MUNICIPAL WATER USE IN NORTHERN COLORADO: DEVELOPMENT OF EFFICIENCY OF USE CRITERION

by

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Colorado Water Resources Research Institute

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Colorado Water Resources Research Institute
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Application Summary

Project: A-042-COLO *Municipal Water Use in Northern Colorado: Development of Efficiency-of-Use Criterion*

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Water shortages, high costs of treatment and rapid growth of urban communities have imposed severe pressures on water utilities, especially those serving small towns. In order to evaluate how such a group of cities could better meet their demand for water, this study was inaugurated. Twenty-five cities and towns in Northern Colorado were selected. Their water use patterns were characterized by whether or not they were metered, whether summer water use restrictions were customarily imposed and whether their source of supply was ground water or surface water. In addition, the towns were grouped into two population groups: those classified as urban with populations between 13,000 and 100,000 and those with populations less than 13,000.

Water officials and managers of the towns were personally interviewed. Water customers were surveyed using a random sample taken from the lists of water customers for selected towns. The selected towns were chosen so that one town represented a category of similar towns. These categories were: (1) rural, unmetered towns that had restrictions; (2) rural metered towns that had restrictions; (3) rural unmetered towns that did not have restrictions, (4) rural metered towns that did not have restrictions. The urban towns were similarly classified giving eight possible categories. Since

there were no unmetered, urban towns without restrictions, this category was eliminated. Questionnaires were mailed to 125 water customers in each of the seven sample towns.

The results of the consumer survey were compared with the managers' opinions so that areas of commonality and areas of difference could be determined.

Based on this study it can be concluded that long-range conservation policies of the area towns have yet to be formulated. Public education on water matters appears to be the key to successful water conservation. Most managers were convinced that their city could handle a drought situation and that their customers would cooperate in any necessary conservation effort. The customer survey confirmed these convictions. However, experience may indicate that managers should not rely on restrictions on use to reduce demand over the long run, because such regulations appear to lose their impact with time. Rather, restrictions should be used to reduce peak demands during water short periods. Water demand can be modified by metering and price adjustments, and to some extent by water-saving devices.

Conservation measures such as water-saving devices and changes in outdoor vegetation have been advocated in a sporadic manner if at all. The psychological effect of such measures needs to be recognized even if the actual savings are small.

Water Conservancy Districts and other forms of regional cooperation in the sale, transfer and development of water supply and distribution are likely to play increasingly important roles in municipal water affairs for towns such as those studied. Such organizations could, in addition to water supply administration, control demand through required metering, price schedules and limiting use of restrictions to emergencies only. In addition, they could be effective vehicles for conducting workshops and other educational efforts leading to improved water conservation.

Long range conservation recommendations for the small cities and towns include the following:

- Implement universal metering.
- Develop new sources of supply and/or acquire new rights.
- Require low-flow devices in new construction.
- Require more use of native vegetation, or limit lawn sizes, in new housing areas.
- Establish a uniform or increasing block price structure.
- Reuse water for irrigation or other non-drinking purposes.
- Restrict growth (favored by consumers but not by managers).

Drought contingency plans should be developed by each utility to include plans to:

- Implement restrictions or rationing on a definite schedule depending on severity of drought.
- Apply a penalty rate price structure to maintain revenues.
- Require installation of water-saving devices in all households.
- Promote public education of drought severity.

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Many people assisted in the data collection and patiently answered questions about their practices and their attitudes regarding water supply and wastewater disposal management. The following list includes some of these people and also others who have given us the benefit of their comments on the report. Some individuals may have been inadvertently omitted, and we thank them also. The Town Clerks have been especially helpful in locating officials and in providing many necessary details. The report and its conclusions, are, of course, the sole responsibility of the authors.

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ABSTRACT

Water shortages, costs of treatment and rapid growth impose severe pressures on urban water utilities, especially those serving smaller cities and towns. In this study of more than two dozen Northern Colorado towns data was acquired on residential water use and the attitudes and perceptions of water officials and managers with regard to water conservation and meeting future demands. In addition, a random mail survey was made of water customers of selected towns to assess the consumers' attitudes toward various water conservation programs and how shortages should be met. The results of this three-pronged effort permitted a comparison of managers' attitudes with those of consumers leading to various recommendations for development of water conservation programs that would be implementable.

Recommendations for long-range conservation include universal metering, development of new supplies and water rights, requirements for low-flow devices and native vegetation in new housing areas, increasing block pricing, public education, reuse of water for non-drinking puposes, and possibly restrict growth.

Drought contingency plans are a priority need and should include a) public education of drought and its consequences, b) installation of water saving devices, c) implementation of restrictions and allotments, and d) surcharges on prices for metered services.

Chapter 1

INTRODUCTION

In making decisions regarding water sources, storage, distribution, and subsequent disposal, the managers of water and wastewater systems of cities and towns with rapid growth rates have the options of increasing their supply, or of trying to make more efficient use of their present water supply. This study looks at the pattern of water use in some 25 eastern slope communities of Northern Colorado, and examines the incentives, or disincentives, including consumer attitudes, which affect decisions on more efficient use of existing water supplies.

I. Efficiency-in-Use

Efficiency-in-use is used here to mean meeting a desired goal, in this case the demand of urban consumers for water, with a minimum of effort, expense or waste. In this connection it is, perhaps, important to make a distinction between demand and use. Traditionally water demand has been considered synonomous with water use. However, some management strategies affect use without necessarily affecting demand; others affect use and may alter demand after time is allowed for adjustments. For example, if water is rationed for lawn irrigation, consumers may use less even though their demand for lawn water remains the same. In time they may shift to smaller lawns or some type of vegetation requiring less moisture, or be satisfied with the appearance of their lawns and then their demand as well as their use decreases. Attempts by municipalities to restrict the quantity or the nature of water use or to alter its time pattern of usage, as well as other measures which affect either the immediate use of, or the long-term demand for, water are examined in this study in relation to efficiency-in-use.

II. Perspective

Domestic water withdrawals are a relatively small proportion of total withdrawals in the U.S., about six percent nationally. In the West, about 35 percent of this withdrawal is consumptively used, amounting to about two percent of the national consumptive use. Irrigation, on the other hand, accounts for 47 percent of total national withdrawals, and 81 percent of consumptive use (U.S. Water Resources Council, 1978). Likewise, in the Front Range area of Colorado municipal use is a small portion of total water use as compared with agriculture. With increasing population growth along the Front Range, municipal use can be expected to assume greater importance, and to compete more and more with the agricultural, energy-related and other uses for the limited water supply.

In his Water Resources Policy Reform message of June 6, 1978, President Carter reaffirmed his commitment that water conservation would be a cornerstone of Federal water resources policy, stating that:

> Managing our vital water resources depends on a balance of supply, demand and wise use. Using water more efficiently is often cheaper and less damaging to the environment than developing additional supplies. While increases in supply will still be necessary, these reforms place emphasis on water conservation and make clear that this is now a national priority.

At the state level, Governor Richard D. Lamm in his opening address to the Colorado legislature on January 4, 1979, stressed that:

> As we develop our water resources, we also must intensify our conservation and wise utilization of water. Too often in the past we have forgotten that we live in a semi-arid region. With new demands and competition, it is clear that conservation is the best way of stretching our limited resources. Moreover, we know that conservation can help to reduce, and in certain cases eliminate, the expensive and capital intensive requirements of water development and treatment.

Neither of these statements define the word "conservation", or do they indicate how and by whom water not used in one way is to be allocated for other uses.

In an effort to clarify the meaning of "conservation", the U.S. Water Resources Council (1979) considered it as a part of planning:

> Water conservation shall be fully integrated into project and program planning and review as a means of achieving both the national economic development and environmental objectives. Water conservation consists of actions that will (a) reduce the demand for water; (b) improve efficiency in use and reduce losses and waste; and (c) improve land management practices to conserve water. A clear contrast is drawn between the above conservation elements and storage facilities for new supplies.

While this statement still does not define conservation, it does offer three policy options which are open to managers of municipal water supplies. These options are in fact considered in varying degrees by all the towns participating in this study but applied by a relatively small number of them.

Numerous strategies for urban water conservation have been proposed along with estimates of the amounts of water expected to be saved (see Flack et al., 1977, for a handbook describing them). An illustrative list of water conservation measures and regulations affecting municipal policies

(Baumann et al., 1980) is given in Table 1. These include regulations, restrictions/rationing, reduction of system losses, incentives and subsidies, and public education; all of which can be implemented by the utility. Other programs, although sponsored by a utility, are implemented by the water consumers themselves and include various voluntary compliances and self-initiated responses to conservation.

The extent and degree to which these conservation methodologies have been put in practice in the Northern Colorado cities and towns will be delineated in the following chapters.

TABLE 1

MEASURES AFFECTING WATER USE AND DEMAND

REGULATIONS

Federal and State Laws and Policies

A. Presidential Policy
B. PL 92-500
C. Clean Water Act Amendment 1977
D. Safe Drinking Water Act

Local Codes and Ordinances

A. Plumbing Codes for New Structures
B. Retrofitting
C. Sprinkling Ordinances
D. Changes in Landscape Design
E. Water Recycling

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A. Rationing
   1. Fixed
   2. Variable Percentage Plan
   3. Per Capita Use
   4. Prior Use Basis

B. Determination of Water Use Priorities
   1. Restrictions on Public and Private Recreational Uses
   2. Restrictions on Commercial and Institutional Uses
   3. Car Wash and Similar Restrictions

MANAGEMENT

A. Decrease of Loss in Transmission, i.e., Lined Ditches, Piped, etc.

B. Leak Detection

C. Rate Making Policies
   1. Metering
   2. Pricing Policies
      a. Marginal Cost Pricing
      b. Increasing Block Rate
      c. Peakload Pricing
      d. Seasonal Pricing
      e. Summer Surcharge
      f. Excess Use Charge

D. Tax Incentives and Subsidies

E. Use of Waste Water Flow to Increase Usable Supplies Through Trading.

EDUCATION

A. Direct Mail

B. News Media

C. Personal Contact -Speaker Program

D. Special Events -School Programs

Source: Adapted from Baumann et al.(1980)

Chapter 2

THE STUDY AREA AND COMMUNITIES

I. The Study Area

The communities selected for this study are part of the geographic area commonly known as the Northern Colorado Front Range. This area, which lies along the foothills of the east slope of the Rocky Mountains north of Denver, consists primarily of Boulder, Larimer, and Weld Counties. The climate is semi-arid, with precipitation averaging approximately 15 inches annually.

The entire Front Range has been experiencing unprecedented population growth for the past 20 years. During the decade 1960-1970, the population of the United States increased 13.4 percent; Colorado's population increased 24.8 percent; and the population of the Front Range urban counties increased 33.8 percent (Foss, 1978). This rapid growth will continue to tax the capabilities of area water utilities to meet the increased demand for water supplies for municipal uses.

Twenty-five cities and towns in the Northern Front Range area were selected for this study including all the larger cities and a group of the smaller towns, some using surface supplies and some with groundwater sources. Three mountain communities as well as two groundwater towns further east on the South Platte river were also included to a certain extent. Figure 1 is a map showing the locations of the communities.

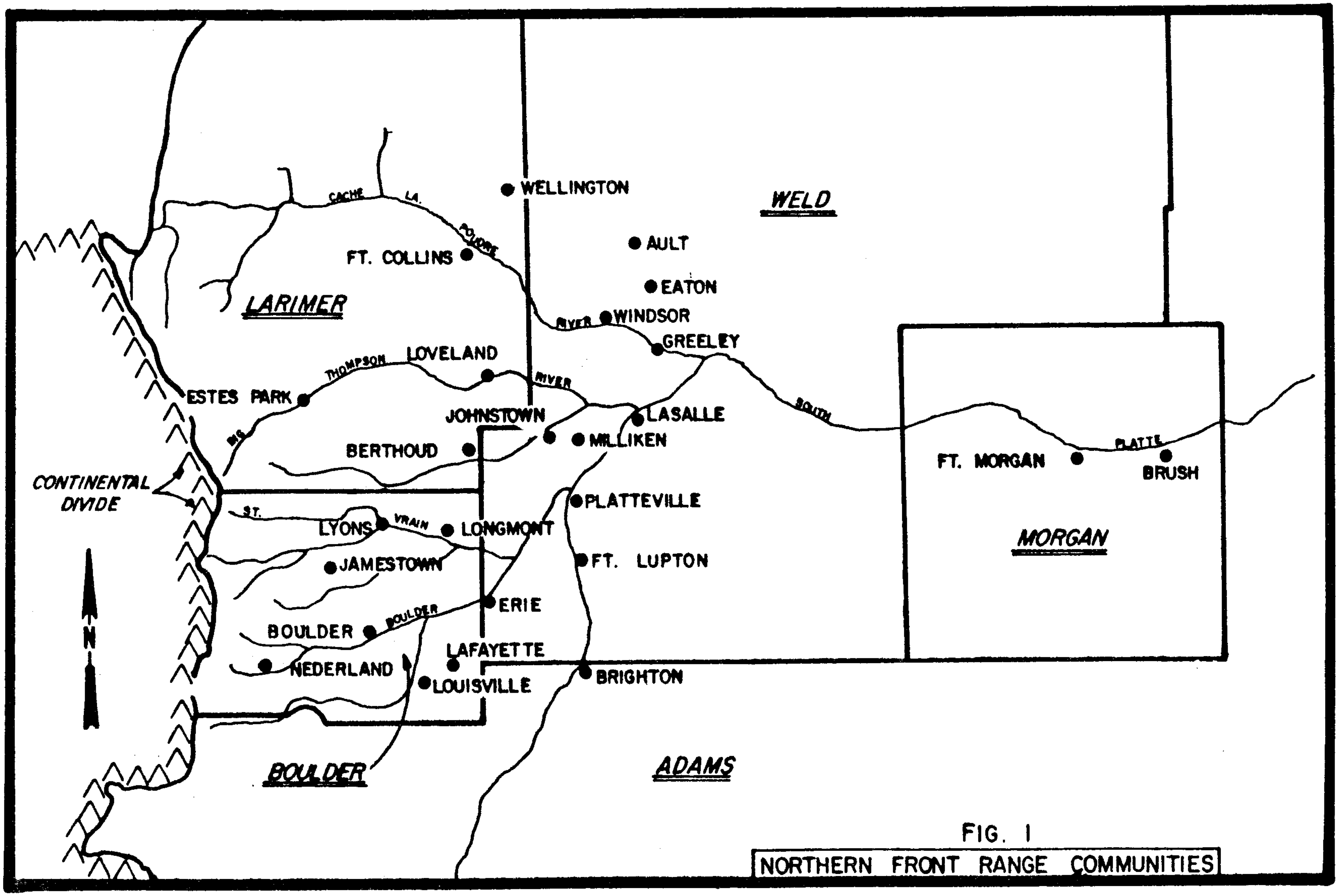


FIG. 1

NORTHERN FRONT RANGE COMMUNITIES

The towns are generally neat, well kept and very green, with many single family residences surrounded by lawns and trees. The mountain towns have more native vegetation, with little or no lawn area. Irrigated farmland separates the communities in the plains area, with dryland farming or pasture between those on the more rolling land, except where strip development encroaches along some highways. Mean precipitation varies from 12.2 inches per year in Greeley to 18.9 inches in Boulder, making summer irrigation a requirement for green lawns.

Present projections of population growth for the sample towns indicate an average increase of 50 percent between 1980 and 1990, with a range of 11 to 119 percent (Table 2). The water systems of these towns serve about 372,000 people, and by the year 2000 are expected to serve nearly 500,000. The five larger towns contain 84 percent of the people served.

In this study, the communities have been segregated on four bases: (1) population, (2) whether their residential water users are on meters or flat rate, (3) whether restrictions on water use were in effect during the study period 1975-78, and (4) the source of supply, surface or groundwater.

II. Water Supplies

The municipalities in the study area derive their raw water supplies from either surface runoff or groundwater. Surface runoff originates from two sources: in-basin or native runoff and trans-mountain diversions from the west slope of the Continental Divide. In-basin surface water originates from the South Platte River and its tributaries which drain the study area. The towns obtain their water supply from four sub-basins: Boulder Creek, St. Vrain Creek, Big Thompson River and the Cache la Poudre River. All the

TABLE 2

TYPE OF WATER SYSTEM AND POPULATION
NORTHERN COLORADO TOWNS, 1980 AND 1990

	1980	1990	Percent Change
Groundwater - unmetered			
Brighton	12,287	17,433	+42
Eaton	2,200	3,200	+45
Fort Lupton	3,500	4,600	+31
Fort Morgan	10,000	(not available)	
La Salle	2,000	3,200	+60
Plattville	1,730	2,410	+39
Wellington	2,000	2,700	+35
Groundwater - metered			
Brush	4,087	4,539	+11
Surface water - unmetered or partially metered			
Greeley	65,760	89,000	+35
Fort Collins	80,200	112,500	+40
Longmont	47,300	68,200	+44
Loveland	31,300	43,400	+39
Berthoud	3,800	5,300	+39
Louisville	6,200	13,600	+119
Lyons	1,350	2,000	+48
Jamestown (mt.)	230	<500	± 95
Nederland (mt.)	900	1,500	±66
Surface water - metered			
Boulder	76,895	90,904	+18
Ault	1,100	2,000	+82
Erie	1,800	2,500	+39
Estes Park (mt.)	2,100	3,000	+43
Johnstown	1,590	1,850	+16
Lafayette	8,500	11,900	+40
Milliken	1,500	2,500	+40
Windsor	4,000	7,500	+88

Source: County Planning/Land Use Departments of Boulder, Larimer and Weld Counties; Dept. of Local Affairs, State of Colorado.

larger towns, and 12 of the smaller ones, use surface sources. The remaining eight smaller towns use wells which pump water from aquifers tributary to the streams of the study area.

A. Surface Water Rights.

Towns utilizing surface water runoff for municipal use receive their water from a combination of four different types of water rights; 1) direct flow, 2) storage rights, 3) irrigation ditch company stock, and 4) Colorado-Big Thompson Project water. A listing of the types of rights held by the towns is shown in Table 3. Towns seeking to increase their water supplies usually purchase ditch company stock or units of Colorado-Big Thompson Project water. Due to the fact that the surface water supply along the Front Range is already overappropriated, the filing for new direct flow rights is impractical. Several towns have, however, filed for new storage rights. This option may still be viable depending on available flows, proposed reservoir sites, and the market price of existing water rights.

B. Groundwater Rights.

The towns utilizing groundwater for municipal supplies, with the exception of Jamestown withdraw water from wells tributary to the South Platte River. These wells are subject to senior surface water rights on the South Platte. All of these towns are members of G.A.S.P., Groundwater Appropriators of the South Platte. GASP acts to replace a portion of the depletions to the river on behalf of the groundwater users in order to prevent junior wells from having to cease pumping when streamflows are inadequate to meet senior surface water rights. (The future operation of GASP is uncertain because the legality of its operations has not yet been tested in the Colorado courts.)

TABLE 3

SURFACE WATER RIGHTS OWNED BY MUNICIPALITIES, 1979

Town	Direct Flow[a]	Storage[b]	Ditch Company[c]	CBT Units[d]
Ault[e]	—	—	—	360
Berthoud	Big Thompson River #1 (7.14 cfs)	—	Handy Ditch - 9 Shares Loveland Lake & Ditch - 3 Shares	432
Boulder	Boulder Creek (70 cfs)	Barker (8000 AF) Other Reservoirs	Various Ditch Company Shares	19,500
Erie	—	—	South Boulder Canyon Ditch - 120 Shares Leyner-Cottonwood Ditch - 155 Shares	0
Estes Park	Fall River, Black Canyon, Glacier Creek	—	—	45-
Ft. Collins	Cache La Poudre (19 cfs)	Joe Wright (6700 AF)	Various Ditch Company Shares	10,200
Greeley	Cache La Poudre (12.5 cfs)	Small Reservoirs (13,230 AF)	Various Ditch Company Shares	18,200
Johnstown	Big Thompson River	—	Home Supply Ditch, 1.25 Shares	615
Jamestown	—	—	Left Hand Ditch, 24 Shares	0
Lafayette	—	Wanaka Reservoir (150 AF)	Howard Ditch, South Boulder & Bear Creek Ditch, Dry Creek #2 Ditch, Goodhugh Ditch, Davidson Ditch	0
Longmont	St. Vrain Creek	Buttonrock (18,000 AF) Other Small Reservoirs	Various Ditch Company Shares	7,800
Loveland	Big Thompson River (9.44 cfs)	(600 AF)	Various Ditch Company Shares	7,000
Lyons	North St. Vrain (4.9 cfs)	Buttonrock (300 AF)	—	250
Louisville	—	Marshall (93 AF) Louisville - (290)	Various Ditch Company Shares	0

TABLE 3 (Continued)

SURFACE WATER RIGHTS OWNED BY MUNICIPALITIES, 1979

Town	Direct Flow	Storage	Ditch Company	CBT Units
Milliken[e]	—	—	—	85
Nederland	Middle Boulder Creek	Barker - (19AF)	North Boulder Farmer's Ditch	0
Windsor[e]	—	Donath Lake	Louden Ditch	—

a. Direct flow in cubic feet per second (cfs).

b. Storage units in acre-feet (AF).

c. Ditch company shares yield different quantities of waters.

d. CBT - Colorado Big Thompson Project, North Colorado Water Conservancy District.

e. Windsor, Ault, and Milliken are supplied by independent water districts.

III. Water Use, Metering and Rates

The type of water source, status regarding metering, and average daily water use per capita in 1978, are shown in Figure 2. Many town records do not separate industrial and commercial use from residential use. The values have been adjusted to remove the largest industrial users, but they are only approximate.

Using the total water use divided by the town population to give the average per capita daily use for each town, the groundwater towns without meters used the largest amount, an average of 288 gpcd; the surface water towns without meters followed with 184 gpcd; and the surface water towns with meters used least with 161 gpcd. The one metered groundwater town used 171 gpcd. Four of the towns did not have complete records for 1978. The towns are clearly handicapped by poor record keeping; only 11 of the 25 had adequate records of use over the period 1975-1978.

Unmetered towns charge a flat-rate to inside-the-city, single family residential customers. Although classed as unmetered, some towns do have metered single-family residences within the city limits, for instance, approximately one-third of Greeley's single family customers are metered. Minimum charges to flat-rate users ranged from less than $4 per month in Greeley to over $12 per month in Loveland as shown in Table 4. Most towns have additional charges for flat-rate customers based on the number of rooms or lot size.

Water rates in the metered towns, shown in Table 5, differed markedly with respect to minimum charges. The minimum charge ranged from a low of $2.50 per month in Boulder to a high of $10.50 per month in Milliken. The minimum amount of water associated with the base charge also varied. Boulder

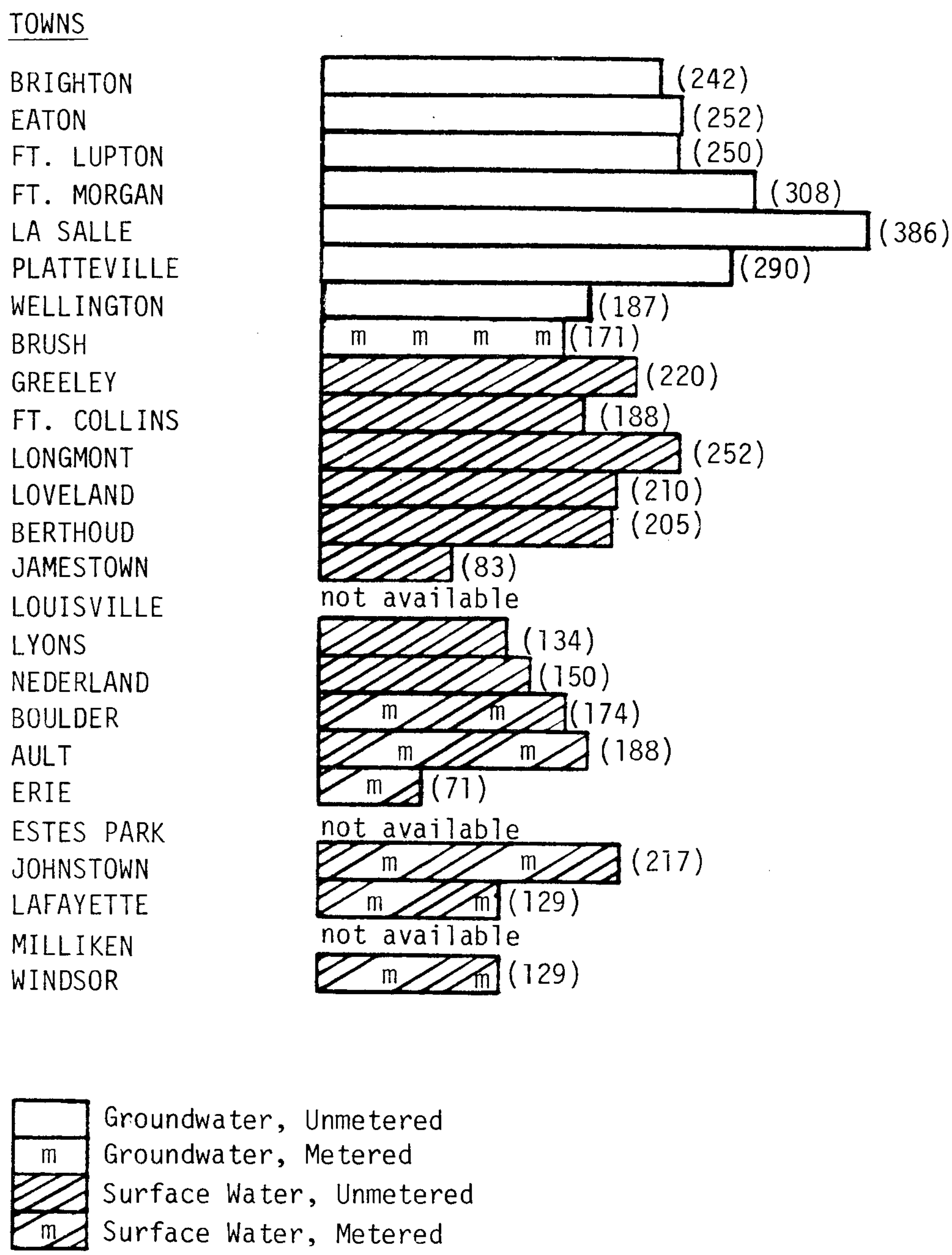


FIGURE 2

WATER SOURCE, STATUS REGARDING METERING
AND AVERAGE DAILY WATER USE (GCD)
FOR STUDY TOWNS, 1978

TABLE 4

FLAT-RATE MONTHLY WATER CHARGES IN UNMETERED TOWNS

	Minimum Charge	
Berthoud	$ 7.00	Based on Lot Square Footage
Brighton	4.00	Based on Number of Rooms
Ft. Collins	4.65	Based on Lot Square Footage
Ft. Lupton	4.33	Based on Lot Frontage
Ft. Morgan	4.00	—
Greeley	3.15	Based on Rooms, Plus a Sprinkling Charge
Jamestown	7.50	Based on Number of Baths
Johnstown*	10.00	—
La Salle	7.25	Based on Lot Frontage
Longmont	7.75	Based on Number of Rooms
Loveland	12.33	Sprinkling Charge
Lyons	9.00	—
Nederland	8.67	—
Platteville	5.50	Summer Sprinkling Charge
Wellington	4.80	—

* Johnstown is metered but a flat rate is charged for the winter months.

TABLE 5

MONTHLY WATER RATES IN METERED TOWNS

Town	Minimum Charge and Minimum Amount	Marginal Price for Exceeding Minimum	Cost for First 10,000 Gallons
Ault	$7.75/3,000 gal	$0.60/1,000 gal	$11.95
Boulder	$2.50/2,000 gal	$0.43/1,000 gal	$5.94
Brush	$8.00/5,000 gal	$0.30/1,000 gal	$9.50
Erie	$11.00/3,000 gal	$1.00/1,000 gal	$18.00
Estes Park	$6.75/2,500 gal	$1.06/1,000 gal	$14.70
Greeley	$3.90/10,000 gal	$0.31/1,000 gal	$3.90
Johnstown	$10.00/20,000 gal	$0.25/1,000 gal	$10.00
Lafayette	$10.00/10,000 gal	$1.00/1,000 gal	$10.00
Louisville	$5.50/10,000 gal	$0.45/1,000 gal	$5.50
Milliken	$10.50/6,000 gal	$1.00/1,000 for next 3,000 gal then $0.70/1,000	$14.20
Windsor	$6.90/3,750 gal		$14.45

had the lowest minimum of 2,000 gallons per month while Johnstown had the largest with 20,000 gallons per month.

Marginal price, the cost per 1,000 gallons greater than the minimum amount, also showed a great deal of variation. None of the utilities had a rate structure in which the unit price charged was greater than the equivalent unit price within the minimum, although Lafayette had an average price structure in which the marginal unit price was the same as the minimum unit price. Marginal prices ranged from a low of $0.25 per 1,000 gallons in Johnstown to a high of $1.06 per 1,000 gallons in Estes Park. Only Milliken had a decreasing block rate once the minimum had been exceeded. None of the utilities had an inverted or increasing block rate often advocated as a conservation measure.

A. Operating Revenues and Costs.

For several of the towns, for which data was available, revenues derived from the sale of treated water as well as the operation and maintenance (O&M) costs associated with the treatment and delivery of this water are given in Table 6. The values are given as unit revenues and costs per acre-foot of water produced at the water treatment plant. Even though the O&M costs do not reflect the total cost of providing water since debt service and depreciation are not included, it is possible to compare operating revenues with operating costs. As expected, the metered towns derived greater revenues per unit of water produced than the unmetered towns. Revenues ranged from a high of $370 per acre-foot in Windsor to a low of $65 per acre-foot in Fort Morgan. Also, as expected, the metered towns had greater O&M costs than the unmetered towns. This is primarily due to the additional administrative costs involved in meter reading and billing.

Every town except Brush had unit revenues greater than unit costs although it could not be determined if the excess revenues were sufficient to cover the true costs of providing water service.

TABLE 6

SELECTED TOWNS' OPERATING REVENUES AND O&M COSTS - 1978

Town	Operating Revenues/AF	O&M Costs/AF
Unmetered Towns		
Berthoud	$148	$123
Brighton	102	34
Ft. Collins	156	83
Ft. Morgan	65	58
Greeley	105	52
La Salle	87	63
Longmont	153	120
Loveland	115	90
Metered Towns		
Ault	$280	$247
Boulder	176	98
Brush	184	195
Estes Park	253	207
Windsor	370	322

B. New Customer Fees.

Many towns have a stated policy that new growth should pay for itself. For water supply this translates into tap-on fees, plant investment fees, and water rights fees that cover the costs of providing service to new customers. Tap-on and plant investment fees, usually stated as one lump sum, varied considerably among the towns as shown in Table 7. Total tap fees ranged from a low of $375 to a high of $2,220 for a 3/4" single family residential tap. Part of this wide range is attributable to the different capital costs required for treatment facilities for groundwater as compared with surface water supplies. At present, groundwater is only chlorinated while surface water is typically treated by coagulation, sedimentation, and filtration before chlorination. Tap fees for groundwater towns ranged from $375 to $1,500 while surface water towns ranged from $500 to $2,200. Given current conditions of the money market, it appears that the lower range of fees for both groundwater and surface water supplied towns do not reflect the full costs of supplying new customers.

C. Water Rights Donation Policies.

In keeping with the "pay as you go" policy most towns have adopted water rights donation policies that require new developments to provide the water rights needed to service them. Many of the towns using surface water supplies require that 3 acre-feet of water be donated for every gross acre of development. It is rarely stated if the 3 acre-feet is average annual yield or how the yield is to be determined. The yield at the municipal water treatment plant can be substantially less than the yield as measured at the point of diversion due to losses in transit. Several towns reported that agricultural water rights that have been donated were not usable in their system or that the subsequent change-in-use decree or change in point-of-diversion decree limited the amount of water available for municipal use.

TABLE 7

TAP-ON AND PLANT INVESTMENT FEES, 1979

Source of Water Supply	Town	Total Tap Fee*
Groundwater	Brighton	$1,270
	Brush	$375**
	Eaton	$1,500
	Ft. Lupton	$1,000
	Ft. Morgan	$400
	Platteville	$1,000
	Wellington	$900
Surface Water	Ault	$1,400**
	Berthoud	$950
	Boulder	$1,300**
	Estes Park	$2,220**
	Ft. Collins	$1,245
	Erie	$1,800**
	Greeley	$750
	Johnstown	$500**
	Lafayette	$1,800**
	Longmont	$975
	Loveland	$1,015
	Louisville	$1,900**
	Lyons	$1,000
	Milliken	$1,200
	Nederland	$1,100
	Windsor	$1,000

*Includes tap-on and plant-investment fee; labor extra; for 3/4" tap.

**Includes cost of meter.

Of the eight towns currently using groundwater supplies, six now require or will accept surface water rights for donations. The groundwater supplied towns are experiencing water quality problems (see Table 8). The cost of treating groundwater to acceptable standards is generally regarded as prohibitive and many of these towns are investigating the possibility of utilizing only surface water supplies in the future.

TABLE 8

WATER QUALITY OF MUNICIPAL GROUNDWATER SUPPLIES

Town	Date of Sample	Total Hardness	Total Dissolved Solids**	Nitrates***	Gross Alpha Radioactivity****
Brighton	9/23/76	525 mg/ℓ	1,050 mg/ℓ	13.6 mg/ℓ	40±21 pCi/ℓ
	2/23/77	NA	NA	9.0	NA
	2/23/77	NA	NA	15.7	NA
	2/23/77	NA	NA	7.8	NA
	3/26/79*	NA	NA	8.0	31±14
Brush	12/9/76*	90	120	1.1	12±6
Eaton	6/22/77*	670	1,150	1.5	NA
	4/20/78	NA	NA	5.1	41±5
Ft. Lupton	1/21/77	460	1,000	17.9	NA
	6/2/77	NA	NA	8.7	47±18
Ft. Morgan	4/20/78	NA	NA	5.1	94±26
	4/20/78	NA	NA	5.3	102±27
	4/20/78	NA	NA	5.8	75±23
	4/21/78	NA	NA	7.4	72±24
	4/29/78	NA	NA	6.9	53±21
La Salle	12/18/77	510	980	30.0	21±13
Platteville	6/6/77	410	860	7.0	26±14
Wellington	7/21/78	1,300	2,090	7.1	22±21
	7/21/78	1,300	1,890	7.0	NA
	7/21/78	860	1,430	5.0	NA

*Denotes sample was taken from a house tap; other samples taken at well heads

**Recommended limit for TDS is 500 mg/ℓ as $CaCO_3$

***Mandatory limit for Nitrates is 10 mg/ℓ as NO_3

****Mandatory limit for gross alpha radioactivity is 15 pico-Curies/ℓ

NA - Not Available

Chapter 3

MUNICIPAL WATER DEMAND

1. Data Collection

The municipalities within the northern Colorado Front Range area have utilized a variety of schemes to modify demand of their water customers. Twenty-five towns, thought to be representative of the northern Front Range, were chosen for examination of their water use patterns. The primary objective was to collect data on water use for the period 1975 to 1978 and analyze the effects of various demand modification policies on water use and return flows. A secondary objective was to determine the impact, if any, of the 1976-1977 drought on municipal water use. It was originally thought that a great deal of the required data on water use and return flows would be available from the State Water Use Survey being conducted by the State Engineer's Office. The state study, however, was not available at the time of data collection for this study.

Every town water manager was requested to provide monthly water treatment plant flows for the period 1975-1978. Only nine of the twenty-five towns had complete data for this period. A number of the groundwater supplied towns did not have meters on their municipal wells. In several of these towns estimates of pumpage were made by taking the amount of electricity used and assuming the head and pump efficiency. A problem common to both groundwater and surface water supplied towns was that meters had broken and were not replaced or that the meters gave inaccurate readings. Many of the smaller towns experience continual turnover of water management and operating personnel which makes difficult any systematic record keeping procedures.

The attempt to separate single-family residential use from total municipal use also proved to be a difficult task. In the unmetered towns that did not have records of total water produced or did not meter commercial and multi-family users, it was not possible to estimate single-family residential use. In the unmetered towns that did meter commercial and multi-family users, an estimate of system leakage and public uses was required to derive single-family residential use. Surprisingly, an accurate count of the number of accounts and types of water taps serviced was not available for a number of towns. In addition, lack of data processing capability prevented several of the small metered towns from compiling water use data by user class.

Problems in collection of data for wastewater flows were also widely encountered. Many of the smaller towns use sewage lagoon treatment with unmetered inflows or releases. Other towns were serviced by one or two independent sanitation districts. The towns that did have metered wastewater flows, in many cases, had poor record keeping that greatly hampered the retrieval of flow data. Most of the sanitary sewer systems experience excessive infiltration/inflow which prevents reliable estimates of the effects of water-saving devices on return flows.

II. Categorization: Rural and Urban Towns

The twenty-five municipalities selected for study were segregated into a number of categories that were thought to have an impact on water use. A natural separation between the larger or urban towns and cities, all with populations greater than 30,000 and the smaller rural towns, with populations of less than 13,000 was evident. The urban cities were found to have a wide variety of water customers, including numerous commercial/ industrial customers and multi-family users as well as the single-family residential users which typify the smaller towns.

In addition to the population size distinction, water management policies that may reduce water demand were used as a basis for categorization. Metering is the most widely used management tool for modifying water use. Another policy that was found to be common was the use of summer lawn watering restrictions. Water use in the metered and in the flat-rate municipalities, as well as those with and without restrictions, have been examined to evaluate the effects, if any, of these water management policies.

A. Water Use in the Urban Towns.

The five urban towns, i.e. with populations greater than 30,000, service a large number of commercial and industrial water users and would be expected to have a greater gallon per capita per day (gcd) use than the rural towns. Water use, by category of water user, for the year 1978 for the urban towns is shown in Table 9. Residential use, both inside and outside the city limits, averaged 72 percent of the total municipal water demand in these five cities. Water use by commercial and industrial users averaged 19.7 percent, with the lowest percentage of commercial/industrial use reported by Ft. Collins at 13.7 percent. The commercial and industrial water users in both Greeley and Loveland comprise over 26 percent of those towns' water use.

Unaccounted-for water, which includes both system leakage and public

TABLE 9

WATER USE BY CATEGORIES, URBAN TOWNS, 1978

Town	Total Avg Use in mgd	Residential Use: Inside City Metered	Residential Use: Inside City Unmetered	Residential Use: Outside City Metered	Commercial/Industrial Use in mgd: Inside City	Commercial/Industrial Use in mgd: Outside City	Use by Category as Percent of Total Use: Residential	Use by Category as Percent of Total Use: Com/Ind	Use by Category as Percent of Total Use: Unaccounted
Boulder	15.6	10.25	0	1.75	2.4		76.9%	15.4%	7.7%
Ft. Collins	14.7	2.31	7.95	0.93	1.97	0.05	76.3	13.7	10*
Greeley	17.9	3.18	7.07	2.13	3.03	1.78	69.1	26.9	4*
Longmont	11.2	0.70	7.50	0.11	1.36	0.41	74.2	15.8	10*
Loveland	7.1	0	3.83	0.68	1.49	0.39	63.5	26.5	10*

* Estimated

uses such as park irrigation, was estimated by the water managers to be equal to or less than 10 percent in every town. Since all the towns except Boulder are flat-rate, the unaccounted-for water and the flat-rate usage can only be estimates. Greeley reported the smallest unaccounted-for usage, only 4 percent, which appears extraordinarily low.

Water use in the five towns was examined on a gallon per tap per day (gtd) and gallon per capita per day (gpd) basis for various classes of users, as indicated in Figure 3. Due to the differing ways of classifying residential taps used by the towns, the gallon per tap per day estimate is of questionable value for comparison. Loveland, which does not meter its inside-the-city residential users, reported the lowest estimate of 500 gtd. Boulder, the only town which is 100 percent metered, was the next lowest at 613 gtd. Both Greeley and Longmont reported greater per tap usage by their metered than by their unmetered customers. It is likely that the gallon per tap per day estimates are greatly influenced by the number and type of multi-family units in each town.

Analyzing water use on a per capita basis yields more meaningful figures, although the population and leakage have been estimated. Total residential and total municipal use (including leakage) on a per capita basis are shown in Figure 4. The effects of metering on residential water use do not appear to be significant. Loveland and Fort Collins, which are largely unmetered, reported average per capita residential water use of 134 and 143 gallons per day, respectively. Boulder, which is totally metered, reported average residential use of 133 gcd. There are several factors which may explain why Loveland's residential water use is comparable to Boulder's. Loveland was under fairly strict lawn watering restrictions

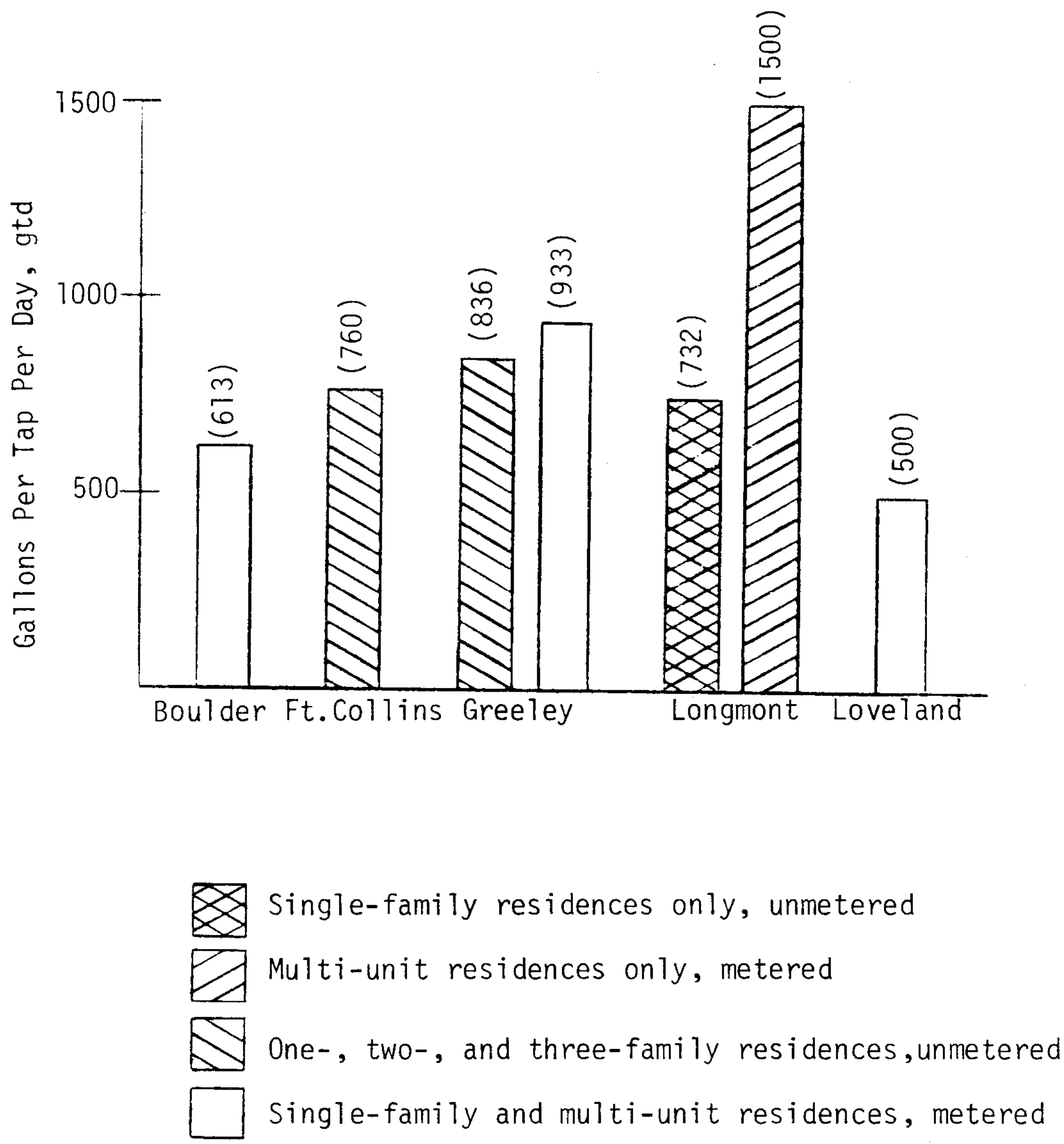


FIGURE 3

INSIDE CITY PER TAP WATER USE, 1978

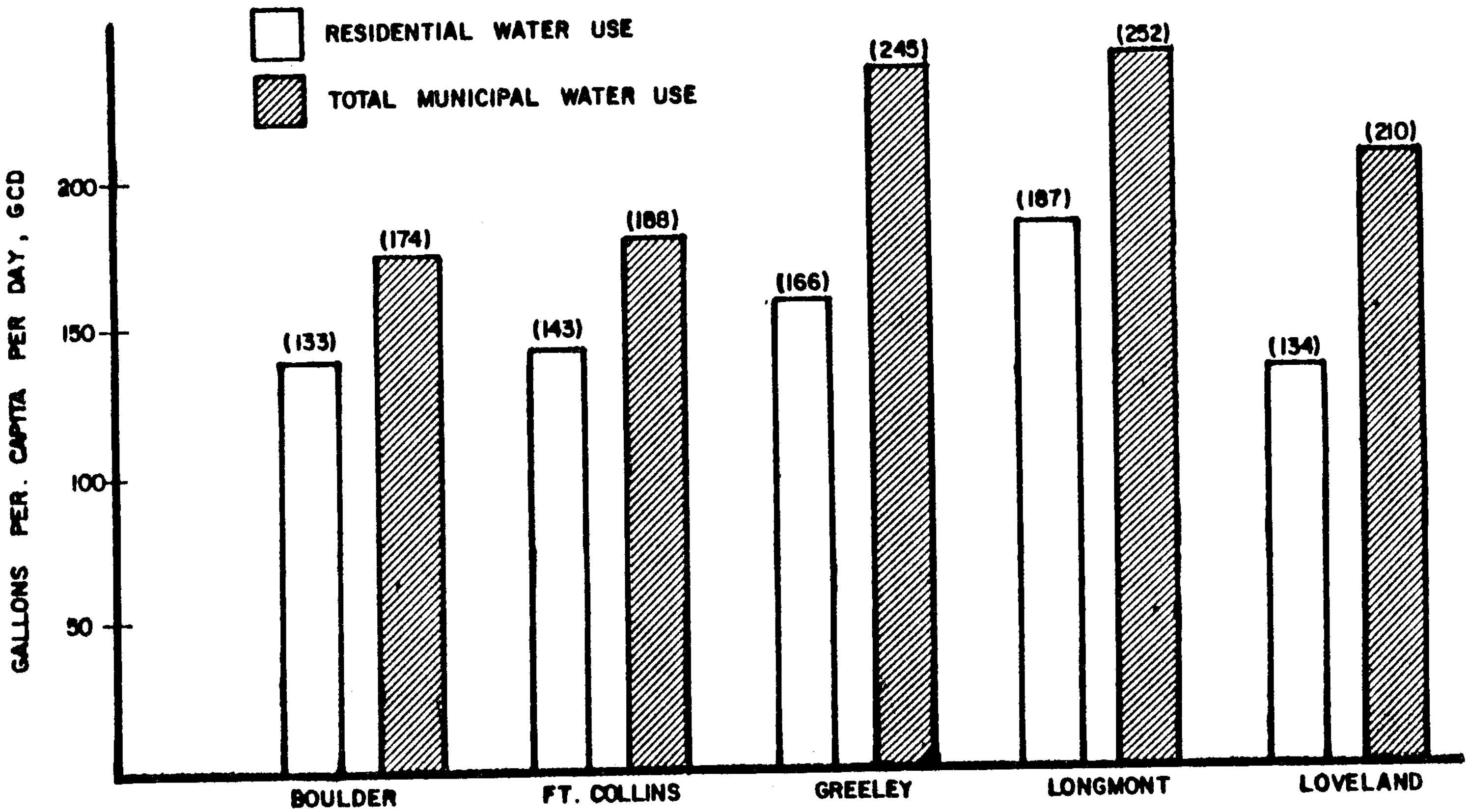


FIGURE 4

RESIDENTIAL & TOTAL PER CAPITA WATER USE, 1978 in 1978 while Boulder had none. The types of restrictions imposed by the various cities will be discussed later. Boulder had a fairly low water rate structure with a marginal cost of $0.43 per 1,000 gallons. A Boulder homeowner would have to use over 22,000 gallons per month to equal the $12 per month summer rate charged Loveland's flat-rate residences. Boulder's rate structure may have been low enough that it did not induce significant conservation relative to flat-rate users on restrictions.

Greeley and Longmont reported the largest residential per capita water use of 166 and 187 gpcd, respectively. Both towns are largely unmetered although Greeley has metered all new residences since 1972. Sprinkling restrictions that limited the hours of watering each day were in effect for both towns. Greeley has a relatively low metered water rate of $0.39 per 1,000 gallons which is used to set the flat-rate charges to unmetered customers.

In the urban towns it appears that a sampling of individual residences would be required to determine the actual effects of metering on water use. The data collected does not indicate significantly lower water use by metered customers at the prices charged in these towns compared with flat-rate customers, all of which, except Fort Collins, were on restrictions.

B. Water Use in the Rural Towns

Data on water use by customer class in the smaller towns was often unavailable; therefore, water use among the smaller towns was compared by dividing the total municipal use by the estimated service population to arrive at a per capita usage figure that included commercial, industrial and public uses as well as system losses. However, water use by single large industries in Brush, Johnstown, Ft. Morgan and Ft. Lupton was subtracted from their total usage. The assumption was that, exclusive of these large water-users, the types and demands of water users in all the small towns are similar.

Municipal water use, on a per capita basis for the rural towns is shown in Figure 5. Water use in the metered rural towns ranged from 71 gcd in Erie to 188 gcd in Ault. The low per capita use in Erie, Windsor, and Lafayette can be partially explained by the fact that a number of the older homes in these towns have wells which are used for lawn irrigation. In addition, all three towns have relatively high water rates compared to Boulder and Greeley. Lafayette was also under strict watering restrictions in 1978 that allowed sprinkling only 2 hours per day every other day.

The unmetered, surface water supplied rural towns exhibited significant variations in water use. Jamestown is a mountain community that was included for comparison purposes. Its cooler temperatures, greater precipitation and less lawn area compared with the other towns all appear to contribute to its low water use of 83 gcd. Lyons is located in the foothills and these same characteristics apply, although to a lesser degree. Berthoud, which averaged 205 gcd, is similar to the groundwater supplied unmetered and surface water supplied metered towns with respect to lot size and climatological conditions.

The groundwater supplied, unmetered towns exhibited significantly greater per capita use than the other categories of water users. Water use averaged 288 gcd, with Brighton the lowest at 242 gcd and LaSalle the largest at 386 gcd. Brush, which is similar to these towns except that it is metered and has the best water quality of any of the groundwater supplied

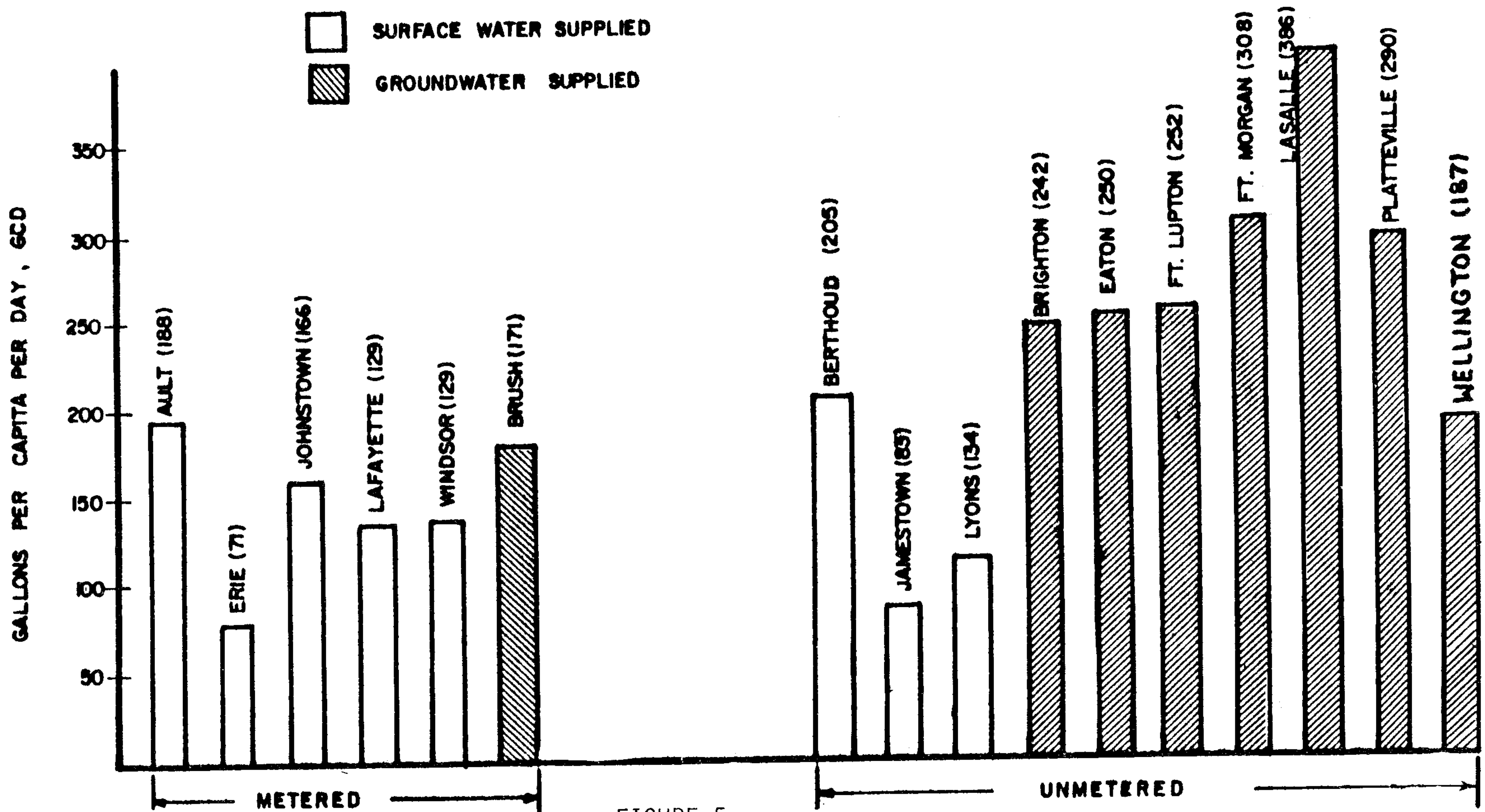


FIGURE 5

PER CAPITA WATER USE, RURAL TOWNS, 1978

towns, had an average use of 171 gcd, 40 percent less than the average water use in its unmetered counterparts. Ault, which is situated in a location similar to that of many of the groundwater supplied towns but is metered and surface water supplied, had an average use of 188 gcd, 35 percent less than the groundwater, unmetered average. Neither Brush nor Ault were under watering restrictions in 1978.

III. Sprinkling Use

Sprinkling use, the amount of water used outdoors primarily for lawn irrigation, can be estimated by a number of methods. A modification of the winter base rate method, as proposed by Haw (1978) has been used in this study. Indoor water use during the summer months has been assumed to be 85 percent of the winter average water use. This would account for the apparent outdoor water use found during the winter months.

Sprinkling use has been examined for the period 1975-78 in those towns that have water use data for this period. Relative water needs of lawns during this period have been calculated using the modified Blaney-Criddle equation (Soil Conservation Service, 1967). Climatic data was used from seven reporting stations in the study area. Average lawn evapotranspiration, effective precipitation and lawn irrigation requirements are shown in Figure 6. Using 1975 as the base year, lawn irrigation requirements were 5 percent greater in 1976, 25 percent greater in 1977 (a so-called drought year) and 5 percent greater in 1978.

Sprinkling use for three metered municipalities are shown in Figure 7. Comparing Figures 6 and 7 shows that sprinkling use did not follow the same pattern as estimated irrigation requirements. In 1977 when sprinkling needs were the greatest, sprinkling use was the lowest. Sprinkling use

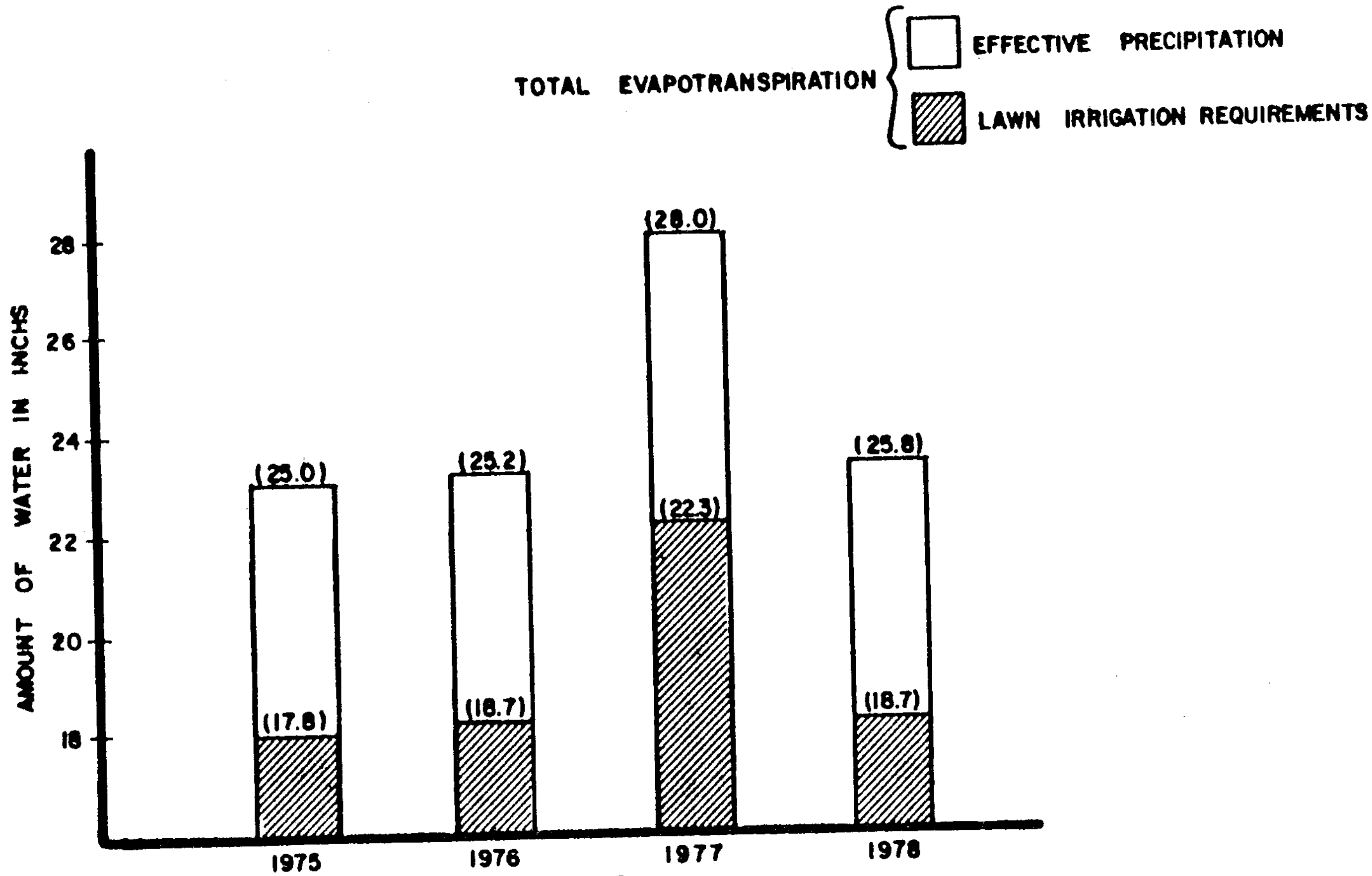


FIGURE 6

ESTIMATED LAWN EVAPOTRANSPIRATION, EFFECTIVE PRECIPITATION & LAWN IRRIGATION REQUIREMENTS

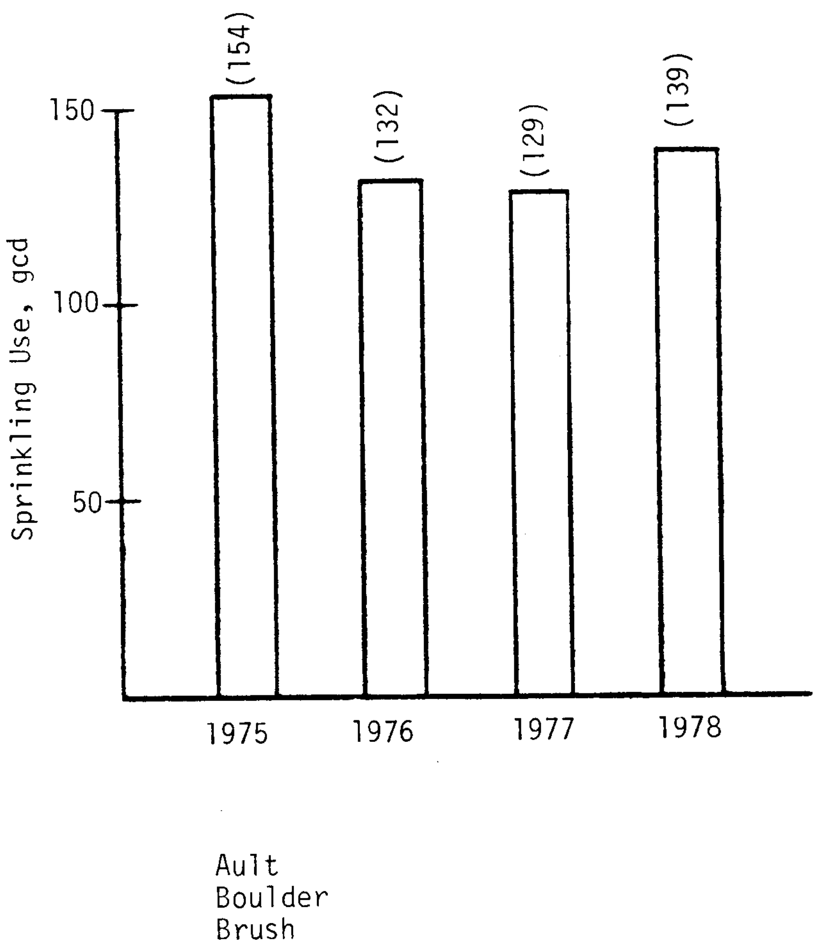


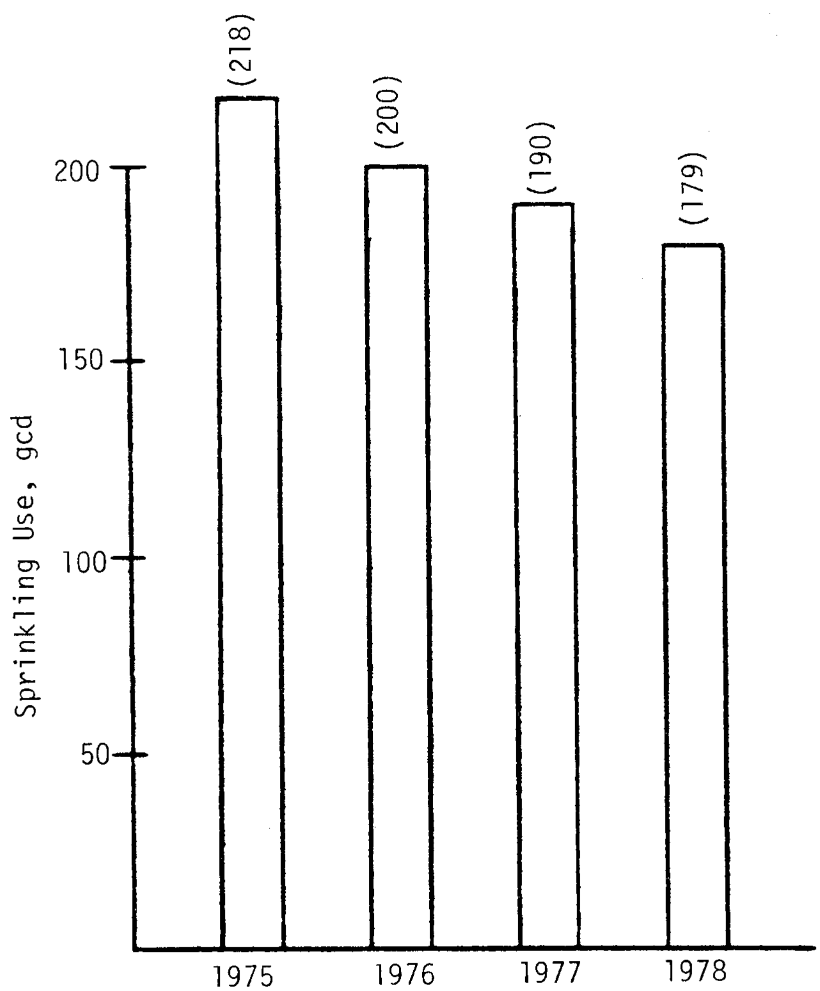
FIGURE 7

AVERAGE SPRINKLING USE IN THREE METERED TOWNS for six unmetered municipalities is shown in Figure 8. Sprinkling use in the unmetered sample showed about the same trend as the metered sample except that sprinkling use averaged 42 percent greater over the four-year period.

Comparing sprinkling use in the metered and unmetered municipalities with the calculated irrigation requirements indicates that some type of demand modification common to both the unmetered and metered communities occurred in 1977. None of the three metered communities included in this analysis were under any type of lawn watering restrictions during the four-year period. Of the six unmetered communities, four were under restrictions for the entire period while one city imposed restrictions for one month in 1977. The period 1976 to 1977 was a drought period in the western U.S., including the northern Front Range. As the drought progressed in 1977, the local mass media increased its coverage of the event, especially the critical water supply situation in Northern California. Though there was not a critical water shortage in the study area, it appears likely that increased public awareness of the drought resulted in voluntary reductions in sprinkling use relative to actual lawn water needs.

IV. Restrictions

Fourteen of the twenty-five study communities imposed some type of sprinkling restrictions during the four year period. Of the eleven towns that had no restrictions, several had tried them in the past but had discontinued them, primarily because the restrictions were judged to be ineffective. Differing opinions regarding restrictions were expressed by the water managers. Several thought that without restrictions, the treatment and distribution capacity of their water systems would be



Berthoud
Brighton
Ft. Collins

Longmont
Loveland
Lyons

FIGURE 8

AVERAGE SPRINKLING USE IN SIX UNMETERED TOWNS severely overloaded. Other managers, including several who had imposed restrictions, stated that sprinkling restrictions actually increased sprinkling demands. This increase in demand was attributed to the observation that many customers would water during their allowed time whether or not the lawn required water. Many water managers noted that sprinkling was often observed during or immediately after a summer rainfall.

The types of sprinkling restrictions used and the reasons for their imposition are outlined in Table 10. Most of the restrictions were instituted due to difficulties in meeting peak day demands or for system pressure regulation. The non-availability of raw water was cited in only two cases. Of the fourteen towns that had restrictions at some time during the study period, only five were metered. Milliken and Windsor, two of the metered communities, had the restrictions imposed by outside water supply agencies. The most common types of restrictions during the study period were every other day watering and a ban on mid-day sprinkling.

A. Sprinkling Use.

Average seasonal sprinkling use in nine communities, over the 1975-78 period, was evaluated on the basis of whether or not restrictions were in effect. Four of the communities, three of which were metered, did not have any restrictions during the study period. Three other towns, all unmetered, had restrictions for the entire study period. Ft. Collins and Berthoud, also unmetered, had restrictions for a portion of the period. Percent changes in sprinkling use and lawn irrigation requirements for the restricted and unrestricted towns are listed in Table 11. All the changes are listed relative to sprinkling use and lawn water needs in 1975. Significant reductions in sprinkling use and increases in lawn irrigation requirements occurred for the unrestricted as well as restricted communities.

TABLE 10

WATERING RESTRICTIONS, 1975-1978

Town	Years in Effect	Type of Restriction	Reason for Restriction
Berthoud	1/75-6/78	Odd-even days; no sprinkling 12-5 p.m. No sprinkling during winter	Peak Reduction
Brighton	1975-1978	Odd-even; sprinkling 4-10 a.m., 4-10 p.m. only	Peak/Pressure Control
Erie*	1977-1978	Odd-even	Peak Reduction
Ft. Collins	7/77-8/77	2 days/week watering; 4-10 a.m. 6-12 p.m. only	Raw Water Insufficient to Meet Demand
Ft. Morgan	1975-1978	Odd-even	Peak/Pressure Control
Greeley	1975-1978	No sprinkling 12-5 p.m.	Peak/Pressure Control
Jamestown	1976-1977	No sprinkling when notified	Raw Water Insufficient
Lafayette*	1975-1978	Odd-even; sprinkling 2 hours/day	Treatment Plant Capacity Insufficient
Longmont	1975-1978	Odd-even; no sprinkling 8 a.m.-6 p.m. in 1978	Peak/Pressure Control
Loveland	1975-1978	Four step plan, increasing in severity	Peak/Pressure Control
Lyons	1975-1977	Odd-even	Treatment Plant Capacity and Problems
Milliken*	1975-1978	No sprinkling 11 a.m.-5 p.m. daily	Imposed by Central Weld County Water District
Platteville	1978	No sprinkling 12-5 p.m. daily	Peak/Pressure Control
Windsor*	1975-1978	No sprinkling 12 a.m.-5.p.m. daily	Imposed by Greeley

*Denotes metered town; all others are unmetered

TABLE 11

RESTRICTED VS UNRESTRICTED SPRINKLING USE

Town	Year	Sprinkling Use	Percent Change in Sprinkling*	Percent Change in Lawn Irrigation Requirement*
		Towns with Sprinkling Restrictions		
Brighton	75	255 gpcd		
	76	232	-10%	+5%
	77	210	-21%	+9%
	78	231	-10	+9
Loveland	75	233		
	76	190	-23	-3
	77	209	-10	+17
	78	155	-50	-2
Longmont	75	191		
	76	161	-19	-7
	77	218	+14	+27
	78	224	+17	-1
Berthoud	75	285		
	76	215	-33	-3
	77	184	-55	+17
Ft. Collins	77	155	-8	+40
		Towns without Sprinkling Restrictions		
Ault	75	160		
	76	149	-7	+7
	77	118	-36	+16
	78	155	-3	+8
Boulder	75	152		
	76	117	-30	+2
	77	131	-16	+16
	78	139	-9	+5
Brush	75	150		
	76	129	-16	+8
	77	137	-9	+27
	78	122	-23	+1
La Salle	75	358		
	76	373	+4	+7
	77	366	+2	+35
	78	418	+17	+8
Ft. Collins	75	167		
	76	162	-3	+28
	78	176	+5	+21
Berthoud	78	180	-58	-2

*Percent changes are relative to 1975

Only LaSalle and Ft. Collins, which were unrestricted, and Longmont, which was restricted, showed increases in sprinkling use relative to 1975. As a group, the changes in sprinkling use and lawn irrigation requirements were not significantly different for the restricted than the unrestricted towns. It is difficult to compare the two groups, however, because the unrestricted towns were largely metered, while the restricted towns were primarily unmetered. In addition, many of the towns with restrictions had instituted the restrictions prior to 1975.

Fort Collins and Berthoud were the only communities to impose or lift restrictions during the study period. Fort Collins imposed restrictions on July 15, 1977 when the flow in the Cache la Poudre River dropped significantly. Due to previous commitments of a portion of their direct flow rights to agriculture, the unexpected lowflow and existing storage could not supply sufficient water to meet demands. The initial restrictions allowed one-fourth of the city to water on each of four weekdays, and half of the city to water on Saturday and half on Sunday. No watering was allowed on Friday. This system was revised on July 27 due to water pressure problems caused by an entire geographical portion of the city watering on a particular day. The altered restrictions allowed twice a week watering on the basis of house address number (Anderson, Miller and Washburn, 1980).

In a report to the City of Ft. Collins, Anderson, et al., analyzed the effect of the 1977 restrictions. The effect of the restrictions was made difficult because late July and early August were unusually wet and cool. Water use declined 41 percent compared to the same period in 1976, but slightly less than half of this decline was attributed to the restrictions. Lower evapo-transpiration rates and increased precipitation were responsible for the rest of the reduction. Anderson, et al., concluded that during a period of normal evapo-transpiration, the restrictions imposed would be expected to reduce Ft. Collins' municipal water use by 19.7 percent.

The town of Berthoud had every other day sprinkling with a mid-day ban on watering for the years 1975-77. On June 1, 1978 these restrictions were lifted. Actual sprinkling use and estimated lawn water requirements on a per capita basis have been computed for the peak irrigation period June-September of each year. The lawn requirements were converted from inches per month to gcd by assuming 2300 square feet of irrigated area for each person within the service district. A ratio of actual sprinkling to estimated lawn needs has also been computed and is listed in Table 12. The actual-to-required sprinkling use ratio in 1978, the year without restrictions, was actually lower than the years 1975 and 1976, when restrictions were in effect. This suggests that, for the town of Berthoud, sprinkling use with every other day restrictions did not differ greatly than sprinkling use when there were no restrictions. The ratio of actual-to-required sprinkling use is significantly lower in 1977, relative to the other three years. This low ratio seems to indicate that water users in Berthoud were responding to outside conservation appeals. The actual-to-required ratio is greater than 1.0 for each year, indicating that water users in Berthoud are not very efficient in their lawn irrigation but over-irrigate to a certain extent or that the lawn irrigation requirement is underestimated.

B. Peak Demand Reduction and Pressure Regulation.

In most of the communities studied sprinkling restrictions were instituted to regulate pressure or to reduce peak demand. High peak usage requires that water treatment and distribution facilities be made larger to accommodate this demand. Peak day demand in the unrestricted towns was significantly lower than in the towns that had restrictions. This may be due to the fact that the unrestricted towns were largely metered while most of the towns that had restrictions were unmetered. (See Table 13). The ratio of peak day to average day was essentially the same value for the unrestricted towns (2.44) as for the restricted towns (2.49). Average use, however, was much greater in the restricted towns. Peak day use followed the same general pattern as sprinkling use, with peaks less in 1977 than in other years. Peak day use did not show a noticeable increase in Berthoud in 1978 when the restrictions were lifted.

TABLE 12

ACTUAL AND REQUIRED SPRINKLING

BERTHOUD (JUNE-SEPTEMBER)

Year	Actual Sprinkling Use in gpcd	Estimated Lawn Irrigation Requirement in gpcd*	Actual Use/ Estimated Requirement
1975	346	178	1.94
1976	329	153	2.15
1977	220	175	1.26
1978	337	188	1.79

*Based on 2,300 ft^2 of irrigated land/capita; derived from interview with town official

A review of historical peak day usage for Loveland reveals that their restrictions have been effective in reducing peak demands. Peak day demand averaged 743 gcd for the period 1960-69 when no restrictions were in effect.

TABLE 13

PEAK DAY WATER: RESTRICTED AND UNRESTRICTED TOWNS

Town	1975 Peak Day	1975 Peak/Average	1976 Peak Day	1976 Peak/Average	1977 Peak Day	1977 Peak/Average	1978 Peak Day	1978 Peak/Average
Unrestricted								
Boulder	483 gpcd	2.67	446 gpcd	2.59	387 gpcd	2.36	402 gpcd	2.31
LaSalle	670	2.09	748	2.16	683	1.98	808	2.08
Ft. Collins	533	2.64	504	2.64	—	—	470	2.50
Berthoud	—	—	—	—	—	—	467	2.30
Restricted								
Ft. Collins	—	—	—	—	440	2.41	—	—
Berthoud	732	2.59	655	2.70	441	2.13	—	—
Greeley	568	2.39	568	2.44	484	2.18	550	2.28
Loveland	632	2.73	562	2.65	491	2.41	531	2.52
Longmont	591	2.64	537	2.51	560	2.35	620	2.46
Brighton	759	3.04	669	2.85	536	2.29	559	2.30

Watering restrictions have been in effect since 1970 and peak day usage averaged 610 gcd for the period 1970-78. Loveland's restrictions are more severe than most, allowing every third day waterings on the average for the period.

In summary, marked differences between the smaller rural towns and the larger urban towns were not observed. The distinction among the towns on the basis of population, if any, is masked by other factors such as source of water, metering and whether restrictions were imposed.

Chapter 4

SURVEY OF THE WATER MANAGERS

In this chapter the results of personal interviews with water officials of the towns are presented. These officials included the professional staffs, town managers, city council members and water board members.

I. The Management of Water

The management of water supply in the towns is carried on by employees responsible to some form of town manager in the larger cities. In the smaller towns they may be directly responsible to elected officials. The mayor and the town council have ultimate responsibility for water supply and, in some cases, wastewater disposal systems. They are usually aided by a water (or water and sewer) board made up of council members or of appointed citizens. The council and board members serve voluntarily in many cases, or receive a small remuneration.

On technical matters, external advisors are called in, usually engineering and law firms. New projects require engineering studies, and legal advice may be needed frequently as many of the smaller towns are in the process of getting their water rights' change of use decrees. The larger towns have the benefit of more consistent relationships with consulting firms, and more opportunity for informal advice from them between studies.

The personnel of the operating departments may be responsible for water supply alone, for water and sewage, or for some combination of other functions including streets and public works in general. In the larger towns such employees may have had engineering training; in the smaller ones they tend to have come through the system of certification and on-the-job training. There is considerable turnover among these personnel.

The elected officials vary in their backgrounds. For some of them, water supply has been a lifelong interest. In one large town, there has been only one chairman of the water board since its formation more than 20 years ago. Many of these people have other connections with water supply such as membership on ditch company boards, participation in the management of water conservancy districts, or their professional field may be water law. There is much less interest shown in the sewage facilities.

The water conservancy districts and the ditch companies in Colorado were originally set up to provide water for irrigation, but they now play an increasing role in the provision of municipal supplies. The districts can stipulate how much water they will provide, under what conditions, and what increase in supply they are willing to allow in the future. They play a strong role in the relations between the agricultural community and the municipalities, both as mediators in disputes and as informal brokers when the cities rent surplus water rights to farmers.

Responsibility for wastewater disposal is more fragmented than that of water supply in the communities. In nine of the towns, the wastewater disposal is undertaken for all or part of the town by a separate Sanitary District, or more than one of them, so there tends to be little or no coordination between the supplying of water and its disposal.

II. Study Methodology

Thirty-seven individuals who play a role in water management were interviewed. Employees of a municipality or a water district made up 21 of these; the other 16 were citizens serving as officials on town councils or on water and/or sanitation boards. They were selected to provide information regarding the water system in each community, and to provide a sample of individuals involved in leadership capacities whose general point of view concerning various water management tools could be examined. Statistics on water use, wastewater management, and water rights acquisition policies were collected separately (see Chapter 3).

The interviews dealt with the past and present problems of water supply and wastewater disposal in the towns. The perceived impact of expected growth on these facilities, and plans for meeting the expected needs were explored. The participants were asked what plans they had for managing demand, if any, and whether or not they had tried various tools designed to do this. The tools included restrictions on use, metering, emergency links to other facilities, water saving devices, appeals to consumers for voluntary reductions in use, leakage reduction and price adjustments. They were asked about the reuse of sewage water, return flows and the effect of their policies on downstream appropriations. Their relationships with other communities, such as cooperative projects to increase supply, or nearby ditch companies were ascertained. They were also asked about their attitudes towards the ability of the Front Range region to meet the municipal water demands of the future, and about what they felt are the attitudes of local consumers towards water use.

III. The Local Situation

Most of the energies of the water departments of these communities over the last two decades have been directed towards increasing their raw water supply and expanding their storage, treatment and distribution facilities to catch up with present and to prepare for future population growth. Those with surface supplies have had to acquire additional water rights, while those with groundwater supplies are in the process of determining how much supply they have, getting it adjudicated, and meeting drinking water quality standards.

The most frequently reported problems were:

Inadequate distribution systems

Inadequate treatment facilities

Lack of raw water

Water quality (in groundwater towns)

A few towns also mentioned storage problems, fiscal difficulties and poor record keeping.

At present, all the surface water managers feel that their town is coping effectively to meet present needs, although some continue to have problems with the elements noted above. The groundwater towns seem to have abundant supplies but because of problems with meeting the EPA quality standards most expect to seek surface supplies within the next two decades.

For the future, all the managers are concerned with the expansion of their supplies to meet projected population growth, but 80 percent of them feel that in their town such growth is being planned for adequately. A few are concerned that the population projections are low, and that they may be faced with additional needs. Specific plans include:

Expansion of treatment facilities

Expansion of storage facilities for raw and/or treated water

Expansion of distribution systems

Obtaining new water rights, sinking new wells, and adjudicating rights already owned

With regard to wastewater disposal, three-quarters of the managers feel their town will have no problem; it is simply a matter of getting the application for Federal funds in soon enough to meet their needs for increased capacity. Others are concerned that red tape will prevent timely expansion, but none see this aspect as a constraint on expanding water supply in the long run. Several towns reported problems with infiltration of groundwater into sanitary sewers.

A. Increasing Supplies.

The towns have tended in the past to be very independent about their water supplies, treatment and storage. Only one-quarter of them have links with other bodies which could provide them with emergency services, although more have interconnections involving storage or transmission of water, but nearly a third have no such links at all.

The Northern Colorado Water Conservancy District brought regional interaction in water through the building of the Colorado-Big Thompson (CBT) project. This interaction will be increased with the realization of the Windy Gap project, designed to bring additional water through the CBT system for the towns of Boulder, Longmont, Estes Park, Loveland, Fort Collins and Greeley.

Another regional scheme under discussion is the Northern Colorado Domestic Water Authority which would provide joint treatment, storage and transmission facilities for CBT water. Towns likely to be interested in this project are Greeley, Loveland, Platteville, Fort Lupton, Eaton, Ault, Berthoud and Lyons. However, because of the large expense involved, most managers were cautious about this project's feasibility for the near future.

A central issue for the towns which are growing rapidly is who shall pay for the increase in water supply and facilities needed to meet the demand of the increased population. A main method of acquisition of new water rights is to require subdividers to bring in a certain number of rights per acre or unit of development, and thus, together with tap-on fees, to "make growth pay for itself". All the towns which allow annexation have such requirements, and the managers feel that they will accomplish their objective, so growth will not have to be paid for by present residents. DiNatale (1980) questions the realism of this view, pointing out that some water rights or ditch company shares may not provide as much firm water yield as expected, or may require a change in point of diversion or use. The same issue of who shall pay arises with metering, and will be discussed in that connection.

B. Management Tools

The first option in municipal water supply management, as perceived by most of these managers, is increasing supply through the purchase of water rights, sinking new wells, increasing the development of new water, or some combination of these. They also consider cutting down on losses in transmission, as for example installing piped instead of ditch transmission of the raw water supply. Few of the towns have an active program for leakage reduction other than ordinary maintenance. In some cases, sewage effluent can be traded for cleaner raw water upstream. This is done by several of the towns, thus in effect enlarging the raw water supply.

The variety of tools used by the towns is shown in Table 14. The two main ones are appeals to the public and restrictions on outside use. Less than half of the towns have tried other tools, including metering.

Some of these tools affect use but not demand; others may affect both. Restrictions on sprinkling affect use but probably not demand. Metering, which combines both a price element and one of notification to the consumer of the amount of water used periodically, affects both short-term and long-term demand.

IV Restrictions

Over half the towns, fourteen in all, have used restriction on sprinkling at some time during the period 1975-1978 (see Chapter 3). However, the managers were very mixed in their assessment of the efficacy of these programs. Based on their own experience, nearly half of those who have used restrictions think that they do reduce usage; the rest are doubtful or even suspect that such regulations increase use, citing the fellow who sneaks the hose into the bushes and leaves it on all night, or people who water during a rain simply because it is their turn (see Table 15).

TABLE 15

MANAGERS' APPRAISAL OF THE EFFECT OF SPRINKLING RESTRICTIONS

	No.	Percent
Tried restrictions and use went up	5	14
Tried restrictions; no effect on use	4	11
Tried restrictions; use decreased	15	43
Have not tried restrictions	11	32

TABLE 14

MEASURES AFFECTING WATER USE

Measure	Towns using measure at some time during study period	
	Percent	Number
Use of appeals to the public for lower use of water (Usually - 36 percent) (Occasionally - 24 percent)	60	15
Restriction on use	56	14
Meters on all taps	36	9
Meters on some taps but not used for billing	36	9
Intensive leakage reduction program	36	9
A plan of action to reduce use	36	9
Restrictions on public bodies, i.e. parks	28	7
Emergency links with other communities	24	6
Raising prices - for fiscal reasons	20	5
- to reduce use	04	1
Requirements for water saving devices in building codes	12	3

The ambiguity arises from the difficulty in assessing results. Restrictions were used by a significantly larger proportion of the surface non-metered towns than by either the groundwater or surface water metered towns. Only one such town, aside from two mountain communities where the vegetation and cooler temperatures dictate little outside seasonal use, had not imposed any restrictions at all. Restrictions appear to be the main tool for these towns for dealing with either peak or total use problems, with further ambiguity as to whether one or both goals are being pursued.

There is some evidence on the subject. Anderson and others (1980) found that in Fort Collins during the 1977 drought where watering was only allowed twice a week at certain hours, water use was reduced 19.7 percent after adjustment for the normal evapo-transpiration rate. The authors suggest that such restrictions shift timing of use more than they cut actual use.

Hanke and Mehrez (1979) studied the effect of restrictions in Perth, Australia, which limit the number of hours when outside sprinklers can be used. These regulations were designed to prevent trunk main and service reservoir capacity from being overextended, and have been in effect for 30 years. Assuming that mean maximum daily temperature and total weekly rainfall are the factors influencing garden watering, with the former the most significant factor, the authors determined that these "light" restrictions reduced monthly water use 11 to 14 percent below what it would have been without restrictions. Since this effect has taken place over 30 years, there would seem to be a reduction in demand as the population adjusted to the restrictions.

There is, however, some indication that because people are uncertain as to the effect of precipitation, they do not want to pass up their watering day, and so may overwater. In the City of Denver, records for 1979 indicate that with watering restrictions water use was reduced for the months of June, July and August as compared to the expected use without restrictions, but for the cooler month of September, still restricted, use was more than the expected amount (Denver Water Department, personal communication).

In Berthoud, where restrictions were imposed from the summer of 1975 until they were lifted in the summer of 1978, the manager is puzzled as to the effect. From analysis of the actual and required sprinkling use from June to September in these years, it would appear that the use in relation to the calculated needs dropped during the drought year of 1977, and then increased in the summer of 1978 when restrictions were lifted, but did not reach the level of the earlier restricted years.

Several towns feel that they have evidence that restrictions reduce peak use and this in itself is a very useful effect. The Berthoud experience, as the Perth study, could indicate some effect on demand, but further research is needed on the subject, so that the managers could have a better idea of expected results.

One town (Greeley) has directly addressed the concept of efficiency of use by requiring that there be no outside watering during the hours of noon to 5 p.m. This measure is designed not to reduce use, but to promote efficient use by restricting watering during the hours of highest evaporation.

V. Drought Contingency Plans

There was little concern among the managers that there would be a drought severe enough to seriously affect them. These towns lie in an area not severely affected by the drought of 1976-77, although conditions varied from one section to another. Those that received Colorado-Big Thompson project water benefited from the Northern Colorado Water Conservancy District's ability to deliver 100 percent of its allotment in 1977, as there was good carryover in the reservoirs for the first year of the drought. However, if the drought had continued one more year, the allotment probably would have dropped to 50 percent (Simpson, 1980), and some cities and towns would have experienced difficulties in meeting demand.

Howe and others (1980) concluded in a recent study that restrictions on the outside use of water were the most economical, rational way of dealing with the infrequent, severe drought. The managers interviewed here place this measure as their first choice in dealing with such a hazard. All but two of them felt that they could reduce use sufficiently through restrictions, despite the qualms shown earlier as to the results, and they were convinced that their customers would cooperate with them.

From other studies this tool appears effective in the short run in cutting use where the public is convinced of a crisis, as in the California drought (Hoffman et al., 1979). The element of crisis is emphasized by these managers also as necessary for public cooperation. None of them felt it likely that a drought could go on long enough to cause severe dislocations, such as serious loss of landscaping vegetation.

A few managers suggested collaboration with agricultural users as to the timing and use of water during a drought in such a way that both would benefit.

There is some concern that reducing use by any means will result in decreased revenue, and therefore hamper the repayment of debts. One of the towns found itself in this difficulty recently when anticipated growth did not occur as quickly as projected (Boulder Daily Camera, 1979).

The managers are quite willing to consider a wide range of measures which might be used to cope with a drought induced shortage, and their approval or disapproval of these is shown in Table 16. It should be noted, however, that these answers are in the context of a severe shortage, an event that most of them do not believe to be likely to occur.

TABLE 16

MEASURES WHICH MIGHT BE USED IN CASE OF A DROUGHT

	Strongly Approve %	Slightly Approve %	Slightly Disapprove %	Strongly Disapprove %
Restrictions on use (e.g. sprinkling hours, etc.)	81	14	5	0
Restrictions on amount per household	14	36	25	25
Restrictions on size of lawn	18	26	37	18
Restrictions on growth	19	28	31	22
Raising the price for consumption above a certain level	50	28	14	8
Using treated sewage water for irrigation	79	8	10	3
Using treated and purified sewage water for drinking	29	34	21	16
Developing additional supplies	95	0	5	0

A. Rationing

The managers were all willing to discuss restrictions on the timing or character of the use of water, but restrictions on the total amount of water allowed to a customer, i.e., rationing, appeared to them as unrealistic, although many were aware of this action on the part of water utilities in California in 1977. Half of them disapproved of this as a management tool, and the other half would consider it only in case of an extreme drought.

During the California drought of 1977, consumers did not mind conserving, once they were convinced of the seriousness of the drought. They preferred a fixed allocation within which they could determine their own priorities for water use, rather than have authorities ban outside use or car washing, for example (Hoffman et al., 1979). If conditions became equally severe in Colorado, this type of reaction might surface.

B. Metering

Eleven of the towns are fully metered, and in several others meters or meter yokes are required on new construction. Further metering is likely to take place in response to the requirements of Federal grants and loans. In the towns which have them, the managers report little dissatisfaction with meters among consumers.

Metering is well substantiated as an effective method of reducing use immediately (Linaweaver et al., 1966), and there is strong evidence that it also reduces long-term demand. Hanke and Boland (1971) note that average residential water use in Boulder decreased 36 percent with the advent of metering in 1961, and did not return to the original level in subsequent years. The effect appears analogous to that of energy use, where individual metering as compared to master metering in a building has been found to save 10 to 35 percent of electricity used for cooling, lighting and appliances (McClelland et al., 1980).

Metering would seem an attractive conservation option but several managers point out that it is costly and difficult to install meters in older homes, and politically dangerous to try to force older residents to pay the costs. As one manager put it, "We're preparing an ordinance to require meters on all new construction. What hasn't been devised yet is how to meter 8,000 existing customers and still have the same people stay in office." In this view it is better to spend money now acquiring new water rights which will appreciate with time and inflation, rather than pay for meter installation (in older homes). Given the population projections, some argue, within 20 years most of the housing will be of recent construction which usually has meters installed.

Several managers referred to the fact that, with meters, revenues were likely to drop in times when consumers conserved, whereas flat rate revenues do not. One city has metered about one-third of its customers through installations in new construction, and uses these readings to set flat rates for the rest of the city. The manager feels this protects it against financial fluctuations, allows adequate rates, and avoids upsetting older residents who would have to pay for meter installation. It does not, however, affect the demand of flat rate users.

C. Price

Over three-quarters of the managers approve of using price as a tool to manage use in times of scarcity (Table 16), but many then quickly add that it seldom can be used that way. Two-thirds of them do not think that their present pricing system contributes to efficient use. Figure 9 illustrates the tenuous relationship between demand and price for seven of the communities studied, although use has been related to price in other studies of the price elasticity of water (Howe and Linaweaver, 1967). In a study conducted by Burns, et al (1975), two similar socioeconomic residential areas in Boulder, which were charged different prices for water, were compared to determine the effects of price on demand. Residential domestic water use for the winter season averaged 5900 gallons per month per household in the area charged 86¢/1000 gallons and 7450 gallons per month per household in the area charged 43¢/1000 gallons. Summer sprinkling use was even more sensitive, the higher priced area using 13,440 gallons/month/household compared with 18,750 gallons/month/household in the lower priced area. On the other hand, in 1972 when Boulder increased water prices from 35¢/1000 gallons to 43¢/1000 gallons, water use actually increased slightly (Flack, 1979).

Most of the towns have considered alternative methods of pricing, often with help from consultants. They have looked at increasing block rates in a metered system, but have rejected them on grounds of the expense of metering, or because it was felt such rates might hurt a few large users such as auto washes or dairy farms which provide jobs. Only one town uses a higher rate for summer use. The managers feel that their town councils are significantly more supportive of price raises than are their consumers. However, the council members are reluctant to raise prices in the face of perceived consumer opposition, especially in towns with many older residents.

D. Water Saving Devices

Only about one-third of the managers have given any consideration to water saving devices such as shower heads or toilet dams. Three of the

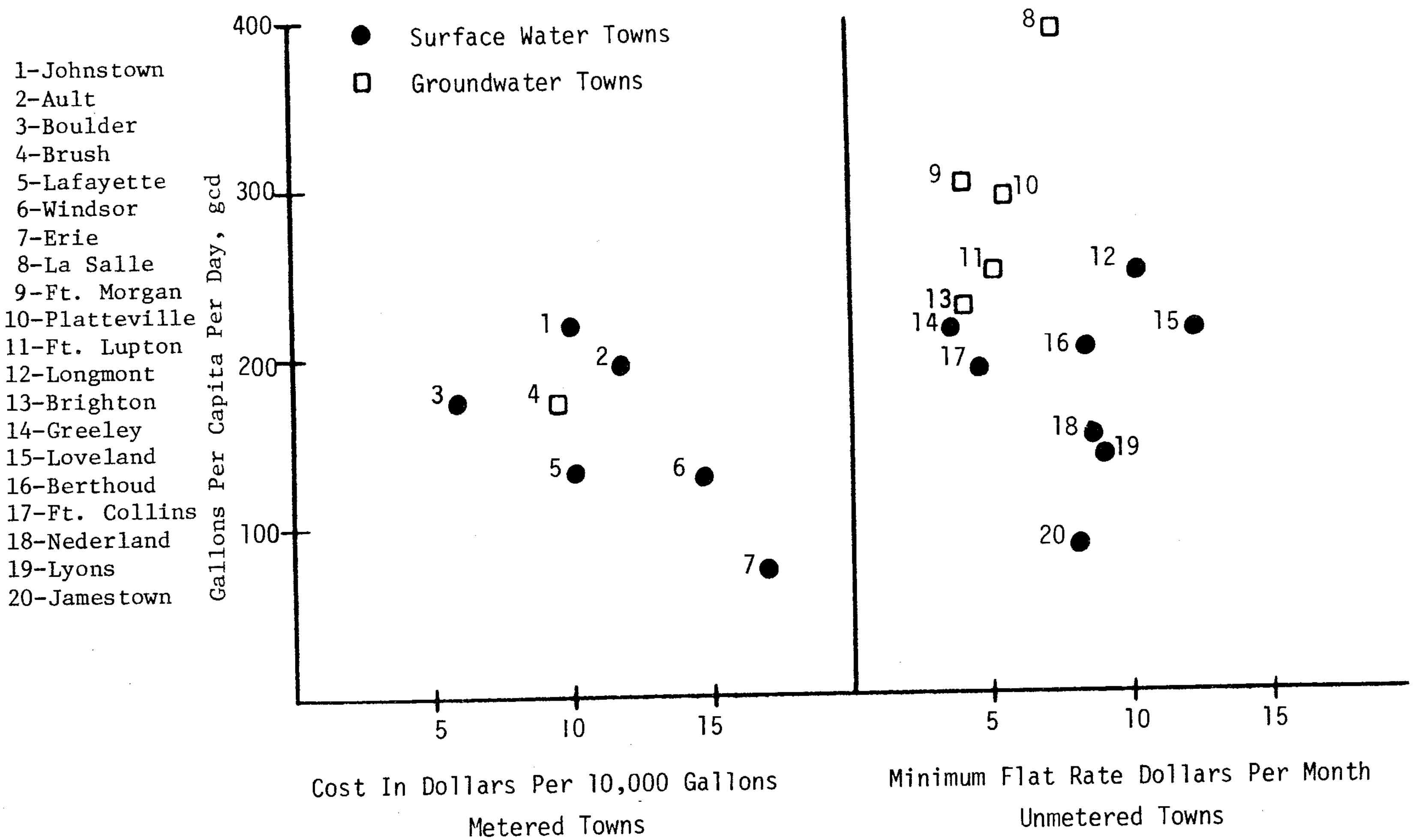


FIGURE 9

USE AND PRICE IN SAMPLE TOWNS, 1978

towns require them in the building code for new construction. Several of the managers argued that they save so little water that it is a waste of time to discuss them. Recent estimates for Denver indicate savings of 6.205 gallons per capita per day for households equipped with these two devices (Morris and Jones, 1980). Flack (1977) estimates that these devices plus faucet aerators could save 35% of the household water use in new construction over regular installations.

E. Appeals to Consumers

Over 60 percent of the managers have used appeals to their customers to cut down on use in times of shortages, and all but one feel that this had some effect in reducing use. Only one town had a somewhat systematic approach to consumer education regarding efficient water use, with a part-time employee designated to carry it out. Others sporadically use American Water Works Association material on conservation either in their bills or in the press when the local paper will print it. An interesting factor at work here is the "spill-over" effect of Denver Water Department publicity during the 1977 drought. Considering the extensive circulation of Denver newspapers in the area, and the fact that much radio and TV coverage originates there, this may well have had an effect on the whole region, although this has not been documented. Several towns complained that use, and their revenues, dropped in this period, despite the hot, dry weather and their plentiful supplies of water. One of the towns near Denver, with abundant supplies, felt obliged to take a conservation stance because of the Denver publicity and regulations and ordered 20,000 pamphlets on methods of saving water, most of which it still had not distributed at the time of this survey.

F. The Long Range View

The managers interviewed do not, on the whole, see themselves as simply providing "all the water people want" at present prices, as was found by Russell et al. (1970) in their study of New England towns. Over half of them responded that they are concerned with prudent use of a scarce resource although their main actions in providing for the future are to assure an adequate supply of water rights and the facilities to treat, store and transmit the water rather than to reduce demand. They are, however, concerned with metering in the future and with a realistic price policy. Many consider the use of water to maintain green lawns and trees as an important civic aesthetic value which people are willing to pay for. As one manager put it, "Council policy is to maintain the town as an oasis on the edge of the desert. And water isn't like oil; you don't use it and lose it".

The other half feel that in the long run, twenty years or more hence, more efficient use of water will be needed as it is in limited supply in the region. However, they see little urgency for present action on increasing efficiency in use.

Neither of these attitudes is associated with the level of use in the towns. It was also thought that paid employees might differ from elected officials in their long-range view, but this was found not to be the case.

VI Return Flows

It was anticipated that there might be some concern about the effect of increased efficiency of water use on the return flows. This was not the case. Most managers feel that they have little flexibility regarding the management of return flows under Colorado water law, but some towns have effectively exploited this resource by trading with farmers downstream who can divert sewage discharge water for irrigation while permitting the town to divert cleaner water at a higher point on the stream. Not every town has carried this process as far as possible. Many towns are constrained from this kind of activity either by the kind of water right owned or by the location or type of their sewage treatment facilities.

VII Conclusions

Despite the rhetoric about conservation and efficient use of water from the national and state capitals, there are few incentives for these managers to respond positively. While many recognize that water resources are limited, they are not prepared to take what they see as unpopular measures to reduce use unless there is a clear and present danger to the community such as a severe drought. They have thought about but are not overly concerned about long range measures to reduce demand, and few of them are sufficiently impressed with the value of alternative uses for water to feel that conservation should be a priority.

All but a few of the smallest towns have considered a range of structural and non-structural measures for managing supply, and in some cases demand, although probably not as systematically as envisioned by the Water Resources Council. For many of the towns, poor record keeping is an obstacle to realistic consideration of alternatives.

Most of the towns use one or more of the tools which have been described for managing the use for water, but seldom in a comprehensive framework. Only one has used very many at a time, and that in a town with poor access to water rights which has had persistent problems in keeping water supply and waste disposal in line with population growth.

A number of towns appear to have placed undue reliance on a policy of water rights fees or donations by developers to provide all the water resources needed for future growth. The acquisition of water rights has become a complicated and competitive process. Experience indicates that many of the towns' water rights donation policies may be inadequate.

Exclusive of water rights donation policies, the majority of the towns did not have well-defined plans for acquiring and managing the water to meet projected growth. Based on interviews, approximately 50 percent of the water managers did not have a working knowledge of the average and minimum yields of the towns' water rights holdings. Methodology differed in estimating the average and especially the dependable or minimum yield. In addition, very little analysis had been performed on the effects of a record drought on the water supply system and options available to meet demand if a water shortage occurred for any reason.

The circumstances in which the towns in the study area are most likely to push for more efficient use of water are:

- In the event of a severe and prolonged drought
- In towns not eligible for Colorado-Big Thompson water, as other rights become scarcer
- In groundwater towns which are forced to shift to surface supplies to improve water quality in line with EPA standards.

Chapter 5

ATTITUDE SURVEY OF RESIDENTIAL WATER CUSTOMERS

This chapter will focus on the water conservation attitudes of water customers in seven northern Colorado towns. From this information, certain recommendations will be made for appropriate water conservation programs in each town.

I. Methodology

The towns to be included in the customer survey were categorized on the basis of population, whether they were metered or unmetered, and if sprinkling restrictions were used. Population was used to define urban towns with more than 12,000 people and rural towns with less than 12,000 people. Note that except for Brighton, this classification has the same results as that used in Chapter 3.

In selecting the seven sample towns, the following Table 17 was constructed. One town was randomly selected from each category as representative of that category. Questionnaires were mailed to randomly selected residential customers in each of these towns.

Towns not included in the customer survey were Milliken, Ft. Morgan, Brush, Berthoud, Ault, and Ft. Lupton. These towns were excluded either because reliable water use data for these towns was not available at the time of the survey, they were remote from the primary area, or they did not wish to participate.

In the following discussion the selected towns and cities are referred to by the category abbreviation which they represent, i.e., first letter refers to size of city or town; R = rural with less than 12,000 population; U = urban with more than 12,000 population. Second letter refers to whether the town is metered; U = unmetered, M = metered. And the third letter indicates if restrictions were in effect where R = restricted, U = unrestricted.

The RMR town selected was Lafayette, the RMU town was Johnstown, the RUU was La Salle, in the urban category Boulder was the only UMU town, Longmont was selected as the UUR town, and the Greeley metered customers were used to represent a UMR town. No town fit the urban, unmetered, unrestricted UUU category.

Once the sample towns were known, the water utility managers were contacted and requested to supply a listing of all the water customers' names and addresses for that town. From these lists, 120 names for each town were randomly selected for the survey. The 840 names and addresses in all seven towns each received a questionnaire by mail.

TABLE 17

CATEGORIZATION OF SAMPLE TOWNS FOR CUSTOMER SURVEY

	Metered Restricted	Metered Unrestricted	Unmetered Restricted	Unmetered Unrestricted
Rural pop.<13,000	Lafayette* Erie Windsor	Estes Park Johnstown* Louisville	Platteville Lyons* Jamestown	Ft. Lupton La Salle* Wellington Nederland
Urban pop.>13,000	Greeley*	Boulder*	Loveland Longmont* Brighton** Ft. Collins	

* Towns selected randomly for survey.

Note 1. Greeley is one-third metered, and these customers were used to represent the UMR town.

2. Other towns who participated in the survey at their own request: Ft. Collins, Brighton.

**Brighton was classed as a rural town in the water use survey of Chapter 3.

A. The Questionnaire - Mailing and Responses

The first mailing, except for Greeley, was on November 26, 1979. Each household in the sample received a cover letter explaining the purpose of the survey, a questionnaire and a stamped self-addressed envelope in which to return the completed questionnaire. (The questionnaire is included in the Appendix.) As the questionnaires were returned, they were checked against the mailing lists and no further contact was made with the respondents. On December 26, 1979, another letter, questionnaire, and self-addressed envelope was sent to the water customers who had not yet replied. A final follow-up letter was sent on January 10, 1980. This last mailing did not include a questionnaire.

Greeley's mailings were made on January 21, 1980, February 4, 1980 and February 18, 1980. This mailing was sent out later than the others because Greeley's mailing list was not available until early January.

Overall the response rate was good for a mail survey. As shown in the following table, over 65 percent of those sent questionnaires participated in the survey.

TABLE 18

RESPONSES TO MAIL SURVEY

	No Response	Responded but DNWTP	Responded after 1st Letter	Responded after 2nd Letter	Total Positive Responses
La Salle	30 (25%)	9 (8%)	53 (44%)	28 (23%)	81 (67%)
Lyons	50 (42%)	10 (8%)	43 (36%)	17 (14%)	60 (50%)
Longmont	24 (20%)	14 (12%)	60 (50%)	22 (18%)	82 (68%)
Lafayette	46 (38%)	7 (6%)	41 (34%)	26 (22%)	67 (56%)
Boulder	29 (24%)	6 (5%)	67 (56%)	18 (15%)	85 (71%)
Johnstown	18 (15%)	14 (12%)	69 (58%)	19 (16%)	88 (74%)
Greeley	22 (18%)	9 (8%)	65 (54%)	24 (20%)	89 (74%)
TOTALS	219	69	398	154	552

DNWTP = Did not wish to participate N = 840

Response rates may have been lower than otherwise because of the holiday season during which the questionnaires were mailed. The highest response rates from Greeley and Johnstown (74%) may be attributed to the special mailing situations. The Johnstown town secretary was supplied with all the necessary mailing materials and she randomly selected the 120 households and mailed the forms using the town's envelopes.

Greeley's mailings occurred after the holiday season. If no reply was received to the first mailing after fifteen days, the follow-up letters and additional questionnaires were sent out. The other towns received their second mailings after a month had elapsed.

Statistical analysis of the response data was achieved by use of the Statistical Package for the Social Sciences (SPSS).

II. Response Analysis

A. Large Scale Water Conservation Methods

In the event of a water shortage, certain steps can be taken to help alleviate the water supply problems. The respondents were presented with several such methods and asked to state whether they strongly approved, slightly approved, slightly disapproved, or strongly disapproved of the method if a future shortage were to occur. The following table illustrates the responses towards permanent restrictions on summer use.

A majority in all towns approved, either slightly or strongly, of restricting summer water use. The urban, metered, restricted (UMR) town had the highest favorable rate (84%) to this method of conservation. The towns with a lower overall approval, RUR at 62%, RMR at 65% and UMU at 68%, also had the highest rates of strong disapproval (20-23%) of this option.

According to the managers of the water supplies of 25 towns, including the seven for this survey, they approved of permanent restrictions on summer water use to deal with a severe drought, with 81% supporting the idea most strongly.

TABLE 19

PERMANENT RESTRICTIONS ON SUMMER WATER USE

Town class	Strongly approve	Slightly approve	Slightly disapprove	Strongly disapprove
*UMR	48%	36%	5%	11%
UMU	36	32	9	23
UUR	48	25	9	18
RMR	26	39	15	20
RMU	33	44	15	8
RUR	31	31	18	20
RUU	30	43	11	16

*UMR = urban, metered, restricted
UMU = urban, metered, unrestricted
UUR = urban, unmetered, restricted
RMR = rural, metered, restricted
RMU = rural, metered, unrestricted
RUR = rural, unmetered, restricted
RUU = rural, unmetered, unrestricted

Another approach to alleviating water supply problems would be to limit the size of lawns. For example, the town could specify that lawns must be less than 50% of a person's landscaping (Table 20). The majority of the consumers in all towns except the rural, unmetered towns approved of this plan but the majority was not large. The city managers interviewed disapproved of this method by 55% to 44% (See Chapter 4).

Restrictions on city growth or population size received a high approval rate. This is illustrated in Table 21, where on the average more than 70% approved of this option.

TABLE 20

LIMITING LAWN SIZE

Town Class	Strongly approve	Slightly approve	Slightly disapprove	Strongly disapprove
UMR	22%	34%	20%	24%
UMU	28	22	16	34
UUR	28	34	14	24
RMR	23	35	12	30
RMU	29	26	16	29
RUR	22	27	26	25
RUU	16	31	14	39

TABLE 21

RESTRICTIONS ON GROWTH

Town Class	Strongly approve	Slightly approve	Slightly disapprove	Strongly disapprove
UMR	31%	26%	21%	22%
UMU	35	25	14	26
UUR	39	30	8	23
RMR	51	30	11	8
RMU	34	27	19	20
RUR	50	28	13	9
RUU	43	31	15	11

According to the majority of the managers, they did not favor placing restrictions on city growth. Thirty-one percent disapproved mildly of these restrictions while 22% were strongly opposed (see Chapter 4).

A highly favorable method among water managers of increasing the efficiency of water use would be to raise the price for water. Increasing prices was strongly favored by 50% of the managers while 28% slightly approved. Consumers' attitudes were not quite the same on this issue. Most towns either only slightly approved or strongly disapproved of raising water use prices as shown in Table 22, although management opinion was that price increases were not favored by consumers.

TABLE 22

INCREASING WATER PRICES

Town class	Strongly approve	Slightly approve	Slightly disapprove	Strongly disapprove
UMR	22%	32%	15%	32%
UMU	32	26	12	30
UUR	8	39	20	33
RMR	29	29	11	31
RMU	18	43	15	24
RUR	21	32	21	26
RUU	10	26	24	40

Overall acceptance of increased prices ranged from 36% to 61%. The unmetered towns were the least receptive to raising water prices.

Using treated wastewater for irrigating parks, golf courses and the like was another method presented to the respondents. Consumers in all categories overwhelmingly favored this approach. Nearly 90 percent of the respondents approved of using treated wastewater for irrigation, and nearly two-thirds strongly favored this type of conservation effort. See Table 23.

TABLE 23

REUSE FOR IRRIGATION

Town Class	Strongly approve	Slightly approve	Slightly disapprove	Strongly disapprove
UMR	75%	20%	1%	4%
UMU	75	17	3	5
UUR	80	16	0	4
RMR	71	18	3	8
RMU	72	17	6	5
RUR	84	14	0	2
RUU	61	27	1	11

Managers of the towns were similarly positive in their attitudes toward reusing treated wastewater for irrigation purposes. Overall manager approval was 87 percent with strong approval by 79 percent (Chapter 4).

Consumers were not receptive to reusing treated and purified wastewater for domestic purposes. Overall disapproval of this method ranged from 58% to 84%. The urban, restricted towns and the rural, unrestricted towns disapproved most strongly. The UMU town shows the highest approval rate of 42%. See Table 24.

Along with questioning the respondents' attitudes towards reuse of treated sewage water for in-house use, the consumers were also asked for their personal reaction to drinking this treated water. Those who disapproved or approved strongly on the first question generally felt the same way on the second question, but those slightly approving or disapproving in some cases became less certain about their opinion (see Tables 24 and 25).

TABLE 24

REACTIONS TO DOMESTIC REUSE - GENERAL

Town class	Strongly approve	Slightly approve	Slightly disapprove	Strongly disapprove
UMR	5%	20%	21%	54%
UMU	20	22	16	42
UUR	7	9	31	53
RMR	11	23	25	41
RMU	6	12	20	62
RUR	15	18	29	38
RUU	7	9	21	63

TABLE 25

REACTIONS TO DOMESTIC REUSE FOR DRINKING

Town class	Strongly approve	Slightly approve	Not sure	Slightly disapprove	Strongly disapprove
UMR	4%	18%	19%	11%	48%
UMU	15	27	17	11	30
UUR	8	8	30	15	39
RMR	14	22	23	10	31
RMU	5	12	18	15	50
RUR	16	10	21	21	32
RUU	7	3	17	12	61

Another related question asked was, "Could this community purify its sewage water and return it safely to its drinking water system?" The results determine whether the community believed the technical knowledge was available to implement a program for the treatment and purification of sewage water for drinking purposes (Table 26).

TABLE 26

TECHNICAL FEASIBILITY FOR REUSE

Town class	Yes definitely	Probably	Not sure tend to think so	Not sure tend to think no	Probably not	Definitely not
UMR	6%	14%	28%	26%	12%	14%
UMU	18	26	33	8	9	6
UUR	9	19	21	29	8	14
RMR	10	16	27	11	20	16
RMU	5	10	18	22	27	18
RUR	19	15	16	21	12	17
RUU	3	7	15	29	29	17

Technical knowledge was believed possible by the UMU town (77%), although only 18% of these respondents were entirely certain. The rural, restricted towns held similar opinions though not quite so strongly, however the RUR town reported 19% (the highest) of the customers feeling certain that this technical knowledge was available. The RUU believed, by 75%, this program was not feasible in their community.

The last measure to be considered in the event of a water shortage was the development of additional mountain supplies. The majority of the respondents (61 - 90%) in all town classifications approved of development (Table 27). The UMU town had the lowest approval rate and this might be attributed to the fact that the town is strongly environmentally conscious.

TABLE 27

DEVELOPING ADDITIONAL MOUNTAIN SUPPLIES

Town class	Strongly approve	Slightly approve	Slightly disapprove	Strongly disapprove
UMR	66%	20%	9%	5%
UMU	37	24	15	24
UUR	69	18	8	5
RMR	77	13	6	4
RMU	66	20	6	8
RUR	44	28	11	17
RUU	58	26	9	7

Town managers favored this approach even more than the customers as 95% approve strongly of mountain water development.

B. Water Saving Devices

In addition to the outside-of-house measures and large scale water supply and conservation methods, water saving devices installed in the home can also help to alleviate water supply problems although on a much smaller scale. The questionnaire included a list of water saving devices for toilets, faucets and showerheads as well as devices to reduce lawn watering. The respondents were asked to state whether or not they had installed such devices.

The following table lists the percentages of those who reported they had installed water saving devices for toilets (Table 28).

The RMR town claims the highest percentage of toilet water saving devices being used (69%). The rural, unrestricted towns (RMU and RUU) reported the lowest usage of these devices.

The brick or plastic bottle was the most popular device for all towns except one. This town, the UMR, claimed the highest usage of low-flush toilets. The toilet dam was the device used the least (0-3%).

TABLE 28

WATER SAVING DEVICES INSTALLED (TOILETS)

Town class	Brick or plastic bottle	Dam	Water saving Valve	Low flush Toilet	Other device
UMR	16%	0%	9%	22%	3%
UMU	28	0	14	6	3
UUR	18	1	13	9	3
RMR	27	3	16	18	5
RMU	9	0	7	10	0
RUR	19	0	17	17	0
RUU	6	0	8	8	1

In addition to the toilet devices mentioned above, respondents were queried on other water saving devices. These included showerflow restrictors, faucet aerators and any device installed to reduce lawn watering. Table 29 indicates the percentage of respondents in each town who have installed any of these devices.

TABLE 29

OTHER WATER SAVING DEVICES INSTALLED

Town class	Showerflow restrictor	Faucet aerator	Device to reduce lawn watering	Other
UMR	40%	35%	37%	0%
UMU	42	42	10	2
UUR	37	45	13	0
RMR	39	31	10	0
RMU	17	30	6	1
RUR	24	34	9	0
RUU	22	34	17	3

The urban towns reported the highest usage of showerflow restrictors and faucet aerators. Usage of both devices in the same household ranged from 20-25%. Rural towns claim a higher usage of the faucet aerators than the showerflow restrictors.

By aggregating the data and running a cross-tabulation on all water saving devices except those that reduce lawn watering, an overall picture can be presented. For all towns, 61% of the respondents claimed the usage of at least one water saving device whereas 39% had no devices installed. Twenty-seven percent of the respondents who had at least one toilet device also had installed a showerflow restrictor. Of the 61% claiming usage of at least one device, 43% had installed only one device, 34% had installed two devices and 23% had installed three or more devices.

Table 30 illustrates the reported installation of water saving devices for each category of device and town.

C. Metering vs. Flat Rate

The respondents were asked several questions on metering vs. the flat rate system. The following table lists the percentage of responses to the question, "Do you think people's water should be metered or is a flat rate charge a better idea?" (Table 31).

The metered towns favor metering much more strongly than the flat rate towns favor the flat rate system. A larger percentage of respondents from the unmetered towns were uncertain as to which method was better.

Respondents were also asked to indicate on which system they would use less water and on which system they would pay less for their water use (see Table 32). Generally, more respondents felt that they would use the same amount of water regardless of the billing system. Two of the three unmetered towns' customers believed they would pay less on their current system. No pattern clearly evolved from the opinions of respondents in metered towns.

TABLE 30

PERCENTAGE OF HOUSEHOLDS REPORTING INSTALLATION OF WATER SAVING DEVICES

Town Class	No Devices	At Least 1 Device	Only 1	Only 2	3 or More	At least One Toilet Device & Showerflow Restrictor	Toilet Devices	No Toilet Devices	Most Popular Toilet Device
UMR	36%	64%	38%	38%	24%	40%	42%	58%	Lowflush
UMU	30	70	38	35	27	38	44	56	Brick
UUR	40	60	32	36	32	38	35	65	Brick
RMR	34	66	41	32	27	39	45	55	Brick
RMU	49	51	57	41	2	7	26	74	Lowflush Valve
RUR	43	57	30	45	25	21	41	59	Lowflush Valve
RUU	49	51	56	31	13	13	20	80	Lowflush

TABLE 31

METERING VS FLAT RATE

Town Class	Metered	Flat rate	Not sure	Other
UMR	86%	6%	8%	0%
UMU	95	3	2	0
UUR	32	49	19	0
RMR	81	11	7	1
RMU	81	9	10	0
RUR	26	52	22	0
RUU	21	57	22	0

Respondents were then asked to indicate the most important reason for their preference towards a flat rate or metering system (see Table 33).

By using a cross-tabulation, those respondents favoring a metered system felt that way primarily for reasons of fairness or equity and, secondly, because they felt that metering conserves water. Those preferring the flat rate system did so because it costs less and, secondly, for fairness or equity.

Next, the respondents were asked to indicate their previous month's water bill and whether or not that bill was, in their opinion, about right, too high or too low (see Table 34). Regardless of whether the towns were metered or unmetered, the majority of the respondents felt their bills were about right. A smaller percentage felt that the bills were slightly high.

D. Water Use Patterns

Three questions concerning the installation of water saving devices and the alteration of landscaping were presented to the respondents. Several statements reflecting various attitudes towards such action were given and the respondents were asked to indicate the statement which best fit their attitudes.

Table 35 illustrates the percentages for responses to each attitude towards the installation of a toilet water saving device that costs about $6 and can be installed in 10 minutes without the use of tools. Urban city consumers are more willing than rural town users to install a toilet dam even if no money were saved, however, all communities appeared willing to cooperate if these devices were required. The RMR town had the largest percentage of all towns requiring that the device pay for itself in two years.

TABLE 32

USE LESS ON METER OR FLAT RATE

Town Class	Use less on Meter	Use Same	Use less on Flat Rate
UMR	43%	57%	0%
UMU	51	46	3
UUR	28	66	6
RMR	38	62	0
RMU	36	63	1
RUR	16	79	5
RUU	22	68	10

TABLE 33

PAY LESS ON METER OR FLAT RATE

Town Class	Pay less on Meter	Pay Same	Pay less on Flat Rate
UMR	33%	31%	36%
UMU	40	33	27
UUR	11	35	54
RMR	39	34	27
RMU	35	48	17
RUR	21	50	29
RUU	6	43	51

TABLE 34

OPINION ON WATER BILLS

Town Class	Very High	Slightly High	About Right	Slightly Low	Very Low
UMR	6%	22%	67%	5%	0%
UMU	4	17	68	8	3
UUR	4	15	76	4	1
RMR	15	32	50	3	0
RMU	2	14	78	4	2
RUR	7	28	53	9	3
RUU	4	17	75	3	1

TABLE 35

REACTIONS TO INSTALLATION OF A TOILET DAM

Town Class	If it Saved Water	Pay for Itself	If Required	If Required & Free	Permit Local Agency to do it	Would Remove it
UMR	56%	18%	21%	4%	0%	1%
UMU	53	15	24	2	4	2
UUR	55	13	22	4	3	3
RMR	42	37	14	3	2	2
RMU	46	18	32	3	0	1
RUR	46	14	22	14	2	2
RUU	31	21	42	4	0	0

A similar question concerning reactions to the installation of a device to reduce shower flow was then asked. Table 36 lists these responses. The rural, unrestricted towns showed the lowest percentage (28%) willing to install a shower flow restrictor merely to save water. The rural, unrestricted and the urban, restricted towns claimed the highest percentages willing to install the device "if it were required".

From analyzing the two questions mentioned above, the overall majority would be willing to install a water saving device in their toilets and/or their showers.

Respondents were also asked whether or not they would be willing to change their landscaping in order to reduce water consumption. Table 37 shows the frequency, in percentages, for each response. Again, most appear willing to change landscaping if required to do so.

Table 38 represents the frequency with which people water their lawns. The largest percentage of people who water their lawns daily or every other day reside in town with restrictions on watering. The largest percentage of people watering twice weekly or less frequently generally reside in metered, unrestricted towns.

Table 39 lists the percentages for the people owning each type water-using appliance in each town. Generally, the urban towns' customers own a larger percentage of garbage disposals and dishwashers than the rural towns. Washing machines are the most prevalent of the appliances in all towns regardless of classification. Urban towns also have a larger percentage of private swimming pools although overall there are very few in any of the towns.

TABLE 36

REACTIONS TO INSTALLATION OF A SHOWER FLOW RESTRICTOR

Town Class	If it Saved Water	Pay For Itself	If Required	If Required & Free	Permit Local Agency To Do It	Would Remove It
UMR	52%	19%	20%	3%	1%	5%
UMU	47	11	18	4	8	9
UUR	45	11	24	4	4	9
RMR	45	24	16	0	5	5
RMU	28	22	35	0	1	13
RUR	41	13	18	5	7	14
RUU	28	17	38	7	0	10

TABLE 37

REACTIONS TO LANDSCAPE CHANGES

Town Class	If It Saved Water	If It Saved $10/yr	If It Saved $50/yr+	If Required	Not If Required	Other
UMR	40%	2%	9%	40%	9%	0%
UMU	34	1	8	40	9	8
UUR	35	5	7	41	7	5
RMR	36	7	21	24	10	1
RMU	23	5	6	59	5	2
RUR	34	4	9	31	18	4
RUU	27	6	55	11	1	0

TABLE 38

FREQUENCY OF LAWN WATERING

Town Class	Daily	Every Other Day	Twice Weekly	Weekly	Every Other Week	Monthly or Less Often	No Lawn
UMR	11%	37%	46%	5%	0%	0%	1%
UMU	5	28	48	14	4	0	1
UUR	5	44	42	8	0	1	0
RMR	13	52	27	0	0	2	6
RMU	2	25	58	14	1	0	0
RUR	16	28	39	5	2	0	10
RUU	9	36	49	5	0	0	1

TABLE 39

OWN WATER-USING APPLIANCES

Town Class	Garbage Disposal	Automatic Dishwasher	Washing Machine	Swimming Pool	Other
UMR	85%	86%	96%	2%	2%
UMU	85	78	88	2	6
UUR	86	73	95	3	1
RMR	86	77	94	0	0
RMU	67	51	96	0	0
RUR	60	50	78	0	0
RUU	74	57	90	1	1

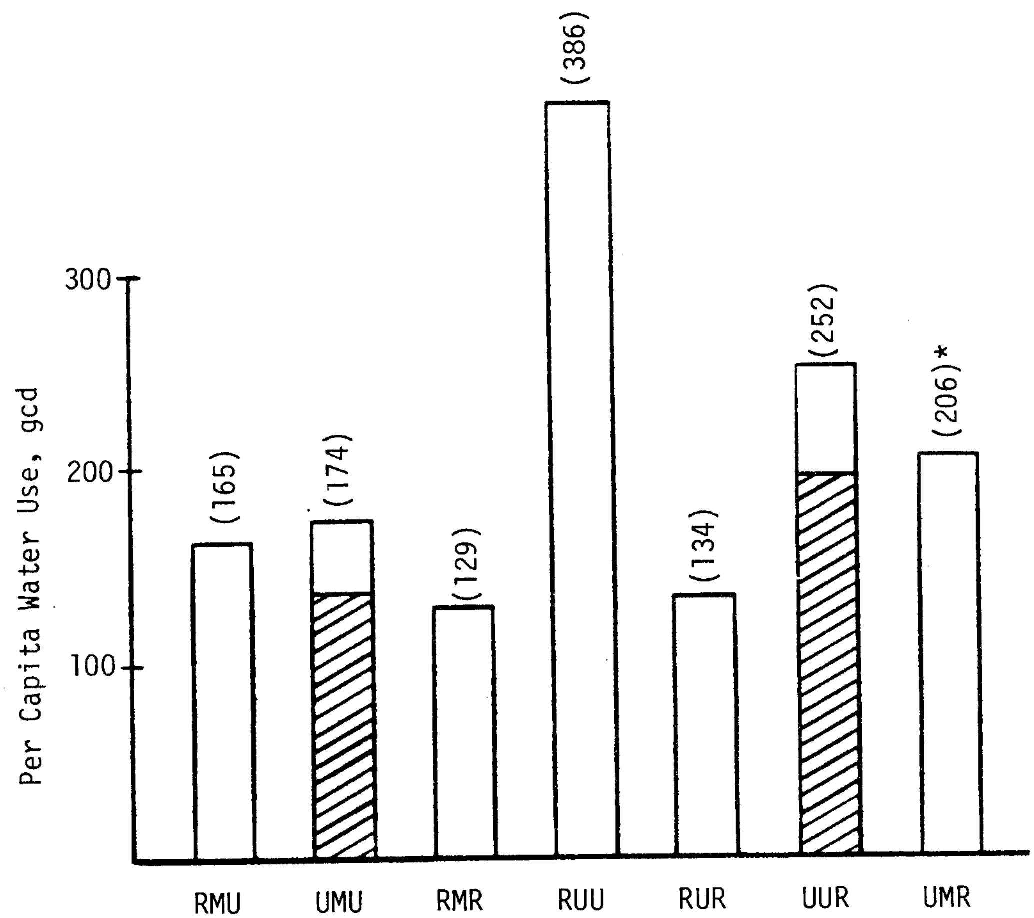
The number of water-using appliances was cross-tabulated with income for each town category. This correlation was highly significant statistically in four of the seven towns. As expected, it was found that those earning at least $25,000 per year were also the ones owning the larger number of water-using appliances.

III. Water Use in the Customer Survey Towns

The towns selected for the customer survey were categorized on the basis of population, whether they were metered or unmetered, and if sprinkling restrictions were used. The sample cities selected are enumerated at the beginning of Chapter 5. Average municipal water use, on a per capita basis for 1978, for each sample town is shown in Figure 10. The unmetered rural town without restrictions had a much greater per capita use than any other category. The lowest averages uses were in the metered and unmetered rural towns that were under restrictions.

Water use during the winter months, November through April (except Greeley, October through March), is shown in Figure 11 for the sample towns. The high winter use in the unmetered, unrestricted town appears to be a result of high system leakage or inaccurate master meters in addition to some outdoor water use. The minimum month winter use for this town was 113 gcd while the maximum winter month of 393 gcd occurred in April. The other sample municipalities also exhibited greater water use in November and April than in mid-winter, though not to the extreme found in the unmetered unrestricted rural town.

Summer water use during the months May to October (except Greeley, April through September) is shown in Figure 12. The unmetered unrestricted



RMU: Johnstown
UMU: Boulder
RMR: Lafayette
UMR: Greeley (metered)
RUU: La Salle
RUR: Lyons
UUR: Longmont

*Greeley, which is one-third metered, was used to represent this category using metered customer data from the survey, 1979.

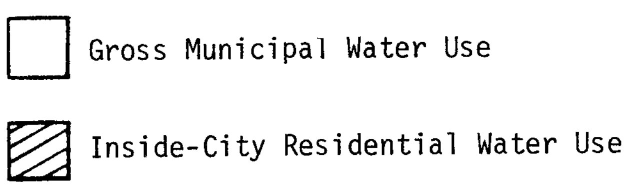
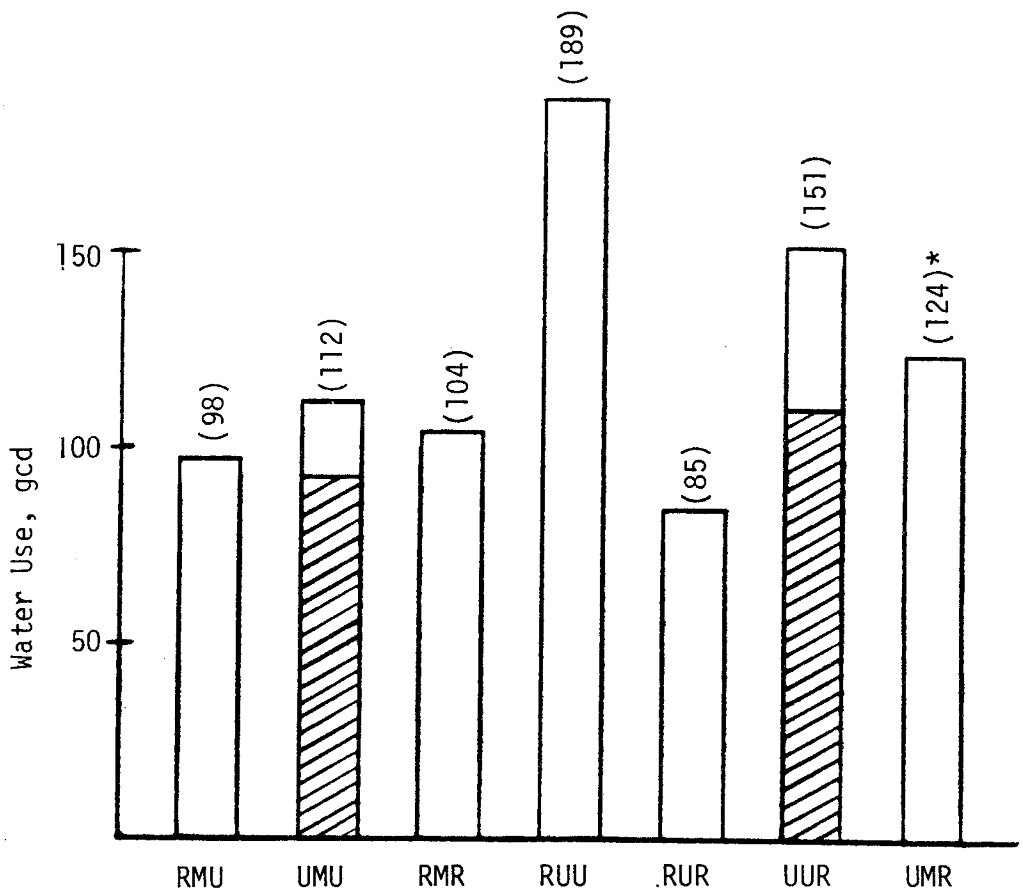


FIGURE 10

AVERAGE WATER USE FOR CUSTOMER SURVEY SAMPLE TOWNS, 1978



RMU: Johnstown
UMU: Boulder
RMR: Lafayette
UMR: Greeley (metered)
RUU: La Salle
RUR: Lyons
UUR: Longmont

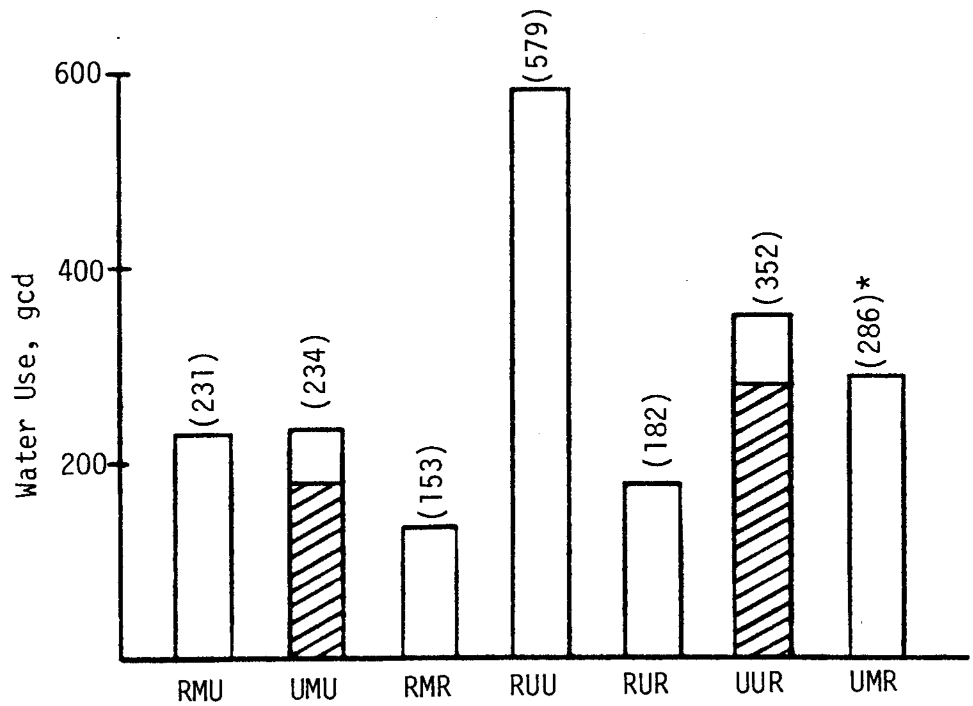
*Greeley data (UMR) is from survey customers ;
Winter, October-March, 1979

Total Water Use

Inside-City Residential Water Use

FIGURE 11

WINTER WATER USE, CUSTOMER SURVEY TOWNS 1978



RMU: Johnstown
UMU: Boulder
RMR: Lafayette
UMR: Greeley (metered)
RUU: La Salle
RUR: Lyons
UUR: Longmont

*Greeley data (UMR) is from survey customers ; Summer, April-September,1979

Total Municipal Water Use

Inside-City Residential Water Use

FIGURE 12

SUMMER WATER USE, CUSTOMER SURVEY TOWNS 1978 rural town once again had much greater per capita water use than any other category. Water use in this town averaged 579 gcd while the lowest use of 153 gcd occurred in the metered rural town with restrictions. The results of this sample seem to indicate that metering is as effective as restrictions in reducing outdoor water use. Greeley's metered water usage is the largest of any of the metered towns, reflecting the low cost of water to that city's metered customers.

IV. Socio-Demographic Variables

In addition to determining the attitudes in each town towards water conservation methods, value can also be derived from learning the effect, if any, of socio-demographic variables on water conservation attitudes.

This analysis included cross-tabulations of such socio-demographic variables as income, education and interest level in local water matters with the water conservation measures mentioned in the previous sections.

Generally, the results did not indicate many statistically significant (95% confidence level) correlations between these two types of variables. Reported here are the frequency distributions of these cross-tabulations. These values were aggregated and four general groups were compared. For example, income was divided into two groups, (1) those earning less than $25,000/yr, (2) those earning $25,000/yr or more. An attitudinal variable with choices of strongly approve, slightly approve, slightly disapprove and strongly disapprove was divided into two groups of (1) approve and (2) disapprove. Comparisons were made among the four groups to determine how responses varied with income.

Interest in local water matters was cross-tabulated with attitude towards reusing treated and purified wastewater for drinking purposes. In all of the urban towns, those with high interest levels in water-related issues approved of reuse more so than those who were not interested. Two of the rural towns also indicated the same results. These towns showed, too, that those with low interest levels disapprove of household reuse of water. The RUR and RMU towns varied from the other towns in that those who approved of household reuse did not necessarily have strong interests in water matters. By the same token, those who disapproved of reuse did not necessarily have a low interest in water matters.

Next, education was cross-tabulated with respondents' personal reaction to drinking treated and purified wastewater. Three of the metered towns showed that those with less education (less than a high school graduate) disapproved more strongly of drinking treated wastewater than those with at least a high school degree. Education seemed to have little effect in the other four towns (UUR, RUU, RMU, RUR) as the percentages for disapproval by those with lower educational levels was quite similar to the percentages for disapproval by those with more education (UUR = 57% & 55%; RUU = 50% & 53%; RMU = 67% & 69%; and RUR = 80% & 77%).

The effect of education on attitude towards technological feasibility of purification of wastewater for drinking purposes was also examined. In all except the two rural, unrestricted towns those with less education did not believe this process would be possible, while those with more education generally felt that the technological knowledge was available. The RMU town, however, indicated a lower percentage of people with higher education levels believing in the availability of technology for reuse, 35% compared to 84%, 51% and 56% in the other towns. Educational level had little effect on attitude towards the technical feasibility in the rural, unrestricted towns.

Interest in local water matters, education and income were all analyzed to determine their effect on permanent restrictions for summer water use. Generally, people approved of this method and did so regardless of their level of interest in water issues, but in the two rural, unmetered towns the majority of the people with little interest in water matters disapproved of this type of conservation.

In most towns, the attitude towards permanent restrictions did not vary with educational levels. The UMU and RUR towns indicated differing attitudes for the two educational categories. Here, those with less than a high school education disapproved of the proposed conservation method while those with higher education approved.

Limiting lawn size was cross-tabulated with the same three socio-demographic variables. Generally, it was found that those who were interested in water matters also approved of limiting the size of lawns while those with little or no interest in water matters did not favor this conservation method, but in three of the rural towns, there was no clearcut response. In the RUU town, those with high interest did not favor restrictions on the size of lawns (53%).

Education appeared as an insignificant factor in three towns: UMR, RMU, UUR. In the UMU, RUU and RUR towns, those with less than a high school education approved of limiting lawn sizes while those with at least a high school education disapproved of this plan. The opposite situation emerged for the RMR town. The better educated approved, the less educated disapproved.

In the UMU and RUR towns those earning less than $25,000 per year opposed restrictions on lawn size while those earning $25,000 or more per year approved of such restrictions. The lower incomes favored lawn size limitations and the higher incomes disapproved in the RMU and UUR towns. Little income effect was found in attitudes of respondents from the RMR, UMR and RUU towns.

Restrictions on city growth or population size was strongly favored regardless of interest level, education or income with two exceptions. In the UMR town, those earning more than $25,000 per year opposed this type of restriction. In the UMU town, those with less than a high school diploma did not favor restricted growth. The managers, on the other hand, rejected growth restrictions with 53% disapproving.

Attitudes towards increasing the price of water varied with interest level in only two towns, RMR and RMU. These two rural, metered towns favored price increases where interest levels were high and opposed price increases where interest levels were low.

In four towns, UMR, UMU, RUR, RUU, educational levels did not affect attitudes towards price increases. In the remaining towns, respondents with less education disapproved of price increases while respondents with at least a high school education favored this mode of conservation.

Respondents earning less than $25,000 per year did not favor increasing prices in the RUR, UUR and UMU towns. Consumers with annual incomes of at least $25,000 per year favored price increases.

Attitudes towards reuse of treated wastewater for irrigation purposes and developing additional mountain supplies were not affected by income education or interest in local water issues. The majority in all towns strongly favored these two approaches.

Chapter 6

INCREASING EFFICIENCY OF USE: INSTITUTIONAL CONSTRAINTS

A great deal has been written about the need for urban water conservation. Most methods for achieving urban water conservation concern increased efficiency of water use both inside the house and outside. Metering, price increases and water-saving devices are the most common in-house methods proposed to increase efficiency of use. Better lawn-watering techniques and more drought tolerant shrubs and grasses, in addition to metering and restructured water rates, have been proposed to increase outside water use efficiency. A reduction in lawn size has also been advocated as a conservation measure.

Colorado water law is such that there are legal barriers to increased efficiency of use. Agricultural use of water for farm irrigation has historically resulted in an efficiency of approximately 45 percent. That is, 55 percent of the water diverted is not consumed by crops or evaporated but seeps into the soil, eventually reaching streams or shallow aquifers where it may be available for reuse by downstream appropriators. The value of many existing senior water rights is based on the continuance of historic return flows. Any increased efficiency-of-use of water that results in less than historic return flows or a disruption in the timing and location of returns can be harmful to downstream appropriators.

The transfer of agricultural water to municipal use results in a change in the timing, location and amount of return flows. The majority of the returns are by way of the sanitary sewer system which usually discharge into a stream at one or two locations. Discharge of municipal wastewater occurs year around, with the flow rate of return nearly constant, although spring and summer returns are slightly higher.

Return flows are also realized from urban lawn irrigation. These returns from lawn irrigation closely mimic historic returns from agricultural irrigation. Another source of municipal return flow is stormwater runoff but in the semi-arid Front Range this can be discounted as a major source.

I. Existing Return Flows

A. Returns via Wastewater Discharges

The percentages of treated waters that were returned through wastewater treatment plant discharges for the period 1975-78 are shown in Figures 13 through 15 for five municipalities. Average return flows, shown in Figure 13, ranged from 79 percent in Berthoud to 29 percent in LaSalle. These estimates have been corrected for differences between water and sewer service areas. Average returns during the winter months are shown in Figure 14. Berthoud and Fort Collins reported significant amounts of infiltration/inflow. The effects of I/I can be seen in Figure 14. Berthoud's winter returns were greater than treated water produced for the study period. La Salle's low percentage of return appears to be a result of inaccurate well pump meters or extremely high water distribution leakage.

Average summer month returns are shown in Figure 15. Boulder, which is metered, had an average summer water use of 231 gcd, and returned 63 percent or 145 gcd, by way of sanitary sewer discharges. Berthoud, which is not metered, had an average summer water use of 331 gcd, and returned 64 percent or 212 gcd. In this sample, infiltration/inflow appears to be more significant in determining the amount of municipal returns than metering.

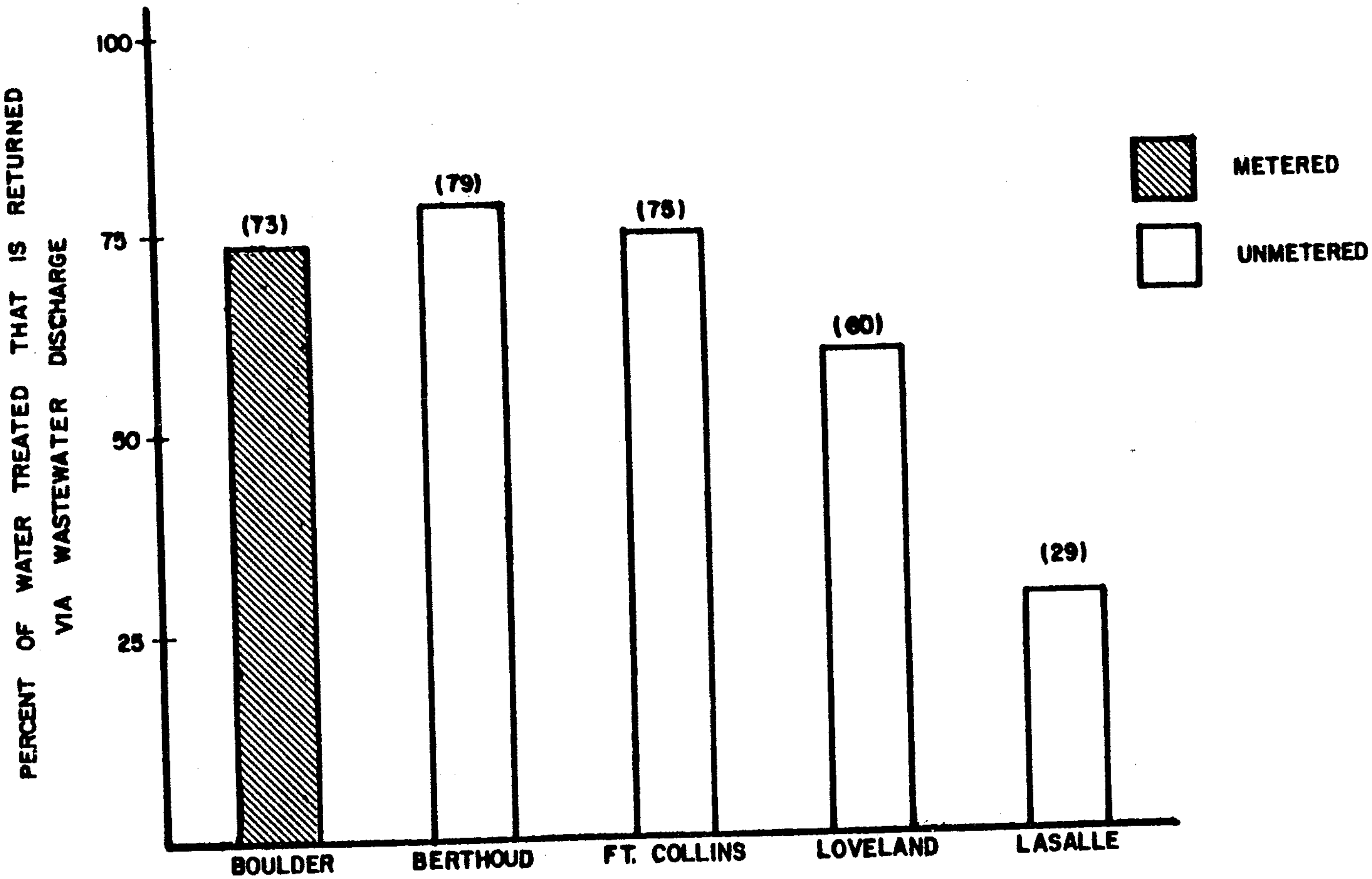


FIGURE 13

AVERAGE RETURN FLOWS, 1975-1978

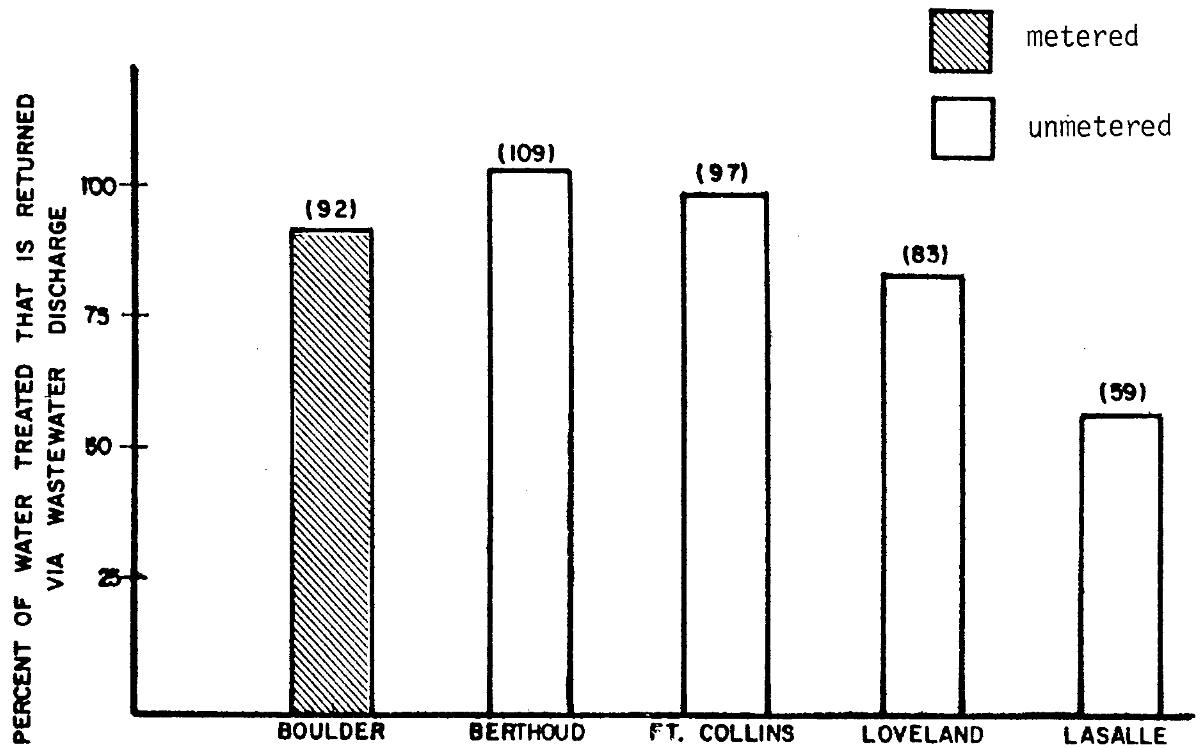


Figure 14

AVERAGE WINTER RETURN FLOWS, 1975-1978

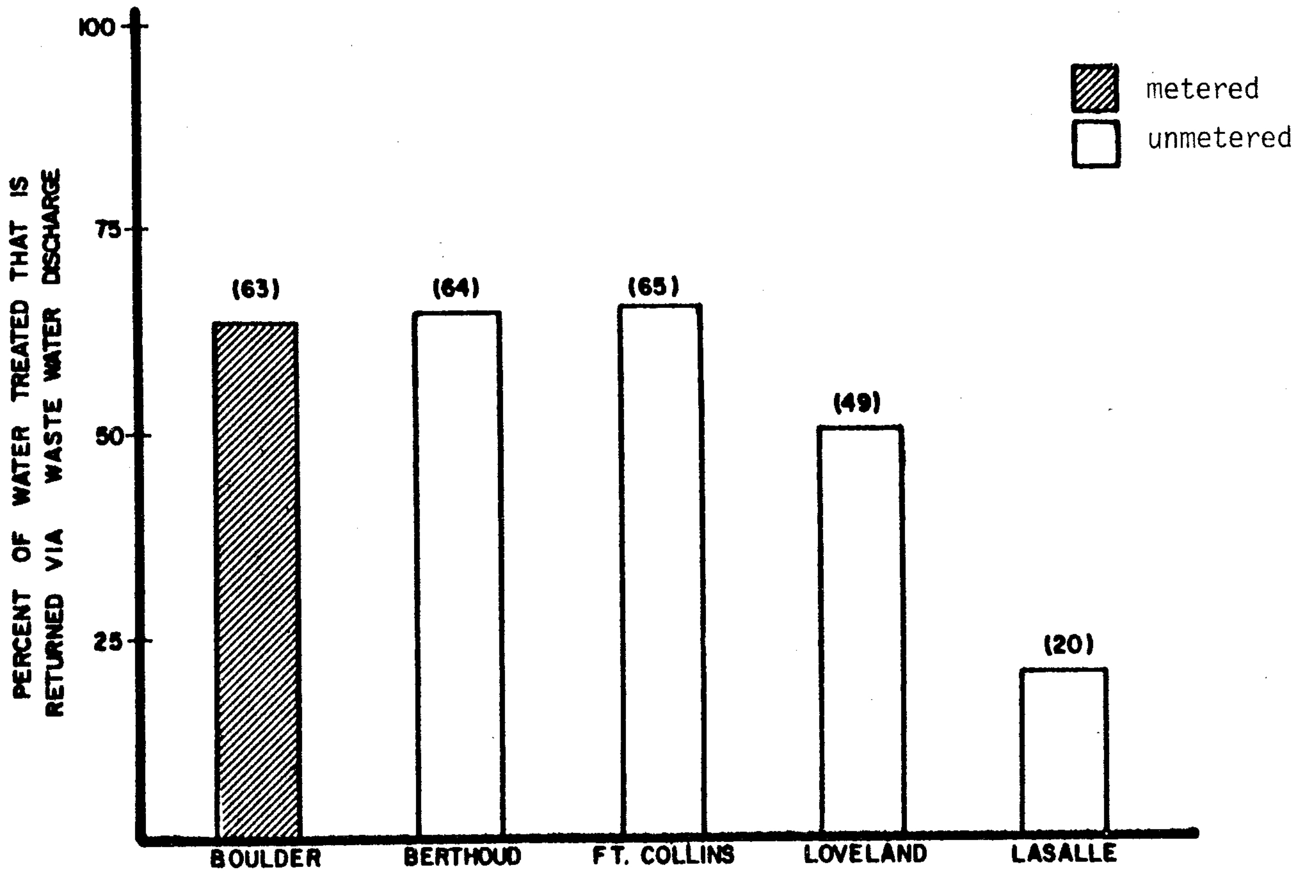


FIGURE 15

AVERAGE SUMMER RETURN FLOWS, 1975-1978

B. Return-Flow from Lawn Irrigation

The actual lawn watering efficiency in each of the study communities can only be evaluated through on-site studies of actual evapotranspiration and sprinkling practices in each municipality. An examination of the data for the town of Berthoud indicates that lawn watering efficiency over the May to October season was 69 percent in 1978. An on-site study conducted in Ft. Collins and Northglenn, Colorado found that irrigation efficiency in Fort Collins was 79 percent for the same period using measured evapotranspiration (Danielson et al., 1979). Haw (1978) compared the modified Blaney Criddle estimates of evapo-transpiration with measured evapotranspiration. Using his results, the irrigation efficiency in Ft. Collins was 67 percent in 1978.

An analysis of the irrigation efficiency in the metered communities of this study has not been performed, but Danielson et al (1979) found that lawn application rates in Northglenn, a metered suburb of Denver, were slightly below measured evapotranspiration. Northglenn's water rates are similar to the highest rates found in the study area, with marginal costs exceeding $1.00 per thousand gallons. Danielson found an increase in lawn quality as water application rates approached measured evapotranspiration, reflecting the fact that application and distribution efficiency cannot be 100 percent, and some over-irrigation is justified for maintenance of green lawns.

The amounts of return flow from lawn irrigation is dependent upon the amount of irrigated area, precipitation, evapotranspiration, and irrigation efficiency. The irrigation efficiency in the unmetered communities appears to be in the range of 50 to 80 percent. The metered communities are probably in the range of 75 to 90 percent. It is doubtful if efficiency can exceed 90 percent, given current lawn watering practices.

Of the amount that is not consumed, a small percentage returns as surface runoff down street gutters and through the storm drainage system. This percentage is probably greater in the unmetered communities because application rates are greater there than in the metered communities.

C. Effects of Increased Water Use Efficiency on Historic Return Flows

A hypothetical water conservation program, designed to increase both indoor and outdoor water use efficiency, has been applied, using the town of Berthoud's 1978 water use data, to examine the probable effects of increased water use efficiency on municipal return flows. The conservation program consists of metering and retro-active fitting of water saving devices in all homes. It has been assumed that this program would result in a 15 gcd reduction in indoor water use, reducing winter sewage flows by 13 percent, from 118 to 103 gcd.

The assumption regarding outdoor water use is that the metering program would increase lawn watering efficiency from 69 to 85 percent, reducing sprinkling use from 180 gcd to 149 gcd. The total reduction in average annual water use from the total conservation program would be from 205 gcd to 174 gcd, a reduction of 31 gcd or 15 percent. The reduction in return flows from wastewater discharge would be from 153 to 138 gcd or 11 percent. The increased lawn watering efficiency would reduce the returns from lawn irrigation by 41 percent from 27 gcd to 16 gcd annually.

A summary of the impacts of this conservation program, in acre feet, is shown in Table 40. The increased efficiency of use would result in an additional 103 acre-feet per year available for use in the town. At reduced

TABLE 40

EFFECTS OF A CONSERVATION PROGRAM, BERTHOUD
(Based on 1978 Data)

All Values in Acre-Feet

	Water Treated			Return Flows					
				Existing Returns		With a Conservation Program		Reduction in Return Flows	
	Existing Production	With a Conservation Program	Reduction in Water Use	Wastewater Discharge	Lawn Irrigation Returns	W.W.**	Irrigation	W.W.**	Irrigation
Summer	483.7	405.0	78.7	316.9	58.4	291.5	34.1	25.4	24.3
Winter	204.6	180.0	24.6	196.7	31.4*	171.7	18.4*	25.0	13.0*
Total Year	688.3	585.0	103.3	513.6	89.8	463.2	52.5	50.4	37.3
				603.4		515.7		87.7	

*35 percent of irrigation returns assumed to occur during winter months.

**Wastewater discharge.

water use rates of 174 gcd this would be sufficient supply for an additional 530 new residents, an 18 percent increase over the 1978 population of 3,000. The total effect on return flows from the increased efficiency would be an apparent loss of 88 acre-feet per year, or 15 percent of the present level of returns. However, if the additional 103 acre-feet per year made available from reduced water use were used to service new customers, additional returns would be generated. Based on existing data, Berthoud returns 88 percent of its water use. This figure is misleading because a great deal of the wastewater returns are excessive infiltration/inflow into the sanitary sewers. The increased efficiency in lawn irrigation would result in less groundwater available for infiltration into the sewers. The actual returns would be the 103 acre-feet used less the consumptive use from new domestic and lawn irrigation uses of approximately 45 acre-feet and the reduced amount of excess lawn irrigation water that might infiltrate into the sewers of approximately 37 acre-feet. The total effect would be a loss of approximately 67 acre-feet or 11 percent in returns although 530 additional residents could be served without developing or purchasing new supplies.

D. Legal, Environmental and Other Implications of Increased Water Use Efficiency

The benefits and costs of a municipal water conservation program extend beyond the obvious benefits of increasing the available water supply for municipal uses and the costs of instituting metering, installing water-saving devices or other conservation methods. Depending upon the type of water right, the increased use efficiency may or may not prove to be beneficial to the municipality's interest. The costs of acquiring or developing new rights, treating this water, and also treating the wastewater, are considerations which should be evaluated.

A municipality which owns waters which can be fully consumed should maximize the efficient use of these waters. The wastewater effluent attributable to this source can be leased to downstream users or possibly exchanged with a ditch company for the better quality water that can be diverted upstream. Since it would be very difficult to lease return flows resulting from lawn irrigation inefficiency, minimizing excess sprinkling use would be desirable. Many municipalities use Colorado-Big Thompson water. Credit cannot be claimed for return flows from use of this water and it cannot be reused. However, historic returns are not required on this water and it would be beneficial to maximize the use of this water.

A municipality which is applying for a change of use or wishes to store direct flow waters may be limited to historic consumptive use unless claims of return flows from municipal use can be quantified. Return flows from lawn watering inefficiency most closely mimic historical returns from agricultural use. However, if the resulting court decree requires that actual returns be monitored and quantified, this is most easily accomplished by reporting returns from sewage treatment plant discharges.

Excessive infiltration/inflows are a common problem for many municipal wastewater systems. The costs of acquiring and developing new water supplies should be compared against the flow-related cost of treating municipal wastewater. If the cost of raw water exceeds the flow-related wastewater treatment cost and credit or exchange can be made for municipal effluent, it may be beneficial to allow excessive infiltration/inflows to continue.

The environmental impacts of developing new water supplies have proven to be a major problem for most new municipal storage projects. Efficient use of existing municipal supplies allow additional growth to be served without developing new supplies and creating adverse environmental impacts. Most municipal water managers favor developing new supplies, expressing the feelings that if new supplies are not developed now, they may not be available at a later date when the excess water made available from conservation has been fully utilized. The same logic also holds true regarding the purchase of existing water rights. With the cost of water rights increasing faster than inflation and competition for existing water rights also increasing, it may be more cost effective to acquire new supplies now and increase efficient water use at a later date when all sources of supply have been exhausted.

Opponents of metering have claimed that it would result in reduced lawn watering and thus less groundwater returns to streams. They suggest that most streams would be dry in the fall and winter months if not for these returns. However, returns to streams from irrigation returns are normally high in total dissolved solids and nitrates and the resulting water quality may not be acceptable to sustain aquatic life. The primary beneficiaries from winter returns are those downstream appropriators who own winter storage rights.

One possible problem that has not yet arisen in the northern Front Range communities is the effect of a long-term drought on municipalities that have already maximized efficient use of their water suppliers. A long-term drought or other water supply emergency may create the need for all communities to achieve significant reductions in water use. A water user that is already maximizing efficient use of water will more likely experience hardships than the inefficient user if major reductions in water use are required. For example, if a 30 percent reduction in existing water use is required, this cutback may result in damage to landscaping of the efficient user while the inefficient user can achieve the required use reduction and still apply sufficient water to maintain the landscaping in acceptable condition.

Chapter 7

POLICIES FOR WATER CONSERVATION

Key factors in achieving effective water management are a general policy for efficient water use and development of contingency plans in the event of a severe water shortage. A long-range urban water conservation policy for the towns of the Northern Colorado Front Range has not been developed. Rapidly increasing populations in this area will place increasing pressures on the existing water systems, allowing limited time for system expansion or development of new water supplies.

The attitudes and perceptions of the water managers and the water customers are very important considerations in achieving maximum effectiveness in the implementation of a conservation program. Where the two groups strongly disagree, problems may result. Therefore, it is best to suggest methods of conservation which both managers and customers view as viable options.

Perhaps the most important single key to successful water conservation programs is informing the public. The water customers must be made aware of water supply and usage problems and the general difficulties of supplying enough water for their needs, both now and in the future. This was demonstrated during the 1976-77 California drought, where it was shown that the extent of the public's belief in the drought determined their willingness to conserve (Hoffman, 1978).

Public education may be achieved in a variety of ways. One way is by distributing information with water bills. Such information may include average daily use and cost for the household, if metered, and what the utility believes the values should be. Also, a brief message could be included about the need for and how to accomplish water conservation. Information may also be transmitted through local press, radio and television stations by means of public service meassages. Towns might also call for a "water conservation day" where water information is distributed in an entertaining yet effective manner through fetes with booths, displays, etc.

I. Policy Implications

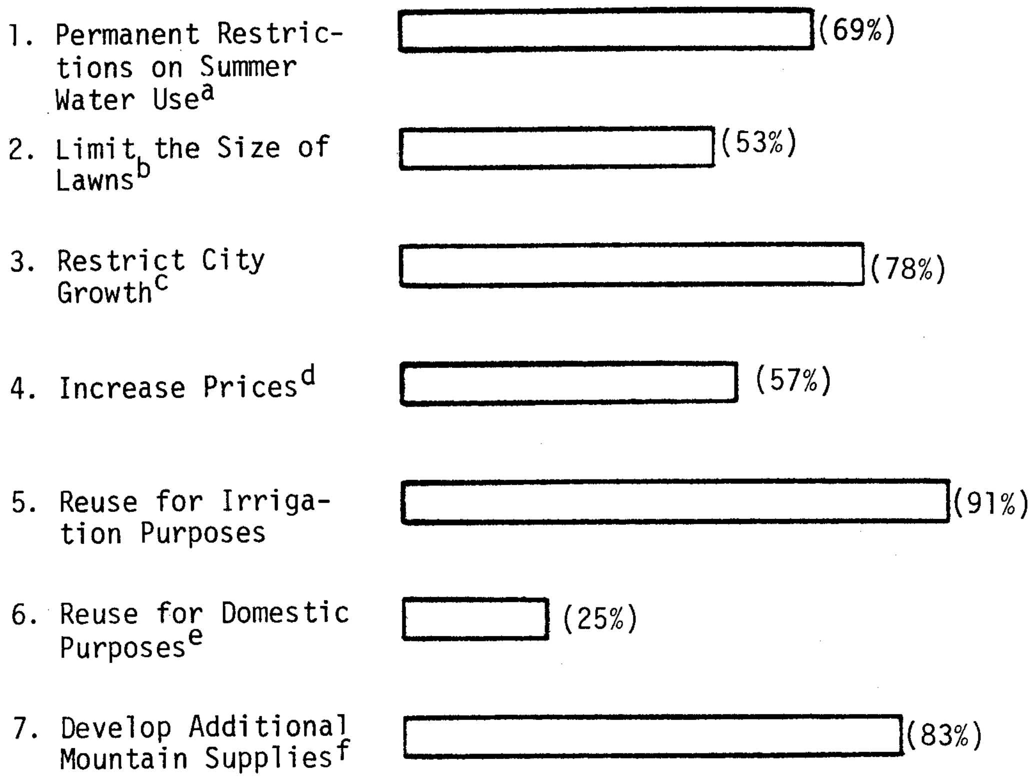
Most managers in this study were convinced that they could handle a drought or other shortage condition by imposing restrictions on use, and that their customers would cooperate with them. Based on the customer survey, this does not seem an unreasonable assumption. However, experience may indicate that managers should not rely on restrictions for reducing use over a long period, because the regulations may lose their efficacy. Managers should clarify their goals as to whether they wish to affect use, by restrictions and/or rationing, or modify demand, through price/demand relationships. If it is the latter, changes such as metering and price adjustments must be considered. The experience of Greeley, which uses partial metering to set flat rates, should be examined in relation to what effect this has on demand.

Appeals to consumers and education about the use of less water consuming vegetation, or about the water use of different appliances have been sporadic or lacking. Those towns which are interested in decreasing long range demand could be much more systematic about this. It may be that water-saving devices such as shower heads have a psychological effect beyond the water and energy they themselves save, but this has not been explored.

The water Conservancy Districts in Colorado are likely to play an increasing role in municipal water affairs as more towns take part in regional agreements, and as ground water towns shift to surface supplies. The Districts already play a strong part in the transfer of water from agricultural to municipal use (and back again as some of it is rented out to farmers). They could provide much more education of urban consumers as to efficient water use, in the same way the Northern Colorado Conservancy District does not in workshops for farmers on the use of irrigation water. They could require meters and uniform pricing schedules as conditions for acquisition of water they control. They could also establish clear policy on the use of restrictions, keeping them as an effective tool for emergency use only, and thus maintaining the resiliency of the system.

The smaller "rural" towns' customers favor restrictions on growth as a tool for dealing with water supply problems. The larger "urban" towns and the rural, unrestricted towns approve of permanent restrictions on summer water use. Towns with restrictions use more water per capita than towns without restrictions, but the latter are usually metered. It is, therefore, recommended that restrictions be implemented only to reduce the peak demand or for emergency use such as droughts. In this study there was little relationship between the differences in water use patterns, attitudes and perceptions and the sizes of the towns. See Figures 16 and 17 for listing of conservation measures favored by consumers in rural and urban towns, respectively.

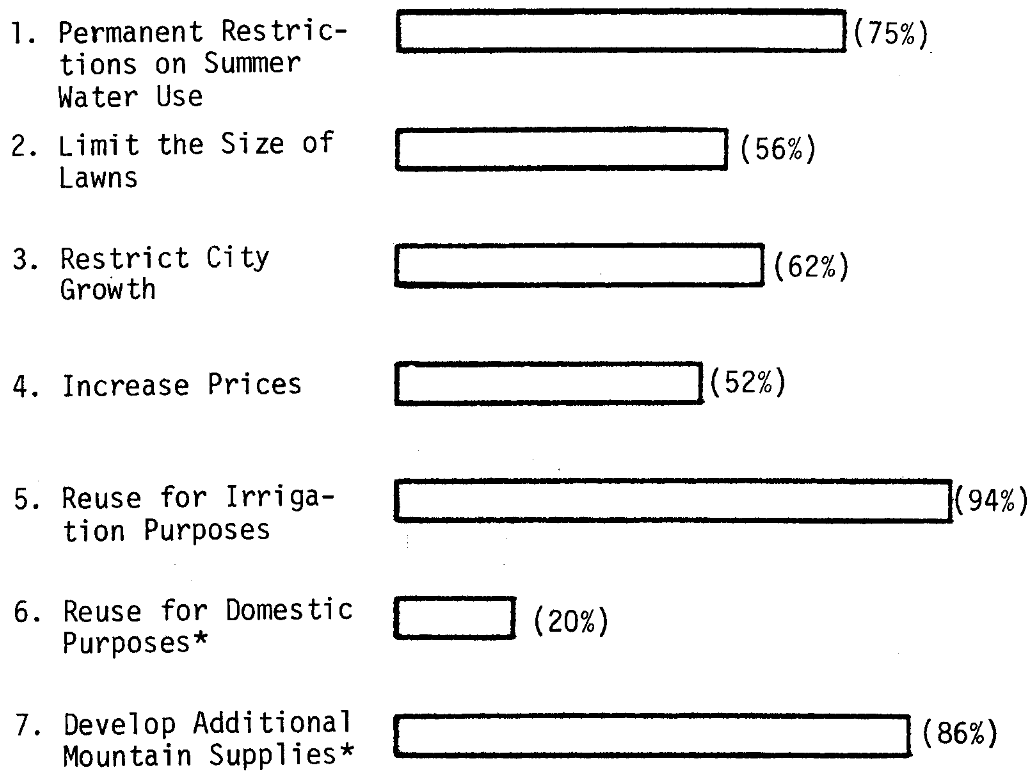
The percentage of customers in each town claiming the use of at least one water saving device varied from 50% to 70%. Additional devices could be installed, but their effectiveness is questionable. Theoretically, these



a. Unrestricted towns agreed (62%,65%)
   Restricted towns agreed (77%,73%)
b. Metered towns agreed (58%,55%)
   Unmetered towns agreed (49%,49%)
c. Metered,unrestricted differed by 17% from the average
d. Unmetered, unrestricted approved at only 36%
e. Restricted towns agreed (34%,33%)
   Unrestricted towns agreed (18%,16%)
f. Unmetered,restricted differed by 11% from the average

FIGURE 16

CONSERVATION MEASURES FAVORED BY CONSUMERS: RURAL TOWNS



*Metered, unrestricted urban towns differed from these values greatly with 42% approval for No. 6 and 61% approval for No. 7

FIGURE 17

CONSERVATION MEASURES FAVORED BY CONSUMERS: URBAN TOWNS devices could save up to 30-50% (State of California, 1976), (Flack, et al., 1977). However, a recent field study indicated an actual savings of only 3% (Morgan and Pelasi, 1980).

The most effective method of reducing the water demand is metering. A 1973 study of water use in New York City showed that metering had a definite effect on water use (Conway, 1973). This is confirmed by data from this study.

The pricing structure for a metered system is an important tool and can aid in the conservation effort. A base rate for some specified quantity and an increasing block rate for amounts above the base would be the most effective. In order to avoid revenue problems during periods of low water use, the base rate could be related to the number of units of water used. A unit might be 1,000 gallons. For instance, in years when water is plentiful the base rate could buy 5 units but in a dry year buy only 2 or 3 units. This is an indirect approach to assuring enough revenues to cover the cost of operation and maintenance of the water supply system during low-use years.

The customer survey results indicate that those currently on a flat rate billing prefer to remain so. This percentage, although the largest of the choices, was not an overwhelming majority: 49%, 52%, and 57% for the unmetered survey towns. Also, the unmetered towns indicated the largest number of consumers unsure of their billing preference compared with metered towns.

Considering this information, required metering on all new buildings plus a concerted public education program to encourage change in attitudes towards metering could be successful. The main disadvantage of metering is the cost factor. If consumers did not have to pay a lump sum for their meter but could pay for it over a period of time, preference towards metering might increase. Also, any subsidies would help increase the approval rate.

Additional conservation measured beyond metering and pricing would probably be required in the event of a severe drought. The Marin Municipal Water District in California saved up to 62% in residential use during the 1976-77 droought by imposing rationing and a subsequent major price increase. Their goal was to reduce the demand by 57% (Hoffman, 1979).

If a drought occurred in northern Colorado, the first responsibility of the water utilities would be to increase public awareness and knowledge of the shortage. Without consumer belief in a severe drought, restrictions may be ineffective.

Once the educational campaign has begun, implementation of restrictions on use should be addressed. The most publicly appealing plan, according to Stroeh (1977), is the allotment system. This method allows the consumer to use a specified quantity of water for any purpose. Managers in this study, however, do not favor this approach. In any event, it can only be implemented in metered utilities.

The preferred approach of both managers and most customers is to impose restrictions on uses of water, i.e. lawn watering, car washing, etc. In addition to restrictions, a penalty rate structure is also helpful in reducing metered water use during a shortage. This also can help alleviate any revenue problems caused by conservation and was the way the Marin Municipal Water District met its income problems during the 1977 drought.

Use of water saving devices should be encouraged during a severe shortage. These devices along with the behavioral changes can result in

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fairly significant in-house demand reductions. Kits containing water saving devices such as a showerflow restrictor, a plastic bottle for toilets and dye tablets for lead detection should be available to the public, either free or at a low cost to the consumer.

II. Recommendations

A. Long-Range Conservation (based on Consumer Attitude Survey and Manager Interviews)

- Implement universal (100%) metering
- Develop new supplies or acquire new rights
- Require low-flow devices in the plumbing code for new construction
- Require native vegetation for new housing areas or limit lawn size
- Establish a base rate plus increasing block price structure
- Public education
- Reuse water for irrigation and other non-drinking purposes
- Restrict growth - an option slightly favored by consumers but not by managers

B. Drought Contingency Plan

- Promote public education of drought severity
- Require installation of water saving devices
- Implement restrictions/allotment system
- Apply a penalty rate structure to metered services

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APPENDIX

Water Use Survey Form

WATER USE SURVEY

PLEASE CIRCLE THE NUMBER OF THE ANSWER THAT MOST CLEARLY EXPRESSES YOUR VIEW OR FILL IN THE BLANK WITH APPROPRIATE NUMBERS.

1. Is this house a single family residence?

   ☐ Yes

   ☐ No

   If answer is no, please do not complete the questionnaire but do return it to us.

2. Do you live inside or outside the city limits?
   1) Inside
   2) Outside
   3) Don't know

3. When did you move to this address?
   1) After September 1, 1978
   2) Between Sept. 1, 1977 and Sept. 1, 1978
   3) Between Sept. 1, 1976 and Aug. 31, 1977
   4) Between Jan. 1, 1971 and Aug. 31, 1976
   5) Between Jan. 1, 1961 and Dec. 31, 1970
   6) Before Jan. 1, 1961 or born here.

4. What would you say was the attitude toward water consumption in your family when you were growing up?
   1) Very careful not to waste
   2) Moderately careful
   3) Didn't worry about consumption at all

5. Do you own or rent this house?
   1) Own
   2) Rent
   3) Other (explain:____)

6. Do you pay the water bill or does someone else who doesn't live here?
   1) We do
   2) Someone else does
   3) Other (explain:____)

7. When was this house built? Give your best guess if you are unsure.
   1) 1975-1979
   2) 1970-1974
   3) 1960-1969
   4) 1950-1959
   5) 1940-1949
   6) 1939 or earlier

8. Is your house water metered? That is, do you pay a bill that varies with the amount of water you use or do you pay a flat rate charge that stays the same no matter how much you use?
   1) Metered
   2) Flat rate
   3) Don't know
   4) Metered but landlord pays the bill

9. How many people live in this household currently, at least most of the time, including yourself? _______

10. How many of these are children 16 years or younger? _______

11. How many rooms are there in your home that are at lease 90 square feet? Include finished rooms in the basement, but exclude bathrooms. 90 square feet is a room ten feet by nine feet and is a small bedroom. _______

12. How many full or 3/4 bathrooms are in your home? A bathroom is any room with a toilet <u>and</u> a bathtub or shower.
    1) 0
    2) 1
    3) 2
    4) 3
    5) 4
    6) or more (please specify_______)

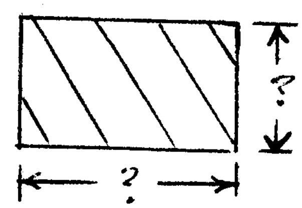
13. Does your home have a toilet which is separate from bathrooms counted above? If so, how many?
    1) none
    2) 1
    3) 2
    4) 3 or more (Please specify_______)

14. How large is the lot your house sits on? Estimate or pace it off. You may place dimensions on the diagram.

    _____ft x _____ ft

    or _______ sq. ft.

lot



15. How large is your lawn and garden area?

    _____ft x _____ft. or _______ sq. ft.

16. During the summer months of June, July, and August, about how often would you water your lawn if there were no restrictions?
    1) Daily
    2) Every other day
    3) Twice weekly
    4) Weekly
    5) Every other week
    6) Monthly or less often
    7) Have no lawn to water

17. Which of the following best describes your main source of lawn water?
    1) City or water district
    2) Irrigation ditch rights
    3) Well
    4) Other (Please specify_________________________________)

18. Do you feel that there is a water shortage problem in your area?
   1) Yes
   2) No
   3) Don't know

19. If your answer is yes, please indicate your primary reason for the shortage.
   1) Too much growth
   2) Poor water planning
   3) Not enough water for existing population
   4) Other, please explain____.

20. If a severe water shortage were to develop in your area during the next 2 years, and you were faced with a choice of the following, which would you choose?
   1) Normal rates with restrictions on use during peak consumption times
   2) No restrictions, but a higher price on all consumption
   3) No restrictions, but a much higher price on all consumption above 75% of your 1977 level.

For questions 21-27: Please place an X in the column that most clearly reflects how you would feel about each of the following steps in case of future water supply problems.

	strongly approve	slightly approve	slightly disapprove	strongly disapprove	
21.	______	______	______	______	Permanent restrictions on summer water use
22.	______	______	______	______	Limiting the size of lawns. for example, to 50% of a person's landscaping.
23.	______	______	______	______	Restrictions on city growth or population size.
24.	______	______	______	______	Raising the price of water for consumption beyond a certain level.
25.	______	______	______	______	Using treated sewage water for irrigating parks, golf courses, etc.
26.	______	______	______	______	Using treated and purified sewage water for drinking and household use.
27.	______	______	______	______	Developing additional mountain supplies.

28. In your opinion, could this community purify its sewage water and then return it safely to its drinking water system? We are interested in technical feasibility here.
    1) Yes, definitely
    2) Probably
    3) Not sure, but tend to think so
    4) Not sure, but tend to think not
    5) Probably not
    6) Definitely not

29. What would be your personal reaction to returning purified wastewater to your drinking water?
    1) Approve strongly
    2) Approve slightly
    3) Not sure
    4) Disapprove slightly
    5) Disapprove strongly

30. Do you think you would use less water over a full year if you were on a meter than if you were on flat rate, or less on flat rate than metered?
    1) Use less on a meter
    2) Use about the same either way
    3) Use less on flat rate

31. Given what you know about water rates in your district, do you think you would pay less for water over a full year on flat rate or on a meter?
    1) Pay less on a meter
    2) Pay about the same either way
    3) Pay less on flat rate

32. Do you think people's water should be metered or is a flat rate charge a better idea?
    1) Metered
    2) Flat rate
    3) Not sure

33. What is the most important reason you feel that way?
    1) Fairness or equity
    2) Conserves water
    3) Costs less
    4) Other (please specify____)

34. In regard to local water matters, would you say that you are
    1) Very interested
    2) Somewhat interested
    3) Slightly interested
    4) Not interested at all

35. Do you know the approximate price of water per 1000 gallons?
    1) Yes (how much?__________)
    2) No

36. How much was your last water bill?
  1) Don't pay it.
  2) $0.00 to $9.99
  3) $10.00 to $19.99
  4) $20.00 to $29.99
  5) $30.00 to $39.99
  6) $40.00 to $59.99
  7) $60.00 to $79.99
  8) $80.00 or over

37. In your opinion, is the cost of your water too high, too low, or about right?
  1) Very high
  2) Slightly high
  3) About right
  4) Slightly low
  5) Very low

FOR QUESTIONS 45-58, CIRCLE YES OR NO

Do you have the following items in this home?

38. Garbage disposal — Yes No
39. Automatic dishwasher — Yes No
40. Automatic clothes washer — Yes No
41. Own swimming pool — Yes No
42. Any other major water-using appliance (please specify ________________)

Have you installed (or had installed) any of the following toilet water-saving devices?

43. Brick or plastic bottle in toilet — Yes No
44. Toilet dam — Yes No
45. Water-saving valve in toilet — Yes No
46. Specially designed low-flush toilet — Yes No
47. Other toilet device — Yes No

Have you installed or had installed any of the following water-saving devices in your home?

48. Shower flow restricter or low-flow showerhead — Yes No
49. Faucet aerator — Yes No
50. Anything to reduce lawn watering — Yes No
  (please describe ________________________________)
51. Other — Yes No
  (please describe ________________________________)

PLEASE RETURN TO CIRCLING BEST ANSWER ONLY

52. Which of the following best describes your reaction to installing a toilet water saving device ("toilet dam") that costs about $6 and takes 10 minutes to install without tools.
    1) "I would do it to save water even if it saved me no money."
    2) "I would do it if it reduced my water bill enough to pay for itself in 2 years."
    3) "I would do it if it were required."
    4) "I would do it if it were required and some local agency provided it for free."
    5) "I wouldn't do it, but I would permit some local agency to come and do it."
    6) "I wouldn't do it and if some local agency did, I would probably rip it out."

53. Which best describes your attitude toward installing a device that reduces the water flow in your shower, that costs $6 and can be installed with a wrench in 10 minutes?
    1) "I would do it to save water even if it saved me no money."
    2) "I would do it if it reduced my water bill enough to pay for itself in 2 years."
    3) "I would do it if it were required."
    4) "I would do it if it were required and some local agency provided it for free."
    5) "I wouldn't do it, but I would permit some local agency to come and do it."
    6) "I wouldn't do it and if some local agency did, I would probably rip it out."
    7) "Don't have a shower."

54. Would you be willing to change your landscaping to greatly reduce your lawn-watering under the following conditions?
    1) to save water even if it saved me no money
    2) only if it saved me $10 per year on my water bill
    3) only if it saved me at least $50 per year on my water bill
    4) only if I were required to do so
    5) not even if I were required to do so

55. Please estimate what your house would sell for in today's market.

1) under $30,000
2) $30,000 to $59,999
3) $60,000 to $99,999
4) $100,000 or over

56. Would you please fill in the occupation of the chief breadwinner in this household? ______________________________

57. Which category best describes the highest level of education completed by the head of this household?

1) grades 1-8
2) grades 9-11
3) high school graduate
4) some college but no degree
5) trade school or 2-year college degree
6) 4-year college degree
7) post-graduate work
8) other (please specify) ____________

58. Please mark the number which best describes your total family income for the last year.

1) under $5,000
2) $5,000 to $9,999
3) $10,000 to $14,999
4) $15,000 to $19,999
5) $20,000 to $24,999
6) $25,000 to $34,999
7) $35,000 to $49,999
8) $50,000 or over

59. If you want to comment on something we may have missed relating to your water consumption, do so here or on the back of this page.