# ECONOMIC FACTORS AFFECTING RESIDENTIAL WATER DEMAND IN COLORADO

**by**

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# THE PHYSICAL AND ECONOMIC EFFECTS ON THE LOCAL AGRICULTURAL ECONOMY OF WATER TRANSFER FROM IRRIGATION COMPANIES TO CITIES IN THE NORTHERN DENVER METROPOLITAN AREA

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Charles Palmer assisted by running the agricultural data through a modified version of the Colorado input-output model to determine the effects of closing down the three irrigation systems. Ken McWilliams drew the maps of the study area and did follow-up work for the irrigation companies on the survey of irrigation farmers.

The irrigation companies provided data on water users and on operations of the systems. Particularly helpful were Proctor Nott, President of Farmers' Highline Canal and Reservoir Company, and Mrs. Eleanor Duran, Secretary; Mr. Adolph Bohlender, President, Farmers' Reservoir and Irrigation Company and Mrs. Bea Schad, Secretary; Mr. Frank Wooley, Secretary (retired), and Mr. James Fukaye, Secretary, Lower Clear Creek Ditch Company.

Any errors in facts or interpretation are those of the authors.

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SUMMARY

Rapid suburban growth north of Denver has caused developing communities to expand their municipal water systems. In order to obtain additional water supplies, the city of Thornton has initiated condemnation suits against three mutual irrigation companies to obtain more water rights. Westminster initiated suits against two of the companies. Population in the northern suburban area grew from 60,000 in 1969 to an estimated 131,000 in 1975. During this period approximately 18,800 acres of land were converted to urban uses.

The three irrigation companies: the Farmers' Reservoir and Irrigation Company, the Farmers' Highline Canal and Reservoir Company, and the Lower Clear Creek Ditch Company, have a service area of about 40,000 acres. Air photos show about 30,000 acres currently irrigated. Of this land, 80 percent is Class II and III lands--some of the highest land classes found in Colorado. Annual average water supply to the companies is about 61,000 acre feet. The cities and other nonagricultural owners already control about 50 percent of the irrigation companies' water supply.

Approximately 400 farms and small tracts receive water from these companies. Two hundred are commercial farms including truck, dairy and other specialty farms. Total agricultural production from the irrigated area amounts to nearly $8 million per year. Over 28 million pounds of fluid milk were produced on dairy farms in the irrigated area in 1974. Value of truck crops is estimated to be $1.8 million; other irrigated crops account for the remaining $6 million. Economic input-output analysis shows that irrigated agriculture contributes 561 jobs to the economy and $4,074,000 in net income. These would disappear from the economy should the water be transferred to municipal use. Complete withdrawal of water immediately precludes irrigated farming, while progressive withdrawal of irrigation water supplies from farms inhibits good farming practices, reduces production and farm incomes, and weakens the base for a viable local agricultural economy.

With the national concern for the preservation of prime lands and the maintenance of agricultural productivity, it would seem that major consideration should be given to ways of preserving this irrigated area.* In the Colorado Front Range, only 6.4 percent of the land in farms is currently irrigated. Continued urban growth, with no additional water brought into the region, will force the urban areas to compete for the irrigation water supply to these lands.

Forecasts of continued urban growth necessitate further development of municipal water supplies. In the past, urban areas have developed new water supplies, including some from the West Slope, to serve growing populations. Until water resources within the state are fully developed, the urbanizing areas should have the responsibility of developing unused water supplies or developing methods of joint use of water, rather than wresting the resource from agriculture.

This is not to imply that the cities are wasteful of domestic water. Indeed, the cities of Thornton and Westminster have some of the lowest per capita deliveries of water observed in cities along the Front Range. The problem is that rather than pursuing the possibility of developing new water or studying the possibility of joint use of water, these cities adopted a policy of taking water that is already in use in the economy.

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*"Statement on Prime Farmlands, Range and Forest Land," Secretary's Memorandum No. 1827, Supplement No. 1, Office of the Secretary, U.S. Dept. of Agriculture, June 21, 1976.

## INTRODUCTION

Urban growth in the United States almost inevitably affects farming and farm land. In some few cases urban expansion extends to lands which have never been in agriculture. Even where farm lands are involved, the impact will not be uniform. The pattern of growth (e.g., urban sprawl, strip city), the location of growth (e.g., east, west, north or south), the character of the soils, the type of agriculture and similar variables will determine the character and degree of impact. However, in most cases three kinds of impacts can be distinguished. First, and most obvious, is the change from farming to urban use of particular acres. Whatever the economic and social gain (or loss) from such a shift might be, it is clear that the production from the specific acres will have been lost. A trade-off has occurred. And a full assessment of costs and benefits requires an analysis of the spillover or externalities of such a shift. Second, and unique to irrigated land, is the impact on farming which occurs when irrigation water is diverted (a variety of legal techniques are available for accomplishing this), returning irrigated, usually highly productive land, to dry-land or desert status. The consequences following water diversion from farm to urban uses are the concern of this study. Anticipating the more detailed analyses to follow, two factors should be noted: 1) only under Western water law which separates water rights from land rights and permits the separate sale of water rights is it possible to preclude certain agricultural uses, i.e., irrigated crops, indirectly without explicitly taking this into account; and 2) irrigated land deprived of water does not immediately become usable for dry-land farming both because of soil/agronomic changes and because of complex farm unit reorganization requirements.

The third impact falls on the farming community. In many cases, either because of the pattern of urbanization or because of the quantity of land affected (or both) a shift in use of some land from farming to urban will undermine the basis for a viable agriculture on the land remaining in farming. The causes of this range from speculation fever to destroying the basis for profitable supply and marketing firms and other infrastructure. Thus, at some point, the reduction of farms in dairying can make the continued operation of a dairy manufacturing plant uneconomic. The discontinuance of truck farming may remove the basis for a successful canning operation. Or the reduction in number of farms will reduce the market for farm machinery, fertilizers, feed and seed to the point where such business enterprises will cease.

This study is an attempt to determine the consequences of removing about 40,000 acres from irrigated agriculture by diverting the water involved to urban uses. It is assumed that urbanization in the Front Range of Colorado will continue and that the diversion of water from farming to urban uses may therefore be unavoidable. But this study suggests, in the sense of the National Environmental Policy Act, that alternative solutions to meeting urban water needs should be considered and a careful balancing of total costs and total benefits encouraged. The trade-offs involved are not simply between the use of a given quantity of water in irrigated agriculture on the one hand and the use of the same water in urban communities on the other hand. Theoretically, the price of the water would determine the marginal utilities and measure the social advantage if only these two alternatives were involved.

However, it appears that there may be other viable alternatives. Studies should be made to determine possibilities for joint use of existing water which would meet some of the urban needs and at the same time provide water to maintain irrigated land. Such a study might show that a cooperative effort between urban and agricultural interests could supply the water needs of both.

Another alternative, of course, is the possibility of diverting additional Colorado River water from the Western Slope. The costs and benefits of this alternative we have not studied. It is clear that, under the Colorado River Interstate Compact, water for diversion within the state is available. It is also clear that at present considerable political hostility exists to such action. Since the scope of this study cannot consider the alternative costs and benefits of such large scale projects, it is not possible to indicate whether further diversions from West to East Slopes are economically or politically wise. To determine this requires further research.

What we are saying is that additional alternatives should be studied with the aim of preservation of most of the 40,000 acres of irrigated agriculture and avoid the negative consequences which we present in some detail, while at the same time providing needed urban water. The policy issue is not simply irrigated agriculture versus urban water, but rather one of also assessing the costs and benefits of other alternatives to determine which course of action would preserve agriculture and meet East Slope urban needs most effectively and be most clearly in the public interest. We repeat that this present study does not provide an answer to this question. Detailed analysis of the costs and benefits of further diversion or joint use of existing water (including on whom costs fall and who benefits, along with assessment of externalities) is needed so that rational trade-offs can be determined and wise policy decisions reached. This study, however, begins to provide needed information on the costs to agriculture and to the region of taking 40,000 acres out of irrigation. The other parts of the analysis remain to be undertaken.

### Background of Urban Competition for Water

For over one hundred years, farmers have been irrigating crops on the north side of lower Clear Creek. This area is one of the earliest irrigated regions on the east slope of the Rockies. Water rights of the companies go back to 1860. During the post-World War II period, people from burgeoning Denver have been spilling over into new suburban towns surrounding the city. Arvada, Westminster, Thornton and Northglenn have sprung up in the area north of Clear Creek. Some irrigated lands had been taken for urban purposes and some of the irrigation water had been converted to municipal use, but for most of the years since World War II, the towns and farmers coexisted with only minor friction.

Through much of this era, the Denver water system has provided water to growing areas outside the city limits. The Denver Water Board has attempted to maintain a policy of developing raw water supplies to meet future growth both inside and outside the city. However, sustained rapid growth pressing against available capacity, disputes over annexations to Denver and difficulties in drawing up mutually satisfactory water contracts between Denver and the suburbs has caused some towns to seek their own water supplies. Now the continuing need for more municipal water by these suburban towns in the face of fully utilized local supplies has resulted in efforts to condemn irrigation water rights to convert them to municipal use. Should current condemnation suits be successful, 400 farmers will be put out of business, and nearly 40,000 irrigated acres of land will be dried up. Moreover, the precedents thus established may signal the ultimate end of irrigation agriculture on the urbanizing Front Range (from Pueblo to Fort Collins).

Suburban Water Problems

The growth of suburban areas beyond the umbrella of the Denver water system meant that such new areas had to develop their own municipal water supply. The necessity for new housing and the lure of inexpensive land for subdivisions encouraged developers to move beyond the immediate metropolitan urban fringe. 1/ Their primary interest was building houses and shopping centers. Water supply and sewage systems were only of minor interest to the main development activity. Water was supplied either by newly formed municipalities or by special water districts or by commercial water companies. 2/ All three types of arrangements were used and continue to exist. Thornton has taken over one of the commercial companies as the basis for its municipal water system and is also the chief water supplier to the City of Northglenn.

A chronic problem of providing water service in new, rapidly growing communities is that of obtaining adequate capital to build soundly designed systems. Bond financing in new areas is stretched to the limit; fiscal reserves are nonexistent, and tax expansion lags. This means that not much money is available to develop new water supplies so the communities seek to acquire raw water as cheaply as possible in the short run. This means that capital intensive projects will be avoided in favor of short-run solutions requiring less investment. It also tends to mean a piecemeal, fragmentized approach as compared to a well-planned, comprehensive approach.

The suburban area north of Denver began to obtain water from Clear Creek (see Fig. 1), from existing reservoirs, and from wells. Bit by bit, shares of stock were purchased in local irrigation companies as irrigated land became urbanized. The wells were a "new" source of water and served the purpose for municipal water until a change in state water law in 1972 began to curb development and use of wells as a water source. Under this law, the state claims wells in the area are tributary to the streams and are therefore inferior to prior surface rights. This also means they may be shut down in dry periods.

As far back as 1963, the City of Westminster was experiencing problems with inadequate municipal water supply. Since then it has expanded Standley Lake (see Fig. 3) to hold additional water for its municipal supply. Most of the surburban areas have been hard pressed to stay ahead of the need for larger water treatment plants, for additions to the distribution systems and for raw water supplies. No significant contracts to obtain water from the Denver Water Board have been concluded and this alternative would seem at least temporarily precluded by both policy and legal constraints.

The inability of the new suburban areas to obtain water from the City of Denver, the threat to the well system, the limited availability of irrigation company stock purchases to meet growing municipal demands for water prompted the Cities of Thornton and Westminster to begin condemnation proceedings in 1973 against the three irrigation systems that have service areas in and near their boundaries.

The three companies are the Farmers' Reservoir and Irrigation Company (Standley Lake Division), the Farmers' Highline Canal and Reservoir Company, and the Lower Clear Creek Canal. Figure 1 shows the location of the irrigation canals in relation to Denver and the suburban cities in Adams and Jefferson Counties.

Maps of Urbanized Land and City Boundaries in the Irrigated Area

Using a variety of highway, county and U.S. Geological Survey maps and air photos, a series of maps was developed to show the nature and extent of urbanization upon the irrigated areas under study.

Figure 2 shows the service areas of the irrigation companies in the spring of 1975. The service areas were outlined by ditch riders, superintendents and other officers of the canal companies.

Figure 3 outlines the city boundaries of Thornton, Westminster, Northglenn, Arvada and the northern boundary of Denver. This map shows the City of Northglenn encapsulated by the extensions of Thornton on the south, east and north, and Westminster on the west. The small enclave of Federal Heights is also almost entirely surrounded by the two cities. Figure 4 shows the extent to which the city boundaries of Westminster and Thornton overlay the irrigation service areas of the companies.

The land actually occupied by urban uses is shown in figure 5. Examination of this map shows that large areas of land within the boundaries of both Thornton and Westminster have not yet been developed for urban uses. A considerable amount of the irrigated lands under the Farmers' Highline Canal has been incorporated into the boundaries of the cities even though urban development does not appear to be imminent. Peculiarities in Colorado annexation law result in this pattern of boundary location. 3/

Additionally, it should be noted that some fairly large areas of urban land to the south of Thornton and Westminster have not been drawn into the boundaries of adjacent cities. These areas are forced to rely on special districts or county government for essential utility services.

A composite of previous maps showing the irrigated service areas of the companies, the boundaries of the cities and the urbanized land areas is

1/ R.L. Anderson. Urbanization of Rural Lands in the Northern Colorado Front Range, ERS, USDA & Colo. Coop. Extension Service, 1973.

2/ James L. Cox. Metropolitan Water Supply: The Denver Experience, Bureau of Governmental Research, Univ. of Colorado, Boulder, 1967; and R.L. Anderson. Price and Delivery of Water in the Northern Colorado Front Range, ERS, USDA & Colo. Coop. Extension Service, 1974.

3/ Colorado Revised Statutes, 1973, Title 31, Ch. 8. See especially 31-8-104 and 31-8-105.

Figure 1--Location of study area and main irrigation canals

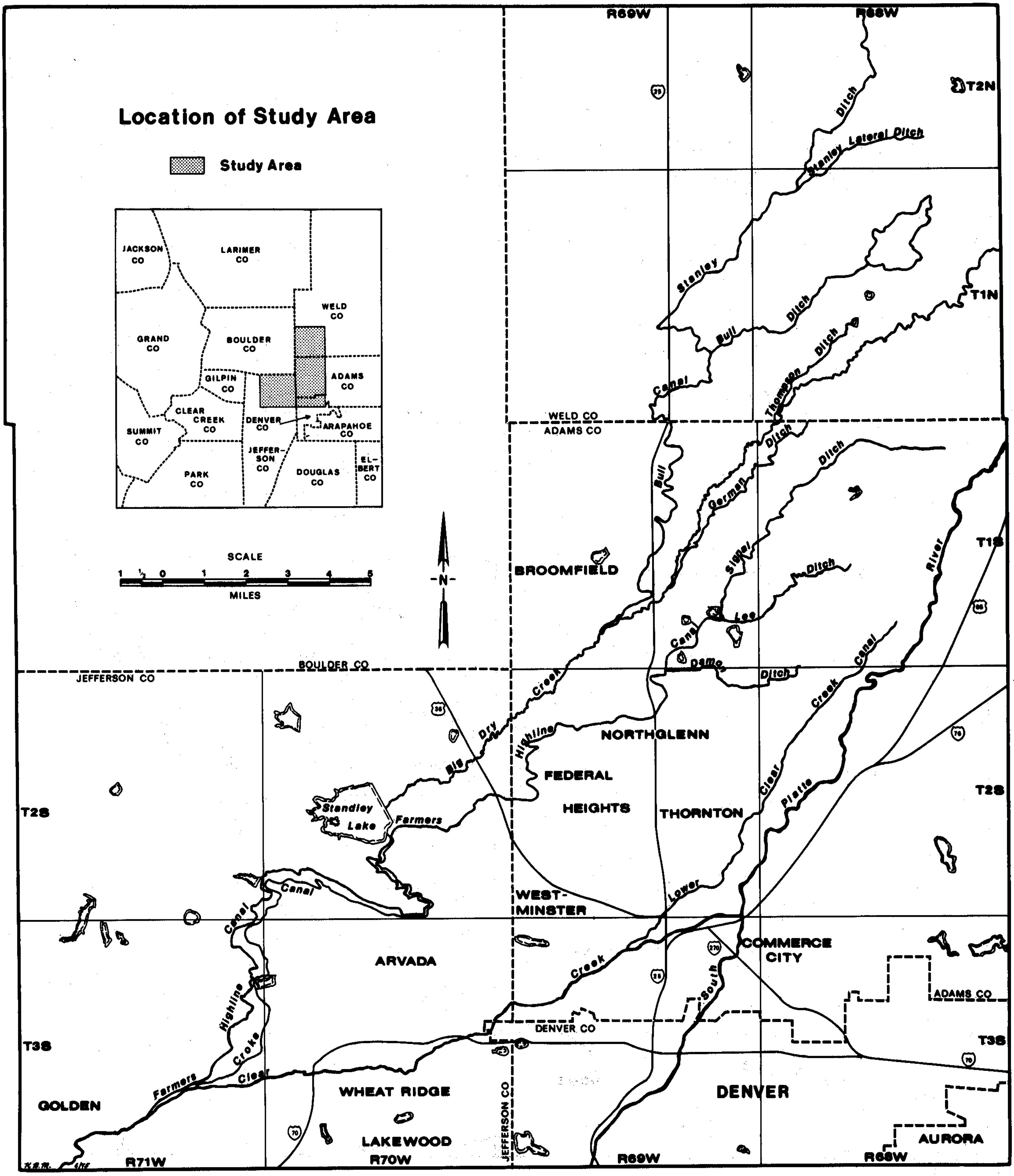


Figure 2--Irrigation service areas of the three companies

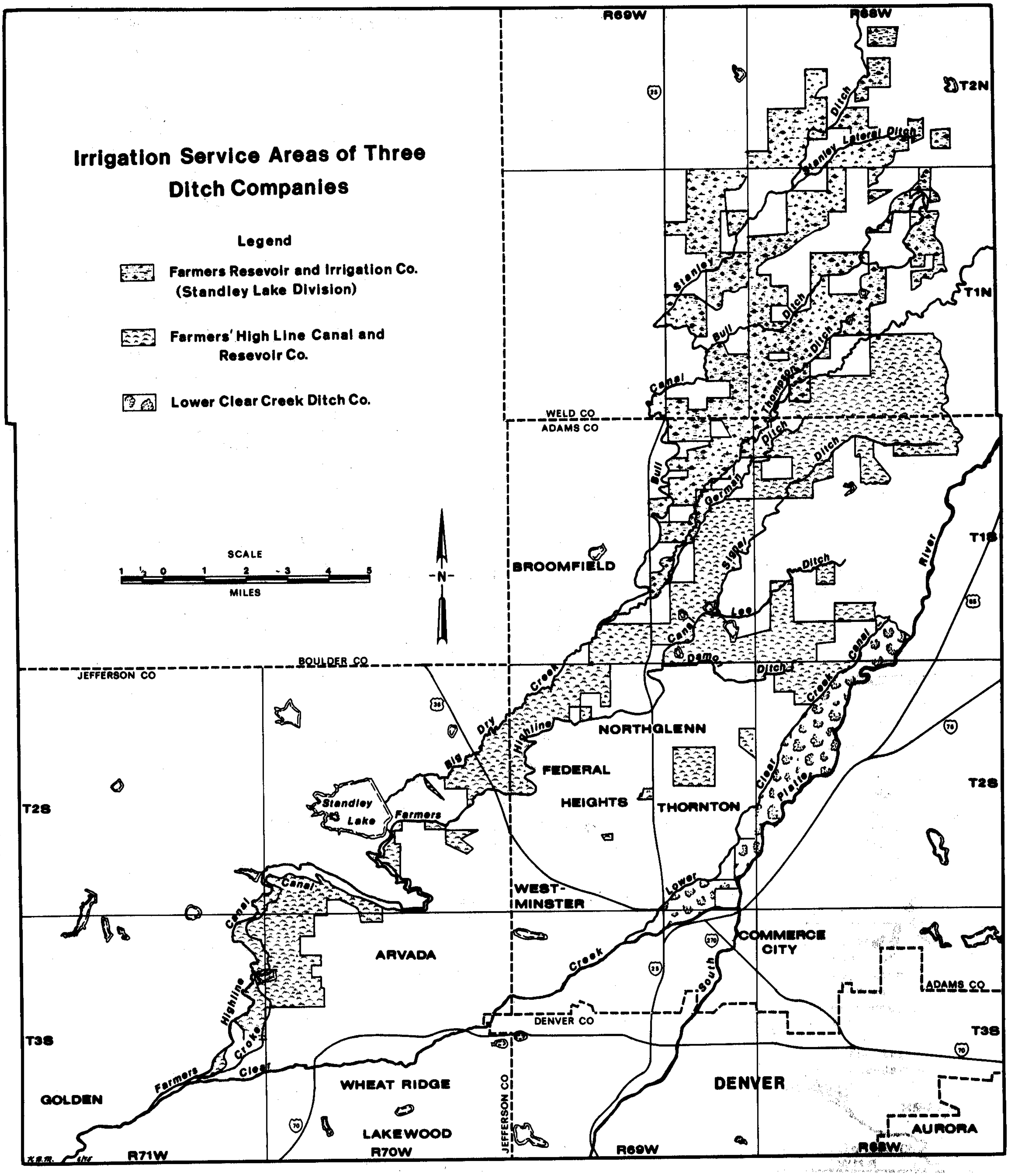


Figure 3--City boundaries in the study area

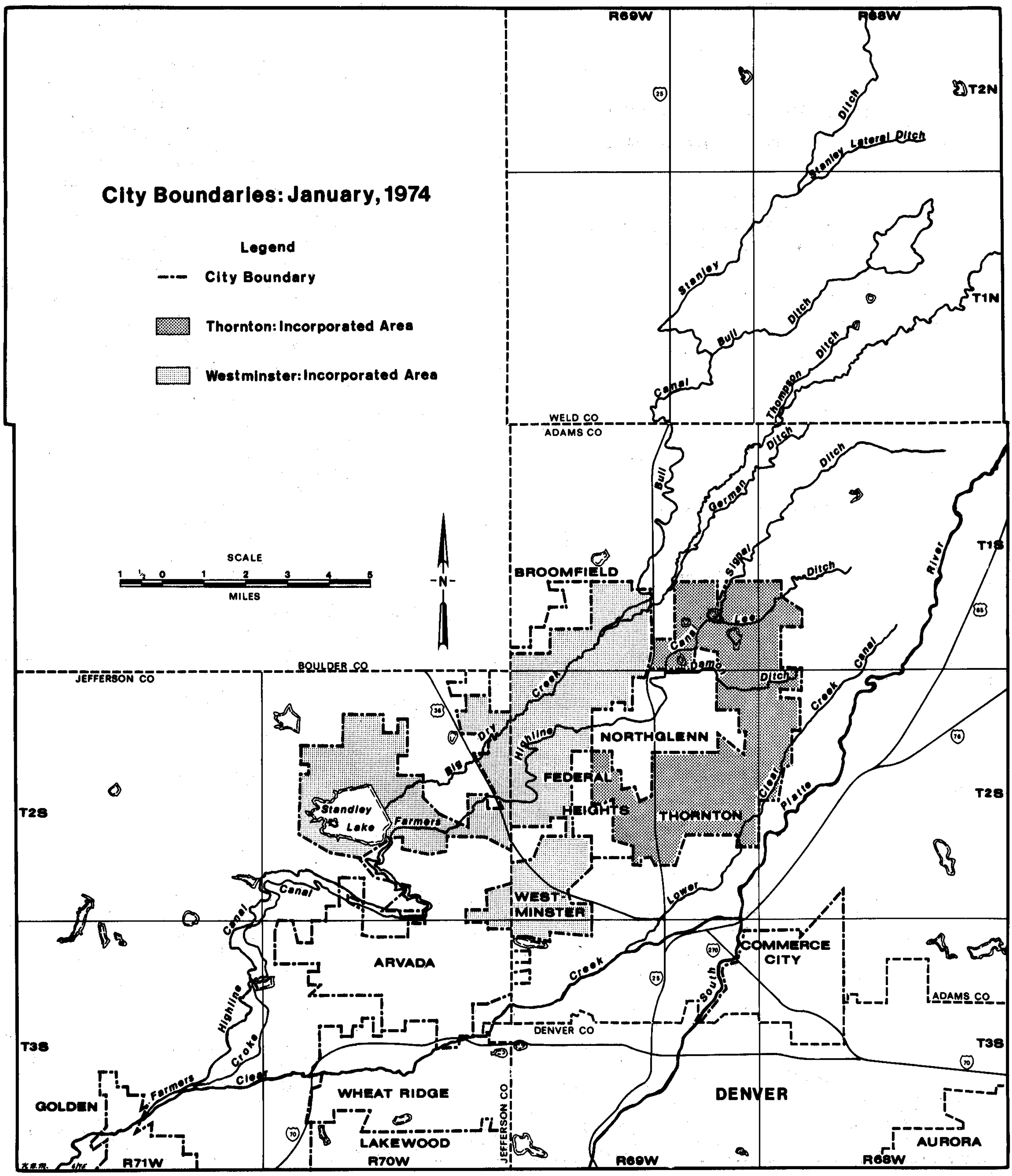


Figure 4--Irrigation areas and city boundaries

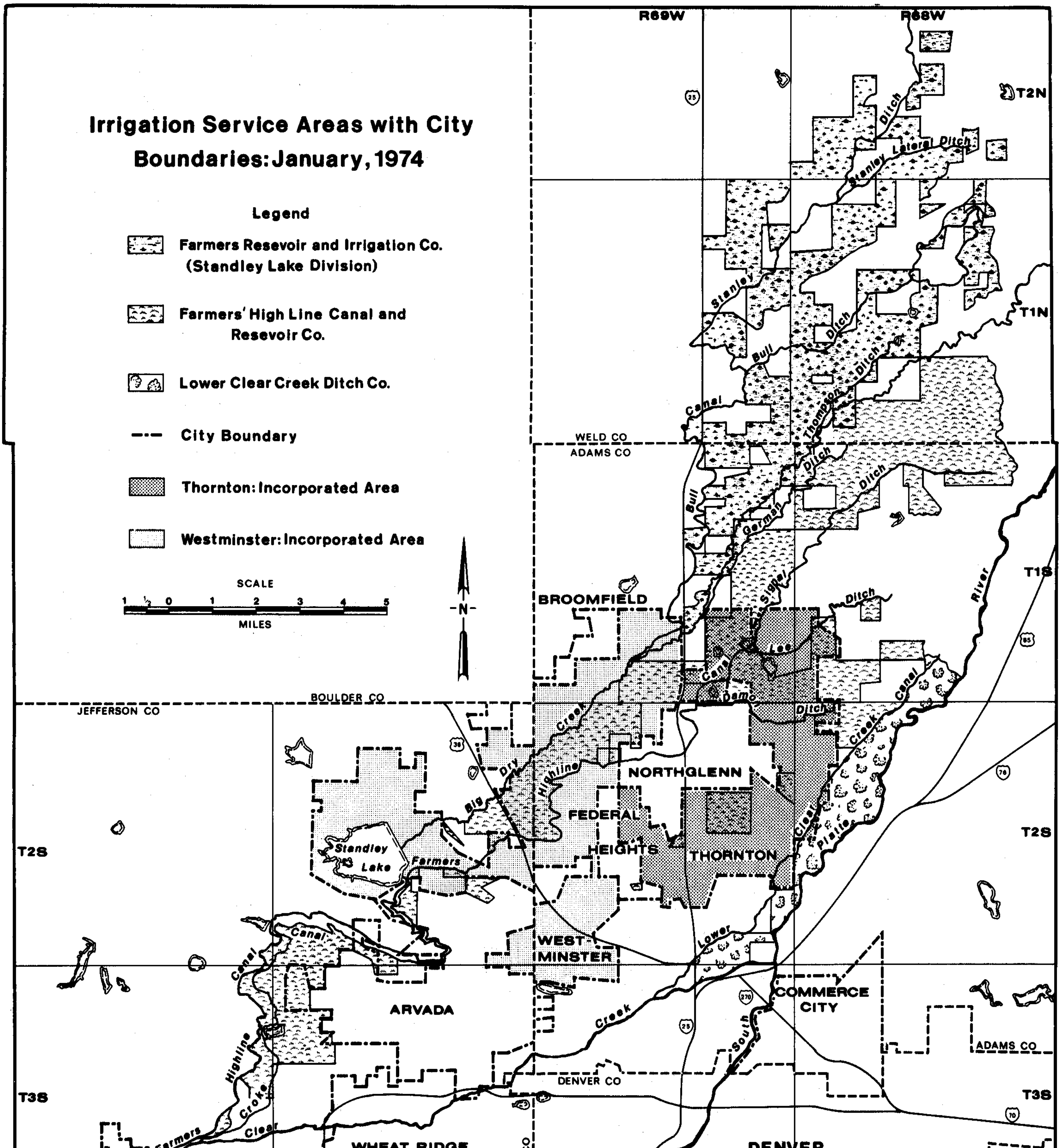
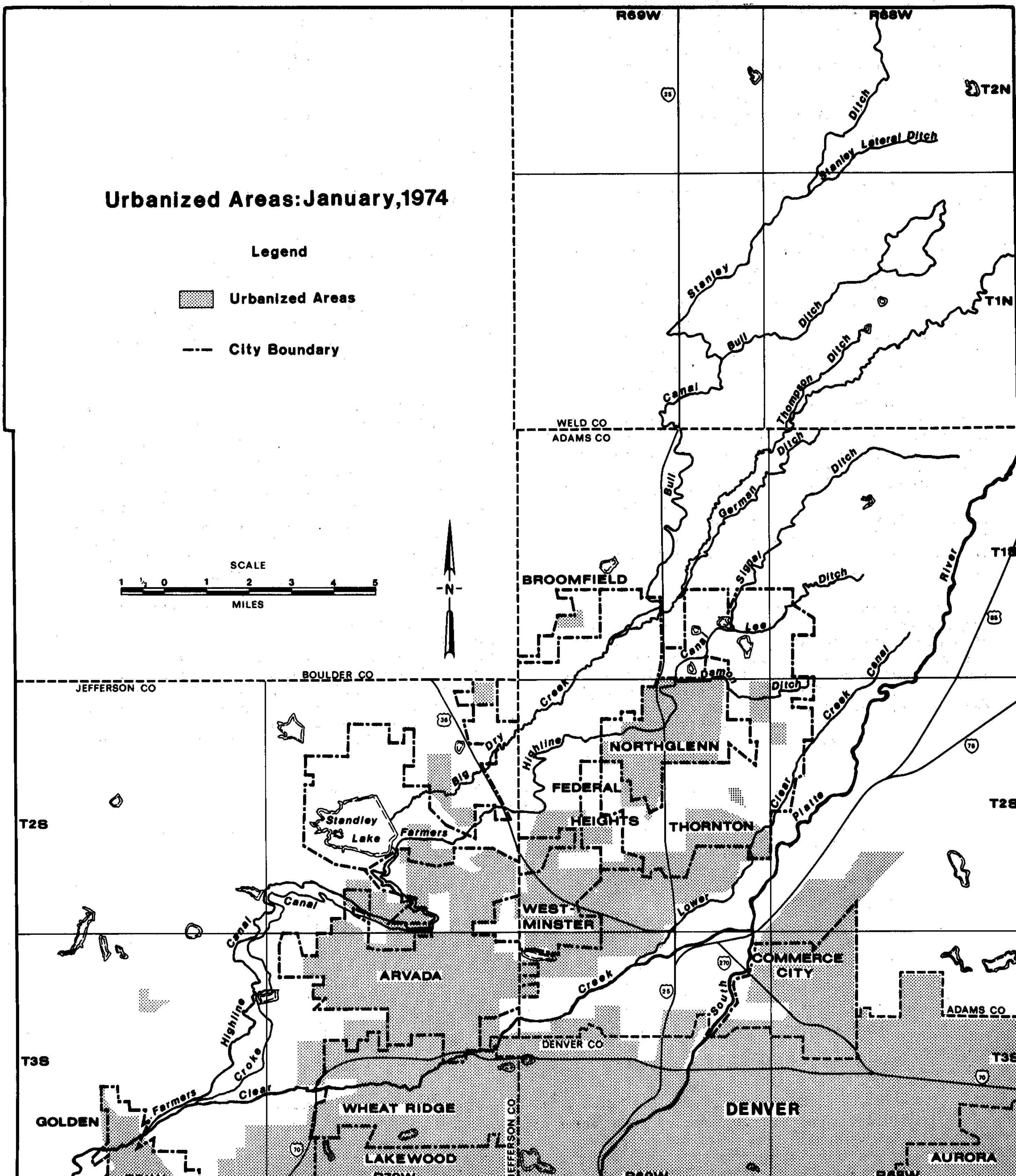


Figure 5--Urbanized area and city boundaries



presented in figure 6. Much of the Farmers' Highline Canal service area lies within the boundaries of Westminster and Thornton while most of the service area of the Farmers' Reservoir and Irrigation Company (Standley Lake Division) lies to the north of the urban development. Lower Clear Creek Ditch Company has some urban development in the upper portion of its irrigated area but for the most part remains free of urban incursion, principally because most of its land lies in a flood plain and, if Colorado land use statutes are followed, will be subject to development restrictions.

Air Photo Analysis of Land Use Change in the Irrigated Area

In order to trace the urban growth in the vicinity of the irrigation systems that are under condemnation, air photos of the area were obtained for 1957, 1963, 1969 and 1974. These photos were examined by an air photo analyst to determine the amount and location of lands converted to urban use. Urbanized land was classified according to the original use and its current urban use. Table 1 contains the detail of lands urbanized in the irrigated service areas since 1957. Not all of this land had been irrigated but the urbanization spread on to irrigated lands in many places. For the most part, it can be assumed that cropland had been irrigated, although the photos may not show this, because farming frequently ceases for a year or more before urban development takes place. Similarly with idle land, farming and pasture use cease some time before urban development begins. This is particularly true in a semi-arid area such as this, because little or nothing grows for a long period after irrigation is stopped.

The air photos show that about 8,100 acres of cropland were urbanized in the Adams County part of the irrigation companies' service area between 1957 and 1974. An additional 2,045 acres of idle land were urbanized during the period. Some of this had been cropland before idling. Altogether in Adams County, there were 11,540 acres of rural land in the irrigated vicinity that were developed for urban purposes between 1957 and 1974.

In the northeastern corner of Jefferson County served by the irrigation companies about 6,500 acres of cropland were urbanized in the same period. We were unable to locate an air photo of the region for the mid-1950s period; thus, urbanized land for that period has been estimated. Our estimate of 2,250 acres for the 1957-63 period is probably conservative. Altogether about 7,335 acres of land were urbanized from 1957-1963 in northeastern Jefferson County.

The total amount of cropland in the vicinity of the irrigated service area that was urbanized was about 18,800 acres in 17 years. In the most recent ten years, actual conversion was 16,625 or an average of around 1,600 acres per year. If we project this urbanization rate over the 40,000 acres of irrigated service area remaining outside urban development, it would take 25 years before all of the irrigated land would be urbanized. However, some proportion, perhaps as much as 50 percent of the land urbanizing, could be nonirrigated land. Some of the irrigated land lies 15 to 16 miles beyond the northernmost fringe of urban development and has only a remote possibility of being urbanized in this century.

Table 2 shows the urban uses of lands in the irrigated service areas of Adams and Jefferson Counties. These data show that residential housing, both open and dense, occupied 75.5 percent of the land urbanized. Commercial, with 7.2 percent, industrial, 5.6 percent, and institutional with 3.1 percent use up much less land. One interesting facet is that up until 1974, in Adams County, an additional 8.4 percent of the land was in mobile home parks. Thus almost 84 percent of the land was used for housing in the urbanizing area.

We are unable to develop precise population density figures for the land urbanized in the irrigated area because the population data are fragmentized between two counties and multiple municipalities. Additionally, some urban development is outside any incorporated municipality and thus falls into county figures that are unusable for this purpose. However, the fact that 68 percent of the residential housing is classified as dense--meaning

Table 1--Rural land urbanized in the vicinity of the service area of the three irrigation companies, 1957-74

| County | Cropland | Idle | Grassland | Total |
|---|---|---|---|---|
| | Acres | | | |
| Adams | | | | |
| 1957-63 | 2,985 | 710 | 1,135 | 4,830 |
| 1963-69 | 875 | 505 | 165 | 1,545 |
| 1969-74 | 4,245 | 830 | 90 | 5,165 |
| County total | 8,105 | 2,045 | 1,390 | 11,540 |
| N.E. Jefferson | | | | |
| 1957-63 1/ | (2,000) | (150) | (100) | (2,250) |
| 1963-69 | 1,025 | 90 | 75 | 1,190 |
| 1969-74 | 3,490 | 285 | 120 | 3,895 |
| County total | 6,515 | 525 | 295 | 7,335 |
| Estimated 1957-74 total | 14,620 | 2,570 | 1,685 | 18,875 |
| 1963-74 actual | 12,620 | 2,420 | 1,585 | 16,625 |

During the last 10.5 years, 1,200 acres of cropland and 1,583 total acres per year have been urbanized.

1/ This is an estimate from the 1963 photo. So far we have not been able to obtain a photo of Jefferson County for the mid-1950s.

Figure 6--Irrigation service area and urbanized land in the study area

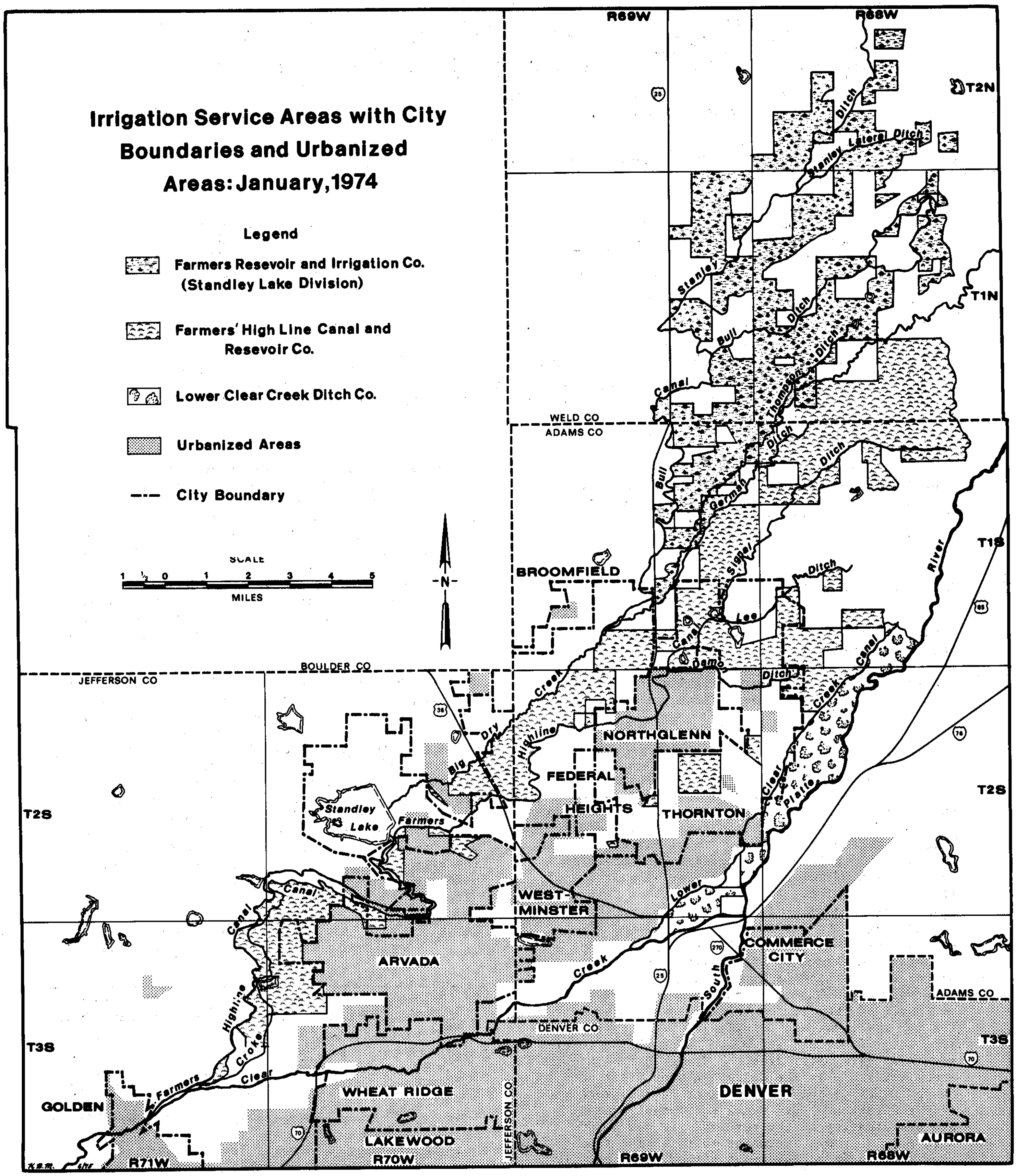


Table 2--Uses of urbanized lands in the irrigation companies' service areas of Jefferson and Adams Counties (1957-1974 in Adams County and northeastern Jefferson County)

| Type of land by counties | Uses of urbanized lands: Residential: Dense | Residential: Open | Trailer: parks | Commercial | Industrial | Institutional | Total |
|---|---|---|---|---|---|---|---|
| | Acres | | | | | | |
| Cropland | | | | | | | |
| Jefferson | 5,213 | 777 | -- | 330 | 65 | 130 | 6,515 1/ |
| Adams | 5,180 | 305 | 1,405 | 425 | 590 | 200 | 8,105 |
| Idle | | | | | | | |
| Jefferson | 180 | 220 | -- | 75 | -- | 50 | 525 1/ |
| Adams | 1,285 | -- | 160 | 230 | 295 | 75 | 2,045 |
| Grassland | | | | | | | |
| Jefferson | 175 | 40 | -- | 60 | -- | 20 | 295 1/ |
| Adams | 830 | 50 | 30 | 240 | 115 | 125 | 1,390 |
| Total | 12,863 | 1,392 | 1,595 | 1,360 | 1,065 | 600 | 18,875 |
| Encircled land 2/ | | | | | | | 3,200 |
| Percent of land | 68.2 | 7.3 | 8.4 | 7.2 | 5.6 | 3.1 | |

1/ 1957-63 land use changes were estimated from urban development in area in 1963.
2/ In addition, there are about 3,200 acres of land almost entirely encircled by urban development.

4 or more dwellings per acre--and 8.4 percent is in mobile home parks suggests that the urban development taking place is basically of an intensive nature. There may be some leapfrogging of subdivisions, but when the land is developed, it is used intensively.

## The Irrigation Companies

Some of the characteristics of the three irrigation companies involved in condemnation of water supplies by the city of Thornton are discussed below. These are: Farmers' Reservoir and Irrigation Company, Farmers' Highline Canal and Reservoir Company and Lower Clear Creek Ditch Company.

### Farmers' Reservoir and Irrigation Company

The Farmers' Reservoir and Irrigation Company is one of the largest mutual irrigation companies in the South Platte Basin. It is divided into 4 main divisions: Barr Lake, Milton Reservoir, Standley Lake and Marshall Reservoir. Total service area is around 67,000 acres. The Standley Lake Division is under pressure from urban areas for acquisition of its water supplies. The service area of this division lies in Adams and Weld Counties, north of the growing Metro Denver area. The cities of Westminster, Thornton and Northglenn have grown into the southern fringe of its service area. Water supply of the division is from storage in Standley Lake Reservoir which has been annexed into the urban perimeter of the City of Westminster. Water sources for the reservoir are principally Clear Creek with some water from Coal and Woman Creeks. The reservoir also gets water from the Church Ditch through stock ownership in the Golden-Ralston Creek and Church Ditch Company. Some water is also received from the Berthoud Pass Canal and Tunnel system. Storage capacity of the reservoir is now 40,000 acre feet. It was increased to this size from 18,250 acre feet under an agreement signed with the City of Westminster in 1963. The company has preferential rights to 30,000 acre feet of storage capacity in the enlarged reservoir. Storage and releases from the reservoir have increased about 5 percent since the enlargement in the mid-1960s. Average delivery per year in a 34-year period (1940-1974) was 12,680 A.F.; in the 13-year period 1961-73 the average delivery was 13,605 A.F. Certain periods in the past have delivered equal or larger amounts, so enlargement of the reservoir did not appreciably enhance water supplies of the farmers under Standley Lake.

In 1974, there were 2,372 shares of stock outstanding in the Standley Lake Division held by approximately 170 stockholders. Table 3 shows a distribution of stockholdings by stockholders. About 60 of the stockholders owned more than 10 shares each. Table 4 shows a distribution of stock ownership by type of owner. Farmers owned about 70 percent of the stock in 1974, cities 21 percent and real estate and other firms approximately 9 percent. Some of the real estate and commercial firms' water is still used for irrigation while most of the city-owned water is used for municipal purposes, golf courses and parks.

Table 3--Share holdings in Farmers' Reservoir and Irrigation Company, Standley Lake Reservoir, 1974

| No. of shares held by stockholder | No. of stockholders | Percent of stockholders |
|---|---|---|
| 1- 5 | 75 | 44.1 |
| 6- 10 | 36 | 21.2 |
| 11- 20 | 33 | 19.4 |
| Over 21 | 26 | 15.3 |
| Total | 170 | 100.0 |

Table 4--Stock ownership by farmers, cities, commercial firms and real estate interests, Farmers' Reservoir and Irrigation Company, Standley Lake Reservoir, 1974

| Stockholder | Number shares | Percent stock |
|---|---|---|
| Farmers and small landowners | 1,654.15 | 69.8 |
| Cities | 505.89 | 21.4 |
| Commercial firms | 110.25 | 4.6 |
| Real estate firms | 101.71 | 4.2 |
| Total | 2,372.00 | 100.0 |

A share of stock delivers approximately 5.4 A.F./share on the long-time average. The company was organized to deliver 10 A.F./share of stock with each share to serve 10 acres of land or 1 A.F. of water per acre. As can be seen, average delivery has been roughly half the anticipated amount.

There are approximately 15,000 acres in the service area of the Standley Lake Division. Air photos of the area taken in 1970 show about 9,600 were irrigated that year. Since 1970 was a water-short year, delivering only 10,200 A.F. compared to 16,600 A.F. the year before and the year after, we can assume that from 10,000 to over 15,000 acres might be irrigated, depending upon the water supply available during a particular year.

Water control under Standley Lake is very good in that all of the supply can be stored in the reservoir and called on demand. In the spring, the board of directors decides on the amount of water available that season and declares a quota that will be delivered per share. The water users can then decide what crops and how many acres to plant based on the irrigation water quota. The farmers can order water to be delivered at the times the crops need it the most. An ideal supply would equal about 1.7 A.F. per acre for diversified crops. However, water supply averages only about 1 A.F. per acre irrigated, but crop yields are generally better than would normally be expected because of good water control and generally favorable soil types.

General farming predominates, with some livestock feeding and dairying. Principal crops (as of 1972) are corn, 35 percent; alfalfa, 28 percent; small grains, 20 percent; miscellaneous crops such as sugar beets, 5 percent; and fallow, 12 percent.

From company records it is estimated that under the Farmers' Reservoir and Irrigation Company, Standley Lake Division, there are 65 small landholders with only a few acres, 64 medium size farms with from 40 to 160 acres and 31 large farms with more than 200 acres.

## Farmers' Highline Canal and Reservoir Company

The Farmers' Highline Canal and Reservoir Company has the largest service area and the most water users of the companies threatened by condemnation. The service area, as delineated by company officials, stretches from near Golden, Colorado to west of Brighton, Colorado, covering approximately 23,500 acres. In 1970, about 21,800 acres were irrigated. The service area falls in three counties--approximately 7,680 acres in Jefferson County, 12,640 acres in Adams County and 3,200 acres in Weld County. The farms in Jefferson County tend to be small holdings with many places having only a few acres. Some of these are urban residences that have horses or homes of part-time farmers such as retirees who raise gardens and livestock for part of their livelihood. There are a number of specialty farms in the Farmers' Highline area including: nurseries, greenhouses, college lands used for education purposes, truck farms, and several schools water their grounds from the canal. The major farming section is in the service area in Adams and Weld Counties. These are predominantly grain and livestock farms including about 20 dairy farms. The irrigated cropping pattern is similar to the Farmers' Irrigation and Reservoir Company, mainly alfalfa, corn, small grain and miscellaneous crops. In fact, several farms receive water from both companies.

Water supply comes principally from Clear Creek with water rights totaling 733.6 c.f.s. This company holds priority number 1 on Clear Creek but the amount is for only .276 c.f.s. Table 5 shows the array of direct flow rights held by the company. As can be seen, its major rights are the most junior, being priority number 57 for 154 c.f.s., priority number 68 for 191 c.f.s. and priority 69 for 335.86 c.f.s. Thus, as the stream flow declines in mid- and late summer, the company is restricted to approximately 50 c.f.s. much of the time and to the small amount of reservoir water. Water rights on the other streams are intermittent and good only during the spring runoff most years. Average water supply from direct diversion and reservoir releases from 1936 to 1972 has been 842 A.F. reservoir and 35,508 A.F. direct flow diversion. Total diversion in 1961-72 averaged 38,721 acre feet. This amounts to approximately 33 A.F. per share of stock.

Table 5--Direct water rights held by Farmers' Highline Canal and Reservoir Company

| Source | Priority number | Date | Amount |
|---|---|---|---|
| | | | C.F.S. |
| Clear Creek | 1 | 1860 | .276 |
| | 3 | 1860 | 1.00 |
| | 5 | 1860 | 3.281 |
| | 9 | 1860 | 39.80 |
| | 30 | 1863 | 1.61 |
| | 32 | 1863 | 2.75 |
| | 42 | 1865 | 2.89 |
| | 48 | 1865 | .808 |
| | 54 | 1870 | .33 |
| | 57 | 1872 | 154.00 |
| | 68 | 1886 | 191.00 |
| | 69 | 1895 | 335.86 |
| Subtotal | | | 733.60 |
| Dry Creek | 1 | 1872 | 193.80 |
| Ralston Creek | 21 | 1872 | 60.00 |
| Leyden Creek | 4 | 1905 | 465.00 |

There are 1,093.66 shares of stock held by water users under the Farmers' Highline system. At the end of 1974, there were 264 stockholders with ownership as shown in table 6. There are a fairly large number of water users with fractional shares because the small landholders do not need more than a fraction of a share to provide irrigation water to their lands. An examination of the types of owners of stock shows that various suburban cities and other governmental units own 51 percent of the stock in the system (table 7). Farmers hold 35.2 percent and commercial firms (some of which farm) own 13.8 percent.

Table 6--Share holdings in Farmers' Highline Canal and Reservoir Company, 1974

| No. of shares held by stockholder | No. of stockholders | Percentage |
|---|---|---|
| 0.0 - .49 | 77 | 29.3 |
| .5 - .99 | 48 | 18.3 |
| 1.0 - 1.99 | 49 | 18.6 |
| 2.0 - 4.99 | 56 | 21.2 |
| 5.0 - 9.99 | 21 | 8.0 |
| 10.0 - 19.99 | 6 | 2.3 |
| 20 and over | 6 | 2.3 |
| Total | 263 | 100.0 |

* * *

Table 7--Stock ownership in Farmers' Highline Canal and Reservoir Company by farmers, cities, institutions and commercial firms, 1974

| Stockholder | Number shares owned | | Percent stock |
|---|---|---|---|
| Farmers and small landowners | 383.73 | | 35.2 |
| Cities and other governments | | | |
| Thornton | 259.34 | 23.71 | |
| Westminster | 230.41 | 21.10 | |
| Arvada | 43.54 | 3.98 | |
| County Government and special districts | 25.0 | 2.28 | |
| Subtotal | 558.29 | | 51.0 |
| Commercial, real estate firms and others | 151.58 | | 13.8 |
| Total | 1,093.6 | | 100.0 |

Water delivery under the Highline is on a run-of-the-river basis and varies with stream flow. The higher the stream flow, the more water in the ditch, and the more rights which can be filled. Headgates are set according to the shares owned in the system. A water user with 4 shares would get 4 times as much water as one with 1 share. Most headgates are open all the time to receive whatever water is in the ditch. The superintendent comes by every other day to open or shut headgates for those who want changes. Whenever changes in headgate settings are requested between routine visits, the company has instituted a charge for the special trip.

Operation of a continuous-flow delivery system is rather rare in this region and typically results in poor water use by farmers. But the Highline Canal is unique in this respect because there are over 80 small farmer-owned reservoirs or holding ponds in the service area. The farmers capture the varying flow from the canal in their own ponds and can then irrigate whenever crops need it. Having the water in small, on-farm reservoirs allows them to irrigate with a larger head than direct canal flow would provide and also allows them to irrigate on particular days as they may choose rather than constantly as a continuous-flow system would demand.

Development of so many small on-farm reservoirs is unusual and resulted principally from the quality of water that formerly came from Clear Creek. In the early days and up to the 1930s, there was considerable gold mining on Clear Creek. The gold processing mills dumped their tailing waters, which contained cyanide and other toxic material, into the creek, contaminating the waters the farmers diverted for irrigation. The farmers built small reservoirs throughout the system, mainly on their own farms or with neighbors, to hold the water until the mining contaminants settled out. Then they could irrigate with the water without damaging the land. Now the practice has developed of holding most of their direct flow water in these small reservoirs as it is diverted and irrigating their crops whenever they choose, giving much better control of timing and amount of irrigation. Many of the soils in the area are rather heavy and often, by proper spacing of irrigations, farmers can get good yields even though total available water may be limited. Certainly this pattern of use will minimize losses from too-heavy irrigations, irrigations when crops don't need it but water is available, night irrigations, administrative losses and so on.

This company also has what they call contract water. There is a small area in the upper part of the system that has water rights attached to the land as part of the water rights decrees. The priorities are very early so these lands always had a good water supply. Whenever the lands with contract water do not use it, the water is left in the canal for use by other farmers in the system. The area where the water has been attached to the land has been undergoing urbanization since the 1950s so that the demand for irrigation water in this area has declined as new landowners have occupied the area. Most urban residents do not use water as intensively as the original irrigation farmers, although some of the contract water is used on lawns, horse pastures, small hay fields and gardens.

There are about 90 farmers with sufficient shares to deliver enough irrigation water to operate commercially viable farms. These operations would be seriously curtailed if water supply was taken because intensive farming with irrigation is necessary to get enough production to permit farming to survive. Even if agronomically feasible (which is doubtful), these farms do not have a large enough land base to change to dry farming. In fact, only a small fraction could remain in farming without irrigation water.

In addition, there are at least 120 other small water users who have a few acres for lawns, gardens, truck crops, pasture for a horse or a beef animal who would be severely hurt if their water was removed. These people, many of whom are retired, do not use a large amount of water, but they produce much of their own food supply and meat and could ill afford the water loss because the compensation they would receive for the water rights would be minimal. Water is an essential factor in their production to which they add their labor. No comparable opportunity for this labor appears available in the area. Thus, removing the water destroys subsistence operations of this type which may not be measured by prices paid for water.

Table 8--Farmer and small landowner holdings of stock in Farmers' Highline Canal Company

| Stock owned | Number farmers | | Total shares | | Total water[1/] Acre feet | |
|---|---|---|---|---|---|---|
| Less than 1 share | 37 | | 24.32 | | 851.2 | |
| (Subsidiary company) | 83 | | 17.18 | | 601.3 | |
| | | 120 | | 41.50 | | 1,452.5 |
| 1 - 2 | 37 | | 58.50 | | 2,047.5 | |
| 2+ - 4 | 22 | | 73.25 | | 2,563.8 | |
| 4+ - 6 | 22 | | 119.25 | | 4,172.0 | |
| 6+ - 10 | 4 | | 32.30 | | 1,130.5 | |
| Over 10 | 4 | | 58.93 | | 2,062.6 | |
| | | 89 | | 342.23 | | 11,978.1 |
| TOTAL | | 209 | | 383.73 | | 13,430.6 |

1/ 35 A.F. per share.

## Lower Clear Creek Ditch Company

The Lower Clear Creek Ditch Company is the third and smallest of the three companies that are under condemnation. Lower Clear Creek Ditch has approximately 2,600 acres irrigated in its service area and is undergoing some urban encroachment in the upper end of the system. This ditch serves the alluvial plain from just above the confluence of Clear Creek with the South Platte downstream along the west side of the river for about 8 miles. In early 1975, 66 stockholders owned 320 shares of stock; the company retains 55.6 shares that it rents to water users on a continuing contract basis. These are referred to as "buying rights" and are measured in inches of flow. Table 9 shows that in early 1975, farmers and ditch companies owned 77.5 percent of the stock; Thornton, 14.5 percent; Adams County, 4.3 percent; and commercial firms, 3.7 percent. There are about 33 small farms, 12 medium and 6 large farms under the system.

Table 9--Stock ownership in Lower Clear Creek Ditch by farmers, city, county and commercial firms, 1975

| Stockholder | Number shares owned | Percent stock |
|---|---|---|
| Farmers and ditch companies | 290.6 | 77.5 |
| Thornton | 54.4 | 14.5 |
| Adams County | 16.0 | 4.3 |
| Commercial firms | 14.0 | 3.7 |
| Total | 375.0 | 100.0 |

The company has one primary water right on Clear Creek--priority number 18, dated October 1884 for 49.5 cubic feet of flow per second. Most earlier rights are for relatively small quantities so that Lower Clear Creek Ditch Company has a good water supply until the latter part of the season. Water delivery is on a continuous basis; each water user's headgate is sized by width according to the shares of stock owned or number of buying rights held. Thus, as the water in the canal rises and falls, each user receives his proportionate share of water. Water users can open and close their headgates at will. Excess water that is left in the canal is dumped into the South Platte.

During the late summer when the stream flow is low so that irrigating is difficult, the company officials will put the ditch on sections. The canal will be checked up so that water is available to the upper section for 3 days. Then all headgates in the section are closed, the check removed and the lower section receives water for 3 days. Normally two sections are used but when water is very low, 3 sections can be used.

The diversions for the Lower Clear Creek Ditch Company range from 5,154 A.F. to 10,940 A.F. with an average of about 8,900 A.F. per year between 1961-73. This amounts to about 24 A.F. per share or about 3.3 A.F. per irrigated acre. This amount of water per acre is significantly larger than the one acre foot per acre which is the standard in the other two companies.

The nature of the farming under the Lower Clear Creek Ditch is dependent upon a higher water supply. The irrigated lands are farmed very intensively, with a large use of labor. It is estimated that somewhere near 1,200 acres are in truck crops, and the remaining acres are in sugar beets, corn silage and other intensive, high-water-using crops. These crops must be irrigated regularly to produce good yields and provide employment for semiskilled seasonal labor. The truck crops, particularly, must be watered every few days so the continuous flow system works well here. Many of the truck farms are small, having only a few acres. These farmers raise 2, 3 and in some cases 4 crops a year. The return per acre from truck crops is higher than the typical irrigated field crops in Colorado. These farms produce a significant proportion of the locally produced vegetables for the Denver market.

## THE SOILS AND LAND USE CAPABILITIES OF THE IRRIGATION COMPANIES' SERVICE AREAS

The effect of transferring irrigation water from farming is determined in part by the quality of the land that will lose its water supply. The agricultural potential of the land under irrigation needs to be compared to its potential for other uses such as dry farming or urban development. One factor in making these comparisons is the determination of the soil types and land forms of the area. Other factors concern questions of land use adjustment, crop patterns and organization of farm management units with little or no irrigated land. One major question is the ability to raise dryland crops on formerly irrigated lands. For several years after the cessation of irrigation it is difficult to produce dryland crops because of high levels of fertility and other soils characteristics.

The following interpretations are made of the land use suitabilities and capabilities for the soils within the irrigation service areas of these companies. It is important to include in the investigation not only directly affected land but also adjacent lands that could either receive water but at present do not, or are so closely associated with affected lands (e.g., integral parts of farm units) that there is a significant possibility of land use change. Additional land could be irrigated if water supplies to the present irrigation systems were increased, or water were shifted from some tracts to others. Some of this potential is indicated in the larger service areas of the companies over the amount of land currently irrigated. More lands could be brought under irrigation by extension of the ditch systems.

The soils of the area were classified by soil series and then examined in detail for their physical characteristics, urban and community development suitability, possible sources for construction materials (gravel, sand, etc.), agricultural capabilities and potential crop yields.

A brief discussion of the types and extent of various soils in the service areas of each company is given following the section on soil classification criteria used in the analysis. Appendix tables A1 through A6 contain information on each soil type and its capabilities for agricultural and urban uses. Maps showing the locations of the major soils series are available in Soil Survey of Adams County and Soil Survey of Weld County, Colorado (unpublished), Soil Conservation Service, U.S. Dept. of Agriculture, 1974.

Soil limitations are rated using the terms slight, moderate and severe. Slight means that soil properties are generally favorable for the rated use, i.e., the limitations are minor and easily overcome. Moderate indicates some soil properties are unfavorable but can be overcome or modified by special planning, design and management. A severe rating indicates that soil properties are unfavorable and difficult to correct or overcome and therefore require major soil reclamation, special design or intensive maintenance. The ratings generally apply to a depth of about 5 feet, and therefore may not be valid if proposed development is intended to go deeper into the soil profile.

Extent refers to the percentage of the area that has a majority of that soil throughout the mapping unit. Slope is rated in percent and the erodibility index refers to the maximum soil loss allowable in tons per acre for irrigated agriculture.

### Classification Criteria for Soil in Various Uses

#### Agricultural Capability[4/]

Agricultural capability represents in a general way the suitability of soils for crop production under both irrigated and dry farming conditions. This is intended to be a practical classification based on the physical limitations of the soils, the risk of damage when farmed, and the way the particular soil responds to treatment. The soils are

4/ Soil Survey of Adams County, Colorado, Soil Cons. Serv., USDA in cooperation with Colo. Ag. Expt. Station, G.P.O., Washington, D.C., Oct. 1974, p. 30.

classified according to degree and kind of permanent limitation in their natural condition, without consideration of major, extensive land forming that would change the slope, depth or other characteristics. These classifications do not consider possible but unlikely major reclamation projects.

The soils have been grouped at two levels: the capability class and the subclass. The capability class (developed by the Soil Conservation Service) is designated by Roman numerals I through VIII, and indicates progressively greater limitations and narrower choices for practical farming use. The classes are defined as follows:

Class I soils have virtually no limitations that restrict their use for farming purposes.

Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III soils have more severe limitations that reduce the choice of plants, require special conservation measures, or both.

Class IV soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland and wildlife.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife and cover.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland or wildlife.

Class VIII soils or landforms have limitations that preclude their use for commercial crop production and restrict their use to wildlife, water supply or for aesthetic purposes.

The capability subclasses reveal the nature of the main limitation on soil use. These are designated by adding a small letter: e, w, or s. The letter "e" indicates an erosion hazard; "w" indicates that water in or on the soil interferes with plant growth or cultivation; "s" indicates that the soil is limited mainly because it is shallow, droughty or stony.

## Crop Productivity

Crop productivity represents the predicted yields for the principal crops of the area and are those obtained by the leading commercial farmers. Rangeland production gives pounds of dry matter production per acre for a good, average and poor year. Each soils series is ranked according to its probable crop production potential.

Some soils are so variable as to make a crop production prediction unreasonable for the entire series. Other soils are not normally cropped and therefore have no crop production estimate. These soils were added up and labeled "acres not rated."

## Community Development Suitability (Urban Uses)

Shallow excavations are a major activity in urban land development. This normally requires digging or trenching to a depth of less than 6 feet. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or stones, and freedom from flooding and absence of a high water table.

The soils are rated to support buildings of not more than 3 stories in height supported by foundation footings placed in undisturbed soil. The features which affect the rating of a soil for buildings include bearing capacity and ease of excavation. In turn, these features are influenced by wetness, susceptibility to flooding, density, plasticity, texture, shrink-swell potential, slope, depth to bedrock, and content of stones and rocks.

Local roads and streets, as rated, have all-weather surfaces (asphalt or concrete) and are expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base of either gravel, crushed rock or stabilized soil material. These roads are graded to shed water and have conventional provisions for drainage and are built from soil at hand. Most cuts and fills are less than 5 feet deep. Soil properties which affect design and construction are load-supporting capacity, stability of the subgrade, and the workability as well as quantity of cut and fill material available.

## Sanitary Facilities Suitability

Septic tank absorption field ratings are for subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil properties affecting performance of the system are permeability, depth to water table or rock, susceptibility to flooding, slope, and large boulders or rocks.

Sewage lagoons are shallow ponds, 2 to 5 feet deep, constructed to hold sewage long enough for bacteria to dissolve the solids. The lagoon has a nearly level floor and sides of compacted soil. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Soil properties which affect the performance of the lagoon are permeability, organic matter, slope and depth to bedrock.

Sanitary landfills are methods of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted and covered. Soil properties affecting the suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, can withstand heavy traffic, and are friable and easy to excavate.

## Recreation Suitability

Playgrounds and parks are a recreation use of land in an urban area. These are used intensively for baseball, football and other organized games, and as lawn areas for less intensive uses. Since many such areas are subject to intensive foot traffic, they require a soil texture and consistency which provides a firm surface. The best soils for intensive recreation uses have a nearly level surface free of coarse fragments and rock outcrops, good drainage, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. If grading and leveling are required, depth to bedrock is also considered.

Paths and trails are used for local and cross-country travel by foot or horseback. It is assumed that such areas will be used as they are naturally. Design and layout should require little or no cutting and filling. The best soils are at least moderately well-drained, are firm when wet but not dusty when dry, are flooded not more than once during the season of use, have slopes of less than 15 percent, and have few or no rocks on the surface.

Picnic areas are attractive natural or landscaped tracts. These areas may be subject to heavy foot traffic with most of the vehicular traffic confined to access roads. The best soils have mild slopes, good drainage; a surface free of rocks, gravel, and cobbles; freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. In addition, the permeability of the soil is considered.

### Suitability for Source Materials for Urban Development

Roadfill is soil used in embankments for roads. The rating reflects the relative ease of excavation and the predicted performance of soil after it is in place.

Sand and gravel suitability provides an indication of the probable location of these construction materials. A soil having a good rating generally has a layer of gravel, sand, etc. at least 3 feet thick, the top of which is at a depth of no more than 6 feet. The ratings do not take into account the thickness of overburden, location of the water table, or other factors affecting mining, nor do they indicate the quality of the deposit.

Topsoil is used for landscaping purposes and the ratings pertain to workability; natural fertility, or the response of plants when fertilizer is applied; and absence of toxic substances. Texture and stone fragments are therefore extremely important in this rating. Also considered in the rating is damage that will result at the area from which topsoil is taken.

The major soil classification for agricultural and urban uses in the service areas of the three irrigation companies are presented below. The appendix tables A1 to A6 show land use capabilities for each soil type under each irrigation company. Irrigated and nonirrigated agricultural uses are those which currently exist while potential urban uses are predicted on the basis of soil characteristics.

### Characteristics and Capabilities of Land Served by the Farmers' Reservoir and Irrigation Company, Standley Lake Division

In 1970, 9560 acres were irrigated in the Standley Lake Division of the Farmers' Reservoir and Irrigation Company, although there are about 15,000 acres in the service area. The water year of 1970 produced only 83 percent of the recent 33-year average and only 63 percent of the last 6 years' average supply. Therefore, the 1970 air photos understate the amount of land normally irrigated under the system. The crops grown were predominantly corn, alfalfa, wheat and barley. The agricultural capabilities are dominantly classes II and III for irrigated agriculture, dropping to classes III and IV for nonirrigated agriculture. This indicates that with proper management yields in this area should be quite good.

Irrigated area in 1970 was 9,600 acres. The amount of irrigated land in each capability class follows:

| Class | Acres | Percent |
|---|---|---|
| II | 6,934 | 72.2 |
| III | 2,013 | 21.1 |
| IV | 398 | 4.1 |
| VI | 235 | 2.4 |
| VII | 20 | .2 |
| | | 100.0 |

Table 10 shows the acreages of the irrigated area under the Farmers' Reservoir and Irrigation Company that are suitable for various crops and the yield potential for that area. These figures do not show total potential production from the irrigated area because most acres can grow a variety of crops. Thus the same acre may be presented as growing spring

* * *

Table 10--Potential production of various crops in irrigated service area of companies

Farmers' Irrigation and Reservoir Company
Irrigated land area - 9,560 acres

| Crop | Acres not rated | Acres of land suitable for specific crop and projected yield: Acres | | Average yield[1/] | Potential production |
|---|---|---|---|---|---|
| Winter wheat, dryland | 4,426 | 5,134 | X | 30 bu. | 154,020 bu. |
| Spring wheat, dryland | 3,372 | 6,188 | X | 20 bu. | 123.760 bu. |
| Alfalfa | 900 | 8,660 | X | 4 T | 34,640 T |
| Sugar beets | 1,850 | 7,710 | X | 19 T | 146,490 T |
| Corn | 1,149 | 8,410 | X | 100 bu. | 841,000 bu. |
| Barley, irrigated | 4,909 | 4,751 | X | 54 bu. | 256,554 bu. |
| Barley, dryland | 5,334 | 4,226 | X | 30 bu. | 126,780 bu. |
| Corn silage | 2,637 | 6,923 | X | 19.5 T | 134,998 T |

1/ These yield figures are representative of the dominant soils present and will vary depending on the particular soils that occur on a given farm (see appendix table A1).

wheat, alfalfa, sugar beets, corn, etc. These figures show the possible yield if all acres suitable for a crop were planted to that crop.

Table 11 shows the number of acres that have various ratings for several types of urban uses and gives the total acreages under each rating.

There are generally only slight and moderate limitations to nonagricultural land uses; however, there are significant areas of severe limitations to developments; if developed, these areas would require major soil reclamation, special design or intensive maintenance. There are sources of engineering and landscaping materials. Gravel is scarce in this area and should be conserved through proper planning.

The investigation found 24,406 acres which, although nonirrigated, would be affected if irrigation ceased on adjoining lands. The agricultural capabilities of these lands are generally poorer; however, there are many areas of nonirrigated class II and III lands which could increase their productivity by adding irrigation water if water were available. The limitations for nonagricultural type developments are about the same as that for the irrigated lands.

## Characteristics and Capabilities of Land Served by Farmers' Highline Canal and Reservoir Company

According to air photos, there were 19,762 acres irrigated in a service area of 21,800 acres under the Farmers' Highline Ditch in 1970. Major crops are corn, alfalfa, wheat, barley and pasture. The agricultural capabilities of the soils generally fall in classes II, III and IV and drop to III and IV for nonirrigated agricultural use. Thus, with proper management, good crop yields should be obtained in this area.

The amount of land in each irrigated capability class on 14,065 irrigated acres in Adams and Weld counties is:

| Class | Acres | Percent |
|---|---|---|
| II | 5,779 | 41.1 |
| III | 4,640 | 33.0 |
| IV | 2,612 | 18.6 |
| V | 406 | 2.9 |
| VI | 75 | .5 |
| VII | 553 | 3.9 |
| | | 100.0 |

Table 12 shows the acreages suitable for various crops and potential yield of the land irrigated under the Farmers' Highline in Adams and Weld Counties only. These data are subject to the limitations outlined earlier. Table 13 shows the potential for urban uses of the land under the system in Adams and Weld Counties. The land in Jefferson County is not included because detailed soils surveys are not available.

Generally, there are only moderate limitations for nonagricultural developments; however, there are some areas with severe limitations to developments; if developed, these soils would require major soil reclamation, special design or extensive maintenance. There are sources of engineering and landscaping materials in this area, which, through proper planning, should be conserved.

The investigation showed there were 12,031 acres which although nonirrigated would be affected if irrigation ceased on adjoining lands. The agricultural capability of these lands is generally poorer than irrigated lands. But there are a significant number of acres which, if water were available, have irrigated agricultural capabilities of Class II and III and, therefore, could be quite productive. The limitations for nonagricultural type developments are about the same as that for irrigated lands; however, there are fewer sources of engineering and landscaping materials.

Included within the irrigated acreages are 7,735 acres in Jefferson County, but no interpretations were made because there has been no soil survey in the county.

* * *

Table 11--Potential for urban use of currently irrigated lands

Farmers' Irrigation and Reservoir Company
Irrigated land area - 9,560

| Suitability for urban development activities | | | | |
|---|---|---|---|---|
| | Acres with soil limitation | | | |
| Activity | Slight | Moderate | Severe | |
| a. Shallow excavations | 8,273 | 1,029 | 258 | |
| b. Dwellings without basements | 2,566 | 4,790 | 2,204 | |
| c. Dwellings with basements | 2,566 | 5,667 | 1,327 | |
| d. Small commercial buildings | 2,554 | 4,822 | 2,184 | |
| e. Streets and small roads | 98 | 5,107 | 4,355 | |
| f. Recreation: playgrounds | 1,982 | 7,110 | 508 | |
| g. Sanitary facilities | | | | |
| Septic tanks | 3,174 | 5,084 | 1,304 | |
| Sewage lagoon | 3,429 | 4,764 | 1,369 | |
| Landfill trench | 8,047 | 1,112 | 401 | |
| Landfill area | 9,122 | 212 | 226 | |
| | Good | Fair | Poor | Unsuitable |
| h. Source materials | | | | |
| Gravel | 0 | 0 | 0 | 9,560 |
| Sand | 0 | 63 | 585 | 8,912 |
| Roadfill | 298 | 6,915 | 2,347 | -- |
| Topsoil | 3,200 | 5,952 | 408 | -- |

Table 12--Potential production of various crops in the irrigated service area of the Farmers' Highline Canal and Reservoir Company in Adams and Weld Counties

14,065 acres of 21,800 acres1/

| Crop | Acres not rated | Acres of land suitable for specific crops and projected yield: Acres | | Average yield 2/ | Potential production |
|---|---|---|---|---|---|
| Winter wheat, dryland | 4,598 | 9,464 | X | 17 bu. | 160,888 bu. |
| Spring wheat, dryland | 9,283 | 4,779 | X | 15 bu. | 71,685 bu. |
| Alfalfa | 1,052 | 13,010 | X | 4.5 T | 58,545 T |
| Sugar beets | 3,635 | 10,427 | X | 20 T | 208,540 T |
| Corn | 3,504 | 10,558 | X | 100 bu. | 1,055,800 bu. |
| Corn silage | 2,962 | 11,100 | X | 18 T | 199,800 T |
| Barley, irrigated | 1,921 | 12,141 | X | 43 bu. | 522,065 bu. |
| Barley, dryland | 4,340 | 9,758 | X | 18 bu. | 175,644 bu. |

1/ There are 7,947 acres in the Farmers' Highline service area in Jefferson County that have not been classified in a soils survey. Thus, about 30 percent of the service area is not included in this analysis.

2/ These yield figures are an average of the dominant soils present and will vary depending on the particular soils that occur on a given farm (see appendix table A3).

* * *

Table 13--Potential for urban use of currently irrigated lands

Farmers' Highline Canal in Adams and Weld Counties
14,065 acres of 21,800 in service area

| Activity | Suitability for urban development activities — Acres with soil limitation: Slight | Moderate | Severe | |
|---|---|---|---|---|
| a. Shallow excavations | 10,941 | 1,895 | 1,017 | |
| b. Dwellings without basements | 445 | 8,934 | 4,474 | |
| c. Dwellings with basements | 445 | 9,328 | 4,048 | |
| d. Small commercial buildings | 370 | 9,009 | 4,474 | |
| e. Streets and small roads | 0 | 7,687 | 6,166 | |
| f. Recreation: playgrounds | 370 | 10,020 | 3,463 | |
| and parks | 377 | 12,345 | 1,131 | |
| g. Sanitary facilities | | | | |
| Septic tanks | 615 | 10,326 | 2,912 | |
| Sewage lagoons | 7,108 | 3,151 | 3,594 | |
| Landfill trench | 10,352 | 1,071 | 2,484 | |
| Landfill area | 12,993 | 401 | 459 | |
| | Good | Fair | Poor | Unsuitable |
| h. Source materials | | | | |
| Gravel | 50 | 33 | 0 | 13,770 |
| Sand | 50 | 356 | 0 | 13,447 |
| Roadfill | 50 | 7,890 | 5,913 | -- |
| Topsoil | 655 | 10,692 | 2,506 | -- |

## Characteristics and Capabilities of Land Served by Lower Clear Creek Ditch Company

Air photos show 2,611 acres irrigated under the Lower Clear Creek Ditch in 1970. This area contains 25 to 30 truck farms cultivating about 1,200 acres. The agricultural capabilities are predominantly II, III and V for irrigated agricultural use with the classifications dropping to III, IV and V for non-irrigated agricultural use. Most of the class V soils are rated as such due to high water tables. Because of the high intensity of management on the truck farms these limitations have been largely overcome.

Practically all land in the service area was irrigated in 1970. The amount of land in each irrigated capability class is:

| Class | Acres | Percent |
|---|---|---|
| II | 1,460 | 55.9 |
| III | 311 | 11.9 |
| IV | 98 | 3.8 |
| V | 448 | 17.1 |
| VII | 294 | 11.3 |
| | | 100.0 |

Production capabilities of the irrigated lands under the Lower Clear Creek Ditch are shown in table 14. The potentials for urban uses are evaluated in table 15. The lands under this system show the poorest potential for conversion to urban uses of the three company areas because most of the irrigated area lies on a flood plain.

Table 14--Potential production of various crops in the irrigated service area of Lower Clear Creek Ditch Company

2,611 irrigated acres

| Crop | Acres not rated | Acres of land suitable for specific crops and projected yield: Acres | | Average yield 1/ | Potential production |
|---|---|---|---|---|---|
| Winter wheat, dryland | 1,909 | 702 | X | 19 bu. | 13,338 bu. |
| Spring wheat, dryland | 1,845 | 766 | X | 19 bu. | 14,554 bu. |
| Alfalfa | 742 | 1,864 | X | 5 T | 9,320 T |
| Sugar beets | 840 | 1,771 | X | 22 T | 38,962 T |
| Corn | 904 | 1,707 | X | 110 bu. | 187,770 bu. |
| Corn silage | 872 | 1,739 | X | 25 T | 43,475 T |
| Barley, irrigated | 872 | 1,739 | X | 46 bu. | 79,994 bu. |
| Barley, dryland | 2,497 | 114 | X | 18 bu. | 2,052 bu. |
| Truck crops | 840 | 1,771 2/ | X | $2,000 3/ | $3,542,000 |

1/ These yield figures are an average of the dominant soils present and will vary depending on the particular soils that occur on a given farm (see appendix table A5).

2/ Because no analysis was made of soils suitable for truck crops, we assume land suitable for sugar beets could also be used for truck crops.

3/ Truck crops are averagedat dollar value because of great variety of crops, yields and price. Some land is cropped more than once a season.

* * *

Table 15--Potential for urban use of currently irrigated lands

Lower Clear Creek Ditch Company
Irrigated land area - 2,611 Acres

| Activity | Suitability for urban development activities — Acres with soil limitation: Slight | Moderate | Severe | |
|---|---|---|---|---|
| a. Shallow excavations | 75 | 1,460 | 1,076 | |
| b. Dwellings without basements | 197 | 0 | 2,414 | |
| c. Dwellings with basements | 197 | 1,460 | 954 | |
| d. Small commercial buildings | 197 | 0 | 2,414 | |
| e. Streets and small roads | 0 | 0 | 2,611 | |
| f. Recreation: playgrounds and parks | 0 | 1,700 | 911 | |
| g. Sanitary facilities | | | | |
| Septic tanks | 197 | 75 | 2,339 | |
| Sewage lagoons | 71 | 1,766 | 774 | |
| Landfill trench | 1,460 | 75 | 1,076 | |
| Landfill area | 1,869 | 19 | 723 | |
| | **Good** | **Fair** | **Poor** | **Unsuitable** |
| h. Source material | | | | |
| Gravel | 158 | 270 | 197 | 1,986 |
| Sand | 492 | 290 | 0 | 1,829 |
| Roadfill | 158 | 197 | 2,256 | -- |
| Topsoil | 0 | 1,732 | 879 | -- |

## Conclusions Drawn From Land Capability Analysis

There would be a significant decrease in agricultural production in the area if the irrigation water supply is removed, as the crop productivity estimates indicate. There are other factors that are important in crop productivity as well. The high fertility level of irrigated cropland is likely to suppress dryland crop yields for several years. Frequently soil moisture levels are high in the spring causing lush growth on the formerly irrigated lands, the large amount of foliage soon depletes available soil moisture and the crop withers and dies. Progressive removal of the irrigation water supply eventually restricts farmers to less desirable cropping patterns resulting in decreases in crop yields and farm income.

There are a large number of capital improvements on the irrigated lands ranging from on-farm reservoirs, pumping facilities, lined ditches to land leveling, fences and farm buildings. Most of the value of these improvements would be lost if the irrigated lands reverted to dryland agriculture. Farmers' estimates of these improvements would indicate a value of more than $7 million (table 22).

The study area, with the possible exception of the Lower Clear Creek Ditch Company area, shows few overriding restrictions to nonagricultural development if properly planned. The Lower Clear Creek area, however, has many severe limitations to urban type uses and therefore would require more careful development than the rest of the area if converted to nonagricultural uses. Except for the Lower Clear

Creek Ditch Company area and parts of Farmers' Highline Irrigation Company, most of the irrigated lands are located some distance from current areas of urban expansion. This suggests that a large amount of currently irrigated farmland is not likely to be subject to urban pressure for some time, but if the water is taken, it will probably be converted to dryland agriculture. Alternatively, it might be left idle.

## THE EFFECT ON AGRICULTURE AND THE AREA ECONOMY OF IRRIGATION WATER LOSS

In previous sections an attempt has been made to outline the situation that has led to competition for irrigation water supplies and to describe the irrigation companies and the physical characteristics of the land served by them.

This section contains a discussion of the farms, the water supply and the agricultural production, and some estimates are made of the economic effect of removing irrigation water from the systems.

### The Survey

In order to evaluate the impact of removing water from the irrigation systems it was necessary to obtain data on the farmers and the farms that would be affected. The irrigation companies had very little recorded information on the agricultural activities of water users served by the companies. The company officials are farmers themselves, and the ditch riders and superintendents have a general knowledge of the farmers who receive water, but they do not keep farm management-type records showing acres of crops, yields, water use or investment on irrigation farms. The companies did not know the total production of crops, the numbers of people employed on farms or many other facts about farms served by the systems.

Since none of this information is recorded, the company officials felt it would be desirable to contact the stockholders who were farming the irrigated lands to determine details of their farming operations. The companies mailed questionnaires to the stockholders who were farming. Responses to the questionnaire were varied.

The company with the smallest service area received responses from 68 percent of its stockholders who farmed 90 percent of the irrigated land. The two larger companies received responses from 49 percent of the stockholders who operated 39.3 percent of the land and 29.8 percent of stockholders operating 36.5 percent of the land, respectively. The main use of the survey information was to determine crop patterns, yields, water use on crops and investment in irrigation farming. With responses from farmers who operated 36.5, 39.3 and 90 percent of the irrigated lands under the various companies and the uniformity of responses as to crop yields, water use on crops, and investment in irrigated lands, it is assumed that projections about the rest of the irrigated area would be reasonably valid.

A comparison of county average yields, and Soil Conservation Service yield potentials with weighted average yields reported by farmers in the companies is shown in table 15A. On most crops, the farmers report yields somewhat below the yield potential as shown by SCS estimates. See Appendix tables A1 through A5 for yield potential by soil type for each company. In relation to county averages, the farmers in these companies reported yields somewhat above the county averages for most crops. Small grain yields tended to be above county averages as did corn silage, alfalfa and sugar beets. The Farmers' Reservoir and Irrigation Company's yields were at or below county averages in several crops but this company's water supply is not adequate to reach yield potentials. The air photos, soil survey analysis, and general observation while in the irrigated area did not reveal areas that appeared to be greatly different from those reporting.

In a general comments section of the questionnaire, many of the farmers offered whatever assistance

Table 15A--Comparison of county average yields, potential yields and yields reported by farmers in the three company areas, 1974

| Crop | County ave. yield 1/ | SCS potential yield for major soils in company area 2/ | | | Weighted average yield reported by farmers in each company | | |
|---|---|---|---|---|---|---|---|
| | | LCC | Highline | FRICO 3/ | LCC | Highline | FRICO |
| Corn, grain | 98 bu. | 110 bu. | 100 bu. | 110 bu. | 105 bu. | 96 bu. | 74 bu. |
| Corn silage | 16.6 T | 25 T | 18 T | 19.5 T | 19 T | 18.8 T | 17 T |
| Barley, irrig. | 53.3 bu. | 46 bu. | 43 bu. | 54 bu. | 60 bu. | 58.4 bu. | 52.9 bu. |
| Wheat, irrig. | 39.3 bu. | 47.9 bu. | 49 bu. | 55 bu. | --- | 45.9 bu. | 44.8 bu. |
| Alfalfa | 3.06 T | 5 T | 4.4 T | 4 T | 3.9 T | 3.9 T | 3.06 T |
| Sugar beets | 15.3 T | 22 T | 20 T | 19 T | 19 T | 19 T | |

1/ 1966-73 Colorado Agricultural Statistics.

2/ Based on yield potential of major soils in each company area as estimated by Soil Conservation Service.

3/ Lower Clear Creek Canal, Farmers' Highline Reservoir and Canal Company, and Farmer's Reservoir and Irrigation Company.

they could to help stave off condemnation of their water supplies, or pleaded for help in stopping what to them will be a catastrophic occurence.

## The Farms

In 1975 there were about 420 farms receiving water from the three irrigation companies. Table 16 shows the size distribution of farms that will be affected with a water loss. Over 200 of these units are small farms that are essentially part-time operations. The owners raise gardens and pasture a few head of livestock, primarily horses or beef cattle. Most of the truck farms are small, but the gross sales are high in comparison to the acreages operated. A 10-acre truck farm can have higher gross sales than an 80-acre farm, short of water, raising only alfalfa and small grain.

The remaining 200 farms, classified as medium to large, are commercial farms. The livelihood of the operators is derived almost exclusively from the land and is dependent upon continued operation. Very few have significant off-farm earnings.

The small farms are from 2 to 20 acres in size, while the medium and large farms are from 40 acres to over 1,500 acres. On these farms water plays an important role in productivity.

Specialty farms are important in the service area of the companies. Records show about 37 dairy farms in the irrigated area. There are also about 37 truck farms and specialty farms such as nurseries and greenhouses in the area.

## Water Supply of the Companies

Average annual water supply of the companies is about 61,235 acre feet; of this, about 44,900 acre feet is obtained from direct stream flow, mainly during the irrigation season (March-April through October-November). The remaining water (about 13,000 acre feet) comes mainly from Standley Lake Reservoir, some of which is stored in the fall and winter and is generally available any time during the year. Water supply of the irrigation companies is shown in table 17. Only the recent 13-year supply is shown here, but for the two large companies, the recent annual average for the past 13 years compares favorably with 40-year and 25-year average annual supplies. This average misses the early 1950s, particularly 1954, which was a period of extreme drought in which supply fell to low levels.

Not all of the water controlled by the irrigation companies is used for irrigation since a significant proportion of their stock is owned by the cities (table 17). Using a recent 13-year average annual delivery, about 23,000 acre feet or 37 percent of the water is held by the cities, and about 13 percent is held by other nonfarm agencies such as other governmental bodies and commercial firms. This leaves about 29,900 acre feet for irrigation use. Any water losses that occur in the system would fall equally on all shareholders. About half of the total water supply has already passed out of agricultural use and the irrigation companies' control. Transfer of this water was accompanied by some irrigated lands moving into urban uses so that the balance of water supply to irrigated lands may not have changed as dramatically as otherwise might have been the case. When lands and

Table 16--Farms under the three irrigation systems1/

| Farm size (acreage) | Farmers' Res. and Irrigation Co. | Farmers' Highline Canal Company | Lower Clear Creek Ditch Company | Total |
|---|---|---|---|---|
| Small | 65 | 120 | 33 | 218 |
| Medium | 64 | 73 | 12 | 149 |
| Large | 31 | 16 | 6 | 53 |
| Total | 160 | 209 | 51 | 420 |
| | | Speciality Farms | | |
| Dairy farms2/ | 8 | 26 | 3 | 37 |
| Truck and specialty farms3/ | 0 | 10 | 27 | 37 |

1/ Estimate based on stock holdings of water users and responses to irrigation company survey.

2/ This is from a count of dairy farms in the study area.

3/ Estimated from survey responses and irrigation officials' count.

Table 17--Water supply of irrigation companies currently available for agricultural use, 1975

| Company | Average water supply[1/] | Owned by cities | Owned by other nonagricultural users[2/] | Owned by farmers |
|---|---|---|---|---|
| | Acre feet | | | |
| Farmers' Reservoir and Irrigation Company | 13,605 | 2,884 | 1,197 | 9,524 |
| Farmers' Highline Canal and Reservoir Company | 38,721 | 18,892 | 6,234 | 13,595 |
| Lower Clear Creek Ditch Company[3/] | 8,909 | 1,327 | 712 | 6,870 |
| TOTAL | 61,235 | 23,103 | 8,143 | 29,989 |
| PROPORTION | 100.0% | 37.7% | 13.3% | 49.0% |

1/ Average water supply 1961-73. See Appendix Table A9 for standard deviation and coefficient of variation.
2/ Includes special districts and other governmental agencies, real estate and commercial firms.
3/ Average 1961-73 with 1962 data missing on Lower Clear Creek.

water are converted to urban use simultaneously, the disruptive effects upon remaining irrigation farmers will probably not be as great as when water is taken by separate action and the land is left without its water supply. At least where land and water are transferred to urban uses together, the disruptive effects are obscured. At the same time, the question of the public interest in even such a combined transfer needs to be examined and the issue of whether market prices for land and water in fact reflect real costs or real value also needs analysis.

It appears that from 1950 to 1974 water was being converted to urban uses at a faster pace than the irrigated land, thus partially accounting for the 10,000 acres that are no longer irrigated. Under Colorado water law, land and water rights usually are held separately. Hence purchase or condemnation of water rights is legally permissible and can have a serious impact on the farm economy generally and on irrigation farming specifically with possible externality effects on the entire regional economy.

The fact that, as a result of purchase or condemnation of water rights or land, there are fewer acres and fewer farmers served from the canals could make the cost of delivering water to the remaining farmers higher than formerly, but if the cities are assessed for their stockholdings and continue to pay the annual assessment on their shares, the direct costs of maintaining a shrinking system on remaining farmers might be lessened. The nonagricultural stockholders will be helping to bear the cost of operating the system in return for their share of the water. But externalities (i.e., negative multiplier effects) might still be considerable.

## Agricultural Production on the Irrigated Lands

Gross agricultural production on the lands for which the three companies provide water is given in table 18. Two production levels are given: actual production and potential production. Actual production is calculated using the yields of crops on

Table 18--Estimated production of farm products from irrigated lands of the three irrigation companies

| Crop | Yield per acre | Actual production (30,000 acres) | Potential production (40,000 acres) |
|---|---|---|---|
| Truck | $1,500 | $1,800,000 | $2,250,000 |
| Corn | 100 bu. | 900,000 bu. | 1,200,000 bu. |
| Wheat & barley | 45 bu. | 337,500 bu. | 468,000 bu. |
| Alfalfa | 3.5 T | 27,650 T | 35,000 T |
| Pasture | 5 AU/A | 15,000 months of grazing | 22,500 months of grazing |
| Sugar beets | 19 T | 26,600 T | 30,400 T |
| Dairy products | | 28,101,00 lbs. of milk | |

1/ Assumes acreages of crops as shown in table 19.

lands that were irrigated in the 1970-74 period. The irrigated lands were determined from air photos and farm survey schedules. The yields are those reported on the survey schedules by farmers under the 3 irrigation systems. Potential production is the amount of agricultural crops that could be grown, based on soil capability, if all the irrigated lands in the service areas of the companies received water.

Truck crops are expressed in dollar value because of the diversity of crops grown and because acres in truck crops may produce more than one crop a year. The farm survey schedules show that over 23 kinds of vegetables are raised in the truck farms.

Corn production is expressed in bushel equivalents. Actual production is now about 900,000 bushels per year. If all land served by the irrigation system received water, corn production could rise to 1,200,000 bushels per year.

Production of small grain, mainly spring wheat and barley, currently is about 337,500 bushels; with all land irrigated it could rise to 468,000 bushels. Alfalfa hay production currently amounts to about 27,600 tons. This could rise to 35,000 tons with more irrigation water. Irrigated pasture use could rise by 7,500 animal unit months. Sugar beet production could rise from an estimated 26,600 tons to over 30,000 tons. These production figures assume no increase in production levels per acre, only more water and more irrigated acres at current yields. Another effect of increased water supply would be higher yields per acre of all crops because these lands have a higher potential than is currently being attained, mainly because of an inadequate water supply.

The general irrigated crop pattern of farms receiving water from the three irrigation companies is shown in table 19. Using average gross returns per acre as reported by farmers for various crops, total gross value of agricultural production from the farms served by the three irrigation companies was about $7.9 million. During the 1970-74 period, about 30,000 acres were in irrigated crop production, but an additional 10,000 acres could be irrigated if the water supply permitted. If all acres were planted to crops with the same yield as the rest of the irrigated land, value of gross agricultural production could be as high as $10.2 million.

If the average water supply available for irrigation is divided into the gross agricultural production on the irrigated lands, each acre foot of irrigation water helps create about $265 of agricultural products, i.e., $7,939,000 agricultural production divided by 29,989 A.F. irrigation water = $264.73 agricultural production per acre foot of irrigation water.

## Milk Production Within the Area

There were 37 dairy farms located within the

* * *

Table 19--Estimated gross value of crops that can be produced on farms under the three irrigation companies

| Crop | Actual acres | Potential acres | Dollars per acre | Estimated gross value on Actual acres | Estimated gross value on Potential acres |
|---|---|---|---|---|---|
| | | | | Dollars | Dollars |
| Truck crops | 1,200 | 1,500 | 1,500 | 1,800,000 | 2,250,000 |
| Corn | 9,000 | 12,000 | 250 | 2,250,000 | 3,000,000 |
| Wheat & barley | 7,500 | 10,400 | 168 | 1,260,000 | 1,747,200 |
| Alfalfa | 7,900 | 10,000 | 200 | 1,580,000 | 2,000,000 |
| Pasture | 3,000 | 4,500 | 30 | 90,000 | 135,000 |
| Sugar beets & mis. crops | 1,400 | 1,600 | 685 | 959,000 | 1,096,000 |
| Total | 30,000 | 40,000 | | 7,939,000 | 10,228,200 |
| Milk production | 28,101,000 lbs. | | | 2,529,100 | |

Table 20--Milk production on farms in the three-company service area, 1974

| Pounds of milk | Number farms | Total production | Total value | Av. no. cows | Av. sales per dairy |
|---|---|---|---|---|---|
| | | Pounds | Dollars | | Dollars |
| Over 1 million | 9 | 17,499,268 | 1,574,934 | 170 | 174,993 |
| 500,000 - 1 million | 9 | 7,357,754 | 662,198 | 72 | 73,578 |
| Less than 500,000 | 8 | 3,244,065 | 291,966 | 35 | 36,455 |
| Total | | 28,101,087 | 2,529,097 | | |

* * *

Table 21--Estimated manpower employed on dairy farms in the three-company service area

| Dairy size | Men per dairy | Number dairies | Total number dairymen |
|---|---|---|---|
| Over 1 million pounds milk production | 4.2 | 9 | 38 |
| 500,000 - 1 million pounds milk production | 2 | 9 | 18 |
| Less than 500,000 pounds milk production | 1 | 8 | 8 |
| Total | | | 64 |

* * *

service areas of the three irrigation companies. During 1974-75, 28,101,087 pounds of fluid milk were sold by twenty-five of these dairies (table 20). The value of the milk was approximately $2,529,000 at an average price of $9.00 per 100 pounds of fluid milk.

Twelve dairy farms did not produce milk during 1974-75. There are many reasons why dairy farms would cease production, one of which has been the relatively poor cost-price relationships for milk production. This condition coupled with uncertainty as to the future of farming in the area may have encouraged a larger than normal abandonment of dairy enterprises in the 1974 period in this area.

The dairy farms that were operational employed approximately 64 men to maintain and operate them. Those that have ceased production probably employed an additional 20 to 30 men when they were operational and could have maintained an additional 500 to 1,000 cows (table 21). These dairy farms could have produced an additional 5 to 10 million pounds of milk annually.

The more than 28 million pounds of milk sold by dairy farmers in this area represent an important source of dairy products for the Denver metropolitan area. The Denver area is a deficit milkshed; in 1974-75, over 56 million pounds of milk were imported. If the remaining dairy farms in the irrigated area were closed, imports would have to be increased by 50 percent immediately. This milk must be shipped in from surplus areas, mainly Utah, Idaho and western Dakota. Each of these areas is far removed and it costs from $500 to $600 to bring a truckload of milk into the Denver market. The transportation costs must be added to the price of the milk. In the past years, Denver had a temporary surplus during summer months; however, in the summer of 1975 there was no surplus. Demand for milk products is estimated to be growing at about a 3 percent annual rate in the Denver area.5/

If the dairy farms are shut down, it could mean that an additional 468 truckloads of milk must be shipped in to replace this production. The additional shipping cost would range from $235,000 to $281,000.

## CAPITAL INVESTED IN IRRIGATION WORKS

### On-Farm Investment

When irrigation water is no longer available to farms in the area, the capital invested in on-farm irrigation equipment and facilities will no longer be usable. Similarly money spent on land leveling, field ditches, turnouts and on-farm holding ponds will largely be lost because these facilities would be of little value to urban development or to dryland agriculture. Moreover, it is doubtful whether prices paid by cities for water rights (shares) would reflect these costs (losses). In essence, the water rights market is an imperfect market.

Farmers in the area were asked to estimate the amount of money they had invested in on-farm irrigation

5/ Mr. Trobaugh, Mountain Empire Dairy Association.

equipment and facilities. About half of the farmers (43 of 93) responding to the survey made such estimates. The estimates of irrigation investment include such things as on-farm control structures, earth and concrete ditches, reservoirs and ponds, syphon tubes, ditch maintenance equipment, motors, pumps, sprinklers, pipes, etc. Some farms have quite high investments in water-handling facilities, others have modest investments, depending on the irrigation company that serves them, topography of the farm, types of crops grown, farm water supply and other factors.

Table 22 shows the estimated investment in irrigation-related facilities. Two levels of investment are included here. The first is the investment in land actually irrigated at the time of the survey and a somewhat lower estimate for land under the system but not irrigated due to a lack of water supply in the two larger systems. In these systems, purchase of water shares by cities and other governmental bodies has already taken irrigation water out of agriculture leaving some land dry. However, since the ditches, control structures and land leveling are installed on the land, this investment should be included in calculating farmer investments in irrigation facilities.

Taking the entire irrigated area served by the three companies into account, the estimate is about $7 million in on-farm investment in irrigation facilities. This is made up of $1,288,000 under Farmers' Reservoir and Irrigation Company, $5,409,860 under the Farmers' Highline Canal and $341,400 under the Lower Clear Creek Ditch.

The Farmers' Reservoir and Irrigation Company shows the least investment per acre mainly because of two factors. First, farming under this system tends to be extensive rather than intensive. More of the acreage is in small grain, alfalfa and corn, crops that require a lower investment in water control facilities. Second, water is stored in Standley Lake and is called on demand by the irrigators so they do not need small reservoirs to hold water on their own farms. Irrigation water is delivered whenever the farmers choose in the quantities needed to irrigate their crops efficiently.

In contrast, the Farmers' Highline Canal has a higher investment in on-farm irrigation works. Since the farmer receives his portion of the water in continuous flow throughout the season, water is often available when it is not needed or in too small a

* * *

Table 22--Farmers' capital investment in on-farm irrigation works and land leveling, three irrigation companies

| Company | Acres | Investment per acre in irrigation works | Investment per acre in land leveling | Total investment | |
|---|---|---|---|---|---|
| **Farmers' Reservoir and Irrigation Company** | | | | | |
| Land currently irrigated | 9,500 | 57.16 1/ | | 543,020 | |
| | | | 35.00 | 332,500 | |
| Additional land capable of being irrigated | 5,500 | 40.00 2/ | | 220,000 | |
| | | | 35.00 | 192,500 | |
| Total | | | | | 1,288,020 |
| **Farmers' Highline Canal and Reservoir Company** | | | | | |
| Land currently irrigated | 21,750 | 201.00 1/ | | 4,371,500 | |
| | | | 33.76 | 734,280 | |
| Additional land capable of being irrigated | 1,750 | 140.00 2/ | | 245,000 | |
| | | | 33.76 | 59,080 | |
| Total | | | | | 5,409,860 |
| **Lower Clear Creek Ditch Company** | | | | | |
| Land currently irrigated | 2,600 | 83.81 | | 217,906 | |
| | | | 47.50 | 123,500 | |
| | | | | | 341,406 |
| Total | | | | | 7,039,286 |

1/ Weighted average investment per acre on 43 farms that reported the investment on 9,327 acres.

2/ Assume an investment of 70 percent of lands currently irrigated.

flow to be useful. In order to make the water supply more useful, farmers in this company have built small reservoirs and ponds to collect the water and hold it until they wish to irrigate. There are around 80 small on-farm reservoirs under the system, which the farmers operate and maintain and which represent significant capital values. Farmers have improved the ditches carrying water to their fields and in some cases catch runoff water from their irrigated fields and pump it back for reuse, all of which has increased the investment in irrigation works.

Farmers under the Lower Clear Creek Ditch do not need as elaborate ponds and reservoirs to catch and hold water as the other systems; they have a considerable amount of investment in on-farm distribution systems because intensive agriculture requires timely and stable application of water.

Land leveling is fairly uniform under the two larger systems and somewhat higher under the Lower Clear Creek Ditch. The intensive nature of truck farming makes it important that field surfaces be very uniform to get even water application and uniform quality of crops.

The investment reported in on-farm irrigation works is not particularly high under any of these three irrigation companies. These systems have been in place for a long time and original development was made at very low costs by today's standards. From an accounting standpoint, much of the original investment has long since been depreciated out, but the real value on a replacement cost basis remains substantial. What the farmers are basically reporting seems to be more recent repair and rehabilitation investment rather than the full value of constructing ditches, turnouts, check dams, field laterals and so on.

Cost of Replacing Irrigation Systems

One way to estimate the value of irrigation development on existing lands is to determine what it would cost to develop new irrigation systems to replace the ones that are to be abandoned. Since there has been no new surface irrigation development in eastern Colorado for some time, the closest substitute development would be the pump-sprinkler irrigation systems that have been installed on dryland in other parts of eastern Colorado. Irrigation engineers at Colorado State University Agricultural Experiment Station 6/ estimate the cost of installing a pump-sprinkler irrigation system at about $400 per acre but ranging from $350 to over $500 per acre depending on type of land, depth of well, size pump and type of sprinkler, length of pipelines and so on.

Table 23 shows the estimates of replacing irrigated acres with pump irrigation development, assuming three levels of cost per acre. These estimates include only on-farm costs with no community costs such as increased electrical capacity or gas supplies to run the pumps.

These estimates are based upon what economists term the opportunity cost or alternative cost doctrine. Firms, in order to obtain the use of resources necessary to replace the same amount of irrigated land, must pay what those resources can earn in alternative uses.

Table 23--Estimated cost of replacing 40,000 acres of irrigated land with pump irrigation development

| Irrigated service area | | Irrigation development cost per acre | Total investment in irrigation development |
|---|---|---|---|
| Acres | | Dollars/acre | Dollars |
| 40,000 | X | 350 | 14,000,000 |
| 40,000 | X | 400 | 16,000,000 |
| 40,000 | X | 500 | 20,000,000 |

Investment costs for well irrigation systems understate replacement costs since these do not include storage reservoirs or ditch systems, the most costly parts of the systems under condemnation in the three-company area. Additionally, since well irrigation is a mining operation and the water supply will be exhausted some years in the future, depreciation accounting must take depletion into account. The possibility of bringing much new land under pump irrigation from wells elsewhere in Colorado is not great because many areas have reached the permissible limit on ground water development.

The farms that are currently irrigated by surface water cannot turn to wells because there is no aquifer under the irrigated area. A check of well records in the State Engineer's office showed only a very few low-capacity wells in the two larger irrigation service areas.

To get some idea of the cost of redeveloping the irrigation distribution systems, we have done a reconnaissance of the length and capacity of the canals of the three systems. Using this data we have tried to estimate the current cost of constructing the same systems. The cost estimates are those used by the U.S. Bureau of Reclamation in estimating the preliminary costs of developing irrigation systems.7/ A reconnaissance estimate of the cost of rebuilding the systems comes to about $18,885,000. This is derived from $11,000,000 to replace irrigation works of the Standley Division of Farmers' Reservoir and Irrigation Company; $7,370,000 for the canals and reservoirs of the Farmers' Highline; and $515,000 to replace the canal of the Lower Clear Creek Ditch Company.

This is only the cost of building the reservoirs and water conveyance system and does not include the on-farm costs of bringing land under irrigation.

Estimation of the cost of reconstructing the canals does not give the whole cost of the irrigation system. The cost of developing the land for irrigation must also be included. This would undoubtedly be larger than the $7 million invested in land improvements estimated by the farmers in the survey. Total land improvement costs could range from $200 to

6/ Dwayne E. Konrad. Deep Well Irrigation on the Colorado High Plains, Coop. Extension Service, Colo. State Univ., Ft. Collins, Colo., Spring 1975.

7/ Costs could vary depending upon the conditions encountered when the canals are built.

$500 per acre depending on conditions. For the whole 40,000 acres the land improvements alone could range from $8 million to $20 million. These estimates are close to the cost of installing sprinkler systems; however, the investment in land leveling and ditch systems will last indefinitely with minor maintenance while sprinkler systems generally have about a 15-year life span, hence annual depreciation would be much lower.

For comparative purposes, proposals by the U.S. Bureau of Reclamation to construct irrigation systems could give some indication of the cost of developing an irrigation system. A report on the San Miguel project in southwestern Colorado was issued in 1966 proposing to irrigate some 38,950 acres. 8/ The cost for irrigation features was estimated at $67,000,000. Annual direct benefits were estimated at $1,272,000. Inflating these figures by the current wholesale price index of 175 of 1967, the cost of this project would now be $117,000,000 and the anticipated direct benefits would be $2,226,000. Using the current day cost figures, the anticipated cost comes to $3,003 per irrigated acre. Originally this was estimated to be $1,720 per acre.

A Bureau project, currently under consideration, shows similar high investments per acre to develop irrigation systems. The O'Neill project in northern Nebraska is estimated to have irrigation costs of $98,514,000 for 77,000 acres or $1,279 per acre to bring irrigation water to the land. 9/ Direct benefits are estimated to be $4,760,000 under 1971 conditions.

If we were to assume $1,200 per acre cost to develop the 3 irrigation systems, the total for 30,000 acres would be $36,000,000 and for the full 40,000 acres, the total comes to $48,000,000. These estimates do not include any value for the water, only the cost of developing physical facilities to bring water to the land.

## The Direct and Indirect Economic Costs of Removing Irrigation Water From Three Irrigation Companies

Any well developed economy, whether national, regional or local is characterized by a high degree of interdependence among producing sectors of that economy. Those who produce goods and services for final consumption are dependent upon other producers for a portion of their factors of production, i.e., for intermediate products. Those who supply factors of production are similarly dependent upon others for their necessary productive ingredients. Producers must also rely on those who provide primary services from governments and others and for goods produced elsewhere that must be imported for use. Whenever one of these resources becomes unavailable or one sector is unable to produce its established products, the impact ripples through the other sectors of the economy, reducing demand for their output, and hence reducing employment and income in a region.

An input-output model is an analytical technique that is designed to describe economic activity on a national or regional scale. The basis for this system is an input-output table that shows how the output of each industry is distributed among other industries or sectors of the economy. At the same time, it shows the inputs to each industry from other industries and sectors. An input-output model of the Colorado economy developed recently at Colorado State University 10/ was employed to show the interdependence of agriculture and other sectors and to calculate the employment and income effects which would be likely to occur were the farms in the three irrigation companies to discontinue production. Since the input-output model is essentially an accounting tool for keeping track of both purchases and sales of every industry, the resulting output reduction in the total economy may be calculated by the model when the output of one or more individual sectors is reduced.

Table 24 is a summary of the dollar impacts on the local economy when the entire output of farms in the three irrigation companies is eliminated. Column 1 shows the direct dollar decline when production in the various agricultural activities ceases. The value of dairy production declines $2,529,000; sugar beets and miscellaneous crops decline $1,094,000; the value of hay produced in the region declines $1,750,000 and truck and other irrigated crop values decline $6,607,500. The change in direct final demand for agricultural products is shown in column 2. The ripple effects of output change on other sectors of the economy from a decline in agricultural production are shown in column 3. Notice that every sector identified is affected except elementary and secondary education. The reason other sectors of the economy are affected is that the agricultural sectors are no longer selling products on the local market, which formerly created business activity for other people. Neither is the agricultural sector buying goods and services to operate the farms, thus the sellers of these items suffer a decline in business. It should be noted that the output change in the service sector of the economy is greater than three of the four agricultural sectors that suffered the output decline. This illustrates the great dependence of the service sector on other sectors of the economy to purchase its services.

The decline in man-years of employment caused by the change in agricultural production is shown in column 4. The estimates of employment were developed by multiplying the change in output by the employment coefficients: $\frac{\text{sector employment}}{\text{sector output}}$. These calculations show that a total of 562 jobs would be eliminated from the economy. There would be 306 full-time jobs lost in the agricultural sector. The reason the number of irrigated farm units exceeds agricultural employment is that 200 of the units are small, part-time farms that produce little for the market. As noted earlier, there are about 200 commercial farms under the irrigation systems. In addition to the decline in farm employment, 256 jobs in the other sectors of the economy will be eliminated. The largest decline would be in the service sector that would lose 123 jobs, trade would lose 34 and chemical and rubber products sector would lose 32 jobs.

Income change is calculated by multiplying the output change by the income coefficients which are:

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8/ House Document No. 435. 89th Congress, 2nd Session, U.S. Government Printing Office, Washington, D.C., 1966.

9/ O'Neill Unit Reevaluation Statement, U.S.D.I., Bureau of Reclamation, April 1971.

10/ S.L. Gray and J.R. McKean. <u>An Economic Analysis of Water Use in the Colorado Economy</u>. In process. Economics Department, Colorado State University, 1975.

Table 24--Estimated direct and indirect economic impacts of reduced production on farms under the three irrigation companies

| Sector | Direct Output Change ($1000) | Direct Final Demand Change ($1000) | Total Output Change ($1000) | Employment Change (Man Years) | Income Change ($1000) |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| 1.Dairy | -2,529.10 | -2,437.566 | -2,529.100 | - 83.460 | - 554.315 |
| 2.Other Livestock | 0.00 | 0.000 | - 488.417 | - 10.257 | - 75.428 |
| 4.Sugar Beets and Misc. | -1,094.40 | -1,068.707 | -1,094.400 | - 26.266 | - 268.518 |
| 5.All Hay | -1,750.00 | -1,354.236 | -1,750.000 | - 54.250 | - 306.273 |
| 6.Other Irrigated Crops | -6,607.50 | -6,073.367 | -6,607.500 | -132.150 | -1,226.517 |
| 7.Dryland Crops | 0.00 | 0.000 | - 46.231 | - 1.341 | - 10.259 |
| 8.Metal Mining | 0.00 | 0.000 | - .904 | - .024 | - .215 |
| 9.Industrial Materials | 0.00 | 0.000 | - 43.313 | - 1.040 | - 7.903 |
| 10.Coal | 0.00 | 0.000 | - 6.267 | - .157 | - 1.928 |
| 11.Petroleum Products | 0.00 | 0.000 | - 19.055 | - .591 | - 7.144 |
| 12.Food and Kindred Products | 0.00 | 0.000 | -1,103.585 | - 12.139 | - 99.618 |
| 13.Textile, Leather, Apparel | 0.00 | 0.000 | - 190.495 | - 10.287 | - 61.857 |
| 14.Lumber and Wood Products | 0.00 | 0.000 | - 14.661 | - .469 | - 2.794 |
| 15.Paper and Allied Products | 0.00 | 0.000 | - 43.553 | - 1.045 | - 7.677 |
| 16.Printing and Publishing | 0.00 | 0.000 | - 59.037 | - 2.480 | - 19.465 |
| 17.Chemicals, Rubber Products | 0.00 | 0.000 | -1,271.180 | - 31.779 | - 297.625 |
| 18.Petroleum Refining | 0.00 | 0.000 | - 11.434 | - .091 | - .747 |
| 19.Primary Metals | 0.00 | 0.000 | - 26.450 | - .794 | - 7.524 |
| 20.Fabricated Metals | 0.00 | 0.000 | - 213.137 | - 3.836 | - 32.681 |
| 21.Electronics | 0.00 | 0.000 | - 120.435 | - 2.890 | - 27.331 |
| 22.All Other Manufacturing | 0.00 | 0.000 | - 37.897 | - 2.034 | - 15.208 |
| 23.Trans., Comm., and Util. | 0.00 | 0.000 | - 529.846 | - 20.664 | - 188.293 |
| 24.Pipeline Trans. | 0.00 | 0.000 | - 44.804 | - .045 | - .484 |
| 25.Natural Gas Distribution | 0.00 | 0.000 | - 56.252 | - 1.181 | - 8.517 |
| 26.Electric Power Generation | 0.00 | 0.000 | - 54.146 | - .866 | - 6.864 |
| 27.Trade | 0.00 | 0.000 | -1,323.601 | - 34.414 | - 204.185 |
| 28.Industrial Services | 0.00 | 0.000 | - 5.064 | - .182 | - 1.979 |
| 29.All Other Services | 0.00 | 0.000 | -2,746.027 | -123.571 | - 616.955 |
| 30.Elem., Second. Education | 0.00 | 0.000 | 0.000 | 0.000 | 0.000 |
| 31.Higher Education | 0.00 | 0.000 | - 30.117 | - 3.494 | - 16.008 |
| TOTAL | | | | -561.847 | -4,074,404 |

* * *

$\left(\frac{\text{sector income}}{\text{sector output}}\right)$. The economy would directly lose $2,355,623 in income from the drop in production of the four agricultural sectors. Indirectly, there would be an additional reduction in income to the economy of $1,718,000 due to the reduction in demand for goods and services in the other sectors of the economy. Total income loss to the economy is over $4 million annually.

These estimates should be considered minimums in that it does not follow through with second and third round effects of a decline in business activity. No decline in demand is considered because this only considers first round effects and does not examine the impact of moving unemployed people out of the area or the introduction of new business activity should this occur to reemploy those displaced as a result of a decline in agricultural activity.

Nonetheless, the estimates from the input-output analysis indicate that the effect of irrigated farms going out of business because of a lack of irrigation water would substantially hurt the economy. Not only would the agricultural sector be damaged but several other sectors of the economy would be adversely affected as well. Almost as many nonfarm jobs would be eliminated as would farm jobs. Incomes to both farm families and nonfarm families would be lost. While the use of the irrigation water for urban purposes would have a growth or multiplier effect, it is doubtful if this would be equal to the losses described because irrigated agriculture has one of the highest business multipliers observed in the Colorado model. 11/ The issue is not one of the water being condemned or no water for developing urban demands, but rather one of possible alternative sources of water supply that would not result in termination of agricultural irrigation. For a long period of time, a substantial part of the growing metropolitan area has been supplied by means of importation of water from the mountain watersheds. As indicated later, undeveloped water still exists in these watersheds.

For those interested in the basic data and technical coefficients used in estimating the economic impact of the change in agricultural production, two tables are included in the appendix. Table A-7 contains the basic data on the dollar value of total original gross output, the water coefficients for production and the dollar value of total gross output change. The water coefficients for agriculture here are a bit higher than those observed on farms of the three irrigation systems, mainly because these systems operate with less water than most

11/ See Forest Walters and Gary Ramey, Colorado Agriculture: Business and Economic Activity. G.S. Bulletin 933, Colorado State Experiment Station, Colorado State University, Ft. Collins, Dec. 1973, p. 6.

irrigated agriculture in Colorado. The farmers are able to do this by having soils with high water-holding capacity and generally good control over water supplies. Table A-8 shows the decline in final demand for products after irrigated agriculture ceases, the anticipated reduction in labor, the decline in income by sectors and the anticipated reduction in water needs.

This analysis does not include the anticipated gains from urban use of water transferred from agriculture. Most of these gains would be difficult to document because most gains in the economy will occur in the future; some of the water converted will be used by existing development which currently is restricted in water use; and if past trends continue, the bulk of the water will be used for residential and commercial uses which traditionally have a low multiplier effect.

## MUNICIPAL USE OF WATER AND IMPLICATIONS OF CONTINUED SUBURBAN GROWTH IN THE NORTHERN DENVER METRO AREA

The water utilities of the cities of Thornton and Westminster derive a large part of their water supply from stock owned in the irrigation companies (table 17). Arvada owns a few shares of Farmers' Highline and Adams County has some stock in the Lower Creek Ditch but holdings by these and other agencies are small.

The two major municipal water systems serve not only their own cities but also some of the surrounding urban areas. Westminster services Federal Heights and Shaw Heights as well as wholesaling water on occasion to Broomfield and Thornton. Thornton serves its residents as well as the city of Northglenn.

The two cities estimate the combined population served by water utilities to be about 119,000. Thornton puts its service population at 80,000 and Westminster estimates 39,000. Water sources used for municipal water by the cities are shown in table 25. Annually the cities process about 5,765,000,000 gallons or 18,522 A.F. of water for municipal use. Over 70 percent of this is from surface water sources and less than 30 percent is from wells. There is little possibility of increasing the ground water sources so additional water must come from existing surface sources, e.g., the irrigation companies' water supplies.

Gross water delivery amounts to 47,264 gallons per capita per year in Thornton and 52,785 gallons in Westminster. On a daily basis, this comes to about 129 gallons per capita in Thornton and 144 gallons in Westminster. These estimates should not be construed as strictly household use but account for all water deliveries including commercial and industrial use as well as municipal uses such as park watering, street cleaning, fire fighting and so on. For comparative purposes, water delivered per capita per day

* * *

Table 25--Sources and delivery of municipal water, Thornton and Westminster water utilities, 1974

| | Thornton-Northglenn | Westminster |
|---|---|---|
| Total water production | 3,781,177,000 gal. = 11,604 A.F. | 2,251,296,000 gal. = 6,908 A.F. |
| Wells | 1,730,512,400 " = 5,310.8 A.F. | --- --- |
| Water from irrigation companies | 2,050,646,600 " = 6,293.3 A.F. | 2,251,296,000 gal. = 6,908 A.F.<br>1,983,814,000 gal. = 6,088 A.F. sold |
| Revenue | $2,724,475 = $234.78/A.F. | $1,132,510 = $186/A.F. |
| Population served | 80,000 | 28,000 (city only) |
| Per capita delivery | 47,264 gal./yr. 129 gal./day | 52,785 gal./yr. 144 gal./day |

| Water supply source / Irrigation company | Thornton-Northglenn: Shares | 13-yr. average: A.F./share | 13-yr. average: Total | Westminster: Shares | 13-yr. average: A.F./share | 13-yr. average: Total |
|---|---|---|---|---|---|---|
| Farmers' Highline Canal & Res. Co. | 259.34 X | 35.0 = | 9,076.9 | 230.4 X | 35.0 = | 8,064.0 |
| Farmers' Res. & Irrigation Co. | 135.85 X | 5.4 = | 733.6 | 328.19 X | 5.4 = | 1,772.2 |
| Lower Clear Creek Canal Co. | 54.5 X | 23.0 = | 1,253.5 | -- | -- | -- |
| TOTAL | | | 11,064.0 | | | 9,836.0 |
| 1974 municipal use of irrigation company water owned by cities | | | 57.0% | | | 70.3% |

in Boulder averages 180 gallons; Broomfield, 175 gallons; Denver, 214 gallons; Longmont, 301 gallons; Fort Collins, 232 gallons and Greeley, 241 gallons. 12/ Thus, it can be seen that Thornton and Westminster can not be accused of delivering excessive amounts of water to the patrons of the municipal water systems. Indeed, water deliveries are low and the pricing of water is relatively high. Westminster derives $186 per acre foot of water processed through its system while Thornton derives $234 for each acre foot of water sold. This contrasts to Boulder which received $132 per acre foot in 1971; Longmont, $97/A.F.; Greeley, $73/A.F.; and Denver averaged $98/A.F. in the city and $166/A.F. for water delivered outside the city. Thornton and Westminster have fairly elaborate rate structures charging varying rates per 1,000 gallons depending on size of meter and quantity per month. Both use increasing rates for increased quantities, and Westminster has a higher winter rate than summer.

Table 25 shows that, in 1974, Thornton used about 57 percent of the 13-year average water delivered by the irrigation company stock that it holds and Westminster used 70 percent of the average delivery of water to its irrigation stock. Because of the fairly wide variation in water available year to year, this means that with the stock these cities now hold they could be short of water during years when the water delivery falls much below the average delivery.

A look at the population growth in the suburban area north of Denver in Adams and Jefferson counties shows the reason for the growing demand for expansion of municipal water supplies (table 26). The census of population reported about 60,000 people in the area in 1960; 105,600 in 1970 and an estimated 131,600 by 1975. Thus, population has more than doubled in the past 15 years. Projected growth rates could result in a population of 156,000 in the area by 1980. 13/

* * *

Table 26--Population growth in the Westminster-Thornton area of Jefferson and Adams Counties, Colorado, 1960-1980

| Year | Population |
|---|---|
| 1960 | 60,000 |
| 1970 | 105,600 |
| 1975 (estimate) | 131,600 |
| 1980 (projection) | 156,000 |

Population estimates and projections from Census of Population 1960 and 1970 and Colorado County Population Estimates, 1970-1980, Colorado Division of Planning and Business Research Division, Graduate School of Business Administration, Colorado University, Table 11, p. 29.

* * *

As indicated Thornton and Westminster water utilities currently serve approximately 119,000 people. Over 71,000 people have been added to the municipal water systems in the last 15 years, with 25,000 more to be added in the next 5 years if growth continues as expected.

Given the projections of continued population growth in the suburban area north of Denver, it is evident that there will be further increases in the urban demand for the water supplies of the three irrigation companies. Thornton and Westminster are currently near the upper limits of utilization of the water supplies held in the irrigation systems. This means that more irrigation water supplies will be required to meet municipal water demands under present policies and practices.

Since only 8.6 percent of the land in farms in Colorado is irrigated, and only 6.4 percent of the farm land in the Front Range area is irrigated, 14/ some community concern for the loss of this resource would seem warranted. As shown in the input-output analysis, irrigated agriculture is an important employer, and an important contributor to the economy of the region. Concerns for the nation's basic food supply, for the maintenance of prime lands in agriculture and for provision of "green belt" open space areas near urban areas add to the importance of considered decisions based on weighing of consequences and assessments of impacts and alternatives. Conversion of irrigation water supplies might be short-sighted, especially if alternative water supplies might be developed to preserve the benefits of irrigated agriculture and avoid the costs of drying up irrigated lands. Between 1957 and 1974, urban growth caused conversion to urban uses of approximately 18,800 acres of rural land, while the condemnation of the water supplies of the three irrigation companies will almost immediately force 30,000 acres of farm land out of irrigated production. Currently 10,000 acres of land under the ditches of these companies are not irrigated because of water transferred to municipal use.

The Denver Water Board has maintained a policy of providing processed water to suburban areas subject to certain restrictions. Broomfield has begun receiving water from the Denver water system in the past few years. However, some of the conditions imposed by Denver are burdensome and costly. Thornton and Westminster have not been able to work out satisfactory arrangements with Denver to obtain water and currently, because of reduced processing capacity, Denver could not supply water to them. Thus the cities have turned to condemnation of irrigation water.

The Denver Water Board has filed claims for additional water supplies from the West Slope. These claims, small if measured by total water diverted in Colorado, have yet to be developed. Expansion of the mountain water collection system could provide water to the growing population of the metropolitan area until beyond the end of the century with only a fairly slow rate of displacement of Front Range agriculture.

The Denver water system, at present, has a total storage capacity of 521,500 acre feet. During 1974--the highest yearly use on record--water use in the

12/ R. L. Anderson. Price and Delivery of Water in the Northern Colorado Front Range, p. 4.

13/ David E. Monarchi. Colorado County Population Estimates--1970 to 1980. Methods and Results, Business Research Division, Graduate School of Business Administration, University of Colorado, Boulder, July 1975.

14/ 1969 Census of Agriculture.

Denver system was 259,328 A.F. Storage was 463,844 A.F. at the start of the year and 419,772 A.F. at the end, resulting in a decline of 44,027 A.F. for the year. However, 1973 showed a gain in storage of 43,400 A.F. Gains and losses vary with runoff conditions in the mountains. During the year, only 17,922 A.F. were taken from Dillon Reservoir which has a capacity of 254,000 A.F. 15/

Given the large potential storage in Dillon Reservoir, the modest urban demands of the Westminster-Thornton municipal systems could be met from this source with only minor increses in withdrawals from Dillon. By 1980, the water demands of the population increase could be met by adding 4,000 A.F. to the Thornton-Westminster water supply. Growth at this same rate through 1990 would require approximately 15,000 A.F. of additional water. 16/ Even the 1990 demand, should it come from the Denver water system, is less than 6 percent of the capacity of Dillon Reservoir.

Currently, Colorado is using about one-half of its assured entitlement under the Upper Colorado River Compact, although most of the remaining water has been claimed. 17/ Diversion of additional West Slope water would be complex and costly, but it appears to be the only substantial source of currently unutilized water that might be available to meet growing municipal demands, while at the same time preserving irrigated agriculture on the Front Range. Another alternative is to make joint use of water for urban and irrigation purposes. This would require collecting and holding the urban waste water for irrigation use during the growing season. A careful comparison of all costs and all benefits involved in these alternatives should precede irreversible decisions which could make the loss of irrigated lands a virtual certainty.

Some argue that growth should be stopped; that people should use less water; that irrigation of lawns and parks should cease; and that a variety of other efforts might be undertaken to conserve the water supply. In the short run, these procedures might reduce demand for municipal water but such proposals to conserve and extend water supplies in the long run seem in varying degrees to be ineffective, impractical, unenforceable or politically objectionable. It is difficult, and it may be unconstitutional, to attempt to restrict people from locating in areas where they choose (i.e., the right to travel). There are, in addition, many reasons for believing that Front Range growth will continue.

It may be possible to get people to use less water, but there are practical limits beyond which conservation measures will require major changes in life styles. To ration water use by price alone (a course frequently advocated by economists) is to hit the lower income groups the hardest, and could contribute to changing the socio-economic structure of some suburban areas. 18/ Moreover, such shifts would place a particularly heavy burden on older sections of urban communities and would affect the lower income families most severely. Studies have shown that the demand for household water is very inelastic (i.e., it does not respond readily to price changes). To prevent by police action the watering of lawns, gardens and parks in a semiarid area such as Colorado could have drastic effects upon the visual aspects of a city. Landscaping would be destroyed, trees wither and die, shrubbery would disappear, all to be replaced by a sparse covering of desert weeds and ever-present dust. To people of the region such a return of the desert may be an undesirable trade-off, especially if it, in fact, results in only modest savings of water. The suggestion to thus convert to desert landscaping may not suit people of the Front Range region, many of whom came recently from more humid climates, 19/ since desert landscaping is more foreign to them than blue grass and often may be much more difficult to establish and maintain. After 100 years of developing housing with lawn areas, the pattern may be impossible to change, even if it were desirable, when alternative costs and benefits are carefully weighed.

With continued growth, the Denver metropolitan region faces far-reaching and difficult decisions in regard to municipal water supplies. It has three choices, each of which will be unpalatable to some segments of society. These choices are: 1) The municipalities in the region can continue on their present short-range course of capturing whatever water is available wherever they can, taking irrigation water supplies for urban needs. 2) The municipalities could rigorously enforce limitations on water use a) in new growth areas, or b) in all urban areas in the region. 3) The cities in the metro region could set about developing additional water supplies which remain still available, unused in the mountain watersheds.

Under choice 1, agriculture would be a prime source because it has long used the bulk of the local water, and these shifts are the easiest to effect in the short run, but efforts could be made to recycle such urban water to agriculture to reduce the effect of converting irrigation water to urban use. Under choice 2, alternative (a) would put the restrictions on new residents and new development, while alternative (b) would restrict water use of all residents. Choice 3 puts the burden on the mountain watersheds and for this reason has come under attack in recent years by environmentalists, whose main interest appears to be the maintenance of natural conditions in mountain streams. They have not always been concerned with the total consequences and the expected trade-offs. During recent decades the mountain watersheds have been the traditional source of "new" water for the Denver water system. Denver has not attempted to claim local irrigation supplies for municipal use since the 1930s. 20/

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15/ 1974 Annual Report, Denver Board of Water Commissioners, Denver, Colo. 80202, p. 20.

16/ The assumption is 50,000 gallons/capita/year which is below current level of use in Westminster, but above that of Thornton.

17/ Critical Water Problems Facing the Eleven Western States - Westwide Study, Executive Summary, U.S. Dept. of Interior, GPO, April 1975, p. 63.

18/ George Walker, Jr. and Norman I. Wengert. Urban Water Policies and Decision-Making in Detroit Metropolitan Region, Univ. of Michigan, July 1970, p. 116.

19/ P.O. Foss. "Politics of Water," Arid Lands in Transition, A.A.A.S., 1970, pp. 165-173.

20/ See L. Hartman and D. Seastone. Water Transfers, R.F.F., Johns Hopkins Press, Baltimore, Md., 1970, pp. 24-25.

Transmountain diversions have been developed successfully in Colorado: the Homestake project, the Frying Pan-Arkansas project, the Denver Water Board's transmountain diversions, the Colorado-Big Thompson project being the most notable. These systems capture the surplus water from snowmelt, hold it in reservoirs and transport it to the east slope to augment deficient local supplies. While such diversions may have adverse local effects, most of the water captured by these systems would be lost to the state of Colorado since diversions occur during seasons of water surplus.

Before the community can make intelligent decisions on any of the alternatives listed above, studies have to be made to specify the benefits and costs of each course of action. Each has its own set of advantages and disadvantages, its own particular benefits and costs and each has a different incidence of benefits and costs. This study has concentrated largely on the "costs" of converting irrigation water to municipal use and did not include the examination of the benefits and costs of joint use of irrigation water for urban and agricultural purposes, developing additional water in the mountain watersheds, or the benefits and costs of water use restrictions. Studies should also be made of these alternatives so that the comparative advantages and disadvantages of each can be specified and weighed. The adverse effects upon the mountain environment could then be balanced against the adverse effects upon irrigated agriculture. The costs and benefits of joint use should be explored and these should be balanced against the adverse effects of water rationing in the urban areas. With this sort of analysis, a more rational choice can be made between the various alternatives. When a choice is made to restrict water use or to secure more water for urban uses from either irrigated agriculture or from mountain watersheds, the community at large will have information available so that the trade-offs are known in each case.

Addendum

Since this report was written, two events have occurred that have a bearing upon the situation described in this report. First, the City of Northglenn and Farmers' Reservoir and Irrigation Company (FRICO) have drawn an agreement whereby FRICO will deliver a specified quantity of water to Northglenn for municipal use. Northglenn will collect and store the waste water and storm runoff in a reservoir for return to FRICO canals for irrigation use. All costs in diverting water to Northglenn for municipal use and returning it to the irrigation system are to be borne by the city.

It should be noted that Northglenn is currently served by Thornton so that it has no water rights and no municipal distribution system. Northglenn must acquire the water utility before the plan can become operational.

The second event occurred September 3, 1976 when the district court in Golden, Colorado dismissed the water condemnation suit brought by the City of Thornton against the Farmers' Reservoir and Irrigation Company. Basis for the dismissal was a 1975 amendment to the condemnation law that required the city to join all stockholders in the irrigation company in the suit. 21/ The city didn't finish adding all stockholders until July of 1976, thus leading to dismissal of the 1973 suit. 22/ The case is being appealed to the Colorado Supreme Court.

The condemnation suits of Thornton against the Farmers' Highline Canal and Reservoir Company and the Lower Clear Creek Ditch Company remained in effect as does Westminster's suit against the Farmers' Reservoir and Irrigation Company.

The outcome of the condemnation procedure is still in doubt and the cities still need additional raw water supplies. Thus, the basic problem of the ultimate allocation of limited water supplies continues to be unresolved.

21/ Colorado Revised Statutes, 1973, 38-6-201 to 38-6-216.

22/ The Denver Post, Sept. 4, 1976, p. 8.

APPENDIX

CODES TO SOIL CLASSIFICATIONS TO INDICATE SOIL LIMITATIONS (FOR USE WITH APPENDIX TABLES 1-6)

e = erosion risk

s = shallow, droughty or stony

w = water in or on soil interferes with farming

| | | | |
|---|---|---|---|
| 1 | Slope | 15 | Dust problem |
| 2 | Depth to bedrock | 16 | Excess humus |
| 3 | Flooding | 17 | Rapid percolation |
| 4 | Shrink - swell | 18 | Cutbank instability |
| 5 | Seepage | 19 | Drainage wetness |
| 6 | Permeability | 20 | Low strength |
| 7 | Stoniness | 21 | Thin soil |
| 8 | Frost action | 22 | Reclamation |
| 9 | Piping | 23 | Erodes easily |
| 10 | Corrositivity | 24 | Texture (sandy) |
| 11 | Slow percolation | 25 | Water table |
| 12 | Texture (fine) | 26 | Sheer strength |
| 13 | Compressibility | 27 | Excess salts |
| 14 | Compaction | 28 | Clayey - fine texture |

Table A1--Soils classification and capabilities for agricultural and urban uses, Farmers' Reservoir and Irrigation Company, Standley Lake Division

| Soil series | Irrigated acreage | Non-irrigated acreage | Extent % | Slope % | Erodibility index | Capability for agriculture: Irrigated agriculture, class | Non-irrigated agriculture, class | Winter wheat bu./acre |
|---|---|---|---|---|---|---|---|---|
| Platner loam, PLB,56A-B | 2,092 | 1,575 | 85 | 0-3 | 5 | IIe-1 | IIIe-1 | 19 |
| Weld loam, 41-B | 1,073 | 1,874 | 85 | 1-3 | 5 | IIe | IIIc | -- |
| Olney (fine, sandy loam), 21B-B | 1,025 | 684 | 85 | 1-3 | 5 | IIe | IVe | -- |
| Nunn clay loam, 41M-B,NaB | 738 | 278 | 85 | 1-3 | 5 | IIe | IIIs | 19 |
| Ulm clay loam, 67-B | 533 | 1,794 | 85 | 1-3 | 5 | IIe | IVe | 16 |
| Wiley & X40-B | 529 | 855 | -- | 1-3 | 5 | IIe | IVe | -- |
| Colby complex | -- | -- | -- | 1-3 | 3 | IIe | VIe | -- |
| Ascalon sandy loam, 55-B, 55-AB | 512 | 1,392 | 85 | 1-3 | 5 | IIe | IIe | 18 |
| Vona loamy sand, 51-B | 304 | 4,967 | 85 | 0-3 | 5 | IIIe | IVe | -- |
| Wiley & X40-C | 280 | 630 | -- | 3-5 | 5 | IIIe | IVe | -- |
| Colby complex | -- | -- | -- | 3-5 | 3 | IIIe | VIe | -- |
| Platner loam, 56A-C,PLB | 277 | 724 | 85 | 3-5 | 5 | IIIe | IIIe | 18 |
| Ulm loam, ULC | 275 | 695 | 85 | 3-5 | 5 | IIIe | IVe | 14 |
| Olney (fine, sandy loam) 21B-C | 240 | 176 | 85 | 3-5 | 5 | IIIe | IVe | -- |
| Aquells & Awuepts, 34-AB | 226 | 387 | 85 | -- | -- | VIw | -- | -- |
| Ulm clay loam, 67C | 225 | 631 | 85 | 3-5 | 5 | IIIe | IVe | 14 |
| Weld loam, 41-A | 224 | 7 | 85 | 0-1 | 5 | IIs | IIIc | 19 |
| Renohill loam & clay loam, 66B-CD | 130 | 98 | 85 | 3-9 | 2 | IVe | IVe | -- |
| Vona loamy sand, 51-C | 129 | 1,888 | 85 | 3-5 | 5 | IVe | VIe | -- |
| Kim loam, X53-B | 111 | 21 | 85 | 3-5 | 5 | IIIe | IVe | -- |
| Nunn clay loam, 41M-A, Nu-A | 105 | 237 | 85 | 0-1 | 5 | IIs | IIIs | 19 |
| Olney loamy sand, 55A-B | 99 | 1,181 | 85 | 1-3 | 5 | IIIe | IVe | -- |
| Vona sandy loam, 51B-B | 91 | 635 | 85 | 1-3 | 5 | IIIe | IVe | 16 |
| Ulm loam, Uld | 48 | 40 | 85 | 5-9 | 5 | IVe | VIe | -- |
| McCook clay loam, X30-B | 40 | 19 | 85 | 1-3 | 5 | IIe | IIIe | -- |
| Ascalon sandy loam, 55-C, AsC | 39 | 312 | 85 | 3-5 | 5 | IIIe | IVe | 18 |
| Otero sandy loam, 53-B | 35 | 74 | 85 | 1-3 | 5 | IIIe | IVe | -- |
| Kim loam, X53-D | 32 | 40 | 85 | 5-9 | 5 | IVe | VIe | -- |
| Nunn clay loam, 17-B | 23 | -- | 85 | 1-3 | 5 | IIe | IIx | -- |
| Valent sand, 72-AB | 23 | 855 | 85 | 0-3 | 5 | IVe | VIe | -- |
| Arvada loam, AdB | 20 | 549 | 85 | 0-3 | 5 | VIIs | VIIs | -- |
| Kim loam, X53-C | 20 | 17 | 85 | 3-5 | 5 | IIIe | IVe | -- |
| Vona sandy loam, 51B-C | 17 | 203 | 85 | 3-5 | 5 | IIIe | IVe | -- |
| Ulm clay loam, 67-D | 11 | 9 | 85 | 5-9 | 5 | IVe | VIe | -- |
| Renohill loam, ReD | 9 | 201 | 85 | 3-9 | 2 | IVe | IVe | -- |
| Vona loamy sand, 51-D | 9 | 117 | 85 | 5-9 | 5 | VIe | VIe | -- |
| Nelson fine, sandy loam, 53M-CD | 9 | 133 | 85 | 3-9 | 3 | IVe | VIe | -- |
| Thedalund loam, 43-CD | 4 | 16 | 85 | 3-9 | 2 | IVe | VIe | -- |
| Ascalon sandy loam, AsD | 3 | 94 | 85 | 5-9 | 5 | IVe | IVe | -- |
| Valent sand, 72-X | 0 | 625 | 85 | 5-9 | 5 | VIe | VIe | -- |
| Galeton, 49-AB | 0 | 373 | 85 | 15 | 5 | IVw | VIw | -- |

| Spring wheat | | Crop production potential | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Irrig. bu./acre | Nonirrig. bu./acre | Alfalfa irrig. T/A. | Sugar beets T/A. | Corn irrig. bu./acre | Corn silage irrig. T/acre | Barley Irrig. bu./acre | Barley Nonirrig. bu./acre | Range production lbs. dry matter/A. H | M | L |
| 55 | -- | 6.0 | 24 | 120 | 20 | 55 | 20 | 1,700 | 1,200 | 800 |
| 60 | 25 | 5.5 | 24 | 120 | 17 | -- | 17 | 1,400 | 1,000 | 800 |
| 60 | 14 | 5.0 | 20 | 120 | 18 | -- | -- | 1,200 | 1,000 | 800 |
| 45 | 19 | 5.5 | 23 | 110 | 26 | 45 | -- | 1,300 | 950 | 800 |
| -- | 16 | -- | -- | -- | -- | -- | -- | 1,100 | 800 | 500 |
| 55 | 15 | 5.5 | 20 | 85 | -- | -- | -- | 1,000 | 800 | 400 |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 60 | 26 | 5.0 | 20 | 120 | -- | -- | -- | 2,300 | 1,700 | 900 |
| 50 | 13 | 4.5 | 20 | 110 | 27 | 45 | -- | 1,800 | 1,600 | 1,200 |
| 45 | 10 | 4.5 | -- | 70 | -- | -- | -- | 1,000 | 800 | 400 |
| -- | -- | -- | -- | 100 | 18 | 45 | 19 | -- | -- | -- |
| 45 | -- | 5.0 | 18 | 100 | 18 | 45 | 19 | 1,700 | 1,200 | 800 |
| 40 | 14 | 3.5 | 17 | 85 | 14 | 40 | 15 | 1,100 | 800 | 500 |
| 55 | 12 | 4.0 | -- | 100 | -- | -- | -- | 1,200 | 1,000 | 800 |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| 40 | 14 | 3.5 | 17 | 85 | 14 | 40 | 15 | 1,100 | 800 | 500 |
| 65 | -- | 6.0 | 28 | 125 | 17 | -- | -- | 1,400 | 1,000 | 800 |
| -- | 15 | 2.5 | -- | -- | -- | 50 | 15 | 1,800 | 1,300 | 750 |
| 35 | -- | 3.5 | -- | 80 | 22 | 35 | -- | 1,800 | 1,600 | 1,200 |
| 45 | 14 | 3.5 | -- | -- | -- | -- | -- | 1,500 | 1,100 | 800 |
| 50 | -- | 5.5 | 24 | 120 | 28 | 50 | -- | 1,300 | 950 | 800 |
| 55 | 13 | 5.0 | 20 | 110 | 12 | -- | -- | 1,800 | 1,500 | 1,000 |
| 55 | 18 | 5.0 | 21 | 130 | 16 | 50 | -- | 1,800 | 1,500 | 1,000 |
| 25 | -- | 3.0 | -- | -- | 12 | 25 | -- | 1,100 | 800 | 500 |
| -- | -- | 3.8 | 16 | 80 | -- | -- | -- | -- | -- | -- |
| 40 | 14 | 4.5 | 19 | 90 | 18 | 40 | 20 | 2,300 | 1,700 | 900 |
| -- | 20 | 5.0 | 20 | 110 | -- | -- | -- | 1,200 | 1,000 | 800 |
| 40 | 12 | 2.5 | -- | -- | -- | -- | -- | 1,500 | 1,100 | 800 |
| -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| -- | -- | 3.5 | -- | 75 | -- | 60 | -- | 3,500 | 2,000 | 1,200 |
| -- | -- | -- | -- | -- | -- | -- | -- | 1,200 | 900 | 600 |
| 45 | 14 | 3.5 | -- | -- | -- | -- | -- | 1,500 | 1,100 | 800 |
| 40 | -- | 4.0 | -- | 90 | 25 | 40 | -- | 1,800 | 1,500 | 1,000 |
| 25 | -- | 3.0 | -- | -- | 12 | 25 | -- | 1,100 | 800 | 500 |
| 20 | 15 | 2.5 | -- | -- | -- | 20 | -- | 1,800 | 1,300 | 750 |
| -- | -- | -- | -- | -- | -- | -- | -- | 1,800 | 1,600 | 1,200 |
| -- | -- | 3.0 | -- | 70 | 25 | -- | -- | 1,700 | 1,500 | 1,000 |
| -- | -- | 3.0 | 20 | 80 | 20 | -- | -- | 1,600 | 1,100 | 800 |
| 35 | -- | 4.0 | -- | 85 | 14 | 35 | 19 | 2,300 | 1,700 | 900 |
| -- | -- | 3.5 | -- | 75 | -- | 60 | -- | 3,500 | 2,000 | 1,200 |
| -- | -- | -- | -- | -- | -- | -- | -- | 4,000 | 3,500 | 3,000 |

Table A2--Limitations of soils for urban development and use, Farmers' Reservoir and Irrigation Company, Standley Lake Division

| Soil series | Total: acres | Shallow excavations | Dwellings without basements | Dwellings with basements | Small commercial buildings | Local roads and streets |
|---|---|---|---|---|---|---|
| Platner loam,PLB,56A-B | 3,667 | Slight | Moderate (4) | Moderate (4) | Moderate (4) | Moderate(4,20) |
| Weld loam, 41-B | 2,947 | Slight | Moderate (2 | Moderate (20) | Moderate (20) | Mod. (20,4,8) |
| Olney (fine, sandy loam), 21B-B | 1,709 | Slight | Slight | Slight | Slight | Severe (8) |
| Nunn clay loam, 41M-B,NaB | 1,016 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Ulm clay loam, 67-B | 2,327 | Slight | Severe (4,2) | Severe (4) | Severe (4) | Severe (20,4) |
| Wiley & X40-B | 1,384 | Slight | Moderate (20) | Moderate (20) | Moderate (20) | Severe (8) |
| Colby complex | | Slight | Mod.-Severe (1) | Moderate (4,20) | Moderate (20,1) | Moderate (20) |
| Ascalon sandy loam, 55-B, 55-AB | 1,904 | Slight | Slight | Slight | Slight | Moderate (8) |
| Vona loamy sand, 51-B | 5,271 | Slight | Slight | Slight | Slight | Moderate (20,8) |
| Wiley & X40-C | 910 | Slight | Moderate (20) | Moderate (20) | Moderate (20,1) | Severe (8) |
| Colby complex | | Slight | Mod.-Severe (1) | Moderate (4,20) | Moderate (20,1) | Moderate (20) |
| Platner loam, 56A-C,PLB | 1,001 | Slight | Moderate (4) | Moderate (4) | Moderate (4,1) | Moderate (4,20) |
| Ulm loam, ULC | 970 | Slight | Severe (4) | Severe (4) | Severe (4) | Severe (4,20) |
| Olney(fine sandy loam), 21B-C | 416 | Slight | Slight | Slight | Slight-Mod.(1) | Severe (8) |
| Aquells & Awuepts, 34-AB | 613 | -- | -- | -- | -- | -- |
| Ulm clay loam, 67C | 856 | Slight | Severe (4) | Severe (4) | Severe (4) | Severe (20,4) |
| Weld loam, 41-A | 231 | Slight | Moderate (20) | Moderate (20) | Moderate (20) | Mod. (20,4,8) |
| Renohill loam & clay loam, 66B-CD | 228 | Mod. (2,1,28) | Moderate (1,20) | Moderate (20) | Moderate (1,20) | Severe (20) |
| Vona loamy sand, 51-C | 2,017 | Slight | Slight | Slight | Slight-Mod.(1) | Moderate (20) |
| Kim loam, X53-B | 132 | Slight | Moderate (20) | Moderate (20) | Moderate (20,1) | Severe (8) |
| Nunn clay loam, 41M-A,NuA | 342 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Olney loamy sand, 55A-B | 1,280 | Slight | Slight | Slight | Slight | Severe (8) |
| Vona sandy loam, 51B-B | 726 | Slight | Slight | Slight | Slight | Moderate (20,8) |
| Ulm loam, Uld | 88 | Slight-Mod.(1) | Severe (4) | Severe (4) | Severe (1,4) | Severe (20,4) |
| McCook clay loam, X30-B | 59 | Slight | Slight | Slight | Slight | Slight |
| Ascalon sandy loam, 55-C, AsC | 351 | Slight | Slight | Slight | Slight-Mod.(1) | Moderate (8) |
| Otero sandy loam, 53-B | 109 | Slight | Slight | Slight | Slight | Slight |
| Kim loam, X53-D | 72 | Slight-Mod. | Moderate (20,1) | Moderate (20,1) | Mod.-Sev.(20,1) | Severe (8) |
| Nunn clay loam, 17-B | 23 | -- | -- | -- | -- | -- |
| Valent sand, 72-AB | 878 | Severe (24) | Slight | Slight | Slight | Slight |
| Arvada loam, AdB | 569 | Moderate (28) | Severe (4) | Moderate (20,4) | Mod. (1,4,20) | Severe (4,20) |
| Kim loam, X53-C | 37 | Slight | Moderate (20) | Moderate (20) | Moderate (20) | Severe (8) |
| Vona sandy loam, 51B-C | 220 | Slight | Slight | Slight | Slight-Mod.(1) | Moderate (20) |
| Ulm clay loam, 67-D | 20 | Slight-Mod. (1) | Severe (4) | Severe (4) | Severe (1,4) | Severe (20,4) |
| Renohill loam, ReD | 210 | Mod.(1,2,28) | Moderate (1,20) | Moderate (20) | Moderate (1,20) | Severe (20) |
| Vona loamy sand | 126 | Slight-Mod.(1) | Slight-Mod. (1) | Slight-Mod. (1) | Mod.-Severe (1) | Mod.(1,8,20) |
| Nelson fine sandy loam, 53M-CD | 142 | Severe (2) | Moderate (2,1) | Severe (2) | Mod.-Sev.(2,1) | Mod. (1,2,8) |
| Thedalund loam, 43-CD | 20 | Moderate (1,2) | Moderate (1,20) | Moderate(1,2,20) | Mod.-Sev.(1,20) | Moderate (1,2) |
| Ascalon sandy loam, AsD | 97 | Slight-Mod.(1) | Slight-Mod. (1) | Slight-Mod. (1) | Mod.-Sev. (1) | Moderate (1,8) |
| Valent sand, 72-X | 625 | Severe (1) | Severe (1) | Severe (1) | Severe (1) | Severe (1) |
| Galeton, 49-AB | 373 | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) |

| Septic tanks | Sewage lagoons | Sanitary land fill area | Playgrounds and parks | Roadfill | Gravel | Sand | Topsoil |
|---|---|---|---|---|---|---|---|
| Moderate (11) | Slight | Slight | Mod.(11)-Slight | Fair(4,20) | Unsuitable | Unsuitable | Fair (21) |
| Moderate (11) | Slight | Slight | Mod.-Slight | Fair (20) | Unsuitable | Unsuitable | Fair (28) |
| Slight | Moderate(17,1) | Slight | Slight | Fair (20) | Unsuitable | Unsuitable | Good |
| Severe (11) | Moderate(16,1) | Slight | Mod.(11,1,28) | Poor (4) | Unsuitable | Unsuitable | Fair (21) |
| Moderate (11) | Moderate (17) | Slight | Moderate (28) | Poor | Unsuitable | Unsuitable | Fair |
| Slight | Moderate (17) | Slight | Moderate (15) | Fair (20) | Unsuitable | Unsuitable | Good |
| Moderate (6) | Severe (5,1) | Moderate (1) | Moderate (9) | Fair (20) | Unsuitable | Unsuitable | Fair |
| Slight | Moderate (17) | Slight | Slight | Fair (20) | Unsuitable | Unsuitable | Good |
| Slight | Severe (17) | Slight | Moderate (24) | Fair (20) | Unsuitable | Poor | Good |
| Slight | Moderate (17) | Slight | Moderate (15,1) | Fair (20) | Unsuitable | Unsuitable | Good |
| Moderate (6) | Severe (5,1) | Slight | Moderate (9,1) | Fair (20) | Unsuitable | Unsuitable | Fair |
| Moderate (11) | Moderate (1) | Slight | Mod.(11,1)-Slight | Fair(4,20) | Unsuitable | Unsuitable | Fair (21) |
| Moderate (11) | Moderate (17,1) | Slight | Moderate (28,1) | Poor | Unsuitable | Unsuitable | Fair |
| Slight | Moderate (17,1) | Slight | Slight | Fair (20) | Unsuitable | Unsuitable | Good |
| -- | -- | -- | -- | -- | -- | -- | -- |
| Moderate (11) | Moderate (1,17) | Moderate (28) | Moderate (28,1) | Poor | Unsuitable | Unsuitable | Fair |
| Moderate (11) | Slight | Slight | Mod.(11)-Slight | Fair (20) | Unsuitable | Unsuitable | Fair (28) |
| Severe (11,2) | Severe (1,2) | Slight-Mod.(1) | Sev.(1)-Mod.(28,1) | Poor(20,21) | Unsuitable | Unsuitable | Poor (21) |
| Slight | Severe (17) | Slight | Moderate (24) | Fair (20) | Unsuitable | Poor | Good |
| Slight | Moderate (17,1) | Slight | Moderate (1,15) | Fair (20) | Unsuitable | Unsuitable | Good |
| Severe (11) | Moderate (16) | Slight | Moderate (11,28) | Poor (4) | Unsuitable | Unsuitable | Fair (21) |
| Slight | Moderate (17,1) | Slight | Moderate (24) | Fair (20) | Unsuitable | Unsuitable | Good |
| Slight | Severe (17) | Slight | Slight-Mod.(1) | Fair (20) | Unsuitable | Poor | Good |
| Moderate (11) | Severe (1) | Slight-Mod.(1) | Sev.(1)Mod.(28,1) | Poor | Unsuitable | Unsuitable | Fair |
| Severe (17) | Slight | Slight | Moderate | Fair | Unsuitable | Fair | Good |
| Slight | Moderate (17,1) | Slight | Slight-Mod.(24,1) | Fair (20) | Unsuitable | Unsuitable | Good |
| Slight | Severe (17) | Slight | Slight-Mod.(1) | Good | Unsuitable | Poor | Good |
| Slight-Mod.(1) | Sev.(17,1)-Mod. | Slight-Mod.(1) | Severe (1) | Fair (20) | Unsuitable | Unsuitable | Good-Fair(1) |
| -- | -- | -- | -- | -- | -- | -- | -- |
| Slight | Severe (17) | Slight | Sev.-Mod. 24) | Good | Unsuitable | Fair | Poor (24) |
| Severe (11) | Moderate (1) | Slight | Severe (11,1) | Poor | Unsuitable | Unsuitable | Poor (27) |
| Slight | Moderate(17,1) | Slight | Moderate (1,15) | Fair (20) | Unsuitable | Unsuitable | Good |
| Slight | Severe (17) | Slight | Mod.(1)-Slight | Fair (20) | Unsuitable | Poor | Good |
| Moderate (11) | Severe (1) | Slight-Mod.(1) | Sev.(1)Mod.(28,1) | Poor | Unsuitable | Unsuitable | Fair |
| Severe (2,11) | Severe (1,2) | Slight-Mod.(1) | Sev.(1)Mod.(28,1) | Poor(20,21) | Unsuitable | Unsuitable | Poor (22) |
| Slight-Mod.(1) | Severe (17,1) | Slight-Mod.(1) | Mod.-Sev. (1,24) | Fair (20) | Unsuitable | Poor | Good-Fair(1) |
| Severe (2) | Severe(2,17,1) | Slight-Mod.(1) | Sev.(1,2)Slight-Mod.(1) | Fair (2,8) | Unsuitable | Unsuitable | Good-Fair(1) |
| Severe (2) | Severe (2,1) | Slight-Mod.(1) | Mod.-Sev.(1,2,15) | Poor (21) | Unsuitable | Unsuitable | Fair (28,1) |
| Slight-Mod.(1) | Mod.-Sev. (11,1) | Slight-Mod.(1) | Moderate (24,1) | Fair (20) | Unsuitable | Unsuitable | Good-Fair(1) |
| Severe (1) | Severe (1,17) | Severe (1) | Severe (1,24) | Fair (1) | Unsuitable | Fair | Poor (1,24) |
| Severe (3,25) | Sev.(3,25,5) | Severe (3,25) | Severe (25,3) | Poor (25) | Unsuitable | Poor | Poor (25) |

Table A3--Soils classification and capabilities for agricultural and urban uses, Farmers' Highline Canal and Reservoir Company

| Soil series | Irri-gated acreage | Non-irrigated acreage | Extent % | Slope % | Erodi-bility index | Capability for agriculture: Irrigated agriculture, class | Capability for agriculture: Non-irrigated agriculture, class | Winter wheat bu./acre |
|---|---|---|---|---|---|---|---|---|
| Platner loam, PLB | 4,566 | 2,444 | >85 | 0-3 | 5 | IIe | IIIe | 19 |
| Platner loam, PLC | 2,151 | 1,715 | >85 | 3-5 | 5 | IIIe | IIIe | 18 |
| Ulm loam, ULC | 2,080 | 1,972 | >85 | 3-5 | 5 | IIIe | IV | 14 |
| Renohill loam, ReD | 1,426 | 1,601 | >85 | 3-9 | 2 | IVe | IVe | -- |
| Ulm loam, ULD | 966 | 864 | >85 | 5-9 | 5 | IVe | VIe | -- |
| Samsil & ShF | 553 | 1,663 | 40 | 3-25 | 2 | VIIe | VIIe | -- |
| Shingle complex | -- | -- | 40 | 3-25 | 2 | VIIe | VIIe | -- |
| Weld loam, 41-B | 348 | -- | 85 | 1-3 | 5 | IIe | IIIe | -- |
| Loamy alluvial - wet, LW | 323 | 165 | 85 | Level | - | Vw | Vw | -- |
| Wiley & X40-B | 248 | -- | -- | 1-3 | 5 | IIe | IV | -- |
| Colby complex | -- | -- | -- | 1-3 | 5 | IIe | VIe | -- |
| Ascalon sandy loam, AsC, 55-C | 209 | 58 | >85 | 3-5 | 5 | IIIe | IVe | 18 |
| Nunn clay loam, NuA, 41M-A | 193 | 72 | >85 | 0-1 | 5 | IIs | IIIs | -- |
| Nunn clay loam, NuB | 133 | 123 | >85 | 1-3 | 5 | IIc | IIIs | 19 |
| Ascalon sandy loam, AsB, 55-B | 99 | -- | 85 | 1-3 | 5 | IIe | IIe | 18 |
| Ascalon sandy loam, AsD, 55-D | 75 | -- | 85 | 5-9 | 5 | IVe | IVe | -- |
| Nunn loam, N1B | 68 | -- | 85 | 1-3 | 5 | IIe | IIIe | -- |
| Wiley & X40-C | 56 | -- | -- | 3-5 | 5 | IIIe | IVe | -- |
| Colby complex | -- | -- | -- | 3-5 | 5 | IIIe | VIe | -- |
| Loamy alluvial gravelly, LV | 50 | -- | 85 | Level | - | Vw | Vw | -- |
| Weld loam, 41-A | 43 | -- | 85 | 0-1 | 5 | IIs | IIIe | -- |
| Arvada loam, AdB | 34 | 196 | 85 | 0-3 | 5 | VIs | VIIs | -- |
| Aquells & Awuepts, 34-AB | 34 | -- | 85 | -- | - | VIw | -- | -- |
| Ascalon sandy loam, 55-A | 34 | -- | 85 | 0-1 | 5 | I | IIe | -- |
| Wet alluvial land, Wt | 33 | -- | 85 | Level | - | Vw | Vw | -- |
| Olney fine sandy loam, 21B-B | 28 | -- | 85 | 1-3 | 5 | IIe | IVe | -- |
| Renohill loam & clay loam 66B-AB | 21 | -- | 85 | 0-3 | 2 | IVe | IVe | -- |
| Ulm clay loam, 67B-CD | 17 | -- | 85 | 3-9 | 5 | IIe | IVe | 16 |
| Kim loam, X53-C | 15 | -- | 85 | 3-5 | 5 | IIIe | IVe | -- |
| Renohill loam & clay loam, 66B-CD | 13 | -- | 85 | 3-9 | 2 | IVe | VIe | -- |
| Haverson loam, 30-B | 12 | -- | 85 | 1-3 | 5 | IIe | IVe | -- |
| Heldt clay, H1D | 11 | -- | 85 | 3-9 | 5 | IVe | VIe | -- |
| Tassil sandy loam, 84-DE | 7 | -- | 85 | 5-20 | 1 | VIe | VIe | -- |
| Wiley & X40-A | 7 | -- | -- | 0-1 | 5 | IIs | IVe | -- |
| Colby complex | -- | -- | -- | 0-1 | 5 | IIs | VIe | -- |
| Gravelly lands, Gr | 0 | 981 | 85 | -- | - | -- | -- | -- |
| Loamy alluvial, Lu | 0 | 63 | 85 | -- | - | Vw | Vw | -- |
| Ascalon sandy loam, AsC | 0 | 58 | 85 | 3-5 | 5 | IIIe | IVe | -- |
| Nunn clay loam, NuC | 0 | 35 | 85 | 3-5 | 5 | IIIe | IVs | -- |
| Ulm loam, U1B | 0 | 19 | 85 | 1-3 | 5 | IV | V | -- |

| Crop production potential | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Spring wheat | | Alfalfa | Sugar | Corn | Corn silage | Barley | | Range production | | |
| Irrig. | Nonirrig. | irrig. | beets | irrig. | irrig. | Irrig. | Nonirrig. | lbs. dry matter/A. | | |
| bu./acre | bu./acre | T/A. | T/A. | bu./acre | T/acre | bu./acre | bu./acre | H | M | L |
| 55 | — | 6.0 | 24 | 120 | 20 | 55 | 20 | 1,700 | 1,200 | 500 |
| 45 | — | 5.0 | 18 | 100 | 18 | 45 | 19 | 1,700 | 1,200 | 500 |
| 40 | 14 | 3.5 | 17 | 85 | 14 | 40 | 15 | 1,100 | 800 | 500 |
| 20 | 15 | 2.5 | — | — | — | 20 | — | 1,800 | 1,300 | 750 |
| 25 | — | 3.0 | — | — | 12 | 25 | — | 1,100 | 800 | 500 |
| — | — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — | — |
| 60 | 25 | 5.5 | 24 | 120 | 17 | — | 17 | 1,400 | 1,000 | 800 |
| — | — | — | — | — | — | — | — | — | — | — |
| 55 | 15 | 5.5 | 20 | 85 | — | — | — | 1,000 | 800 | 400 |
| — | — | — | — | — | — | — | — | — | — | — |
| 40 | — | 4.5 | 19 | 90 | 18 | 40 | 20 | 2,300 | 1,700 | 900 |
| 50 | — | 5.5 | 24 | 120 | 28 | 50 | — | 1,300 | 950 | 800 |
| 45 | 19 | 5.5 | 23 | 110 | 26 | 45 | — | 1,300 | 950 | 800 |
| 60 | 26 | 5.0 | 20 | 120 | 20 | 55 | 20 | 2,300 | 1,700 | 900 |
| 35 | — | 4.0 | — | 85 | 14 | 35 | 19 | 2,300 | 1,700 | 900 |
| 60 | 25 | 5.5 | 25 | 140 | — | — | — | 1,800 | 1,400 | 1,000 |
| 45 | 10 | 4.5 | — | 70 | — | — | — | 1,000 | 800 | 400 |
| — | — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — | — |
| 65 | — | 6.0 | 28 | 125 | 20 | — | 20 | 1,400 | 1,000 | 800 |
| — | — | — | — | — | — | — | — | 1,200 | 900 | 600 |
| — | — | — | — | — | — | — | — | — | — | — |
| 65 | — | 5.5 | 23 | 130 | — | — | — | 2,300 | 1,700 | 900 |
| — | — | — | — | — | — | — | — | — | — | — |
| 60 | 14 | 5.0 | 20 | 120 | 18 | — | 18 | 1,200 | 1,300 | 750 |
| — | 15 | 2.5 | — | — | — | 50 | — | 1,800 | 1,300 | 750 |
| — | 16 | — | — | — | — | — | — | 1,100 | 800 | 500 |
| 45 | 14 | 3.5 | — | — | — | — | — | 1,500 | 1,100 | 800 |
| 20 | 15 | 2.5 | — | — | — | 20 | — | 1,800 | 1,300 | 750 |
| 55 | 20 | 4.5 | 18 | 130 | — | — | — | 1,500 | 1,200 | 800 |
| 25 | — | 3.5 | — | — | — | — | — | 1,700 | 1,200 | 500 |
| — | — | — | — | — | — | — | — | — | — | — |
| 55 | 15 | 5.5 | 19 | 85 | — | — | — | 1,000 | 800 | 400 |
| — | — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — | — |
| — | — | — | — | — | — | — | — | — | — | — |
| 55 | 25 | 4.0 | — | 100 | 20 | — | — | 2,300 | 1,700 | 900 |
| 50 | 20 | 4.0 | — | 90 | — | — | — | 1,800 | 1,400 | 1,000 |
| — | 18-25 | 4.5 | — | — | — | — | — | 1,100 | 800 | 500 |

Table A4--Limitations of soils for urban development and use, Farmers' Highline Canal and Reservoir Company

| Soil series | Total acres | Shallow excavations | Dwellings without basements | Dwellings with basements | Small commercial buildings | Local roads and streets |
|---|---|---|---|---|---|---|
| Platner loam, PLB | 7,010 | Slight | Moderate (4) | Moderate (4) | Moderate (4) | Moderate (4,20) |
| Platner loam, PLC | 3,866 | Slight | Moderate (4) | Moderate (4) | Moderate (4) | Moderate (4,20) |
| Ulm loam, ULC | 4,052 | Slight | Severe (4) | Severe (4) | Severe (4) | Severe (4,20) |
| Renohill loam, ReD | 3,027 | Moderate(12,28) | Moderate (1,20) | Moderate (20) | Moderate (1,20) | Severe (20) |
| Ulm loam, ULD | 1,830 | Slight-Mod.(1) | Severe (4) | Severe (4) | Severe (1,4) | Severe (4,20) |
| Samsil & ShF | 2,216 | Severe (1,28) | Sev. (1,4,20) | Severe(1,4,20) | Severe(1,4,20) | Severe(1,4,20) |
| Shingle complex | -- | Severe (1,2) | Severe (1,2) | Severe (1,2) | Severe (1,2) | Severe (1,2) |
| Weld loam, 41-B | 348 | Slight | Moderate (20) | Moderate (20) | Moderate (20) | Moderate(4,8,20) |
| Loamy alluvial, wet, LW | 488 | Severe (3) | Severe (3) | Severe (3) | Severe (3) | Severe (3) |
| Wiley & X40-B | 248 | Slight | Moderate (20) | Moderate (20) | Moderate (20) | Severe (8) |
| Colby complex | -- | Slight | Mod.-Severe(1) | Moderate (4,20) | Moderate (1,20) | Moderate (20) |
| Ascalon sandy loam, AsC, 55-C | 267 | Slight | Slight | Slight | Slight-Mod.(1) | Moderate (8) |
| Nunn clay loam, NuA, 41M-A | 265 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Nunn clay loam, NuB | 256 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Ascalon sandy loam, AsB, 55-B | 99 | Slight | Slight | Slight | Slight | Moderate (8) |
| Ascalon sandy loam, AsD, 55-D | 75 | Slight-Mod.(1) | Slight-Mod.(1) | Slight-Mod.(1) | Mod.-Severe(1) | Moderate (1,8) |
| Nunn loam, N1B | 68 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Wiley & X40-C | 56 | Slight | Moderate (20) | Moderate (20) | Moderate (20,1) | Severe (8) |
| Colby complex | -- | Slight | Mod.-Severe(1) | Moderate(4,20) | Moderate(20,1) | Moderate (20) |
| Loamy alluvial gravelly, LV | 50 | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) |
| Weld loam, 41-A | 43 | Slight | Moderate (20) | Moderate (20) | Moderate (20) | Moderate(20,4,8) |
| Arvada loam, AdB | 230 | Moderate (28) | Moderate (20,4) | Moderate (20,4) | Moderate (20,4) | Severe (20,4) |
| Aquells & Awuepts, 34-AB | 34 | -- | -- | -- | -- | -- |
| Ascalon sandy loam, 55-A | 34 | Slight | Slight | Slight | Slight | Moderate (8) |
| Wet alluvial land, Wt | 33 | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) |
| Olney fine sandy loam, 21B-B | 28 | Slight | Slight | Slight | Slight | Severe (8) |
| Renohill loam & clay loam 66B-AB | 21 | Moderate (2,28) | Moderate (20) | Moderate (20) | Moderate (20) | Severe (20) |
| Ulm clay loam, 67B-CD | 17 | Slight | Severe (4,2) | Severe (4) | Severe (4) | Severe (20,4) |
| Kim loam, X53-C | 15 | Slight | Moderate (20) | Moderate (20) | Moderate (20) | Severe (8) |
| Renohill loam & clay loam 66B-CD | 13 | Mod.(1,2,28) | Moderate (1,20) | Moderate (20) | Moderate (1,20) | Severe (20) |
| Haverson loam, 30-B | 12 | Severe (3) | Severe (3) | Severe (3) | Severe (3) | Severe (3) |
| Heldt clay, H1D | 11 | Severe (28) | Severe (4,20) | Severe (4,20) | Severe (4,20) | Severe (4,20) |
| Tassel sandy loam, 84-DE | 7 | Mod.-Sev.(1,2) | Mod.-Sev. (1,2) | Mod.-Sev. (1,2) | Mod.-Sev.(1,2) | Mod.-Sev.(1,2,8) |
| Wiley & X40-A | 7 | Slight | Moderate (20) | Moderate (20) | Moderate (20) | Severe (8) |
| Colby complex | -- | Slight | Moderate (20) | Moderate (4,20) | Moderate (20) | Moderate (20) |
| Gravelly lands, Gr. | 981 | -- | -- | -- | -- | -- |
| Loamy alluvial, LU | 63 | Severe (3) | Severe (3) | Severe (3) | Severe (3) | Severe (3) |
| Ascalon sandy loam, AsC | 58 | Slight | Slight | Slight | Slight-Mod.(1) | Moderate (8) |
| Nunn (clay loam), NuC | 35 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Ulm loam, UlB | 19 | Slight | Severe (4) | Severe (4) | Severe (4) | Severe (4,20) |

| Septic tanks | Sewage lagoons | Sanitary land fill area | Playgrounds and parks | Roadfill | Gravel | Sand | Topsoil |
|---|---|---|---|---|---|---|---|
| Moderate (11) | Slight | Slight | Mod. (11) -Slight | Fair (4,20) | Unsuitable | Unsuitable | Fair (21) |
| Moderate (11) | Moderate (1) | Slight | Mod.(1,11)-Slight | Fair (4,20) | Unsuitable | Unsuitable | Fair (21) |
| Moderate (11) | Moderate(1,17) | Slight | Moderate(1,28) | Poor | Unsuitable | Unsuitable | Fair |
| Severe (2,11) | Severe (1,2) | Slight-Mod.(1) | Sev.(1)-Mod.(1,28) | Poor (20,21) | Unsuitable | Unsuitable | Poor (22) |
| Moderate (11) | Severe (1) | Slight-Mod.(1) | Sev.(1)-Mod.(1,28) | Poor | Unsuitable | Unsuitable | Fair |
| Severe(1,2,11) | Severe (1,2) | Moderate (1) | Severe(28,11,1) | Poor(4,20) | Unsuitable | Unsuitable | Poor (1,28) |
| Severe (1,2) | Severe (1,2) | Moderate (1) | Sev.(1,2)-Mod.(1) | Poor (21) | Unsuitable | Unsuitable | Poor (22) |
| Moderate (11) | Slight-Mod.(1) | Slight | Mod.(1,11)-Slight | Fair (20) | Unsuitable | Unsuitable | Fair (28) |
| Severe (3) | Severe (3) | Severe (3) | Severe (3) | Severe (3) | Unsuitable | Fair | Poor (3) |
| Slight | Moderate(17) | Slight | Moderate (1,15) | Fair(20) | Unsuitable | Unsuitable | Good |
| Moderate (6) | Severe (5,1) | Moderate (1) | Moderate (9) | Fair (20) | Unsuitable | Unsuitable | Fair |
| Slight | Moderate(1,17) | Slight | Slight-Mod.(1,24) | Fair (20) | Unsuitable | Unsuitable | Good |
| Severe (11) | Moderate(1,16) | Slight | Moderate(11,28) | Poor (4) | Unsuitable | Unsuitable | Fair (28) |
| Severe (11) | Moderate (1,16) | Slight | Mod. (1,11,28) | Poor (4) | Unsuitable | Unsuitable | Fair (28) |
| Slight | Moderate (17) | Slight | Slight | Fair (20) | Unsuitable | Unsuitable | Good |
| Slight-Mod.(1) | Mod.-Sev.(11,1) | Slight-Mod.(1) | Moderate (24,1) | Fair (20) | Unsuitable | Unsuitable | Good-Fair(1) |
| Severe (11) | Moderate (16,1) | Slight | Mod.(11,1)-Slight | Poor (4) | Unsuitable | Unsuitable | Fair (21) |
| Slight | Moderate (17) | Slight | Moderate(15,1) | Fair(20) | Unsuitable | Unsuitable | Good |
| Moderate (6) | Severe (5,1) | Slight | Moderate (9,1) | Fair (20) | Unsuitable | Unsuitable | Fair |
| Severe (3) | Severe (3) | Severe (3) | Severe (3) | Good | Good | Good | Poor (25) |
| Moderate (11) | Slight | Slight | Mod.(11)-Slight | Fair (20) | Unsuitable | Good | Fair (28) |
| Severe (11) | Moderate(1) | Slight | Sev.(11)-Slight | Poor(22,20) | Unsuitable | Good | Poor(27,22) |
| -- | -- | -- | -- | -- | -- | -- | -- |
| Slight | Moderate(17) | Slight | Slight | Fair (20) | Unsuitable | Good | Good |
| Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3) | Poor (25) | Fair-Good | Fair-Good | Poor (25) |
| Slight | Moderate(17,1) | Slight | Slight | Fair (20) | Unsuitable | Unsuitable | Good |
| Severe (11,2) | Severe (2) | Slight | Mod.(1,11,20,28) | Poor (20,21) | Unsuitable | Unsuitable | Poor (21) |
| Moderate (11) | Moderate(17) | Slight | Moderate(28) | Poor | Unsuitable | Unsuitable | Fair |
| Slight | Moderate(17,1) | Slight | Moderate(1,15) | Fair (20) | Unsuitable | Unsuitable | Good |
| Severe (11,2) | Severe (1,2) | Slight-Mod.(1) | Sev.(1)-Mod.(28) | Poor (20,21) | Unsuitable | Unsuitable | Poor (21) |
| Severe (3) | Severe (3) | Severe (3) | Sev.(3)-Mod.(3) | Fair (20) | Unsuitable | Unsuitable | Good |
| Severe (11) | Moderate(1) | Slight | Severe (11,28) | Poor(4,20) | Unsuitable | Unsuitable | Poor (28) |
| Severe (2) | Severe (2,5) | Severe(1,5) | Sev.(2)-Slight-Mod.(1) | Poor(21,22) | Unsuitable | Unsuitable | Poor (22,1) |
| Slight | Moderate (17) | Slight | Mod. (15) | Fair (20) | Unsuitable | Unsuitable | Good |
| Moderate (6) | Severe (5) | Slight | Moderate(9) | Fair (20) | Unsuitable | Unsuitable | Fair |
| -- | -- | -- | -- | -- | -- | -- | -- |
| Severe (3) | Severe (3) | Severe (3) | Severe (3) | Poor (3) | Unsuitable | Fair | Poor (3) |
| Slight | Moderate(1,17) | Slight | Slight-Mod.(1,29) | Fair (20) | Unsuitable | Fair | Fair (28) |
| Severe (11) | Moderate (1,16) | Slight | Moderate (11,28) | Poor (4) | Unsuitable | Fair | Fair (28) |
| Moderate (11) | Moderate (17) | Slight | Moderate (28) | Poor | Unsuitable | Fair | Fair |

Table A5--Soils classification and capabilities for agricultural and urban uses, Lower Clear Creek Ditch Company

| Soil series | Irrigated acreage | Non-irrigated acreage | Extent % | Slope % | Erodibility index | Capability for agriculture: Irrigated agriculture, class | Capability for agriculture: Non-irrigated agriculture, class | Winter wheat bu./acre |
|---|---|---|---|---|---|---|---|---|
| Nunn Clay Loam, NuA | 808 | 0 | 85 | 0-1 | 5 | IIs | IIIs | |
| Nunn Clay Loam, NuB | 588 | 0 | 85 | 1-3 | 5 | IIe | IIIs | 19 |
| Loamyalluvial, gravelly substratum, LV | 158 | 0 | 85 | Level | - | Vw | | |
| Loamy alluvial, moderately wet, LW | 157 | 0 | 85 | Level | | Vw | | |
| Terrace escarpment,Tc | 138 | 0 | 85 | | | VIIe | VIIe | |
| Sandy alluvial lands, SM | 137 | 0 | 85 | Level | | VIIw | VIIw | |
| Wet alluvial land, Wt | 133 | 0 | 85 | Level | | Vw | Vw | |
| Dacono loam, DaB | 114 | 0 | 85 | 1-3 | 5 | IIIe | IVs | |
| Dacono loam, DaA | 83 | 0 | 85 | 0-1 | 5 | IIIs | IVs | |
| Heldt clay, H1B | 71 | 0 | 85 | 0-3 | 5 | IIIs | IVs | 19 |
| Heldt clay, H1D | 66 | 0 | 85 | 3-9 | 5 | IVe | VIe | |
| Nunn loam, N1B | 64 | 0 | 85 | 1-3 | 5 | IIe | IIIc | |
| Ulm loam, U1C | 43 | 0 | 85 | 3-5 | 5 | IIIe | IVe | 14 |
| Ulm loam, U1D | 32 | 0 | 85 | 5-9 | 5 | IVe | VIe | |
| Samsil & | 19 | 0 | 40 | 3-25 | 2 | VIIe | VIIe | |
| Shingle complex, ShF | | | 40 | 3-25 | 2 | VIIe | VIIe | |

Table A6--Limitations of soils for urban development and use, Lower Clear Creek Ditch Company

| Soil series | Total acres | Shallow excavations | Dwellings without basements | Dwellings with basements | Small commercial buildings | Local roads and streets |
|---|---|---|---|---|---|---|
| Nunn Clay Loam, NuA | 808 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Nunn Clay Loam, NuB | 588 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Loamy alluvial, gravelly substratum,LV | 158 | Severe (3,35) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) |
| Loamy alluvial, moderately wet, LW | 157 | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) |
| Terrace escarpments, Tc | 138 | Severe | Severe | Severe | Severe | Severe |
| Sandy alluvial lands, SM | 137 | Severe (3) | Severe (3) | Severe (3) | Severe (3) | Severe (3) |
| Wet alluvial land, Wt | 133 | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) |
| Dacono loam, DaB | 114 | Severe (18) | Slight | Slight | Slight | Severe (4) |
| Dacono loam, DaA | 83 | Severe (18) | Slight | Slight | Slight | Severe (4) |
| Heldt clay, H1B | 71 | Severe (28) | Severe (4,20) | Severe (4,20) | Severe (4,20) | Severe (4,20) |
| Heldt clay, H1D | 66 | Severe (28) | Severe (4,20) | Severe (4,20) | Severe (4,20) | Severe (4,20) |
| Nunn loam, N1B | 64 | Moderate (28) | Severe (4) | Moderate (4) | Severe (4) | Severe (4) |
| Ulm loam, U1C | 43 | Slight | Severe (4) | Severe (4) | Severe (4) | Severe (4,20) |
| Ulm loam, U1D | 32 | Slight - Mod. (1) | Severe (4) | Severe (4) | Severe (1,4) | Severe (4,20) |
| Samsil & | | Severe (1,28) | Severe (1,4,20) | Severe (1,4,20) | Severe (1,4,20) | Severe (1,4,20) |
| Shingle complex, ShF | 19 | Severe (1,2) | Severe (1,2) | Severe (1,2) | Severe (1,2) | Severe (1,2) |

| Crop production potential | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Spring wheat | | Alfalfa | Sugar | Corn | Corn silage | Barley | | Range production | | |
| Irrig. | Nonirrig. | irrig. | beets | irrig. | irrig. | Irrig. | Nonirrig. | lbs. dry matter/A. | | |
| bu./acre | bu./acre | T/A. | T/A. | bu./acre | T/acre | bu./acre | bu./acre | H | M | L |
| 50 | | 5.5 | 24 | 120 | 28 | 50 | | 1,300 | 950 | 800 |
| 45 | 19 | 5.5 | 23 | 110 | 26 | 45 | | 1,300 | 950 | 800 |
| 40 | | 4.5 | 22 | 100 | 24 | 40 | | 1,200 | 1,000 | 600 |
| 50 | | 5.0 | 26 | 120 | 26 | 50 | | 1,200 | 1,000 | 600 |
| 25 | 19 | 5.0 | 20 | 90 | 20 | 40 | 20 | 1,700 | 1,200 | 500 |
| 25 | | 3.5 | | | | | | 1,700 | 1,200 | 500 |
| 60 | 25 | 5.5 | 25 | | | | | 1,800 | 1,400 | 1,000 |
| 40 | 14 | 3.5 | 17 | 85 | 14 | 40 | 15 | 1,100 | 800 | 500 |
| 25 | | 3.0 | | | 12 | 25 | | 1,100 | 800 | 500 |

| Septic tanks | Sewage lagoons | Sanitary land fill area | Playgrounds and parks | Source materials for: Road fill | Gravel | Sand | Top soil |
|---|---|---|---|---|---|---|---|
| Severe (11) | Moderate (1,16) | Slight | Moderate (11,28) | Poor (4) | Unsuitable | Unsuitable | Fair (28) |
| Severe (11) | Moderate (1,16) | Slight | Moderate (1,11,28) | Poor (4) | Unsuitable | Unsuitable | Fair (28) |
| Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Good | Good | Good | Poor (3,25) |
| Severe (3,25) | Severe | Severe (3,25) | Severe (3,25) | Poor (3,25) | Unsuitable | Fair | Poor (3,25) |
| Severe | Severe | Severe | -- | -- | -- | -- | -- |
| Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Poor (3,25) | Fair | Good | Poor (25) |
| Severe (3,25) | Severe (3,25) | Severe (3,25) | Severe (3,25) | Poor (25) | Fair - Good | Fair - Good | Poor (25) |
| Slight | Moderate (16,1) | Slight | Moderate (1,28) | Fair (4) | Poor | Good | Fair (28) |
| Slight | Moderate (16) | Slight | Moderate (28) | Fair (4) | Poor | Good | Fair (28) |
| Severe (11) | Slight-Mod. (1) | Slight | Severe (28,11) | Poor (4,20) | Unsuitable | Unsuitable | Poor (28) |
| Severe (11) | Moderate (1) | Slight | Severe (28,11) | Poor (4,20) | Unsuitable | Unsuitable | Poor (28) |
| Severe (11) | Moderate (16,1) | Slight | Moderate (11,1) | Poor (4) | Unsuitable | Unsuitable | Fair (21) |
| Moderate (11) | Moderate (16,1) | Slight | Moderate (1,28) | Poor | Unsuitable | Unsuitable | Fair |
| Moderate (11) | Severe (1) | Slight-Mod. (1) | Severe (28,1) | Poor | Unsuitable | Unsuitable | Fair |
| Severe (1,2,11) | Severe (1,2) | Moderate (1) | Severe (1,28,11) | Poor (4,20) | Unsuitable | Unsuitable | Poor (1,28) |
| Severe (1,2) | Severe (1,2) | Moderate (1) | Severe (1,2) | Poor (21) | Unsuitable | Unsuitable | Poor (22) |

Table A7.

This alternative has change in all irrigated ag sectors and dairy sector.

Original data and direct change

| | Sector | Original TGO ($1000) | Water Coef. (Gal./$) | Total Water (Ac. Ft.) | Water Change (Ac. Ft.) | TGO Change ($1000) |
|---|---|---|---|---|---|---|
| 1 | Dairy | 68338.00 | 29.27 | 6138.16 | -227.17 | -2529.10 |
| 2 | Other Livestock | 882918.00 | 6.86 | 18586.49 | 0.00 | 0.00 |
| 3 | | 10.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 4 | Sugar Beets and Misc. | 48729.00 | 1640.89 | 245369.13 | -5510.72 | -1094.40 |
| 5 | All Hay | 85479.00 | 2413.04 | 632960.94 | -12958.52 | -1750.00 |
| 6 | Other Irrigated Crops | 186774.00 | 1215.55 | 696694.21 | -24646.94 | -6607.50 |
| 7 | Dryland Crops | 135271.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8 | Metal Mining | 222015.00 | 50.52 | 34419.03 | 0.00 | 0.00 |
| 9 | Industrial Materials | 195068.00 | 4.51 | 2699.70 | 0.00 | 0.00 |
| 10 | Coal | 42308.00 | 3.21 | 416.75 | 0.00 | 0.00 |
| 11 | Petroleum Products | 128925.00 | 4.77 | 1887.16 | 0.00 | 0.00 |
| 12 | Food and Kindred Prods. | 1787260.00 | .33 | 1809.90 | 0.00 | 0.00 |
| 13 | Textile, Leather, Apparel | 108940.00 | .30 | 100.29 | 0.00 | 0.00 |
| 14 | Lumber and Wood Prods. | 117700.00 | 13.14 | 4745.97 | 0.00 | 0.00 |
| 15 | Paper and Allied Prods. | 53240.00 | .24 | 39.21 | 0.00 | 0.00 |
| 16 | Printing and Publishing | 208600.00 | .08 | 51.21 | 0.00 | 0.00 |
| 17 | Chemicals, Rubber Prods. | 327360.00 | 7.54 | 7574.43 | 0.00 | 0.00 |
| 18 | Petroleum Refining | 89900.00 | 3.57 | 984.87 | 0.00 | 0.00 |
| 19 | Primary Metals | 239580.00 | 9.19 | 6756.46 | 0.00 | 0.00 |
| 20 | Fabricated Metals | 1062756.00 | 1.50 | 4891.90 | 0.00 | 0.00 |
| 21 | Electronics | 528697.00 | .25 | 405.60 | 0.00 | 0.00 |
| 22 | All Other Manufacturing | 94615.00 | 1.88 | 545.85 | 0.00 | 0.00 |
| 23 | Trans., Comm. and Util. | 1081292.00 | 4.70 | 15595.30 | 0.00 | 0.00 |
| 24 | Pipeline Trans. | 267650.00 | .47 | 386.03 | 0.00 | 0.00 |
| 25 | Natural Gas Distribution | 89623.00 | .10 | 27.50 | 0.00 | 0.00 |
| 26 | Electric Power Generation | 112802.00 | 29.70 | 10280.78 | 0.00 | 0.00 |
| 27 | Trade | 5807247.00 | .21 | 3742.33 | 0.00 | 0.00 |
| 28 | Industrial Services | 59412.00 | .59 | 107.57 | 0.00 | 0.00 |
| 29 | All Other Services | 1975044.00 | .59 | 3575.87 | 0.00 | 0.00 |
| 30 | Elem., Second. Educ. | 480580.00 | .56 | 825.86 | 0.00 | 0.00 |
| 31 | Higher Education | 317198.00 | .56 | 545.09 | 0.00 | 0.00 |

Water and employment coefficients were inflated to reflect 1974 price relationships. This was done using 1974/1970 agricultural price and nonagricultural price index. Income coefficients are a percentage of output so they could not be changed without changing the technical coefficients. They probably would not have changed much, and it is difficult to predict in which direction.

Table A8.

This alternative has change in all irrigated ag sectors and dairy sector.

| | Sector | Final Demand ($1000) | Total Gross Output ($1000) | Consumptive Water Use (Acre Feet) | Labor (Man Years) | Income ($1000) | Withdrawal Water Use (Acre Feet) |
|---|---|---|---|---|---|---|---|
| 1 | Dairy | -2437.566 | -2529.100 | -227.165 | -83.460 | -554.315 | -255.182 |
| 2 | Other Livestock | 0.000 | -488.417 | -10.282 | -10.257 | -75.428 | -11.556 |
| 3 | | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 4 | Sugar Beets and Misc. | -1068.707 | -1094.400 | -5510.722 | -26.266 | -268.518 | -9680.479 |
| 5 | All Hay | -1354.236 | -1750.000 | -12958.524 | -54.250 | -306.273 | -22763.662 |
| 6 | Other Irrigated Crops | -6073.367 | -6607.500 | -24646.937 | -132.150 | -1226.517 | -43296.327 |
| 7 | Dryland Crops | 0.000 | -46.231 | 0.000 | -1.341 | -10.259 | 0.000 |
| 8 | Metal Mining | 0.000 | -.904 | -.140 | -.024 | -.215 | -.283 |
| 9 | Industrial Materials | 0.000 | -43.313 | -.599 | -1.040 | -7.903 | -17.117 |
| 10 | Coal | 0.000 | -6.267 | -.062 | -.157 | -1.928 | -.069 |
| 11 | Petroleum Products | 0.000 | -19.055 | -.279 | -.591 | -7.144 | -.786 |
| 12 | Food and Kindred Prods. | 0.000 | -1103.585 | -1.118 | -12.139 | -99.618 | -11.717 |
| 13 | Textile, Leather, Apparel | 0.000 | -190.495 | -.175 | -10.287 | -61.857 | -1.923 |
| 14 | Lumber and Wood Prods. | 0.000 | -14.661 | -.591 | -.469 | -2.794 | -1.154 |
| 15 | Paper and Allied Prods. | 0.000 | -43.553 | -.032 | -1.045 | -7.677 | -.163 |
| 16 | Printing and Publishing | 0.000 | -59.037 | -.014 | -2.480 | -19.465 | -.136 |
| 17 | Chemicals, Rubber Prods. | 0.000 | -1271.180 | -29.412 | -31.779 | -297.625 | -183.691 |
| 18 | Petroleum Refining | 0.000 | -11.434 | -.125 | -.091 | -.747 | -.481 |
| 19 | Primary Metals | 0.000 | -26.450 | -.746 | -.794 | -7.524 | -2.868 |
| 20 | Fabricated Metals | 0.000 | -213.137 | -.981 | -3.836 | -32.681 | -4.114 |
| 21 | Electronics | 0.000 | -120.435 | -.092 | -2.890 | -27.331 | -.521 |
| 22 | All Other Manufacturing | 0.000 | -37.897 | -.219 | -2.084 | -15.298 | -1.640 |
| 23 | Trans., Comm. and Util. | 0.000 | -529.846 | -7.642 | -20.664 | -188.293 | -38.209 |
| 24 | Pipeline Trans. | 0.000 | -44.804 | -.065 | -.045 | -.484 | -.646 |
| 25 | Natural Gas Distribution | 0.000 | -56.252 | -.017 | -1.181 | -8.517 | -.171 |
| 26 | Electric Power Generation | 0.000 | -54.146 | -4.935 | -.866 | -6.864 | -98.819 |
| 27 | Trade | 0.000 | -1323.601 | -.853 | -34.414 | -204.185 | -8.773 |
| 28 | Industrial Services | 0.000 | -5.064 | -.009 | -.182 | -1.979 | -.092 |
| 29 | All Other Services | 0.000 | -2746.027 | -4.972 | -123.571 | -616.955 | -49.886 |
| 30 | Elem., Second. Educ. | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 31 | Higher Education | 0.000 | -30.117 | -.052 | -3.494 | -16.008 | -.513 |
| | Total | | | -43406.760 | -561.847 | -4074.404 | -76430.981 |

Table A9--Annual water diversions, standard deviations and coefficient of variation, three irrigation companies, 1961-1973

| Year | Farmers' Reservoir and Irrigation Company | Farmers' Highline Canal and Reservoir Company | Lower Clear Creek Ditch Company |
|---|---|---|---|
| | Irrigation Company | | |
| | | Acre Feet | |
| 1961 | 12,811 | -- | 9,936 |
| 1962 | 14,235 | 45,556 | -- |
| 1963 | 6,762 | 42,154 | 8,568 |
| 1964 | 8,778 | 27,925 | 8,624 |
| 1965 | 11,862 | 33,250 | 9,288 |
| 1966 | 11,388 | 48,678 | 9,900 |
| 1967 | 14,235 | 21,534 | 6,320 |
| 1968 | 16,607 | 38,776 | 5,154 |
| 1969 | 16,608 | 40,884 | 10,057 |
| 1970 | 10,202 | 41,180 | 10,940 |
| 1971 | 16,608 | 41,850 | 10,751 |
| 1972 | 18,980 | 45,470 | 9,829 |
| 1973 | 17,794 | 37,402 | 7,550 |
| TOTAL | 176,870 | 464,659 | 106,917 |
| Mean | 13,605.38 A.F. | 38,721.5 A.F. | 8,909.75 A.F. |
| Std. Deviation | 3,703.24 A.F. | 7,457.27 A.F. | 1,776.22 A.F. |
| Coefficient of variation | 27% | 19% | 19% |