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EVALUATION OF NORTH DAKOTA'S FIRST RURAL WATER SYSTEM

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ABSTRACT

Development of rural water systems is occurring rapidly in the Northern Great Plains. The Grand Forks-Traill Rural Water Association, organized in 1969 and operating since December, 1972, presented an excellent opportunity to document and analyze the organizational process, member and nonmember characteristics, water quality and quantity delivered by the system, and economic and social changes in homes and communities related to the water system.

Some findings of the study were:

1. Quality of water used by members improved significantly;

2. Quantity of water used by members improved more rapidly than by nonmembers.

3. Significant increases in population and housing occurred in one community and other communities appeared to remain stable or have slight gains since 1970.

4. Fluctuations in water pressure were minimal in the Rural Water Association.

5. Members purchased more home appliances and were more apt to remodel homes than nonmembers.

Nelson, William C., Coila Janecek, and Richard L. Witz
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Final Report of Rural Water System Research Team, North Dakota Water Resources Research Institute, and North Dakota Agricultural Experiment Station, North Dakota State University, Fargo, North Dakota, July, 1976.

KEYWORDS: economic impact, engineering evaluation, rural areas, water systems, water quality, population changes

FOREWORD

This is the final report of the research team evaluating the Grand Forks-Traill Rural Water Users Association. The research was sponsored by the North Dakota Agricultural Experiment Station, the North Dakota Water Resources Research Institute, and the North Dakota State Water Commission.

This report summarizes the findings of the project. Detail on methodology and results can be obtained from other project publications (listed on page 88) or by contacting members of the research team.

Acknowledgement and appreciation is granted to several persons who have assisted the project team:

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I. INTRODUCTION

The basis for this report was a three-year research project on the Grand Forks-Traill Rural Water System by the Departments of Agricultural Economics, Agricultural Engineering, and Textiles and Clothing at North Dakota State University. It was financed by the Agricultural Experiment Station, Water Resources Research Institute, and the North Dakota State Water Commission.

Rural Water Associations

Rural water associations are composed of people organized in non-profit corporations or cooperatives with the purpose of jointly providing water to rural and small town residences. In North Dakota, the associations include 310 to more than 1,200 household and business consumers. In other states, there are rural water systems with as few as 10 to 15 consumers. Size of a system depends on the population density of an area, location of water source, and the size of investment in wells, pumps, and distribution systems.

Rural water systems consist of miles of underground pipe, wells, pumps, reservoirs, accounting procedures, maintenance, and management. The last item, management, is frequently left off the list of essentials, but is as important to a successful rural water system as the manager is to a farm operation (Sloggett, 1974).

Rural and municipal water systems differ greatly. Fire protection determines the water main sizes of a municipal distribution system. Rural water systems are not designed to provide fire protection, but are designed to provide enough water to supply farm demands.

North Dakota had 18 systems organized by December, 1975, with four operating, two under construction, and twelve in various stages of planning (Figure 1).

Rationale

A large part of North Dakota and many other states in the Great Plains have insufficient ground water supplies. Insufficient supply can be either an absolute lack of ground water, or more frequently, ground water with mineral and/or bacteriological contamination making it unusable for human and animal consumption.

Recent technological advances in polyvinyl "plastic" pipe and in large "plows," which bury the pipe to depths of seven feet, allowed the formation of rural water systems in the Northern Great Plains. Financial assistance, in the form of low interest loans and grants, was made available through the Farmers Home Administration. These two factors plus the need for good quality water have facilitated the rapid development of rural water systems.

Previous studies of the effect of rural water systems have been few and limited in scope.

The procedures involved in forming rural water systems were outlined by Palmby (1971), however, no detail was presented. Research reported by Petersen (1971) dealt with the effect of a priori community organization on the organization and management of rural community water systems in one Mississippi county. Strong local leadership was found to be essential for the formation of rural community water systems; however, engineering consultants often promoted and organized the initial effort to form a multifamily water system. A guide, written by Smythe and Vacin

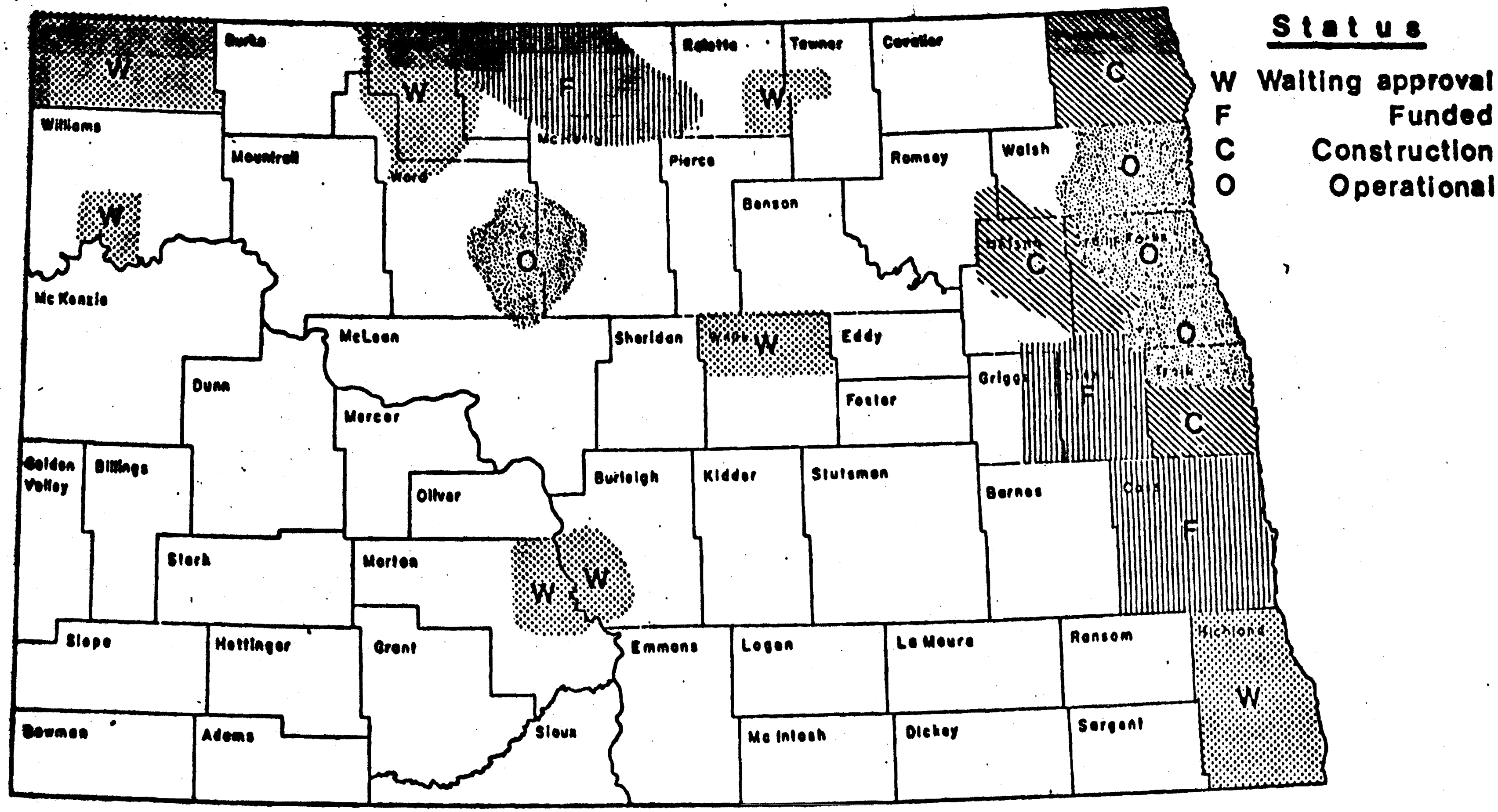


Figure 1. RURAL WATER SYSTEMS IN NORTH DAKOTA AS OF DECEMBER, 1975

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

(1969), on the process of forming and operating a rural water system was oriented toward situations in Kansas.

Although several studies--USDA (1965), Kerr (1969), and Humes (1971)--have included factors, such as water quality, costs of individual wells, and decreasing water tables, there has been no detailed analysis of why one individual joins a rural water system and his neighbor does not. Humes states that rural people are sold the system by engineering and law firms on the basis of emotional appeals. A few citizens join due to expectations of rising land values, government subsidies, and real needs, but Humes hypothesizes that the majority of the members are sold on the emotional argument that they are going to have "city water and the good life."

Palmby (1971) described several systems in Kansas and Missouri; however, no attempt was made to evaluate the systems. Humes (1971) states that "studies by outside engineers have shown that typical district systems have inadequately sized pipes, lower-than-city flow rates and particularly at the end of pipe runs, unrealistically low pressures."

Rural water systems have an impact on home improvement from the standpoint of increased use of water-using and other appliances and conveniences, such as bathroom and laundry facilities. Members of a water system in Kansas were asked what items they had purchased as a result of the rural water system. There were 58 out of 97 responses to the questionnaire in which members indicated purchases of household equipment. Purchases were estimated at a value of $135,000 for an average expenditure per member of over $2,300 for a five-year period (Smythe, 1969).

Black and Veatch (1967) estimated that additional private benefits of $65.45 and public benefits of $6.90 per year occurred as the total dissolved solids of water decreased from 1,750 ppm to 250 ppm. The savings were due to decreased laundry costs, increased life of clothing, and decreased costs of maintenance on private and public water lines.

The study in Kansas (Smythe, 1969) indicated that 43 of the 49 farmers who specialized in livestock production had increased their livestock numbers as a result of the rural water system. Livestock farmers were able to improve their programs by installing automatic waterers in pens and pastures and sprinkler cooling systems for livestock on feeding floors. There was also water available for dairy farmers which permitted some farmers to switch from Grade C to Grade A milk production (UDSA, 1965).

Land values in Kansas, where rural water systems began operating in 1962, have increased substantially as a result of these systems (Smythe, 1969). Respondents from one rural water system in Kansas indicated that land values had increased an average of $26.47 per acre as a result of the water system. Land values in the system area were also compared to those in another region of the same county based on actual land sales. It was determined that there were fewer sales of land in areas served by the rural water system, and land in the area of the system which was sold brought an average of $43.50 per acre more than land sold in the area not served by a water system. Similar studies in other states have also indicated increased land value as an impact of rural water systems. A study made in Mississippi (Landry, 1973) found that all but 10 of 226 responding associations reported increases in land value. These 226 associations reported increases that ranged

from 26 per cent to greater than 500 per cent. A study in Tennessee (USDA, 1965) found property values had risen 10 per cent because of rural water systems.

There is evidence that rural water systems contribute to the stability of population in an area. Respondents in two studies in Mississippi (Landry, 1969) indicated population stabilization and rural residential construction were impacts of the rural water systems. Research relating new water and sewer systems to the population of small towns indicated the overall growth rate of towns having systems was much greater than that of towns lacking them, although usually population growth had led to the formation of these systems (Stam, 1974). Rural water systems have helped stem the tide of out-migration for many towns that were faced with declining population due to an inadequate water supply.

Objectives

The objectives of this project were:

1. To develop a guide to assist rural people in forming and operating a rural water distribution system.

2. To determine what factors influence an individual's decision to participate in a rural water distribution system.

3. To evaluate the rural water distribution system with respect to delivery of adequate quantity and quality of water to its members.

4. To analyze the socioeconomic impact of the rural water distribution system on its members and the community.

Procedure

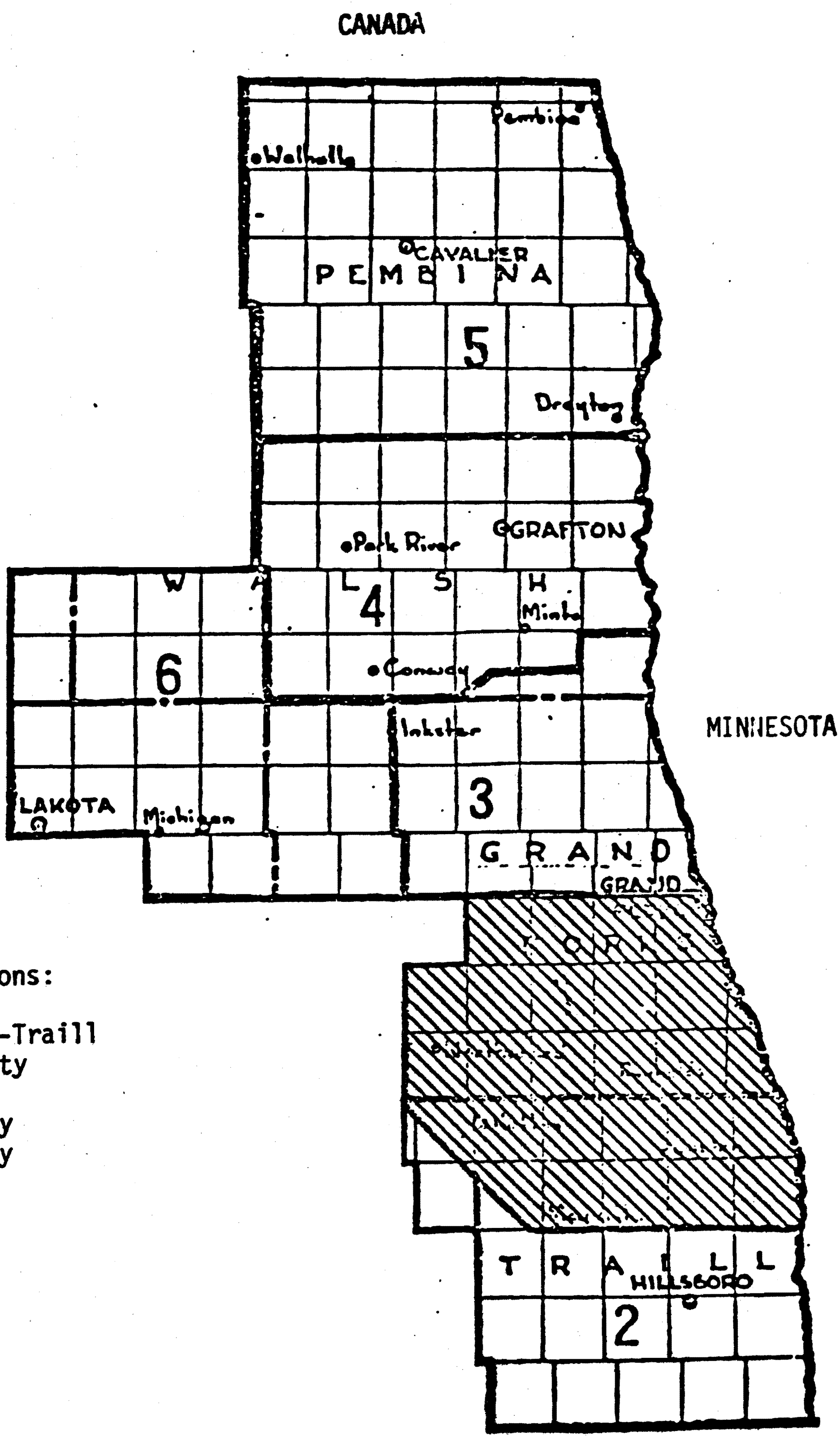
The formation of the Grand Forks-Traill Water Users Association, the

first in North Dakota, presented a unique research opportunity to obtain pre and post information. The association was officially organized on June 26, 1969, with a final completion of the system on December 15, 1972. Approximately 1,337 members are served by the association, and in addition the communities of Hatton and Northwood purchase water on a wholesale basis (Figure 2). The system consists of more than 500 miles of water pipe, five large wells, and 11 reservoirs. Construction costs of $3,975,000 were financed by an FHA 40-year loan. Each member was required to pay an initial membership fee of $50 and a hookup charge of $200.

All five wells are located in the Elk Valley Delta sand and gravel deposit. The Elk Valley consists of an outwash, delta, and glacial lake deposits that have been altered by waves and overlaid with beach ridges. Aquifer thickness in the area where the wells are located was reported to be 30 to 35 feet deep (5). Depths to the bottom of the well screens also vary, their range is between 60 and 100 feet. Combining the maximum sustained yields of all five wells results in 700 gallons per minute (gpm) to the entire system.

The initial source of data was 207 personal interviews (166 members and 41 nonmembers) with households in the area of the Grand Forks-Traill system (Table 1). The stratified random sample of 207 was selected with the aid of the water association membership list, township maps, records of property owners, and county extension agents in the two counties.

Twenty-eight participants in the initial sample indicated laundry problems and were reinterviewed to obtain additional information. Water samples from these 28 households and from 10 commercial water suppliers were analyzed for mineral and bacteriological content.



Water Associations:

1. Grand Forks-Traill
2. Traill County
3. Agassiz
4. Walsh County
5. North Valley
6. Tri-County

Figure 2. GRAND FORKS-TRAILL RURAL WATER USERS ASSOCIATION DESIGNATED BY SHADED AREA

TABLE 1. SAMPLE STRATIFICATION, GRAND FORKS-TRAILL WATER SYSTEM, 1972

Stratification	Nonmember*	Member	Total
Farm With Livestock	8	33	41
Farm Without Livestock	15	58	73
Nonfarm Rural Resident	15	33	48
City Resident	3	42	45
Total	41	166	207

*Eight additional nonmembers were interviewed. However, they had attempted to join the system and, therefore, were eliminated from the sample group.

SOURCE: Toman, Norman E., "Economic Impact of North Dakota's First Rural Water District," unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1975.

The directors of six rural water systems were contacted by mail in July, 1972, to obtain information on the organization process.

After the system began operation, six cooperators from various geographic areas of the systems were selected for an intensive laundry study and six cooperators were selected for monitoring water pressure and quantity on an hourly basis. These studies occurred from spring, 1973, to January, 1975.

Numerous interviews with county extension agents, real estate agents, personnel from the engineering firm who designed the system, Farmers Home Administration officials, and the directors and manager of the system occurred throughout the study period.

The final data source was a set of reinterviews with 165 of the 207 members and nonmembers from the 1972 survey. An attempt was made to contact each of the 1972 interviewees in June, 1974 (Table 2). Differences between the two groups were due to: 1) inability to contact the household; 2) noncooperation; 3) change in residence; 4) change in membership; and 5) erroneous 1972 classification.

TABLE 2. SAMPLE STRATIFICATION, GRAND FORKS-TRAILL WATER SYSTEM, 1974

Stratification	Nonmember	Member	Total
Farm With Livestock	13	34	47
Farm Without Livestock	6	32	38
Nonfarm Rural Resident	8	28	36
City Resident	12	32	44
Total	39	126	165

SOURCE: Toman, Norman E., "Economic Impact of North Dakota's First Rural Water District," unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1975.

II. ORGANIZATION PROCESS

The process of organizing a rural water association can be quite complex and time consuming. There are at least five major steps to the process, including generation of interest, membership drive, feasibility studies, formal organization, and initial operating procedures.[1]

Generating Interest

The first step in forming a water user's association is to make people aware that there is a program available to assist them with their water needs. Organizational assistance is available from the state office of the Farmers Home Administration (FHA) and Cooperative Extension Service personnel, but an area will have to rely primarily on local participation and organization in order to form an association.

The state office of the FHA recommends that the people interested in forming an association try to encourage an existing local organization to support the project. This organization could be a Chamber of Commerce, church organization, county commission, or any organization that has some influence in the community.

The associations that have been formed in North Dakota have been promoted by existing local organizations or an ad hoc group has set up the initial meetings to create interest in the community. Either method may be used, but it may be more practical to make use of an existing community organization.

When people in an area show interest in forming a water association, informational meetings should be scheduled to explain the rural water association program. Participants in these informational meetings usually

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[1]Interviews with the officers of the six water associations in North Dakota, July, 1972, provided the information for this discussion.

include a representative of an engineering firm, a representative of the state FHA office, and officers of other water user associations.

Scheduling informational meetings at different dates and locations eases the problem of obtaining membership commitments in a two-fold manner: 1) it reduces the possibility of conflicts with other events and 2) provides answers to questions that people have after the initial exposure to the project.

A steering committee should be formed if enough interest is shown at the informational meetings. There is not a fixed number of people who should serve on a steering committee, but an important criterion in selecting a committee is to have representatives from all areas within the potential borders of the association.

Membership Drive

The steering committee is responsible for making a preliminary survey of the water requirements in the area and contacting each prospective member. Presentation of the case for membership is more effective if the committee member is well known by the prospective members. If there is a personal conflict between a committee member and some of the people in his designated area, some other member of the committee should be selected to talk to them.

A lawyer should be engaged at this stage to assist in writing a membership contract. This contract should specify the initial membership fees, what they can be used for, and what happens to any unspent funds. In addition, a brief questionnaire should be developed to obtain information on each person contacted. This questionnaire should include:

1) Number in the household.
2) Estimate of water consumption.
3) Number and type of livestock.
4) Present sources of water.
5) Reasons for not joining the association.

A pamphlet containing essential information about water associations in the state and the Midwest area should be distributed to each contacted household. Information included would be the probable cost for members, required density of members, expected quality of water, and advantages to communities and farm operations.

When a person indicates interest as a water user, he should be requested to pay a membership fee. The first two associations in North Dakota required their potential members to pay $50 as an initial fee and $200 before final connection to the system. Problems have occurred in collecting the $200 portion of the fee and these two associations recommend that the whole membership fee be collected at one time. The $250 membership fee was recommended by FHA and may vary in other associations.

The membership fees are used to defray initial costs of the association and what is not expended is put into a reserve fund. Should the association disband, any money left from the membership fees normally is returned to the members.

Some people may not want to join the association when first contacted. The reasons should be recorded and this can be used as a guideline if there is a need to recontact the person at a later date.

After the steering committee has contacted all of the people in the area, a meeting should be held with FHA to determine if there are enough members to form an association. FHA makes an estimate of the revenue from water usage by members, and if this will cover the operating

expenses and repay the FHA loan, an association is tentatively feasible.

The cost of installing a rural water system was approximately $8,000 to $10,000 per mile in 1974. Other costs to be taken into consideration are maintenance of the system, manager salary, and billing costs.

The revenue is calculated by multiplying the estimated monthly use per member by the appropriate cost on the rate schedule times number of members. An estimate of monthly use can be derived from the water survey questionnaire completed by members when they pay their membership fees.

The rate schedule is partially determined from this usage estimate. The rate schedule that the members are willing to pay will vary in different areas depending on their water needs. An area that has a large number of members which have a difficult time obtaining water may be willing to pay a higher rate schedule than an area where members already have a fairly good water supply. The rate schedule in effect in August, 1974, for the Grand Forks-Traill Water Users Association had an $8 minimum monthly charge (Table 3).

TABLE 3. RATE SCHEDULE FOR THE GRAND FORKS-TRAILL WATER USERS ASSOCIATION, AUGUST, 1974

Amount of Gallons	Cost/1,000 Gallons
First 1,000	$8.00
Next 2,000	3.50
Next 2,000	3.00
Next 2,000	2.50
Next 5,000	2.00
Next 5,000	1.50
Next 8,000	1.25
Over 25,000	1.00

SOURCE: Personal Interview, Manager, Grand Forks-Traill Water Users Association, August, 1974.

The rate schedule is reviewed each year and can be adjusted if either a surplus or deficit of funds is found after all expenses have been paid, including those required by the terms of the credit agreement.

Formal Organization

The association can be formed as either a nonprofit corporation or a cooperative.

Under FHA financing, all profits to a corporation, after reasonable reserves, are to be passed on to consumers in more favorable rates.[2] No profits can return directly to member users, so a nonprofit corporation is probably the most desirable form of organization. A cooperative would transfer the profits in the form of dividends instead of lower rates. Members are not personally liable for association debts in either form.

Formation of either a nonprofit corporation or a cooperative is very similar. Five or more adults, one of whom must be a resident of the state, may form a cooperative by signing, acknowledging, filing, and recording the articles of the association. The articles have to be filed with the Secretary of State and a $16 filing fee is required.

A nonprofit corporation is a corporation having no capital stock and not being operated for financial profit. One or more persons may incorporate a corporation by signing, verifying, and delivering articles of incorporation in duplicate to the Secretary of State along with a $16 filing fee.

Feasibility Study

If the FHA tentatively approves the eligibility of the association,

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[2]Personal letter written by Richard L. King, attorney for Grand Forks-Traill Water Association, to author, February, 1973.

the steering committee can use part of the money secured from the membership fees to hire an engineering firm to conduct a detailed feasibility study to answer the following questions (USDA, 1970):

1) What is the potential membership density?
2) What would be the best source of water for people in this area?
3) What size and type of distribution lines would be needed to supply the water to the members? Where would the lines be located?
4) What is the estimated cost of the project?
5) What is the average cost per member?

This feasibility study must be completed before a loan to a rural water association can be approved by the FHA.

When the feasibility study has been reviewed and membership funds have been collected, the FHA authorizes the loan docket to be completed.

An association indebtedness to the FHA could not exceed $4,000,000 when the first North Dakota applications were made; however, at present there is no legal limitation on the amount of the loan. The loan is made to an association based on need, feasibility, and repayment ability. Repayment ability is determined by the projected amount of water that will be used by the members.

The maximum term on all loans is 40 years. However, no repayment period can exceed any statutory limitation on the organization's borrowing authority nor the useful life of the improvement to be financed. The interest rate varies, but cannot legally exceed five per cent (USDA, 1970).

After the water association has been approved, the engineers begin work on the final design of the system. They determine the number of members to be connected to the system. An average of one user for each one-half mile of pipeline appears necessary in order to make construction feasible in North Dakota. A member may not be connected to the system if he is isolated in relation to other members. The membership fee is

refunded when this occurs.

When the final design is completed, it will be submitted to the FHA along with the entire loan docket for final approval.

The contracts for construction are released after all papers are reviewed by the FHA. The contract is between the association and the construction firm.

Items that should be contained in the contract are payment schedule, penalty for late compliance, warranty of the construction work for an extended period of time, and a performance bond. A performance bond requires the contractor to perform specifically what he has agreed to do (Black, 1957).

The contractor is responsible for bringing the pipe to a central location in the farmyard of each rural member. Members who live in town will have the pipe laid to the edge of their lot.

The contractor also is responsible for damage to crops and to return the land to the same or reasonably the same condition it was prior to laying of the pipe.

The association provides the curb stop, pressure reducing valve, and the meter. Members are responsible for connecting their water line to the curb stop and providing a frost proof area, such as the house basement, for the meter. Members will have to install a frost proof pit for their equipment if a basement is not available.

Operating Procedures

Many of the water user associations in North Dakota have contracted with a rural electrical cooperative to handle the billing and accounting procedures. This appears to be a more efficient method than for each association to set up its own accounting office. Each member is

responsible for reading his own meter and reporting the reading to the association. The charges are calculated and a bill is sent to the member.

The size of the water systems in North Dakota, $2 to $4 million investment, makes a full-time professional manager a necessity. A good manager relieves the board of directors of many problems and is probably the best guarantee of satisfied members and a smoothly functioning system.

Additional people may be interested in joining the association after the system is operating. Policies for late joiners differ between associations. The first item that has to be taken into consideration is the design criteria. Systems are designed to provide a certain amount of water per any 24-hour period. If the association has a surplus which can be used there may be provisions for additional memberships. New members would have to wait for supplementary financing to become available if the system is operating at full capacity. The funds would be used for larger pipe sizes and/or additional reservoirs.

Summary of Responsibilities

The steering committee plays the most critical role in the organizational process. They set up and conduct the informational meetings; make initial contacts with the attorney, engineering firm, and the FHA; conduct the preliminary survey of potential members; and collect membership fees. They are responsible for formally incorporating the organization and remain in charge until a board of directors is selected.

The engineering firm's responsibility can be extensive or quite limited. The engineering firm which was hired by the first two districts took a very active role in organizing informational meetings, contacting

potential members, and assisting the steering committee in all aspects of the organizational stage. The engineering firm may also prepare reports for the lending agency and assist in advertising for bids. The other responsibilities of the engineering firm are to conduct the final feasibility study, design of the actual system, and supervision of construction.

The attorney for an association has a multitude of responsibilities.[3] He becomes involved in the early stages as a legal counsel to the steering committee and aids in preparing contracts, securing a charter from the Secretary of State, and completing all forms and procedures on financing from the FHA. The attorney also is needed to coordinate with engineering firms on advertising for construction bids, securing rights-of-way and real estate necessary for construction, assisting in negotiating contracts with any wholesale customers, and checking the legality of construction contracts. During the actual construction stage, the attorney continues to be responsible for the legal aspects of any changes in easements, rights-of-way, and disagreements with any of the parties involved in the system. In addition, the attorney frequently acts as the secretary of the board of directors and is involved in setting up the management and accounting procedures for operation of the system.

The Farmers Home Administration has been the financing agency for each water users association in North Dakota. As such, the FHA has been involved in all aspects of organization and operation, particularly in setting membership fees, rate schedules, economic feasibility of the associations, and completion of final loan agreements.

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[3] King, Richard L., "A Checklist for Organizing a Rural Water Distribution System," presented to class in Agricultural Law, University of North Dakota Law School, Grand Forks, North Dakota, February 13, 1973.

The board of directors is the governing arm of the association. They are elected by the members and represent the members when dealing with other groups and individuals. The board is charged with making policy within the bylaws of the association and must also make decisions on details of system operation. The members have the responsibility of electing the board of directors, reading their own meter, and submitting the payment to the association. In addition, the members frequently are required to make the connection from their system to the association's water lines.

III. CHARACTERISTICS OF MEMBERS AND NONMEMBERS

The age of adults in the member residences was substantially lower, 55 per cent less than 55 years, versus nonmembers where only 30 per cent were less than 55 years old (Table 4). The number of children in the home also differed between members and nonmembers. Sixty-one per cent of the member households included one or more children, while only 22 per cent of nonmember households contained one or more children. Seventy-six per cent of the nonmembers had lived in their present home for more than 20 years as compared to 50 per cent of nonmembers.

TABLE 4. CHARACTERISTICS OF MEMBERS AND NONMEMBERS, GRAND FORKS-TRAILL, 1972

	Members	Nonmembers
Age - Less than 55	55%	30%
Children - 1 or more	61%	22%
Residence - 20 years or more	50%	76%
Wealth		
Homes at $15,000+	40%	7%
Land - 320 acres+	74%	30%

SOURCE: Nelson, William C., N.E. Toman, and C.O. Hoffman, "Impact of Rural Water Systems in North Dakota," paper presented to the North Dakota Society of Farm Managers and Appraisers, Fargo, January 5, 1976.

Wealth also was a distinguishing characteristic between members and nonmembers. Forty per cent of the member residences were valued at more than $15,000, while only 7 per cent of the nonmembers valued their homes above $15,000. More than 320 acres of land were owned by 74 per cent of farm members as opposed to only 30 per cent of farm nonmembers.

Water Sources

The source of water prior to the formation of the Grand Forks-Traill Water Users Association appeared to be an important factor in the membership decision. A higher proportion of the nonmembers had their own wells (67 per cent) and cisterns or ponds (33 per cent) than did members (Table 5).

TABLE 5. SOURCE OF WATER, MEMBERS AND NONMEMBERS, GRAND FORKS-TRAILL WATER USERS ASSOCIATION, 1972

Source	Member	Nonmember
	percent	
Well	47	67
Hauled	71	60
10 or more loads per year	64	14
$100 or more expenditures	51	23
Rain (cistern or ponds)	18	33

SOURCE: Nelson, William C., and Clayton O. Hoffman, Rural Water Users Associations in North Dakota Why? How? Who?, Agricultural Economics Report No. 105, North Dakota State University, Fargo, 1975.

Sixty-four per cent of the members averaged more than 10 loads of hauled water annually (1,000 to 2,000 gallons per load) and hauling costs of more than $100 per year were incurred by 51 per cent. On the other hand, only 14 per cent of the nonmembers hauled more than 10 loads per year and only 23 per cent had expenditures for water hauling of over $100 annually. Twenty-five per cent of persons who joined the association had been without water for one or more days during the year before hookup as compared to 7 per cent of the nonmembers.

Statistical Analysis

A statistical analysis was performed to identify the characteristics

which were significantly related to members and nonmembers.[4] Fourteen characteristics were significantly related to the decision to join or not join the rural water association (Table 6).

Households with residence of high value and high water costs had a greater probability of being a member than households with low dwelling and water costs (designated by a + sign in Column 1). Presence of a cistern, however, would decrease the probability of the individual joining the association (designated by a - sign in Column 1). Use of these three characteristics led to a correct classification of 71 per cent or 147 of the 207 households in the total sample into member and nonmember groups.

Division of the respondents into nonfarm and farm groups resulted in 74 per cent of farm residents and 69 per cent of nonfarm residents classified correctly with respect to their membership. Water cost, cisterns, water hardness, and number of household major appliances were statistically related to nonfarm member and nonmember groups. Membership in the system of the farm resident group was related to the value of the dwelling, length of residence, number of dairy cattle, and frequency of washing vehicles at home.

Division of the respondents into four groups yielded better results. Eighty-six per cent of the rural nonfarm residents were classified correctly in nonmember and member groups by three characteristics: value of dwelling, length of residence, and age of resident. Two characteristics,

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[4]Discriminant analysis was the technique employed to identify statistically significant characteristics. Each discriminant equation presented in Table 8 was significant at a 5 per cent level and each characteristic was significant at a 25 per cent level. This means that there is less than or equal to a 25 per cent probability of rejecting a characteristic which is actually related to the membership decision.

TABLE 6. SUMMARY OF SIGNIFICANT CHARACTERISTICS IDENTIFIED IN THE STATISTICAL ANALYSIS OF MEMBERS AND NONMEMBERS[a]

Characteristic	Total Sample	Two-Way Classification		Four-Way Classification			
		Nonfarm	Farm	Rural Nonfarm	Rural Town	Farm Without Livestock	Farm With Livestock
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. Value of Dwelling	+		+	+		+	+
2. Annual Water Cost	+	+			+		
3. House With Cisterns	-	-					
4. Water Hardness		+					
5. Number of Appliances		+					-
6. Length of Residence			-	+		-	-
7. Number of Dairy Cattle			-				-
8. Gallons Used for Crops			+				
9. Number of Times Vehicles Washed			-				-
10. Age of Resident				-	+		
11. Number of Acres Operated						+	
12. Number of Wells						-	+
13. Number of Times Without Water							+
14. Number of Swine							-
Per cent of Sample		69%	74%	86%	74%	77%	
Classified Correctly	71%	Average = 71%			Average = 81%		95%

[a]The actual coefficients computed in the discriminant analysis are presented in Hoffman, Clayton, "North Dakota's First Rural Water System," unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1973, pp. 65-98.

total water cost and age of resident, correctly classified 74 per cent of rural town residents into member or nonmember groups.

Farm residents with above average dwelling valuations and number of operated acres were members of the system more frequently than those who had private wells and had lived on farms for many years. Ninety-five per cent of the farms with livestock were correctly identified as members or nonmembers by eight characteristics. The value of dwelling, number of wells, and number of times which water was not available were positively related to membership. The number of appliances, length of residence, number of dairy cattle and swine, and frequency of washing vehicles at home were negatively related to membership.

Value of dwelling was the most important characteristics identified in the analysis. It was positively related to membership in five of the seven equations. Annual cost of obtaining water was positively related to membership in three of the seven analyses. Other characteristics, such as length of residence and age of resident, were also significantly related to membership; however, the direction of their relationship varied among the groups. For example, length of residence was positively related to membership in the rural nonfarm group, but negatively related in the farm, farm without livestock, and farm with livestock groups.

In general, persons likely to support and join a rural water association will:

1) Own a newer, higher valued home.
2) Have high annual costs of obtaining water.
3) Not have a cistern.
4) Be younger with more children living at home.

Reasons for Membership

Members and nonmembers of the association were asked to specify their reasons for joining or declining membership in the water association. Five different reasons were accepted from each person, with the first reason given a point value of five and subsequent answers one less for each response. A total value was calculated for each response to facilitate ranking their reasons in order of importance (Table 7).

TABLE 7. RATIONALE FOR JOINING THE GRAND FORKS-TRAILL WATER USERS ASSOCIATION, 1972

Reason	Total Points[a]	Per cent
1. Convenience	536	37.3
2. Increased Quantity of Water	181	12.6
3. Stable Quantity of Water	180	12.5
4. Community Pressure	121	8.4
5. Cost of Hauling Water	89	6.2
6. Improved Quality of Water	79	5.5
7. Effect on Housing Value	60	4.2
8. Effect on Land Value	56	3.9
9. Cost of Well	35	2.4
10. Reserve Supply of Water	11	.8
11. Stable Pressure for Water	4	.3
12. Penalty for Late Membership	4	.3
13. Other than Listed	81	5.6
Total	1,437	100.0

[a]Five reasons in order of importance were obtained from each respondent, the first reason was given a value of five and subsequent reasons one less for each response and the final step was to sum the total points for each reason.

SOURCE: Nelson, William C., and Clayton O. Hoffmann, Rural Water Users Associations in North Dakota - Why? How? Who?, Agricultural Economics Report No. 105, North Dakota State University, Fargo, 1975.

Most people joined the system for the convenience of having an increased and stable supply of water available. This is indicated by the first three

reasons for joining the system. The fourth reason, community pressure, refers to an individual joining the system to assure that the system would come into the community. An example of community pressure is a farmer who wants to join the system but is isolated from other members. He would have to convince the people living near him to join the association, thereby decreasing the cost per household for the system to come into that area. The increase in land and housing value from having an adequate water supply also was rated high.

Cost of hauling or private wells relative to the anticipated costs of the system water had little influence according to members of the system. Nonmembers expressed more concern about cost as the proposed rate schedule of the system was a major reason for not joining the system.

Other major reasons for not joining the system were consistent with the previous information; the persons who had a satisfactory well or other water sources were not likely to join the system. Low water consumption was given frequently as a reason for not joining the system by older people, families with no children or a small amount of water using equipment.

IV. WATER CONSUMPTION AND PRESSURE LEVELS

Annual Water Consumption

Water consumption records for members were available for three years. There were complete records for 111 of the 126 members interviewed. The mean value of water usage rose by 21.7 per cent from 1972 to 1974 and by an additional 22.0 per cent in 1975 (Table 8).

TABLE 8. COMPARISON OF WATER CONSUMPTION OF SYSTEM MEMBERS PER YEAR IN 1972, 1973, 1974, AND 1975

Year	Mean Number of Gallons Consumed		Per cent Increase from 1972	
	Members	Nonmembers	Members	Nonmembers
1972[a]	25,536.0	11,556		
1973[b]	38,887.8	N.A.	52.2	
1974[b]	47,313.0	14,748	85.3	27.6
1975[b]	55,867.9	N.A.	118.8	

[a]1972 data for members and nonmembers and 1974 data for nonmembers are mean values of households interviewed.

[b]1973 is from December of 1972 through November of 1973, 1974 is from December of 1973 through November of 1974, and 1975 is from December of 1974, through November of 1975.

N.A.: Not Available.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

Eighty-six per cent of the members who previously hauled water discontinued the practice. Eighty per cent of the nonmembers who hauled water in 1972 continued to haul water in 1974.

Average daily consumption for the 21 nonmembers who hauled water was 39.6 gallons per day. In 1973, member consumption per day of system water

averaged 106.5 gallons; in 1974, it was 126.6 gallons; and in 1975, it was 153.1 gallons. Average family size for those using hauled water was 2.8 persons. Average family size for those who used system water was 3.4 persons.

Residents who relied on hauled water used it primarily for domestic purposes as compared to system members who used water to a greater extent outdoors and for livestock, as well as for domestic purposes (Table 9).

TABLE 9. FREQUENCY OF RESPONSES REGARDING USES OF SYSTEM AND HAULED WATER

Use	Members Using System Water		Users of Hauled Water	
	n	Per cent	n	Per cent
Domestic	35	28.7	20	62.5
Domestic and livestock	2	1.6	2	6.2
Domestic and outdoor	77	63.1	10	31.2
Livestock	1	0.8	0	0.0
All	7	5.7	0	0.0
Totals	122[a]	99.9[b]	32[c]	99.9[b]

[a]Total does not equal 126 because some respondents classified as members were not using the water.

[b]Total does not equal 100 due to rounding.

[c]Total does not equal 23 because those who used hauled water in addition to other sources were included.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

Daily Water Consumption and Pressure

Cooperator Selection

Daily water requirements of six cooperators within the Grand Forks-Traill Water System were monitored on a 24-hour basis. Selection of cooperators was based on the recommendations made by the Grand Forks-Traill Water System Manager and the Traill County Cooperative Extension Agent. Water meter readings were taken every five minutes starting at 0600 and ending at 2200 which was expected to be the period of greatest consumption. From 2200 to 0600 the following day, meter readings were taken at 10-minute intervals. Table 10 indicates the farm and family characteristics of each cooperator.

TABLE 10. INDIVIDUAL COOPERATOR CHARACTERISTICS

Cooperator #	Farm Home	Family Size	Number of Livestock	Water Softener
1	yes	7	0	no
2	yes	4	0	no
3	no	6	0	no
4	yes	6	10	yes
5	yes	2	0	yes
6	yes	5	250	no

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

Family size ranged from two through seven. With families of various sizes, variations in water use rates and demand times could be expected. Both farms with livestock used water from the system for their stock.

Data Acquisition Periods

From each cooperator a minimum of five days' water consumption was

obtained. At five of the six installations, observations were made for one, two, or at the most three consecutive days before terminating the sequence in favor of additional data at a later date. Five-minute readings for 16 hours and 10-minute readings for 8 hours were obtained.

Photographic Equipment

Photographic equipment used in obtaining water consumption data included a battery-operated (Super 8) home movie camera equipped with an automatic eye and an auxiliary 2+ close up lens. At this distance the field of view was approximately 5 inches by 7 inches and spatial arrangement of indicating equipment within this small space was sometimes difficult (Figure 3).

The camera and lights were operated by a solid state control timer. Features of the control timer included independent 16 and 8-hour cycles that were set for respective intervals of 5 and 10 minutes. At all recording installations the 16-hour cycle started taking 5-minute readings at 0600 and the 8-hour cycle started taking 10-minute readings at 2200. These intervals imply that 196 readings were taken during the 16-hour cycle and 48 readings were taken during the 8-hour cycle. With 5 and 10-minute intervals, a 50-foot roll of film would record five to eight days of water consumption depending on battery strength.

Correct exposure was insured by a sequential switching system that turned the lights on before the camera had advanced film. The camera motor control circuit was adjusted to expose three frames of film at each recording interval.

At every "Super 8" installation, lighting was provided by two 150-watt reflector flood lamps placed two or three feet from the water meter at a 45-degree angle. The camera's automatic eye provided correct

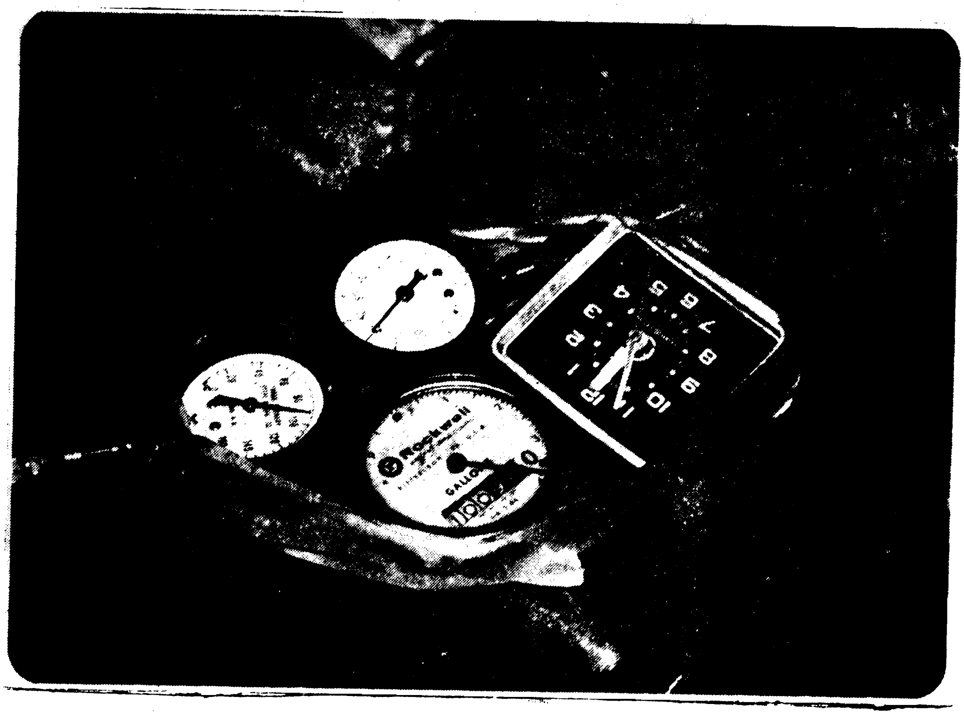

Figure 3. Water Measuring Equipment

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

exposure. To eliminate problems of light reflection, the face cover on the clock and the gage lenses were removed. The convex lens on the water meter was not removed as it was permanently attached at the factory.

Gauges used in this study registered pressures from 0 to 100 psi. At all installations two inch diameter gauges were used in order that space would be left in the field of view for a clock and water meter. A small electric alarm clock was used for time recording at all six recording stations. Water consumption was measured with meters calibrated to read to the nearest 0.1 gallon.

At some locations data was acquired with a Model H-16 Bolex. Features of this camera include: a reflex view finder, single frame film advancement, and a lens capable of focusing on objects as close as 18 inches. At 24 inches the field of view included an area 6½ inches by 9¼ inches. Lighting used was similar to the light source used in the "Super 8" installations. The Bolex camera was not automatic. A light meter was used to determine "f" stop and shutter speeds that coincided with the amount of light available.

A 115-volt Samenco control for time lapse photography was attached to the camera with a mounting plate. The solenoid was activated every five minutes exposing one film frame. Film advancement was accomplished with a spring similar to the type used in a mechanical or wind-up clock. A single winding exposed 720 film frames. Using a five-minute interval, 24 hours a day exposed 288 frames per day. A single winding recorded 2½ days of water consumption. Exposing 720 frames of 16 mm film required 18 feet of film. From this it can be concluded that this camera could be completely wound five times and capture 12½ days' water demands before running out of a 100-foot roll of film. Each time an 18-foot segment was

exposed the film was cut, the exposed segment was removed, and another take-up spool was placed in the camera.

Like the control panel designed for the "Super 8" camera, the control turned the lights on before activating the camera. Unlike the "Super 8" control circuitry, the Samenco movie control was mechanical and had only one daily cycle. Since the 16 mm control system had only one daily cycle, data obtained with this system was made compatible to the data acquired by the "Super 8" recording system by recording data every five minutes and then omitting every other observation between 2200 and 0600 hours.

In every installation the camera and recording equipment was fastened to a floor joist in the basement. When activated, the solenoid operating the H-16 Bolex made an objectionable noise. No installations were made under a bedroom or other location where the solenoid noise might be a nuisance.

Total and Maximum Demands

Data from five farms and a house in town have been compiled and arranged in graphic and tabular form. Figures 4 through 17 indicate both the 24-hour average hourly demand and the standard deviation for each hour's consumption. In every graph displaying the standard deviation, the average daily demand has been shown as a horizontal line. Water demands for each farm or household were graphed to indicate the time and rate of flow.

The total daily demand, maximum 5-minute demand, maximum hourly demand, the hour in which the maximum 5-minute demand occurred, and the time when the maximum hourly demand occurred have been determined and compiled in Table 11.

TABLE 11. WATER REQUIREMENTS OF EACH COOPERATOR

Cooperator	Date	Daily Demand gallons	Maximum 5-Minute Demand gallons	Maximum 5-Minute Demand time	Maximum Hourly Demand gallons	Maximum Hourly Demand time
Cooperator 1	Mar. 19, 1974	154	17	2040	37	2000
	Mar. 20, 1974	189	19	1855	56	1850
	Mar. 21, 1974	126	13	0920	26	0920
	May 23, 1974	314	21	1730	110	1635
	May 24, 1974	246	20	1400	51	0505
	Average	205				
Cooperator 2	Aug. 29, 1974	278	31	1110	52	1950
	Aug. 30, 1974	197	24	2205	27	2200
	Aug. 31, 1974	307	24	2255	71	2035
	Sep. 7, 1974	198	17	1050	54	1030
	Sep. 8, 1974	369	22	2155	71	1425
	Average	270				
Cooperator 3	Oct. 31, 1974	275	15	1925	72	1850
	Nov. 1, 1974	598	24	0620	103	0815
	Nov. 2, 1974	225	25	0645	90	0610
	Nov. 3, 1974	239	32	1005	104	1000
	Nov. 4, 1974	461	42	1110	110	1040
	Average	360				
Cooperator 4	Sep. 14, 1974	634	21	2135	106	1105
	Sep. 15, 1974	462	23	0735	79	1135
	Oct. 24, 1974	2203	45	0740	180	0730
	Nov. 1, 1974	1896	46	0710	183	0620
	Nov. 8, 1974	306	26	1810	56	0820
	Average	1100				
Cooperator 5	Nov. 20, 1974	63	10	2040	28	2015
	Nov. 21, 1974	191	11	1740	41	1720
	Dec. 13, 1974	22	1	2040	5	2010
	Dec. 14, 1974	25	5	1605	6	1605
	Dec. 15, 1974	50	6	1455	7	0620
	Average	70				
Cooperator 6	Dec. 20, 1974	1332	38	1015	306	1010
	Dec. 21, 1974	769	30	1300	164	1230
	Dec. 22, 1974	1156	30	1535	178	1140
	Jan. 4, 1975	1494	50	1050	296	1025
	Jan. 5, 1975	1770	50	1140	318	1115
	Average	1304				

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

Twelve consecutive 5-minute readings or 6 consecutive 10-minute readings if it was after 2200 were used to determine the maximum hourly demand. Determining the maximum hourly demand in this manner indicated the beginning of the maximum hourly demand within 5 minutes. This explains why the maximum hourly demands start at any time and are not coincident with the beginning of the hour.

Composite curves for the five farms and a house in town indicate the water demand magnitude on an hourly basis during the observation period. Data were obtained from each residence on a different day so that composite curves do not indicate simultaneous demands.

During the hours of 0600 to 2200, 12 readings were taken each hour for five days at each location providing 60 meter readings from which the standard deviation was computed for every hour within this time period. Between the remaining hours of 2200 and 0600 the next day, six meter readings were taken each hour accumulating 30 readings during the eight-hour cycle from which the standard deviation was computed. One standard deviation on each side of the mean indicated the range in which 68 per cent of the water demand rates would be expected to be found.

The average consumption of cooperator #1 for the five observation days equaled 205 gallons. The standard deviation accompanying the average daily consumption was $\pm$ 75 gallons. As indicated in Figure 4, the average daily demand was found to be 8.45 gallons per hour. Peak demand rates occurred at 0500 and 1700. Consumption between 2300 and 0400 approached zero, while early afternoon and evening consumption rates were near 10 gallons per hour.

An examination of daily data showed that at 1600 and 1700 the highest demand occurred each day. The maximum hourly and maximum 5-minute demand occurred during the same hour on four of the five recording days.

Standard deviations subtracted from the hourly means in this graph and the following graphs often resulted in negative values indicated below the zero line when plotted on a graph. It is not realistic to assume that any of the hourly demand rates were negative. But when the standard deviation was larger than the mean, subtraction of the standard deviation from the mean resulted in a negative value that was statistically correct, but meaningless in terms of actual water consumption levels. The negative standard deviations which fall below the zero consumption line in Figures 4 through 14 have no meaning. In Figure 4 and all following maximum hourly demand graphs the larger hourly demands possessed larger standard deviations.

Figures 6 and 7 describe the water use pattern for cooperator #2 with a family of four with no livestock. Average daily consumption at this farm was 270 gallons per day with a standard deviation of $\pm$ 74 gallons per day. At this farm, highest demands occurred in the early afternoon and after 1900. Water demands at these peak times were observed almost every day. Only twice during the peak flow periods was a zero water demand observed. From midnight to 0600 water demands were zero or close to zero on every recording day. However, one irregular demand during this time was large enough to produce a noticeable curve rise. Maximum hourly demand rates were nearly equal at 1300, 1500, 2000, and 2200.

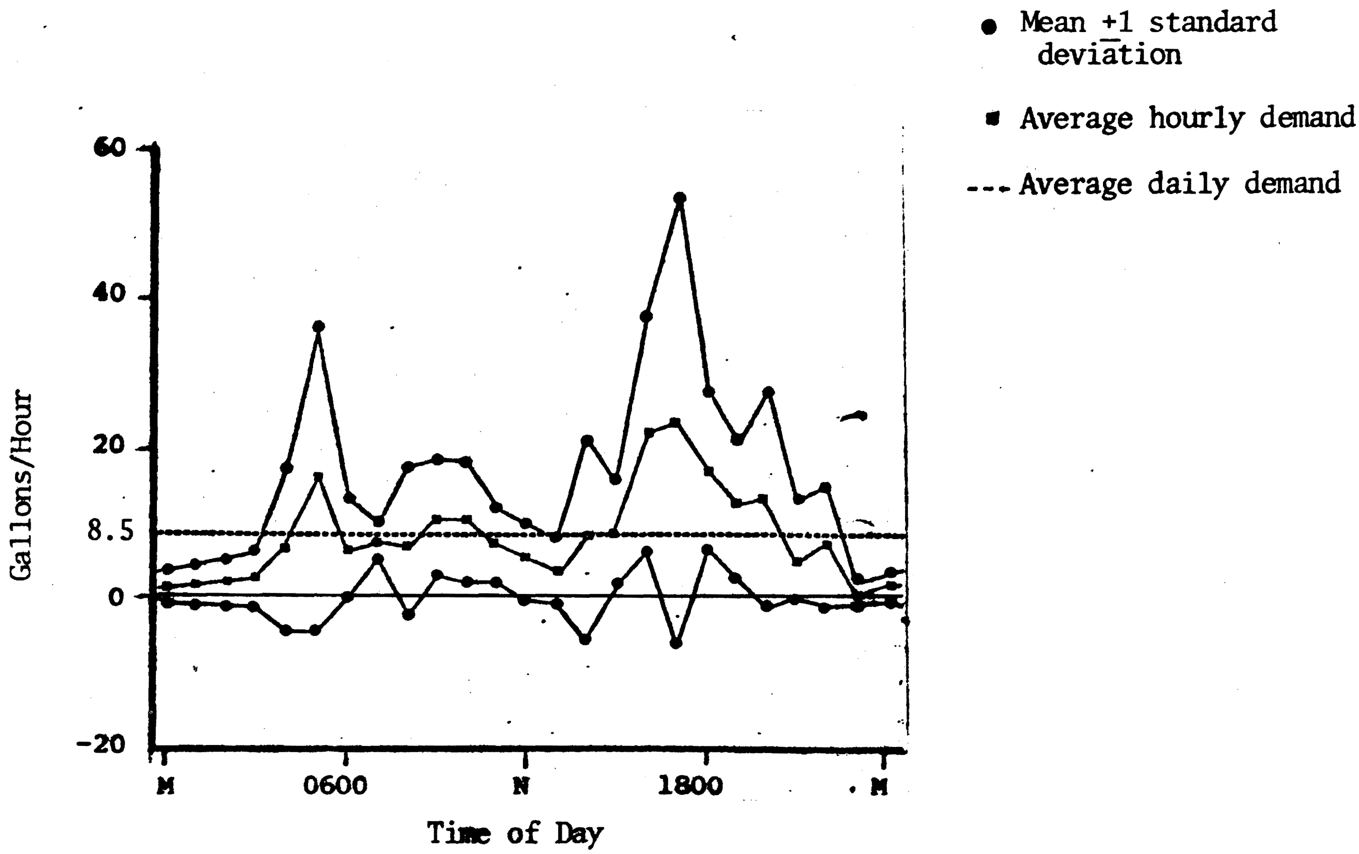

Figure 4. AVERAGE HOURLY DEMAND FOR COOPERATOR #1

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

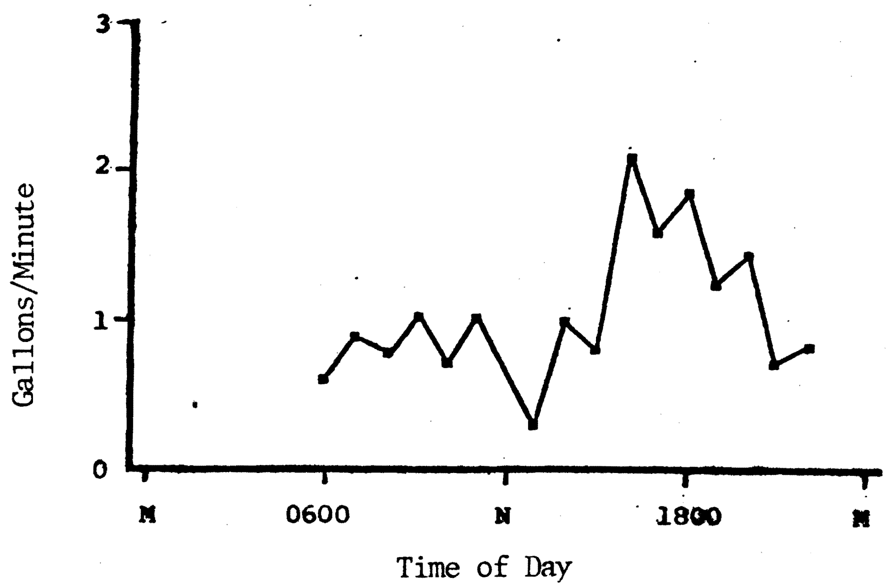

Figure 5. MAXIMUM 5-MINUTE DEMANDS FOR EACH HOUR BETWEEN 0600 AND 2200 FOR COOPERATOR #1

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

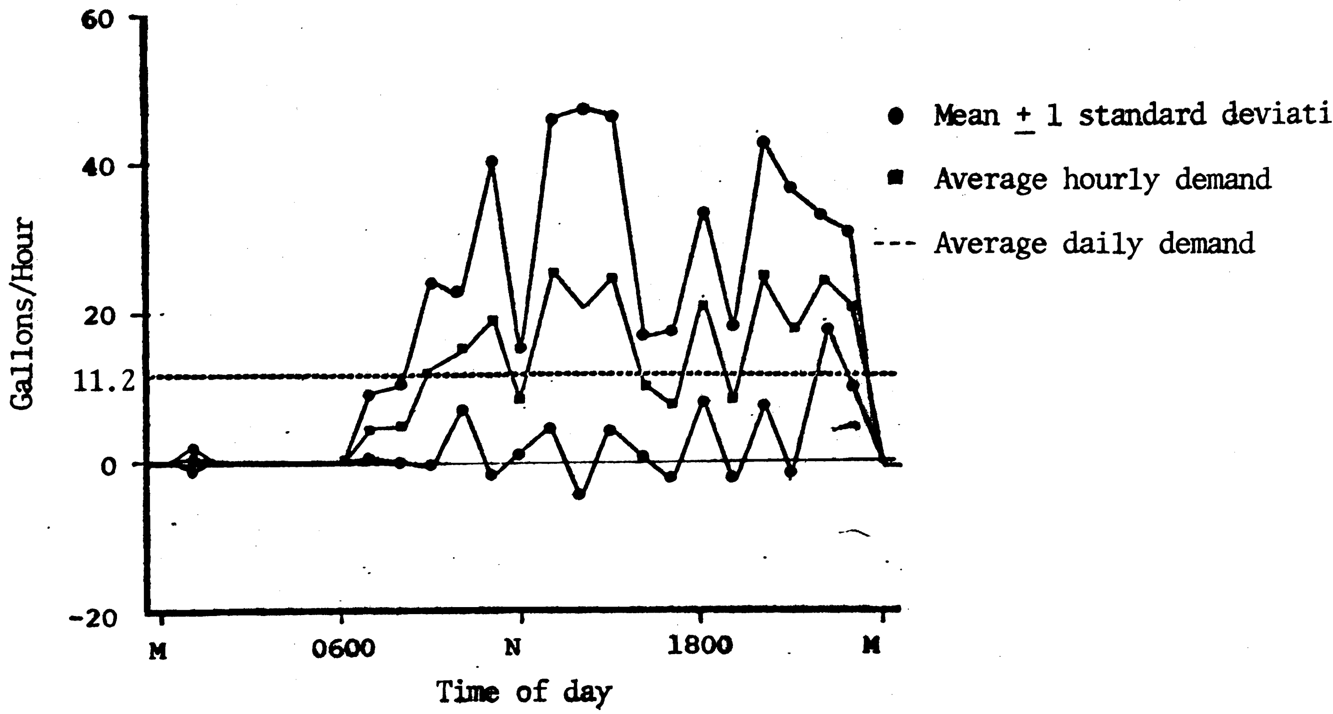

Figure 6. AVERAGE HOURLY DEMANDS FOR COOPERATOR #2

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

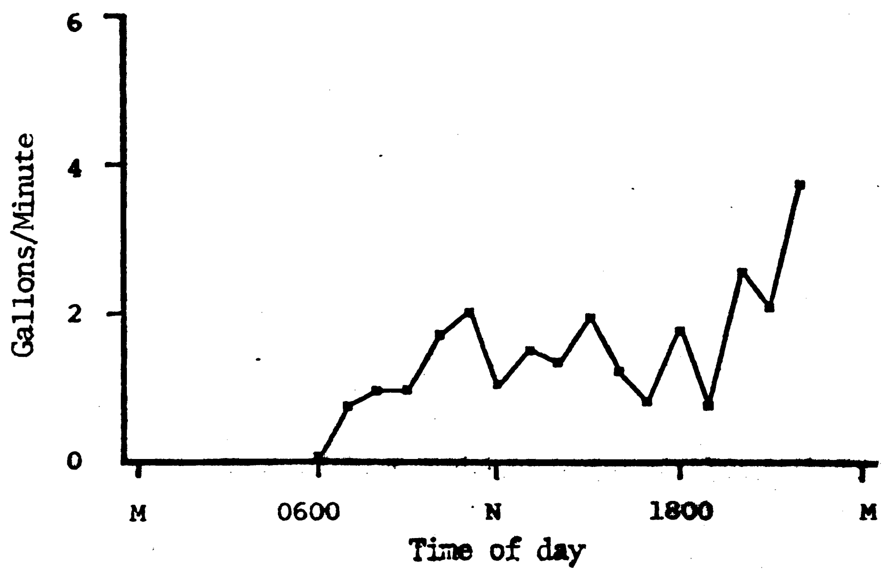

Figure 7. MAXIMUM 5-MINUTE DEMANDS FOR EACH HOUR BETWEEN 0600 AND 2200 FOR COOPERATOR #2

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

The maximum 5-minute demand rates in Figure 7 were highest at 2000 and 2200. Peak demands occurring at 2000 and 2200 coincided with the maximum hourly demand on two of the five recording days. Morning demands were lower than afternoon demands and traditional evening meal time demands were lower than demands exerted after 1900.

Water usage habits of cooperator #3 with a family of six residing in a small town are illustrated in Figures 8 and 9. An average daily demand of 360 gallons per day with a standard deviation of $\pm$ 164 gallons per day was observed at this location. With the exception of the second day, the 5-minute demand and the maximum hourly demand occurred during the same hour every day.

Consumption before 0600 was unexpected as the house did not contain an automatic water softener or other time controlled equipment that could require 45 gallons per hour or more. Demands of 20 and 52 gallons per hour occurred at 0100 and 0200 on the second day. A demand of 45 gallons per hour was noticed at 0300 on the third day. One-third of the hourly demands for 0100, 0200, and 0300 during the five-day period were zero and most of the remaining hourly demands during these hours were close to zero. The curve rise at 0100, 0200, and 0300 has been attributed to a single high demand at each hour.

Consumption at this location was entirely for domestic purposes. Peak demand periods occur in the morning at 0600 and 1100. As indicated by Figure 8, midafternoon requirements were moderate and evening consumption was low. Fluctuation occurred in water demands during peak consumption periods. If water consumption was above the average flow rate at a given hour on one day, the next day little or no water may be drawn during this period. The high point in Figure 8 occurs at 1000

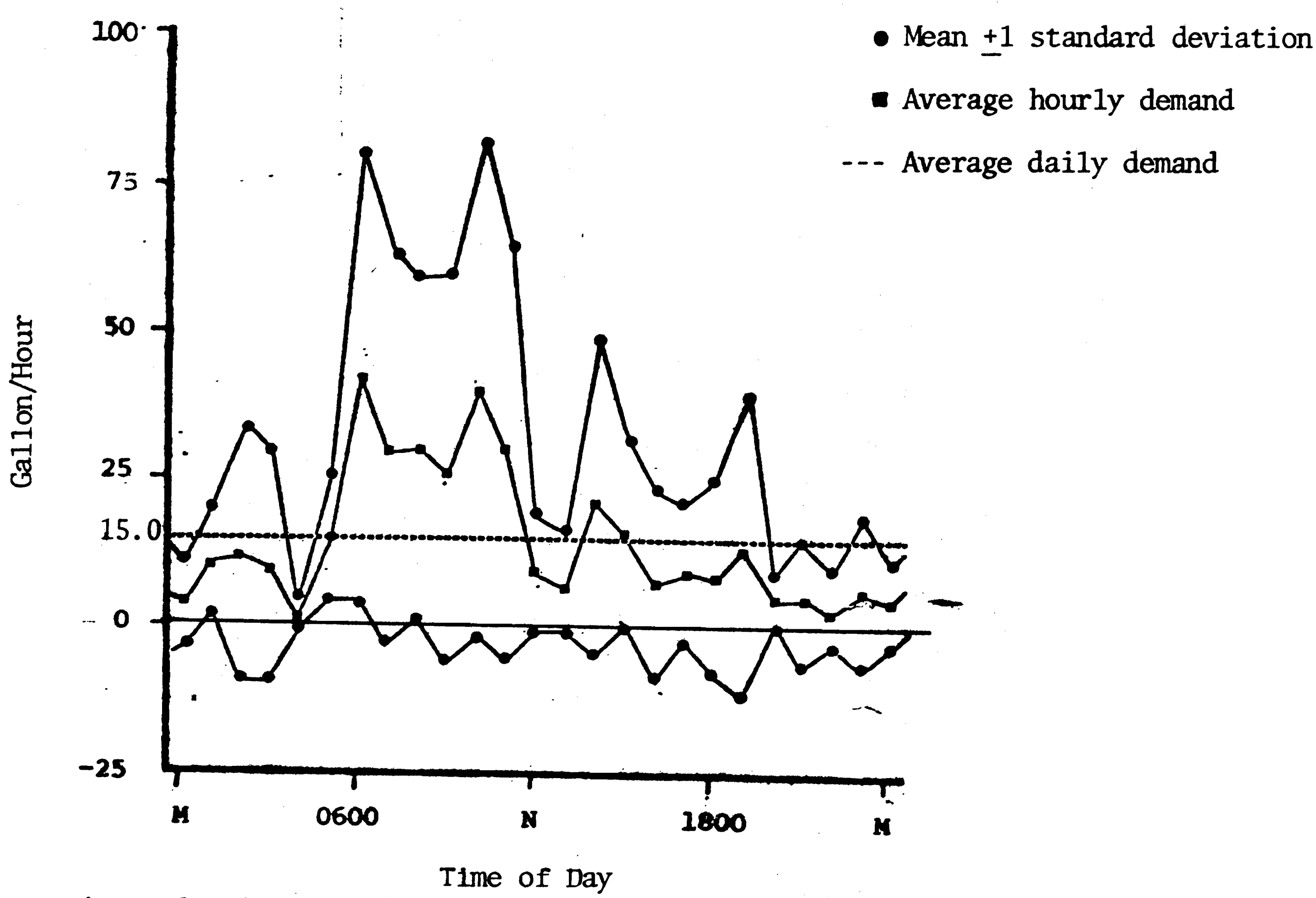

Figure 8. AVERAGE HOURLY DEMAND FOR COOPERATOR #3

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

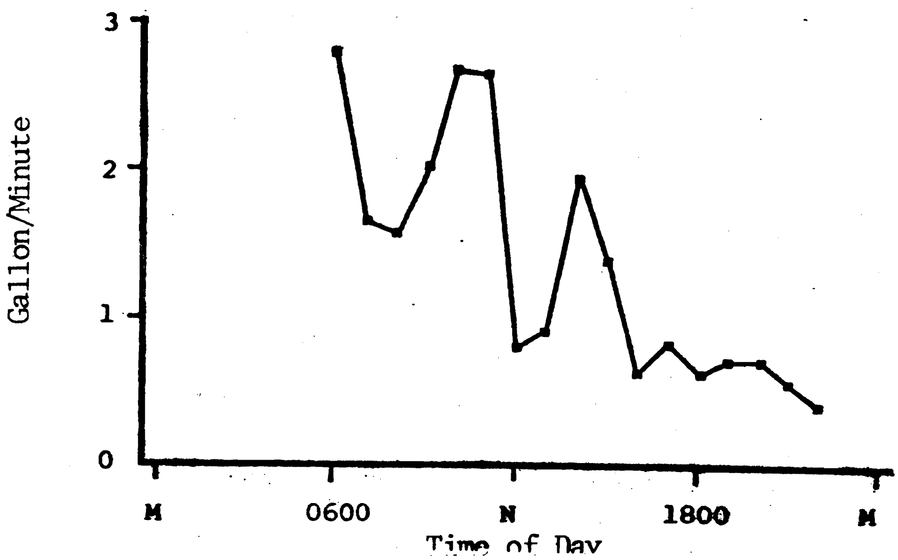

Figure 9. MAXIMUM 5-MINUTE DEMANDS FOR EACH HOUR BETWEEN 0600 AND 2200 FOR COOPERATOR #3

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

indicating peak hourly demand during the five-day period occurred at this time. A high demand on the graph at this time was attributed to the additive effects of days four and five having their maximum hourly demands during this time. Somewhat smaller curve rises are attributable to maximum hour demands occurring at some time other than at 1000 on the three remaining days.

A similarity in curve patterns for Figures 8 and 9 indicate that the maximum hourly demands and maximum 5-minute demands are coincidental.

At times when the hourly demands were high in Figure 8, the 5-minute demands were high in Figure 9. Figures 8 and 9 both show the trend of decreasing water requirements from noon to midnight.

Figures 10 and 11 represent the water demand of cooperator #4 with a family of six. The five-day average demand for this farm having 10 head of livestock was 1,100 gallons per day or 46 gallons per hour. The standard deviation of 881 gallons per day was almost as large as this average daily consumption.

Between midnight and 0600 Figure 10 depicts a demand schedule of nearly 25 gallons per hour during the five-day observation period. A check of the raw data used in comprising this segment of the curve indicated that during the hours of midnight to 0600 more than half of the hourly demands were zero. Volumes of 60 to 70 gallons per hour were observed on days three and four at every hour between midnight and 0600, and were responsible for the curve being well above zero at times when little or no water would normally be used.

Similarities in Figures 10 and 11 are present at 0700, noon, 1800, and 2100 when the peaks occur together. Lower flow rates observed on Figure 10 are also present in Figure 11.

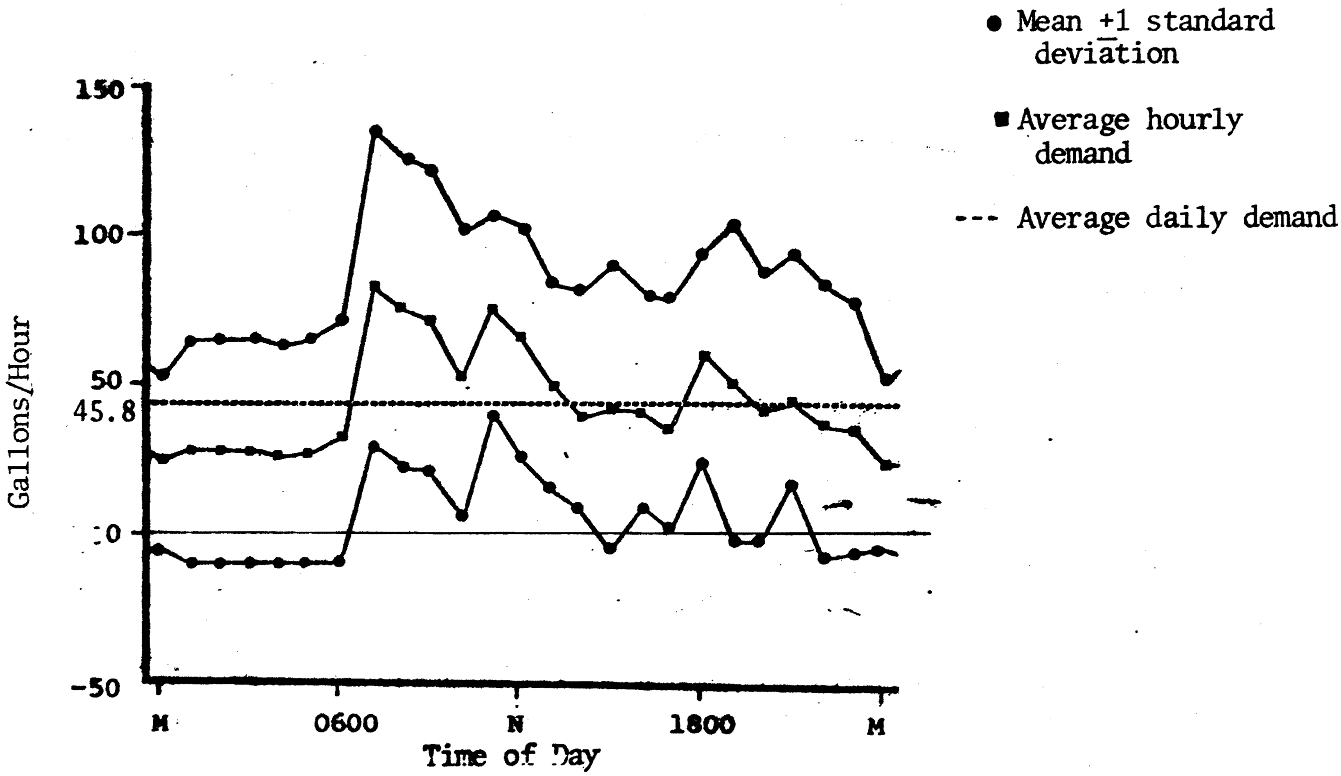

Figure 10. AVERAGE HOURLY DEMANDS FOR COOPERATOR #4

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

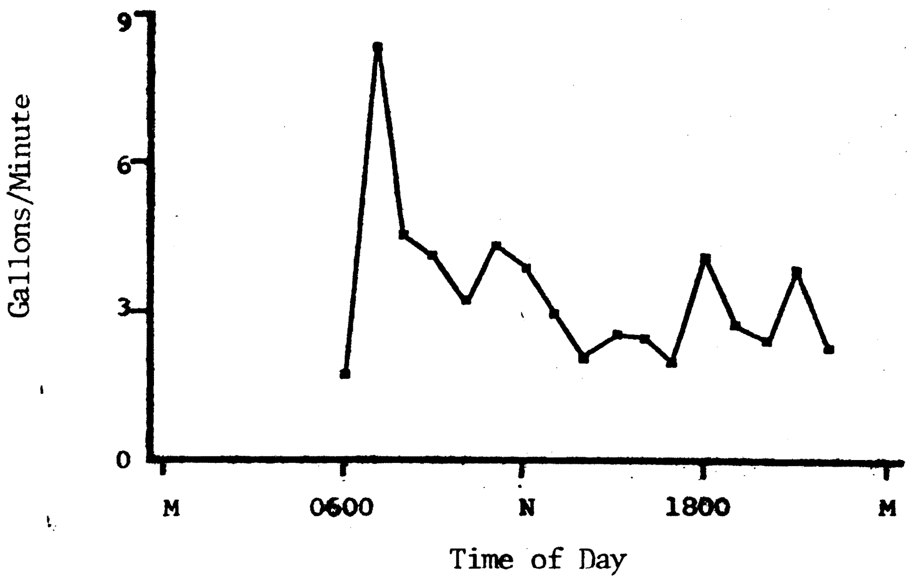

Figure 11. MAXIMUM 5-MINUTE DEMANDS FOR EACH HOUR BETWEEN 0600 AND 2200 FOR COOPERATOR #4

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

Both figures indicate flow rates were highest between 0700 and noon. In the afternoon and evening, demands decreased with the exception of 1800 and 2100. During the peak period at 0700 the maximum hourly demand and maximum 5-minute demand fall within this hour on days three and four. Most maximum 5-minute demands and maximum hourly demands occurred during the peak demand periods at 0700, 1100, and 1800 as shown in Figure 10.

Examination of the raw data indicated a variation from 7 to 183 gallons per hour during the peak use times of 0700, noon, 1800, and 2100. Zero water meter readings were not observed during peak demand times.

Water usage habits of cooperator #5 with a family of two that did not raise livestock are shown in Figures 12 and 13. An average daily consumption of 70 gallons per day with a standard deviation of equal quantity was measured in this farm home. Of the six homes that were observed in this study, average daily demand was lowest at this farm. Low consumption at this residence is partially explained by the frequent absence of one or both of the family members. Expected water usage of a family that was frequently away should be lowest during the normal working hours and highest before 0800 and after 1800.

The water requirements before 0600 were unexpected and occurred during three of the five observation days. On the remaining two days no water was used during this time. An explanation of how the water was used during this time was unavailable. The house contained a manual water softener that was not capable of regenerating automatically. When hourly water use rates are low as they were at this farm, a volume requirement of 30 gallons is sufficient to cause a rise in the hourly consumption curve. Hourly demands were low at this farm, consequently, the 5-minute demand could be expected to occur during the maximum hourly demand time.

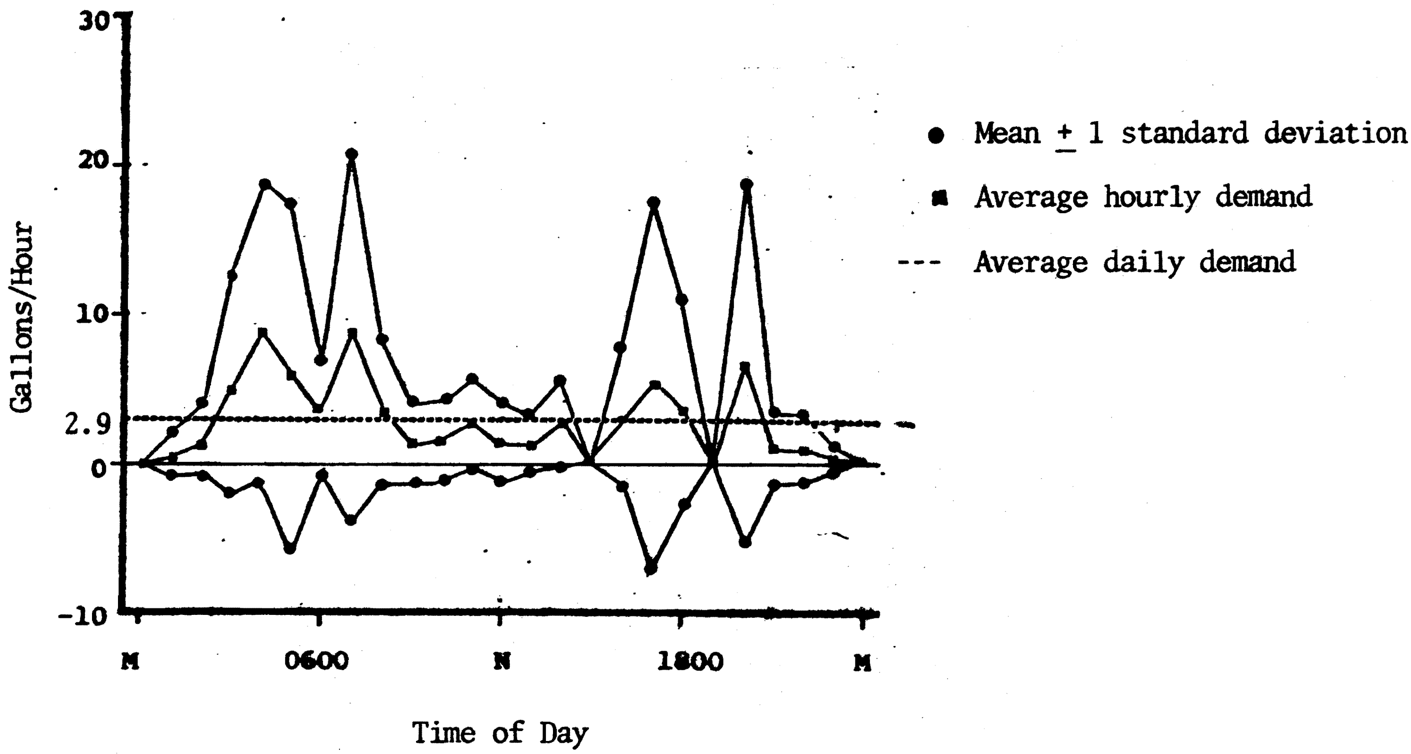

Figure 12. AVERAGE HOURLY DEMAND FOR COOPERATOR #5

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

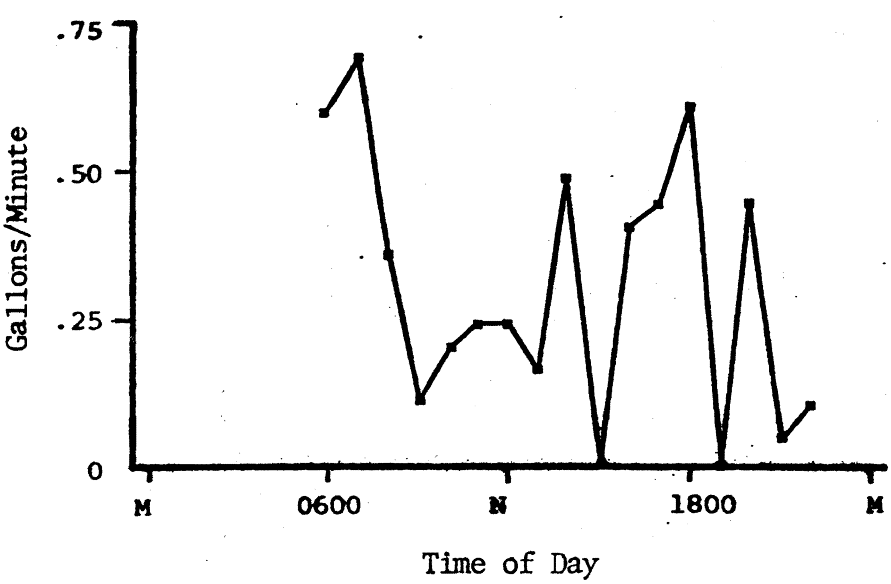

Figure 13. MAXIMUM 5-MINUTE DEMANDS FOR EACH HOUR BETWEEN 0600 AND 2200 FOR COOPERATOR #5

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

Raw data from this farm indicated that during the first four days the maximum 5-minute demand and maximum hourly demand occurred simultaneously in the afternoon and evening. A summary of the raw data from this farm may be found in Table 11.

A simultaneous occurrence of the 5-minute maximum demands and maximum hourly demand is indicated by comparison of Figures 12 and 13. The peaks on these two graphs occur at the same time of day. During peak periods shown on Figure 12, demands were not consistent for each day when meter readings were taken. More often than not no water flow was detected during the peaks that occurred in the early evening hours. Again, high flow rates occurring once or twice on a given hour during the five-day period were large enough to cause the curve to rise sharply above the average daily demand.

Average hourly demands in this household were low. Variability in hourly demands was high and no demand often occurred. Consequently, when the standard deviation was subtracted from the hourly average most of these values were negative.

The last farm cooperator, #6, selected for measurement of water requirements, owned 250 head of livestock. Water demands were higher for this farm compared to the five other cooperators. This farm family included five members. Household water use was only a small part of total water requirements as most of the water used on this farm went to the livestock.

Daily water demands at this farm averaged 1,304 gallons per day and the standard deviation was 374 gallons per day. While the average daily demands, average hourly demands, and maximum hourly demands were highest at this farm, the standard deviation was smaller here than at

farm #4. Usage occurred at all times of the day. Highest average hourly consumption occurred between 1000 and noon as indicated in Figure 14. During this time the livestock tanks were filled. The maximum hourly volume measured on any day between 1000 and 1200 was 318 gallons per hour. This was the only farm where standard deviations shown in Figure 14 were positive at each of the 24 hours during the day.

Compared to the morning requirements, hourly demands before 0800 are low. Nevertheless, Figure 14 indicates the livestock operation required between 10 and 20 gallons per hour before 0800. Water requirements were highest in the morning, moderately high in mid-afternoon and at 1800, and lowest in the evening. Both Figures 14 and 15 indicate morning and afternoon demands, but of different durations.

Figure 15 indicates that the maximum 5-minute demands occurred at the same time that the maximum hourly demand occurred.

Composite Average Demands

Average hourly demands and maximum 5-minute demands from all six cooperating households were totaled on an hourly basis and are presented in Figures 16 and 17.

Peak demand periods shown in Figure 16 resemble an electric utility's daily power curve as the peaks occur at noon and at 1800. An average daily demand of 139 gallons per hour for the house in town and five farms was observed.

Observed Water Pressure

In addition to total and maximum demands, line and household pressures were observed in every home. Since these values were found to be stable throughout the day, the scope of this study was oriented toward volume

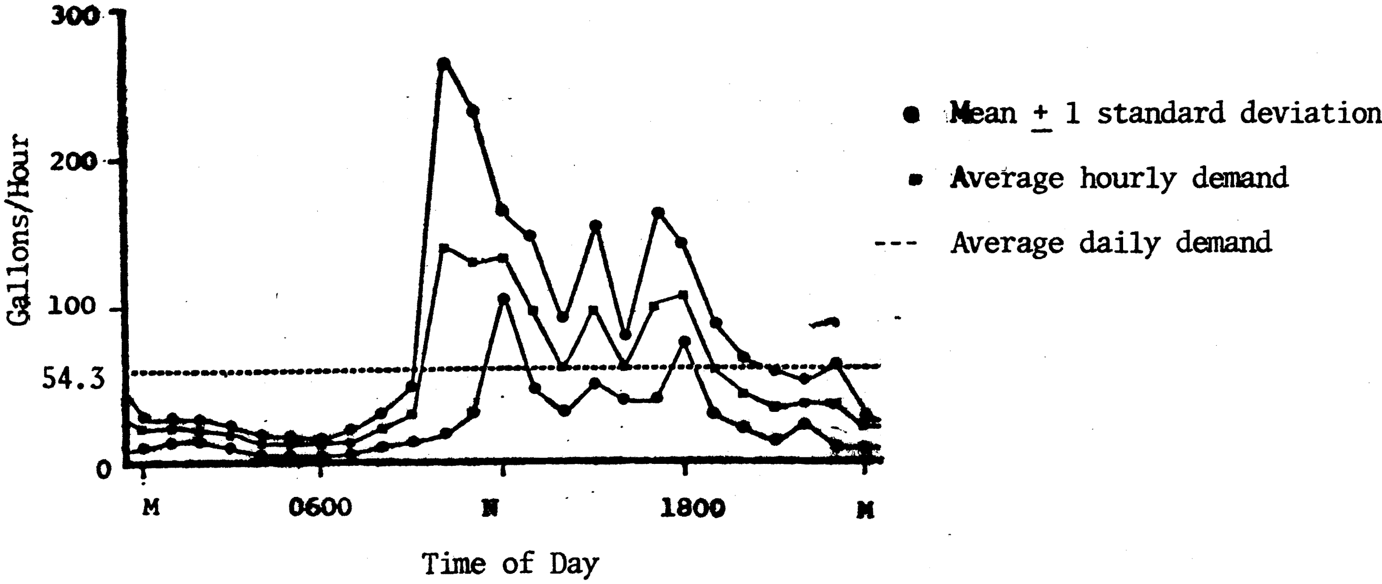

Figure 14. AVERAGE HOURLY DEMAND FOR COOPERATOR #6

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

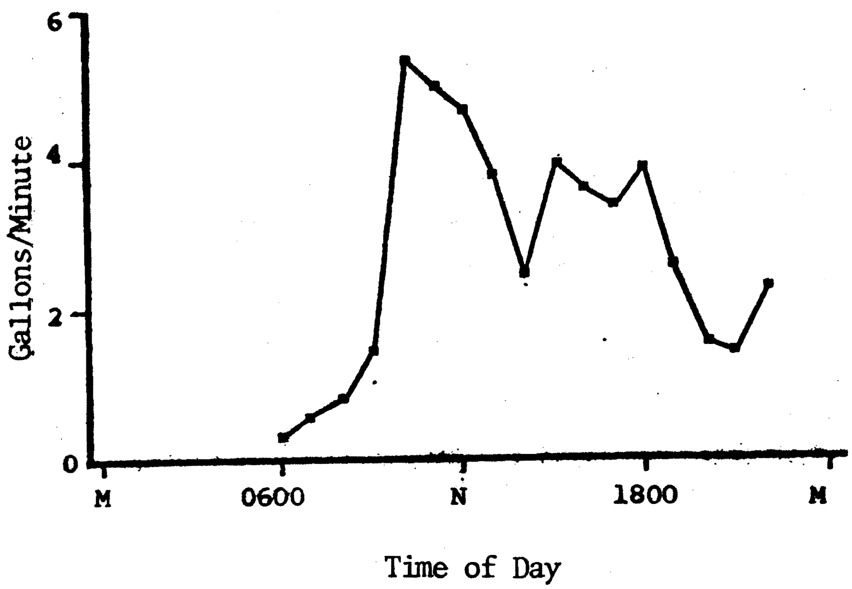

Figure 15. MAXIMUM 5-MINUTE DEMANDS FOR EACH HOUR BETWEEN 0600 AND 2200 FOR COOPERATOR #6

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

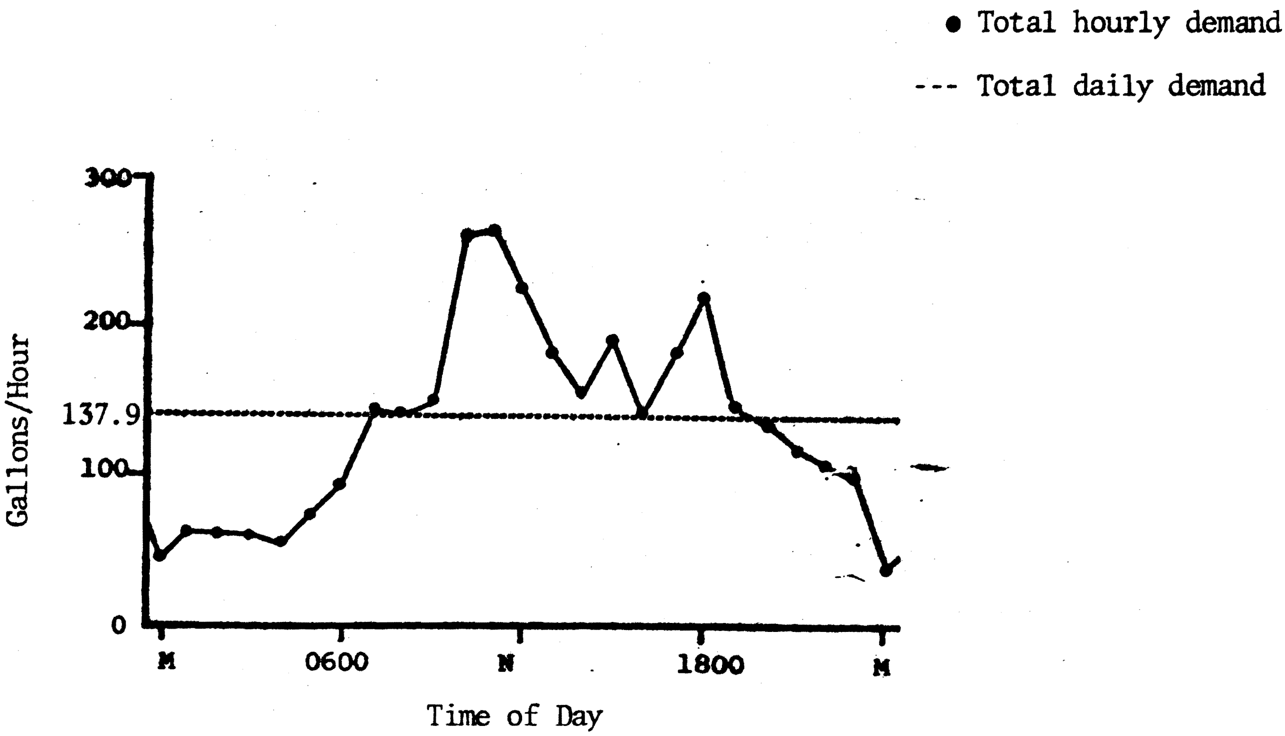

Figure 16. TOTAL DEMANDS OF SIX COOPERATORS

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

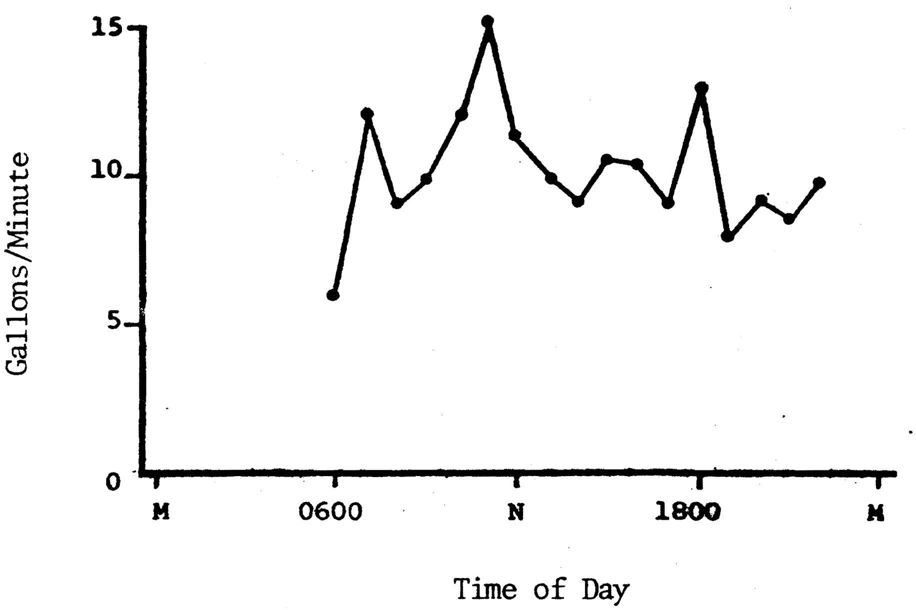

Figure 17. COMPOSITE OF 5-MINUTE MAXIMUM DEMANDS FOR SIX COOPERATORS

SOURCE: Wertz, Richard L., "North Dakota Rural Water Demand Study," unpublished M.S. thesis, Department of Agricultural Engineering, North Dakota State University, Fargo, 1975.

instead of pressure. The ability of a water system to maintain the desired pressure, usually 40 pounds per square inch, is a strong indication that the system adequately meets the user's demands. Fluctuations in line pressure were ± 10 pounds per square inch while household pressure was found to vary ± 5 pounds per square inch because of the ability of the pressure reducer to maintain consistency in the house when line pressure fluctuated. In the 7,500 volume and pressure observations that were made during this study, line pressures less than 20 pounds per square inch were rare and instances of no water pressure occurred only twice.

Member Opinions Regarding the Water Supply

Available Quantity

Of the 126 members interviewed, 125 responded to a question which asked the respondents to rate their water supply in regard to the quantity of water readily available. The system was rated excellent by 74.6 per cent and above average by 11.9 per cent. The water supply was rated average by 9.5 per cent; 3.2 per cent rated their supplies as below average or poor.

A response to the same question was obtained from 37 nonmembers. The supply was rated excellent by 56.4 per cent of the nonmembers and 7.7 per cent rated their supplies as above average. An average rating was given by 28.2 per cent and only 2.6 per cent rated the supply as below average (Table 12).

TABLE 12. FREQUENCY OF MEMBER AND NONMEMBER RESPONSES REGARDING QUANTITY OF WATER READILY AVAILABLE

Response	Members n	Members Per cent	Nonmembers n	Nonmembers Per cent
Excellent	94	74.6	22	56.4
Above average	15	11.9	3	7.7
Average	12	9.5	11	28.2
Below average	1	0.8	1	2.6
Poor	3	2.4	0	0.0
No response	1	0.8	2	5.1
Totals	126	100.0	39	100.0

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

Convenience

Of the 125 members who responded to a question on convenience, 83.3 per cent rated their supply excellent and 7.9 per cent rated their supply above average. An average rating was given by 5.6 per cent of the respondents who were members. Giving their supply a poor rating in regard to convenience were 2.4 per cent of the members.

A total of four nonmembers did not respond to the question, but of the 35 who did respond, 41.0 per cent rated their supplies excellent and 5.1 per cent rated them above average. An average rating was listed by 35.9 per cent of the nonmembers and below average by 7.7 per cent (Table 13).

TABLE 13. FREQUENCY OF MEMBER AND NONMEMBER RESPONSES REGARDING CONVENIENCE OF THEIR WATER SYSTEM

Response	Members n	Members Per cent	Nonmembers n	Nonmembers Per cent
Excellent	105	83.3	16	41.0
Above average	10	7.9	2	5.1
Average	7	5.6	14	35.9
Below average	0	0.0	3	7.7
Poor	3	2.4	0	0.0
No response	1	0.8	4	10.3
Totals	126	100.0	39	100.0

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

Stability of Pressure

Rating the water system for stability of pressure, 59.5 per cent of the members interviewed indicated it was excellent; 16.7 per cent indicated it was above average. In response to the same question, 11.9 per cent indicated the system water pressure to be average. A below average or poor rating was given by a total of 8.8 per cent.

Nonmember's responses indicated 35.9 per cent of those replying felt pressure of their water system was excellent, and 7.7 per cent felt it was above average. Giving their systems a rating of average were 5.1 per cent of the nonmembers. None of the nonmember respondents rated their systems as below average or poor in regard to stability of water pressure (Table 14).

TABLE 14. FREQUENCY OF MEMBER AND NONMEMBER RESPONSES REGARDING STABILITY OF PRESSURE OF THEIR WATER SYSTEMS

Response	Members		Nonmembers	
	n	Per cent	n	Per cent
Excellent	75	59.5	14	35.9
Above average	21	16.7	3	7.7
Average	15	11.9	2	5.1
Below average	5	4.0	0	0.0
Poor	6	4.8	0	0.0
No response	4	3.2	20	51.3
Totals	126	100.1[a]	39	100.0

[a]Total does not equal 100 due to rounding.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

Quantity of Water Used

Consumers' perceptions about their water usage were obtained from the rural water system members. They were asked whether they felt their usage had remained the same, increased, or decreased since the installation of the rural water system.

The majority of the respondents felt their usage had increased. Combining the categories of "increased, but not doubled" and "doubled," it was found that a total of 67.5 per cent felt their usage had increased. Only 3.2 per cent felt their usage had decreased and 25.4 per cent felt usage had remained the same (Table 15).

TABLE 15. FREQUENCY OF MEMBER RESPONSES REGARDING THE AMOUNT OF WATER USED

Response	n	Percent
No change	32	25.4
Increased, but not doubled	66	52.4
Doubled	19	15.1
Decreased	4	3.2
No response	5	4.0
Totals	126	100.1[a]

[a]Total does not equal 100 due to rounding.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

V. WATER QUALITY ASSESSMENT

Quality of the water was determined by bacteriological and chemical analyses of water samples. The analyses were also considered in regard to consumer satisfaction using the following variables: staining on appliances, staining on plumbing fixtures, discoloration of white fabrics, and laundry done away from homes.

Bacteriological Water Quality

Water samples collected from 10 commercial suppliers and 28 individuals who indicated laundry problems during the initial phase of the study were used to determine the characteristics of water in use in the system area prior to the operation of the system. This is referred to as "before" water. Characteristics of water used by members following operation of the system were determined by the analyses of samples taken from six major cooperators and the system wells. This water is referred to as "after."

Bacteriological quality of the system was determined by analyzing water samples from the major cooperators and the wells. Results of the tests for total bacterial population count for the major cooperators are found in Table 16. Results of the tests for total bacterial population for the wells are found in Table 17. The samples obtained from cooperators four and five on April 24, 1973, and from cooperator two on August 8, 1973, had counts which were higher than the other counts. These high counts occurred after line breaks or after rainfall in excess of one inch, according to Rice (1975).

All coliform bacteria reports for the water samples obtained from the wells and six major cooperators were satisfactory. Of the samples

TABLE 16. TOTAL BACTERIAL POPULATION COUNTS OF WATER SAMPLES FROM THE SIX MAJOR COOPERATORS ON THE GRAND FORKS-TRAILL SYSTEM

Cooperator and Sample Number	Date of Collection 4/24/73	7/07/73	8/08/73	4/18/74	4/08/75
	number per milliliter				
Cooperator #1					
Sample 1[a]	61	35	35	1	99
2[b]	22	14	25	18	12
3[c]	83	67	0	0	23
4[d]	13	20	36	3	7
Cooperator #2					
Sample 1	48	23	1020	22	58
2	6	7	289	2	3
3	30	66	323	1	5
4	12	7	366	1	2
Cooperator #3					
Sample 1	25	42	28	2	121
2	21	10	91	[e]	7
3	2	22	12	41	3
4	14	3	46	[e]	20
Cooperator #4					
Sample 1	202	33	50	3	193
2	58	20	20	6	86
3	630	18	54	8	5
4	6	23	87	10	7
Cooperator #5					
Sample 1	595	33	0	128	13
2	403	20	3	0	5
3	890	72	3	40	0
4	300	4	3	0	5
Cooperator #6					
Sample 1	0	10	21	51	7
2	10	20	43	12	3
3	50	53	46	6	10
4	6	22	66	20	10

[a]Sample taken from the cold tap immediately.
[b]Sample taken from the hot tap immediately.
[c]Sample taken from the cold tap after one minute.
[d]Sample taken from the hot tap after one minute.
[e]Cooperator was not home and access to a hot tap was not possible.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

TABLE 17. TOTAL BACTERIAL POPULATION COUNTS OF WATER SAMPLES FROM THE GRAND FORKS-TRAILL SYSTEM WELLS

Well and Sample Number	Date of Collection				
	7/07/73	8/08/73	4/18/74	5/20/74	5/16/75
	number per milliliter				
Well #1					
Sample 1[a]	10	0	9	14	5
2[b]	3	13	126	4	8
Well #2					
Sample 1	0	0	3	9	62
2	0	0	2	1	5
Well #3					
Sample 1	7	20	37	2	7
2	3	0	1	81	8
Well #4					
Sample 1				3	23
2				6	7
Well #5					
Sample 1				14	50
2				10	13

Note: Wells #4 and #5 were not yet in operation at the times of the first three sample collections.

[a]Sample taken immediately.
[b]Sample taken after one minute.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

collected during the initial phase of the study, three or 7.9 per cent of the samples from private wells were unsatisfactory.

Chemical Water Quality

The chemical characteristics of the before and after water were determined through chemical analyses of the water samples. The mean values and range of values of the chemical characteristics of the two water supplies and the

Public Health Service Drinking Water Standards are found in Table 18.

Water being provided by the system wells is within recommended limits for all constituents except iron. The mean value for after water for iron is 0.571 mg/1; the recommended limit is 0.3 mg/1.

Physical Characteristics

Members and nonmembers were asked if there were undesirable characteristics of the water, such as color, odor, taste, or clarity. Members' responses are found in Table 19. There is no proof that the above indicated occurrences of undesirable physical characteristics for members are the result of iron in the water. However, the high level of iron does suggest a cause. None of the nonmembers indicated any of these characteristics in their water supplies.

Laundry Analysis

Six of the 28 families who indicated problems with laundry in the 1972 survey were selected to participate in an intensive laundry analysis. Each household used white cotton test fabrics (one yard square swatches) with their normal laundry to determine the degree of discoloration from system water and test fabrics were laundered in the Textiles and Clothing Research Laboratory at North Dakota State University.

All swatches decreased in breaking strength in the warp direction between the unlaundered sample and the twentieth laundering. This is attributed to the fact that all swatches exhibited some stretching over twenty launderings in the warp direction due to water hardness and to build-up of minerals, such as iron, during laundering. No chlorine bleach or other laundry additive was added in any laundering which could have influenced the end results. In the filling direction, all swatches

TABLE 18. CHEMICAL WATER QUALITY BEFORE AND AFTER OPERATION OF THE GRAND FORKS-TRAILL RURAL WATER SYSTEM AND PUBLIC HEALTH SERVICE STANDARDS FOR DRINKING WATER

Chemical Characteristic	Before		After		PHS Standard
	Mean	Range	Mean	Range	
Sulfate[a]	585.4	2.00 - 1550.00	70.6	36.00 - 96.00	250.0
Chloride[a]	404.04	0.00 - 1333.00	3.82	2.00 - 9.00	250.0
Iron[a]	0.734	0.01 - 9.33	0.571	0.06 - 12.00	0.3
Nitrate[a]	2.20	0.01 - 34.00	0.3	0.00 - 12.00	45.0
Fluoride[a]	0.93	0.18 - 2.25	0.11	0.00 - 0.50	1.2
Sodium[a,b]	388.68	1.80 - 1176.00			
Alkalinity[a]	277.2	44.70 - 1117.00	252.7	218.00 - 290.00	
Hardness[a]	535.1	4.00 - 1683.30	288.2	0.00 - 336.00	
pH	7.76	6.85 - 9.40	7.62	7.00 - 8.30	
Dissolved Solids[a]	1880.7	115.00 - 4490.00	369.5	304.00 - 431.00	500.0
Electrical Conductivity[c]			579.9	512.00 - 635.00	

[a] Measured in parts per million.
[b] Sodium content was not included in the chemical analysis reports in the after water.
[c] Electrical conductivity was not included in the chemical analysis reports in the before water.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

TABLE 19. FREQUENCY OF MEMBER RESPONSES REGARDING PHYSICAL CHARACTERISTICS OF THE SYSTEM WATER

Characteristic	Frequency of Response n (126)	Per cent
Color	17	13.5
Taste	7	5.6
Odor	0	0.0
Cloudiness (turbidity)	1	0.8
Rusty appearance	3	2.4

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

increased in breaking strength after the first laundering, due to shrinkage of most of the swatches. There was an increase in breaking strength between unlaundered swatches and the twentieth laundering in all cases except cooperator six and the laundered control sample in the filling direction (Table 20).

There was a slight difference in breaking strength readings between the laundered controls and the samples laundered by cooperators in the Grand Forks-Traill water system (Figure 18). This difference was not significant.

It was indicated by the statistical analysis that the change in breaking strength in both warp and filling directions was significant at the .01 level between the unlaundered swatches and the swatches after twenty launderings for those laundered at the Textiles and Clothing Research Laboratory and by cooperators.

Staining on Appliances and Plumbing Fixtures

Members and nonmembers were asked whether iron or manganese in the water caused staining (Table 21).

TABLE 20. TENSILE STRENGTH OF A COTTON TEST FABRIC BEFORE LAUNDERING AND AFTER 1, 5, 10, 15, AND 20 LAUNDERINGS[1]

	Times Laundered											
	Warp						Filling					
Cooperator	0	1	5	10	15	20	0	1	5	10	15	20
Control	54	54	53	52	52	51[2]	39	42	43	42	40	39
1	52	52	50	50	49	48[2]	38	40	41	39	39	40
2	53	54	52	52	50	49[2]	36	41	43	40	39	39
3	54	54	53	55	53	51[2]	37	43	43	42	41	40
4	53	52	50	50			36	39	40	41[2]		
4[3]	54	53	53	54	52	50[2]	38	41	40	41	40	40[2]
5	53	51	51	50	49	49[2]	36	40	42	40	39	38[2]
6	53	52	51	51	50	50[2]	36	38	40	39	38	36

[1]Tensile strength of fabric measured in pounds.

[2]Strength change significant at .01 level as found by analysis of variance.

[3]Cooperator 4[3] is the same cooperator as 4, however, results of 4[3] is with use of a water softener.

SOURCE: Rice, Sally Ann, "The Evaluation of Water Quality of the Grand Forks-Traill Water System," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1975.

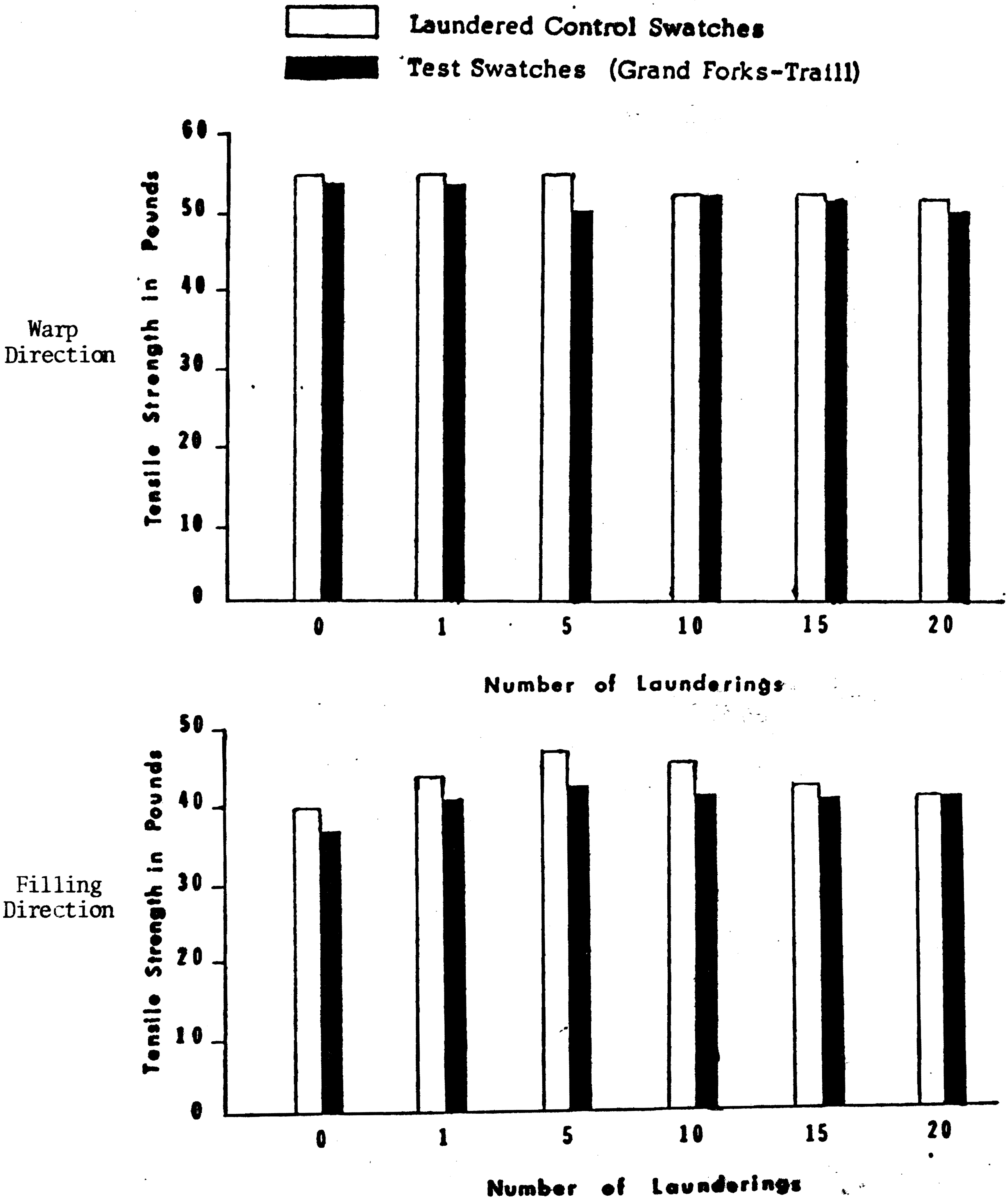

Figure 18. TENSILE STRENGTH IN POUNDS OF A COTTON TEST FABRIC IN WARP AND FILLING DIRECTIONS BEFORE LAUNDERING AND AFTER 1, 5, 10, 15, AND 20 LAUNDERINGS

SOURCE: Rice, Sally Ann, "The Evaluation of Water Quality of the Grand Forks-Traill Water System," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1975.

TABLE 21. FREQUENCY OF MEMBER AND NONMEMBER RESPONSES REGARDING STAINING ON APPLIANCES AND PLUMBING FIXTURES DUE TO IRON OR MANGANESE PRESENT IN THE WATER SUPPLY

Response	Members		Nonmembers	
	n	Per cent	n	Per cent
No	95	75.4	34	87.2
Yes	25	19.8	2	5.1
No response	6	4.8	3	7.7
Totals	126	100.0	39	100.0

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

It was found that the water delivered to rural water system members resulted in more staining on appliances or bathroom fixtures than the water being used by nonmembers. Iron content of system water was higher than Public Health Service standards. There was no difference in observed discoloration of fabrics or clothing for members and nonmembers. Also, it was found there was no difference in the number of member and nonmember respondents doing laundry away from home because of dissatisfaction with laundry results.

VI. CHANGES IN HOUSEHOLDS AND CITIES RELATED TO THE WATER SYSTEM, 1972-1975

Cost Comparisons

Cost serves as a common denominator in comparing rural water systems with commercially hauled water and private wells. The cost comparisons presented here are based on the rate schedule for the Grand Forks-Traill System as of August, 1974, and private well costs published by the Minnesota Water Well Association and reprinted by the North Dakota Water Conservation Committee.

Investment costs for a 100-foot well and a six-inch casing were $4,948, including interest at 8 per cent for 20 years; $7,236 for a 200-foot well; $9,316 for a 300-foot well; and $509 for the rural water system (Table 22).

TABLE 22. COST COMPARISON OF PRIVATE WELLS AND RURAL WATER SYSTEM

Cost Category	Private Well 100-Foot	Private Well 200-Foot	Private Well 300-Foot	Rural System
1. Total Investment Cost (20-year life)	$4,948	$7,236	$9,316	$500
2. Investment Cost/Day $/7,300 Days	0.68	0.85	1.27	0.07
3. Variable Cost/Day $.02/Hr. (24 hr.)	0.48	0.48	0.48	15.35
4. Total Cost/Day at 432,000 Gal./Mo.	1.16	1.33	1.75	15.42
5. Total Cost/Day at 25,000 Gal./Mo.	0.71	0.88	1.30	1.85
6. Total Cost/Day at 10,000 Gal./Mo.	0.70	0.87	1.29	1.14
7. Total Cost/Day at 5,000 Gal./Mo.	0.69	0.86	1.28	0.77

SOURCE: Nelson, William C., N.E. Toman, and C.O. Hoffmann, "Impact of Rural Water Systems in North Dakota," paper presented to the North Dakota Society of Farm Managers and Appraisers, Fargo, January 5, 1976.

This investment yields a daily cost of $.68, $.85, $1.27, and $.07, respectively for a 100-, 200-, and 300-foot well and rural water system.

Operating costs were calculated at full capacity, 14,400 gallons per day, with an electric cost of $.02 per hour, $.48 per day, by the Minnesota Water Well Association. Daily consumption of 14,400 gallons is equal to 432,000 gallons per month and results in a total cost per day ranging from $1.16 to $1.75. Cost of supplying 432,000 gallons per month from a rural water system is $15.42 per day. This volume of water is capable of supporting 288 people; 1,200 steers; or 3,600 hogs.

A typical family, three to four people, uses approximately 5,000 gallons per month (Table 23).[5] At this consumption level, a rural water system costs $23.10 per month; a 100-foot well, $20.70; a 200-foot well, $25.80; and a 300-foot well, $38.40. Cost of commercially hauled water averaged $7.24 per 1,000 gallons in 1974, yielding a monthly cost of $36.30. Thus, a rural water system is competitive in cost with private wells and only about one-half the cost of commercial hauling for family use only. This cost difference, $23.10 vs. $36.40 per month, was one of the major economic benefits of the Grand Forks-Traill system.

At higher consumption levels, 10,000 and 25,000 gallons per month, rural water systems cost more per month than private wells, but are still competitive with deep wells. The cost advantage of rural water systems relative to commercially hauled water becomes greater as consumption increases due to the decreasing cost rate structure of rural water systems.

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[5] Average monthly usage per household in 1975 was 4,656 gallons. Similar results are indicated in Water Quality and Consumer Costs, published by Orange County Water District, Santa Ana, California, 1972 and by Jay L. Treat in Kansas Rural Water Districts Cost Efficiency Comparison by District Size and Water Source, Cooperative Extension Service, Kansas State University, Manhattan, Kansas, October, 1974.

TABLE 23. NUMBER OF PEOPLE AND LIVESTOCK SUPPORTED BY VARIOUS LEVELS OF WATER USE PER MONTH AND COST PER MONTH

	Gallons Per Month			
	5,000	10,000	25,000	432,000
Consumers				
People	3.33	6.67	16.67	288.00
Steers	13.88	27.78	69.44	1,200.00
Dry Cows	11.11	22.22	55.55	960.00
Milking Cows	4.76	9.52	23.81	411.43
Hogs	41.67	83.33	208.33	3,600.00
Costs Per Month				
100-Foot Well	$ 20.70	$ 21.00	$ 21.30	$ 34.80
200-Foot Well	25.80	26.10	26.40	39.90
300-Foot Well	38.40	38.70	39.00	52.50
Rural Water System	$ 23.10	$ 34.20	$ 55.50	$ 462.60
Commercial Hauled Water ($7.24/ 1,000 gal.)	$ 36.30	$ 72.30	$180.90	$ 3,127.68

SOURCE: Nelson, William C., N.E. Toman, and C.O. Hoffman, "Impact of Rural Water Systems in North Dakota," paper presented to the North Dakota Society of Farm Managers and Appraisers, Fargo, January 5, 1976.

In response to a question concerning attitudes about the cost of the system water, 11.1 per cent of the members considered the cost to be very high, and an additional 27.0 per cent rated it high. Rating the cost average were 49.2 per cent of the members, and 3.2 per cent rated the cost as below average (Table 24).

Purchase of Major Water Related Appliances

A total of 69 members (55 per cent) purchased major water using appliances as compared to six nonmembers (15 per cent). It was found that of the 69 members who purchased appliances, 15 had purchased two appliances, 4 had purchased three appliances, and 2 had purchased four appliances. The six nonmembers who had purchased major water using

TABLE 24. FREQUENCY OF MEMBER RESPONSES REGARDING THE COST OF SYSTEM WATER

Response	n	Per cent
Very high	14	11.1
High	34	27.0
Moderate	62	49.2
Low	4	3.2
Very low	0	0.0
No response	12	9.5
Totals	126	100.0

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

appliances each purchased only one. The appliances purchased most frequently were clothes washers, dishwashers, hot water heater, water softener, and clothes dryer. A difference of approximately $200 per household spent for appliance purchases was estimated after adjusting for the different characteristics of the member and nonmember groups by regression analysis.

Owner Appraised Value of Homes

Nearly 90 per cent of the members interviewed responded to a question which asked if they felt the value of their homes had increased due to the water system. Of the 111 who responded, 89.2 per cent indicated the value had increased. The majority of the respondents were unable to give an estimate of the actual value of the increase. Of the 32 who did respond, seven felt the increase in value was over $10,000; five felt the increase was between $5,001 and $10,000; and 20 felt it was $5,000 or less.

Home Improvement and Construction

Remodeling or building a new home was considered to be home improvement. Of the 39 nonmembers interviewed in 1974, 7.7 per cent had remodeled their homes since they were interviewed in 1972. None of the nonmembers had built new homes. For the same two-year period, 20.6 per cent of the 126 members interviewed had remodeled their homes; 1.6 per cent of the respondents had built new homes. A total of 22.2 per cent of the members had made home improvements (Table 25).

TABLE 25. NUMBER OF MEMBERS AND NONMEMBERS WHO REMODELED OR BUILT NEW HOMES BETWEEN 1972 AND 1974

Response	Members		Nonmembers	
	n	Per cent	n	Per cent
No Change	98	77.8	36	92.3
Remodeled	26	20.6	3	7.7
Built New Home	2	1.6	0	0.0
Total	126	100.0	39	100.0

SOURCE: Toman, Norman E., "Economic Impact of North Dakota's First Rural Water District," unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1975.

The three nonmembers who remodeled their homes spent a total of $1,765 on the improvements or an average of $588. The amount of money spent by members who remodeled was obtained from 13 of the 26 who had remodeled. They spent a total of $34,070 or an average of $2,621.

A large number of new residents in the area built new homes or brought in mobile homes (Table 26). In about 1.5 years, 113 new homes

and 20 mobile homes were connected to the system, an estimated value of over $4,000,000. This change may be unique to the Grand Forks-Traill system as a number of other events occurred during this time. The city of Thompson also installed a sewage system in 1971-72. A sugarbeet plant was constructed between Buxton and Hillsboro and the area west of Grand Forks contains a military air base.

TABLE 26. NEW HOUSES AND MOBILE HOMES CONNECTED TO THE GRAND FORKS-TRAILL SYSTEM BETWEEN JANUARY 1, 1973, AND AUGUST 29, 1974[a]

Location	Number of Houses	Number of Mobile Homes	Value of Houses	Value of Mobile Homes	Total Value
Buxton	21	4	$ 735,000	$ 32,000	$ 767,000
Reynolds	20	3	700,000	24,000	724,000
Thompson	21	4	735,000	32,000	767,000
Area Between Thompson and Grand Forks	51	9	1,785,000	72,000	1,857,000
Total	113	20	3,955,000	160,000	4,115,000

[a]The total number, 133, was obtained from Randall Loeslie, manager of the Grand Forks-Traill Water Association. These figures are based on an estimated 15 per cent of the total being mobile homes; an average value per house of $35,000 obtained from Sandra Rushing, city clerk of Thompson, North Dakota; and estimated value per trailer of $8,000.

SOURCE: Toman, Norman E., "Economic Impact of North Dakota's First Rural Water District," M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1975.

Gross Business Volume

Gross business volume of Buxton, Cummings, Reynolds, and Thompson was found in North Dakota Sales and Use Tax Statistical Reports and adjusted for inflation using the Consumer Price Index (all items).

For purposes of this study, 1970 was used as the base year. The figures from the reports show that the amount of increase in gross business volume between 1970 and 1975 was 128.9 per cent for Thompson, 56.2 per cent

for Reynolds, 51.1 per cent for Cummings, and 30.8 per cent for Buxton. Increase in gross business volume for the state during the same period was 57.3 per cent. The increase in Thompson of gross business volume was more than twice that experienced by the state as a whole (Table 27).

Direct and Indirect Economic Effects

The total economic impact of a given expenditure is based on the "spinoff" or "respending" effects. For example, each $1.00 spent for home construction is estimated to generate another $1.44 in the region.[6] Use of this concept makes it possible to estimate the total economic impact of the rural water system.

The construction of the system itself costs $3.7 million and had an estimated total impact of $5.4 million (Table 28). Construction of homes, public facilities, and businesses had a total impact of $6.6 million while nearly $400,000 was due to appliance purchases. These three categories were basically one-time expenditures; they have an effect when they are made, but do not reoccur annually. System operating expenses are annual, but are largely a transfer of expenditures previously being made to commercial water haulers.

Population and School Enrollment

Population data were obtained from Bureau of the Census Reports. School enrollment data were obtained from North Dakota Educational Directories.

Census reports are compiled every 10 years -- 1940, 1950, 1960 and 1970. In 1975, Thompson city officials made a request to the Census Bureau for a special census. Officials felt population had increased since 1970 to the extent that there was a need for a special census. A dramatic

[6] Documentation is presented in Senechal, Donald M., "Analysis of Validity of North Dakota Input-Output Models," unpublished M.S. thesis, North Dakota State University, Fargo, 1971.

TABLE 27. PERCENTAGE OF INCREASE OR DECREASE IN GROSS BUSINESS VOLUME OF BUXTON, CUMMINGS, REYNOLDS, THOMPSON, AND NORTH DAKOTA, USING 1970 AS THE BASE YEAR

	Percentage of Increase or Decrease				
	1970-1971	1970-1972	1970-1973	1970-1974	1970-1975[a]
Buxton	+ 8.41	+ 9.31	+ 27.45	+ 34.09	+ 30.79
Cummings	+ 8.07	- 2.33	+ 16.28	+ 39.77	+ 51.11
Reynolds	- 6.69	-16.81	+ 24.89	+ 38.59	+ 56.22
Thompson	+ 0.13	+23.60	+ 48.26	+105.12	+128.90
North Dakota[b]	+ 1.84	+15.67	+ 34.56	+ 60.13	+ 57.25

Note: Data are from the North Dakota Sales and Use Tax Statistical Reports, North Dakota Tax Commission, Bismarck.

Note: Figures for 1971 through 1975 have been adjusted for inflation using the Consumer Price Index (all items).

[a]Adjusting for inflation for 1975 was done by using an average of the monthly Consumer Price Indices for January through November since December figures had not been published at the time this calculation was made.

[b]Includes all cities, villages, and other post offices.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

TABLE 28. SUMMARY OF THE IMPACT OF EXPENDITURE RELATED TO THE GRAND FORKS-TRAILL WATER SYSTEM, GRAND FORKS-TRAILL WATER ASSOCIATION, 1974

Category	Direct Expenditures	Total Dollar Impact
System Installation	$3,764,000	$5,408,208
Residences, Public Construction, and Business Construction	4,804,000	6,581,323
Appliance Purchases	243,540	392,026
System Operating Expenses	76,780	135,281

SOURCE: Toman, Norman E., "Economic Impact of North Dakota's First Rural Water District," M.S. Thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1975.

increase in population was experienced by Thompson in the five-year period between 1970 and 1975 (Table 29). Thompson showed slight increases (276 in 1940 to 291 in 1970) prior to the 1975 report which shows an 87.4 per cent increase between 1970 and 1975. North Dakota population has shown an overall decrease of 3.8 per cent. Census data for 1975 were not available for Buxton and Reynolds. Population in Reynolds increased slightly between 1940 and 1950, but decreased between 1950 and 1970 from 335 to 236. In Buxton, population decreased between 1940 and 1970 from 404 to 235.

School enrollment figures are available for every school year. Data were obtained for the school years 1970-1971 through 1975-1976 (Table 30).

Prior to 1960, there were three schools -- Buxton, Reynolds, and Thompson -- within the system area. Buxton and Reynolds consolidated to form Central Valley School, leaving only two schools.

The period between 1970 and 1975 resulted in an overall increase of 2.7 per cent in school enrollment for Central Valley. During the same period, Thompson experienced an increase in school enrollment of 21.4 per cent. In the five-year period, total North Dakota school enrollment dropped 14.1 per cent.

TABLE 29. PERCENTAGE OF INCREASE OR DECREASE IN POPULATION IN BUXTON, REYNOLDS, THOMPSON, AND NORTH DAKOTA, USING 1940 AS THE BASE YEAR

	Percentage of Increase or Decrease			
	1940-1960	1950-1960	1940-1970	1940-1975[a]
Buxton	- 4.2	- 20.5	- 41.8	
Reynolds	+ 6.3	- 14.6	- 25.1	
Thompson	- 2.2	+ 5.1	+ 5.4	+ 92.8
North Dakota	- 3.5	- 1.5	- 3.8	

Note: Data were obtained from Bureau of the Census reports.

[a]Data for 1975 are available only for Thompson due to a special census requested by city officials.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

TABLE 30. PERCENTAGE OF INCREASE OR DECREASE IN SCHOOL ENROLLMENT IN CENTRAL VALLEY, THOMPSON, AND NORTH DAKOTA, USING 1970 AS THE BASE YEAR

	Percentage of Increase or Decrease				
	1970-1971	1970-1972	1970-1973	1970-1974	1970-1975
Central Valley[a]	+ 0.5	+ 5.3	+ 2.9	+ 2.1	+ 2.7
Thompson	+ 0.4	+ 2.0	+10.7	+18.7	+21.4
North Dakota[b]	+ 3.9	+ 1.8	- 0.3	- 3.7	- 9.9

Note: Data were obtained from the State Department of Education and represent enrollment in grades K through 12.
[a]Includes Buxton and Reynolds.
[b]Includes all high school districts.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

Consumer Opinion of Community Changes

Both members and nonmembers responded to questionnaire inquiry regarding occurrence of community changes due to the rural water system. Responses were grouped into nine categories. These categories and the frequency of response in each are found in Table 31.

TABLE 31. MEMBER AND NONMEMBER OPINIONS REGARDING COMMUNITY CHANGE DUE TO THE RURAL WATER SYSTEM

	Frequency of Response			
	Members (126)		Nonmembers (39)	
Response	n	Per cent	n	Per cent
Increased Land Value	1	0.8	1	2.6
Community Growth	5	4.0	2	5.1
Community Facility Expansion	5	4.0	2	5.1
Higher Taxes	1	0.8	0	0.0
Greater Convenience	8	6.3	2	5.1
Older Population Remaining on Farms	1	0.8	0	0.0
Rural Housing Increase	22	17.5	3	7.7
Easier Living	4	3.2	0	0.0
Sanitation Benefit	1	0.8	0	0.0
No Response	81	64.3	32	82.1

Note: The number in parentheses under members and nonmembers indicates the number of each that were interviewed. Totals may not equal these numbers due to the fact that some subjects had more than one response.

SOURCE: Legreid, Pamela J., "Water Quality of a Rural Water System as it Relates to Consumer Satisfaction and Socio Economic Impact," unpublished M.S. thesis, Department of Textiles and Clothing, North Dakota State University, Fargo, 1976.

There were four categories which contained higher frequencies of response than the others. Of the members responding, 17.5 per cent indicated that rural housing had increased; 7.7 per cent of the non-members were in agreement. Satisfaction that was shown by convenience with their water supplies was indicated by 6.3 per cent of the members and 5.1 per cent of the nonmembers. Four per cent of the members and 5.1 per cent of the nonmembers thought that community growth had occurred and that community facilities had expanded.

Negative Effects

The rural water system had negative effects on the problem of urban sprawl, on commercial water haulers, and possibly, on well drillers. Water haulers obviously experienced a decreased demand for their service as 98 per cent of the members no longer bought hauled water and several water haulers ceased operation. The effect on well drillers is probably not large in the Grand Forks-Traill area as only 47 per cent of the members had a well prior to the system and only 10 per cent of the members had abandoned their wells between 1972 and 1974. None of the 166 households interviewed in 1974, however, had drilled a new well since 1972.

The most serious unplanned effect of the system might be facilitating the growth of subdivisions and individual homes on productive agricultural land outside of a municipality. Sixty of the 133 new homes built between January, 1973, and August, 1974, were located in rural areas. The rural water systems make the need for effective land use planning more urgent.

VII. CONCLUSIONS AND RECOMMENDATIONS

"The Evaluation of North Dakota's First Rural Water System" was an interdisciplinary project being investigated by three departments at North Dakota State University -- Agricultural Economics, Agricultural Engineering, and Textiles and Clothing.

The objectives of the project are:

1. To develop a guide to assist rural people in forming and operating a rural water system.
2. To determine what factors influence an individual's decision to participate in a rural water distribution system.
3. To evaluate the rural water system with respect to the delivery of adequate quantity and quality of water to its members.
4. To analyze the socioeconomic impact of the rural water distribution system on its members and the community.

Conclusions

Organizational Procedures

The associations formed in North Dakota had several organizational procedures in common. To generate interest in an area, they held many informational meetings to acquaint people with rural water systems. A steering committee was formed if there was enough interest shown at the informational meetings. The steering committee made the preliminary survey of the water requirements and contacted each prospective member. People who were interested in joining the system were required to pay a membership fee which varied in amount among associations. After each person had been contacted, a meeting was held with FHA to determine the feasibility of an association. When FHA tentatively approved the eligibility of an association, an engineering firm was hired to conduct a detailed feasibility study. An attorney was hired to draft the bylaws of the

association and a board of directors was elected. The associations can be formed as either a nonprofit corporation or a cooperative. FHA authorized the loan to be completed after the feasibility study had been reviewed and membership funds had been collected. The contracts for construction were released after all papers were reviewed by FHA.

Differences Between Members and Nonmembers

The discriminant analysis revealed that there were several variables that separated members from nonmembers.

Characteristics that separated members and nonmembers were:

(1) Value of dwelling.

(2) Total water cost.

(3) Length of residence.

(4) Number of cisterns.

(5) Number of dairy cattle.

(6) Number of times vehicles washed at home.

The value of the dwelling averaged \$14,500 for members and \$8,700 for nonmembers. The total water cost of members was more than twice the cost of nonmembers prior to operation of the system. The members were paying \$93.98 per year for water compared to \$41.76 per year for nonmembers.

Nonmembers had a longer length of residence -- 39.35 years relative to 25.52 years for members. Twenty-seven per cent of the nonmembers had cisterns compared to 14 per cent of the members. The nonmember livestock producers had 3.65 dairy cattle and the members had only 0.52 dairy cattle per farm.

The statistical analysis indicated that as the members and nonmembers

were divided into categories according to their residence characteristics, the correct classification by discriminant analysis became more accurate.

Water Quantity and Pressure

Maximum hourly demands and maximum five-minute demands occurred at the same time with 70 per cent consistency, except for the data obtained from one cooperator.

All demands fluctuated to such an extent that standard deviations were frequently larger than the average water demands -- other than the water drawn for 250 head of livestock at the one farm. The maximum five-minute demand was found to be at least 28 per cent of the maximum hourly demand 50 percent of the time.

Pressure consistency may be used as a measure of system adequacy. Fluctuations in system line pressures were ± 10 pounds per square inch, while household pressures were found to vary ± 5 pounds per square inch. The regeneration of an automatic water softener, harvesting of specialty crops, and livestock drinking from automatic watering cups created a water demand during the night. Greatest livestock water demands would be expected during the day; but, if the livestock areas are illuminated, the possibility of occasional nighttime water consumption exists.

Water use variations among users were found to be large. Farm size, type of farming operation, and family size are some of the factors involved in farm and home water demands.

Water consumption by members more than doubled between 1972 and 1974 compared to an increase by nonmembers of 28 per cent. Comparison of member's consumption of water from the system between 1973 and 1974 indicated an increase of 21.7 per cent and a 22 per cent increase between 1974 and 1975. Water costs for members increased by 47 per cent between

1972 and 1974 compared to an increase of 4.5 per cent for nonmembers. Part of the increased cost for members was the result of a 33 per cent increase in rates in April, 1974.

Most members had discontinued hauling water and used water for domestic purposes, as well as for outdoor and livestock use; whereas, those who hauled water used water primarily for domestic purposes.

Water Quality

All bacteriological analyses of water at the system well sites were satisfactory. A few instances of fairly high bacteria counts were found at two locations during the first six months of system operation.

Chemical water analyses revealed substantial improvement in water quality after system installation. A significant loss in fabric breaking strength at the .01 level was shown for fabric laundered in water classified as very hard and in water containing iron.

Installation of a rural water system in Grand Forks and Traill Counties resulted in improved quality of water for members. The water was within limits set by the Public Health Service for all constituents except iron.

Household and Community Changes

Considerable impact resulted directly from the installation of the water system. The expenditure for installation, including engineering and attorney fees, generated a total impact of over $5.4 million. Operating expenses for the association generated a total expenditure of over $135,000 annually. These expenditures represent an impact to the region that was solely attributable to the presence of the rural water association.

Public, business, and residential construction expenditures and mobile home purchases generated a total impact of over $6.8 million. Much of this expenditure may have taken place regardless of the presence of the rural water district; however, the extent of new construction suggests that the water system did have an effect.

The estimated relationship of rural water system membership to investment in appliances generated total expenditures of $392,000. This value was obtained by projecting the impact per member determined by regression to the total member population.

Members were more likely to purchase major water using appliances than were nonmembers. Members' responses reflected feelings that being on the rural water system increased the value of their homes and were more likely to have remodeled or built a new home than were nonmembers.

A comparison of changes in value estimated by members and nonmembers was made with respect to the value of homes, land, and farm buildings. Nonmembers indicated greater percentage increases than members in all three property categories, although both members and nonmembers indicated substantial increases. The value of agricultural land was estimated to have increased 64 per cent by members and 91 per cent by nonmembers. Appraisal agents of a real estate agency, Federal Land Bank, and the Farmers Home Administration located in Grand Forks were not able to estimate the effect of the water system on property values.

Quantitative changes analyzed included changes in livestock numbers, number of acres of farmland owned, number of acres operated, and changes in the volume of water consumption. Livestock production by both members and nonmembers had decreased, although nonmembers had decreased production by a slightly higher percentage than members. Relatively

few livestock are produced in the Grand Forks-Traill area; therefore, this area may not be applicable for use in estimating the effect of a water system on livestock production.

The average size of farm operated increased 6 per cent for members and 3 per cent for nonmembers. The average farmland acreage owned by members increased 4 per cent, while that of nonmembers decreased 5 per cent. There were few sales of land for nonagricultural purposes by either members or nonmembers, although more sales and requests for sales were noted by members than by nonmembers.

Gross business volume in four small towns on the system increased by 54 per cent from 1970 to 1975 after adjustment for inflation. One community, Thompson, requested a special census in 1975 which revealed an 83 per cent population increase after three decades of stability. The two school districts serving the major portion of the area increased enrollment by 10 per cent between 1970 and 1975, while total state enrollment decreased by an equal percentage.

Recommendations for Future Research

Since data collection and analysis were done for this report, treatment of the water delivered to system members has begun. Treatment includes fluoridation, chlorination, and polyphosphate feeding. It is suggested that further study be undertaken in the following areas:

1. Water quality analysis of the treated water to determine the quality difference between that water and the previous water and compliance with Public Health Service recommendations.

2. Analysis of the effects of polyphosphate addition to the water on clothing and fabrics laundered in the water.

3. Determination of the effectiveness of the addition of polyphosphates as sequestering agents.

4. To explore the use of an iron filtration system along with water treatment through chlorination in a public water supply.
5. To explore the effects of age of plumbing and individual water tap fixtures on the bacteriological contamination of water.
6. Observe demands for the entire system by measuring volume pumped from the wells on a daily basis.
7. Observe household and farm demands within another rural water distribution system in another part of North Dakota.
8. To use a flow activated relay in the camera control circuit. This relay would eliminate all zero flow readings, permit camera operation only when a demand was measured, and increase the number of water demands that could be placed on a roll of film.

The elapsed time for this evaluation may not have been sufficient to allow for the full impact of the system to have taken effect. This may be particularly true in light of the problems experienced with the system during the first several months of operation. A second evaluation of the Grand Forks-Traill Water Users Association after several years of operation may provide a more accurate determination of the full economic impact of the system on its members and the community. A concurrent evaluation of at least one other North Dakota water system would increase the reliability of the study.

Construction costs for rural water systems have increased to a level that makes financing difficult to obtain. A study of financing alternatives might provide information that would facilitate financing the improvement of present systems, as well as the development of proposed systems. A detailed cost comparison of private systems, commercially hauled water, water hauled by the individual, treatment alternatives, and rural water systems would be very beneficial.

A continued evaluation of the operational procedures of rural water systems would be of value to new associations.

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