11-1-1981

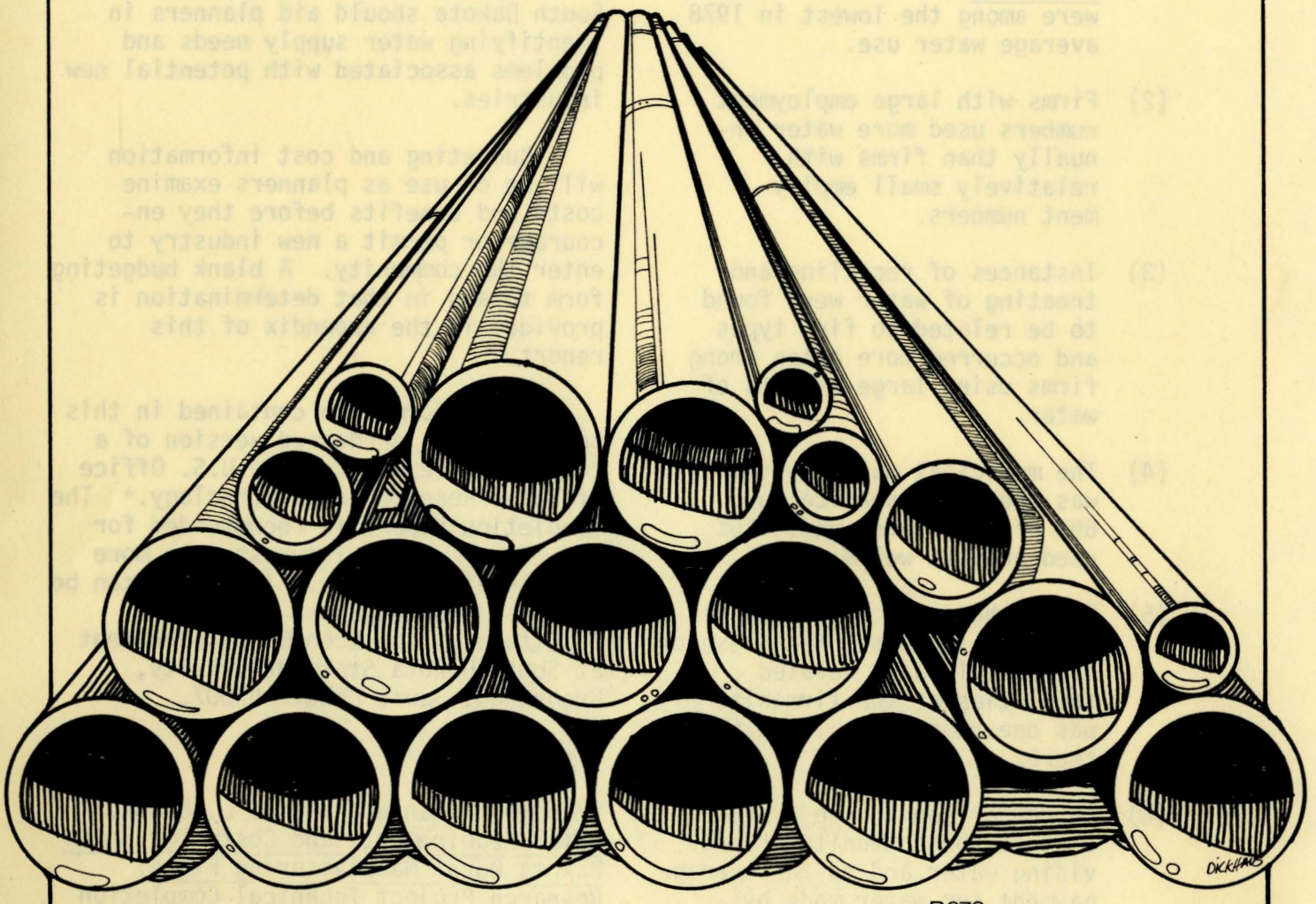
Water Use by Rural Manufacturing Firms in South Dakota

R. Hoffman

T. L. Dobbs

Water Use

By Rural Manufacturing Firms In South Dakota



B678
Agricultural Experiment Station
South Dakota State University
Brookings, South Dakota

SUMMARY AND CONCLUSIONS

In a first report on the water requirements of manufacturing firms that may be important in the future growth of rural South Dakota, the major findings are:

(1) Instruments (SIC - 38) and food (SIC - 20) firms averaged the highest annual level of water use in 1978. Lumber products (SIC - 24) and transportation (SIC - 37) firms were among the lowest in 1978 average water use.

(2) Firms with large employment numbers used more water annually than firms with relatively small employment numbers.

(3) Instances of recycling and treating of water were found to be related to firm types and occurred more often among firms using large amounts of water.

(4) The municipal water system was the water service for 69% of the firms, while 26% used private wells.

(5) Firms that used large amounts of water indicated the presence of special water related facilities at the firm site was one reason for locating there.

(6) In comparison to the average cost to the community of providing water and to the average payment for water made by municipal customers in general, there does not appear to be a clear overall case of overpayment or underpayment for water by new manufacturing firms locating in South Dakota communities.

The estimates of water use by different manufacturing firm types can be used by planners in evaluating the need for water system expansion when new industries are considered as potential municipal water customers. Descriptions of water requirements of firms which have recently located in South Dakota should aid planners in identifying water supply needs and problems associated with potential new industries.

Budgeting and cost information will be of use as planners examine costs and benefits before they encourage or permit a new industry to enter the community. A blank budgeting form to aid in that determination is provided in the appendix of this report.

The information contained in this bulletin is a condensed version of a completion report for the U.S. Office of Water Research and Technology.* The completion report is recommended for the reader who is interested in more details of the study. Inquiries can be addressed to the Water Resources Institute or the Economics Department at South Dakota State University, Brookings, South Dakota 57007.

---

*Randy Hoffman and Thomas L. Dobbs. Water Requirements and Costs for South Dakota Rural Manufacturing Firms. Research Project Technical Completion Report for the Office of Water Research and Technology. Economics Department, South Dakota State University, Brookings, October 1980.

Water Use By Rural Manufacturing Firms In South Dakota

Randy Hoffman
Research Associate in Economics

and

Thomas L. Dobbs
Associate Professor of Economics

Problems in rural municipal water supply have become increasingly important in recent years. With many small town government officials and development groups attempting to attract industry to stimulate the local economy, a new competition for water sometimes arises between manufacturing firms and traditional rural water users such as agricultural and residential users. Often rural communities need to make decisions on whether or not to expand a water system in order to accommodate new manufacturing firms without access to detailed information concerning either the cost of the proposed expansion or the real need for an expansion. As industrial growth pressures on municipal water systems increase, it is important for planners in rural communities to have access to disaggregated manufacturing firm water usage and cost information.

Local governments need to know the magnitudes and costs of additional services required to attract new manufacturing firms. Among these services may be water supply in many instances.

Regional and state agencies also need to consider the implications of encouraging or discouraging one type of water use relative to another. Local Planning Districts and state agencies are involved in encouraging various types of industrial development. At the same time, allocation decisions may have to be made in some areas which will affect the amount of ground or surface water available to the various economic sectors.

Although feasibility studies for individual projects are sometimes available, there is little research information on a broader scale which deals with water requirements of non-farm industries that may be important in the growth of rural South Dakota.

Study Objectives

To meet these concerns and to begin filling the information void in water usage and costs, three objectives were drawn up for this study:

(1) to determine water requirements of the types of manufacturing firms which have located in non-metropolitan communities (less than 50,000 persons) of South Dakota in recent years, with emphasis on eastern South Dakota;

(2) to determine added costs to communities of supplying water and associated conveyance facilities to new manufacturing and processing firms; and

(3) to determine patterns of sharing these water supply costs between manufacturing firms and the local communities in which they reside.

Relevance of Research

Before completion of this study, the best source available for estimation of water usage in South Dakota by type of manufacturing firm was the Census of Manufacturers. From data contained in the Census of Manufacturers, the number of employees in firms from across the country in each Standard Industrial Classification (SIC) category and the total fresh water intake of those firms can be obtained. Using this information, the average water intake per employee for manufacturing firms in each SIC category can be calculated. The multiplication of the average water usage per employee times the number of employees of a firm in a given SIC category will yield an estimate of water usage for that firm. However, the water statistics provided by the Census of Manufacturers are only for firms that use 20 million gallons or more of water annually.

The reliability of an estimate of a firm's water usage based upon Census of Manufacturers data depends upon two things:

(1) that the number of firm employees is highly correlated with total firm water usage; and

(2) that South Dakota water usage by manufacturing type is very similar to national patterns of relatively large firms.

The water usage estimates of manufacturing firms recorded in this study are not based on the second assumption above. Rather, the estimates are based upon actual water usage by manufacturing firms located in South Dakota, broken down by both manufacturing type and employment size. We feel that this information will provide much more accurate estimates of needed water capacity under rural South Dakota conditions than will estimates based upon nationwide Census of Manufacturers data for large firms.

Procedures

Surveys were used as the main instruments to obtain data needed for this study. The surveys included the following:

(1) a mail survey of a sample of manufacturing firms that have recently located in South Dakota;

(2) a personal interview survey of a subsample of manufacturing firms that responded to the mail survey; and

(3) a personal interview survey of municipal officials in the communities in which the firms selected in number (2) above are located.

The initial mail survey was sent to 209 manufacturing firms that had located in non-metropolitan communities in South Dakota since approximately 1970. The 127 firms (61%) that responded were classified by each Standard Industrial Classification (SIC) code according to the products each manufactured. A list of the SIC codes referred to in this study is shown in Table 1. The abbreviated description of SIC categories shown in the right-hand column of Table 1 will be used in the remainder of this report.

From the 127 firms responding to the mail survey, 18 were selected for case studies. Taken together, the 18 firms represented (1) various manufacturing types; (2) different town sizes; (3) geographical distribution throughout four planning districts in eastern South Dakota; (4) a wide range of water usages; and (5) a range of employment size characteristics.

Personal interviews were conducted with each case firm's representatives,

Table 1

Standard Industrial Classification (SIC) Codes for Manufacturing Sector

Two-Digit SIC Code Number	Description of Products in Each SIC Classification	Abbreviated Description
01	Agricultural Production - Crops	Crops
02	Agricultural Production - Livestock	Livestock
10	Metal Mining	Metal Mining
14	Mining and Quarrying of Nonmetallic Minerals, Except Fuels	Nonmetallic Mining
20	Food and Kindred Products	Food
22	Textile Mill Products	Textile Mill
23	Apparel and Other Finished Products Made from Fabrics and Similar Materials	Apparel
24	Lumber and Wood Products, Except Furniture	Lumber
25	Furniture and Fixtures	Furniture
26	Paper and Allied Products	Paper
27	Printing, Publishing, and Allied Industries	Printing, Publishing
28	Chemicals and Allied Products	Chemicals
30	Rubber and Miscellaneous Plastic Products	Rubber, Plastics
31	Leather and Leather Products	Leather
32	Stone, Clay, Glass and Concrete Products	Stone, Concrete
33	Primary Metal Industries	Primary Metal
34	Fabricated Metal Products, Except Machinery, and Transportation Equipment	Metal Products
35	Machinery, Except Electrical	Machinery
36	Electrical and Electronic Machinery, Equipment and Supplies	Electrical
37	Transportation Equipment	Transportation
38	Measuring, Analyzing, and Controlling Instruments, Photographic, Medical and Optical Goods, Watches and Clocks	Instruments
39	Miscellaneous Manufacturing Industries	Miscellaneous

Source: Department of Economic and Tourism Development, Industrial Division, South Dakota Manufacturers and Processors Directory, 1979.

as well as with local municipal water and finance officials in communities in which the case firms were located. From these interviews, information of three types was obtained:

(1) actual physical facilities installed by either the firm or the municipality to supply an adequate quantity and quality of water to the firm;

(2) the costs of the facilities; and

(3) the methods used to finance construction of the facilities and to share costs between the communities and the case firms.

Interpretation of Statistical Analysis

The results of tabular and statistical analyses are presented throughout this report and are used to discern broad patterns of manufacturing water use in South Dakota. They are not meant to mask differences that will in fact exist between individual firms and communities. This report provides a basis for general manufacturing water use planning. Feasibility studies and then precise planning continue to be needed for final decisions concerning individual firms and communities.

Formulation of Capital Cost Budget for Municipal Water System Expansion

Capital costs are defined in this study as any costs of expanding or improving capital items in the municipal water system to service new firms beginning production in a community. This includes material, labor, interest, and professional services involved in design and construction. The basic format for the budget was adapted from a 1979 Oklahoma study on rural water systems (Goodwin, Doeksen, and Nelson).

Drawing from the case studies, a list was made of capital items typically needed for municipal water supply expansions. Current cost data were obtained in part from bids for selected water supply projects financed by the Farmers Home Administration in South Dakota during 1979. Data were also obtained from 1979 construction bids made by a local engineering firm for water supply projects. This engineering firm also provided ad hoc consultation on costs of elevated steel water towers.

Using data from both of these sources, costs of expanding a hypothetical water system were estimated. The example was actually very similar to the expansion of a water system in one of the case study communities.

MAIL SURVEY RESULTS

Results Related to Water Usage by Manufacturing Firms

The total water usage of each responding firm in 1978 was reported on the mail survey. Each firm was then classified according to its water usage, its manufacturing type, and its employment size. Subsequent analyses were carried out to determine any interrelationships among those three variables that could aid planners in predicting the water usage of a new firm intending to locate in their community.

Average annual water usages of the firms in each manufacturing category, as reported on the mail surveys, are shown in Table 2. Instruments firms were the highest annual users of water in 1978, with an average of 20,470 thousand gallons per firm. Second largest in water usage were food firms, averaging 7,270 thousand gallons per firm in 1978.

Lowest in average 1978 water usage were lumber firms, with an average of only 188 thousand gallons. Also on the lower end of the water usage scale were transportation firms, where the average firm used 213 thousand gallons in 1978.

Table 2

Mean Annual 1978 Water Usage by Standard Industrial Classification (SIC) Category

SIC Category	Number of Firms Reporting Water Usage			Mean Water Usage (1,000 gallons)		
	Eastern S.D.[1]	Western S.D.[2]	All S.D.	Eastern S.D.[1]	Western S.D.[2]	All S.D.
20 (Food)	18	4	22	8,276	2,745	7,270
23 (Apparel)	7	0	7	249	---	249
24 (Lumber)	4	3	7	312	23	188
28 (Chemicals)	7	0	7	254	---	254
30 (Rubber, Plastics)	6	0	6	499	---	499
32 (Stone, Concrete)	6	3	9	4,598	1,660	3,618
34 (Metal Products)	4	1	5	57	5,000	1,045
35 (Machinery)	12	1	13	989	100	920
36 (Electrical)	3	0	3	676	---	676
37 (Transportation)	7	0	7	213	---	213
38 (Instruments)	2	0	2	20,470	---	20,470
	TOTAL 76	12	88[3]	AVERAGE 3,169	1,761	2,977

[1] Eastern South Dakota is defined as the area within Planning Districts I, II, III, and IV.

[2] Western South Dakota is defined as the area within Planning Districts V and VI.

[3] Although 127 usable responses to the survey were received, only 88 firms recorded their 1978 annual water intake.

The case study results shown later in this report refer only to eastern South Dakota. Therefore, the water usage results shown in Table 2 are broken down by eastern and western regions of South Dakota. A large majority of the reporting firms were in South Dakota's eastern region. In most cases, firms of given manufacturing types in the eastern region reported higher average annual water usages than did firms in the western region.

Average annual water usage by employment size is reported in Table 3. Each firm was placed in one of four groupings according to its number of employees.

Firms in the smallest employment category (0-25 employees) used the smallest amount of water in 1978--an average of only 1,073 thousand gallons per firm. On the other hand, firms of the 251 or more employee category (the largest employee size category) recorded the highest average annual water usage; those firms averaged 14,419 thousand gallons in 1978.

Because water usage per firm tended to increase with the size of a firm's employment, an attempt was made to determine the strength of the relationship between the two variables through simple regression analysis. The analysis indicated that the number of persons employed by a firm will make a significant difference in the total annual water usage of that firm. However, employment is only one of many factors that has a significant impact

Table 3

Mean Annual 1978 Water Usage by Employment Size

Employment Size	Mean Water Usage* (1,000 gallons)	Number of Firms Reporting
(1) 0-25	1,073	47
(2) 26-100	4,417	27
(3) 101-250	4,901	10
(4) 251 or more	14,419	3
	TOTAL	87[1/]

*Analysis of variance yielded a test F-value not significant at the $\alpha = .05$ level, but significant at the $\alpha = .10$ level. In other words, the statistical test gives us considerable confidence that mean water usage does differ among firms in different employment size groupings.

[1/] Although 88 firms indicated their total water intake in 1978, only 87 of those recorded their employment. Tables throughout this report indicate varying numbers of responding firms. This is because some firms answered parts of the mail questionnaire with different degrees of completeness than did others; hence, some questionnaires could be used in certain parts of the analysis and not in others.

on the total annual water usage among manufacturing firms in South Dakota.[1/]

Table 4 shows the average 1978 water usage per employee in each SIC category. The highest average water usage per employee in 1978 was 267,806 gallons--for employees of food firms. In contrast, electrical firms recorded the lowest average water usage per employee (2,153 gallons).

1/ The regression analysis resulted in the following equation:

$X_1 = 1409.89 + 27.161X_2$

X_1 = thousands of gallons of water used in 1978

X_2 = number of employees

Only 8.2% of the variation in X_1 was explained by X_2.

Major Purposes of Water Use by Manufacturing Firms

The manufacturing firms responding to the mail survey recorded what they considered to be major purposes of water use within their plants. A major purpose was defined as a use in which relatively large volumes of water were consumed or needed in comparison to total water usage by the firm. There

Table 4

Average Annual 1978 Water Usage Per Employee in Each Manufacturing SIC Category

SIC Category	Average Annual Water Usage Per Employee	Average Number of Employees Per Firm	Number of Firms Reporting
	----------Gallons---------		
20 (Food)	267,806	28.4	21
23 (Apparel)	4,325	57.6	7
24 (Lumber)	4,683	40.1	7
28 (Chemicals)	21,707	11.7	7
30 (Rubber, Plastics)	36,630	16.2	5
32 (Stone, Concrete)	114,263	31.7	9
34 (Metal Products)	36,545	28.6	5
35 (Machinery)	21,338	37.7	12
36 (Electrical)	2,153	29.5	2
37 (Transportation)	4,494	47.4	7
38 (Instruments)	36,717	557.5	2
Average for All Categories	69,927	45.6	Total 84

were five major purposes of water use listed on the mail survey:

(1) drinking and sanitation,
(2) production,
(3) heating or cooling,
(4) fire protection, and
(5) other miscellaneous uses.

Results shown in Table 5 indicate that 70% of all the responding firms considered drinking and sanitation to be a major use of water at their plants. Production was listed by 40% as a major water use, and 19% said heating or cooling constituted a major use of water for their firm. Fire protection was recorded by 15%, while 5% said some "other" purpose was a major use of water.

Table 5 also illustrates the relationship between manufacturing firm type and major purposes of water use. A large percentage of the food, stone and concrete, and instruments firms indicated production was a major purpose of water use at their plants. Firms in these SIC categories are also relatively large annual consumers of water.

Except for the paper and instruments categories, in which there were only a few reporting firms, heating and cooling purposes did not show up as an extremely frequent major use of water.

Drinking and sanitation was reported as a major use of water by 70% or more of the firms in the SIC categories of apparel, lumber, paper, chemicals, machinery, electrical, transportation, and instruments. Except for instruments, the firms of all of these SIC categories are characteristically low annual water users.

A large percentage of the lumber and electrical firms reported fire protection as a major use of water. Although few in number, most of the instruments and paper firms also considered fire protection a major use of water.

Reported Facilities for Water Recycling, Water Treatment, and Fire Protection

Certain types of manufacturers may require installation of special capital items to insure an adequate amount of water of the quality needed. And in some cases, a community may want to provide incentives, such as subsidized utilities or buildings, to encourage prospective firms to locate there. Therefore, community planners must know the special water needs of various types of manufacturing firms, so that the structure that is built can be effectively used by a particular incoming firm or can be adapted for use by the firm at low cost. These specialized needs are usually for recycling, treatment, or fire protection equipment.

Several types of manufacturing firms which have recently located in South Dakota indicated on the mail survey that water is recycled in their plants (Table 6). However, in only three SIC categories--food, rubber and plastics, and instruments--did more than 50% of the responding firms acknowledge water recycling activity. In general, firms which are heavy water users tended to recycle more often than did those with low water usage. Recycling was usually done with water used for heating or cooling purposes.

As is the case with water recycling, instances of water treatment (before use) by manufacturing firms are dependent upon the type of product being manufactured, as well as on the quality of water initially available to the firm. Some firms in all but three SIC categories reported that some water treatment occurred in their plants (Table 7). However, only in the SIC category instruments did over 50% of the firms indicate they treated water before use. Water softening was the most common water treatment reported.

Location, as defined by planning district, could not be linked to instances of water treatment before use by manufacturing firms.

Table 5

Percentage of Firms Indicating What Purposes Are Major Uses of Water[1/]

SIC Category	Proportion of Firms Indicating Each Purpose Was Major					Total Number of Firms Reporting
	Production	Heating & Cooling	Drinking & Sanitation	Fire Protection	Miscell-aneous	
	----------Percent----------					
20 (Food)	76	19	43	5	14	21
23 (Apparel)	0	0	100	14	0	7
24 (Lumber)	0	0	71	57	0	7
26 (Paper)	0	100	100	100	100	1
28 (Chemicals)	33	33	83	0	0	6
30 (Rubber, Plastics)	33	33	33	0	0	3
32 (Stone, Concrete)	80	10	30	10	10	10
34 (Metal Products)	40	0	80	0	0	5
35 (Machinery)	25	25	81	13	0	16
36 (Electrical)	25	25	100	50	0	4
37 (Transportation)	20	10	100	10	0	10
38 (Instruments)	50	100	100	50	0	2
OVERALL %	40	19	70	15	5	TOTAL 92

[1/] Many firms indicated more than one purpose as being a major use of water.

Table 6

Percentage of Firms Indicating Water Recycling Activity

SIC Category	Percent Indicating That Firm Recycles	Total Number of Firms Reporting
	--------Percent--------	
20 (Food)	57	23
23 (Apparel)	0	2
24 (Lumber)	0	5
26 (Paper)	0	1
28 (Chemicals)	33	3
30 (Rubber, Plastics)	67	3
32 (Stone, Concrete)	0	11
34 (Metal Products)	0	3
35 (Machinery)	15	13
36 (Electrical)	33	3
37 (Transportation)	17	6
38 (Instruments)	50	2
OVERALL %	28	TOTAL 75

One other water related capital item of significance reported by the mail survey respondents was fire protection facilities; 29 of the responding firms possessed a sprinkler system at the plant site(Table 8). Six firms reported water towers at the plant site for fire protection.

Even though a firm may not consider fire protection a major use of water, it may see the need to install facilities for the potential use of water for that purpose.[2/]

2/ Adequate fire protection facilities may be required by a firm's insurance company, city ordinances, or both.

Table 8 breaks down the reported facilities for fire protection by manufacturing type. In only two SIC categories, lumber and instruments, did over 50% of the firms report the presence of sprinkler systems. The two instrument firms reported both water towers and sprinkler systems at the plant site.

Water Sources, Water Related Location Decisions, and Problems in Water Supply

The source of water supply that a firm might use is important information to community planners for two reasons:

Table 7

Percentage of Firms Indicating the Treatment of Water before Use

SIC Category	Percent Indicating That Firm Treats	Total Number of Firms Reporting
	--------Percent--------	
20 (Food)	35	23
23 (Apparel)	0	1
24 (Lumber)	33	3
26 (Paper)[1/]	--	--
28 (Chemicals)	25	4
30 (Rubber, Plastics)	33	3
32 (Stone, Concrete)	9	11
34 (Metal Products)	0	3
35 (Machinery)	15	13
36 (Electrical)	0	2
37 (Transportation)	33	3
38 (Instruments)	100	2
OVERALL %	25	TOTAL 68

[1/] The firm from SIC Category 26 did not respond to this question.

(1) If a firm is likely to join the municipal water system, then planners can evaluate the sufficiency of the water system to serve both new and old customers and can also outline physical and financial options for water system expansion if it is deemed necessary.

(2) If a firm is likely to require an independent water system, then community developers may want to consider providing a water source at a potential plant site in an attempt to attract a new firm to the community.

A majority (69%) of the firms that have already located in South Dakota use their community's municipal water system (Table 9). A private well served 26%, while 5% used a rural water system or some other system. A higher percentage of the firms in western South Dakota reported using a private well than did firms in eastern South Dakota.

There appears to be a correlation between type of manufacturing firm and

Table 8

Number of Firms Indicating the Presence of Fire Protection Facilities
(of total reporting on this question)

SIC Category	Indication of Water Tower		Indication of Sprinkler System		Indication of Both Water Tower & Sprinkler System 1/
	Yes	No	Yes	No	Yes
	Number of Firms				
20 (Food)	2	22	4	21	1
23 (Apparel)	0	11	1	11	0
24 (Lumber)	0	10	7	4	0
26 (Paper)	0	1	0	1	0
28 (Chemicals)	1	5	1	5	1
30 (Rubber, Plastics)	0	6	1	5	0
32 (Stone, Concrete)	0	12	1	11	0
34 (Metal Products)	0	5	1	4	0
35 (Machinery)	0	22	9	13	0
36 (Electrical)	1	6	1	5	0
37 (Transportation)	0	10	1	9	0
38 (Instruments)	2	0	2	0	2
TOTAL	6	110	29	89	4

1/ One firm that had a water tower did not answer the sprinkler system question.

Table 9

Sources of Water Supply for Manufacturing Firms in South Dakota

Water Source	Percentage of Firms Using Each Source		
	Eastern S.D.	Western S.D.	All S.D.
	----------Percent----------		
Municipal	71	59	69
Private Well	24	35	26
Rural Water System	2	6	2.5
Other System	3	0	2.5
Total Percent	100	100	100
(Number of Firms Reporting)	(95)	(17)	(112)

use of a private well. Firms with private wells often belonged to SIC categories in which firms are characteristically high annual water users--such as food and rubber and plastics.[3] Conversations with these firms' personnel indicated that private wells often are used as a backup or supplemental source when municipal service has been disrupted.

No discernible overall pattern existed between the size of town where a firm had located and the source of water used by the firm. However, a disproportionate share of the firms located in towns with populations under 500 had developed private wells and did not use the municipal water system.[4]

Certain firms (by SIC category and volume of water used) located in areas because of special water related considerations, such as the presence of a well or water tower at the plant site (Table 10). Food and instruments firms reported special water considerations affected their location decisions more often than did firms of other manufacturing types.

Water related problems (such as poor quality and lack of pressure) occurring after firms had located in communities could not be linked strongly to manufacturing types, town sizes, or geographic locations. The types of firms reporting water problems which could limit their growth in the community are shown in Table 11.

CASE STUDY RESULTS

Eighteen of the manufacturing firms responding to the mail survey were selected as case studies. From personal interviews, detailed information on actual construction of water related facilities by both the case firms and their host communities was gathered. This information was used in formulating the cost budget in this

[3] For more detail concerning responses in this subject area, see Hoffman and Dobbs, pp. 53-56.

[4] For more detail, see Hoffman and Dobbs, pp. 56-59.

Table 10

Percentage of Firms Influenced in Location Decision by Special Conditions Concerning Water Supply

SIC Category	Percent Indicating That Location Decision Was Influenced	Total Number of Firms Reporting
	----------Percent----------	
20 (Food)	42	26
23 (Apparel)	8	13
24 (Lumber)	8	12
26 (Paper)	0	1
28 (Chemicals)	0	7
30 (Rubber, Plastics)	0	7
32 (Stone, Concrete)	17	12
34 (Metal Products)	0	5
35 (Machinery)	4	23
36 (Electrical)	0	7
37 (Transportation)	8	12
38 (Instruments)	50	2
OVERALL %	14	TOTAL 127

section and in establishing the patterns of cost responsibility assumed by the case firms and their respective local municipalities in paying for the installation of water facilities.

Water Supply Cost Budgets

Whenever a community is considering expansion of its water system to accommodate a potential new firm, local planners must evaluate the costs and benefits to the community of such an expansion. Costs of the expansion therefore need to be estimated in a preliminary way, prior to a decision on whether or not to contract a full feasibility study. Once the approximate level of costs for the water project is known, planners need to determine possible ways to fund such a project. One of the purposes of this report is to provide a budgeting procedure which community planners can use in determining what items will be needed as a part of an expansion of the municipal water system and to aid in estimating the approximate costs of those items.

Each water supply project will contain items that are peculiar to that particular undertaking, but there are some items that are commonly added to existing municipal systems when a new

Table 11

Percentage of Firms Indicating Limits to Plant Expansion Due to Water Supply Problems

SIC Category	Percent Indicating Problems in Expansion Due to Water Supply	Total Number of Firms Reporting
	----------Percent----------	
20 (Food)	12	26
23 (Apparel)	0	12
24 (Lumber)	9	11
26 (Paper)	0	1
28 (Chemicals)	0	6
30 (Rubber, Plastics)	14	7
32 (Stone, Concrete)	18	11
34 (Metal Products)	0	5
35 (Machinery)	13	23
36 (Electrical)	0	7
37 (Transportation)	17	12
38 (Instruments)	0	2
OVERALL %	10	TOTAL 123

firm is connected. Table 12 lists some items that might be installed when a water system is expanded. The items and their costs were taken from bids on 1979 water projects funded in part by the Farmers Home Administration (FmHA) and from consultation with a local engineering firm.[5/]

It is not the purpose of this study to provide a feasibility analysis for individual communities. Rather, it is to provide a general guide to the types of capital equipment that might have to be provided for a water system expansion and to give "ball-park" estimates of the costs involved. If the "ball-park" estimates of the costs are deemed not excessive, then the individual community can initiate or contract for a formal, detailed feasibility study.

From Table 12, a sample cost budget for a municipal water system expansion was calculated (Table 13).

Most of the items in Table 13, as well as the size and quantities of each item, were taken from an actual munici-

5/ Personal interviews with FmHA personnel in November 1979 and with engineering firm personnel in January 1980.

Table 12

1979 Costs of Commonly Used Items in Expansions of South Dakota Municipal Water Systems

Item	Cost (Installed)
A. Pipe[1] (Per foot)	($)
1. 10" PVC	11.00
2. 8" PVC	9.00
3. 6" PVC	6.75
4. 4" PVC[2]	5.75
5. 2" Service Pipe[2]	7.25
6. 1" Service Pipe[2]	4.50
7. 3/4" Service Pipe[2]	4.25
B. Valves, Tees, Bends, Reducers, Caps, Sleeves, Stops	
1. 10" gate valve and box	720.00
2. 8" gate valve and box	591.75
3. 6" gate valve and box	463.25
4. 4" gate valve and box	350.00
5. 10" x 10" x 10" tee	320.00
6. 10" x 10" x 6" tee	291.75
7. 10" x 10" x 4" tee	290.00
8. 8" x 8" x 8" tee	250.00
9. 8" x 8" x 6" tee	245.00
10. 8" x 8" x 4" tee	241.75
11. 10" 45° bend	154.25
12. 8" 45° bend	116.75
13. 6" 45° bend	83.00
14. 4" 90° bend	75.25
15. 10" x 8" reducer	138.00
16. 8" x 6" reducer	98.00
17. 6" x 4" reducer	78.75
18. 4" x 3" reducer	53.25
19. 10" cap	79.00
20. 8" cap	73.25
21. 6" cap	51.75
22. 4" cap	38.25
23. Tapping sleeves	58.25
24. 2" corporation stop	91.00
25. 1" corporation stop	46.00
26. 3/4" corporation stop	46.00
27. 2" curb stop	165.00
C. Hydrants, meters	
1. 6" fire hydrant	643.00
2. 5" fire hydrant	395.00
3. 2" outside meter	374.00

-continued-

Table 12 (continued)

Item	Cost (Installed)
4. 1 1/2" outside meter	266.00
5. 1" outside meter	108.00
6. 3/4" outside meter	80.00
7. 5/8" outside meter	60.00
D. Elevated Steel Storage Tanks	
1. Actually constructed, 500,000 gallons[3/]	450,000.00
2. Actually constructed, 1,000,000 gallons[3/]	700,000.00
3. Generally:	
a. 500,000 gallons or less	$1 per gallon
b. More than 500,000 gallons	Less than $1 per gallon, due to economies of size
E. Professional Fees and Other Costs (as % of total construction costs)	
1. Legal	3%
2. Engineering	15%
3. Interest[4/]	7%
4. Contingencies	10%

Sources: Farmers Home Administration interviews and consultations with local engineering firm and lending institutions.

1/ Pipe is most generally constructed of PVC (polyvinyl chloride), cast iron, ductile iron, or asbestos - cement (A.C.). PVC seems to be coming into use more frequently. The actual cost of installation will vary, depending on the depth at which the pipe must be installed.

2/ In many cases, the firm, rather than the municipality, is responsible for service line installation.

3/ These water towers were actually constructed at the costs stated during 1979. The actual cost of a water tower will vary, depending on the amount of understructure that must be provided.

4/ The interest rate refers to the percentage cost of using the borrowed money during construction. Local banks indicated the annual rate of interest on this money was around 14 percent in late 1979. It was assumed that the construction period would approximate six months.

Table 13

Sample Capital Cost Budget for a Municipal Water System Expansion

Type and Size of Item	Quantity		Cost/Unit (1979)		Total Cost (1979)
A. Lines (materials, placement and labor):					
1. PVC 10"	3,640 ft.	x	11.00	=	$40,040.00
2. PVC 6"	610 ft.	x	6.75	=	4,117.50
3. PVC 4"	50 ft.	x	5.75	=	287.50
Sub Total					$44,445.00
B. Valves, tees, bends, caps, sleeves, stops (materials, placement and labor):					
1. Tee 10" x 10" x 10"	3	x	320.00	=	960.00
2. Tee 10" x 10" x 6"	2	x	291.75	=	583.50
3. Gate Valve 10"	3	x	720.00	=	2,160.00
4. Gate Valve 8"	3	x	591.75	=	1,775.25
5. Gate Valve 6"	3	x	463.25	=	1,389.75
6. Gate Valve 4"	1	x	350.00	=	350.00
7. 45^{o} Bend 10"	1	x	154.25	=	154.25
8. 45^{o} Bend 6"	1	x	83.00	=	83.00
9. Reducer 10" x 8"	2	x	138.00	=	276.00
10. Reducer 8" x 6"	2	x	98.00	=	196.00
11. Cap 10"	3	x	79.00	=	237.00
12. Cap 6"	1	x	51.75	=	51.75
13. Corporation Stop 1"	2	x	46.00	=	92.00
Sub Total					$ 8,308.50
C. Hydrants, meters					
1. Fire Hydrant 6"	5	x	643.00	=	3,215.00
2. Service Meter 2"	1	x	371.00	=	374.00
3. Service Meter 3/4"	2	x	80.00	=	160.00
Sub Total					$ 3,749.00
D. Elevated steel storage facilities (complete, operational):					
1. 175,000 gallons	1	x	175,000.00	=	175,000.00
Sub Total					$175,000.00
Total Construction Costs (A + B + C + D)					$231,502.50
E. Professional Fees and Other Costs					
1. Legal (3% of construction cost)				=	6,945.08
2. Engineering (15% of construction cost)				=	34,725.38
3. Interest (7% of construction cost)				=	16,205.18
4. Contingencies (10% of construction cost)				=	23,150.25
TOTAL PROJECT COST					$312,528.39

pal water system expansion experienced by one of the case study communities. That particular community has a population of between 1,000 and 2,500 people. The firm involved employs between 25 and 100 people, uses 500,000 to 1,000,000 gallons of water per year, and belongs to the transportation SIC category.

The data in Tables 12 and 13 refer to items that are likely to be necessary in expanding a municipal water system to a new firm's property line or building. Depending upon the type of firm, there may also be water related capital items that need to be installed at the firm site. Excluding service line pipe, these items fall into three main categories: (1) water treatment equipment; (2) recycling equipment; and (3) sprinkler system for fire protection. Some firms may also have their own water towers for fire protection purposes.

Information on the exact components and costs of water treatment, recycling, and sprinkler systems was not sufficiently available to construct a detailed budget for those items, as was done for the items in Table 13. The complexity of treatment and recycling systems varied considerably among the case study firms, depending mostly on the type of manufacturing firm involved.

Water treatment facilities ranged from none to a simple water softener to a complete water treatment plant implementing the use of zeolite softening and manganus sand and rock. Costs that could be obtained varied from $1,300 for treatment equipment installed in 1977 to $100,000 for certain equipment installed in 1972-73.

A wide range in degree of sophistication also exists for recycling systems. Differences depend on the type of industry being examined. One of the most common purposes of recycling was for cooling, with water being transferred to a hot water holding tank, then to a cooling tower, and finally to a cool water holding tank to be reused from there. An observed system of this type in one of the case studies contained the following principal components: (1) cooling tower; (2) two 5,000-gallon steel storage tanks; and (3) six water pumps, with necessary piping and fittings. The installation cost of this system in 1976 was approximately $35,600. In 1979 prices, the cost would be close to $50,000.[6/]

Reported costs for sprinkler systems from the case study firms ranged from $18,000 in 1977 to $47,500 for a system started in 1975 and added to through 1978. One 1978 system was priced at $34,000 and covered 70,000 square feet of the plant.

Costs reported in this section can be updated by community planners by using standard, published price indices.

Patterns of Sharing Costs between Firms and Communities

Generally speaking, the cost for the majority of capital items installed outside of the case firms' property lines were initially paid for by someone else, usually the municipality or a local development corporation (Table 14). The governmental or quasi-governmental entities were often aided by grant money from the federal government, especially in the case of high-cost water system expansions needed to maintain or increase local employment opportunities.

Costs of facilities installed within the case firms' property lines were almost always paid for by the firms themselves. However, the costs of installation for three of the service lines located within firm property lines were paid for by the municipality or by a local development corporation.

6/ Calculated from the Department of Commerce's Composite Cost Index for 1976 and August of 1979.

Table 14

Entity that Initially Financed Components of Water Supply for Firms in the Case Studies[1/]

Item	Paying Agent (Frequency)						Total Cases with Each Item
	City	City With Grant	Local Development Corporation	Local Development Corporation with Grant	Firm	Firm with Grant	
Extension of Municipal Water Lines	2	3	3	2	0	1	11
Construction of Municipal Water Tower	0	2	0	0	0	0	2
Firm Service Line Installation	1	1	0	1	9	1	13
Firm Recycling Equipment	0	0	0	0	7	1	8
Firm Treatment Equipment	0	0	0	0	8	1	9
Firm-owned Storage Tanks	0	0	0	0	4	1	5
Firm-owned Wells	0	0	0	0	2	1	3
Firm Sprinkler Systems	0	0	0	0	12	0	12

[1/] Total number of case studies was 18.

Although initial responsibility for the payment of costs for water related capital items installed outside the case firms' property lines fell to the municipalities or local development corporations, the potential for these costs being recouped through municipal water charges to the firms was examined. From discussions with municipal officials and examination of water rates and charges in the case study communities, potential mechanisms for recouping costs appeared to be of three types:

(1) Hookup fees. Hookup fees examined usually were meant to cover the costs of material and labor needed to connect a service line to the municipal system at one point. In most cases, hookup fees were not large enough to pay for extension of municipal water mains or other expansions of the municipal system that might be needed to help supply a new firm with water.

(2) Minimum water charges per time period. Six of the case communities had water rate schedules that charged more for industrial and commercial water users than for residential users. Some systems merely charged a higher rate per unit of water used. Other systems charged a minimum monthly or quarterly rate that was higher for larger meters. Most of the case firms possessed large meters that were indicative of large service pipe sizes. These large pipe sizes were usually required to assure an adequate volume of water to the sprinkler systems in case of fire.

(3) Lease-purchase agreements. The case municipalities or local development corporations could, in some cases, be recovering the costs of water system expansion through the terms of lease-purchase agreements for land and buildings with the case study firms.

To determine if the case firms were bearing their share of municipal water supply costs, the average water payments by firms on municipal systems were compared to the average costs of water for their respective systems. These figures were then compared to the average payment for water by all customers on each of those municipal systems. Results for the case firms on municipal water systems are shown in Table 15 and can be summarized as follows:

(1) Eight of the case firms were paying less, on average, for water than it cost the municipality, on average, to supply the water. The average payment for water by one other case firm was equal to the municipality's cost of supplying the water.

(2) In ten cases, the average payments per thousand gallons for water by all municipal customers exceeded the average payments made for water by the case firms. This includes all nine cases referred to in (1).

These data would seem to indicate that the case firms were not carrying their full share of the load in paying for costs of municipal water supply. However, in six of the seven cases in which the average payments for water by the case firms exceeded the average costs for water incurred by the municipalities, those payments also exceeded the average payments made for water by all municipal customers. Thus there does not appear to be a clear pattern of overpayment or underpayment for water by the case firms, either in comparison to the costs of providing water by municipalities or in comparison to the payments made by municipal customers in general.

Analyses based upon average costs and payments have obvious limitations. Had data permitted, it would have been desirable to extend the analysis to marginal costs and charges associated with particular firms, taking into account distinctions between fixed and variable water supply costs at various points in time and how these costs affect decisions on rates to charge different customers.

Table 15

Costs of and Payment for Water Supply in Case Study Communities[1/]

Case	Costs and Charges		
	Average Cost of Water Supply in Case Communities	Average Amount Paid by Case Firms for Municipal Water	Average Amount Paid by All Municipal Customers on Metered Sales
	Dollars Per 1,000 Gallons		
1. Community A			
Case #3	1.14	---	0.72
Case #6	1.14	1.34	0.72
2. Community B			
Case #10	1.13	0.70	0.92
3. Community C			
Case #1	0.65	0.67	0.60
Case #8	0.65	0.69	0.60
Case #14	0.65	0.69	0.60
4. Community D			
Case #4	0.56	0.70	0.73
Case #13	0.56	0.41	0.73
5. Community E			
Case #5	0.72	0.57	0.65
6. Community F			
Case #7	0.99	0.83	1.03
Case#12	0.99	0.85	1.03
7. Community G			
Case #9	0.67	1.08	0.75
Case #18	0.67	1.05	0.75
8. Community H			
Case #17	0.94	0.94	1.04
9. Community I			
Case #15	1.07	0.97	1.00
10. Community J			
Case #16	1.01	0.91	1.04
11. Community K			
Case #11	1.62	1.02	1.65
12. Community L			
Case #2	1.09	---	1.72

[1/] For more detail concerning the procedures used to calculate the figures shown in this table, see Hoffman and Dobbs, pp. 85-91.

BIBLIOGRAPHY

Business Research Bureau. The Relationship of Water to Industry and Recreation in South Dakota. Prepared for the South Dakota Water Resources Commission. University of South Dakota, Vermillion, September 1970.

Fernstrom, John R. Bringing in the Sheaves: Effective Community Industrial Development Programs. Corvalis, Oregon: Oregon State University Extension Service, 1973.

Goodwin, H. L., Gerald A. Doeksen, and James R. Nelson. Economics of Water Systems in Rural Oklahoma. Oklahoma State University Agricultural Experiment Station Bulletin B - 745, July 1979.

Hoffman, Randy and Thomas L. Dobbs. Water Requirements and Costs for South Dakota Rural Manufacturing Firms. Research Project Technical Completion Report for the Office of Water Research and Technology. Economics Department, South Dakota State University, Brookings, October 1980.

Kollar, K. L., and John Matticks. "The 1977 Market for Water and Wastewater Treatment Equipment." Construction Review. 25(1979):4-19.

Nie, Norman H., C. Hadlai Hull, Jean G. Jenkins, Karin Steinbrenner, and Dale H. Bent. Statistical Package for the Social Sciences. 2nd ed. New York: McGraw-Hill, Inc., 1975.

South Dakota Department of Natural Resources Development, Division of Resource Management. South Dakota Water Plan, Vol. II-E and F, December 1978.

Tauer, Loren W., and Thomas E. Daves. Commercial Bank Financing for Industrial Development. Bulletin 649 of South Dakota State University, Agricultural Experiment Station, Economics Department, 1977.

U.S. Corps of Engineers. Eastern South Dakota and Upper Big Sioux, South Dakota and Iowa Water Supply Study. Draft Reconnaissance Report, n.d.

U.S. Corps of Engineers. Western Dakotas Region of South Dakota Water Supply Study. Draft Reconnaissance Report, December 1979.

U.S. Department of Commerce, Bureau of the Census. "Water Use in Manufacturing." Special Report Series of the 1972 Census of Manufacturers. MC72(SR)-4, September 1975.

U.S. Department of Commerce, Industry and Trade Administration, "Statistical Series: Costs and Prices." Construction Review. 25(1979):55-58.

ACKNOWLEDGEMENTS

This research was supported by the South Dakota State University Agricultural Experiment Station under Project No. 109 and by the South Dakota State University Water Resources Institute and the Office of Water Research and Technology of the U.S. Department of the Interior under Agreement No. 14-34-0001-9044 and Project No. A-071-SDAK. The research assistance of Mrs. Diane Landon was extremely valuable throughout the data collection, tabulation, and statistical analysis phases of this study. Mrs. Nancy Hurtig's very responsible typing of the manuscript is also acknowledged.

Appendix

SAMPLE CAPITAL COST BUDGET FORM FOR

MUNICIPAL WATER SYSTEM EXPANSION

Type & Size of Item	Quantity		Cost/Unit		Total Cost
A. Lines (materials, placement and labor):					
1.	_____	x	_____	=	_____
2.	_____	x	_____	=	_____
3.	_____	x	_____	=	_____
4.	_____	x	_____	=	_____
5.	_____	x	_____	=	_____
Sub Total			A	=	_____
B. Valves, tees, bends, caps, sleeves, stops (materials, placement, and labor):					
1. Tee	_____	x	_____	=	_____
2. Tee	_____	x	_____	=	_____
3. Tee	_____	x	_____	=	_____
4. Tee	_____	x	_____	=	_____
5. Tee	_____	x	_____	=	_____
6. Gate Valve	_____	x	_____	=	_____
7. Gate Valve	_____	x	_____	=	_____
8. Gate Valve	_____	x	_____	=	_____
9. Gate Valve	_____	x	_____	=	_____
10. Gate Valve	_____	x	_____	=	_____
11. Bend	_____	x	_____	=	_____
12. Bend	_____	x	_____	=	_____
13. Bend	_____	x	_____	=	_____
14. Bend	_____	x	_____	=	_____
15. Bend	_____	x	_____	=	_____
16. Reducer	_____	x	_____	=	_____
17. Reducer	_____	x	_____	=	_____
18. Reducer	_____	x	_____	=	_____
19. Reducer	_____	x	_____	=	_____
20. Reducer	_____	x	_____	=	_____
21. Cap	_____	x	_____	=	_____
22. Cap	_____	x	_____	=	_____
23. Cap	_____	x	_____	=	_____
24. Cap	_____	x	_____	=	_____
25. Cap	_____	x	_____	=	_____
26. Corporation Stop	_____	x	_____	=	_____
27. Corporation Stop	_____	x	_____	=	_____
28. Corporation Stop	_____	x	_____	=	_____
29. Corporation Stop	_____	x	_____	=	_____
30. Corporation Stop	_____	x	_____	=	_____
Sub Total			B	=	_____

C. Hydrants, meters

1.	Fire Hydrant	_____	x	_____	=	_____
2.	Fire Hydrant	_____	x	_____	=	_____
3.	Fire Hydrant	_____	x	_____	=	_____
4.	Fire Hydrant	_____	x	_____	=	_____
5.	Service Meter	_____	x	_____	=	_____
6.	Service Meter	_____	x	_____	=	_____
7.	Service Meter	_____	x	_____	=	_____
8.	Service Meter	_____	x	_____	=	_____
	Sub Total			C	=	_____

D. Elevated steel storage facilities (completely operational):

1.		_____	x	_____	=	_____
2.		_____	x	_____	=	_____
3.		_____	x	_____	=	_____
	Sub Total			D	=	_____

TOTAL CONSTRUCTION COSTS (A + B+ C + D) = _____

E. Professional Fees

1.	Legal	= _____
2.	Engineering	= _____
3.	Interest	= _____
4.	Contingencies	= _____
	TOTAL PROJECT COST	= _____

November 1981

B 678

WATER USE BY RURAL MANUFACTURING FIRMS IN SOUTH DAKOTA

Contents

Published in accordance with an Act passed in 1881 by the 14th Legislative Assembly, Dakota Territory, establishing the Dakota Agriculture College and with the Act of re-organization passed in 1887 by the 17th Legislative Assembly, which established the Agricultural Experiment Station at South Dakota State University.

File: 5.5-7.4-1--1M--11-81--514