MANAGEMENT OF FARM IRRIGATION SYSTEMS

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IRRIGATION MANAGEMENT IN THE POUDRE VALLEY OF NORTHERN COLORADO

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30.1 INTRODUCTION

The Poudre Valley of Northern Colorado is an important irrigated agricultural area of the state (Figure 30.1). The Poudre Valley has been at the forefront of various institutional, legal and administrative solutions to water problems since settlement in the 1860s.

The irrigated portion of the valley comprises approximately 100 000 ha of a gross area of an estimated 1600 square km of Larimer and Weld counties. The growing season extends 120 days on the average from mid-May to mid-September, with some years having 150 or more days of frost free period.

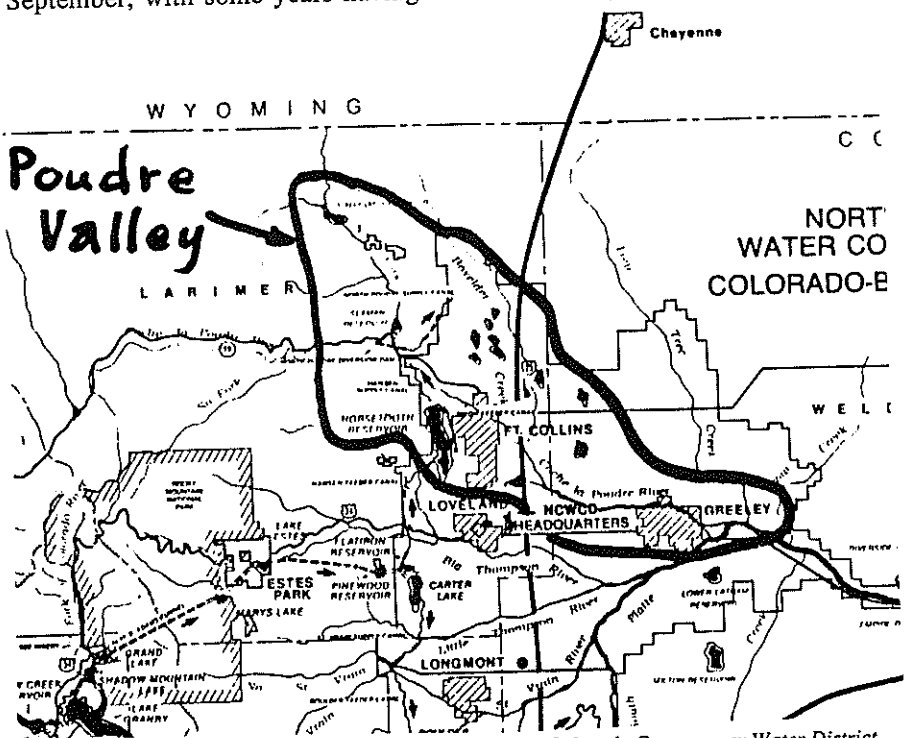

Figure 30.1. Location of the Poudre Valley in the northern Colorado Conservancy Water District.

Annual rainfall ranges from 20 to 40 cm with an average of 30 cm. May is the wettest month.

The valley floor averages 1500 to 1600 m above sea level. The soils are of medium texture and well suited for irrigation. Salt accumulations in the irrigated soils are not a particular problem. The ground and surface irrigation water is of high quality. The aquifer below the floor of the valley often produces in excess of 120 L/s to irrigation wells, which number more than 500 in the private sector.

Agriculture in the Poudre Valley includes both irrigated and dryland, the latter mostly wheat and natural grassed rangelands. Irrigated crops include primarily alfalfa, maize, sugar beets, beans, and barley. The majority of the irrigation is accomplished by surface methods with center pivot and sideroll sprinklers increasing.

The mutual ditch company and the district type of organization recognized under state laws tend to work extremely well in the Poudre Valley. The mutual ditch company is a non-profit corporation that requires payment of 40 to 50% of the annual assessments (water charges) before water is delivered to members' farms. The Northern Colorado Water Conservancy District (NCWCD) was formed to manage the supplemental water for agriculture from the Colorado River Basin west of the continental divide. The district does have taxation powers of a quasi-municipality type.

The Colorado Big Thompson (CBT) project was constructed by the U.S. Bureau of Reclamation and turned over to the NCWCD for operation and maintenance. It provided a major supplemental water supply to the farms of the Poudre Valley and the lower South Platte Basin prior to Nebraska, and a 1300 million m^3 capacity supplemental reservoir below Horsetooth mountain. The drought hazard was severely curtailed by completion of this project.

Colorado farmers exploited surface water starting in the 1840s and rapid groundwater exploitation from the 1920s through the 1960s in the upper reaches of the South Platte (one of which covers the Poudre Valley). Because of rapid overexploitation and other legal reasons, the Office of the State Engineer (irrigation) imposed a moritorium on water development projects in the basin. This moritorium halted new water storage projects and the drilling of new wells. The more affluent and aggressive farmers of the valley were able to drill wells before the moritorium. Some farmers of the area were denied this access to groundwater because of their lesser command of capital to invest in drilling wells or their position on the sloping lands on the rim of the valley, a position lacking a productive aquifer with economic pumping depth.

Colorado Water Law states that he who develops a water source first in time, retains his right infinitum, as long as the water is put to beneficial use. The water right is a use entitlement, with the state retaining ownership. The use right is a form of property that can be bought and sold, inherited, and leased temporarily. Private individuals as well as private not-for-profit corporations can hold these water rights and provide water to shareholders in proportion to their investments in the corporation. Within the corporation, the equity of water access is assured according the shares owned by the member. Between mutual

ditch companies, however, allocations are based on the seniority of water dates at filing. Very junior water rights rarely get water and usually only during a flood stage of the Poudre River.

The state law was modified in 1967 to place the groundwater into the sequence of water rights. The *one river doctrine* allowed the wells to be an alternate point of diversion from the river, but required that the groundwater users develop an augmentation plan for the replacement of the water taken out of the *one river system.*

The Colorado system of water administration is highly legalized. The system uses the courts to file water rights, to settle disputes to redress grievances and assign penalties for damages caused by one party to another. While the court system is impartial in its judgement and allows each person the chance to protect his or her rights, it requires specialist lawyers and expert hydrologist and hydrogeologist to help protect those rights.

Due to the legalism of the system, individuals, mutual ditch companies, and even the quasi-municipal districts find themselves in a seemingly endless cycle of litigation and attempted problem solution through lawsuit. Individuals, companies, and districts may be denied full justice, due to an inability to pay. This institutional reality prevails throughout the Colorado irrigation community.

30.2 FRAMEWORK FOR IRRIGATION MANAGEMENT ANALYSIS

An analytical framework for the analysis of irrigation organizations was developed by The Cornell Irrigation Studies Group (Uphoff et al., 1986). Irrigation system development and the management techniques that evolve with time vary according to 1) the physical setting; 2) the social structure; 3) the cultural precedents; 4) the biological circumstances; 5) the administrative structure; and 6) the economic opportunities for crop production. The framework provides three common categories dealing with a) water use, b) structures, and c) organizations. This framework is used in the following section of analysis and provides comparisons of irrigation system management around the world.

30.2.1 Irrigation Management

Irrigation management has three distinct entities as focal points of activity: the *water*, the *structures*, and the *organization*. The irrigation activities that focus on *water* emphasize obtaining an adequate and assured supply (acquisition), scheduling (allocation), utilization at the right place and at the right time (distribution), and prevention and removal of excesses (drainage). The activities that focus on *structures* emphasize provision of control (design and construction to capture and provide safe direction), operation (achieve timely release and adjustment in proper quantity and elevation), and maintenance (sustaining the capability to provide the scarce resource). The activities that focus on *organizations* emphasize the actions of individuals or organizations to manage the structure (decision-making, mobilizing resources, and communicating the plans and schedules) and conducting all these actions

within certain consensural rules (carefully managing water conflict) to deliver the water to the point of use for agricultural production.

These three major focuses of irrigation management activity, along with the four subdivisions of each, form a three-dimensional management matrix (Figure 30.2). Any individual management can be related to one of the subdivisions of each of the major focus areas. The matrix defines 64 management categories in all, categories that are useful to guide the comparison of irrigation system management approaches across climatic, cultural, and national boundaries. This analysis will omit the design and construction categories and, thus, will only look at 32 of the management category combinations.

30.2.2 Performance Criteria

The management matrix (Figure 30.2) facilitates the comparison of irrigation systems. To go beyond comparison, the evaluation of systems requires some criteria and standards against which performance may be judged.

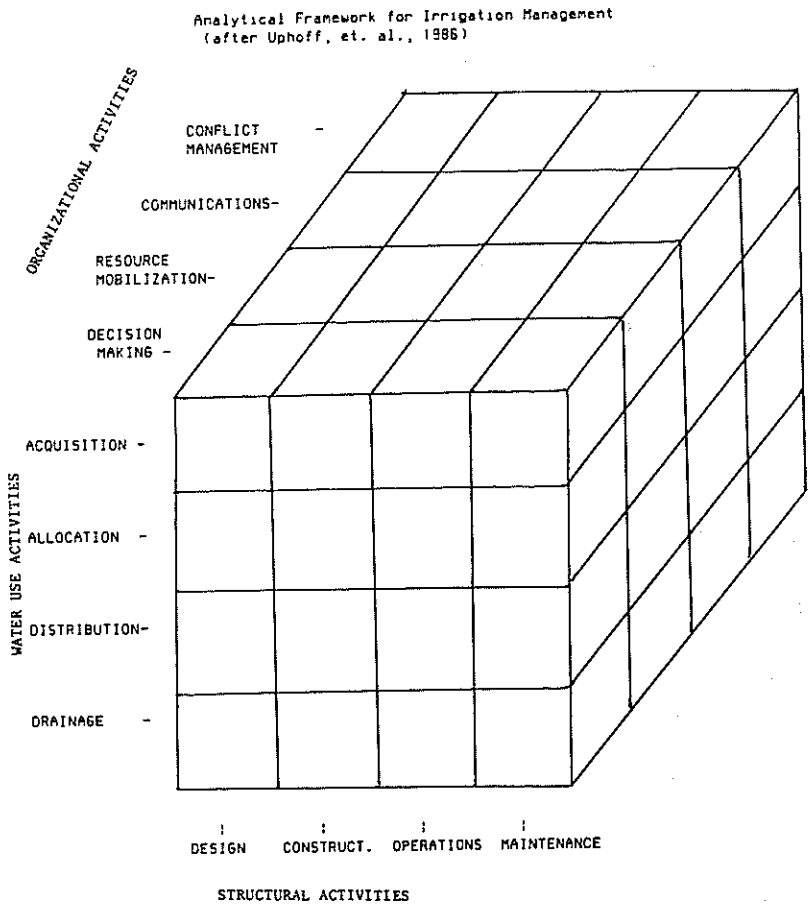

Figure 30.2. Analytical framework for irrigation management

For the farmer the ultimate measure of performance is *productivity*, yields, total production, and economic returns that provide a suitable margin or return over costs. The farmer is concerned that he has enough water (adequacy), that it comes when he needs it (*reliability*), and that he gets his fair share (*equity*). *Stability* of the enterprize and stability of the resource base (relative to erosion, waterlogging and salinity) are concerns of the farmer that relate to his ability to remain in business. These five considerations of productivity, adequacy, equity, reliability, and stability are the primary five criteria upon which the irrigation system performance is judged by farmers in general and in northern Colorado in particular. Society as a whole has an interest in an environmentally sound agriculture as well as a stable, rural, productive machine for domestic food security.

30.3 WATER INSTITUTIONS IN NORTHERN COLORAOO

The evolution of the administrative and organizational superstructure of northern Colorado irrigation accompanied the settlement of and irrigation development in the state. Settlers, often frustrated miners whose golden dreams didn't pan out or traders who saw the advantages of growing food locally, supplemented by a wave of immigrant farmers were the first to divert water from the Poudre-South Platte Rivers near Greeley. Irrigation was encouraged by land speculators and local publishers such as Horace Greeley.

The water shortages that eventually developed and the resulting conflicts led to the development of the Colorado Legal Codes defining the appropriation doctrine and the administrative structure that exists to administer the water rights within the state today. The management of irrigation is basically accomplished in the private sector, but state and federal agencies have important roles in assisting and defining the private sector limits of irrigation management.

30.3.1 The Public Sector

Federal Government. The federal reclamation act of 1903 created the U.S. Bureau of Reclamation (USBR) to reclaim lands and develop new lands for irrigation in the states west of the Mississippi River. USBR projects required local farmer initiative and support from the respective state congressmen and senators to fund appropriation bills for the locals to construct the projects. Western states congressional delegations have consistently supported each other to obtain water development projects for their constituencies.

State Government. Colorado's Office of the State Engineer, under the Department of Natural Resources, is responsible for irrigation within the state. The work of the State Engineer's Office is the administration of water rights. The state is divided into seven divisions based on the river basins with a divisional engineer responsible for each. The divisional engineers have water commissioners to administer the water to headgates to ditches in hydrologic divisions of the major basins.

Local Government. Colorado passed the Water Conservancy District

Act in 1937 enabling a local public entity to receive the infrastructure constructed by the Bureau of Reclamation. The Northern Colorado Water Conservancy District was the first such special creation of the state. The district was originally designed as a quasi-municipal entity to interface with federally sponsored reclamation projects, to provide local ownership and the means for amortization of facilities, and to manage those facilities in the public interest. (Other examples of quasi-public districts on a more localized basis and for a more specific functional basis are the irrigation districts and the drainage districts.) Today the Northern District, as it is known, manages all the infrastructure that deals with irrigation, while the Bureau of Reclamation retains the hydropower or revenue generating portion of the infrastructure. The district earns revenues from charges imposed on delivery of water through its system and from a one mil tax on all property within the project boundaries, both agricultural and municipal as common beneficiaries of the water.

30.3.2 The Private Sector

Two water users organizations are examples of collective organizations representing groups of water organizations. First are the respective county Underground Water Users Associations. Second is the Cache La Poudre Water Users Association. It has membership that includes the heads or representatives of each of the major ditch companies, the underground water users, the municipalities and towns, the rural domestic water supply district, and major industrial water users. It charges dues from the member entities to cover the cost of lobbying the state legislature, retaining a lawyer to scrutinize all water legislation and applications for water use rights, and other activities in the mutual interest of water users of the valley. It is federated in the Colorado Water Congress with other like-associations throughout Colorado. The Colorado Water Congress is likewise federated with three nearby states in the Four States Water Council for similar purposes.

The most important irrigation organizations in Colorado are the mutual ditch companies. Individual farmers do not have the resources to individually divert, store, convey, distribute, or remove excesses. Mutual ditch companies are formed by the groups of farmers who share a water source or ditch to meet their collective water needs. These are stock issuing organizations that operate on a non-profit basis to provide dividends to shareholders in the form of water.

30.4 MUTUAL DITCH COMPANIES

These private organizations are addressed on the basis of the four organizational categories of the analytical framework: decision-making, resource mobilization, communication, and conflict management. These considerations are presented in the following sections and tabulated in the tables.

30.4.1 Decision-Making

Decision-making is accomplished at several levels in local irrigation organizations. As an example, the North Poudre Irrigation Company (NPIC)

organization chart represents the large, influential irrigation companies in the Poudre Valley, (Figure 30.3.). As emphasized by this chart, the shareholders are in the primary position as owners of the company. The shareholders number approximately 600 persons and entities such as farmers, corporations, municipalities, and speculators. These owners hold 10,000 shares of stock and, in turn, vote their stock to elect five directors on a staggered annual basis. The directors meet to elect their officers and to hire a secretary and a manager for the company.

The manager remains on a year-to-year contract, as do all of the clerical, operational, and maintenance employees. At the bottom of the chart are the clients or water users of the companies services. Most of these clients are also shareholders, but some are mere purchasers of water from the company.

The mutual ditch companies generally have an annual meeting to review the past years activities and expenditures, approve the planned budget and assessments for O&M (on a share basis), elect new members to the board of directors, approve reports by the president and manager of the company, and other items of new business. The voting is according to the shares of stock in the company owned by each member. Large municipal, organizational, and institutional shareholders such as the City of Fort Collins, Eastman Kodak Company, and Colorado State University have substantial holdings of stock in the company but do not participate actively in these meetings as a rule.

The next level of decision-making occurs at the monthly board of directors meetings. The board meets with the manager of the company to review the current water storage status and prospects for direct flow diversions for the coming month. The regular board meeting is generally an all day affair for which the members receive only travel expenses and a per diem allowance.

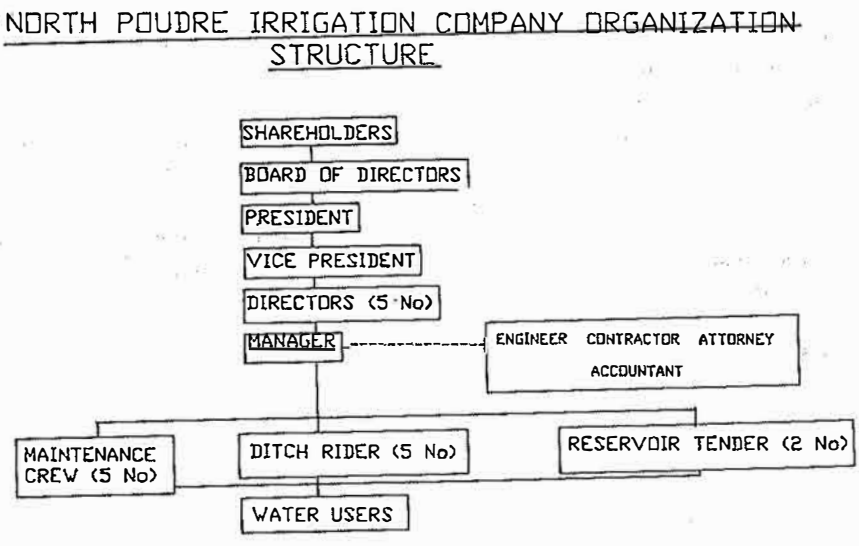

Figure 30.3. Organizational chart of a mutual ditch company.

The essence of leadership in the non-profit mutual ditch company is voluntary service. Some board members serve for only one term, others for 20 or 30 years depending on their interest and ability to be re-elected.

The third level of decision-making is by the hired manager of the company. This person is variously referred to as the manager or superintendent and has broad general knowledge of irrigation but does not require a degree in engineering. The manager decides on weekly operations and maintenance activities, and daily water releases in response to water orders placed over the telephone to the water accounts bookkeeper of the company.

The fourth level of decision making is that of the individual farmer. He determines the needs of his crops, the amount of water that he has in his account according to the allocation made by the board of directors, and decides how much water to order for each of his crops. In general, scientific irrigation scheduling is not practiced. Farmers depend on their experience to determine how often each crop should be irrigated as modified by the weather and the appearance of the crop and with a view of actual measures of potential demand as published by the local newspaper on a daily basis. Farmers can also decide to acquire more water shares on the open market or to rent water from other share holders who have excess. These are mostly comprised of industrial and municipal owners of water who have generally purchased a large buffer stock for anticipated growth. Farmers can also decide to install a tailwater reuse system, if the tailwater runoff has not had a legal water use right filed on it as a regular inflow. A drainage ditch thus becomes a water source with a legal water right for downstream water users of another company.

30.4.2 Resource Mobilization

Resource mobilization represents the appropriation, marshalling and utilization of funds, manpower, materials, information, or any other inputs needed by the company. Significant funds may be raised by assessments, loans from state agencies such as the Water Conservation Board, and from commercial banking sources. Large projects may require several million dollars raised from these three sources.

A signification portion of resource mobilization is represented by farmer participation. The construction of the systems was achieved through contributed labor and associated horse power and equipment. The contribution of time by members as voluntary leaders of the mutual ditch companies remains a strong manifestation of good farmer participation for the mutual benefit of the association.

30.4.3 Communication

Communication has a central role in irrigation management in the Poudre Valley. Farmers communicate their views on the management of the system, on the expenditure of funds for operations, maintenance and rehabilitation, and on the selection of directors to represent them on the board. Farmers communicate their water orders to the water accounts bookkeeper over the telephone. They meet their ditch riders and communicate their concerns verbally and face-to-

face daily on the ditch banks at specified times throughout the irrigation season.

The manager communicates by phone to various ditch riders and reservoir gate keepers daily at specified times. He follows problems or special concerns with site inspections and meetings with ditch riders and the operations foreman in the field. He also communicates with the River Commissioner and the water dispatcher of the Northern District (NCWCD) on a daily basis over the telephone.

30.4.4 Conflict Management

Conflict occurs naturally in any human interaction and becomes especially important when dealing with a scarce resource such as irrigation water. Because humans tend to have long memories and past conflicts may never be fully resolved, we will use the nomenclatare of conflict management rather than conflict resolution. Conflict can occur at every level of organization in the irrigation community. Who becomes the conflict manager depends on where the conflict happens and on the type of conflict. If the conflict occurs below the company outlet, the personnel of the company will not become involved: it is considered to be a private matter between the individuals. Sometimes a neighbor or third-user on the ditch will intervene to help resolve the problem, or the parties will seek a solution in the courts.

Conflict management occurs at several levels with a mutual ditch company. The ditch rider interfaces with the farmer shareholders of the company and may intervene when two farmers have problems that relate to the supply they receive from the canal owned by the company. The usual complaint is a perceived shortage of water. In many cases, the ditch rider prefers to err on the high side rather than to possibly come under the scrutiny of the company manager or operations superintendent. If the problem is raised to the manager, his obligation to the shareholders is to deliver their water as allocated by the board of directors. He will intervene in conflict between users to the extent that the issue involves water delivery or that he may know them personally. Only very serious matters are elevated to the Board of Directors of the company. These are usually conflicts with outside individuals or entities. Generally they have to do with water rights, emergency situations involving short-term, high intensity rainfall events, unplanned water spills from ditches or reservoirs, and land right-of-way issues with non-irrigators. To the extent that these matters can be handled by the board president or assigned to the manager they are addressed. When legalities are involved, they are generally elevated to the director's level for discussion or to the company's lawyer on retainer.

Conflict among companies is dealt with by the Cache La Poudre Water Users Association. The discussion of water supply and allocation at the regular monthly meetings can head off or directly address irrigation conflict. The association may also seek legal redress when the collective body feels that the water rights may be injured by the actions of a member or an outside actor. The association tries by collective effort to resolve conflicts internally and avoid taking matters to court.

30.5 STRUCTURAL ACTIVITIES OF THE MUTUAL DITCH COMPANY

Of the structural activities identified above, this case study will focus only on operation and maintenance. Operation refers to the act of utilizing structures to deliver water, while maintenance refers to sustaining the life of these structures in order to facilitate water handling. *Operations and Maintenance* as used here form the heart and central issues of *IRRIGATION MANAGEMENT*.

The following sections briefly present operations and maintenance in the irrigation management categories of acquisition, allocation, distribution, and drainage. Tables 30.1a, b, c, and d focus on ditch company operations and Tables 30.2a, b, c, and d focus on ditch company maintenance. The matrix format covers the four organizational functions of decision-making, resource mobilization, communication, and conflict management and answers the questions a) who does what organizational function; b) what specifically is done; c) where is it accomplished; and d) when it is accomplished.

30.5.1 Operations Related to Acquisition of Water

Acquisition of water occurs from surface or sub-surface sources either by construction and operating physical structures such as dams, weirs or wells or by actions to obtain some share of an existing supply. Acquisition of water supply by the mutual ditch company usually consists of a one time, or at most, a several time activity in the life of the organization. Acquisition in the Colorado sense of the word is the process of applying for a water use right by filing an application with the water court, corresponding to a portion of the civil, district court system under state government. In the early years, 100 to 130 years ago, this was done incrementally as new lands were brought under cultivation by new groups or as more lands were added onto the service areas of existing systems. With the full subscription of the normal runoff of the Poudre River during the growing season among the various ditch companies, the definition of the off-season use rights was initiated for storage of water in small surface reservoirs. The rolling terrain of the upper or northern portion of the Poudre Valley lent itself to the construction of numerous small reservoirs having active storage capacities of 0.12 to 25.0 million cubic meters (MCM) of water. Those companies with junior diversion rights tended to be most active in the late 19th and early 20th century rush to develop small reservoirs. After this, the private individual development of groundwater became an acquisitional strategy.

With the drought of the 1930s, the farmers banded together to lobby for the construction of the Colorado Big Thompson Project (CBT), the last major water augmentation plan that the Poudre Valley is likely to experience. In fact the Poudre Valley remains a relatively water abundant portion of the state. This occurs to the extent that the northern suburban towns of Denver are actively attempting to buy Poudre Valley water and transport it to the supply systems of the towns for municipal and industrial (M&I) water. These four periods (1850s thru 1870s for direct diversions, 1880s thru early 1900 for reservoir storage, 1900s thru 1960 for groundwater development, and late 1930s thru mid-1950s for supplemental CBT water development) represent the times when the farmers

individually or through their mutual ditch companies or water users associations actually acquired water.

30.5.2 Operations Related to Allocation of Water

Allocation of water is based on the holding of water use shares by users. It is the process by which the board of directors determines how much water will be available to each share. Since it is based on ownership of shares of stock, the allocation policy determines who shall have access to water, the relative sequence in which the water becomes available and how much they shall receive.

The allocation process in the Poudre Valley is in the hands of the mutual ditch companies. The collective water rights include the sum of the direct diversion flows, the storage water, and the CBT supplemental water. The allocation of this water is generally a stepwise, monthly procedure. It takes place incrementally as diversion water is available from the river. Storage water is known more certainly before the season with an adjustment for the surface evaporation and subsurface percolation estimates from historical experience. The CBT water is also subject to estimations of availability from snow melt. The Board of Directors of the Northern District allocates water for the entire season based on the proposition of bringing the water supply up to the needed amount for the entire district for the whole irrigation season. The norm seems to be 0.70 acre foot/unit of CBT owned or rented. In dry years, when the runoff is expected to be less, the amount of water allocated per unit or share of CBT stated as a percentage would go higher to 0.80, 0.90, or even 1.00 in case of extreme drought. In this way, the CBT water is a buffer supply to even out the effects of drought.

The ditch companies seek snow pack readings from the Soil Conservation Service and from the Northern District as early as January for the irrigation season that begins in April. Monthly snow pack assessments continue through April as the runoff begins and the company board of directors begins its monthly allocation of water on a share basis. The incremental process represents the safe, conservative approach to allocation, always allocating only the amount of water that is assuredly available from direct diversions, from small reservoir storage, and from the units of CBT owned by the company. When excess, unappropriated runoff occurs in the months of April and May with an early thaw, the River Commissioner informs the ditch companies of the availability of free or "*penalty*" water. The penalty water availability is passed on to the shareholders who are able to use the water before the crop season. Penalty water has a definite life of one or two weeks, hence the term penalty. The essence is "*use it or lose it*". Penalty water is not charged to the water account of the shareholder and remains free to the opportunistic shareholder who needs to fill the root zone for future crop use or irrigate to promote germination.

30.5.3 Operations Related to Distribution of Water

Distribution of water brought from the source for sharing among users has

four important dimensions: equity, adequacy, reliability, and flexibility. The spacial distribution of water across the service area of the company is the equity issue. The irrigation companies of the Poudre Valley generally assure the shareholders their full supply at the outlet from the company canal to the farmers' ditch. This form of distribution in which "*the company assumes the shrinkage*" or losses in conveyance and distribution manifests complete equity and guarantees uniform treatment to all shareholders despite the distance from the source. In most companies the shrink is planned in the annual water balance. The rate that has been operationally experienced is of the order of magnitude of 10 to 20%.

The adequacy issue does not concern the company as it does the farmer. Whether the amount of water supplied relative to the amount demanded by the crop is adequate remains the private matter of the individual farmer. How far the farmer spreads his limited water allotment depends on his resource base and ability to own or rent water. The timing of water distribution, hence the reliability issue, depends somewhat upon the season. In peak demand periods, the water distribution is sometimes rationed according to the ownership of shares due to a lack of ditch capacity. In those cases, the rule of thumb limits farm delivery to 1.2 L/s per share owned with no deliveries to shareholders owning less than five shares. In other than peak demand periods, farmers can generally draw water as they see fit. Water orders placed by 2:00 P.M. daily are generally started by 6:00 A.M. the next day. When excessive demands do occur, the delivery is sometimes delayed by 24 hours. The quasi-demand system of water distribution demonstrated by the Poudre Valley systems represents a high degree of flexibility. The limitations are only the capacity of the distribution lateral, the ownership of shares in the company, and the account balance of the individual shareholder.

30.5.4 Operations and Related to Drainage and Reuse of Water

Drainage represents the removal of water where excesses occur and must be removed to assure a sustained agricultural system. Excesses occur both as temporary or longer term surplus water in the soil profile as well as runoff from the farm, particularly from surface irrigation practices. Farm runoff provides the potential for reuse on the farm of origin or to downstream users.

Most mutual ditch companies in the Poudre Valley do not have specific drainage functions. Many ditches have a favorable lower topographic position to capture the runoff from other systems and, in turn, use that captured amount as an extra supply.

30.5.5 Ditch Company Maintenance Activities

The mutual ditch company operates under a maintenance philosophy which might be bluntly stated as follows: "if it still works, don't fix it", or "the ditch doesn't have to be beautiful to be functional". The fiscal conservatism of the rural sector comes through very clearly in the way that the companies invest in and maintain the system. When investments can be made with the government putting the money up front with repayment over many years on soft

terms, the farmers will opt for a *concrete and steel* solution. If the company has to save substantial amounts by setting aside money from annual O&M assessments, as well as borrowing from state institutions and commercial banks, the decisions that might require *concrete and steel* are often settled at *earth and timber* levels of expenditures. The result is that structures that have important safety considerations have *concrete and steel* investments and the ones that have the lesser public safety hazards and lower levels of potential losses with a structural failure are built at investment levels of *earth and timber*.

The major ditch companies have a specialized maintenance group, generally headed by a maintenance foreman, who is hired by the manager. The manager has the ultimate responsibility and answers to the Board of Directors on all matters of maintenance of the system. The maintenance budget is a major component of the annual assessment voted upon by the shareholders in the annual meeting.

During the irrigation season, the maintenance foreman continuously observes the system and prepares a list of major maintenance items for the non-irrigation or off-season when maintenance can be conducted. The foreman and the manager list the major maintenance jobs and attach associated priorities and estimated costs. Several persons who are on the maintenance crew year-round continue to do preventative maintenance and control weeds during the April through September period. After the September shutdown of the system, the permanent employees who have had operational duties in the summer are shifted to the maintenance crew. Maintenance in the off-season is continuous, with tree cutting, silt removal, riprapping, and gate repairs never ceasing even for inclement weather. Major maintenance that requires the replacement of a structure and the placement of concrete is obviously scheduled in the periods of good weather and with temperatures above freezing–not uncommon in the Poudre Valley during warm spells in the winter.

Most of the large irrigation companies have substantial investments in maintenance facilities and equipment. Often this includes substantial workshop and garage facilities. Power equipment includes graders, backhoes, and tractor-mounted brush hogs and front end loaders. Portable welders and generators and the necessary hand tools are within the command of the maintenance crew. Items of equipment that are infrequently used are generally available from commercial leasing firms for the duration of need.

Table 30.2a, b, c, and d provides insight to ditch company maintenance activities related to the four structural activities irrigation acquisition allocation distribution and drainage. As can be seen, a great deal of authority is placed with the manager of the company by the board of directors who, in turn, answers to the shareholders. The system of duties and responsibilities is not so different from that of a private for profit firm. Accountability of the manager for operations and maintenance to the board is clearly defined. The manager can be fired at any time and his contract is only renewed on an annual basis. The manager, in turn, has hiring and firing capability over his foreman and workers. These are samples of how a private irrigation company works, not making a profit and answering always to the owners of the company.

30.6 WATER USE ACTIVITIES BY THE FARMER

Individual farmers also engage in the two basic irrigation activities, operations and maintenance. These are further subdivided and applied to the water use activities including acquisition, allocation, distribution, and drainage. These water use activities will be discussed in the following sections followed by a comprehensive look at the complex sets of decisions, resource mobilization, communications, and conflict management in which individual farmers in the Poudre Valley of Northern Colorado engage. Each of these four dimensions of water use will be displayed in Table 30.3 for operations and in Table 30.4 for maintenance activities.

30.6.1 Acquisition

The acquisition of water from surface or sub-surface sources is either by creating a new source or operating physical structures, such as ponds, weirs or wells, to obtain some share of an existing snow melt source of supply. The streams are generally over-appropriated, such that junior water use rights holders can only obtain diversion water during peak runoff periods in the spring and early summer, if at all. This always leaves them without water for the last half of the growing season.

Acquisition by the farmer is generally accomplished in one of three ways in the Poudre Valley. *First*, the individual farmer buys some shares of water in a ditch company that serves the vicinity of his farm or buys some CBT units of water that a local common carrier of water can deliver to his farm for a modest fee. *Second*, he can apply for a permit to drill a well. If this is denied, he can apply to the state engineer's office for the transfer of an abandoned well position from another farmer and purchase the right to use that well on his own farm nearby. *Third*, he can lease water from the many industrial and municipal water share owners who have purchased excess supplies as a hedge against future water shortages and attendant high prices. On a short-run basis and with the current relative surplus of water in the valley, the latter lease or rental of water is often the most economical strategy to follow. The recent rental rates have been at or below the annual rate of assessments for the basic O&M fees, and the farmer doesn't have the ownership cost of the water which may be as high as $1000 per acre. This acquisition strategy may be useful only as long as the relative abundance of water continues. Should a period of drought follow the current period, the strategy would likely not be so favorable.

30.6.2 Allocation

The allocation of water is the assignment of specific amounts of water per share rights or units owned by the users. The allocation process thereby determines who shall have access to water and when and how much they shall receive.

For the individual farmer, this is complicated by his ownership of wells on his farm for which he pays a nominal assessment to the Larimer or Weld County Underground Water Users Association and a substantial cost for the electricity to operate the pumps. The farmer must pay the entire amount of the

assessment for the shares that he owns in the mutual ditch company, so in effect he is penalized if he does not use all of the water allocated to him. On the other hand, in order to receive a preferential rate for electricity, he must use his wells for a minimum equivalent number of kilowatt hours per year. In a sense the conjunctive use situation is really quite straightforward. The strategy is to use the ditch company water up to the limit of its availability as it is allocated month by month by the board of directors and use the wells to cover peak demands for water that exceed the surface water availability. With the introduction of water-saving technologies, such as side roll and center pivot sprinkler systems, some farmers have been able to sell off shares of surface water use rights thus reducing their capital investment, reducing their O&M assessments, and using the sale proceeds to payoff land debts. Others have decided to more completely depend on their wells and the rental market for the balance of their water needs as their allocation strategies.

30.6.3 Distribution

The distribution of water brought from the source is the partitioning of the supply among uses and among users with three important dimensions. *Distribution* must be accomplished at specified places where *equity as distribution in a spacial sense* is the relevant performance evaluation parameter. Distribution must be accomplished in certain specified amounts where *adequacy is the performance parameter ratio of supply relative to demand for water. Distribution* must be accomplished at certain times where *reliability as distribution in a temporal sense* is the relevant performance parameter.

The individual farmer is concerned about distribution below the outlet of the ditch company, through a farm ditch that he operates alone or communally with several other farmers. Once the water reaches his land, his concern turns to the distribution among his field ditches to the points of release to his fields. Farmers in the Poudre Valley often opt for lined channels or closed conveyances on their farms which have traditionally been cost-shared at a 50% rate by the federal government. This is done by the Agricultural Stabilization and Conservation Service (ASCS) in the name of water conservation. When the water reaches the field, distribution then becomes important in the application uniformity issue. Uniformity relates to the evenness of water storage in the soil moisture, root zone profile across the field. Surface irrigation methods are notoriously poor with regard to root zone storage, and sprinkler systems have a decided advantage in this type of performance. The relative abundance of water in the mid-1980s, the 100% payment for O&M assessments whether or not all water is used, and the restriction placed on some farmers who have produced runoff to certain natural streams have all acted as efficiency disincentives in four important ways. These include disincentives to economizing on water use, to reduction of tailwater runoff, to the reuse of water on the farm and, ultimately, to the uniform storage of water in the soil profile.

30.6.4 Drainage and Reuse of Water

The drainage of water is the removal of excess supply which occurs as a

rising water table or as tailwater runoff from sloping fields. In many cases, this spills over into acquisition when we include the tailwater reuse systems which sometimes become practical and economical (especially when subsidized by the federal government in cost sharing, conservation programs by ASCS).

Because of the presence of medium textured, soils and substantial relief across much of the irrigated area of the Poudre Valley, drainage has not been a particularly important problem for individual farms. Drainage does become a problem for the farmer who decides to save his runoff that traditionally went to a natural stream or drainage network. The problems arise when a downstream farmer has filed for and successfully adjudicated a water use right to the water in that natural stream. The upstream user will usually be forced to continue his inefficient contribution of runoff to the stream in order not to injure the water use right of the downstream user. This is one of several ways in which the appropriation doctrine of Colorado maintains the status quo and sustains inefficiency in farm irrigation.

Tables 30.3 and 30.4 present the 16 matrix item combinations of Uphoff's Cube that correspond to farm level operational considerations and farm level maintenance considerations. These are the three-dimensional combinations of organizational concerns, structural oriented activities, and water uses. As mentioned earlier, the structural categories of design and construction are omitted as inappropriate for this case study of irrigation management.

30.6.5 Individual Farmer Irrigation Operations

In Tables 30.3a, b, c, and d, attempts have been made to address the four fold question framework of *who* is taking *what* action, *where* does he do it, and *how often or when* does he do it. The operational questions apply to the acquisition, allocation, distribution and drainage functions in successive tables. Within each table, management functions of decision-making, resource mobilization, communication, and conflict management stratify the answers to the WHO, WHAT, WHERE, WHEN questions. All of the following sections applies to the individual farmer as the level of consideration. They are in the order of surface water, groundwater, and rented water (usually surface water from another share holder in the same mutual company in the case of the acquisition of water).

All of the individual and collective farmer activities in irrigation operations and maintenance emphasize private sector activity and individual perceptions of benefit from participation in group activities. The predominance of the private sector follows the principle of the government building projects only to have them turned over to local organizations for repayment of the capital investment for irrigation and for management by local groups.

30.6.6 Individual Farmer Maintenance

Tables 30.4a, b, c, and d attempt to address the four-fold question framework of *who* is taking *what* action, *where* does he do it and *how often or when* does he do it. The maintenance questions apply to the acquisition, allocation, distribution, and drainage functions in successive tables. Within

each table, management functions of decision-making, resource mobilization, communication, and conflict management stratify the answers to the WHO, WHAT, WHERE, WHEN questions. All of Table 30.4 applies to the individual farmer as the level of consideration.

30.7 SUMMARY AND CONCLUSIONS

Analysis of this case study of irrigation management in the Poudre Valley of northern Colorado provides an overview of the Colorado system of irrigation administration. This administrative system includes the water laws governing water use rights, the establishment of privately controlled mutual ditch companies, public quasi-municipal entities acting as interfaces to the federal and state agencies that construct major irrigation facilities, and the administration of water rights by the state engineer's office and the water courts.

An analysis of the heirarchy of organizations including private as well as public provides an indication of the importance placed on irrigation water in the Colorado, western, semi-arid agricultural context. Concerns for potential transfer of water from agriculture and the future of hydro-power capacity generation indicates the shifting emphasis of public water priorities in Colorado. The irrigation community's reaction to perceived attack by outside interests indicates a protectionist attitude that will undoubtedly give way to free market economics under which water is transferred to the highest bidder.

Analysis of the irrigation community of the Poudre Valley utilizes a framework with three dimensions: 1) organizational activities; 2) structural, water control activities; and 3) water utilization activities. The organization activities include a) decision-making, b) resource mobilization, c) communication on water matters, and d) water conflict management. The water control structural activities include: a) irrigation facilities design, b) construction of facilities, c) operation of the system, and d) maintenance of the irrigation facilities. The water use activities encompass: a) acquisition of water supplies, b) allocation of irrigation, c) distribution of water, and d) drainage of excess water as necessary.

Consideration of the case indicates the over-riding importance of 10 factors on the management of the irrigation system summarized as follows:

First, the emphasis placed on the water right is paramount. The water right as a private property use right is a sacred part of the Colorado system. The protection of the sanctity of the right leads to the state administrative and judicial structures to assure that these property rights are protected.

Second, the ability to transfer these rights in the open marketplace is held in high regard. With the bidding up of the price of water rights, agriculturalists insist on their right to seek the highest bidder. This attitude makes them little different than some of the original speculators and settlers of the area. The principle allows the gradual transfer of the water rights to municipal and industrial uses and, in the long run, will force greater efficiency in the use of water. An example is the conversion from surface to automated overhead irrigation.

Third, the farm economics of tradeoffs of costs and returns in the labor, capital, land, water, and credit use determines the irrigation methods and the resulting efficiency of the system. With farm labor relatively scarce and expensive, the water application techniques and durations favor labor minimization and long set intervals that have low efficiency in water application.

Fourth, the low efficiency of application is compensated by the physiographic and water right factors that allow water to be recaptured and reused downsteam. The resulting irrigation system efficiency is exceptionally high for a predominantly gravity surface irrigation system. The topography and underground geologic factors often allow the lower level supply ditches to recapture runoff and interflow from higher ditches and their respective irrigated fields in a serendipitous reuse system. The ability of a down stream water user to file a water right on an upstream users drainage water helps to assure reuse and a high system efficiency, but low farm level efficiences.

Fifth, the principle of private farmers' organizations performing the ultimate irrigation management activities, water control structural activities, and the water utilization activities remains the central concept of irrigation management in this case study of western U.S. irrigated agriculture. The farmers in this system are proud of their private status and their independence from government control. In fact, farmer lobbying led to the state law that permitted the formation of intermediate buffer organizations, known as automonous, public conservancy districts with local control, to keep the federal and state governments out of their private matters. On the other hand, they have been very successful over the years in lobbying for state and federal projects repaid on soft terms for irrigation and water development that are a direct subsidy to irrigated agricultural production and the private farmer-producers.

Sixth, slow technology adaptation by irrigation organizations and by farmers is guided by pragmatism, subsidies, legislative mandates, and the farm economics described previously. The basic conservatism of the rural sector does not automatically accept new as always better. Deliberation on selection and application of technology are the norm in the mutual ditch companies.

Seventh, natural consolidation of irrigation companies has occurred as a matter of convenience and in the interest of economical operations. As the cost of managing systems has risen with wage increases, the evolution of specialized managers covering wider service areas has been the driving force behind consolidation. Urbanization on the margins of the cities and towns of the northern front range will most likely over take more irrigated area, and small ditch companies will be consumed by the municipalities who are also hungry for more water reserves for the future.

Eighth, the long gestation period for new water projects to gain approval for environmental reasons and the need for power revenues to subsidize and amortize investments in new capital facilities are the new realities of future water projects. Sometimes it appears that projects languish due to inconsistancies of policies of the government, either federal or state. One office may attempt to encourage certain types of investment while another department

absolutely requires that some environmental standard be fulfilled. This often appears to be the dilemma of democracy.

Ninth, political awareness characterizes the farmer irrigators in the Poudre Valley. They are organized in water users associations to provide a watchdog function to assure that their water rights are not injured by other outside interests. They have paid lobbyists in the state capitol, who work to get legislation in favor of irrigation and agricultural projects. The lobby and interest group activity reaches a federation at the state level and ultimately to a four state level. These techniques were learned from the earlier generations who lobbied for the Colorado Big Thompson Project and all of the associated administrative enabling legislation that resulted in the current administrative system.

Tenth, the principle of integrated groundwater and surface water in one interlinked hydrologic system represents a recognition of reality and has led to a pragmatic solution for the placement of the very junior groundwater rights into the priority system through specially designed augmentation plans. Pragmatism and give-and-take characterize the way that farmers in northern Colorado's Poudre Valley deal with irrigation to serve agricultural interests.

References

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