply & Storage Co
Timnath (Cache la Poudre)	10,070	Cache la Poudre Res Co (Greeley No 2)
Claymore	883	Pleasant Valley & Lake Canal
Cobb Lake	22,300	Windsor Res & Canal Co
Curtis	1,525	Water Supply & Storage Co
Douglas Res	8,834	Windsor Res & Canal Co
Fossil Creek Res	11,508	North Poudre
Indian Creek Res	1,908	North Poudre
Luna Pond (Res No 5)	4,082	Water Supply & Storage Co
Kluver Res	1,503	Water Supply & Storage Co
Demmel (Res No 2)	3,910	North Poudre
Hackel (Res No 3)	3,441	" "
Res No 4	1,674	" "
Bee Lake (Res No 5)	8,413	" "
Res No 6	9,986	" "
Clarks Lake	871	" "
Res No 15	5,526	" "
Res No. 8	10,524	Windsor Res & Canal Co
Res No 8 Annex	3,607	Windsor Res & Canal Co
Richards Res (Res No 6)	960	Water Supply & Storage Co
Rocky Ridge	4,492	Water Supply & Storage Co
Terry Lake	8,145	Larimer & Weld Res Co
Warren Lake	2,354	Warren Lake Res Co
Water Supply & Storage No 3	4,750	Water Supply & Storage Co
Water Supply & Storage No. 4	1,012	Water Supply & Storage Co
Windsor Lake	1,275	New Cache la Poudre Irrigation Co
Windsor Res	17,689	Windsor Res & Canal Co
Woods Lake Res	2,687	Woods Lake Farms Co
Horstetooth Res	151,752	U.S.B.R.

Table 7. (Continued)

Name	Cap (AF)	Ownership
Park Creek	7,155	North Poudre
Barnes Meadow	898	City of Greeley
Big Beaver (Hourglass) Res	1,693	City of Greeley
Chambers Lake	8,824	Water Supply & Storage Co
Comanche Res	2,629	City of Greeley
Dowdy Res	1,619	Colorado Dept. of Game, Fish & Parks
Italligan Res	6,428	North Poudre
Tor Wright Res	800	North Poudre
Luna Drain Res	4,400	Water Supply & Storage Co
Peterson Res	892	City of Greeley
Seaman Res	5,008	City of Greeley
Eaton (Worster) Res	3,749	Divide Canal & Res Co (Larimer & Weld)

Table 8. List of minor reservoirs most of which have very little data available.

Plains Reservoirs

Drake Reservoir
Neff Lake
Seeley Lake
Lee Lake
N. Gray Reservoir
S. Gray Reservoir
Gray No 3 Reservoir
College Lake
Dixon Reservoir
Donath Reservoir
Gress Reservoir
Kitchell Reservoir
Deadman Lake
Nelson Reservoir
Benson Lake
Williams Reservoir
Mahood Reservoir
James Reservoir
Angel Lake
Saxton Lake
Packard Reservoir
Owl Creek Reservoir
Antelope Reservoir
Brewer Lake
Howards Lake
Briscoe Lake
Lindies Lake
Darling Reservoir
Neuman Reservoir
Watson Lake
Cole Reservoir
Mason Reservoir
Rowe Bros. Reservoir
McGrew Reservoir
Thomas Lake Reservoir
Oklahoma Reservoir
Bubbles Lake
Caverly Reservoir
Crom Lake
Hinkley Lake
Morris Reservoir
Duck Lake
Mud Lake
Loop Lake
Law Reservoir
Franklin Lake
Swanson Lake

Mountain Reservoirs

Trap Lake
Twin Lake
Zimmerman Lake
Cameron Pass Reservoir
Timberline Lake
Bellaires Lake

Reservoirs under the management of the North Poudre Canal include the newly constructed Park Creek Reservoir, Halligan, Fossil Creek, the Boxelder Reservoirs, Clark Lake, Indian Creek Reservoir, Miners Lake, Caverly, Spitzer, Demmel, Wasson, Bee Lake, Hackel, Reservoirs No. 4, No. 6, and No. 15, and some others. Although the North Poudre Canal is the northern-most company, it is of particular significance to note that it is a major stockholder in the Fossil Creek Reservoir which is almost at the southern-most boundary of the entire system. The twenty-six mountain reservoirs have a total decreed capacity of about 48,000 ac-ft. Most of these are owned by irrigation companies, and six are owned by the city of Greeley.

The Plains Storage Rights for approximately 65 reservoirs have decreed storage amounting to about 176,200 ac-ft (without Horsetooth Reservoir). There are approximately 90 or more reservoirs in the plains section. Many of these reservoirs have been operating at less than decreed capacity due to sediment buildups, phreatophytic growth, and deterioration of the facilities.

Historically, the mountain reservoirs are filled during periods of high runoff caused by melting snows. The plains reservoirs are usually filled from April to June with some fall storage, but some are filled during the period of October to May when other uses do not require the water. Most of the reservoirs lie on the northern upstream half of the canal system, and there is little conflict from downstream users to fill the reservoirs, if a call is not on the river.

The right to use water for storage purposes during the irrigating season is junior to those rights for direct irrigation. That is, when all the water in the river is needed to satisfy rights for direct application to the land, no water can be taken into storage.

Reasons for an Exchange System

The Cache la Poudre River has more land available for irrigation than there is water to supply it, as is the case in most of the arid West. As was stated earlier, this area was one of the first to develop; it was also one of the first areas to encounter the problems caused by an inadequate water supply. This area was also one of the first to solve the problem.

The flow of the Cache la Poudre River is always highest in June with an average virgin flow of 1769 cfs. The maximum monthly virgin river flow for the last 35 years has been 3590 cfs, and the minimum, 530 cfs.

Using the list of existing appropriations of Cache la Poudre water users, it can be shown that most of the canals have several enlargements over their original decree, each of which has a priority date dependent upon the date of construction of the expansion. For instance, the Greeley No. 2 Canal has an original decree, No. 37, for 110 cfs, with claims prior to theirs for river water for the amount of 759.26 cfs. The Greeley No. 2 Canal secured three more enlargements, the last

being No. 83 which credited the canal with an additional 121 cfs, making a total appropriation of 585 cfs. However, the third enlargement is preceded by prior demands on the river for 2574.9 cfs, which must be satisfied before the 121 cfs can be diverted.

The Larimer and Weld Canal has a fourth enlargement, No. 88 for 571 cfs, its main appropriation, which is preceded by claims on the river for 2735.87 cfs. The Larimer County Canal has appropriation No. 100 for 469.80 cfs with senior claims in the amount of 3653.91 cfs. The North Poudre Canal has an initial appropriation for 315 cfs, but has to satisfy prior rights for the amount of 4129.71 cfs.

As can be seen from the above discussion, most of the major canals could not operate even in June, the largest water month of the year. The average river flow at the mouth of Poudre Canyon for June is 1769 cfs, while the last enlargement for the Greeley No. 2 Canal has 2575 cfs in prior claims. The river has had two years in the last 35 which could satisfy these claims, much less the rights of the Larimer and Weld Canals or the North Poudre Canal.

Ignoring the contribution of the Colorado-Big Thompson water which started in 1951, it was the above conditions which caused the evolvement of an intricate exchange system.

Anderson has stated that the existing exchange system for this area was possible for three major reasons: (1) company ownership of water rights; (2) development of private and corporate storage reservoirs, and (3) the contribution of the Colorado-Big Thompson Project (C-BT).[478]

Company ownership of waters removes the restriction that a water right is appurtenant to a specified tract of land and allows the water to be moved between several parcels of land. The reservoir system made possible a dependable water supply late in the summer. The C-BT, under its charter, can easily transfer water anywhere within the Northern Colorado Water Conservancy District (NCWCD) from any one use to any other use.

There are three basic types of transfers which have evolved along the Cache la Poudre River: (1) exchanges between stockholders in a company; (2) exchanges between companies; and (3) exchanges of C-BT water.

Transfers involving persons belonging to a ditch company are handled by the company office, if the canal is large; or, if it is a small ditch or private reservoir, on an individual agreement-payment basis. The large companies often maintain a service to facilitate the "rentals" by having a list of those who have surpluses and how much water is surplus; and, when any stockholder requests additional water, the company can effect the transfer with a minimum of difficulty. Many companies set a fixed rate of exchange while others leave the price up to the seller. Also, some ditches have elected to have no intra-ditch exchanges (e.g., the Whitney Ditch). Anderson, again, has stated that these exchanges amount to about 6 percent of

the total diversion. These intra-ditch transfers have a legal basis under Colorado Law as stated below:

> CRS 1963, 148-6-5 It shall be lawful for the owners of ditches and water rights taking water for the same stream, to exchange with, and loan to, each other, for a limited time, the water to which each may be entitled, for the purpose of saving crops or using the water in a more economical manner; provided, that the owners making such loan or exchange shall give notice in writing signed by all the owners participating in said loan or exchange, stating that such loan or exchange has been made, and for what length of time the same shall continue, whereupon said water commissioner shall recognize the same in his distribution of water.

Some people have been able to acquire more water than they can possibly use and rent this excess every season. Since there is no property tax on a water right, renting of water can be a lucrative source of supplemental income.

Transfers between ditch companies take place only in conjunction with the reservoirs in the valley. From the previous discussion, and a look at the map of the reservoir system, it can be discerned that very few reservoirs can be made to actually serve the lands of their owners. Fortunately, through the Cache la Poudre solution to water shortages, whether a reservoir lies above or below a canal is of little significance as long as it can be utilized or the exchange is the only criterion for usefulness.

The exchange system was the child of necessity because it had become imperative to move the water from areas where it could not be utilized to where it could be used. The main reason for the exchanges was that the ditches with high priority dates and no reservoirs wished to ensure themselves of a late water supply, while the other junior rights just needed to ensure themselves of a water supply.

The process gained legal acceptance in 1897 when the following law was enacted legalizing the exchange and providing for the measurement of waters:

> CRS 1963, 148-6-4 When the rights of others are not insured thereby, it shall be lawful for the owner of a reservoir to deliver stored water into a ditch entitled to water or into the public stream to supply appropriations from said stream, and take in exchange therefor from the public stream higher up an equal amount of water, less a reasonable deduction for loss, if any there be, to be determined by the state engineer. Provided, that the person or company desiring such exchange shall be required to construct and maintain under direction of the state engineering measuring flumes or weirs and self-registering devices at the point where the water is turned into the stream

or ditch taking the same or as near such as is practicable so that the water commissioner may readily determine and secure the just and equitable change of water.

There are some other values of the transfer system besides the more economical use of water. There is the fact that it does not involve lengthy and costly litigation for changes in points of diversion. Also, the use of water on the upper portions of a stream for irrigation will increase the natural flow of the stream by return flows later in the season and prevent low stages which would occur without the regulatory action of subsurface return flows. In time, the return of seepage flows will ensure the lower portion of the drainage a steady supply and thereby enable larger acreages to be farmed or cultivated. However, the last brings about a relatively minor decrease in water quality.

Municipalities such as Boulder, Loveland, Greeley, Fort Collins, and Longmont have competed for any C-BT water being sold, even if it is not immediately needed, thus raising the price to a point where, if a farmer no longer wants C-BT water, it will invariably go to a municipality because agriculture cannot afford to pay for it.

Although the municipal and domestic water districts have acquired almost 23 percent of the C-BT water, the loss to agriculture is not as great as it would seem at first glance for three reasons: (1) the cities have expanded and taken over lands previously used for agriculture; (2) there are much larger return flows from cities than from a corresponding agricultural area, even though the same amount is approximately needed on a per acre basis for both uses; and (3) at the present time, the cities have surplus water and are "renting" it to agricultural and industrial users.

Transbasin Diversions and Imports

The natural flow of the Cache la Poudre River is augmented by a number of transmountain and transbasin diversions. The Cache la Poudre River is over-appropriated as are most streams in Colorado and the imported water was developed to supplement the supply. However, the direct importation is limited as a result of a number of federal stipulations and litigations such as the Laramie River Decree, the Colorado River Compact, and the North Platte River Decree.

At the present time, the largest imported or foreign water into the Cache la Poudre drainage is the Colorado-Big Thompson Project (C-BT).

It should be recalled from the previous discussion, that with the passing of time the number of canals in the valley continued to grow and the area rapidly overtaxed the capability of the Poudre River. It was also found that in the latter part of the year there simply was not enough water to adequately supply crops so that annually crops burned. The change came in the form of the Colorado-Big Thompson Project. This Project

was initiated before the Second World War but its completion did not occur until 1956, due to shortages in World War II and the need to satisfy water rights on the western slope.

The project was designed to collect water from the watershed of the Colorado River and transport it through a 13.2 mile tunnel beneath Longs Peak into a tributary of the Big Thompson River. Water deliveries were begun in 1951. Of all the water developed by C-BT, approximately 46 percent is allocated to the Cache la Poudre area.

Horsetooth Reservoir, with a capacity of 151, 752 acre-feet, is the main facility in the Cache la Poudre area. The reservoir supplements agricultural and domestic water users as well as fulfilling a recreational function. The Colorado Big Thompson Project is capable of supplying about 720,000 acre feet of water to the Colorado eastern slope area. However, even before the project was entirely completed, it was supplying water to the eastern slope. For example, 1954 was an extremely dry year and even though the project was not completely finished, it was able to supply well over 300,000 acre feet of water which saved many of the crops that particular year.

The Colorado Big Thompson Project involves a combination of two agencies. The first one is the Northern Colorado Water Conservancy District (NCWCD), which has the distinction of being the first water conservancy district in the United States. This agency is an organizational entity which contracted with the federal government to maintain the irrigation system and to repay the government contract which was held for the construction of the Project. On the other hand, the NCWCD is not responsible for power generation and the operation and maintainance of a power system. Such a responsibility is completely under the control of the Bureau of Reclamation. Yet, the Conservancy District and its shareowners do enjoy the advantages of the revenues from the power generation. Such revenues are poured back into the cost of operating the irrigation part of the Project and this creates a savings for the water owners.

In addition to C-BT, there are or have been nine other trans-mountain diversions (Table 9) of which six are still in operation. These mountain diversions contribute about 45,000 acre-feet of water annually to the valley.

There are also four transbasin diversions from the Big Thompson River. They are the Louden Ditch and three via the Greeley-Loveland Canal, the Boomerang and Grapevide Laterals and Oklahoma Reservoir.

Interestingly, the development of the transmountain diversions started at about the same time as reservoir development in the Cache la Poudre Valley was undertaken.

Finally, in the general overview on water supplies in the areas a few remarks can be made concerning groundwater development. Within the criteria of maximum development of all water sources in a basin, there are tremendous economic benefits to

Table 9. Transmountain diversions contributing to the Cache la Poudre Valley (except Colorado-Big Thompson Project).

Name	Period of Operation	Average Flow Per Year AF	Ownership
Laramie Poudre Tunnel	1914-1970	10902	Water Supply & Storage (2/3) Larimer & Weld Canal (1/3)
Wilson Supply Ditch	1914-1970	2248	Larimer & Weld Canal
Michigan Ditch	1913-1970	2285	North Poudre Canal
Cameron Ditch	1912-1970	196	Water Supply & Storage Co
Skyline Ditch	1895-1970	12390	" "
Grand River Ditch	1896-1970	12622	" "
Bob Creek Ditch	1920-1950	282	City of Greeley
Columbine Ditch	1921-1956	95	City of Greeley
Lost Lake	1899-1944	219	Water Supply & Storage

be derived from coordinating the use of surface and ground water. Conjunctive utilization requires an accurate knowledge of ground water use, water table fluctuation and trends, and quality, plus an understanding of the local economic, legal, social, and political views and conditions.

There is a severe shortage of ground water information in the Cache la Poudre Valley from which to base any estimates of safe yield, data on water quality, or annual recharge and outflows of the subsurface waters. There is very little antecedent information on pumping yields, ground water levels, or pumping tests. Information regarding geologic factors, natural recharge, and deep percolation of irrigation waters is inadequate for a rigorous evaluation of the system.

According to Rohwer, the first irrigation well in the Cache la Poudre area and in the state was dug in 1885 east of Eaton by E. F. Hurdle, who later dug two other wells nearby. The pumps were probably driven by a steam tractor engine and later converted to gasoline.[479]

In 1913, about 27 wells for irrigation in the Cache la Poudre Valley were reported. In 1941, Code stated that there were 593 irrigation wells.[480] By 1964 it was indicated that there were about 1300 irrigation wells pumping an estimated 85,800 acre-feet. At the present time, there are about 1396 wells having an approximate annual volume of 200,000 acre-feet.

The Organization of Irrigation Companies

Parallel to physical developments concerning the supply and distribution of water in Poudre Valley, there have also been organizational changes and the building of institutions aimed at maximizing agricultural production. Thus, before we proceed with the topics of water related land use, water budget analysis, and a concluding discussion as to the challenge (and opportunity) of consolidation in the Valley, we need briefly to summarize key points of the organization and functioning of irrigation companies.

As mentioned earlier, the natural flow of water through Poudre Valley is exclusively through the Poudre River. Even impounded water finds its way, one way or another, into the Poudre River and then is diverted out of the Poudre River by the river commissioner. The natural flow of the Poudre River, supplied primarily by the Rocky Mountains west of the Fort Collins area, is augmented by a diversion canal which brings water from the Laramie River, and by water which comes from the Colorado Big Thompson Project and which is stored in Horsetooth Reservoir.

The return flow is also very significant in the Poudre Valley area because such a flow is ajudicated and owned by various irrigation companies. This water is impounded generally at the lower end of an irrigation company's area and it is then traded to another company which is located down river from the first irrigation company. This second irrigation company,

the lower company, will trade water which is impounded in the mountains to the upper company for the water that they have stored here in the Valley. For example, the North Poudre Irrigation Company is located in Wellington; the New Cache la Poudre Irrigation Company is located in Greeley. During the irrigation year the North Poudre Irrigation Company in Wellington irrigates its land and stores the water in the Reservoir adjacent to Windsor. This water is then traded to the New Cache la Poudre Irrigation Co. which runs the water from Windsor Lake into its canal system and irrigates the land around Greeley. To repay this debt the New Cache la Poudre Irrigation Co. gives the North Poudre Irrigation Co. water which is stored in lakes at the mountains west of Fort Collins.

This complex use of return flow allows the farmers in the Poudre Valley area to first of all, optimize the water which is potentially available to them; and secondly, and more important, such procedures allow various people in the area to obtain the water which they are entitled to according to their water rights. Without this very complex system of water trades it would be impossible to irrigate the amount of land which is presently being tilled in the Greeley-Fort Collins area. In addition, this water supply has been augmented by water from deep water wells. The water is pumped directly from the ground, dumped into irrigation ditches and used as flood irrigation from that particular point on.

To conclude the introduction setting the stage for the organization of irrigation companies, the Poudre Valley area presently has few prospects of gaining new water from outside areas. All of the water which is available on the western slope is owned by various organizations and cannot be diverted to the eastern slope. All of the water which is available in the Poudre River has been ajudicated and these rights have been so totally exploited that the last rights on the river can only be satisfied if the Poudre River is in a state of virtual flood. The potential of exploiting the underground resources in drilling more wells is also significantly limited by the state engineer's office because the state engineer is now compelling farmers to register their wells. This is nothing more than a preliminary step toward ajudicating water wells in the Fort Collins - Greeley area. The ajudication of wells becomes necessary because so many people have been exploiting the underground water, that the water table began to drop at an alarming rate.

Legally irrigation water is defined as the property of the people of the state of Colorado and this water is to be used in a way which is deemed beneficial to the people of that state. Historically, water has been a very emotionally-laden issue in the Poudre Valley area because this has been an area of very fertile land but chronically water short. Despite the help provided by the Colorado-Big Thompson project, water is still in somewhat of short supply. The water companies in the Fort Collins area are defined by the State in the water laws. All of the irrigation companies in the area, and there are about 40 of them, have 5 men on the board of directors. The larger companies serve as high as 350 members and the smallest

companies serve as few as 15 members. Ninety percent of all water in the area is supplied by 4 irrigation companies. These companies are the Eaton Ditch Co., Eaton, Colorado; the North Poudre Irrigation Co., Wellington; Water Supply and Storage, Fort Collins; and the New Cache la Poudre Irrigation Co., located in Greeley. All of these companies date back into the mid-1800's for their water rights. However, it should be pointed out that these major four companies are in a sense large federations, since all four of them serve several smaller companies as a part of the main company. Such an arrangement is nothing more but an economic means attempting to maximize the efficiency of the irrigation companies. These companies are organized under the direction of the state engineer's office and Colorado state law. All of them are mutual companies with no dividends paid to the shareholders, other than those expressed in the form of irrigation water. The general water authority delineation can be seen in the descriptive diagrams of Figure 14.

The board of directors in the companies of the valley receive their position through election by shares. Every person who owns property is able to vote and help elect the man who he feels should be chosen to represent him on the water board. Because of many part-time farmers in the area, much of the voting is done by proxy vote. The role of the members of the board of directors in Poudre Valley is one of forming policy. Their task is not to say how the company should be run in its day-to-day operation but primarily as to what the general policies should be and how such policies should be implemented in the day-to-day operation. All in all, the role of a representative or board member is one of directing the irrigation company in a way that it will be most beneficial for the majority of the water owners in the company. Since board members are considered representatives of various groups, their task of representation is also one of maintaining the best interests of particular groups who own shares in the irrigation company. In interviews conducted in the Valley, no one felt that being on the board of directors was a terribly prestigious position. All people interviewed felt it was a necessary task which must be done so that water will be delivered, delivered economically, and that the irrigation company will have an administration which will see that the task gets done. It was noted, however, that all board members of the irrigation companies during the field investigation, were relatively successful farmers and for the most part elderly. They had the time to invest in administering the irrigation company because they were semi-retired or in a few cases, totally retired.

The same is also true for the actual management of the irrigation companies, which tends to have older persons. Retirement of ditch riders and water masters is something which most irrigation companies dread because most irrigation management people maintain these positions for many years. Quite often, the board of directors will not permit a man to retire when he reaches retirement age because they feel he is too valuable to be replaced by a beginner. The expertise and training of such people is primarily one of applied knowledge. By working long on the system, the water master or the ditch rider

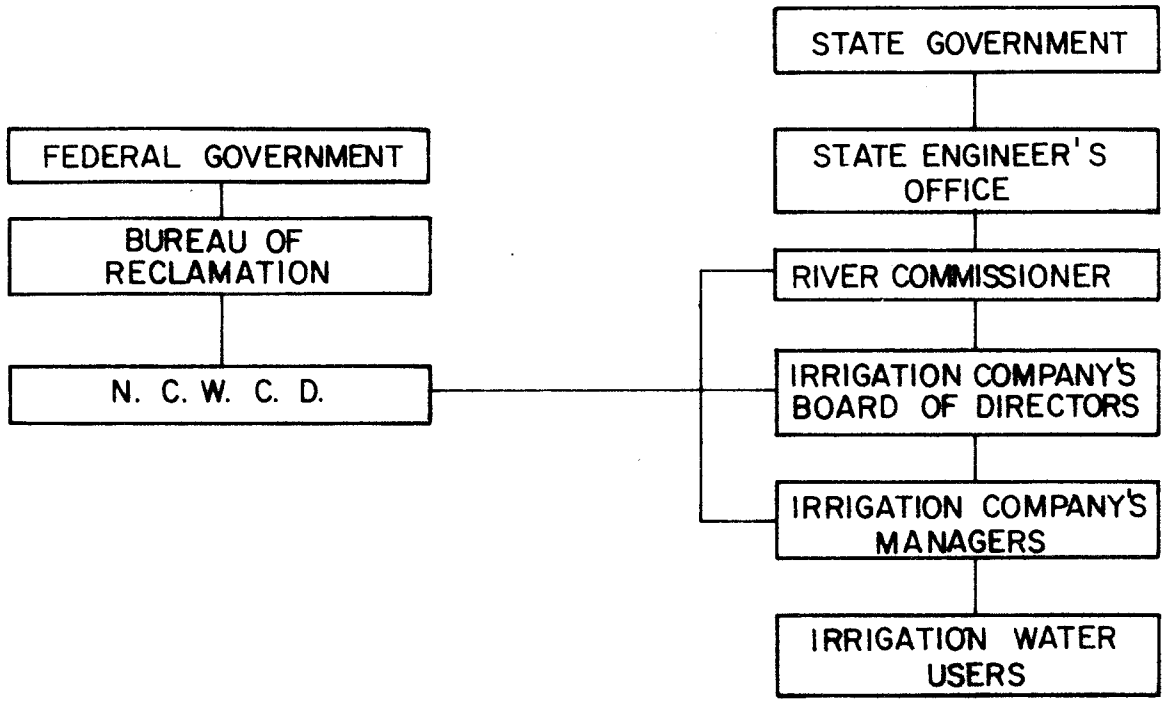


Fig. 14. Descriptive Chart of Water Authority in Poudre, Colorado

has an immense understanding of every day problems and the intricacies of distribution, and he is capable to deal with the problems which are encountered through his applied knowledge. As indicated above, the board of directors dictates only general policy to these men. The day to day operation of irrigation companies is something which the managers themselves take care of. Thus, the task of hiring a new water master is a very uncomfortable process for an irrigation company and the members of the board do their best to keep their men as long as possible. On the other hand, the effect of the shareholders on the managers is somewhat distant. Although they receive their instructions in terms of general policy from the board of directors, the water masters and ditch riders still have to maintain a great number of ties with the irrigators themselves as they actually deliver the water to these shareholders. As a result, many of the management people have defined themselves as being someone who has to sympathize with the problems of the various farmers and act as intermediaries offering help for the alleviation of individual problems.

Broadly speaking, the irrigation companies in Poudre Valley are more or less the same as they were 75 to 100 years ago. However, when it is absolutely necessary, certain innovations and changes must be undertaken. Changes in the surrounding environment, new conditions of life, and the need to maintain or improve the efficiency of the system, provide a continuous challenge to the survival of a given company. Canal lining, for example, or the maintenance of the physical effectiveness of the system is a task which most irrigation companies simply have not engaged in. The cost of lining canals has been considered prohibitive, although on occasion seepage has been so terribly high that some canals had to be lined.

Before concluding this section on the organization of irrigation companies in the Poudre Valley, a few points need to be emphasized; namely, water rights and practices. Needless to say, the water rights themselves are strictly defined by law and firmly adhered to the rate and amount of water allocation. On the other hand, water trades, such as those described previously between the North Poudre Irrigation Co., and the New Cache la Poudre Irrigation Co., can vary from day to day, week to week, and water year to water year depending on agreements which are renewed every year.

Various other norms, traditions, and flexible organizational procedures characterize the actual operation of the various irrigation companies. For example, the norms concerning the election of board members are part of a relatively passive process. Many of the agricultural water users in the area are part-time farmers, working simultaneously in other industries in the Valley. As a result, when the annual water meetings are held, these individuals, for one reason or another, are unable to attend. Therefore, they use the mechanism of voting by proxy. A proxy vote is best described as a vote for the status quo. As a result the election of board members is nothing more than going through the motions of an election on an annual basis. There really is no consequence or significance to such an annual ritual in the eyes of many water owners in

the Poudre Valley area. For larger changes in policy (if and when a change is to be made) the decision of the board is presented to the actual electorate or the shareholders and, assuming this is a major decision, the shareholders will be asked to vote as to their disagreement or agreement with the potential change. Although this is not required by law, it is part of the organizational procedures to present such major decisions to the entire body of shareholders. On the other hand, changes concerning operational or procedural matters, require little attention, unless they involve higher costs, or for some reason they are to receive less water than they are entitled.

Generally, the members of the irrigation company typically vote for someone who is in office. The person who is occupying a particular position, is considered to be doing an adequate job. The voting is essentially routinized with most of it done by proxies and only in exceptional circumstances or grievances a more formal and longer procedure may be followed. Budgets are prepared within the organization and they are a relatively formal procedure; every year when the vote is taken the board of directors describes the new budget and analyzes the various categories. At the same time, the budget is also an informal document. Since the budget is based on the previous year's experience, any other additional expenses are simply added in as they occur. A budget is nothing more than an expected description of anticipated costs for the following year.

Finally, changes in management are somehow difficult to ascertain given the low turnover and the lengthy service of water masters and ditch riders. The major reasons for letting a manager or an employee of importance go would be one of an employee who has utterly failed to meet the expectations of the company in terms of water delivery. These include the lack of water delivery at the appointed time, and carelessness with maintaining the proper amount of water in the irrigation system so that water would be washing over the banks and breaching the canal system. These are, however, very unusual situations and the irrigation system is generally characterized by stability, routinization, and minimal personnel turnover.

Patterns of Water Use

The water from the Poudre River is used not only for agricultural purposes but also for domestic urban uses and industrial purposes. There is water available in Horsetooth reservoir for domestic purposes, but the various municipalities avoid using the Horsetooth water. This is primarily due to the fact that such water has dead algae which is fairly costly to filter. The Poudre River water, on the other hand, is very pure and, thus, it is much cheaper to divert Poudre River water, dump it into the culinary system as raw water, take it to the processing plant, and purify it as domestic water. This process is much easier and much more economical than using available water from Horsetooth reservoir. For industries also, the water is of high quality -- a fact that figured prominently in the considerations for the establishment of Kodak in Windsor.

This industry demands extremely high quality water and receives it through the Greeley Municipal Water System. Agriculturally, the water which is used in the Poudre Valley is relatively abundant and of quite high quality, too.

The efficiency in agricultural water use in Poudre Valley is typical of most western areas. Some agricultural users are sprinkling but the water that is used for sprinkling is primarily taken from water wells rather than irrigation ditches. The reason for this is that the water comes out of the wells under pressure from a pump and it is just as easy to continue to maintain this pressure and run it through sprinkler nozzles as to dump it into an open irrigation ditch. The majority of the farmers in Poudre Valley are using flood irrigation techniques; it must be pointed out, however, that a higher number of farmers in Poudre Valley use sprinkling than in the other areas of the present investigation.

The amount of irrigation water available in Poudre Valley is approximately 3.5 acre feet per acre of land. These amounts vary depending upon the water rights which have been purchased by the various agricultural water users. Since water rights in Colorado are not attached, it is very possible and conceivable for an irrigator in Poudre Valley to have a double water right or even more than this. Pumping is a matter of the individual pump owners prerogative. The owner can pump as little or as much water from his well as he wishes. The only inhibiting factor in terms of pumping is the amount of electricity that a farmer is willing to use in receiving the water. The prices in Poudre Valley vary but all costs are based on the number of shares that are owned, as well as to how large a share is. In North Poudre Irrigation Company, for example, one share equals about 6 acre feet of water and users are charged about $20.00 per share. Larimer County No. 2 ditch, which serves the Fort Collins area charges $60.00 per share, but one share equals about 100 acre feet of water. Generally, the costs are designed to cover operation and maintainance as well as contract obligations. The land owners in Poudre Valley who own Colorado Big Thompson shares, for example, are still presently engaged in the task of paying off the repayment contract to the federal government.

Another way of viewing patterns of water use in the area is to inquire about the extent of knowledge of the water situation and requirements in the valley. From preliminary interviews (with more accurate data envisaged through the in-depth survey of Phase II), the majority of people, especially the part-time farmers, are somehow ignorant concerning exact information on water supply and distribution requirements. Most of the part-time farmers (and they are a significant number) know that the water comes from the Poudre River, but beyond that, they know little as to how the water is obtained from year to year and how much they are entitled to. Quite often the extent of their knowledge is summarized in such statements as: "Well yes, I have a good water right," or "I could have a better water right." For a large number, it would be fair to say that they know little about the diversionary process, or

how many second feet they are entitled to. These are questions that are simply left to the irrigation company. The irrigation company, as far as most people are concerned is charged with the task of protecting these particular water rights. The pervasive feeling of satisfaction rests primarily on the intricate system of exchange described above. If it were not for the complex water exchanges and trades, impoundments and pumps, the water supply for the amount of land which is presently under cultivation would not be adequate.

In terms of actual scheduling, the Poudre Valley area goes from a situation of the water supply in some canals being made available totally on a demand basis, to other smaller canals operating on a rotating basis. Scheduling varies from company to company and sometimes from time of year to time of year. For example, in the latter part of the year, such as in August, when a great deal of water is needed sometimes the canals which function on a demand basis are compelled to use a form of semi-rotation (or quasi-demand) simply because the demand for water is so high and the ability of the canals to deliver much water does not exist.

The diversion of most water into Poudre Valley takes place at the mouth of Poudre Canyon approximately 12 miles northwest of Fort Collins. There are also a few other diversions which take their water directly from the Poudre River over in that area. The land in the Poudre Valley area has been leveled and very extensively prepared. This has been done by the local farmers with the cooperation of the SCS and much of the land in the area is as flat as a table and highly condusive to good crops. This is particularly true in the area around Greeley. The application of water on the farm is accomplished in three major ways: flooding, sprinkling, and a combination of sprinkling and flooding. Many times the flooding is done with water which is delivered through the canal system. It is rather economical to take water which is delivered in an open canal and simply run it across the land in a flooding fashion. Sometimes, however, the water from the pumps is delivered under pressure. This water can be dumped into an open irrigation ditch and then flooded onto the ground. However, often the farmers take advantage of the pump water being under pres sure, and simply keep the water in a pipe and sprinkle their crops. Sprinkling has two distinct advantages. One is the ease of irrigation; it is much quicker to irrigate using a sprinkling system, because the system is set and the farmer can go off and ignore it and not worry about his crops being washed away. The sprinklers can be set so that they deliver amounts of water equal to a gentle rain or an amount equal to a very heavy rain or something in-between. Sprinkling can also save a great deal of water; the water loss through seepage is almost eradicated by augmenting a flooding system with sprinklers. On the other hand, the disadvantages of sprinkling are also obvious. Sprinkling is a very expensive proposition and only the more prosperous farmers are willing, or able, to undertake this costly endeavor.

A question that is often raised in agricultural water use is that of efficiency and effectiveness of the amount utilized. Efficiency in terms of irrigation implies the output or how much can be obtained from a given plot of land for the amount of water, fertilizer, seed, and physical effort that is placed into it. Many experts tend to think only in terms of one-to-one relationships, by simply stating that one acre of land will produce X amount of crop for X amount of water. This is a rather misleading way of analyzing the amount of water and the amount of production that the water will give, primarily because it is overlooking the amount of effort invested. A farmer who plants a plot of land does not weed it, clearly will not be as productive as land which is very carefully weeded. Land which is not properly fertilized also will not be as productive as land which is very carefully fertilized. Factors such as these have to be considered when one discusses general efficiency of water use. More important, the way in which the water is applied has to be particularly considered. Land can be both over-watered and under-watered. When land is sprinkled, there is no problem of under- or over-watering because the land owner has much more precise measurements available to him. He knows exactly how much water he has put on a piece of land and how many hours or minutes that water has run. However, when flood irrigation is implemented, measurement becomes more difficult. As the water starts at the head of the land and is run through the bottom of the particular plot, the upper end of the property receives much more water, for a much longer time than does the bottom end of the plot. For this reason it is very difficult to estimate whether the land has been over-watered or under-watered. Since many farmers have more water than they really need, they tend to over-water the land simply in order to use the water right. Although it may harm their crops, they over-irrigate because they are afraid that otherwise this water will be taken from them. Here then we have the paradox where efficiency may clash with equity, a situation based on the nature of the water rights. This point, it will be recalled, was particularly discussed in Part Three as a major problematic situation for agricultural water use in the West.

Speaking of measurement as an index of efficiency, the rate of release from the reservoirs and the Poudre River are known almost down to the cubic inch. Once the water reaches the private irrigation companies, however, the ability to measure varies from a situation where excellent measurement is provided to a situation where there is no measurement whatsoever. Typcially, the larger companies provide better measurement than smaller companies. Many of the smaller companies, for example, Pleasant Valley Irrigation and Canal Co. would have to be described as totally inadequate in terms of water measurement when it comes down to the individual lateral and individual farmer or water user level; most of this water is used on small plots of land of 3 to 10 acres. Part of the present project was devoted to an analysis of water budgets. Before we proceed with such an analysis, however, it is important to relate the land uses depleting the system.

Water Related Land Use

Water related land use is one of the first and most important steps in evaluating depletions from the system. Evapotranspiration is the largest single contribution to water losses, and the acreages of the various uses can be combined with estimates of potential consumptive use and available water supplies to arrive at "ball park" figures for evapotranspiration.

The land use data utilized in this study was collected over an eight week period during the summer of 1970. The land use mapping index is listed in Table 10. The aerial photographs which covered the portions of Larimer and Weld Counties which are served by the Cache la Poudre water, or lie within the watershed, were taken during July and August of 1969. This was particularly advantageous as land use changes were minimal and adjustments and updating were easily accomplished.

The land use data has been summarized by canal and is listed in Table 11. The data presented is for the entire irrigated acreage falling within the boundaries of the study area.

Water Budget Analysis

Theoretically, a hydrologic budget can be prepared for any area or system regardless of shape or size. The ideal area for a water budget analysis has easily and accurately measured total inflows and total outflows and the budgeting procedure merely involves internal balancing to satisfy the boundary conditions set by the known inflows and outflows. The Cache la Poudre Valley, while having good measurements of the inflows, has no good measurement of the outflows. Therefore, the internal balancing procedure could not be carried out in this case. Outflows are computed, not measured, and although they are in the "ball park" they should be used with certain reservations.

Ground water outflow and/or change is the "catch-all" category of the budget. All the errors and uncomputed unknowns are reflected in this block of water. The values presented here could be in error by as much as 50 percent.

The budgets presented herein are based completely on historical data and no attempts were made to determine effects of future changes.

Also, the quantitative data have not been combined with specific water management decisions or suggested avenues of approaches to water resource problems. Such studies are expected to follow at a later date. Rather, the data have been used to determine a valley-wide mean monthly and mean annual water budget. This has been accomplished by preparing month-by-month water budgets for each of 34 irrigation companies in the valley for the time period covering the 1951-1970 water years. A month-by-month Poudre Valley water budget was obtained by summing the budgets for the 34 irrigation companies for each month. Finally, a mean monthly budget for the valley was

Table 10. Land use mapping index used in Cache la Poudre water related land use inventory - Summer, 1970.

A. Irrigated Cropland

1. Corn
2. Sugar Beets
3. Potatoes
4. Peas
5. Tomatoes
6. Truck Crop
7. Barley
8. Oats
9. Wheat
10. Alfalfa
11. Native Grass Hay
12. Cultivated Grass, Hay
13. Pasture
14. Wetland Pasture
15. Native Grass Pasture
16. Orchard
17. Idle
18. Other

B. Dry Croplands - Precipitation Only

C. Municipal & Urban Land Use

1X. Inhabited Farmsteads
1. Uninhabited Farmsteads
2. Residential Yards
3. Urban
4. Stock Yards
5. Schools

D. Industrial

1. Power Plants
2. Refineries
3. Meat Packing
4. Other

E. Open Water Surfaces

1. Major Storage
2. Holding Storage
3. Sump Ponds
4. Natural Ponds

F. Phreatophytes

1. Cottonwood
2. Salt Cedar
3. Willows
4. Rushes or Cattails
5. Greasewood
6. Sagebrush and/or Rabbitbrush
7. Wild Rose, Squawberry, etc.
8. Grasses and/or Sedges
9. Atriflex

Table 11. Land use inventory--Cache la Poudre Valley, Colorado.

	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	TOTAL
North Poudre Canal	6,722	2,172	0	36	0	0	2,595	893	134	6,952	13	2,388	857	123	920	6	99	2,238	26,148
Poudre Valley Canal	1,770	467	0	0	0	5	779	173	0	1,343	0	1,130	184	143	93	18	117	941	7,163
Larimer County Canal	15,380	6,562	96	0	32	3	1,773	1,131	598	8,554	2	1,531	1,337	74	580	103	11	3,737	41,504
Jackson Ditch	584	0	0	0	0	3	79	132	0	457	0	952	80	155	63	3	0	8	2,516
Little Cache La Poudre Ditch	366	7	0	0	0	3	16	114	0	242	0	210	78	313	56	7	0	0	1,412
Larimer and Weld Canal	26,135	6,540	612	97	0	16	2,879	1,251	283	11,721	13	882	1,828	486	368	6	163	2,294	55,574
Ames Ditch	30	0	0	16	0	0	0	0	0	17	0	0	0	58	0	0	0	15	136
Lake Canal	3,234	663	0	0	0	0	637	147	59	1,824	0	410	404	469	454	0	0	304	8,605
Coy Ditch	1	0	0	0	0	0	0	0	0	0	0	31	0	64	0	3	0	18	117
Timnath Reservoir Inlet	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0
Greeley No. 2 Canal	24,318	3,816	138	62	0	60	664	825	263	5,871	21	815	1,488	1,313	278	0	64	2,550	42,546
Whitney Ditch	763	307	0	0	0	0	291	27	36	459	0	31	48	283	0	0	0	9	2,254
Ogilvy Ditch	1,605	261	0	0	0	0	0	60	1	386	2	31	100	80	0	0	0	123	2,649
Ft. Collins Pipeline	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0
Charles Hansen Canal	160	0	0	0	0	0	0	23	182	268	0	5	96	189	0	0	0	0	923
Dixon and State Board of Ag	54	16	0	0	0	0	19	3	0	144	0	111	36	0	0	15	0	55	453
Pleasant Valley and Lake Canal	1,171	22	14	0	0	22	464	197	0	1,445	60	1,045	845	94	203	78	4	104	5,768
Greeley Pipeline	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0
New Mercer and Larimer County	6,639	1,256	59	0	0	17	2,285	639	16	3,974	0	1,507	1,387	494	217	15	0	655	19,160
Arthur Ditch	442	191	12	0	0	1	200	76	39	299	0	125	126	172	8	0	0	94	1,785
Chaffer Ditch	173	59	0	0	0	0	55	35	0	91	0	29	90	102	0	0	0	0	634
Boxelder Ditch	540	190	0	0	0	0	187	69	14	451	0	143	29	71	0	0	15	170	1,879
Fossil Creek Reservoir Inlet	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0
Louden Ditch	1,220	130	0	0	16	1	293	67	77	1,059	112	415	513	61	270	0	31	33	4,298
Oklahoma Reservoir	1,232	222	0	0	0	0	307	27	112	657	0	51	83	16	0	0	0	287	2,994
B. H. Eaton Ditch	285	182	0	0	0	0	134	0	0	271	0	16	5	53	0	0	0	78	1,024
Boomerang Ditch	2,320	107	3	0	0	0	135	52	43	643	0	14	167	24	6	0	6	128	3,648
Jones Ditch	142	0	0	0	0	0	20	0	10	128	0	0	0	52	0	0	0	3	355
Grapevine Ditch	1,774	143	16	0	0	0	33	82	0	524	0	222	156	111	224	0	0	142	3,427
Greeley No. 3 Canal	1,419	70	2	0	0	0	43	184	13	482	0	703	65	824	158	0	0	151	4,114
Boyd Ditch	157	0	0	0	0	0	0	14	0	44	0	28	37	259	10	0	0	13	562
Ft. Collins-Loveland Water District	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0
Ft. Collins Municipality	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	-0	0
Miscellaneous	696	66	0	0	0	0	62	112	0	2,019	173	1,294	196	94	95	0	0	830	5,637

Table 11. (Continued)

	P	C1X	C1	C2	C3	C4	C5	TOTAL	D1	D2	D3	D4	TOTAL	E1	E2	E3	E4	TOTAL
North Poudre Canal	34,228	295	13	0	3	507	0	818	2	0	0	360	362	0	0	20	3,043	3,063
Poudre Valley Canal	6,828	141	4	4	145	148	6	448	0	2	0	401	403	0	0	10	1,990	2,000
Larimer County Canal	15,603	560	17	1	668	905	0	2,151	0	26	0	213	239	152	94	45	1,386	1,677
Jackson Ditch	159	41	0	14	83	29	0	167	0	0	4	0	4	0	0	1	298	299
Little Cache La Poudre Ditch	45	36	0	12	136	31	0	215	0	0	0	31	31	0	0	3	129	132
Larimer and Weld Canal	8,374	591	36	25	243	1,032	0	1,927	0	0	0	199	199	1,293	4	60	1,171	2,528
Ames Ditch	83	5	0	5	32	25	0	67	0	0	0	62	62	0	0	0	19	19
Lake Canal	512	111	12	0	216	236	0	575	0	0	0	411	411	0	0	0	126	126
Coy Ditch	0	1	0	0	7	5	0	13	0	0	0	0	0	0	0	0	0	0
Timnath Reservoir Inlet	0	-0	-0	-0	-0	-0	-0	0	-0	-0	-0	-0	0	-0	-0	-0	-0	0
Greeley No. 2 Canal	13,312	533	33	57	432	1,376	3	2,434	0	0	0	737	737	184	0	99	589	872
Whitney Ditch	49	27	0	0	0	32	0	59	0	0	1	83	84	0	0	0	29	29
Ogilvy Ditch	1,331	8	16	20	0	104	0	148	0	0	0	46	46	0	0	4	230	234
Ft. Collins Pipeline	0	-0	-0	-0	-0	-0	-0	0	-0	-0	-0	-0	0	-0	-0	-0	-0	0
Charles Hansen Canal	3,351	46	0	14	54	82	0	196	0	0	0	28	28	878	0	135	46	1,059
Dixon and State Board of Ag	1,949	19	0	15	14	50	18	116	4	0	0	116	120	475	0	8	107	590
Pleasant Valley and Lake Canal	11,190	156	3	226	1,130	88	137	1,740	0	0	0	50	50	172	0	2	237	411
Greeley Pipeline	0	-0	-0	-0	-0	-0	-0	0	-0	-0	-0	-0	0	-0	-0	-0	-0	0
New Mercer and Larimer County	1,488	227	5	37	1,647	394	312	2,622	0	0	0	58	58	0	0	353	1,042	1,395
Arthur Ditch	416	18	0	3	1,449	81	215	1,766	0	0	0	212	212	0	0	0	59	59
Chaffer Ditch	16	2	0	0	0	8	0	10	0	0	0	59	59	0	0	0	38	38
Boxelder Ditch	755	10	0	0	0	30	0	40	0	0	0	33	33	0	0	0	37	37
Fossil Creek Reservoir Inlet	0	-0	-0	-0	-0	-0	-0	0	-0	-0	-0	-0	0	-0	-0	-0	-0	0
Louden Ditch	4,674	59	0	0	0	71	0	130	0	0	0	0	0	0	0	0	235	235
Oklahoma Reservoir	4,930	48	3	0	0	47	0	98	0	0	0	0	0	0	0	0	93	93
B. H. Eaton Ditch	239	9	0	0	0	10	0	19	0	0	0	0	0	3	3	3	27	36
Boomerang Ditch	1,355	66	1	0	17	58	0	142	0	0	0	26	26	0	0	0	23	23
Jones Ditch	11	3	1	0	0	3	0	7	0	0	0	0	0	0	0	0	17	17
Grapevine Ditch	911	74	0	113	417	29	50	683	0	0	0	10	10	0	0	591	87	678
Greeley No. 3 Canal	587	128	0	237	2,927	149	350	3,791	0	0	0	143	143	0	0	80	118	198
Boyd Ditch	29	4	0	0	0	2	0	6	0	0	0	3	3	0	0	5	18	23
Ft. Collins-Loveland Water District	0	-0	-0	-0	-0	-0	-0	0	-0	-0	-0	-0	0	-0	-0	-0	-0	0
Ft. Collins Municipality	0	-0	-0	-0	-0	-0	-0	0	-0	-0	-0	-0	0	-0	-0	-0	-0	0
Miscellaneous	434,089	237	13	0	125	237	0	612	13	0	0	2	15	102	0	9	1,512	1,623

Table 11. (Continued)

	F1	F2	F3	F4	F5	F6	F7	F8	F9	TOTAL	TOTAL ACREAGE
North Poudre Canal	245	0	42	207	0	0	0	3,069	0	3,563	68,182
Poudre Valley Canal	195	0	0	95	0	0	0	1,004	0	1,294	18,136
Larimer County Canal	151	0	2	350	0	0	0	1,468	0	1,971	63,145
Jackson Ditch	24	0	0	32	0	0	0	187	0	243	3,396
Little Cache La Poudre Ditch	141	0	0	0	0	0	0	26	0	167	2,002
Larimer and Weld Canal	318	0	0	493	2	0	0	1,119	0	1,932	70,534
Ames Ditch	33	0	0	0	0	0	0	0	0	33	400
Lake Canal	260	0	0	19	0	0	0	174	0	453	10,682
Coy Ditch	9	0	0	0	0	0	0	0	0	9	139
Timnath Reservoir Inlet	-0	-0	-0	-0	-0	-0	-0	-0	-0	0	0
Greeley No. 2 Canal	696	0	57	217	0	0	0	930	0	1,900	61,801
Whitney Ditch	118	0	0	17	0	0	0	51	0	186	2,661
Ogilvy Ditch	604	0	0	0	0	0	0	38	0	642	5,050
Ft. Collins Pipeline	-0	-0	-0	-0	-0	-0	-0	-0	-0	0	0
Charles Hansen Canal	47	0	0	24	0	0	0	10	0	81	5,638
Dixon and State Board of Ag	16	0	1	0	0	0	0	62	0	79	3,307
Pleasant Valley and Lake Canal	213	0	0	0	0	52	0	489	0	754	19,913
Greeley Pipeline	-0	-0	-0	-0	-0	-0	-0	-0	-0	0	0
New Mercer and Larimer County	380	0	0	48	0	0	0	857	0	1,285	26,008
Arthur Ditch	72	0	0	0	0	0	0	19	0	91	4,329
Chaffer Ditch	37	0	0	9	0	0	0	0	0	46	803
Boxelder Ditch	119	0	0	0	0	0	0	20	0	139	2,883
Fossil Creek Reservoir Inlet	-0	-0	-0	-0	-0	-0	-0	-0	-0	0	0
Louden Ditch	42	0	0	59	0	0	0	489	0	590	9,927
Oklahoma Reservoir	35	0	0	3	0	0	0	120	0	158	8,273
B. H. Eaton Ditch	93	0	0	8	0	0	0	36	0	137	1,455
Boomerang Ditch	2	0	0	39	0	0	0	201	0	242	5,436
Jones Ditch	51	0	0	13	0	0	0	51	0	115	505
Grapevine Ditch	9	0	0	43	0	0	0	26	0	78	5,787
Greeley No. 3 Canal	227	0	9	28	0	0	0	78	0	342	9,175
Boyd Ditch	1	0	0	1	0	0	0	0	0	2	625
Ft. Collins-Loveland Water District	-0	-0	-0	-0	-0	-0	-0	-0	-0	0	0
Ft. Collins Municipality	-0	-0	-0	-0	-0	-0	-0	-0	-0	0	0
Miscellaneous	461	0	269	167	0	0	0	2,474	-0	3,371	445,347

obtained by averaging each item in the budget for the 20 years. Although the water budgets cannot be completely accurate, the results are believed to be in the proper range of expected values. The mean monthly and mean annual Poudre Valley water budget is given in Table 12. Many of the numbers listed in this table require some study in order to discern how they were computed. As a result, an attempt will be made to explain how the numbers in Table 12 were developed. The explanation will proceed down the list of budget parameters.

River inflows, tributary inflows, diversions to cropland, direct reservoir use, Colorado-Big Thompson use, direct imports, river exchange, reservoir exchange, river to storage, C-BT to storage, and imports to storage (rows 1 through 11) are data derived from outside the model. These data have been collected by numerous outside sources such as the U.S. Geological Survey and local irrigation companies. At first glance, an apparent discrepancy in the budget items is the magnitude of the diversions to cropland. However, these flows represent not only the diversions directly from the river system, but also the diversions from the enormous reservoir storage in Cache la Poudre Valley, and thus can be expected to exceed river inflows.

The next segment of the budget is the quantity of water and its distribution reaching the farming areas. The total diversion to cropland (row 12) is the sum of the rows 3, 4, 5, 6, 7, and 8, plus a segment of the cropland return flows. Because of the methods employed for irrigation in the area, a certain amount of the water applied to the higher lands returns as surface runoff and possibly groundwater interception into lower lying canals. The surface water to cropland (row 13) is the total diversion minus this quantity of return flow being reused. The amount eventually being applied to the root zone is arrived at by extracting the operational losses in the canal system, and the field tailwater, both of which are functions of the conveyance efficiency and the farm efficiency assumed. The pumped water (row 15) to cropland has been explained and its percentage reaching the root zone (row 16) was computed using appropriate efficiencies. The final segment is the total amount to the root zone (row 18), which is the sum of the surface and pumped root zone quantities plus the cropland precipitation (row 17).

From this point, the fact that this budget is an average of the valley-wide budget for the previous twenty years, which in turn were derived from the individual canal budgets, must be clearly understood. It is possible to have simultaneously occurring contradictory conditions existing somewhere in the system. For example, the root zone budget shown in rows 19 through 24 is not obvious from inspection. The difference between the cropland potential consumptive use (row 19) and the actual consumptive use (row 20) is the valley-wide consumptive use deficiency listed in row 23. However, as a rule, row 24 indicated a consumptive use surplus, thereby indicating that certain irrigation companies had deficiencies while others experienced surpluses. Also, there is a variation from year-to-year for any one particular irrigation company. If one irrigation

Table 12. Mean monthly and mean annual water budget for Cache la Poudre Valley, Colorado.

		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1	River Inflows	4,400	2,400	1,800	1,800	1,800	2,200	5,700	44,300	88,600	38,300	14,600	6,900	212,800
2	Tributary Inflows	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Diversions to Cropland	9,400	1,300	1,100	1,000	1,000	1,300	4,500	50,600	89,600	58,100	36,100	22,200	276,100
4	Direct Reservoir Use	1,000	0	0	0	0	0	500	4,600	4,900	13,800	16,400	12,700	53,900
5	CBT Direct Use	1,000	0	0	0	0	0	700	8,700	6,000	21,800	31,700	15,100	85,000
6	Direct Imports	0	0	0	0	0	0	0	2,300	8,000	12,500	3,900	500	27,200
7	River Exchange	400	0	0	0	0	0	0	-900	-2,300	-4,900	-2,900	0	-10,600
8	Reservoir Exchange	200	0	0	0	0	0	100	0	3,500	800	400	0	5,000
9	River to Storage	3,700	100	0	100	0	100	4,900	10,200	14,700	600	100	800	35,300
10	CBT to Storage	3,500	0	0	0	0	0	0	0	0	0	0	1,800	5,300
11	Imports to Storage	0	0	0	0	0	0	0	200	0	0	0	0	1,100
12	Total Diversion to Cropland	13,400	2,500	1,900	1,500	1,000	3,300	9,200	87,800	134,500	140,500	147,800	85,900	629,300
13	Surface Water to Cropland	12,000	1,300	1,100	1,000	1,000	1,300	5,800	65,300	109,700	102,100	85,600	50,500	436,700
14	Amount to Root Zone	4,900	600	500	400	400	600	2,400	27,700	46,600	43,400	36,400	21,400	185,300
15	Pumped Water to Cropland	1,800	0	0	0	0	0	3,100	16,300	24,800	38,400	43,800	34,300	162,500
16	Amount to Root Zone	1,100	0	0	0	0	0	1,900	9,800	14,900	23,100	26,300	20,600	97,700
17	Precipitation on Cropland	17,700	8,400	5,000	4,700	5,500	14,700	23,600	46,100	35,500	26,500	24,200	23,800	235,700
18	Total Amount to Root Zone	23,700	9,000	5,500	5,100	5,900	15,300	27,900	83,600	97,000	93,000	86,900	65,800	518,700
19	Cropland P.C.U.	31,000	5,500	2,700	1,900	2,700	6,200	17,700	39,700	92,500	116,200	113,700	67,800	497,600
20	Cropland Consumptive Use	30,900	4,100	2,300	1,600	2,500	5,700	15,900	38,900	84,800	90,600	93,000	52,900	423,200
21	Accumulated Soil Moisture	118,200	39,000	38,600	38,700	37,400	37,500	38,200	57,500	61,000	60,500	56,800	34,000	617,400
22	Soil Moisture Depletion	0	5,200	5,700	5,600	6,900	6,700	6,100	3,700	17,000	34,400	55,000	77,700	224,000
23	Consumptive Use Deficiency	100	1,400	400	300	200	500	1,800	800	7,700	25,600	20,700	14,900	74,400
24	Consumptive Use Surplus	8,500	1,500	1,500	600	500	5,200	5,400	28,500	9,800	7,100	7,000	6,300	81,800
25	Total Return Flows	84,100	3,100	1,100	2,800	2,800	3,500	44,200	148,200	142,300	132,400	129,800	67,300	761,600
26	Cropland Return Flows	19,100	1,200	1,100	1,000	900	1,500	9,300	30,800	25,600	20,800	22,700	11,400	145,400
27	Conveyance Losses	1,700	200	200	200	100	200	900	9,800	16,500	15,300	12,800	7,600	65,500
28	Additions to Ground Water	55,000	-2,300	-100	600	300	-2,000	25,000	99,300	90,100	72,600	74,500	36,500	449,500
29	Domestic Use and W.S. Evap.	9,500	4,200	2,000	1,400	1,900	4,700	10,700	19,700	25,800	34,900	28,700	17,500	161,000
30	Supply to Wetlands	75,800	-500	1,200	1,700	1,300	-200	35,100	131,700	119,000	99,300	102,800	51,500	618,700
31	Precipitation on Wetlands	1,200	600	300	300	400	1,000	1,600	3,200	2,500	1,800	1,700	1,700	16,300
32	Wetland Consumptive Use	1,700	600	200	100	100	300	800	1,600	3,300	5,900	5,600	3,600	23,800
33	Use from Ground Water	2,500	600	200	100	100	300	3,800	17,900	28,100	44,300	49,400	37,900	186,300
34	Surface Outflows	-2,500	4,000	3,000	2,600	2,200	4,500	3,400	-12,300	-6,100	-51,400	-57,900	-35,100	-145,600
35	G.W. Outflows and/or Change	35,900	-3,500	-1,200	-400	-600	-3,500	15,700	68,500	64,500	51,800	51,800	25,100	304,100

company experiences a surplus during any one month during the 20 years, then a surplus will be shown for the mean monthly budget. The quantity shown in row 24 can only be determined from individual canal budgets. Another example is that sometimes the total supply to the root zone (row 18) is insufficient to meet potential consumptive use and is also smaller than the actual consumptive use. The difference has been provided by a removal from the root zone storage which is then reflected in the following month's budget.

The total return flows (row 25) are the flows returning from the root zone and field tailwater. The magnitude of this parameter equals the sum of the total cropland diversions and precipitation minus the actual consumptive use and the changes in the storage of the root zone. It should be noted that the available storage of the root zone has been assumed variable over the water year and is primarily a function of the rooting depths of the crops. Consequently, during the transition periods between an increasing root zone capacity and/or a decreasing root zone capacity, water in the root zone is either leaving or entering the quantity described as total return flows. The cropland return flows (row 26) have been assumed to be about 25 percent of the quantity of the sum of the total return flows and wetland precipitation (row 31), minus the sum of the domestic use and water surface evaporation (row 29), minus the wetland consumptive use (row 32), and minus conveyance losses. The 25 percent factor has not been applied when a negative value for cropland return flow has resulted from the computational process.

The addition to groundwater is another budget parameter which may be difficult to understand due primarily to the nature of the variable root zone capacities. However, the flows are the difference between the supply to wetlands minus the sum of the wetland consumptive use and the cropland return flows. The use from groundwater (row 33) is the sum of the wetland consumptive use and the pumped diversions. The groundwater outflows and storage changes are the difference between the groundwater return flows and the pumped diversion.

The surface outflows are the difference between the sum of the river inflows, tributary inflows, total return flows, and the returns from domestic use and the quantity called ATSDIV. This quantity (ATSDIV) is the total surface diversion minus the sum of the canal diversions for the Poudre Valley Canal, Fort Collins Pipeline, North Poudre Canal, the river exchanges with these canals, and the total surface diversions for the London Ditch, Oklahoma Reservoir, Boomerang Ditch, and the Grapevine Ditch.

Since the groundwater outflows from Poudre Valley are not measured, it becomes difficult to develop any reliable technique for adjusting the water budget listed in Table 12. The mean annual outflow has been computed as being roughly 300,000 acre-feet (Table 12). Some insight into the accuracy of this estimated outflow can be gleaned by looking at the accuracy of various budget items.

The direct diversions from the river system are measured, but surface return flows could only be estimated. If the discharge measurements are accurate within 5 percent, then the error would be on the order of 30,000 acre feet annually.

The potential consumptive use cannot be accurately computed unless elaborate field studies are undertaken. At best, the accuracy in estimating potential consumptive use can only be 10 percent, which would amount to an error of approximately 50,000 acre-feet per year.

An analysis of the consumptive use deficiency for each irrigation company was undertaken. In Table 13, those irrigation companies which showed a ratio of mean annual consumptive use deficiency to mean annual potential consumptive use greater than 10 percent are listed. Although not shown in Table 13, many of the irrigation companies showed a mean annual consumptive use deficiency of less than 5 percent, which is very good. The high water deficiency rates shown for the Charles Hansen Canal, New Mercer and Larimer County Canal, Dixon and State Board of Agriculture Canal, and Grapevine Ditch have lands under the canal system which are not adequately irrigated. The water deficiencies shown for the Chaffler Ditch and Greeley No. 2 Canal reflect the inability of the water budgeting procedure to take into account subirrigation, which is prevalent for the lands served by these canals. The lack of an adequate water supply for the Poudre Valley Canal is primarily due to having very little appropriated water. The consumptive use deficiency shown for the Larimer and Weld Canal may be possible, but would be suspect. The error in computing the consumptive use deficiency could easily amount to 10,000 or 30,000 acre-feet per year.

The error in computing the total surface and groundwater outflow from Poudre Valley could be roughly 90,000-110,000 acre-feet annually, with 30,000 acre-feet being attributable to errors in diversion records, 50,000 acre-feet resulting from inaccuracies in computing potential consumptive use, and another 10,000-30,000 acre-feet charged against inaccuracies in computing actual consumptive use (which yields consumptive use deficiency). Taking into account that the above estimates of error could be even larger, but recognizing that some of these errors would have to compensate for one another, it seems likely that the total of surface and groundwater outflow from Poudre Valley is in the range of 200,000-400,000 acre-feet on a mean annual basis.

The above rather detailed discussion of the water budget was necessitated by the fact that only more accurate water parameters can guarantee efficient operation of the system. Given such technical data, it may be useful in the concluding section, to discuss the potential for more effective irrigation organization and an efficacious allocation of water resources.

Conclusion

Seasonal maldistribution of water would be a very serious problem in the Cache la Poudre Valley if it were not for the

Table 13. Irrigation companies having high ratio of consumptive use deficiency to potential consumptive use.

Name of Canal Co.	Total Irrigated Land, acres	Mean Annual Cropland Potential Consumptive Use (PCU), acre-feet	Mean Annual Consumptive Use Deficiency (CUD), acre-feet	Ratio of CUD to PCU, %
Chaffler Ditch	633	1,096	376	34
Poudre Valley Canal	6,222	10,832	3,347	31
Charles Hansen Canal	923	1,944	579	30
New Mercer & Larimer County	19,070	36,438	10,055	28
Larimer & Weld Canal	50,112	114,724	21,644	19
Boyd Ditch	561	614	110	18
Dixon & State Board of Agriculture	436	769	133	17
Grapevine Ditch	3,421	6,740	1,155	17
Greeley No. 2 Canal	42,418	85,385	14,602	17
Oklahoma Reservoir	2,990	6,555	926	14
Boomerang Ditch	3,647	7,423	967	13
Louden Ditch	4,139	8,793	1,108	13
Lake Canal	8,591	16,946	1,784	11
Pleasant Valley & Lake Canal	5,771	10,534	1,100	10

highly developed use of return flows, ground water supplies, regulatory surface storage facilities, and the Colorado-Big Thompson Project. All contribute to a very high degree of water use efficiency within the valley.

Generally, water is available for irrigation in four broad categories: (1) river water diverted under direct flow decrees, (2) river water diverted under storage decrees, (3) reservoir or river exchanges, and (4) pumped diversions. At the present time, there is a very dependable water supply, largely due to the Colorado-Big Thompson Project. Crop needs are being adequately satisifed by available supplies even though the irrigation distribution system was not originally planned as an integrated system.

A water budget involving the hydrologic compilation of the quantitative effects of irrigated lands and diversion quantities and irrigation demand has shown that the water needs on the Cache la Poudre Valley are being satisfied at this time. Surplus and deficits for given application and conveyance efficiencies have, however, shown misallocation of water. By comparing the locally deficient areas and surplus areas, it can be seen that reallocation within the basin would be quite feasible. A basin management scheme would most likely be the most desirable political and socially desirable alternative.

Irrigation basically consists of two problems: (1) getting the water into the ground and (2) where and when to apply it. The first is a problem of farm management, and the second is a combined problem of basin and farm management.

Farm irrigation management involves the determination of water needed, control of water quality, uniformity of application, and personal attention to irrigation. Basin management involves insuring the maximum water supply at the problem periods in the crop growth.

It should be again emphasized that importations into the Cache la Poudre Valley are developed as far as is legally possible; ground water mining is being held near constant by legislation, and almost all available surface storage facilities are developed. Water reuse has become highly developed as a result of the surface water shortages before the advent of the Colorado-Big Thompson Project. If basin management authorities were to explore any approach to increasing the water supply or improving the distribution characteristics of the system, it must be done by increasing the efficiency of the existing system.

Increasing the efficiency of the system becomes then an imperative of future survival, given the above constant conditions in supply and the emerging conflicting demands in water use. Perhaps we need to speculate a little bit here concerning the potential for consolidation as a means for increasing efficiency and effectiveness of the system.

The advantages of consolidation in the Poudre Valley would be first of all a situation of significant economic benefits.

In reality such an ad hoc consolidation has already been implemented in many respects, because Poudre Valley has now four very large irrigation companies which control 90 percent of all water coming into the Valley. These four irrigation companies are in essence a federation of many smaller irrigation companies all housed in the same office. This is done simply because it has been much more efficient to house the various groups in one office, having one main group of managers operating the system and delivering the water to the various companies all through a centralized office. These organizational advantages of the federation (or "consolidation") have already been noticed by the local users. Unfortunately, however, consolidation of canals has not taken place. If the canals were to be consolidated, there would be a drastic reduction in the number of canals in the area. This would lead to additional advantages, such as increased safety for the children in the area, savings from diminished maintenance, abandonment of old canals (to be used for many other social uses, as e.g. long strip type parks, bicycle paths, bridle paths, etc), and generally water savings resulting from a more tightly organized system.

What should be avoided here is especially compulsory consolidation, which would lack both the support and legitimacy of the water users in the valley. As a result the emerging, consolidated organization would probably meet with a great deal of buffetting, dissention, and marked contention among various people in the area. The perennial fear in the valley is that a consolidated system might take not only water rights away, but eventually the water itself and with it the power to administer the company in a way beneficial to all users. The background of such apprehensions, as well as some more specific recommendations of how to implement consolidation are further explored in Phase II. Suffice to say here, that despite present relative water supply abundance, the circumstances outlined above point out to the serious consideration of consolidation.

As things stand now, the probability of consolidation in Poudre Valley is rather small. It would be necessary for some form of external impetus or event to be presented to the people of the valley before consolidation would become a reality. Such outside events seem rather remote, although there is an increasing awareness of larger trends and changing circumstances in the area. The water situation will probably continue under a present decentralized, loosely "consolidated" or federation system.

The major goal as stated by the irrigation companies in the valley is one of supplying to the people the amount of water to which they are entitled to, at the lowest possible cost. Yet, both officers and users in the various irrigation companies are aware of the need for improved methods of water application as evidenced by such efforts as sprinkling, and ditches which are lined with concrete. Typically these lined ditches are found on the individual's property and they are his private ditches rather than being the canal system or the lateral system. Rarely is a canal lined and when it is done it is because the seepage at a particular point was so great that it was nearly prohibitive to carry water through this particular point.

On the other hand, increased bureaucracy through consolidation seems to be the stumbling block in the minds of many users. Farmers feel that there would be more levels of bureaucracy for them to have to work with, with a resultant loss of voice and power due to the multi-layers and increased levels of bureaucracy.

If one were to speculate on a market with graduated water costs, it would be fair to say that the probability of having a free water market in the Poudre Valley area is fairly limited unless the legal definition of water rights were to be changed. Farmers are entitled to a specific number of second feet of water from their diversion, whether this water is adequate or more than adequate. The only way that this could be changed would be through buying the water from them or altering the law so that this water could be taken from the land and used in another way.

An opportunity for consolidation was presented with the establishment of the conservancy district, when the supplemental water is administered through a consolidating organization. The District serves all of the irrigation companies and any of the companies which wish water have to order that water from the district. Thus, the district tends to be an equalizing factor which draws the companies together, particularly when one of the sources of water which is exchanged and traded is the Colorado-Big Thompson Water.

An event which may facilitate consolidation (if not coordination) is the practice of farmers getting together in the spring and walking the ditch. Walking the ditch is going out and cleaning the ditch and preparing the ditch for the year's activities. This process is typically done in the spring prior to letting water into the main ditch and the laterals. This process of walking the ditch serves more than a mechanistic function of simply cleaning the ditch. The process of walking the ditch allows the people along the ditch to get to know one another, to renew friendships, to reinforce friendships, to smooth over previous misunderstandings, and serves as a catalyst for discussing the year's forthcoming irrigation problems and activities. Walking the ditch has been described by some irrigators as "a process of keeping us from killing each other during the year." In this process of walking the ditch the people performing this service are in a position to increase their knowledge of the irrigation company. Such increased knowledge may also help in the alteration of water related attitudes so that users are much more amenable to the needs and overall feelings of the group. A person who has invested some of his time and some of his energy into maintaining the system and helping to rebuild it can be much more satisfied with it and also understand the necessity of coordinated action and centralized organization.

However, as society becomes more complex, and with the encroachment of urbanization, the tendency of all of the water users to walk the ditch diminishes. As a result many users become isolated members of irrigation companies having little understanding of the demands for efficiency and collective

action. They tend to be less satisfied with the irrigation companies simply because they really do not have any knowledge of the functions of the company. They simply pay their water assessment and expect their water to be delivered to them. Their attachment to the company becomes a secondary relationship. This may be proven at the end a truly facilitating factor for consolidation, since quite a number of people have no real attachment for their irrigation company. As long as they get their water they are happy. If it is a consolidated company that is fine with them, provided that water arrives at the time specified.

The future in Poudre Valley points more toward voluntary water consolidation. This is primarily due to the spreading of urbanization upon the agricultural hinterland. The Poudre Valley area is rapidly turning into an urbanized territory within the confines of an urban triangle described above. As this growth continues the irrigation companies will be compelled to look toward one another for support if they are to survive. The irrigation organizations in the area are fully capable of making the transition from independent companies to consolidated systems. Legally, the water rights can be satisfied in a water poor year as well as in a water rich year. And physically the capability exists for such an integration. The major impediment are the water users themselves; many of them are older people who view water as their personal property with water rights not to be tampered with by anyone from the outside. Such users are a vanishing breed, however, because much of the farmland in the area is moving into large agri-business. Commercial farms are becoming prevalent in the area and many of the smaller farms are simply being taken over or turned into subdividions by various development companies. Consolidation in the area, an apparent organizational necessity, may come about as an inevitable evolution to a fast changing and rapidly urbanizing dynamic territory.

GRAND VALLEY

Location and Physiography

Grand Valley is located in west central Colorado very near the Utah border. The city of Grand Junction, which is a name derived from the junction of the Colorado and Gunnison rivers very near the city, is the largest community on the West Slope (that portion of Colorado west of the Continental Divide). The Colorado River enters the Grand Valley from the East, is joined by the Gunnison River at Grand Junction, Colorado, and then exits to the West. A major characteristic in the area is the high contribution to the total salt flows in the basin as illustrated in Figure 15. The primary source of salinity is from the extremely saline aquifers overlying the marine deposited Mancos shale formation. The shale is characterized by lenses of salt in the formation which are dissolved by water from excessive irrigation and conveyance seepage losses when it comes in contact with the Mancos shale formation. The introduction of water through these surface sources percolates into the shallow ground water reservoir where the hydraulic gradients it produced displace some water into the river. This displaced water has usually had sufficient time to reach chemical equilibrium with the salt concentrations of the soils and shale. These factors also make the Grand Valley an important study area for the interaction of water quantity and quality, since the conditions encountered in the valley are common to many locations in the basin.

The plateaus and mountains in the Colorado River Basin are the product of a series of uplifted land masses deeply eroded by wind and water. However, long before the earth movements which created the uplifted land masses, the region was the scene of alternate encroachment and retreat of great inland seas. The sedimentary rock formations underlying large portions of the basin are the result of material accumulated at the bottom of these seas. In areas similar to the Grand Valley, the upper portions contain a large number of intertonguing and overlapping formations of continental sandstone and marine shales, as shown in Figure 16. The lower parts are mostly marine Mancos shale and the Mesa Verde group of related formations. This particular geology is exhibited in about 23 percent of the basin in such common locations as the Book Cliffs, Wasatch, Aquarius, and Kaiparowits Plateaus, the cliffs around Black Mesa, and large areas in the San Juan and Rocky Mountains.

The geology of an area has a profound influence on the occurrence, behavior, and chemical quality of the water resources. In the mountainous origins of most water supplies, a continuous interaction of surface water and ground water occurs when precipitation in the form of rain and melting snow enter ground water reservoirs. Eventually, these quantities of ground water return to the surface flows through springs, seeps, and adjacent soil in regions downstream. A further consequence of such a flow system is the addition of water from streams to the ground water storage during periods of high flows and subsequent return flows during low flow periods. The

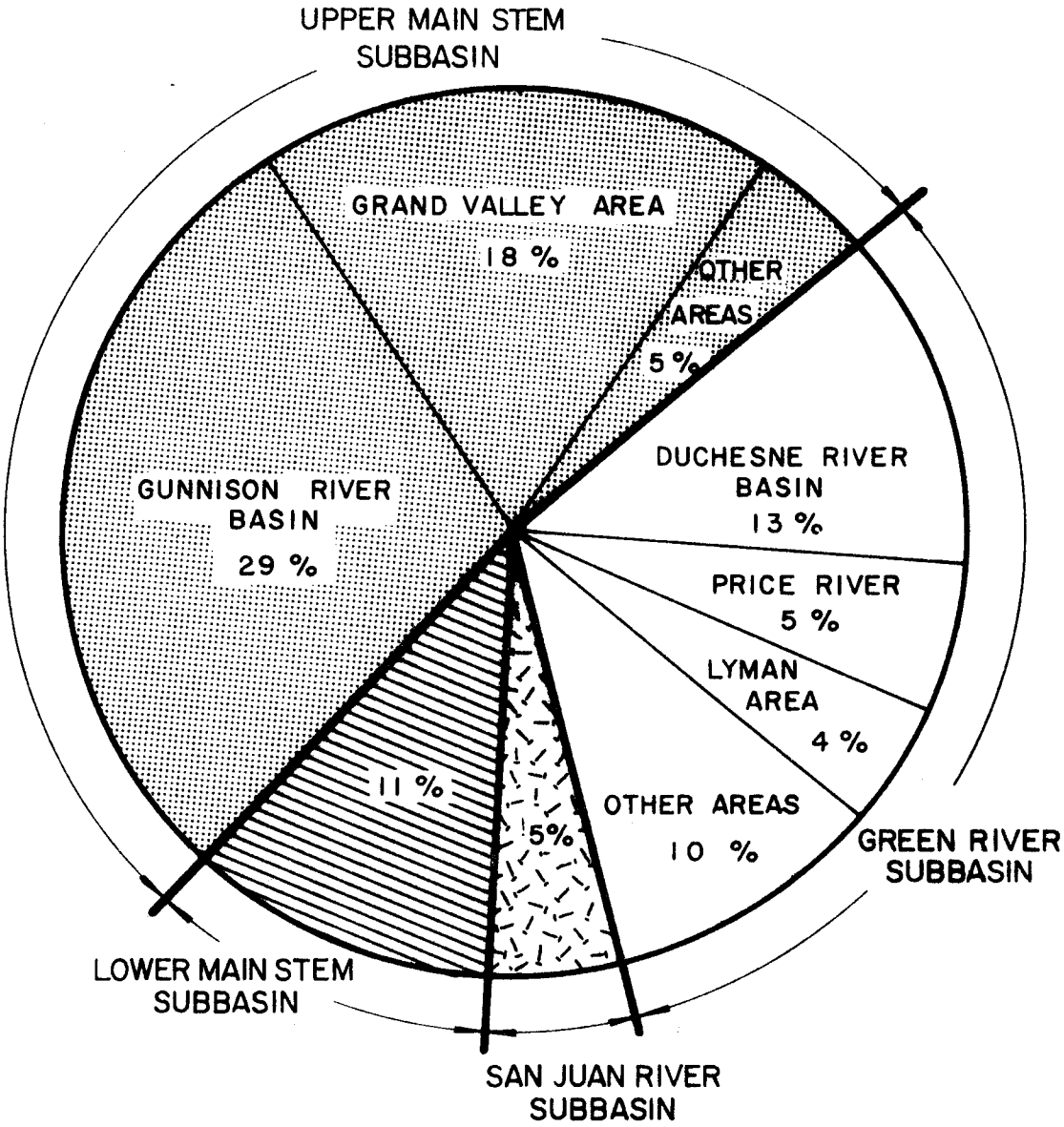


Figure 15. Relative magnitude of agricultural salt sources in the Colorado River Basin.

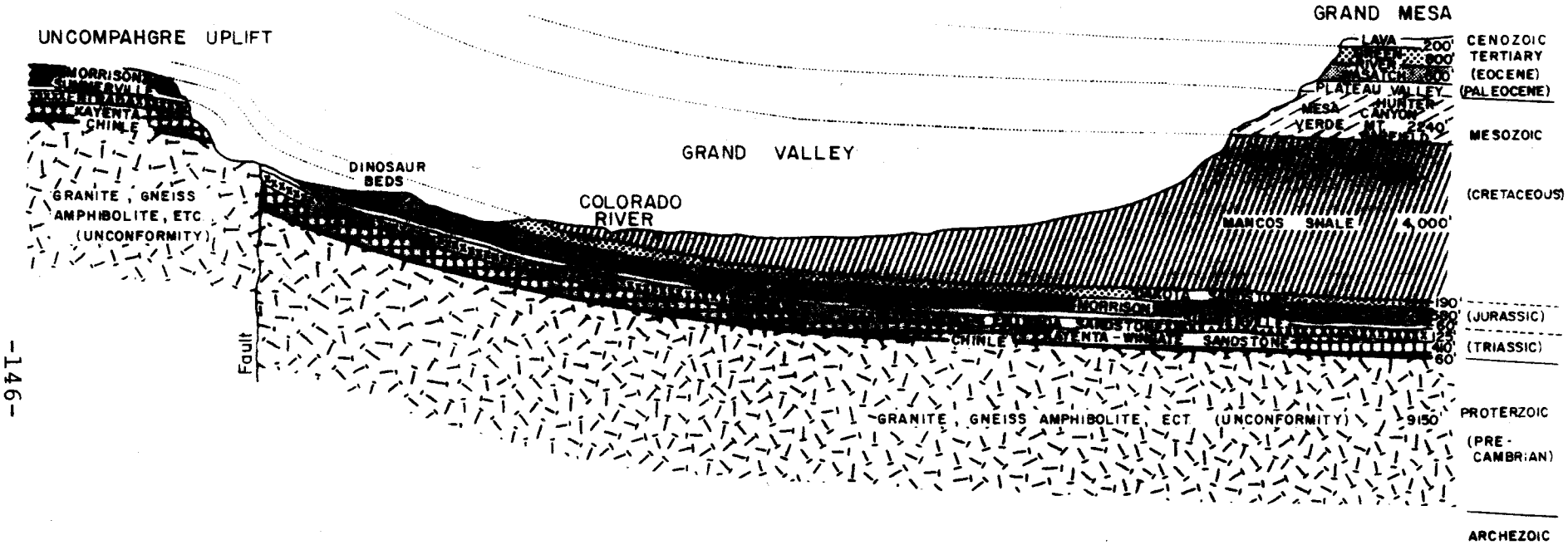


Figure 16. General geologic cross-section of the Grand Valley.

resulting continuous interaction of surface water and ground water allows contact with rocks and soils of the region which affect the chemical characteristics imparted to the water.

The interior valleys of the basin (the Grand Valley is a good example) do not receive large enough amounts of precipitation to significantly recharge the ground water storage. Usually, the water bearing aquifers are buried deep below the valley floor and are fed in and along the high precipitation areas of the mountains. Shallow ground water supplies are predominately the result of irrigation. Although the water in the consolidated rock formations of the valley region does not contribute significantly to the stream flows as is the case in higher elevations, it does have a pronounced effect on water quality due to the large volumes of natural salts contained in these formations. High intensity thunderstorms bring surface runoff in contact with the rocks and soils which then distribute their chemical characteristics. Erosion by rivers and streams has deposited alluvium high in natural salts along certain valleys, with these natural salts being returned to the surface waters when moisture, either from precipitation or irrigation, percolates through the alluvial soils.

The desert climate of the area has restricted the growth of natural vegetation, thereby causing the soils to be very low in nitrogen content because of the absence of organic matter. The natural inorganic content is high in lime carbonate, gypsum, and sodium, potassium, magnesium, and calcium salts. With the addition of irrigation, some locations have experienced high salt concentrations with a resulting decrease in crop productivity. Although natural phosphate exists in the soils, it becomes available too slowly for use by cultivated crops and a fertilizer application greatly aids yields. Other minor elements such as iron are available except in those areas where drainage is inadequate. The soils are of relatively recent origin as they contain no definite concentration of lime or clay in the subsoil as could be expected in weathered soils. Some areas in the valley have limited farming use because of poor internal drainage, which results in water logging and salt accumulations.

Evaporation and transpiration from crops, phreatophytes, and other land uses results in a loss of salt-free water to the atmosphere and a deposition of salt in the soil profile. The magnitude of these losses depends on the acreage of each water use. As a part of a valley wide evaluation, the various acreages of land uses were mapped in 1969. The acreages for each land use are shown in Table 14.

Climate

The mountain ranges in the Upper Colorado River Basin have much more influence on the climate than does the altitude. The movement of air masses is disturbed by the mountain ranges to the extent that the high elevations are wet and cool, whereas the low plateaus and valleys are dryer and subject to wide temperature ranges. A common characteristic of the climate in the lower altitudes is hot and dry summers and cold winters. Moist

Table 14. Land use in Grand Valley during 1969 for each canal.

Use	Grand Valley Canal (including Mesa County Ditch) Acreage	Total	Government Highline Canal Acreage	Total	Orchard Mesa Irr. Dist. Acreage	Total	Price Ditch Acreage	Total	Stub Ditch Acreage	Total	Redlands Water & Power Co. Acreage	Total
Corn	6828		5979		767		535		71		124	
Sugar Beets	1726		3452		51		0		0		32	
Potatoes	96		95		78		0		0		3	
Tomatoes	133		31		66		2		0		17	
Truck Crop	147		161		53		0		33		0	
Barley	2373		1644		247		263		0		18	
Oats	1530		963		82		70		0		55	
Wheat	63		15		26		22		0		0	
Alfalfa	5454		7019		948		551		97		531	
Native Grass Hay	84		0		20		35		0		0	
Cultivated Grass and Hay	1621		450		213		109		6		31	
Pasture	3962		1533		597		369		43		1139	
Wetland Pasture	0		11		144		0		0		0	
Native Grass Pasture	587		47		0		198		0		115	
Orchard	555		695		3493		1575		247		371	
Idle	4557		2948		909		571		111		610	
Other Cropland	11		126		0		6		0		0	
Subtotal		29,727		25,169		7,694		4,306		608		3,046
Farmsteads	1300		685		234		108		25		94	
Residential Yards	53		28		244		163		5		38	
Urban	3925		759		703		264		2		713	
Stock Yards	262		157		182		12		0		40	
Subtotal		5,540		1,629		1,363		547		32		885
Refineries	40		0		0		0		0		0	
Other Industrial	642		0		0		0		0		0	
Subtotal		682		0		0		0		0		0
Open Water Surfaces	798		635		135		37		31		63	
Subtotal		798		635		135		37		31		63
Cottonwoods	343		612		92		10		4		78	
Salt Cedar	1402		2262		116		24		2		841	
Willows	138		122		10		40		7		60	
Rushes or Cattails	433		344		85		16		0		9	
Greasewood	4023		3211		498		75		38		231	
Sagebrush or Rabbitbrush	0		3		32		0		0		1	
Grasses and Sedges	1		0		17		12		0		0	
Subtotal		6,340		6,554		850		177		51		1,202
Precipitation Only	3591		10,429		964		337		51		1235	
Subtotal		3,591		10,429		964		337		51		1,235
Total		46,678		44,416		11,006		5,404		773		6,431

Pacific air masses can move across the basin, but dry polar air and moist tropical air rarely continue all the way across the basin. Movement of both types of air masses is obstructed and deflected by the mountains so that their effects within the basin are weaker and more erratic than in most areas of the country.

Most of the precipitation to the basin is provided from the Pacific Ocean and the Gulf of Mexico whose shores are 600 and 1000 miles from the center of the basin, respectively. The air masses are forced to high altitudes and lose much of their precipitation before entering the basin. During the period from October to April, Pacific moisture is predominant, but the late spring and summer months receive moisture from the Gulf of Mexico.

The monthly distribution of precipitation and temperature for Grand Junction is shown in Figure 17. The climate in the area is marked by a wide seasonal range, but sudden or severe weather changes are infrequent due mainly to the high ring of mountains around the valley. This protective topography results in a relatively low annual precipitation of approximately eight inches. The usual occurrence of precipitation during the growing season is in the form of light showers from thunderstorms which develop over the western mountains. The nature of the valley location with typical valley breezes provides some spring and fall frost protection resulting in an average growing season of 190 days from April to October. Although temperatures have ranged to as high as 105°, the usual summer temperatures range in the middle and low 90's in the daytime to the low 60's at night. Relative humidity is usually low during the growing season, which is common in all of the semi-arid Colorado River Basin.

Human Community

Although numerous hieroglyphics and abandoned ruins testify to occupation of the Colorado River Basin long before settlement began, the first people encountered in the Grand Valley were the Ute Indians. The first contact these peoples had with white men was recorded in 1776 when an expedition led by Fathers Dominiquez and Escalante passed north of what was later to be Grand Junction and across the Grand Mesa. The region was subsequently visited by fur trappers, traders and explorers. In 1839 one such trader named Joseph Roubdeau built a trading post just upstream from the present site of Grand Junction.

In 1853, Captain John W. Gunnison led an exploration party into the Grand Valley from up the Gunnison River Valley in search of a feasible transcontinental railroad route. As Captain Gunnison and his party traversed the confluence of the Colorado and Gunnison Rivers, an error was made by the expedition recorder as to the proper naming of the rivers. Beckwith referred to the Gunnison River as the Grand River and the Colorado River as the Blue River or "Nah-un-Kah-rea" as it was known to the Indians. The mistake was later corrected, however, since the Colorado River was known as the Grand River as early as 1842. As a result of the Meeker Massacre of 1879, the Utes were

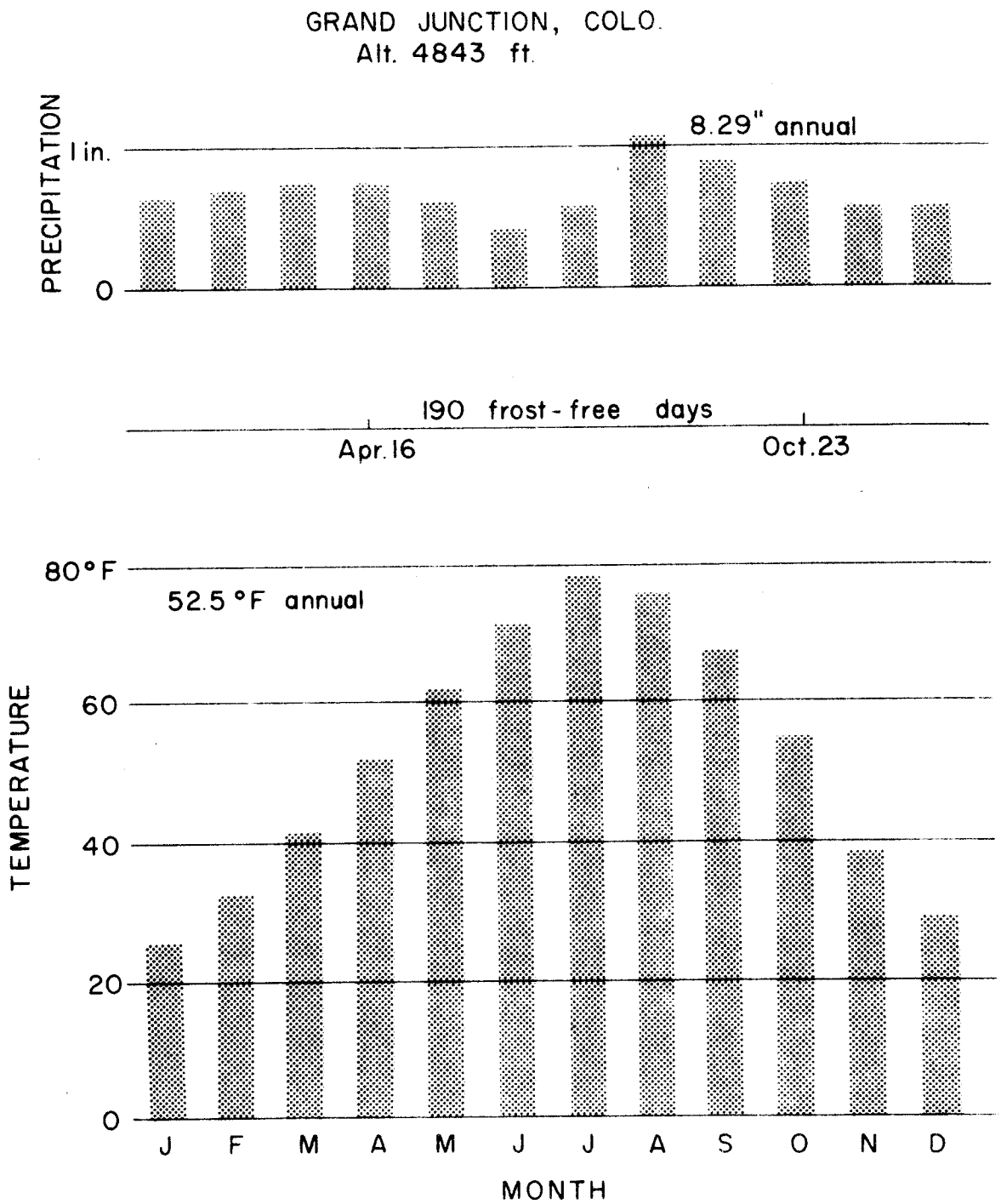


Figure 17. Normal precipitation and temperature at Grand Junction, Colorado.

forced to accept a treaty moving them out of Colorado and onto reservations in eastern Utah. After the completion of the Utes' exit in September 1881, the valley was immediately opened up for settlement with the first ranch staked out on September 7, 1881 near Roubdeau's trading post. Later that year on September 26, George A. Crawford founded Grand Junction as a townsite and formed the Grand Junction Town Company, October 10, 1881. On November 21, 1882, the Denver and Rio Grande Railroad narrow-gage line was completed to Grand Junction via the Gunnison River Valley and thus assured the success of the settlement.

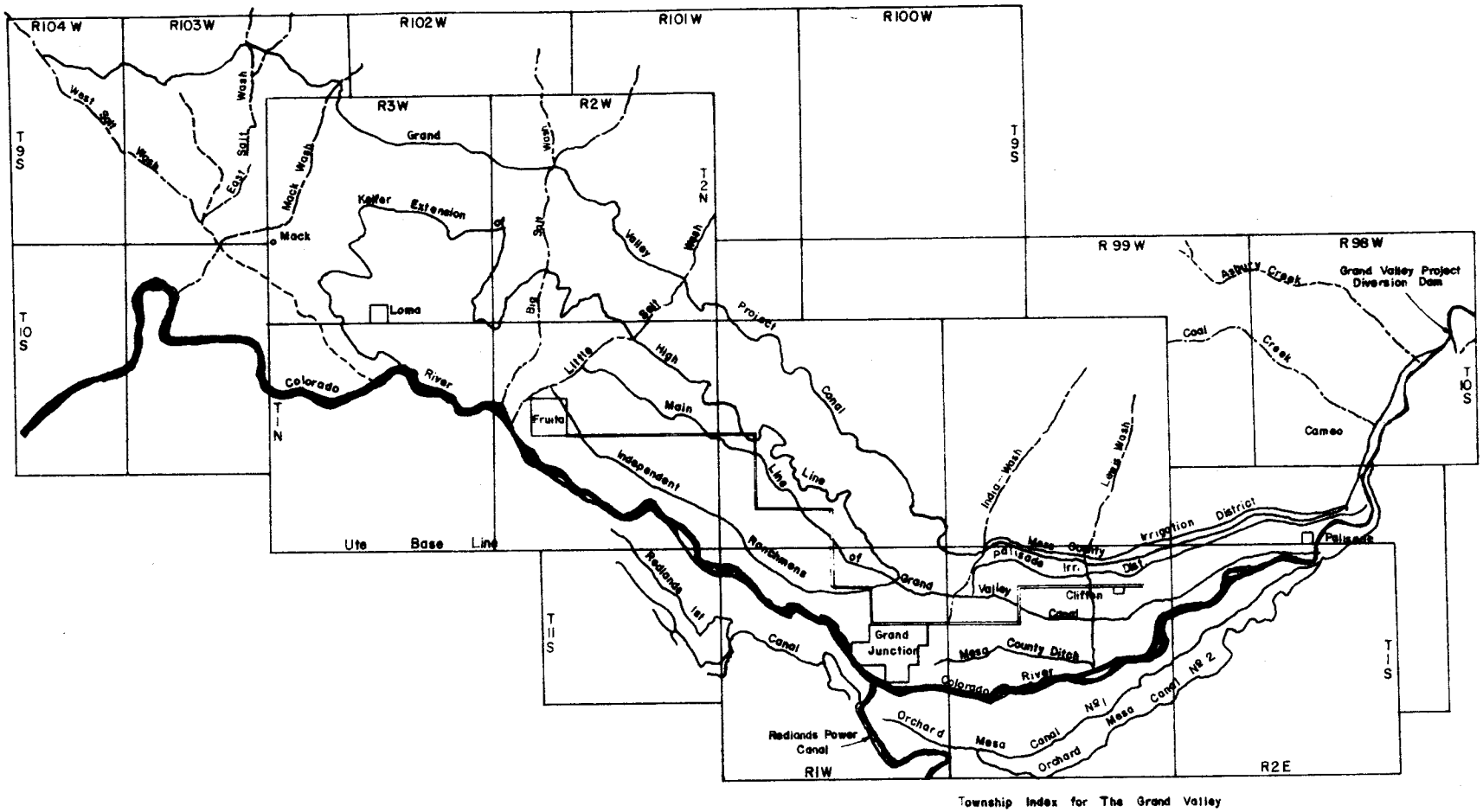
Early exploration concluded that the Grand Valley had limited potential for agriculture since the terrain appeared very desolate. A great deal of appreciation for this judgment can be acquired just passing through the area and noting the landscape outside the irrigated agricultural boundaries. In 1853, Beckwith described the valley as, "The Valley, twenty miles in diameter, enclosed by these mountains, is quite level and very barren except scattered fields of greasewood and sage varieties of artemisia - the margins of the Grand (Gunnison) and Blue (Colorado) Rivers affording but a meager supply of grass, cottonwood, and willow." Soon after the settlement began, it was realized that the climate could not support a non-irrigated agriculture. As a result, irrigation companies were organized to divert water from the river for irrigation. In the year 1883, when the county was organized, marks also the beginning of water being diverted in the area. The first canal built (the Pacific Slope Ditch) brought water to the Grand Junction community itself, and was soon followed by a whole series of subsequent canals as depicted in Figure 18.

From the time of the initial settlement, the area grew rather slowly primarily due to limitations of water. In 1912, the first Reclamation Project of 62 miles of canal provided water for a 40 mile strip along the river. Its construction provided the impetus for the establishment of rich fruit growing areas and increased significantly the agricultural productivity of the area.

Even with the coming of the Grand Valley project, population remained fairly stable until the early 1950's (Table 15). During the 1950's, uranium production became an additional source of employment contributing to a significant population increase for that decade.

Grand Valley is only one of the two counties on the Western Slope of Colorado which has shown a population increase. All other counties in the area have shown a net decline (sometimes a dramatic one) between the 1960 and the 1970 censuses. The continued growth of the Grand Valley area can be attributed to a combination of continuous mining and of successful irrigated agriculture.

Although not as pronounced as on the Eastern slope, there are trends of urbanization around the Grand Junction area. The Grand Junction division, which one may call the "Greater Grand Junction City" area grew at a rate of 52.6 percent over



Township Index for The Grand Valley

Figure 18. Grand Valley canal distribution system.

Table 15. Population increase in Mesa County and Grand Junction, 1900-1970.

	Mesa County		Grand Junction	
	Number	Percent Increase	Number	Percent Increase
1900	9,267	--	3,503	--
1910	22,197	139.5%	7,754	121.4
1920	22,281	00.3%	8,665	11.7
1930	25,908	16.2%	10,247	18.3
1940	33,791	30.4%	12,479	21.8
1950	38,974	15.3%	14,504	16.2
1960	50,715	30.1%	18,694	28.9
1970	54,374	7.2%	20,170	7.9

the 1960-1970 census period, with a total population of 28,527. Other settlements in the Valley have grown at a much lower rate. As a matter of fact, two areas in the Grand Valley area have shown a decline in population: the town of Fruita (population 1822 in 1970) and the Palisade division showed a net population decline of -28.8 percent during the same time period with a total of 1964 inhabitants in 1970.

Of the total population in Grand Valley, 20,170 inhabitants can be classified as urban dwellers, with the remaining majority of 34,204 classified as rural according to the Census Bureau count of 1970. In terms of population composition in the predominantly white population, there is a high proportion of persons over 65 years of age (12.0 percent), a fact reflected in the high median age of 32.3 years. Among those employed (20,125 persons in 1970), 1,474 are in agriculture, 468 in mining, 1,561 in construction, and 2,041 individuals in manufacturing.

Further growth of the area will depend primarily on further exploitation of natural resources, such as oil shale, natural gas, petroleum, and particularly coal. In addition, a major potential for the area is recreation and tourism. The area has long been known for its aesthetic value and for its fish and game. Deer hunting, elk hunting, and fishing are major magnets of attraction.

It should be noted, however, that large scale development of natural resources, such as in particular oil shale, require large amounts of water for their processing. Thus, given the existing problems of salinity, the interrelationship between irrigation and other water uses becomes a crucial one for the future of the region.

Irrigation Development

The system of irrigation most common to the area is surface flooding either by borders or furrows. The relief north of the Colorado River is about 50 feet per mile sloping south towards the river. As a result, care is taken to prevent erosion in most cases by irrigation with small streams. Most farms in the area are small and have short run lengths. However, the small irrigation stream allows adequate application. The quantity of water delivered to the farmer is plentiful so the usual practice is to allow self-regulated diversions. Although the method of irrigation is quite similar throughout Grand Valley, there is considerable contrast in land use. The lands at the upper (eastern) end of the valley are largely orchards, which is also the case for the Orchard Mesa lands, which are south of the Colorado River. Larger tracts of farm land are located in the western portions of the valley, with many of these lands having good soils, which contribute to the production of high yield crops.

Salinity is the most pressing problem facing the future development of water resources in the Colorado River Basin. Because of the progressive deterioration in mineral quality towards the lower reaches, the detrimental effects of using

an increasingly degraded water are first seen in the lower basin. As a result of the continual development in the upper basin, most of which will be diversions out of the basin to meet large municipal and industrial needs, water ordinarily available to dilute the salt flows will be depleted from the system, causing significant increases in salinity concentrations throughout the basin. The economic penalty resulting from a use of lower quality water will be incurred by those users in the lower system. The U.S. Environmental Protection Agency has estimated that the present economic losses from salinity are $16 million annually. If water resources development proceeds as proposed without implementing a salinity control program, the average annual economic detriments (1970 dollars) would increase to $28 million in 1980 and $51 million in 2010. These damages do not reflect further costs downstream to Mexico.

The bulk of the salt loads passing into the lower reaches is attributable to the upper basin. Salinity management in the upper basin must therefore concern itself with the aspect of salt loading in the river system from municipal, industrial, agricultural and natural sources. The other aspect, which is the salt concentrating effects, is related to consumptive use, evaporation, and transbasin diversions. Although several methods of controlling salinity, such as phreatophyte eradication (although controversial from a wildlife standpoint) and evaporation suppression on reservoirs, are desirable, the most feasible solutions are in reducing inflows from mineralized springs and more efficient irrigation prac tices. In any case, the salinity management objectives in the upper basin must necessarily be concerned with a reduction in the total salt load being carried to the lower basin in order that the detrimental salinity effects anticipated from further development can be limited. Salinity control must be practiced at all locations in the basin if the economic losses to downstream users are to be minimized.

Since the Colorado River Basin is not a rapidly growing municipal and industrial area, the pollution problems are primarily associated with agriculture. Thus, a major aspect of reducing the salt inputs in the upper basin must be the effective utilization of the water presently diverted for irrigation by comprehensive programs of conveyance channel lining, increasing irrigation efficiency on the farm, improved irrigation company management practices, and more effective coordination of local objectives between the various institutions in the problem areas. Salinity is no longer a local problem and should be considered regionally. In irrigated areas, it is necessary to maintain an acceptable salt balance in the crop root zone which requires some water for leaching. However, when irrigation efficiency is low and conveyance seepage losses are high, the additional deep percolation losses are subject to the highly saline aquifers and soils common in the basin and result in large quantities of salt being picked up and carried back to the river system. Therefore, a pressing need exists to delineate the high input areas and examine the management alternatives available to establish the most effective salinity control program. In this challenge of efficient

agriculture lies the key problem for understanding the operation of the irrigation system in the valley.

We need to see briefly some of the historical background associated with the development of irrigation in the Valley.

The present Grand Valley Canal system comprising approximately 110 miles of canals and subcanals is the result of a consolidation of the Grand River Ditch Company, Grand Valley Canal Company, Mesa County Ditch Company, Pioneer Extension Ditch Company, and the Independent Ranchmen's Ditch Association. The construction of what is now the main line Grand Valley Canal probably began in 1882 since the original priority is dated August 22, 1882, although A. J. McCune who was the engineer for the Grand River Ditch Company filed a statement with the clerk and recorder of Mesa County, Colorado on April 5, 1883 that construction commenced January 10, 1883. At this time, the the ditch was owned by Matt Arch, E. S. Oldham, William Oldham, John Biggles, and William Cline who planned for a capacity of about 786 cfs. However, the early development times were uncertain and the company, like many others, was facing financial trouble so was sold to the Traveler's Insurance Company which also acquired title to the other four companies now making up the system. On January 29, 1894, the Grand Valley Irrigation Company was incorporated when the Certificate of Incorporation was filed with the Secretary of State's Office and the title was acquired from the insurance company.

The water rights of an agricultural area in the Western United States often are complex due to the nature of system evolution necessary to develop an area. In general, such is the case in the Grand Valley area. Upon the organization of the company, an application was made for an adjudication of its water rights from the Colorado River. The application for the Grand Valley Canal was awarded a decree of 520.81 cfs, July 27, 1912, with the priority date of August 22, 1882, which was priority No. 1 on the Colorado River. The hearings which lead to the adjudication established an irrigated acreage of 30-35 thousand acres with a probable 20% system loss rate. On July 25, 1914, the First Enlargement of the Grand Valley Canal was awarded Priority No. 358 and dated July 23, 1914 for 195.33 cfs, of which 75.86 cfs is conditional upon the addition of 4,661.25 acres to the system.

Although the original decree was based on an estimated acreage of 30-35,000 acres, later investigation revealed the acreage was slightly less than 40,000 acres, plus the additional 4,661.25 acres not yet developed, for a total of about 44,000 acres. If the usual 200-day irrigation season is experienced, this water right amounts to approximately 5.76 acre-feet per acre, from which an estimated 20% loss rate of 1.05 acre-feet per acre leaves about 4.71 acre-feet per acre for irrigation.

The company is organized in the corporation format. The division of water among irrigators is on the basis of shares of the capital stock of the company comprising a total of 48,000 shares. Thus, an individual holding one share of

stock would be entitled to 4.23 acre-feet of water at his turnout. It should be noted that this figure does not include the loss rates of the company. In addition, these figures do not include the 75.86 cfs of conditional water. In 1971, the water assessment was $15.00 for the first share and $2.40 for each additional share. Occasionally, some assessments cannot be paid, in which case a period is given for the irrigator to reclaim the water share, after which grace period the share is sold at auction.

Grand Valley Project

The Grand Valley project which now serves water to four irrigation companies, the Grand Valley Water Users Association, the Orchard Mesa Irrigation District, Palisade Irrigation District (Price Ditch), and the Mesa County Irrigation District (Stub Ditch), is the result of considerable effort and a long series of disappointments. Before describing in detail the companies themselves, it is interesting to describe briefly the history of development leading to the present day conditions.

When the Ute Indians moved out of the valley and the first benefits of irrigation were being realized, the opportunity for further development of irrigation above and beyond the Grand Valley could be seen. The fruit industry prospered almost from the time early settlers experimented with deciduous fruit culture that eventually gave the valley a reputation as a high quality orchard locality. However, neither the capital nor the authorization to develop additional lands was available until 1902 when the Federal Reclamation Act was passed. Although the act was passed, no provision for operation was made. The Bureau of Public Surveys was charged with the responsibility to investigate locations which could be developed. Early in September 1902, J. H. Mathis arrived in Grand Junction with a small party of engineers to survey the Grand Valley for its feasibility as an experimental reclamation project.

When the investigation was almost completed, an event occurred which is probably the worst disaster to occur in the valley. T. C. Henry, unscrupulous promoter from Denver, arrived on the scene and convinced local people he could finance, build and operate a system far better than could the government. By a majority of two votes, the local citizens accepted the proposal, causing the government to withdraw, even though the engineers had found Grand Valley to be a feasible location for a reclamation project.

In 1904, T. C. Henry was forced to admit that he had neither a plan nor a prospect for action in the Grand Valley. Fortunately, the efforts of the people were sufficient to revive government interest in the potential project. In June 1907, James R. Garfield, Secretary of the Interior, officially approved the project and allocated $150,880 to begin the permanent survey of the project. The project at this point entailed what is now known as the Government Highline Canal and its construction was increasingly important to the local people because of the continued success agriculture had been enjoying.

In fact, the future of the fruit industry looked so promising that one six-acre peach orchard sold for $24,000, or $4,000 per acre.

The Grand Valley was not yet through with T. C. Henry. In 1907, he contacted the Magenheimer Brothers of Chicago who had been successful in dredging operations along Lake Michigan. Since the exploitation of irrigation projects was both a popular and a successful business, they took up the line. Together with four local promoters, they organized a district (later to become the Orchard Mesa Irrigation District) covering about 10,000 acres on the south side of the river. In addition, plans were being made by the Magenheimers to take over the remainder of the government project (Water Users Association).

The increasing demand for the project prompted the local people in the Association to submit a proposal to provide $125,000, if the government would match this amount, for starting construction. In October 1908, Secretary Garfield accepted the challenge and approved the proposal. Local pledges in the form of work allocations were soon called upon and construction began; but at four o'clock on May 4, 1909, the same day work started, the new Secretary of the Interior, R. A. Ballenger, suspended construction with no reason stated. Ballenger had been asked by Senator Henry M. Teller from Denver to abandon the project because private capital was available for the work and in such cases the government should not interfere. This information had been given the Senator by a prominent law firm of Denver which was representing the Magenheimer-Henry combination. The local people sent representatives to Washington to investigate the work stoppage and just happened to visit Senator Teller, who then told them what had happened. Unfortunately, a great deal of effort by numerous individuals failed to sway Ballenger, who still would not give reason for his attitude. In 1911, Ballenger resigned and was succeeded by Walter L. Fisher who finally gave his approval; and on October 23, 1912 work was again initiated. Thus, the Association escaped falling into the hands of the Magenheimers.

The construction of the Orchard Mesa system was begun by placing a $163 per acre cost on the 10,000 acres of land with six percent interest bearing bonds and warrants. The system was so poorly constructed that portions failed before the system was completed. This was all made possible because the Magenheimers had gained control of the Board of Directors, and although the idea was met with bitter opposition by local people the election carried. From that time on, T. C. Henry and the Magenheimers embezzled the farmers and the district to the point of final collapse. Phony construction companies, phony construction and phony personnel finally brought the district near financial collapse.

Finally, an earnest plea was made to the government that rehabilitation of the Orchard Mesa system be included among construction efforts with the Association. The plea was heeded and the system saved, a cost which is still being repaid.

The efforts of T. C. Henry and the Magenheimer Brothers are not unlike many that have occurred throughout the West. Many people were ruined by their actions and the memory is still very real. It is almost miraculous that the irrigation companies in the Grand Valley and many other areas are still operating.

With the abbreviated history surrounding the Grand Valley Project, the operation and water rights of the 4-canal system may be better understood.

Grand Valley Water Users Association. The Grand Valley Water Users Association was incorporated February 7, 1905 and later renewed the incorporation September 11, 1945. It operates the Government Highline Canal which serves about 44,416 acres of irrigable land. In addition, the Association diverts 800 cfs during the non-irrigation season for power development through a siphon across the Colorado River shortly below the main diversion. During the irrigation season, 400 cfs is used for power development, with the remaining 400 cfs through the irrigation pumps. The power generated with this water is sold to the Public Service Company of Colorado to help pay the debt on the original project.

A summary of the water rights is listed in Table 16 and will be referred to later in the descriptions of the other canals.

The land use survey conducted in 1969 under the Government Highline Canal, which was listed in the previous Table 14, varies somewhat from that originallyllisted by the early land surveyors. However, the classification systems are also different.

The operation of the Grand Valley Water Users Association is on a corporation basis, and although stock is registered in the County Recorder's Office, none has ever been issued. The Bureau of Reclamation classified the land into one of five categories: Class 1 - good orchard; Class 1A - young orchard; Class 2 - good agricultural lands; Class 3 - fair agricultural lands; and, Class 4 - poor agricultural lands. On the basis of this classification, a farmer can sign up for his irrigable acreage which allows him at the present time four acre-feet per acre, above which (if the supply is available) he is charged for the excess. There are restrictions on the time rate of delivery, however, which are imposed when the supply is limited. This restriction is usually a limit of 1 cfs per 40 acres and sometimes as low as 0.75 cfs per 40 irrigable acres; this practice has, in the past, been necessary only during the peak use months of the summer. During the fall and spring, water is usually delivered on a demand basis. It should be further noted that although a farmer signs up for a fixed area of irrigable acreage, he may apply the water as he wishes on his property. In addition, when the property is sold he is allowed only to sell water for the irrigable acreage being sold, so in effect the water is tied to the land and non-shareholders or outside acreage cannot obtain Association water.

Table 16. Water right decrees for the Grand Valley Project.

	Name of Ditch	Original Appropriation Date	Decree Allowed (cfs)	Use of Right
(1)	Orchard Mesa Power Canal	3- 6-89	110.70	Irrigation
(2)	Palisade Irr. Dist.	10- 1-89	573.00	Pumping
(3)	" " "	" "	80.00	Irrigation
(4)	Orchard Mesa Power Canal	8- 2-98	139.30	Irrigation
(5)	E. Palisade Irr. Dist.	10- 1-00	10.20	Irrigation
(6)	Mesa County Irr. Dist.	7- 6-03	627.00	Pumping
(7)	" " "	" "	40.00	Irrigation
(8)	Mann Pumping System	9-10-03	1.00	Irrigation
(9)	Orchard Mesa Irr.	10-25-07	195.00	Irr, Pump
(10)	" " "	" "	75.00	Irrigation
(11)	" " "	" "	180.00	Conditional
(12)	Grand Valley Project	2-27-08	730.00	Irrigation
(13)	" " "	" "	400/800	Power
(14)	Rose Point Power	7- 2-10	113.25	Irrigation
(15)	Orchard Mesa Irr.	4-26-14	100.00	Conditional
(16)	Palisade Irr. Dist.	6- 1-18	23.50	Irrigation

Table 16. (Continued)

Comments
(1) Abandon, land now in Orchard Mesa Irr. Dist., 10 cfs irr., rest pumping, rights not transferred to District.
(2) Power plant abandon, decree usable only with approval of Bureau of Reclamation.
(3) Decree delivered by Gov't Highline Canal, point of diversion changed by decree of 7-25-41.
(4) Same as (1).
(5) Former steam pumping plant, now gravity from Orchard Mesa Power Canal, Orchard Mesa Irr. Dist. owns decree.
(6) Same as (2).
(7) Decree now delivered by Gov't Highline Canal by gravity and pumping, point of diversion not formally changed.
(8) Former steam pump from river, now pumped from Orchard Mesa Power Canal, electric motor.
(9) Now diverted through Gov't Highline Canal, but through same pumping plant, point of diversion changed.
(10) Same as (9).
(11) Same as (9), made absolute in decree of 7-25-41, 130.0 cfs power, 50 cfs irrig.
(12) Quantity fixed in decree of 7-25-41 as above, same applies for power and domestic.
(13) Quantity fixed in decree 7-25-41 with priority date as above, 400 cfs irrigation season, 800 cfs non-irrigating season.
(14) Abandon, decree property of Orchard Mesa Irr. Dist., no change in point of diversion.
(15) Conditional water claimed for irrigation, none claimed for pumping water.
(16) Date of this decree is date of change of point of diversion to Gov't Highline Canal (3). This decree provides for laterals fed directly from project canal to Palisade lands.

The price of water in the Association is based on an assessment of the irrigable acreage on the following basis:

In 1971, for example,

$1.40/acre repayment of government land
$4.00/acre for operation and maintenance
$1.20/acre-ft of excess used over 4 acre-ft/acre allocated.

The minimum assessment is $20 per farm. In 1971 there were approximately 24,000 acres assessed as compared with the 25,000 irrigable acres.

Orchard Mesa Irrigation District. The Orchard Mesa Division of the Grand Valley Project was formed by request of the people of the Orchard Mesa Irrigation District when the prior operation was facing bankruptcy. The District was organized under the 1905 Colorado Statute covering irrigation districts, which was later revised to the 1921 Colorado Law.

The operation of the district in many ways is similar to the Association in that the water duty and land classification are the same. The Orchard Mesa Irrigation District is now provided water through a siphon diversion from the Government Highline Canal into the Orchard Mesa Power Canal. During the irrigation season, 1/2 of the 800 cfs in the canal is diverted through the Orchard Mesa Irrigation District pumps which lift 80 cfs 40 feet into the Orchard Mesa #2 Canal and 60 cfs 130 feet into the Orchard Mesa #1 Canal.

The price of using water in the District is based again on the land classification. However, the procedure is similar to the assessment technique used by county government. The Board of Directors for the District prepares a budget consisting of repayment for irrigation system rehabilitation by the government, operation and maintenance, etc. Then, the budget is approved by the Tax Commission of Colorado and the State Auditor. The valuation of land is then checked with the County Assessor, from which a mill levy is set to obtain the money. In 1971, the assessed acreage was 9,199 acres, which was assessed on the following basis:

Class 1	$11.05/acre
Class 1A	$ 8.71/acre
Class 2	$ 8.71/acre
Class 3	$ 7.15/acre
Class 4	$ 5.85/acre

Of the total revenue collected, at a rate of 130 mills, 43 goes to repay the government and 87 for operation and maintenance. The 1969 land use breakdown in the District is summarized in Table 14.

Palisade Irrigation District. The Palisade Irrigation District, with essentially the same organizational format as the Orchard Mesa Irrigation District, operates the Price Ditch. This ditch is supplied 66-68 cfs through a turbine pump just off the Government Highline Canal as it exits through Tunnel No. 3.

An additional 22-24 cfs is delivered through turnouts in the Highline Canal, as can be noted in Table 16. The Agricultural area served by the Price Ditch is listed in Table 15.

Both the Palisade Irrigation District and the Mesa County Irrigation District were organized independently of the government projects. Their history is somewhat unknown to the writers, but they consolidated their systems with the Highline Canal when it was built, presumably to streamline their operation.

Mesa County Irrigation District. The Mesa County Irrigation District, which operates the Stub Ditch, has an irrigation water right of 40 cfs as listed in Table 16. The operation and organization of this district is similar to the previous five districts mentioned. At the turbine pump serving the Price Ditch, 15 cfs is pumped into the Stub Ditch, with the remaining 25 cfs being diverted directly from the Highline Canal to agricultural lands within the boundaries of the Mesa County Irrigation District. The irrigated land under the Stub Ditch is included in Table 14.

Redlands Water & Power Company

The Redlands Water & Power Company, a mutual ditch company, irrigates about 3,000 acres southwest of Grand Junction and south of the Colorado River. The water supply is diverted from the Gunnison River in a canal carrying 670 cfs. Six cfs is used for irrigation of lands below the power canal, 610 cfs for power generation and 54 cfs is pumped to an initial height of 127 feet for irrigation. Small areas in the project are served by higher lifts, the highest being at about 300 feet. Electricity in excess of pumping needs is sold to project settlers and to the Public Service Company. Land use classification resulting from the 1969 survey is listed in Table 14.

Conveyance System

Consideration of the water distribution system is an essential part of most water management and salinity control alternatives, which suggests that a broader perspective of system improvement, which includes salinity control, is required. The delivery system in the valley is divided into the canal or ditch subsystem and the lateral subsystem. The division between the two subsystems is based on management responsibility. The canal companies and irrigation districts divert the appropriated water right from the river, transport the water in the canal subsystem, and control the delivery of water through the canal turnout, but they generally assume little responsibility for the water below this point. The canal and ditch subsystem can, thus, be defined as that part of the delivery network which is controlled by irrigation authorities. The lateral network, extending beyond the turnout from the canal or ditches, is managed by cooperative agreements between the individual users served by the turnout. The transfer of responsibility between the two phases should be the equitable measurement and charge for the water at the turnout, but there is

little incentive to make this effort with the abundance of water. A notable exception are the turnouts comprising the Water Users Association under the Government Highline Canal, where individual measurements are made and recorded.

The canals and ditches in the Grand Valley, shown previously in Figure 18, are operated and maintained by the respective organizations mentioned earlier. Discharge capacities at the head of the canals range from above 700 cfs in the Government Highline Canal to 30 cfs in the Stub Ditch and diminish along the length of each canal or ditch. The lengths of the respective canal systems are approximately 55 miles for the Government Highline Canal, 12 miles each for the Price, Stub, and Redlands Ditches, 110 miles for the Grand Valley system, and 36 miles for the Orchard Mesa Canals.

The management of the canals and ditches in the area varies between canals, as well as with changes in the water supply. For example, during periods when river flows become small, restrictions are placed on the diversion into the Government Highline Canal. This is possible because the flows are measured and recorded at each individual turnout in that system, and it is required since their water rights are junior to others. On the other hand, in most instances along the other canals measurements are not made because little shortage is experienced. Another practice used extensively in the region is the regulation of canal discharges at points in the system by varying the amounts of spillage into the natural wasteways and washes. Neither of these practices - inadequate flow measurement and canal spillage - are conducive to either good water management or salinity control.

The dilemmas being faced by irrigation officials are numerous, but can be traced to one factor. When the demand for irrigation was realized and the canal alignments located, the expected demand for water was based on the total area of land under the canal. However, when the acreages of raods, homes, phreatophytes, etc., are deducted, the water available for each acre is significantly increased. For example, under the Grand Valley Canal are 44,774 acres of which only 28,407 are irrigable. Consequently, instead of having a water duty (annual volume of water diverted from the river per unit area) of 5.76 acre-feet per acre, there is more than 9 acre-feet per irrigable acre. The result is a two-fold problem:

(1) With the excess of water available to the irrigators, it is more economical to be wasteful, because failure to provide adequate water to crops during critical growing periods can affect yields more than an over-irrigation.

(2) The history of development in the Western United States has always shown water to be a valuable commodity to an area and as such, the rights one has are to be protected since the rights not historically diverted are lost. Consequently, the Grand Valley must divert its rights for fear of losing them.

In short, it is not the practice of agriculture to be wasteful, but the laws regulating the use of water dictate that a user either be wasteful or give up a valuable right.

A few remarks are also needed for the lateral system. The term "lateral" refers to the small conveyance channels delivering water from company operated canals to the cropland. When water is turned into the lateral system, it becomes the responsibility of the users entitled to the diversion. Single users served by an individual turnout are not uncommon, but most laterals serve several irrigators who decide among themselves how the lateral will be operated. Most of the multiple-use laterals, which may serve as many as 100 users, are allowed to run continuously with the unused water being diverted into the drainage channels. This practice would be almost completely eliminated if the only water diverted was that quantity appropriated to each acre in the company water rights. The costs that would be passed on to the irrigator for a more regulated canal system would also provide added incentive for more efficient water management practices below the canal turnout. Thus, there would be an indirect economic incentive for better management.

There appears to be a considerable need for system rehabilitation in the form of linings and regulating structures prior to placing restrictions on lateral diversions. The reason is simply that little means of water distribution on an equitable basis below the canal turnout exists. Aside from the canal turnouts themselves, which could be rated individually, no observable means of measurement exists. Without adding control and measurement structures, it would be impossible to either regulate lateral diversions or equitably distribute the water among users.

Water Management in the Grand Valley

The saline soil conditions associated with inadequate drainage and the basin-wide urgency of rising salinity concentrations make water management in the Grand Valley increasingly important. The inefficiencies apparent in present practices of water use result from a combination of abundant water supply, low water costs, and critical soil and topographic characteristics. These problems would have been dealt with more substantially long ago, if the economic penalties had been more severe. In the Grand Valley, the 30% of the acreage highly affected by poor water management was an insufficient deterrent to offset the belief that use must be made of all water rights in order to protect them. Nevertheless, the time has approached when the growing salinity problem in the Colorado River Basin, complicated by recent and planned development in the Upper Basin States has forced areas like the Grand Valley to plan for more efficient management of water.

The Grand Valley Water Purification Project, Inc. (a consortium of local irrigation companies organized to seek improvements in the conveyance system), interested citizens, and state legislators have realized the need to promote investigations that will lead to a feasible salinity control program

for the valley. This attitude is extremely farsighted and will prove beneficial to the irrigators in the area by studying all available solutions and providing for increased farm output to offset the costs that will be incurred.

The internal phases of a salinity control program in the valley involve canal system management, on-farm water use improvements, and drainage.

Canal System Management. Although the primary use of water is on the farm, the primary control is not. Therefore, the first step in effecting a sound management scheme is the incorporation of more rigid water company controls. It has been alluded to several times in the preceding sections that the adjudicated water supply under normal water years is especially abundant, on the order of 8-9 acre-feet per irrigated acre. With such a high water duty, waste and inefficient use is encouraged. There are several conditions existing that should be improved. These include the increased control of canal diversions to reduce spillage into natural washes and drains, company control of lateral turnouts to avoid the excessive waste below in the form of dumping water into the drainage system when not used in multiple use systems, and control on the delivery mechanism such as a call period to efficiently meet irrigation demands.

On-Farm Water Management. Excessive application of water to soils in the Grand Valley is undoubtedly the primary cause of salt inputs to the river system. Increased irrigation efficiencies will be the most influential factor affecting improvements in salt contribution, drainage problems, and crop production. It is estimated that the valley wide farm efficiency ranges between 30 to 40%. In this range of operation every acre-foot of water consumptively used by crops must be accompanied by about two and one-half acre-feet that flows as deep percolation or field tailwater. If improved canal management measures were present, farm efficiency would be sharply enhanced. The real need in this area is a program to demonstrate improved irrigation methods and to convince irrigators of the benefits.

Drainage. The present open ditch drainage system is largely ineffective in reducing the high water tables and, for the most part, is used mainly as a conveyange for field tailwater. The reason for the general inadequacy of these drains is based on the fact that insufficient attention appears to have been given to the true characteristics of the problem. Piezometric readings and stratum surveys taken throughout the valley indicate that a relatively impermeable layer confines a cobble aquifer commonly producing a vertical gradient. The confining layer has been found to be discontinuous in at least one location, allowing water to move more freely into and out of the cobble, thus increasing the drainage potential. Measurements of hydraulic conductivity and hydraulic gradients show conclusively that most flows into the river, occurring as subsurface flows, are transmitted by the cobble aquifer.

Improved drainage for Grand Valley should be a combination of interceptor drains to collect ground water flows from higher lands, pump drainage to relieve vertical gradients and lower water tables in selected areas, and field tile-type drainage to control the fluctuations of the moisture levels in the root zone. These are known to be important principles in successful farming operations.

An improved drainage system without an accompanying increase in on-farm water use efficiency and improved operation of canals would only magnify the already critical problem. Obviously, if the water tables are lowered, more water can and will be applied, irrigated acreages will increase into the reclaimed areas, and salt loadings would probably rise. However, if effective drainage accompanies improved water management practices in general, the productivity of local agriculture will be greatly increased as the salt problem is alleviated.

Institutional Requirements. When all aspects are considered, the institutional constraints compromising the wishes of local water users and regional salinity planners will be the most difficult and the most important to resolve. Salinity control in the Grand Valley simplifies immediately to the restricted use of water resulting in a quantity that need not be diverted. The question immediately confronted is what happens and who obtains the water saved by salinity control programs in the Grand Valley? The legal constraint here is the possibility of forced abandonment of some of the decreed water right in the valley and then, the successive reapportionment to other uses. Thus, the water use must be changed from irrigation to another desired use if it is to be left in the valley supply.

Ineffective drainage, excessive salt inputs to the Colorado River, and marginal agricultural production from at least 30% of the valley are not three independent problems, just one - poor water management practices by an irrigated agriculture. Grand Valley is not unique in this respect, either. Consequently, the implementation of salinity control measures will require the formation of an administrative body to coordinate the activities of the various entities concerned with irrigation in the valley. These and similar questions suggest a valley authority for coordinating the salinity control program. The basic structure of this institution would allow it to seek salinity control funding, research funding, etc., and to transmit pertinent data and planning efforts between the federal-state entities and the local organizations. It would also stimulate the interest and investigation of economic, social, and legal problems influential in salinity reductions.

The prospect of obtaining federal money for canal and lateral lining as a first step in salinity control in the late 1960's led to the organization of the Grand Valley Water Purification Project, Inc. (GVWPP). The next step is a logical extension of the GVWPP into a regional salinity management coordinating council. Since the present organization of GVWPP is

comprised of local irrigation and drainage officials, it seems justified to broaden the format to include such responsibilites.

The possibility of organizational consolidation at the local level among the existing irrigation companies to facilitate more efficient irrigation operations as well as operating the valley salinity control program should also be considered. Such a consolidation would allow a pooling of personnel, equipment, and finances, thereby providing some savings in operational costs, but more importantly, allowing the entire Grand Valley irrigation enterprise to be operated as a truly integrated system.

In January 1972, a new organization, "Grand Valley Canal Systems, Inc.," was formed. This organization has membership on the Board of Directors from the Grand Valley Irrigation Company, Mesa County Irrigation Districts, Palisade Irrigation District, Redlands Water and Power Company, and Fruita Canal and Land Company. The principal purpose of this entity is:

> To promote the efficient and proper use of irrigation water in the Grand Valley area of Mesa County, Colorado; to protect the quality and quantity of water available for irrigation purposes in said Grand Valley; to promote a cooperative effort between companies and districts distributing irrigation water through the said Grand Valley area of Mesa County, Colorado; and to do and perform all things deemed beneficial for the interest of the individual users and distributors of irrigation water in said area.

Noticeably absent in this organization is the Grand Valley Water Users Association and the Orchard Mesa Irrigation District. Although this organization does not completely accomplish the goals of "Consolidation in Irrigation Systems," it does represent a large step forward to the eventual achievement of an integrated Grand Valley irrigation system. Of particular interest is that this organization resulted from the strong emphasis upon salinity control in the Colorado River Basin.

To sum up the case of the Grand Valley: this was a case where the physical problem of salinity control is acting as a catalyst for organizational change. Although no in-depth sociological survey of the area was conducted, it has become apparent that, as in many other valleys in the West, coordination and centralized organizational approaches are imperative means for survival and for meeting the changing circumstances of both the physical and the social surrounding environments.

ASHLEY VALLEY

Location and Physiography

Ashley Valley is located in northeastern Utah, with the town of Vernal being the central community. The valley is bordered by the Uinta Mountains on the north, a low mesa on the east, and by Asphalt Ridge on the west. The southern portion of Ashley Valley is composed primarily of waste land with only isolated tracts of arable land.

Ashley Valley is drained by Ashley Creek, a tributary of the Green River, which in turn is a tributary of the Colorado River. The main tributary of Ashley Creek is Dry Fork Creek. Both Ashley and Dry Fork Creeks rise in small glacial lakes at the base of Marsh Peak (elevation 12,219 feet) in the Uintas. They run through deep canyons which have been cut through the upturned geological formations of the Uinta Range and converge about 5 miles northwest of Vernal. From this point, Ashley Creek flows 20 miles in a southeasterly direction to its confluence with the Green River.

Heavy stands of timber interspersed with flat grassy parks and glacial lakes are characteristic of the upper reaches of the Ashley Creek drainage basin. Sagebrush and juniper cover the lower hills. Lands in the valley range in elevation from 4,500 feet in the southern portion of the area to 5,700 feet in the northern portion. Ashley Valley is a slightly elongated area approximately 15 miles long and 5 miles wide. The lands slope uniformly from the surrounding hills to Ashley Creek and are of gentle gradient. Several natural drainage channels drain into Ashley Creek, dissecting the land into long flat ridges.

Ashley Valley is situated along the south flank of the Uinta Mountains, which form the largest east-west trending range in the United States, approximately 160 miles in length and averaging 45 miles in width. It extends from Kamas, Utah, on the west to Cross or Junction Mountain, Colorado, on the east. The Uinta Mountains, a broad anticlinal arch with an east-west axis, have a maximum relief of about 8,500 feet. The highest point is Kings Peak, 13,500 feet above sea level. The post-mature surface has been incised by deep canyons and pronounced glaciation is evident in all areas. Rocks varying in age from the old precambrian to recent are exposed on the south flanks. They are all sedimentary and all dip to the south in well defined strata, often spectacular in colors of red, purple, green, yellow and white hues.

During this process of folding and erosion of the Uinta Mountains, Ashley Valley has been eroded through the overlying upper Cretaceous and Tertiary formations and into the very soft shales of Mancos formation, which were at one time tilted and exposed to the surface. A layer of waterworn cobblestone and gravel lies immediately above the Mancos shale. This is presumably material from the Bishop Conglomerate of the Miocene age, and consists of rounded to subangular, tan, purple or red

quartzite boulders from the pre-Cambrian Uinta quartzite series, in a sand matrix from the Uinta Mountains, plus rocks from other formations exposed by earlier erosion.

The valley alluvium, which varies in depth from a few inches to about 60 feet, is part of the great quantities eroded from the crest of the Uinta and transported by the numerous streams emerging along the south flank. The alluvium is composed of the finer materials; mainly clays, silts, sands, gravels, tuffs, and carbonaceous material from the various sedimentary strata comprising the limbs of the south flank of the Uinta Range.

Climate

Ashley Valley is characterized by rather wide extremes in temperature and precipitation. Ordinarily, summer days are warm with occasional short periods of hot weather; however, summer nights are generally cool. Winters are cold and short. Maximum and minimum temperatures recorded at Vernal are 103° F. and -38° F., respectively, while mean annual temperature is 44° F. The frost-free period averages 119 days. Killing frosts, however, have occurred as late as the middle of June and as early as the last day of August.

Winds are common but seldom violent. During the spring months, westerly winds often blow for several days at a time. Hail storms are rare and seldom damage crops. Also, the humid ity is unusually low.

Precipitation averages 8.52 inches annually in the valley, but varies widely from year to year. Variations are 170 to 50 percent of normal. Summer rains frequently augment the streamflow during July, August, and September. At times, these storms reach cloudburst proportions, thereby causing some damage. Annual precipitation in the mountains to the north, chiefly winter snows, averages more than 19 inches.

A weather Bureau station has been maintained at Vernal since 1894. The climatic data for this station are tabulated in Table 17.

Human Community

In the summer of 1776, ten Spaniards, led by Father Escalante, a Catholic Priest, passed through the valley in quest for a direct route from Santa Fe to Monterey, California. These were the first white men to enter and they reported a land dry and arid with sandy soil. The vegetation was sage brush, cactus and desert plants. They also recorded wild animals and Indians living there.

General Wm. N. Ashley entered the area in 1825, leaving his name to both Ashley Creek and Ashley Valley. He was on a trapping expedition with Jim Bridger and Andrew Henry, founder of the Rocky Mountain Fur Company.

Table 17. Summary of climatic records at Vernal.

Month	Precipitation (inches) Average	Yearly maximum (1941)	Yearly minimum (1934)	Temperature (degrees F.) Average	Maximum	Minimum
January	0.55	0.69	0.58	15	54	-38
February	.49	.30	.22	22	62	-32
March	.69	.62	1/T	34	75	-12
April	.91	1.96	.76	46	84	5
May	.79	.70	.20	54	90	12
June	.68	1.22	.47	62	100	25
July	.53	.33	.35	69	103	33
August	.82	2.07	.51	67	99	32
September	.84	2.60	0	59	94	17
October	.97	3.07	0	48	84	8
November	.57	.55	1.13	33	72	-16
December	.68	.67	.40	21	61	-32
Annual	8.52	14.78	4.62	44	103	-38

1/ Trace

Pardon Dodd built the first house in Ashley Valley in 1873 out of timber and mud. He was Indian Agent at White Rocks from 1868 to 1872 prior to moving into Ashley Valley to become a stockman. Agriculture began in the valley in the spring of 1874 when a ditch was excavated to irrigate land on the Dodd ranch. In 1879 another group of settlers, the Robert Snyder family which included the first woman in the valley were the beginning of the populating of the Ashley Valley. Settlers from Salt Lake City were part of the development of the area, an exploration and settlement program that went as far north as Southern Idaho and as far south as San Bernardino, California. By 1880 three large canals (Ashley Central, Ashley Upper, and Rock Point) were built.

It was necessary for the settlers to make their communities self-supporting because of isolation due to the bad roads and lack of railroad facilities. The first crops grown in the valley were corn, wheat, and potatoes. Alfalfa, small grains, and pasture have been the principal crops of the unit area. Then, as well as now, there were few immediate cash crops, livestock and animal products being the source of cash income. The Ashley Valley area is well adapted to the production of livestock because of the excellent pasturage afforded by the Uinta Mountains and also the irrigated pasturage in the valley. Sheep and cattle raising are both important branches of livestock production.

Being predominantly Morman, the communities of Ashley Valley are characterized by strong traditions concerning water and agriculture. Mormons who settled the area felt that every man should have and farm a definite plot of land. This land should be equally divided, with a proportionate amount of good and poor land. This leads, of course, to a situation of high land fragmentation. Similarly, the water in the community has been handed down traditionally as a part of the Mormon doctrine. The man who worked most in developing the diversion system, should be entitled to the most water. But this water has to be used in a beneficial way. If the water is not used in a beneficial manner, whatever this loose term may mean, that water could be taken away from the individual. Water is a very prized personal possession in this particular part of the country simply because land without water is worthless. So, for the most part, people tend to be judicious in their use of the water that is allocated to them.

Uintah County today is one of the more isolated counties in the Western United States. It is approximately four hours from Salt Lake City to Vernal, the county seat, which is found in the middle of Ashley valley. The returns of the 1970 census show that the Vernal area is increasing in population, but not with the dramatic rates of other Western regions (Table 18). The city of Vernal, the major community within the valley, is situated near the center of Ashley Valley and is the largest trading center within a radius of 80 miles. Its population reached 3,908 people in 1970 (Vernal division, which includes Vernal city has a population of 9,322 persons). The farm population (the rural population was estimated to be 5,314 in

Table 18. Population increase in Uintah County and Vernal 1900-1970.

	Uintah County		Vernal	
Year	Number	% Increase	Number	% Increase
1900	6,458	--	--	--
1910	7,050	9.1	836	--
1920	8,470	20.1	1,309	56.6
1930	9,035	6.7	2,344	79.6
1940	9,898	9.5	2,119	-9.5
1950	10,300	4.1	2,845	34.2
1960	11,583	12.4	3,655	28.4
1970	12,684	9.5	3,908	6.9

1970), is concentrated in the rural communities of Maeser, Naples, Glines, South Vernal, Ashley, and Davis. An interesting aspect of the population composition in the area is the large percentage of persons under 18 years of age (43.7 of the total), a marked difference from other areas of the present study. One of the reasons for this event is that many of the people in their older ages do not appear to remain in the area. This is partly true also because the majority of the people who have settled in the area have come only in the last few years. Such people were primarily attracted to the area by the mine and mineral activities. Thus, agriculture in the county employs only 480 people as contrasted to mining which employs 715 individuals.

Agricultural development centers around livestock production and the raising of forage crops and small grains. Several small industries centered around agricultural production have been established in the area. These include creameries, a flour mill, and meat processing plants.

Agriculture is followed in industrial importance by the production and processing of large deposits of mineral resources. Gilsonite, a hydrocarbon found only in the Uinta Basin, is mined at several points near the area for use in a variety of products such as battery cases, paints, varnishes, and roofing compounds. Its exploitation has attracted a large amount of outside capital. A pipeline conveys pulverized gilsonite suspended in water to a refinery near Fruita, Colorado, where the gilsonite is processed into gasoline and other fuels. Native rock asphalt is mined from extensive deposits in the area west of Vernal. Sub-bituminous coal also is mined in the vicinity.

Oil is produced in the southern portion of Ashley Valley, as well as in the nearby Rangely district. Most of the oil is transported by pipeline for processing in Salt Lake City, but a small refinery at Jensen, 12 miles from Vernal, produces gasoline and other petroleum products for local consumption. A plant is also operated at Jensen for processing natural oil for fuel oil, asphalt paints, and road-surfacing material.

Lumber from nearby forests is processed for local consumption by a number of small mills. Mine timbers are cut and hauled to the Carbon coal area in Utah and the Sweetwater district in Wyoming.

The marked population increase observed in the post World War II years can be traced to in-migration from expansion of the soil industry in the Rangely district of Colorado (50 miles east) and from a new oil field in the southern portion of Ashley Valley. Because Vernal is the nearest trading center, it has absorbed most of the influx of workers and prospectors. Many new homes and business buildings have been constructed to meet housing and business needs. Part of the growth can be also attributed to the natural attraction of the area, an asset to be further exploited by recreational activities. All in all, despite the continuous trends of growth, the area is not expected to become a major urban center. However, as long as mining

continues (and with the potential of further exploitation of the asphalt ridge west of the valley) there is a guarantee of a good economic basis and of sustained growth.

Irrigation Development

Ashley Creek is characterized by high discharges from snowmelt in May and June followed by rapidly receding flows which are far below irrigation requirements. As early as 1888, efforts were made to develop storage for the erratic water supply. About 1,100 acre-feet of storage capacity is available on Ashley Creek. This is provided in a group of small glacial lakes (Long Park, Twin Lakes, Mirror Lake, and Goose Lake) on the headwaters of Ashley Creek. An additional 5,740 acre-feet of capacity is provided for Ashley Valley in Oaks Park Reservoir on Brush Creek which lies north of Ashley Creek. Water is diverted by the Oaks Park Canal from the reservoir to Ashley Creek.

Presently irrigated lands in the valley are served by six major canals and ditches diverting from Ashley Creek (Figure 19). These include the Ashley Upper, Ashley Central, Highline, and Rock Point Canals and the Island and Dodds ditches. The Colton ditch is combined in the Ashley Upper Canal and the Hardy ditch in the Ashley Central Canal. In addition to the diversions by the main canals and ditches, there are some small diversions made by individuals or small groups of private interests. In the southern portion of Ashley Valley, the Union and River Canals supply some small areas with high water from Ashley Creek and return flows from irrigated lands in the valley.

Through storage regulation and water exchanges, the Vernal Unit of the Central Utah Project was constructed in the late 50's and early 60's to provide water for irrigation and municipal use. This project provides an average of 18,000 acre-feet of supplemental irrigation water annually, as well as increasing the municipal water supply of Vernal, Maeser, and Naples by an average of 1,500 acre-feet annually. The Steinaker Reservoir (the first impoundment of the Central Utah Project) was constructed to a capacity of 37,560 acre-feet at an offstream site on Steinaker Draw about 3.5 miles north of Vernal. The water from Ashley Creek is diverted by the Ft. Thornburgh Diversion Dam located on Ashley Creek 4 miles northwest of Vernal. From the diversion dam, the water is conveyed eastward to the reservoir through the 3.1-mile long Steinaker Feeder Canal and conveyed south 11.8 miles to existing canals and ditches that are intercepted by the Service Canal.

Irrigation water is distributed primarily through major existing canals and ditches, including the Ashley Upper, Ashley Central, Rock Point, and Highline Canals and the Island and Dodds ditches. Some water is also distributed by small canals and laterals in private ownership in an area along Ashley Creek, known as the River Bottom area. Diversion structures for the Rock Point and Ashley Central Canals and the Island and Dodds dichhes are included in the new Ft. Thornburgh Diversion Dam.

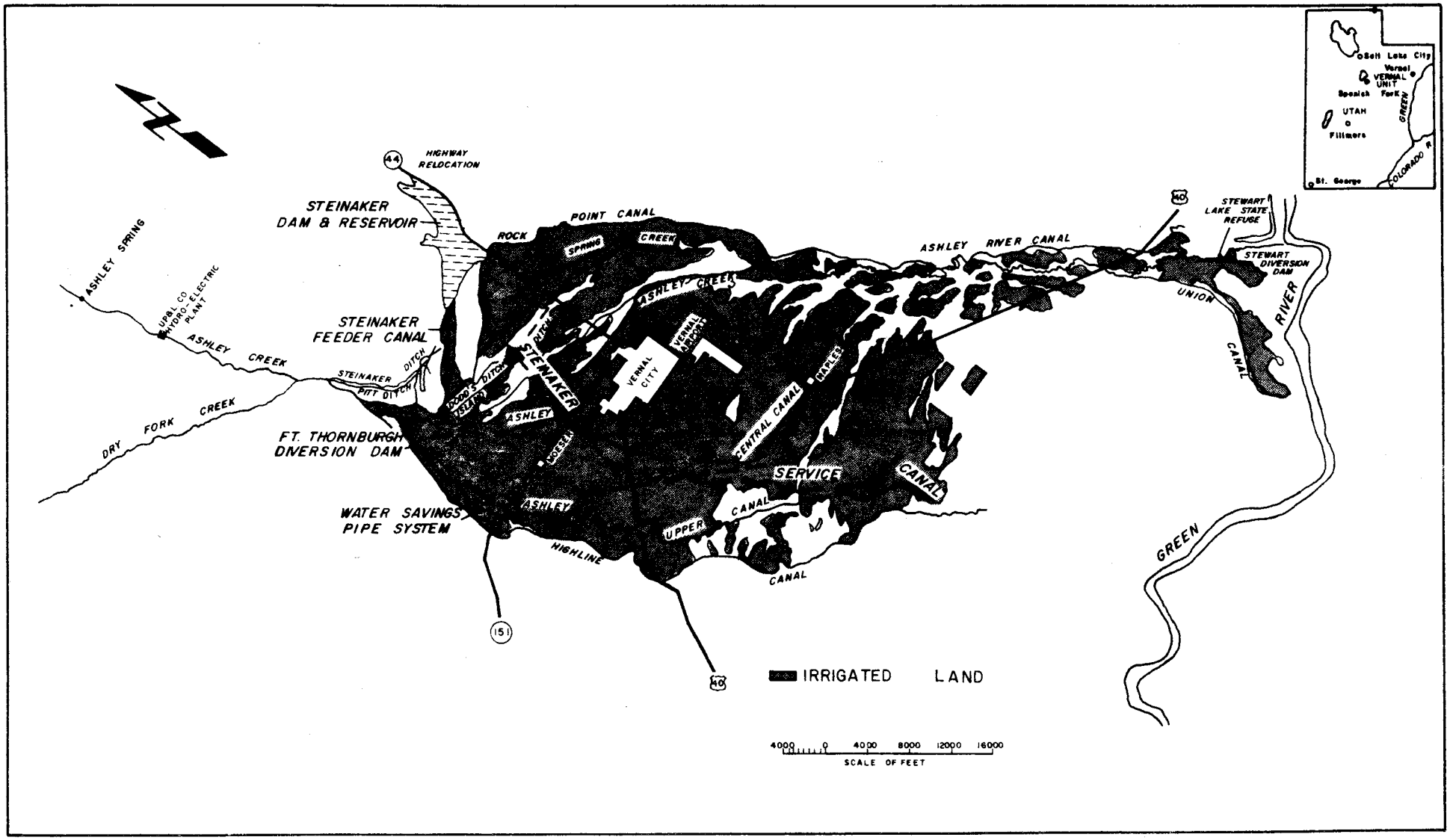


Fig. 19. Ashley Valley irrigation system

Water for the Ashley Central Canal is diverted by the dam for control and measurement and then returned to the creek channel for rediversion farther downstream. The Ashley Upper and Highline Canals continue to divert from Ashley Creek above the diversion dam. The Steinaker Service Canal intercepts and provides water to some existing canals and ditches, including the Ashley Central and Rock Point Canals and the Island and Dodds ditches, as well as some laterals of these canals and ditches and of the Ashley Upper Canal. Some new laterals have also been constructed for distribution of the water from the Steinaker Service Canal.

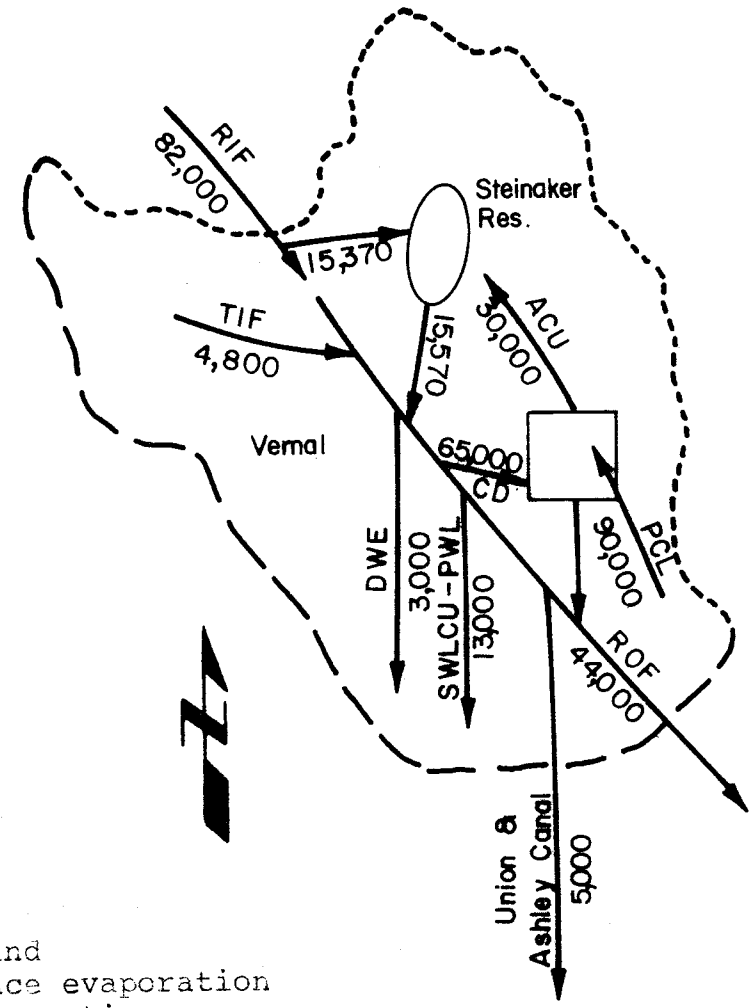
We need to look at the same time at the general picture of water supply and water budgets in the area. Ashley Valley is the drainage area of Ashley Creek below the stream gaging station, "Ashley Creek at Sign of the Maine." The river inflow to Ashley Valley is the river outflow from the Ashley-Dry Fork headwaters. The distribution of mean monthly and mean annual flows for the 1931-1960 time period is represented in Table 19, while Figure 20 gives a flow diagram of the mean annual water budget for Ashley Valley. The diversions to cropland for the 1931-1960 time period were estimated from 1963-1966 diversion records, which coincide with the initial operation of Steinaker Reservoir. This reservoir is an off-channel storage site with waters from Ashley Creek being conveyed to the reservoir by means of the Steinaker Feeder Canal. The water released from Steinaker Reservoir is used for irrigation in the Vernal area. The consumptive use for the valley was determined from the water budget. Ashley Valley exports canal diversions to the Jensen area through the Union and Ashley Upper canals. The mean monthly and mean annual distribution for the river outflow station 9-2715, "Ashley Creek near Jensen," was obtained from USGS records and USBR estimates for missing years. No estimate of groundwater is given. USBR records indicate there is little subsurface flow in the Ashley Basin area.

Water Rights and Reservoir System

Decree of 1897. Rights to the flow of Ashley Creek were adjudicated and a decree made in November 1897 in the Fourth Judicial Court of the State of Utah. The decree apportioned the entire flow of the creek among the water users. Several companies and numerous individuals were each awarded a certain portion of the total flow. Water under the various 1897 rights is now almost entirely distributed through six canals and ditches, the total diversion capacity of which has been accepted in operating practices over many years as 500 second-feet. The 1897 decree then, while ostensibly covering the entire flow of Ashley Creek, is in practice limited to 500 second-feet. The approximate percentages of the 1897 rights conveyed by each canal and ditch are tabulated below. Percentages shown for the Ashley Upper and Ashley Central Canals include water acquired from these canals by the municipal water systems and now diverted into a pipeline from Ashley Spring located above the canal intakes and above the "Sign of the Maine" stream gaging station.

Table 19. Mean monthly and annual water budget for Ashley Valley.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
River inflow Ashley Cr. nr. Sign of the Maine	3,470	2,590	2,130	1,830	1,530	1,620	4,000	23,510	24,450	8,140	5,160	3,570	82,000
Tributary inflow Ungaged inflow	210	160	140	140	180	270	450	1,150	1,010	530	350	210	4,800
Stanaker Reservoir Net change in storage	-210	1,540	1,540	1,260	1,050	1,110	1,380	3,070	4,620	-5,980	-5,610	-3,770	0
Total surface inflow	3,890	1,210	730	710	660	780	3,070	21,590	20,840	14,650	11,120	7,550	86,800
Exported flow Union and Ashley Up. Irr. Co. Canal diversions	420	0	0	0	0	0	40	1,730	1,300	720	400	390	5,000
Diversion to cropland	3,600	0	0	0	0	0	530	18,310	17,820	12,390	7,110	6,240	65,000
Amount to root zone	1,740	0	0	0	0	0	250	3,730	8,550	5,950	3,410	2,520	31,200
Cropland precipitation	780	730	820	690	630	710	840	800	800	690	780	730	9,000
Root zone supply	2,520	730	820	690	630	710	1,090	9,580	9,350	6,640	4,190	3,250	40,200
Cropland P.C.U.	2,490	0	0	0	0	0	0	6,300	8,370	10,300	6,950	2,890	37,300
Root zone supply P.C.U.	30	730	820	690	630	710	1,090	3,280	980	-3,660	-2,760	360	2,900
Accum. soil moisture	2,000	2,330	2,750	3,040	3,270	3,580	3,970	5,500	3,880	2,620	1,560	2,150	---
Change in soil moisture	-150	330	420	290	230	310	390	1,530	-1,620	-1,260	-1,060	590	0
Consumptive use deficit	270	0	0	0	0	0	0	0	0	3,770	2,400	730	7,300
Actual C.U. cropland	2,220	0	0	0	0	0	0	6,300	8,370	6,600	4,350	2,160	30,000
Addition to groundwater	450	400	400	400	400	400	700	1,750	2,600	1,300	900	500	10,200
Return flow from cropland	1,860	0	0	0	0	0	280	9,530	9,270	6,440	3,700	2,720	33,800
Total of return flows	2,310	400	400	400	400	400	980	11,280	11,870	7,740	4,600	3,220	44,000
Domestic use &W.S. evaporation	160	60	50	50	50	130	280	440	530	590	450	210	3,000
Supply wetland & G.W.	2,020	1,550	1,080	1,080	1,010	1,050	3,200	12,300	13,060	8,690	7,760	4,930	57,800
Wetland precipitation	540	500	570	480	440	400	580	550	540	470	540	500	6,200
Wetland cons. use	930	0	0	0	0	100	340	3,270	4,270	5,050	3,940	2,100	20,000
Outflow and/or G.W. change	1,630	2,050	1,650	1,540	1,450	1,440	3,440	9,670	9,330	4,110	4,360	3,330	44,000
Estimated G.W. change	30	-350	-850	-960	-1,050	-1,060	840	-2,630	-2,970	2,910	3,560	2,530	0
River outflow Ashley Creek nr. Jensen	1,600	2,400	2,500	2,500	2,500	2,500	2,600	12,300	12,300	1,200	800	800	44,000



Legend

RIF = River inflow
TIF = Tributary inflow
CD = Canal diversion
PCL = Precipitation on Cropland
ACU = Actual consumptive use
TRF = Total return flow from cropland
DWE = Domestic uses and water surface evaporation
SWLCU = Total wetland potential consumptive use
PWL = Precipitation on wetland
ROF = River outflow

Fig. 10. Flow diagram of mean annual water budget for Ashley Valley

Canal or ditch	1897 water rights (approximate percent)
Ashley Upper Canal (includes Colton ditch)	36
Ashley Central Canal (includes Hardy ditch)	34
Rock Point Canal	20
Island ditch	7
Steinaker ditch	2
Dodds ditch	1
Total	100

Miscellaneous decrees. Rights for the use of Ashley Creek flows for irrigation have been decreed since the original decree of 1897, primarily for use of flood waters and return flows from irrigation.

The Highline Canal which diverts near the head of Ashley Valley has no right under the Decree of 1897 but uses water from Ashley Creek under a right acquired through an application made to the State Engineer in 1912. By this right the canal is entitled to 182 second-feet of the Ashley Creek runoff after the runoff reaches 500 second-feet.

Water users under the Union and River Canals in the lower part of Ashley Valley hold rights to return flows and flow waters of Ashley Creek. These rights were obtained by application in 1909 and 1911, respectively, and were adjudicated by court decree in 1915. The decree provides for primary rights of 10-6/7 second-feet to the Union Canal Company, 5-5/7 second-feet to the River Irrigation Company, and 6/7 second-foot to other minor users. It further provides for secondary rights totaling 35-1/10 second-feet.

Storage Rights. A number of applications have been filed with and approved by the State Engineer to store water on Ashley Creek and its tributaries and on other nearby streams for use as needed in the Vernal area. The State Engineer's approval of an application gives the applicant permission to proceed with the construction of works and use of water, but a final certificate of appropriation is issued only for the amount of water applied for or the amount of water beneficially used, whichever is less. No certificates of appropriation have yet been issued on storage rights for the Vernal area although four small reservoirs have been constructed on tributaries of Ashley Creek and one on Brush Creek with rights under approved applications as shown below.

Reservoir	Drainage area	Right for which application has been made (acre-feet)
Long Park	Ashley Creek	500
Twin Lakes	Ashley Creek	360
Goose Lake	Ashley Creek	150
Mirror Lake	Ashley Creek	100
Oaks Park	Brush Creek	7,500

All of the storage reservoirs are operated for the benefit of the Ashley Valley Reservoir Company although some of the rights are held by Government agencies pending repayment of loans granted for construction. The capital stock of the Ashley Valley Reservoir Company and in turn its reservoir water were distributed in 1956 among Ashley Valley irrigators and municipalities as shown below.

Name of stockholder	Shares owned	
	Number	Percent of total
Steinaker ditch	108.00	0.5
Highline Canal	4,407.46	19.6
Ashley Upper Canal	9,991.50	44.4
Ashley Central Canal	5,235.52	23.3
Rock Point Canal	1,165.76	5.2
Island ditch	20.00	.1
Municipal system (Vernal, Maeser, and Naples)	1,564.55	6.9
Total	22,492.79	100.0

Other Water Rights. The Utah Power and Light Company has by application to the State Engineer acquired a right to use 55 second-feet of water from Ashley Creek for its hydroelectric powerplant on that stream. Water rights for the municipal water system have been acquired by the purchase of irrigation water.

Vernal Unit Rights. In order to receive storage benefits from the Vernal Unit, boards of directors of all of the canal and ditch companies served by the Vernal Unit have approved resolutions stating that they are willing to limit diversions to amounts that can be used beneficially under a pattern of need to be determined by the Bureau of Reclamation.

The Bureau of Reclamation on February 20, 1945, filed with the State Engineer Application No. 16387 to appropriate 50,000

acre-feet of water annually for the Vernal Unit, at the time planned as an independent development. The application was approved by the State Engineer on September 30, 1946.

The water being utilized under the Vernal Unit is a portion of the water of the Upper Colorado River Basin to which Utah is entitled by terms of the Upper Colorado River Basin Compact. This compact, approved by Congress April 6, 1949, apportions consumptive use of the water of the upper basin among the upper basin states.

Patterns of Water Use

As emphasized above, prior to the Steinaker project, water was diverted directly from Ashley Creek into a series of canals which are owned by the irrigation companies. In the past, during the first two months of the irrigation season, May and June, the people of the Valley had adequate water, but during the months of July and August many times their crops burned. The Steinaker Reservoir in theory overcomes this problem, as a feeder canal diverts water from Ashley Creek into it. The remainder of the water, if there is an excess in the early part of the year, continues down Ashley Creek and it is either used by the people in Ashley Valley or it eventually winds up in the Green River.

The Reservoir offers another interesting problem which has to be dealt with by the community, namely the elevation of its outlet. This outlet is too low to supply the upper canal. It can only supply the two lower canals, so that water has to be exchanged or somehow subtly arranged so that the people who are entitled to receive water from Steinaker may do so. This is accomplished by delivering Ashley Creek water to the upper canal and calling it Steinaker water, while the lower canals receive impounded water which is called Ashley Creek water. In any case and despite confusing nomenclature, water is traded and exchanged by the manager of the Ashley Valley Water Users Association, so that the individual's water rights will be satisfied, according to the provision that all persons within the Valley boundaries are entitled to Steinaker water.

Urban versus rural water uses present no particular problems in the area because all of the urban water comes from springs located north of Ashley Valley. These springs are encased inside a concrete building with the water dumped directly into a pipeline. The rural water, on the other hand, is conveyed entirely through Ashley Creek and the canal system. The return flow from Ashley Valley dumps into the Green River which continues southward until it joins the Colorado River in southern Utah. The return flow is rather salty because Ashley Valley is an area with some salinity problems. At the same time, agricultural wells are virtually nonexistent in the area.

From the industrial point of view, very little water is used because the mining industry removes the ore in the area and then it is shipped out to refineries outside the Valley. The oil industry also pipes all of the fuel from Ashley Valley to Salt Lake City with the refineries there processing it.

In terms of agriculture, the water users in Ashley Valley typically use between three and four acre feet of water for every acre of land under cultivation. The mean is approximately 3.5 acre feet. The cost of this water is based on two different scales. Water which comes from Ashley Creek, which is considered primary water and part of the prior appropriation right of the land owner, costs $1.50 per acre foot. This water is diverted directly from the Creek and goes into the canal system. The water from Steinaker Reservoir (which is considered secondary water) costs $2.75 per acre foot. Because of its supplemental character and high cost, many people in the valley are rather antagonistic, since they feel that the water is theirs and if they did not have a reservoir they could have used it anyway. Needless to say, there is a failure to recognize that such water would have been available only in May and June and then it would have simply run down the river. Nevertheless, there is a great deal of hostility concerning the increased cost of the water which is stored in Steinaker. Many farmers feel that they should not be compelled to pay the extra $1.25 for the supplemental water.

Organization of Irrigation Companies

From the historical evolution described previously, the role of beneficial use of water must be once again stressed. Despite its vagueness, beneficial use has been interpreted as a means for appropriate water utilization. With the cultural tradition of Mormon settlement and development and with the legal power incorporated in the prior appropriation doctrine, one can better understand the organization and operation of the irrigation companies in the Valley.

There are five irrigation companies in the Valley: the Ashley Upper Canal with 520 members, the Ashley Reservoir Co. with 250 members, the Central Canal Co. with 250 members, the Highline Canal with 100 members, and the Rock Point Canal Co. with 78 members. The five companies were fromed during the 1800's by pioneers who entered the Valley. With the completion of the Steinaker project in 1962, radical changes in the five irrigation companies became necessary, especially because, as was mentioned earlier, the upper two canals were not being able to deliver water from the reservoir.

As Steinaker Dam became a reality, the irrigation companies of Ashley Valley soon realized that the increased supply of water would be expensive and it would be necessary to distribute it as efficiently as possible. Crops no longer would be dependent upon natural streamflow, but good management would be necessary to assure an adequate water supply for the hot summers.[481]

These companies requested the Utah State University Extension Services to help develop a method of water delivery and record keeping. Various meetings resulted in the following recommendations: (1) A central office be organized where all the business of the irrigation companies could be handled. (2) A manager be hired for the office and the chairman or president of each company form a committee or board of directors

for the Central Office. (3) A communication system be established for irrigators, water masters and the Central Office. (4) Water masters be schooled on water policy and system procedure. (5) Irrigation structures be re-built or improved so that water deliveries could be measured. (6) Water be ordered and recorded in acre-feet and an up-to-date account be kept of the amount each water user has used. (7) Water delivery would be changed from a rotation system to a call or demand system.

The Central Office did become a reality. Officials of four canal companies approved the recommendations and a Central Office committee was formed in May 1964. Later, the Rock Point Canal Company joined the association.

Irrigation company records were transferred from private homes to the office located in downtown Vernal. The records, business, and stock valued at $1.8 million are now consolidated and administered in one conveniently located office. With improved office facilities and procedures, including card files and name plates for IBM mailing, the Central Office rapidly gained a reputation as an efficient place to transact the business of water ownership and delivery.

Instructions were given to water users, water masters and ditch riders on procedures for requesting water and each shareholder was informed in the spring how much water he could anticipate. Water users now order their water direct from the Central Office.

The problems of accounting for and delivering water are not simple and easy for the Central Office, but their solution is easier than formerly when business was usually conducted on someone's front lawn or in the field. Some of the difficulty of administration results because there are three sources of water rights: (1) primary and secondary water from natural streamflow, (2) water from the reservoirs in the high mountains, and (3) water from Steinaker Reservoir. Some canal companies have only secondary water rights, while others have all three water rights. However, the Central Office has done a remarkable job of supplying water under these conditions. It has meant careful accounting and accurate records and while it is difficult now, under the old system it was often impossible for water masters who kept their records in a booklet carried in their hip pockets.

Steinaker Dam and the formation of the Central Office have increased the cost of water. At the same time, they have given the farmer an assured supply of water that has resulted in increased production.

As indicated earlier before Steinaker Dam was built, a farmer could expect to get about 2 acre-feet of natural stream water for each acre at a cost of $.50 per acre-foot and 1 acre-foot of high mountain reservoir water at $2.50 per acre-foot.

Three acre-feet of water per acre might be enough to grow a crop in Ashley Valley, but most of this water was gone before it was needed.

Water from Steinaker Reservoir is estimated at $2.75 per acre-foot. Efficient water users, however, have reported that 1 acre-foot from Steinaker Reservoir has been adequate to supplement their present supply.

Not enough time has elapsed to determine accurately the increased production resulting from Steinaker Dam and better distribution methods by the Central Office. However, farmers are reporting that alfalfa land, just poor pasture before, is now producing 2 to 3 tons per acre. Alfalfa land producing 2 to 3 tons per acre before, is now producing 4 to 5 tons. Barley production has increased as much as 50 bushels per acre. Most important, farmers feel that crop failures due to drought are a thing of the past.

The new organization, the Ashley Valley Water Users Association has not eliminated the basic companies. They continue to exist as companies with their own canals. The major difference is that now the Ashley Valley Water Users Association delivers the water to the canals. Water from Ashley Creek is delivered to the upper two canals and that from Steinaker to the lower two canals. This is done because during the latter part of the year water is not adequate for the upper two canals and all of it is diverted into them in an attempt to satisfy the needs of the water users on the upper part. The lower part, i.e., the lower two canals, receive their share with minimal difficulty. To the present the upper two canals appear to have received their fair share of water and there have been minimal complaints, if any complaints at all.

The Association has been a very important sign of the cooperative forces within the community. The construction of Steinaker Dam and the establishment of a central irrigation office, however, were not the end of community efforts in Ashley Valley. Already such committees as the Central Office Committee and the Uintah County Conservancy District are at work to bring more land into production and provide an adequate future supply of water for industrial and city use by developing water from Dry Fork.

The Central Office Extension Service, Conservancy District, and Soil Conservation Service are busy seeking ways to eliminate excessive seepage losses of water from the canals. Plans include eliminating the Upper Canal and enlarging the Highline Canal to carry the water of both canals. This new canal would then be lined and distribution laterals would be constructed with pipe. Water could then be delivered to farmers under pressure. In addition, operation and maintenance costs would be greatly reduced.

Other future goals include a complete call system of delivery, better access roads along the canals, and better measuring and turnout structures, all of which lead to better production and a more abundant life through combined efforts of everyone.

Before we continue further with the discussion of the potential for joint action in the valley, we need to have a closer look at some of the organizational features of the existing irrigation companies.

The board of directors are elected to their positions by the shareholders from the various companies. There are two levels of elections which have to be considered. First there is the board of directors for the individual companies. This group of directors is elected within the individual irrigation company by the individual shareholders. The president of the board in each company serves also as a member of the board of directors of the Ashley Valley Water Users Association (AVWUA), who in turn elect their own president of the board. The role of the AVWUA water board in speaking for the entire Valley, is one of making policy decisions for the larger organization. They make any changes which are deemed necessary so that the manager of the system can deal with it. Broad financial decisions are outlined by the board, with every day decisions made part of the budget which is dealt with once a year. The role of the individual member on the AVWUA board is one of being representative of his own company and he is there to protect and defend the interest of the particular company.

Being on the board of directors can be seen from two different angles. First, it has been described as a thankless task which no one really wants to have, but one that has to be done. The other side of the coin is one in which if a man is elected to such a position he is also placed in a position of trust by the other individuals. The individual board member speaks for the company as a whole and there is a certain amount of status attached to such a position of trust. At the same time, the expectations of the board members are rather poorly defined. The individual water owner could care less what the board members do so long as the company does not increase the amount of cost per unit of water or there are no nasty disputes in the system. They expect a board member to be there in their stead and to carry forth their wishes succinctly summarized in two brief mottos: (1) "keep the cost of water down," (2) "see that we receive our fare share of the water."

Management of the Association has been mostly informal. The present manager was selected for the position because he was aware of the needs of the farmers and he felt that he had a plan which would allow all people on all four canals to receive their fair share of water. He simply went about accomplishing this task by trial and error. Although he had no formal training, he had experience from other members of his family, who had worked on water tasks for many years in the past. The manager carries forth the instructions of the board of directors and directs the office personnel and ditch riders per the instructions handed down by the board.

The task of supervision can be broken into various areas. The ultimate power of the company lies in the hands of the shareholders; if they wish to exercise their power they can do this by voting in the election. The shareholders at the annual

meeting vote on any major construction which will be done within the system, any major alterations and their related costs, and discuss the proposed budget.

Elections are also held at this time for part of the members of the board of directors. Since individuals have already been elected on the irrigation company level, the board election is simply a reaffirmation and mere formality. The entire annual process is organized by the board of directors and presented to the membership, with a certain amount of prior knowledge and prior negotiation so that a minimum discussion takes place at the formal meeting (not that occasionally there are no flare-ups or open disputes). All in all, those who own a great deal of water are the ones who become members of the board. They are typically order men who have been successful farmers and who have the time in making policy decisions for the company or the Association. The term of office is a long one, and once elected, they usually maintain this position until death or resignation.

The effect of the shareholders in reality is rather minimal. They hold their meetings during the day once a year; those who are interested come in and they discuss the issues and deal with them appropriately. There is a small group of farmers who control and run the irrigation policy. The rest of the people proxy and very little is done in terms of changing the status quo. In essence, the shareholders have a minimal effect on the company simply because they appear quite satisfied with the present policies and no particular friction mars the sedate atmosphere of the formal meetings.

Water Management in Ashley Valley

The system described so far can be considered one of stability and of high informal mechanisms of control. The major change in the Valley has the completion of the Steinaker Reservoir which provided both the impetus and the need for a drastic reorganization and centralization of past individual management schemes. The necessity to bring about a more efficient irrigation organization has given the people of the Valley a taste and an experience of what concerted action implies. This is even more true, if it is also recalled that the Steinaker system is under the direction of the Uintah Water Conservancy District, which in turn works closely with the Central Utah Water Conservancy District, with both of them, finally, being part of the Central Utah Project. Thus, a great network of interdependent organizations and sets of administrative linkages have set the stage for a coordinated approach of a more formal consolidation.

The spirit of cooperation and satisfaction that has been particularly strengthened with the creation of the Steinaker Reservoir can be seen in the various responses of the special survey (see later Part V). More than anything else, the adequacy of the water supply was central in all favorable responses. Of those asked, 57.6 percent responded that they had enough, while 29.3 percent felt that they had barely enough.

Only 12.5 percent responded that they did not have enough water for a normal year's crop production. In another question of the survey concerning overall satisfaction, 73.9 percent of those responding expressed satisfaction and only 1.1 percent very unsatisfied with the water they were receiving.

To date, the scheme of association of the five irrigation companies has worked quite well because the water owners on all four canals have been able to receive their water as it has been dictated by the water rights they own. If a situation emerges where water would not be available, provision has been made so that the earliest rights receive their water first. However, such an amicable arrangement has been viewed with skepticism by those interviewed. The adoption of the form of association of the companies has not been unanimously enthusiastic (and this can be seen in a number of responses in Part V). Generally, the existing antagonism can be traced to the fear of a loss or infringement of existing water rights. The innovative and coordinative organizational form has been accepted by the people of Ashley Valley simply because there was no other choice. The people who were on the higher two canals did not have enough water; the people who were on the lower two canals received an adequate supply of water, but the system did not meet the needs of many people who were above the two lower canals.

The Ashley Valley Water Users Association has provided coordination and centralization, without obliterating at the same time the individual companies. Thus, as a first stage this "federation" provided a necessary transition which maximizes administrative efficiency and, at the same time, guarantees the always precious water rights. Needless to say, there are significant advantages from further consolidation, such as a new consolidated canal system, lining for the prevention of seepage, other technological innovations (e.g., centralized sprinkling systems), and further organizational integration. Yet, despite expressed advantages quite a number of people are fearful of the loss of their water rights and, if nothing else, of the ability to govern themselvers.

In any case, real consolidation seems to be only a matter of time in Ashley Valley. The people are acutely aware that the seepage from the old existing canal system is rather great. They are very much aware that these losses could be significantly reduced by implementing a consolidated system capable of meeting the higher costs of effective maintenance.

Organizationally the consolidation would be very simple since the framework already exists. As for the general climate or preparedness for consolidation, once again the overriding consideration is cost. The goal of the irrigation companies is to supply the most water possible for the cheapest possible price, a goal aggressively and actively pursued by all companies. The larger farmers are particularly vocal on such goals. On the other hand, some people who are irrigating small plots of land feel that the irrigation company is busily perpetuating itself and not maintaining any interest in their particular problems. To a certain extent there is some

justification to this. The irrigation company is not accustomed to delivering water to a man who has a half acre of land. It is rather costly to deliver this water to the individual and it is considered to be a rather arduous task by many ditch riders.

The water which is available in Ashley Valley is capable of supporting the population, the agricultural industry, and to meet the industrial needs in the valley, minimal as they may be. There is also enough water that the Valley can grow and continue to prosper in both the industrial and agricultural sectors. However, the Valley is rather limited in terms of its potential for agricultural expansion. There is limited land which can use the water in the Valley simply because of the elevation of the surrounding hills. On the other hand, the surrounding oil and mining industry are booming and appears to be on the upswing as more mines are being dug and many more oil wells are being drilled every day. The Flaming Gorge Reservoir is becoming a major pole of attraction for tourists and outdoor doorsmen. Such new demands for industry and recreation may provide the new impetus for consolitation. If the Steinaker Project had not been built, most probably the Valley would still have five separate and independent irrigation companies. People in the arid western part of the United States are too jealous of their water rights and they guard them far too jealously to ever allow them to become part of a consolidated system, unless some type of an external impingment is thrust upon them. New water demands for other uses may be one of those instances. In other cases, rapid urban growth, and the premium placed on water consumption, may be the catalyst for consolidation. In Ashley Valley, although metropolitanization is not in the horizon, expanding economic activities, linkages with much larger water projects, and last, but not least, the happy experience gained through the Water Users Association make more than probable a future consolidated system.

Location and Physiography

The Utah Lake drainage area lies in the north central part of the state of Utah, as shown in Figure 21. The area is part of the drainage system of the Great Salt Lake, which in turn is a part of the Great Basin. The Utah Lake drainage area includes lands which drain into Utah Lake and are above the stream gaging station, "Jordan River at Narrows."

The boundaries of the Utah Lake drainage fall within five counties (Utah, Sanpete, Juab, Wasatch and Summit), the major part being in Utah County. The drainage area, which is 3,092 square miles in area, is divided into subareas, as shown in Figure 22. The size of each subarea is given in Table 20. The areas of major concern are Utah Valley and Northern Juab Valley.

The Utah Lake drainage area is divided into several subunits which are separated by hydrologic divides. These are the Francis subarea, Heber Valley, Cedar Valley, Utah Valley (including Northern Utah Valley, Southern Utah Valley and Goshen Valley) and Northern Juab Valley.

Heber Valley and Francis subunits are located on the middle and upper reaches of the Provo River above Deer Creek Reservoir. The Kamas area is located above the proposed location of Jordanelle Reservoir, a part of the Central Utah Project. Therefore, it is not included in this study. Heber Valley is located below the proposed Jordanelle Reservoir and drains into Deer Creek Reservoir.

Cedar Valley is a subbasin located on the west side of Utah Lake, which is bounded on the east by the Lake Mountains and on the west by the Oquirrh and East Tintic mountains. Cedar Valley contains no perennial streams, but does provide a small contribution of water to Utah Lake.

The largest subunit in the drainage area is Utah Valley. Utah Valley is bounded on the east by the Wasatch Mountains and on the west by Utah Lake and the Lake Mountains. The valley opens to the south over a low ridge into Northern Juab Valley and is bounded on the north by the Traverse Range.

For the present study, Utah Valley can be divided into four districts, each being supplied from a separate river system. These are the Lehi-American Fork district, Provo district, Spanish Fork district and Elberta-Goshen district. These districts are supplied by the American Fork River, Provo River, Spanish Fork River and Currant Creek, respectively; Currant Creek is supplied by Northern Juab Valley return flows stored in Mona Reservoir. The Alberta-Goshen District consists of the western part of Goshen Valley not supplied by the Spanish Fork River system. These districts are served by water distributing canals or irrigation companies, as shown in Figures 23 and 24.

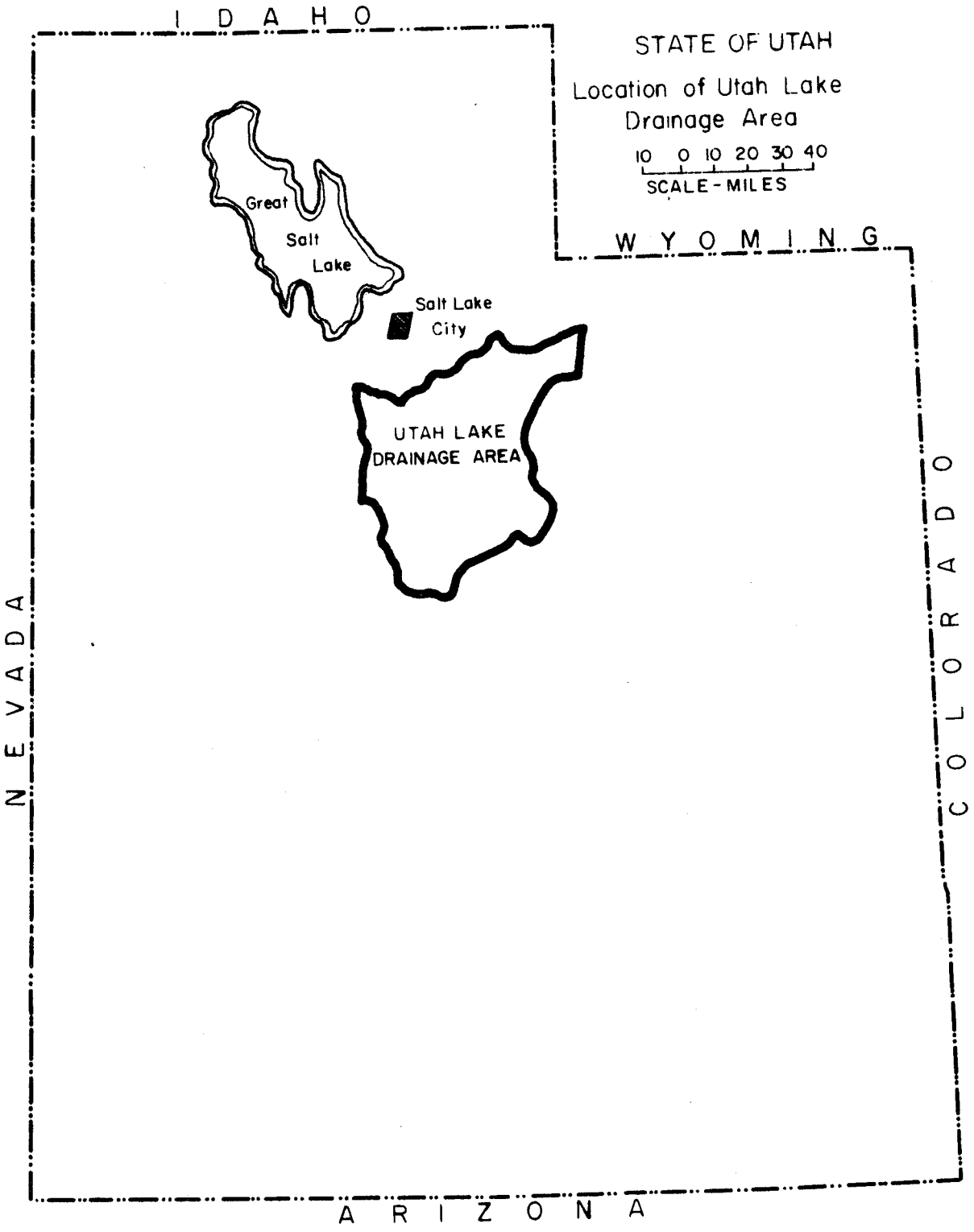


Figure 21. Location of the Utah Lake drainage area.

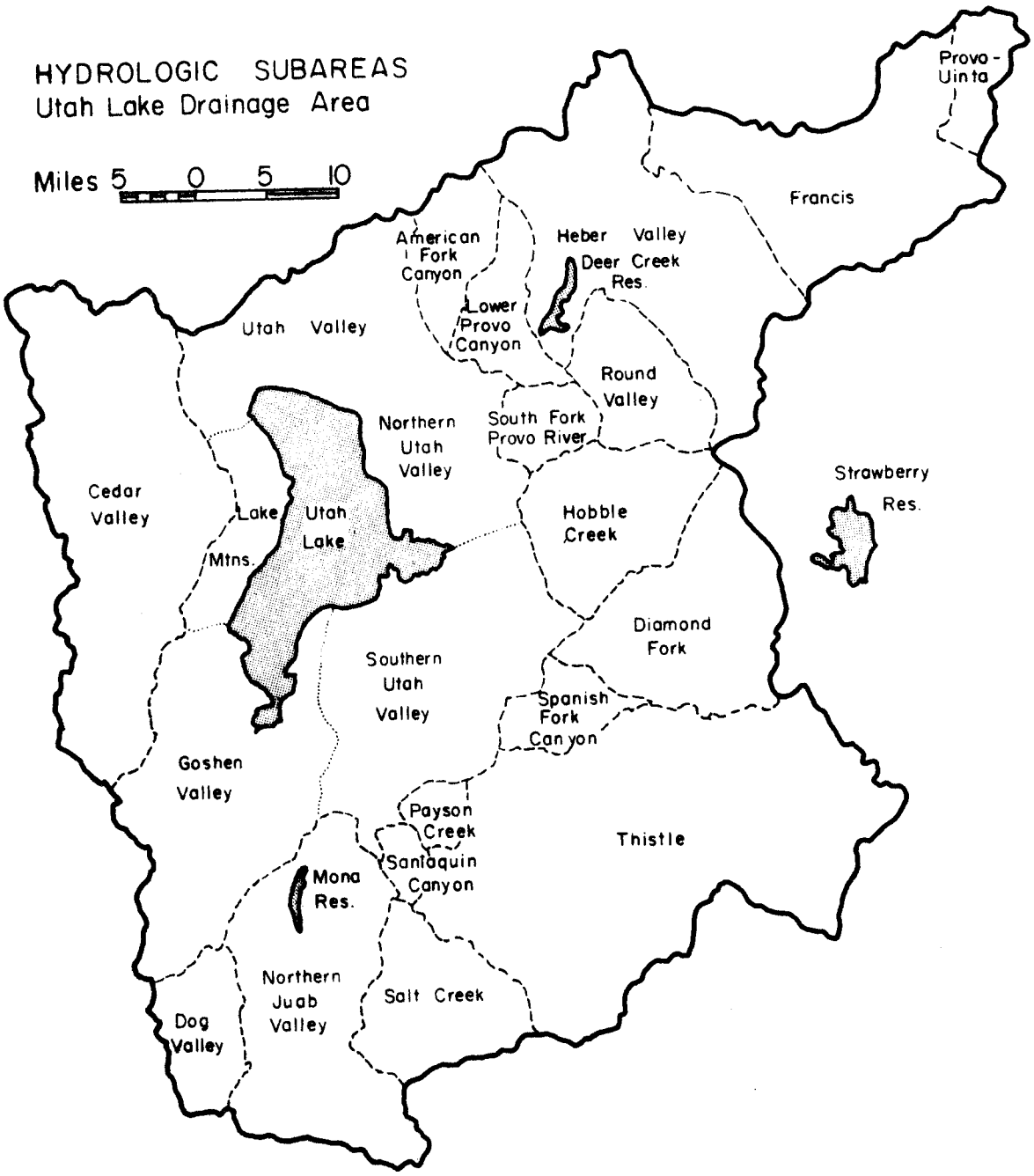


Figure 22. Hydrologic subareas of Utah Lake drainage area.

Table 20. Size of hydrologic areas within the Utah Lake drainage area.*

Hydrologic Area**	No.***	Area	
		Acres	Sq. Mi.
(Heber-Kamas)	--	293,120	458.0
Francis (Kamas)	11	129,920	203.0
Heber Valley	13	163,200	255.0
(Utah Valley)	18	612,480	957.0
Cedar Valley	17	201,600	315.0
(Northern Juab Valley)	2	132,736	207.4
Other areas			
Salt Creek	1	61,184	95.6
Dog Valley	3	35,776	55.9
Santaquin Canyon	4	9,344	14.6
Payson Creek	5	12,032	18.8
Thistle	6	290,560	454.0
Diamond Fork	7	93,400	146.0
Spanish Fork Canyon	8	23,680	37.0
Hobble Creek	9	67,200	105.0
Provo-Uinta	10	19,200	30.0
Round Valley	12	46,016	71.9
South Fork Provo River	14	19,200	30.0
Lower Provo Canyon	15	28,800	45.0
American Fork Canyon	17	201,600	215.0
(Utah Lake drainage area)	--	2,147,948	3,356.2

*Numbers in parentheses indicate reference number in bibliography.

**Areas in this study indicated by parentheses.

***Number refers to subarea designation in State hydrologic inventory.

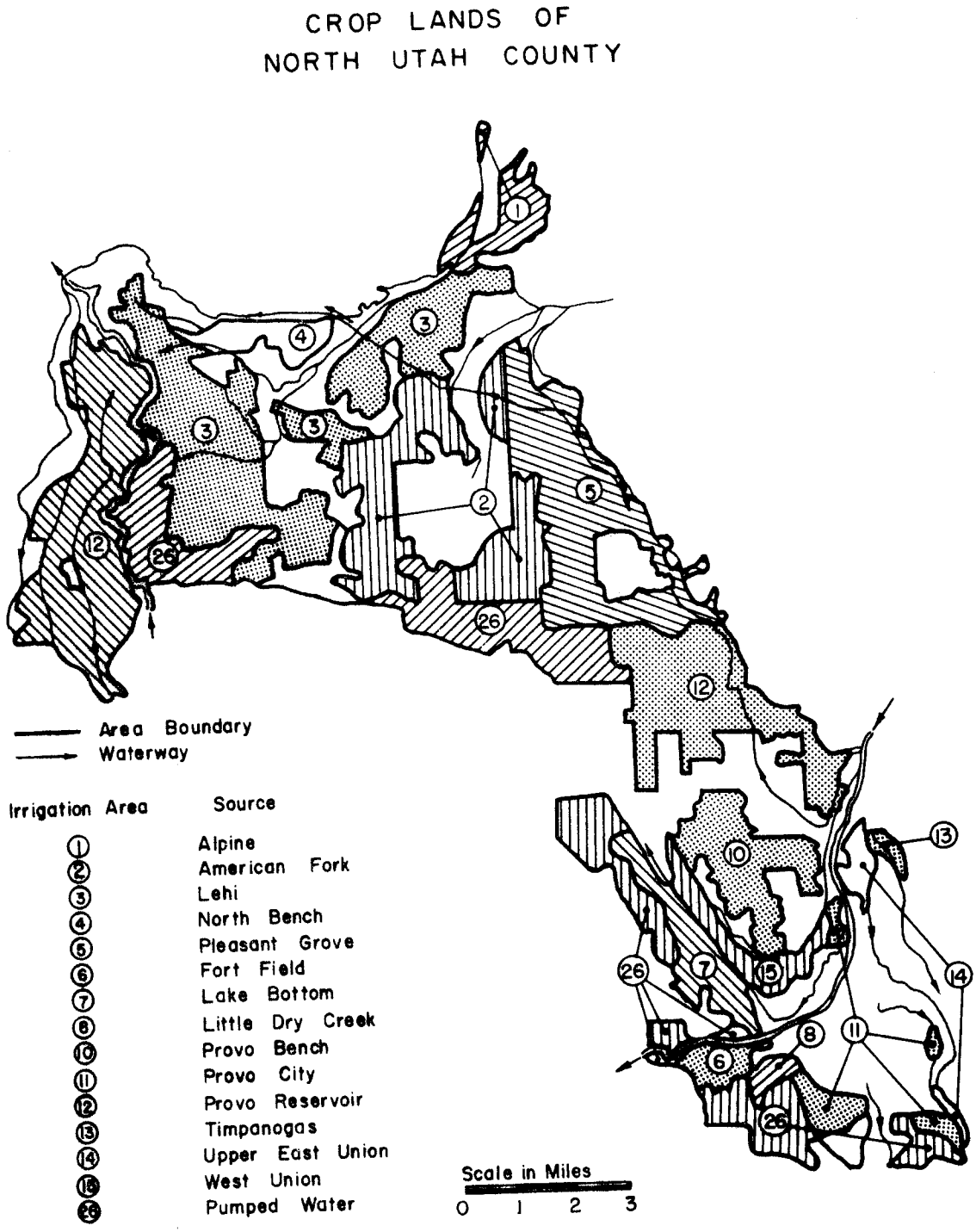
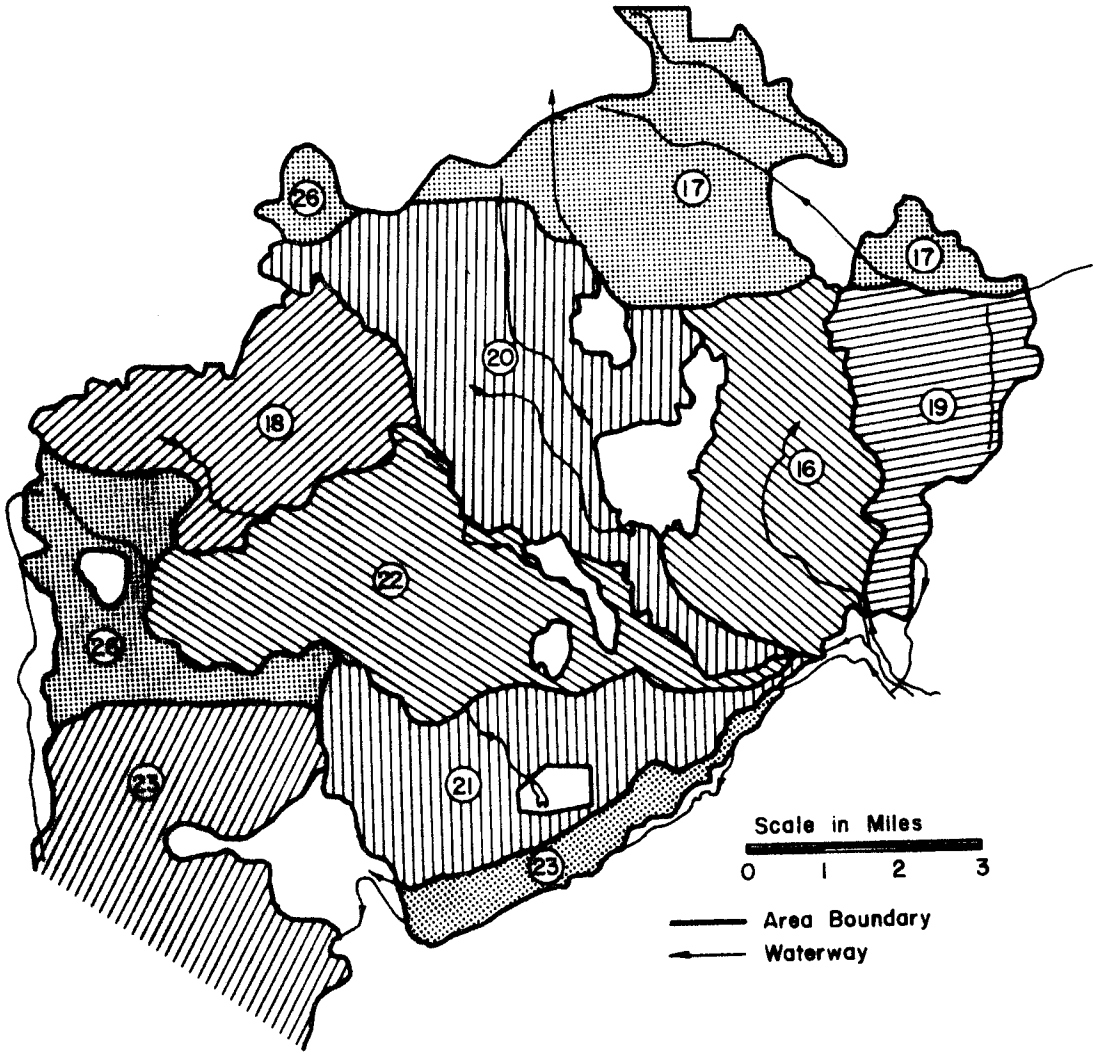


Figure 23. Irrigation districts in Northern Utah Valley.

CROP LANDS OF
SOUTH UTAH COUNTY



Irrigation Area	Source
16	East Bench
17	Hobble Creek
18	Lake Shore
19	Mapleton
20	Mill Race

Irrigation Area	Source
21	Salem Canel
22	Spanish Fork South
23	Strawberry Highline
26	Pumped

Figure 24. Irrigation districts in Southern Utah Valley.

Northern Juab Valley is a continuous strip of valley lands in Northern Juab County. The valley is bounded on the east by the Wasatch Mountains and extends from York Ridge on the north to Levan Ridge on the south. Included in Northern Juab Valley are two smaller areas on the west side of Juab Valley, the West Mona lands west of Mona Reservoir and an area southwest of Nephi. These two areas adjacent to the West Hills and Long Ridge Hills form the west boundary of Northern Juab Valley. Northern Juab Valley is supplied by Salt Creek and drains into Mona Reservoir.

All waters from the Utah Valley eventually drain into Utah Lake. Utah Lake is shallow, averaging eight feet in depth with a maximum of about twenty feet. The lake has gently sloping shores causing large changes in surface area with fluctuations in surface elevation. The lake is located in the valley center, the main body being about 19 miles long in the north-south direction and 10 miles wide. A swampy area called Provo Bay is connected to it on the east side by a narrow channel. The outlet for Utah Lake is the Jordan River, which runs in a northerly direction through Salt Lake County and eventually empties into Great Salt Lake.

The valley floor was, at one time, part of the Pleistocene Lake Bonneville. Therefore, the valley floor consists of lacustrine gravel, silt and clay sediments overlapping alluvial fans of pre-Lake Bonneville age, spreading out from the mountains.

Surface features may be grouped into benches, river bottoms, alluvial fans, and lake bottoms. The benches are wide delta areas of highly permeable alluvium. The flat slope and high elevation of these benches results in these areas being served by separate canal companies. River bottom soils are along major rivers. The soils are permeable alluvium and are set apart from the benches by differences in elevation. Alluvial fans are located at the river mouths and the mountain base. The soil is a well drained alluvium with a lacustrine silt surface. The lake bottom borders Utah Lake.

The 219,658 acres of agricultural land in the Utah Lake drainage area is the largest user of water. There is 162,150 acres, or 74 percent, of the agricultural land that is irrigated. The rest is dry land farming.

Alfalfa, pasture, grain, corn, sugar beets and orchards are representative irrigated crops, with the largest amount of irrigated land being used for alfalfa and pasture. The areas are summarized in Table 21.

Climate

The climate of the Utah Valley may be described as temperate and arid. Low rainfall, low humidity and high evaporation rates result in sparse vegetation. The soils are not leached by rainfall and therefore have not lost the original plant nutrients. Also, the soil is highly calcareous with little organic matter. The summers are usually mild with cold

Table 21. Agricultural lands in the Utah Lake drainage area.

Hydrologic Area[a]	No.[b]	Crop Area, acres[c]	Phreatophytes and Native Vegetation, acres[d]
(Heber-Kamas)	--	20,682	6,141
Francis (Kamas)	11	1,553	956
Heber	13	19,129	5,185
(Utah Valley)	18	117,760	40,500
(Lehi-Am. Frk.)	18a	20,492	1,937
(Provo)		23,495	8,080
(Spanish Fork)	18b-18c	73,773	17,554
Goshen Valley	18c	15,785	12,929
Cedar Valley	17	3,328	26
(Northern Juab Valley)	2	12,391	550
Other areas	--	7,989	62
Thistle	6	5,176	------
Round Valley	12	2,813	62
Utah Lake drainage	--	162,150	47,279

[a]Areas in this study indicated by parentheses.
[b]Numbers are hydrologic subarea designation.
[c]Includes classes A1 to A11 and A13.
[d]Includes classes C1 to C4 (very dense to light density growth).

winters, particularly in the higher elevations. The climatological characteristics of the area are summarized in Table 22.

Generally, the precipitation decreases moving west of the Wasatch Mountains. In Northern Utah Valley, Southern Utah Valley and Northern Juab Valley, the annual precipitation varies from 12 to 16 inches. In Cedar and Goshen Valleys, it is less than 12 inches. On the high peaks of the Wasatch Mountains, the precipitation is over 30 inches. The mountain valleys receive from 15 to 20 inches of precipitation.

The temperature varies with altitude and latitude. There is about 3 degrees Fahrenheit decrease in mean annual temperature for each 1,000 feet increase in altitude and about 2 degrees Fahrenheit decrease for each degree increase in latitude. The mean annual temperature ranges from 40 to 50 degrees Fahrenheit on the valley floor. For the Wasatch Mountains, the mean annual temperature ranges from 35 to 45 degrees Fahrenheit and the Heber-Francis areas vary from 40 to 45 degrees Fahrenheit.

Human Community

Salt Lake Valley was settled by the Mormons in 1847 and shortly thereafter Utah Valley was explored. The first people to arrive and divert water, came in 1848. They were a relatively transient group that remained in the Valley for a short time. In fact, in the spring of 1849 a stockade was built and log houses were erected for pioneer settlers in the Utah Valley. From this point on irrigation rapidly developed. As the number of settlers increased, more and more canals were dug and a more complex system of irrigation water was developed in the Valley. The earliest diversions from the Provo River were along the bottom land where a minimum of effort was required and from there it gradually developed into a much more complex system. The first project of any consequence was started in the early 1900's; this was the Strawberry Reservoir which is located on the east side of the mountains from Utah Valley. The water is diverted through an inverted siphon or tunnel running under the Wasatch Mountains. This project was completed in 1929 and it supplies water to the south end of Utah Valley. Deer Creek Reservoir which is an on-channel impoundment of the Provo River was started in 1938 and finished in 1942. The war intervened at this time and no further work was done on the project until after the war when the project was completed in 1962.

The population of Utah Valley is essentially the population of Utah County. The 1970 census showed the population for the county as being 137,776 inhabitants (Table 23). The county is broken into 7 subdivisions or divisions, those being the American Fork Pleasant Grove Division, Goshen Division which is the southern part, Lehi Division, northern part, Orem Division, Provo Division, Spanish Fork Division, and Springville-Mapleton. The major city in the area is Provo which taken together with the Orem Division account for almost 80,000 inhabitants in the county. To these, if we add other larger communities in the area such as American Fork, Pleasant Grove, and Springville, it can be seen that by 1970 over 110,000 of

Table 22. Climatic characteristics of the Utah Lake drainage area

Station	Elevation ft.	Mean Annual Precip., In.	Mean Annual Temp., °F	Median frost free period*	
				Dates	Days
Utah Lake (Lehi)	4497	9.82	48.6	May 16 to Sep 24	132
Provo	4545	12.81	49.6	May 19 to Sep 22	127
Elberta	4690	10.22	50.6	May 14 to Oct 1	141
Spanish Fork PH	4711	16.79	52.0	May 1 to Oct 15	168
Lower American Fork PH	5044	16.45	52.2	Apr 30 to Oct 21	175
Heber	5593	15.05	44.5	Jun 19 to Sep 4	78
Snake Creek PH	5950	22.25	43.3	Jun 10 to Sep 4	87
Soldier Summit	7460	16.09	38.7	Jun 19 to Aug 13	56

*50 percent probable chance that 32°F will occur after indicated dates.

Table 23. Population increase in Utah County and Provo, 1900-1970.

	Utah County		Provo City	
Year	Number	% Increase	Number	% Increase
1900	32,456	--	6,185	--
1910	37,942	16.9	8,925	44.3
1920	40,792	7.5	10,303	15.4
1930	49,021	20.1	14,766	43.3
1940	57,382	17.0	18,071	22.3
1950	81,912	42.7	28,937	60.1
1960	106,991	30.6	36,047	24.6
1970	137,776	28.8	53,131	47.3

the total population of the county live in urbanizing areas. At the same time 20,642 persons were classified as rural. In terms of population composition, the median age in Utah Valley is impressively low at 21.5 years (due also to the large number of students at BYU), with the proportion of older population 65 years or older being only 6.6 percent.

The pattern of population growth in Utah Valley as well as in the whole Wasatch front, bears striking similarity to parallel population and spatial developments along the Colorado eastern front. An emerging strip city with high rates of growth, more recently in the suburban fringe, and an increasing attraction for industrial concerns. Thus, while the rate of growth for Utah County between 1960-1970 was 28.8 percent, that of Provo city was almost double, 47.3 percent. The pattern of population growth and distribution in the Valley have remained more or less constant over the years, with the Provo-Orem area having the lion's share of the total population. Population projections for the major towns and cities of the areas are equally impressive as the following composite table of future population indicates (Table 24).

The important conclusion from all these numbers is the fact that rapid urbanization creates new competing water demands, with associated friction from the urban spillover to the surrounding rural hinterland.

Strong in-migration can be attributed to the desirability of the area in the eyes of many people who are Mormons and who wish to return home. The only inhibiting factor in this continuous growth process is the number of jobs available. Presently, there exists in Provo the Geneva Works of the U.S. Steel Corporation and Brigham Young University which has an enrollment of approximately 25,000 students. U.S. Steel offers approximately 5,000 jobs. U.S. Steel related industries provide also additional employment, but the potential for further industrial expansion seems rather limited. According to the 1970 census only 1567 persons were employed in agriculture, 627 in mining, 2675 in construction and 9292 in manufacturing.

To sum up the brief demographic profile of the Valley, it is a young, rapidly growing, fast urbanizing, and increasingly industrializing population, in a rich crescent area pressed against the Wasatch Front Range in the West and bounded by Utah Lake in the east. It is in this setting, that a highly homogeneous, predominantly Mormon population developed also patterns of water use regulated by strong customs and the presence of the Church. As it has also been described earlier in the case of Ashley Valley, the overriding characteristic of water was its beneficial use. The man who owns the largest amount of water would be also the man who worked the most in the construction of the diversion system. If such a person had too much water, but did not use his water beneficially (with whatever the exact interpretation of such a loose term), this water could be taken from him. This, of course, led many people to always claim -- whatever the amount -- that they are getting an optimum use from their water.

Table 24. Estimated population for the major municipalities in Utah County

Year		1960	1966	1980	2000	2020
Utah County						
U.C.T.S.	(2)			177,200	247,400	317,600
U. of U.	(2)	107,001	121,277	170,380	233,780	296,930
U.C.P.C.	(2)			151,800	196,550	241,400
U. of U.	(revised)			195,440	268,130	339,930
Provo						
U.C.T.S.				60,000	79,000	98,000
U. of U.		36,047	41,434	68,000	75,000	92,000
U.C.P.C.				56,000	65,250	74,500
Orem						
U.C.T.S.				36,000	58,750	81,500
U. of U.		18,394	22,028	33,500	56,000	78,500
U.C.P.C.				30,000	45,500	63,000
U. of U.	(revised)			37,000	61,600	85,800
Springville						
U.C.T.S.				14,000	21,000	28,000
U. of U.		7,913	8,666	12,500	18,750	25,000
U.C.P.C.				10,900	16,400	22,000

Table 24. (continued)

Year	1960	1966	1980	2000	2020
American Fork					
U.C.T.S.			12,000	19,000	26,000
U. of U.	6,373	7,352	11,300	17,900	24,500
U.C.P.C.			10,000	15,500	21,000
Pleasant Grove					
U.C.T.S.			8,000	10,300	12,600
U. of U.	4,772	5,372	7,600	9,500	11,200
U.C.P.C.			7,000	8,300	9,600
Spanish Fork					
U.C.T.S.			11,000	15,000	19,000
U. of U.	6,472	7,127	10,200	13,950	17,500
U.C.P.C.			8,900	12,440	14,980
Lehi					
U.C.T.S.			7,000	9,750	12,000
U. of U.	4,377	4,801	6,600	8,800	11,000
U.C.P.C.			5,950	7,550	9,150
Alpine					
U.C.T.S.			1,500	2,400	3,300
U. of U.	775	935	1,450	2,275	3,100
U.C.P.C.			1,350	1,925	2,500

Table 24. (continued)

Year	1960	1966	1980	2000	2020
Lindon					
U.C.T.S.			1,800	2,400	3,000
U. of U.	1,150	1,271	1.750	2,275	2,800
U.C.P.C.			1,600	1,850	2,300
Mapleton					
U.C.T.S.			3,000	4,500	6,000
U. of U.	1,516	1,781	2,800	4,100	5,400
U.C.P.C.			2,500	3,500	4,500
U. of U. (revised)			5,600	8,100	10,800
Salem					
U.C.T.S.			1,480	2,040	2,600
U. of U.	920	1,011	1,400	1,900	2,400
U.C.P.C.			1,260	1,600	1,940
Payson					
U.C.T.S.			5,800	7,250	8,700
U. of U.	4,287	4,442	5,600	6,840	8,180
U.C.P.C.			5,000	5,800	6,600
Goshen					
U.C.T.A.			765	1,175	1,390
U. of U.	392	460	690	990	1,300
U.C.P.C.			460	755	1,050

Table 24. (continued)

Year	1960	1966	1980	2000	2020
Santaquin					
U.C.T.S.			2,000	2,850	3,700
U. of U.	1,183	1,187	1,800	2,625	3,450
U.C.P.C.			1,200	2,000	2,800
Genola					
U.C.T.S.			580	790	1,000
U. of U.	380	410	550	725	900
U.C.P.C.			490	600	710
Unassigned Municipal Growth (1)					
U.C.T.S.			13,040	12,370	12,200
U. of U. (1)			15,330	13,140	11,000
U.C.P.C.			9,650	8,235	6,820
U. of U. (revised)	12,100	13,000	33,400	36,900	40,000

(1) This is growth which could occur in the future in any of the incorporated communities.

(2) U.C.T.S. - Population studies projected by Utah County Transportation Study.
U. of U. - Population studies projected by University of Utah.
U.C.P.C. - Population studies projected by Utah County Planning Commission.
U. of U. - Revised - University of Utah studies with minor local additions in some areas and population projections used in this report.

Water in Utah Valley is a rather emotionally laden issue. Although there have not been range wars and shootings to an extent that might be found in other areas outside of Utah, there has been a great deal of conflict concerning water in this area. In Utah Valley, in the past when there was a dispute concerning water, this dispute would be taken to Church leaders and the Church leaders would act as judge and jury in bringing this dispute to an equitable solution. The case would be heard by the elders of the Church, the elders would define the party who was at fault, and would determine retribution to the injured individual. The word of the church was the final judgment in the case.

Water Supply System

The two major streams draining the Utah Lake area are the Provo River and the Spanish Fork River. The American Fork River, Hobble Creek, Summit Creek, Payson Creek, Salt Creek and Currant Creek are the smaller principal streams. A summary of annual flows of these streams is given in Table 25.

The Provo River originates in the Uinta Mountains and empties into Utah Lake, flowing through Kamas and Heber valleys and across Northern Utah Valley. Due principally to the Provo River, the Northern Utah Valley (north of Provo City) receives about 70 percent of the total inflow to Utah Valley while having less than 40 percent of the irrigated land. The volume of natural inflow is highly variable with about one-half the annual flow occurring during April through June and one-sixth of the annual flow occurring during July through September. The river is fully appropriated.[482]

The Spanish Fork River heads in the Wasatch Plateau west of Soldier Summit and discharges to Utah Lake, flowing across southern Utah Valley. The natural flow of the river has a high discharge in the months of April through June and a low discharge in the months of July through September, similar to the Provo River. It has two major tributaries, Thistle Creek and the Diamond Fork. The Diamond Fork serves as a conveyance for interbasin transfers to the Spanish Fork area from Strawberry Reservoir.

Streamflow regulation has occurred along the Spanish Fork and Provo Rivers with little regulation on any other streams. Fifteen small reservoirs have been developed at the headwaters of the Provo River, which contribute about 8,000 acre-feet of irrigation water annually. The Deer Creek Reservoir, located at the lower end of Heber Valley, releases 96,700 acre-feet annually to the Provo River and provides municipal and industrial water in Salt Lake County through the Salt Lake Aqueduct. The Strawberry Reservoir, located in the Uinta Basin, provides interbasin exports through the Strawberry Tunnel into the Diamond Fork River.

Mona Reservoir provides the only significant regulation of a minor stream in the drainage area. It is located on Currant Creek at the northern edge of Northern Juab Valley. It stores

Table 25. Mean annual flow of major streams in the Utah Lake drainage area.

River	Mean Annual Flow, acre-feet
Provo River	
near Kamas	34,300
Duchesne Tunnel	37,200*
Weber-Provo Diversion Canal	56,200*
at Hailstone	214,500
Ontario Tunnel	10,000*
Dry Creek and Fort Creek	20,000
American Fork River	38,200
Battle Creek	4,000
Grove Creek	3,000
Rock Creek	8,000
Hobble Creek	29,500
Spanish Fork River	
at Thistle	56,400
Strawberry Tunnel	60,800*
at Castilla	151,400
Payson Creek	9,400
Summit Creek	8,900
Salt Creek near Nephi	19,300
Currant Creek below Mona Reservoir	15,000
Jordan River	261,000

*Transbasin import.

return flows from Northern Juab Valley and Currant Creek flows to supply the Elberta-Goshen district of the Southern Utah Valley.

Strawberry Reservoir impounds water from an entirely different watershed and it is brought in through a trans-mountain diversion. The natural flow of Hobble Creek and American Fork Creek are, for all intents and purposes, unimpeded and there is an adequate supply early in the year but later in July and August the amount of water available tends to rapidly decrease. The return flow of water in Utah Valley is dumped into the Utah Lake drainage. By the time water reaches the Utah Lake it is fairly degradated. The water coming through Spanish Fork River is degradated by passing through a clay bed and the clay is carried in suspension which causes some top sealing of the soil when it is used for irrigation. It is not at all suitable for potable use, but the people who use it for agricultural purposes are very satisfied with it and few have complained about the problem of top sealing. The water which finally arrives in Utah Lake is used as irrigation water in Salt Lake Valley through complex trade agreements. Irrigation water is supplied to Salt Lake Valley and potable water is given in return for it. There are wells in Utah Valley; there is a huge underground reservoir underlying the entire Valley and this is a closed basin so the pumping is very carefully controlled by the state engineer's office.

The six principal groundwater basins in the Utah Lake drainage area are shown in Figure 25. These basins are Kamas Valley, Heber Valley, Cedar Valley, Northern Juab Valley, Northern Utah Valley and Southern Utah Valley, including Goshen Valley. Kamas Valley and Cedar Valley will not be considered in this study except for the inflow of Cedar Valley water to Utah Lake. Kamas Valley is above the proposed Jordanelle Dam and the outflow from this area is reflected in downstream measurements of the Provo River. Also, Heber Valley outflows are reflected as inflows to Deer Creek Reservoir. A summary of the pumping from aquifers in the three main basins is given in Table 26.

The water table is maintained and carefully checked with wells' permits given very judiciously. The wells range from artesian wells which are many times used as potable water sources, to agricultural wells which are very large and used for industrial as well as agricultural purposes. U.S. Steel maintains several deep water wells, with the water used in the cooling process of the steel. The water, once used, is stored in a lagoon and recycled back through the mill. The company does not use Utah Lake water, but it discharges some of its effluents into the lake.

Finally, a number of springs, owned by various municipalities contribute direct water into the pipelines and through the processing plant and into the culinary water. Great efforts have been made by various municipalities to protect the purity and high quality of water from these springs.

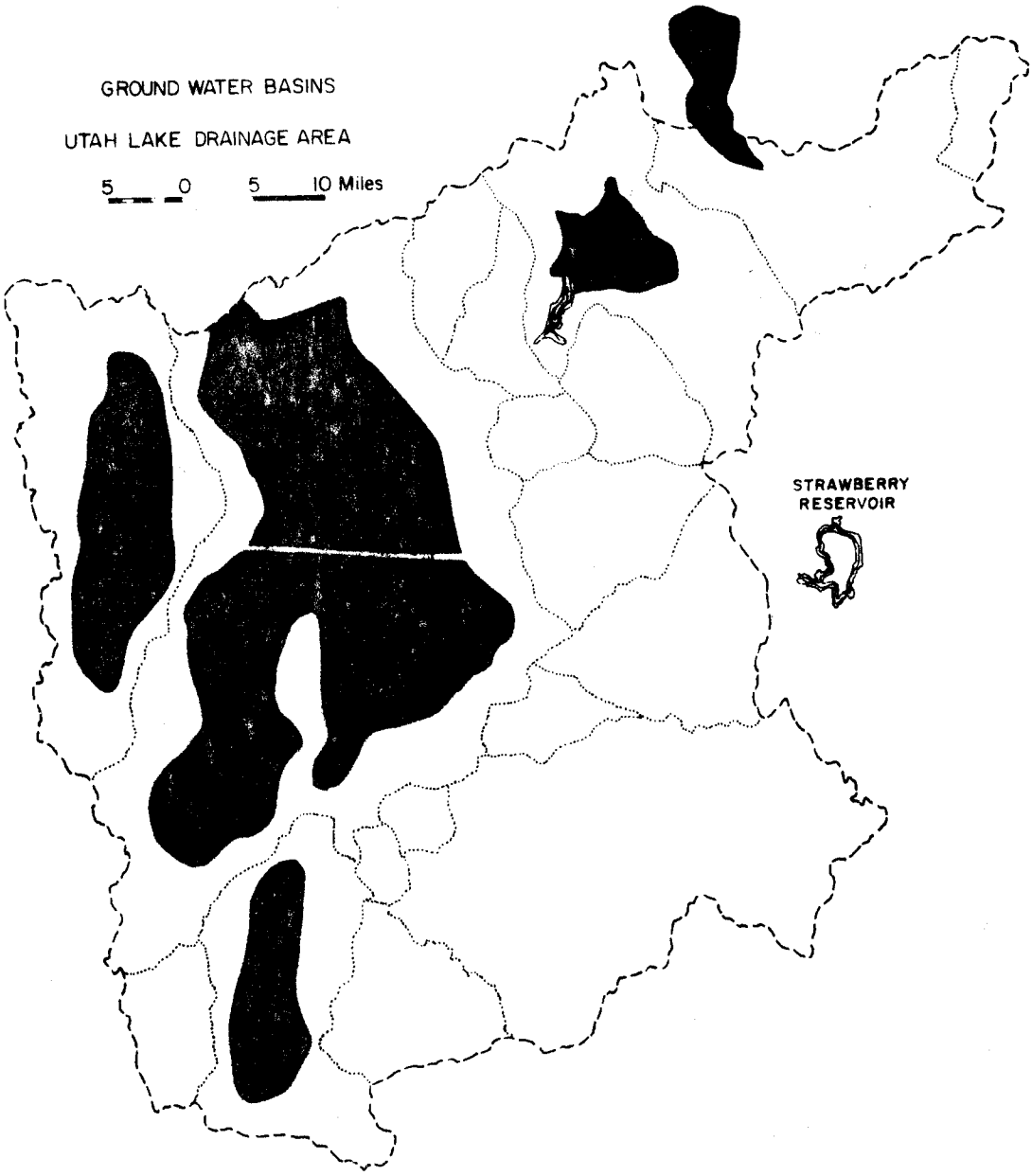


Figure 25. Principal groundwater basins in the Utah Lake drainage area.

Table 26. Groundwater pumping in the major basins of the Utah Lake drainage area.

Area and Classification of use	Discharge for water year, in acre-feet						
	1962	1963	1964	1965	1966	1967	1968
Northern Utah Valley							
Irrigation	35,000	34,000	29,600	29,100	37,000	38,300	
Flowing wells	25,000	25,000	25,000	25,000	25,000	28,000	
Pumped wells	10,000	9,000	4,600	4,100	12,000	10,300	
Industry	7,000	9,800	9,000	6,900	7,200	7,300	
Public Supply	5,000	3,300	5,200	3,800	8,200	8,900	
Domestic	2,500	2,500	2,500	2,500	2,500	12,600	
Total (rounded)	50,000	50,000	46,000	42,000	54,900	67,000	
Southern Utah Valley							
Irrigation			8,100	6,600	12,300		
Flowing wells			2,900	2,900	2,900		
Pumped wells			5,200	3,700	9,400		
Industry			600	540	540		
Public Supply			900	120	900		
Domestic			10,100	10,100	10,100		
Total (rounded)			19,700	17,400	23,800		
Goshen Valley							
Irrigation			9,000	13,400	18,800	13,300	
Flowing wells			0	0	0	0	
Pumped wells			9,000	13,400	18,800	13,300	
Industry			30	30	186	2	
Public Supply			10	20	19	20	
Domestic			150	140	140	140	
Total (rounded)			9,200	13,600	19,100	13,500	

Table 26. (continued)

Area and Classification of use	Discharge for water year, in acre-feet						
	1962	1963	1964	1965	1966	1967	1968
Northern Juab Valley							
Irrigation		17,100	15,500	14,700	21,200	17,300	
Flowing wells		14,600	13,000	12,200	19,200	15,300	
Pumped wells		2,500	2,500	2,500	2,000	2,000	
Industry		50	50	50	50	50	
Public Supply							
Domestic		100	100	100	100	100	
Total (rounded)		17,200	15,600	14,800	21,400	17,440	

Irrigation Development and Organization

Water was first diverted from Provo River in 1848 and other diversions continued as new settlers came into the Valley. Most of the companies were formed by the middle 1800's so that by 1900 no new companies appeared in the area. In 1926 the name Strawberry Water Users Association was coined and then placed on the market for sale. A little bit later, in 1938, the Deer Creek Dam was started and water was first sold in 1942. The old canal systems were used, and in time were rebuilt to handle more water. The Provo river was rechanneled, a project completed as late as 1962. In more recent years the Central Utah Project has been under construction. When completed it is envisaged as part of a highly complex system of providing municipal, industrial, and irrigation water all along the fast growing strip development along the Wasatch front.

There are approximately 75 irrigation companies in Utah Valley. The companies are quite similar in composition and in organization. As mentioned earlier the four major sources of water in the valley (Provo River, Spanish Fork River, Hobble Creek, and American Fork) supply 93 percent of all irrigation water. The rest, 7 percent, comes from small companies which are privately owned. Of the 93 percent of the Valley water described above, 80 percent comes from the Provo River which is supplied with water from Strawberry Reservoir in the east side of the Wasatch Range. The water from both reservoirs is controlled under contracts with the Bureau of Reclamation, with the constractees being the Provo River Water Users Association (PRWUA), also called Deer Creek, and the Strawberry Water Users Association (SWUA). Both Users Associations do not directly supply water to the farmers, but to the irrigation companies which in turn supply the water to the farmers. The irrigation companies must receive their water first due to prior water rights, and the Associations get the last rights so that they in effect are able to save the flood waters which were lost in years prior to the projects. Presently, the irrigation companies are able to purchase water from the Associations and provide the farmers with water for the latter part of the summer. This last water is extremely valuable, since before the projects Utah Valley farmers found their streams nearly dry by the end of July, and their crops burned. There is a third component which will be increasingly important in the future, namely the contribution of the Central Utah Project (CUP) and its contractee, the Central Utah Water Conservancy District (CUWCD).

Urban water presently is supplied through the series of springs mentioned earlier and Deer Creek Reservoir. Deer Creek supplies water to the Utah Valley area as well as to the Salt Lake Valley area. The rural water is derived through the ajudicated rights system of the 1800's. Even with the construction of Strawberry Reservoir and Deer Creek Reservoir, the natural flow rights must be honored first. Thus, the irrigation companies which existed prior to the construction of these two projects receive their water first and then the two projects have the later water rights. This is both a blessing

and a curse. During extremely water rich years, the two impoundments are able to catch all of the flood waters and hold them for future use. On the other hand, in a rather water poor year, the reservoirs may not receive any water at all due to their low priority in the ajudicated rights system.

It is interesting to notice that the last project is a very expensive one. Compared to Strawberry Reservoir which cost about $40.00 per acre, CUP water is estimated to reach $500.00 per acre. Also, the number of acre feet vary from season to season, but Deer Creek averages between 3.0 to 3.5 acre feet. In SWUA, the lower land holders have about 3.0 acre feet, while the higher ones have about 2.0 acre feet. The higher land is quite sandy and it could use at least 4.0 acre feet, while the lower land could be farmed with less than the alloted 3.0 acre feet.

The last remark brings forth an interesting observation concerning agricultural water use in the Valley. Because of the benches (the lens of sand and gravel areas left by old Lake Bonneville), there is a need for abundant water to adequately water the crops which are located on those particular slopes. The lower areas, the areas which are located near the river bed are primarily a loamy type soil, highly productive not needing as much water as the upper bench areas. Since the earliest settlers first irrigated the lowlands, the river banks and the river bed areas, one can find also there earlier and larger water rights. Typcially the people in the lower areas have 3.0 to 3.5 acre feet of water for every acre of land they own. The people on the benches typically have only two acre feet of water for every acre of land they own. As mentioned above, the sandy soils on the benches could probably use 3 or maybe 4 acre feet of water very easily, while the people down in the river bottoms could probably use 2 acre feet and still have adequate water supplies. In terms of water efficiency, the area may be described as somewhat inverted in terms of needs and applications of water, a result of historical circumstances and not a response to actual needs today.

The costs of water in Utah Valley can only be dealt in a very general way because of the diversified conditions of 75 different irrigation companies. Some companies buy their water from the Deer Creek project through the Provo River Water Users Association or from the Strawberry Reservoir through the Strawberry Water Users Association. The water which comes directly from Deer Creek costs $1.25 per year for delivery costs, and $2.85 more in construction costs for each share of water. As this water goes from the river to the various irrigation companies, a delivery cost is added, so that the average cost of water is in the neighborhood of $6.50 to $9.00 for every acre foot of water delivered to the individual. The SWUA has an actual cost per acre foot of water of $10.00 to $12.00; fortunately, the Strawberry project being an older project is now just about paid off and since the contract is nearly retired this has helped to reduce costs because construction costs are no longer being charged. At the same time, the SWUA is generating power and the power revenues are used to pay for part of the high operating costs in terms of delivery water. Thus,

in reality, the SWUA charges about $2.50 per acre foot for water delivered to the irrigation company. When water reaches the individual user, the total cost reaches $6.50 to $9.00 for every share of water which is delivered.

Parenthetically, it may be noted that the industrial water is primarily connected with the U.S. Steel plant. During the mid-1940's when this mill was built, most of the water rights which did not belong to anyone were acquired by the U.S. government. The government built this mill during the Second World War in an attempt to protect the industries of the United States from attack. Before the mill was completed, the war ended and the U.S. Steel bought the mill from the federal government. As a result, the owner of the mill and of all associated water rights and responsibilities is also the U.S. Steel Corporation. U.S. Steel, nevertheless, acquired all additional water rights that it could possibly purchase. These were surface rights as well as underground rights. There is little marked antagonism that can be detected today between the community and the steel mill in terms of water rights.

The organization and operation of the irrigation water companies are controlled by farmers. Diversified as they are, the various companies in the Valley can be grouped into three major categories: 1) Most of them can be classified as "formal, original companies." 2) A few small companies can be classified as "informal, original companies." 3) A few later large companies and younger associations can be classified as "reservoir companies."[483] Although the degree of formality differs from the loosely organized ones of category 2 to the more structured organization of the reservoir companies, there is generally a great deal of simplicity, informality, and flexibility in the running of all companies.

Essentially a board of directors is charged with the task of providing the leadership and general policy for the company, with the actual day-to-day operation delegated to an individual who is an employee of the company. The last is charged with the primary task of seeing that the agricultural water is delivered to the various groups.

The board of directors receive their position through elections and the voting individuals are the individual shareholders within the irrigation company. The role of the board is one of making policy decisions concerning the irrigation company and to define the general needs of the company in terms of how large the budget should be for the following year's operation. As in so many other instances in the West, the individual board member is the representative of the shareholders with the explicit obligation of carrying forth their interest, needs, and desires concerning water use. Once again, the status of being on the board is viewed with great ambivalence both by the members of the board as well as by individuals who elect them. It is the same thankless job described elsewhere, but at the same time a vital spot for generating policy guidelines. Since the successful farmers are the ones usually interested and/or elected, they are the ones who seem to know best what is going on, or at least have the largest vested interest for water

delivered at the cheapest costs. Cost, over and over again, is the main consideration in meeting company objectives, followed closely by the need of fulfilling prescribed water rights.

As the companies become more formal (as is the case of reservoir companies), the requirements for organizational efficiency also increase. The Provo Water Users Association has a 17 man board which serves 16 different water companies (municipal, industrial, and irrigation with thousands of patrons). Of all board members, 8 represent urban water interests, with the remaining 9 agricultural and irrigation interests. The 17 members are elected by shareholdings, with the class "A" share electing 8 members, class "B" share electing 2, all holders over 10,000 getting one more member and the manager being an ex officio member. Contrasted to such formal organizations and to an office staff for PRWUA of 22 full-time employees, other "informal, original companies" have no officers, no records, no assessment with little, if any, work done on the ditches. There are such companies with only five shareholders.

The most critical position throughout every company is that of the water master. He is the one responsible for the actual delivery of the water, the representative of the company with whom the farmers are most in contact. Like all other officers, he is a farmer and a shareholder. His training, as well as the training of all water managers is an informal one. Although water knowledgeable, they typically learn water management within their family, and quite often positions have been handed from one family member to another. This knowledge is mostly one of experience and sensitivity as to the overall system, the idiosyncratic characteristics of the organization, and the specialized needs of the users. The manager is also charged with the task of supervising any office employees which the company has. These could be office girls or they could be ditch riders or both in the case of larger companies. The effect of the shareholders on the manager is somewhat varied. Typically, his job is to supply the water to them and to keep them happy. One manager described his job as that of being a crying towel. On the other hand, individual shareholders have little to do with larger policy questions, which are the prerogative of the board of directors. Such a policy is formulated at the annual meeting by the members of the water board and is placed for approval before the group of shareholders. They in turn (and quite often this is only a ritual), vote affirming or denying the particular policy or provision thereof.

Voting is primarily done by proxy rather than through attendance of the annual meetings. Stockholders meetings are usually held during the day, sometime in winter, generally around the first or second month of the year. The large farmers attend the meetings and make their feelings public at this particular time. The smaller farmers, the part-time farmers, and other small land owners typically receive a proxy vote by mail. They sign this vote and return it to the irrigation company and that is usually the extent of their voting or participation. The proxy will simply support or be used as a support for the incumbent of the irrigation company unless

there is some very significant reason for wanting to get rid of a particular individual. Changes in management are rather infrequent; very rarely is a manager fired from his position, in fact many managers become so old that they have to quit because they simply are not able to carry forth their task.

All in all, the companies, their organization and management reflect a high conservative atmosphere with diffused responsibility and authority for meeting the increasing demands of centralized planning in an urbanizing, industrializing social environment. One may speculate that despite the early historical centralizing presence of the Church, the jealousies surrounding precious water rights have led to segmentalization of power among competing groups, multiplicity of jurisdictions and organizations, and a pervasive sense of diffusion and decentralization.

The fragmentation outlined above is also accentuated by the changing character of the social life of the communities in the area. Very few full-time farmers still remain in the area, with an estimated 80-90 percent of all farmers in Utah Valley considered as part-time farmers. Thus, bureaucratic diffusion overlapps with the lack of knowledge and/or interest from many users who have other jobs competing with the attention required for full-time farming.

As it is to be expected, attitudes towards water depend on its seasonal availability. During water poor years, people become acutely aware of its scarcity and use judiciously all available supplies. From the reconnaissance interviews, it seems that most people are reasonably well satisfied with the available water, the project, and the management of the two water associations in the Valley. There were some complaints expressed earlier by old timers, people who had been in the Valley as agricultural water users prior to the advent of the Deer Creek project. Such people feel that the Deer Creek project has somehow taken water that they previously had. This may be true in the early part of the year when the flood waters boil down Provo River, but in the latter part of the year the Provo River dries up to a trickle. It is then that these individuals enjoy a reasonably fair share of water.

The water right system that currently exists in Utah Valley would not be a great impediment to consolidation. Assuming that one cannot overcome the psychological barriers associated with water ownership, a system of ranking the rights in terms of their ajudication dates would be a simple process to insure the rights of individual irrigation water users within a consolidated system. Perhaps one way of visualizing such change is through a fairly straightforward process of taking the ajudicated water rights and giving them a priority according to their dates; if for any reason the water rights cannot be met for all water right owners, a system of ranking under a consolidated system would be implemented. This means that the senior rights would receive water first and if there was any water left over this would be distributed to the junior rights according to their rank in terms of the water priority system.

Yet, such simplistic proposals do not solve the problems of hostility from a voluntary program of centralization and consolidation. However, mergers are resisted by a number of farmers who are afraid of being short changed on water rights or being dominated by outside more powerful groups. Yet, both PRWUA and SRWUA are already providing the experience for working in federations, especially with groups (such as urban interests) which represent new and increasing water demands; but both projects have been met with hesitency. Many people did not feel that these projects were needed, or that their water supply was short enough to justify the cost of the Deer Creek project. Similar criticisms on increased cost are also now raised by a number of individuals concerning the Central Utah Project. But cost is only one of the considerations for future consolidation. More important is the underlying question of the changing demands and of the ability to meet increased needs in the Valley given the present trends of continuous population growth and economic expansion.

Future Water Demands

The water demands in Utah Valley, and the supplies which satisfy them, will change significantly in the future. Population of the industrialized sections of Utah Valley will have tripled by the year 2020 and doubled in the present rural areas. This constitutes a necessary reallocation of the existing supplies from agriculture to municipal uses, resulting in a change in the time distribution of demands as well as changes in absolute amounts of water needed.

Anticipation of problems resulting from these changes has prompted the State of Utah to endorse the Central Utah Project, which encompasses the Utah Lake drainage area. The Central Utah Project involves transporting water from the Colorado River Basin into Utah Valley to facilitate changing demands in the area, and also to provide water for transfer north to Salt Lake County and south to the Sevier River Basin.

The Central Utah Project (CUP) will be a primary source of additional water for the Utah Valley and also for the Salt Lake Valley. The major thrust of the Central Utah Project is one of taking water from the relatively unpopulated areas, such as the slopes of the Uintah Mountains, diverting it through a series of reservoirs and power generators to be used in the Utah and Salt Lake Valley areas. The major problem, which will be encountered with CUP, is the high cost of the water estimated to approximately $500 per acre, a very steep price if water is to be used primarily for agricultural purposes. In addition, given the emerging megalopolitan concentration across the Wasatch front, problems of pollution, effluent discharge will be accentuated.

Coming back to the agricultural demands under the Central Utah Project, the Lehi-American Fork district of Utah Valley will receive no supplemental irrigation water. The Central Utah Project will benefit the Provo District, which will obtain water from construction of Jordanelle Reservoir. The enlargement of Strawberry Reservoir will provide additional irrigation

water to the Spanish Fork, Northern Juab Valley, and Elberta-Goshen districts. Therefore, each one of these divisions (Lehi-American Fork, Provo, and the Strawberry Reservoir service areas) will be analyzed separately since no water is exchanged between them.

Also alterations to the present Utah Lake will be constructed as a part of the Central Utah Project. A dike will be constructed across Goshen Bay to reduce lake evaporation and to provide more opportunity for development of recreation and wildlife on and around the lake.

For the various divisions of the Valley, we need now to combine hydrologic descriptions and population projections in order to generate future water use demands.

Lehi-American Fork. The Lehi-American Fork district remains unchanged with respect to water supply. Dry Creek and the American Fork River remain the sources of supply to this division of the valley. However, the increase in municipal and industrial demand and the resulting changes in agricultural demand were taken into account. The future demands were compared to the twenty-one years (1945-1965) of supply from Dry Creek and American Fork River to obtain projected monthly shortages for future conditions, such as anticipated for the year 2020. Also, projected additions to Utah Lake were determined from analysis of return flows from the area.

Provo River Supply Area. The Provo River supply area will be changed significantly with the Central Utah Project. At the present time, Deer Creek Reservoir, on the Provo River below Heber Valley, is the only major control structure on the river system. Excess water not required to be delivered to rights on the Jordan River will be stored in the proposed Jordanelle Reservoir, to be located about six miles above Heber Valley. Released storage from Jordanelle Reservoir will be available for use in the area extending from Provo City to Salt Lake City. The Salt Lake Aqueduct will be used to convey water from Deer Creek Reservoir to Salt Lake County. All existing small storage above Jordanelle Reservoir will be replaced except for amounts necessary for irrigation above the reservoir and for fish and wildlife.

Operation of Jordanelle and Deer Creek reservoirs must be coordinated to regulate flow of the Provo River. Deer Creek Reservoir is located on the Provo River below the Heber Valley agricultural area. Deer Creek receives return flows from Heber Valley and some small interbasin transfers in addition to the flows of the Provo River. An operation study of Deer Creek Reservoir yielded the historic monthly inflows to Deer Creek Reservoir for the period 1945-1965, without Jordanelle Reservoir. This reservoir would serve to regulate flows from the transfers, Heber Valley return flows, and water released from Jordanelle Reservoir. Water would be released from Deer Creek Reservoir to the Salt Lake Aqueduct and to municipal and agricultural areas in Northern Utah Valley not satisfied by the present water supplies. Jordanelle Reservoir located just

below the U.S. Geological Survey (USGS) stream gaging station, "Provo River at Hailstone," would serve as storage for the water measured at the Hailstone station. Water would be released from Jordanelle to satisfy Heber Valley demands and maintain the contents in Deer Creek Reservoir. General locations of the Provo River portion of the Central Utah Project are shown in Figure 26.

As the capacity of the Jordanelle Reservoir has not been decided, analysis of three capacities, 150,000 acre-feet, 225,000 acre-feet and 325,000 acre-feet, was made. Predicted shortages, additions to Utah Lake, and water available for transport to Salt Lake County were determined for physical conditions projected to be in existence during the year 2000 and the year 2020.

Strawberry Reservoir Supply Area. The Strawberry Reservoir will provide supplemental water to all of the Utah Lake drainage area south of Provo Bay. The reservoir will be enlarged to accommodate Colorado River Basin transfers through the Strawberry Aqueduct, which collects flow from several tributaries of the Duchesne River. This water will be released through the Syar Tunnel to the headwaters of Diamond Fork of the Spanish Fork River and will then travel to the proposed Hayes Reservoir. This reservoir will be located on the Diamond Fork just above its junction with the Spanish Fork River. Also, water may be conveyed to Northern Juab Valley through the Wasatch Aqueduct and the Mona-Nephi Canal. Mona Reservoir will be enlarged to accommodate Strawberry Reservoir water conveyed via the aqueduct in order to supply water to the Elberta-Goshen district.

The three reservoirs in this area must be operated to supply the demands within the area. Hayes Reservoir stores flows of the Diamond Fork and is used first to satisfy demands of the Spanish Fork area, which exceed the flows of the Spanish Fork River. Hayes Reservoir spills are sent through the Wasatch Aqueduct to Northern Juab Valley or to supplement water in Mona Reservoir.

Northern Juab Valley demands exceeding the flows of Salt Creek are satisfied by Strawberry Reservoir water through the Wasatch Aqueduct. Also, Elberta-Goshen demands, which exceed the contents of Mona Reservoir, are supplemented by Strawberry water. Remaining Strawberry Reservoir water is used to satisfy shortages in the Spanish Fork area or to finish filling Mona Reservoir. If water is still available in Strawberry Reservoir, it may be transferred to the Sevier River Basin through the Wasatch Aqueduct and Mona-Nephi Canal. A general location map of these features is shown in Figure 27.

Utah Lake. Utah Lake will be affected in a number of ways by the Central Utah Project. Utah Lake will receive additional return flows from increased demands on the new reservoirs and releases for power generation. However, it will not receive excess flows from the Provo River or the Diamond Fork as it previously did. The Goshen and Provo bays of Utah Lake will be

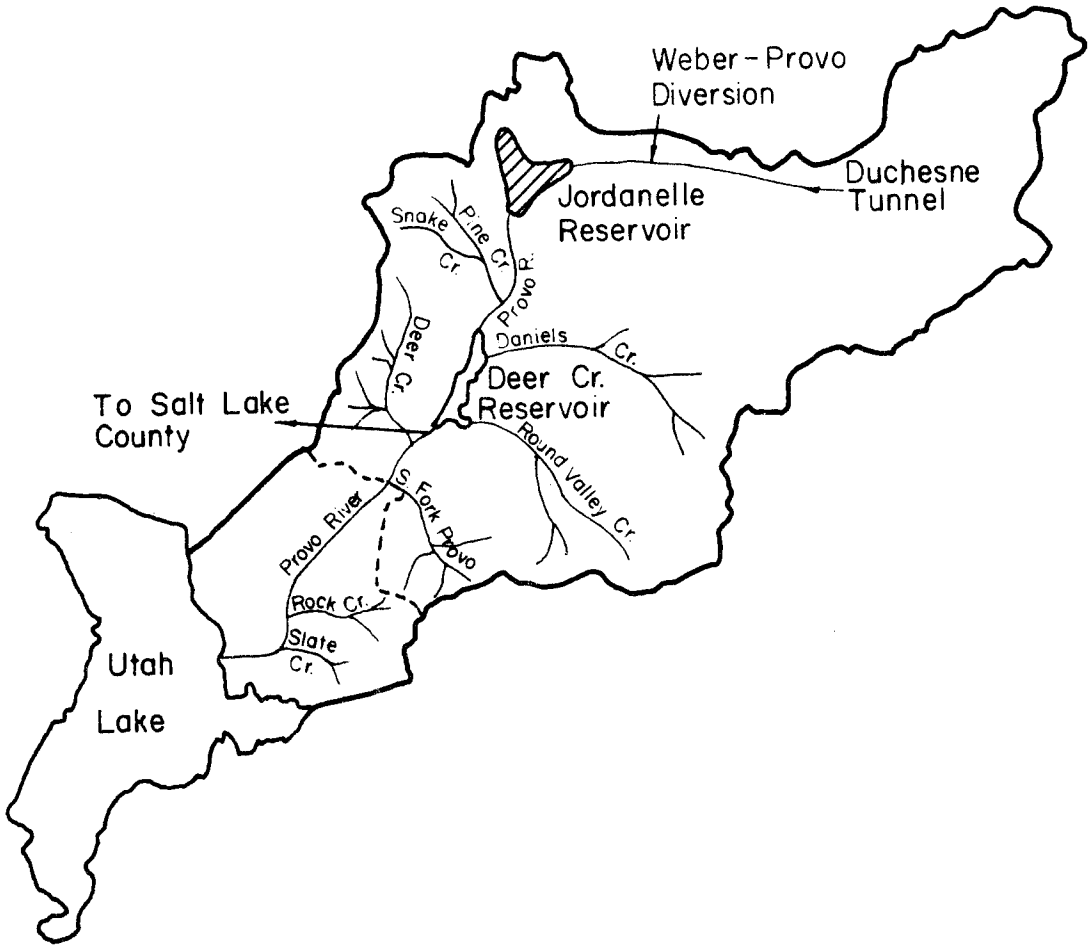


Figure 26. Provo River supply area of the Central Utah Project.

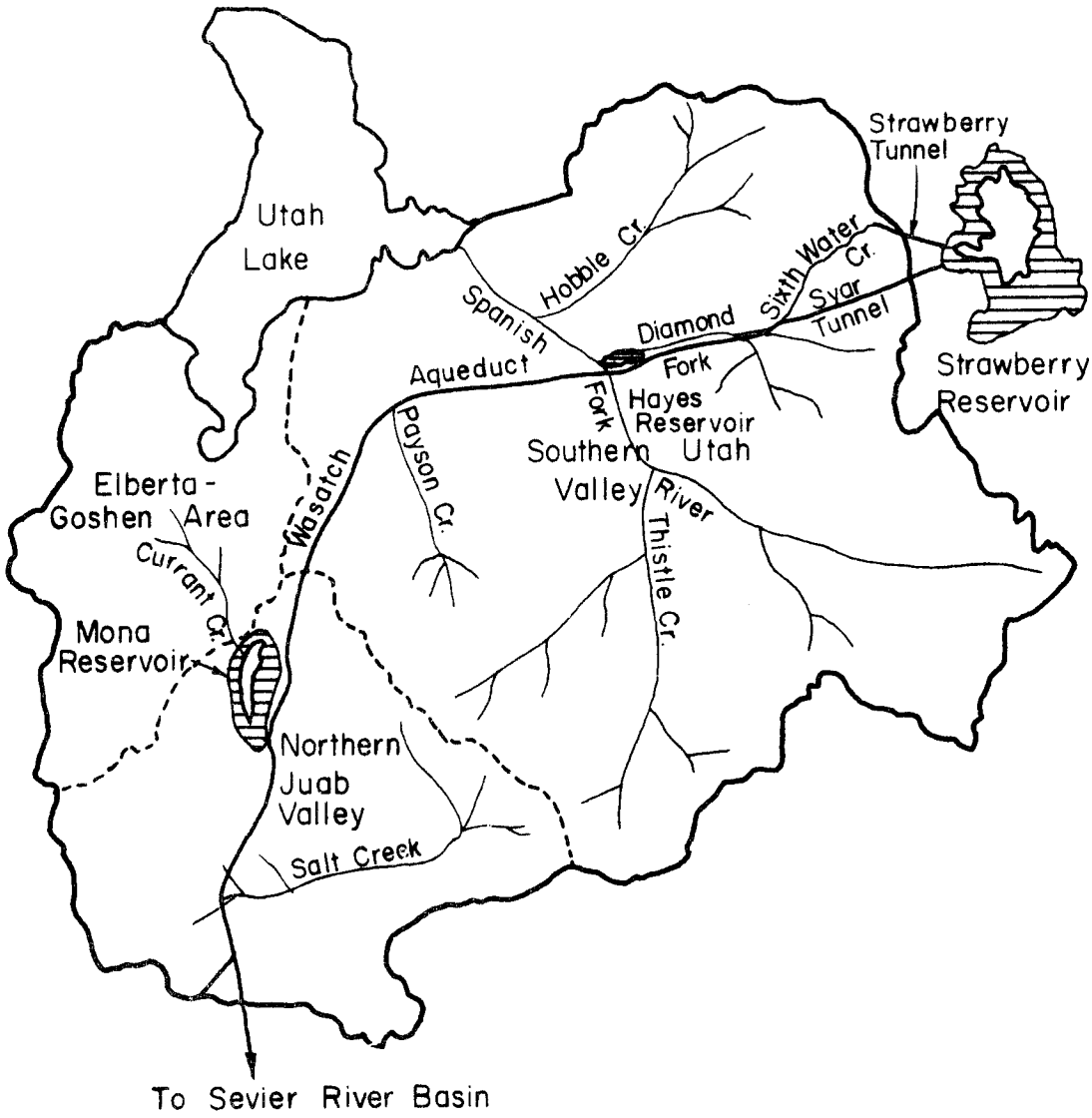


Figure 27. Strawberry Reservoir service area of the Central Utah Project.

separated from the main body of the lake by dikes to reduce evapotranspiration losses.

The lake will be separated into three parts by the construction of the Goshen Bay dike and the Provo Bay dike. The 5.4 mile-long Goshen Bay dike will extend northwest across Utah Lake from Lincoln Point. An area covering about 27,000 acres at the southern extremity of the lake will be cut off. This area will provide a storage capacity of about 220,000 acre-feet. An emergency outlet will be constructed in the dike to spill lake water into the bay in times of flood. Goshen Bay will not be reclaimed for agriculture because of the high salt content of the return flows to Goshen Bay and the poor texture of the bay floor. Present planning envisions using the bay as a waterfowl refuge. The 6.5 mile-long Provo Bay dike will separate Provo Bay from the main body of the lake. The bay covers about 7,500 acres with a storage capacity of about 23,000 acre-feet. Facilities will be constructed to divert flood and non-irrigation season flows of Hobble Creek around the bay to Utah Lake. Some of the higher lands in the bay will be reclaimed for irrigation.

The main portion of the lake will store water for use on the Jordan River and in Salt Lake County. A general location map of Utah Lake is shown in Figure 28.

Population and Water Use Projections

Population projections for Utah County were taken from Economic Research Service data (see also earlier discussion). These projections were then divided into estimates for the Lehi-American Fork district, Provo district and Southern Utah Valley, which is frequently referred to as the Spanish Fork area in the hydrologic analysis. The census data were plotted and the curves extrapolated to obtain projected values of population for each area of interest (Figure 29).

Also, the Economic Research Service provided projections on industrial and non-industrial or municipal water use. Plots indicating these trends for Utah County, Juab County and Salt Lake County are shown in Figures 30 through 32. These county-wide projections were then subdivided into estimates for each study area within the county. U.S. Bureau of Reclamation data has divided total urban demand between Northern and Southern Utah Valley. The same relative proportions were used for the Economic Research Service data. The municipal use was divided according to relative proportions of the total population, taken from Figure 29 (Table 27). Then, the resulting municipal demands were subtracted from the total obtained from the USBR. The industrial water demand for the Lehi-American Fork district had to be estimated. The resulting urban demands are shown in Table 28.

Salt Lake County water demands were compared with the possible transfers of Utah Valley water through the Salt Lake Aqueduct. The flows of water through the aqueduct were compared with the change in demand in Salt Lake County between

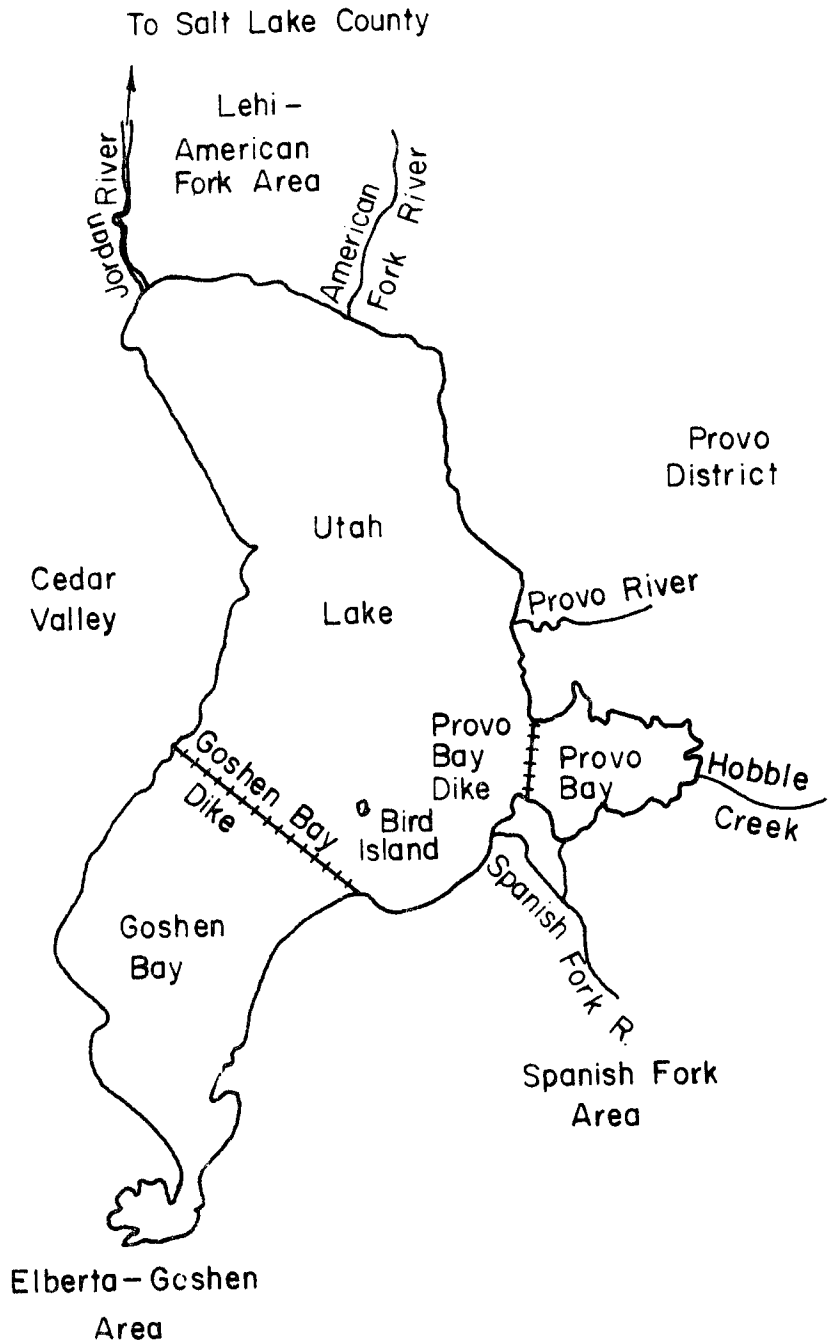


Figure 28. Utah Lake proposed alterations.

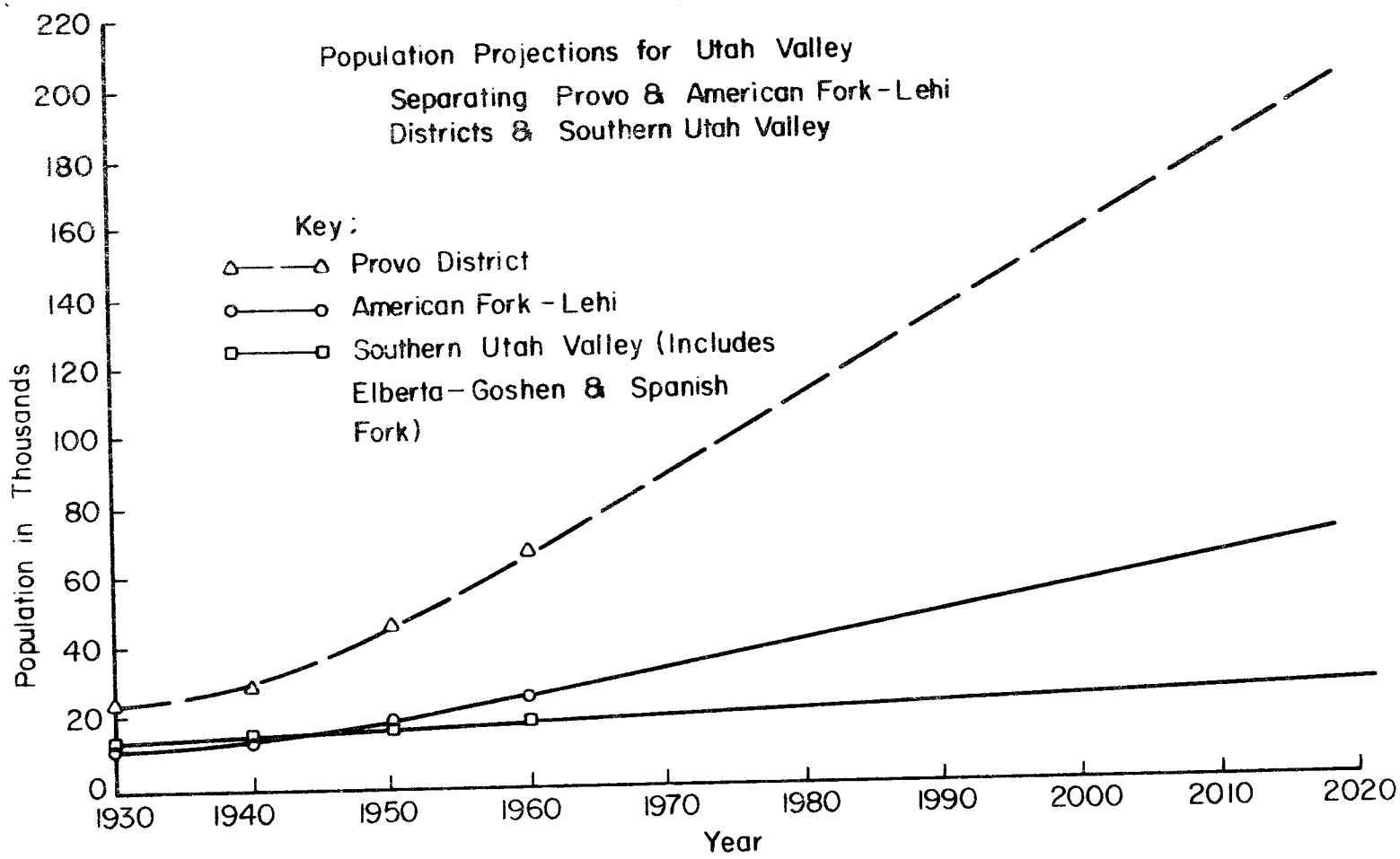


Figure 29. Population projections for Utah Valley.

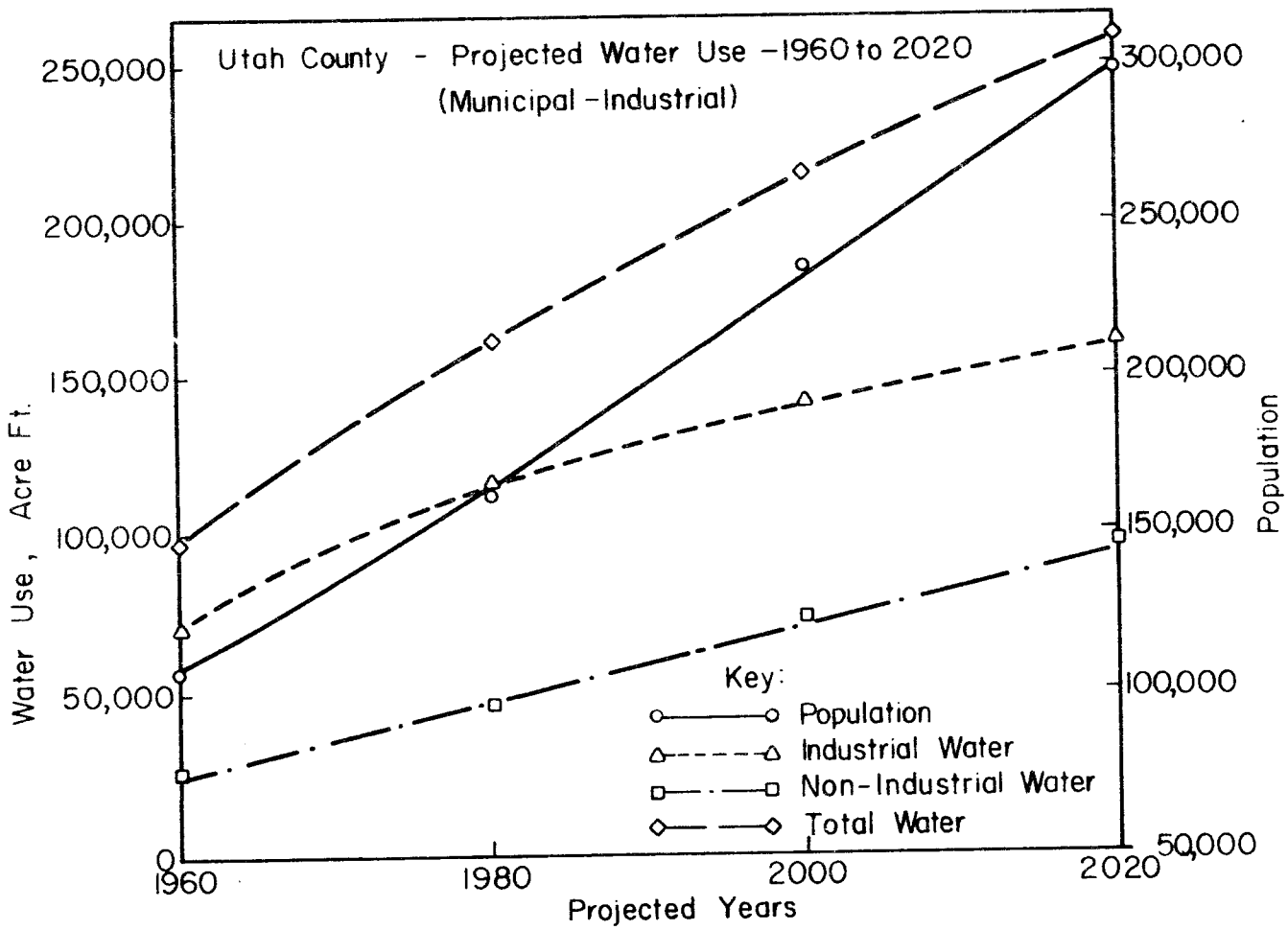


Figure 30. Projected urban water use in Utah County.

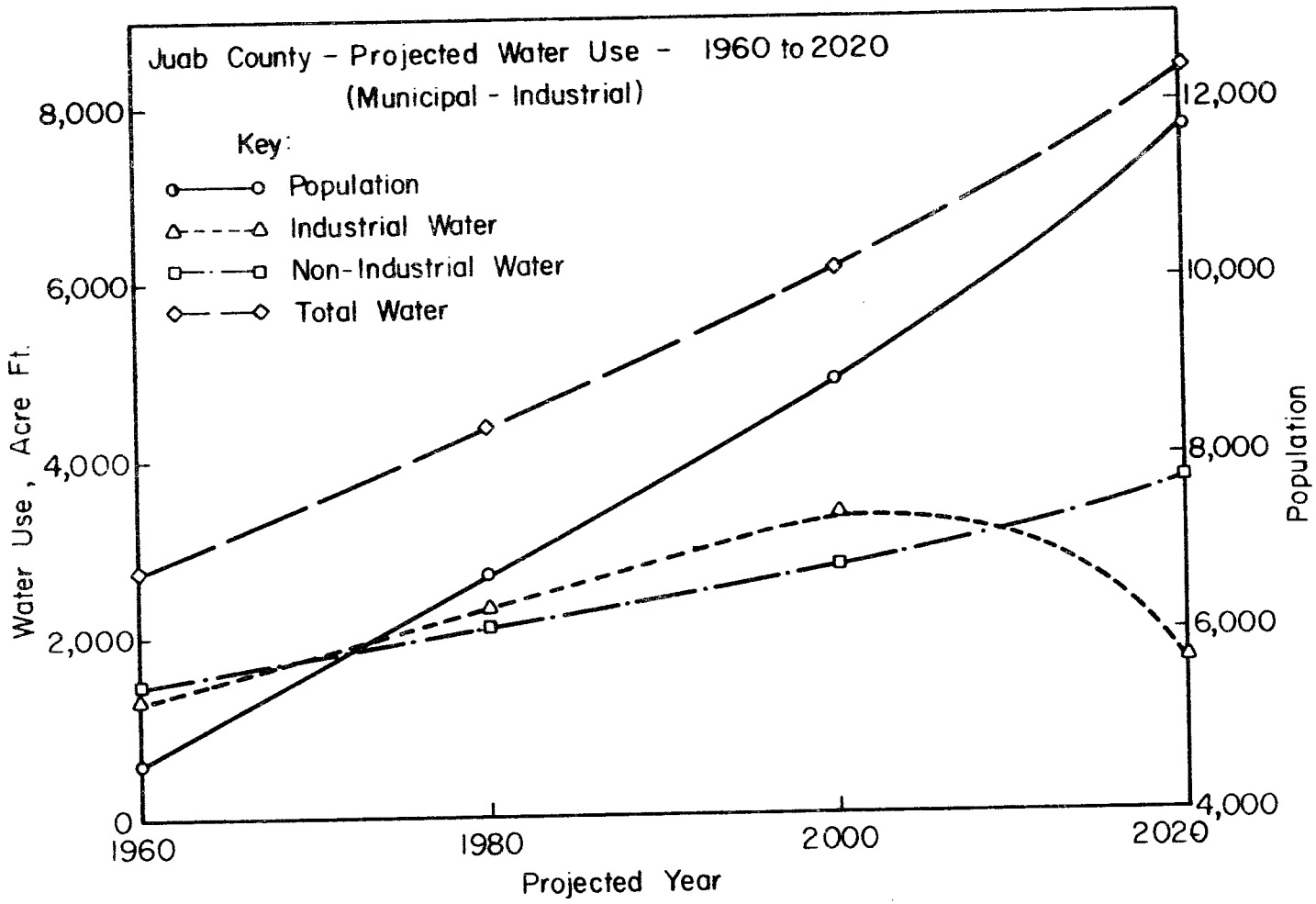


Figure 31. Projected urban water use in Juab County.

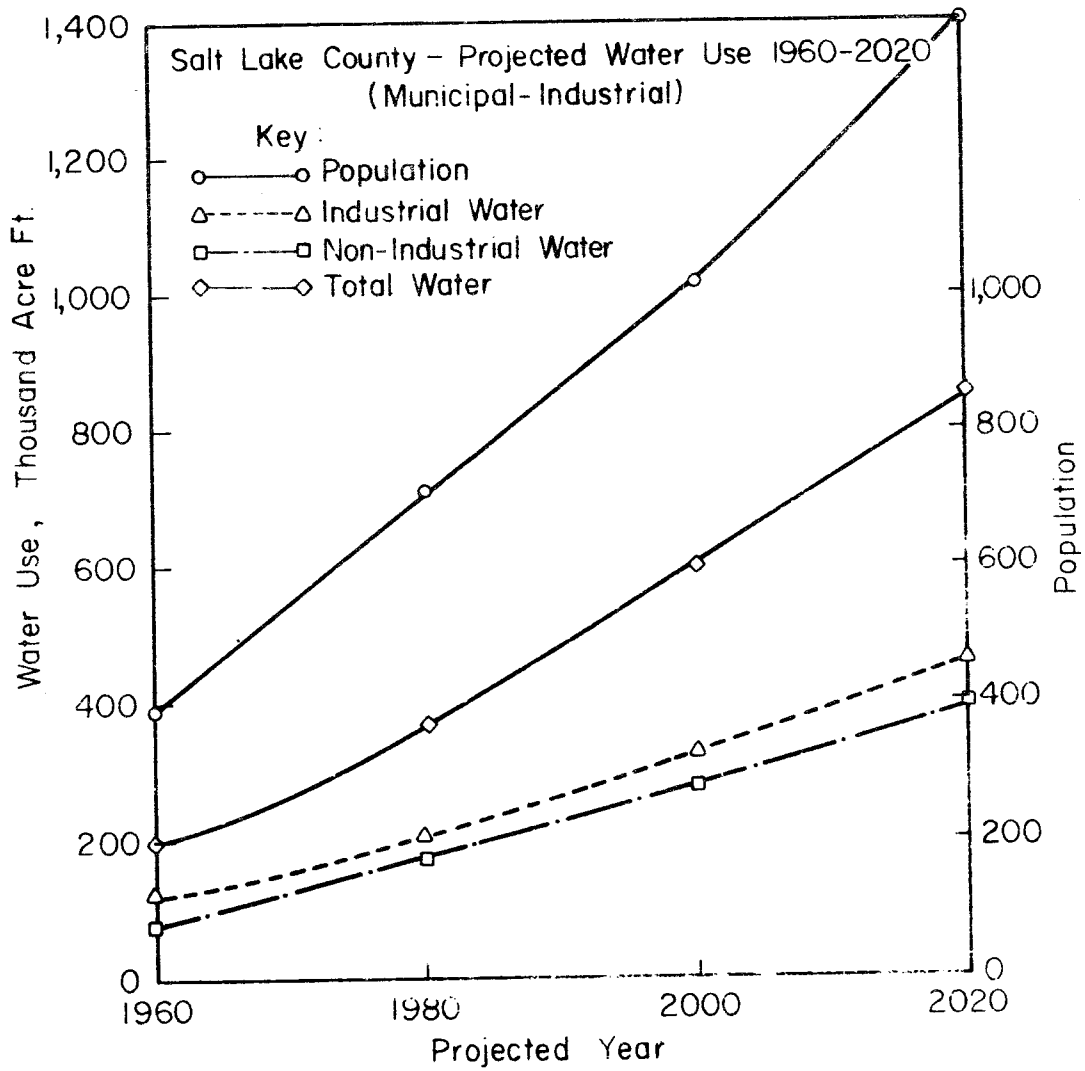


Figure 32. Projected urban water use in Salt Lake County.

Table 27. Population in each area of Utah Valley.

Area	Population			
	1960	1980	2000	2020
Lehi-American Fork	25000	40000	55500	71500
Provo	65000	111000	158000	204000
Spanish Fork	16000	18800	21800	24300
Elberta-Goshen	1000	1200	1700	2200
Subtotal	107000	171000	237000	302000
Northern Juab Valley	4600	6700	8800	12000
Total	111600	177700	245800	314000

Table 28. Mean annual urban water use in the study areas of Utah Valley.

ANNUAL WATER USE IN UTAH VALLEY

AREA	1960		1980		2000		2020	
	Urban Use	Percent of Total	Urban Use	Percent of Total	Urban Use	Percent of Total	Urban Use	Percent of Total
Northern Utah Valley	90,000	91.7	148,800	92.5	198,000	92.2	235,900	91.1
Southern Utah Valley	8,140	8.3	12,070	7.5	16,750	7.8	23,000	8.9

ANNUAL WATER USE IN SUBAREAS OF UTAH VALLEY

SUBAREA	1960		1980		2000		2020	
	Municipal	Industrial	Municipal	Industrial	Municipal	Industrial	Municipal	Industrial
Lehi-American Fork	6,500	1,000	10,700	1,500	17,000	2,200	23,000	3,000
Provo	18,000	64,500	29,800	106,000	48,600	130,000	65,600	144,000
Spanish Fork	2,000	6,000	5,000	7,500	6,700	10,000	7,800	15,000
Elberta-Goshen	250	-	350	-	500	-	750	-
Northern Juab Valley	1,400	1,300	2,100	2,300	2,800	3,300	3,700	1,600

each 20-year period. This demand was assumed to occur at a constant monthly rate.

Needless to say, the future expansion of the urban areas will result in conversion of present agricultural lands to municipal and industrial uses. Increases in land use by urbanization were determined for each subarea by determination of an urban population density. Then, using population data, an acreage increase was determined, which would correspond to an agricultural acreage decrease. The estimated population density (persons/acre) was calculated to be 33.6 persons per acre. If all population expansion is attributed to urban growth, an increase in population of 34 persons would result in a one acre decrease in agricultural land.

In addition to the decrease in agricultural acreage due to municipal expansion, the Central Utah Project proposes bringing additional land into agricultural production. The proposed CUP additions must be added to the decreases in agricultural acreage resulting from increased population to obtain a net decrease or increase of agricultural land. The average monthly potential consumptive use per unit area of agricultural land was determined for each area. This was multiplied by the collective net acreage change in each area to get the total change in water demand from 1960 to any projected year, as shown in Table 29.

Analysis of Model Results

Tables resulting from the model operations can be analyzed to arrive at some useful conclusions concerning future water needs in Utah Valley. Some general trends in shortages and surpluses in each of the areas are shown. Inflows to Utah Lake indicate water that could be used farther downstream or utilized in the Utah Valley if the means to do so are justified. Some idea of proper reservoir sizes may be obtained from the models. Also, some limitations on the Central Utah Project are shown through the different aqueduct sizes used in the model. This analysis may also suggest some alternative priority systems for the Central Utah Project, different from that used in the model.

Lehi-American Fork Area. The Lehi-American Fork area has both significant shortages and surpluses throughout the year. During the winter months of November through May, there are surpluses, with shortages occurring in the three summer months. This indicates pronounced shortages to agriculture, with the urban demands being met in the winter months. There is a net shortage throughout the year of 10,000 acre-feet per year at the present time. The amount of shortage increases to 35,000 acre-feet per year in the projected year of 2020. Therefore, upstream reservoir storage would not eliminate shortage to this area if American Fork water was the only supply.

Additions to Utah Lake from this area are in excess of 50,000 acre-feet per year for present conditions. This figure decreases to less than 40,000 acre-feet per year for the year

Table 29. Monthly change in agricultural water demand.

1980 AREA	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lehi-American Fork	-52	0	0	0	0	0	-37	-138	-253	-337	-226	-106
Provo	-139	0	0	0	0	0	-92	-347	-594	-806	-598	-284
Spanish Fork	-9	0	0	0	0	0	-6	-24	-44	-59	-41	-18
Elberta-Goshen	-1	0	0	0	0	0	0	-2	-3	-4	-3	-1
Northern Juab Valley	-8	0	0	0	0	0	-5	-18	-31	-41	-31	-16

2000

AREA	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lehi-American Fork	-100	0	0	0	0	0	-71	-260	-480	-640	-437	-201
Provo	560	0	0	0	0	0	370	1400	2398	3260	2410	1144
Spanish Fork	4	0	0	0	0	0	318	1212	2198	2950	2055	909
Elberta-Goshen	1770	0	0	0	0	0	1242	4870	8675	11610	8500	4150
Northern Juab Valley	1615	0	0	0	0	0	1020	3660	6320	8440	6320	3380

2020

AREA	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Lehi-American Fork	-146	0	0	0	0	0	-104	-388	-707	-943	-644	-296
Provo	562	0	0	0	0	0	370	1400	2398	3259	2415	1144
Spanish Fork	449	0	0	0	0	0	313	1192	2160	2900	2018	894
Elberta-Goshen	1750	0	0	0	0	0	1241	4860	8660	11600	8500	4150
Northern Juab Valley	1600	0	0	0	0	0	1010	3635	6270	8380	6270	3355

2020 as a result of increased shortage to agriculture, which has a lower efficiency of use than urban demands. Possible means of importing water from elsewhere in the Utah Lake drainage may be necessary to satisfy demands in this area.

Provo District. The analysis in the Provo district concerns the size of Jordanelle Reservoir and its effect on the shortages and surpluses that will occur in the area. Also, possible exports to Salt Lake County are analyzed, as well as inflows to Utah Lake. At the present time, the agricultural and urban demands are both satisfied. Also, Deer Creek Reservoir remains full nearly all the time without Jordanelle Reservoir, indicating a surplus of water in this area.

A shortage occurs in the Provo district during the summer months in the years 1960 and 1961 for 1980 projected conditions. Without Jordanelle Reservoir, shortages would occur frequently in the projected years 2000 and 2020. If the Jordanelle Reservoir is in operation, the shortages only occur in a few years in the early 1960's. Treating Jordanelle Reservoir as if it has unlimited capacity (1 million acre-feet) results in shortages in the years 1960 and 1961. There is not enough water available in the Provo District to completely satisfy the demands for those two years. However, the demands in this area are completely satisfied the remainder of the time. The contents of the reservoir at this capacity reach a maximum of about 570,000 acre-feet in the analysis for the year 2000.

The computer model was used to determine the effect that decreasing the capacity of Jordanelle Reservoir would have on the water shortages in the district. The capacities of 1,000,000, 325,000, 225,000 and 150,000 acre-feet are discussed.

If the monthly average shortages for 2020 are added for each capacity, there is very little difference, the mean annual shortage being 9500 acre-feet for 1,000,000 acre-feet capacity and 13,500 acre-feet for 150,000 acre-feet capacity. Therefore, the deciding factor is a shortage in one or two months of one year in the 2020 projected conditions.

Comparing the 325,000 acre-feet capacity with the maximum possible, the months of July, August, September, and October have differences in shortages. The additional shortages for the 325,000 acre-feet reservoir occur in the year 1960, the maximum difference being in July when a 27,000 acre-feet shortage occurs for that month in 1960. The total annual difference in shortage between the two capacities for the 21 years is 47,000 acre-feet or an average of roughly 2300 acre-feet per year. A reservoir capacity of 225,000 acre-feet results in only 16,000 acre-feet additional shortage in the 21 year period, that occurring in the month of August, 1959. This is a little more than 500 acre-feet of average shortage per year. There is a total of 27,000 acre-feet additional shortage incurred in decreasing the reservoir capacity from 225,000 to 150,000 acre-feet. This is an annual average of 1500 acre-feet per year additional shortage. Therefore, the additional water made available to the area in each case must justify the added cost

of increasing the reservoir size. The average annual shortages for each case are shown in Table 30. The increased demand for water in 2020 as compared with 1980 results in greater shortages with Jordanelle Reservoir than existed prior to the time that it is assumed to be in operation, which is the year 2000.

In addition, the model attempted to satisfy present demands of Salt Lake County and any water in excess of the capacity of Jordanelle or Deer Creek Reservoirs was available for export. The present demands from Salt Lake County can be met in most analysis years, except for the years 1960, 1961, and 1962. The shortages in future projected years vary with the size of Jordanelle Reservoir. There is seldom a time when water is available for export in addition to Salt Lake County's present demand.

Average annual shortages under present Salt Lake County demands along with average annual possible exports to Salt Lake County are listed in Table 31 for various capacities of Jordanelle Reservoir. Most of the available exports occur in a few months in the early 50's. Exports from Deer Creek Reservoir to satisfy present demands can be made, but no water is available to satisfy any future Salt Lake County demands. However, the increased return flows to Utah Lake may be used to satisfy these demands.

Inflows to Utah Lake are dependent upon the assumed size of Jordanelle Reservoir. During the winter months, there usually are no shortages. Therefore, if the reservoir capacities are not exceeded, the inflows to Utah Lake will be repetitious for each water year for a given month. The only time deviations occur is at times when there is reservoir spill. These spills have a definite effect on the average annual inflows to Utah Lake, which are given in Table 32.

The largest inflow to Utah Lake occurs under 1960 conditions when Jordanelle Reservoir is not storing water. This water in excess of Deer Creek Reservoir capacity flows into Utah Lake. Under 1980 conditions, the inflows are still high because of the absence of Jordanelle Reservoir, but the demand is greater, resulting in additional storage capacity in Deer Creek Reservoir for catching flood flows, thereby decreasing the quantity of spills.

Strawberry Reservoir Service Area. The Strawberry Reservoir service area is greatly altered by the Central Utah Project. The Hayes Reservoir and Wasatch Aqueduct operations make significant differences in the shortages and also the additions, or return flows, to Utah Lake from each of the districts served by this component of the Central Utah Project. The three aqueduct sizes analyzed as a part of this study provide an insight into determining an adequate capacity. The demands for water exports to the Sevier River Basin also dictate the aqueduct capacity.

The greatest shortages in this area under present conditions occur in Northern Juab Valley, which obtains water from

Table 30. Average annual water shortage in the Provo district.

Analysis Year	Jordanelle Reservoir Capacity (acre-feet)	Average Annual Shortage (acre-feet)
1960	-	0
1980	-	8,500
2020	150,000	13,500
2020	225,000	12,000
2020	325,000	11,500
2020	1,000,000	9,500

Table 31. Average annual shortages to present demands and possible additional exports to Salt Lake County.*

Analysis Year	Jordanelle Reservoir Capacity (acre-feet)	Shortages to Present Demands (acre-feet)	Possible Exports to Salt Lake County
2020	1,000,000	3,062	1,188
2020	325,000	3,786	9,900
2020	225,000	4,149	14,800
2020	150,000	4,510	18,000

*Exporting only reservoir spills.

Table 32. Average annual inflows to Utah Lake from the Provo area.

Analysis Year	Jordanelle Reservoir Capacity (acre-feet)	Annual Inflow to Utah Lake (acre-feet)
1960		231,286
1980		209,238
2020	1,000,000	159,167
2020	325,000	165,948
2020	225,000	170,804
2020	150,000	172,366

small streams, particularly Salt Creek. Small surpluses exist in Northern Juab Valley in the winter months, but there are very significant shortages in the summer months. The average annual shortage in Northern Juab Valley is 32,000 acre-feet in the summer months, with an average annual surplus during the winter months of 6500 acre-feet.

The Spanish Fork area has excess water in all but the months of July and August, under present conditions. In these two months, Strawberry Reservoir water is used to eliminate the shortage in most years. A small infrequent shortage is noted in a few months when the capacity of the Strawberry Tunnel is exceeded. The average annual excess in the Spanish Fork area is 131,000 acre-feet under present conditions.

The Elberta-Goshen area has negligible shortages and no excesses. Mona Reservoir is always able to satisfy the demands, but never exceeds its capacity under both present and 1980 conditions.

The Spanish Fork district's only shortages are in July and August, a negligible amount of 2000 acre-feet under both 1960 and 1980 conditions. This area still has 128,000 acre-feet annual excess in the winter months under 1980 conditions. Northern Juab Valley's annual shortages have increased to 325,000 acre-feet with only 5500 acre-feet of surplus water.

No shortages occur in the Spanish Fork area for the analysis years 2000 and 2020 for any capacity of the aqueduct. The average annual excess in 2020 was 127,000 acre-feet in this area for an aqueduct capacity of 9000 acre-feet. Northern Juab Valley shortages are not completely eliminated in 2020 for the 9000 acre-foot capacity aqueduct, with the average annual shortage being 2500 acre-feet, this occurring in the months of July and August. The shortage becomes only 600 acre-feet with the 11,000 acre-foot aqueduct capacity.

The analysis of data indicate some limitations on the system due to reservoir and aqueduct capacities. In the analysis years 1960 and 1980, the system is adequate to supply the area with the existing water supplies, with Strawberry Reservoir never emptying, but filling to capacity on occasion. Also, the shortages in the Spanish Fork area in 1980 indicate the Strawberry Tunnel is reaching its capacity. Mona Reservoir is adequate for the demands of 1980 as well as the present, since it is never emptied under either condition, but seldom reaches capacity.

Addition of the Central Utah Project adds considerably to the complexity of the system but removes many of the limitations in the present water delivery system. Lack of shortages in the Spanish Fork area indicates the capacity of the Syar Tunnel is adequate, even for increased capacities of the Wasatch Aqueduct. Hayes Reservoir is filled to capacity most of the time for all capacities of the aqueduct. Mona Reservoir is at capacity in the winter months and is depleted almost entirely in the summer months. Strawberry Reservoir is filled to

capacity infrequently, but maintains its end of month contents to more than 400,000 acre-feet for all aqueduct sizes.

The Wasatch Aqueduct is a major control in providing adequate water supplies for transfer to the Sevier River Basin. The Wasatch Aqueduct is filled to capacity all the time, thereby allowing maximum possible exports to the Sevier River Basin.

The possible exports to the Sevier River Basin are excess waters in the Strawberry Reservoir supply area which are transported through unused capacity in the Wasatch Aqueduct. Therefore, these exports are directly related to the aqueduct size. The capacity available in the aqueduct is a minimum for 2000 conditions as the industrial demand decreases in the Strawberry Reservoir supply area in 2020. The average annual amount that may be exported in the year 2000 for the aqueduct capacities of 9000, 10,000 and 11,000 acre-feet per month are 18,800, 27,400 and 36,300 acre-feet, respectively for analysis year 2000.

Inflows to Utah Lake include return flows from the Elberta-Goshen and Spanish Fork areas and spills from Hayes and Mona reservoirs. These inflows to Utah Lake are given in Table 33. The increase from 1960 to 1980 is primarily due to increased demands on Strawberry Reservoir by the Spanish Fork district, as there are no spills from Mona Reservoir in either time period. The demands are not appreciably greater in the Elberta-Goshen area. The inflows to Utah Lake more than double when the Central Utah Project is in operation. This is due to increased water supplies in all areas, thereby decreasing water shortages.

Limitations and Possible Alternative Systems

Limitations of the system can be seen and some possible changes may be suggested in the operation of the Utah Lake drainage area water system. Some changes in transport water in the area may result in less shortage. Also, reservoir and adueduct sizes may be estimated. All alternatives were not modeled because the added work would make this study prohibitive.

The perpetual shortages in the Lehi-American Fork area could partially be remedied by using water from the Provo area. At present, Deer Creek Reservoir has sufficient water to supply Lehi-American Fork needs, but would not adequately supply both areas by the year 1980. After 1980, water designated as export water to Salt Lake County from the Provo district could be used in the Lehi-American Fork area, utilizing the increased return flows from all areas to supply Salt Lake County demands via Utah Lake. Also, the analysis of possible exports to Salt Lake County in addition to its present demands indicates no water is available for that purpose in any significant amounts directly from Deer Creek Reservoir. Therefore, any water transported to satisfy increasing needs in Salt Lake County must come from Utah Lake.

Table 33. Average annual inflows to Utah Lake from the Strawberry Reservoir service area.

Analysis Year	Wasatch Aqueduct Capacity (acre-feet per month)	Average Annual Inflows to Utah Lake (acre-feet)
1960	-	85,682
1980	-	88,266
2020	9,000	211,834
2020	10,000	212,327
2020	11,000	212,778

An adequate capacity for Jordanelle Reservoir is difficult to analyze. The additional shortages incurred by decreasing the size to 150,000 acre-feet justifies a capacity greater than 150,000. If average annual shortages are the criterion used, a 325,000 acre-foot capacity results in only 500 acre-feet savings in a total shortage of 11,500 (4.3%) over the 225,000 acre-foot capacity, which clearly cannot be justified. If the criterion is based upon the total shortage during the 21 year period of study, the 325,000 acre-foot reservoir capacity results in eliminating shortages only 4 months oftener in the entire 252 months analyzed. This is a savings that has very weak justification. If the object is to intercept all available water to eliminate the most possible shortages, it should be increased to 500,000 acre-feet. This last criterion could very well be the one used for arriving at 325,000 as the proper capacity, as this model has determined demands on the reservoirs to be the actual water use requirements and not actual historical diversions. Using actual historical diversions as demand will result in more water being taken from the reservoirs; therefore, less water will be accumulated in Jordanelle than this model shows. If the steel industry could be informed as to the proper 4 months in 21 years to be on strike, the 225,000 acre-feet capacity would possibly be ideal for any criterion used.

The reservoirs in the Strawberry Reservoir service area may be similarly analyzed. Mona Reservoir is of adequate size for both the preproject demands and after the capacity increase. The reservoir is not filled during the winter months at the present time, but shortages do not occur in Elberta-Goshen. After increasing the capacity of Mona Reservoir as part of the Central Utah Project, the reservoir is filled during the winter months and is emptied in late summer, with no shortages in the Elberta-Goshen area. Hayes Reservoir is full a majority of the time, spills in the winter months, and does not become empty at any time. The model added water to Hayes from Strawberry Reservoir at the end of every month. Therefore, natural flows of Diamond Fork would be spilled. The analysis of data also indicates that Strawberry Reservoir is never emptied and seldom reaches capacity. This would indicate Strawberry Reservoir's enlarged capacity should be decreased. The end of month capacity after 1980 is less than 300,000 acre-feet only in the first few years when the reservoir is filling. This water is never used in the project area, indicating a possibility of decreasing the capacity to 4 or 5 hundred thousand acre-feet. Such an analysis could be accomplished with the model, but was not undertaken as a part of this study. Decreasing the capacity of Strawberry Reservoir could possibly result in a more efficient use of Hayes Reservoir, also. The Wasatch Aqueduct is utilized almost completely for the project area, with little export water if the 9000 acre-feet per month aqueduct capacity is used. Therefore, the size of the aqueduct above 9000 acre-foot capacity would be determined by the amount of water that was to be exported to the Sevier River Basin. The model analysis attempted to satisfy an export demand of 36,000 acre-feet per year by the year 2020. The average possible export in 2020 for a capacity of 10,000 acre-feet per month is 29,600

acre-feet, and an export of 37,800 acre-feet is possible for an aqueduct capacity of 11,000 acre-feet per month. The figures for year 2000 given previously indicate the aqueduct must be near 11,000 acre-feet capacity if the criteria are to be satisfied for all analysis years.

The rather lengthy discussion of projected future demands were forwarded mostly as an indication of the strong population and other pressures facing the Valley in the years to come. In this fast changing situation and with the competing or multiple uses of water, the consolidation of irrigation systems becomes not only a meaningful organizational alternative, but also a pressing need for future survival.

Conclusion and Synthesis

The prospects for consolidation in Utah Valley continuously increase as the CUP becomes more and more a reality. CUP will incorporate the use of Strawberry as well as the Provo River water associations and in the final analysis, the conservancy district will control nearly all of the water which enters Utah Valley. An organizational structure is, therefore, emerging which could also serve as the springboard for a consolidated organization. Already the Central Utah Water Conservancy District, which is located in Orem, acts as an independent entity contracting with the federal government for the repayment of the CUP and the eventual management of the project when it becomes a reality. The Central Utah Water Conservancy District will not only maintain the water structures, the diversion canals, the impoundments, and other facilities needed, but it will also be charged with the task of maintaining and operating the power generating facilities in the system.

The complexity of water management in the area has already developed through the two associations formal and informal agreements for exchange. Since the headwaters of the Provo and Strawberry Rivers are in other drainage areas, a fact which dictates careful diversion of water. For example, the headwater of the Provo River can be diverted down into the Deer Creek area or it can also be diverted into the Weber River which runs into the Ogden area, about 100 miles north of Utah Valley. This water would be impounded in other reservoirs if it were to become a part of the Weber River and, indeed, on occassion this water is diverted into the Weber River. The relationship of Utah Valley with other drainages is already rather complex requiring a more concerted scheme of intra- and inter-basin organizational arrangements.

The innovative character of the CUP will facilitate the potential for consolidation and future consolidation attempts will probably meet with most success if they were oriented as a part of the water conservancy district structure rather than as grass-roots mergers. The constant fears of a loss of water rights will have to be allayed, as well as the feelings of a loss of autonomy, primary group identification, and identification with a certain power base.

It seems once again that an external stimulus may act as a catalyst for bringing about consolidation of segmentalized and fragmented irrigation companies. The Central Utah Project provides means for redistributing the existing water supply, along with providing imported water. The elimination of shortages in all areas of the Valley removes also the perennial fear of irrigators concerning potential losses of water rights in any consolidation attempt. However, CUP must be operated as a single management unit, with the proper legal means to control the distribution of the water supply in order to most nearly satisfy the demands. This requires that a consolidation of the existing separate irrigation companies take place to allow the distribution of water from areas of surplus to those areas short of water. The existing management system in the Valley not only prevents maximum utilization of the facilities provided by the Central Utah Project, but it is also thoroughly inadequate to meet the accelerating demands resulting from rapid urbanization and industrialization.

EDEN VALLEY

Location and Physiography

Eden Valley is located in the Green River subbasin of the Colorado River Basin, in southwestern Wyoming. The Eden Valley is in the drainage area of the Big Sandy Creek which is a tributary of the Green River. The project lands range in elevation from 6,560 to 6,680 feet above sea level. The valley lies 40 miles north of Rock Springs, Wyoming (Figire 33) in Sweetwater County. The two community centers are Farson and Eden.

The Eden Valley area is almost entirely an agricultural area with most of the 300 residents dependent for their livelihood on production of beef cattle, sheep, dairy cattle, and livestock feeds. Only a few other opportunities are available for employment, primarily the service industries.

The Eden Valley area has a temperate, semi-arid climate. The summers are relatively cool and the winters are cold. The mean annual temperature is about 38° Fahrenheit, with extreme temperatures ranging from -48° Fahrenheit to 95° Fahrenheit. The average growing season for frost-resistant crops is about 90 days, but the growing season for the more delicate crops is much shorter. The products grown in Eden Valley are fairly limited due to the short growing season. Often hay, as well as grain, are cut rather quickly, because it has happened in the area to have a freeze in the middle of July. The records indicate that freezing temperatures have occurred in every month of the year. Cool temperatures and frost restrict the variety of crops that can be successfully produced in the area to forage grasses, alfalfa hay, hay pastures, small grains, and a few hardy vegetables. Precipitation averages about 7 inches per year, with about 3 to 3 1/2 inches occurring during the five month period from May to September. There are occasional summer rain storms. Ordinarily winter precipitation consists of snow that stays on the ground until spring.

Since the valley is located in an arid region, the use of irrigation for the production of crops is a necessity. The water for irrigation is diverted from both Big and Little Sandy Creeks. The water from Big Sandy Creek is stored in Big Sandy Reservoir. Eden Reservoir is an off-stream reservoir where the water from Little Sandy Creek is diverted and stored. The water from these two reservoirs are used to irrigate 9,000 of the 13,500 acres of land covered by water rights.

Human Community

The 1970 census does not list separately Eden Valley. The closest approximation is Sweetwater County, which is divided in such a way that the Rock Springs North Division can be used as a basis for estimats. Sweetwater County had a population of 18,391 individuals in 1970. The Rock Springs North Division had a population of 18,391 individuals. The Rock Springs North Division had a population of 1,218 individuals, compared to 2,139 in 1960, a rather steep population loss of 43.1 percent,

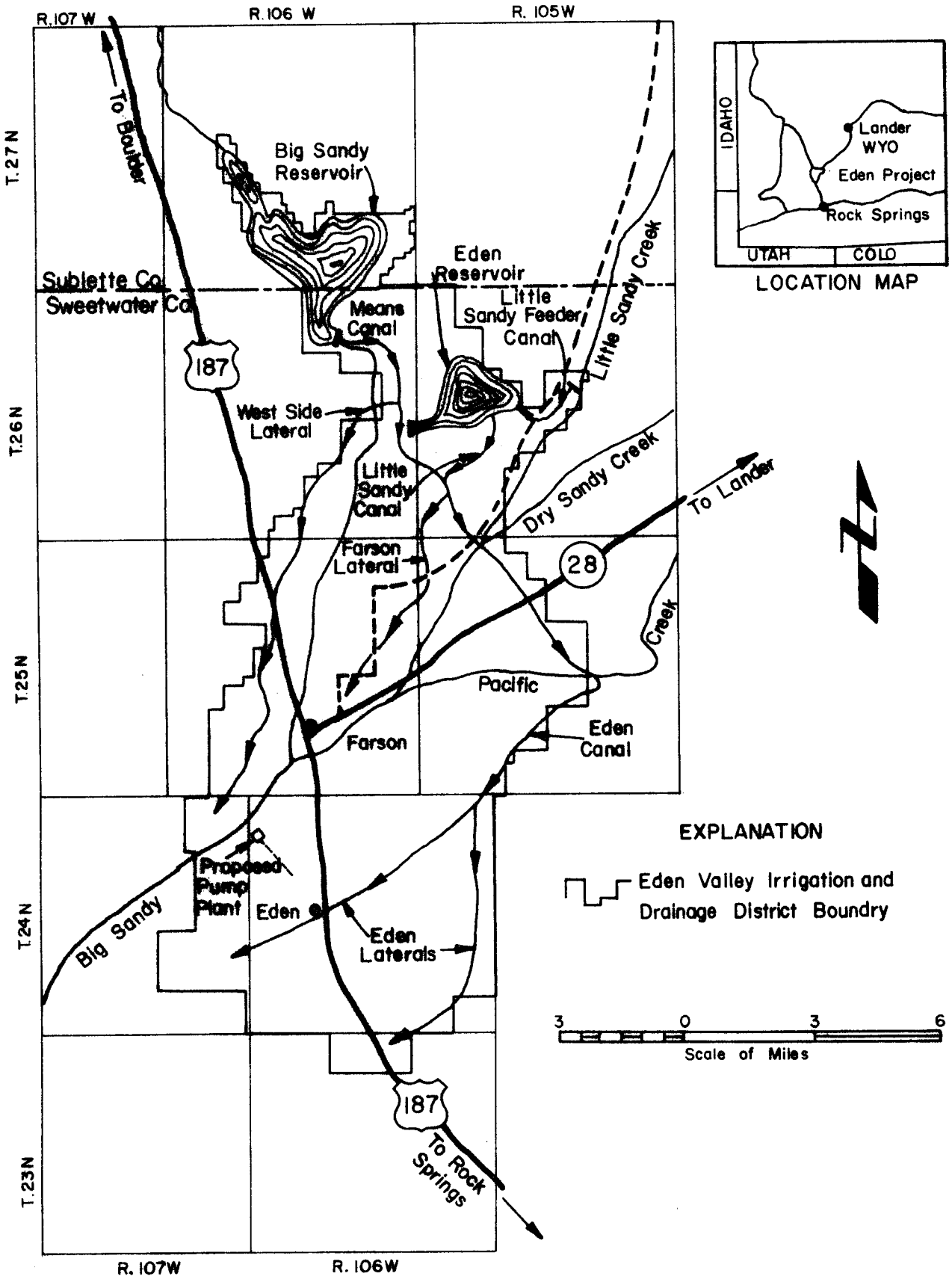


Figure 33. Location and general map of Eden Valley.

as contrasted to a modest increase for the rest of the County (Table 34). The population in the Eden-Farson area is approximately 400. This is an estimation made according to a survey in 1970 and does not constitute an official figure. There is no urban center in the entire area, with the total population in Rock Springs North classified as rural. The median age of the people in Rock Springs North is 28.9 years, with those over 65 years of age constituting 8.9 percent of the total population. The employment distribution for Sweetwater County reflects the predominantly agricultural character, with 2,640 persons employed in agriculture, 1,340 in mining, 508 in construction and 568 in manufacturing. Eden Valley is exclusively agricultural with no mining or construction activity and certainly no manufacturing.

Everything in Eden Valley points out to the smallness of social organization and the restricted scale of community development. There are 71 water users with a few other service people to augment the small number of people in the community. Besides farming, a few small grocery stores, the post-office, and a small motel round up the communal organization. Such a small community exemplifies also the cultural homogeneity typical of primary groupings, with strong informal control, and deep bonds of interpersonal relations. In such a setting and in a water-poor area, this vital resource is the most critical element of survival. Typical of the centrality of water and of the strong mechanisms of control is the case when the water master opens the irrigation headgate for an individual; that headgate is then locked so that the water cannot be increased or decreased by anyone except the possessor of the key. "This is one way of keeping everyone honest," was the description offered for this practice. More than anything else, people are very emotional about water and terribly concerned about getting their fair share of the water. (For further expression of such feelings, see also the analysis of the special survey, later in Part V).

Water and Irrigation Development

The route adopted by the first immigrant trains of 1842 in their journey to Oregon and California traversed an opening in the Wind River Mountains discovered by Ezekiel Williams in 1807 and now known as South Pass. Emerging from this pass, the pioneer caravans traveled in a southwesterly direction for 25 miles through the Big Sandy drainage and the area now comprising Eden Valley.

Permits for irrigation were first issued to settlers to divert water from the Big Sandy Creek for lands within the Eden Project area in 1886. The Eden Irrigation and Land Company was the original owner of the Eden Irrigation Project. The Company organized the first official project in 1905, and in the following year requested the withdrawal under the Carey Act of 56,327 acres. A total of 95,653 acres were withdrawn, but only 28,336 acres were patented to the State. A total of 13,882 acres were covered by water right sales made by the Company. Eden Reservoir and canals, and a large

Table 34. Population increase in Sweetwater County, 1900-1970.

Year	Number	% Increase
1900	8,455	--
1910	11,575	36.9
1920	13,640	17.8
1930	18,165	33.1
1940	19,407	6.8
1950	22,017	13.4
1960	17,920	18.6
1970	18,391	2.6

reservoir at Leckie Ranch to store water transported from the headwaters of Big Sandy Creek and East Fork of New Fork River were proposed. However, the Leckie Ranch Reservoir was never started. Construction bonds were issued by the Eden Irrigation and Land Company in the amount of $800,000. Construction commenced in the summer of 1907 and was completed in 1914. Settlement of land under this development began in 1910.

Through default in meeting bond obligations the project passed into the hands of a receiver in 1927 and was then purchased by the Rock Springs Water Company. This Company, incorporated that same year, carried on with the management of the project for a few years and then went into receivership. At that time, 13,822 acres were covered with water right and irrigation water was supplied to 9,000 acres of land. In 1932 the Wyoming Land and Water Company, a Wyoming corporation, purchased the project at a foreclosure sale for $20,000.

Water rights were originally sold for $30 an acre, then later for $50 an acre. Rights for the majority of the lands of the original project were purchased at the latter figure. Original contracts provided for annual operation and maintenance charges not in excess of 40¢ per acre. In later contracts the assessment was fixed at 80¢ per acre. About 70 percent of the original area covered by water right sales was subject to the 40¢ charge and 30 percent of the lands to the higher cost.

Works originally constructed had sufficient capacity to serve lands as intended, although many structures were evidently poorly designed and constructed. With operation and maintenance (O & M) charges limited to 40¢ per acre, or even 80¢ per acre, the various companies which have owned the project since it was first started were handicapped by insufficient funds for O & M and found it impossible to make necessary repairs resulting in a project that continuously deteriorated. In recent years funds collected for operation and maintenance have scarcely been adequate for employment of ditch riders during the irrigation season, leaving very little for necessary repairs of structures vital to the successful and reliable operation of an irrigation project.

Poor surface and subsurface drainage became evident on portions of the irrigated lands. The use of irrigation water apparently had been wasteful with more water applied to the land than necessary for good crop growth and there was evidence of high water losses by seepage from canals and laterals. A high water table developed over the relatively impervious underlying sandstone and shale formations that restrict ground water percolation.

Because of the weakened condition of the Eden irrigation system and serious drainage problems, the U.S. Bureau of Reclamation (USBR) investigated possibilities of rehabilitating and extending the project. The Bureau formualted a plan of development that involved construction of a dam at the Big Sandy site on Big Sandy Creek, in lieu of the Eden

reservoir, to impound 35,000 acre-feet of active storage for the purpose of serving 20,000 acres of previously irrigated and new lands. In addition to construction of the Big Sandy Dam, the plan provided for enlargement of the Eden Canal, rehabilitation and extension of the existing lateral system, and construction of drains. The plan was approved for construction by the President on September 18, 1940, under the provisions of the Water Conservation and Utilization Act of August 11, 1939. The Bureau of Reclamation was designated as the construction agency and the Department of Agriculture was made responsible for land development, operation and maintenance, and collection of reimbursable costs. Construction of the Big Sandy Dam and Reservoir was started July 30, 1941, with Civilian Conservation Corps labor. Work was about 16 percent complete when stopped by order of the War Production Board in December 1942. Construction had not commenced on any other project features.

By the time the first water was released from Big Sandy Reservoir for irrigation (May, 1953), the estimated total costs of rehabilitating the project, extending it, land preparation and settlement had increased from $2,445,000 to $8,731,000. Due to the fact that the Work Projects Administration and the Civilian Conservation Corps had been disbanded there were no provisions for non-reimbursable contributions to offset a part of these costs.

Because of the great increase in construction costs as an outgrowth of World War II and loss of financial support by such agencies as the Work Projects Administration and the Civilian Conservation Corps, the Bureau determined that reauthorization of the project by Congress would be necessary before construction could be resumed. In January, 1949, the USBR made a report in which it recommended that the plan of development for the project be revised. Completion of the project was authorized by the Act of June 28, 1949, Public Law 132, 81st Congress, 1st Session (63 Stat. 277). This authorizing act provided for such modification in the physical features of the project as the Secretary of the Interior may find will result in greater engineering and economic feasibility. The law also provides that of the construction costs, not less than $1,500,000 for a project of 20,000 irrigable acres, or a proportionate amount thereof shall be reimbursable by the Water Users in not to exceed 60 years. (Calculated on a per acre basis, repayment would be at a rate of $1.25 per acre per year).

The Colorado River Storage Project Act of April 11, 1956, (70 Stat. 105) provides for the use of power revenues for repayment assistance to the Eden Project for costs of the project beyond the financial capability of the water users to repay. This provision is in accordance with the terms of the Eden Project Act of 1949.

A contract between the United States and the Eden Valley Irrigation and Drainage District encompassing repayment, operation and maintenance, and other matters was signed June 8, 1950.

Construction was resumed in 1950 with minor modifications in the project plan as reauthorized in 1949. Construction of all irrigation facilities except deferred drainage was completed in 1960. Big Sandy Dam was completed in 1952 and storage of water started in 1953. The Means Canal was used for the first time in 1953. Canals and laterals and the initial drainage system were completed in 1959. Rehabilitation of the Little Sandy Diversion Dam Canal and the Eden Reservoir outlet works were completed in 1960.

The principal project storage is provided by Big Sandy Reservoir on Big Sandy Creek. The reservoir has a capacity of 39,700 acre-feet of which 33,000 acre-feet is usable for irrigation, 1,400 acre-feet for fish and wildlife, and 5,300 acre-feet for sediment storage. The sediment storage was determined from a reservoir resurvey conducted in 1964. Reservoir water is conveyed to lands west of Big Sandy Creek through the project's Means Canal and the West Side lateral and to lands east of the creek through the Means Canal and the preproject Eden Canal which was enlarged and relocated by the project and its lateral system enlarged to serve both previously irrigated and new lands. Continued use of the old Eden Reservoir was not contemplated in the project definite plan report of May 1953 because of its unstable condition. As construction of the new works proceeded, it was determined that the Eden Reservoir should be continued in service at partial capacity. To accomplish this, the Little Sandy Feeder Canal, which was to have been rehabilitated and extended, was routed through the reservoir instead of around it and the reservoir outlet was rehabilitated.

The 1949 authorization for the Eden Project provided for irrigation of about 20,000 acres of land. Only about 17,500 acres, however, have been developed and prepared for irrigation. gation. The developed lands include about 9,850 acres that were settled under the original Carey Act program through private enterprise and about 7,700 acres that were developed under the 1949 authorization. Land development was not extended beyond 17,500 acres after it became evident that the available water supply would not be adequate for the 20,000 acres authorized. With some assistance through the U.S. Department of Agriculture, further improvements are currently being made by farmers on a cost-sharing basis. Improvement work includes land leveling, enlargement of farm turnouts, and on-farm distribution systems to increase irrigation efficiency.

Annual precipitation within the area includes rain and snow, averaging about 7 1/2 inches per year. Project soils are sandy and require frequent applications of water. An average of 1.38 acre-feet of water per acre is required for consumptive use by crops. The average annual farm delivery requirement is about 3.0 acre-feet per acre with variations from farm to farm depending upon soil.

An average annual water supply of 59,000 acre-feet was anticipated at the time of project construction. It has averaged about 51,300 acre-feet annually during the last 12

years. Further, conveyance losses are high in some sections of the project because of porous soils. Also, an average farm efficiency of 58 percent was anticipated at the time of construction but under actual operation the efficiency has averaged about 32 percent during the first few years and about 41 percent during recent years.

Beginning in the spring of 1960, the USBR undertook a general review of the Eden Project water supply problems. In 1961, 6.6 miles of the West Side Lateral were treated with Chevron Soil Sealant and in 1962 it was applied to other laterals. Also, in 1962 Soil Sealant-13 was applied to 3.4 miles of the McComas Lateral. Subsequent measurements of losses have indicated that this type of sealant loses its effectiveness rapidly and is not considered a satisfactory lining except for short periods of time.

Investigations of the substrata of the Eden Valley have revealed that the entire area is underlain by an artesian aquifer. The investigations show that the Wasatch formation sandstones are the principal artesian aquifers in the area with the principal water zones being about 500 to 1,800 feet below the ground surface. Investigations of the aquifer reveal that the water is high in sodium and would have to be diluted with surface water before it would be suitable for irrigation use.

The water obtained from wells could be utilized for irrigation in one of two ways as follows: (1) Wells could be drilled in the vicinity of irrigation canals, where the water could be mixed with surface water during the irrigation season; or (2) Wells could be drilled in the vicinity of reservoirs, then the water could be run directly into the reservoir the year around and mixed with reservoir water. The latter method would be the most economical since the well could be utilized continuously.

A test well was drilled by the USBR near the Big Sandy Reservoir in 1962. Data from this well revealed that a continuous flow of around 90 gallons per minute is the most that could be expected from a flowing well in this vicinity. The tests also indicate that the transmissibility of the aquifer is low and thus the number of wells that could be developed adjacent to the existing reservoirs would be limited. Thus, since the groundwater supply is of such a small magnitude, it has been neglected as a source of supply in these water studies.

Based on USBR test results, it is calculated that a 50-year sustained discharge of 25-100 g.p.m. can be expected from individual wells drilled within the area where the water can be recovered for irrigation use in Eden Valley. The calculated long-term yields of the 5 USBR test wells are given in Table 35.

Based upon the results from the test wells, it is unlikely that the flow into the irrigated area through the

Table 35. Calculated long-term discharge of test wells in Eden Valley, Wyoming.

Well designation		Discharge in g.p.m.			
No.	Name	1 year	10 years	25 years	50 years
1	Bureau	86	76	72	71
		(actual = 86)			
5	Coppes	129	104	100	98
8	General Petroleum	90	80	76	74
14	Meyer	73	62	58	56
15	Mrak	28	26	25	24
	Average	81	70	68	65

aquifers is great enough to support a groundwater irrigation development. Even if a great error is assumed and the flow were to be tenfold greater than the test results would indicate, the flow would not be over 3,300 gpm (7 cfs). This quantity is insufficient to materially supplement the irrigation water supply. Furthermore, about 30 wells would be required with only a few of which could be located near the Big Sandy Reservoir where they could discharge the year around.

If a larger number of wells were developed in the project area with a total capacity exceeding the inflow to the area, there would be a slow decay of pressures and a resulting serious reduction in flow until eventually the total output of the wells would equal the inflow. There is also the possibility of some invasion of poor quality sodium carbonate water in the southern reaches of the project area following a significant reduction in pressure.

Diverting water from the East Fork of New Fork River to supplement the flows of Big Sandy and Little Sandy Creeks was also investigated. Additional water from the East Fork of New Fork will require additional storage regulation in a new Sander Ranch Reservoir on Big Sandy Creek. Because of objections from the people in the New Fork drainage area, future work on diversions from East Fork will depend upon results of stream flow measurements being obtained by the U.S. Geological Survey and also a decision by the State of Wyoming approving the diverting of water into the Big Sandy drainage area.

In January, 1966, a contract for $461,981 was awarded for earth lining of the Means Canal and West Side Lateral and Sublaterals. This work was completed in 1967. The annual water savings resulting from this lining work amounts to about 4,700 acre-feet annually. Additional lining and farm delivery facility modifications are under contract which should contribute to the water supply and its use efficiency on farms.

By contract of June 8, 1950, with the United States, the Eden Valley Irrigation and Drainage District assumed responsibility for repayment of project costs and agreed to assume responsibility for project operation when notified by the Secretary of the Interior. The project was turned over to the district in 1970 and they are operating the water collection and supply system at this time with technical assistance from the USBR.

The natural flows of Big and Little Sandy Creeks presently being diverted as irrigation water supplies in Eden Valley are of excellent quality for irrigation. The water entering Eden Valley contains approximately ten tons of salt per day, or a total dissolved solids (TDS) concentration of 160 ppm, while the variation of TDS is between 50 and 250 parts per million (ppm). The water leaving the valley carries about 250 tons of salt per day with the TDS concentration varying between 400 and 3800 ppm. These values are dependent upon the flow of the streams. The lower values of TDS correspond with the higher flow rates. The average flow rates, TDS concentrations, and

volume of salts are shown in Figure 34 for inflows and outflows from Eden Valley.

The irrigation of 13,000 acres in Eden Valley contributed approximately 200 tons of salt per day, or an average of 5.6 tons per acre per year, for each of the 1965-1966 calendar years. The salt load yield from these irrigated areas was among the highest observed within the Green Basin, and results from leaching of the soluble gypsiferous sediments. These salts increase the amount of calcium and sulfates in the water. The increase in the amount of sodium and carbonates in the surface water is due to the presence of "trona" (soda ash) in the soil.

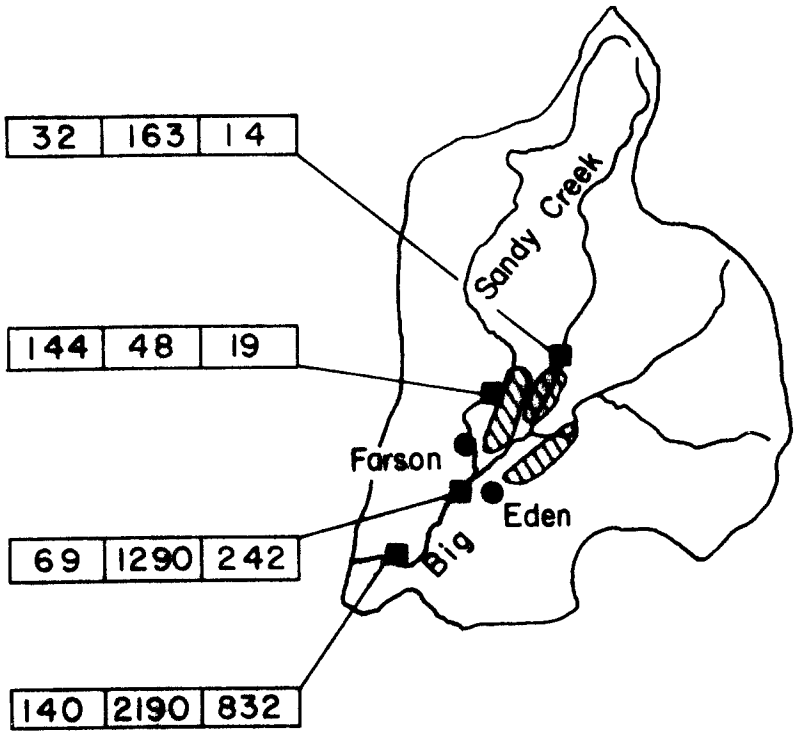
The extremely large quantities of water that are evaporated from the reservoirs and irrigation channels also serves to concentrate the dissolved salts. The consumptive use of the water also adds to this concentrating problem.

The majority of the salinity contained in the groundwater supplies of Eden Valley are the result of marine deposits from an inland sea which covered the area in geologic time. As precipitation and deep percolation losses from irrigation moved through the soil profile and into the ground water reservoir, natural salts are taken into solution and transported back to the surface river downstream from Eden Valley.

The salts present in the groundwater supplies vary with depth. The water from the deep artesian aquifers is essentially a sodium bicarbonate water of a moderate concentration, the total dissolved solids ranging from 500 to 800 ppm. The shallower artesian wells show generally higher total dissolved solids. None of these waters are suitable for irrigation. The water from the deep artesian aquifers can be used for irrigation safely if it is diluted with water from the Big Sandy Reservoir. Using the water from the Coppes Well (No. 5) as an example, water of this chemical characteristic will require dilution with 8 volumes of the late season water from the Big Sandy Reservoir and 11 volumes of early season water. The alternative to dilution would be to add approximately one ton of gypsum per acre-foot of well water.

One last observation in connection with water development is that an estimation has also been made of land use in Eden Valley. All of the land use data utilized were collected during the month of June, 1970. Aerial photographs having a scale of 1 inch - 1,000 feet were obtained from the U.S. Department of Agriculture. The aerial photographs were taken into the field and the land use at the time (Summer 1970) was marked on the appropriate photograph in accordance with the water related land use index shown in Table 36.

The aerial photographs which covered Sweetwater and part of Sublette County were taken in 1960. Although there was a 10 year difference between the time the photographs were taken and the land use survey was conducted, there was little evidence of any major changes having taken place.



KEY

Salinity Sampling Station ■

Flow (cfs)	TDS Conc. (mg/l)	TDS Load (tons / day)

LEGEND

Natural Runoff (Entire Drainage Area)

Irrigated Land

Figure 34. Flow and quality at key sampling stations and location of principal salinity sources in Eden Valley for 1965-66.

Table 36. Land use mapping index.

A. Irrigated Cropland

7. Small grains
10. Alfalfa
11. Native grass hay
12. Cultivated grass and hay
13. Pasture
14. Wet land pasture
15. Native grass pasture
17. Idle

C. Other Land Use

1. Farmsteads
2. Residential yards
4. Stock yards

E. Open Water Surfaces

4. Reservoirs and canals

F. Phreatophytes

1. Cotton wood
2. Salt cedar
3. Willows
4. Rushes or cattails
5. Grease wood
6. Sage brush
8. Grasses

R. W. Right of Way: Highways, County roads

Each section of a township was planimetered to arrive at an acreage. The acreage of each land use within the section was determined by use of a balance. The technique used was to take each section and cut it from the base map and weigh it on the Balance, which read to ten-thousandths of a gram. The different land classifications were then cut from the section and weighed. The weights were then converted to an acreage using a ration technique. These values are summarized in Table 37 which shows the land classification under each different canal and stream which serves the land.

The Organization of the Irrigation Company

It should be recalled from earlier pages that irrigation development in Eden Valley went through a series of changes and receiverships, finally coming under the supervision of the Department of Interior, when the land was homesteaded. At the same time, since the Valley is in Wyoming, general legal provisions prescribe the status of water as part of the land. Thus, as an attached water right it is impossible to sell the land without selling the water right as part of the property, too.

In the generally small, water-poor, environment of Eden Valley, there was only one company, although it changed hands over time. When it went through the last receivership the government continued with a consolidated company supplying the water for the old land owners as well as the new land owners who were coming in as a part of the homestead act. Throughout its history, the company (which uses the label of Water District), especially after its reorganization in the 1930's, came either under the direct supervision of the Bureau of Reclamation, or or indirectly as today when the Bureau of Reclamation oversees the irrigation in the Valley, with the farmers themselves making the decisions concerning the actual operation of the company. The size of the company is one that serves approximately 17,000 acres of land, delivering about 38,000 acre feet of water. In 1971 during a field survey, 71 individual water users were counted.

As in so many other cases with irrigation companies in the West, the board of directors receive the position through an election at the annual meetings. Contrasted, however, with the long terms in many other instances, individual members of the board of directors in Eden Valley remain in this position for only a few years. There is a widespread understanding that the responsibility of directing the affairs of the company should be passed around among the people in the Valley rather than giving the job to one individual and compelling him to carry the load for many years. The role of the board in Eden Valley is a fairly active one, with policy decisions tending to change fairly regularly. As elsewhere, the role of the member on the board is to represent the people of the Valley as fairly as he can and to express the wishes of the people of the Valley as clearly as possible. Again, contrasted to other cases, in Eden Valley there is a certain amount of status derived from being on the board of directors. Despite the minimal financial

Table 37. Land summary by canals and streams for Eden Valley, Wyoming. (All units in acres)

Classification	Means Canal	W. Side Lateral	Eden Canal	Big Sandy Creek	Little Sandy Creek	Little Pacific Creek	Big Sandy Reservoir	Eden Reservoir	Total
A 7		218	1517		58			3	1796
A10		3003	5577		60			4	8744
A11		103	1188		162				1453
A12		57	862						919
A13		10	1996		30				2036
A14			17						17
A15		91	2049						2140
A17		313	1068		51				1432
Total A		3795	14274		361			7	18437
C 1		21	175		7			1	204
C 2			40						40
C 4		1	72						73
Total C		22	287		7			1	317
E 4	55	94	192	104	13		374	970	1802
F1H			89	2					91
F1M			5						5
F1L			23						23
F2H									
F2M									
F2L									
F3H			11						11
F3M									
F3L			7						7
F4H			77						77
F4M	73		11					68	152
F4L			91						91
F5H			74						74
F5M	9		372						381
F5L			318						318
F6H			1654						1654
F6M		4	2099	107	19			203	2432
F6L	1253	7939	22812	2039	38		2665	5414	42160
F8H			1079		1735				2814
F8M		3	368	311					682
F8L		93	982	856	855	52	147	537	3522
Total F	1335	8039	30072	3315	2647	52	2812	6222	54494
RW	18	53	280		3		12	31	397
Total	1408	12003	45105	3419	3031	52	3198	7231	75447

compensation and the overall thankless character of the job, there is both the satisfaction and status from the knowledge that one represents the will of the people in such an important area of community survival. At the same time, larger decisions and policy questions are brought into the annual meeting for consideration by the entire membership.

The water rights in Eden Valley are very carefully spelled out by state law and the state law is adhered to very closely. The election of the board of directors is part of a very active voting process of all water owners. Proxies are rarely exercised in the Eden area and most of the people who are water owners in the area exercise actively their right to vote. For major policy changes the board of directors meet regularly and discuss the advantages and disadvantages of any proposed alternation; the manager is, then, instructed to implement such changes.

Besides the board members, the company has six employees on the payroll: one bookkeeper, one water master and four ditch riders. The most important position is that of the water master who makes the day-to-day decisions. The ditch riders are the men who keep the peace in the water system by watching the actual water distribution and the timely on-farm delivery.

The water master, as a manager of the company, received his original training in the context of the Eden project. In Eden Valley, the man who is the manager of the company managed the same company as an employee of the federal government; and when he retired, he was hired by the Valley people to continue to process and manage water for them in the Eden Valley area. The overall supervision of the manager is performed, of course, by the board of directors who are responsible for policy changes. The manager maintains the office and directs the activities of the office personnel. He also directs the activities of the ditch riders and sees that their work is performed satisfactorily. He and his ditch riders are constantly checking with the farmers to be sure that they are receiving their appropriate amount of water, and that they are not encountering any special water problems. In this respect, the influence of the shareholders in Eden Valley is rather great, demanding continuous presence by the water master and his skillful handling of interpersonal relations. The use of ditch riders, in particular, has eliminated most earlier conflicts with the hostility of the users directed primarily against the Bureau of Reclamation held responsible for not allocating any more water from other proposed dams, such as the flood dam envisaged on the Hod Sanders Ranch.

In terms of the actual operation of the irrigation system in Eden Valley, a major influence for its efficient organization has also been the Bureau of Reclamation. Since the repayment contract has not begun to run, the Bureau has been able to implement a number of innovations that otherwise could not be made by a system operated by individual farmers. Here one can observe in particular the efficiency which characterizes the delivery of water.

The water is diverted from the Big and Little Sandy Creeks by on-channel impoundments and it is held there until it is needed or requested by the farmers downstream. The land in Eden Valley has been extensively prepared by the Soil Conservation Service. The canal systems, the laterals, the ditches, the turnouts were all engineered and designed and constructed by the Soil Conservation Service for the use of farmers. This was done as part of the homesteading operation in the late 1940's and early 1950's. The water itself is applied to the land in very large amounts, very quickly so that the amount of loss is minimized on the sandy land.

The physical efficiency of the system in Eden Valley is probably among the best in the West. A large amount of money has been spent for canal lining, primarily clay which has been placed in the canals and then rolled into place. The measurement of the water in Eden Valley is also excellent. The markers in the reservoir are exact and the water master knows precisely how much water is in the reservoir at the beginning of a water year. This amount is, then, divided among the number of acres that are owned in the Valley with each acre receiving its appropriate amount. Each canal and lateral has a measure, and when the water is delivered to the individual's headgate, the ditch rider has the means of measuring the precise amount of water going through a parshall flume. There is continuous monitoring, so that if an individual is receiving too much water, the headgate will be closed down; or if he is receiving too little water, the amount will be increased so that everybody will receive the amount ordered and ultimately his fair share of water.

In the context of the discussion of efficiency, it should be noted that the Bureau of Reclamation, when the project was originally conceived, felt that the amount of transpiration would be minimal. However, the amount of evapotranspiration was grossly underestimated. Engineers have calculated that there was an underestimation of evaporation by about 35 percent, as well as an underestimation of canal and reservoir seepages. As a result the number of acres that were originally allocated for irrigation had to be drastically reduced so that roughly 17,000 acres would receive an adequate share. Most farmers interviewed in Eden Valley still felt that they had more land than they had water to irrigate. As a result, they would subtly leave plots of their land fallow for a year and use the water on other plots so that they would have enough irrigation water available.

Individual water users in Eden Valley are acutely aware of the amount of water that is available to them at the beginning of the water year, as well as of their allocated share that they have to use during the year. Every time they use water, the irrigation company presents them with a card indicating how much they have used and how much more they are entitled to.

The overall adequacy of water in Eden Valley can be described as meagre. Most of the users in the Valley felt that

they did not have enough water and that they would be delighted to get more water so that they could more adequately irrigate their crops. The amount of water available to users varies from 2-3 acre feet annually with the mean amount about 2.5 acre feet with some land, according to the opinion of farmers needing 4.0 acre feet or more.

Thus, the irrigation system in Eden Valley is very limited as to the amount of water it can deliver in any one particular time period. Since the farmers use very large amounts of water for rather short time periods, the canal many times is taxed to capacity. Theoretically, the water is delivered on demand of the water owner, but since most of the people need large amounts of water at the same time, a form of demand rotation has been implemented. A user will tell the water manager approximately when he needs the water and how much he will need and the water manager will deliver that water as close to that time or after the time requested as possible. The number of irrigations in the Valley is typically three or four due to the short growing season and to the limited amount of water available.

All in all, the people of Eden Valley are extremely efficient in their use of water. They are constantly trying to get the most from what they have. Farmers will use 10 second feet of water to irrigate their land; this very large head of water is used in an attempt to get the water over the very sandy soil quickly. In the long run this can help create a water savings. The people of the Valley are constantly investing more money into canal linings and ditch linings in an attempt to save every drop of water that is available. The cost of the water in Eden Valley in the past has been $2.85 per acre of land and the amount of water which is available is proportionately divided. The water price is fixed by acres of land owned rather than by acre feet of water used. This $2.85 per acre does not include the repayment contract payment estimated to be $1.25 per acre.

An interesting part of the attitudes of people towards water is the pervasive antagonism against the federal government, primarily the Bureau of Reclamation. The users in Eden Valley feel that the Bureau has spent great sums of money on the project and the return for these great sums is minimal. The majority of the expenditures, above the cost of building the impoundment itself, have been made for repairs and changes, such as canal lining, new turnouts, etc., increasing ultimately the cost of the repayment contract, costs which ultimately must be borne by the people.

There are also some mixed feelings concerning the total amount of available water. The people of Eden Valley complain first of all that the amount of water available is not exactly the amount of water which they were told would be available. Secondly, complaints are also aired against the project as not being complete. The number of acres promised have not exactly materialized, with many acres left fallow on the periphery without water.

In a question asked in the special survey, 62.7 percent of those asked expressed dissatisfaction with the administration of the irrigation project by the Bureau of Reclamation, as contrasted to 74.5 percent of the individuals who were satisfied with the water that they were receiving, or with the actual water services that they were receiving. In essence this disparity points out to an interesting situation where there is satisfaction with the actual running of the irrigation companies, within the confines of the project, but with high dissatisfaction with the limitations imposed by the Bureau of Reclamation (either in terms of the money spent, and/or with the total amount of water made available). Water supply and distribution, then, are key elements for the survival and continuous efficient performance of the system.

Water Budget Analysis

The temporal and spatial distribution of water flows in a hydrologic system such as the agricultural area of the Eden Valley is random in nature and complex. In order to describe the water flows, water budgets can be prepared which delineate the flows at various points in the system. However, the detail implemented in the analysis depends on the availability of accurate data, the objectives of the investigation, and the results desired. The purposes of this study were adequately satisfied by a monthly examination of the water budgets for the period between 1963 and 1969. This retrospective analysis of past events eliminates the need or desirability of considering the random nature of the important parameters.

The computation of water budgets is usually a lengthy procedure. To facilitate the large number of calculations necessary, a model was developed in which the hydrologic components and their interrelationships could be mathematically described. The model of the water flow system in the Eden Valley has been subdivided into five parts: (1) Valley Inflows, (2) Reservoir Water Budget, (3) Cropland Water Budget, (4) Ground Water Budget, and (5) Valley Outflows. This section is given as a description of these components and their identification. A schematic illustration of the valley water system is shown in Figure 35.

Valley Inflows. The main water sources available to supply agricultural demands in the valley originate with the surface inflows of the Big Sandy River and Little Sandy Creek. Precipitation is another important segment of the cropland water supply, but it will be noted in a later section.

The flows of the Big Sandy River enter the valley and are immediately captured and stored within the capacity of Big Sandy Reservoir. Although the reservoir includes provisions for releasing water back into the stream channel, the excess capacity and associated cropland needs are such that nearly all of the water is diverted for irrigation.

The discharges of Little Sandy Creek are partially, or totally, diverted into Eden Reservoir, which is an offstream storage reservoir. The flows bypassing the diversion continue

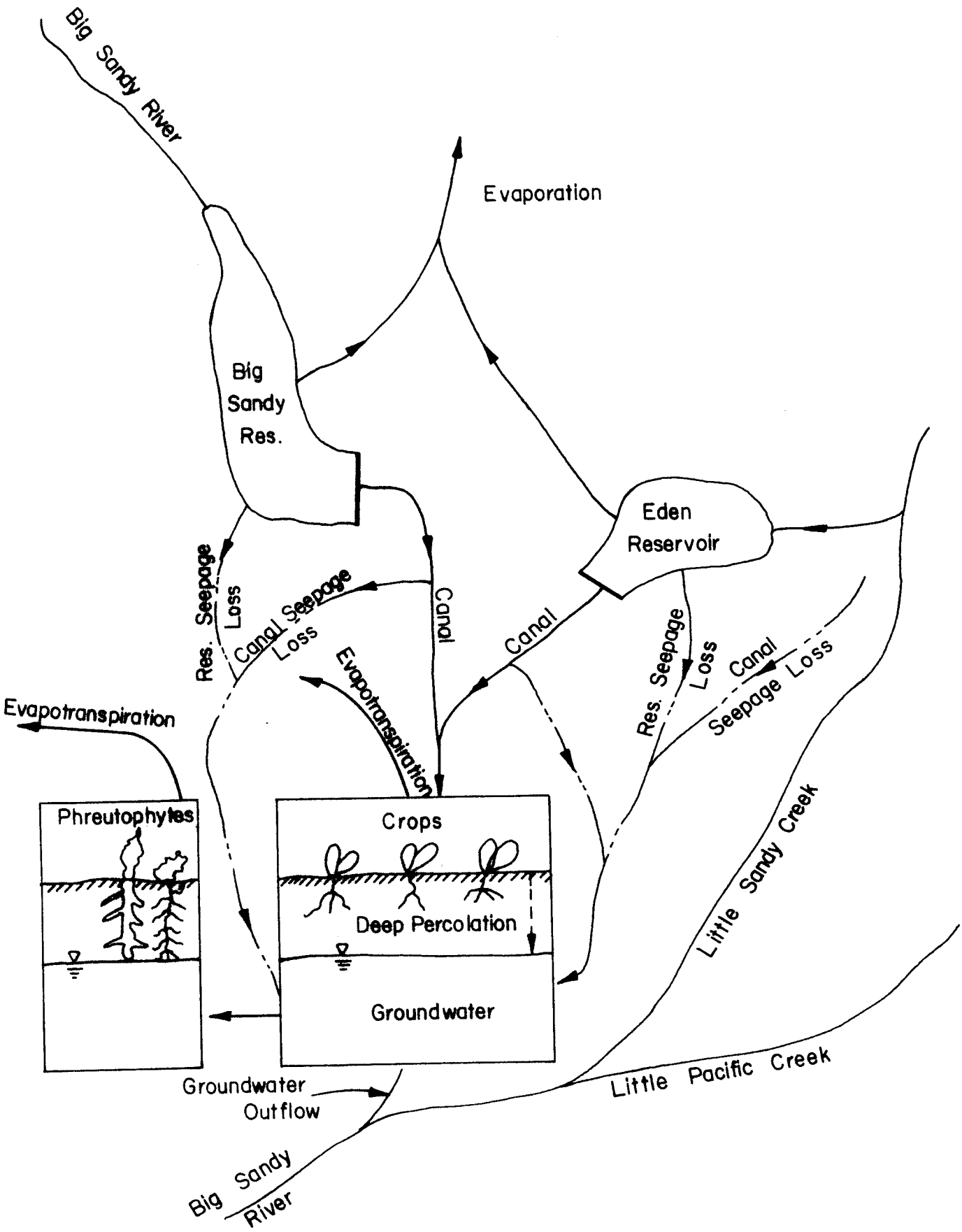


Figure 35. Schematic water flow diagram for Eden Valley.

through the valley and exit, while those added to storage in the reservoir are used exclusively for irrigation.

Reservoir Water Budget. Upon impounding the stream inflows in the two regulating reservoirs, the water may be divided into four basic flows: (1) seepage losses into the groundwater basin, (2) evaporation losses, (3) conveyance seepage into the ground water, and (4) applications to the cropland. Items 3 and 4 represent cropland releases from the reservoirs, but have been further delineated in this section for convenience sake.

Reservoir operational data was collected which not only yielded the inflows and outflows, but the total losses as well. To distinguish the seepage losses from those occurring as evaporation, the evaporation rates were estimated using the modified Blaney-Criddle method for computing evapotranspiration.

The flows released into the conveyance and distribution system for farm delivery consists of seepage and crop applications. Estimates and field measurements of seepage rates were used to evaluate conveyance efficiencies. It was determined that about 25 percent of the reservoir diversions resulted in canal and lateral seepage losses.

Cropland Water Budget. The water diverted from the supply canals and the incident precipitation combine to form the water supply to the crop acreage. This water which enters the root zone is not entirely utilized by the growing crops. Some water percolates through the root zone into the ground water basin.

Only a portion of the rainfall or snowfall striking the crop surfaces is available for consumptive use by the plants. Some precipitation is immediately evaporated back into the atmosphere, some simply runs off the surface, and the remainder enters the root zone. In this study, the effective precipitation (that entering the root zone) was assumed to be 70 percent of the total precipitation.

The moisture finding its way into the crop root zones may either percolate into the groundwater basin, be utilized in plant transpiration, or fill existing deficits in the soil moisture storage in the root zone. Three basic alternatives occur.

(1) Irrigation and precipitation are sufficient to meet the crop demands and fill existing deficiencies in the root zone storage. Deep percolation would result from the excess water.

(2) Irrigation and precipitation are together insufficient to supply plant requirements, but available soil moisture is enough to satisfy the difference. No percolation losses would be expected in this case.

(3) Irrigation, precipitation, and available soil moisture storage are insufficient to meet the plant needs. In this case, the plants utilize what water is available and again no deep percolation losses are allowed.

Groundwater Budget. The water entrapped in the groundwater basin behaves similarly to the regulating reservoirs. The combined inflows from reservoir seepage, conveyance seepage, and percolation from the root zone represents the water in the subsurface aquifers. This water is either consumed by the phreatophytes or returns to the natural stream channels and flows from the valley.

In order to determine the quantities of return flows, it is necessary to monitor the rising and falling water table. Then, by knowing the moisture-holding capacity of the soils and aquifers, the changes in water table elevation can be related to the total storage changes in the basin.

The amount of water transpired by the phreatophytes is again estimated from the Blaney-Criddle technique described earlier. The precipitation which falls on these acreages is assumed to be utilized by the phreatophytes.

Valley Outflows. The irrigation return flows, inflows from Pacific Creek and Little Sandy Creek bypass come together at the valley exit and flow into the stream channel of Big Sandy River. In many hydrologic areas, a significant quantity of water may actually be flowing under the stream gauging stations through the underlying soils. In this investigation, these flows have been assumed to be of the same magnitude as the similar flows passing beneath the valley inlet gauging stations, and have therefore been neglected.

Mean Monthly and Annual Budget. The month-by-month water budgets for water years 1963 through 1969 (October 1, 1962 to September 30, 1969) have been averaged to arrive at the mean monthly and mean annual water budget listed in Table 38 for Eden Valley.

The total water inflows to Eden Valley consist of approximately 83,000 acre-feet to Big Sandy and Eden reservoirs; flows not diverted from Little Sandy Creek to Eden Reservoir (Little Sandy Creek Bypass) amounting to 6,700 acre-feet annually; mean annual Pacific Creek flows of 2,200 acre-feet; and a mean annual precipitation on croplands of 8,400 acre-feet. Thus, the total inflow to the system is roughly 100,000 acre-feet annually.

The depletions from Eden Valley consist of 3,200 acre-feet annually of reservoir evaporation; mean annual consumptive use by crops of 30,900 acre-feet, and an annaul water use by phreatophytes of 28,600 acre-feet. Thus, the water used by phreatophytes is nearly equal to the water consumed by croplands. The total depletion to the system is roughly 63,000 acre-feet

Table 38. Mean monthly and mean annual water budget for Eden Valley, Wyoming for the period 1963-1969. (All units in 100 acre-ft)

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Annual
Valley Inflows													
Big Sandy Reservoir	22.5	14.8	9.9	8.7	8.0	14.0	45.4	142.1	286.0	138.4	34.6	23.0	747.4
Eden Reservoir	2.6	1.0	0.0	0.0	0.0	2.3	10.0	13.5	36.5	10.1	3.3	1.8	82.1
Total Inflows	25.1	15.8	9.9	8.7	8.0	16.3	55.4	155.6	323.5	148.5	37.9	24.8	829.5
Reservoir Water Budget													
Big Sandy Reservoir releases	0.4	0.0	0.0	0.0	0.0	0.0	0.0	64.7	166.6	171.3	106.4	30.8	540.2
Eden Reservoir releases	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5	15.0	13.7	24.4	4.5	58.2
Reservoir Seepage losses	6.0	6.7	6.4	4.3	4.4	4.1	6.1	15.5	24.0	19.0	7.2	6.3	110.9
Reservoir Evaporation	2.0	0.5	0.0	0.0	0.1	0.4	1.7	3.7	5.3	7.7	6.3	3.8	31.5
Conveyance Seepage losses	0.1	0.0	0.0	0.0	0.0	0.0	0.0	16.3	45.4	46.2	32.7	9.0	149.7
Cropland Applications	0.3	0.0	0.0	0.0	0.0	0.0	0.0	48.9	136.2	138.7	98.1	26.4	448.6
Cropland Water Budget													
Water Applied	0.3	0.0	0.0	0.0	0.0	0.0	0.0	48.9	136.2	138.7	98.1	26.4	448.6
Precipitation	5.6	3.1	5.1	2.5	3.5	3.9	6.5	10.0	22.4	4.9	9.4	7.5	84.4
Consumptive Use	11.6	5.0	0.0	0.0	0.0	0.3	14.5	36.4	66.5	83.5	60.4	38.8	309.0
Root Zone Storage Depletion	5.7	7.6	2.5	0.0	0.0	0.0	8.5	0.0	0.0	0.0	0.0	0.0	0.0*
Additions to Groundwater	0.0	0.0	0.0	0.0	3.5	3.6	0.0	14.0	92.1	60.1	47.1	3.1	223.5
Ground Water Budget													
Total Additions	7.0	6.7	6.4	4.3	7.9	7.7	6.1	45.8	161.5	125.3	87.0	18.4	484.1
Storage Change	-30.3	-11.7	- 4.5	- 2.1	2.2	- 6.6	-29.8	18.6	106.5	21.0	-11.7	-47.3	4.3
Phreatophyte Use	19.9	3.9	0.0	0.0	0.3	1.8	8.7	21.3	41.3	74.9	70.0	43.9	286.0
Return Flows	17.4	14.5	10.9	6.4	5.4	12.5	27.2	5.9	13.7	29.4	28.7	21.8	193.8
Valley Cutflows													
Big Sandy River	19.4	17.3	12.9	8.7	9.0	20.4	50.6	40.9	66.1	71.0	32.1	23.7	372.1
Pacific Creek	0.0	0.0	0.0	0.0	0.4	5.0	12.7	1.4	1.9	0.4	0.4	0.3	22.5
Little Sandy Creek Bypass	2.0	2.8	2.0	2.3	3.2	2.9	4.0	6.8	14.0	22.9	2.9	1.6	67.4
Big Sandy Reservoir Bypass	0.0	0.0	0.0	0.0	0.0	0.0	6.7	26.8	36.5	18.3	0.0	0.0	88.3

* End of year storage deficit in root zone.

annually. Therefore, the mean annual outflow from Eden Valley is 37,000 acre-feet.

Conclusion

Eden Valley is an extreme case of a small, homogeneous, consolidated system, serving a limited area under general conditions of water scarcity. The total water supply could be increased by additional supplies either from the Hod Sanders property or from the Sweetwater River. All of the water that is available in the Valley is directly controlled by the Eden-Farson Ditch Company. No one receives water before anyone else and everyone receives an equal amount of water per acre owned. If new water were brought in it would probably be divided as the other water is, on an equal basis. Each acre of land would simply receive more water and that water would be used by the individual as he saw fit.

The system in Eden Valley is already a consolidated one with a high degree of centralization, coordinated activities, and one main canal (divided into two other smaller delivery canals and a series of laterals bring water to individual properties). There is neither a conservancy district in the Eden area, nor subordinate irrigation companies. The system of organization is single, with direct lines between users or their company and the Bureau of Reclamation. In such a single setting the advantages of consolidated action, as it is occurring in the Valley, are rather obvious both in terms of economic efficiency and social effectiveness.

Water in Eden Valley is perhaps the strongest social bond bringing the entire community together. That, and what they consider as the common external enemy, the Bureau of Reclamation, are the major issues that unite the community, the small agricultural enclave in a relatively hostile ecological setting. But above anything else, this Valley dramatically depicts both the advantages and the difficult questions concerning irrigated agriculture in the West. In trying to develop a tenacious living under adverse environmental circumstances, the farming in the community has to face both the economic exigencies of limited agricultural output and the forthcoming cost of the repayment contract. The lesson to be learned from such a marginal situation is that only highly centralized and coordinated actions, such as in a consolidated district, may make possible survival and successful meeting of increasing future competing demands.

RIVERTON VALLEY

Location and Physiography

Riverton Valley is situated in the Wind River Basin, Fremont County, in west-central Wyoming. The Wind River Basin is an upper drainage area to the Bighorn Basin of northwestern Wyoming and the Lower Bighorn Basin in south-central Montana. The Wind River Basin has an area of about 7,800 square miles, is about 130 miles long, and ranges up to 70 miles in width. It is bounded on the west and southwest by the Wind River Range, which forms part of the Continental Divide; on the northwest by the southern portion of the Absaroka Range; on the north by the Owl Creek, Bridger, and southern extremity of the Bighorn Mountains; on the east by high tableland; and on the south and southeast by Beaver Rim and the Rattlesnake Mountains. The elevation ranges from about 4,600 feet at a low point on the Wind River to 13,785 feet on Gannett Peak in the Wind River Range. Elevation of the irrigated lands in Riverton Valley ranges from 4,700 to 5,400 feet.

The major stream in the basin is the Wind River. From its sources in the Wind River and Absaroka Mountains, the Wind River flows southeasterly to its junction with the Popo Agie River near Riverton, thence northeasterly to Boysen Reservoir and out of the basin by way of the Wind River Canyon. At the mouth of this canyon, the Wind River becomes the Bighorn River, a change in name only. The stream follows a northerly course through the Bighorn and Lower Bighorn Basins to its confluence with the Yellowstone River in Montana.

The interior of the basin is an expanse of irregular and diverse features such as rolling uplands, level river terraces and benches, high buttes, broken ridges, eroded gulleys and washes, occasional badlands, and undulating prairie land. Cultivated land in the basin lies on the broad terraces and benches and on the flood plains along the main stream courses.

Practically no crops can be grown in the valley without irrigation because the precipitation on the valley floor amounts to only 9 inches annually. The importance of irrigation and crop production is illustrated by figures from the U.S. Census of Agriculture for Fremont County; about 98 percent of the harvested crop is from the 100,000 irrigated acres and about 57,000 of these acres are on the Riverton Reclamation Project (irrigated lands served by a construction project of the U.S. Bureau of Reclamation).

The Riverton Reclamation Project is located on a portion of the Wind River Indian Reservation. In general, the Project land is situated in the Wind River Basin north of the river and extends from Bull Lake on the east, and north to Boysen Reservoir. The First and Second Divisions of the Project included in the Midvale Irrigation District, part of which is now in the Third Division Irrigation District, constitutes the northern part of the Project. Five Mile Creek and Muddy Creek, tributaries of the Wind River which empty into Boysen Reservoir from the west, drain most of the Project area (Figure 36).

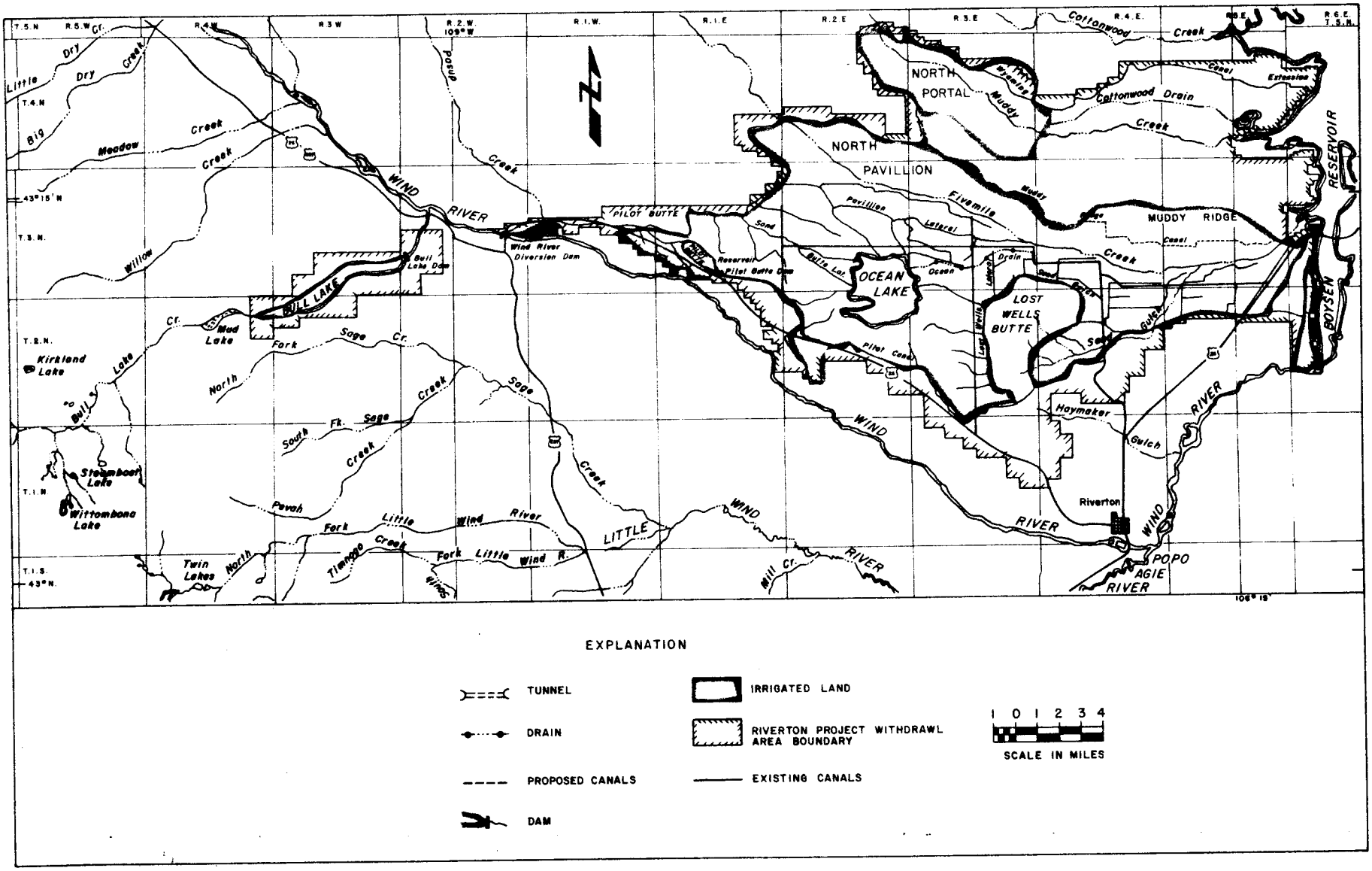


Figure 36. Riverton Valley, Wyoming

The Midvale Irrigation District consists of the older portions of the Project which were essentially completed prior to World War II, the Pilot Extension area at the extreme east end of the Midvale District, plus the Lost Wells area which lies to the east of Ocean Lake (a large body of water formed by irrigation return flows and waste waters in a natural depression). The latter two areas were developed and settled soon after the end of World War II.

The Third Division of the Project is divided into five distinct areas, as follows:

(1) the North Pavillion area which lies north of the north-west corner of the Midvale Irrigation District along both sides of Five Mile Creek;
(2) the Muddy Ridge area which lies east of the North Pavillion Area along the north side of Five Mile Creek;
(3) the north branch of Muddy Ridge which includes the land lying between the Muddy Ridge area and Muddy Creek;
(4) the north Portal area which lies north and east of the North Pavillion area and which includes land on both sides of Muddy Creek and a small acreage which drains into Cottonwood Creek north of the Project; and
(5) the Cottonwood Bench area which is a large relatively flat mesa between the North Portal area and the Boysen Reservoir.

Weather data from stations at Shoshoni, Pavillion, and Riverton reflect climatic conditions in the valley. These data are summarized in Table 39. The climate of the basin is arid. The mean annual precipitation is less than 10 inches, of which not more than 6 inches falls during the growing season. The frost-free period is long enough for successful production, with irrigation, of diversified cash and feed crops such as alfalfa, small grains, dry beans, potatoes, and sugar beets. The growing season has a high percentage of clear days. Hail storms cause occasional damage to growing crops in small, localized areas of the valley. Prevailing winds blow from the north and west. During the late winter and spring, the winds reach velocities sufficient to remove topsoil from unprotected fields and, at times, to damage growing crops.

The Human Community

Population growth in Wind River Basin has followed the expansion in irrigation, although in recent years petroleum production, tourist trade, and recreation have become increasingly important in the basin's economy and have contributed greatly to the growth. The relationship between the expansion of irrigation and the growth in population between 1840 and 1950 is indicated in the following tabulation.

Table 39. Climatological data for Riverton Valley.

Item	Unit	Riverton	Pavillion	Shoshoni
Altitude	feet, msl	4,954	5,440	4,820
Period of record	years	38	36	12
Mean annual precipitation	inches	9.61	9.73	7.14
Mean May-Sept. precipitation	inches	5.66	6.05	4.33
Mean annual temperature	deg. F.	42.9	44.6	45.5
Mean May-Sept. temperature	deg. F.	62.0	63.6	66.6
Mean annual frost-free period	days	130	144	149

Year	Population	Acres of irrigated land
1890	2,500	18,000
1920	10,490	66,000
1940	16,095	121,600
1950	19,580	134,000

Riverton Valley is part of Freemont County, which with the exception of the decade between 1920-1930 has showed a continuous rate of increase (although a diminishing rate according to the latest census (Table 40). With more emphasis on the Riverton Valley, one may utilize the census distinction referring to the Riverton division which in 1970 showed a total population of 12,244 (an increase of 8.5 percent over the last decennial count). Two communities are to be found in the Valley, the small town of Pavillion and the city of Riverton. Pavillion is a small agricultural settlement of 181 persons according to the 1970 census (a decrease of 4.7 percent from the population of 1960). The city of Riverton, on the other hand, has showed a significant increase (16.5 percent) above the average for the county and for the state as a whole.

As far as the population distribution for the entire Riverton Division is concerned, 7,995 persons can be classified as urban with the rural population counted at 4,249. The population pyramid of the Valley is highly typical of similar demographic profiles in Valleys all over the West, with a median age of 25.5 years with the percentage of those over 65 being 7.1. In terms of employment, the population of the county is predominantly divided between agricultural workers (1,021) and mining (1,545) with less people in the construction industry (802) and manufacturing (687).

The difference in growth patterns between Riverton city and Pavillion can be explained not only in terms of the general trends of urbanization all over the West, but also because of the fact that the homesteaded land in the Pavillion area was resold back to the federal government in 1962; approximately 50 homesteads were sold back to the federal government.

As one looks toward the future there are signs that slow growth will probably continue in the Valley. A major source of future growth depends on the further extraction of natural resources such as petroleum, coal, and various minerals.

The economy of Fremont County is based upon irrigation farming, livestock grazing, mineral production, and tourist trade. As in Wyoming in general, the distribution of the population is closely related to crop production, particularly in irrigated areas. The City of Riverton is not only the agricultural center of the area, but also the headquarters for oil companies, dairy processing, timber treating, uranium reduction, and petroleum refining plants.

In 1961, the 59,333 acres of land irrigated on the Riverton Project produces a gross crop value of $2,726,800 or $45.96 per

Table 40. Population increase in Freemont County and the city of Riverton, 1900-1970.

	Freemont County		Riverton City	
Year	Number	% Increase	Number	% Increase
1900	5,357	--	--	--
1910	11,822	120.6	--	--
1920	11,820	00.0	--	--
1930	10,490	-11.2	1,608	--
1940	16,095	53.4	2,540	58.0
1950	19,580	21.6	4,142	63.0
1960	26,168	33.6	6,845	65.2
1970	28,352	8.3	7,995	16.8

acre, compared with an average of $57.09 for the projects in the northern portion of the Missouri River Basin.

According to a June 1962 report of the U.S. Department of Agriculture, the estimated market value, excluding building, of the irrigated cropland is $132 per acre and that of the adjacent grazing land, $14 per acre. Central station electricity is used on over 99 percent of the farms. About 70 percent of the farms have telephones; 240 miles of improved roads serve the area, and about $490,000 in annual federal income tax payments are attributable to the Riverton Project irrigated lands directly and indirectly. Because of the availability of livestock feed and forage, the Basin's livestock industry with its 5-month supplemental feeding requirement, has a built-in economic stabilizer. Liquidation of foundation herds has been averted in unusually severe winters and drought periods.

As a homesteaded area, the Riverton Valley community has the heterogeneous character of both the people who came from various parts of the country and original inhabitants, such as the people from the nearly Indian Reservation. The water which flows through the community has created different feelings. Many people who owned land and sold it back to the government are still in the area; they traded their land to the government for other land or sold it outright. These people seem to be particularly bitter: they are the ones who claim that they did not have enough water; that the soil on the farms which they homesteaded was too shallow, and the land soured because of high alkaline content; and, generally they feel strongly that they were mislead in terms of the quality of the land they were homesteading. On the other hand, a majority of the members of the community have described the area is rather water rich. Many of them reported that they had as much as 6 acre feet of water for every acre of land. Indeed, the probability of running out of water would be extremely low during a normal year.

History of Irrigation Development

The Wind River Basin was visited by white men as early as 1843. Permanent settlement in the basin followed establishment of a military post in 1869 at the present site of Lander. This post served to protect settlers from Indian attack.

The Wind River Reservation was established in the Wind River Basin by treaties with the Shoshone Indians in 1863 and 1868. Cessions of parts of the reservation were made to the United States in late years, thus modifying considerably the original area of the reservation. The Northern Arapahoe Indians were permanently settled on the reservation in 1878.

Most of the present irrigated lands were included in the Wind River Indian Reservation during the early pioneer days. Thus, settlement of the area by white people occurred relatively late. On March 3, 1905, Congress enacted legislation ratifying an agreement with Indians of the Wind River Reservation ceding lands north of Wind River to the United States. Preparations were made for the disposal of these lands under the homestead laws.

The first reference to the area as a possible irrigation project is noted in the Third Annual Report of the U.S. Reclamation Service. That document mentions a report entitled "Reconnaissance of Strip of Shoshone Indian Reservation in Wyoming." The reconnaissance survey was probably made in July, 1904.

In February, 1906, the State of Wyoming was granted a permit to make a survey for the development of the irrigable land. The surveys were made and engineering plans formulated. The State of Wyoming advertised for construction of the Project on July 2, 1906. Construction of a short canal, Wyoming Canal No. 2, to deliver water to about 7,000 acres in the Riverton Valley was undertaken by the Wyoming Central Irrigation Company in 1906-1907. The Company encountered difficulties that prevented construction of other canals. The greatest of these difficulties involved execution of repayment contracts with the homesteaders which would have enabled the company to finance its operation.

The Wyoming Central Irrigation Company failed to resume construction and eventually relinquished all of its permits, water rights, rights-of-way, and easements to the Wyoming State Board of Land Commissioners. To the extent needed, these were later acquired by the Bureau of Reclamation. The area served by the Wyoming Canal No. 2 is not included in the Riverton Reclamation Project as it is known today.

An Act of Congress on May 18, 1916 (39 Stat. 158) appropriated $5,000 for surveys and development of the Wind River Indian Reservation. From this amount, $2,000 was allotted for investigation of the ceded portion of the Reservation and financed the preparation of the first engineering report on the Riverton Project. This report was published as House Document No. 1767, 64th Congress, 2d Session.

Preliminary strip topography was taken for approximately 17 miles along the proposed routes of the Wyoming and Pilot Canals, and a preliminary soil survey was completed by the University of Wyoming. An estimate of water supply and storage requirements was made, an abstract of water rights was prepared, and a rough estimate was made of the cost of the project. In 1917, $5,000 were appropriated for a more detailed examination of the Project area. This investigation, in addition to a more extensive soil survey, included a reconnaissance drainage survey and detailed topographic mapping of the Wind River Diversion Dam site.

The Project was authorized for construction by the Secretary of the Interior on June 19, 1918 under the terms of the Indian Appropriation Act approved by Congress on May 25, 1918 (40 Stat. 590). This Act also provided $100,000 for the continuation of investigations and initiation of construction.

A first Order of Withdrawal of Public Lands was approved September 27, 1918 subject to segregation and restoration of lands determined to be nonirrigable or unnecessary for

construction purposes. Approximately 464,000 acres were withdrawn under this Order.

By the Act of June 5, 1920 (41 Stat. 915) the United States Reclamation Service was designated as the agent to perform the work for the U.S. Indian Service. Until October 1, 1920, all disbursements for the Riverton Project came from Indian Service appropriations. At this time expenditures of Reclamation Service funds began.

After 1920, the history of the construction of the Project consists of a series of stop-and-go decisions that made efficient and orderly development of the Project impossible.

Water was first delivered on the Riverton Project to farms near Morton in the spring of 1925.

In June 1925, Secretary Herbert Work and his party toured the Project area and before leaving, ordered all construction to cease. Construction was resumed in 1928. The appropriation Act for Fiscal Year 1931 provided that before any money appropriated for the Riverton Project could be spent, three conditions had to be met:

(1) the construction of, or commitments for the construction of a sugar factory in the Riverton area;
(2) the construction of a railroad to the town of Pavillion;
(3) the execution of a satisfactory repayment contract with the Midvale Irrigation District.

The first two conditions were never met. A repayment contract with the Midvale Irrigation District was executed in 1931. Construction was again resumed in 1935 under the Emergency Relief Appropriation Act when a reimbursable appropriation of $1 million was made available. Lack of funds in 1939, followed by World War II, again stopped construction.

The Riverton Extension Unit, cited in Senate Document 191, 78th Congress, 2d Session (1944), includes a portion of the Riverton Project which is now designated as the Third Division. The Riverton Extension Unit was included in the initial stage of the Missouri River Basin Project, construction of which was authorized in Section 9(a) of the Flood Control Act of December 22, 1944 (58 Stat. 887). Construction of the Riverton Extension Unit (Third Division) was not initiated under the Missouri River Basin Project authorization because funds for that project were not available when reclamation homesteads were in demand for veterans of World War II, whereas Riverton Project funds were available.

In 1946 construction was resumed on a "crash" basis for the settlement of returning service men. This program continued through 1951 after which it was restricted principally to drainage works. During recent years the failure to reach agreement on a contract with the Third Division Irrigation District has stopped the drainage and canal lining programs essential to the continued irrigability of project lands.

Water and Land Resources

The Wind River is the source of water supply for irrigation of the Riverton Valley. Bull Lake Creek, principal tributary above the Wind River Diversion Dam, joins the river about 4 miles above the diversion dam.

The Wind River and its tributaries drain an area of about 2,000 square miles above the diversion dam. Headwaters of the river rise on the northeastern slope of the Absaroka Range, at elevations of 13,800 feet and 12,200 feet above mean sea level, respectively. Average annual runoff of the river above Bull Lake Creek is estimated to be 660,000 acre-feet. The runoff is derived mainly from snowmelt, with occasional increments of rainfall.

Bull Lake Creek drains an area of about 222 square miles, consisting of high mountainous terrain. Headwaters of the creek reach an elevation of 13,720 feet at Fremont Peak on the northeastern slope of the Wind River Range. Average annual runoff of the creek is 210,000 acre-feet.

Analyses of stream samples taken at Riverton show that the water of Wind River contains from 125 to 480 parts per million of total dissolved solids. The quality of water for irrigation ranges from good to excellent. Spring floods carry less concentration of salts and smaller amounts of sodium than late summer flows. The increased amount of sodium in the water during the late summer is from return flow that enters the stream above Riverton.

Water rights have been adjudicated for 80,466 acres between Wind River Diversion Dam and the Wyoming-Montana State line with priority over the natural flow permit under which the Riverton Project has been constructed and operated. However, most of this acreage is below Boysen Reservoir, with adjudications for 21,997 acres between the diversion dam and Boysen Reservoir. Water right permits prior to the Riverton Project permits have been issued for a total of 115,689 acres between Wind River Diversion Dam and the State line, with 42,137 acres located between the diversion dam and Boysen Reservoir.

Boysen Reservoir is being utilized to satisfy the prior downstream appropriators, thus allowing the upstream appropriators a greater and fuller use of the natural flows occurring above Boysen Reservoir.

The Riverton Project has been constructed and operated under permit No. 7300 with priority date of August 7, 1906, for an appropriation of natural flow of Big Wind River. This permit, with the exception of that part previously assigned to the Riverton Ditch Company, was assigned to the United States from the State Board of Land Commissioners in 1919. Pilot Butte Reservoir was constructed under permit No. 1865 Res. and permit 1868 Res., with priority dates of August of August 7, 1906, and December 24, 1908, respectively. Permit No. 1865 Res. was for a total capacity of 31,692 acre-feet, and permit No. 1868 Res.

was for an additional 2,508 acre-feet. Bull Lake was constructed under two permits: Permit No. 1408 Res. and Permit No. 3912 Res. Permit No. 1408 was filed for a capacity of 74,908 acre-feet, and Permit No. 3912 Res. was filed for a capacity of 70,402 acre-feet. The total of these two permits is 145,310 acre-feet.

The Riverton Valley Project, which is irrigated by the LeClair (Riverton No. 2) Ditch and the Wyoming No. 2 Canal, is being operated under Permit No. 7300, the same permit as for the Riverton Project. The Riverton Valley Project obtained its permit under an assignment from the Wyoming Central Irrigation Company, the original holder of this permit, and by an additional assignment from the State Board of Land Commissioners. An agreement executed in 1917 by the State Board of Land Commissioners and the Riverton Valley Irrigation Company conveyed a preferred priority in Permit No. 7300 to the Wyoming Canal No. 2 and LeClair (Riverton No. 2) Ditch.

As far as land resources are concerned, more than 80 percent of the area is the Wind River Basin is range land, and about 2.7 percent is irrigated land. The range land, though it produces a sparse forage, has long been used for grazing livestock.

Irrigated land in the basin is cropped as follows: small grain, 21 percent; alfalfa, other hay, and pasture, 59 percent; dry beans, 8 percent; other row crops, 4 percent; and seeds and miscellaneous crops, 8 percent. More than three-fourths of the irrigated land is thus used for producing forage and feed crops (pasture, hay, and grain).

The bulk of the irrigated land in the Wind River watershed is concentrated under 3 projects which are supplied by 4 main canals. These are the Riverton Project, which is supplied by the Wyoming Canal; the Riverton Valley Project, which is supplied by the LeClair (Riverton No. 2) Ditch and the Wyoming No. 2 Canal; and the Indian Service's Wind River Unit, which is supplied by the Dinwoody Canal. The remainder of the irrigated land in the watershed is under small ditches which divert water from the main stream and tributaries.

The Riverton Valley Project is operated by a private irrigation district and includes all of the low land adjoining the north of the Wind River in the vicinity of Riverton. Some of this land is Indian owned, and the Indian Service cooperates with the district in irrigating and operating this part of the project. All of the irrigation works on the south side of Wind River between Dinwoody Creek and Riverton lie inside the reservation and were built and are now operated by the Indian Service.

The total acreage, including the Riverton Project, which is dependent upon the stream flow of the Wind River between the diversion dam and Riverton is 108,030 acres. The acreage outside the Riverton Project has priority to the natural flow of the Wind River. The acreages under the various canals and ditches are listed in Table 41.

Table 41. Distribution of irrigated land under each canal in Riverton Valley.

	Acres	
Riverton Project:		
First Division of Wyoming Canal	1,522	
Second Division of Wyoming Canal	15,575	
Third Division of Wyoming Canal	28,060	
Pilot Canal	30,126	
Subtotal		75,283
Riverton Valley Project:		
LeClair (Riverton No. 2) Ditch	13,240	
Wyoming No. 2 Canal	12,030	
Subtotal		25,270
Irrigated land under miscellaneous ditches between diversion dam and Riverton:		
DeShaw Ditch	306	
Hurtado Ditch	713	
Aragon Ditch	970	
Kinnear Ditch	1,050	
Johnstown Ditch	3,910	
Subtotal		7,477
Grand Total		108,030

Because of the relatively short growing season and cool temperatures, only semi-hardy and hardy crops are adapted in the Riverton Valley. Alfalfa, grass, oats, barley, wheat, clover, beets, beans, potatoes, corn, and legume seeds can be produced profitably. A few fruits, such as apples, raspberries, and strawberries can be grown, but commercial production of these fruits is questionable.

Alfalfa is the principal hay crop grown with yields averaging about 2 tons per acre, but yields up to 6 tons have been obtained. With increasing awareness of the benefits of phosphate fertilizers and selective spraying, alfalfa yields should increase. Alfalfa hay and seed, and cereals, largely oats, have been grown almost exclusively in the North Pavillion and North Portal areas.

Sugar beets, a contract crop, produce dependable yields averaging about 12 tons per acre. The by-products, beet tops and beet pulp, are used in feeding and fattening sheep and cattle.

Commercial beans are a good cash crop. The climate, except for an occasional late frost in the spring or an early frost in the fall, is ideal for growing beans. Beans do not require early planting, they do not demand a high degree of fertility, they have a ready market, they are easily harvested in the fall, and they are usually out of the way by the latter part of September.

Peas were tried on North Pavillion and North Postal without success. Potatoes grown in the valley are of good quality and produce good yields.

There seems to be a good future for livestock production and feeding. Feed crops, such as alfalfa hay, feed grains, pastures, and the newer hybrid corns, can be grown successfully. By proper pasture management and fertilization, high pasture yields can be obtained. Because of soil characteristics, climatic conditions, and types of adapted crops, farming operations should tend toward a livestock economy with limited intensive farming.

About 57 percent of the irrigable land broken out of sagebrush in 1949 and 1950 was planted to alfalfa for seed production. Success was almost immediate. During the first five years of operation, seed yields averaged 250 pounds per acre. Favorable seed prices further elevated the outlook insofar as returns to the farm unit.

Trouble began when varying degrees of seepage appeared, particularly in the lower lying areas of farmers' fields. About the same time, alfalfa seed yields began to decline and in the second five-year period had dropped to 76 pounds per acre. Farmers were reluctant to give up weed production and individually attempted to vary management practices in a vain effort to duplicate the favorable combination of factors which existed initially. During this time, acreages in alfalfa seed production remained at about the same level.

When it became apparent that seed production alone could not sustain farm income, some farmers diversified by including such crops as field beans, small grains, and sugar beets in their crop rotations. Others elected to harvest their row-planted seed alfalfa for hay.

In general, experience has shown that irrigation projects built on soils overlying sandstone and shale barriers invariably lead to problems associated with drainage, water management, and accumulation of excess salts. The Riverton Valley is no exception. Much of the land originally classified as irrigable has seeped (high water table and high saline and sodic conditions) and is now beyond economic reclamation. In fact, it is estimated that the ratio of nonproductive land to good land is about 2 to 1.

The drainage problem was recognized early after the lands were opened for settlement and the Fogarty, Maierhofer and Mitchell report dated July 20, 1951, effectively pointed out the urgency of the problem and consequences if not heeded. Since that time, the Bureau of Reclamation, with few exceptions, has followed the recommendations in the report with the result that some lands are now under a system of open and closed drains. Whether or not some of the drains have provided adequate protection to the lands they drain and thereby assure sustained agricultural production with reasonable management is a subject of disagreement between some farmers on the project and Bureau personnel who designed the systems.

Most of the better irrigable lands that remain in the Riverton Valley are those situated on the higher terraces underlain by gravel and on the long sloping lands situated on broad alluvial fans. In general, terrace soils have good natural drainage. Where excess ground water is confined and artificial drains are required, drainage installations usually operate satisfactorily.

The soil mantle on alluvial fans with slopes of 1 to 4 percent tends to become finer textured as one proceeds downslope. The thickness of soil mantle generally varies from 5 to 10 feet, or more, and becomes quite shallow at the base or toe of the formation. Hydraulic conductivity (water transmission characteristics) of the soil material decreases sharply in the lower-lying positions and, in general, these areas are seeped or are becoming seeped. Upward movement of ground water and dissolved salts including sodium give rise to "white" or "black" alkali deposits on the soil surface as water evaporates.

Soil textures in the upper 5- to 10-foot mantle are predominantly loamy sands, loamy fine sands, and sandy loams having a relatively high intake (or infiltration) rate. Consequently, application of irrigation water in excess of crop needs, allowing for a reasonable application efficiency, plus seepage from unlined canals, results in accumulation of ground water above underlying impervious shale and sandstone barriers. Subsurface water movement downslope is often restricted by undulating shale or sandstone underground barriers causing high water table conditions that must be artificially drained. Furthermore,

downslope water movement is relatively slow and if not intercepted and removed by drains, water can "pile up," so to speak, as it moves to lower position. Hence, it is possible that lands of a good farmer downslope could suffer irreparable damage from high water table if his neighbor above consistently uses excessive amounts of irrigation water or if excessive seepage occurs from unlined canals above, or both.

The contour ditch irrigation method for close growing crops and furrow methods for row crops are used almost exclusively. The use of contour ditches with corrugations is not the most efficient method available for applying irrigation water. In some instances, the farmer has no other choice, but the majority of fields could be readily adapted to the border strip irrigation method. Such a system provides more positive control of irrigation water and, if operated properly, allows for higher application and distribution efficiencies.

Efficient water application requires: (1) land leveling for uniform distribution of water, (2) adjustment of stream size to width and length of run to allow equal intake opportunity of water applied, and (3) a knowledge of when to irrigate and how much water is needed to replenish the amount used by the crop, plus an additional increment (about 10 to 15 percent) for leaching where excess salt is a problem. Some farmers have used land leveling equipment for better water control. Others have seemingly done little or nothing to improve the surface of lands broken out of sagebrush.

Excessive use of irrigation water by farmers appears to be a factor contributing to high water table conditions. In several instances, farmers use a 2 to 3 cfs stream divided into two contour ditches with about 1 second-foot in the upper and 2 second-feet in the lower ditch. This amount of water is applied to an area generally 50 feet wide and about 400 feet long (approximately 0.5 acre). The amount of water applied in one 12-hour set to 0.5 acre would be equivalent to a 24-inch depth of water over the area watered or approximately 3 to 5 times the amount of water required to satisfy crop needs and allow for some unavoidable application losses. This quantity of water would more than completely saturate the soil profile. In the Fogarty-Maierhofer-Mitchell report, the following statements were made:

> In view of the above, the Bureau is faced with an extremely serious situation on the Riverton Project in that many of the lands now settled and those proposed for future development and settlement and not suitable for irrigation farming or are not adequately protected against adverse drainage conditions associated with irrigation. About 11,200 acres are now affected by water logging, high water table, and accumulation of harmful quantities of neutral and alkaline salts. Although most of the losses in productive land have occurred on older portions of the project which have been irrigated for a number of years, a considerable amount of the new land is being affected at an alarming rate after only one or two years of irrigation.

The above described situation has resulted principally from inadequate land classification, construction of irrigation facilities before completion of proper land classification, disregard of the results of the land classification, excessive leakage of water from canals and laterals, inadequate drainage facilities and excessive use of irrigation water. The land classifications have been inadequate, though in some cases made two or three times, because of the use of inexperienced classifiers with only limited supervision, failure of the classifiers to appreciate fully the significance of low permeability and high amounts of sodium in the soils, conductance of land classification during winter months when field conditions were unfavorable for the accomplishment of reliable work, and failure to schedule sufficient time to complete proper land classification. As to the construction of irrigation facilities before completion of proper land classification, works reportedly have been constructed to serve new lands with full knowledge that the lands were not fully classified and that some of them could be no better than the worst of the old Midvale District land.

. . . The soil and drainage problems on the project are neither new nor unexpected as they were first pointed out by J. T. Whistler in 1916, long before the project was constructed; by D. W. Murphy and A. T. Strahorn in 1917; by W. G. Harper in 1925, and by others later.

. . . Of considerable concern is the question of the disposition of lands affected by canal and drainage problems, but of utmost concern is the social problem of the settlers whom we have permitted to settle on lands of unsatisfactory quality. The sufficiency of many of the farm units in the North Pavillion area and most of the units in the North Portal area is seriously questioned. It is extremely probable that within 10 years a majority of these farm units will lack sufficient irrigable land to support a family. Lands which may be affected in the future pose the question of whether they should be forever subsidized or whether we should permit continued operation, realizing that many of the settlers on them will ultimately fail.

The above quotes reflect the problems encountered with irrigation development in Riverton Valley. Considerable effort has been made to correct the situation, but much remains to be done.

The Organization of Irrigation Companies

There are three major irrigation companies in Riverton. Two of them are old irrigation companies which have adjudicated rights from approximately 1910 (The LeClair Riverton Irrigation District and the Riverton Irrigation District). The

third company is the Midvale Irrigation District which supplies water to an area called the Third Division. This is the area that had particular problems with homesteaders who felt that they had not been given the land which had been described. The Midvale District is being consolidated with land under the jurisdiction of the Bureau of Reclamation.

The reservoir system in the area works in conjunction with the Boysen Reservoir which is located in some distance from the Riverton Valley. The Boysen water is used as a supplemental source for the Riverton Valley people; there are water rights located below the Riverton area which have ajudication date prior to the settlement of the Riverton area. These rights must be satisfied before the Riverton people may use the water. Whatever return flow reaches the river is used as part of the water to satisfy the senior rights which are located down the river. Presently, there are no wells in the Riverton Valley area, since there appears no immediate need for alternative water supplies.

Almost all of the water in the area is used for agricultural purposes. There is no major industry in the valley, with only some light manufacturing. In terms of water use, there seems to be a rather low degree of efficiency. Quite a number of canals were full of moss because the water moved so slowly in them that it looked more like a stagnant pond. The canals are rather large and very deep, capable of carrying a great deal of water. The abundance of water seems to contribute to wasteful patterns of use. The quantity of water needed for this land was estimated between 3 and 4 acre feet, depending upon the amount of sand found in the soil; typically, however, the allocation of water was 6 acre feet for every acre of land owned. This represents, indeed, quite an amount of water and the people interviewed readily admitted that they had more than enough water. At the same time, the water prices per acre feet in the area are quite cheap. The water cost works out to approximately $3.00 per acre of land; this is computed on the amount of about 6 acre feet of water per acre of land. As a matter of fact, the Midvale Irrigation Company which serves 60,000 acres of land in the Third Division was so successful in its fiscal operations, that as the manager of the system indicated, the District had enough money in the bank that the system could run for one full year without collecting a dime from the water users. The cost estimates in the valley were based on only two sources of water (Boysen Reservoir and Bull Lake) and all water that came down the Wind River was subject to only a minimum delivery charge. It would be practically free since the total cost per acre of land for 6 acre feet was $3.00 and if 6 acre feet were used, farmers were paying about 50¢ per acre foot.

The water companies themselves are fairly young as compared to water companies in other states. Two of the companies were started in about 1910. The third company, the Midvale Irrigation Company, was started after the Second World War with the homesteading of the area of the Third Division. The two original irrigation companies serve approximately 40,000 acres, about equally divided between the two. The big company is the

Midvale Irrigation Company which supplied water to the 60,000 acres of the Third Division and to other land under federal jurisdiction.

Essentially, the organization and operation of the irrigation companies is similar to other cases discussed. A board of directors elected by the constituents (water users) provides general policy guidelines and hires a staff to maintain and operate the irrigation system in the Valley. The actual operation and day-to-day activities of a company are performed by the staff with the larger accountability resting always on the shoulders of the governing board.

The board of directors receive their position through the annual election. Most typically, rather than elaborate manuevering and nominations, there is an almost automatic reelection of those who are already on the board. Once again the board provides the broad outlines of a policy for the irrigation company which will guide the operation of the company over a year's time. If for any reason policy has to be changed, reevaluated, or restated, the board can do so also at its monthly meeting.

The status of being on the board is minimal, part of the thankless character of the task to be performed. This is a job with which you get stuck, and difficult to get rid of. As such the board is primarily comprised by older, more successful farmers. The board seldom receives any criticism in Riverton, primarily because water is so abundant. As contrasted to other areas of scarcity (such as notably Eden), expectations for board performance were at an absolute minimum in the Riverton Valley.

The manager and water master of the Midvale Irrigation Company was a bureaucrat, i.e., he worked for the Bureau of Reclamation when the Riverton Project was being revised after the Second World War. As explained, he took this position because he had been there while the system was being built and he had been trained during this time to understand the inner workings and requirements of operating this system. In essence, he was especially trained but he also gained a great deal of practical experience by being on the site as the construction was going forth. The other two companies, on the other hand, rely on more traditional means for the management of their organizations. Quite often the position of water master is passed around to members of the family.

The effect of the shareholders on the management of the irrigation company is minimal. Since users are receiving their share of water, they really have very little to complain about. One area, however, in which complaints are heard is drainage. The area does have drainage problems and it is necessary to maintain a very complex system of drains and tile drains so that the land will not be filled full of salts from the water and become soured. This is one of the few areas of complaints and lively discussion within the organizations.

The water rights in the Riverton area are very clearly spelled out by the law. These is no real need for any

additional informal agreements, since water is so abundant. Operationally the membership has very little to say about any policy changes. The management will implement any change which is necessary, but due to the very large water supply there is no need for change from present practices, as nobody worries about any scarcity. Organizational change is also minimal; it seems the only time a man is replaced on the board is when he dies. Actually, there have been no changes in management in the Riverton area in the past 20 years.

In terms of water use patterns, because of the fact that most of the users are full-time farmers, there is a high degree of involvement in company affairs, high attendance at the annual meetings, and periodic discussions of water issues with the management. Water is made available to the people in the Riverton Valley area on demand. The canal system is so large that water can be delivered to any water user at any time with no particular difficulty. The number of irrigations needed and the amount used varies from crop to crop, but overall it seems apparent that the land and the crops are overirrigated due to the fact that water is so plentiful in the area. The application of water in the area is one of flooding. Limited resourcefulness is needed in terms of dealing with the water since it is so plentiful. There is no need to eliminate water losses or to try to conserve water since it is so prevalent. It is this abundance, however, which has all the potential of disaster in terms of drainage problems, as discussed previously.

Although people seem to be rather passive as to efficient and effective water utilization, there exists high awareness as to the problems and needs of appropriate drainage. There is a continuous discussion as to how appropriate tile drains would be dug or maintained, or how problems of drainage could be solved. At the same time, overall satisfaction with irrigation in the Valley although relatively high, it had the exception of the homesteaders after World War II, who still claim that their land was not of the high quality claimed. (Officials on the other hand, point out that these ex-GI's were not really farmers, and were unsuited for the task of working effectively the new land.) Today, however, the general level of satisfaction is again high, because the land which is a part of the Third Division is being rented by various farmers who were already in the area; they seem to be making a good profit off the land and they seem reasonably satisfied with both the land and with the water rented.

The stage for consolidation has been set in the Valley with the direct tying of the Midvale Irrigation District to the Bureau of Reclamation. The other two irrigation companies could be brought into the Midvale District as a part of the district; their water rights would be honored at any time, particularly in a water-poor year. The two earlier companies and their water share owners would receive the water prior to any later dates. Thus, consolidation has now reached a point in the area where the advantages are one of centralizing the entire operation for the benefit of the people. At the same time, most of the people are not particularly upset with the prospect of consolidation.

For example, in the summer of 1971, it was announced in the local newspaper that the entire system would be consolidated. No particular opposition seemed to emerge. Again, the key factor has been the abundance of water, a situation radically different from so many other areas in the West, where scarcity has always created major stumbling blocks with the threat of potential loss in any attempt or discussion of consolidation. It should be also noted that the system of consolidation as tentatively planned in the area would be one of total integration of all three companies. They would be housed in the same office and would use the same general facilities. Canals would not be rebuilt or redug; it was felt that the canal system as it presently existed was adequate (given the abundance of water) and that they would continue to use the canals and laterals until a time when they were felt to be inadequate or too old.

All in all, consolidation is now becoming a reality in the Riverton Valley. The remaining consolidation will cause minimal discomfort or even reaction from the people because of the abundance of water. Consolidation then becomes a rather simple transition to a more economically efficient and organizationally effective system of operating irrigation in the Valley. In addition, the catalyzing role of the federal government should point out how local initiative can be substituted by larger intervening forces.

TRUCKEE-CARSON IRRIGATION DISTRICT (NEWLANDS PROJECT)

Location and General Characteristics

Water uses in the vicinity of Fallon, Nevada represent an interesting case of competing water demands. The irrigated lands surrounding Fallon receive waters from Lahontan Reservoir which was constructed in the 1910's by the U.S. Bureau of Reclamation on the Carson River. In addition, the Derby Diversion Dam diverts water from the Truckee River into the Truckee Canal, which empties into the Lahontan Reservoir. The irrigation return flows from the Fallon area are used: (1) to flood irrigate lands in the Carson Lake Pasture which is used for cattle grazing; (2) to flood the Canvas Back Duck Club which is a private club; and (3) as a water supply for the Stillwater Wildlife Refuge which is managed by the U.S. Bureau of Sport-Fisheries and Wildlife. Competing water demands consist of U.S. Bureau of Indian Affairs requests to halt the decline of water levels in Pyramid Lake, which is located at the end of the Truckee River, in order that recreational capabilities can be developed; and upstream storage developments by the U.S. Bureau of Reclamation. Thus, three different agencies of the U.S. Department of the Interior are competing for the water supplies of the Carson River and Truckee River (Figure 37).

In 1967, all land receiving river water whether directly or indirectly was classified and placed within water use categories by the firm of Clyde-Criddle-Woodward, Inc. Each category of land use was so established that a rate of water consumption could be applied to it. Approximately 69,800 acres of land lying below Fort Churchill on the Carson River and below Derby Dam on the Truckee River were cropped and irrigated in 1967. Of this, some 51,800 acres, or three-fourths, was under the Truckee Carson Irrigation District (TCID). The Newlands Project, including most of TCID lands, contained some 57,400 acres of crop land or nearly 85% of the total irrigated cropped land found in the combined systems. More than five percent of the agricultural land was idle during 1967 which can be considered a reasonable amount. Most older irrigation projects have this much or more land lying idle in any one year.

Of special interest are the relatively large areas of non-agricultural land that consume river water either directly or indirectly. The survey showed 19,225 acres of permanent water surface and some 44,172 acres of dense and very dense phreatophytes. Thus, there are nearly 64,000 acres of heavy water consuming non-agricultural lands, or nearly as much area as was covered by agricultural crops in 1967.

The total irrigation water consumed on the 69,810 acres of agricultural land actually irrigated during 1967 is estimated to be 117,855 acre feet, based on the sums of the unit uses by the various crops and other water consuming areas and a rough check of the water entering the area. This is about 1.7 acre feet per acre which is very much in line with estimates by the Bureau of Reclamation in its feasibility reports.

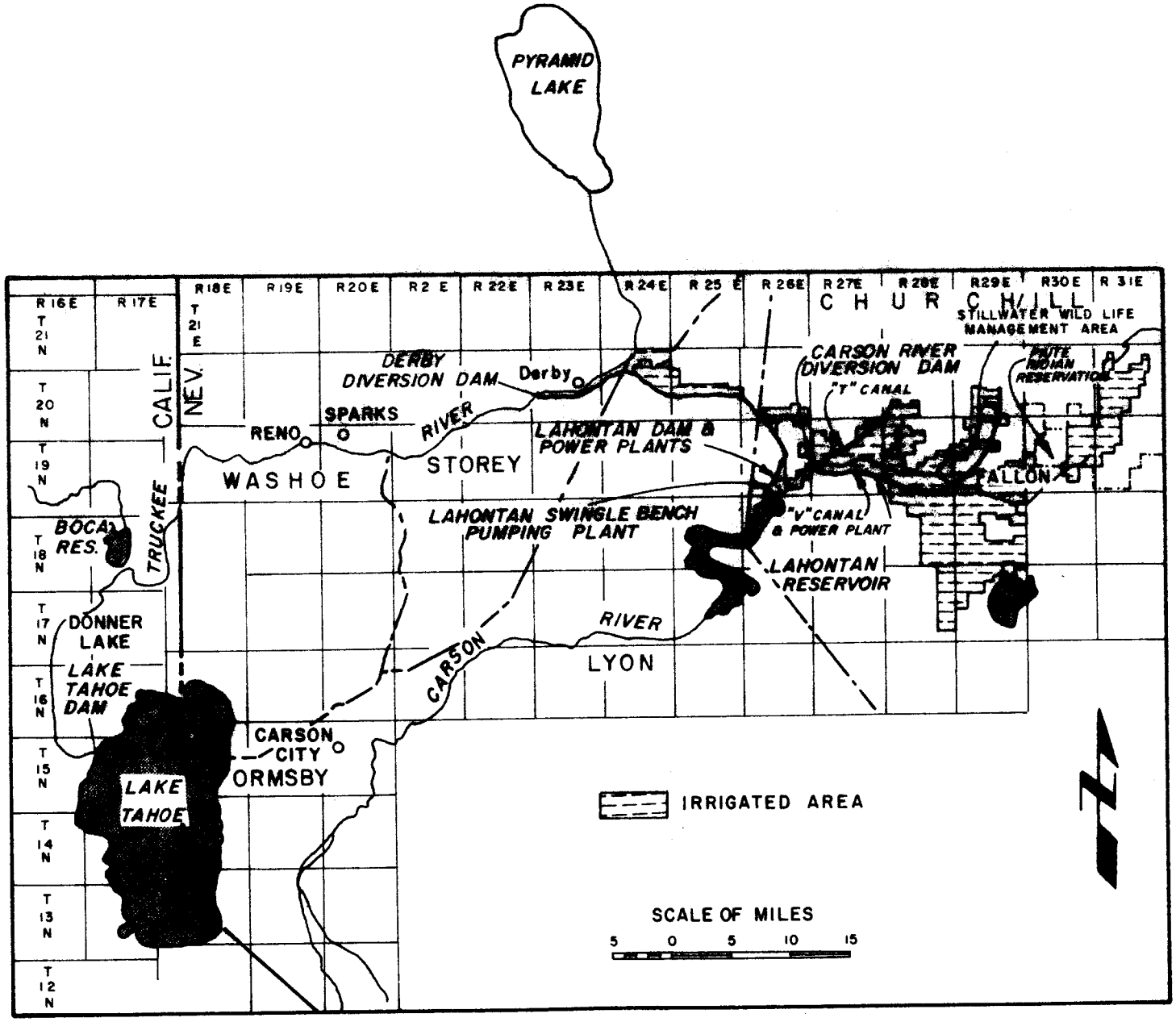


Fig. 37. Location of Truchee-Carson Irrigation District, Nevada

Irrigation diversion requirements for the 51,889 acres of Truckee-Carson Irrigation District lands actually irrigated in 1967 is estimated to average 5.0 acre feet per acre or a total of 259,445 acre feet annually. If all agricultural land getting water through Truckee Canal or from Lahontan Reservoir (67,642 acres) were allowed water at the rate of 5.0 acre feet per acre, the diversion requirement would be 338,210 acre feet. However, it is estimated that not less than half of the 338,210 acre feet diverted would pass on through the main project farm lands for such uses as the Carson Pasture and the wildlife refuges in the area. In addition to the return flows from irrigation, certain uncontrollable spills would occur during years of heavy runoff plus a minor amount of side inflow to the wildlife areas.

Human Community

The general landscape of the area where the Truckee-Carson Irrigation District is located is typical of the arid west, with small valleys traversed by the rivers. The barren land that surrounds the District contrasts sharply with the rich, fertile soil of the irrigated areas. A single consolidated irrigation company dominates irrigation of the Fallon area, an area widely known for its agricultural products. The mellons grown in the area are of high quality, and turkeys in Fallon find their way in many homes all over the country. High quality alfalfa rounds a crop picture of primarily hay, small grains, truck farm produce and other related food for cattle.

The TCID is to be found in Churchill county, an area close to the city of Reno. The population of the county was found to be 10,513 inhabitants in 1970, a rather significant increase (24.4 percent) over the 8,452 persons enumerated in the 1960 census (Table 42). With the exception of the city of Fallon (with 2,959 inhabitants in 1970), most of the population is widely scattered all over the area of the District. In addition, 1,045 individuals were stationed at the Fallon Naval Air Station, approximately 10 miles outside the city.

Most of the growth in the area took place outside the city of Fallon, which registered an 8.2 percent increase between 1960-1970 as contrasted to 24.4 percent for the county and 71.3 percent for the State.

The predominantly rural population showed a median age of 27.0 years, with a significant proportion of people (9.3 percent) of age 65 and over. The character of the county is also reflected in the employment statistics. According to the 1970 census, 495 were employed in agriculture, 23 in mining, 307 in construction, and 180 in manufacturing. However, it should be pointed out that quite a few citizens in the area are part-time farmers with many of them primarily employed by the Naval Air Station, a major employer in the area.

As contrasted to other areas in the arid West, Fallon is characterized by significant in-migration, a steady stream of what the local people described as "urban refugees," from such places as San Francisco and Los Angeles. Most of these people

Table 42. Population increase in Churchill County and Fallon, 1900-1970.

	Churchill County		Fallon	
Year	Number	% Increase	Number	% Increase
1900	830	--	--	--
1910	2,811	238.6	--	--
1920	4,649	65.3	1,753	--
1930	5,075	9.1	1,758	00.2
1940	5,317	4.8	1,911	8.7
1950	6,161	15.8	2,400	25.6
1960	8,452	37.1	2,734	13.9
1970	10,513	24.4	2,959	8.2

are buying "ranchettes," small land ranging between 5 to 10 acres, laid out in typical subdivision patterns.

Most of Nevada's valleys are so arid that they offer little enticement to systematic farming. Prior to the advent of the irrigation project in the area, large ranchers were the dominant feature. Homesteaders were not really encouraged to go into the area until after the dam had been built and water was made available. At this time the area was homesteaded. Thus, today the community is totally dependent upon the project water which makes settlement possible; without such water, the area would once again return to large cattle ranching. Prior to the advent of the project, water was diverted and used by the large ranchers but it was used only to a limited extent simply because there was not enough water available, and the area that could be covered by diverted water entailed great distances. In any case, the water in the state of Nevada is attached to the land, although interestingly enough, when the irrigation project was conceived, water was ajudicated by the federal government. Water was to be provided for 87,500 acres of land and 50,000 acres of pasture. Any water above the total amount could be taken by the federal government.

Waters of the Truckee and Carson Rivers have been developed progressively over the century since settlement of the area commenced. On both streams certain water rights are recognized as having priority over those of the Newlands project.

The 1926 contract between the United States and the Truckee-Carson irrigation district provides that of water from the Truckee and Carson Rivers, decreed or thereafter to be decreed to the United States, the Newlands project shall have a prior right to the economical and beneficial use of sufficient water to irrigate 87,500 acres of land. The contract provides that until this right has been satisfied none of the water of these streams shall be diverted or impounded by the United States for use on other lands. This right is only a contract right as between the two parties to the 1926 contract. The contract further stipulated that the bottom lands would receive 3.5 acre feet of water, with the higher land under cultivation receiving 4.5 acre feet. Although the optimum in many parts of the area is as much as 6 acre feet, the mean amount of water delivered is 3.68 acre feet for every acre of land presently under cultivation.

Irrigation Development and Organization

Historically, Fallon was among the leaders of reclamation projects. The Newlands project in west-central Nevada was one of the first reclamation projects authorized and constructed under the Reclamation Act of 1902. First known as the Truckee-Carson project, it was renamed in 1919 in honor of the late Senator Francis G. Newlands of Nevada. Construction of the various project features extended over the period from 1903 to 1913. The project was operated by the United States until January 1, 1927, and thereafter it has been operated by the Truckee Carson Irrigation District.

The Newlands project utilizes water from the Carson and Truckee Rivers, both of which flow northeast from the slopes of the Sierra Nevada.

The Carson River flow is controlled by the Lahontan Reservoir, located on the river just above the major portion of the project lands. The total reservoir capacity is 273,600 acre-feet below the spillway crest and 291,000 acre-feet with 20 inches of flash board above the spillway. The active capacity is 4,000 acre-feet less than the total capacity. Water released from storage can either flow through or bypass the 1,600-kilowatt Lahontan Power Plant located at the base of the Lahontan Dam. About 6 miles below the reservoir the water is diverted to canals on both sides of the river by the Carson Diversion Dam, creating the North and South Carson Divisions commonly referred to jointly as the Carson Division.

Truckee River water is diverted to the Newlands project at the Derby Diversion Dam. It is conveyed by the 31-mile Truckee Canal and is released either into the Lahontan Reservoir at the Lahontan Dam or is dropped through the power plant to the Carson River below the dam. Part of the water carried by the Truckee Canal is used to irrigate lands along the canal route in what is designated as the Truckee Division of the project. This division also includes some lands served by diversion from the Carson River through the Rock Dam ditch above the Carson Diversion Dam. Sometimes when diversions from Truckee River are insufficient for the irrigation of lands in the Truckee Division, water is pumped from the power penstock below the Lahontan Dam and "backed up" in the Truckee Canal about 3 1/2 miles. It is then diverted into the lateral serving the Swingle Bench portion of the Truckee Division.

In addition to Lahontan Reservoir, Lake Tahoe located high on the Truckee River with an active capacity of 732,000 acre-feet provides partial regulation of Truckee River flows. A low dam at the outlet of the lake is a feature of the Newlands project.

There are 400 miles of canals which carry the water to be used for irrigation, and another 400 miles of drainage canals which are used to carry away the water after it has been used. For the most part the water is used for irrigation and leaching, so once it has passed through the soil it becomes of limited use even though it may be used for irrigating again. However, it is of limited value because of the high degree of salt. The irrigation company maintains not only the delivery system but also the drainage system as a necessary part of the irrigation system. Assessments made as part of the delivery costs are used to maintain the actual drainage system.

Early planning for the Newlands project was made on the basis of irrigating about 300,000 acres but by the time the 1926 contract was signed the prospective irrigable area had been reduced to 87,500 acres. In the pending action to adjudicate the water of Carson River, the Newlands project asserts a right to irrigate 87,500 acres of cultivated land plus 50,000 acres of pasture land. At present the district is obligated to

provide water to about 70,000 acres of land either through contracts between the United States and individuals based on rights antedating the project or through accepted applications for project water. All of the 70,000 acres are commonly referred to as being under water right contract and are distributed by project divisions approximately as follows:

Truckee Division	6,970 acres
North Carson Division	6,990 acres
South Carson Division	56,040 acres
Total	70,000 acres

There are no wells in the area because of high salinity or springs that may augment the water supply. Indeed, there is a potential for less water in the area as a result of a pending court dispute with the neighboring Indians who own Pyramid Lake in the vicinity of the project. Pyramid Lake is an old lake which existed because it was fed by the Truckee River. As diversions took place, Pyramid Lake is receiving a minimum amount of water. The Indians of the nearby reservation are in the process of suing the TCID in an attempt to receive enough water back so that they can maintain the Lake and plan a recreation area around the beautiful shores.

The outcome of the court fight could set a new water prececent because the Bureau of Reclamation is also involved. The Indians claim the water by prior access, while the Newlands' people claim the water because they bought and paid for the project construction. The Bureau of Reclamation has indicated that it belongs to neither of them. The Bureau of Reclamation maintains that the water is owned by the U.S. Government and that the users simply enjoy a stewardship of the water. The Bureau of Reclamation contends that if the users do not properly maintains and repair the system, the water will return to the charge of its owner, the federal government. TCID feels that if the U.S. Government is able to win the case, then the farmers will stand to lose some of their water now, and in the future they may lose it all. These are the farmers who have repaid the Federal contract for the original construction, and they have also paid for the operation and maintenance of the system since 1927.

The water which comes into the area is primarily agricultural in nature. There is, of course, some culinary water but the population in this area is rather small so it constitutes a very small part of the total water used. The agricultural water is carried by open canals to the 1200 members of the irrigation company. These canals are quite inefficient. The canal which diverts water from the Truckee River to the Carson River has an enormously high loss rate; it has been estimated to run as high as 50 percent. Of about 400,000 acre feet diverted from the Truckee River, only 250,000 were taken from the diversion canals when it arrived at the Lahontan Reservoir.

Water costs in the area amount to $4.50 per acre of land. A 50¢ drainage charge is also charged for every acre of land with the $4.50 assessment used primarily as money for operation and maintainence of the irrigation system. Costs of operation

are defrayed by two sources in the Truckee-Carson Irrigation District. One source consists of the ownership of a large pasture by TCID, in which re-used water is applied. The pasture is large enough to handle 6,000 head of cattle and the local farmers use the land at a cost of $1.75 per animal per month. The second source of income is the Lahontan Reservoir, which has a power generating capacity.

The irrigation company was first formed in 1902 when the project was first envisioned and the project was run by the federal government until 1927. At this time the farmers took over the complete project and all of its obligations. Since that time they have maintained the project and paid for it. The actual organization and operation of the irrigation company is quite sophisticated, with a manager, a water master and ditch riders, or a total of 45 employees, a relatively large office staff under the direction of a board of directors or governors.

The board of directors is a seven man body elected by the various individuals in the seven different regions served by TCID. Each man is selected as a representative of the people in each one of these areas and is expected to present grievances, defend rights of his "constituency" and generally protect the interests of his people in the subareas. As in so many other cases, the board provides general policy guidelines, usually expressed in the budget presented annually to the water owners of the area. Similarly, they make any other decisions which are necessary in terms of board policies during the year. Thus, the role of the member on the board is one of first of all representing the interests, wants, and desires of the membership from his district or subarea, and second being a member of the policy formulating group which sees that the business of the irrigation company is properly dealt with.

In this area, being a member of the board carries significant status and importance. This is a position of particular responsibility but one of no renumeration. The members of the board were considered to be important decision makers, with their decisions having significant implications for the population of the area. Indeed, the water users in the area are particularly selective as to whom they elect to represent them on the board. As elsewhere, here too, members of the board tend to be older men who had been rather successful in the area, but by no means retired. A number of the board members interviewed were still actively farming and maintaining their property. The shareholders expect the board members to put time, as much time as necessary, into maintaining the interests of the irrigation company and acting as the important policy-making mechanism of the compnay.

The training and experience of the manager of the TCID, as in many other cases, has been an informal one. He was recruited specifically for the task but his experience and training came simply by running the system. As the system grew, he was able to grow with it and continue to supply the water in a satisfactory manner. The manager in this area is truly the most organizational type among all managers in the areas of the

present study. The manager of the TCID maintains the office personnel, makes sure that they are doing the specific job as defined, spending very little time out on the irrigation system. This is done by the water master and the ditch riders, but he does check on them to make sure that everything is operating appropriately. The best way to describe his tasks would be one of implementing the policy delineated by the board of directors. He is supervised and hired by the board of directors. The effect of the manager on the shareholders in terms of policy making is rather minimal. He really does not have much to do with the policy making aspects of the organization. On the other hand, he is the man who makes the daily operational decisions and if, for any reason, there is a situation where water has to be delivered on rotation rather than demand (because the system is not large enough to carry all the water needed) he has to make such a decision. Generally, this is not the case; he simply implements the policy of the board and delivers the water when it is requested.

One may describe the TCID as quite innovative and progressive. The farmers who are members of this irrigation company have been supportive of many changes. For example, when the dam was originally built it was not designed to be a power-generating unit; however, the membership and the board of directors saw the possibility of potential income through power generating facilities. This item was brought to a vote with the people in the valley agreeing that it should be done. Although the TCID is capable of leveeing bonds and borrowing money, it has not to this date leveed a bond. Money was borrowed from local banks for the power generating facility and paid off with the resulting revenues.

The water supply for the Newlands Project has generally been plentiful during the project's history, although some droughts have occurred where water diversions have been restricted. There seems to be considerable evidence that crop production may not have suffered in proportion to the water shortages.

Field observations made in 1967 indicate that individual farmers are doing a reasonably good job of applying water to the cropped lands. However, project management may be somewhat lax in limiting water delivered to the canals when the farmers do not need it, in charging farmers for the water diverted to the canal but not used, in improving storage and conveyance structures to limit losses, and in developing the potential reuse of water within the project.

Although "loose" handling of water may have qualified as meeting the beneficial-use test some 60 years ago when the project was first constructed and when the population of Nevada and of the entire United States was far less than in 1967, present demands for water for the many competing uses make it unreasonable to assume that only one acre foot of each five diverted be beneficially used on the project lands.

Much of the Newlands project land is located in the relatively flat Carson River Valley where application of excess

water raises the water table and creates drainage problems which are costly to resolve. The more water "wasted" on the farm lands and the more allowed to seep from the canals and ditches, the more elaborate the drainage system must be to keep the lands productive. The sandy "bench" lands of the project lie above the major areas of flat land and excess water applied to such "droughty" soils might well be picked up and reused on the project lands lower elevation. Excessive applications of water on the bench lands adds to the drainage problem on the valley lands below. Perhaps some responsibility for meeting the drainage cost on the lower lying lands should be on those creating the problem. This in turn would encourage more efficient use of the water.

At the present time, there is considerable reuse of irrigation water on the project, although such use is not necessarily reflected in the amount of drainage water actually picked up and re-distributed through project works. The major reuse comes about naturally by the deep-rooted crops, such as alfalfa feeding on ground waters. Thus, the average net consumptive irrigation water requirement in the valley may be even less than the 1.7 acre feet per acre computed since some portion of this requirement may be obtained from the ground water.

Only 117,855 acre feet of river water (annual consumptive use minus precipitation falling on the areas) is required for all irrigated and cropped land in the study area. For year 1967, approximately 449,313 acre feet of river water was consumed by natural vegetation and from water surfaces or nearly four times the beneficial agricultural consumptive use.

The total use of river water was estimated to be 567,168 acre feet. This corresponds to the 10-year (1956-65) measured flow of the Carson River past Fort Churchill of 238,500 acre feet, diversion into the Truckee Canal of 296,800 acre feet, and an estimated consumption of river water on the 1,824 acres of irrigated land and incidental water consuming areas between Derby Dam and Pyramid Lake of about 13,300 acre feet or a total amount available for consumption of 548,600 acre feet.

The measured inflow of 548,600 acre feet is only 18,568 or 3 percent less than the computed use of 567,168 acre feet based on crops and other land uses. In addition, it is safe to assume that some unmeasured side inflow to this large area occurs, probably sufficient to balance the consumed use arrived at by the inflow-outflow method and the integration method.

Studies conducted by Clyde-Criddle-Woodward, Inc. for the U.S. Bureau of Indian Affairs regarding water management alternatives for stabilizing the water levels of Pyramid Lake resulted in the following summary and conclusions.

1. The water consumption of the lower Carson River area was computed by the "integration" and "inflow-outflow" methods. The results of the analyses by these two methods show a close check as to the total amounts of water consumed within this study area. Approximately 550,000 acre feet of river water is

consumed annually on areas below Fort Churchill and under the Truckee Canal below Derby Dam.

2. Of the total amount of water consumed in the study area, only about one out of each 5 acre feet is consumed beneficially by the agricultural crops. All of the rest is incidental uses of surface and underground waste from the irrigated lands plus administrative losses and unavoidable spill from the storage reservoir.

3. Using an average annual diversion requirement of 5.0 acre feet per acre for actual cropped acreage (51,889 acres) in 1967, TCID would require 259,445 acre feet including all lands served below Derby Dam while the total Newlands Project (57,366 acres) would require 286,830 acre feet. The total requirement for all land irrigated (67,642 acres) was 338,210 acre feet.

4. If the water diversions for project lands are limited to the rather liberal rate of 5.0 acre feet per acre for agricultural lands, and if the use of Carson River waters are maximized, demands from the Truckee River through the Truckee Canal will be substantially less than has occurred during recent years. Using these criteria would allow an additional 100,000 acre feet of Truckee River water to reach Pyramid Lake each year.

5. Increasing project efficiency in the use of water for Newland Project Lands would require little change in present farm systems on the agricultural lands under the project. The major saving would come from improved water management practices on the system and some tightening down in the use of water by the irrigators. One way to encourage more efficient use would be to have the water delivered only on demand and the farmer charged for all water ordered whether he uses it or not.

6. Even with suggested smaller diversion from the Truckee River, including spills, approximately 200,000 acre feet of water would still be available for Carson pasture and Stillwater Wildlife Refuge.

7. Raising Lahontan Dam by six feet would add approximately 68,000 acre feet of storage capacity. Under the operation criteria used in this study, the increased capacity would make an additional 16,000 acre feet of usable water available in the Carson system and would decrease the diversion requirement from Truckee by this same amount.

8. Anything done upstream on the Truckee River to deplete the flow of the stream at Derby Dam will reflect on the inflow to Pyramid Lake. However, considerable regulation and use of Truckee River water for municipal, industrial and other purposes might occur with little effect on the waters reaching Pyramid Lake. The major effect of anticipated activity upstream from Derby Dam will be a change in the time in which the water reaches the dam. Increased development around Reno and the Truckee Meadow area should tend to slightly increase the flow in the river at Derby Dam, whereas storage in Stampede Reservoir would

tend to deplete it because of evaporation from the new water surface.

9. Any diversions from the Truckee-Carson River systems would adversely effect the flow into Pyramid Lake.

But as in many areas of the West the challenge of future survival in the TCID area is a larger one. The people of the valley when asked about the advantages or disadvantages of consolidation were highly positive. Most felt that they were able to get their water, that their voice was heard in the company and that a streamlined organization made possible efficient operation. The apprehension comes more from fears of urban encroachment, the closeness of Reno and the increasing appearance of "commuters" as far as Sacramento. Urbanization, increased recreation, and the influx of people buying ranchettes may alter the basic character of the area and, thus, provide a new challenge that this consolidated system may be able to meet through the concerted action and planning of a well-integrated and efficiently running organization.

SALT RIVER VALLEY, ARIZONA

Location and General Characteristics

Of all valleys examined in this study, Salt River is the largest and most complicated, but at the same time a poignant example of a large and successfully integrated system. It is only such a progressive and organizationally cohesive system that can meet the special challenge of meeting water demands in a rapidly expanding metropolis and plan simultaneously for a combination of irrigated agriculture and spreading municipal territory.

Salt River Valley consists roughly of a half-million acres in central Arizona. It is semi-desert, with alluvial soils suitable for agriculture, but with a low rainfall pattern which makes irrigation a necessity. The surface water available is provided by the Salt and Verde Rivers, which are fed by a 13,000-square-mile watershed (Figure 38). Modern farming, and more recently large-scale urban and commercial developments, would not be possible until huge multi-purpose storage dams were built on the Salt and Verde Rivers to harness their erratic flow. These dams, built in the early years of this century, furnish presently water to a 250,000-acre area known as the Salt River Project.

The dams and related facilities are operated by the Salt River Project Agricultural Improvement and Power District and the Salt River Valley Water Users' Association, which together form the Salt River Project, a non-profit organization managed by landowners located within the project land area.

The Salt River Project was created in 1903 to serve a community of fewer than 20,000 persons. Toward the end of the 1960's the community of which the project was a part had grown to over 800,000. As one of the first reclamation projects authorized under the National Irrigation Act of 1902, in 1967 it developed and delivered water and electric energy for much of the metropolitan Phoenix area and for the adjacent agricultural areas. The water-service area had increased to 238,000 acres to which over a million acre-feet of water was distributed annually. Electric energy was distributed to over 130,000 customers.[484]

As a general observation, the landscape of the metropolitan Phoenix area could best be described as extremely arid with the minimum rainfall typical of desert territories (7.47 inches). The average minimum temperature is 55.7°F., the annual average maximum temperature is 84.6°F. The average summer temperature for the fourth of July is 104°F. The Salt River Valley is an area of approximately a half million acres, surrounded by low lying hills which are called "mountains" by the local people. These are dry mountains; the major sources of water for the area are the Salt River and the Verde River which flow down from Superstition mountains.

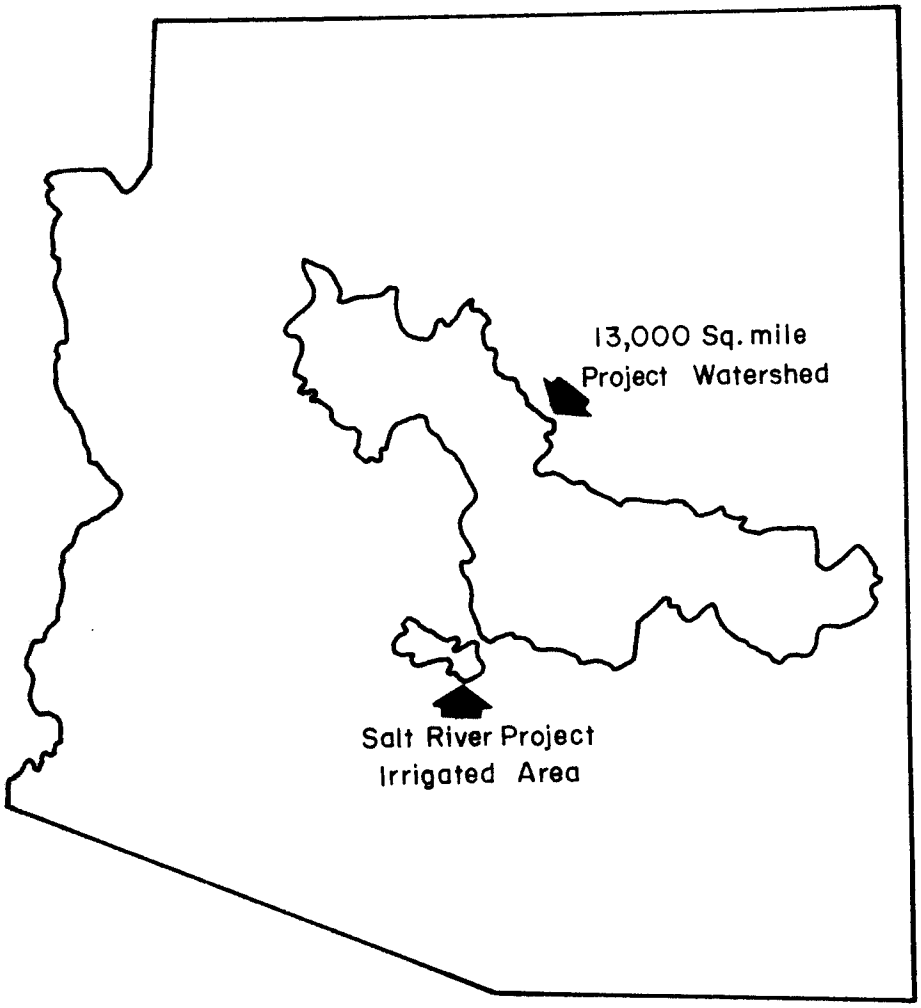


Figure 38. Location of Salt River Project watershed and irrigated areas.

The soils in the Phoenix area can be very productive when water is available. Most crops grown there have significantly higher yields when compared to national averages. For example, the average cotton grown in the United States is about 436 pounds per acre; in the Salt River area the cotton yield is 979 pounds per acre. The forms of farming that are found are primarily oriented around the following crops: alfalfa, alfalfa seed, small grains, cotton, potatoes, various sorghums and sugar beets.

Human Community

The air of a frontier area is still pervasive in Arizona. Only in the last few decades has the growth of the state shown trends and patterns long apparent in other parts of the United States--rapid urbanization and decline of the rural population, and the shift from an economy based entirely on primary resources to one dependent also on industry, manufacturing, and services.[485] Still, the state is relatively underpopulated compared to the rest of the nation, with a total number of 1,773,428 inhabitants (969,425 or 54.6 percent of which reside in Maricopa County--the Phoenix metropolitan area).

The population growth in the metropolitan Phoenix area has been phenomenal. The entire county has grown to 967,555 in the 1970 census, or an increase of 45.8 percent over the 1960 census (Table 43). This phenomenal growth is even more dramatic when one examines some of the cities which comprise metropolitan Phoenix. For example, Scottsdale, an area which was primarily agricultural in the 1960's had grown 576.5 percent between the last two census (or an explosive growth from 10,026 inhabitants in 1960 to 67,823 by 1970). Essentially, then, Maricopa County and the Salt River District experienced the geometrical growth that Figure 39 so amply illustrates.

The major shift that had occurred from 1903 (when Salt River Project started) to today was significant of surrounding communities and of the boundaries of the Salt River Reservoir District. In 1903 the boundaries of the reservoir district included all of the metropolitan Phoenix community. By 1970 the metropolitan Phoenix community extended beyond the reservoir district in many places. This change has been forcing the project to concern itself with citizens of a larger community who receive no direct service from it but who could affect decisions made regarding the project's place in the general area.

Thus, population growth, the blossoming of the metropolitan area, and the spreading of the urban agglomeration all over the valley has been changing the general cultural character of the "community." The community of which the irrigation project was a part had shifted from one in which a high percentage of people were directly involved in organizational decision-making and received direct service from the organization to one in which a very low percentage were directly involved in decision-making, and the percentage receiving a direct service, either water or electric, was not as large. The majority of those

Table 43. Population increase in Maricopa County and the city of Phoenix, 1900-1970.

	Maricopa County		Phoenix City	
Year	Number	% Increase	Number	% Increase
1900	20,457	--	5,544	--
1910	34,488	68.5	11,134	100.8
1920	89,576	159.7	29,053	160.1
1930	150,970	68.5	48,118	65.6
1940	186,193	23.3	65,414	26.4
1950	331,770	78.1	106,818	63.2
1960	663,510	99.9	439,171	311.1
1970	969,425	45.8	581,562	32.4

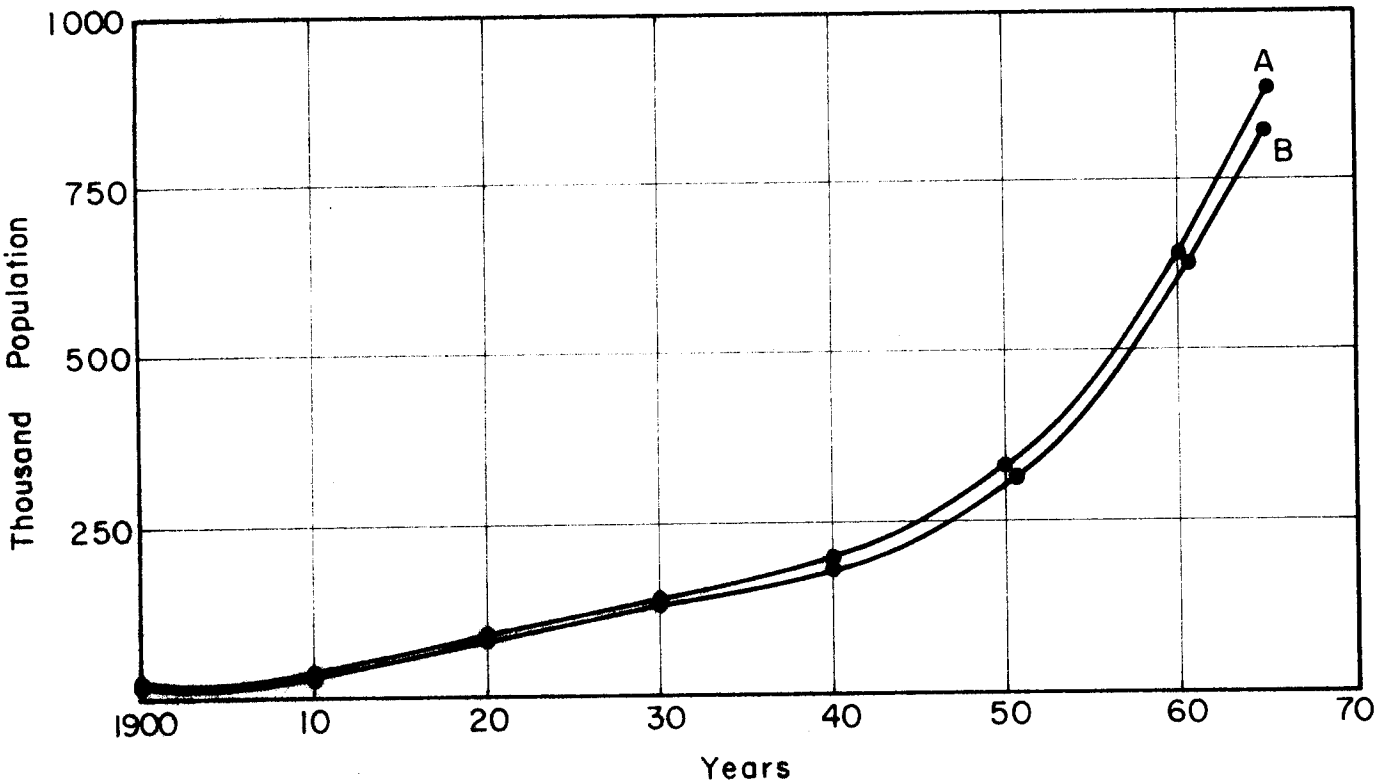


Figure 39. Population of Maricopa County (upper curve) and estimated population of the Salt River District (lower curve).

receiving a direct service remain relatively uninformed as to the basic purposes and goals of the project, and how these purposes and goals relate to the area.[486]

Future trends point out to even higher numbers and expansion, in particular, of the urban population. By 1970 the urban population in the valley was 884,157 with the rural segment accounting for 83,365 inhabitants. This area, whose growth began rather modestly after World War II, is faced with a veritable flood of in-migrants from colder climates and from areas of lesser opportunity.

The City of Phoenix has been the core of the urban expansion with Glendale, Tempe, and Mesa as lesser cores. Past expansion has been easterly and westerly in the valley, for in these directions lay the interchange of commerce, the principle railroads, the routes to the Coast, and easily developed land in large acreages. As urban pressures continued, the need for space on flat lands opened up south Phoenix, Deer Valley, and Paradise Valley although river beds, low hills, and distance were once deterrents. From the cores, urban expansion moved, wave-like, outward with light density dwellings on the periphery followed by denser concentrations.[487]

Projected populations are even more dramatic. Already in 1973, it has been reported that Arizona's population is increasing much faster than even the most optimistic analysts had forecast. Arizona tops the nation in rate of growth and various projections estimate sharply higher population totals for 1980 than the "reasonable" 2.4 to 2.5 million that was predicted earlier. To indicate the exploding rates of growth one may contrast population change for Maricopa County and the State between 1960-1970 and estimated change between 1970-1980 according to projections by Battelle for the Arizona Department of Economic Planning and Development:[488]

	Percent Change	
	1960-1970	1970-1980
Maricopa County	+46.1	+75.3
Arizona	+36.2	+71.0

Indeed, if such estimated growth takes place, Arizona could be the 7th largest state west of the Mississippi River, and the largest in the Rocky Mountain Region. Looking further into the future the study of John Carollo Engineers quoted above has produced a composite chart of expected population growth in the Valley Metropolitan Area (the focus of their study) shown in Figure 40.

All the above rates and future trends were included in order to emphasize the key point of the phenomenal growth of the area and the associated water demands. Other aspects of human community are also important, before we enter into the discussion of the development of irrigated agriculture and its new role in a fast urbanizing and industrializing valley. Briefly, the composition of the population shows that it is significantly

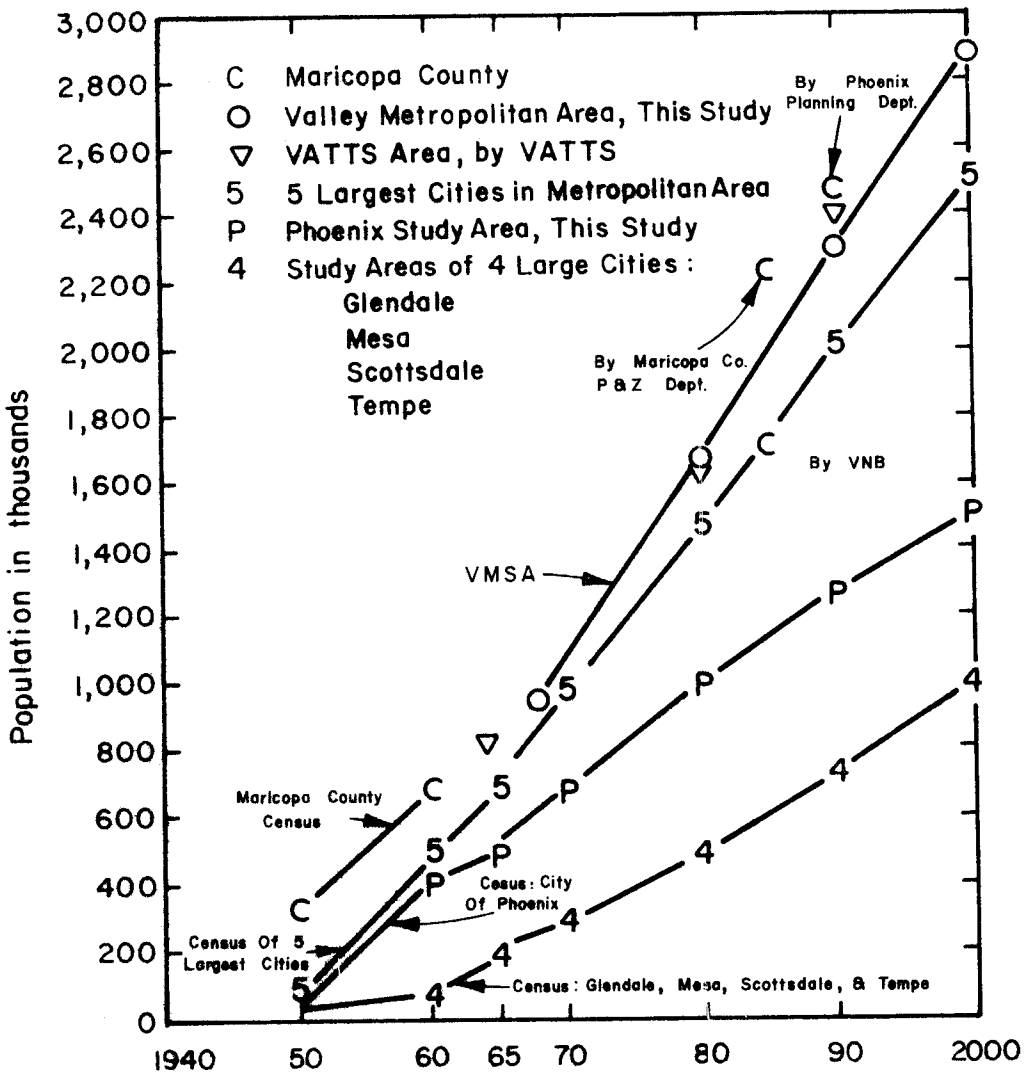


Fig. 40. Population growth in the Salt River Valley metropolitan study area

aging, having a median age of 29.9 years and a percentage of those over 65 of 10.7 in 1970. At the same time, the data for employment in 1970 show the new character of the area. In Maricopa county 12,312 individuals were employed in agriculture, as contrasted to 73,472 in manufacturing, 58,900 in services, and 26,739 in construction.

In the context of the booming Arizona economy, the Salt River Valley Water Users' Association, one of the two legal components making up the Salt River Project, was considered successful. This success could be measured by crop production, stimulus to economic development, repayment of reclamation fund debts, and development of tax revenues. As contrasted to many other irrigation systems, the Salt River Project has impressive headquarters befitting any modern corporation. This complex organization, employing over 2,000 people, uses the latest computer technology and facilities, highly centralized system of operation, including remote control. All in all, the streamlined operation and edifices stand out as symbols of the importance of water for the region. It is difficult to imagine that such an impressive system had its start only 70 years ago.

Irrigation Development

Within two years from the close of the Civil War, pioneers had settled in the Valley, and in 1867 their first canal excavation was undertaken. After a diversion from the flowing Salt River, the canal passed through what is now downtown Phoenix. By 1869 cultivation was well established on a few hundred acres; such success encouraged the construction of more canals, among them Grand Canal (1878), Arizona Canal (1883), Consolidated Canal (1891). By 1884 some 35,000 acres were under cultivation and by 1902 the acreage was about 132,000.[489]

The early diversions of water from the Salt River used brush dams or any other material that could be put into the riverbed in order to impede the flow and, thus, use water for irrigation. Such makeshift systems were unsatisfactory as they were often washed away. The need for a constant supply of irrigation water became paramount. The drought period during 1898-1904 took perhaps a third of the cultivated lands out of production. Major floods in 1891 and 1905 destroyed diversion structures and portions of canals. Credited to the February 1891 flood--the greatest of record--is an estimated 300,000 cfs discharge rate of which 50 percent came from the Verde watershed.

An approach to dam building through federal financing came into being in 1902 with the Congressional passage of the Newlands Act providing for a Federal Reclamation Program. To transact business in connection with dam building and general water management, a committee of 25 citizens was formed which culminated into the Salt River Valley Water Users' Association incorporated under Territorial laws in 1903. This became the first organization of its kind formed to take advantage of the new act. The SRVWUA set up a project area of some 250,000 acres of which about 180,000 acres could be irrigated by gravity; the U.S. Reclamation Service recommended that the remaining lands

above the gravity zone be served by surface and ground waters raised by electrically driven pumps. Thus, electrical power generation was justified and built into Roosevelt Dam (1905-1911) on the Salt River. Granite Reef Diversion Dam (1906-1908) split the released flow to either side of the Valley.

As Smith has observed, the landowners of the valley did not stampede to commit their land to the association. One reason was that they had to commit themselves to repaying the costs of construction, estimated at $1.50 per acre of land for the ten-year repayment period specified in the National Irrigation Act. Other reasons were that some landowners perceived the association as an attempt by landowners with inferior water rights to take their water, fear that the association would usurp local control of the water, and such personality constraints as ignorance, selfishness, and resistance to change.[490]

Government officials, especially officials of the Reclamation Service, newly created, were anxious to begin a project. Through the late spring and early summer of 1903 these officials began to apply pressure to the officers of the water users' association. Finally, in an eleventh-hour rescue, Benjamin Fowler, of Glendale, the individual who had provided the leadership in the struggle to obtain water storage, persuaded enough landowners to commit their land to the association. Of a possible 250,000 acres, 150,000 were subscribed to the association, and the government agreed to begin construction of a dam in Tonto Basin.

The original intention was to construct a dam large enough for a storage reservoir with a small hydroelectric generatic capacity. The sequence of events and construction, however, showed the rapid evolution of the entire valley. The Roosevelt Dam, dedicated in 1911, is approximately 80 miles from Phoenix and the furthest from the Valley, located at the confluence of the Salt River and the Tonto River. The capacity of the Roosevelt Dam is 1,381,580 acre feet, or over 50 percent of all the water impounded in the project. This structure is by far the largest of the six existing structures which constitute the Salt River Project and since it was the first built its storage capacity was considered at that time adequate for the needs of the people of the Salt River Valley. At the time of the construction, the need for energy generation at the Roosevelt Dam was not considered to be a priority item, and thus, only a small generator was incorporated into the structure. This unit was designed only to generate energy for construction needs and the raising of ground waters, and not necessarily for sale to the general public.

At the time the Roosevelt Dam was being built, the need for a diversion structure was very apparent. So the Granite Reef Diversion Dam was built approximately 50 miles down the Salt River channel. This structure was built at the confluence of the Salt and Verde Rivers. Shortly after the completion of these two structures, the Salt River water users realized that with further construction approximately 800,000 additional acre feet could be impounded.

The next structure to be built was the Mormon Flat Dam. This structure was built between 1923 and 1925. The storage capacity of this unit is 57,852 acre feet. Included in this structure as an integral component part was a hydro-electric unit capable of generating ten thousand kilowatt hours of energy. The electricity generated at Mormon Flat was combined with the two new hydro units installed in the Roosevelt Dam. The next structure to be built was the Horseshoe Mesa Dam with a capacity of 245,138 acre feet. It was begun in 1924 and finished in 1927. Additional hydro electric units were installed in this structure. It was equipped with three 10,000 KW hydro units. This structure was built approximately half way between the Roosevelt Dam and the Mormon Flat Dam.

It became very apparent that there was a need for additional regulation of the water which was used in the power generation process from the three earlier built structures. In 1928 the Stewart Mountain Dam was started which when it was finished had a storage capacity of 67,765 acre feet. This structure was built below the Mormon Flat Dam and at the time of its construction another hydro unit was installed as a part of the Stewart Mountain Dam, generating 10,500 KW.

Until this time (approximately 1928) the Salt River Project was primarily in the irrigation water business and not the power generation organization of later years. But with the construction of the Stewart Mountain Dam a critical turning point was reached when energy generation became more than a simple byproduct of the water available. The generating capacity became of central economic significance, and the forerunner of today's Public Service of Arizona began sharing costs of energy generation with the Salt River Project.

The Bartlett Dam marks construction of another unit on the Salt River Project. It was started in 1936 and finished in 1939. The maximum storage capacity for the Bartlett structure is 178,477 acre feet. This unit was strictly a control of flow structure. It does not have any hydro-electric generating facilities built into it. The Bartlett structure was the last structure to be built prior to the Second World War. The last unit was Horseshoe Dam built in 1944 and finished in 1946 (with spillway gates in 1949). The Horseshoe Dam impounds 139,238 acre feet of water, and has no electricity generating capacity.

Until the 1920's the ground water had been little used for irrigation, and the primeval subsurface water lay not far beneath the land. As the network of canals, laterals, and ditches began to fully cover the irrigable land, the broad application of river water resulted in percolation sufficient by 1924 to waterlog some of the farmed areas. Drainage wells were drilled and pumped to lower the water table. In 1929, by agreement with the SRVWUA, the Roosevelt Irrigation District built canals and aqueducts to carry off this hitherto wasted water for use on lands west of the Agua Fria River where the local ground water was poor in quality and where no surface water was available. The district also drilled wells along the 30-mile canal and exported water from these wells westward across the Agua Fria River.

Prior to 1940, irrigation with surface water had caused the water table to rise not only along the Salt River but also in Deer Valley, in lower Paradise Valley, and in the area east of the Roosevelt Water Conservation District. However, after 1940 the cultivated area irrigated by gravity expanded, and local ground water was pumped to irrigate the new fields. Also, during dry years, ground water was pumped within the gravity area to supplement surface water supplies. This brought the water table down. In fact, with the sustained high agricultural demand for well water, the table has receded so far as to raise questions of economic continuance in some parts of the Valley.[491]

As indicated earlier, World War II is a significant separating line for the evolution of the valley. To start with, slowly in order to provide business centers in an agricultural area of some 370 square miles, it was inevitable that numerous service communities developed. The slow growth became the avalanche of the late 1950's with the expansion of industry, higher education, resort activities, retirement centers, and technical businesses. The incorporation of five major communities shows chronologically the emergence of the metropolitan giant in the Valley: Phoenix 1881, Tempe 1894, Glendale 1910, Mesa 1923, and Scottsdale 1951. More recently suburban sprawl, subdivisions, and leap-frog development accentuate the patterns of scatterization, so similar to other urban concentrations in the Mountain Region.

As far as is known every valley community obtained domestic water from pumped wells, and this is still the case with all, excepting Phoenix and Tempe which are using surface water in addition. To obtain a better quality of water, Phoenix developed a surface water infiltration gallery on the Verde River in 1922. Three years after Horseshoe Dam was completed, the City of Phoenix paid for the installation of additional flood gates on that dam so as to secure credits for possible impounded flood waters. Critical water shortages due to lack of production facilities caused Phoenix to expand the Verde Works with a filtration plant in 1947. Later, two more filtration plants taking water from the Arizona Canal were built in 1954 and 1964. Presently, domestic water is supplied to the desert metropolis from pumped wells in subsurface aquifers and from four plants treating surface waters. Many of the expanding urban areas have developed solely on aquifers whose water tables have steadily declined since World War II. The continuous urban expansion pressures--predicted to be even greater than heretofore--will levy increasing demands on available water resources, thus raising cogent questions of how much water is needed at what locations and when.[492]

Today the Salt River Project stands out as a major enterprise operated by a staff of 2,175 employees. Facilities of the project include the six storage dams with a water-storage capacity of 2,072,000 acre-feet and 69,690 kilowatts of hydroelectric generation capacity, 138 miles of canals of which 34 percent are lined, 872 miles of laterals of which 54 percent are lined, 243 miles of waste drainage ditches, 243 irrigation

wells, three steam electric plants in the Salt River Valley with 528,472 kilowatts of generating capacity, and, of course, all the necessary distribution facilities. In 1967 the total water, electricity, and general plant in service was valued at $252,375,989 on the basis of original cost estimates (Figure 41).

This formidable project, collectively known as the "Salt River Project" has both historical and organizational differen tiations. Through the years of operation, two separate legal entities and organizations developed: one for developing and delivering water and one for developing and delivering power. Gradually, the Salt River Valley Water Users' Association (SRVWUA)--the primary focus of our inquiry--was combined (although legally distinct) with the Salt River Project Agricultural Improvement and Power District. Salt River Project (SRP) or the project refers simply to the whole, both water and power.

The project has continuously been expanding, reorganizing, and innovating. For example, the past method of manually controlling the delivery of water is gradually phased out through the introduction of an IBM 360 computer which through telemetry regulates water flow. This computerized water delivery system will not only allocate the amount of water being delivered into the various canals and laterals but it will also control the amount of water which passes through the hydro generating units at the various structures. The six storage structures will be used as stepping stones, so that in times of high generating needs, water will pass through the generators, supplying the Phoenix area with power. During the low energy times, the water will be pumped back up into the upper reservoir where it originally came from, so that is can be used for running through the generator at another time. This entire process will be incorporated into the routines in the computer with theoretically no manual control of the water.

In 1950, the SRP began a very extensive rehabilitation of the Salt River Project. The estimated cost at the time was $100,000,000 and it would run until 1977. This proposed renovation took the form of further lining canals and laterals with concrete, rebuilding gates and in general trying to increase efficiency of the delivery system.

Of the approximately half million acres of arable land in the Salt River Project, about 240,000 acres are actually paying their annual water assessments. The other approximately 260,000 acres are not paying their water rights but they are still entitled to the water if they wish to pay the rights. Water not paid for is used by domestic water companies. The Salt River Project refers to them as domestic water contracts. The SRP delivers water as a part of these delivery systems to the cities of Phoenix, Glendale, Peoria, Tempe, and Gilbert. These contracts are generally set up on a ten year basis and at the end of the ten year period the water contract is renegotiated. Actually, the sale of water by the various communities provides them with significant revenue. The city of Phoenix, for example, was buying in 1971 water for approximately $2 an acre foot and then was selling this raw water for approximately $250 an acre foot.

Fig. 41 Salt River Project, Arizona.

Organization of the Irrigation System

The natural flow which comes down from the Superstition Mountains is about 3/4 of a million acre feet annually. The reservoirs which are owned by the Salt River Project are capable of impounding over 2 million acre feet. The residual water (about 1/4 million acre-feet) is impounded and held for emergency for short years and also for recreation purposes. The 700,000 feet are used every year for agricultural, industrial, and domestic purposes.

The range of "farmsteads" in the Salt River area vary from 3,000 acres to 1 acre. There are 115 farms of 160 or larger, 289 between 100-160 acres and so on, with 47,000 units under 1 acre. Obviously the data point out to the changing character of the valley, since only 404 full-time farmers in the Phoenix metropolitan area receive water from the Salt River Project.

The total acreage in the irrigation project was 238,252 acres in 1967. From 1957 to 1967 the net area being farmed decreased from 79 to 64 percent of the total area. The area in urban land use, subdivision, commercial, and industrial, increased from 16 to 32 percent of the total acreage. The average rate of decrease in farm acreage was 3,700 acres per year, although the actual rate had been below this figure since 1963.[493]

It is interesting to notice in Smith's study that while urban water use had increased and farm water use had decreased, the water duty trend since 1957 showed the opposite. Farm water use per acre had increased, while the urban water use per acre had decreased. Two major factors explained the increasing water duty on farm lands--the cost-price squeeze and better water measurement. The industrialization of farm operations to cope with the cost-price squeeze had the effect of increasing the quantity of water used per acre. Cropping patterns were adapted for more efficient utilization of land. Each adjustment had the effect of increasing the quantity of water used per acre. The cost of water had not increased like other costs, and water was used, when possible, to increase crop production. Operating against increased water use per acre due to the industrialization of farming were water-conservation programs. Cement lining of farm irrigation ditches and the services of the agricultural technician enabled more efficient water use and could increase production with less water. But, the association emphasis on careful measurement of the amount of water delivered to farmers worked in the opposite direction. It increased the amount of water recorded as delivered. This had the effect of increasing the farm water duty, since farmers were being charged more nearly for the quantity of water they actually were using.[494]

It might be recalled that the SRP is the first project completed under the Reclamation Act (the Truckee-Carson Irrigation District was the first started, but it was completed after the SRP). The project can be classified among the most successful projects created by the federal government. The assets of the company, in terms of the power generating facilities and of the various dams and canal systems which the Project owns

and maintains, run into the hundreds of millions of dollars. The number of employees involved in the consolidated system of the Salt River Project number well over 2,000 and, in fact, the number of those who work specifically with water--primarily agricultural water--are well over 500. The company, the Salt River Project, was designed to serve the people in the area and was initially administered by the Bureau of Reclamation. In 1917, the shareholders of the Salt River Project began to question the federal operation because the expenses seemed to be growing at a disproportional rate. At that time, the Project was taken over by the people themselves, under the general name of the Salt River Project (with the distinctions made earlier between the association and the district).

In this brief summary, it will be impossible to discuss in detail the complex structure of such a large corporate entity as the SRP. We need only to highlight some organizational aspects of the system that indicate the scope of operations, the interlocking divisions, and generally the character of a major company with an important role in irrigated agriculture. One needs only to pick up the latest annual report, with the multicolor charts and photographs, to appreciate the extent of the project.

The overall organizational structure of the Project (as a result of reorganization in 1970) is shown in Figure 42. There are 10 members on the board of directors, chosen to direct the policy making of the Salt River Project. As it is to be expected, in the past the members of this 10 man board were primarily prominent, successful farmers. However, the changing composition of the population is similarly reflected in the membership of the board. In more recent years new members of the board have been selected because they are very competent and quite well informed as to a broad spectrum of water uses. In addition to the board of directors and governors, there are also 30 councilmen from the various districts who are elected by the local shareholders (3 members from each of the 10 districts). The councilmen act as laison members of the governing body in order to inform the various water users as to what is going on within the Salt River Project; they also serve as channels of communication between users and the board.

The role of the board of directors is primarily that of policy making, major organizational changes, and generally provide overall direction and guidelines. As in every major organization, there is quite a status from being on the board of directors and governors, since it is widely recognized that such members are well informed and prominent or influencial members of the community. The 30 councilmen also enjoy considerable status, although their primary role is one of a laison man rather than that of a policy maker.

The management of the Salt River Project is highly trained and highly specialized. The degree of specialization in the Salt River Project is probably much greater developed than in any other irrigation organization in the United States. Specialists from other parts of the nation, as well as from many

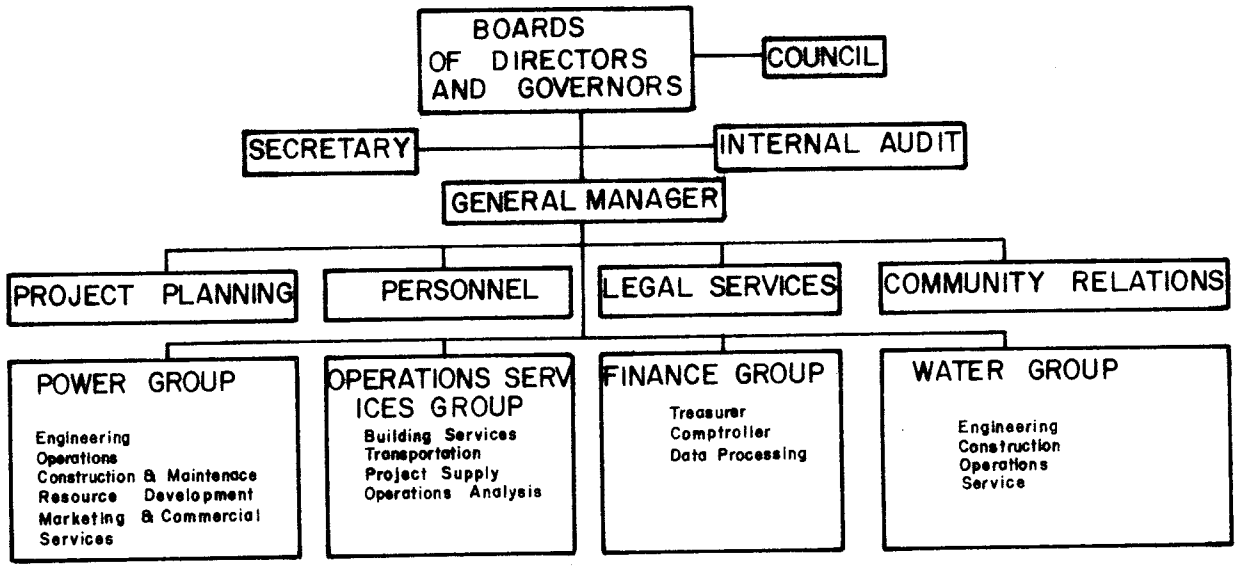


Figure 42. Organizational chart of Salt River Project.

other countries have repeatedly visited the project as a model of corporate operation. The earlier organizational figure has provided a glimpse of the intricate structure. There is horizontal as well as vertical stratification of the workers within the organization. There are varying levels of experience and no one man would be capable of running even one division within the company, let alone the entire organization. Overall, the management comprises a group at one end of the continuum with the working people within the company composing the other end. What one may describe as the "labor group" are members of the linemens union; periodically their contract has to be renewed through negotiations between the linemens union and the management of the Salt River Project. This provides naturally a point of contention with the Salt River Project management feeling that they have been somewhat usurped in their roles when they find themselves compelled to negotiate a union contract.

The roles of supervision within the Salt River Project are clearly laid out in terms of job descriptions. Employees are hired (and fired) in terms of their competence rather than familiar and informal ties that had certain influence in irrigation organization in other areas described previously.

Finally, the effect of the shareholders on the company would have to be described at best as being rather indirect. The workers involved are protected by their union and the management people do not really come in contact with the everyday water users or the everyday power users; they come in contact with the board of governors and the group of 30 councilmen. Voting is done by the water owners themselves. Until very recently a man had to own at least 5 acres of land before he could vote.

The budget of the SRP is a rather complex process of analyzing previous power revenues and anticipated power revenues, anticipated construction of new projects, anticipated rennovation of existing project. The SRP must also maintain a rather large amount of money for repairs. When flash floods occur on the system the repairs can be very costly. The SRP gains nearly all of its revenues for its budget from the power generation, and what it receives from its water assessments is actually a deficit cost. It costs more to transport the water and deliver it to the various agricultural water users than the agricultural water user actually pays for it. The deficit is more than paid for through the revenues received from power generation.

Changes in management would be typical of any type of a complex organization. The loss of one or two executives within the company would really not constitute a major crisis for the organization because the tasks and the legitimacy of the organization have been well prescribed and completely routinized.

The agricultural water users interviewed in the Phoenix area were extremely aware of the amount of water that they owned. They knew that they were entitled to 2 acre feet, they knew that if it was available they could get a third acre foot, and they also knew if they had pump rights or not. The Salt River

Project also maintains 243 irrigation wells. This well water is allocated to the various farmers on the basis of what are called "pump rights" and any farmer who wished to purchase pump rights was entitled to purchase two acre feet per acre of land which he owned. Not all of the farmers availed themselves of this opportunity, but nevertheless this water was available and can be used by farmers in the Salt River Project.

The water pumped from the wells, interestingly enough, has a stigma upon it. Most farmers believe that the well water is not as good as the surface water, so the only equitable solution the Salt River Project could find was one of mixing the well water with the surface water. The result is everyone gets an equal share of the good surface water and some of the somewhat less good pump water. Of those interviewed, the majority felt that their supply would be adequate if used prudently.

All water in the SRP is available on demand. Needless to say, there are limitations placed on the system because there are many people all using the same consolidated system. As a result sometimes it takes the SRP 24 to 48 hours before it is capable of delivering water which is requested by the various people in the Valley. But generally it is made available at the time that it is requested.

The number of irrigations in the SRP are determined by the time of year and the type of crop. Winter crops do not need as much water as summer crops simply because there is a little bit of rain available and the winter crops do not suffer quite as much heat as do the crops grown in the dead of summer. The water rights are specifically laid out in the contract with the federal government from the early 1900's. When an irrigator wants water he calls a number which is listed as the Salt River Project. The number is manned 24 hours a day. Unless there is an emergency, a zanjero (a Mexican term for water protector) who is a ditch rider, is sent out to supply the water, clean the ditch, or do anything else needed for the delivery of the water to the owner. When the water owner calls in he gives to the SRP office his water user number and his canal and lateral number.

The diversion of water is thoroughly performed by the SRP. The SRP has several water masters who are in charge of different parts of the system. The water is under the control of these water masters from the time it leaves the impoundment until the time that is is delivered by the zanjero to the farmer or the municipality who ordered the water. Although there is an increasing use of sprinkling, the vast majority of the farmers in the Phoenix area still are using the old flood irrigation techniques; the water comes to them by canal, sometimes through a pipeline and they take the water directly from the pipeline or the ditch and flood their fields with the water. The agricultural users are entitled to water on varying levels depending on their rights. The agricultural users are entitled to 3 acre feet of water per acre of irrigated land. The first two acre feet are supplied at a cost of $2.50; a third supplemental acre foot can be supplied for an additional $3.50 if the additional water is available. Some of the farms in the area were able in

the past to purchase pump rights for the cost of $14 per acre, pump rights were made available. Then if a farmer needs more than his three acre feet and he has purchased a pump right which is also an attached right he can buy from the Salt River Project two additional acre feet of pumped water, but this water costs $7.50 for every acre foot of pumped water which is received.

Scarcity of water was and remains the key problem in the area. The physical efficiency of the SRP is rather apparent. Many of the canals are concrete lined, and similarly, many farmers have also lined their ditches with concrete. The SRP has been compelled to line their ditches because the water is so scarce in the area that they simply cannot afford to lose water through seepage. On the other hand, many canals which have been lined once have their concrete cracking and decaying. A continuous program of replacement and repair attempts to cut down any water losses. Organizational effectiveness involves also a accurate measurement of water delivered. Close records are being kept with sophisticated mechanisms of monitoring and checking.

The SRP is linked with many systems in the area. The SRP finds itself in a Valley where it controls a majority of the land under cultivation. The SRP serves 250,000 acres of agricultural land, but with several other water districts (which are defined legally as municipalities) surrounding the Project. These water districts supply water to an additional 100,000 acres of land. The SRP in terms of its linkages with these companies does everything it can to facilitate the companies in their operation and gives them any and all information it has concerning ways of dealing with various situations that may be encountered. Such help ranges from dealing with leaky pipelines to the problem of the sinking water table. The last is the overriding concern of all in the Valley, since the water table is dropping at the rate of 5 vertical feet per year (counting recharge from rainfall and irrigation).

The consolidated, highly centralized and strongly bureaucratic system of the Salt River Project is bound to continue growing as the population in the area expands and more power is needed for both residential and industrial uses. However, the total water supply will probably not increase a great deal in the area as far as existing sources in the area are concerned. A central effort here is the Central Arizona Project which is designed to take water from the Colorado River and through an intricate system of canals deliver it between Phoenix and Tucson. However, in an earlier part of this report the point was made as to the impasse of the project with pending legal battles, environmental suits, and threatening noises from a number of other states. In any case it is interesting to notice that there have been approximately four times more applications than there is water available in the Central Arizona Project. Some people have been proposing other schemes for the increase of the water supply, such as recycling, manipulation of the watershed in Superstition Mountains, desalination, etc.

One thing is sure, however. There is little room for arguing about organizational improvement as a vital means for water efficiency (an argument made in many other cases). The Salt River Project is a unique combination of corporate, cooperative, municipal, and public organization. It has a unique set of basic purposes and goals developed through time as the project performed its tasks of developing and delivering water and electric energy for farmers and an increasingly urban community. Resources are wisely used, through an impressive organized system. With this system the challenge of future survival transcends the typical discussion of improving efficiency, of organizational alternatives, and of a better delineation of the rural-urban interface. The challenge of this case exemplifies and magnifies the ultimate problems of comprehensive planning and development in the arid West. No organizational scheme (and one cannot find a better model than the SRP) can operate in a vacuum of larger policies of growth and of a realization that the consolidation of irrigation companies is but a facet of long-range and forceful social policies or regional balances and ecological compatibility.

PART FIVE

COMPARATIVE ANALYSIS AND EMERGING PERSPECTIVES

INTRODUCTION

The previous presentation--of varying depth, detail and level of analysis--of the eight research areas was part of Phase I of the study concerning consolidation of irrigation systems. During this phase a major thrust was directed towards a broad delineation of the physical and socio-economic conditions prevailing in the various irrigation systems. What we need at this point, is to provide a comparative perspective on all these areas, summarize conditions, common or different, in the various irrigation systems, and explicate the framework pertaining to achieved, attempted, or hoped for consolidation.

Thus, Part V contains first of all a summary recapitulation (with an eye towards key characteristics) of the conditions prevailing in the irrigation systems in the selected areas of research. A second section is more specifically devoted to attitudes of users in two areas, Eden, Wyoming, and Ashley, Utah, in order to illuminate further conditions through the additional insight of feelings towards the world around, levels of satisfaction, perception of alternatives, and especially views towards consolidation. With the presentation of such data, a third section that follows recapitulates the theoretical approach of the study and attempts to reorganize the understanding of how in the context of an efficient and effective irrigation system, consolidation and organizational re-arrangements play a vital role. The last section in this Part then, provides the background for the continuity to Phase II, i.e., the intended concentration to specific recommendations concerning the engineering, social, legal, and economic feasibility of consolidation and a final evaluation of organizational restructuring for irrigated agriculture in the West.

Again, it should be emphasized that the presentation of the the eight areas during Phase I was done not so much for providing equal depth analysis of each system, but more with an emphasis towards common problems, the creation of a continuum of conditions that would allow the delineation of crucial factors that pertain to potential future consolidation of presently non-consolidated systems. The selection of four areas for an in-depth look (especially during Phase II) underlines the key thrust of a comparison of small simple systems (Eden) to medium (Ashley), to expanding and fast urbanizing complex systems (such as Poudre and Utah).

SUMMARY OF THE RESEARCH AREAS

General Background

As discussed in Part IV, the research areas under consideration are semi-desert, with limited amounts of rainfall, served primarily by reclamation projects which provide water during the

latter part of the irrigation year. All of these areas are valleys which have a mountain range relatively nearby in which the irrigation water is generally impounded or diverted. The climatic conditions of these areas are part of the typical arid regions, with rather harsh winters (Salt River Valley being the exception). The soil in the areas is generally fertile and productive, provided that it is given adequate water. Farming in these areas is mostly the family size farm with some corporate farming occasionally appearing in a few cases (as again in Salt River). The larger of the family-size farms would be approximately 1,500 to 3,000 acres and the smaller farms would be cared by part-time farmers who are farming anywhere from 10 to 100 acres of land. The exclusive majority of the farms use modern machinery, with the larger farms investing great sums of money in very sophisticated machines used to prepare the land and harvest the crops. The products which are typically grown on these agricultural areas are small grains, corn, alfalfa, sugar beets, and in the case of the Salt River Valley citrus fruits and cotton. All of the areas with the exception of the Salt River Valley are capable of production for about 120-150 days of the year. The Salt River Valley is capable of producing two complete crops per year and the growing season there is approximately ten months.

The agricultural areas in isolated places such as Eden Valley appear to be losing population. On the other hand, large areas like Phoenix are growing very rapidly as part of the nation-wide trends of urbanization and metropolitanization. Similarly, the Utah Valley and the Poudre Valley, as parts of well-irrigated urban cases are showing marked rates of growth, with the population differences between the 1960 and the 1970 censuses amounting to over 30 percent for the decade.

The distribution of the population in the various areas is typically around an urban place, of more than 2,500 people. The size of the urban population varies according to the valley and so does also the population in the rural hinterland. The largest population is that of the Salt River Valley, a total of approximately one million people. Most of these people are found in the city of Phoenix and the other urban places which are surrounding Phoenix (Maricopa County). The smallest population is to be found in Eden Valley. The population there was estimated to approximately 400 people. The smallest area in terms of acres of land under cultivation would also be Eden Valley with approximately 16,000 acres of land under cultivation. The largest area once again would be the Salt River Valley with approximately a quarter of a million acres being served by the Salt River Project, and another 100,000 acres surrounding the area being served by other water sources. The juxtaposition of a number of characteristics and underlying dimensions of the various areas are summarized in Table 44.

The composition of the population in the various areas is fairly homogeneous. Riverton, Wyoming, on the other hand, includes an Indian reservation and a diversified population mix. The poorest area would probably be the Eden Valley and the best economically endowed area would have to be the Salt River region. Utah Valley, Fallon, Vernal, Poudre and the Riverton Valley could

Table 44. Summary characteristics of the eight valleys of the study.

General Characteristics	Eden	Ashley	Riverton	Grand Valley	Poudre	Utah	Truckee-Carson	Salt River
Sources of Water	Big Sandy Creek --held in Big Sandy Reservoir.	Ashley Creek--held in Steinaker Reservoir.	Bull Lake Boysen Reservoir	Gunnison and Colorado Rivers.	Colorado Big Thompson and Poudre River.	Provo River and series of reservoirs.	Impoundments on Carson River and water from Lake Tahoe.	Salt and Verde Rivers with series of dams and diversion.
Socio-Demographic Area	Population 500, estimated. No major town.	Vernal population 5,000, estimated, Ashley Valley population 12,000 estimated.	Freemont County 28,352 with Riverton Division, 12,244 strong rural character.	County population 54,374 with greater Grand Junction accounting for 28,527. Among the two counties on Colorado's West Slope showing trends of growing.	Weld County - 89,086 Larimer County - 88,664 Two major towns (Ft. Collins, 43,000, Greeley, 40,000) Sum both counties - 177,750	Utah County 137,776 with Provo and Orem accounting for over 80,000 people (urban 117,134 to 20,642 rural).	Churchill County 8,452 with the city of Fallon 2,734.	Maricopa County, 967,520; Urban, 844,157; with metropolitan Phoenix accounting for most of the population.
Urban-Rural Water Use	Rural--All farmers are full-time. Drinking water from private wells.	Both--Many part-time farmers in the area.	Rural--All water diverted is used for irrigation.	Both--Many part-time farmers in the area. Many are employed in mineral extraction.	Both--Rural using most of water. Municipal water taken from Poudre River because it's better water and cheaper to process.	Both--the Provo River water users association supply domestic, industrial and agricultural water.	Predominantly rural--Drinking water is supplied by Fallon or the individual farmer so that all impounded water is used for electrical generation and irrigation.	Rural water users use most of the water, but there are 47,000 water users on less than one acre of land. High domestic use.
Large-Small	Small--71 users in valley. One irrigation company. Water almost exclusively for agriculture.	Medium--1,124 users. Five main irrigation companies in valley. All housed in one office.	Medium--(545 users) 100,000 acres are under irrigation and 60,000 more could be opened up. About 600,000 acre-feet are available for agricultural use.	Rather small with 44,000 acres irrigated from one consolidated office. The system has about 110 miles of ditches.	Large--6,200 users. Approximately 34 irrigation companies in valley. 90% of supply used for irrigation.	Large--with about 25 irrigation companies in the Valley. There are 115,000 acres of irrigated land, and two water users associations.	Fairly large--(1,200 users). The company supplies 406,000 acre feet to 62,500 acres of cultivated land and 50,000 acres of pasture.	Large--One consolidated company, supplying electricity and water. Supplies about 1,000,000 acre feet per year to 57,000 users and households. Largest and most powerful company in study.
Complex-Simple	Simple--No water exchange due to attached water rights.	Complex--Water exchanges with CUP to Utah Valley area. Irrigation companies are forced to operate as one company.	Simple--There are three different companies operating independently.	Simple--The five old companies were consolidated into one company. The whole system has the complex problem of salinity in the Colorado River.	Complex--BOR, NCWCD, River Commissioner, Rural drinking water, City drinking water, water exchanges.	Complex--water must pass through the water users association to the irrigation company. There are electricity generators, and complex inter-basin exchanges. Utah Valley is one of focal points of the CUP.	Complex--The company operates a pasture rental system, a large drainage system and collects a drainage charge. The company leases a power plant at the dam site. The company has 45 employees.	Complex--with no exchange, delivering both domestic and agricultural water. Industrial water is provided as a part of domestic supplies. SRP is a complex bureaucracy employing 2,262 of which 574 alone are in the water sector.
Organization Static-Dynamic	Dynamic--Board members change. Water poor area; innovations to get more use from water are common.	Static--Consolidation was not by choice. Dam forced de facto consolidation. Water board members seldom change.	The companies are fairly dynamic, because of land sales and the need to reorganize after such sales.	The company is fairly dynamic due to the challenge of salinity control but with little organizational change in recent years.	Static--Water rich area. Water board membership seldom changes.	The water companies have remained relatively static. CUP may force some organizational change.	The water delivery system has been static and little change has been made from original scheme.	SRP is a dynamic, expanding organization employing latest technologies.
Consolidated-Nonconsolidated	Consolidated--Under Government Irrigation Project.	Legally non-consolidated, but in reality consolidated under Ashley Valley Water Users Association.	Non-consolidated but some of the land in the Midvale Irrigation Company to be sold by the Government will probably result in consolidation.	Consolidated in 1894.	Not consolidated, but a complex system of water exchanges cause interdependence of companies.	Nonconsolidated--The irrigation companies have different appropriation dates, and to this day, honor the dates. Potential for consolidation through CUP.	Consolidated at the time of construction.	Consolidated at construction of Roosevelt Dam in 1911.

Utah Valley, Fallon, Vernal, Poudre and the Riverton Valley could be characterized as financially reasonably well-off.

All of the areas with the exception of Eden Valley and to a lesser degree Ashley Valley have been characterized in recent years by in-migration. This in-migration in many cases would best be described as the urban refugees part of a centrifugal movement of suburbanization, a new breed of "rurbanites" actively looking for a combination of rural stability and nearby urban amenities.

The settlement of all areas took place mostly in the mid or late 1800's. The first settlers who arrived in the areas of the study were agriculturally oriented and the first thing that they did was to clear and prepare the land in any way which was necessary so that crops could be planted. Typically, the first year that they were there preparations were started so that water could be diverted from the creek or river which they had settled close to. These diversions were usually plentiful in the spring. In fact, the water would be so abundant that many times the farmers had problems with flooding and, then, in the latter part of the irrigation year (July and August), the streams would dry down to a trickle and the crops would burn leading to a situation of very low productivity. Thus, the need for dry farming became rather obvious. Dry farming is typically limited to small grains. Such things as hay and corn were simply not very productive because they could not grow long enough to reach maturity. One or two crops of hay at best could be harvested in this situation and the corn, if it matured at all, would probably be marginal.

The introduction of irrigation projects in the research areas started after 1902. The 1902 the Newlands Bill was passed by Congress, a bill which provided the impetus for the construction of irrigation projects in the U.S. The Newlands Bill resulted to the first project (Newlands Project) being built in Fallon, Nevada. Shortly thereafter the Salt River Project was also begun under the same bill. Most of the other projects of the study were completed after the Second World War. Many were started before the Second World War, such as the Eden Project and the Colorado-Big Thompson Project, but the construction was stopped during the War because of the critical need for manpower. Projects in the Utah Valley (such as the Strawberry and the Deer Creek Reservoirs) were completed prior to the Second World War.

Historically, most of these systems could be described as areas which were developed through the Homestead Act. Phoenix was settled originally by traders who were travelling through the area and they began diverting the water onto the land simply because this was one of the few places that water was available. In Utah, both Vernal and Utah Valleys, were settled by the Mormons. There, although there have been settlers prior to the Mormons, the real development occurred after the Mormons arrived in the state. The other areas were settled between 1850 and early 1900's, mostly under the Homestead Act.

Again, the communities in the areas under consideration are naturally rather homogeneous areas of fairly long-time residents mostly descendants of people who originally settled the area (Salt River is an obvious exception). As a result, the typical patterns of interest in water have been handed from father to son and any antagonisms or hatreds which the parents bore concerning water situations have been handed to the children. Many of the social activities of the community in the past centered around water and its importance to the community. That is to say, functions such as cleaning ditches and preparing for the forthcoming water year served as important social events, accentuating group solidarity and interpersonal relations between individuals and irrigation companies. The actual construction of the older projects was also another form of strong social bonds, as farmers had to band together forming their own organization. More recent projects, on the other hand, have led to a situation in which the relationships between the agricultural water user and the supplier of the water are of a secondary nature, as contrasted to the strong primary ties of earlier projects. This secondary relationship is best explained by looking at the very contractual nature of the project's construction. The individuals in the various valleys to be served must sign a contract with the federal government, in essence using their land as collateral so that the project will be built. The water will be purchased from this project and used on the land, but the project must be paid for in the majority by the water users. This presently constitutes 95% of the contract with the federal government picking up the other 5% of the contract. The repayment money for these projects comes from two main sources. One is the sale of the water. This water could be sold for agricultural use which is very cheap water indeed; for industrial use which is typically more expensive water; and, finally, domestic or municipal use which is the highest category in terms of cost. The second main area would be the sale of power from the water which passes through the impoundment. Typically the sale of power is the largest contributor to the repayment of the initial construction contract.

Organization of Irrigation Companies and Patterns of Water Use

The majority of the water in the various areas results from the natural flow water impounded and stored in on- and off-channel reservoirs fairly near the location where the water will be used. All of the areas in the study have at least one impoundment and in the case of the Salt River Project there are six such impoundments. The Utah Valley and Ashley Valley areas (when one considers the impoundments which are or will be built by the Central Utah Project) are served by a complex system of several impoundments diverting water from the Uintah Mountain area to the Wasatch Front area. Most of the areas do not pump a great deal of water. The two areas which are very deeply involved in pumping are the Poudre Valley area and especially the Salt River Valley. The Salt River Valley is presently being pumped to such an extent that the water table is actually declining at a rate of approximately five vertical feet per year (considering also the amount of recharge which perks down from irrigation water). Return flow from the various irrigation

projects is used one way or another. All areas have ajudication rights on the return flow water. This water may be impounded by individuals, by irrigation companies, or even by the main irrigation company such as the Salt River Project or the Eden Irrigation Company and redistributed as a part of the existing amount of water. In every case, all return flow is used and every attempt is made to exploit this water to a maximum. All areas have a certain number of natural springs in them, but the major areas really cannot use much of this water simply because springs are very limited in their output. Areas such as Vernal and Provo have enclosed the springs in concrete and this water is used as culinary water but the amount of spring water is limited enough that it has to be augmented by water from other sources. The availability of new water supplies in the various areas is rather limited simply because all of the water which exists has been ajudicated and is defined as real property of someone in another part of the state or in another watershed. Already, some water has been diverted from other areas. A poignant example is the Poudre Valley where the Colorado-Big Thompson Project takes water from the west slope of the Rockies, carries it through tunnels under the Continental Divide and deposits it on the eastern slope. A similar project is constructed in the Utah and Ashley Valley areas, taking water from the Uinta Range which would normally flow into the Colorado River and on to the Pacific Ocean and diverting this water from the Uinta over to the Provo and American Fort Rivers and using it for industrial, municipal, and irrigation purposes in the Provo-Salt Lake city areas.

The urban use of water takes priority over agricultural use. It has never become necessary in the western United States to compel any irrigation company or any group of irrigators to give their agricultural water to a city so that this water could be used for urban purposes. If this were necessary, the municipality could simply force the water exchange and, thus, the city could use the water for domestic purposes. Typcially, though, urban and rural water supplies come from the same source. For example, the Salt River Project supplies urban water for the city of Phoenix and the metropolitan area; industrial water also comes through the same complex. The main difference between the domestic water and the agricultural water is that the domestic water is diverted, run through the processing plant and placed in the closed piped culinary water system, where the agricultural water remains on the surface and it is carried through a complex of open canals to its destination. The same is true for the Provo area where the Deer Creek Project supplies not only agricultural water, but also industrial and municipal water from the impoundment. The water is carried by the Provo River part way down Provo Canyon and then it is diverted into a pipe system which carries the water to Salt Lake City or to the Provo-Orem area.

Agricultural water use varies significantly in the various systems of the study. The physical amount of water used varied from an optimum of 6 acre feet per acre in the Riverton area to about 2 acre feet of water in the Eden area (the minimum ration of water in the Salt River area was also 2 acre feet with another acre foot if possible, plus pump water). In terms of

overall efficiency, it is quite difficult to make a general statement as to the value of irrigation water because there are many intervening variables which have to be considered, such as the quality of soil, the amount of care the soil gets, the amount of fertilization the soil gets, the amount of care the crops get, the time of irrigation (whether it was too soon, too late, whether the crops had begun to burn or not).

Organization and Operation of Irrigation Systems

The legal beginnings of all irrigation companies or irrigation areas can be traced back to the prior appropriation doctrine of 1849. This doctrine finds its roots in the application of water for mining purposes in the California gold rush. It became necessary during the gold rush for a man to own the water in a particular area where he was mining because the first miners on the scene quickly found themselves in a situation where they were inundated by other individuals coming in and attempting to take their water from them. The "junior" individuals came and begun mining gold and using the water. Once the water was diverted it was no longer available to the "senior" miners. Thus, the Prior Appropriation Doctrine grew out of such a situation with the first water user filing an ajudicated claim with the State Engineer's Office or the appropriate government agency which entitled him to that water first. Broadly, the prior appropriation doctrine describes who is entitled to the water, at that particular ranked position he should be placed, the actual amount of water which he is entitled to divert from the stream, and lastly, the point at which the individual is entitled to divert the water from the stream. At approximately the same time, the prior appropriation doctrine also appeared among the Mormon pioneers in the Salt Lake and Utah Valley areas. The water in these areas was divided according to beneficial use and the ability of the person to use such water. Need and benefit were the two main criteria for the use of this water. Also, the amount of time spent by an individual working on diversions being built was very significant. If an individual was not willing to work on the construction of the diversionary system, he was not entitled to water. So, he had to put in the time building the system, and then once the water was available he had to demonstrate he had a need for the water and could use it beneficially. Indeed, the benefit and need clauses are found in most state laws in one form or another.

Historically, availability of water has been a major point of contention in the West. Many people have died and there have been range wars over water supplies. The Mormons in Utah have killed one another on occassion over water as did also the people in the Salt River area, the Poudre Valley and Eden Valleys, as well as in many areas of the arid West. Most disputes in the past have centered around two problems: first, the actual date of an appropriated water right which was accepted by another individual; and, second the conflict between an individual who had a prior right and who believed that someone else with a prior appropriated right was taking more than his fair share of the water. Often, hatreds and mistrusts among the various users of irrigation water have been handed from one individual in a family to another down through the generations.

Even today, antagonisms persist among families whose feuds about water started 75 to 100 years ago.

When various irrigation companies were originally established they were usually rather small with their participants being the original settlers of the valley. Such settlers would form an irrigation company, build the diversionary structures, and begin farming. When a later group of settlers would come, they would also go through the same process and file rights which would be secondary or junior to the previous group. Such a process could go on until the known supply of the river has been reached or exceeded.

As it is to be expected, the original companies at the time of their organization were very small, but as time progressed and more modern machinery became available the increasing activities in the various projects affected also the structure, form, and size of these companies. The canal system would become larger and the amount of land under cultivation would become similarly larger, within the limits of the overall amount of water which the particular streams were capable of producing. Such a situation was drastically altered when irrigation projects were built by the federal government. The large scale federal irrigation projects in addition to augmenting through interbasin exchanges would invariably impound all of the water which would be deemed as waste water, flood water, or excess, hold it in a reservoir and then release it at a future time in the form of supplemental water. Most areas have kept their original ajudicated water rights which are honored by the federal projects. Exceptions to this are the Salt River Project, the Newlands Project, the Eden Project and the Riverton Project. All of these areas were designed as consolidated systems and the water within them is owned by the irrigation company and the people who own the land. In all four of these systems the water is attached to the land and the water and the land are one entity.

The typical structure of irrigation companies or systems in the areas under examination consists of a board of directors or governors, a management sector, and operational or field personnel. The board of directors who is in charge of the irrigation company results through election by the members of the irrigation company. In situations where a water conservancy district exists the members of the board of these organizations are typically chosen by the courts and they are given a position of responsibility in determining the policy of the water conservancy district.

The role of a member of the board of directors revolves primarily around the formulation of broad policy guidelines. Whenever a given irrigation company needs a major decision the board of directors will meet, discuss the issue at hand, and decide, unless the decision is considered of extreme importance for the entire company then it is presented to the entire body of the irrigation company at the annual meeting for voting. Issues which are typically brought to a vote by the entire membership of the irrigation company involve the annual budget, or major changes within the system (such as the addition of

generators to the system, or the construction of new facilities), new impoundments, major overhauls of the canal system, etc.

Being on the board of directors has been described variably all the way from a thankless, miserable job, to one in which there is high prestige and a certain amount of personal satisfaction in doing the job. Size of company is not a necessary correlate for status achievement in a given board. All in all, the members of the board of directors are expected to fulfull the task of being a mediator for the individual irrigation water users and to carry forth their wishes and desires to the best of their ability. Needless to say, the smaller the system, the more direct the representation and the more intense the involvement in cases of grievances or conflicts.

The management sector of all irrigation companies or systems, with the exception of the intricate bureaucracy of the Salt River Project, has remained more or less informal. Managers or directors have received their training usually as an employee of the Bureau of Reclamation, or they may have learned to run the system through experience and knowledge, transmitted (especially in the past) through a long line of family involvement. Such training and experience is usually acquired through long field involvement, rather than formal training, use of documents or other forms of managerial skill improvement.

The supervision of the managers of irrigation companies falls under jurisdiction of the board of directors. The manager or superintendent, water master, or whatever the title may be, is in charge of the day-to-day operation of the irrigation company. He does not formulate or change general policy; he simply carries forth the policy formulated by the board of directors. The major task of the manager of an irrigation company is to oversee the activities of the people who are employed by him, such as ditch riders and other clerical people who maintain the records for the irrigation company. More than anything else managers are hired because of their knowledge of the irrigation system, their feel for the area, and perhaps, implicitly, for their ability to negotiate or resolve contention and/or conflict.

The influence of the shareholders on the management is rather minimal. The task of the management is to deliver the water at the appointed time and be sure that the amount of water which has been requested is delivered or the amount which the individual is entitled to is delivered. As long as this is done (and in most cases there have been no dramatic vagaries), the effect of the shareholders on the management is minimal if not neglibible.

Perhaps one of the more interesting parts in company involvement has to do with the election of various board members, an annual event where the primacy of full-time farmers becomes evident. The annual shareholders meeting is held during the day sometime in the winter. This is arranged so that individuals who are part-time farmers and who also have a vested but not pressing interest in water are for all intenses and purposes eliminated from attending the water meetings. The result is

that the part-time farmer who owns water but is holding down a full-time job is in essense unable to attend the meetings unless he has a very pressing issue which he wishes to present. Such an individual will vote by way of a proxy which in effect is nothing more than a vote for the status quo of the existing organization. Also, the part-time farmer typically holds a small percentage of the total number of shares within the organization and so even if he is dissenting his vote is so small that it makes little difference in terms of the overall voting situation. Thus, the people who most often attend the annual water meeting are the large, full-time farmers who own a lion's share of the water. What all these imply is that the larger farmers determine in practice the direction and broad guidelines for the operation of the farm and they tend to dominate the organization, guarding often jealously the status quo of the system. Change under such circumstances cannot usually come from the inside. In such a situation, given encroaching urbanization, suburban expansion, and industrial growth, such systems as Poudre Valley and Utah Valley are beginning to feel the pressure from external sources for organizational re-adjustment, better management, and, generally, responsiveness to a new and dynamic surrounding environment.

As to the general normative practices concerning water rights, one may observe that there is little room for maneuvering since the priority in terms of ajudicated rights is fixed in a legal statement which cannot be altered. Many times however, it becomes necessary to have the water delivered at times in which it is difficult if not impossible to receive the water under existing legal requirements. In such cases informal trades and exchange agreements have grown up in many areas which allow irrigation companies and individuals to trade water in the early part of the year when they have an abundant supply of water and receive back the water which they traded in the latter part of the year. These types of informal water trades and agreements tend to take place wherever water rights are not attached to the land. When water rights are attached to the land, as is the case in Arizona, Nevada, and Wyoming, the law will specifically prohibit informal transfers of water.

One last remark here concerning actual and perceived water use patterns. Throughout various areas of the study, there seems to exist limited knowledge as to particularities of water rights, organizational procedures, or policy implications. Water knowledge and perception of irrigation efficiency and effectiveness were items which were particularly examined both in interviews and in the surveys of Phase I, as important variables affecting consolidation efforts or determining predisposition for change. Later this item is more carefully scrutinized, but part of the problem challenge of consolidation has to do both with misconception and "false" apprehensions as to the water supply, adequate distribution, and effective use patterns. In most cases, the water supply of the system was considered adequate by the various water users. The people in the Eden Valley area, e.g., felt that their water supplies were barely adequate and many of them felt that they were not adequate. They could use more water. In other areas, such as the Riverton Valley area, the people although they had blatantly more water than

they were using. In fact, the canal system in the Riverton area was very large and very deep and the water flowed so slowly through these canals, simply because the people weren't using the the water, that large clumps of moss were growing in the canals.

In terms of patterns of water use, there are two main methods of scheduling or delivering water, rotation and demand. A third type could be a combination of demand supplied on a rotating basis. This last type occurs in situations where water demand is very high at a specific time and the company simply cannot deliver it because the canal system is not capable of delivering that much water. There seems to be a direct correlation between type of water scheduling and the size of land holding. Areas in which the land is very fragmented, such as the metropolitan Phoenix area, the water is delivered on a rotation basis, since it is impossible to satisfy the multitude of simultaneous demands of a large number of small shareholders. On the other hand, where large plots of land are found, such as the hinterland surrounding metropolitan Phoenix, demand is the rule rather than the exception. This is also the case in most of the large agricultural plots such as Eden Valley, Poudre Valley, Riverton, and Utah Valley, especially with the larger irrigation companies. In essence, then, the scheduling of water is dependent on two factors: a) the limitation of the canal system; and, b) the degree of land fragmentation in the particular area.

The amount of irrigation water needed and the number of irrigations needed varies from area to area and, of course, from crop to crop. It is very difficult to say how much is needed because of various intervening variables. For example, a small grain grown an a very sandy land would need a very large head of water in the early part of the irrigation season, but would need absolutely no water toward the latter part of July and August. Sugar beets, on the other hand, in a rather loamy soil would need a limited amount of water in the early season, but would need a great deal of water in the latter part of the season, and the irrigations would also have to be fairly frequent. It is at this point, that careful water budgets become extremely important for increasing the efficiency of a given irrigation system, through precise measurement and effective delivery operations.

The measurement of water is typically done by means of Parshall flumes which are very accurate. They will measure with within 2% the amount of water passing through them. The larger the irrigation company the more accurately the water is measured. Such projects as the Salt River Project measure their water with high accuracy. In the smaller irrigation companies, however, it is very difficult to determine whether the individual is getting his fair share or not. Someone up the ditch may have a head gate cracked and he is stealing water from the person who is supposed to be irrigating. The weir at the canal may not be open as far as it should be or it may be open too far and someone further down the canal is being cheated of their water. In many of the areas, particularly with the smaller irrigation companies, given the diversity of structures and the scale of operation, it is difficult to measure the water on the

individual land level. This problem is accentuated in water rich areas. There, the people are not as much concerned if they are getting all of their water or too much because there is more than enough to go around.

Consolidated and Non-Consolidated Systems: Some Preliminary Remarks

If one were to consider actual or potential consolidation of an irrigation system, immediate attention must be paid to existing water rights. These water rights can be satisfied in several ways. One is to build the project leaving the water rights untouched; simply supply the water rights and, then, all the water which is caught in the impoundment may be delivered as supplemental water to the people who wish to purchase it. Another way is to abolish all water rights and consolidate them as part of the new composite irrigation system. However, this type of merging disenfranchises in essence the original settlers and deprives them of the water right which they had. A third way of dealing with potential merging is the creation of a hierarchy of water rights under a consolidated system. The hierarchy of water rights in a water rich year becomes superfluous because everyone will receive water and everyone will receive the water which they are entitled to. But during a water poor year the hierarchy would be implemented by the existing authorities. Senior rights would receive but the junior rights would not receive their water. This ranking of irrigation water rights may overcome one of the main criticisms expressed when consolidation is discussed, namely the fear of senior rights in a water poor year.

Most agricultural water users are very interested in new ways of using water but they will not consider implementing changes unless they have tangible proof that a benefit will be derived from this alteration. This proof is sometimes very difficult to come by and many times the old timers simply will not look or will not discuss a solution which is on paper. They would have to see this benefit in actual practice before they would even consider using the innovation.

During the reconaissance of the irrigation areas of the study, there seem to appear some distinct differences between valleys which were consolidated and those which have a multitude of non-consolidated companies. Water users in non-consolidated areas were not as much concerned with water costs and they seemed to be quite satisfied with the prices they were presently paying. At the same time, they did not seem to be particularly concerned with water losses, such as seepage, phreatophytes, and any other loss which may be incurred. Their preoccupation was with water rights. The people who held senior water rights were extremely concerned that in times of water shortage or a poor water year, if they were under a consolidated system, they would not receive the amount of water which their present rights granted them. They wanted some form of clear-cut, hard, firm guarantee that they would receive their present water rights. Overall, water users in unconsolidated areas expressed satisfaction with the amounts of water they were receiving, the modes and methods of delivery, and for the most

part the large agricultural users seemed to be satisfied with the personnel of the irrigation company.

Agricultural water users in consolidated areas were much more capable of articulating the advantages of concerted action. Water delivery was one of the items of high satisfaction with water users in consolidated systems. They were able to receive their water in the amount which they order and more importantly they were able to order the water. Water available on demand seems to be the major differentiating item between consolidated and non-consolidated systems. The consolidated canals were larger and capable of carrying more water so that they could receive their water when they asked for it. Again, in all areas where consolidation prevails, it has been brought about by external forces rather than internal, voluntary demand for merging. Eden Valley was designed as a consolidated project, Salt River Project was designed to be a consolidated project, and so was the Newland Project. Ashley Valley is a rather unique situation, because the construction of the impoundment made necessary consolidation in order for the water users to obtain the water to which they were entitled.

The probability of new projects facilitating consolidation seems rather remote in most of the present areas simply because most of the water resources in the areas have now been exploited. The Central Utah Project will just about use all water available to the Utah Valley area as well as water which is available to the Ashley Valley area. Riverton and Eden Valleys have exploited their water. Eden does have an option of diverting water from the Sweetwater River but whether this will become a reality or not is a rather debatable point. The Salt River Valley and Poudre Valley both have exploited all the water that they possibly can. The Salt River Project will indirectly find a little relief from the Central Arizona Project but the water which will be available from the Central Arizona Project has already been filed for to such an extent that there are four times more applications than there is water potentially available to it. Thus, the external factor mentioned repeatedly above will be increasingly the changing socio-economic character of the areas, rather than massive schemes of water transfers or additional impoundments.

There is no reason to repeat again the advantages of consolidation (physical, legal, social, economic, etc.) that were mentioned at an earlier part of the report. As stated earlier to provide a better understanding of the challenge of consolidation is important not only to see the structural parameters--constraints and/or facilitators--characterizing the valleys of the study; it is equally crucial to understand the preparedness toward change and the web of attitudes towards water, irrigation organization, and the surrounding world in a given valley. To that purpose a major part of the present multi-disciplinary study was also directed towards a delineation of feelings towards consolidation, especially in the form of juxtaposition between consolidated and non-consolidated areas. The next section will present the general thrust of the survey, some preliminary findings, and explicate the overall design that will permit in Phase I comparison of four irrigation systems, i.e., Eden, Ashley, Poudre, and Utah.

Introduction: The Design of the Study

The general propositions guiding the systematic examination of an irrigation system have already been presented in Part II, pp 43. From the sociological point of view, attempts towards consolidation will also depend on the individual's knowledge and attitudes towards each of the major clusters of constraints and/or constraints (engineering, legal, socio-economic), as well as his overall orientation towards change and the future. This implies:

a) an understanding of the individual's interpretation of engineering, legal, and socio-economic constraints and/or facilitators;
b) an understanding of the individual's proclivity towards change (both organizational and socio-economic; and,
c) an understanding of the individual's perception of alternatives in the context of his knowledge of the irrigation system and of his level of satisfaction with present arrangements.

Emphasis in all the above is placed on the degree of congruence between satisfaction with present arrangements, the predisposition towards change, and the perception of alternatives that may affect in particular organizational effectiveness or an irrigation system's performance. Organizational effectiveness indicates the extent to which an organization, given certain resources and means, achieves its objectives without incapacitating its means and resources and without placing undue strain on its members. Finally, if organizational change is to take place, as a result of changes in external environmental conditions, such alterations will affect an irrigation system's structure and procedures either through different size, the addition of new capacities and technologies, the filling of different roles, or changes in the overall organizational form.

The earlier adoption of systems analysis has permitted us to elaborate a model where inputs (resources) processed through the system (functioning as means) will contribute to outputs (our achievement of objectives). For a given irrigation system, particularly the smaller ones and/or those characterized by inertia and highly traditional and informal means of operation, the key question is that of a movement away from a survival model (meeting objectives under marginal conditions of operation) to an effectiveness model, which includes both the conditions under which the structure is maintained and also the meeting of new conditions under which processes and activities may contribute effectively to the meeting of old and emerging goals and objectives. What is essentially implied in all the above is some measurement of goal attainment under given conditions and through a distinction between efficiency (which implies system performance with economic considerations as prime standards) and effectiveness (which utilizes mostly social considerations and the attainments of broader social objectives).

Rather than discussing further at this point the theoretical merits of the above definitions, it may be more useful to introduce the general design of the survey. Figure 43 summarizes the overall thrust of the survey and the major categories of variables of the questionnaire used for eliciting responses.

The basic approach used in this research has been what in methodological jargon is referred to as an "after-only" design. Although analogous to an experimental design, it lacks randomization and physical control over the independent variables; the effects of the independent variables are already present in the study population. Thus, the assignment of respondents into appropriate groups is made statistically rather than physically, as in the ideal experimental design. On the other hand, this is a flexible design, not only appropriate for field situations such as the one of the present study, but also flexible enough to allow simultaneous measurement of a variety of independent and dependent variables.

As mentioned above in Part II, the design of the questionnaire contains information around two major clusters of independent variables: socio-economic background of irrigation users and property characteristics of their holdings; and, the relationship and identification of the individual user with the particular irrigation company as well as a series of items referring to perceived dangers or anxiety from inadequacies of present conditions and/or from emerging trends in a given area. An intermediate variable of particular significance contains a cluster of questions around water use patterns of individual users. Finally, three clusters of variables contain the dependencies of the present research: the degree of traditionalism - modernism, the extent of satisfaction with present arrangements, and the perception of alternative or future courses of action.

For each of these categories of variables, appropriate indices and "scales" were constructed with the effort of creating at least ordinal measures of the variables involved. The items of the questionnaire (which is to be found in Appendix I) give an idea of the level of measurement attempted. Briefly, and without entering at this point into any detailed discussion of the methodological considerations or the problems encountered in establishing measurement equivalence (to be explicated in separate reports and in the final analysis of Phase II) the following "variables" or indicators of the design were utilized in the preliminary analysis of data:

1. Socio-economic background or gross assets (items)
2. Level of living (scale)
3. Property characteristics (items)
4. Relationship or participation in irrigation company (items)
5. Level of knowledge of irrigation affairs (scale)
6. Perception and level of anxiety (scale and items)
7. Structural characteristics of water use patterns (items)
8. Attitudes towards water use (scale)

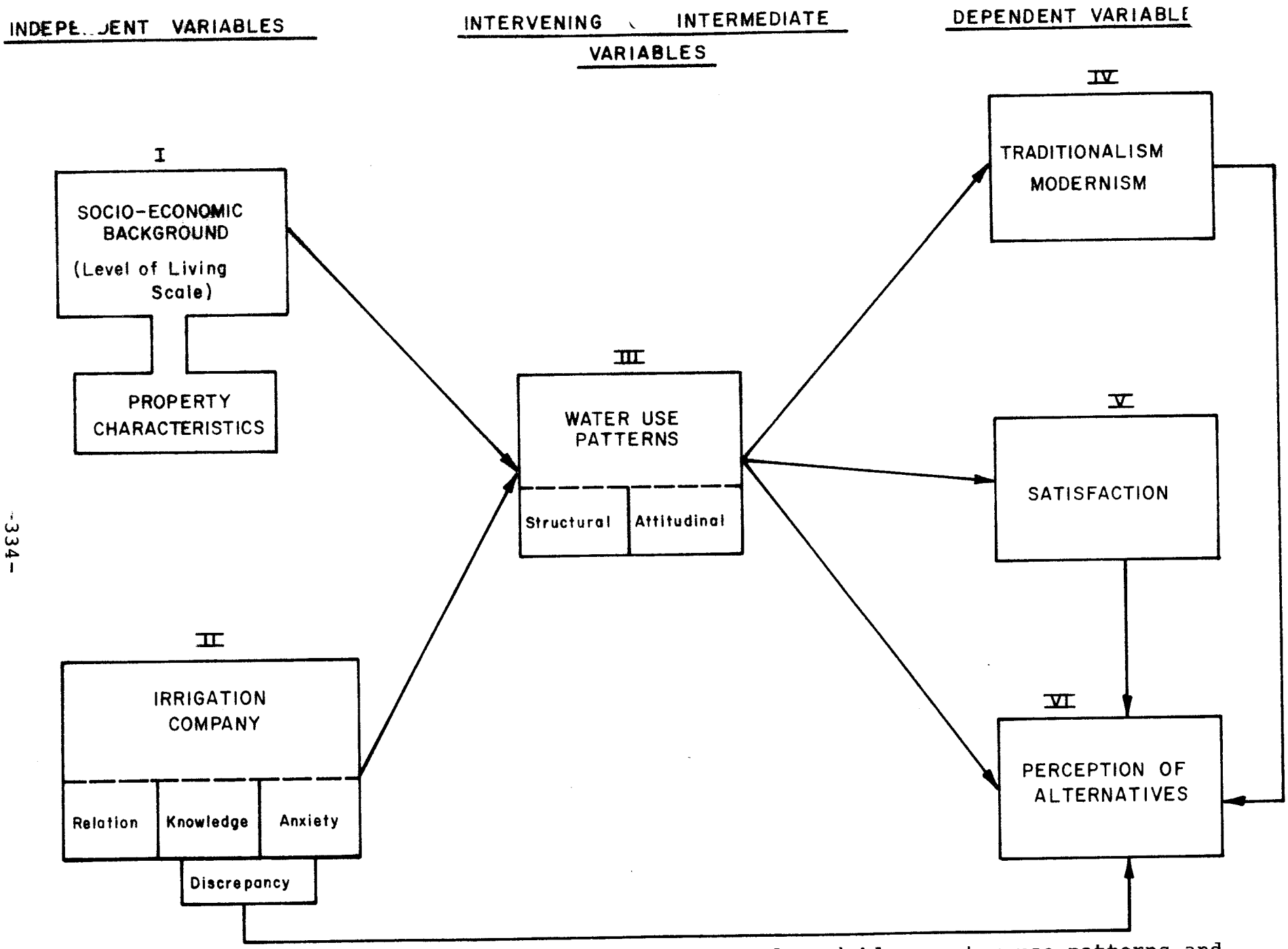


Figure 43. The design of the study relating background variables, water use patterns and individual's satisfaction and predisposition to change.

9. Modernity - traditionalism (scale)
10. Satisfaction with present arrangements (items)
11. Perception of alternatives (items)

As it can be seen, despite the construction of scales empirical differences made it imperative to use often components of scales as individual measures. Such individual measures are also additional guarantees for avoiding fallacies involved in ecological correlations, or fallacies committed when inferences made at one level of aggregation or on any subset of observation are to be applied to other levels or sets.

Before proceeding any further with the elaboration of the design and the presentation of results a few additional remarks are needed concerning the generation of items for the survey instrument. In addition to the review of literature for determinants of attitudes towards water resources items were solicited through earlier reconnaissance of the various areas and through the conduct of a series of interviews with officials of various irrigation companies. The last was not only important for the creation of a general profile of irrigation systems in each valley, but also for the identification of issues and persistent concerns in irrigated agriculture in each area. The schedule for this open-ended interview (the bulk of which was completed in the summer of 1970) can be found in Appendix II. A pretesting of the questionnaire during the fall and winter of 1970 made possible further focusing of the items, correction of questions, and addition of other items before the conduct of the survey in the summer of 1971.

The research design of the study provided the basis for the derivation of a series of hypotheses either directly from the general model of the present study or deductively by combination of two or more of the basic propositions stated in Part II. Using the categories of variables of Figure 43 an extensive number of hypotheses can be generated. Indicative of the vast number of relationships tested are the central hypotheses listed in Table 45.

Despite the arrows of the design and the testing of interrelationships, no causative model of analysis was attempted at this stage. It is envisaged that with the addition of two more areas in Phase II, a sequential process can be established such that a chain-like series of phenomena can be attributed the production of a given result. Even more, it would be ideal (and this is currently explored) to use recursive systems, i.e., systems in which two way causation is ruled out, thus yielding a pattern without reciprocal causation or feedback (a system that is presently idealized in the descriptive design of Figure 43).

In essence, then, since at this stage there is no emphasis on the testing of causal models (where one needs to satisfy such criteria as high correlation between variables adjacent in the system, or that partial correlations, holding the intervening factors constant, should approximate zero). This first analysis of data is leased on a descriptive presentation of major results. At the same time, besides descriptive

Table 45. Central hypotheses developed for general model.

I → III

Socio-Economic Background (Level of Living Scale) → Water Use Patterns: Structural | Attitudinal

1.0 The higher the level of living the lower the tendency to keep the old irrigation policy.
1.1 The higher the level of living the higher the water satisfaction.
1.2 The higher the level of living the higher the modernism score.
1.3 The higher the level of living the higher the water knowledge.

I → III

Property Characteristics → Water Use Patterns: Structural | Attitudinal

2.0 The higher the total acres operated the higher the tendency to keep the old irrigation policy.
2.1 The higher the total acres operated the higher the water satisfaction.
2.2 The higher the total acres operated the higher the modernism score.
2.3 The higher the total acres operated the higher the water knowledge.
3.0 The higher the sum of ownership the higher the tendency to keep the old irrgation policy.
3.1 The higher the sum of ownership the higher the water satisfaction.
3.2 The higher the sum of ownership the higher the modernism score.
3.3 The higher the sum of ownership the higher the water knowledge.

II → III

Irrigation Company: Relation | Knowledge | Anxiety → Water Use Patterns: Structural | Attitudinal

1.0 The higher the feeling of belonging to the company the higher the tendency to keep the old irrgation policy.
1.1 The higher the feeling of belonging the company the higher the satisfaction score.
1.2 The higher the feeling of belonging to the company the lower the modernism score.
1.3 The higher the feeling of belonging to the company the higher the water knowledge.
2.0 The higher the water knowledge the higher the tendency to keep the old irrigation policy.
2.1 The higher the water knowledge the higher the satisfaction.
2.2 The higher the water knowledge the lower the modernism score.
3.0 The higher the administrative effectiveness score the higher the tendency to keep old irrigation policy.
3.1 The higher the administrative effectiveness score the higher the satisfaction.
3.2 The higher the administrative effectiveness score the lower the modernism score.
3.3 The higher the administrative effectiveness score the higher the water knowledge.

III → IV

Water Use Patterns: Structual | Attitudinal → Traditionalism Modernism

1.0 The higher the tendency to keep old irrigation policy the lower the modernism score.
2.0 The higher the water satisfaction the lower the modernism scale.
2.2 The higher the water knowledge the lower the modernism score.

III → V

Water Use Patterns: Structural | Attitudinal → Satisfaction

3.0 The higher the tendency to keep old irrigation policy the lower the satisfaction.
4.1 The higher the modernism score the lower the satisfaction.
4.2 The higher the water knowledge the higher the satisfaction.

III → IV

Water Use Patterns: Structural | Attitudinal → Traditionalism Modernism

5.0 The higher the tendency to keep the old irrigation policy the lower the alternatives to system.
6.0 The higher the water satisfaction the lower the alternatives to the system.
7.0 The higher the modernism score the higher the alternatives to the system.
8.0 The higher the water knowledge the lower the alternatives to the system.

II → VI

Irrigation Company: Relation | Knowledge | Anxiety → Perceptions of Alternatives

1.0 The higher the tendency to keep the old irrigation policy the lower the alternatives to the system.
3.0 The higher the admisistrative effectiveness the lower the alternatives to the system.

statistics, measures of association for ordinal data were also used (such as Kendal's tau). Later analysis with Goodman and Kruskal's gamma has been used, especially because the measurement is imprecise and because the cross-sectional nature of observations may tend to minimize observed association (an additional methodological consideration for the wider adoption of gamma--especially in Phase II--is that it qualifies as a proportional reduction of error statistic).

As in many similar cases, there is no agreement or standard criterion as to the strength of a given statistical relationship. It is widely accepted, however, that relationships below .20 are slight (almost negligible relationship); between .20-.40 low correlation (definite but small relationship); between .40-.70 moderate correlation (substantial relationship); between .70-.90 high correlation (marked relationship); and, above .90 very high correlation (very dependable relationship). On the other hand, given the type of data and the non-experimental character of most sociological work, many sociologists argue that any relationship above .50 can be considered as strong.

Tests of significance were also run since the study involved a sampled population. The most widely accepted level of significance is .05, which although used in the following analysis, it does not necessarily constitute a sacred barrier for the acceptance or rejection of a relationship.

Again, as it was emphasized throughout the present report because of the descriptive character of Phase I, there is no special effort to dwell on detailed analysis of both primary and secondary data. The section that follows is intended to provide a generalized impression and overview of the findings of the survey. Further, detailed testing and "causal" inferences will be attempted with the data collected during Phase II. Ultimately a combination of four different areas, under a variety of socio-economic conditions and with the major distinction between consolidated and non-consolidated systems, may provide the comparative framework for a cogent analysis of factors affecting consolidation efforts.

Attitudes Toward Consolidation: From the Preliminary Findings in Eden and Ashley Valleys

A total of 51 respondents in Eden Valley, and 184 in Ashley Valley comprise the sample in these two areas. Rather than describing in detail the various characteristics of the respondent, we want to concentrate at this point on questions relating primarily to water satisfaction, knowledge of the system and perception of alternatives.

Despite their intensive use of water in both valleys, most users can be generally described as relatively uninformed as to water rights or how much water the company is entitled to. In fact, almost 80 percent of the respondents in both areas, in answering the water knowledge scale, could be described as poorly informed about the exact dimensions of the surrounding water rights. Such a measure of the lack of general water knowledge is not necessarily a reflection of ignorance as to

their own personal property or as to the water allocated to their land. Most of them had a fair idea of the amount of water which they were entitled to, but they were not really informed in terms of how the irrigation company allocated the water to them, how the irrigation company came about deciding as to how much water was allocated to them; and, finally, they had little knowledge of the workings of the company or the officials in the organization. Interestingly enough, about 75 percent of the water users did state that they were satisfied with the water that they were receiving and with the way that is was delivered to them. Thus, it may be inferred that the lack of water knowledge is dependent on their satisfaction and the resulting apathy as to the exact details of administering the water.

Again for both valleys, a great deal of satisfaction was expressed concerning the water master, the irrigation company and the ditch rider. Almost universally in both valleys, the water users described the activity of these three categories as being quite satisfactory, with only a few complaints against the procedures used by the administrators in the company for delivering their water. Yet, when the water users were questioned concerning their knowledge of such people as the river commissioner, the state engineer's office, the bureau of reclamation, and generally about the larger environment affecting irrigation in their valleys, a pervasive negativism tended to characterize responses concerning "outsiders." For example, the Bureau of Reclamation in Eden Valley seemed to be the butt of a great deal of hostility on the part of the water users, primarily because it was widely felt that the Bureau of Reclamation had not satisfactorily completed the irrigation project in the valley, nor had it satisfactorily allocated the water to the users in the valley. Similarly, the water users in Ashley Valley expressed some hostility toward the Central Utah Project and the Bureau of Reclamation lumped together as the culprits for taking good water from Ashley Creek and substituting it with not as good water from the Green River.

Despite such broad agreement as to overall satisfaction between a consolidated system and a relatively non-consolidated system, there are some important differences emerging in these two cases. We may look, therefore, a little bit closer on some select items of the questionnaire in each of these two valleys.

Eden. According to the results of the study, 86.3 percent of the land owners in Eden Valley owned and operate their own tracts of land. This is the main source of income for the majority of these individuals and, thus, they do have a great deal of vested interest in the output from their agricultural endeavors (Table 46). On the other hand, more than three quarters of the farmers in the Eden Valley irrigate tracts which are larger than 100 acres (76.5 percent), and slightly more than 1/4 of these agricultural land users have tracts of land which constitute areas greater than 300 acres (Table 47). Since the majority of the farmers in Eden Valley are involved in a full-time agricultural pursuit, they are very deeply concerned with the irrigation company, exercising their voice in the irrigation

Table 46. Results of Eden Valley sociological investigations (Variable 011 sum of land ownership).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Owner operator	1.00	44	86.3	88.0	88.0
Part owner	2.00	2	3.9	4.0	92.0
Mostly rented	3.00	2	3.9	4.0	96.0
Other	4.00	2	3.9	4.0	100.0
	0.00	1	2.0	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 50

Missing observations - 1

Table 47. Results of Eden Valley sociological investigations (Variable 036 shares water owned).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Small owner	1.00	8	15.7	17.0	17.0
Medium owner	2.00	25	49.0	53.2	70.2
Large owner	3.00	14	27.5	29.8	100.0
	0.00	4	7.8	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 47

Missing observations - 4

company, attempting to extract as much from their land as possible and vitally concerned with getting their fair share of the water. Yet, when interviewed, 43.1 percent of the irrigation users felt that they only had little influence in the irrigation company with only 3.9 percent feeling that they had quite a bit of influence in the running of the main company (Table 48). However, when asked how much "say" members should have about how the irrigation company is run, 43.5 percent answered strongly for more input. All in all, many of the respondents felt that the outcome of decisions in the irrigation company was in no way influenced by their participation or voicing of complaints.

Turing now to specific items of satisfaction or dissatisfaction with the system, of all the interviews conducted in Eden Valley, 92.2 percent of the water users replied that they were at least somewhat satisfied with the water master and the procedures which he uses to deliver their water, and 54.9 percent said they felt that his activities were very effective (Table 49). It should be pointed out that the water master is an employee of the farmers, recruited by them after he retired from the Bureau of Reclamation. Similar feelings were also expressed about the ditch rider. About 90.2 percent of the respondents felt that the ditch rider was at least somewhat effective and 49.0 percent felt that he was very effective in carrying forth his duty. In the same vein, when the people were questioned about the irrigation company and how satisfied they were with its operation, only 27.5 percent found it very effective (Table 50). This contrasts with 39.2 percent of the respondents who felt that they definitely identify with their irrigation company (Table 51). (Interestingly enough, 68.0 percent of respondents attend regularly the annual meetings).

An interesting question affecting both the satisfaction with and the operation of a company has to do with water rights. Table 52 summarizes the feelings of the respondents towards the rewriting of existing water law. Similar feelings of disagreement were also registered when a question was asked about the usefulness of the prior appropriation doctrine (Table 53). Yet, there are widespread feelings that the old ways of irrigation policies are not the best as it is attested from Table 54. Indeed, both the data of the survey, formal interviews, and participant observation pointed out that water users in the area were willing to listen and if the proposed activity seemed feasible, they were willing to try it and make every attempt to use their water to the absolute best. When these farmers were asked if they could even further maximize their water use, 37.3 percent reported that they perceive of other alternatives to the present irrigation system (Table 55). When probed about this item, responses centered around such ideas as importation of water from another watershed and the construction of transmountain diversions.

When the agricultural water users were questioned in terms of their general satisfaction with water, almost three fourths expressed satisfaction with the irrigation activities in the valley, though a good number of them said that they would like to see a provision made so that the existing water could be

Table 48. Results of Eden Valley sociological investigations (Variable 047 influence you have on co.).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Quite a bit	2.00	2	3.9	3.9	3.9
Some	3.00	16	31.4	31.4	35.3
Very little	4.00	22	43.1	43.1	78.4
None at all	5.00	11	21.6	21.6	100.0
	0.00	0	0.0	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

Table 49. Results of Eden Valley sociological investigations (Variable 079 water master).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Dont know	0.00	4	7.8	7.8	7.8
Relative ineffective	2.00	1	2.0	2.0	9.8
Somewhat effective	4.00	18	35.3	35.3	45.1
Very effective	5.00	28	54.9	54.9	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

Table 50. Results of Eden Valley sociological investigations (Variable 081 the irri. co.).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Dont know	0.00	6	11.8	11.8	11.8
Absolute ineffective	1.00	1	2.0	2.0	13.7
Relative ineffective	2.00	1	2.0	2.0	15.7
Undecided	3.00	9	17.6	17.6	33.3
Somewhat effective	4.00	20	39.2	39.2	72.5
Very effective	5.00	14	27.5	27.5	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

Table 51. Results of Eden Valley sociological investigations (Variable 049 you identify with the co.).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Very much	1.00	9	17.6	17.6	17.6
Quite a bit	2.00	11	21.6	21.6	39.2
Somehow	3.00	9	17.6	17.6	56.9
Very little	4.00	17	33.3	33.3	90.2
None at all	5.00	5	9.8	9.8	100.0
	0.00	0	0.0	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

Table 52. Results of Eden Valley sociological investigations (Variable 088 rewrite water laws).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Strongly agree	1.00	6	11.8	12.0	12.0
Agree	2.00	8	15.7	16.0	28.0
Undecided	3.00	19	37.3	38.0	66.0
Disagree	4.00	14	27.5	28.0	94.0
Strongly disagree	5.00	3	5.9	6.0	100.0
	0.00	1	2.0	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 50
Missing observations - 1

Table 53. Results of Eden Valley sociological investigations (Variable 094 prior appropriation not used).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Strongly agree	1.00	2	3.9	4.1	4.1
Agree	2.00	8	15.7	16.3	20.4
Undecided	3.00	11	21.6	22.4	42.9
Desagree	4.00	20	39.2	40.8	83.7
Strongly disagree	5.00	8	15.7	16.3	100.0
	0.00	2	3.9	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 49
Missing observations - 2

Table 54. Results of Eden Valley sociological investigations (Variable 108 irri. best with old ways).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Ajdusted Frequency (Percent)
Strongly agree	1.00	1	2.0	2.1	2.1
Agree	2.00	6	11.8	12.5	14.6
Undecided	3.00	4	7.8	8.3	22.9
Disagree	4.00	35	68.6	72.9	95.8
Strongly disagree	5.00	2	3.9	4.2	100.0
	0.00	3	5.9	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 48

Missing observations - 3

Table 55. Results of Eden Valley sociological investigations (Variable 115 alternatives to system).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Yes	1.00	19	37.3	37.3	37.3
No	2.00	19	37.3	37.3	74.5
No opinion	3.00	13	25.5	25.5	100.0
	0.00	0	0.0	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

allocated in different patterns in different situations (Table 56). For example, many times a farmer will find himself in a situation where he simply is not able to use all of the water which is allocated to him. This might be due to a particular crop that he is growing which does not need a lot of water. So the water surplus which he has simply is left in the reservoir and at the end of the year the water is lost. The water users expressed concern and desire that this water could be loaned, sold, traded, or whatever else to other users who might find themselves in need of water in the particular year that it was being used.

Again, as it was pointed out earlier, a good number of the agricultural water users, even in such a small area as Eden Valley, could be termed as poorly informed of their water rights as measured by a series of questions concerning knowledge of the irrigation system. In fact, 82.4 percent of the mostly large water users in Eden Valley could be described as poorly informed (see also Table 57). Since the responses to this particular scale were so low, the scale has been examined several times in terms of face validity. No particular flaws in the face validity can be detected, and thus the only explanation remaining has to do with the lack of in-depth knowledge as to what is going on within the irrigation system of the area.

The impounding structure in Eden Valley has been in existence for over ten years, but the Bureau of Reclamation has been putting the finishing touches on the delivery system for the past several years. This involves the construction of new turnouts for water delivery, increasing the size of the ditches and in some cases relining ditches when the first lining has collapsed. This Bureau work seems to be one of the sore points of the water users in the valley. The water users are expressing concerns that the Bureau has not lived up to its end of the bargain and as a result, until 1972, the water users were refusing to pay the water contract which had been negotiated with the government for the construction of the project. So when the water users were asked about the need for improvement on the irrigation system this strikingly new irrigation project was described by 72.6 percent of the water users as needing at least a minimum of betterment for proper delivery (Table 58).

Speaking of improvements and change, if the scale of administrative effectiveness is taken as a single item, 62.7 percent of the water users agree that the water administration in the valley was not particularly effective (Table 59). This statement seems to apply more to the Bureau of Reclamation than to the water masters, the ditch riders, and the irrigation company when it will be recalled, have scored very high in previous questions.

To close this rather cursory overview of some selected findings in the survey, two additional items may illuminate some of the central questions raised. One has to do with the users evaluation of his irrigation efficiency (Table 60). When asked so, 25.5 percent answered negative, a rather significant proportion when added to those who were not sure (13.7

Table 56. Results of Eden Valley sociological investigations (Variable 150 water satisfaction).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Undecided	3.00	13	25.5	25.5	25.5
Agree	4.00	34	66.7	66.7	92.2
Strongly agree	5.00	4	7.8	7.8	100.0
	0.00	0	0.0	Missing	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

Table 57. Results of Eden Valley sociological investigations (Variable 147 sum of water knowledge).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Highly knowable	1.00	2	3.9	3.9	3.9
Knowable	2.00	7	13.7	13.7	17.6
Somewhat knowable	3.00	14	27.5	27.5	45.1
Ignorant	4.00	28	54.9	54.9	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

Table 58. Results of Eden Valley sociological investigations (Variable 148 sum irri. improvement).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Dont know	0.00	2	3.9	3.9	3.9
Low improve	1.00	12	23.5	23.5	27.5
Medium improve	2.00	19	37.3	37.3	64.7
Some improve	3.00	11	21.6	21.6	86.3
High improve	4.00	7	13.7	13.7	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

Table 59. Results of Eden Valley sociological investigations (Variable 149 administration effective).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Dont know	0.00	5	9.8	9.8	9.8
Absolute ineffective	1.00	12	23.5	23.5	33.3
Relative ineffective	2.00	20	39.2	39.2	72.5
Undecided	3.00	6	11.8	11.8	84.3
Somewhat effective	4.00	6	11.8	11.8	96.1
Very effective	5.00	2	3.9	3.9	100.0
	Total	51	100.0	100.0	100.0

Valid observations - 51

Missing observations - 0

Table 60. Results of Eden Valley sociological investigations (Variable 061 do you irri. efficiently).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Yes	1.00	29	56.9	59.2	59.2
No	2.00	13	25.5	26.5	85.7
Not sure	3.00	7	13.7	14.3	100.0
	0.00	2	3.9	Missing	100.0
	Total	51	100.0	100.0	100.0

Table 61. Results of Ashley Valley sociological investigations (Variable 011 sum of land ownership).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Owner operator	1.00	151	82.1	83.4	83.4
Part owner	2.00	13	7.1	7.2	90.6
Mostly rented	3.00	14	7.6	7.7	98.3
Other	4.00	3	1.6	1.7	100.0
	0.00	3	1.6	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 181

Missing ovservations - 3

percent). It is interesting to notice in this respect, that the proportion for a non-consolidated system, such as Ashley is about the same, with 29.3 percent characterizing their irrigation procedures as relatively inefficient.

Finally, while there is much analysis to be done, one particular question needs immediate attention. When respondents were asked to rank various alternatives for improving the performance of the water system, 10.5 percent of those answering the questions in Eden Valley indicated consolidation, an obvious answer to an already consolidated system. On the other hand, in the similar question in Ashley Valley 54.2 percent (the majority of respondents) forwarded consolidation as an important means for improving the water system. It is also interesting to notice, that in the last case, in a subsequent question, 25.9 percent consider better management as one of the distinct advantages of consolidation.

Ashley Valley. Parallel tables and remarks can also be made for the other area of the survey. However, the agricultural water users in Ashley Valley are somewhat different than the users in Eden because the majority are not full-time agricultural people as was found in Eden Valley. In Ashley it has been estimated that somewhere between ten and twenty individuals are full-time farmers. The rest of the people range in terms of water users who own a small tract of land, or several fragmented tracts of land on down to the individual who simply uses irrigation water to water a small garden or his lawn. Nevertheless, 82.1 percent of all land owners in Ashley Valley do own and operate their own land (Table 61). Again, this includes people in town who are just watering a small garden. Of this group 72.8 percent of the land owners can be classified as small and 16.3 percent can be described as medium or larger (Table 62). In this case medium would mean those who are involved in irrigating 100 to 300 acres of land. There were thirteen individual farmers who owned tracts of land greater than 300 acres.

Of the individuals interviewed in Ashley valley, 33.8 percent felt that they had at least some influence on the irrigation company with 3.3 percent of the group claiming strong influence on the affairs of the irrigation company (Table 63). This implies that the majority of the population feel that they had nearly no voice in the activities of the irrigation company and that when it came to influencing decisions, their inputs would be in their opinion marginal at best.

Following the same examples of selected findings as in Eden Valley, 84.3 percent of all water users stated that they were at least somewhat satisfied with the water master and the procedures which he was using to deliver their water (Table 64). Almost half (49.5 percent) went so far as to say they felt the water master was very effective in carrying out his assigned duties for the irrigation company. The ditchrider also was favorably described, with 78.3 percent of the respondents indicating that ditch riders were somewhat effective in carrying out their duties. In terms of overall satisfaction with the irrigation company, 71.2 percent replied that the company was at least

Table 62. Results of Ashley Valley sociological investigations (Variable 036 shares water owned).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Small owner	1.00	134	72.8	81.7	81.7
Medium owner	2.00	17	9.2	10.4	92.1
Large owner	3.00	13	7.1	7.9	100.0
	0.00	20	10.9	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 164

Missing observations - 20

Table 63 Results of Ashley Valley sociological investigations (Variable 047 influence you have on co.).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Very much	1.00	6	3.3	3.4	3.4
Quite a bit	2.00	15	8.2	8.4	11.8
Some	3.00	41	22.3	23.0	34.8
Very little	4.00	66	35.9	37.1	71.9
None at all	5.00	50	27.2	28.1	100.0
	0.00	6	3.3	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 178

Missing observations - 6

Table 64. Results of Ashley Valley sociological investigations (Variable 079 water master).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Dont know	0.00	16	8.7	8.7	8.7
Absolute ineffective	1.00	1	.5	.5	9.2
Relative ineffective	2.00	5	2.7	2.7	12.0
Undecided	3.00	6	3.3	3.3	15.2
Somewhat effective	4.00	64	34.8	34.8	50.0
Very effective	5.00	91	49.5	49.5	99.5
	9.00	1	.5	.5	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 184

Missing observations - 0

Table 65. Results of Ashley Valley sociological investigations (Variable 081 the irri. co.).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Dont know	0.00	23	12.5	12.5	12.5
Absolute ineffective	1.00	3	1.6	1.6	14.1
Relative ineffective	2.00	8	4.3	4.3	18.5
Undecided	3.00	19	10.3	10.3	28.8
Somewhat effective	4.00	85	46.2	46.2	75.0
Very effective	5.00	46	25.0	25.0	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 184

Missing observations - 0

somewhat effective in carrying out tasks of delivering the water, as contrasted to 66.7 percent for the same category in Eden Valley (Table 65). On the other hand a small proportion identifies definitely with the company (25.0 percent) as contrasted to 39.2 percent in Eden (Table 66).

When legal matters were discussed with the water users it was found that many of the water users were quite uninformed concerning the water laws. When the question was asked concerning the rewriting of water laws the distribution in Table shows significant variation from that of the respondents in Eden Valley. The same is also true for their feelings concerning changes to the prior appropriation doctrine (Table).

When the respondents were asked questions concerning the old ways of irrigation, 70.7 percent reported that the old ways were not necessarily the best ways (Table 69). Yet, once again, when the respondents were questioned concerning alternatives to the present system, 33.7 percent recommended a series of alternatives (with consolidation ranking the highest among them) (Table 70). It should be pointed out, that when the people of Ashley Valley talk about consolidation, they do not necessarily refer to the amalgamation of the irrigation offices which are consolidated into the Ashley Valley Users Association. Their concern is more with the canals themselves, their reconstruction and consolidation into larger, newer and more efficient structures. Finally, in terms of overall satisfaction the distribution of responses is fairly similar to that of Eden Valley (Table 71).

As it should be expected a higher proportion of users in Ashley Valley (especially among smaller water users) are relatively ignorant of the intricacies involved in water management and the system operation (Table 72).

Since the merging of the five irrigation companies at the time of the construction of the Steinaker canal, the area has been improved by the construction of the service canal which supplies about half of the water users in the valley. Contrasted to Eden Valley, less people seemed to be interested in significant further improvements (Table 73), although overall percentages of interest seem to be about the same (67.4 percent for Ashley as contrasted to 72.6 for Eden).

The last table here (Table 74) refers to administrative effectiveness as an indication of areas needing further improvement. Here, a significantly lower number of respondents (47.3 percent as contrasted to 62.7 percent in Eden) found present administration somewhat ineffective. At the same time, those who did not know or were undecided was larger, a reflection of both the size and character of the valley and of the lack of the expressed hostile climate towards outside agencies in the case of Eden.

A similar long list of other variables is contained in the analysis of the two systems. Parallel to this a large number of cross-tabulations has been made in order to unearth further

Table 66. Results of Ashley Valley sociological investigations (Variable 049 you identify with the co.).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Very much	1.00	14	7.6	8.0	8.0
Quite a bit	2.00	32	17.4	18.2	26.1
Somehow	3.00	41	22.3	23.3	49.4
Very little	4.00	63	34.2	35.8	85.2
None at all	5.00	26	14.1	14.8	100.0
	0.00	8	4.3	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 176

Missing observations - 8

Table 67. Results of Ashley Valley sociological investigations (Variable 088 rewrite water laws).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Strongly agree	1.00	9	4.9	5.0	5.0
Agree	2.00	22	12.0	12.3	17.3
Undecided	3.00	96	52.2	53.6	70.9
Disagree	4.00	47	25.5	26.3	97.2
Strongly disagree	5.00	5	2.7	2.8	100.0
	0.00	5	2.7	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 179

Missing observations - 5

Table 68. Results of Ashley Valley sociological investigations (Variable 094 prior appropriation not used).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Strongly agree	1.00	4	2.2	2.2	2.2
Agree	2.00	27	14.7	15.2	17.4
Undecided	3.00	79	42.9	44.4	61.8
Disagree	4.00	51	27.7	28.7	90.4
Strongly disagree	5.00	17	9.2	9.6	100.0
	0.00	6	3.3	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 178
Missing observations - 6

Table 69. Results of Ashley Valley sociological investigations (Variable 108 irri. best with old ways).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Strongly agree	1.00	5	2.7	2.8	2.8
Agree	2.00	28	15.2	15.5	18.2
Undecided	3.00	20	10.9	11.0	29.3
Disagree	4.00	116	63.0	64.1	93.4
Strongly disagree	5.00	12	6.5	6.6	100.0
	0.00	3	1.6	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 181
Missing observations - 3

Table 70. Results of Ashley Valley sociological investigations (Variable 115 alternatives to system).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Yes	1.00	62	33.7	35.6	35.6
No	2.00	49	26.6	28.2	63.8
No opinion	3.00	63	34.2	36.2	100.0
	0.00	10	5.4	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 174
Missing observations - 10

Table 71. Results of Ashley Valley sociological investigations (Variable 150 water satisfaction).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Strongly disagree	1.00	2	1.1	1.1	1.1
Disagree	2.00	1	.5	.6	1.7
Undecided	3.00	42	22.8	23.2	24.9
Agree	4.00	124	67.4	68.5	93.4
Strongly agree	5.00	12	6.5	6.6	100.0
	0.00	3	1.6	Missing	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 181
Missing observations - 3

Table 72. Results of Ashley Valley sociological investigations (Variable 147 sum of water knowledge).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
	0.00	3	1.6	1.6	1.6
Highly knowable	1.00	8	4.3	4.3	6.0
Knowable	2.00	10	5.4	5.4	11.4
Somewhat knowable	3.00	25	13.6	13.6	25.0
Ignorant	4.00	138	75.0	75.0	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 184
Missing observations - 0

Table 73. Results of Ashley Valley sociological investigations (Variable 148 sum of irri. improvement).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Dont know	0.00	21	11.4	11.4	11.4
Low improve	1.00	39	21.2	21.2	32.6
Medium improve	2.00	66	35.9	35.9	68.5
Some improve	3.00	40	21.7	21.7	90.2
High improve	4.00	18	9.8	9.8	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 184
Missing observations - 0

Table 74. Results of Ashley Valley sociological investigations (Variable 149 administrative effectiveness).

Value Label	Value	Absolute Frequency	Relative Frequency (Percent)	Adjusted Frequency (Percent)	Cumulative Adjusted Frequency (Percent)
Dont know	0.00	30	16.3	16.3	16.3
Absolute ineffective	1.00	51	27.7	27.7	44.0
Relative ineffective	2.00	36	19.6	19.6	63.6
Undecided	3.00	33	17.9	17.9	81.5
Somewhat effective	4.00	21	11.4	11.4	92.9
Very effective	5.00	13	7.1	7.1	100.0
	Total	184	100.0	100.0	100.0

Valid observations - 184

Missing observations - 0

relationships between. In addition a series of matrices for relationships have been constructed in order to unearth factors associated with the key variables of the study, such as perception of alternatives and proclivity to change (see Tables 75 and 76).

Given the limited situation of the two valleys in providing a true testing ground of attitudes toward consolidation, the analysis of data was more centered towards a preparation for Phase II, rather than presentation of results of this stage. What is envisaged is, therefore, an in-depth elaboration of the present data in combination with additional material collected in two truly controversial cases for consolidation, Poudre and Utah Valleys. Thus, four systems can provide us with a wider spectrum for meaningful inference and for juxtaposition of attitudes concerning present irrigation practices and potential for improvement.

It is more important at this point, rather than elaborating further the primary data of these two systems, to turn our attention to a recapitualtion of the problem of Phase I, re-emphasize the descriptive parameters of the effort, and, thus, prepare the ground for both conceptual improvements and specific operations for Phase II.

TOWARD A CONCEPTUAL SYNTHESIS

Irrigation has played throughout history a strategic role in the continuous course of agricultural development. Irrigated agriculture provided, and continues to provide, the agrarian basis of society. An important point always to be discussed with an historical overview of irrigated agriculture is that after the basic or central productive goal of an irrigation system is achieved, i.e., sufficient production for survival and economic growth, other social goals also appear which greatly complicate the institutional arrangements of an irrigation system. Such developments and goals, however, carry with them both benefits and disadvantages. On the one hand, the control of water resources and the establishment of an irrigated system of agriculture in places where rainfall is inadequate or unreliable permit the establishment of highly productive agricultural practices, followed by an expansion of human population and economic growth. On the other hand, an irrigation system carries with it not only certain technological imperatives which cannot be ignored, but also important social constraints for the operation of what will eventually become a highly complex system.

Thus, as societies become much more complex and diversified and demands continuously increase and expand in scope and intensity, the use of scarce water resources and the increasing preoccupation with preservation of the natural environment become much more important concerns in concerted planning. In any water resource development, three major problematic situations give rise to a continuous re-examination of the parameters of the water use system:

Table 75. Matrix X relationships for selected variables in Eden Valley.

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
X_1	Land Owned		.21*	.01	.30*	.15*	.21*	.11	.11	.23	.12	.14	.05	.23*	.22*
X_2	Water Owned			-.13	.17*	.02	.37*	.02	.07	.04	.00	.24*	.15	.15	.36*
X_3	Your Influence in the Company				-.14	.04	.26*	.05	.13	.08	.04	.13	.01	.23*	.22*
X_4	Effectiveness of the Water master					.45*	.49*	.01	.04	.15	.19*	.08	.01	.49*	.21*
X_5	Effectiveness of the Ditch Rider						.28*	.18*	.16*	.03	.34*	.10	.11	.24*	.01
X_6	Effectiveness of The Irrigation Co							.18*	.05	.24*	.05	-.17*	.13	.55*	.40*
X_7	Water laws should be Rewritten								.27*	.29*	.09	-.03	.16*	.05	.13
X_8	Prior Appropriation is no longer needed									.19*	.06	.09	.07	.03	.15
X_9	The old Irrigation Policy is best										.14	.01	.02	.31*	.03
X_{10}	Alternatives to the Present System											.13	.07	.06	.06
X_{11}	Water Knowledge												.04	.17*	-.14
X_{12}	Need for irrigation System Improvement													.02	.31*
X_{13}	Administrative Effectiveness														.22*
X_{14}	Water Satisfaction														

*Significant at the .05 level

Table 76. Matrix of relationships for selected variables in Ashley Valley.

		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
X_1	Land Owned		-.01	.04	.08*	.15*	.03	.10*	.05	.12*	.07	.10*	.02	.08*	.06
X_2	Water Owned			.25*	-.04	.00	.07	.06	.17*	.02	.21*	.29*	.09*	.12*	.14*
X_3	Your Influence in the Company				.09*	.03	.13*	.00	.26*	.03	.18*	.26*	.22*	.14*	.18*
X_4	Effectiveness of the Water master					.59*	.42*	.06	.05	.08*	.01	.05	.02		
X_5	Effectiveness of the Ditch Rider						.42*	.08*	.03	.09*	.00	.04	.00	.34*	.05
X_6	Effectiveness of The Irrigation Co							.06	.21*	.11*	.15*	.16*	.00	.49*	.27*
X_7	Water Laws should be Rewritten								.18*	.00	.11	.02	.03	.09*	.20*
X_8	Prior Appropriation is no longer needed									.06	.17*	.17*	.03	.23*	.36*
X_9	The old Irrigation Policy is best										.06	-.14*	.01	.13*	.20*
X_{10}	Alternatives to the Present System											.28*	.19*	.22*	.07
X_{11}	Water Knowledge												.11*	.27*	.16*
X_{12}	Need for irrigation System Improvement													.03	.07
X_{13}	Administrative Effectiveness														.21*
X_{14}	Water Satisfaction														

*Significant at the .05 level

1. Continuously changing economic and social conditions, such as increasing population, demands for more food, urbanization, and industrialization, and the ensuing conflicts of competing water demands.
2. The strong presence of institutional constraints, result of long historical and cultural practices, embodied in laws and judicial doctrines and in traditions reflecting the norms and practices of a given society and community.
3. Increasing concern with adverse environmental impacts and consequences. This concern stems either from an already ecologically fragile environment (natural sources of pollution), or from manmade perturbations, such as the misuse of the land and the various forms of the despoliation of the water supply.

Such trends create new and different demands for water to be supplied to communities. The urgency for a more cogent water development policy is due not only to past and present trends of population increase, urbanization, industrialization, and ecological awareness, but also to projections and forecasts of forces of continuous growth in the coming decades. This is particularly important for such arid regions as the Western United States where forces of change combine with scarcities of the natural environment to create a pressing need for planning and reorganization of presently inefficient systems.

Among the major points which have directed this multidisciplinary effort has been a central argument that natural resources need always to be understood within the context and in relation to a surrounding socio-economic environment. Water has meaning and importance where socially used for the achievement of certain objectives. Its physical availability and natural characteristics are certainly constraining factors, but it is its eventual social use that makes it a valuable resource.

Thus, as part of an integrated social system the use of water must be socially controlled through sets of institutions. This means that the way in which water supplies, patterns of water distribution and water reclamation or reuse practices are regulated in a given society will depend largely on the nature, structure, and evolution of its particular water system as affected by the larger socio-cultural environment and the specific ecological circumstances of a given region.

Dwindling uncommitted lands, negative environmental effects, increasing demand for food from rapidly growing populations make it imperative to examine also the wise use of water resources as a vital part of the quest for the development of a major policy for achieving important social and economic objectives. In trying to provide some general directives for water development and general growth, we need to emphasize the importance of the proper mix of resources and the organizational and institutional frameworks for effective system operation.

It should be noted from the beginning that in any attempt towards planning, economic growth and material progress can be achieved not only by an effective use of given resources but

also by a general economic tendency orientation and capacity of responding to what Wiener has labelled "a growth environment."[495] This growth environment incorporates the capacity of a socioeconomic system to modify its structure and to respond with greater variety and greater coordination and control to improved conditions. Thus, in the case of irrigated agriculture, increased production becomes part of a well-coordinated effort of improving incentives, allocating goods, and channelizing growth to desirable directions, including cumulative growth and equitable distribution throughout society. To meet such harmonization of economic and social goals, strong political mechanisms must also exist that can translate directives into action and bridge discrepancies between social intentions and actual performance. Finally, climatic constraints, physiographic features, engineering potentialities, the general social context, and multi-objective multi-level planning are essential ingredients of efforts attempting to integrate physical and social goals and of shaping a new socio-economic system which will facilitate increased production and provide diversified mechanisms of coordination and control leading to conductivity for a growth environment.

The general orientation with the systems approach throughout this study is part of the overall effort of integrating physical and non-physical dimensions of irrigation systems and in establishing a common vocabulary among diverse disciplines.

In such an input-thruput-output model we attempt to utilize a dynamic systems analysis approach which requires:

1. Delineation of our objectives and goals as well as of alternatives.
2. Description of the system (boundaries).
3. Constraints of the system (inputs).
4. Time constraints and diachronic considerations (short vs. long-range).
5. Techniques for systems analysis.
6. Evaluation of the performance of the systems.

In line with our major agrument in delineating the factors facilitating or hindering the operation (and in our study the consolidation) of irrigated agriculture, our primary focus is on the following inputs or constraints of an irrigation system:

1. Engineering inputs (part of natural resources inputs) having two major dimensions:
   a) hydrology or water supply problems, such as time history, diversions and crop water demands;
   b) network requirements (water facilities), such as canals, pumps, delivery systems, and irrigation return flows.
2. Social inputs, such as ecological and demographic characteristics and the normative resources of communities within which irrigation systems are located.
3. Legal inputs, such as the substantive water law, legal aspects of surface and ground water, duty of water, administrative aspects of law, requirements and

limitations, and the specific allocations of individual water rights.

4. Economic inputs, such as conditions of production and processing, markets and marketing, forms of capital formation, and diversifies aspects of capital resource allocation.

Needless to say, there is a great variety of irrigation systems because of different geographical conditions, cultural circumstances and above all because of the general character of the water supply, namely whether inadequate, unreliable, or supplemental. Yet, despite great variations in scope, extent and organizational form, all water systems encompass common elements and parallel institutional mechanisms which result from the following crucial questions:

1. How will the water resources be used in the productive process?
2. Who will plan and how will the production facilities be installed and organized?
3. Which individuals shall exercise control over the acquisition, distribution, use, and reclamation of water resources?
4. What will be the distribution and marketing of goods and services produced, including also the installation and operation of distribution facilities?

The answering of such questions provides the basis for the description and understanding of a given irrigation system. If we utilize the previous argumentation, we may delineate a simplified version of a local irrigation system designed to achieve maximum agricultural productivity through the application of water by human agencies (Figure 44).

While Figure 44 shows the overall structure of an irrigation system, and the more or less static considerations in terms of the constraints of the natural and socio-cultural environments, Figure 45 attempts to provide another view of the dynamic aspects in the operation of a given irrigation system. An irrigation system's functions can be broken down into the following dynamic processes, each of which requires a vast array of organizational structures and complex rules and procedures affecting crucial considerations of decision-making and the eventual success of new organizational forms and operations, such as consolidation:

1. Water supply and water source considerations including new or potential sources of supply.
2. Water control aspects and characteristics of diversion, storage, reservoirs, and wells, and the assorted institutional forms of regulation.
3. Water distribution systems, the means of transmission and patterns of water flow.
4. Water utilization, the system of irrigation and crop operation, as well as cultural practices and scheduling programs.
5. Water reclamation and aspects of drainage, including field outlets, release of full water, and irrigation return flow.

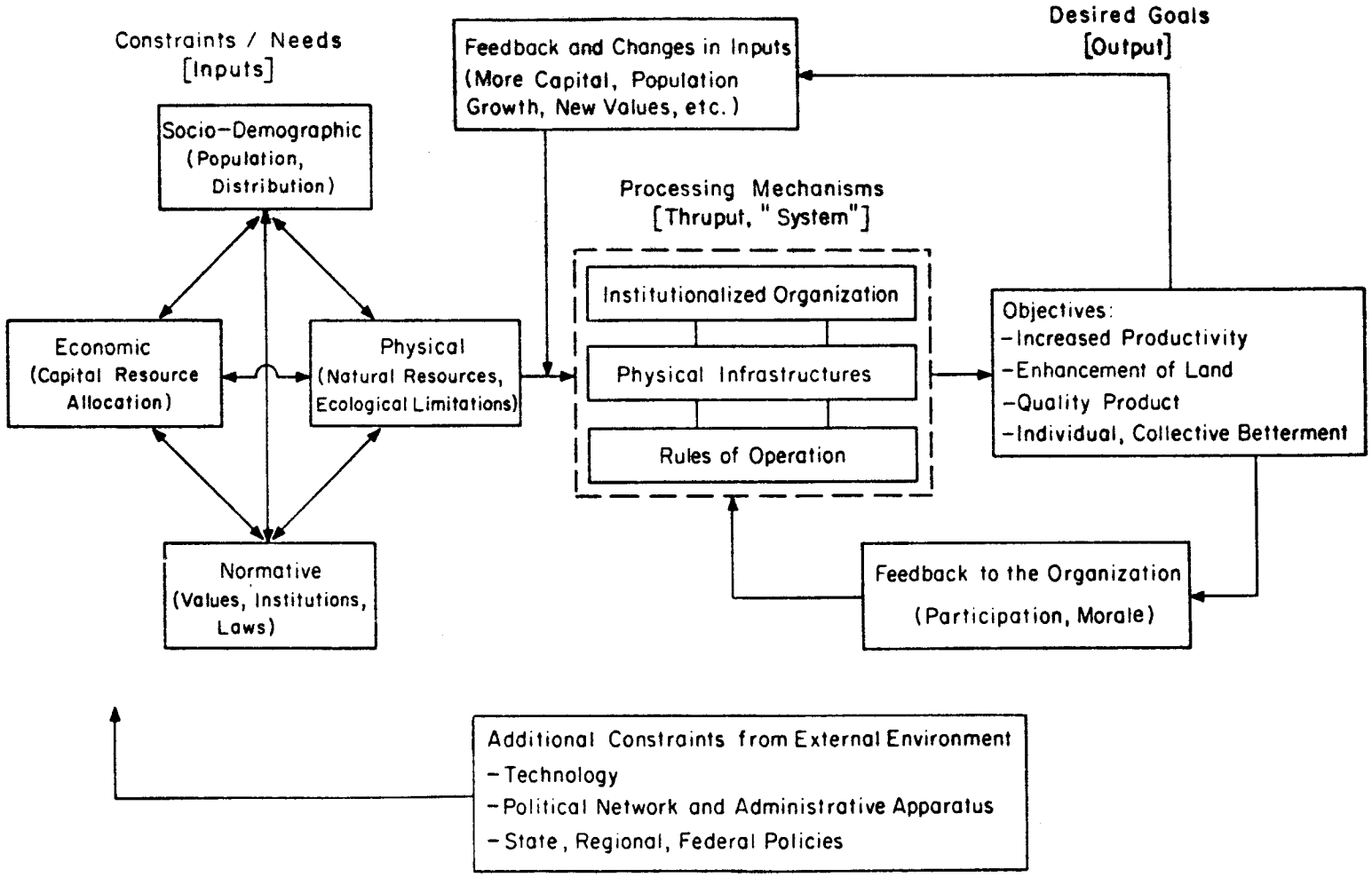


Figure 44. Simplified Version of a Local Irrigation System.

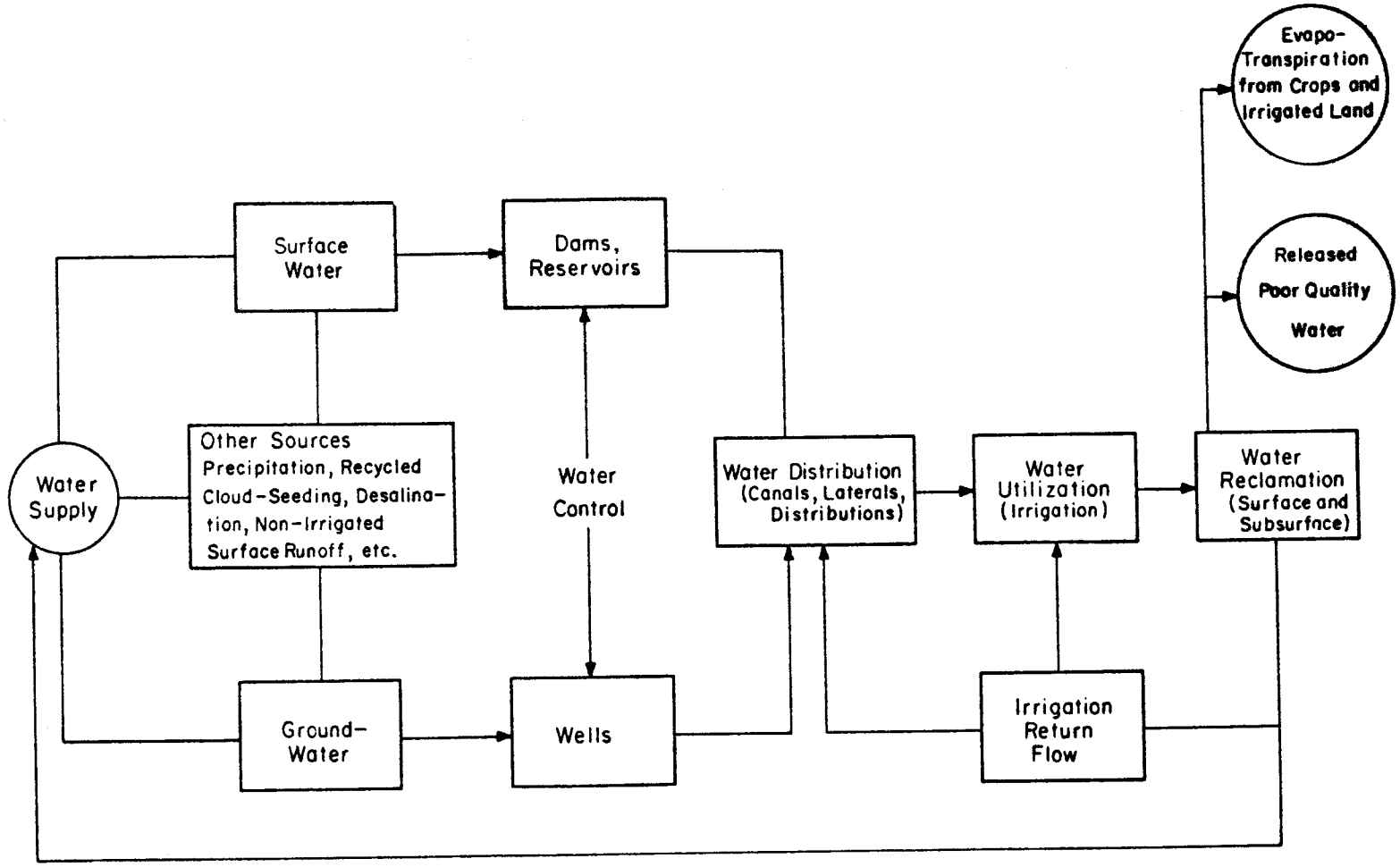


Figure 45. Irrigation Water System Functions and Dynamic Processes.

What both the previous two figures try to emphasize is the multiplicity of levels of analysis and the multiplicity of functions in an irrigation system. Most important, at each level and for each subsystem component part and function, problems of institutional order arise, difficulties of organizational arrangements, and need for specific understanding of the normative rules involved at each stage or phase of a dynamically operating irrigation system. To generalize this argument, the following points should be particularly stressed:

1. Successful development and management of water resources requires much larger institutional arrangements, different from the presently prevailing highly segmentalized and individualized approaches in various valleys of the West.
2. Norms and cultural values concerning water use must be coordinated within a larger social planning domain, especially with regard to water rights.
3. Each proposed water system, independent of its level of intervention or analysis, must develop unique patterns much more responsive to the specific people and cultural conditions found in a given region, rather than simply blindly transmitting generalized information from other areas.
4. The larger the scope of the irrigation (and water) system and the greater the scale of analysis, the more complicated the organizational arrangements and, therefore, the more the need for coordinating powers and comprehensive planning.

In essence, then, changes in the organizational form and operation of a given irrigation system through consolidation will create significant pressures for adjustment of individuals, groups, and institutions. New organizational forms may produce a counter-reaction on the part of those in established roles and positions of power, influence or authority. Two contending forces seem to emerge in established agricultural areas with the introduction of new organizational arrangements. On the one hand, there must be a mobilization of the people, their organizations, and their resources to protect old goals and established traditional procedures. On the other, innovative schemes are required in order to meet the changing conditions of agricultural production, as well as new institutional forms for adapting to changing socio-economic conditions. It has been observed that in many projects not only of irrigation but of other forms of innovation and change opposition and resistence to changes seems to come from the following elements or conditions of the social structure:[496]

1. Beliefs, feelings, values. Those people who live and share certain beliefs and feelings about the present ways and the appropriate way of life unless persuaded by a new rationale or a new set of knowledge and beliefs, they will block the acceptance of the change.
2. A new organizing scheme of irrigation may produce goals which are incompatible with pre-existing objectives and goals of people in a given agricultural area. Unless aspirations of both individuals and

groups can be redefined or adjusted as to be supportive of the new irrigation project, we may expect opposition in the implementation of the particular project.

3. Normative structure. Rules, expected behavior, and laws are inherent in any social structure, groups or organizations. The normative structure includes not only the definitions of appropriate behavior in relation to farming practices, but also laws or specific rules regulating the distribution, use, and control of water. Such long-established practices and legal requirements are important forces of resistance to proposed changes. Therefore, a whole new series of norms regulating the relationship among water users plus definition of the means for the systematic distribution of the water to serve the needs of all the people in the project must also emerge in order to insure control and absorption of the changes in the community.
4. Roles, statuses, and power. It should also be realized that the alteration of any irrigation system in already established agricultural areas clashes with ongoing social situations of individual members of the group and of communal groups. New irrigation practices not only produce a new set of goals but additional roles and positions as well as new sources of authority and influence. In many instances existing roles and positions of power become inappropriate and in many respects dysfunctional. Thus, those who are to lose from the introduction of a new irrigation project unless they become part of needed new roles and positions, they are expected to provide resistance to a new irrigation project. Any new program, therefore, needs to introduce new power arrangements which will not be suspected and resisted, but well defined and understood as part of a well-thought plan of water use and control.

By now, the reorganization of irrigation companies in many Western areas and the efforts towards consolidation leads us to much broader considerations of planning and development. To be done properly, planning for water development obviously cannot be isolated from the planning of other resources, both natural and human. The comprehensiveness of water and related water resource planning has been the subject of controversy and debate in the literature. It has been recognized, however, that in order to be able to maximize the benefits from any water resource project, a much larger systematic analysis of the surrounding environment is needed, a broadening of the horizons of traditionally narrow planning efforts, and increased sensitivity to decision-making problems associated with multi-objective and multi-dimensional interventions.

The basic goal in the formulation of a framework for integrated irrigation projects is to provide the best use, or combination of uses, of water and related resources to meet foreseeable or conceivable needs in the context of national and regional economic development, and the overall promotion of the well-being of people. Thus, moving beyond general considerations of social planning and utilizing earlier remarks of

systems orientation, our efforts for integrated management should involve among others the following factors:

1. Land resources considerations, such as land classification, land use, and capabilities, settlement, and drainage.
2. Water resources considerations, such as water supply, water quality and treatment, water requirements, water rights, project operation studies, and hydraulic design requirements.
3. Engineering and geological considerations such as foundations and materials and general physical plan formulation.
4. Financial considerations, such as economic criteria for plan formulation, economic justification, cost allocation to various purposes, repayment of capital investment, maintenance and replacement costs, etc.
5. Socio-cultural considerations, such as the size of population affected, density, composition, mobility, spatial distribution, household composition, community services, associations, etc.
6. Legal considerations, such as rights to use of water, international agreements, land acquisition and rights of way.
7. Political considerations such as the determination of public interest in contemplated development, establishment of government policy and enabling legislation, administrative apparatus, political network, patterns of communication, organizational requirements for supervision of the operation of projects, program and budget requirements control.

Looking back at all the general considerations of policies and planning affecting integrated irrigation management, we may distinguish three central issues, result of some of the major societal trends discussed earlier in this report:

1. The release of water for new demands.
2. The maintenance of agricultural productivity.
3. The minimization of water quality degradation.

By now it has become apparent that the water management organization and the efficient allocation and use of existing resources are crucial factors for the success of any water project. Among the most crucial factor in alternative means for meeting water demands are all the attempts of improved organizational and institutional arrangements and increased efficiency in water management. We may see the improvement in water management not only in terms of typical technical solutions, such as improved water measurement, modification of delivery schedule, and modernization of project facilities; equally important are also the non-technical considerations which exemplify our concern with the socio-economic environment or any water system. We may begin with management improvements in operational practices, such as streamlining of companies, innovative administrative procedures, trained personnel, etc. The consolidation of irrigation companies and districts will contribute to achievement of lower operating costs per unit area and more

efficient regulation and control of the water supply, as well as avoidance of duplication and increased capital waste. Other institutional changes such as the interpretation of the legal doctrine are also crucial efforts for improving water management. Comprehensive planning and concerted social policies are part of the larger complex scene of resource utilization in most countries. Finally, education programs are all important as informational inputs attempting to reach all those responsible for the operation of a given irrigation system and the ultimate use of water on the farm.

In summary, then, the following points for a successful irrigation project need re-emphasis:

1. Maintenance and protection of all water rights.
2. Delivery of an adequate water supply to the water users when water is needed.
3. Improvements to keep the physical structures and properties in working order, guaranteeing optimum use of water and of water facilities.
4. Keeping records of water deliveries and project costs needed in order to insure equitable water distribution and evidence of beneficial use.
5. Educating water users in the means of obtaining high water use efficiency.
6. Developing sound budgets for covering costs of operation and maintenance and obtaining necessary funds by assessments, loans, bonds, etc., for continuous financing.
7. Streamlining of operations and integration of physical and non-physical structures, especially in the form of a consolidated organization.

The basic task of such an organization is to operate and maintain the irrigation system efficiently so that planned water management can be made effective. Organizationally then, an irrigation authority, wherever size allows it, should be comprised of two bodies, one for policy, the other for routine technical and administrative tasks. Efficient operation, on the other hand, implies not only a well-maintained irrigation and drainage system, but also trained personnel familiar with the operational procedures covering an entire range of a well-integrated system of irrigation. What should be emphasized is that such procedures covering an entire range of a well-integrated system of irrigation. What should be emphasized is that such procedures need to be up-dated periodically, and, therefore, the organization should also incorporate a system of feedback of information concerning its adequacies of operation for continuous review and improvement. Feedback mechanisms must exist and continuous monitoring of the performance of the system must be maintained in order to meet present inadequacies, as well as forecast future bottlenecks in the system.

With the above general remarks concerning both the need for comprehensive planning and integrated organization of irrigation projects, we have come full circle back to the introductory theme of the report: given the emerging complex relation of irrigated agriculture to a changing socio-cultural milieu, a

change in approach is imperative. The new approach and directions, based on the integration of engineering undertakings and socio-economic activities, become imperative requirements in order to provide more cogent solutions to problems of local and regional survival or further growth.

How can we achieve this effort of integrated water management by taking into account both technological capabilities and social organizational principles? To start with we realize that people and social institutions are equally vital elements to efficient water management as technology is. Regardless of our difficulties in making people change well-established patterns (which may look to us as inefficient or wasteful), we need to develop an appreciation of existing customs and of the great amount of inertia that needs to be overcome if we are to bring about change in long-established practices. Improved water management cannot be successfully accomplished without proper education and training.

Education and training for improved water management can be seen as a two-fold attempt. First, as a means of encouraging public response in implementing a water plan by keeping the public informed and interested and, thus, water users in the area feeling that they are becoming part of an emerging scheme of irrigated agriculture. Second, as a higher level educational process and professional training programs on the professional, the technical, and the field level.

A previous distinction between efficiency, effectiveness, and efficacy has helped us raise an important point concerning the evaluation of the consequences and the benefits and/or costs associated with consolidated irrigation systems. Irrigation systems are not only abstract simulation models repsonding to general physical or broad economic imperatives. All irrigation programs include individuals and communities that have developed a pattern of life and whose welfare and future may even depend on inefficient water systems. Even a marginal or not particularly efficient agriculture fulfills the purpose of being a supportive social system for a number of individuals and part of the ongoing life of quite a number of people in a given society. It is not easy to dictate a planning policy that would be based only on criteria of efficiency and effectiveness without considering at the same time the so-called "human factor." In other words, because of the social costs of dislocation and disruption, many times a policy of continuing present practices may be dictated as a response to long established cultural practices and social arrangements.

There is no need at this point to reiterate all the potential advantages from the consolidation of many of the irrigation systems in the West. The central point raised in this section reflects also concern not only with the obvious savings from the concentration of fragmented and wasteful structures and of inadequate procedures; more important, the changing socio-economic circumstances in the arid west made imperative the creation of larger organizations which may have the capacity to respond to the challenges of new water demands, and to the needs for economic survival. This is why our expanded

conceptual framework attempted to relate consolidation of irrigation companies to a much broader perspective of systematic linkages and of comprehensive planning and development.

IN LIEU OF CONCLUSION: PREPARING FOR PHASE II

As repeatedly emphasized throughout the report, the thrust of the present study was a comparative description of eight irrigation areas in the West in order to provide a general framework of crucial engineering, legal, and sociological factors (constraints and/or facilitators) involved in any effort of consolidating irrigation systems. Strong emphasis was placed throughout in delineating the consolidation challenge as a need of not only effectively merging adjoining irrigation systems into a single unit, but also as a necessary means for meeting the larger quest for efficient utilization of water resources in the context of rapidly changing socio-economic conditions in the West. To recapitulate, therefore, this phase of the research involved a broad analysis and interpretation of a host of factors affecting the consolidation of irrigation systems by providing:

1. An overview of typical irrigation systems problems and developments.
2. A delineation of the consolidation problem through comparative analysis of eight areas, ranging from small to large and from already consolidated to highly diversified or fragmented irrigation systems.
3. An overview of the legal aspects involved in any proposition of consolidation, through a detailed analysis of both the substantive law as well as administrative procedures and organizational arrangements per each state where the study systems are to be found.
4. A detailed exposition of the physical and non-physical dimensions of all eight irrigation systems, description of each area in terms of physiography, historical development, availability of water resources, organization and management of the irrigation systems, and overall evaluation of future prospects.
5. A contrast through the wealth of engineering, legal, and sociological material of the advantages of integrated water management schemes and the provision of a common vocabulary and approach as to what irrigated agriculture and consolidated systems entail.
6. A sharpening of the conceptual and methodological focus by a multidisciplinary design revolving around a systematic analysis of irrigated agriculture.
7. A combination of not only structural conditions affecting the consolidation of irrigation systems, but also the attitudinal background through in-depth examination of feelings towards change and towards water use in two areas.

It should be particularly stressed that the general and predominantly descriptive character of the study was an intended result of the attempt to develop an "interdisciplinary" team and way of thinking that may help diminish the typical

compartmentalized approaches to such investigations. In addition to substantive findings in each area of concern (engineering, legal, sociological) there is also the overall gain of common problematication in the area of water resources and to action programs requiring multi-disciplinary and multi-objective presence. Thus, Phase I was essentially one of a process of sensitization to the holistic character of understanding the consolidation challenge.

What is more important at this stage is to transform the general awareness, the broad findings of this phase and the integrated conceptual scheme into more specific recommendations as to the feasibility of consolidation and as to the actual steps involved into the particular process of implementing integration. For that purpose two key sensitive areas of urban-rural interface and of rapid growth have been selected (Poudre Valley and Utah Valley) where competing water demands make more urgent the need for integrated water management systems. Furthermore, at this phase it is important to interrelate economic considerations to the other conditions for consolidation, so that a final evaluation can be made of the efficiency and effectiveness, as well as significance of consolidation and organizational rearrangements for irrigated agriculture in areas facing a drastic transformation of their rural hinterland. Thus, the objectives of Phase II stand out as key points in summarizing the overall approach of this research and in integrating engineering, economic, legal, and sociological aspects of the investigation. Such key objectives for the development of a more consistent framework of both description and implementation of consolidation are subdivided by major areas below.

1. To determine and evaluate the engineering characteristics of the system:
   a. The hydrology of water supply to the areas will be assessed in order to evaluate the magnitude of the supply, but more important, to evaluate its time variation;
   b. The physical characteristics of the systems will be ascertained with respect to capacity, conveyance losses, water measurement and control structures, land served, and type of agriculture;
   c. The method(s) of operating each system will be determined with respect to delivery, flow measurement, operational losses, conveyance efficiency, farm efficiency, and operation and maintenance costs;
   d. Water deficits and surpluses will be computed for each irrigation company in the two valleys in order to ascertain the need for water transfers within the total irrigation system; and
   e. Alternative physical and operational systems will be studied for improving the efficiency of water use in each of the two areas.
2. To identify and measure the economic benefits and costs of the alternative physical and operational systems which have been shown to be technologically feasible:
   a. Both private and social economic effects will be evaluated;

b. Though most available data are of a pecuniary nature, an attempt will be made to include non-pecuniary considerations in the overall analysis;
c. An attempt will also be made to incorporate indirect as well as the direct effects of consolidation in the study;
d. Besides optimization of the immediate water systems, the study will include consideration of the maximization of welfare for the entire system involved both directly and indirectly;
e. The primary economic objective is the determination of whether or not any of the alternative consolidation systems is economically feasible within the context of all involved interests.

3. To identify and analyze more concertedly from a legal perspective:
   a. Federal and state laws and court decisions which relate to local water organizations and determine whether they operate as impediments to consolidation;
   b. State laws regarding business organizations and corporations to determine procedures for merger, along with possible impediments;
   c. Water rights held by selected irrigation organizations to establish the legal right of individual users in a consolidation proposal;
   d. What institutional alternatives are available to traditional agricultural irrigation companies in synthesizing rural operations with urban needs;
   e. Legal constraints in shifting from rural water uses to urban and industrial uses and the impact upon the water right; and

4. To provide an understanding of the social factors involved in the water systems:
   a. Explicate institutional arrangements which control the use of water and determination of possible organizational impliments to consolidation.
   b. Examine the perceptions of satisfaction with the present organization in relation to rules, forms, and performance of the organization and cultural practices and attitudes related to water use patterns.
   c. Explore the perception and presence of organizational alternatives, as expressed in new organizational schemes of consolidation. In particular, the following aspects will be considered:
      i) the general orientation towards social change;
      ii) the beliefs associated with consolidation and the existing level of information about consolidation;
      iii) the perceived social risks and the degree of anxiety involved in potential consolidation or the alternatives to present organizational arrangements; and
      iv) the congruence between degree of satisfaction, predisposition towards change, and the perception of alternatives.

The selection of the two areas for an in-depth examination of the types of requirements needed for achieving consolidation is a natural culmination of the attempt to relate broad trends to specific recommendations. These areas present the most complicated cases of a maze of irrigation companies operating under changing conditions of increased land use transformation, population influx, the meshing of urban fringes with the rural hinterland, and industrial expansion in an ecologically fragile environment. Concentrated research efforts on Utah Valley and Poudre Valley, supplemented by the insight and information gained about the other areas during Phase I, will provide the background for concrete proposals of consolidation, as a necessary consequence of four interrelated national and regional trends:

1. Increasing population, particularly the continuous movement of people to the West.
2. Increasing urbanization and the augmented demand for municipal services with a resultant conflict between farm and non-farm water uses.
3. Increasing industrialization which affects both the total volume as well as the quality of water supply.
4. Increasing concern with ecological mismanagement, with increased requirements and cost of pollution, which will affect both agricultural and non-agricultural water uses.

The maximum welfare of the entire system is the ultimate criterion for analysis. The welfare of the entire system is said to be maximized when it is impossible to increase the welfare of one part of the system without decreasing the welfare of some other part of the system. A particular consolidation plan cannot be judged as increasing general welfare if one group benefits at the cost of another.

Consolidation demands the structural as well as normative integration of x number of irrigation companies for the manifest purpose of obtaining a "greater good" (e.g., increased operational efficiency and increased availability of water supply).

Consolidation, however, requires not only changes in organizational arrangements, but also modifications among participants of the system in the perceptions of goals, roles, and norms required in a new, expanding organizational scheme. These perceptions, and the extent of consensus between them, are among the crucial variables in explaining change or the state of readiness for organizational change.

Consolidation, therefore, requires the acceptance of an ideational innovation. It implies the movement from a perceived situation of an existing interlocking system of values and roles to that of a new form of social arrangements. This, however, does not mean exclusive preoccupation with factors facilitating change, but also analysis of forces hindering innovative attempts.

It has become apparent, as the work from Phase I has indicated, that consolidation of irrigation systems is a necessary part of an integrated policy of water development of improved

water management, and of a coordinated effort towards an efficient and effective maximization of limited natural resources. If nothing else, national trends of growth, limited water supplies, the increasing population, and the multiplicity of uses call for new integrated forms of the interaction between policy determining institutions, local participants, and water users at large.

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[6]R.E. Clark (ed.), Waters and Water Rights, § 5.16 at 295(1967)

[7]Reagle v. Square S. Land and Cattle Co., 733 Colo. 392, 276 P2d 235 (1954); City and County of Denver v. Northern Colorado Water Conservancy District, 130 Colo. 375, 276 P2d 992 (1954).

[8]Id.

[9]R.E. Clark, (ed), Id. § 55.3 at 382; Low v. Rizor, 25 Ore. 551, 37 P.82 (1894); City and County of Denver v. Northern Colorado Conservancy District, 130 Colo. 375, 276 P2d 992 (1954); Colorado River Water Conservation District v. Rocky Mountain Power Co., 158 Colo. 136, 406 P2d 798 (1965).

[10]R.E. Clark (ed.), Id.;Steptoe Livestock Co. v. Gulley, 53 Neb. 163, 295 P. 772 (1931).

[11]R. E. Clark (ed.), Id. § 19.2 at 85; Barner v. Sabron, 10 Nev. 217, 233 (1875); Creek v. Bozeman Water Works Company, 15 Mont. 121, 38 P.459 (1894); Whitcomb v. Helena Water Works Co. 151 Mont. 443, 444 P2d 301 (1968).

[12]R.E. Clark (ed.) Id., § 54.1 at 367 et. seq.; R. L. Dewsnup, Legal Aspects of Water Salvage, pp. 13-15, (report to the National Water Commission, 1971); City and County of Denver v. Sheriff, 105 Colo. 193, 96 P2d 836 (1939).

[13]R.L. Dewsnup, Id.

[14]R.E. Clark (ed.), Id., § 29.5 at 172.

[15]R.E. Clark (ed.), Id., § 18.3 at 83 and 53.1 at 344 et. seq. Cook v. Hudson, 110 Mont. 263, 103 P2d 137 (1940); Whitmore v. Murray City, 107 Utah 445, 154 P2d 748 (1944); Provo Bench Canal and Irrigation Co. v. Linke, 5 Utah 2d 53, 296 P2d 723 (1956).

[16]R.E. Clark (ed.), Id. § 18.3 at 83 and 29.5 at 172.

[17]Dello United States v. Willow River Power Co., 324 U.S. 449, 65 Sup. Ct. 761 (1945).

[18]"A usufruct is the right of enjoying a thing, the property of which is vested in another, and to draw from the same all the profit, utility, and advantage which it may produce, providing it be without altering the substance of the thing." Black's Law Dictionary, 4th ed. (Rev.) 1968.

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[20]R.E. Clark (ed.) Id., § 51.7 at 296.

[21]R.L. Dewsnup, Id., at 16.

[22]R.E. Clark (ed.), Id., § 51.7 at 297, R.L. Dewsnup, Id.,at 16.

[23]R.L. Dewsnup, Id.

[24]A.R.S. § 45-101 (1956).

[25]Id. § 45-102 (1956).

[26]Id., § 45-105 (1956).

[27]Id., § 45-106 (1956).

[28]Ariz. Const. Art. 17, § A.R.S. s 45-101 (1956); Clough v. Wing, 2 Ariz. 371, 17 P. 453 (1888); Maricopa County Municipal Water Conservation Dist. v. Southwest Cotton Co. 39 Ariz. 65, 4 P2d 369 (1937). However, the United States has riparian rights in at least its reserves lands. Ariz. Const. Art. 17, § 1; Brasker v. Gibson, 2 Ariz. App. 91, 406 P2d 441 (1965).

[29]A.R.S. § 45-142 (Supp. 1971). Note, however, that a legislative classification of water as subject to an available to appropriation acts as a limit on rights to so acquire non-classified waters. Bristor v. Cheatham, 75 Ariz. 227, 222 P2d 173 (1953). Note, also, that a long, continued use of seasonal water flowing in a canyon without objection has been held to be a valid appropriation even without a permit. England v. Ally Ong Hing 105 Ariz. 65, 459 P.2d 498 (1969).

[30]A.R.S. 45-143(A)(1956).

[31]Smith v. Trott, 36 Ariz. 166, 283 P. 726 (1930).

[32]A.R.S. § 45-148 (1956).

[33]Id. § 45-149 (1956).

[34]Id., § 45-152(A)(1956).

[35]Id., § 45-231 (1956).

[36]Id., § 45-232 (1956).

[37]Id., § 45-233 (1956).

[38]Id., § 45-234 (1956).

[39]Id. § 45-240 (1956).

[40]Salt River Valley Water Users' Assn. v. Norveil, 29 Ariz. 499, 242 P 1013 (1926).

[41]A.R.S. § 45-241 (1956).

[42]Id. § 45-143 (A)(1956).

[43]Gould v. Maricopa Canal Co. 8 Ariz. 429, 76 P. 598 (1904).

[44]Clough v. Wing, 2 Ariz. 371, 17 P. 453 (1888), See also England v. Ally Ong Hing, 105 Ariz. 65, 459 P2d 498 (1969).

[45]State of Arizona v. State of Calif. 283 U.S. 423, 51 Sup. Ct. 522 (1931).

[46]Fourzan v. Curtis, 43 Ariz. 140, 29 P2d 722 (1934).

[47]A.R.S. s 45-171(1956); Whiting v. Lyman Water Co. 59 Arizona 458, 129 P2d 995 (1942).

[48]25 Cf. footnotes 14 and 15 in the Substantive Law introduction, supra.

[49]Arizona Cooper Co. v. Gillespie, 12 Ariz. 190, 100 P. 465 (1909).

[50]A.R.S. § 45-141 (Supp. 1971 and § 45-175 (1956); State of Arizona v. State of Calif. 298 U.S. 558, 56 Sup. Ct. 848 (1936).

[51]A.R.S. § 45-142 (1956) requires that a person desiring an appropriation right or a construction right must apply for a permit. This, along with § 45-148 (1956) which provides that a refusal of an applicant precludes construction by him of any structure for appropriation, forms a requirement that public notice and application be accomplished before any overt act so that the overt acts, i.e., construction, proceeds with public sanction thus eliminating many estoppel problems.

[52]Sullivan v. Jones, 13 Ariz. 229, 108 P. 476 (1910).

[53]Maricopa County Municipal Water Conservation Dist. No. 1 v. Southwest Cotton Co. 39 Ariz. 65, 4 P2d 369 (1937).

[54]A.R.S. § 45-150 (Supp. 1971).

[55]A.R.S. 45-109 (1956).

[56]Gila Water Co. v. Gila Land and Cattle Co., 28 Ariz. 531 238 P. 336 (1925); Adams v. Salt River Valley Water Users' Assn. 53 Ariz. 374, 89 P2d 1060 (1939).

[57]Arizona is not the only state which does not explicitly define the term, Cf. footnotes 8, 9, and 10 in the Substantive Law introduction, supra.

[58]Ariz. Const. Art. 17 § 2, A.R.S. §§ 45-10 (B) and 45-141 (b) (Supp. 1971).

[59]Clough v. Wing, 2 Ariz. 371, 17 P. 453 (1888); Gould v. Maricopa Canal Co. 8 Ariz. 429, 76 P. 598 (1904); State of Arizona v. State of Calif. 283 U.S. 423, 51 Sup. Ct. 522 (1931); Whiting v. Lyman Water Co., 59 Ariz. 458, 129 P2d 995 (1942).

[60]Salt River Valley Water Users' Assn. v. Kovacovich, 3 Ariz. App. 28, 411 P2d 201 (1966). The definition continues, however, "...act becomes appurtenant thereto; it is in no sense a floating right, nor can the right once having attached to a particular piece of land be made to do duty to any other land." This strict appurtenancy rule has been statutorily abrogated. See A.R.S. s 45-172 (Supp. 1971).

[61]R.E. Clark (ed.) Id. s 29.5 at 172; Bristor v. Cheatham, 75 Ariz. 227, 255 P2d 173 (1953).

[62]A.R.S. s 45-147 (Supp. 1971). The use for mining, however, does not include the right to send tailings and waste from reduction works downstream to the detriment of prior users for irrigation. Arizona Cooper Co. v. Gillespie, 230 U.S. 46, 33 Sup. Ct. 1004(1913).

[63]R.E. Clark (ed.) Id., § 18.3 at 83 and 53.1 at 345.

[64]A.R.S. § 45-102 (1956) See also § 45-149 (1956) allowing as permit to appropriate to be assigned subject to land department approval.

[65]Id., § 45-172 (Supp. 1971).

[66]Id. at subsection 6. Note the effect of this on the Kovacovich decision, Cf. footnote 37 above.

[67]England v. Olly Ong Hing, 8 Ariz. App. 374, 446 P2d 480 (1968).

[68]A.R.S. § 45-25-2 (9) (Supp. 1971).

[69]Id., § 45-2506 (Supp. 1971).

[70]United States v. Willow River Power Co., 324 U.S. 449, 65 Sup. Ct. 761 (1945).

[71]A.R.S. §§ 45-101 (B); 45-143 (B)(1956), 45-142 (3) (supp. 1971).

[72]R.L. Dewsnup, Legal Aspects of Water Salvage at 5 (report to the National Water Commission, 1971).

[73]Pima Farms Co. v. Proctor, 30 Ariz. 96, 245 P. 369 (1926).

[74]A.R.S. § 45-106 (4) (1956).

[75]Id., § 45-109 (5) (1956).

[76]Lambey v. Garcia, 18 Ariz. 178, 157 P. 977 (1916); Wedgworth v. Wedgworth, 20 Ariz. 518, 181 P. 952 (1919).

[77]Salt River Valley Water Users' Assn. v. Kovacovich, 3 Ariz. App. 28, 411 P2d 201 (1966).

[78]A.R.S. § 45-141 (A)(Supp. 1971).

[79]A.R.S. § 45-101 (C)(1956).

[80]Gould v. Maricopa Canal Co., 8 Ariz. 429, 76 P. 598.

[81]Gila Water Co. v. Green, 29 Ariz. 304, 241 P. 307 (1925).

[82]Colo. Const. Art. XVI § 5, C.R.S. §§ 148-2-1, 148-21-2 (1971).

[83]Stockman v. Leddy, 55 Colo. 24, 129 P. 220 (1912), West End Irrigation Co. v. Garvey 117 Colo. 109, 184 P2d 476 (1947).

[84]C.R.S. § 148-21-8 (1971).

[85]Id., §§ 148-1-2, 148-11-3, 148-21-17, 148-21-34 (1971).

[86]Colo. Const. Art. XVI, §§ 5, 6. C.R.R., §§ 148-2-1, 148-21-2, 148-21-34(2)(f); See also Black v. Taylor, 128 Colo. 449, 264 P2d 502 (1953).

[87]Colo. Const. Art. XVI, § 6.

[88]C.R.S., § 148-18-2(3)(1971).

[89]Id., § 148-21-3(6); Four Counties Water Users Assn. v. Colorado River Water Conservation District, 169 Colo. 416, 425 P2d 259 (1967).

[90]Metropolitan Suburban Water Users Assn. v. Colorado River Water Conservation District, 365 P2d 273 (Colo. 1961).

[91]C.R.S., § 148-21-18 (1970); See Also Terliamis v. Cerise 133 Colo. 329, 295 P2d 224 (1956).

[92]C.R.S. § 148-21-18 (G)(1971).

[93]Id., § 148-21-19 (1971).

[94]Id., §§ 148-21-19; 148-21-20 (1971).

[95]Id., § 148-21-3 for oomplete definition.

[96]Id., § 148-21-23 (2)(1971).

[97]Id., § 148-21-23 (3)(1971).

[98]C.R.S., § 148-21-3 (8)(1971).

[99]Cf. footnotes 14 and 15 in Substantive Law introduction, supra.

[100]C.R.S. § 148-21-3 (9)(1971).

[101]Four Counties Water Users Assn. v. Colorado River Water Conservation District 159 Colo. 499, 414 P2d 469 (1966).

[102]Reagle v. Square S Land and Cattle Co., 133 Colo. 392, 276 P2d 235 (1954); City and County of Denver v. Norther Colorado Water Conservancy District, 130 Colo. 375, 276 P2d 992 (1954).

[103]C.R.S. § 148-21-3 (10)(1971).

[104]Colo. Const. Art. XVI § 6; Thomas v. Guirand, 6 Colo 530 (1883); Coffin v. Left Hand Ditch Co., 6 Colo. 443 (1882).

[105]C.R.S., §§ 148-21-3(9); 148-21-21(1); City and County of Denver v. Northern Colorado Water Conservancy District, 130 Colo. 375, 276 P2d 992 (1954); Four Counties Water Users Assoc. v. Colorado River Water Conservation District, 159 Colo. 449, 414 P2d 469 (1966).

[106]C.R.S., § 148-21-44(1971); City and County of Denver v. Northern Colo. Water Conservancy District, 130 Colo. 375, 276 P2d 992(1954); Rocky Mountain Power Co. v. White River Electric Association, 151 Colo. 45, 376 P2d 158 (1962).

[107]C.R.S. § 148-21-27(1971).

[108]Brighton Ditch Co. v. City of Englewood, 124 Colo 366, 237 P2d 116 (1951).

[109]C.R.S. § 148-21-3(5)(1971). Note the idea of segregation of property from its natural source.

[110]Id., § 148-21-21 (2)(1971).

[111]Four Counties Water Users Assoc. v. Colo. River Water Conservation District, 161 Colo. 416, 425 P2d 259, 262, (1967).

[112]Colorado River Water Consrvation District v. Rocky Mountain Power Company 158 Colo. 331, 406 P2d 798 (1965); Four Counties Water Users Assoc. v. Colorado River Water Conservation District, 159 Colo. 449, 414 P2d 469 (1966).

[113]C.R.S., § 148-21-3(7)(1971).

[114]City and County of Denver v. Sheriff, 105 Colo. 193, 96 P2d 836 (1939).

[115]Colo. Const. Art. XVI § 6.

[116]R.E. Clark (ed.), Id., §§ 18.3 at 83 and 53.1 at 345.

[117]West End Irrigation Co. v. Garney, 117 Colo. 109, 184 P2d 476 (1947). A priority is also a property right. Brighton Ditch Co. v. City of Englewood 124 Colo. 366, 237 P2d 116 (1951).

[118]C.R.S., § 118-1-2 (1971).

[119]Id., § 50-2-1 (1971).

[120]Id., § 148-21-21-(3)(1971).

[121]Id., § 148-6-5(1970).

[122]Enlarged Southside Irrigation Ditch Co. v. John's Flood Ditch Co., 120 Colo. 423, 210 P2d 982 (1949).

[123]Black v. Taylor, 130 Colo. 481, 264 P2d 502 (1953).

[124]Colo. River Water Conservation Dist. v. Rocky Mountain Power Co., 158 Colo. 331, 406 P2d 798 (1965); Four Counties Water Users Assoc. v. Colorado River Water Conservation District, 159 Colo. 499, 414 P2d 469 (1966).

[125]R.L. Dewsnup, Legal Aspects of Water Salvage at 5 (report to the National Water Commission, 1971).

[126]C.R.S., §§ 148-21-2; 148-21-35(2)(f). See also Fellhauer v. People, 167 Colo. 320, 447 P2d 986 (1968).

[127]C.R.S., § 148-21-35 (2)(1971).

[128]Id., § 148-7-7(1971).

[129]Surface Creek Ditch and Reservoir Co. v. Grand Mesa Resort Co. 114 Colo. 543, 168 P2d 906(1946).

[130]Mountain Meadow Ditch and Irrigation Co. v. Park Ditch and Reservoir Co., 130 Colo. 537, 277 P2d 527 (1954).

[131]C.R.S. § 148-21-28 (2)(j)(1971).

[132]Id., § 148-21-3 (13)(1971).

[133]Id., § 148-21-3 (14)(1971).

[134]Beaver Brook Reservoir Co. v. St. Vrain Reservoir Co., 6 Colo. App. 130, 40P. 1066 (1895).

[135]Door v. Hammond, 7 Colo. 79, 1 P. 693 (1883).

[136]Knopp v. Colorado River Water Conservation District, 131 Colo. 42, 279 P2d 420 (1955).

[137]N.R.S. § 533.025(1970); Bergman v. Kearney 241 F. 884 (Nev. 1917).

[138]In re Manse Spring and Its Tributaries, 60 Nev. 280, 108 P.2d 311 (1940); Application of Fillipini, 66 Nev. 17, 202 P2d 535 (1949).

[139]N.R.S. § 533.305 (1970).

[140]Id., § 532.110 (1970).

[141]Application of Fillipini, 66 Nev. 17, 202 P2d 535 (1949).

[142]N.C.L., §§ 79 0-7891 (1929).

[143]N.R.S. § 533.030 (1)(1970); Application of Fillipini, 66 Nev. 17, 202 P2d 535 (1949).

[144]N.R.S., § 533.085 See Also, County v. Kearney 37 Nev. 314, 12 P 803 (1949).

[145]Robison v. Bate, 78 Nev. 501, 376 P2d 763 (1963).

[146]N.R.S. § 533.090(1970). The requirements set forth herein may be waived in cases with 10 or less appropriators who waive these requirements in writing. § 533.215.

[147]N.R.S. § 533.170(1970); Carpenter v. Sixth Judicial District Court, 59 Nev. 42, 73 P2d 1310 (1937).

[148]N.R.S. § 533.200(1970).

[149]In re Manse Spring and Its Tributaries, 60 Nev. 280, 108 P2d 311 (1940). See footnotes 14 and 15 in the Substantive Law introduction, supra. Cf. footnotes 14 and 15 in Substantive Water Law introduction, supra.

[150]Application of Fillipini, 66 Nev. 17, 202 P2d 535 (1949).

[151]Doherty v. Pratt 34 Nev. 343, 124 P. 574 (1912).

[152]Barnes v. Sabron 10 Nev. 217 (1875).

[153]Id.

[154]N.R.S., § 533.075 (1970).

[155]Id., § 533.430(1970); Jahn v. Sixth Judicial District Court, 58 Nev. 204, 73 P2d 499(1937).

[156]Ophir Silver Mining Co. v. Carpenter 4 Nev. 534(1869). A reasonable time for application depends on the circumstances of the case. Rodgers v. Pitt, 129 F. 932(Nev. 1904); In re Humbolt River System 362 P2d 265 (1961).

[157]N.R.S. s 533.395 (1970).

[158]See, N.R.S., § 533.335, 533.540 (1970) for requirements of the application.

[159]Id., § 533.325(1970).

[160]Id., § 533.380(1970).

[161]Id., § 533.390(1970).

[162]Walsh v. Wallace, 26 Nev. 299, 67 P. 914(1902); Rodgers v. Pitt, 129 F. 932(Nev. 1904).

[163]Miller and Lux v. Rickey, 127 F. 573(Nev. 1904); Steptoe Live Stock Co. v. Gulley, 53 Nev. 163, 295 P. 772(1931).

[164]Nevada is not alone in this. See footnotes 8, 9 and 10 in the Substantive Law introduction, supra. There have been specific uses recognized as beneficial, however, Recreation is beneficial. N.R.S. s 533.030(2). Watering livestock is beneficial. N.R.S. s 533.490. And irrigation is recognized judicially as well as by common usage. Miller and Lux v. Rickey, 127 F. 573(Nev. 1904).

[165]N.R.S. § 533.035 (1970).

[166]A person is defined as including a corporation, an association, the United States, and the state as well as a natural person. N.R.S. § 533.010(1970).

[167]N.R.S. § 533.050(1970).

[168]Id., § 533.380 (1970).

[169]Id., § 533.400(1970).

[170]Id., § 533.410(1970).

[171]Id., § 533.055(1970).

[172]Nenzel v. Rochester Silver Corporation, 50 Nev. 352, 259 P. 632(1927); Adams-McGill Co. v. Hendrix 22 F. Suppl. 789 (Nev. 1938). R.E. Clark (ed) Id. §§ 18.3 at 83 and 53.1 at 345.

[173]Prosole v. Steamboat Canal Co., 37 Nev. 154, 140 P 720 (1914); In re Manse Spring and Its Tributaries, 60 Nev. 280, 108 P2d 311 (1940); Application of Fillipini, 66 Nev. 17, 202 P2d 535 (1949).

[174]N.R.S., § 533.425 (1970).

[175]Id., § 533.345(1970).

[176]Id., § 533.385(1970).

[177]Id., § 533.040(1970).

[178]Prosole v. Steamboat Canal Co. 37 Nev. 154, 140 P 720(1914).

[179]N.R.S., § 533.060(3)(1970); Application of Fillipini, 66 Nev. 17, 202 P2d 535 (1949).

[180]N.R.S., §§ 533.035, 533.060(1), 533.070(1)(1970); Reno Power, Light and Water Co. v. Public Service Commission, 300 F. 645 (Nev. 1921).

[181]N.R.S. § 533.070(2) (1970).

[182]Id., § 533.065(1)(1970).

[183]Id., § 533.065(2)(1970); Ramelli v. Gorgi 38 Nev. 552, 149 P. 71 (1915).

[184]Raeder v. Stein 23 Nev. 92, 42 P. 867 (1895); Doherty v. Pratt, 34 Nev. 343, 124 P. 574(1912).

[185]Tonkin v. Winzell, 27 Nev. 88, 73 P. 593 (1903).

[186]R.L. Dewsnup, Legal Aspects of Water Salvage at 5 (report to the National Water Commission, 1971).

[187]Ryan v. Gallio, 52 Nev. 330, 286 P. 963 (1930).

[188]N.R.S. § 533.045 (1970).

[189]Id., § 533.530(1970).

[190]Id., § 533.460(1970).

[191]N.R.S. § 533.060 (2)(1970).

[192]In re Waters of Manse Spring and Its Tributaries, 60 Nev. 280, 108 P2d 311(1940); In re Determination of Relative Rights in and to the Waters of Franktown Creek, 77 Nev. 348, 364 P2d 1069(1961).

[193]Anderson Land and Stock Co. v. McConnell, 188 F. 818 (Nev. 1910).

[194]In re Waters of Manse Spring and Its Tributaries, 60 Nev. 280 108 P2d 311(1940); In re Determination of the Relative Rights in and to the Waters of Franktown Creek, 77 Nev. 348, 364 P2d 1069(1961).

[195]U.C.A. § 73-1-1 (1953), Wrathall v. Johnson 86 U. 50, 40 P2d 755(1935); Riorden v. Westwood 115 U. 215, 203 P2d 922(1949); McNaughton v. Eaton, 121 U. 394, 242 P2d 570(1952); Fairfield Irrigation Co. v. White 18 U2d 93, 416 P2d 641 (1966).

[196]U.C.A. § 73-3-1 (1953); Munroe v. Irie, 2 U. 535 (1880); Wrathall v. Johnson, 86 U. 50, 40 P2d 755 (1935).

[197]Utah Const. Art. XVII § 1; U.C.A. § 73-1-3; Gunnison Irrigation Co. v. Gunnison Highland Canal Co. 52 U. 347, 174 P. 852 (1918); Oldrayd v. McCrea 65 U. 142, 235 P. 580 (1925).

[198]U.C.A. § 73-2-1; Tanner v. Bacon, 103 U. 494, 136 P2d 957 (1943); United States v. District Court of Fourth District, 121 U. 1, 238 P2d 1132 (1951); Bullock v. Hanks, 22 U (2d) 308, 452 P2d 866(1969).

[199]U.C.A. § 73-2-1; Munroe v. Irie, 2 U. 535 (1880).

[200]Id. § 73-3-2 (Supp. 1971).

[201]Id., § 73-3-8 (Supp. 1971).

[202]Id., § 73-3-17(1953).

[203]Id., § 73-3-14(1953);Brady v. McGonagle, 57 U. 424, 195 P. 188 (1921).

[204]U.C.A. § 73-4-1(1953); Rocky Ford Canal Co. v. Cox, 92 U. 148, 59 P2d 935(1936).

[205]U.C.A. § 73-4-11(1953); Orderville Irrigation Co. v. Glendale Irrigation Co. 17 U 2d 282, 409 P2d 616 (1965).

[206]U.C.A. § 73-3-1 (1953).

[207]Sowards v. Meagher, 37 U. 212, 108 P. 1112(1910); Coray v. Holbrook, 40 U. 325, 121 P. 572(1912); Bountiful City v. De Luca 77 U. 107, 292 P. 194 (1930); Wrathall v. Johnson 86 U. 50, 40 P2d 755 (1955).

[208]Lake Shore Duck Club v. Lake View Duck Club, 50 U. 76, 166 P. 309(1917); Jansen v. Birch Creek Ranch Co. 76 U. 356, 289 P. 1097(1930). It appears that this doctrine is limited to Utah. Other states have allowed appropriations to be made to those having non-possessory interests in land (Issac Walton League in Wyoming, for instance).

[209]U.C.A. § 73-3-8 (Supp. 1971).

[210]Id., § 73-3-11 (1953).

[211]Hardy v. Beaner County Irrigation Co. 65 U. 28, 234 P. 524 (1924); Additionally, a water right is based on annual use during the water use period of each year or the entire year. In re Water Rights of Escalante Valley and Drainage Area, 104 U. 2d 77, 348 P2d 679(1960).

[212]Salt Lake City v. Salt Lake City Water & Electrical Power Co., 24 U. 249, 67 P. 672(1902); U.S. v. Caldwell, 64 U.490, 231 P. 434(1924). See also footnotes 14 & 15 in Substantive Law in introduction, supra.

[213]Mosby Irrigation Co. v. Criddle 11 U. 2d 41, 354 P2d 848 (1960).

[214]Garner v. Anderson, 67 U. 553, 248 P. 496 (1926).

[215]U.C.A. s 73-3-1(1953); Brady v. McGonagle, 57 U. 424, 195 P. 188 (1921); However, this appropriation right does not exclude subsequent appropriations of new water from the same source. Crawford v. Lehi Irrigation Co. 10 U2d 165, 350 P2d 147 (1960).

[216]U.C.A. 73-3-8 (Supp. 1971).

[217]Id., 73-3-21 (1953).

[218]Id., 73-3-5 (1953).

[219]McGarry v. Thompson, 114 U. 442, 201 P2d 288 (1948); Lehi Irrigation Co. v. Jones, 115 U. 136, 202 P2d 892 (1949). The ability to perfect an appropriation requires reasonable diligence to complete construction, such time limit to be set by the state engineer and extended by him if made necessary by circumstance. U.C.A. § 73-3-12; Carbon Canal Co. v. Sanpete Water Users Assn. 19 U2d 6, 425 P2d 405(1960). Diligence in construction is a question of fact to be determined from surrounding circumstances; Carbon Canal Co. v. Sanpete Water Users Assn., 10 U. 2d 376, 353 P2d 916 (1960). When proceedings for an extention of time in which to file proof of an appropriation of water, any doubt would be resolved in favor of due diligence in expeditious development of water and against delay. Carbon Canal Co. v. Sanpete Water Users Assn. 19 U2d 6, 425 P2d 405 (1960).

[220]Riordan v. Westwood, 115 U. 215, 203 P2d 992 (1949); McNaughton v. Eaton, 121 U. 391, 242 P2d 570 (1952).

[221]U.S.A. § 73-3-1(1953). Even rights which had been acquired by adverse possession prior to 1939 have a presumption against them. Use of water within the Drainage Area of Green River, 12 U2d 102, 363 P2d 199 (1961).

[222]Sowards v. Meagher, 37 U. 212 108 P.1112(1910); Bountiful City v. De Luca, 77 U. 108, 292 P. 194(1930); Crawford v. Lehi Irrigation Company 10 U.2d 165, 350 P 2d 147(1960).

[223]Watering stock directly from a stream without making a diversion has been sanctioned on the grounds that water flowing naturally in a stream was common property to which all have equal rights. This right to freely use water is subject to appropriative rights which must be the subject of a diversion. Adams v. Portage Irrigation, Reservoir and Power Co. 95 U. 1, 72 P2d 648(1937).

[224]Cassity v. Castagrio 10 U. 2d 16, 347 P2d 834(1959). Here the court appeared troubled by the problem of how to tell what water and how much was appropriated. This points to the importance of segregating the property claimed from the natural source.

[225]However, beneficial use is declared to be a "public use"--the meaning of which is that eminent domain powers may be used to condemn water uses for beneficial uses. U.C.A. § 73-1-5 and 73-1-6 (1953). Cf. footnotes 8, 9 and 10 Substantive Law introduction, supra.

[226]Utah Const. Art. XVII § 1, U.C.A. § 73-1-3 (1953); Gunnison Irrigation Co. v. Gunnison Highland Canal Co. 52 U. 347, 174 P. 852 (1918); Big Cottonwood Lower Canal Co. v. Cook, 73 U. 383, 274 P. 454 (1929), McNaughton v. Eaton 121 U. 394, 242 P2d 570 (1952).

[227]R.E. Clark (ed.), Id. § 29.5 at 172.

[228]U.C.A. § 73-3-21 (1953).

[229]R.E. Clark (ed.) Id., § 18.3 at 83 and 53.1 at 345.

[230]U.C.A. § 73-1-10 (1953); See Petrofesa v. R.G.W.R. Co., 110 U. 109, 169 P2d 808 (1946).

[231]Id.

[232]Id.

[233]Id., § 73-1-11 (1953). Deciding what water is and is not appurtenant is confusing but necessary because of § 73-1-10 and 73-1-11. Courts appear to have decided this on a case by case basis. In re Johnson's Estate, 64 U. 114, 228 P. 748 (1924); Cortella v. Salt Lake City 93 U. 236, 72 P2d 630(1937).

[234]Descret Livestock Co. v. Sharp, 123 U. 353, 259 P2d 607 (1953).

[235]U.C.A. § 73-1-2 (1953).

[236]Sowards v. Meagher 37 U. 212, 108 P. 1112(1910); Big Cottonwood Tanner Ditch Co. v. Shurtfiff, 49 U. 569, 164 P. 856 (1917).

[237]R.L. Dewsnup, Legal Aspects of Water Salvage at 5 (report to the National Water Commission, 1971).

[238]Little Cottonwood Water Co. v. Kimball 76 U. 243, 289 P. 116 (1930); Wrathall v. Johnson, 86 U. 50, 40 P2d 755 (1935); Wayman v. Murray City Corp. 23 U2d 97, 458 P2d 861 (1969). It is also to be noted that there is a positive duty to return surplus water to the stream from which it was taken, Brian v. Fremont Irrigation Co. 112 U. 220, 186 P2d 588 (1947).

[239]U.C.A. § 73-1-4 (1953).

[240]Promotory Ranch Co. v. Argile 28 U. 398, 79 P. 47 (1904); Hammond v. Johnson, 94 U. 20, 66 P2d 894 (1937).

[241]Wellsville East Field Irrigation Co. v. Lindsay Land and Livestock Co., 104 U. 448, 137 P2d 634(1943); Kirk v. Criddle 12 U2d 112, 363 P2d 777 (1961).

[242]Desert Livestock Co. v. Hoopiania, 66 U. 25, 239 P. 479 (1925); Hammond v. Johnson 94 U. 20, 66 P2d 894 (1937); Kirk v. Criddle, 12 U.2d 112, 363 P2d 777 (1961).

[243]Rocky Ford Irrigation Co. v. Keuts Lake Reservoir Co. 104 U. 202, 135 P2d 108 (1943).

[244]Wyo. Const. Art. VIII, § 1; Wyo. Stats. § 41-2(1957); Northside Canal Co. v. State Board of Equilization 8 F2d 739 (1925); Mitchell Irrigation District v. Sharp 121 F2d 964 (1941).

[245]Wyo. Const. Art. I, § 31; Wyo. Stats. § 41-2 (1957).

[246]Willey v. Decker 11 Wyo. 496, 73 P 210(1903); Merrill v. Bishop 74 Wyo. 298, 287 P2d 670 (1955); Hunziker v. Knowlton 78 Wyo. 241, 322 P2d 141 (1958).

[247]Wyo. Stats. § 41-2 (1957); Willey v. Decker 11 Wyo. 496, 73 P 210 (1903).

[248]Wyo. Stats. § 41-5 et. seq. and §§ 41-201 et. seq. (Supp. 1971).

[249]Wyo. Stats. §§ 41-165 et. seq. (1957); Wyo. Stats. § 41-212.1 (Supp. 1971); Anita Ditch Company v. Turner 389 P2d 1018 (Wyo. 1964).

[250]For a discussion of the Wyoming system of administrative adjudication, see R. E. Clark, Id., § 23.2 at 126-128.

[251]Wyo. Stats. § 41-165 et. seq. (1957); Syo. Stats. § 41-212.1 (Supp. 1971).

[252]Anita Ditch Company v. Turner 389 P2d 1018 (Wyo. 1964); White v. Wheatland Irrigation District 413 P2d 252 (Wyo. 1966).

[253]Cambell v. Wyoming Development Co. 55 Wyo. 347, 100 P2d 124, 102 P2d 745 (1940). See also, R.E. Clark, Id. at 127.

[254]Wyo. Stats. § 41-2 (1957).

[255]See footnotes 14, 15 in the Substantive Law introduction, supra.

[256]Wyo. Stats. § 41-201 (1957).

[257]Wyo. Const. Art. 13, § 5.

[258]State v. Laramie Rivers Co., 136 P2d 482 (1943).

[259]Moyer v. Preston, 6 Wyo. 308, 44 P845 (1896).

[260]Wyo. Stats. § 33-366 (1957).

[261]Wyo. Stats. § 41-201.

[262]Id.

[263]Wyo. Stats. § 41-181 and 41-212 (1957); Wyo. Hereford Ranch v. Hammond Packing Co., 33 Wyo. 14, 236 P 764 (1925); Cambell v. Wyoming, 55 Wyo. 347, 102 P2d 745 (1940); Laramie Rivers Co. v. Le Vasseur, 65 Wyo. 414, 202 P2d 680 (1949).

[264]Wyo. Stats. § 41-206 (1957).

[265]Id.

[266]Id.

[267]Id.

[268]Wyo. Stats. § 41-211 (1957).

[269]Id.

[270]Reagle v. Square S. Land and Cattle Co. 733 Colo. 392, 276 P2d 235 (1954); City and County of Denver v. Northern Colorado Water Conservancy District, 130 Colo. 375, 276 P2d 992 (1954).

[271]Wyo. Stats. § 41-181 and 41-212 (1957).

[272]Wyo. Stats. § 41-181 (1957).

[273]Cambell v. Wyoming, 55 Wyo. 347, 102 P2d 745 (1940); Hunziker v. Knowlton, 78 Wyo. 241, 322 P2d 141 (1958).

[274]Wyo. Stats. § 41-188 (1957).

[275]Wyo. Stats. § 41-10.4 (1957).

[276]Wyoming is not the only state which does not define this term. See footnotes 8, 9, 10 in the Substantive Law introduction, supra.

[277]R.E. Clark (ed.) Id., § 29.5 at 172. Note, again the role of "reasonableness" in determining what is beneficial.

[278]City and County of Denver v. Sheriff, 105 Colo. 193, 96 P2d 836 (1939).

[279]R.E. Clark (ed.) Id., § 19.4 at 90 for some uses classed as nonbeneficial.

[280]Wyo. Stats. § 41-47 (1957).

[281]Wyo. Const. Art. VIII, § 3; Wyo. Stats. § 41-2 (1957); Mitchell Irrigation District v. Sharp 121 F2d 964 (1941).

[282]Wyo. Stats. § 41-3 (1957).

[283]Wyo. Stats. § 41-4 (1957).

[284]Wyo. Stats. § 41-3 (1957).

[285]Wyo. Stats. § 41-3 and 41-4 (1957).

[286]Id.

[287]Id.

[288]Day v. Armstrong 362 P2d 137 (Wyo. 1961).

[289]Wyo. Stats. § 41-3 (1957).

[290]R.E. Clark, (ed.), Id. §§ 18.3 at 83 and 53.1 at 345; Whitmore v. Murry City, 107 Utah 445, 154 P2d 748 (1944); Provo Bench Canal and Irrigation Co. v. Luike, 5 Utah 2d 53, 296 P2d 723 (1956).

[291]Wyo. Stats. § 41-2 (1957). See also footnotes 14 and 15 in Substantive Law introduction, supra.

[292]Wyo. Stats. Id.

[293]Wyo. Const. Art. I, § 33.

[294]United States v. Willow River Power Co. 324 U.S. 449, 65 Sup. Ct. 761 (1945).

[295]Wyo. Stats. §§ 41-181 and 41-212 (1957).

[296]Wyo. Const. Art. VIII, § 3; Wyo. Stats. § 41-2 (1957 .

[297]Wyo. Stats. §§ 41-148 and 41-181 (1957).

[298]Wyo. Stats. § 41-184 (1957).

[299]Wyo. Stats. § 41-2 (1957).

[300]Wyo. Stats. §§ 41-5 thru 41-8 (1957).

[301]R.L. Dewsnup, Legal Aspects of Water Salvage at 5 (report to the National Water Commission, 1971).

[302]Wyo. Stats. § 41-63 (1957).

[303]See footnotes 8, 9, 10 in Substantive Law introduction, supra.

[304]Wyo. Stats. § 41-47 (1957).

[305]Ward v. Yoder, 355 P2d 371, 357 P2d 180 (Wyo. 1960).

[306]Wyo. Stats. § 41-48 (1957).

[307]Wyo. Stats. § 41-49 (1957).

[308]Wyo. Stats. § 41-50 (1957).

[309]Wyo. Stats. § 41-53 (1957).

[310]"Not for hire" is used here to mean not for profit and limiting delivery to members only except in very unusual circumstances.

[311]Another difference is that legal title does not vest in the association as with mutual companies. See footnote 6 supra, this section.

[312]This type of organization is an apparent rarity in the United States. The cooperative--so familiar in agricultural communities--is founded for a different reason than are mutual irrigation associations. The mutual irrigation organization is not a business to foster business relations and its existence does not depend on the patronage and good will of its members. Its business is to distribute water to members--the title to which is held by them. In light of this observation, this

discussion will present an organization which, though title to water remains in the individual, the spirit of the association is that of a cooperative. This is so unless the government chooses to formalize the arrangement by law. Such an organization may have the right blend of formality and informality for developing nation such as Pakistan which is trying to move forward but still needs some of the old customs to hold on to.

A statement of policy which might be pertinent to Pakistan's problems in agricultural development and to which this type of organization is directed is found in Utah Code Annotated, § 3-1-1 (1953).

[313]Utah Code Ann., § 3-1-10 (1953). The qualifications for an incorporator may be similar. See, Id., § 3-1-3 (1953).

[314]Suggestions as to what items might be covered in such articles may be found in Utah Code Ann., § 3-1-5 (1953). Too, provisions for amending these articles and for establishing by-laws as well as delineating the powers of such an association. See, Utah Code Ann., § 3-1-6 through 3-1-9 (1953). Also, see the discussion of organization, supra., this section.

[315]This formal signing of a document may well act as More of a deterrent to wrongdoing than a mere formal agreement.

[315]Note that this is not a corporation which has a life of its own but merely an association of persons who may leave at any time they wish. Not having a life of its own requires no submission of rights to create the separate entity.

[316]For definition of a tenancy in common, see footnote no. 19, infra, this section.

[317]Shares would, of course, be based on the amount of water right that an individual brought to the association as his rights bore on the total rights of all members. See, Smith v. North Canyon Water Co., 16 U. 194, 52 P. 283 (1898), Candelaria v. Vallejos, 13 N.M. 140, 81 P. 589 (1905).

[318]Tangible, physical evidence of a water right may provide helpful in dealing with people not familiar with conceptual rights and mere entries in ledgers.

[319]This right to sell or assign flows from the nature of a tenancy in common (which see) which dictates that each tenant owns his individed interest in the total individually--not jointly--and so he is free at all times to dispose of it. See, Biggs v. Utah Irrigation District Co. 7 Ariz. 331, 64 P. 494 (1901).

[320]New Mexico Stats. § 75-14-25.1 (1953) defines them as political subdivisions of the state.

[321]This may be pertinant to Pakistan's situation of many small farmers on one ditch off a minor canal.

[322]New Mexico Stats. § 75-14-1 et. seq. (1953).

[323]Id., § 75-14-31 through 75-14-37 (1953).

[324]Id., § 75-14-25 (1953).

[325]Id., § 75-14-7 (1953).

[326]Id., § 75-14-11 (1953), Utah Code Ann., § 3-1-9 (1953). See also, Slosser v. Salt River Valley Canal Co., 7 Ariz. 376, 65 P. 332 (1901).

[327]Members of unincorporated associations are usually regarded as tenants in common of the combined properties, and their rights and responsibilities as against each other are limited by the original agreement. Therefore, while this agreement (which may be termed the "articles of agreement" in cases of unincorporated entities or "articles of incorporation" in corporate bodies) need not be elaborate, it should contain a clear statement of the purpose of organizing and of the respective interests, duties, obligations and rights of members. Also, note that some statutes allow the by-laws to provide for these items in cases of incorporated associations. Colo. Rev. Stats. § 30-3-10 (1963), Utah Code Ann., § 3-1-8 (1953) are examples of this.

[328]A tenant in common is described in one case where two or more hold the same (property) with interests accruing under different titles, or accruing under the same title, but at different periods, or conferred by words of limitation importing that the grantees are to take in distinct shares. The only unity which is vital is the unity of possession. Whyman v. Johnston 62 Colo. 461, 163 P.76 (1917). See also, Binning v. Miller 56 Wyo. 129, 102 P.2d 64 (1940) rehearing denied 56 Wyo. 129, 105 P.2d 278 (1940).

[329]Farmers' High Line Canal and Reservoir Co. v. Southworth, 13 Colo. 111, 21 P. 1028 (1889), Nicholas v. McIntosh, 19 Colo. 22, 34 P.278 (1893).

[330]Johnston v. Little Horse Creek Irrigation Co., 13 Wyo. 208, 79 P.22 (1904). Note that this relationship is built and depends on a mutual trust. Violation of this "fiduciary relationship" will be enjoined. Webster v. Knap, 6U.2d 273, 312 P.2d 557 (1957).

[331]Fry v. Lowden, 70 Cal. 550, 11P 838 (1886); Nichols v. McIntosh, 19 Colo. 22, 34 P. 278 (1893). It appears that the basis for these rulings is the fiduciary relationship, i.e., the trust between members inherent in tenancies in common. By gaining unfair advantage over fellow members, this fiduciary relationship is breached and, if allowed to go unchecked, would lead to the disintegration of the association. See, Webster v. Knop, 7 U.2d 273, 312 P.2d 557 (1957).

[332]Biggs v. Utah Irrigation Ditch Co., 7 Ariz. 331, 64 P. 494 (1901); Rose v. Mesmer, 142 Cal. 322, 75 P. 905 (1904); Gray v. Quiller, 144 Colo. 54, 344 P.2d 99 (1960). The question of abandoning a water appropriation is relevant. Though the general rule of law is that real property must not be abandoned, exceptions are made in the case of appropriate water rights

because of the scarcity of the commodity and because of the demand for the product. A Colorado court has held that each of several water appropriators using a ditch in common may separately abandon his right thereto, and an injury to one by virtue of the others abandonment of all or part of the ditch by change of point of diversion of place of use is not an actionable injury. See, Brighton Ditch Co. v. City of Englewood, 124 Colo. 366, 237 P. 2d 117 (1951).

[333]Arnett v. Linhart, 21 Colo. 188, 40 P. 355 (1895); Buller v. Buller 62 Col. App. 2d 694, 145 P. 2d 653 (1944).

[334]There were no more recent cases on this point discovered than the two cited below.

[335]Candelaria v. Vallejos, 13 N.M. 140, 81 P.589 (1905); Bartholemew v. Fayette Irrigation Co. 31 U.1, 86 P. 481 (1906). See also, Kinney on Irrigation and Water Rights, 2nd Ed. § 1462 (1912) for a discussion of this point. The test seems to be whether vested rights will be injured by the majority. If they will be, and the change requested cannot be effected without hurting a minority, the rule seems to be as stated--that the majority cannot run roughshod over the minority. But where no injury would result, a minority may not stand in the way. Too, where maintenance of the ditch becomes impossible--therefore the good of the community is at stake--without a change which will adversely affect a minority, the good of the community at large will prevail and the minority's objections will be to no avail.

[336]Id.

[337]Bartholemew v. Fayette Irrigation Co. (see above); Fisher v. Bountiful City, 21 U. 29, 59 P.520(1899).

[338]The duty to maintain the ditches and works may be statutorily imposed. See, Colo. Rev. Stats., § 31-14-8 (1971). See also, Arnett v. Linhart, 21 Colo. 188, 40 P.355 (1895); Smith v. North Canyon Water Co., 16 U. 194, 52 P.283 (1898); Compton v. Knuth, 117 Colo. 523, 190 P.2d 117 (1948) and First National Bank of Denver v. Groussman, 28 Colo. App. 215, 483 P.2d 398 (1971).

[339]Colo. Rev. Stats., § 31-14-4(1) (1965); New Mexico Stats., § 75-14-23 35. seq. (1953).

[340]Colo. Rev. Stats., Id.; Wyo. Stats. s 36-106 (1957) and s 41-221 for stockholders using water on land under the line of the same ditch.

[341]Cache La Poudre Irrigation Co. v. Weld Reservoir Co., 25 Colo. 144, 53 P. 318 (1898).

It is to be noted, too, that loss of water by seepage or evaporation, after diversion from the stream or ditch, is not an injury to or a loss of a water right as between ditch contenants. Brighton Ditch Co. v. City of Englewood, 124 Colo. 366, 237 P.2d 116 (1951).

[342]Colo. Rev. Stats. § 30-3-12 (1963); Utah Code Ann., § 3-1-13 (1971), New Mexico Stats., § 75-15-3(1953). For convenience, the first directors may simply be appointed with elections held thereafter. It is usually provided that directors and executive officers be chosen from the members or stockholders. See Utah Code Ann., § 3-1-3 (1953); Colo. Rev. Stats., § 30-3-12 and 30-3-13 (1963). From this it is obvious that the job is usually not full-time so the member can also pursue his agricultural activities. Salary, therefore, is not great and a per diem basis may be best, i.e., $10 per meeting plus travel expenses. This may be varied depending on the amount of time an individual is required to devote to company business.

[343]Colo. Rev. Stats., § 30-3-16 (1963); Utah Code Ann. § 3-1-14 (1953). It is to be noted that the whims of the members are controlled by requiring at least ten percentum of the members to join in the petition to request an election for removal of a director. In addition, officers appointed by directors may also be removed by this method. See Utah Code Ann., § 3-1-16 (1953) and Wyo. Stats., § 17-175 (1957).

[344]Colo. Rev. Stats., § 30-3-10 (1963); Utah Code Ann., § 3-1-8 (1953); Wyo Stats., § 17-159 (1957); West's annotated Corporation Code, § 12900 (1955).

[345]Colo. Rev. Stats., § 30-3-9 (1963); Utah Code Ann., § 3-1-7 (1953); Wyo. Stats., 17-169 (1957).

[346]Utah Code Ann., § 3-1-32 (1953). However, members may lose their vote if they do not respond to a public notice for impending election within the prescribed time or if their stock is not fully paid or if they are delinquent in payment of their assessments. See Utah Code Ann., Id., New Mexico Stats., § 75-15-3 (1953); and West's Annotated Corporation Code, § 12801 (1956).

[347]Utah Code Ann., § 3-1-20-(1953).

[348]Colo. Rev. Stats., 30-3-11 (1963) which provides for one annual meeting or more meetings per year if desired; Utah Code Ann., § 3-1-12 (1953); Wyo. Stats., § 17-174 (1957). Notice of meetings must be sent to members in order to give them adequate time to adjust their schedules and prepare to attend. See Utah Code Ann., Id.(10 day requirement) and Wyo. Stats., Id. (20 day requirement).

[349]West's Annotated Corporation Code, § 12702. But note that this section provides that any member who has voting rights may vote. Members may lose their rights by not paying for their stock certificates or by being delinquent in payment of their assessments. See footnote no. 37, supra. Too, stock may be issued with no voting rights.

[350]New Mexico Stats., § 75-15-3 (1953).

[351]Colo. Rev. Stats., s 30-3-15 (1963); Utah Code Ann., s 3-1-10(b) (1953); Wyo. Stats., s 17-172(s)(1957); West's Annotated Corporation Code, s 12702. Digression: As can be seen, this arrangement is more popular than the one allowing voting shares to be determined by the amount of water rights. There are dangers in both positions, of course. Where voting shares are allotted by amount of water rights, it is immediately apparent that the large land holders will probably control things. Where reform is sought and the vast majority of persons affected by the proposed reform are small landholders as is the case in Pakistan--this drawback would likely impugne the entire effort.

On the other hand, the inequities of allowing the small owner to dictate policy to one who has a much larger investment and interest at stake, too, is immediately apparent.

Some middle ground would be best. As a suggestion, it might prove feasible to establish a system of cumulative voting. In this suggestion, voting stock would be distributed on the basis of water rights owned but in an election, a stockholder may cast as many votes in the aggregate as he holds shares of stock multiplied by the number of directors or issues upon which he is voting. He may cast the whole number for only one candidate or issue or he may divide them. This makes it possible for minorities to organize and elect a representative or push an issue through but it would not give them total control. Neither would the major owners have absolute control.

[352]Utah Code Ann., § 3-1-11 (E) (1953); Wyo. Stats., § 17-172(7) (1957).

[353]Colo. Rev. Stats., § 30-3-15(7) (1963); West's Annotated Corporation Code, § 12404 (1956). It is also to be noted that assessments may vary according to the class of stock held. It has been held that no problem arises so long as assessments are made on a pro-rata basis which assumes an equal burden per share among each class of stockholder. See Robinson v. Booth-Orchard Grove Ditch Co. 94 Colo. 515, 31P2d 487 (1934).

[354]Colo. Rev. Stats., s 30-1-4 (1963); Utah Code Ann., s 3-1-13 (1953); Wyo. Stats., s 17-173 (1957).

[355]C.R.S., s 30-3-3 also 30-3-6 (1963); U.C.A. s 3-1-9 (1953); Wyo. Stats., s 17-171 (1957).

[356]Three is obviously the smallest number possible as provided for in Utah Code Ann. § 3-1-13 (1953). Five, however, is not uncommon, Colo. Rev. Stats., § 30-3-12 (1963). Larger boards may be allowed and designed to represent geographical districts or special interests. See Colo. Rev. Stats., § 30-3-12 (1963) and Wyo. Stats., § 17-173 (1957). Allowance for district delineation may be provided for in the by-laws.

[357]Utah Code Ann., § 3-1-13; 3-1-15 (1953) and Wyo Stats., § 17-173 (1957).

[358]Colo. Rev. Stats., § 30-3-10 (1963).

[359]Colo. Rev. Stats., § 30-3-12 (1963); Utah Code Ann., § 3-1-13 (1953); Wyo. Stats., § 17-173 (1957).

[360]Colo. Rev. Stats., § 30-3-12(4) (1963); Utah Code Ann., § 3-1-13(111) (b) (1953).

[361]Colo. Rev. Stats., § 30-3-13 (1963); Utah Code Ann., § 3-1-15 (1953).

[362]In small companies the two offices probably would be combined because there would not be enough duties to keep two people busy. Too, in the interests of policy stability, it is best to simplify the managerial structure where possible.

[363]Colo. Rev. Stats., Id.

[364]To eliminate the petulant and baseless harassment of officials, it is usually provided that, to remove an officer or director, the action must be based on cause. See West's Ann. Corporation Code § 12600 (1955) and Utah Code Ann., § 3-1-16 (1953).

[365]To ensure that an action for removal is based on solid complaints (see above), it is generally provided the charges must be in writing (Colo. Rev. Stats., § 30-3-16 (1963); Utah Code Ann., Id. and Wyo. Stats., § 17-175 (1957) and that a petition for removal must be signed by a percentage of members, usually five (Colo. Rev. Stats., Id.) or ten percent (Utah Code Ann. Id., Wyo. Stats., Id.). In cases where directors come from districts, a larger percentage of members of that district is required. Upon filing a valid petition with the secretary of the association, the director against whom the charges are filed is notified of the charges to allow time to prepare rebuttal or defense. At the next regular meeting of the association, a general election is held (presumably after the merits of each side are considered) to put the matter to a vote. A majority of votes cast (not of total membership) determines the outcome. See Colo. Rev. Stats., Id., Utah Code Ann., Id. and Wyo. Stats., Id.

[366]They may or may not be incorporated. See section on unincorporated Voluntary Associations.

[367]"at cost" means not for profit. See West's Ann. Calif. Public Utilities Code §2705.

[368]West's Ann. Public Utilities Code § 2725 (Supp. 1972); Combs v. Agricultural Ditch Co., 17 Colo. 146 28 P.966 (1892).

[369]In some states, these are organized under special statutes for non-profit corporations. See Utah Code Ann., § 16-6-18 through 16-6-53 (Supp. 1971); Wyo. Stats., § 17-122.1 through 17-122.14 (1957).

[370]In some areas stock is statutorily and judicially prohibited from being appurtenant. Utah Code Ann. s 73-1-10 (1953); Hatch v. Adams 7 U.2d 73, 318 P.2d 633 (1957).

[371]Colo. Rev. Stats. § 31-14-1 (Supp. 1967); Wyo. Stats. 17-188 (1969). See also, Wiley v. Decker, 11 Wyo. 496, 73 P.210 (1903).

[372]Corporations are creatures of statutes. See Colo. Rev. Stats. 31-14-1 (Supp. 1967).

[373]Zion's Savings Bank and Trust Co. v. Tropic and East Fork Irrigation Co. 102 U. 101, 126 P.2d 1053 (1942).

[374]Russell, Theodore W., Mutual Water Companies in California, XII Southern California Law Review 157-158 (1939).

[375]There are the usual small assets such as office equipment but this description is of the assets comprising the corporation primarily.

[376]Profits are reflected in extra water on a pro rata basis for shareholders.

[377]West's Ann. Public Utilities Code § 2701 (1956).

[378]Not necessarily for profit.

[379]Even supplying surplus water left over after all shareholders had been taken care of has been sufficient to create a public interest. Yucupa Water Co. no. 1 v. Public Utilities Commission, 9 Cal. 239, 357 P.2d 295 (1960).

[380]West's Ann. Public Utilities Code § 2701 (1956).

[381]Id. § 2705 (Supp. 1972); J.M. Howell v. Corning Irrigation Co., 177 Cal. 513, 171 P.100 (1918); Allen v. Railroad Commission 179 Cal. 68, 175 P. 455, Cert denied 249 US 601, 63 L Ed. 797 (1918).

[382]Leavitt v. Lassen Irrigation Co. 157 Cal. 82, 106 P. 404 (1909).

[383]Francioni v. Soledad Land and Water Co. 170 Cal. 221, 149 P. 161 (1915).

[384]Williamson v. Railroad Commission, 193 Cal. 22, 222 P. 803 (1924).

[385]Merely providing the bylaws or articles that a corporation will or will not be affected with a public interest will not of itself be decisive. Allen v. Railroad Commission, 179 Cal. 68, 175 P. 466, cert. denied 249 US 601, 63 L. Ed. 797 (1918).

[386]There are some situations which allow mutual company to sell to outsiders. Among these are delivering to others in a bona fide water emergency for the duration of the emergency. Companies have also been allowed to deliver to lessees of their stock and to outside land leased by one of the company stockholders. West's Ann. Public Utilities Code § 2705 (1972 Supp.).

[387]Using condemnation is in the nature of eminent domain and is affected with public interest. Though the cases are not entirely in harmony (see, Nash v. Clark 27 U. 158, 75 P. 371 affirmed 198 US 361, 49 L Ed. 1085 (1904)) there is a serious danger that such a use will result in public status and regulation as seen in Lamb v. California Water and Telephone Co. , 21 C.2d 33, 129 P.2d 371 (1942).

[388]Supply Ditch Co. v. Elliott, 10 Colo. 327, 15 P. 691 (1887).

[389]Rocky Ford Canal Co. v. Simpson, 5 Colo. App. 30, 36 P. 638 (1894); Miller v. Imperial Co. No. 8, 159 Cal. 27, 103 P. 227 (1909).

[390]Supply Ditch Co. v. Elliott (see above); Farmers' Independent Ditch Co. v. Agricultural Ditch Co. 22 Colo. 513, 45 P. 444 (1896). The trust spoken of is a revocable trust during the lifetime of the grantor. He may sell his shares at any time unless a lien has attached as a result of nonpayment of an assessment. Title does not vest. East River Bottom Water Co. v. Boyce, 102 U. 149, 128 P.2d 277 (1942).

[391]Supply Ditch Co. v. Elliott (see above); Farmers' Independent Ditch Co. v. Agricultural Ditch Co. (see above); Montrose Canal Co. v. Lautsenhizer Ditch Co. 23 Colo. 233, 48 P. 532 (1896).

[392]Goodell v. Verdugo Canon Water Co., 138 Cal. 308, 71 P. 354 (1903; Butterfield v. O'Neill, 19 Colo. App. 7, 72 P. 807 (1903)). Officers may also be ordered to do something on a writ of mandamus issued pursuant to a complaint by a stockholder. Along the same lines, quo warrants amy issue to face an officer to explain his action.

[393]Farm Investment Co. v. Alta Land and Water Co., 28 Colo. 408, 65 P.22 (1901).

[394]The trust is revocable and the corporation does not have the right, generally to sell a shareholder's stock. East River Bottom Water Co. v. Bouce, 102 U. 149, 128 P. 2d 277 (1942). To sell the stock would be a violation of the trust duty to act in the interests of the stockholders. However, in the absence of implied restrictions, a power to sell stock has been implied from the power of the corporation to acquire and own water rights. Old Mill Ditch and Irrigation Co. v. Estell, 65 Or. 586 133 P. 90 (1913). This is a danger avoided by using care in drafting the charter or articles of incorporation. See also, Consolidated Peoples' Ditch Co. v. Foothill Ditch Co. 205 Cal. 54, 269 P. 915 (1928); and Billings Ditch Co. v. Industrial Commission, 129 Colo. 69, 253 P.2d 1058 (1953). However, some courts still have difficulty ignoring the corporate firm. See Denver Joint Stock Land Bank v. Markham, 106 Colo. 509, 107 P.2d 313 (1940): Big Goose and Beaver Ditch Co. v. Wallop, (Wyo.), 382 P.2d 388 (1963).

[395]Rocky Ford Canal Co. v. Simpson, 5 Colo. App. 30, 36 P. 638 (1894); Fuller v. Azusa Irrigating Co., 138 Cal. 204, 71 P. 98 (1902); Genola Town v. Santaquin, 96 U. 88, 80 P.2d 930 (1938); Locke v. Yorba Irrigation Co., 35 Cal. 2d 205, 217 P.2d 425 (1950).

[396]Biggs v. Utah Irrigation Ditch Co. 7 Ariz. 331, 64 P.494 (1901). Thus stock represents ownership of the corporate assets. It follows that this stock represents part of the irrigation system that delivers the water. But in mutual companies--as opposed to commercial companies--this stock also represents the right to the service of water from the company's system.

[397]Cache La Poudre Irrigation Co. v. Larimer and Weld Reservoir Co., 25 Colo. 144, 53 P.318 (1898); "Stock not appurtenant is personal property." Denver Joint Stock Land Bank v. Markham, 106 Colo. 509, 107 P.2d 313 (1940). Similarly where stock is not appurtenant, a deed or mortgage to the land carries with it no right in a ditch company supply water thereto. Oligarchy Ditch Co. v. Farm Investment Co., 40 Colo. 291, 88 P. 443 (1906).

[398]Stone v. Imperial Water Co. No. 1, 173 Cal. 39, 159 P. 164 (1906); Woodstone Marble and Tile Co. v. Dunsmore Canyon Water Co., 47 Cal. App. 72, 190 P.213 (1923); Wheat v. Thomas, 209 Cal. 306, 287 P.102 (1930); See also, Bank of Visalis v. Smith, 146 Cal. 398, 81 P. 542 (1905); Kennard v. Binney, 62 Cal. App. 732, 217 P.808 (1923).

[399]Colo. Rev. Stats. § 188-1-2 (1963); Wyo. Stats. § 41-254 (1957); Stesel v. Santa Ana River Water Co., 35 Cal. App. 2d 117, 94.2d 1052 (1939).

[400]Cache La Poudre Irrigation Co. v. Larimer and Weld Reservoir Co., 25 Colo. 144, 53 P.318 (1898).

[401]Colo. Rev. Stat. 31-13-7 (1963); Rocky Ford Canal Co. v. Sampson, 5 Colo. App. 30, 36 P. 638 (1894); Wheeler v. Northern Colorado Irrigation Co., 10 Colo. 582, 17 P. 487 (1888); Millver v. Imperial Water Co. 156 Cal. 27, 103 P.227 (1909); Lindsay-Strathmore Irrigation District v. Wutchumna Water Co., 111 Cal App. 688, 296 P. 933 (1931) and Sherwood Irrigation Co. v. Vandework (Colo.), 331 P.2d 810 (1958).

[402]Miller v. Imperial Water Co. (See above).

[403]Mountain Supply Ditch Co. v. Lindekugel, 24 Colo. App. 100, 131 P. 789 (1913).

[404]Colo. Rev. Stats. § 31-14-8 (1971); Wyo. Stats., § 41-217 (1957); Mountain Supply Ditch Co. v. Lindekugel, 24 Colo. App. 100, 131 P. 789 (1913); Engel v. Henry, 59 Cal. P.U.C. 457 (1962).

[405]O'Connor v. North Truckee Ditch Co. 17 Nev. 245, 30 P. 882 (1883); Rocky Ford Canal Co. v. Sampson, 5 Colo. App. 30, 36 P. 638 (1894). This is qualified in some instances and can be provided for in a company's contract. For example, Acts of God, forcible entry, hostile diversion or temporary damage by flood or accident may excuse a failure to deliver water. However, if a shortage might have been prevented by judicious action on the part of the company, liability for damages suffered as a result of that shortage might have been prevented by judicious action on the part of the company, liability for damages suffered as a result of that shortage may result. Pawnee Land and Cattle Co. v. Jenkins, 1 Colo. 425, 29 P. 381 (1892).

[406]Wyo. Stats. § 41-181 (1957) provides a limitation of one cubic foot per second for every seventy acres of land.

[407]Necessarily, these plans can only be used where the land area to be supplied is fixed in advance and where the supply of water is more than adequate to cover the stockholders' demands. Too, existing stockholders must have the right to veto the issuance of new stock if their water supply will be diminished by such issuance. Where a company is a public or quasi-public concern, a public agency will make the determination of sufficiency. See West's Ann. Public Utilities Code § 2708 (1956); Sunkist Homes Inc. v. Southern California Water Co. 54 Cal. P.U.C. 204 (1955).

[408]Colo. Rev. Stats. § 31-14-4 (1965); Wyo Stats. § 36-106 (1957); Fuller v. Azusa Irrigation Co., 138 Cal. 204, 71 P. 98 (1902). See also Wyo. Stats. 41-221 (1969) for stockholders using water on land under the line of the same ditch.

[409]See footnote 22, supra and discussion following.

[410]Calahan v. Chilcott Ditch Co., 37 Colo. 331, 86 P. 123 (1906); McHale v. Goshen Ditch Co., 49 Wyo. 100, 52 P. 2d 678 (1935); Henderson v. Kirby Ditch Co. (Wyo.) 373 P. 2d 591 (1962). The assessment may sometimes be in labor or money. Colo. Rev. Stats. § 31-14-4(1); New Mexico Stats., § 75-14-23 35. seq. in cases of community ditches.

[411] Colo. Rev. Stats. § 31-14-4 (1965); Wyo. Stats. § 36-106 (1957).

[412]See Colo. Rev. Stats. § 31-14-14(4). Also, Stevens v. Curtis, 122 Col. App. 2d 30, 264 P.2d 606 (1953).

[413]Green and Griffen Real Estate and Investment Co. v. Salt River Valley Water Users' Association, 25 Ariz. 354, 217 P.945 (1923). It should be noted that appurtenancy is being gradually abrogated in the districts which recognized it pursuant to a policy of making water available in the most advantageous places rather than "lock" it to one piece of land. See Ariz. Rev. Stat. § 45-172 (1972).

[414]Federal Land Bank v. Bissonette, 51 Idaho 219, 4 p.2d 364 (1931).

[415]Farmers' Pawnee Canal Co. v. Henderson 46 Colo. 37, 102 P. 1063 (1909). Since however, assessment is the only way to raise extra revenue for mutual companies, this type of provision will rarely, if ever, appear.

[416]Laramie Rivers Co. v. Watson, 69 Wyo. 333, 241 P. 2d 1080 (1952). A more direct method of enforcement of payment is to simply refuse delivery of water. Such methods are recognized in New Mexico (see; New Mexico Stats., § 75-14-24 and 75-14-41) (in the case of the community ditch or cooperative association) and in Wyoming (see; Wyo. Stats § 36-106 and 41-221 (1957)). In New Mexico, a fine may be assessed before the water is denied (New Mexico Stats. § 75-14-34 (1953)).

[417]Under this category it has been held in early decisions that a company may make a ratable reduction in the amount of water to shareholders in time of a drought. Since then, this has been codified in at least one state. West's Ann. Public Utilities Code, § 2711 (1956). Fuller v. Azusa Irrigation Co. 138 Cal. 204, 71 P. 98 (1902); Goodell v. Verungo Canon Water Co., 138 Cal. 308, 71 P. 354 (1903).

[418]Bethune v. Salt River Valley Water Users' Association, 26 Ariz. 525, 227 P. 989 (1924).

[419]Old Mill Ditch and Irrigation Co. v. Estell, 65 Or. 586 133 P. 90 (1913); There is tension between this ruling and the general duty imposed on a company to restrain from acting to the detriment of its stockholders, and, in deed, to act for their benefit under the trust arrangement resulting from the contractual relationship discussed in § 3 and 4 supra.

[420]Again, note the discussion in §§ 3 and 4, supra. See also, Stuart v. Davis, 25 Colo. App. 568, 139 P. 577 (1914).

[421]Note the suggested plans for stock issuance and the assumptions attendant to each in § 4, supra.

[422]Laramie Rivers Co. v. Watson, 69 Wyo. 333, 241 P.2d 1080 (1952).

[423]Bartholomew v. Fayette Irrigation Co., 31 U.1, 86 P. 481 (1906).

[424]See, for example, Colo. Rev. Stats., § 31-16-3 (1971 Supp.).

[425]It may be the state government or federal government. See 32 U.S. Statutes at Large 388 § 5 (1902) New Mexico Stats. § 75-17-1 (1953) and West's Annotated California Water Code §51000 (1966).

[426]It may be one person such as the Secretary of the Interior in the case of the United States or may be composed of persons with appropriate backgrounds.

[427]32 U.S. Statuts at Large 388 § 6 (1902), 43 U.S.C. 416.

[428]Act of June 17, 1902, 32 Stat. 388, 43 U.S.C. 416. See also, West's Annotated California Water Code, § 43530 through 43559 (1966).

[429]Donley v. West (Cal. App.), 189 P. 1052 (1920).

[430]Act of April 11, 1956, 70 Stat. 107, 43 U.S.C. 620b; Act of July 9, 1965 79 Stat. 217, 16 U.S.C. 4601-18(c). The problem of such vast power does not exist may be found in R.E. Clark, Waters and Water Rights, Vol. 2, § 116.1 (1967). This volume contains an extended discussion of the Reclamation program in the United States and is relied heavily upon herein.

[431]Act of June 17, 1902, 32 Stat. 389, 43 U.S.C. 421, Broad authority is also provided to the Secretary in acquiring lands for relocation. See Act of Aug. 4, 1939, 53 Stat. 1197, 43 U.S.C. 389.

[432]Act of Sept. 2, 1964, 78 Stat. 808, 43 U.S.C. 945a.

[433]Fox v. Ickes 137 F.2d 30 (C.A.-D.C., 1943), certiorari denied 320 U.S. 792, 64 S.Ct. 204 (1943).

[434]Act of June 17, 1902, 32 Stat. 390, 43 U.S.C. 372.

[435]Act of August 4, 1937, 53 Stat. 1191, 43 U.S.C. 485e.

[436]In re Bridges Valley Water Conservation Dist., 401 P.2d 289 (Wyo. 1965).

[437]Act of June 17, 1902, 32 Stat. 390.

[438]This provision for apportionment may either appear in the statute or may be provided for in contracts for water or in the rules and regulations of the association.

[439]It is to be noted, however, that a procedure whereby interested parties might submit and hear evidence in a lawsuit proceeding is probably desirable as a check on power abuse.

[440]Act of Aug. 13, 1914, 38 Stat. 687, 43 U.S.C. 469. See also, Fox v. Ickes, 137 F.2d 30 (C.A.-D.C., 1943), certiorari denied 320 U.S. 792, 64 S.Ct. 204 (1943).

[441]Act of August 13, 1914, 38 Stat. 687, 43 U.S.C. 492; Swigart v. Baker 229 U.S. 187, 33 S.Ct. 645 (1913).

[442]Except on a showing of fraud or on a decision so arbitrary, capricious or grossly erroneous as to constitute bad faith. See United States v. Fort Belknap Irrigation District, 197 F.Supp. 812, (D. Mont., 1961). This case delineates the two uses as follows: "Construction costs" are those incurred constructing an irrigation system and putting it in condition to furnish and properly distribute water or where expenditures are necessary because of faulty original construction in violation of contractual or statutory requirements or where the capacity of the original system must be expanded. However, when conditions must be remedied because of the use of the system or to maintain it as an efficient, effective going concern, they are chargeable to "operation and maintenance."

It is to be noted that under this rule the same work may be "construction" in one situation and "maintenance" in another. For instance, construction to increase capacity may be a result of an oversight in one case but may be necessary to fulfill needs which develop incident to normal and ordinary operation in another case. From this, it can be seen that the facts of each case determine the result of the applied test. See Nampa and Meridian Irrigation District v. Bond, 268 U.S. 50, 45 S.Ct. 383 (1925) for an illustration of this problem.

[443]The Act of June 17, 1902, 32 Stat. 389, provided that the entire cost of construction was to be assessed on a per acre basis on project land and paid in not more than ten annual installments. Nothing is mentioned about interest, however, so there is a considerable public underwriting. Also, the ten year requirement has now been extended to a more realistic forty year limit. See Act of August 4, 1939, Ch. 418, § 9(d), 53 Stat. 1195, 43 U.S.C. 485 h (d).

[444]The actual and estimated costs often vary. Because the contract limits the cost of repayment, this cost may not be raised automatically. However, construction may be halted until an amended cost estimate is inserted in the contract. It is interesting to note that an action by the artiter for the difference between actual and estimated cost will not lie on a theory of unjust enrichment. Fox v. Ickes (see above). The question of duress and bad faith involved in stopping construction has apparently never arisen.

[445]See footnote 20, supra.

[446]Act of June 17, 1902, 32 Stat. 388 § 5.

[447]Id.

[448]Act of August 4, 1939, Ch. 418, § 9(d)(1), 53 Stat. 1195, 43 U.S.C. 485(d)(1).

[449]Act of August 8, 1958, 72 Stat. 542, 43 U.S.C. 485h(d)(3).

[450]See, for example, West's Annotated California Water Code, § 51231 (1966) and Hawley v. Reclamation District No. 730 220 Cal. 271, 30 P.2d 505 (1934).

[451]Objections can be made on the grounds of disparity between the Commission's estimate and the local users association's estimate. Honegger v. Reclamation District No. 1619, 190 C.A.2d 684, 12 Cal. Reptr. 76 (1961).

[452]Act of August 4, 1939, Ch. 418 § 6, 53 Stat. 1191, 43 U.S.C. 485e and West's Annotated California Water Code, § 57522 (1966).

[453]Act of August 4, 1939, Ch. 418, § 6, 53 Stat. 1191, 43 U.S.C. 485e.

[454]Act of August 13, 1914, Ch. 247, §§ 3, 6, 38 Stat. 687, 688, 43 U.S.C. 480, 496. Sale of the parcel is also possible (West's Annotated California Water Code, § 51600 through 51618) though redemption of the sold tract is allowed, if accomplished within a year, by paying the purchase price and interest to the buyer. West's Annotated California Water Code, § 51646 through 51654 (1966).

[455]Consolidation and merger provisions are covered in the following state statutes: Ariz. Rev. Stat. 10-341 to 10-349, Colo. Rev. Stat. Ann. 31-7-1 to 31-7-8, Nev. Rev. Stat. 78.450 to 78.560, Utah Code Ann. 16-10-66 to 16-10-76, Wyo. Stat. Ann. 17-36.63 to 17-36.72.

[456]The Model Act are:

Section no.	Title
71	Procedure for merger
72	Procedure for consolidation
73	Approval by shareholders
74	Articles of merger or consolidation
75	Merger of subsidiary corporation
76	Effect of merger or consolidation
77	Merger or consolidation of domestic and foreign corporations
80	Rights of shareholders to dissent
81	Rights of dissenting shareholders

[457]Ariz. Revised Statutes § 10-342-344
Colo. Revised Statutes § 31-7-8
Nev. Revised Statutes § 78.470
Utah Code Annotated § 16-10-68
Wyoming Statutes Annotated § 17-36.65

[458]Ariz. Revised Statutes § 10-347
Colo. Revised Statutes § 31-7-8
Nevada Revised Statutes § 78.505
Utah Code Annotated § 16-10-75
Wyoming Statutes Annotated § 17-36.71

[459]Colorado Revised Statute § 31-16-3

[460]Colorado Revised Statute 31-14-10.

[461]The Nation's Water Resources (1968), passive.

[462]Colorado: Option for the Future (Final Report of the Colorado Environmental Committee, March 1972), p. 14.

[463]Richard L. Berkman and W. Kip Viscusi, Damming the West. New York: Grossman Publishers, 1973.

[464]Charles Howe, et.al., "Future water demands: the impacts of technological change, public policies, and changing market conditions on the water use patterns of selected sectors of the U.S. economy, 1970-1990." Washington, D.C.: Resources for the Future, Inc., 1971 (Report prepared for the National Water Committee), p. 171; see also the argumentation in Earl O. Heady et.al., "Future water and land use: effects of selected public agricultural and migration policies on water demand and land use." Iowa State University Center for Agricultural and Rural Development, 1971 (Report prepared for the National Water Committee).

[465]Laurence McBride, "Arizona's Coming Dilemma: Water Supply and Population Growth." Ecology Law Quarterly, 2(1972):361.

[466]Neal R. Peirce, The Mountain States of America; People, Politics and Power in the Eight Rocky Mountain States. New York: W. W. Nortar and Co., Inc., 1972.

[467]Robert A. Young, "The Arizona Water Controversy: An Economist's View," Journal of the Arizona Academy of Science, 6(1970):5.

[468]McBride, op.cit., p. 383.

[469]Ibid, p. 361.

[470]Arizona: Its People and Resources (By members of the faculty of the University of Arizona) Tucson: The University of Arizona Press, 1972, p. 119.

[471]H. H. Landsberg, et.al., Resources in America's Future: Patterns of Requirements and Availabilities, 1960-2000 Published for Resources for the Future. Baltimore: John Hopkins Press, 1963:378-383.

[472]Heady, et.al., op.cit.

[473]The Nation's Water Resources.

[474]Ibid.

[475]See among others the work of James P. Law, Jr. and Jack L. Witherow (eds.) Water Quality Management Problems in Arid Regions. Ada, Oklahoma, 1970.

[476]Evans, Robert G., [66]Hydrologic Budget of the Poudre Valley," Unpublished M.S. thesis, Colorado State University, Fort Collins, Colorado (1971).

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[479]Carl Rohwer, History of Irrigation by Pumping Wells in Colorado, USDA Unpublished Report, 1953.

[480]W. E. Code, Use of Groundwater for Irrigation in the South Platte Valley of Colorado, Colorado Agricultural Experiment Station Bulletin 483, 1943.

[481]Part of the exposition that follows is adapted from Richard E. Griggin and Ben. W. Lendsey, "Committee Water Development in Ashley Valey," Utah Science, Vol. 27, No. 1, March 1966, pp. 18-23.

[482]M. L. Hyatt, G. V. Skogerboe, F. W. Haws, and L. H. Austin, Hydrologic Inventory of the Utah Lake Drainage Area, Report WG 40-3, Logan, Utah Water Research Laboratory, Utah State University, November 1969.

[483]See also the extensive discussion in James Hudson, Irrigation Water Use in the Utah Valley, Utah, Chicago, Department of Geography Research Paper No. 79, 1962, esp. pp. 118 ff.

[484]Courtland L. Smith, The Salt River Project; A Case Study in Cultural Adaptation to an Urbanizing Community. Tucson: The University of Arizona Press, 1972, p. 1.

[485]Arizona: Its People and Resources, Tucson: The University of Arizona Press, 1972, p. 71.

[486]Smith, op.cit., p. 99.

[487]Waterworks Report for the Valley Metropolitan Area of Phoenix, Arizona, 1968 (John Carollo Engineers - Submitted November 30, 1968) p. 9.

[488]Reported in Arizona Progress (A monthly newsletter of the Valley National Bank of Arizona), May 1973.

[489]Waterworks Report etc., p. 5.

[490]Smith, op.cit., p. 12.

[491]Waterworks Report, etc., p. 6.

[492]Ibid, p. 3.

[493]Smith, op.cit., p. 91.

[494]Ibid, p. 93.

[495]Wiener, Aaron, The Role of Water in Development: An Analysis of Principles for Comprehensive Development, New York: McGraw Hill, 1972.

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APPENDIX I

Survey Questionnaire for Eden and Ashley Valleys

Dear Respondent:

An earlier letter of ours might have reached you already explaining briefly the purposes of our study concerning social aspects of irrigation in five western states.

The attached questionnaire is designed to gather information on aspects of life in this community and some general opinions about water use in this area. This information can help us understand some very important questions. We hope, therefore, that you will answer the questionnaire with care.

Most of the questions are answered by circling or checking an appropriate response. Please be sure to answer every question. If you think that more is to be said about any question, feel free to write in your comments.

The information you will be giving us will be completely confidential and will be used strictly for research purposes. Do <u>not</u> sign your name. We are interested in group statistics such as averages and percentages.

Needless to say, the success of our study depends on your completing the questionnaire to the best of your ability. We appreciate your help in letting us complete what we consider an important research.

To begin with, we would like to ask you a few questions about you and your family.

1. How long have you lived in this area? (please circle)

   1. Less than one year
   2. 1-5 years
   3. 6-10 years
   4. 11-15 years
   5. Over 15 years

2. Please circle the number of the age group containing your age.

   1. Under 20
   2. 21-29
   3. 30-39
   4. 40-49
   5. 50-59
   6. 60-69
   7. 70 or over

3. What was the highest grade of school you have completed? (CIRCLE YOUR CHOICE.)

   Grades: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
   Trade school: 1, 2, 3, 4
   College: 1, 2, 3, 4, 5 or more
   Business school: 1, 2, 3, 4
   Other:_____

4. What is your REGULAR occupation? (Please be specific.) (If you have more than one job, give the one with the most income.)

   _____

5. How many acres do you operate?

   1. Acres owned personally _____
   2. Acres owned in part _____
   3. Acres rented _____
   4. Other (please specify) _____

   Acres in crops this year _____

6. Do you rent part of your land out?

   1. Yes
   2. No

   (If Yes) How many acres do you rent out?_____

7. What is the number of acres left fallow each year?_____

8. What types of crops do you grow?

   1) _____
   2) _____
   3) _____
   4) _____

9. What is the approximate production of these crops per acre?

1) _____
2) _____
3) _____
4) _____

10. What was the total value of farm products sold from your farm in:

1970 _____
1969 _____

11. What is the approximate total value of your farm equipment? (Please circle.)

1. Less than $25,000
2. $25,001 to $50,000
3. $50,001 to $75,000
4. $75,001 to $100,000
5. $100,001 to $125,000
6. $125,001 to $150, 000
7. More than $150,000

12. Do you belong to one or more irrigation companies?

1. One
2. More (Please specify number _____.)

13. Do you serve presently in any of them in an official capacity?

1. Yes
2. No

14. Have you ever served as an official in an irrigation company before?

1. Yes
2. No

15. How long have you been with your main irrgation company?

1. Less than one year.
2. 1-5 years
3. 6-10 years
4. 10-15 years
5. More than 15 years

16. How long have you been served by your Conservancy District?

1. Less than one year
2. 1-5 years
3. 6-10 years
4. 10-15 years
5. More than 15 years

17. Do you use water from any other source than the irrigation company?

    1. No
    2. Yes (Please check) ___Private well
       ___Conservancy District
       ___Other (please specify)_____

18. How many shares or water rights do you own?_____

19. Approximately how much water does your main irrigation company handle?
    _____ acre feet

20. How many shares are there in the company? _____

21. How many acre feet of water would you estimate the reservoir owned by your company holds?
    _____ acre feet

22. What is the annual average amount of water impounded in your main company's reservoir each year?
    _____

23. How much water does your main irrigation company distribute each year?
    _____

24. Could you tell us how many members are in the board of directors of the main irrigation company you belong to?
    Number _____

25. When are the directors elected (how often elections are held)?
    _____

26. From your knowledge of your major irrigation company, how are costs assessed?

27. Is the irrigation company cirrently paying a repayment contract?

    1. Yes
    2. No
    3. I don't know
    (If Yes) How much of your total assessed cost goes to the repayment contract? _____

28. How much influence do you feel you have on your main company?

    1. Very much
    2. Quite a bit
    3. Some
    4. Very little
    5. None at all

29. How much "say" do you feel members should have about how the the irrigation company is run?

    1. Less say
    2. About the same
    3. More say

30. Do you feel that you belong or identify with your major irrigation company?

    1. Very much
    2. Quite a bit
    3. Somehow
    4. Very little
    5. None at all

31. Do you attend the annual stockholders meeting?

    1. Regularly (almost every year)
    2. Occasionally (on and off, quite a few)
    3. Seldom (very few)
    4. Never

32. Do you feel the present water assessments of your major company are:

    1. far too low
    2. somewhat too low
    3. don't know
    4. about right
    5. somewhat too high
    6. far too high

33. In your opinion, is the water accurately measured?

    1. very well measured
    2. fairly well measured
    3. not so well measured
    4. very badly measrued
    5. I really don't know

34. Most years, do you feel that you have an adequate water supply late in the summer?

    1. Adequate
    2. Barely enough
    3. Not at all

35. If you don't have adequate water supply what are the alternatives for gaining additional water?

36. Do you sue all the water available to you?

    1. Yes
    2. No
    3. I am not sure

37. Do you have a seepage problem?

1. Yes
2. No

38. Is shrink (seepage from your water delivery):

1. taken from your water delivery?
2. taken from the irrigation company's water supply?
3. taken from the district's water supply?
4. taken from another source (state source)

39. How much shrink (carrying charge) occurs in your delivery?

1. 0-10%
2. 11%-20%
3. 21%-30%
4. 31%-40%
5. More than 40%

40. Is there a need for improving the delivery system by lining or new structures?

1. Definitely so
2. I am not sure
3. Not really

41. If there is a need for improvement, is it because of:

1. seepage
2. phreatophytes (water weeds)
3. operating and maintenance costs
4. inadequate canal maintenance
5. Inadequate control
6. erosion

42. Do you feel that you are efficiently irrigating your land?

1. Yes
2. No
3. Not sure

43. Approximately how much of your water is lost due to deep perculation or runoff?

1. 0-10%
2. 11%-20%
3. 21%-30%
4. 31%-40%
5. More than 40%

44. Are there any problems with other people using water out of turn?

1. Yes
2. No
3. Don't know

45. Are there ever any problems in this area with not getting the right amount of water according to your shares?

1. Yes
2. No
3. Don't know
(If Yes) What are the causes of this?

46. Do you have any problems around here because of what other people are doing with the water in other areas?

1. Yes
2. No
3. Don't know
(If Yes) What are these proplems?

47. Have you ever complained or discussed complaints about water conditions with officials (local, distric, or State)?

1. No
2. Yes (please check all items that apply):
___ high assessment
___ poor service
___ poor management
___ unequal treatment of users by the company
___ measurement troubles
___ special fees or assessments
___ (please specify) _____

48. To what extent do you see a pressing need in your main irrigation company for improvement in the following areas:

	Quite a lot of improvement	Some type of improvement	Only a minimal change or improvement	It is adequate as it is	I really don't know
1. Water assessments					
2. Use and maintenance of equipment					
3. Ditch maintenance and repair					
4. Water shrinkage					
5. Delivery methods and measurement					
6. Water schedule and delivery					
7. Personnel of the company					
8. Better office facilities					

49. In evaluating the performance of overall water administration that serves you, could you please tell us by checking the categories below how effective do you consider the administration of the water by:

	Very Effective	Somewhat Effective	Undecided	Relatively Ineffective	Absolutely Ineffective	Don't know or Haven't any contact
1. The water master						
2. The ditch-rider						
3. The irrigation company						
4. The conservancy district						
5. The river commissioner						
6. The State Engnr.						
7. Bureau of Reclamation						
8. Courts						

50. Generally, compared to other irrigation companies, how would you rate your main irrigation company?

1. Far better than the other irrigation companies
2. Somewhat better than the other irrigation companies
3. Just as good as the other irrigation companies
4. Not quite as good as the other irrigation companies
5. Somewhat worse than the other irrigation companies
6. Far worse than the other irrigation companies

Please give us some of your opinions about each of the following items, just as you feel when you first read each statement. Check the answer most like your own feelings in terms of whether you agree or disagree with the item covered. Please do not leave any item unanswered.

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
51. Most of the State's water laws should be rewritten.					
52. People who use water are a lot more able to decide how to distribute water than are the water officials.					
53. What we need in this area is a place where we can go and get results on water matters.					
54. Water officials in the company don't care much what people like me think.					
55. There is nothing wrong with the present water distribution.					
56. Generally, the board pays a lot of attention to the average water user in this area.					
57. The prior appropriation doctrine is no longer useful in today's complex society.					
58. It seems to me that water officials don't really care how much I pay for water.					
59. It really doesn't do much good for a person to vote in water company elections.					
60. This irrigation company would probably be in much better shape today if the Conservancy District had never been created.					
61. There should be more restriction upon the sale and transfer of water rights.					
62. As long as I have plenty of water I don't care about what water officials do.					

We would like now to have your opinion about some more general items. The following statements have been given to a large number of people in other parts of the country. These are all matters of opinion. Please check how you feel when you first read each statement.

	Strongly Agree	Agree	Unde-cided	Dis-agree	Strongly Disagree
67. You can't really make progress without change.					
68. I would rather be a person who tries to make do with what he has; being dissatisfied all the time just leads to problems.					
69. Long term progress is more important than immediate benefits.					
70. In whatever one does, the "tried and true" ways are always the best.					
71. The irrigation company policy is best when it maintains the old accepted ways of doing things					

We would like to ask you now a few questions concerning the future of your area, community, and irrigation company.

72. Generally, are things changing in this area?

    1. Yes
    2. No
    3. Don't know
    (If Yes) How?

73. Speaking of change and water, has there been any important change in the past 10 years in the use of water in this area?

    1. Yes
    2. No
    3. Don't know
    (If Yes) In what way?

74. Do you think that the present system of water rights should be changed in any way?

    1. Yes
    2. No
    3. Don't know
    (If Yes) Could you explain how you would like to see such a change?

75. Do you think there are other alternatives to the present water system?

1. Yes
2. No
3. I have no opinion

76. (If Yes) Please rank 1, 2, 3 the following alternatives in terms of how important you consider them for an improved water system. (Put 1 for the most important, 2 for the next and 3 for your third choice in terms of importance.)

___ Turning the system into a private profit making organization.
___ Asking the local water district.
___ Asking the State to run the system.
___ Converting the company into a private water association.
___ Consolidating the smaller companies into a larger one.
___ Other (please explain).

77. Generally, what in your opinion are the main advantages (if any) for consolidating irrigation companies.

78. Also, can you give us the main disadvantages which would in your opinion occur if irrigation companies consolidate?

79. Which of the following do you consider the most significant future problems for water organizations in this area? (Please rand the three most important by putting 1 for the most significant, 2 for the next and 3 for your third choice in terms of significance.)

___ maintenance of water quality
___ maintenance of adequate water supply
___ efficiency of water delivery systems
___ protection of present water rights
___ protection against greater governmental regulation
___ developing adequate planning program
___ maintenance of a fair rate structure
___ other (Please explain)

80. Which of the following do you consider to be the most significant barriers to effective water planning in this area? (Please rank as before - 1 for the most important in your opinion, 2 for the next, etc.)

___ lack of financial resources
___ lack of trained personnel and management
___ lack of public support
___ lack of technical information
___ present water law
___ unavailability of water resources
___ lack of communication among water officials
___ rapid population growth
___ other (Specify)

Finally, we would like to ask you about your home and about some items which you or members of your family may own. Please check theappropriate response.

81. How many rooms do you have in your house (not including unfinished basements, bathrooms, porches, closets, halls, or storage areas)?
(SPECIFY THE NUMBER) ___

82. Is there a specific room used as a "family room"?
YES ___ NO ___

83. Is there a separate room used for recreation?
YES ___ NO ___

84. Do you have a piped in water supply?
YES ___ NO ___

85. How many bathrooms do you have
(SPECIFY THE NUMBER) ___

86. Is there a central heating system?
YES ___ NO ___

87. Do you have an automatic washing machine?
YES ___ NO ___

88. Do you have a clothes dryer?
YES ___ NO ___

89. Do you have an automatic dishwasher?
YES ___ NO ___

90. How many T.V. sets do you have?
ONE ___ TWO OR MORE ___ NONE ___

91. Do you have a color T.V. set?
YES ___ NO ___

92. Do you have a piano or electric organ?
YES ___ NO ___

APPENDIX II

Profile of Irrigation Companies

(Profile of Irrigation Companies)

IDENTIFICATION

1. Name and identification of irrigation company

2. Place (identify location on map)

3. Person in charge of irrigation company and how can he be reached (e.g. address, telephone)

4. Date of investigation

5. Person interviewed and orgainizational (if any) affiliation

6. Remarks (other useful hints on the set-up and circumstances of the investigation)

I. PERSONNEL (and status positions)

A. Organization chart description

1. Total number of personnel and identification by number in each status category

Total Number_____

a. Officers
b. Members
c. Employees
d. Users

2. How are status positions obtained within the organization? (How is one elected? Becomes member? etc.)
   a) Are there dual nature status positions (such as e.g. officer and/or member, etc.)?
   b) Are various positions ascribed and/or achieved? (e.g. because of land ownership? family title?)

3. Functions of personnel (e.g. some description of duties and obligations)
   a) Describe also some typical tasks of key functionairies (e.g. ditch-master, etc.)

II. FACILITIES (The Organization Parts of the Irrigation Company)

A. Organization Structure

1. Type of organization (e.g. District? Mutual Irrigation Co.? Commercial Irrigation Co.?)
   a) Is it only one of the above types or is it mixed? (e.g. Mutual and Commercial)
   b) Has the Company always been of the same type (e.g. did change sometime from Commercial to Mutual?)

2. Organizational History
   a) Length of existence (when established, ceased and/ or continued again)
   b) Chronology of major developments (in addition to date of origin, major projects, consolidation attempts, reorganization efforts, reclamation efforts, conflict situations, etc.)
   c) Capital formation and original financing (how was it done, amount of investment, etc.)

3. Organizational Prescriptions
   a) Charter characteristics and power prescribed by statutes (attach any relevant documents, legal prescriptions, etc.)
   b) Stated purpose of Company, including by-laws of operation (Do relevant documents exist, such as advertisements, annual reports, organizational material, etc.)
   c) Span of control (structure and characteristics of managements) including authority lines. Typical authority charts included:

B. Resource Allocation

1. Forms of continuous financing
   a) Replenishment of capital stock (how? when? has it been used extensively?)
   b) Issuing of bonds (has it been done? are there provisions for?)
   c) Any other assessments for major financing?

2. Revenue
   a) How are costs assessed? What are typical costs?
   b) Any other revenues? (e.g. tolls, connections with other systems, land?)

3. Enforcement of payments and collections
   a) What are the procedures?
   b) What are the legal mechanisms for enforcement?
   c) Any history of difficulties and/or conflicts with respect to payments?

4. Water Distribution
   a) Types of water privileges existing in the system (written or oral agreements; appurtenance; land or stock)
   b) One or multiple irrigation companies' water use? (Are there multi-company arrangements for water use of a particular farm? Is some water at a given season from one company and another company at other times? What type of problems (conflicts), if any, emerge in such arrangments?)
   c) Methods of water delivery (e.g. continuous flow; rotation; on demand).

APPENDIX II

Profile of Irrigation Companies

PROJECT PUBLICATIONS

"Hydrologic Budget of the Poudre Valley," Unpublished M.S. Thesis, by Robert G. Evans, Department of Civil Engineering, Colorado State University, Fort Collins, Colorado. September 1971.

"Water Management in Utah Valley," Unpublished M.S. Thesis, by Thomas L. Huntzinger, Department of Agricultural Engineering, Colorado State University, Fort Collins, Colorado. November 1971.

"Effects of Interbasin Transfers upon Water Management Alternatives in Central Utah," by Gaylord V. Skogerboe and Thomas L. Huntzinger, Water Resources Bulletin, Journal of the American Water Resources Association, October 1971.

"Water Management Aspects of Consolidating Irrigation Systems," by Gaylord V. Skogerboe. Paper AEP71-72GVS1, Agricultural Engineering Department, Colorado State University, Fort Collins, Colorado. Paper presented before ASCE Irrigation and Drainage Division Specialty Conference on "Optimization of Irrigation and Drainage Systems," Lincoln, Nebraska, October 6-8, 1971.

"Legal and Institutional Constraints in Consolidating Irrigation Systems," by George E. Radosevich, Paper AEP71-72GER4, Department of Agricultural Engineering, Colorado State University, Fort Collins, Colorado. Paper presented before ASCE Irrigation and Drainage Division Specialty Conference on "Optimization of Irrigation and Drainage Systems," Lincoln, Nebraska, October 6-8, 1971.

"State Legal Structures and Institutional Arrangements for Water Resources Development," Western States Seminar on Water Planning, Conference Proceedings, held January 12, 1971.

"Social Processes in Water Management Systems," by Evan Vlachos, In Urban Water Systems (special edition of the Proceedings of June 1970 Colorado State University Institute). Edited by L. S. Tucker, D. C. Taylor, and M. L. Albertson (three volumes). Fort Collins, Colorado, 1971, Vol. 3, pp. XI-12..XI-29.

"Organizational Aspects of Irrigation Systems," by Evan Vlachos and Bert Ellenbogen, Paper AEP71-72EV-BE3. Paper presented at the Annual Meeting of the Rural Sociological Society, Denver, Colorado. August 1971.

"Organizational Alternatives in Consolidating Irrigation Systems," by Evan Vlachos. Paper AEP71-72EV2. Paper presented at the ASCE Irrigation and Drainage Division Specialty Conference on "Optimization of Irrigation and Drainage Systems," Lincoln, Nebraska, October 6-8, 1971.

"Water Right Changes to Implement Water Management Technology," by George E. Radosevich, Proceedings, National Conference on Managing Irrigated Agriculture to Improve Water Quality, Grand Junction, Colorado, May 16-18, pp. 265-280.

"Sociological Considerations in Irrigation Water Management: Facing Problems of Water Quality Control," by Evan C. Vlachos, Proceedings, National Conference on Managing Irrigated Agriculture to Improve Water Quality, Grand Junction, Colorado, May 16-18, 1972, pp. 285-306.

SELECTED WATER RESOURCES ABSTRACTS

INPUT TRANSACTION FORM

W

Title

CONSOLIDATION OF IRRIGATION SYSTEMS: ENGINEERING, LEGAL, AND SOCIOLOGICAL CONSTRAINTS AND/OR FACILITATORS

Author(s)

Gaylord V. Skogerboe, George E. Radosevich and Evan C. Vlachos

Organization

Environmental Resources Center
Colorado State University
Fort Collins, Colorado 80521

Report Date

Performing Organization Report No.

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Supplementary Notes

Abstract The results from Phase I have indicated that consolidation of irrigation systems is a necessary part of an integrated policy of water development for improved water management, and of a coordinated effort towards an efficient and effective maximization of limited natural resources. National trends of growth, limited water supplies, the increasing population, and the multiplicity of uses call for new integrated forms of the interaction between policy determining institutions, local participants, and water users at large.

17a. Descriptors

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